Environmental Assessment of the Alaskan Continental Shelf

Annual Reports of Principal Investigators for the year ending March 1977

Volume VII. Receptors — Fish, Littoral, Benthos

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF INTERIOR
Bureau of Land Management

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Outer Continental Shelf Environmental Assessment Program

Boulder, Colorado

March 1977

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratory

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Bureau of Land Management

DISCLAIMER

VOLUME VII

RECEPTORS - FISH

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* indicates final report

Project Completion Report

Research Unit No. 19
May 1975 - September 1976

Alaska Marine Environmental Assessment Project

HERRING SPAWNING SURVEYS - SOUTHERN BERING SEA

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SUMMARY

Surveys were conducted from Unimak Pass to the Yukon River Delta to determine the spatial and temporal distribution of Pacific herring and other forage fish. The importance of herring to domestic users was documented and may exceed 300 m.t. in some years at the present levels of exploitation. Cape Romanzof, Nelson Island, Goodnews Bay, Metervik Bay, Port Moller Bay, Port Heiden Bay and Herendeen Bay were identified as major herring spawning areas. Herring generally spawned in the intertidal zone on marine algae (*Fucus* and or *Zosteria* species). Irregular rocky shorelines comprised of cliffs or bluffs with large rock outcroppings were most frequently encountered with herring spawn, while shallow secluded bays were utilized to a lesser extent. Herring spawning occurred immediately after ice breakup in late May and June. Spawning and migration of herring appeared to proceed in a northward direction with both prespawning and postspawning populations present throughout early spring and summer. Large concentrations of capelin were observed in the study area. Capelin spawning was generally confined to exposed, fine sand and gravel beaches. Spawning populations of eulachon and boreal smelt were studied, but no spawning documentation was accomplished.

Oil exploration and leasing activities are eminent in the study area. The geographical and climatological characteristics associated with most herring spawning habitats encountered in the study area may preclude effective cleanup and containment activities associated with oil spills. These intertidal habitats and herring spawn would be highly subject to surface-born contaminants. This same potential exists for other forage fish species. More studies are needed to further define spawning areas and to document the effects of crude oil upon eggs, larvae and spawning substrates of forage fish species in the Bering Sea.

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INTRODUCTION

This report describes studies conducted under Research Unit 19 (R.U. 19), HERRING SPAWNING SURVEYS-SOUTHERN BERING SEA. This program was one of the State of Alaska contracted Outer Continental Shelf (OCS) projects. Federal funds were made available through the Bureau of Land Management (BLM) and administered by the National Oceanic and Atmospheric Administration (NOAA). Limited funding in Fiscal Year (FY) 1975 resulted in reconnaissance surveys during selected spawning dates. Only a small portion of the coast included in R.U. 19 was surveyed in 1975 due to time and fund limitations. The area between Cape Newenham and the Yukon River Delta was selected for study due to the lack of documented information and its proximity to the Alaska Department of Fish and Game (ADF&G) office in Bethel. The refunding level of R.U. 19 in FY 1976 was $142,100 and areas between Unimak Pass and the Yukon River Delta were examined.

Pacific herring (Clupea harengus pallasi) in the study area are known to play an important role in subsistence utilization by coastal residents, but the magnitude and importance of this harvest has not been documented. Herring are a commercially exploitable resource of potential benefit to Alaskan coastal residents as well as a potential major international food source. In addition, herring and their spawn as well as other forage fish species constitute one of the fundamental sources of food for many species of fish, mammals and birds.

Japanese and Soviet fleets have harvested some 45,000 metric tons of herring annually in the eastern Bering Sea since 1970 (Fishery Management Plan, 1976). Although this harvest occurs primarily to the north of the St. George Basin in Bristol Bay, the stock is believed to reproduce along the coast from Unimak Pass to Norton Sound (Dudnik and Usol'tsev, 1972). Leasing and development of any of these coastal areas could affect the status of this important resource.

Herring and capelin are known to spawn in intertidal and shallow subtidal zones. Developing eggs and larvae are, therefore, highly susceptible to surface-borne pollution. Little information exists regarding the range, distribution, seasonal occurrence, relative abundance, life history and locations of spawning areas. These data are necessary to provide information for predicting and mitigating impacts of potential oil and gas exploration and development on the coastal herring resource.

Specific objectives include the following:

1. determine seasonal occurrence, distribution and relative abundance of spawning herring and their spawn in intertidal and shallow subtidal zones.

2. determine the dependence upon and utilization of herring and their spawn by coastal residents.

3. determine the important life history characteristics (age, sex and size composition) of selected spawning populations.

4. determine the kinds of mineral and plant substrates used for spawning.

Similar information on selected species belonging to the families Osmeridae and Ammodytidae were collected incidentally throughout the study. Species studied included boreal smelt (*Osmerus mordax dentex*), capelin (*Mallotus villosus*), eulachon (*Thaleichthys pacificus*) and Pacific sandlance (*Ammodytes hexopterus*).

ACKNOWLEDGEMENTS

Excellent assistance was obtained from Commercial Fisheries staff ADF&G biologists in flying aerial surveys. Their assistance was sometimes provided during the peak of salmon field season activities. Following is a list of ADF&G staff Biologists and the area of their assistance:

1. Michael Nelson, Bristol Bay Area Biologist Dillingham Cape Newenham.

2. Richard Randall, Bristol Bay Assistant Area Biologist Ugashik River to Dillingham.

3. Don Bill, Bristol Bay Assistant Area Biologist - Ugashik River to Dillingham.

4. Fritz Kuhlmann, Norton Sound - Kotzebue Area Biologist Western Coast of Alaska north of Cape Newenham.

5. Mike Geiger, Yukon Area Biologist Kuskokwim River to Yukon River.

6. Ronald Regnart, Regional Supervisor, Region III Western Coast of Alaska.

7. Pete Jackson, OCS coordinator, acted as the immediate scientist in charge for the Kodiak portion of R.U. 19 and was frequently consulted for project level advice.

Following is a list of temporary personnel and their duties during the 1976 field season:

1. Irving Warner, Assistant Project Investigator, supervision and reporting of studies conducted from Unimak Pass to Ugashik Bay.

2. Pam Shafford, Fishery Biologist, Kodiak laboratory crew leader and assistant to Irv Warner.

3. Michael Whelan, Fisheries Technician, Kodiak laboratory assistant.

4. Frank Morgan, Fisheries Technician, mobile herring crew

5. John Marholic, Fisheries Technician mobile herring crew.

6. Tom LeMon, Fisheries Technician Togiak herring crew.

7. Donna Manders, Fisheries Technician Togiak herring crew.

8. Michael Jonrowe, Fisheries Technician crew leader-
West Coast herring crew.

9. Eugene Joseph, Fisheries Technician West Coast herring crew and subsistence surveys south of Yukon River Delta.

A literature search was conducted by Dorothy Lunsford, librarian (ADF&G, Juneau), at the University of Washington Fisheries library. The result of this search made up the bulk of the literature base on hand at Kodiak.

Assistance was also provided by National Marine Fisheries Service, University of Alaska, OCSEAP Juneau Project Office and other ADF&G personnel.

A special thanks is in order for the west coast Alaskan natives whose cooperation and assistance contributed to a successful subsistence survey.

CURRENT STATE OF KNOWLEDGE

The current state of knowledge of forage fish in the Bristol Bay-Bering Sea area is quite limited. Zagoskin (1967) mentioned the importance of herring subsistence utilization by resident natives during the mid-1800's. Virtually no biological work was attempted on herring from this region until the 1920's. Rounsefell's (1929) work represents the first actual biological studies conducted on Bering Sea herring. Mention is made several times in his report of herring vertebrae counts taken at Unalaska and Golovin Bay (Norton Sound). Documentation of several life history parameters of herring are included in his report as well as the condition of the fishery in Alaska.

The herring fishery in the early portion of the 20th Century centered around salt curing and later declined because of poor marketing conditions arising from foreign competition. Rounsefell indicated that the earliest American commercial effort on Bering Sea herring took place during the early part of this century at Golovin Bay. He also pointed out that the first extensive commercial fishery existed in Western Alaska in 1928 when about one-half of the central Alaska purse-seine fleet fished at Unalaska in the Aleutian Islands (Photograph 24). The Unalaska herring fishery reached an apparent peak in the 1940's, when nine herring salteries existed in the Unalaska region, and ended in 1946.

Commercial effort on herring in the Bering Sea-Bristol Bay region resumed in 1967 where a small commercial fishery has occurred annually in the Togiak Bay area. This fishery takes place in the spring for both prespawning herring for sac roe extraction and spawn on kelp, in contrast to the earlier fisheries for a salt cured product. The high fat content desired for salt curing necessitates fishing herring in the fall The Togiak fishery has failed to develop into anything more than a small scale operation. Prevailing inclement weather, existing market prices, high operating costs and fluctuations in herring abundance, have been cited as reasons for the failure of the fishery to develop (Randall, 1975). Commercial effort has resulted in about 1.2 million pounds of herring in the round being harvested and an additional harvest of over 0.75 million pounds of roe on kelp, since the Togiak fishery's inception. Randall's 1975 report on age, length and weight analysis of Togiak herring stocks was the first American biological work published on southwestern Alaska herring stocks since 1929.

Foreign fishing effort for herring in the eastern Bering Sea began in the Pribilof Island area in 1961 by the Soviet fleet. They were joined by the Japanese in the mid-sixties, and both nations have continued to fish these stocks. Effort essentially begins with trawling by both nations during the winter months and continues into the early spring with the Japanese gillnet fishery (Photograph 23). Although nothing is known concerning Japanese research efforts on herring in the Bering Sea, Soviet research began in 1959 and continued until 1961 (Dudnik & Usol'tsev, 1964). Herring stocks were investigated in the eastern portion of the Bering Sea shelf, from the Alaska Peninsula to St. Lawrence Island. The primary aim of the Soviet research on herring was to determine temporal and spatial distribution to assess relative abundance by area. Results from Soviet investigations revealed that winter concentrations of herring occurred northwest of the Pribilof Islands and at the southern margin of the ice fields. They also suggested that other areas of wintering possibly exist further north under the ice fields.

These foregoing studies comprise the investigators' knowledge of forage fish research in the Bering Sea, with the exception of cruise reports by various American, Canadian and foreign agencies, which list simple occurrence.

The literature base for Pacific herring in more southerly latitudes was extensive as it is a commercial species of long standing on the west coast of the United States and Canada. Current knowledge used to study herring in 1976 was gleaned from Moberly and Blankenbeckler's (ADF&G biologists) work on this species in Alaskan waters. Rounsefell's (1929) historical monograph was used for historical reference and Nagasaki's (1957) techniques for determining herring fecundity were employed.

Davenport (Personal Communication) discussed capelin spawning along the north coast of the Alaska Peninsula. In 1959 the federal management agent for the Alaska Peninsula discussed a phenomenal eulachon run which occurred in Bear River (Port Moller) during that same year.

> "...The vast size of the smelt run, its timing in conjunction with the red salmon run, and the subsequent demise of the spawning smelt could have resulted in an avoidance reaction by red salmon to enter the river in usual numbers, and also could have produced a temporary pollution condition on the stream....It was estimated that the ten mile concentration numbered from two to five million fish (eulachon) or more...." (Chrostowski, 1959).

Aside from other anecdotal sources, forage fish activities in the Bering Sea have been scarcely documented and their biology unknown. Literature from the east coast of Canada and the northern coasts of the Scandanavian countries were used for this study's capelin and boreal smelt investigations such as Wilford Templeman (1949) and P.M. Jangaard (1974). Wendel E. Smith's (1955) work was used as background material for eulachon. Other sources are cited in the text.

STUDY AREA

The study area includes all coastal waters from Unimak Pass north to the Yukon River Delta including Nunivak Island. The coastline of this area totals 3,594 kilometers (km) or 2,233 statute miles (Figure 1). A new research unit (RU 19E), Finfish Resource Surveys in Norton Sound and Kotzebue Sound, was funded in FY 1976 and added 2,496 km (1,551 mi) of coastline studies under direction of the Principal Investigator (P.I.). Consequently, the study area was divided into two sections to facilitate data collection and supervision of field crews. Mr. Irving Warner, Assistant Project Investigator (A.P.I.) directed studies from Unimak Pass to Ugashik Bay (1,166 km). Mr. Louis Barton (P.I.) directed studies from Ugashik Bay to the Yukon River Delta (2,428 km). Results are presented separately for each of these two study area sections.

SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Subsistence Utilization Surveys

Radio and typed news releases were made in selected communities throughout the study area, in late May and early June, to explain the scope and purpose of the OCS program and to solicit local cooperation in the subsistence utilization studies. The first release in 1976 was aired in Dillingham the last week of May and the second one in Bethel on June 1. These releases were followed by meetings in Hooper Bay, Scammon Bay and Tanunak on June 3 and 4 to disseminate subsistence catch calendar forms. An attempt was also made to hold a village meeting in Goodnews Bay.

Fourteen villages in the study area were included in the subsistence survey. Periodic interviews and collection of subsistence calendar forms were conducted by a two-man crew in conjunction with herring spawning surveys. Both commercial and air taxi services were utilized for the subsistence survey.

Following is a list of information that was solicited:

1. Fishery resources by species utilized by village.

2. Amount (when possible) of key species utilized in weight or actual numbers. Such species included herring and salmon.

3. Methods of fishing and resource utilization.

4. Spatial and temporal distribution and spawning information of various fishery resources as possible.

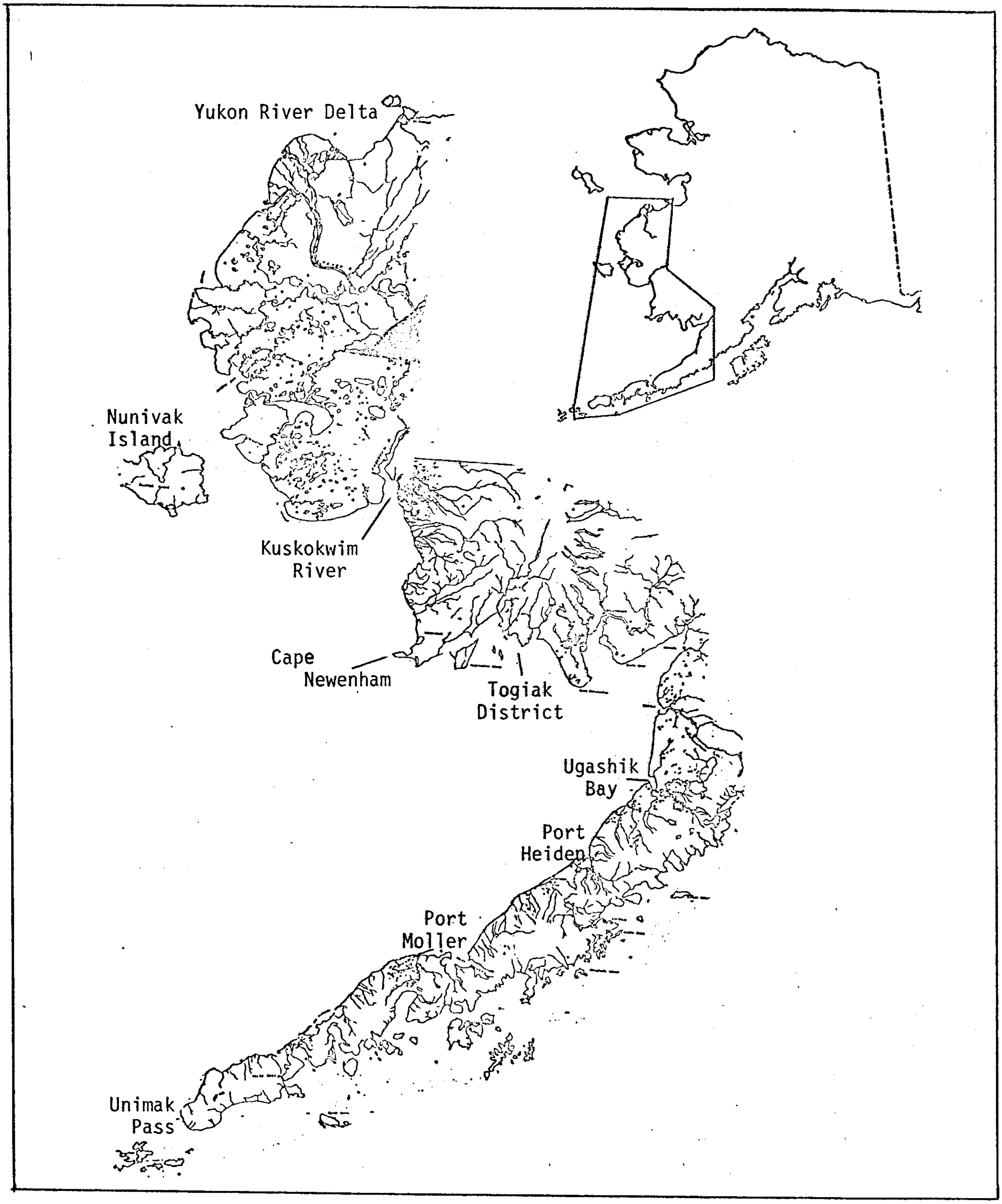

Figure 1. Study area for Research Unit 19; Unimak Pass to the Yukon River Delta (3,594 km), 1975-76.

Similar information was solicited from other local residents whenever they were encountered during the course of field investigations.

Aerial Surveys

The entire coastline of the study area was divided into census areas delineated by prominent geographical features prior to field investigations (Table 1). These divisions were made to facilitate transcribing aerial survey data onto a data management format with key-punching output to be later submitted to The National Oceanic Data Center (NODC) for archiving. At least two aerial reconnaissance surveys were to be attempted of the entire study area within the range of estimated spawning dates. Aerial surveillance of primary spawning areas was conducted as frequently as possible and initiated with the onset of ice breakup in the Bering Sea. The purpose of the surveys was to monitor the location, timing and relative abundance of spawning populations of herring and other forage fish species.

Aerial surveys were conducted from chartered aircraft (single and twin engine, fixed wing) at altitudes ranging from 75-500 m and air speeds of about 160-260 km/hr. Portable tape recorders were utilized to record aerial survey data, and the information was transcribed daily onto aerial survey data management forms. Polaroid sunglasses were worn to reduce sun glare and enhance water depth visibility. Following is a listing of data parameters recorded during each survey:

1. Observer, aircraft type, speed, altitude, time.
2. Weather, sea conditions, stage of tide.
3. Species identity and location of fish schools.
4. Number and surface area estimates of fish schools.

Limited aerial herring surveys along portions of western Alaska have been conducted by ADF&G personnel prior to OCS investigations. The relative abundance of herring during these surveys was estimated by subjectively categorizing sighted schools into one of three arbitrary groups: 1) Small schools which have an estimated surface area of less than 50 m^2 (about 500 ft^2), 2) Medium schools with surface area estimates between 50-450 m^2 (about 500-5000 ft^2), 3) Large schools estimated to be greater than 450 m^2 in surface area. This method was also used during aerial surveys conducted under R.U. 19, in FY 75.

Attempts were made to photograph as many schools of fish and spawn (milt) as possible with a hand-held 35 mm camera utilizing color slide film. The altitude, film and frame numbers were recorded on forms for each individual photograph. The location of the photographed target was recorded on U.S.G.S. topographical maps and a corresponding number entered by its location signifying the frame number of the photograph taken. A polarizing filter was used in taking all aerial photographs to minimize surface water glare. Surface area estimates were obtained

Table 1. Census areas from Unimak Pass to the Yukon River Delta, R.U. 19, 1976

Census Areas				Linear Shoreline Distance		Census Area Mid point 1/
Area	No.	North* Latitude	West* Longitude	Miles	km	(km)
Cape Sarichef - Cape Mordvinof	1-A	54°38'30"	164°40'32"	18.0	29	14.5
Cape Mordvinof - Cape Lapin	1-B	54°54'20"	164°17'32"	13.7	22	11.0
Cape Lapin - Chunak Point	1-C	55°03'15"	163°47'25"	31.1	50	25.0
Chunak Point - False Pass	2-A	54°58'28"	163°26'53"	20.5	33	16.5
False Pass - Cape Krenitzin	2-B	54°57'28"	163°15'50"	46.0	74	37.0
Cape Krenitzin - Cape Glazenap	2-C	55°08'55"	163°14'08"	21.1	34	17.0
Cape Glazenap - Moffet Point & Amak Is.	2-D	55°21'01"	162°41'30"	73.3	118	59.0
Moffet Point - Lagoon Point	3-A	55°48'21"	161°57'30"	70.8	114	57.0
Nelson Lagoon & Walrus & Kritskoi Is.	3-B	55°58'00"	161°07'40"	54.1	87	43.5
Herendeen Bay	3-C	55°42'50"	160°42'25"	75.2	121	60.5
Point Divide - Entrance Point	3-D	55°46'21"	160°46'16"	64.6	104	52.0
Entrance Point - Ilnik	4-A	56°20'30"	160°14'53"	62.1	100	50.0
Ilnik - Reindeer Creek	4-B	56°50'45"	158°57'29"	96.3	155	77.5
Reindeer Creek - Cinder River Lagoon	5-A	57°13'11"	158°28'05"	32.9	53	26.5
Cinder River Lagoon - Smokey Point	5-B	57°30'54"	157°50'59"	44.7	72	36.0
Smoky Point - Kvichak River	6	58°14'00	157°30'00"	118.1	190.0	95.0
Kvichak River - Nusagak	7	58°38'50"	158°00'20"	79.5	128.0	64.0
Coffee Point - Tvativak Bay	8	58°23'10"	158°48'00"	83.9	135.0	67.5
Kulukak Bay	9	58°55'10"	159°36'30"	28.0	45.0	22.5
Metervik Bay - Togiak	10	58°52'00"	160°00'00"	46.6	75.0	37.5
Summit Island	11	58°51'00"	160°14'20"	6.4	10.3	Perimeter
Round Island	12	58°36'20"	159°58'00"	4.7	7.5	Perimeter
Crooked Island	13	58°43'40"	160°17'40"	14.9	24.0	Perimeter
High Island	14	58°45'00"	160°24'10"	10.9	17.5	Perimeter
Togiak - Asigyukpak Spit	15	58°48'30"	160°49'20"	77.7	125.0	62.5
Hagemeister Island	16	58°48'50"	160°42'00"	66.8	107.5	Perimeter
Asigyukpak Spit - Cape Newenham	17	58°36'30"	161°43'20"	60.6	97.5	48.5
Cape Newenham - Chagvan Bay	18	58°39'40"	161°52'00"	32.6	52.5	26.3
Chagvan Bay	19	58°50'00"	161°46'00"	14.3	23.0	11.5
Chagvan Bay - Goodnews Bay	20-A	58°54'40"	161°47'10"	20.2	32.5	[illegible]6.3
Goodnews Bay	20-B	59°07'00"	161°36'10"	30.8	49.5	24.8
Goodnews Bay - Kuskokwim River	21	59°25'30"	161°51'20"	104.9	168.6	84.4
Kuskokwim River - Kolavinarak River	22	59°47'10"	163°46'20"	109.4	176.0	88.0
Kolavinarak River - Cape Vancouver	23	60°29'00"	165°00'50"	47.7	76.8	38.4
Cape Vancouver - Kinglick River	24	60°39'00"	165°09'00"	27.3	44.0	22.0
Nunivak Island	25	60°17'30"	165°41'00"	290.0	466.0	Perimeter
Hazen Bay	26	61°40'00"	165°00'00"	50.0	80.5	40.3
Angyoyaravak Bay	27	61°12'40"	165°38'30"	40.4	65.0	32.5
Hooper Bay	28	61°31'30"	166°02'00"	46.6	75.0	37.5
Kokechik Bay	29	61°39'40"	165°48'00"	35.7	57.5	28.8
Scammon Bay - Black River	30	61°57'00"	165°43'20"	60.6	97.5	48.8
Black River - North Mouth Yukon River	31	63°08'30"	164°33'50"	120.0	193.0	96.5

1/ Linear shoreline distance on either side of census area mid point.

* Latitude and Longitude of mid point of census area.

by placing a calibrated grid over projected slides. Grid calibration was obtained from the camera focal length and altitude at which a particular photograph was taken. Individual schools and/or aggregations of schools, as well as spawn (milt), from FY 76 OCS surveys were grouped into one of the three categories used in previous years, after estimating surface areas from an analysis of 35 mm slides.

Ground Surveys

To complement aerial survey data collection, two-man ground crews were deployed to primary spawning areas. The actual location of these ground crews varied throughout the season when herring began to spawn, and was determined from aerial survey observations. Fach crew was equipped with inflatable boats, portable camps and various types of sampling equipment.

The main objectives of the ground surveys were to determine species composition and primary spawning habitats. Water temperatures, weather conditions, escarpment type, beach type (intertidal and subtidal) and the occurrence of algae beds, Fucus and Zosteria (eelgrass) species, was also recorded. Further data collection included herring samples for age, length, fecundity and stomach content analysis.

Primary spawning areas were examined by boat and foot surveys. Beaches were walked at low tide and observations made in reference to egg density and distribution and types of spawning substrates utilized. The following four subjective categories were utilized to estimate substrate density: 1) very light - 0% to 10%, 2) light - 11% to 35%, 3) medium - 36% to 65%, and 4) heavy 66% to 100%.

The density of spawn was recorded based on Moberly's (1971) following criteria:

Intensity of Spawn	*Zosteria* sp. (per linear cm)	*Fucus* sp. (per square cm)
very light	1 - 25	1 - 50
light	25 - 100	50 - 200
medium	100 - 250	200 - 500
heavy	250 - 500	500 - 1000
very heavy	500+	1000+

All observations were recorded on U.S.G.S. topographical maps.

Variable mesh gillnets ranging from about 28-80 mm (stretch mesh), were utilized by the ground crews for obtaining herring age-weight-length data. These gillnets, which ranged from approximately 17-21 m in length and 1.75 m in depth, were randomly fished in primary spawning areas by driftnetting offshore or setnetting onshore. On most occasions beach sets were made "dry" at low tide, allowed to be inundated by the incoming tide and picked the following tide cycle. In addition, a New England fish trawl was operated from the M/V PAT SAN MARIE, under charter to the National Marine Fisheries Service (NMFS): forage fish specimens taken incidentally to demersal fish and shellfish operations on the north side of the Alaska Peninsula were retained through an interagency request from the A.P.I.

All herring samples processed throughout the entire study area were measured in standard length (hypural length) and all other species were measured in fork length. Scale and/or otolith collections were placed in 7.6 x 12.7 cm field envelopes, with the data recorded for each specimen. Gonads were fixed in either 50% isopropyl alcohol, 50% methyl alcohol, standard Gilson's solution or 10% formalin solution. Whole specimens, when taken at inshore sites, were fixed in 50% methyl alcohol. Nearly all specimens were processed at field sites, while samples from the R/V PAT SAN MARIE were frozen whole and transported to the Kodiak laboratory for processing.

Herring were aged by reading scale annuli. The most favorable results were achieved with a binocular dissection scope equipped with a substage reflected light source. A microfilm viewer was used for aging but was found to be less effective than the dissection scope.

Herring fecundity was determined by both volumetric and weight methods but the latter proved to be the most efficient and accurate. The displacement method entailed displacing 1 cc of water with eggs for three replicates from each female, counting the number of eggs in each replicate, finding the displacement of the remaining eggs and extrapolating egg content. Weight analysis techniques consisted of breaking the ovaries up manually by repeated washing through a sieve. Eggs were dried on filter paper for five to seven days at temperatures of 30° to 35° C. Three sub-samples of 250 eggs were weighed per individual, as outlined by Nagasaki (1958) and later employed by Rumyantsev (1970). A total sample was weighed and fecundity calculated from the mean weight of the three sub-samples.

Stomachs were removed from herring periodically throughout the season, placed in a 10% formalin solution and preserved for later analysis. Samples were forwarded to the Institute of Marine Science, University of Alaska, for analysis. Results on these specimens are tentatively planned to be presented in the project completion report for R.U. 19 E, due in October, 1977.

Both scales and otoliths were used to age Osmerids. Boreal smelt scales were mounted on glass slides and read according to the "shiny line" technique (McKenzie, 1957) after thorough cleaning. Smelt otoliths were cleared by the enzymatic method (Purter, 1962) and aged according to Chugnova (1963). Otoliths were read from the outside lobes while submerged in glycerin.

Attempts to age capelin by scale analysis were unsuccessful due to scales not being taken from preferred body areas (Pitts, 1958). Proper scale aging techniques can be found in Templeton (1946) and Jangaard (1974) while otolith aging techniques are presented by Winter (1968).

PART I

Results and Discussion for studies conducted from Ugashik Bay to the Yukon River Delta

RESULTS

Subsistence Utilization

The only herring subsistence surveys ever conducted along the western Alaska coast occurred in 1975 and 1976, as part of OCS research investigations. The 1975 survey included only four coastal villages in the Yukon-Kuskokwim River delta region representing 133 fishing families. Reported herring catches in numbers of fish were as follows: Tanunak 87,130, Umkumiut 131,795, Toksook 136,810, and Hooper Bay 11,085. The total reported harvest was 366,820 herring for the four villages.

Fourteen villages were surveyed from the Yukon River Delta to Cape Newenham in 1976, and a total subsistence harvest of 181,285 pounds (82.2 m.t.) of herring was reported by local residents (Table 2). The fourteen villages included: Scammon Bay, Hooper Bay, Chevak, Newtok, Mekoryuk, Tanunak, Umkumiut (Nightmute), Toksook, Chefornak, Kipnuk, Kwigillingok, Kongiganak, Quinhagak and Goodnews. No herring were reported taken at Kongiganak. A total of 185 fishermen were contacted and/or returned subsistence catch forms representing approximately 149 fishing families. From these returns and contacts only 133 fishermen reported herring catches representing an estimated 114 families (Table 3). This results in approximately 1,590 pounds of herring per fishing family. A 1970 population census, conducted by the Bureau of Census, revealed a total population of 2,683 people in these villages, excluding Kongiganak (University of Alaska, 1973). The greatest subsistence utilization of herring by fishing family for the villages surveyed occurred at Nelson Island (Figure 2).

Villagers at Hooper Bay, Tanunak, Umkumiut and Toksook caught 140,935 pounds (63.9 m.t.) or about 78% of the total 1976 harvest of 181,285 pounds (82.2 m.t.) taken by the fourteen villages surveyed. Subsistence fishermen at both Nelson Island and in Hooper Bay indicated that herring runs in those areas in 1976 were not as great as in 1975.

The 1976 survey revealed no subsistence use of herring in the village of Quinhagak. Poor response was obtained from the local residents of Goodnews Bay and Kipnuk concerning herring subsistence catches.

Commercial Utilization

A single commercial venture for herring, in Metervik Bay in 1976, consisted of a roe on kelp fishery and resulted in a record harvest of 295,780 pounds (Nelson, Personal Communication) (Table 4). Local fishermen indicated that the 1976 market for whole herring (sac roe production) was not profitable and thus no commercial operations apart from the roe on kelp fishery occurred in 1976 in this area. The majority of commercial harvest consisted of herring spawn on the rockweed kelp (*Fucus* sp.), however one processor employed divers to harvest a limited amount of spawn on *Laminaria*. Divers indicated this to be less profitable, probably due to sparse patches of *Laminaria* together with the apparent preference of herring to spawn on *Fucus* in this area.

It should be pointed out that only female weights were recorded in the Bristol Bay fishery during 1967-72 so actual poundages landed were considerably greater than reported, possibly double. Thus, reported

Table 2. Subsistence survey results as conducted under R.U. 19 for 14 villages from Cape Newenham to the Yukon River Delta, 1976. 1/

Village	Herring	Smelt	Capelin	Tomcod	Whitefish	Irish Lord	Sole	Trout	Blackfish	Pike
Scammon Bay	1,390# 2/			79 3/	235	4	16			
Hooper Bay	6,007#			215	780	2	19			
Tanunak	30,593#			20						
Umkumiut (Nightmute)	18,660#		1,140#	30						
Toksook Bay	85,675#	125#	600#		150		40#			
Mekoryuk	2,360#					3		5		
Newtok	300#				174				10#	1,484
Chevak	1,400#			730	215	200	8			
Kipnuk*	1,500#				100#					
Kwigillingok	21,350#				300					
Kongiganak										
Chefornak	12,050#									
Quinhagak		6,450								
Goodnews Bay*										
Estimated Totals	181,285#	6,500	1,740#	1,074	2,000	209	75	5	10#	1,484

1/ With the exception of herring, capelin, pike and blackfish, the exact species of other fishery resources utilized for subsistence purposes could not be varified by the subsistence surveyor. Common names were given by local residents, however, it is believed that smelt refer to boreal smelt, tomcod refer to saffron cod, whitefish refer to *Coregonus* sp. and trout refer to char. Subsistence use of adult salmon by species was monitored by ADF&G management personnel.

2/ Represents pounds of fish.

3/ Represents numbers of fish.

* Indicates villages of poor response.

Table 3 . Subsistence use of herring by fishing family in 14 villages from Cape Newenham to the Yukon River Delta, 1976.

Village	Village Population 1/	Herring Fishing Families 2/	Number Returns 3/	Herring Catch (pounds)	Pounds of Herring per Family 4/
Scammon Bay	166	4 5/	4	1,390	348
Hooper Bay	490	28	35	6,007	215
Chevak	387	9	12	1,400	156
Newtok	114	1	1	300	300
Mekoryuk	249	7	8	2,360	337
Tanunak	274	14	18	30,593	2,185
Umkumiut (Nightmute)	127 6/	6	7	18,660	3,110
Toksook	257	22	22	85,675	3,894
Chefornak	146	12	15	12,050	1,004
Kipnuk 8/	325	3	3	1,500	500
Kwigillingok	148	8	8	21,350	2,669
Kongiganak	190	---	---	0	---
Quinhagak 7/	---	0	---	0	---
Goodnews 8/	---	---	---	?	?
Total	2,873	114	133	181,285	1,590

1/ Total population, 1970 census, University of Alaska, Institute of Social, Economic and Government Research, Sept., 1973, Vol. X, No. 2.
2/ Estimated number of families that fished for and utilized herring for subsistence purposes in 1976.
3/ Number of fishermen contacted and/or returning catch forms who captured herring.
4/ Estimated poundage of herring utilized by herring fishing families.
5/ When surveyed, most villagers were commercial fishing for salmon at Black River.
6/ Population estimate for the village of Nightmute.
7/ This village does not utilize herring for subsistence.
8/ Poor response from these villages on subsistence herring catches.

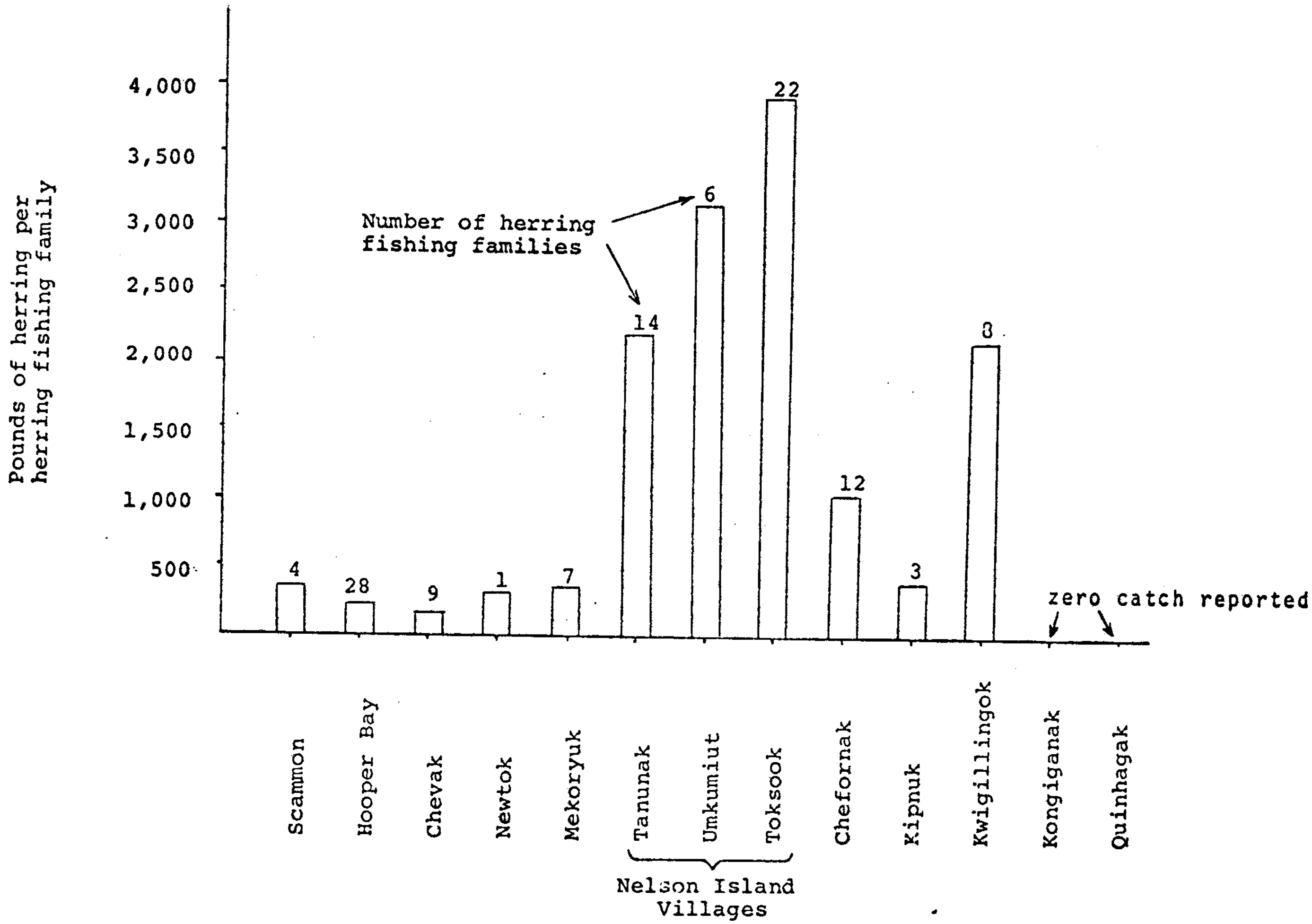

Figure 2 . Subsistence utilization of herring in pounds by herring fishing family for 13 villages, from Cape Newenham to the Yukon River Delta, 1976.

Table 4. Commercial harvests and wholesale value of Pacific herring and herring roe-on-kelp in Bristol Bay, 1967-1976. 1/

Year	Herring			Roe-on-Kelp 3/			
	Number of Operators	Number of Fishermen	Catch (pounds) 2/	Number of Operators	Number of Fishermen	Harvest (pounds)	Total Value
1967	1	27	268,902	-	-	-	$ 27,000
1968	2	37	181,765	1	1	54,600	68,000
1969	2	23	94,481	1	3	10,125	15,000
1970	3	17	55,195	1	5	38,855	17,000
1971 5/	-	-	-	1	12	51,795	31,000
1972	1	19 4/	162,434	1	12	64,165	50,000
1973	2	26	102,147	1	10	11,596	27,000
1974	2	11 4/	246,256	3	23	125,646	193,000
1975	2	39	111,185	2	44	111,087	142,000
1976 5/	-	-	-	4 6/	-	295,780	127,000
Total	15	199	1,222,365	15	-	763,649	697,000
Average	2	25	(1967-72) 152,555 (1973-75) 153,196	1.7	-	84,850	70,000

1/ All herring and kelp production are of Togiak origin.
2/ Catch in pounds reflects only the female herring from 1967-72 where most males were discarded and not weighed. Catches since 1973 include weights for sexes combined.
3/ Harvest of roe-on-kelp has been limited exclusively to rockweek kelp (*Fucus furcatus*).
4/ Includes some effort by purse seine gear with remainder of catch taken with gill nets.
5/ No commercial effort for whole herring.
6/ Preliminary Figures.

catches do not necessarily reflect herring abundance in this area. The annual average harvest for whole herring, excluding 1971 and 1976, equals approximately 69 m.t. with 1967 producing an estimated high, in excess of 225 m.t., and the lowest harvest taken in either 1970 or 1973 (about 45 m.t.). An average of 38 m.t. of roe on kelp have been taken annually since 1968. The average annual wholesale value of the fishery, (including both whole herring and roe on kelp) is approximately $70,000.

Aerial Surveys

Aerial observations in 1975 from Cape Newenham to the Yukon River Delta, revealed the presence of 109 schools of fish on three surveys conducted on May 31, June 8, and June 20 (Regnart, 1975). The relative size and location of fish schools are presented in Table 5.

Most schools were observed in water less than 20 m deep and within 200 m of shoreline. The only evidence of active spawning was observed on June 20, approximately 2.4 km south of Cape Vancouver, and on May 31 inside Goodnews Bay. The greatest concentration of schooled fish was observed adjacent to Cape Vancouver on June 20.

Alaska Department of Fish and Game personnel conducted aerial surveillance for the presence of schooled fish in the Bristol Bay area in 1975 throughout the Togiak fishing district to Cape Newenham. Results from these observations reveal a total of 453 schools observed on three surveys made May 31, June 2 and June 15 (Baxter, 1975).

In 1976, aerial surveys were completed on 80 census areas along the coast, from Ugashik Bay to the Yukon River Delta (census areas 6-31), throughout the period May 20 to July 7. Aerial surveillance was intensified as spawning activity became apparent. Surveys included more than 45 hours of airtime, 5,955 km (3,700 mi) of coverage and 19 survey days. An estimated total count of 832 individual fish schools and 42 active spawning encounters (i.e., observed milt) were documented in 1976 (Table 6). Weather conditions and size of the study area were determining factors in the actual number of surveys conducted, and consequently all surveys were flown on an opportunistic basis.

Bristol Bay Area

No schools of forage fish were observed between Ugashik Bay and Cape Constantine (census areas 6-8) on the Nushagak Peninsula, when surveyed on May 28, and June 3, 1976. It was noted that areas characteristic of prime herring spawning habitat were lacking along this section of coastline.

The first encounter of schooled fish north of Ugashik Bay in 1976 occurred on May 27 in Metervik Bay. These fish were identified as herring and no milt was observed from the air until May 29, also in Metervik Bay. Schools of forage fish (the majority identified as herring) remained present along the coast from Kulukak Bay to Togiak Bay (census areas 9-10) through June 12, when the last survey was conducted (Table 6). Spawning herring were observed in this area from June 1 through June 7 with the peak of spawning occurring in Metervik Bay between June 1 and June 3 as determined from aerial surveys.

Table 5. Number of fish schools classified as to relative size, Cape Newenham to Yukon River Delta, 1975.

Area Surveyed 2/	Date	Fish School Size 1/				
		Small	Medium	Large	Unclassified	Total
Cape Romanzof (20,30)	6/20	2	(other schooled fish present)			2
Nelson Island (23,24)	6/20	47	9	4		60
Cape Newenham to Kuskokwim River (18,19,20A,20B,21)	5/31				5	5
	6/8	35	7			42
	Total	35	7	0	5	47
Total 1975		84	16	4	5	109
3/Togiak to Cape Newenham (11,12,13,14,15,16,17)	6/15				230	230
3/Kulukak Bay to Togiak (9,10)	5/31				75	75
	6/2				44	44
	6/15				104	104
	Total				223	223
Total 1975					453	453

1/ Classification of sighted fish schools:

small - surface area estimated less that $50m^2$
medium - surface area estimated 50 - $450m^2$
large - surface area estimated greater than $450m^2$
unclassified - no surface area estimate made

2/ Numbers in parentheses indicate census areas.
3/ Inshore Marine Resources, Bristol Bay, Alaska, 1975. Rae Baxter, Alaska Department of Fish and Game

Table 6 . Number of fish schools and spawning observations classified as to relative size, Ugashik Bay to Yukon River Delta, 1976.

Area Surveyed2/	Date	Fish School Size1/ Sm.	Med.	Lg.	Unc.	Total	Active Spawning3/
Cape Romanzof (29,30)	6/28			1	5	6	
	7/7						1
	Total	0	0	1	5	6	1
Nelson Island (23,24)	6/15			1		1	
	6/24						1
	6/28	116 4/	0	10		126 4/	
	Total	116	0	11		127	1
Nunivak Island (25)	7/6	0	0	0		0	1
Cape Newenham to Kuskokwim River (18,19,20A,20B,21)	6/3						1
	6/12	10				10	1
	6/25				1	1	
	Total	10	0	0	1	11	2
Togiak to Cape Newenham	6/3						4
	6/12	68				68	2
	Total	68	0	0		68	6
Kulukak Bay to Togiak (8,9,10)	5/27	4				4	
	5/29		1			1	1
	6/1	3	2	11	1	17	8
	6/3			5	11	16 5/	9
	6/7				178*	178*	10
	6/12	64		46	294*	404 5/	3
	Total	71	3	62	484	620	31
Estimated Total 1976		149	3	74	606*	832	42

1/ Classification of sighted fish schools (active spawning not included):
- small - Surface area estimated less that 50m^2
- medium - Surface area estimated 50-450m^2
- large - Surface area estimated greater than 450m^2
- unclassified - No surface area estimate made.

2/ Numbers in parentheses indicated census areas.

3/ Observed milt.

4/ Survey of only Kangirlvar Bay; the north side of Nelson Island was fogged in.

5/ Conservative count.

* Majority of schools were small in surface area).

The largest concentration of schooled fish observed between Togiak Bay and Cape Newenham (census areas 11-17) occurred on June 12, when 68 small schools were observed, in addition to two areas of spawning; the first about seven kilometers west of Tongue Point and the second located inside Asigyukpak Spit. The majority of schools observed in census areas 11 through 17 were believed to be capelin and not herring. The distribution and timing of fish schools observed by air in Bristol Bay in 1976 are shown in Figure 3.

Cape Newenham to the Kuskokwim River

Inclement weather conditions inhibited aerial surveys conducted in 1976 from Cape Newenham to the Yukon River Delta. A total of 144 schools of fish and five observations of spawning were documented between the first week in June through the first week in July (Table 6). Eleven schools of fish were observed from Cape Newenham to the Kuskokwim River, ten of which were observed on June 12. The exact identity of these fish could not be determined from the air, and were located immediately south of Chagvan Bay and inside Goodnews Bay. Only two observations of spawn were made; one in Goodnews Bay on June 3, and one on June 12 between Chagvan Bay and Security Cove.

Nelson Island, Nunivak Island and Cape Romanzof

The largest concentration of schooled fish occurred on June 28 in Kangirlyar Bay, when 126 schools with an estimated total surface area of 5,897 m^2 was observed. Later subsistence surveys of Umkumiut and Toksook Bay suggested that the majority of these fish were herring with lesser quantities of capelin also present. The only spawning documented from the air at Nelson Island occurred on June 24 at Cape Vancouver.

Two aerial surveys were made of Nunivak Island (census area 25). A single observation was made on July 6, when spawning was encountered on the eastern side of the island. Intensive bird predation on exposed Fucus at low tide was observed at Cape Manning and at Triangle Island. Attempts to collect Fucus samples were unsuccessful due to large ocean swells and exposed rocks. Consequently, exact identity of this spawn was not made. The bird activity was assumed to be on herring spawn, as suggested from later interviews with local residents from the village of Mekoryuk. An earlier survey of Nunivak Island during the first week of June revealed no activity of any type present.

Six schools of fish were observed from the air on the north side of Cape Romanzof on June 28. Spawning was observed on July 7 immediately south of the military base in Kokechuk Bay (Figure 4).

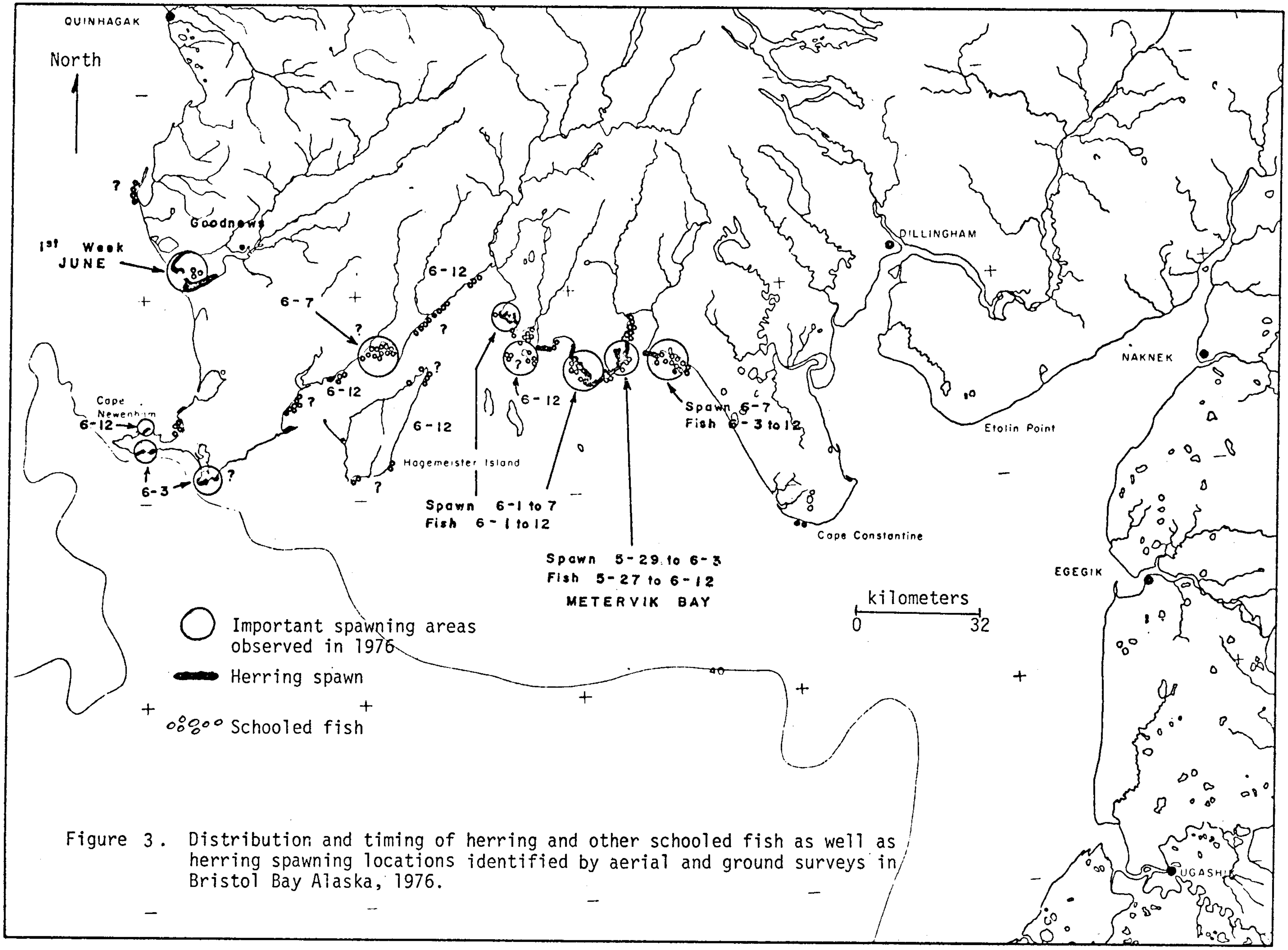

Figure 3. Distribution and timing of herring and other schooled fish as well as herring spawning locations identified by aerial and ground surveys in Bristol Bay Alaska, 1976.

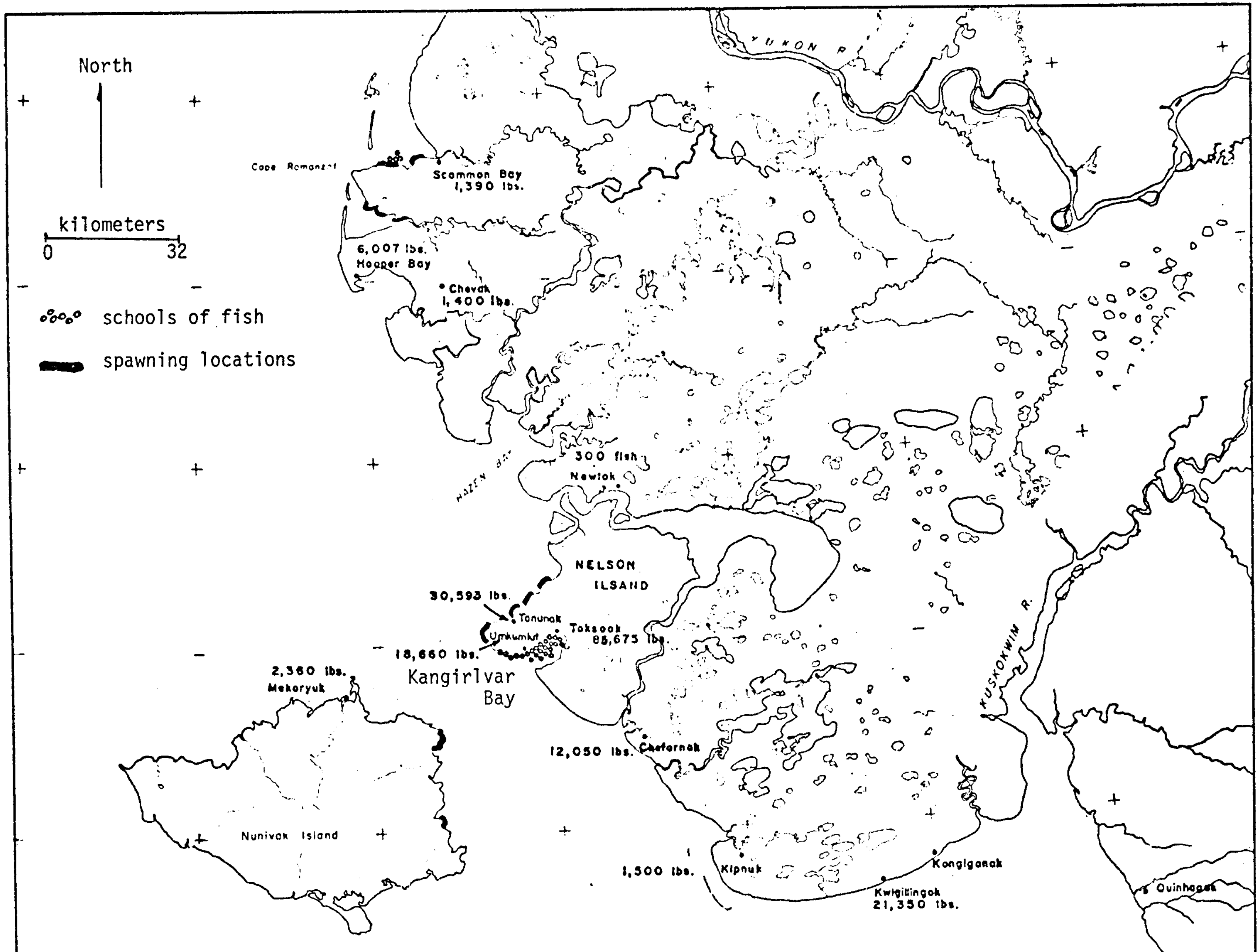

Figure 4 . Distribution of fish schools and herring spawn as well as subsistence herring catches (pounds) by village, western Alaska coast, 1976.

GROUND SURVEYS

Kulukak Bay to Togiak Bay

A herring crew was flown to Metervik Bay on May 27. This crew sampled spawning populations of herring, monitored egg deposition and spawning substrates from Kulukak Bay to Togiak Bay until June 12. The crew was informed by local commercial fishermen upon arrival that a first wave of herring spawners had frequented Metervik Bay on May 24. They also indicated that herring in Metervik Bay spawn in two waves and travel in a westerly direction toward Togiak Bay. No evidence of schooled herring was found from earlier aerial surveys flown May 20 and 25 in census areas 9 and 10.

The first large patch of exposed *Fucus* in Metervik Bay was observed at low tide on May 28. A limited amount of *Zosteria* was also present and both species were covered with herring spawn. Spawning was not observed. Ground observations revealed that *Fucus* was not generally associated with gravel beaches, consequently no herring spawn was encountered in such areas. It was determined that herring eggs eye in two to three days, at which time they are unfit for commercial sale.

The crew determined that *Fucus* was the preferred substrate for herring spawn and that it generally occurred only on rocky outcroppings. Many eyed eggs were observed in Metervik Bay on May 31 from the first spawning wave. Daily water temperatures monitored for the last five days in May averaged 4°C. No temperatures were taken during the month of June.

A second wave of herring spawners arrived in Metervik Bay on June 1, with concentrated spawning for the next two days through June 3. This second wave resulted in egg deposition over a very large area, with the greatest concentration on the easterly side of Kulukak Point. The heaviest concentrations in Metervik Bay were observed in the center of the bay on a small island, which was exposed at low tide. Local fishermen enroute to and from Togiak on June 5 reported much herring spawning activity was occurring on the eastern coast of Togiak Bay.

The ground crew terminated their surveys in Togiak on June 12 and on that date received reports from the local cannery that herring runs were over and that smelt runs were just beginning. The relative distribution of herring spawn on *Fucus* from Kulukak Point to Togiak Bay as recorded in 1976 is shown in Figure 5. It should be realized that part of the coast from Kulukak Bay to Togiak Bay was not surveyed and consequently these findings are not complete. The classification of herring spawn density was made subjectively, as opposed to a quantitative evaluation made by other crews sampling farther west.

Goodnews Bay

A second ground crew sampled in Goodnews Bay from June 10 to June 13 and results indicated herring had spawned prior to their arrival. The primary herring spawning area was found to occur in the southwest

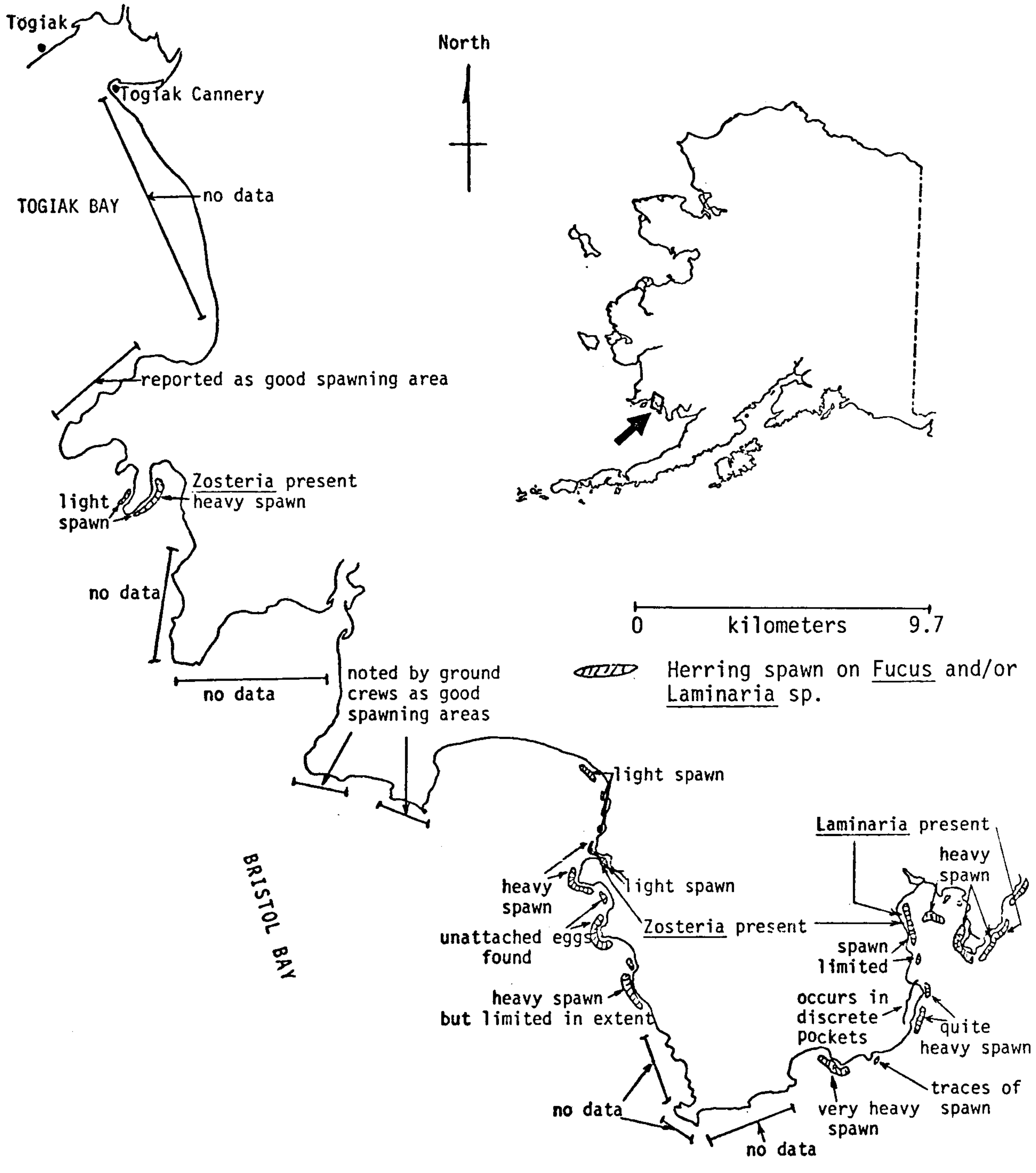

Figure 5 . Distribution of herring spawn on Fucus and/or Laminaria sp. as identified by ground surveys May 27-June 12, Togiak district, Bristol Bay, 1976.

corner of Goodnews Bay by the South Spit (Figure 6). Unlike the Togiak area, the primary spawning substrate was found to be eelgrass (Zosteria sp.) and gravel beaches with particles usually less than 15 cm in diameter. Water depth averaged about two meters deep at the South Spit and a mud bottom prevailed.

Eelgrass was found washed on shore in clumps (mats) from Little Beluga Hill to Small's River. On these mats, herring spawn ranged from very light (0-50 eggs per linear cm) to light (50-200 eggs per linear cm). Inside the South Spit an eelgrass plain was found and was presumed to be the source of the eelgrass mats mentioned above.

A second important spawning area lay inside the North Spit, but was smaller in size than the area occurring at the South Spit. Eelgrass was observed in medium amounts and herring spawn ranged from light to medium. Limited amounts of eelgrass with very light spawn were encountered from the North Spit along the coast to Beluga Hill. Little vegetation was found to occur in the remainder of the bay, and only intermittent traces of herring spawn was noted on patches of eelgrass. No capelin were observed in the bay during the time of the survey.

Throughout the four-day survey a total of 12.8 gillnet hours of fishing were conducted and resulted in the following catches: 88 herring; seven rainbow smelt, three flounder (unidentified), two Dolly Varden, one cod (unidentified). Forty-eight herring were taken on June 11 in seven minutes of gillnet fishing in the southwest corner of the bay.

Nelson Island Area

Herring crews sampled the coastline of Nelson Island (Cape Vancouver) on two occasions. The first survey occurred from June 19 through June 24 and included the coastline from Aternak Point to Hazen Bay. The second survey was on July 13 and 14 and included the coastline from five miles east of Toksook to Tanunak. A total of 5.1 gillnet hours resulted in a catch of 96 herring, two capelin, and one adult pink salmon during the first survey. The catch per unit of effort (CPUE) equaled 18.8 herring per net hour on this survey and 1.3 herring per net hour on the second survey when a total of 3.0 net hours was fished.

Results of spawn deposition and distribution are shown in Figure 7. No Fucus was found from Aternak Point to about 2.4 km south of Cape Vancouver with the exception of a small area at Uluruk Point where no spawn was found. Medium to heavy concentrations of Fucus were then observed from about 2.4 km south of Cape Vancouver along the coast to Talurarevuk Point. No herring spawn was observed in the above areas when surveyed June 19 and 20. The bottom type in this area consisted of rock and beaches with rocks ranging in size from approximately 0.5 to 1.5 m in diameter. Only one adult pink salmon was captured in this area in 1.8 hours of fishing time.

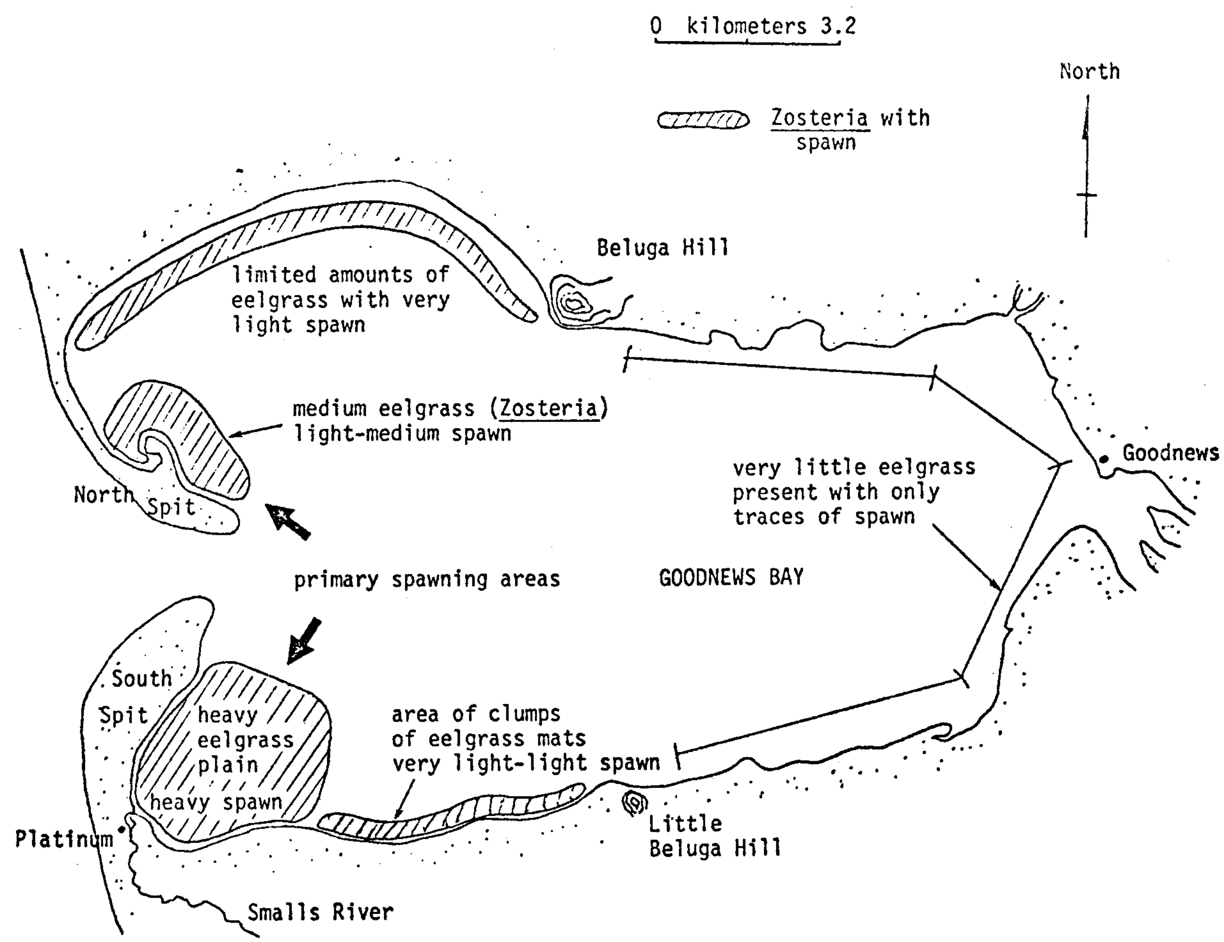

Figure 6 . Distribution of eelgrass (Zosteria sp.) and herring spawn identified by ground surveys June 10-13 in Goodnews Bay, 1976.

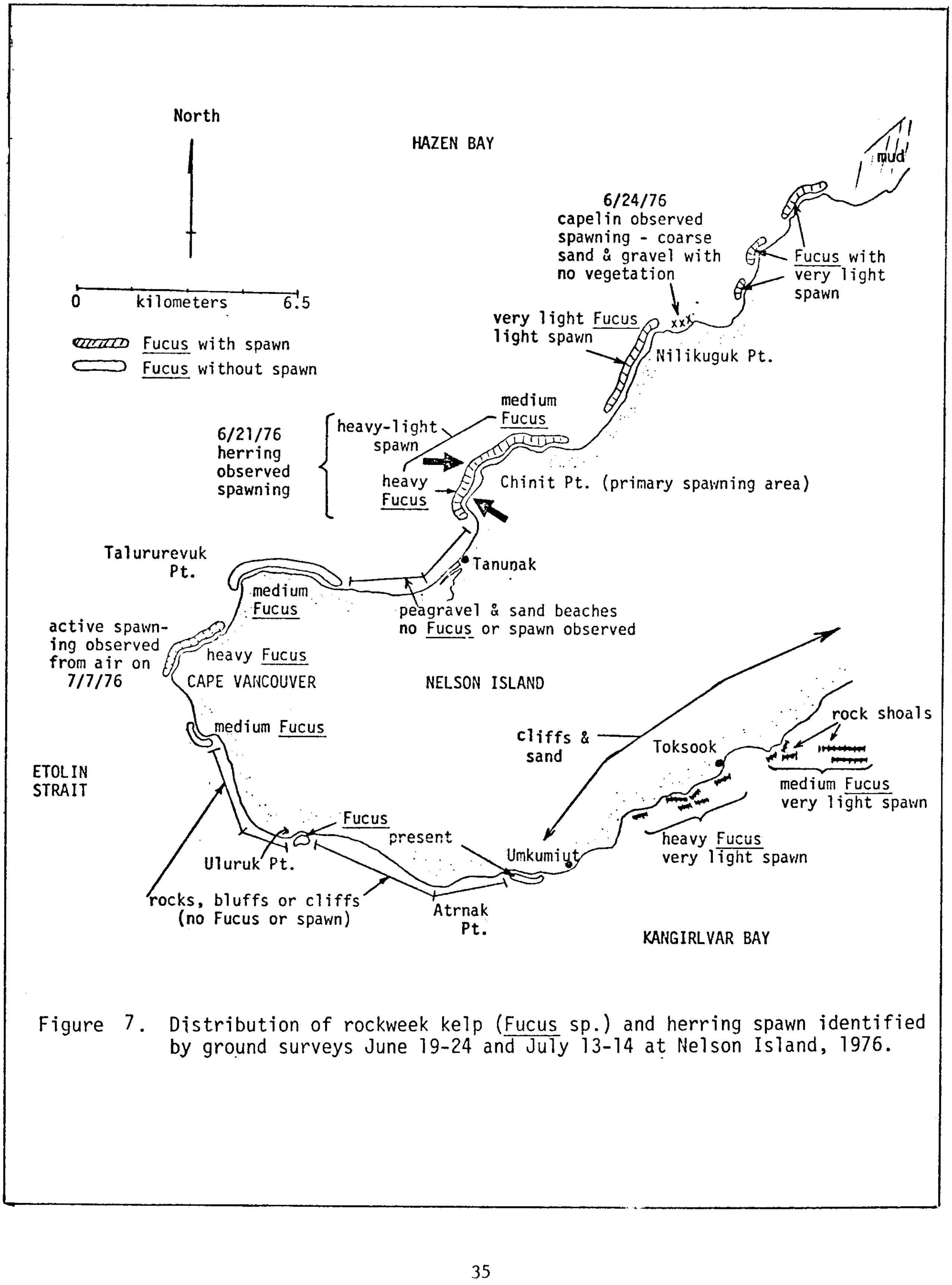

Figure 7. Distribution of rockweek kelp (Fucus sp.) and herring spawn identified by ground surveys June 19-24 and July 13-14 at Nelson Island, 1976.

The first herring spawn was encountered on Fucus about 1.6 km south of Chinit Point on June 21, and herring were observed actively spawning on that date at Chinit Point. The surface water temperature was recorded as 4° C. A single flounder (species unknown) was seen actively pursuing herring eggs. Water color in the active spawning area was a characteristic white from herring milt. Egg deposition was recorded as heavy on medium concentrations of Fucus at Chinit Point. In this area, 2.3 hours of fishing time resulted in 94 herring and one capelin on June 21.

Approximately 1.6 km north of Chinit Point more spawning was observed on medium Fucus. Rockslides forming shoals were covered with medium Fucus and light spawn. Fucus with concentrations of very light spawn occurred intermittently from this point to the end of the survey at Hazen Bay.

Capelin were observed spawning on June 24 about one kilometer north of Nilikuguk on coarse sand beaches. White water, characteristic of herring spawn, was not observed. A sample of capelin was hand collected for length and sex determinations. Only males were found. Dead capelin occurred on the beaches and were preyed upon by gulls. The water temperature was recorded at 4° C and egg samples, which had been deposited in the gravel were collected.

The Toksook Bay area was examined on July 13 where rock reefs and heavy Fucus concentrations were observed. Very light concentrations of herring spawn were found. This was the only area documented by the OCS crew in 1976 in Kangirlvar Bay possessing herring spawn. Fucus was checked for herring spawn deposition from Cape Vancouver to Chinit Point on July 14, but none was found indicating that hatching at Chinit Point occurred within 24 days in 1976.

Cape Romanzof Area including Kokechuk Bay and Hooper Bay

Hooper Bay was sampled on June 27 and 28. The Bay is about one to two meters deep and consists of a mud/sand bottom with virtually no marine vegetation. Although no egg deposition or spawning were observed, a total of seven gillnet hours produced 57 herring and two adult chum salmon for a CPUE on herring of 8.1 per net hour. A sample of these herring was taken for length and age analysis and it was noted that two females were spawned out. Water temperatures ranged from 8.5° to 13.5°C for the two days. Three aerial surveys of Hooper Bay, conducted the second and last week of June and the first week of July revealed no schooled fish or spawning present. However, survey conditions were rated poor due to turbid water conditions.

Results of the ground survey made in Kokechuk Bay and Scammon Bay from July 4 through July 8 are shown in Figure 8. The southern shore of Kokechuk Bay is composed of a large mud flat and no Fucus or spawn was located. Light to medium concentrations of Fucus occurred along the north side of Kokechuk Bay from 1.6 km south of Paimiut to about 3.2 km south of Cape Romanzof. Beaches along this section are primarily composed of rocks 0.6 to 1.2 m in diameter and possess a sandy bottom.

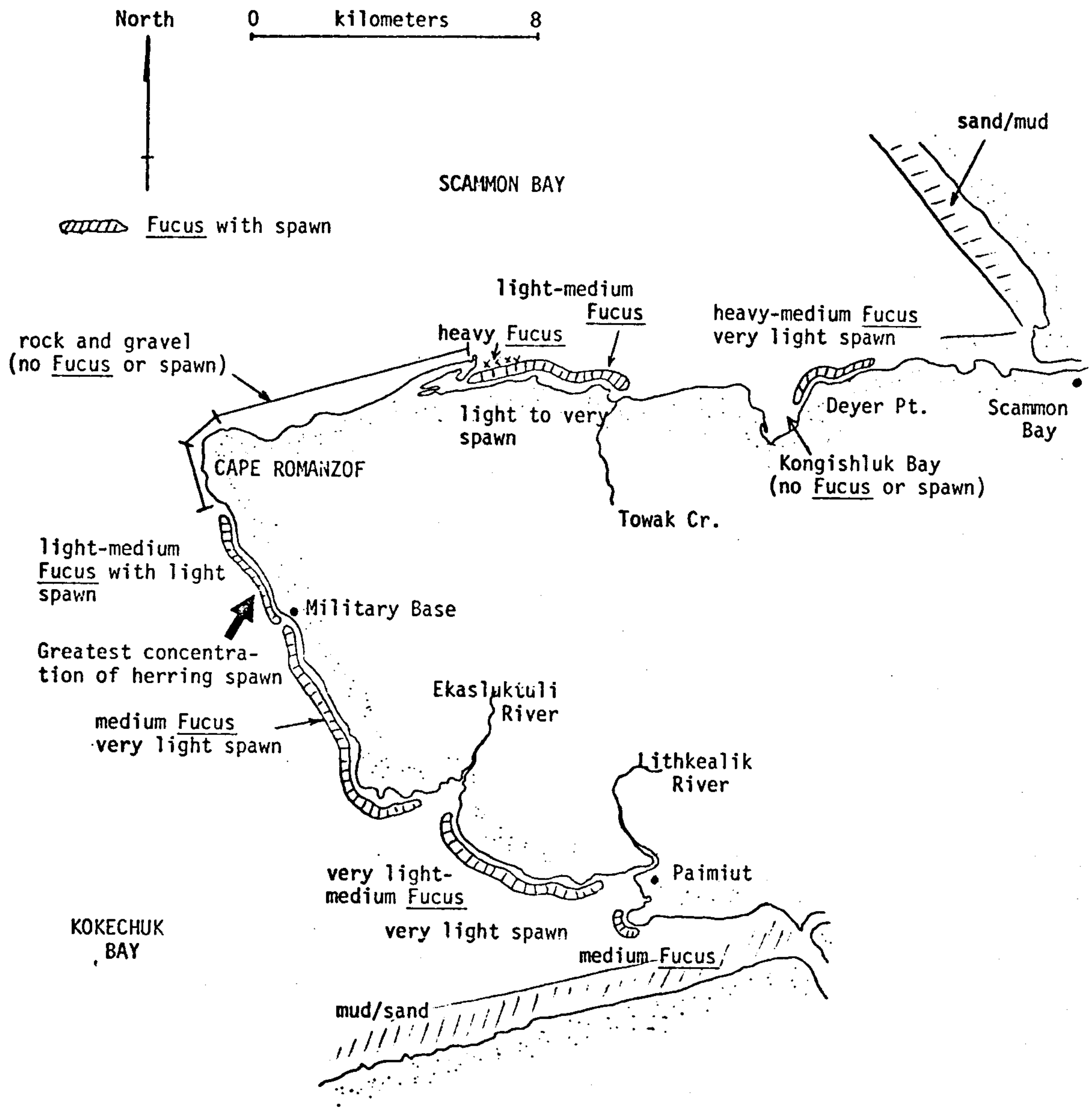

Figure 8. Distribution of rockweed kelp (Fucus sp.) and herring spawn identified by ground surveys July 4-8 in Kokechuk Bay and Scammon Bay, 1976.

The most concentrated area of herring spawn was located immediately north of the military base. Fucus in this area occured in medium concentrations and spawn deposition was light. All other areas where Fucus occurred contained very light spawn deposition. Fucus was absent in only two river estuaries, the Ekasluktuli and Lithkelaik Rivers.

A total of 4.5 gillnet hours resulted in a CPUE of 7.6 herring per net hour in Kokechuk Bay. Water temperatures ranged from 8.5° to 11°C. A total of 44 herring, one adult pink salmon, one round whitefish, and one broad whitefish were captured. Two of the herring captured were spawned out.

Herring spawn was observed in only two locations north of Cape Romanzof. Spawn deposition varied from very light to light and Fucus concentrations from light to heavy in these areas. No spawn or Fucus was observed west of the sand spit to Cape Romanzof. Light concentrations of Fucus and no spawn was observed in Kongishluk Bay.

Eight gillnet hours resulted in a total catch of 14 herring, one whitefish (unidentified), one brown Irish Lord, one flounder (unidentified), and one prickleback. The herring CPUE was 1.8 per net hour and six of the 14 captured were spawned out. Water temperatures north of Cape Romanzof ranged from 8.5° to 12°C on July 7 and 8. The primary spawning substrate for herring was Fucus. A small amount of spawn was seen on bare rock both north and south of Cape Romanzof.

The west coast herring ground crews found that seals were good indicators of the presence of schooled fish. Bird activity was not as reliable but did help locate egg deposition in some instances. Limited spawning was also reported on bare rock. It was observed that herring eggs would not adhere to bare rock if either were coated with mud.

Age-Length Sampling

Herring were sampled for length, sex ratios and age analysis from selected spawning populations. Samples were obtained in 1976 from herring stocks in Metervik Bay, Goodnews Bay, Nelson Island and Hooper Bay.

The average standard lengths for herring males, females and combined sexes are presented by age class in Table 7 for samples collected in the above four areas in 1976. A limited number of samples collected at Scammon Bay in 1975 are also included.

The combined sex-age composition data for herring sampled in Metervik Bay indicates a dominant age class of VIII (52%). Age groups IX and VI constituted 15 and 11% of the age composition, respectively, with age IV, V, and VII herring appearing in similar but less dominant strength. Traces of age X and XII herring were also documented. Seventy-one percent of the herring sampled were older than seven years.

Age analysis of herring sampled at Nelson Island most closely resembled those at Metervik Bay, with dominant age VII individuals (38%) followed by age group VIII at 20% and age group IV at 18%.

Table 7. Herring average standard lengths in millimeters by sex and age class, west coast Alaska, 1975-76 (R.U.19).

Area	Sex	AGE CLASS III	IV	V	VI	VII	VIII	IX	X	XI	XII
Metervik Bay n = 54	Male			244	246	286	284	292			302
	Female		217	244	231	286	278	289	290		
	Combined		217	244	237	286	281	291	290		302
Scammon 1/ Bay n = 24	Male				(257)*	(270)*	(284)*				
	Female				(253)*	(277)*	(284)*				
	Combined				(255)*	(273)*	(284)*				
Nelson Island n = 45	Male	200	224	233	248	268	258		263		
	Female		235	222		265	301	295			
	Combined	200	228	231	248	267	277	295	263		
Goodnews Bay n = 56	Male		223	221	250			267			
	Female	219	220	224	240	288	281	290			
	Combined	219	222	222	246	288	281	284			
Hooper Bay n = 25	Male		211	204	230	260					
	Female	188	226	218	262						
	Combined	188	219	211	246	260					

1/ 1975 data.

* Estimated standard lengths; taken as 10mm less than fork length.

Five and six-year-old herring appeared in equal strength (9%) and only traces of age III, IX and X herring were found. Sixty-two percent of the herring sampled were older than six years.

Age group IV was dominant in samples analyzed from both Hooper Bay and Goodnews Bay, 72 and 63% respectively. Only 20 and 29% of herring older than four years were sampled in Hooper Bay and Goodnews Bay, respectively. The oldest herring sampled in Hooper Bay was age VII and age VIII in Goodnews Bay.

The 1975 herring samples from Scammon Bay indicated two dominant year classes of equal strength: 42% age VI and 42% age VII. Only two additional age classes were encountered: 13% age VIII and 4% age IX. These samples were obtained from subsistence catches.

Comparisons of overall age composition of herring sampled in 1975 and 1976 by location are shown in Figures 9 and 10.

The sex ratio for herring was consistently in favor of males with the exception of Hooper Bay. Sex ratios in Metervik Bay and Goodnews Bay approached a one to one ratio.

DISCUSSION

Subsistence Utilization

Pacific herring are normally among the first species of fish to appear along the coast after ice breakup. Dependence upon them as a subsistence item varies along the coast by area and village; apparently a function of village location. Village inhabitants who reside in areas where herring stocks far outnumber salmon, such as at Nelson Island, utilize herring more extensively as a subsistence item. Villages located where large runs of adult salmon occur supplement their subsistence needs with herring, with most effort being directed towards salmon. A typical village of this type is Hooper Bay. Inland or coastal villages, where large concentrations of herring or salmon are not common rely more heavily on pike, smelt, blackfish and whitefish species.

Subsistence use of capelin was minimal in 1976 with only 1,140 pounds reported taken in Umkumiut and 600 pounds in Toksook.

Ugashik Bay to Dillingham

There has been no documented herring spawning along the coast from Ugashik Bay to Dillingham and areas characteristic of prime spawning habitat are lacking. A single local resident has been documented to utilize herring as a subsistence item in this area, at the mouth of the Egegik River (ADF&G files). Occasional observations by Department Biologists indicate these herring may be prespawning stocks enroute to spawning areas further up the coast, possibly the Togiak area, and are present at Egegik in the spring for a very short period (Randall, personal communication). Further subsistence utilization of herring in the area, if any occurs, is considered to be minimal.

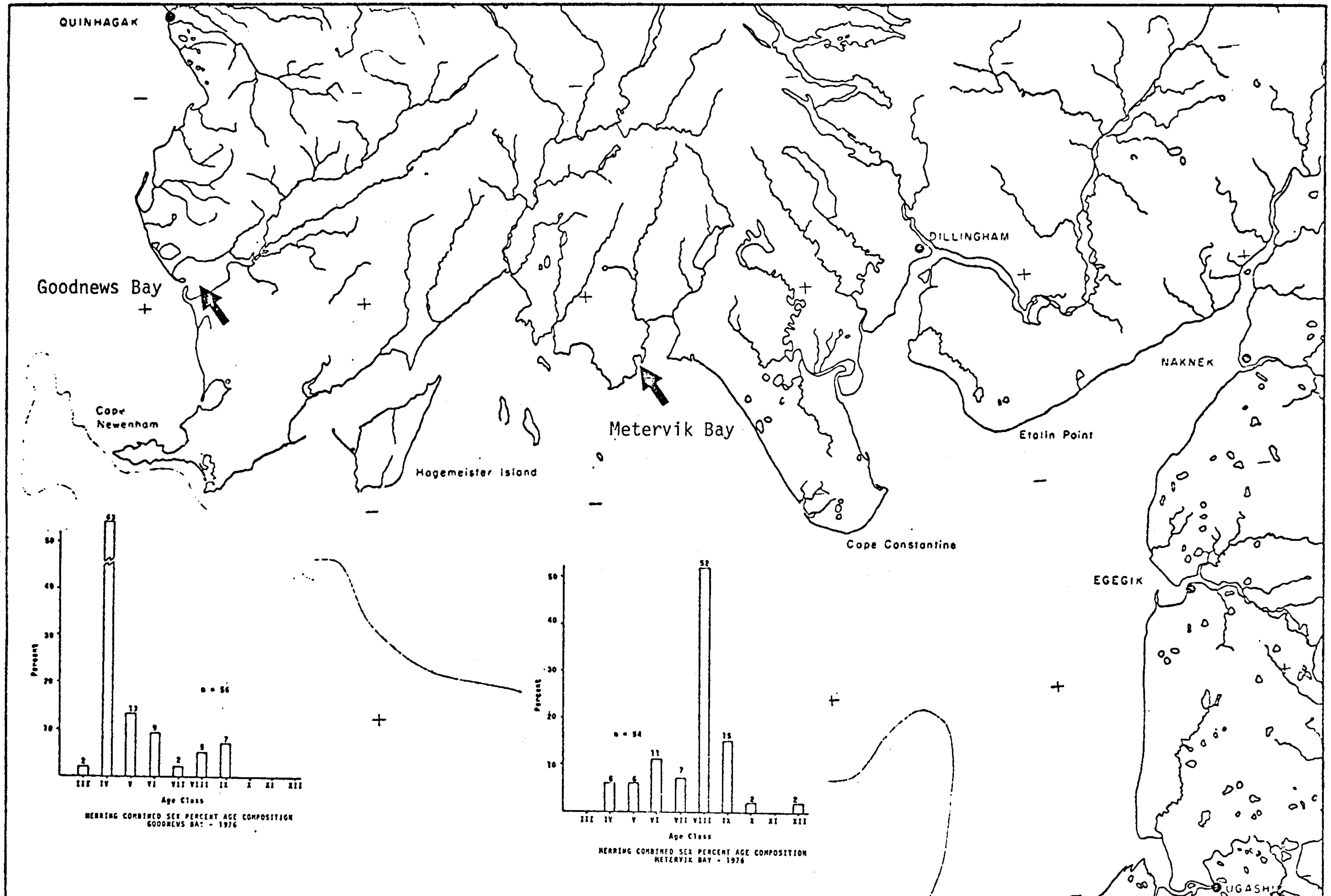

Figure 9. Percent herring age composition for Metervik Bay and Goodnews Bay, 1976.

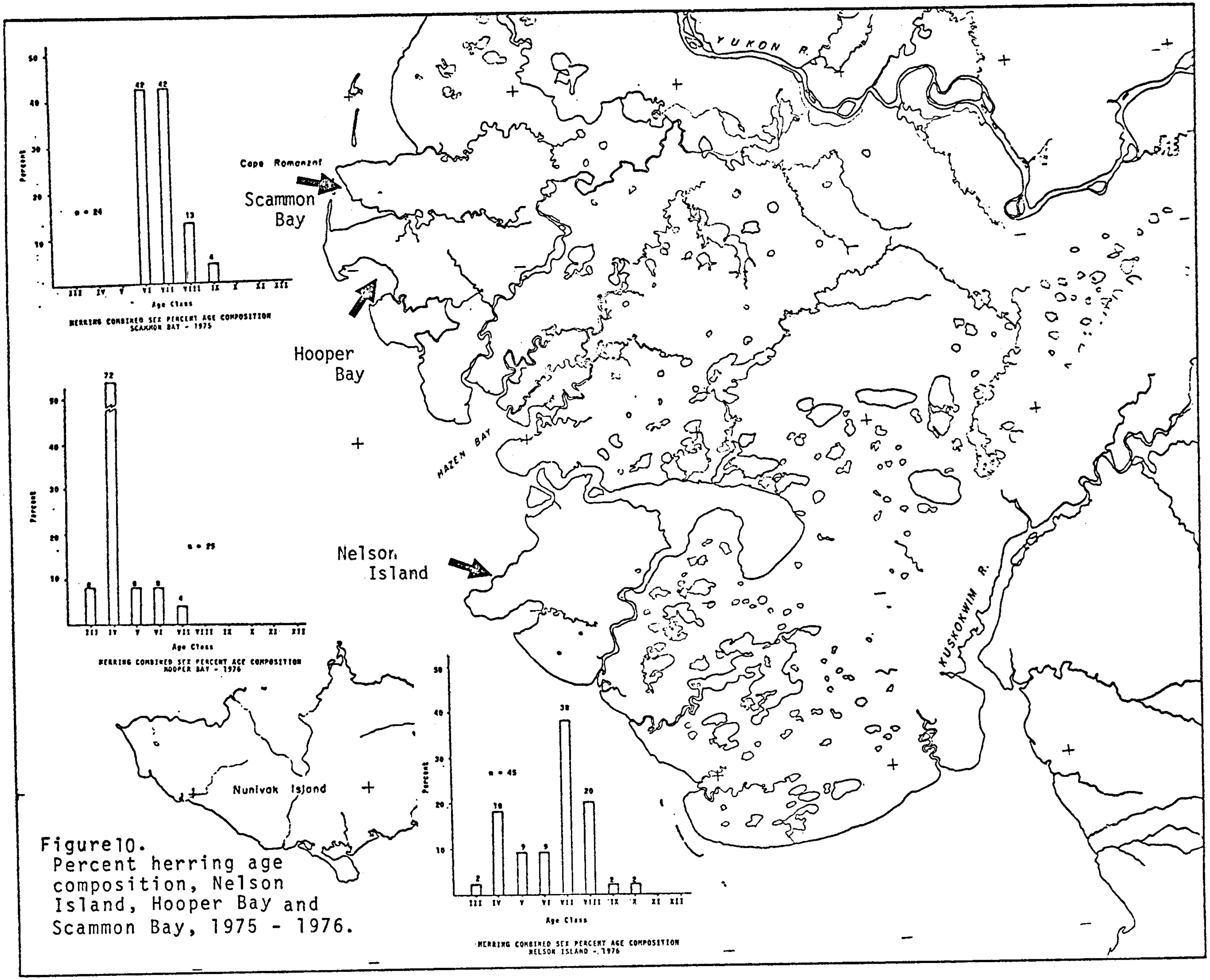

Figure 10. Percent herring age composition, Nelson Island, Hooper Bay and Scammon Bay, 1975 - 1976.

Dillingham to Cape Newenham

Herring use as a subsistence item has never been monitored in the Togiak district. Most effort, however, centers in Metervik Bay and along the coast west to the village of Togiak. The majority of herring fishing by local residents in this area is for commercial purposes although most fishermen retain a limited amount for subsistence needs. Most of the herring subsistence use is believed to be supplemented by various species of Pacific salmon.

Cape Newenham to Kuskokwim River

Subsistence use of herring between Cape Newenham and the Kuskokwim River does occur but is primarily limited to the Goodnews Bay area. No herring were taken in Quinhagak in 1976 and poor response by local residents in Goodnews Bay was encountered during the subsistence survey. However, the use of herring as a subsistence item in Goodnews Bay is not considered to be as great as occurs in those villages located between the Kuskokwim and Yukon Rivers.

Kuskokwim River to Yukon River Delta

The greatest use, by far, of herring as a subsistence item occurs in villages between the Kuskokwim and Yukon Rivers, including the village of Mekoryuk on Nunivak Isalnd, with three Nelson Island villages, Tanunak, Umkumiut and Toksook utilizing the most.

Results from the 1975 subsistence survey revealed numbers of herring captured as opposed to the 1976 survey, when estimated poundages of herring were reported. An attempt was made to quantify the 1975 results to weight for comparative purposes. A comparison of length-weight relationships for age VI and VII herring sampled in Togiak and at St. Michael was made. Age VI and VII were the two equally dominant age groups sampled at Scammon Bay in 1975.

Randall (1975) showed the mean combined standard length for age VI herring males and females to be 248.5 mm, and corresponding mean combined weights to be 217.5 gms, from samples collected during the 1974 commercial catch in Metervik Bay. The mean lengths and weights of age VII herring from the same commercial sample were 261.0 mm and 235.8 gms, respectively. Limited sampling on Norton Sound herring in 1964 at St. Michael, revealed average combined lengths and weights for age VI herring to be 230.7 mm and 158.8 gms, respectively. Those for age VII herring were 235.8 mm and 175.2 gms, respectively (Geiger, 1964).

The estimated standard lengths for age VI and VII year herring sampled in 1975 at Scammon Bay revealed themselves to be similar in size to the herring sampled in Metervik Bay in 1974. Assuming an average herring weight of 175 gms (0.39 pounds) for the subsistence harvest reported in 1975, an estimated 143,060 pounds or 64.9 metric tons (m.t.) were harvested in the four villages reporting catches (Hooper Bay, Tanunak, Umkumiut and Toksook). Assuming an average weight of 227 gms (0.50 pounds) per herring would indicate an estimate of 183,410 pounds (83.2 m.t.) were harvested. It is believed that the herring harvest in

1975 from these four villages fell within this range (64.9 - 83.2 m.t.) The four villages surveyed in 1975 reported a total herring catch, in 1976, of 140,935 pounds (63.9 m.t.) or about 78% of the total west coast reported harvest of 181,285 pounds (82.2 m.t.) between the Yukon-Kuskokwim River Deltas.

The opinion of people surveyed in coastal villages south of the Yukon River Delta was that the 1976 herring run wasn't as large as in previous years. Villagers at Nelson Island usually fish 3-4 days and are done for the season, because "normal" (larger) herring runs result in large catches in only a few days. This year the opinion was that the fish were coming in small numbers and were more scattered. Local residents at Nelson Island and Hooper Bay stated that lengths of herring captured in 1976 were much smaller than those harvested in 1975. Comments by residents at Hooper Bay revealed that only larger fish were captured, while the majority of herring passed through their subsistence gillnets. Most all residents felt that a late ice breakup in 1976 resulted in the herring run being "later than any years prior". The first run of herring took place around the second week in June and the second run appeared in the last week of June. In view of this, a comparison of herring harvests in the four villages surveyed in both 1975 and 1976, suggests that the estimated range of harvest in 1975 (64.9-83.2 m.t.) is reasonable and that the actual harvest would probably be toward the upper limits.

Most of the comments of local residents interviewed on Nelson Island were directed toward the probable cause of herring arriving in scattered numbers in 1976. They felt that this was due to foreign fishing vessels observed fishing in the vicinity earlier in the spring. This feeling was shared by many other coastal residents along the western coast of Alaska in 1976.

Aerial Surveys

Problems Encountered

Although technical in nature, a large problem encountered with aerial surveys in 1976 was associated with recording the actual number of fish schools and spawn (milt) onto data management forms. This problem stemmed from the requirement that latitudes and longitudes of each school be recorded also. To meet this requirement, 35 mm color slides were made of as many individual schools as possible or else aggregations of several schools when in close proximity to one another.

It was logistically impossible to record the latitude and longitude of each individual school when large concentrations of several schools were encountered in a given area. Therefore, the surface area of aggregate schools on many occasions were estimated from analysis of 35 mm slides and thus entered as a single school (observation) along with a corresponding latitude and longitude. This accounts for only 154 entries (observations) of fish schools and respective latitudes and longitudes into the data management format, although 832 fish schools and 42 observations of spawn were actually documented along the coast.

High altitude photographs of a particular area should be attempted as weather permits, when large concentrations (many schools) of fish are encountered, to assist in determining relative abundance either by surface area estimates, actual counts or both.

A second problem of equal magnitude associated with aerial surveys was determining species identity of many fish schools. This was especially true in areas where both capelin and herring have been documented to spawn. Several factors were used to assist in identifying fish schools; such as, location or area where observed, beach and escarpment type, date observed, ground survey results and previous aerial survey information. It was found that size and shape of schools was of little value in determining species composition.

Capelin Spawning Habitat

Investigations showed that, generally, two distinctly different habitat types exist for spawning herring and capelin populations. Schools of spawning capelin were usually observed along clean, fine gravel beaches. Concentrations of capelin spawners tended to disperse along such beaches in the surf zone, making them difficult to detect from aircraft. Many spawning capelin populations probably went undetected during aerial surveys.

Ground crews sampling the coastline at Nelson Island, found capelin spawning just east of Chinit Point. A small sample obtained for length determination contained only males. Females were not observed although eggs were collected from the gravel beach at the same location. The characteristic white water color typical of herring spawners was not present. Jangaard (1974) indicated that beach spawning capelin along the Newfoundland and Labrador Coasts in June and July generally spawn at night or in dull, cloudy weather. If the same conditions hold true for many western Alaska capelin populations, their spawning activities would be greatly underestimated by aerial surveillance.

Capelin spawning areas could often be identified by the rows of capelin left stranded on beaches from their spawning activities. Gull and other bird activity were good indicators in such instances.

Because herring schools encountered tended to be larger and more dense, small scattered schools along clean beaches could often be reliably identified as capelin except in those areas, such as the Togiak district, where the spawning areas of both species overlap. Schools observed several hundred meters from shore in such areas were usually documented as forage fish, species unknown.

Herring Spawning Habitat

Herring were usually observed spawning in areas where the shoreline morphology included cliffs or bluffs with large jagged outcroppings; where beaches occur in such areas, they are usually intertidal only. Spawning substrates consisted primarily of rocks covered with rockweed kelp (*Fucus* sp.). However, ground surveys showed that almost any substrate (e.g., *Laminaria* sp., bare rocks, gillnets) was utilized under conditions of dense spawning. Most herring spawning was confined to the intertidal zone, and where deeper spawning was observed by ground crews, it was confined to depths shallower than five meters. Herring spawning habitats identified in the Togiak district, at Nelson Island, Cape Romanzof and parts of Nunivak Island are typical of the spawning habitat described above.

A second herring spawning habitat was found in shallow bays, beaches or slough areas where eelgrass (Zosteria sp.) was common. The bottom type was usually mud and/or sand in such areas and intertidal and subtidal spawning occurred in water depths of less than two meters.

In such areas as Goodnews Bay, herring eggs were deposited on eelgrass (Zosteria sp.). Herring spawn has been documented to occur on roots of rye-grass (Elymus sp.) and sedges (Carex sp.) exposed at low tide in some of the coastal slough areas of Hazen Bay and along portions of the coast north of the Kuskokwim River (Baxter, personal communication). Baxter pointed out that rye-grass was not a marine form but occurred in the splash zone (brackish water). Roots of this plant were left exposed at low tide on the cut-bank side of many sloughs in the above areas. Such areas must be surveyed by boat and foot due to extensive tidal flats exposed at low tides.

Spatial and Temporal Considerations

Due to inclement weather conditions in 1976 and consequential opportunistic aerial surveillance, time of spawning activity and complete documentation of all spawning habitats throughout the study area from Ugashik Bay to the Yukon River Delta were not obtained for all herring and capelin populations. However, it is felt that primary herring spawning areas have been documented through literature searches, aerial surveys, ground surveys and interviews with many local residents. A summary of all available data on known spawning areas for capelin and herring from Ugashik Bay to the Yukon River is presented in Figures 11 and 12.

Results of OCS investigations reveal that both herring and capelin spawn throughout much of the study area during the spring and early summer (late May through July). Herring spawn was observed on the Naskonat Peninsula and Hazen Bay as late as August 1972, on clumps of rye-grass (Elymus sp.) roots which had been carried to shore at high tide (Baxter, personal communication). Consequently, the exact origin of these grass clumps could not be documented.

Herring spawning activity in 1976 was first documented on May 24, and such activity was noted through June 12 in the Togiak district from the Nushagak Peninsuls to the village of Togiak. Baxter (1975) indicated spawning was still in progress in the same area on June 15 in 1975.

Spawning herring and capelin were observed north of Cape Vancouver on Nelson Island in June 1976, although little evidence of spawning was observed in Kangirlvar Bay. This may be characteristic of most years due to the lack of suitable spawning habitat. However, Kangirlvar Bay may be important for schooling fish prior to their spawning activities further along the coast. This was suggested by the extremely large concentrations of schooled fish observed on June 28, 1976.

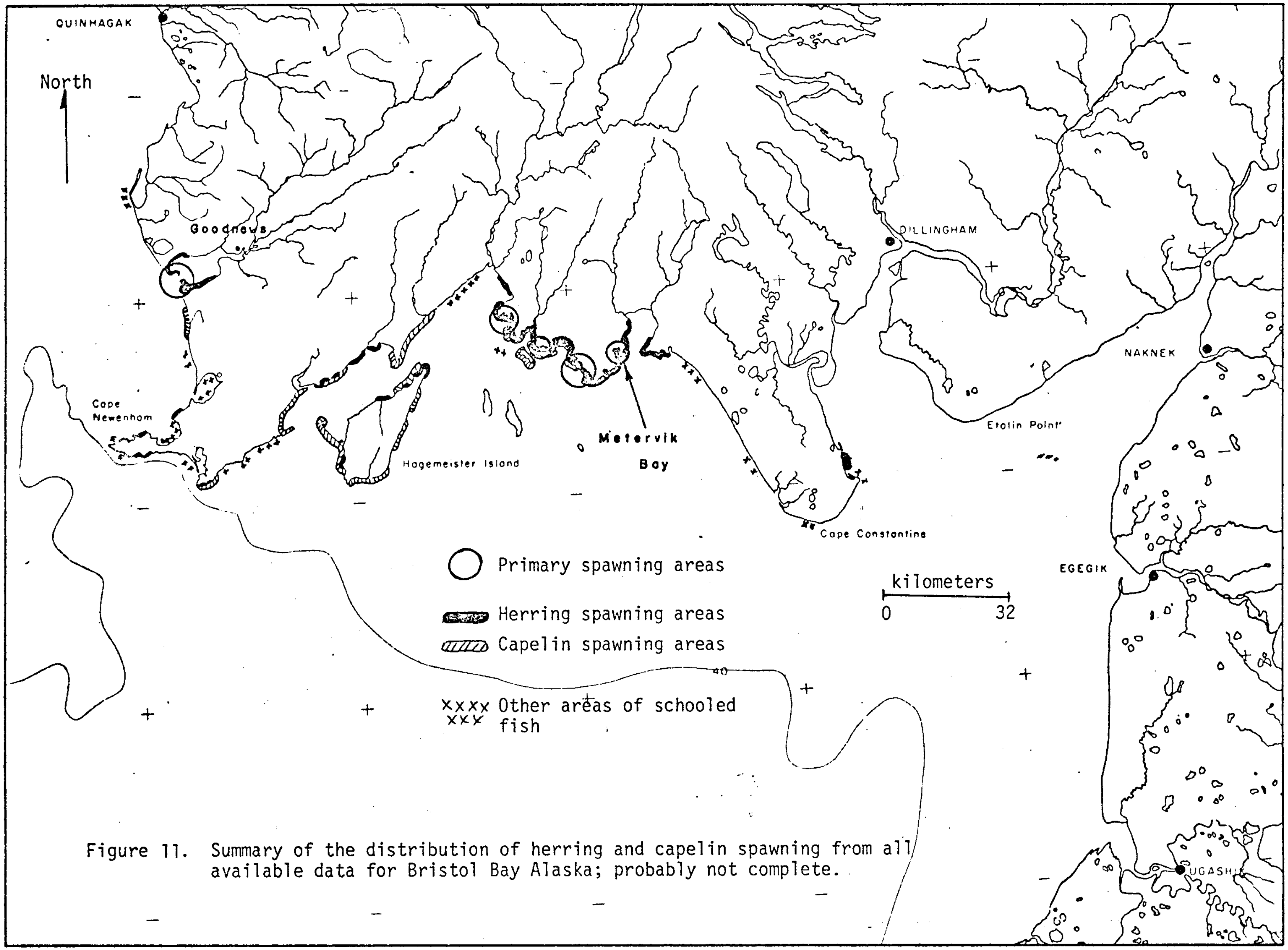

Figure 11. Summary of the distribution of herring and capelin spawning from all available data for Bristol Bay Alaska; probably not complete.

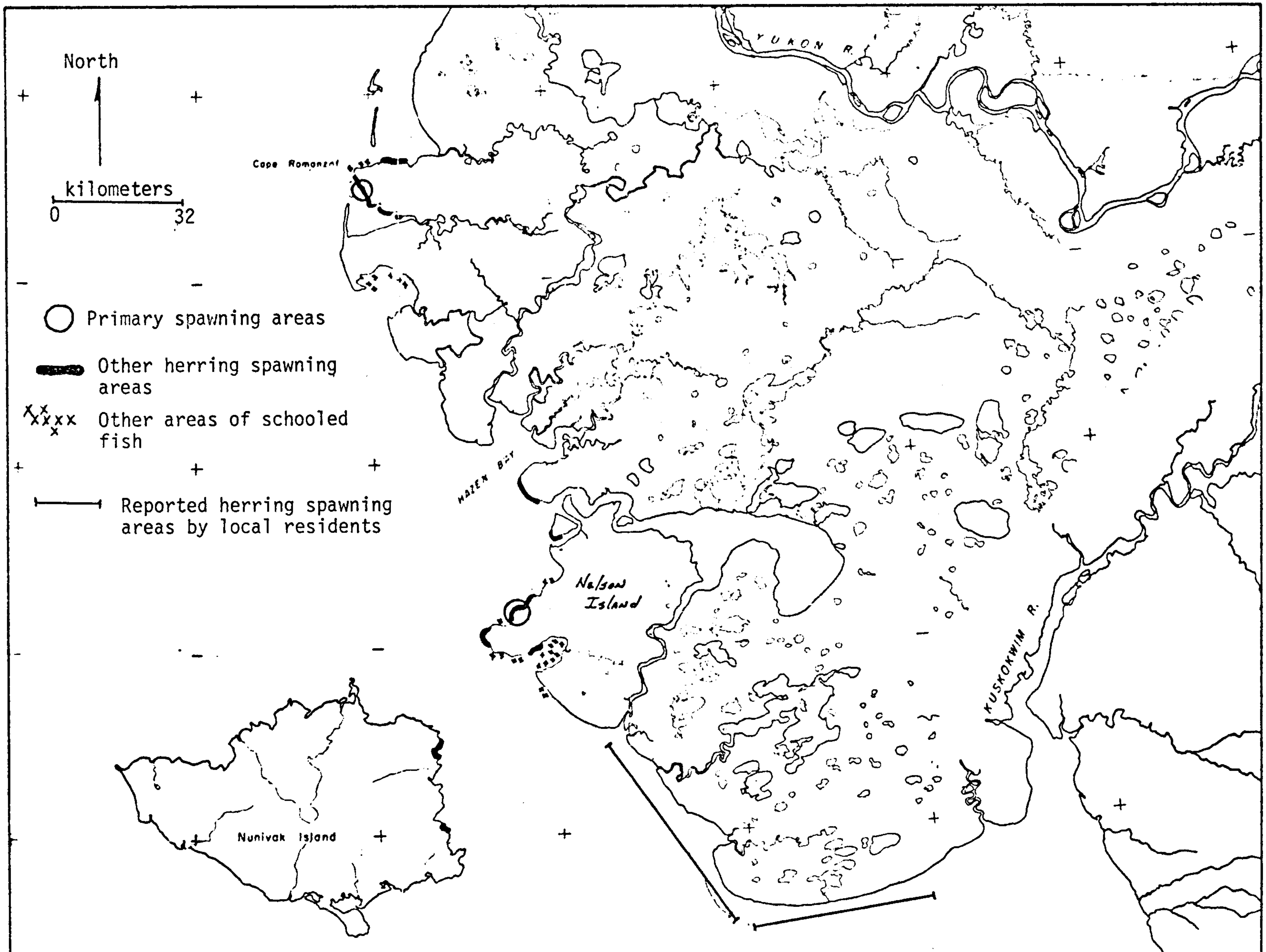

Figure 12. Summary of the distribution of herring spawning from all available data for the western Alaska coast; probably not complete.

Available information indicates that herring schools generally appear earlier in the spring, almost immediately following ice breakup, with capelin showing a few days later, often in the same areas. Herring apparently precede capelin to spawning areas by a few days and spawning and migration appears to proceed in a northward direction along the coast.

PART II

Results and Discussion for Studies conducted from Unimak Pass to Ugashik Bay

RESULTS

Introduction:

The study area for this portion of the RU 19 project completion report extends from Cape Sarichef on the southwestern tip of Unimak Island to Ugashik Bay which lies on the north coast of the Alaska Peninsula in the southern portion of Bristol Bay. Within this area lie the large estuarine systems of Izembeck Lagoon, Port Heiden, Port Miller-Herendeen Bay (which is the southern most range of the Walrus), and Ugashik Bay. This area includes some of the most productive salmon fisheries in the world as well as numerous locations that are presently under exploration for fossil fuel potential. Onshore test drilling is now in progress in the Herendeen Bay area, and this area is under prime consideration for transfer of crude oil across the Alaska Peninsula through Portage Valley to the Pacific side at Balboa Bay.

The only offshore island along the north coast of the Alaska Peninsula is Amak, which offers suitable habitat for vast numbers of Alcids and Larids, as well as a large population of Steller's sea lion and lesser numbers of harbor seal. A large number of bird rookeries exist in the study area in addition to those on Amak Island, the most conspicuous being those at Cape Seniavin and between Cape Mordvinof and Cape Sarichef on Unimak Island. Thousands of sea otter were seen during aerial census flights, some in large aggregations as far as two miles offshore from Moffit Point. Emperor geese winter along this coast and as many as 3,000 to 4,000 in a single flock were seen in St. Catherine's Cove in the Bechevin Bay complex (adjacent to False Pass). Also, the extensive eelgrass system found at Izembeck Lagoon is essential to the habitat of black brant which stop here during their spring and fall migrations.

Two basic habitat types were encountered in this portion of the study area: 502 km of open shoreline and 665 km of closed shoreline (i.e. inside bays or estuarine systems). The former habitat type is typified by open, surf beaten beaches with gradual gradients. The latter ranges from quiet intertidal estuaries to steep, rocky shorelines.

Subsistence Utilization

The least amount of effort was devoted to surveying local residents for subsistence utilization of fishery resources. Information obtained in this regard was primarily anecdotal and obtained on an opportunistic basis by questioning residents of four of the seven villages in the study area. These interviews indicated that subsistence utilization of herring was negligible, whereas that for capelin and boreal smelt was primarily for recreational purposes. Those interviewed reported that herring were present only in small numbers; most local residents under age fifty, however, weren't cognizant of the large population of spawning herring at Port Heiden Bay.

Harvesting of capelin by coastal residents has been described by Jangaard (1974). Present day opportunity for capelin utilization by residents of the Meshik-Port Heiden area has been enhanced by the use of four-wheel-drive ATVs and three-wheeled Honda trail bikes. The entire village's assortment of motor vehicles has frequently been seen to set out for the beach on evenings that capelin run. Thousands of Larids follow the schools as they move toward shore. Dozens of harbor seals have been seen offshore, presumably feeding on the fish prior to their spawning activities. Abruptly, capelin begin pouring in on the crest of waves and the harvest begins with cast nets, dip nets, buckets and, on occasions, by hand.

Aerial Surveys

A total of 15 separate census flights (140 hours of air time) were flown throughout the study area from April 12 through July 12, 1976. Coverage included approximately 10,610 kilometers (5,735 miles) of coastline and resulted in 649 schools of forage fish observed. No fish were sighted on 9 of the 15 flights. All schools seen were located in one of two distinct habitat types: 1) Open ocean beaches with gravel/rock substrate type, 2) Inside bays or inlets with rock/kelp substrate type. Location of schools observed appeared to be stationary; i.e., numbers of schools counted remained fairly constant between southbound census flights and northbound return flights on the same day to the base station. Aerial photography, while attempted in order to estimate school size, was generally unsuccessful in this portion of the study area due to inadequate equipment and inherent variables associated with aerial photography. The majority of schools were spherical in shape, although schools were seen to change shape drastically when actively pursued by predators.

An index of school density was considered as the number of schools observed per kilometer of coastline flown (Table 8). This index was used in making spatial and temporal comparisons of the abundance of forage fish schools within and between individual surveys. The largest number of forage fish schools was observed in census area 4A during the weeks of June 5 through June 26. The greatest concentration of forage fish was in census area 5A (immediately north of Port Heiden) during the week of June 19 (1.73 schools per kilometer). No fish schools were seen in census area 2A and 2B, despite the fact that these areas appeared to offer optimum herring spawning habitat. These areas included Bechevin Bay, the large estuarian complex at False Pass.

All surveys were flown on an opportunistic basis due to inclement weather conditions and scheduling difficulties with local air taxi services. Attempts were made to fly surveys at low tides, although this was seldom possible. Bird feeding activity was helpful in locating forage fish schools. Single engine aircraft was utilized on 11 of the 15 surveys, precluding open water navigation; hence it was possible to survey Amak Island only twice during the study period. Neither of these two surveys coincided with the peak time of forage fish spawning.

All fish schools seen from the air were enumerated. However, positive species identification was possible on only two occasions when low level flying was attempted. This latter task was done infrequently as it proved riskier than anticipated.

A close relationship between results obtained by ground crews (fish captured) and aerial surveys (schools counted) was found to exist concerning the relative abundance of fish (Figure 13). Test fishing was

Table 8. Forage fish schools seen by aerial survey per kilometer flown in census areas 1 - 5, north Alaska Peninsula: April-July, 1976.

Census Area	Week Beginning 4-10	4-17	4-24	5-1	5-8	5-15	5-22	5-29	6-5	6-12	6-19	6-26	7-3	7-10
1A	-	0	-	-	-	-	0	-	-	-	.068	.034	-	-
1B	-	0	-	-	-	-	0	-	0	-	0	.36	-	-
1C	0	0	-	0	-	0	0	-	0	-	0	0	-	-
2A	0	-	-	0	-	0	0	-	0	0	0	0	-	-
2B	-	0	-	0	-	0	0	-	0	-	0	0	-	-
2C	0	0	-	0	-	0	0	-	.059	-	0	0	-	-
2D	0	-	-	0	-	0	0	-	0	.50	0	0	-	-
3A	0	0	-	0	-	0	0	-	.035	.385	.122	.043	-	-
3B	-	0	-	0	-	-	0	-	-	.034	.022	.022	-	0
3C	-	0	-	0	-	0	0	-	.256	.173	.206	.016	-	0
3D	0	-	-	0	-	0	-	-	.153	.110	0	.019	-	0
4A	0	0	-	0	-	0	0	-	.13	.305	.325	.10	-	0
4B	0	0	-	0	-	0	.0032	-	.058	.0516	.058	.012	-	0
5A	0	0	-	0	-	-	0	-	.018	0	1.73	.41	-	0
5B	0	0	-	0	-	-	0	-	.013	0	0	0	-	0
Total Km Flown	735.5	911.9		1116.35		903.6	1217.65		1050.75	1438.75	1493.15	1049.40		693.25
Schools Seen/Km	0	0		0		0	.00082		.07328	.17376	.14	.0514		0

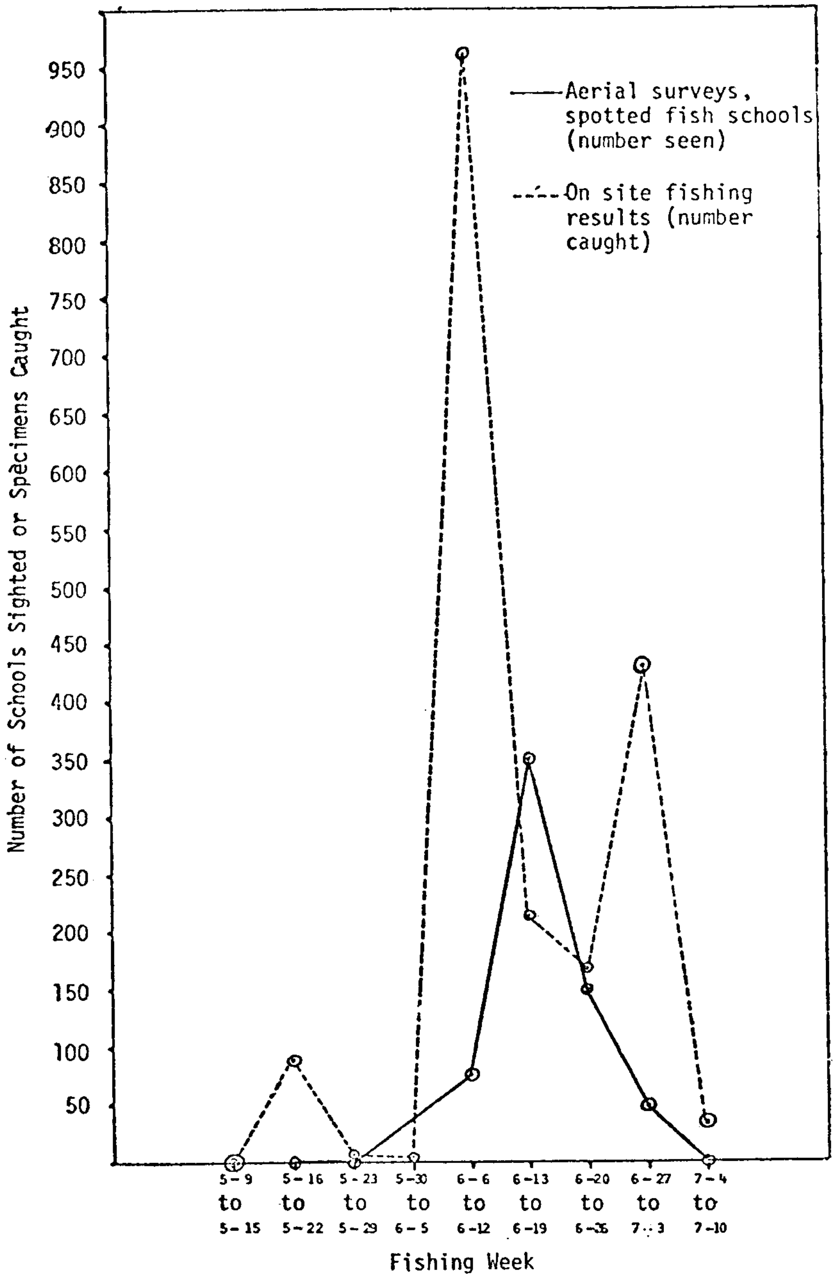

Figure 13 Temporal abundance of forage fish in onshore and nearshore spawning grounds of the north Alaska Peninsula between Cape Sarichef and Smokey Point as determined by aerial surveillance and on-site test fishing, May - July 1976.

conducted in the general area of the Meshik test site in Port Heiden and also in Herendeen Bay. As capelin were observed in Port Heiden Bay for only a seven-day period, it was assumed that fish observed from the air in Port Heiden were capelin and herring, with the majority likely being herring (Figure 14). Capelin were not caught in any quantity at Herendeen Bay and Port Moller, consequently fish schools observed in these areas were assumed to be herring.

GROUND SURVEYS

Five onshore and six offshore stations were fished periodically from May 21 through October 19, 1976 (Table 9 and Figure 15). A total of 459 herring, 643 capelin, 878 boreal smelt, 30 eulachon and 398 fish of miscellaneous species (primarily from the genera *Salvelinus* and *Lumpenus*) were captured and processed by ground crews at onshore stations. A total of 1,190 herring and 102 capelin were captured at the offshore sample stations. These offshore samples were frozen and later processed in Kodiak (Table 10).

A total of 227.1 gillnet hours were fished during the spring and summer of 1976 for an overall catch per unit effort (CPUE) of 8.23 specimens per net hour. A total of 35 gillnet hours were fished during the fall for a CPUE of 2.71 specimens per net hour. In addition longline gear was fished for 14 skate hours at the intertidal area of Reindeer Creek, 2.5 miles from Port Heiden airfield (each unit of longline gear was 30 meters long with 30 hooks of variable size). No fish were captured with this gear type.

Pacific Herring

The first Pacific herring was captured on May 20 at Meshik Beach (Port Heiden). Catches of this species continued until June 29 when the last four specimens were captured at Meshik Beach. Catch records and examinations of herring gonads from Port Heiden and Herendeen Bays positively indicate that the peak of herring spawning in 1976 on the north coast of the Alaska Peninsula occurred between June 7 and 12. Water temperatures and salinity values were monitored at Meshik Beach from May 1 through October 20 (Figure 16). Temperatures ranged from 8.5° to 9.0° Centigrade during the peak of spawning at Port Heiden Bay.

Spawning activity of herring was determined by visual examination of gonads and/or direct observation of spawning activity (e.g. herring spawn on test nets and bird predation on roe at low tide). Herring spawn was deposited on gillnets being fished in Port Heiden Bay and thousands of Larids were observed feeding in the shallows during every low tide during what was believed to be the peak of herring spawning. Gonad maturity index values (Moberly, 1971) were obtained from female and male herring (Table 11); these values increased until the peak of spawning, at which time spent fish began to appear in the catch. No spent fish were caught in Herendeen Bay, yet gonad indices indicated obvious spawning conditions. No spawning was documented throughout the study area by direct observation of milt in the water.

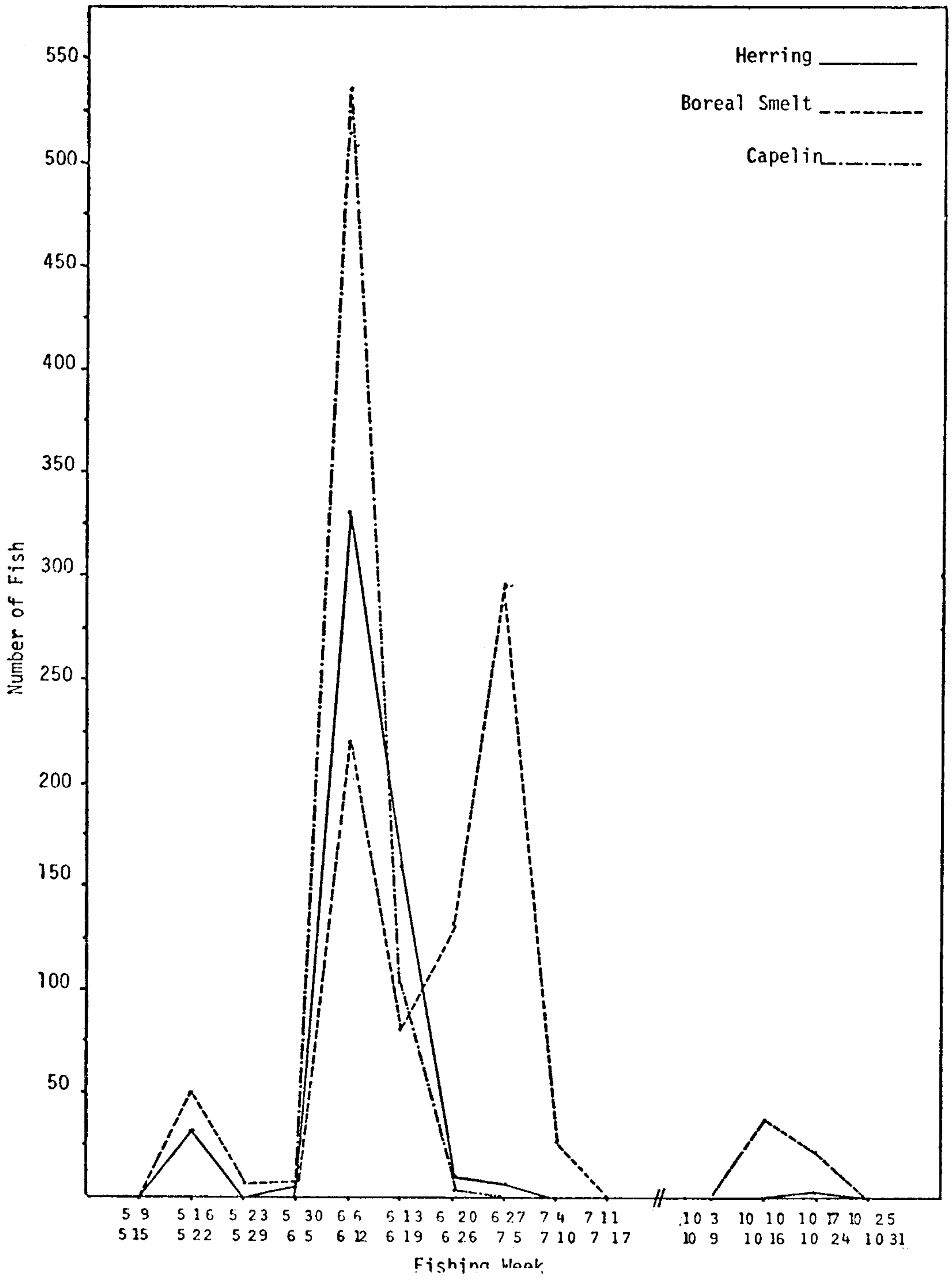

Figure 14. Weekly forage fish catch by species on the north Alaska Peninsula between Cape Sarichef and Smokey Point, May - October 1976.

Table 9. Location of forage fish sampling areas in the southern Bering Sea between Smokey Point and Cape Sarichef: May - October, 1976.

Sampling area #	Depth	Date Caught	Geographic Location
1	40 fathoms	5/21/76	30 mi N W of Cape Leontovich
2	49 fathoms	5/17/76	30 mi N W of Cape Sarichef
3	28 fathoms	5/23/76	30 mi N W of Seal Island
4	23 fathoms	6/10/76	100 mi S W of Cape Newenham
5	44 fathoms	5/20/76	90 mi E of Pribilofs
6	15 fathoms	5/23/76	20 mi W of Strogonoff Pt.
7	Onshore	5/12 - 7/5/76	Herendeen Bay airstrip
8	Onshore	5/12 - 7/5/76	Herendeen Bay cannery
9	Onshore	5/12 - 7/5/76	Port Moller (Open Beach)
10	Onshore	5/12 - 7/5/76	Seal Islands
11	Onshore	5/12 - 7/5/76 10/12 - 10/19/76	Meshik Beach

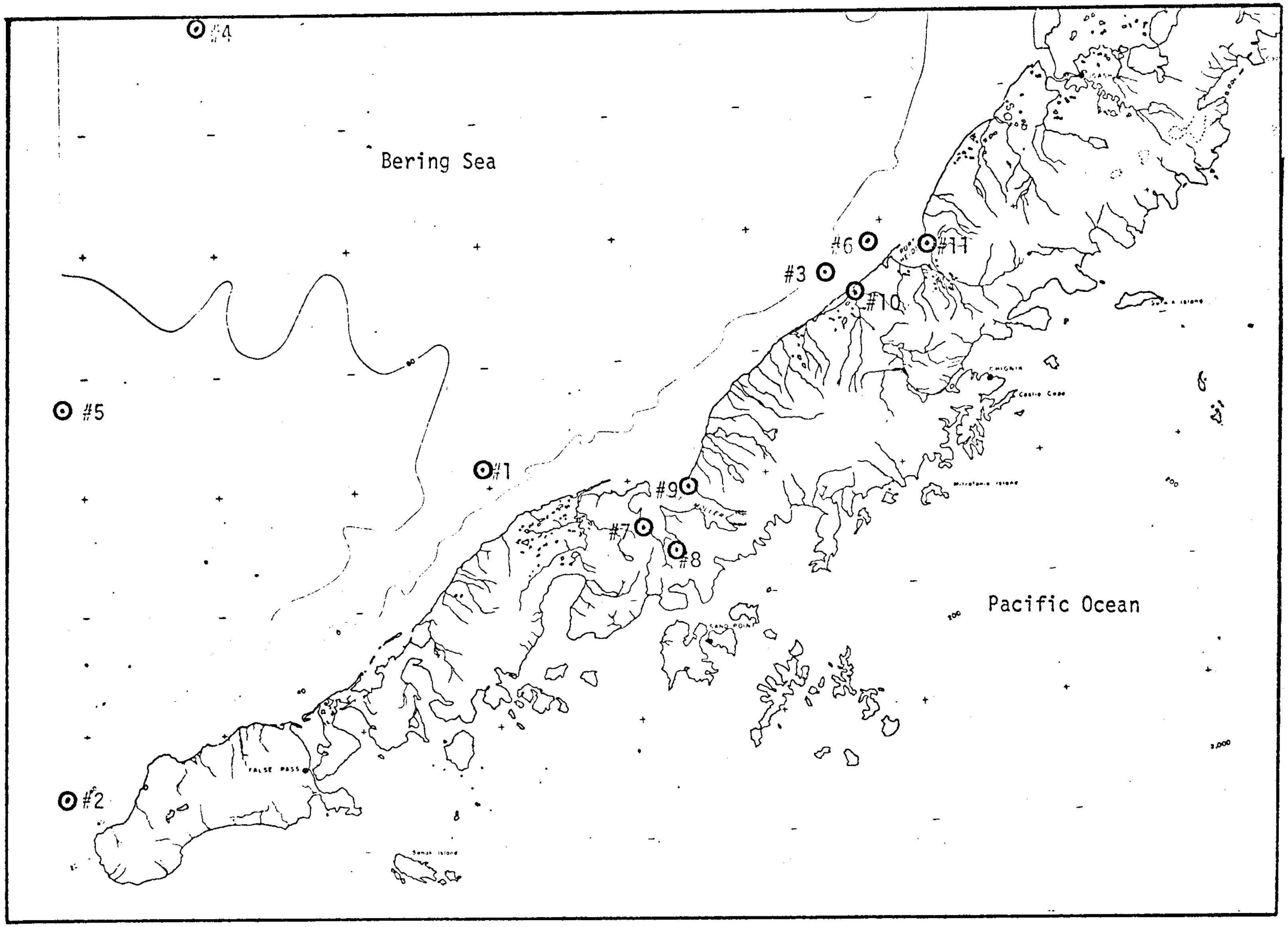

Figure 15. Onshore and offshore forage fish sampling locations in the eastern Bering Sea between Cape Sarichef and Smokey Point, May through October 1976.

Table 10. Catch by species by area for onshore and offshore fishing in Eastern Bering Sea, May through October, 1976.

Area	Herring	Capelin	Boreal Smelt	Eulachon	Misc.	Total
Port Heiden Spring	205	608	804	30	197	1,844
Port Heiden Fall	1		62		32	95
Port Moller		28	1			29
Herendeen Bay	235	5	11		84	353
Seal Islands		2			85	87
Totals	459	643	878	30	398	2,408
Offshore Station 1	139					139
Offshore Station 2	421					421
Offshore Station 3	89					89
Offshore Station 4	286					286
Offshore Station 5	255					255
Offshore Station 6		102				102
Totals	1,190	102				1,292
Grand Totals	1,649	745	878	30	398	3,700

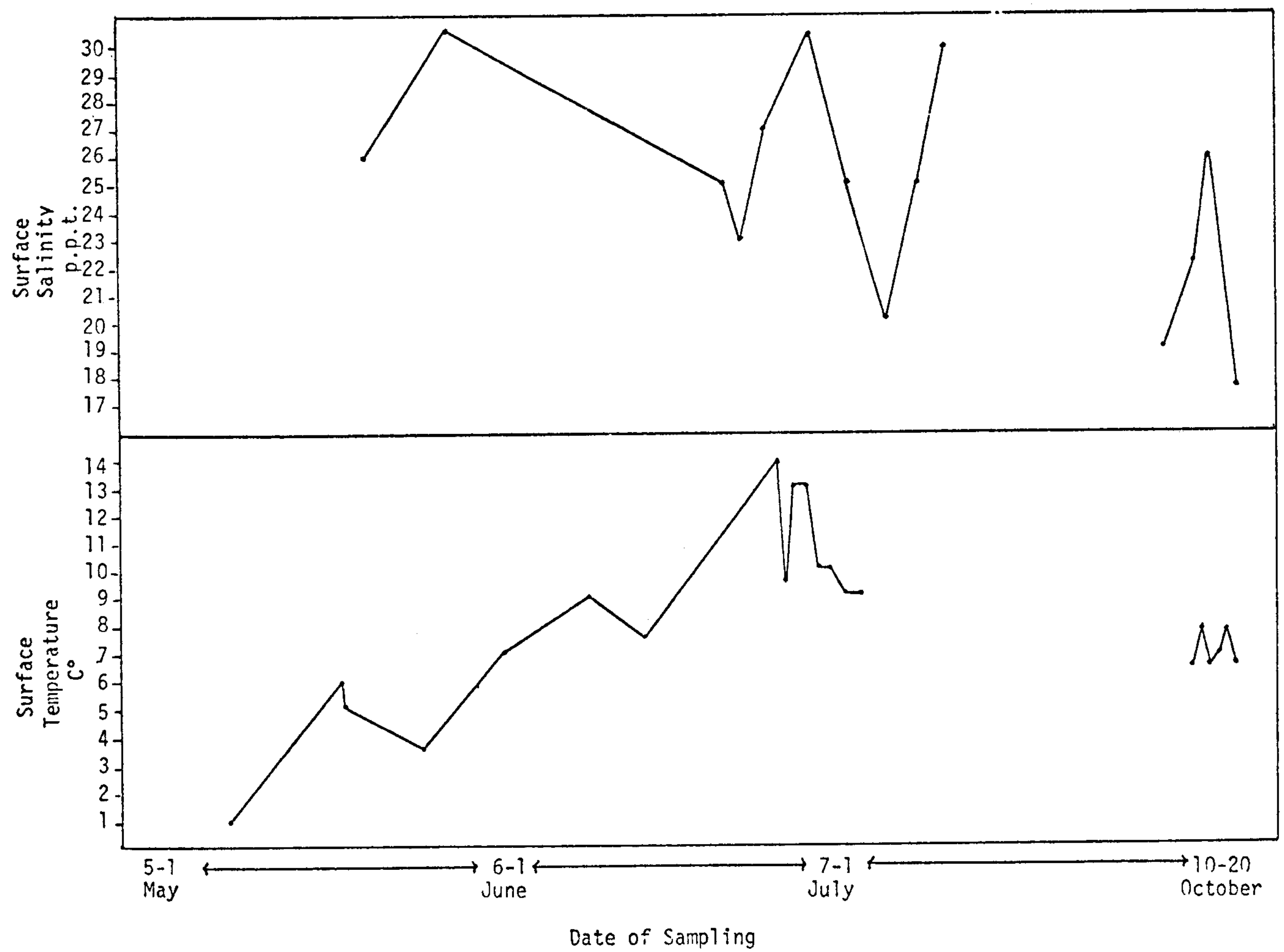

Figure 16. Temperature and salinity profiles of Port Heiden (Meshik Beach) forage fish sampling area on the north Alaska Peninsula, April - October 1976.

Table 11. Characteristics utilized to determine maturation stages of herring and assign maturity index numbers, Cape Sarichef to Smokey Point: April - September, 1976.

Maturity Index	Key Characteristics
I	Virgin herring. Gonads very small, threadlike, 2-3 mm broad. Ovaries wine red. Testes whitish or grey brown.
II	Virgin herring with small sexual organs. The height of ovaries and testes about 3-8 mm. Eggs not visible to naked eye but can be seen with magnifying glass. Ovaries a bright red color; testes a reddish grey color.
III	Gonads occupying about half of the ventral cavity. Breadth of sexual organs between 1 and 2 cm. Eggs small but can be distinguished with the naked eye. Ovaries orange; testes reddish grey or greyish.
IV	Gonads almost as long as body cavity. Eggs larger varying in size, opaque. Ovaries orange or pale yellow; testes whitish.
V	Gonads fill body cavity. Eggs large, round; some transparent. Ovaries yellowish, testes milkwhite. Eggs and sperm do not flow, but sperm can be extruded by pressure.
VI	Ripe gonads; eggs transparent; testes white; eggs and sperm flow freely.
VII	Spent herring. Gonads baggy and bloodshot. Ovaries empty or containing only a few residual eggs. Testes may contain remains of sperm.
VIII	Recovering spents. Ovaries and testes firm and larger than virgin herring in Stage II. Eggs not visible to naked eye. Walls of gonads striated; blood vessels prominent. Gonads wine red color. (This stage passes into Stage III).

[1] From in house works; Data Collection Procedures for Herring, by Stan Moberly, no year.

Age analysis of stocks spawning onshore indicated that they were dominated by four year old fish, with three year olds being the second most abundant age group. Offshore catches, while also dominated by four year old fish, contained ten percent two year olds and two percent one year olds (Figure 17). Sex ratios for onshore and offshore herring samples were found to be similar at 53 and 55 percent females, respectively. Length frequency analysis of offshore herring catches compliment age results by assuming a bimodal distribution as opposed to the unimodal distribution seen in onshore samples (Figure 18).

The Von Bertalanffy growth equation was shown to fit growth data for offshore herring and these data generally concurred with those by Rumyantev and Darda (1970) (Figure 19).

Fecundity analysis was conducted on 56 female herring of age groups III-X. One out of every ten females captured was sampled with 18 being from offshore stations 1 and 2 (Figure 15). Standard lengths of fish sampled ranged from 192-276 mm and whole fish weights ranged from 80-312 gms. The estimated number of eggs per female ranged from 12,687 to 84,875. The mean egg count for all herring sampled was 26,473, their mean length was 221 mm, and their mean weight was 142 gms. Gonad maturity indices ranged from III-VI. A direct relationship was observed between fecundity and body length at both onshore and offshore stations (Figures 20 & 21, Table 13). Attempts to compare herring fecundity and body condition factors with age for both onshore and offshore samples suggest that no correlation exists between these parameters (Table 12). This may, however, be due to a problem with fecundity interpretation as discussed later in this report.

The use of alcohol to preserve herring eggs proved less effective than Gilson's solution which is used by most herring researchers (Blanken-blackler, Personal Communications). Gilson's solution aided in dissolving the ovarian membrane, facilitating separation of eggs prior to fecundity determination. Alcohol (both methyl and isoprophyl) did not dissolve the ovarian membranes. Some ovaries fixed in alcohol, in fact, proved to be so adherent to the membrane and each other that it was impossible to separate eggs for enumeration. Whole specimens, on the other hand, were successfully preserved in 50% methyl alcohol and maintained good lifelike coloration and showed no signs of autolytic digestion for four months.

Primary onshore herring spawning areas in 1976 were determined to be Herendeen Bay, Port Moller Bay, Port Heiden and, to a lesser extent, the north coast of Unimak Island. Bechevin Bay, although offering abundant and apparently very suitable habitat for herring spawning (i.e. extensive kelp beds and secluded rocky bays), was not utilized for spawning. Anecdotal information obtained from local residents indicates that no significant herring spawning has occurred in this area during the last 20 years.

Boreal Smelt

A total of 378 boreal smelt were taken from onshore sampling sites during 1976: 816 in the spring/summer and 62 in the fall. Boreal smelt

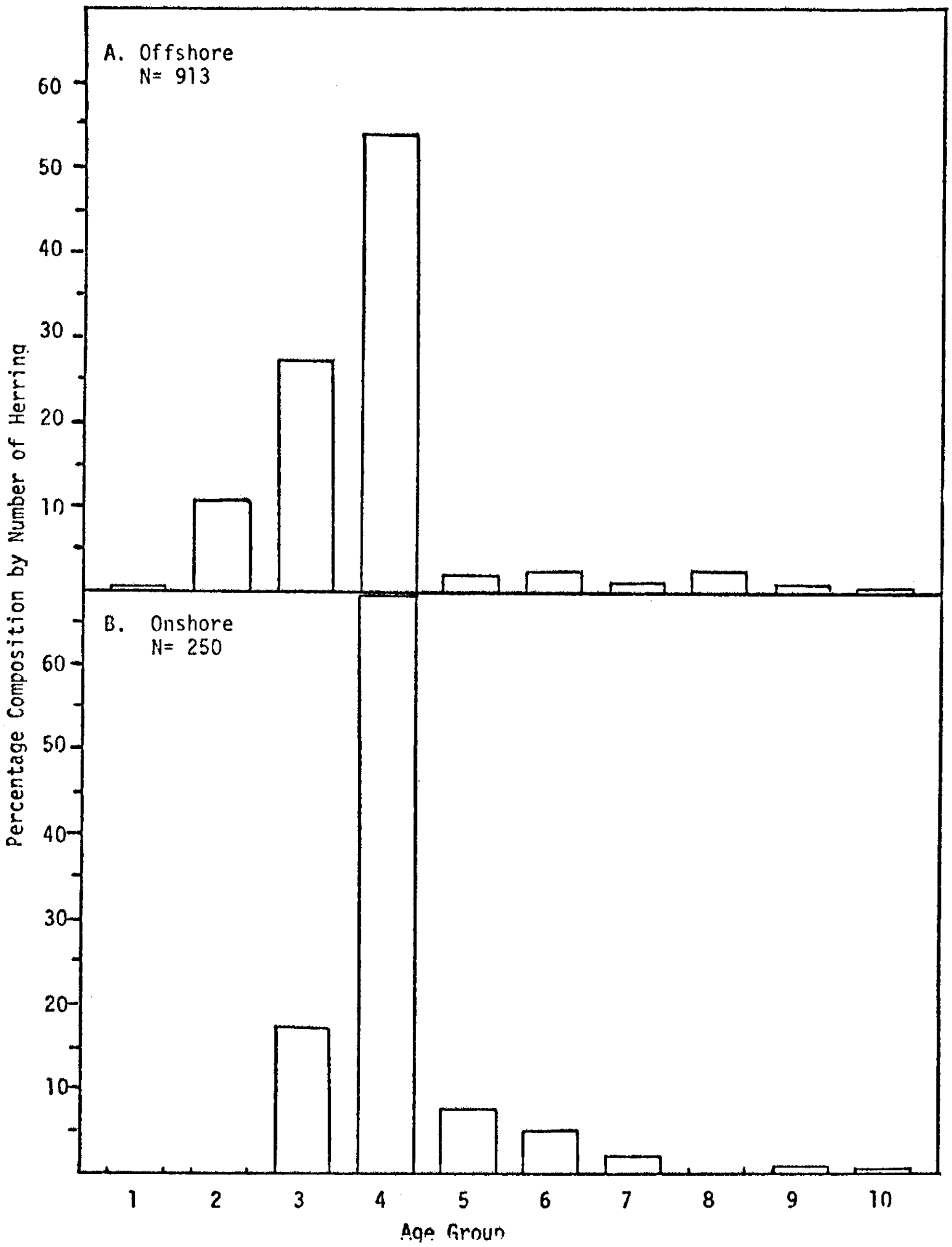

Figure 17. Age group composition of Pacific herring *(Clupea harengus pallasi)* from onshore and offshore catches in the southern Bering Sea between Cape Sarichef and Smokey Point during June and July of 1976.

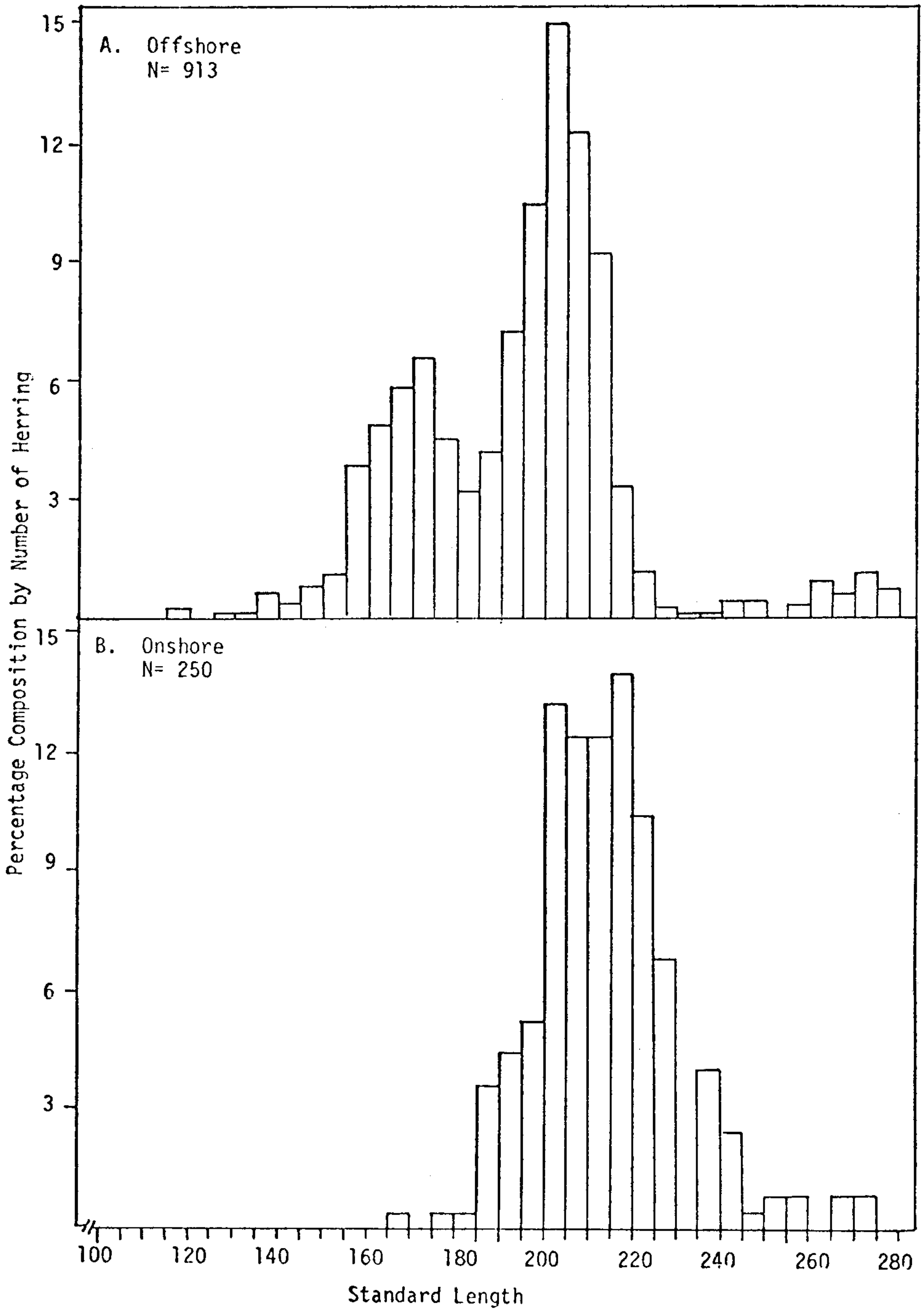

Figure 18. Size composition of offshore and onshore Pacific herring *(Clupea harengus pallasi)* catches in the southern Bering Sea between Cape Sarichef and Smokey Point during June and July of 1976.

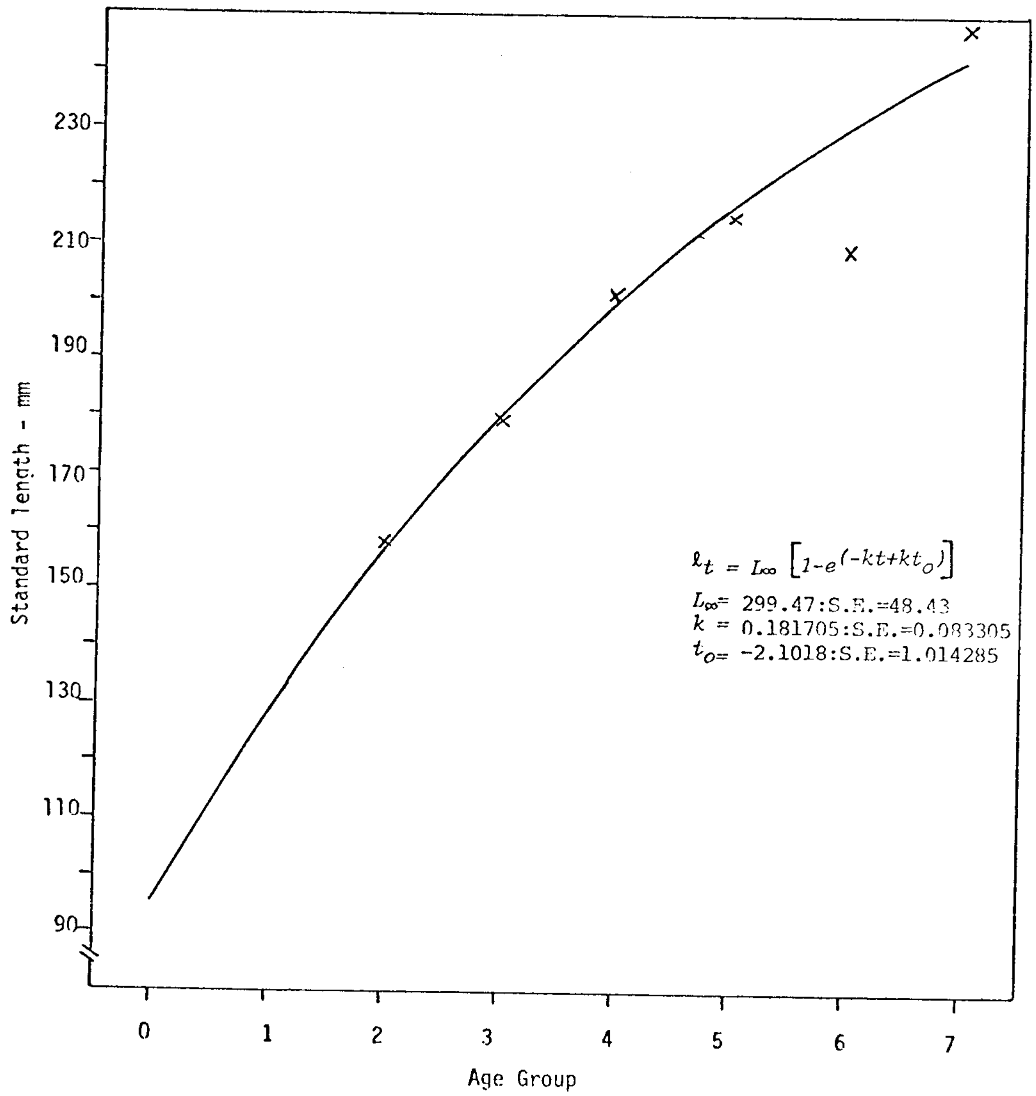

Figure 19. Growth rate of Pacific herring from offshore sampling stations in southern Bering Sea as determined by fitting Von Bertalanffy growth equation to actual data points obtained. Actual mean lengths of age groups indicated by "X". June-July, 1976.

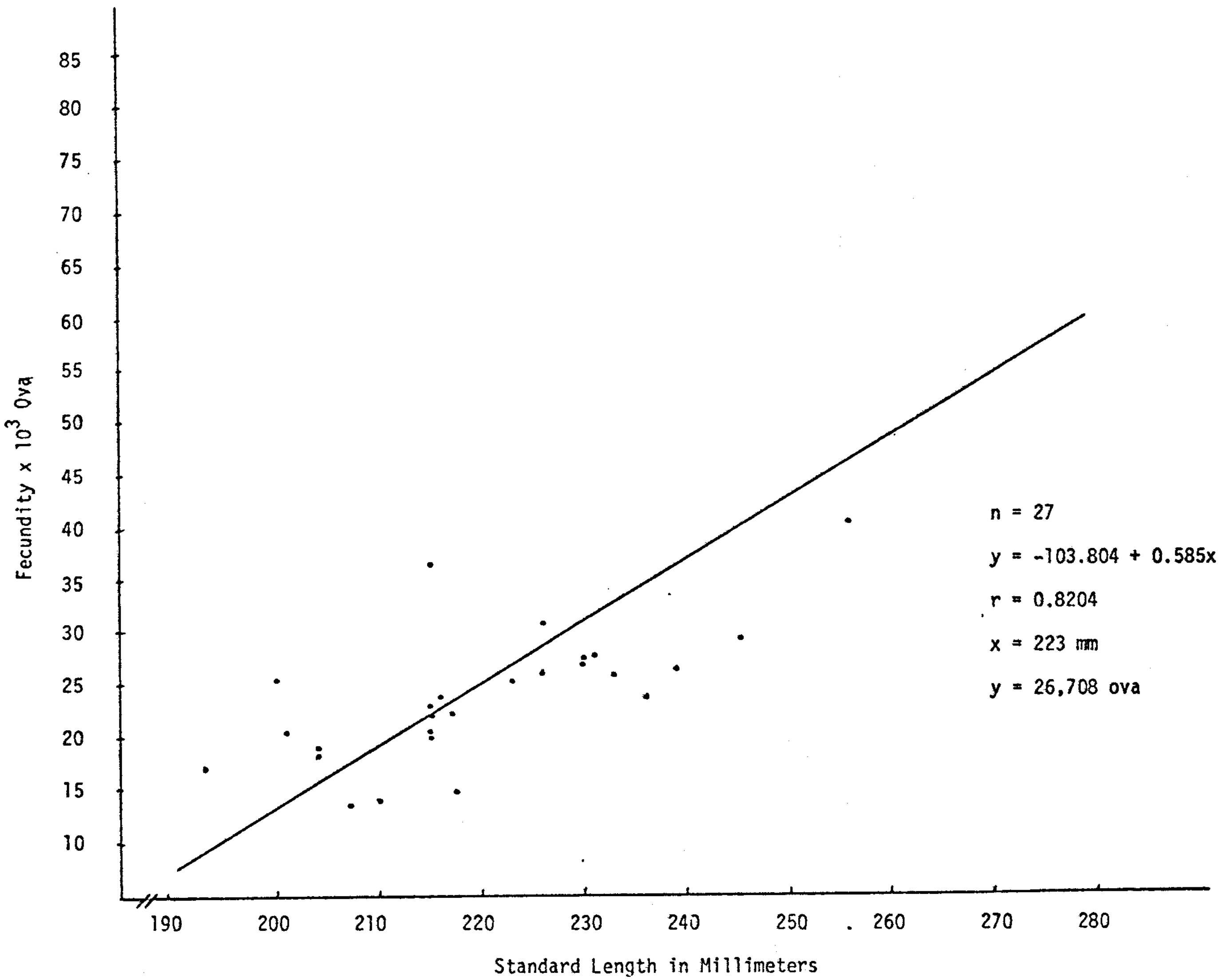

Figure 20 Relationship of fecundity to body length of Pacific herring *(Clupea harengus pallasi)* in onshore sampling locations of the north Alaska Peninsula between Cape Sarichef and Smokey Point, May - July 1976.

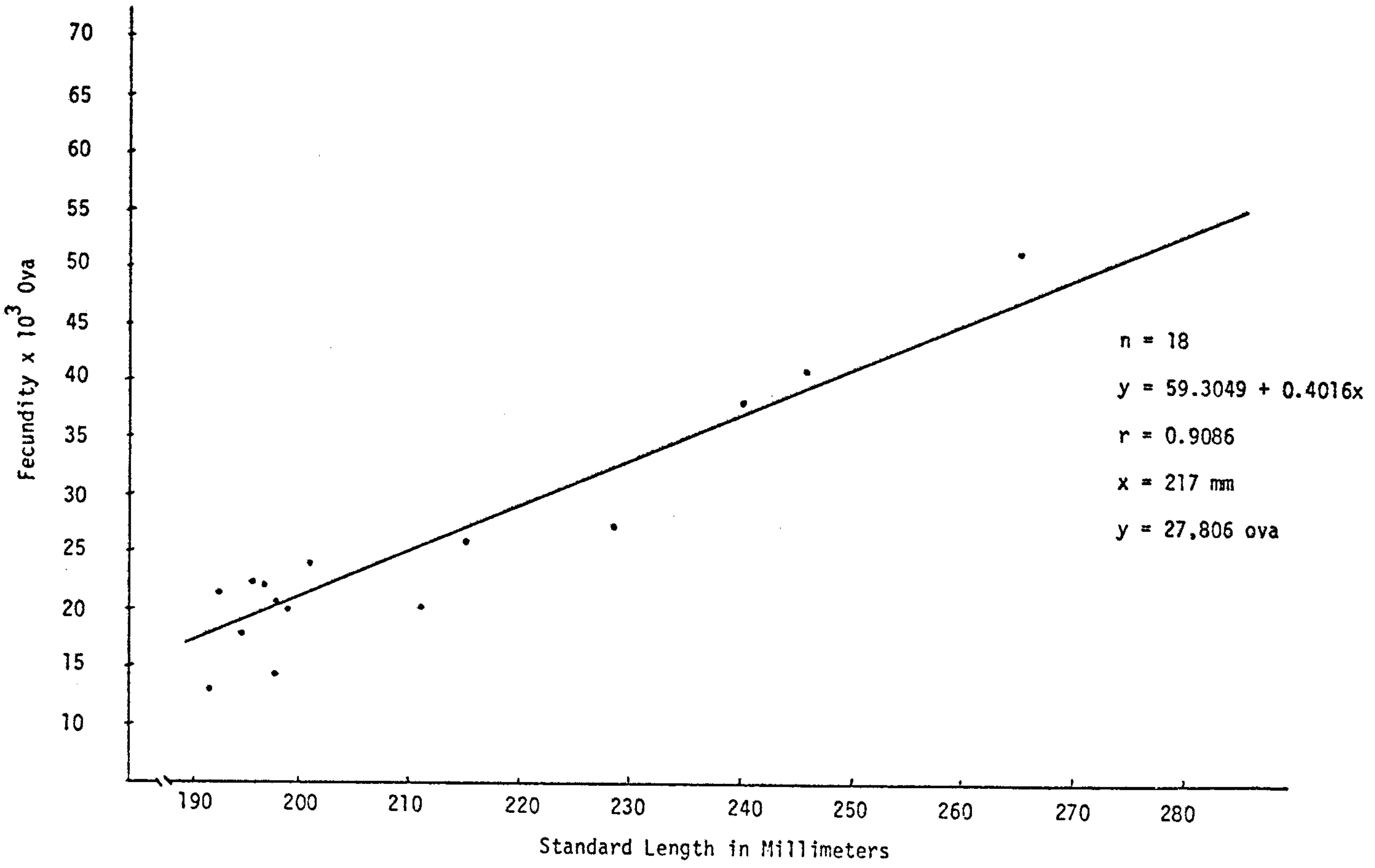

Figure 21. Correlation of estimated fecundity and body length of Pacific herring *(Clupea harengus pallasi)* caught in offshore sampling stations of the southern Bering Sea, July 1976.

Table 12. Mean fecundity and condition factors[1] of Bering Sea and Northern Alaska Peninsula herring by area and age group, 1976.

Area		Age in Years 3	4	5	6	7	8	9	10	Spec.
Offshore Eastern Bering Sea	Fecundity X 10^3	17.9	24.3	-	14.3	-	49.5	-	51.2	
	Cond. Factor X 10^{-5}	1.4	1.39	-	1.22	-	1.56	-	-	15
Onshore Northern Alaska Pen.	Fecundity X 10^3	-	23.9	19.7	28.4	36.3	-	-	-	
	Cond. Factor X 10^{-5}	-	1.25	1.22	1.33	1.44	-	-	-	22

[1] $c = w(gm)/l^3(mm)$

Table 13. Relationship of length to fecundity of Pacific herring from onshore and offshore sampling locations in the eastern Bering Sea, May - June, 1976.

Standard Length (mm)	Onshore: Cape Sarichef - Ugashik Mean Number of eggs	Number of Fish	Offshore: Eastern Bering Sea Mean Number of eggs	Number of Fish
191-200	18,435	3	19,912	9
201-210	20,022	8	23,714	1
211-220	21,026	10	22,898	2
221-230	27,916	7	27,470	1
231-240	27,354	6	38,082	1
241-250	34,075	1	40,987	1
251-260	40,402	1	-	-
261-270	50,468	1	43,583	2
271-280	84,875	1	58,084	1
281-290	-	-	-	-
291-300	-	-	-	-

(rainbow, American or Toothed smelt) were among the first forage fish captured. The first specimen was captured on May 20, and this species proved to have the widest temporal distribution and the highest total catch of any species encountered on onshore sampling sites. The prominent teeth of these smelt become easily entangled in the thin monofilament gillnets, making their catchability factor high; this perhaps created a bias in species catchability. Otoliths were randomly taken from 78 specimens and used to verify scale aging as well as in a weight frequency distribution to supplement other aging methods (Figure 22). An attempt was made to "fit" the Von Bertalanffy growth equation to age-length data from boreal smelt. Results indicate that the growth rate of boreal smelt does not fit the basic Von Bertalanffy assumption that growth rate decreases with age. This latter analysis, assuming valid age determination, indicates that the growth rate of boreal smelt increases with age.

Mature and immature smelt were often captured simultaneously. The majority of mature fish were captured during May in spawning condition, frequently with the sex products flowing. Mr. Lou Gwartnuy (ADF&G, King Salmon) obtained a sample of spawning smelt in King Salmon Creek (Naknet River) during May, 1976 for this study. Comparison of gonad maturity indices of boreal smelt captured during the spring/summer activities to those captured in the fall clearly showed that smelt caught in the spring and summer were obviously in a ready state of spawning, whereas nearly all those caught in the fall were spent (Figure 23).

A total of 150 scales and 50 otoliths were aged as per techniques described earlier. Age composition analysis of boreal smelt sampled from intertidal spawning habitats (primarily from the surf of smooth sandy beaches) of the southern Bering Sea between Cape Sarichef and Smoky Point between June and July of 1976 indicates the presence of four size/age groups, with age III group being dominant (Figures 24 and 26). The largest smelt captured measured 263 mm in length. Comparison of size composition profiles between males and females indicates little difference in length between the two sexes (Figure 25). All smelts captured usually had full or partially full foreguts containing, in order of occurrence mysids, amphipods, larval fish and polychaete worms.

No significant fluctuation of sex ratio was observed throughout the study period, this ratio being heavily inclined toward males. The sex ratio of smelt captured in the spring and summer was 35% females, while 32% females were captured during the fall.

Capelin

Capelin were the most geographically widespread forage fish species encountered and constituted the second most abundant species captured at onshore stations during 1976. They were observed washed up on beaches from Cape Krenitzen north to Smoky Point at Ugashik Bay. Capelin stocks appeared to be dominated by a single year class and showed definite signs of sexual dimorphism. Males were differentiated from females by such characteristics as "hairiness" along the lateral line during the

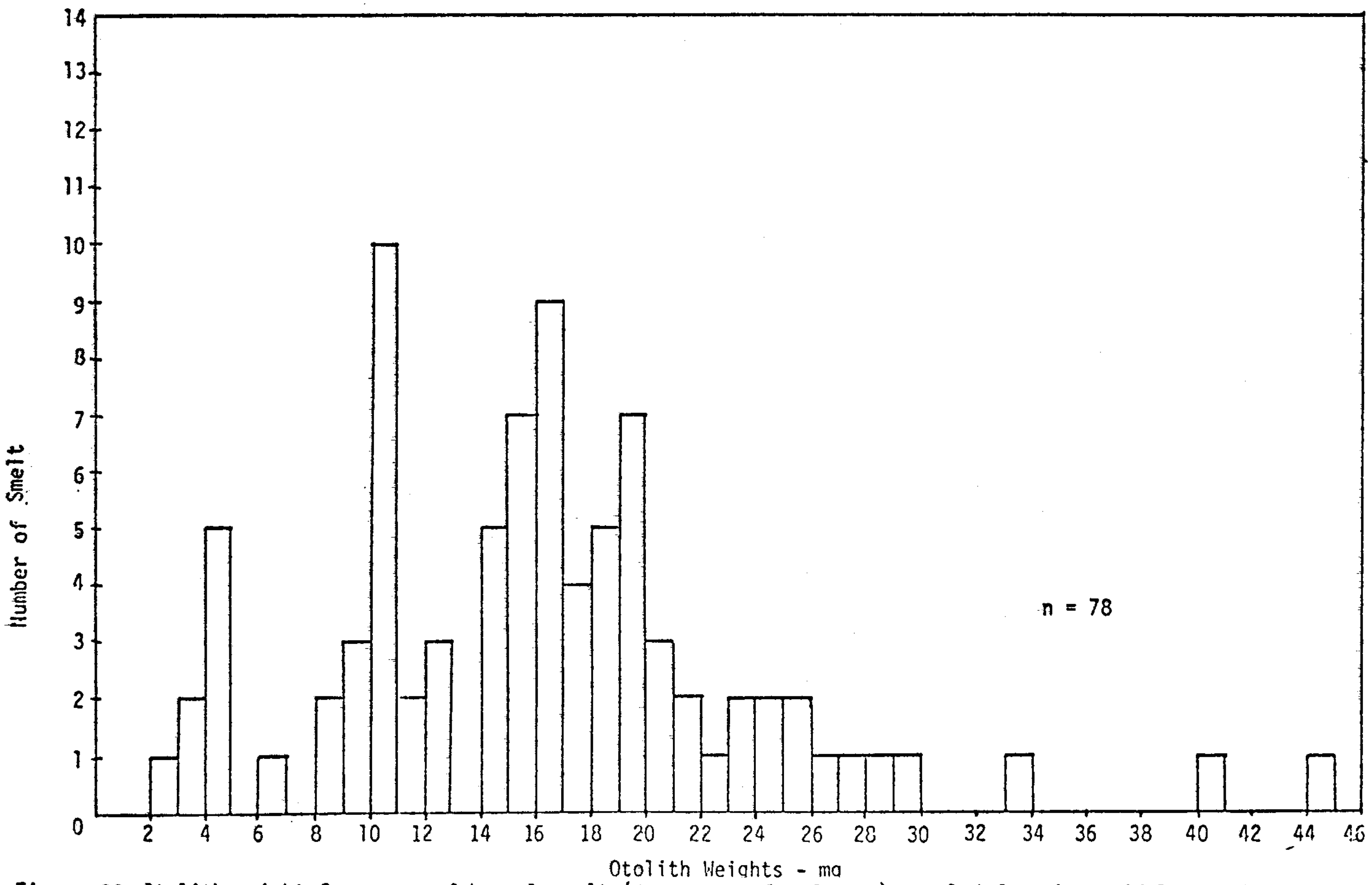

Figure 22. Otolith weight frequency of boreal smelt (*Osmerus mordax dentex*) sampled from intertidal spawning habitat of the north Alaska Peninsula between Cape Sarichef and Smokey Point, May - July 1976.

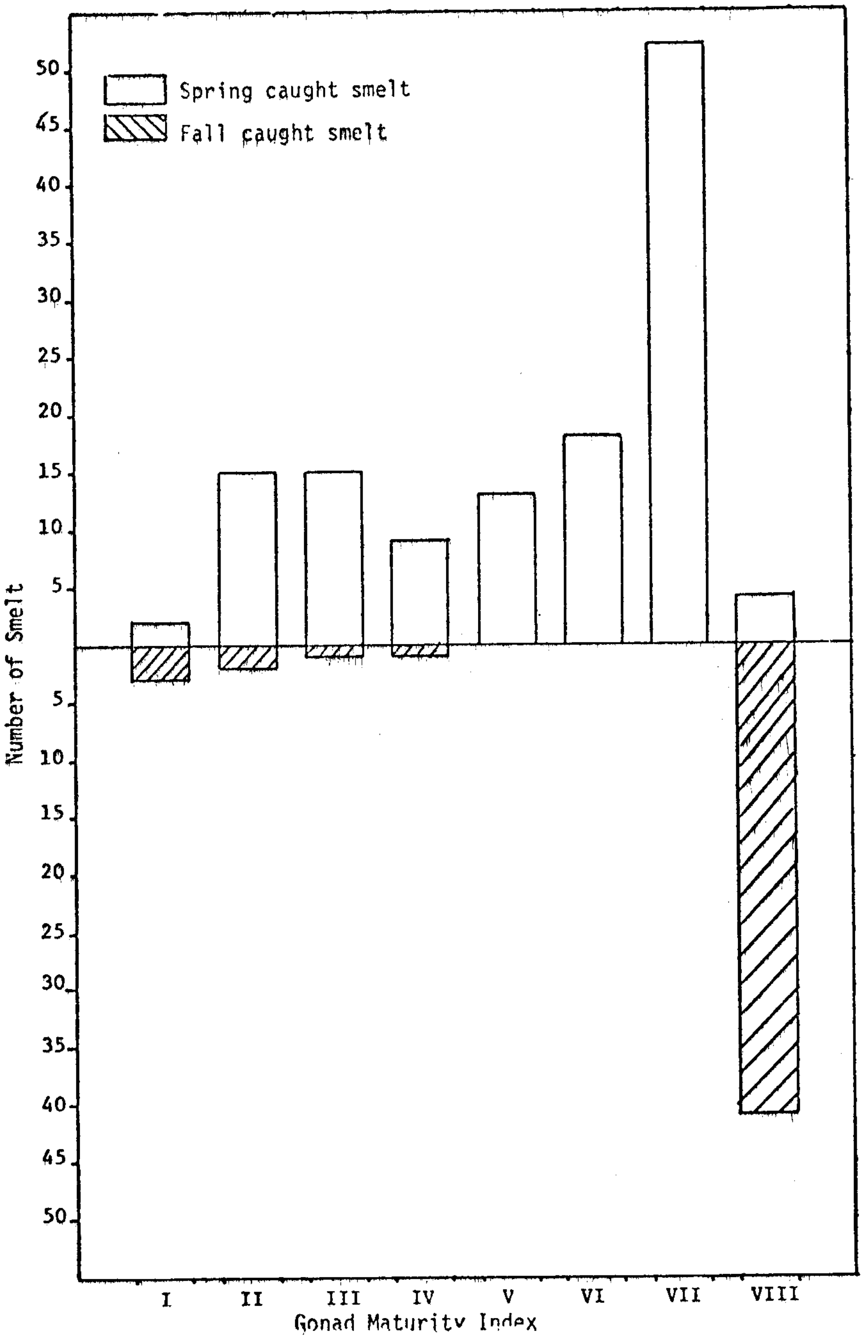

Figure 23. Comparison of sexual maturity of boreal smelt stocks on the north Alaska Peninsula between spring and fall as determined by test fishing, May - October 1976.

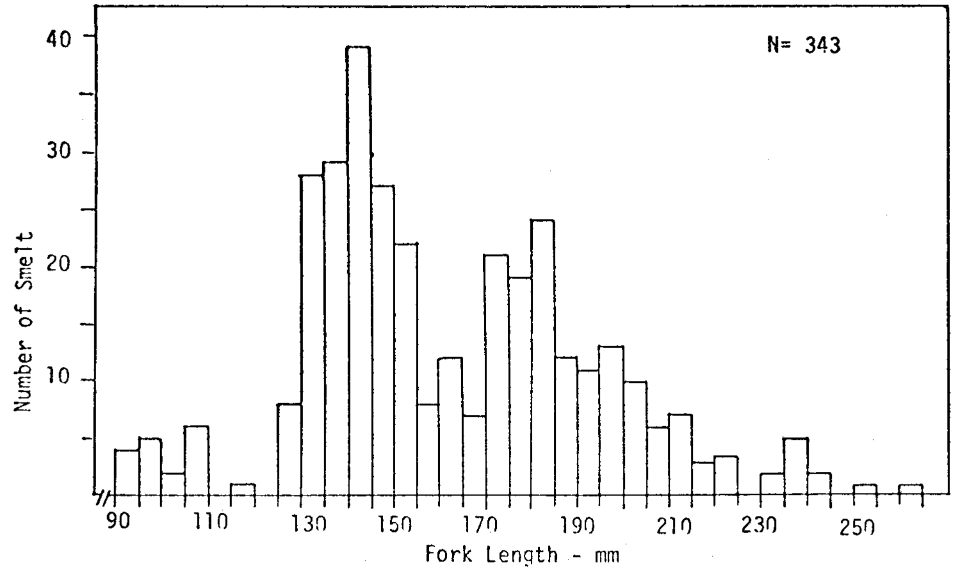

Figure 24. Size composition of boreal smelt *(Osmerus mordax dentex)* sampled from intertidal spawning habitat of the southern Bering Sea between Cape Sarichef and Smokey Point during June and July of 1976.

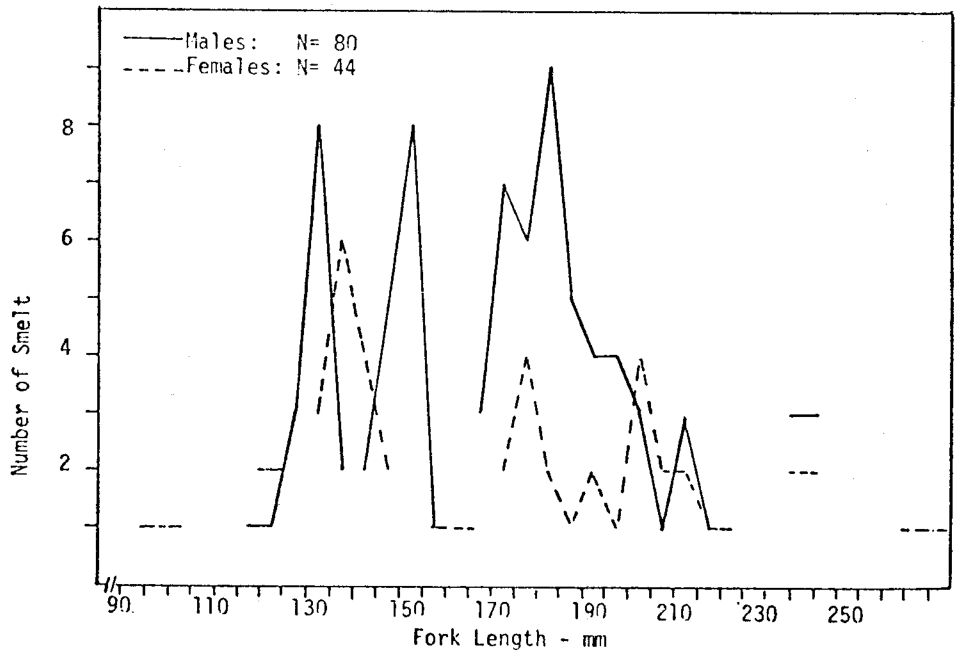

Figure 25. Comparative size composition of male and female boreal smelt *(Osmerus mordax dentex)* obtained from intertidal spawning habitat of the southern Bering Sea from Cape Sarichef to Smokey Point, June - July 1976.

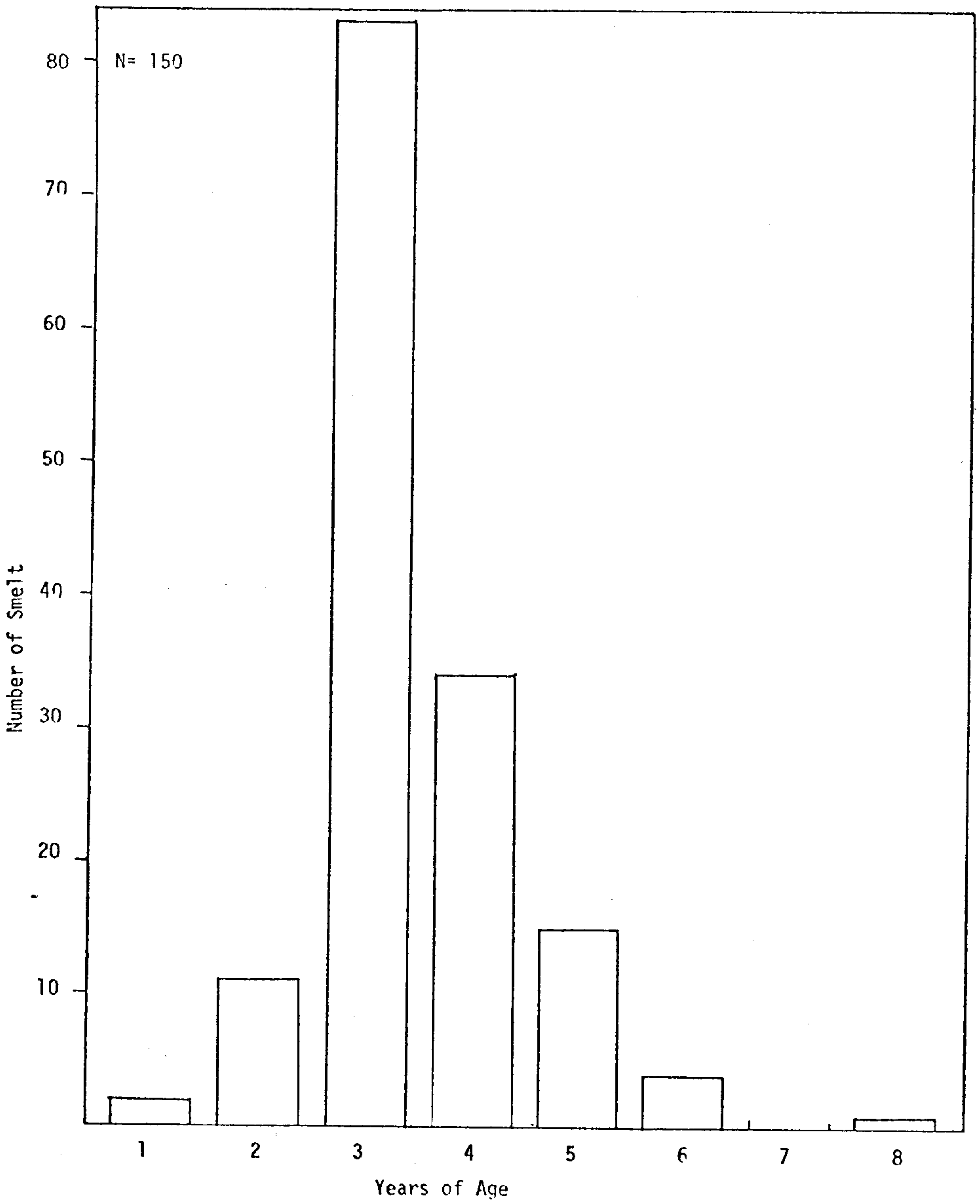

Figure 26. Age frequency of boreal smelt *(Osmerus mordax dentex)* sampled from intertidal spawning habitat between Cape Sarichef and Smokey Point on the north Alaska Peninsula during June and July of 1976.

spawning period, pronounced metamorphosis of the fins during spawning, a more rapid growth rate (Figure 27), and their being less gracile than females (Templeman, 1948).

Evidence obtained during this study as well as that by other investigators suggests that capelin segregate by sex in intertidal waters immediately prior to spawning. On two occasions beach stranded capelin were randomly examined by hand at Port Moller and Meshik. It was necessary at Port Moller to sort hundreds of capelin by hand in an attempt to obtain a 50:50 sample of males and females, and still only six females could be located. A similar phenomenon occurred at Meshik; the sex ratio in a sample of capelin randomly obtained from the surf was 21 males to two females.

Scales and otoliths were taken from capelin and aged, but results were inconclusive due to small sample sizes and difficulties in age interpretation. Information on age structure is relative only and obtained from analysis of a fork length frequency distribution of 295 fish. This analysis incicates that a single dominant size group occurs between about 130-150mm (Figure 28).

Eulachon

A total of 30 eulachon were captured during the spring/summer activities and none in the fall, making this the second least abundant species encountered. Age, weight and length samples were taken. However, scales proved unreadable. Otoliths were taken and read in a manner similar to boreal smelt, although results proved inconclusive due to difficulties in age interpretation and the small sample size.

The first eulachon was captured during late June and catches were consistently small until summer fishing terminated on July 5, 1976. All sampling indicated that eulachon were in ready spawning condition in early June; all specimens had shed their teeth prior to examination (an indication that spawning has been completed).

Sand Lance

Only one sand lance was captured during 1976, resulting in it being the least abundant taxa encountered. This single sand lance was caught during the fall fishing efforts at Meshik Beach. This species was noted also in varying abundances in stomachs of boreal smelt and sculpins captured during that time of the year.

A single specimen of forage fish not previously described as inhabiting the Bering Sea was caught during these spring/summer activities in Herendeen Bay - it was identified as a surf smelt, *Hypomesus pretiosus*.

DISCUSSION

Pacific Herring

The difference in growth rate between offshore and onshore herring stocks was shown by the chi square test to be significant. This test was conducted to determine the probability of these offshore and onshore stocks being from the same population. This analysis indicated that the probability of this being the case was one in one hundred, or significantly

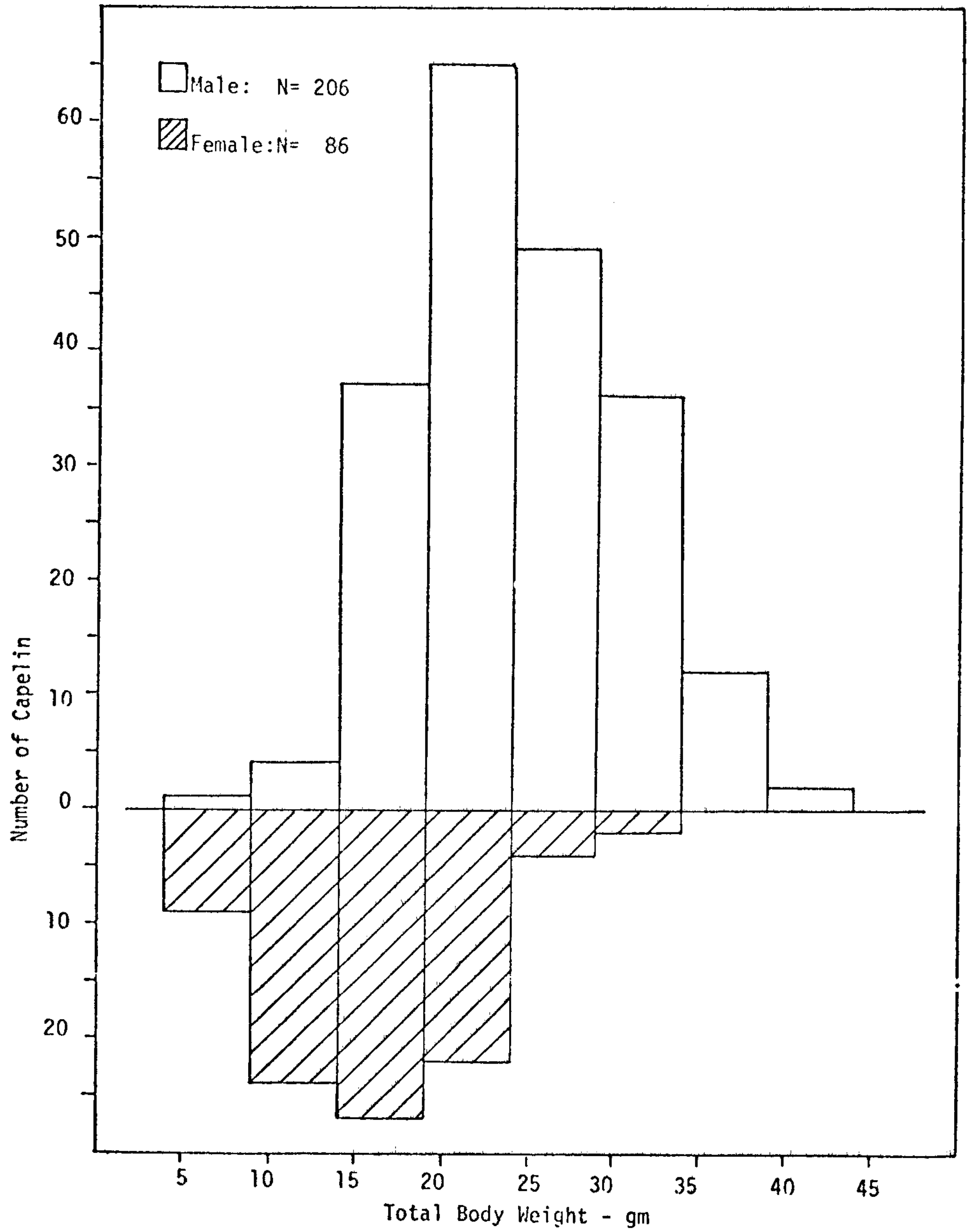

Figure 27. Comparative weight composition of male and female capelin (*Mallotus villosus*) sampled from intertidal spawning habitat of the southern Bering Sea between Cape Sarichef and Smokey Point during June and July of 1976.

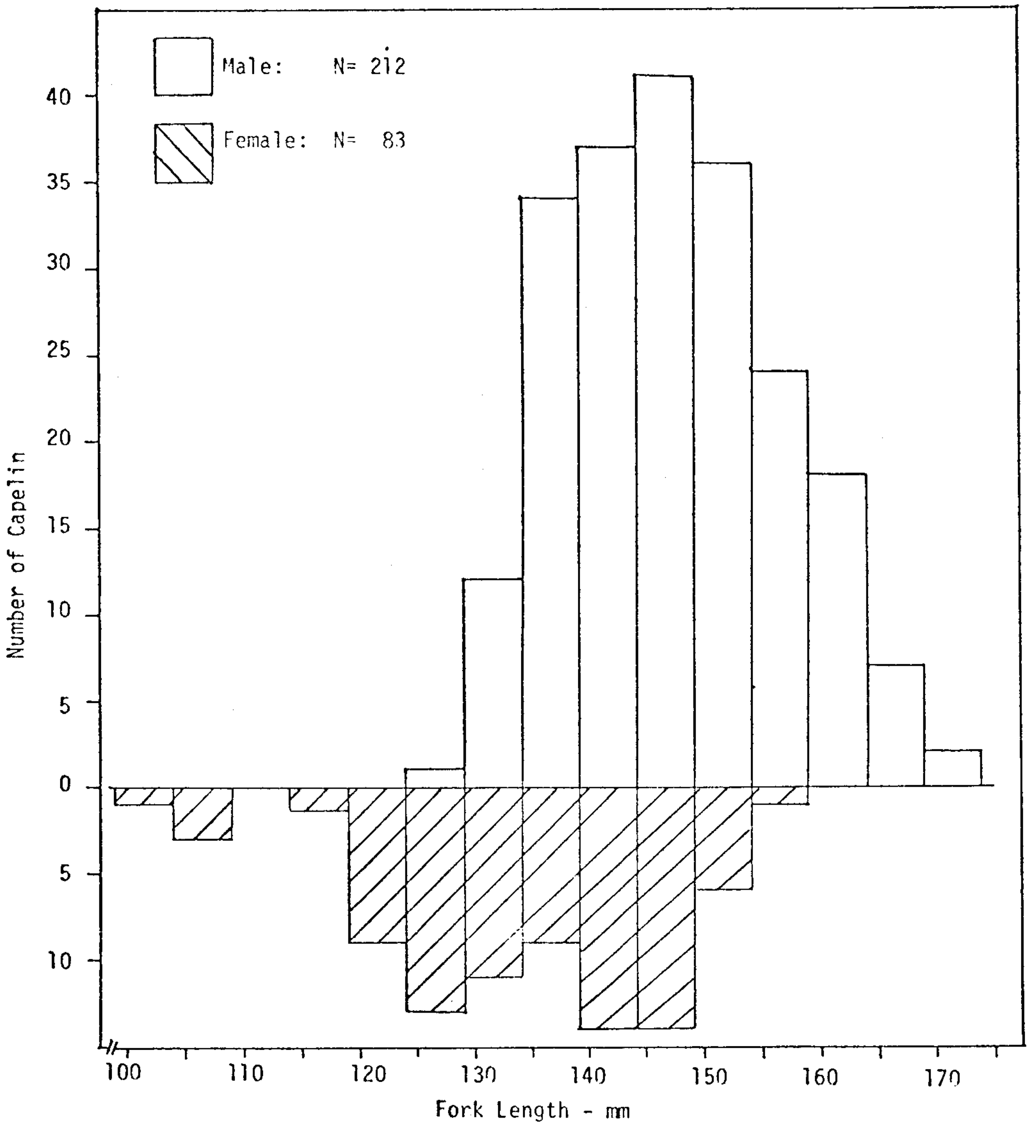

Figure 28. Comparative size frequency composition of male and female capelin (*Mallotus villosus*) sampled from intertidal spawning habitat of the southern Bering Sea between Cape Sarichef and Smokey Point during June and July of 1976.

different at the 99 percent level. It is probable, therefore, that fish caught offshore were from a different population than those taken onshore. This contradicts preliminary indications discussed in the October 1, 1976 quarterly report.

While both offshore and onshore herring catches were dominated by four year old fish, those offshore contained one and two year olds whereas those onshore did not. The absence of one and two year old herring from onshore samples suggests that herring in the Bering Sea do not mature until they are three years old. This concurs with other herring research done in the eastern Bering Sea. Rumyantsev and Darda (1970) stated that herring begin to mature at age III, although some mature specimens were also encountered among two year olds. Rounsefell (1929) concluded that none of the two year old herring sampled throughout Alaska were mature Shaboneev (1969) states that herring begin to attain sexual maturity at age two years and that roughly one half of the fish were sexually mature at age four.

Moberly's gonad index system, while useful as a relative expression of herring maturity, is subjective and subject to variation between observers. Studies on herring maturity based on this index in 1976 indicated that onshore herring stocks had a higher gonad maturity index than those simultaneously sampled offshore; this suggests that mature offshore herring spawned later or not at all (Figure 29). This implied difference, however, was later shown not to be true, the error being due to the subjective nature of interpretation. Herring with sex products not flowing, but with gonads filling the body cavity, were determined to be class IV by investigators in the Kodiak laboratory; field crews, on the other hand, classified herring in this condition as class V. This variance in interpretation explains why data originally indicated that inshore stocks had a higher maturity index. Subsequent fecundity studies of these two groups, which employed the more quantitative dry weight methods of fecundity determination (Nagasaki, 1958), indicated that the reproductive state of both onshore and offshore herring stocks were very similar. This suggests that offshore as well as onshore spawning activity may have occurred in the study area during 1976. Offshore spawning by Pacific herring has been documented in Fish and Wildlife Resource Inventory Of the Cook Inlet and Kodiak Areas (Volume II, 1976) which is a compendium resource publication of ADF&G. As documented evidence of deep water spawning by Pacific herring is lacking, the biologist who observed this occurrence was contacted; he stated that extensive quantities of herring spawn were seen and identified on Tanner crab pots set at a depth of approximately 36 m, 19 km south of Augustine Island, in Kamishak Bay (Daisy, Personal Communications).

Rumyantsev and Darda (1970) found that herring in the southern Bering Sea spawn both onshore and offshore. They concluded further that offshore spawning occurred on the Continental Shelf during June, while onshore spawning occurred in the bays along the north coast of Alaska Peninsula during May. Anecdotal evidence gathered from natives and/or commercial fishermen in 1976 indicated that Pacific herring in the southern Bering Sea spawned in deep water off the coast of the Alaska Peninsula. Several natives indicated that harbor seals and sea lions had been observed surfacing with herring spawn covering their heads and coating their whiskers. Commercial fishermen also mentioned they had seen herring spawn intermixed with their trawl catches.

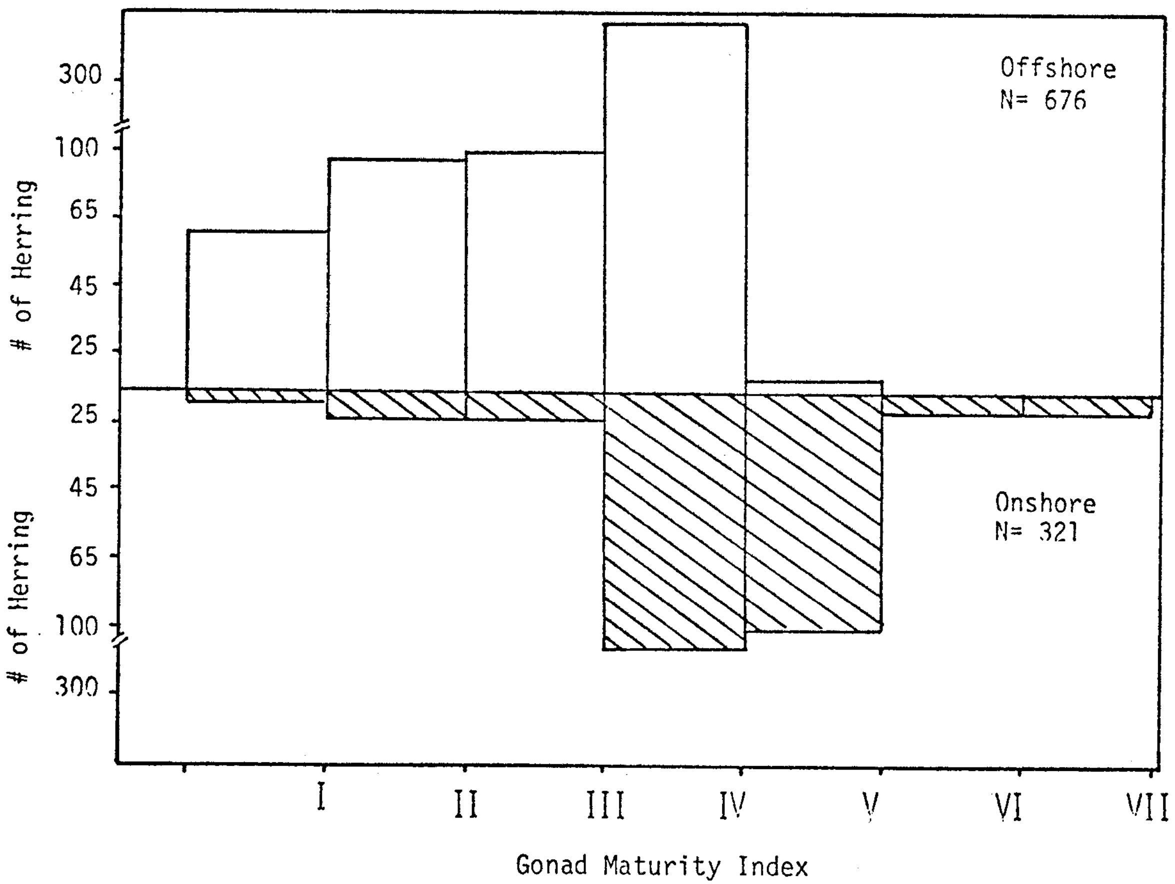

Figure 29. Composition of Pacific herring *(Clupea harengus pallasi)* by stage of gonad maturity from onshore and offshore locations of the southern Bering Sea between Cape Sarichef and Smokey Point, May - July 1976.

Boreal Smelt

Boreal smelt are the most important forage fish species throughout the study area from a sports/subsistence fishery standpoint. This species was the most abundant captured at the Meshik test site where large concentrations congregated near the mouth of river systems. A subsistence-sports level fishery exists in King Salmon Creek, a tributary of the Naknek River. Meshik residents also stated that they fished this species in the Meshik River during the winter for subsistence purposes.

Field observations of boreal smelt in the study area indicate they ascend tributary creeks of large rivers during the evening to spawn. McPhail and Lindsey (1970) report that both anadromous and fresh water races of this species occur. These anadromous races frequently have been documented to spawn hundreds of miles up major river systems (Hart, 1973). Boreal smelt in the study area were captured in salt or brackish water with sex products running and with partial skeins of eggs; therefore, one of three possibilities may occur concerning the spawning habits of these anadromous smelt: 1) they ascend rivers to spawn in the evenings and during the day return to estuaries to feed, 2) spawning takes place in brackish water in estuaries, 3) adult smelt do not always "spawn out" fully prior to their descent to salt water for their summer feeding cycle.

Capelin

Due to the chaotic manner in which capelin spawn, it is possible that some ripe fish find themselves excluded from beach spawning because of spatial circumstances. Such an exclusion might precipitate spawning further offshore in deeper water. Capelin spawning has been documented in water depth up to 60 m (Templeman, 1948). Fish which are unable to spawn inshore may move back out with spent schools and wait for the deeper waters to warm prior to spawning. Consequently, deep water spawning would be expected to occur later in the season. Evidence of repeat spawning by this species was found in samples taken from Alitak Bay (Kodiak Island) in August, 1976.

Jangaard discusses the fact that capelin "school" by sex immediately prior to spawning, with males schooling much closer to the spawning beaches than females. When females leave their school and swim toward the beach, males accompany them (often one to each side) and ride the crest of the waves to the beach where spawning occurs. He also mentions that sex ratios of capelin are often biased by location of catch as well as by means of capture; i.e. more females would be expected in samples seined offshore than from surf samples taken with cast nets. The fact that spawn was observed present in a large percentage of capelin collected on the beach in 1976 suggests that many of these fish had not completed spawning prior to their demise. Schools of male capelin could possibly approach close enough to the surf to become caught by oncoming waves and be unable to return to the sea. This, in view of the facts that males school closer to the beaches than do females and that spawning was frequently observed on falling tides, may explain the biased sex ratios in samples obtained.

Capelin are well known as a highly marketable species and it is felt that capelin stocks in the southern Bering Sea definitely have the potential for becoming a commercially valuable fishery resource; this potential, however, has not yet been realized. In view of the large number of capelin windrows observed on the beaches and limited amount of flying time possible, aerial survey results of 1976 are considered a low estimate of the total number of capelin schools observed during spawning.

Very large fisheries exist for capelin in the Atlantic Ocean and Barents Sea: 1.6 million metric tons of capelin were harvested in the Barents Sea by the Norwegian fishing fleet along with 37,000 metric tons by the Soviets (Jangaard, 1974). Although this study is not attempting to conclude that the southern Bering Sea resource is comparable with that of the Barents Sea, it does indicate that Bering Sea capelin stocks appear in sufficient abundance to be of potential commercial value.

Eulachon

Eulachon are known to be a major component of the forage fish population of the southern Bering Sea even though very few were captured at onshore sites during 1976. A phenomenal run of eulachon has already been cited and extensive anecdotal accounts have been collected from the local residents confirming annual runs of eulachon up the Sandy and Bear rivers. Bartlett (Personal Communication) indicates that eulachon are also captured during high seas trawling in the Bering Sea and Bristol Bay region.

Runs of eulachon are thought to begin in the north Alaska Peninsula in July (Davenport, Personal Communication, and Chrostowski, 1957), and this supposition is further confirmed by local residents. It is felt that catches of eulachon would have been larger if 1976 summer fishing activity had continued until mid to late July.

Little can be said regarding the biology of this andromous species except that they were in ready spawning condition in early July. Scales cannot be used for aging purposes during spawning since their outside edges are degenerating at this time (Smith, 1955).

Sand Lance

One sand lance was captured during the 1976 test fishing efforts and others noted in stomachs of boreal smelts and sculpins. Consequently, nominal level presence can only be assumed. Anecdotal evidence indicated large quantities of this species in the Bristol Bay/Bering Sea region.

General Interpretations and Comparisons

Habitat type was noted during all aerial surveys. Data collected from ground crews together with general life history characteristics concerning Pacific herring strongly indicated that forage fish observed in areas with sheltered rocky habitat were primarily herring. Most schools seen along open exposed beaches composed of loose sand and/or gravel were believed to be capelin. This was strengthened by the fact that several days after extensive windrows of capelin were observed on open beaches all fish schools in these habitat types had disappeared. Termination of capelin spawning activity coincided with the disappearance of open beach fish schools seen on aerial surveys.

Results of studies conducted on the north coast of the Alaska Peninsula in 1976, indicate the presence of significant spawning populations of forage fish. The two most abundant species as determined from aerial surveys were capelin and herring, respectively (Figure 30). These were followed by boreal smelt, eulachon, and sand lance. Pacific herring were not thought by American fisheries scientists to be heavy utilizers of this portion of the study area, although the opposite was concluded by Soviet researchers. Prior to the spring of 1976 it was believed that the only significant run of herring on the north Alaska Peninsula occurred at Herendeen Bay. One of the most significant results of this study has been to demonstrate that the north coast of the Alaska Peninsula contains three to five major herring spawning locations. Considerable potential exists for expansion of these stocks into areas not presently utilized, but possibly utilized two or three decades ago.

Boreal smelt of the southern Bering Sea are a wide ranging group, capelin are strictly marine, whereas eulachon are wholly anadromous. Boreal smelt are partially anadromous; more correctly, they are fresh water residents which visit the estuarian systems in circumpolar regions for two to four months a year and spend the majority of their lives in major river systems. Their ecological importance as forage fish in the marine system throughout the study area is uncertain, but it appears their abundance is high.

Capelin, herring and sand lance are subject to potential impact from marine pollution throughout their entire life, while the anadromous eulachon are subject to this potential throughout nearly their entire lives, ascending into fresh water for only a brief period to spawn. Boreal smelt, on the other hand, are in the marine environment only intermittently for three to four months each year, the remainder of their life history being in fresh water.

Oil exploration activity is under way in this portion of the study area. Test drilling has begun in the Herendeen Bay area, and one of the largest semisubersible oil rigs in the world is presently test drilling in the southern Bering Sea 90 miles northeast of Unimak Pass. Leasing is imminent.

It has been demonstrated by Kunhold (1969) that water extracts of different crude oils were highly toxic to herring eggs when indubated under a film of 10^3ppm and 2.10^4ppm. The mean survival time of herring eggs under these conditions was 2.5 to 3.5 days, and survival time for newly hatched herring larvae was nearly identical. This work further demonstrated that eggs are more resistant to crude oil than are larvae which become increasingly less resistant as the yolk sack reabsorbs.

Kunhold concluded further that different varieties of crude oil effect fish eggs differently. Crude oil from Venezuela was shown to be highly toxic and cause higher mortality than that from Iran, whereas crude oil from Libya seemed to be nearly non-toxic. The effect of crude oil upon fish eggs was more severe than pure mortality figures indicate. Many larvae newly hatched from these affected eggs had deformed bodies of abnormal flexures of the tail and were unable to move normally through the water; most died within one day of hatching.

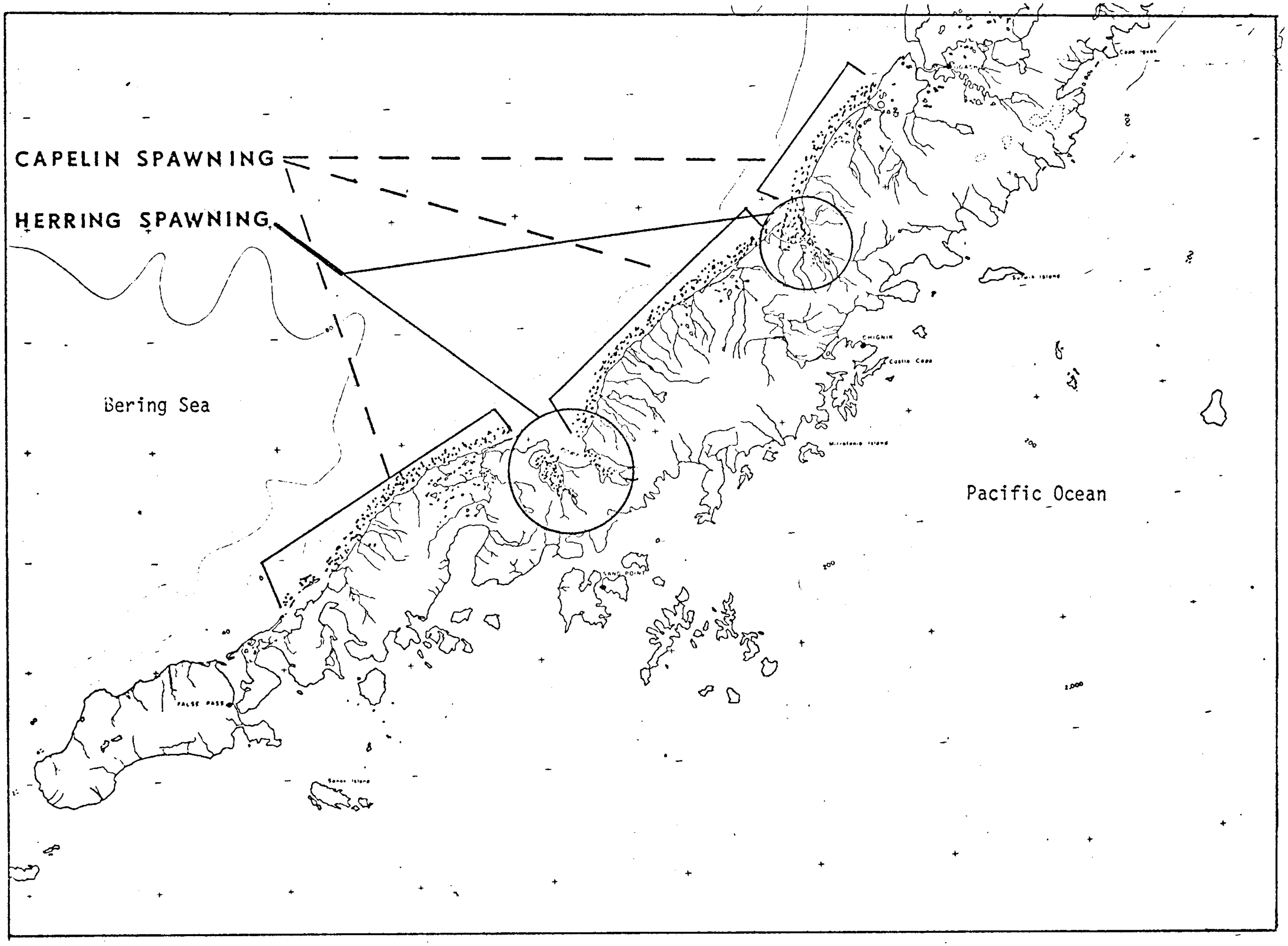

Figure 30. Primary forage fish spawning areas on the north Alaska Peninsula between Cape Sarichef and Smokey Point as determined by aerial surveillance and on-site test fishing, April - October 1976.

PART III

Project Conclusions and needs for further study

CONCLUSIONS

Subsistence fishing by coastal residents south of the Yukon River Delta is one of the most important elements in their culture and diet. The herring component of the subsistence fishery in the study area is greatest between the Yukon River Delta and Cape Newenham. Eleven villages between the Yukon-Kuskokwim River deltas alone reported a total subsistence herring catch of 82.2 m.t. in 1976. Indications are that this reported harvest was less than in 1975.

Herring are also utilized for subsistence in the Togiak district of Bristol Bay but their importance and extent of use is not believed to be as great as in the area between the Yukon River Delta and Cape Newenham. Much of the subsistence need from fishery resources in this area is supplemented by various species of Pacific salmon. Unlike the area north of Cape Newenham, most of the effort in the Togiak district for herring is directed towards commercial fishing.

Baxter (1975) reported the subsistence utilization of capelin in the Togiak area as minor, with limited numbers taken by dip net along the north side of Togiak Bay. He further stated that one commercial operator indicated capelin might be worth two to three cents per pound if he could be assured of at least one million pounds per year. Results from aerial surveys suggest that capelin may be a commercially exploitable resource in this area. Such a potential is also believed to exist along portions of the north coast of the Alaska Peninsula for both capelin and herring; presently they are utilized to a limited degree for subsistence purposes only. Boreal smelt are apparently the most important subsistence fishery item in this latter area.

Timing of herring spawning in the coastal waters of western Alaska appears to be greatly influenced by climatological conditions. Generally, most populations appear immediately after ice breakup in late May and early June. Spawning and migration of herring populations appear to occur in a northward direction along the coastline with both prespawning and postspawning populations present throughout early spring and summer. Oil related activities including exploratory work or other development could be a potential hazard to herring and capelin populations during the following time periods: May through June in the Togiak district of Bristol Bay and northern coast of the Alaska Peninsula; and June through early August between the Yukon-Kuskokwim River deltas.

Relatively few areas were identified in 1975 and 1976 from OCS investigations as primary herring spawning habitat. Although these data are probably incomplete, it appears that a relatively small portion of the western Alaska coastline in the study area is utilized for spawning by herring. The lack of information on juvenile herring distribution and timing immediately after hatching makes a statement on vulnerability difficult. However, oil related activity scheduled during the late spring and early summer months in or near major herring and capelin spawning areas, should be subject to careful scrutiny.

Most major herring spawning areas are in locations where the shoreline is comprised of cliffs or bluffs with large rock outcroppings and strong prevailing winds. Herring eggs were primarily deposited on Fucus. It is felt that such areas are not conducive to efficient oil containment and clean-up in the event of spills and in many instances may preclude such measures. Such a situation could lead to extremely high mortality of herring spawn since most occurs intertidally throughout the study area, and thus is highly subject to surface-borne contaminants. It is also reasonable to assume that such spills could have similar affects upon other species of forage fish common throughout portions of the study area. Capelin spawning was generally confined to exposed, fine sand and gravel beaches, a coastal environment type which Hayes (1976) classifies as highly susceptible to long-term oil spill damage due to oil penetration into the substrate.

It has been shown that the domestic use of herring (subsistence and commercial) may exceed 300 m.t. in some years, especially when the market price for sac roe is good and weather conditions favorable for commercial harvest. An additional harvest of about 150 m.t. of roe on kelp may also be experienced in some years. The importance of the herring resource to western Alaska is evident.

It is assumed that the foreign fishery on herring in the Bering Sea utilize herring stocks originating from the study area. Dudnik and Usol'tsev (1961) found during a three-year study, 1959 to 1961, that a major wintering area of herring occurred northwest of the Pribilof Islands and the southern margin of the icefields. They stated that at the end of the wintering period,

> "the area occupied by herring increased somewhat near the time of departure from the wintering grounds and migrations were in two directions: northeast and Southeast . . . . This new fishing area of the east Bering Sea stock of herring is of major commerical importance."

Later studies by Rumyantsev and Darda (1970) noted that large concentrations of herring winter near Nunivak Island, Unimak Island, St. Matthew Island and the Pribilofs, then move toward the Alaska coast and into bays during summer.

Soviet and Japanese vessels have harvested in excess of 45,000 m.t. of herring annually in the Bering Sea since 1970. A substantial decline in herring abundance in the Bering Sea is suggested from:

1. A downward trend in total catch from the peak year of 1968-69 through 1974-75.

2. A general downward trend in CPUE of small Japanese trawlers.

3. A sharp decline in CPUE of large Japanese trawlers (Mason 1976, not seen by author).

Fredin (1974) also mentions several signs of deterioration of the eastern Bering Sea herring stocks. Obviously, any deleterious effects of oil exploration and development could have a devastating impact upon these apparently already deteriorated stocks. The integrity of Alaska's coastline will directly determine the future abundance of this important resource to both its foreign and domestic users.

NEEDS FOR FURTHER STUDY

More studies are needed to accurately document all primary spawning areas for herring and other forage fish populations. This task could not be completely accomplished in the reduced time frame of R.U. 19 due to inclement weather conditions common to western Alaska, apparent annual fluctuation in herring abundance and timing of spawning activities. Large area, synoptic surveys are still warranted, but continuing programs in specific areas of importance are also needed. Age structures should be monitored prior to any oil activities, in order to properly assess potential changes in herring population structures after oil development. Herring egg and larval development, distribution and migration need to be studied and documented as well as the extent of any offshore spawning. Reid (undated) points out that environmental conditions during the early life stages of herring account for much of the fluctuation in population abundance. The affects of oil contaminants on primary herring spawning substrates, e.g., *Fucus* and *Zosteria* species, should be assessed. Continued monitoring of herring subsistence utilization in selected villages, together with limited biological sampling will provide an accurate assessment of herring abundance and utilization along major sections of the western Alaska coastline.

Kuhnold (1969) demonstrated that different crude oils affect fish eggs differently. Thus, the need for Bering Sea crude oil toxicity tests is evident. Present knowledge indicates that even slight spills of crude oil at the right time and place could possibly have devastating affects upon herring larvae and eggs.

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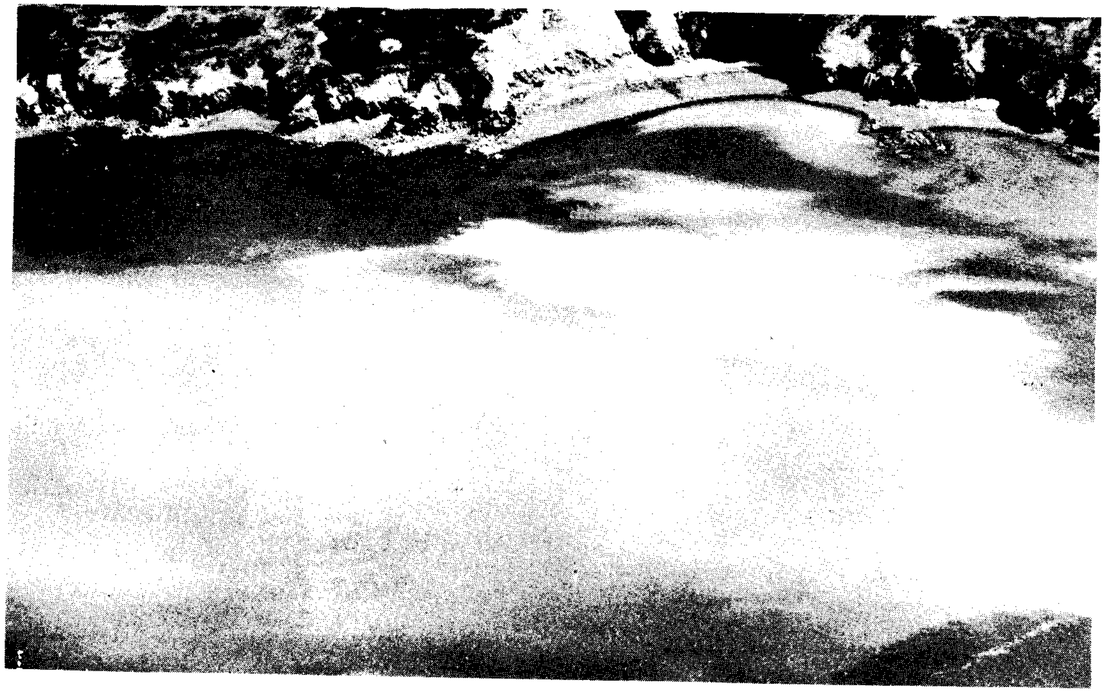
APPENDIX A

Photographs

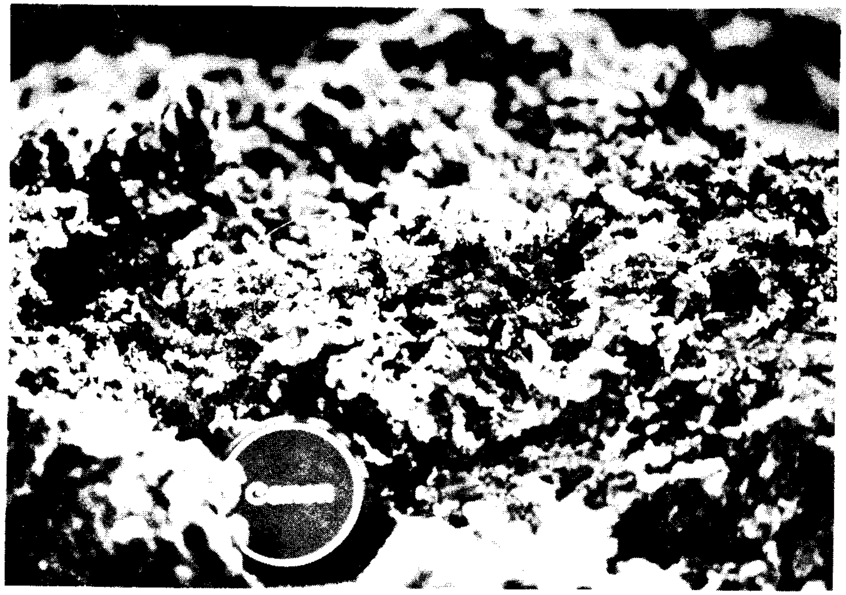


Photograph 1. Intertidally spawning herring observed on May 29, 1976 in Metervik Bay. A characteristic white to yellow-white color is produced from milt released by males. Surface area was estimated in excess of 7,800 m^2. Note OCS ground crew in lower right foreground.

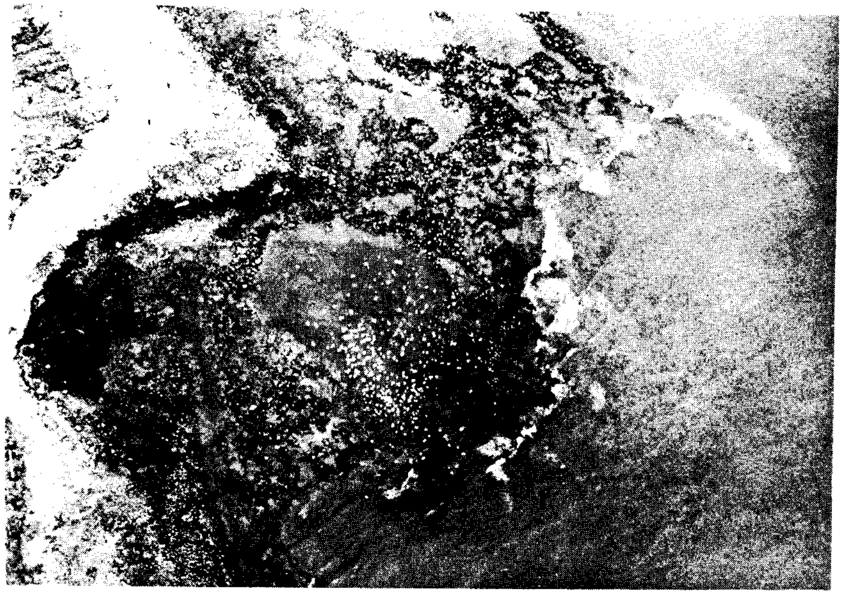
Photograph 2. Spawning herring observed June 12, 1976, two miles east of Estus Point on the mainland in Hagemeister Strait. The shoreline is typical of most areas where herring were observed spawning throughout the study area; cliffs or bluffs with large jagged rock, outcroppings and little or no beaches.

Photograph 3. Herring schools observed on June 12, 1976, about 15 miles west of Right Hand Point, Togiak district. Surface area estimated in excess of 1,200 m^2. Gulls were frequently seen with migrating fish schools.

Photograph 4. Herring concentrations observed adjacent to Toksook village on June 28, 1976, in Kangirlvar Bay. An estimated surface area in excess of 5,900 m^2 was observed. Note subsistence gillnetting effort. Villagers at Toksook caught 85,675 pounds of herring for subsistence purposes in 1976.



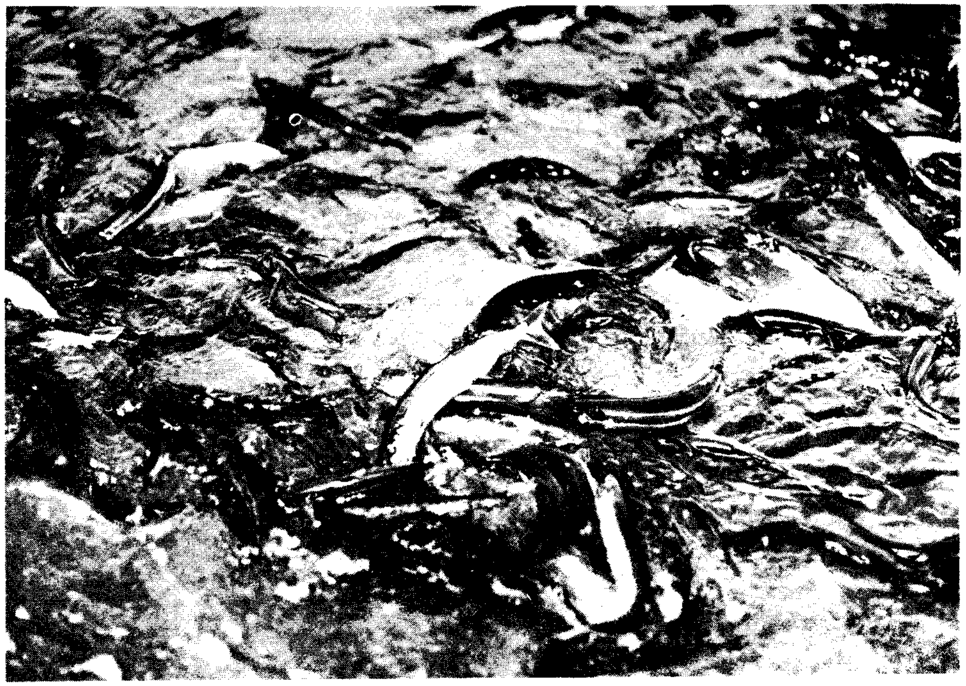
Photograph 5. Herring spawn on the rockweed Kelp (*Fucus* sp.) near Chinit Point, Nelson Island, 1976. *Fucus* was documented as the primary spawning substrate for herring throughout most parts of the study area.



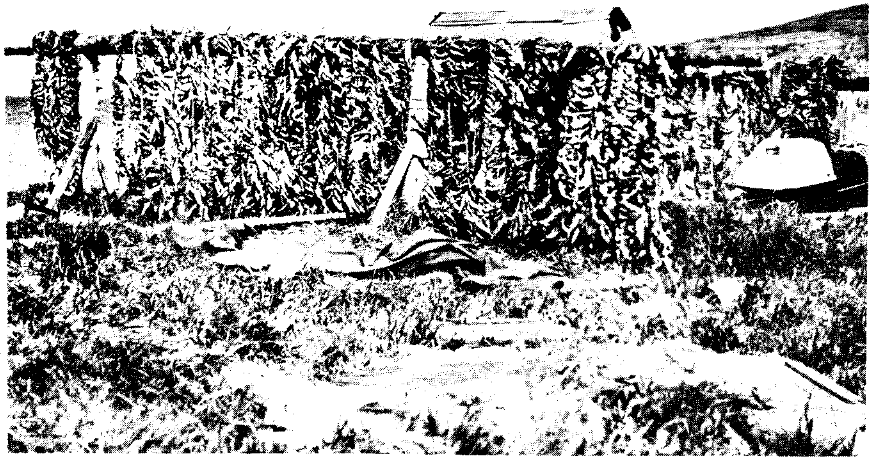
Photograph 7. Spawn on *Fucus* exposed at low tide near Cape Manning, Nunivak Island, July 7, 1976. Note heavy bird predation.

Photograph 6. Herring spawn on eelgrass (*Zosteria* sp.). A second major herring spawning substrate common along sections of the western Alaska Coastline.

Photograph 8. OCS herring ground crew hand sampling spawning capelin at Nilikuguk Point, Nelson Island, June 24, 1976. Note capelin carcasses on beach. This is typical of capelin spawning habitats throughout the study area; clean, small gravel beaches.



Photograph 9. Spawning capelin at Nilikuguk Point, Nelson Island, June 24, 1976. No white water color characteristic of herring spawn was observed. Note enlarged anal fin of spawning males.



Photograph 10. Strings of herring being sun-dried for subsistence use at Tanunak, 1976. Herring are woven into grass strings. Strings are about 5 feet long and contain about 75 herring each. Herring were a major subsistence item for local residents throughout the study area.

Photo 11. Cessna 206. Plane used on 12 of 15 aerial surveys. Areas 1–5, 1976.

Photo 12. Catch of herring in gill net; Herendeen Bay, 1976.

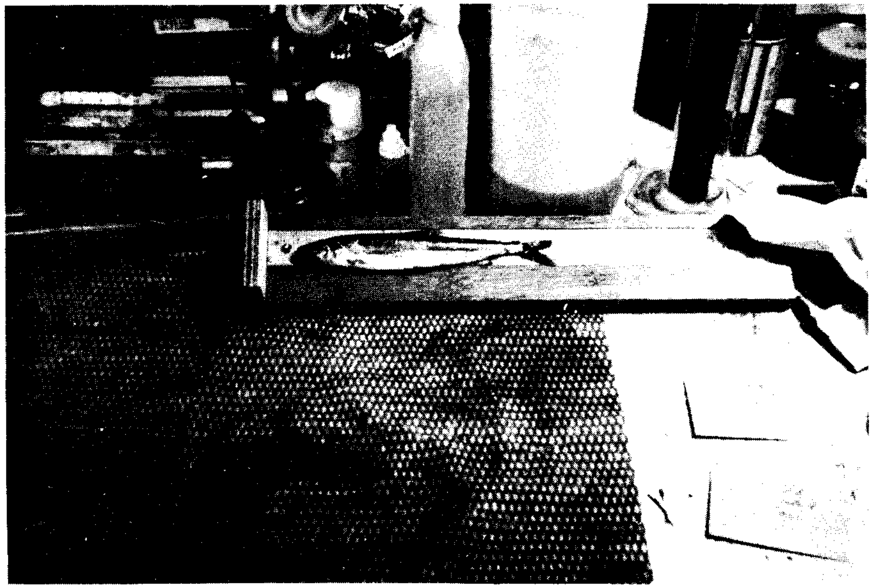


Photo 13. Boreal Smelt on standard measuring board; Port Heiden, 1976.

Photo 14. Largest herring of season on measuring board; Herendeen Bay, 1976

Photo 15. Mobile field crew processing catch; Herendeen Bay, 1976.

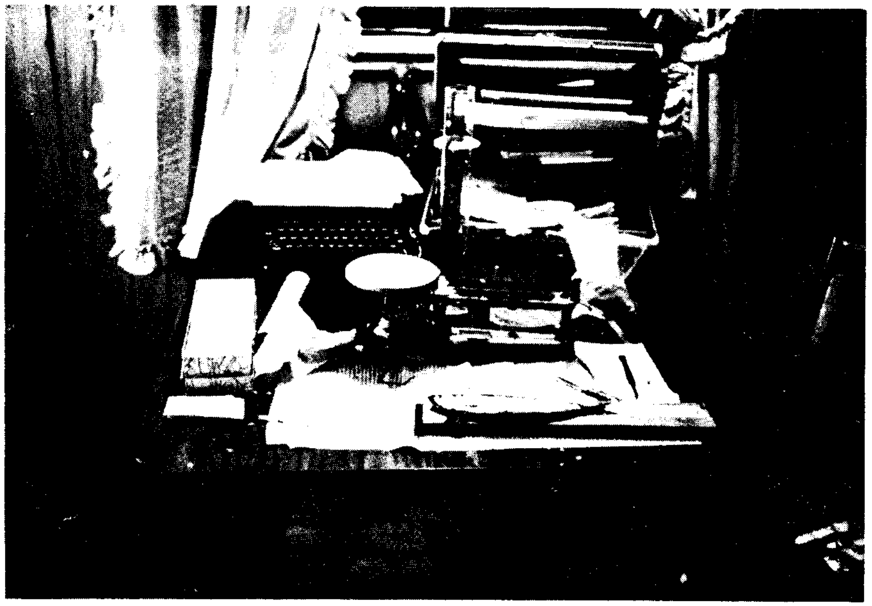


Photo 16. Meshik facility where most Port Heiden samples were processed. 1976.

Photo 17. Offshore specimens being processed at Kodiak base laboratory, 1976.

Photo 18. A regenerated herring scale; not suitable for aging.

Photo 19. 4-year-old herring scale.

Photo 20. 8-year-old herring scale.

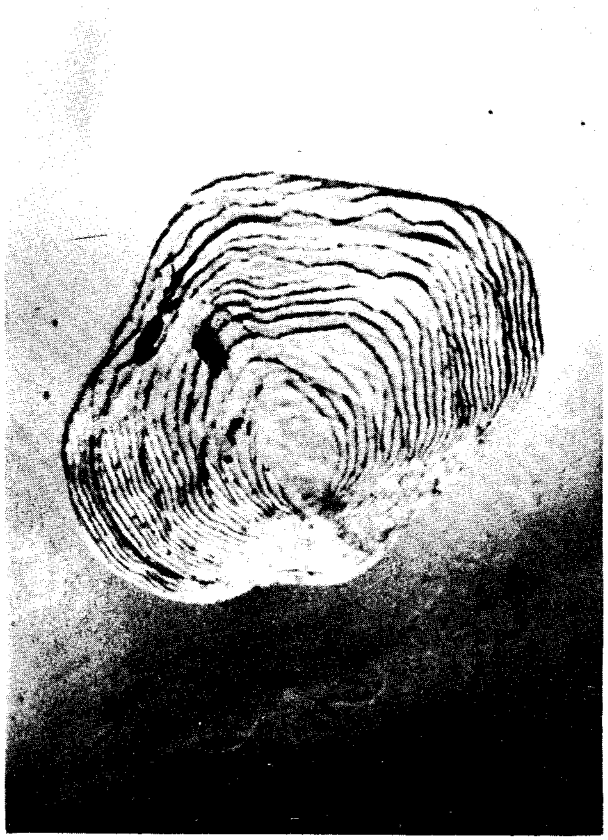


Photo 21. 5-year-old boreal smelt scale.

Photo 22. 7-year-old boreal smelt scale.

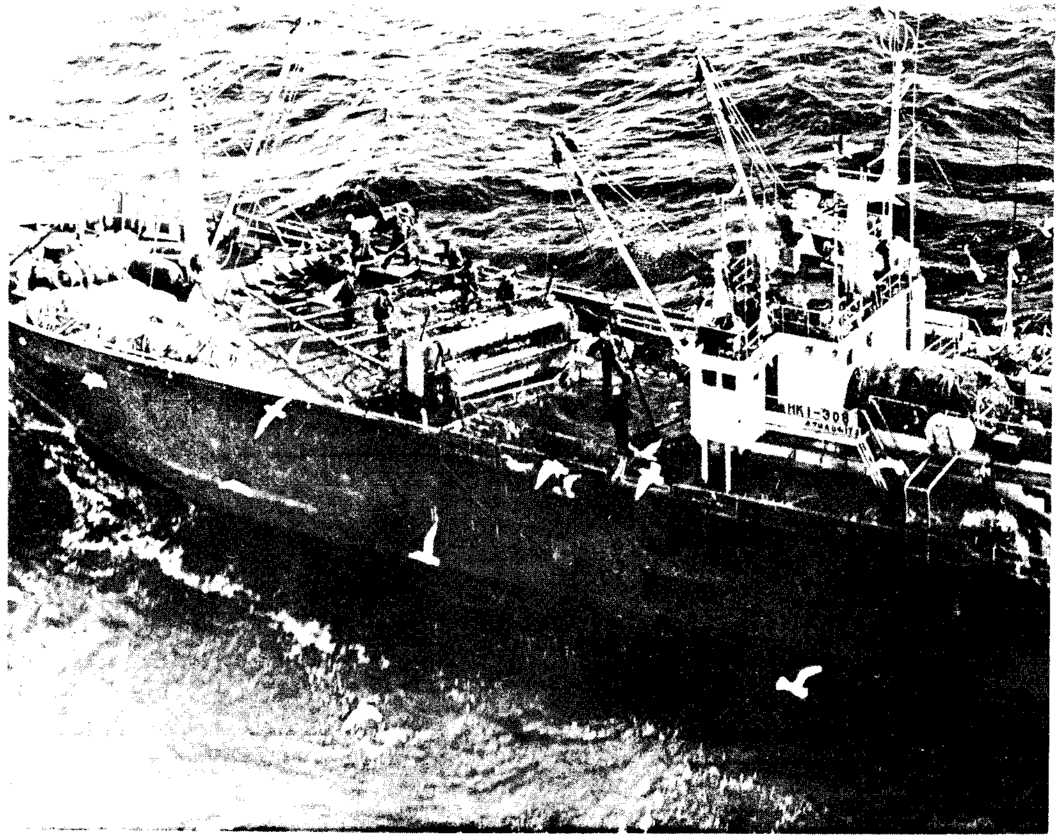


Photo 23. Japanese high seas fishermen cleaning nets of herring, Bering Sea, 1976. (Photo courtesy of N.M.F.S.)

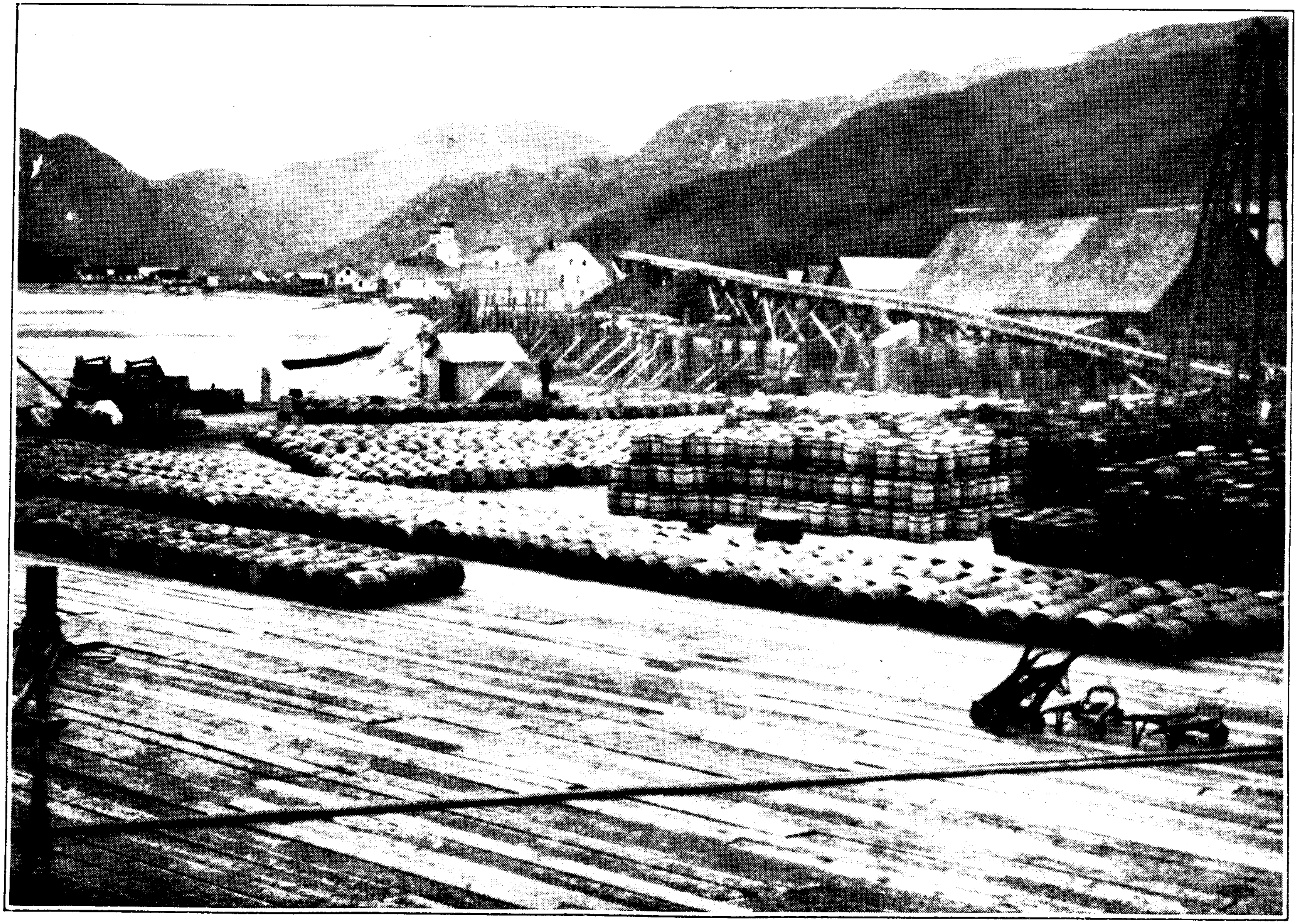


Photo 24. —The dock at Unalaska during the height of the herring run in August, 1928, showing the piles of empty barrels and the rows of packed barrels ready for shipment

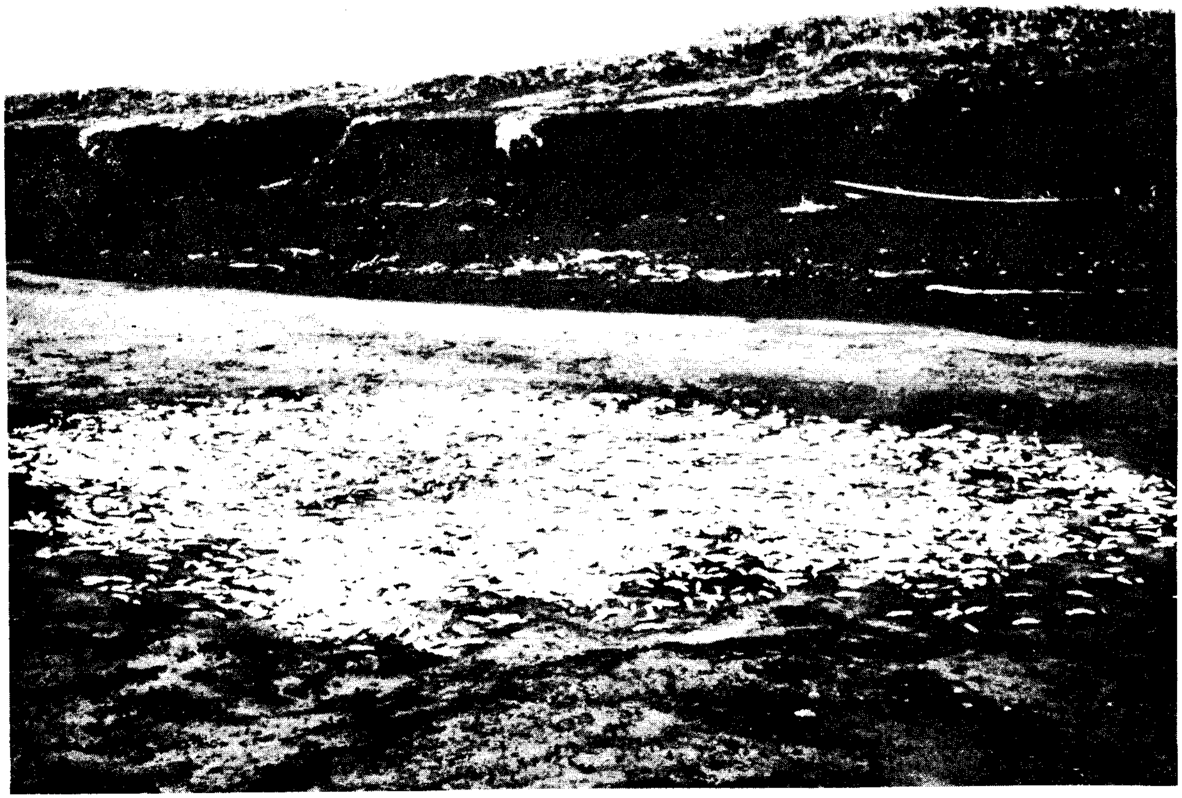


Photo 25. Capelin washed up on beach; Port Moller, 1976.

Photo 26. Capelin on beach; Port Moller, 1976.

APPENDIX B

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ANNUAL REPORT

Research Unit 19E
March 1976 - Sept 1976

Alaska Marine Environmental Assessment Project

FINFISH RESOURCE SURVEYS IN NORTON SOUND AND KOTZEBUE SOUND

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INTRODUCTION

This report describes studies conducted under Research Unit (R.U.) 19E, FINFISH RESOURCE SURVEYS IN NORTON SOUND AND KOTZEBUE SOUND, for Fiscal Year (FY) 1976. The program is one of the State of Alaska contracted Outer Continental Shelf (OCS) projects. Federal funds were made available through the Bureau of Land Management (BLM) and administered by the National Oceanic Atmospheric Administration (NOAA). This Research Unit was initially funded in March, 1976 for $146,825 as an extension to R.U. 19, HERRING SPAWNING SURVEYS - SOUTHERN BERING SEA. Additional funding for FY 77 (October 1, 1976 through September 30, 1977) amounted to $250,825, of which $100,000 is designated for large vessel sampling in offshore waters in Norton Sound and Kotzebue Sound. This paper does not describe work conducted since October 1, 1976.

The stimulus for these investigations is provided by proposed offshore leasing of the Continental Shelf for oil exploration and development, in conjunction with the lack of knowledge concerning the range, distribution, seasonal occurrence, relative abundance and life history characteristics of important fishery resources occurring throughout the study area. These data are necessary to provide information for predicting and mitigating impacts of potential oil and gas exploration and development on coastal fishery resources within the study area.

Specific objectives include the following:

1. Determine the spatial and temporal distribution, species composition and relative abundance of pelagic finfish in the coastal waters of Norton Sound and Kotzebue Sound east of 166° W Longitude.

2. Determine the timing and routes of juvenile salmon migrations as well as examine age and growth, relative maturity and food habits of important species in Norton Sound and Kotzebue Sound east of 166° Longitude.

3. Determine the spatial and temporal distribution and relative abundance of spawning populations of herring and other forage fish within the study area.

4. Monitor egg density, distribution and development and document types of spawning substrates of herring and other forage fish species.

5. Monitor local resident subsistence utilization of the herring fishery resource.

To accomplish the task outline above, three studies were conducted in FY76 under R.U.19E: 1) Subsistence fishery utilization survey of coastal residents, 2) Spawning herring surveys, and 3) Pelagic finfish surveys.

ACKNOWLEDGEMENTS

Following is a list of temporary employees and their respective duties during the 1976 field season:

Don Seagren, crew leader for gillnetting studies conducted during Leg II of the *Miller Freeman* cruise.

Catherine Tate, coastal subsistence surveys from Stebbins to Point Hope.

Dan Schneiderhan, coordination and logistical support for inshore test fishing operations.

Pete Mikolaitis, crew leader Golovin Bay inshore test fishing.

Jay Field, crew member Golovin Bay test fishing.

John Edmundson, crew leader Unalakleet inshore test fishing.

Donna Manders, crew member Unalakleet test fishing.

Jerry Ruehle, crew leader St. Michael inshore test fishing.

Tom LeMon, crew member St. Michael test fishing.

Don Acker, crew leader Flat Island test fishing.

Pat Reinhard, crew member Flat Island test fishing.

Alaska Department of Fish and Game staff biologists provided excellent assistance in flying coastal herring surveys. A special thanks is in order for the National Marine Fisheries Service (NMFS) for their cooperation in permitting gillnetting studies to be conducted aboard the NOAA ship *Miller Freeman*, and to Mr. Rae Baxter (ADF&G) for conducting the gillnetting activities during Leg I.

Much logistical support and program coordination was provided by the OCSEAP Juneau Project Office.

Thanks is also due to the coastal natives for their cooperation and assistance provided during the subsistence surveys.

CURRENT STATE OF KNOWLEDGE

Pacific herring (*Clupea harengus pallasi*) and other fishery resources in the study area are known to play an important role in subsistence utilization by coastal residents, but the magnitude and importance of this harvest has not been documented. Zagoskin (1967) mentioned the importance of herring subsistence utilization by resident natives as early as the mid-1800's. The first actual biological studies on Bering Sea herring was conducted by Rounsefell (1929). Mention is made several times in his report of herring vertebrae counts taken at Unalaska and Golovin Bay (Norton Sound). Documentation of several life history parameters of herring are included in his report as well as the condition of the fishery in Alaska.

The herring fishery in the early portion of the 20th Century centered around salt curing and later declined because of poor marketing conditions arising from foreign competition. Rounsefell indicated that the earliest American commercial effort on Bering Sea herring took place in the early part of this century at Golovin Bay, "...since before 1909". Volumes of the Pacific Fisherman (1917-1942) indicate that in excess of 3.2 million pounds of fall herring were commercially processed in Norton Sound from 1916 to 1941, of which 98.6 percent was from Golovin (Table 1). This figure is based upon 125 pounds of herring packed per barrel. Brown (1974) indicated that this was the most common pack although barrel capacity was greater. Wigutoff (1950) reported that each barrel pack in Golovin contained a net weight of 250 pounds of herring. This would result in a total production of about 6.1 million pounds and consequently, the former figure is considered by this writer to be a minimal estimate. Actual production was probably about five to six million pounds.

Rounsefell (1929) also pointed out that the first extensive commercial fishery existed in western Alaska in 1928 when about one-half of the central Alaska purse seine fleet fished at Unalaska in the Aleutian Islands. This fishery ended in 1946. Commercial effort on herring in the north Bering Sea (Norton Sound) resumed on an experimental basis in 1964 at Unalakleet and has continued on a sporatic basis ever since. This fisheries is on spring herring for sac roe extraction in contrast to the earlier fall fisheries for a salt cured product.

Barton (1977) indicates that herring may be a commercially exploitable resource of potential benefit to coastal residents of western Alaska as well as a potential major international food source. Japanese and Soviet fleets have harvested some 45,000 metric tons (m.t.) of herring annually in the eastern Bering Sea since 1970 (Preliminary Fishery Management Plan, 1977). This harvest has come from three fisheries: a Japanese trawl fishery, a Soviet trawl fishery, and a Japanese gillnet fishery. Although the bulk of this harvest has come from the two trawl fisheries which operate along and inside the 200-meter line between the Pribilof Islands and St. Matthew Island during the winter-spring months, the Japanese gillnet fishery has operated in the past, off the Bering Sea coast of Alaska from Bristol Bay to Norton Sound during the spring months, usually April into June. Dudnik and Usol'tsev (1972) believe the trawl harvests are on stocks which reproduce along the coast from Unimak Pass to Norton Sound.

Herring are known to spawn in intertidal and shallow subtidal zones in the study area, often on exposed beaches. Developing eggs and larvae are therefore highly susceptible to surface-borne pollution. Herring and their spawn constitute one of the fundamental sources of food for many species of fish mammals and birds.

The greatest information available on the fishery resources in the northern Bering Sea and Kotzebue Sound is contained in records kept by the Alaska Department of Fish and Game (ADF&G). The bulk of this data deals with the five species of Pacific salmon indigenous to the study area, of which chum salmon are the most abundant. Most information concerns timing and magnitude, age, size and sex relationships and spawning distribution of adult returns. Virtually nothing is known in

Table 1. Northern Bering Sea fall herring production, 1916 - 1941.

Year	Location	Number of Processors	Scotch Cured Barrels	Scotch Cured Half Barrels	Hard Salted Barrels	Remarks
1916	Golovin	4	559*			*Norwegian pack as opposed to Scotch style.
	Teller	1	9*			
1917 1/	Golovin	5	1,275*			1/ Introduction of Scotch method of curing by U.S. Bureau of Fisheries.
	Teller	1	300*			
1918	Golovin	11	5,169* 2/			
	Council	1	167*			
1919	Golovin	6	2,555* 3/			2/ Includes 500 bbls. of Scotch style.
1920	Golovin	4	331			
1921	Golovin	1	562			3/ Includes 900 bbls. of Scotch style.
	St. Michael	1	60			
1922	Golovin	2	500			
1923	Golovin	1	352			
1924	Golovin	1	750			
1925	Golovin	1	200			
1926	Golovin	1	620			
1927	Golovin	1	490	100		
1928	Golovin	1	850 4/	370		4/ Includes 435 bbls. of bloater stock.
1929	Golovin	1	200* 5/	887*		
1930	Golovin	3	1,637 6/	1,614		5/ Plus an additional 432 half tierces of bloater stock.
1931	Golovin	2	219 7/	180		
1932	Golovin	3	3,533 8/	905		6/ Includes 26 tierces and 500 half tierces; plus an additional 62 tierces of roused herring.
1933	Golovin	2	8 9/	75		
1934	Golovin	1		42	100	
1935	Golovin	1		57	96	7/ Plus an additional 238 half tiercse of bloated stock.
1936	No commercial operations reported					
1937						8/ Plus an additional 31 tons of bloater stock.
1938	Golovin	1		35	62	
1939	Golovin	1		27	30	9/ Plus an additional 25 tons of bloater stock.
1940	Golovin	1	16	22	85	
1941	Golovin	1			30	

Summary: 10/

1,159,688 lbs.	Norwegian cured (35.2%)
1,600,813 lbs.	Scotch cured (48.6%)
434,375 lbs.	Bloater stock (13.2%)
50,375 lbs.	Hard salted (1.5%)
49,600 lbs.	Roused herring (1.5%)
3,294,851 lbs.	All products (1916-1941)

10/ One full barrel equals 125 pounds net (R.J. Browning, Fisheries of the North Pacific, 1974). One tierce equals 800 pounds (Pacific Fishermen 1931). A total of 98.6% of the total production from 1916-1941 was processed in Golovin. Based upon 250 lbs. of herring per barrel, increases the total production to 6,160,100 lbs.

regards to the relative abundance, distribution, migrational patterns and rearing habitats of juvenile salmon after taking up residence in the marine environment in the early spring months. The commercial salmon fishery occurring in Norton Sound and Kotzebue Sound provides local residents with a major source of employment.

Other species common to the fresh water and coastal marine habitats in the study area are: sheefish (Inconnu), several species of whitefish, Arctic char, lake trout, grayling, burbot, suckers, sculpins, blackfish, sticklebacks, lampreys, smelt and several species of cods, flat fishes, crabs, shrimps and molluscs (Cunningham, 1975). Fifty-two fish species were captured and identified in August 1959 in the Chukchi Sea/Kotzebue Sound area under bioenvironmental investigations of Project Chariot (Wilimosky, 1966). Most of the forms were benthic or demersal with the pelagic element limited to about eight species. Nine fresh water species were identified. Among the catches, an estimated 1,000 herring were captured in a gillnet set made at Cape Thompson. It was stated that small catches of smelt (Osmeridae) were often experienced in midwater sets below the thermocline.

Field sampling with variable mesh gillnets by Alt (1971) in the Pt. Clarence, Grantley Harbor and Imuruk Basin area in July, 1970, resulted in 23 species of fish, of which, nine were marine form. Herring were captured in Imuruk Basin and the lower Agiapuk River. Six nights of gillnet fishing in the Agiapuk River in 1971 resulted in nine species, of which least cisco was the most abundant (Alt, 1972). Herring were again included in the catch.

Alt (1971, 1972) also discussed spawning populations and domestic use of sheefish on the Koyuk River, Kobuk River and Selawik Lake - Hotham Inlet area. Herring, ranging in size from 115-160mm in total length, were reported as comprising the major food item (the only identifiable species) in sheefish captured in Hotham Inlet in late November, 1963 (ADF&G Files).

These foregoing studies comprise the investigator's knowledge of pelagic finfish research in the north Bering Sea and Kotzebue Sound area, with the exception of cruise reports by various American and foreign agencies, which list simple occurrence.

STUDY AREA

The study area includes all coastal waters of western Alaska extending North from the Yukon River Delta to Point Hope (Figure 1). The coastline of this area totals 2,496 kilometers (km) (1,551 miles). Subsistence utilization surveys were conducted throughout the entire study area from the Yukon River Delta to Point Hope. Spawning herring investigations included the coastal waters from the Yukon River Delta to Eschscholtz Bay in Kotzebue Sound. The study area for nearshore test fishing of pelagic finfish consisted of the coastal waters from the Yukon River to Golovin Bay in Norton Sound, while offshore test fishing for pelagic species included both Norton Sound and Kotzebue Sound waters.

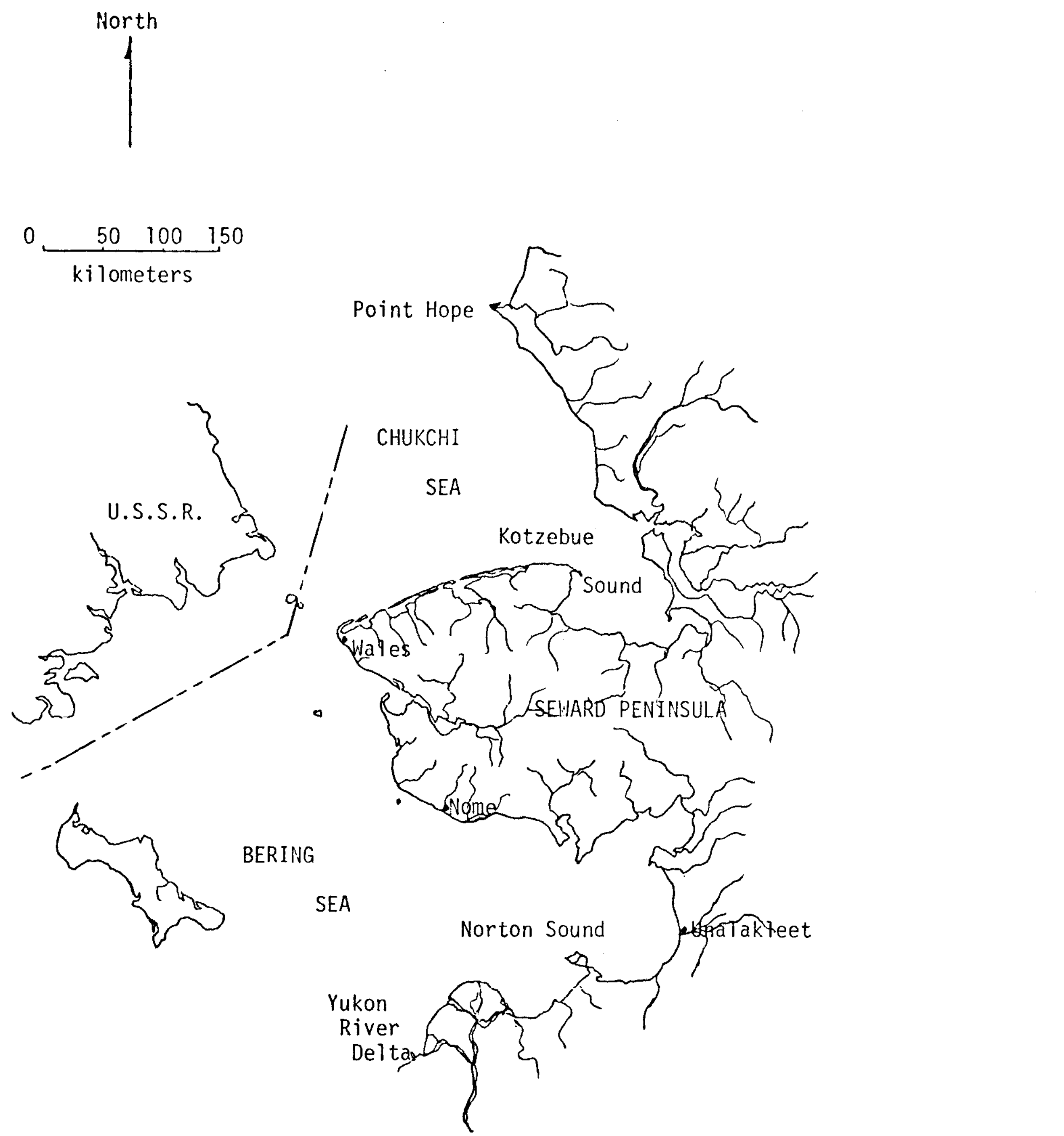

Figure 1 . Study area for Research Unit 19 E, Finfish Resource Surveys in Norton Sound and Kotzebue Sound, 2,496 kilometers, 1976.

SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Subsistence Utilization Surveys

A news release was broadcast over the local Nome radio station on May 24, 1976 to explain the purpose of the OCS research program and to solicit local cooperation in subsistence utilization studies. Listeners were informed that monthly catch calendar forms would be distributed to local village post offices for their use in reporting subsistence catches. They were also given instructions in reference to form completion and notified that Fish and Game personnel would be periodically collecting these forms and interviewing local residents throughout the coming summer.

Twelve coastal villages were included in the subsistence survey north of the Yukon River Delta to Point Hope. A temporary fishery technician frequented villages about every two weeks from July 5 through September 5 to interview local residents and document subsistence catches by species. Following is a list of information that was solicited:

1. Fishery resources by species utilized by village.

2. Amount, when possible, of key species utilized in weight or actual numbers.

3. Methods of fishing and resource utilization.

4. Spatial and temporal distribution and spawning information of various resources as possible.

Aerial Surveys

The entire coastline of the study area was divided into census areas delineated by prominent geographical features prior to field investigations (Appendix Table 1). These divisions were to facilitate trans-cribing aerial survey data onto a data management format with key-punching output to be later submitted to the National Oceanic Data Center (NODC) for archiving. At least two aerial reconnaissance surveys were to be attempted of the entire study area within the range of estimated spawning dates. Aerial surveillance of primary spawning areas was conducted as frequently as possible and initiated with the onset of ice breakup in Norton Sound. The purpose of the surveys was to monitor the location, timing and relative abundance of spawning populations of herring and other forage fish species.

Aerial surveys were conducted from chartered aircraft (single engine, fixed wing) at altitudes ranging from 75-500 m and air speeds of about 160-260 km/hr. Portable tape recorders were utilized to record aerial survey data and the information was transcribed daily onto aerial survey data management forms. Polaroid sunglasses were worn to reduce sun glare and enhance water depth visibility.

Following is a listing of data parameters recorded during each survey:

1. Observer, type aircraft, speed, altitude, and time.

2. Weather, sea conditions, and stage of tide.

3. Species identity and location of fish schools.

4. Number and surface area estimates of fish schools.

Limited aerial herring surveys throughout the study area were conducted by ADF&G personnel prior to OCS investigations. The relative abundance of herring during these surveys was estimated by subjectively categorizing fish schools into one of three arbitrary groups: 1) small schools which have an estimated surface area of less than 50 m^2, 2) medium schools with surface area estimates between 50-450 m^2, and 3) large schools estimated to be greater than 450 m^2 in surface area. These same groupings were utilized to classify the relative abundance of herring populations as conducted under Research Unit 19 in the southern Bering Sea (Barton, 1977).

Attempts were made to photograph as many schools of fish and spawn (milt) as possible with a hand held 35 mm camera using color slide film. The altitude, film and frame numbers were recorded on aerial forms for each individual photograph. The location of the photographed target was recorded on USGS topographical maps and a corresponding number entered by its location signifying the frame number of the photograph taken for later analysis. Surface area estimates were obtained by placing a calibrated grid over projected slides. Grid calibration was obtained from the camera focal length and altitude at which a particular photograph was taken. All fish schools and/or aggregations of schools as well as spawn observed during the 1976 OCS surveys in Norton Sound and Kotzebue Sound were grouped into one of the three above categories for comparative purposes. Schools which could not be photographed were subjectively categorized into these groupings at the time of the survey.

Pelagic Finfish Surveys

Pelagic fish sampling of onshore waters (0-3 fathoms) was restricted to Norton Sound only due to project funding levels in 1976. These surveys were based from four field camps: Unalakleet, Golovin, St. Michael, and Flat Island (south mouth of the Yukon River).

Unalakleet

A two man crew established a base camp in Unalakleet on June 17 from which to extend operations. Sampling terminated on September 1. Their sampling area extended south from Unaklakleet for a distance of about 30 km to Tolstoi Point and north from Unalakleet approximately 65 km to Cape Denbigh. The crew operated from a seven meter (22 ft.) open skiff and was equipped with a mobile camp and various types of fishing gear consisting of variable mesh gillnets, beach seines, dip nets, and cast nets. Both floating and sinking variable mesh gillnets of either monofilament or multifilament nylon were utilized. Gillnets varied in size from 47.6 meter (m) pannels (13 millimeter (mm), 19 mm, 25 mm, 32m m) to 57.6 m panels (13 mm, 25 mm, 38 mm, 51 mm, 64 mm). Depth of the gillnets varied from 2.4 to 3.0 meters. Two 61 m beach seines of 3.2 mm and 6.4 mm mesh were fished. One beach seine haul and two gillnet sets were made at each sample station when possible. An inshore set was made with a floating gillnet and an off-shore set was made when possible with a sinking gillnet. Permanent sampling stations were established after a reconnaissance of the study area early in the season.

Sampling with dip nets and cast nets was conducted randomly between established sampling stations. These fishing gear were utilized primarily for species composition on schools of fish observed in areas apart from established sample locations.

The time fishing gear was deployed and retrieved was monitored as well as depth of sample station, distance from shore, weather conditions, water temperatures, tidal stage, beach and biota type, and the presence of marine mammels or birds.

Golovin Bay

A base camp was established in Golovin on July 3 from which a two man crew conducted sampling operations until September 21. Sampling was conducted from a five meter (17 ft.) Boston Whaler and included the coastal waters inside Golovin Bay extending from Rocky Point to Cape Darby. The crew was equipped with a mobile camp and various fishing gear. Observations made at each station, sampling techniques and gear types held consistent with those of the Unalakleet crew.

St. Michael

A two man crew stationed at St. Michael was responsible for sampling coastal waters extending from Cape Stebbins to Tolstoi Point from June 17 to August 23. Only sinking and floating variable mesh gillnets were utilized as capture gear in this area because characteristics of the beaches hindered the use of beach seines.

Flat Island

A two man OCS crew was deployed to Flat Island (south mouth of the Yukon River) on June 9. The crew shared facilities with an ADF&G management crew that was conducting adult salmon studies. The OCS crew was equipped with variable mesh gillnets consisting of the same specifications as Unalakleet, Golovin Bay, and St. Michaels nets. Hand purse seines 30.5 m long by 3.0 m deep and 6.4 mm mesh size were utilized as opposed to beach seines. The primary study area included approximately 650 km^2 (250 mi^2) of the Yukon River Delta including Kwikluak Pass, Alakanuk Pass, and Kwiguk Pass (Figure 2).

Sampling by the Flat Island crew consisted of a reconnaissance type survey, since little was known of the distribution of pelagic finfish in the area. Few permanent sampling sites were located due to the extremely large area to be covered and the unlikely chance that replicate sets could be made. The first area covered was in the immediate vicinity of Flat Island and the Kwikluak Pass. The OCS camp was relocated to the village of Emmonak on July 17 where sampling Alakanuk Pass and Kwiguk Pass could be more readily accomplished. These areas were sampled from July 20 through August 5.

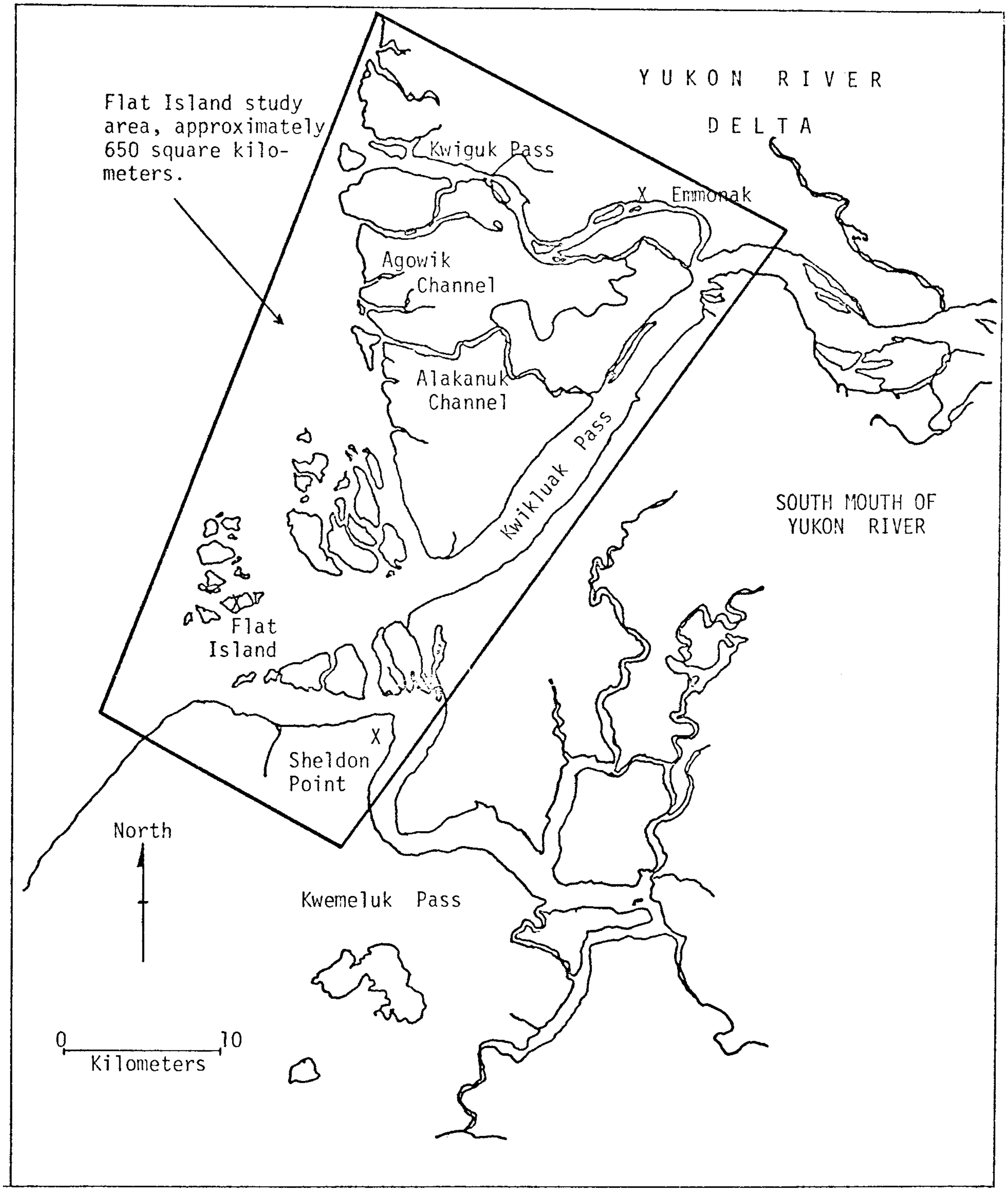

Figure 2. Flat Island (south mouth of the Yukon River) study area, 1976.

Sampling and Data Analysis

Biological sampling by all four pelagic fish crews held consistent and included the following being monitored:

1. The total catch of all finfish by species and gear type was recorded for each set.

2. Incidental catches of shellfish, molluscs, etc. was also recorded.

3. Lengths were taken on not more than 25 fish of each species captured per set by gear type and the type of length measurement recorded.

4. No length measurements were recorded on adult salmon, molluscs or shellfish.

5. No more than eight juvenile salmon of each species captured by seine nor more than four per panel size in gillnets were preserved for age and foregut analysis for each set.

6. Fifty to sixty herring were preserved for length, age, fecundity, and foregut analysis per set in the case of large catches.

The study area was divided into seven sections for ease in reporting pelagic fish survey results: Golovin Bay (area A), Cape Denbigh to Egavik (area B), Egavik to Tolstoi Point (area C), Tolstoi Point to Cape Stebbins (area D), Fish River (area E), Bluff to Pocky Point (area F), and Flat Island (area FI) (Figure 3). Areas A, B, C, D, and FI received the most intense sampling effort while areas E and F received limited sampling.

The field season was divided into six, two weeks sampling periods in which catch results were examined by species and gear type.

1. June 22 - July 6

2. July 7 - July 21

3. July 22 - August 6

4. August 7 - August 21

5. August 22 - September 6

6. September 7 - September 21

The biweekly sampling periods were established to facilitate examination of results obtained in areas A, B, C, and D. In these areas alone, permanent stations were selected and repeatedly fished. Since few stations were fished on a repeated basis at Flat Island, little can be said about temporal distribution of species occurring within that area itself. However, spatial comparisons between the Flat Island study area and other areas in Norton Sound can be made.

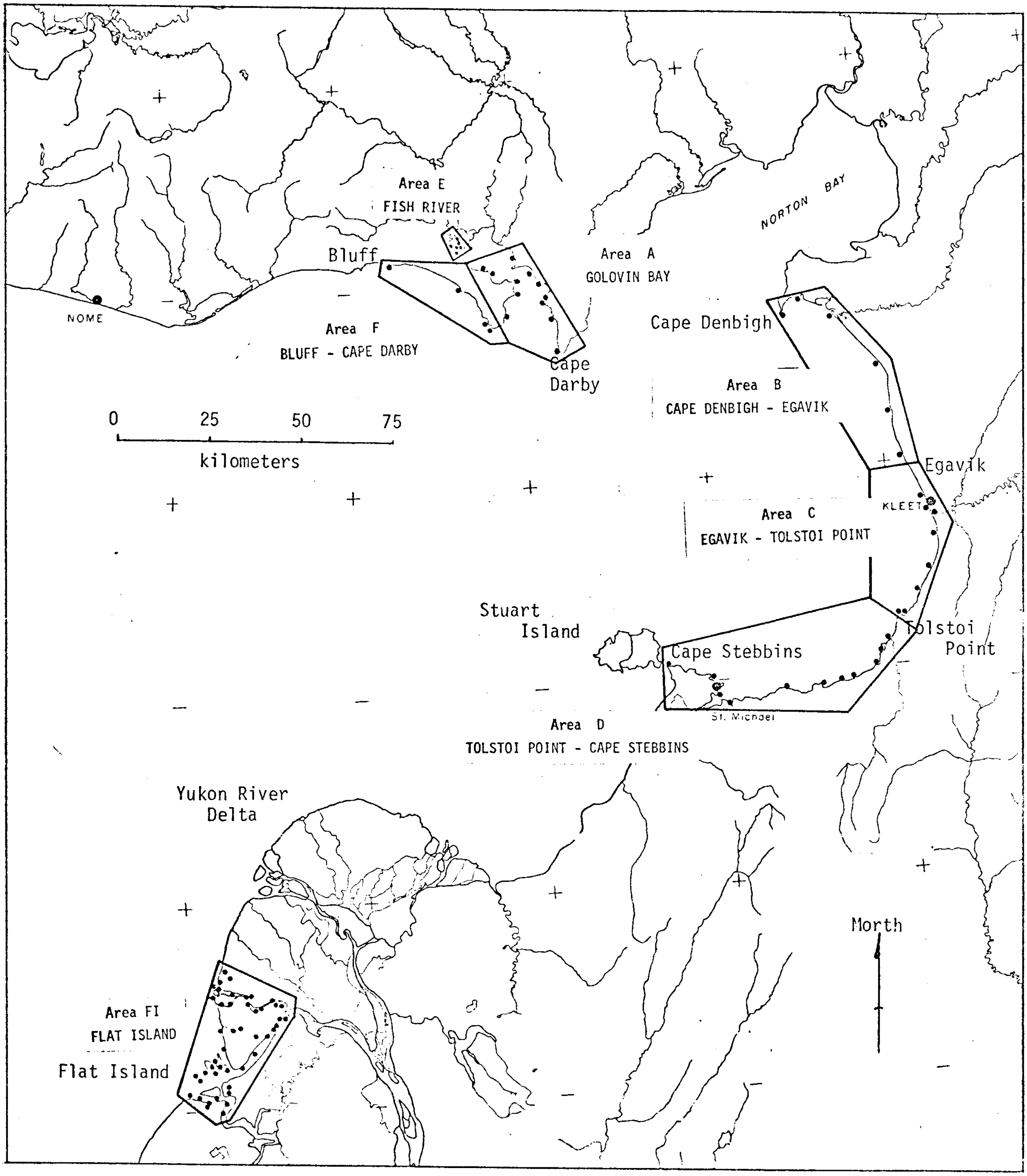

Figure 3. Location of sampling stations for nearshore pelagic fish survey in Norton Sound early spring through early fall, 1976.

Large Vessel Sampling

It was realized in the course of field investigations that the NOAA ship Miller Freeman would be conducting demersal and pelagic fish trawl studies in the northern Bering Sea and Chukchi Sea during September and October. Arrangements were made for ADF&G personnel involved with RU 19E investigations to conduct gillnetting studies on board the vessel. Seven, fifty by three fathom shackles connected together to form 350 fathoms of long net were fished in hours of darkness for approximately eight to ten hours each night. A radio buoy, marker and floats were attached to the end of the net for ease in recovery. The seven shackles varied in mesh size as follows: 21 mm, 35 mm, 42 mm, 64 mm, 83 mm, 114 mm, and 133 mm. Upon retrieval of the gillnets, catches were removed from each shackle and placed into separate baskets in order that catch records could be obtained by mesh size.

Several gillnet stations were reoccupied to determine temporal changes in species composition and density. Duration between initial and replicate sets varied from a few days to two weeks. Approxi-mately 24 hours were spent at each replicate site. Four gillnet sets were performed including an 8-10 hour set identical to the earlier evening set, and three day-time sets of eight, four and two hour duration. Location of replicate sets varied. Sampling procedures for the replicate and variable time gillnet sets was held consistent with those methods used for the standard evening sets.

The Miller Freeman cruise was divided into two legs with the first being conducted from September 2 through September 24 and the second from September 27 through October 13. Gillnet sample stations for the entire cruise are shown in Figure 4.

RESULTS

Subsistence Utilization

Twelve coastal villages were surveyed from the Yukon River Delta to Point Hope in 1976. The twelve villages included: Stebbins, St. Michael, Unalakleet, Shaktoolik, Moses Point, Elim, Golovin, Teller, Shishmaref, Deering, Buckland, and Point Hope (Table 2). Fishery resources utilized by village are listed according to the common name given by villagers. In most cases the actual species could not be varified as none were available during the time surveys were conducted. This is only important for species listed apart from salmon and herring.

Excluding Point Hope, 137 fishing families were documented of which 88 were contacted throughout the survey period. A 1970 population census conducted by the Bureau of Census, revealed a total population of 2,376 people residing in these twelve villages (University of Alaska, 1973). It was noted that quite a divergence of opinion to proposed OCS oil development existed. In most cases local residents were not cognizant of the proximal implications of oil exploration. However, those residents with a greater knowledge of OCS plans for Alaska consistently expressed hopes to preserve the fishery at all costs and to discourage any potentialities for damaging their renewable resources.

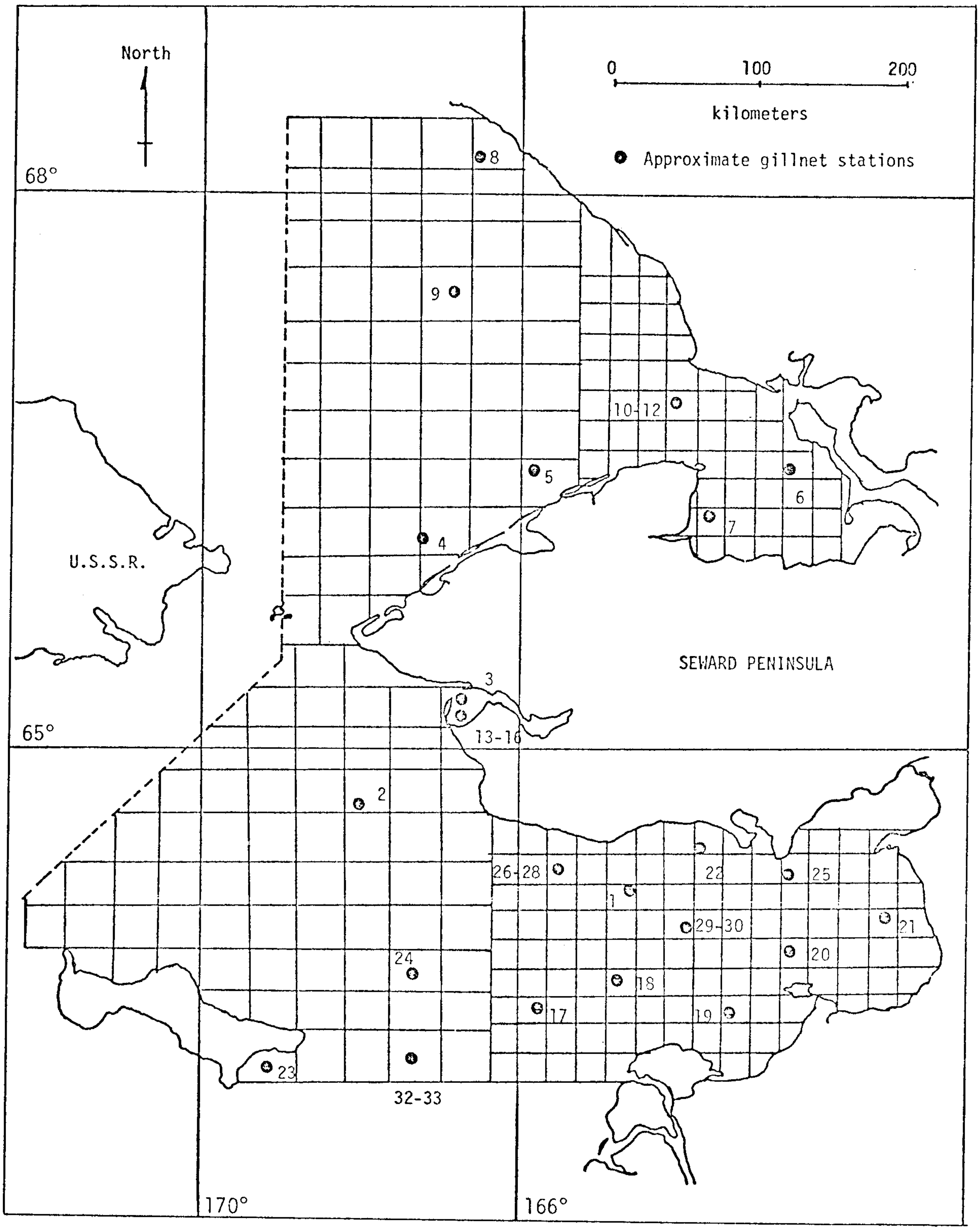

Figure 4 . Approximate variable mesh gillnet sampling stations and set numbers during the M/V Miller Freeman cruise from September 2 through October 9, 1976.

Table 2 . Subsistence survey results as conducted under R.U. 19F for 12 villages from the Yukon River Delta to Point Hope, July 5 - September 5, 1976.

Village	1970 pop. census	Salmon: pink	Salmon: chum	Salmon: king	Salmon: silver	Salmon: sockeye	herring	Smelt Species	Whitefish Species	Tomcod (Saffron cod?)	Flounder Species	Arctic Grayling	Trout (Arctic Char?)	Bullheads	Lingcod	Skipjacks	Northern Pike	Cigarfish	Mud Sucker	Blue Cod	Pollock	Halibut	Blackfish Species	Needlefish	Sheefish (Inconnu)
Stebbins	231	564	4,285	471	1,071		2,463	X	X	X	X		X									X	X	X	X
St. Michael	207	39	2,385	89	50	2	2,734 1/	X	X	X	X														
Unalakleet Shaktoolik	434 151	1,076	920	26	234		300	X	X	X	X	X	X												
Moses Point Elim	- 174	5,016	1,548	22	X		150	X	X	X	X	X	X	X	X	X									
Golovin	117	1,995	1,128	0	11		0	X	X	X		X	X												
Teller	220	200	5,800	4	X	200	X	X	X	X	X		X	X	X	X	X								
Shishmaref	267	410	300	5	5	50	X	X	X	X	X	X	X	X	X					X					
Deering	85	21	731	0	88		X	X	X	X	X	X	X	X				X							
Buckland	104	23	600	3	10		X	X	X	X	X	X	X	X					X		X				
Point Hope	386	X	X					X	X	X		X													
	TOTAL	9,344	17,697	620	1,469	252	5,647																		

1/ An additional 17,000 pounds of herring were taken commercially for sac roe extraction, after which carcasses were given to local residents for subsistence purposes. Figures shown in this table are considered to be minimal (conservative estimates).

Stebbins/St. Michael

Subsistence fishing for herring by villagers in St. Michael and Stebbins is usually associated with ice breakup in Norton Sound when spawning runs appear. St. Michaels subsistence fishermen concentrate their efforts in St. Michaels Bay while subsistence effort for herring by Stebbins villagers occurs on the north and eastern shore of Stewart Island. People from both villages have traditionally considered herring as a major subsistence item; however, in recent years it has declined in importance. It was reported that the absence of dog teams in Stebbins, commercial salmon fishing in the Yukon River and firefighting employment has reduced the need to harvest herring intensively. One villager from Stebbins indicated that an average of 15 herring runs usually occurred annually and that in the last five years there has been an average of only three annually. Both Stebbins and St. Michael waters are closed to commercial salmon fishing. It was unanimous amongst residents from both villages that Japanese were making a large dent in the fishery resources and they indicated there were fewer fish than in previous years. One exception to this was the herring runs that occurred in St. Michael in 1976. Villagers there felt the subsistence catch was good.

Unalakleet/Shaktoolik

Subsistence use of herring by Unalakleet residents occurs, but most families are actively involved in a commercial salmon fishery which apparently affects the level of subsistence fishing. One long time resident stated that traditional herring runs (1940s) began in the area on May 28 and were extremely large in magnitude but present runs are markedly smaller in comparison. In 1976, ten fishing families were contacted reporting only 300 herring taken. Of these, one fisherman put up three strings of herring (about 50/string) and an additional three 25 pound tubs full. These herring were taken on June 27 immediately east of Klikitarik in 30 minutes of gillnet fishing. On that date, large concentrations of herring were present at Klikitarik and hundreds of seals were reported actively feeding on them. Limited subsistence effort by Unalakleet residents also occurred at the mouth of the Unalakleet River in 1976.

Approximately ten families from Shaktoolik subsistence fish for herring with effort being concentrated immediately south of Cape Denbigh. Residents indicated that most summer subsistence fishing is for salmon while herring are only fished for in mid-July. No herring catches were reported in 1976 but use was considered to be minimal.

Moses Point/Elim/Golovin

Herring fishing effort by villagers from Moses Point and Elim was surprisingly small despite numerous reports of herring runs and their locations. According to villagers, herring spawn annually from early to mid-June on rocky beaches in front of Elim, at Iron Creek (between Elim and Moses Point) and at the mouth of the Kwik River. Spawning patterns of "smelt" (probably boreal smelt) were also described as taking place on the beaches at the mouths of the Koyuk and Bonanza Rivers from late June to mid-July. Nine families from Moses Point and Elim were contacted and they reported a total of 150 herring taken for subsistence purposes.

Herring fishing is primarily with set gillnets although some families utilize beach seines.

Local residents at Golovin reported two separate runs of herring occur annually; early June through mid-June and late September through early October. The commercial salmon processing facility in Golovin obtained about a 30 pound sample of herring near the end of May to be checked for percent roe recovery and oil content. A 14.3 percent recovery by weight was obtained from that sample (Rod Price, personal communication). No commercial or subsistence effort occurred on the spring run of herring to Golovin Bay in 1976. Several local people expressed plans to seine for herring during the fall run to Golovin.

Teller/Shishmaref

Both herring and smelt species are extensively fished by the Teller residents. It was reported that runs occur both during the spring and fall in the Tuksuk Channel. Most people put away two barrels of herring and smelt each. An opinion on subsistence fishing in Teller was offered by one of the long-time local residents.

> "Subsistence fishing is going to increase because more and more people are becoming disenchanted with snow machines. About ten years ago, 50 percent of all fish catches went to dog sleds. Today the figures have decreased to about 10 percent, but because of high gasoline prices and the lack of maintenance skills, people are returning to their dogs."

Herring are an important subsistence item to the villagers of Shishmaref. Ten out of thirteen fishing families were contacted and indicated they had completed their subsistence fishing efforts by mid-August, having taken enough for the winter to supplement subsistence hunting; about two barrels each. Local residents indicated that spring and fall runs of herring occur to the Shishmaref area and they expressed much interest in the possibility of initiating a commercial herring fishery.

Deering/Buckland/Pt. Hope

The villages of Deering and Buckland experience a later ice breakup of the Chukchi Sea than occurs in Norton Sound and consequently, information included in the survey is not complete since the last survey was made on August 5-6. However, residents from both villages indicated that herring runs occur in the fall months. Dependence upon herring as a subsistence item in these villages is probably much less than the other villages surveyed in Norton Sound. It was reported from Buckland that herring apparently no longer play an important subsistence role and that the lack of sled dogs and changing times have attributed to this fact. Residents indicated that Eschscholtz Bay and Elephant Point are two areas where spawning activity occurs. Residents from both villages utilize beach seines as a primary gear for harvesting nonsalmon subsistence fish. Buckland residents also indicated that subsistence fishing and the effort placed upon it were greatly influenced by whale harvests.

Most of the information obtained on subsistence fishing at Point Hope came from one fisherman. He stated that Point Hope residents are basically dependent upon marine mammals for subsistence. Apparently salmon subsistence is greatly reduced and herring subsistence is nil. Other fishes utilized for subsistence to a limited degree include: tomcod (probably saffron cod), whitefish species, lingcod, smelt, and Arctic grayling.

Commercial Utilization

Kawerak Inc. was involved in the only commercial operation for herring north of the Yukon River Delta in 1976. The operation took place exclusively in St. Michael Bay. Two commercial fishermen from Petersburg Fisheries Inc. were contracted by Kawerak Inc. to assist in the commercial capture of herring in St. Michael for commercial roe extraction. After extracting roe herring were then given to the local residents of St. Michael for subsistence purposes. Personnel involved in the commercial operation arrived in St. Michael on June 19 which was too late by local resident estimation for capturing herring. Villagers stated that herring began to spawn on rocks in St. Michael Bay about June 15, 1976, and that water temperatures were about 5.5°C.

The first few days of the commercial venture were spent in building processing facilities. A total of 17,000 pounds of herring were captured in St. Michaels Bay between June 22 through June 30 (Table 3). Because villagers received the herring after roe extraction, accounts for the lack of herring subsistence fishing effort in St. Michael. This is possibly one reason local residents in St. Michael felt herring subsistence catches were good in 1976. Kawerak's commercial effort was more effective in capturing herring on a large scale than past subsistence efforts by local residents in St. Michael.

Aerial Surveys

Aerial surveys in 1976 were completed on 26 census areas along the coast from Cape Stebbins to the village of Shishmaref (census areas 35-45), throughout the period June 10 through July 25. Aerial surveillance was initiated with the onset of ice breakup in Norton Sound and was intensified during the peak of spawning activities. Surveys included more than 32 hours of air time, 2,342 km (1,455 miles) of coverage and 12 survey days. A total of 226 fish schools were counted along the coast from Cape Stebbins to Shishmaref during the period June 10 through July 25 (Table 4 and Figure 5). In addition, seven observations were

Table 3. Commercial harvest of spring herring for sac roe production in Norton Sound, 1964-1976.

Year [1]	location	sac roe (pounds)	percent recovery	herring (pounds)	herring (metric tons)
1964	Unalakleet	?	?	40,000	18.1
1965-70	No Operations				-
1970	Unalakleet	1,345	8.4%	16,000	7.3
1971	Unalakleet	3,180	8.2%	39,000	17.7
1972	Unalakleet	8,734	26.0%	33,706	15.3
1973	Unalakleet	2,160	3.0%	71,264	32.3
1974	Unalakleet	0 [2]	0	5,264	2.4
1975	No Operations				-
1976	St. Michael	?	?	17,000	7.7
			Total	222,234	100.8

1/ G. A. Rounsefell (Contribution to the Biology of the Pacific Herring, *Clupea pallasi*, and the Condition of the fishery in Alaska, 1929) states that "a small fishery has been carried on at Golovin Bay . . . since before 1909". Volumes of the Pacific Fisherman (1917-1942) reveal that in excess of 3.2 million pounds of fall herring were processed in Norton Sound (98.6% in Golovin) from 1916-1941: 48.6% Scotch style, 35.2% Norway style, 13.2% bloater stock, 1.5% hard salted and 0.8% roused herring. This production is based upon 125 lbs of herring per barrel, and thus is considered a very conservative estimate. No commercial operations occurred from 1942-1962. ADF&G records indicate six boats took 3600 lbs of fall herring on October 10, 1963 in Golovin to be salt cured. Since 1963 all operaions have been directed toward spring herring for sac roe production.

2/ Roe loss was due to herring spoilage in the round and poor quality of herring roe.

Table 4 . Number of fish schools and spawning observations classified to relative size as determined from aerial surveys from Cape Stebbins to Shishmaref June 10 to July 25, 1976.

Area Surveyed 1/	Date	Fish School Size 2/ Sm.	Med.	Lg.	Unc.	Total Number Schools	Spawn No.	Spawn Sur. Area 3/
Cape Stebbins-Unalakleet (35-37)	6/10 4/	18				18	3	3,930
	6/16				None	-		
	6/21				None	-		
	6/26	7	3			10	1	6,271
	7/7				None	-		
	7/9				None	-		
Total		25	3			28	4	10,201
Unalakleet-Cape Denbigh (38)	6/20 5/						1	4,181
	6/26 5/	1	1	1		3		
	6/30 5/		8			8	1	1,756
	7/19				None			
Total		1	9	1		11	2	5,937
Bald Head-Cape Darby (40)	6/30 6/	2	3			5		
	7/15 6/	14	7	5		26		
Total		16	10	5		31		
Rocky Point-Cape Spencer (42-43)	6/30		1			1		
	7/15	2	7			9		
	7/19 7/				None			
	7/21 7/	23	28	14		65		
Total		25	36	14		75		
Cape Spencer-Wales (44)	7/21 8/	11	12	15	20	58	1	8,051 9/
Wales-Shishmaref (45)	7/25	7	14	1	1	23		
Estimated Total 1976		85	84	36	21	226	7	24,189

1/ Numbers in parenthesis indicate census areas.

2/ Classification of fish schools:

small - surface area estimated less than $50m^2$
medium - surface area estimated 50 - $450m^2$
large - surface area estimated greater than $450m^2$
unclassified - no surface area estimate made

3/ Surface area estimates in square meters.

4/ Most observations were made at Klikitarik.

5/ All observations made on south side of Cape Denbigh.

6/ All observations made in vicinity of Elim and Iron Creek.

7/ Observations made between Cape Wooley and Cape Spencer.

8/ All schools observed on south side of Grantley Harbor.

9/ Not positively identified as spawn.

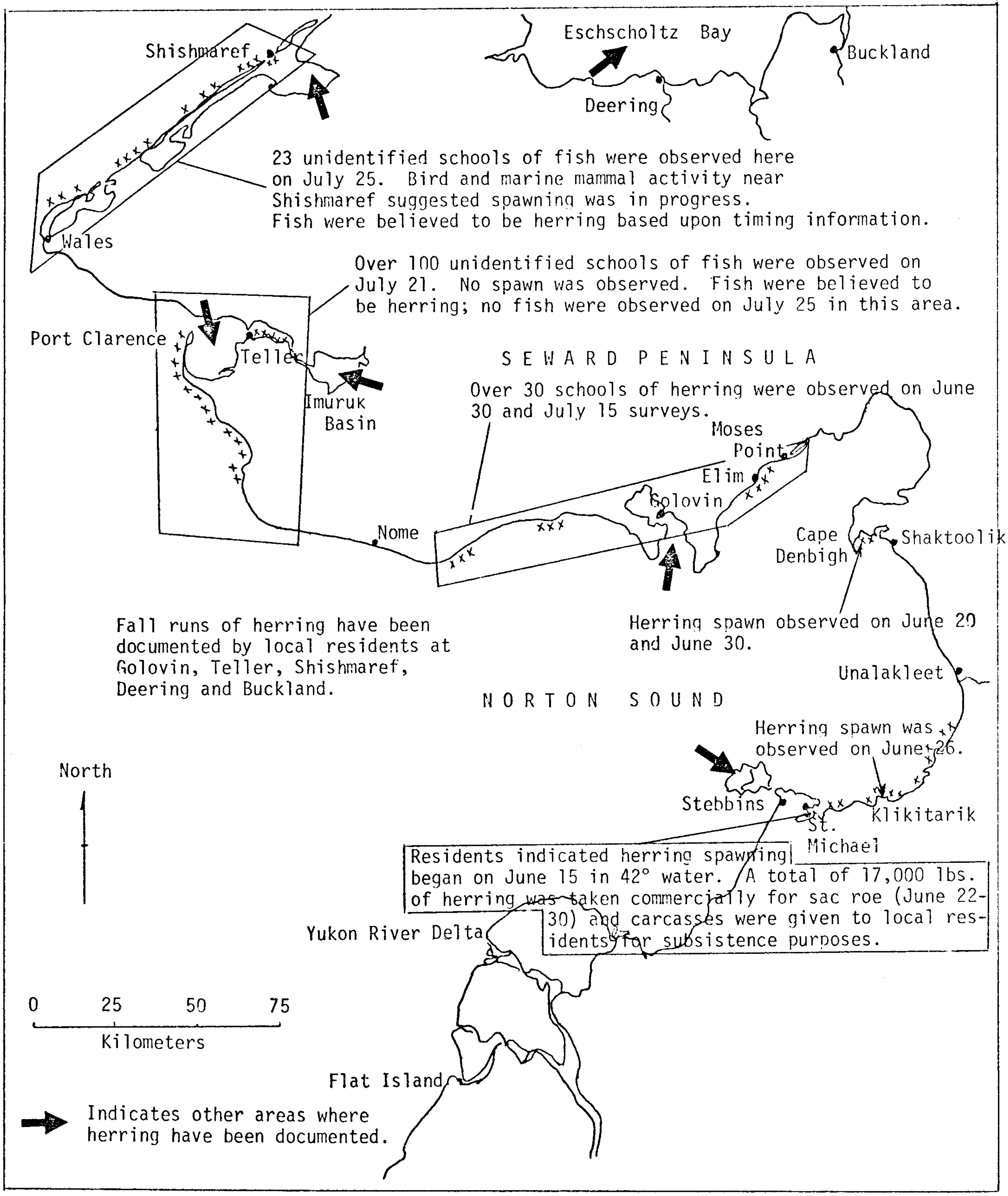

Figure 5 . Spatial and temporal distribution of fish schools observed in Norton Sound (1976) as well as areas were herring have been documented.

made of spawn (milt). Inclement weather conditions and size of the study area were determining factors in the actual number of surveys conducted and consequently, all surveys were flown on an opportunistic basis.

Cape Stebbins to Unalakleet

The first encounter of schooled fish occurred on June 10. A survey was made of the coastline from Unalakleet to Stuart Island and the only ice free areas observed extended from Tolstoi Point to St. Michael Bay and a small area on the southeast side of Stuart Island. Three small fish schools were observed about eight kilometers east of St. Michael. Fifteen small schools and three areas of milt were located at Klikitarik. Aerial observers did not believe these fish or spawn to have been herring due to configuration of schools and coloration (rusty brown) of spawn. Norton Sound pack ice precluded landing to varify species composition.

The first encounter of herring by aerial surveys along this section of Norton Sound occurred on June 26. Two schools, one medium and one small in size, were observed immediately east of Klikitarik in addition to an estimated 6,271 m^2 of herring milt. As already stated a single subsistence fisherman from Unalakleet captured over 100 pounds of herring in 30 minutes of fishing at this same location on June 27.

Eight more schools of herring were observed on June 26, five in the vicinity of Poker Creek (about 21 km south of Unalakleet) and three at Tolstoi Point. No milt was observed.

Although this section of the study area was surveyed four more times on June 16, June 21, July 7 and July 9, no other observations of fish or spawn was documented. Survey conditions during ~~these four~~ surveys ranged from good to unacceptable, being a function of water turbidity, cloud cover and wind.

Unalakleet to Cape Denbigh

Herring spawn was observed on the south side of Cape Denbigh on the first survey flown from Unalakleet to Cape Denbigh. This survey was flown on June 20 and the surface area of the spawn was estimated to be 4,181 m^2. No schools of fish were observed until June 26 when three herring schools were identified, again on the south side of Cape Denbigh. Four days later, on June 30, eight more herring schools (medium in size) and one area of spawn (1,756 m^2 surface area) were again observed at Cape Denbigh, thus indicating at least two waves of spawning occurred in 1976 at this location. A July 19 survey revealed no activity of any type occurring at Cape Denbigh. No fish or spawn was observed elsewhere between Cape Denbigh and Unalakleet in 1976.

Norton Bay (East of Cape Darby)

The only observations made of schooled fish in Norton Bay were near the mouth of Iron Creek (about four kilometers east of Elim). Two small and three medium herring schools were observed on June 30, and 26 additional herring schools, ranging from small to large in size, were seen on July 15. No spawn and other schooled fish were observed elsewhere in

Norton Bay in 1976, but aerial coverage of the east end of the Bay was not made.

Nome to Cape Darby

No observations were made in Golovin Bay in 1976 and no spawn was observed from Nome to Rocky Point. Only ten schools of herring were seen: one medium school at Square Rock on June 30, two medium and two small schools at Topkok on July 15, and five medium schools at Cape Nome on July 15.

Nome to Cape Prince of Wales

Sixty-five unidentified schools of fish (believed to be herring) were observed on July 21 from Cape Wooley to Cape Spencer. No spawn was observed and all schools were documented migrating in a northward direction, usually within 300-400 meters of the shoreline. Although no fish were observed inside Port Clarence, one area of possible herring spawn was documented near the village of Mission. An estimated surface area of 8,051 m^2 of milt was made, but the surveyor was apprehensive about the authenticity of this observation. An additional 58 unidentified fish schools were observed along the southern shore of Grantley Harbor from the village of Teller to the Tuksuk Channel on the same survey. No spawn was seen. A return survey on July 25 revealed no schooled fish or spawn anywhere between Nome and Cape Prince of Wales including Port Clarence and Grantley Harbor.

Cape Prince of Wales to Shishmaref

Twenty-three schools of fish were seen on July 25 scattered along the coastline within 300 meters of shore from Cape Prince of Wales to the village of Shishmaref. Although no milt was observed on this survey, the presence of 200-300 gulls and eight seals feeding near a large school of fish immediately inside the southern entrance of Shishmaref Inlet suggested that spawning was in process. The identity of all schools observed during this survey was not established but they were believed to be herring based upon timing information obtained from the villagers of Shishmaref.

Pollution

Oil slicks were documented on two occasions during aerial surveys conducted in 1976. The first observation was made on June 21 inside St. Michael Bay. A caterpillar tractor, operated by Kawerak Inc., became stuck in the intertidal zone at low tide while in the process of constructing boat launching facilities for commercial herring operations. The cat was partially submerged by an incoming tide resulting in an oil slick, carried toward the center of St. Michael Bay by an offshore wind. This incident was reported to the Habitat Protection Section (ADF&G) in Fairbanks.

A second slick was observed on July 21 inside Grantley Harbor at the village of Teller. The oil slick was originating from the M/V Helen, which stern was completely submerged. A heavy sheen was visible at an altitude of 518 meters (survey atlitude) with an estimated surface area of 18,000 m^2. Several schools of fish were observed within less than one half kilometer from the slick. This incident was reported to the Habitat Protection Section in Fairbanks and the U.S. Coast Guard.

Nearshore Pelagic Finfish Surveys

A total of 35 species of finfish were identified by sampling crews in the coastal waters of Norton Sound from the Yukon River Delta to Golovin Bay during the period of June 9 through September 21, 1976 (Table 5). All pricklebacks and sculpins were grouped into their respective families, Stichaeidae and Cottidae. Arctic char (*Salvelinus alpinus* was the most widespread species being captured in all seven areas, while nine species were common only to areas A, B, C, D and FI: Bering cisco, (*Coregonus laurettae*) boreal smelt, (*Osmerus mordax dentex*), chum salmon (*Oncorhynchus keta*), humpback whitefish (*Coregonus pidschian*), least cisco (*Coregonus sardinella*), pink salmon (*Oncorhynchus gorbuscha*), starry flounder (*Platichthys stellatus*), coho salmon (*Oncorhynchus kisutch*) and ninespine stickleback (*Pungitius pungituis*). Other species that were common only to areas A, B, C and D included: Bering poacher (*Ocella docecaedria*), Pacific herring (*Clupea harangus pallasi*), rock greenling (*Hexagrammus legocephalus*, sculpins, saffron cod (*Eleginus gracilis*) and yellowfin sole (*Limanda aspera*).

A total of 32,458 finfish were captured during the season, of which 91.5 percent were taken with seines (beach and handpurse). Only 8.5 percent were captured with variable mesh gillnets. A summary of the total catch, total effort, negative effort (effort resulting in no catch), catch per unit effort and number of species capture per area by gear type are shown in Table 6, while the same information by sampling period for areas A, B, C and D are found in Appendix Table 2.

Norton Sound Surveys

Excluding area FI, a total of 397.3 gillnet hours was fished, of which 21 percent revealed negative catches. The average gillnet set was 1.1 hours and resulted in a catch per unit effort (CPUE) of 5.2 fish per net hour. Only four of 127 beach seine sets, 3.1 percent, resulted in negative catches. The average catch per beach seine set was 232.3 fish.

The gillnet CPUE in area C was the greatest (9.2) followed closely by that in area B (8.7). Areas A and D had gillnet CPUEs of 2.9 and 2.7, respectively. The highest beach seine CPUE occurred in area A (348.6 fish per set). The CPUEs for beach seines fished in areas B and C were 49.6 and 149.2, respectively. The beach seine CPUE in area C (149.2) changes to 93.8 when the results of two seine sets made inside the Unalakleet River mouth are removed. A total of 1,184 pond smelt and 997 boreal smelt were captured in these two sets.

The three most frequently occurring species captured in beach seines for the entire sampling period in areas A, B, C and D were boreal smelt (59%), Bering cisco (52%) and saffron cod (43%). The three most frequently encountered with gillnets were saffron cod (28%), Bering cisco (21%) and least cisco (20%). The three most abundant species captured in these areas (combined gear types) were Pacific sand lance

Table 5. List of common and scientific names with code of fish species captured in the nearshore waters of Norton Sound and area where captured, 1976.

Code	Common Name	Scientific Name	Capture Site A	B	C	D	E	F	FI
AC	Arctic char	Salvelinus alpinus	X	X	X	X	X	X	X
AF	Arctic flounder	Liopsetta glacialis	X	X	X				
AP	Alaska plaice	Pleuronectes quadrituberculatus	X	X	X				
B	Burbot	Lota lota leptura							X
BC	Bering cisco	Coregonus laurettae	X	X	X	X			X
BP	Bering poacher	Ocella dodecaedria	X	X	X	X			
BS	Boreal smelt (rainbow, toothed)	Osmerus mordax dentex	X	X	X	X		X	X
BW	Broad whitefish	Coregonus nasus	X		X	X	X		X
C	Capelin	Mallotus villosus	X		X				
CS	Chum slamon	Oncorhynchus keta	X	X	X	X			X
HO	Pond smelt	Hypomesus olidus		X	X				
HW	Humpback whitefish	Coregonus pidschian	X	X	X	X			X
KS	King salmon	Oncorhynchus tshawytscha	X	X	X				X
LC	Least cisco	Coregonus sardinella	X	X	X	X	X		X
LD	Longhead dab	Limanda proboscidea		X	X				
LR	Ringtail snailfish	Liparis rutteri			X				
NP	Northern pike	Esox lucius							X
NS	Northern sucker	Catostomus catostomus							X
P	Pricklebacks	Stichaeidae		X	X	X		X	
PH	Pacific herring	Clupea harengus pallasi	X	X	X	X			
PS	Pink salmon	Oncorhynchus gorbuscha	X	X	X	X	X		X
RG	Rock greenling (terpug)	Hexagrammus lagocephalus	X	X	X	X			
RW	Round whitefish	Coregonus cylindraceus			X				
S	Sculpins	Cottidae	X	X	X	X	X		
SC	Saffron cod	Eleginus gracilis	X	X	X	X		X	
SF	Starry flounder	Platichthys stellatus	X	X	X	X	X		X
SH	Sheefish	Stenodus leucichthys							X
SL	Sandlance	Ammodytes hexapterus	X					X	
SP	Sturgeon poacher	Agonus acipenserinus	X			X			
SS	Coho salmon	Oncorhynchus kisutch	X	X	X	X	X		X
S3	Threespine stickleback	Gasterocteus aculeatus	X						
S9	Ninespine stickleback	Pungitius pungitius	X	X	X	X	X		X
TP	Tubenose poacher	Pallasina barbata aix	X	X	X				
UB	Unidentified bony fish			X	X		X		
UL	Unidentified larval fish			X			X		
WG	Whitespotted greenling	Hexagrammus stelleri	X	X	X				
YS	Yellowfin sole	Limanda aspera	X	X	X	X			
		TOTAL	26	26	29	19	10	5	16

A Golovin Bay (Rocky Point - Cape Darby).
B Cape Denbigh - Egavik.
C Egavik - Tolstoi Point.
D Tolstoi Point - Cape Stebbins.
E Fish River (Inside Golovin Lagoon).
F Rocky Point - Bluff.
FI Flat Island (South Mouth Yukon River).

Table 6 . Total effort, negative effort, catch per unit effort, catch and number of species captured by gear type and sample location in Norton Sound (OCS-R.U. 19E), 1976.

Sample Area		Gear 1/	No. Stations	No. Sets	Effort 2/ Negative	Effort 2/ Total	Total Catch	Total 2/ CPUE	No. Species Captured
A		GN	13	125	35.0	127.1	368	2.9	18
		BS	9	62	4	62	21,995	348.6	22
B		GN	6	59	5.7	70.3	612	8.7	21
		BS	6	24	0	24	1,191	49.6	21
C		GN	7	73	8.7	86.6	796	9.2	23
		BS	7	36	0	36	5,371 3/	149.2	26
D		GN	11	100	27.0	100.0	272	2.7	19
		BS	0	-	-	-	-	-	-
E		GN	4	6	4.3	6.3	7	1.1	3
		BS	3	4	0	4	734	183.5	9
F		GN	4	7	3.0	7.0	11	1.6	2
		BS	1	1	0	1	216	216.0	4
	Total	GN	45	370	83.7	397.3	2,066	5.2	24
		BS	26	127	4	127	29,507	232.3	32
FI		GN	91	91	164.5	1,084.0	704	0.6	16
		PS	63	63	14	63	180	2.9	9
	Grand Total	GN	136	461	248.2	1,481.3	2,770	1.9	28
		BS + PS	89	190	18	190	29,687	156.2	33
							32,458		35

1/ GN-Gillnet; BS-Beach seine; PS - hand purse seine.

2/ Gillnet effort is expressed as number of hours fished and CPUE is number of fish per net hour. Seine effort is expressed as number of good sets and CPUE is number of fish per good set.

3/ Figure does not include one lamprey (unidentified).

(Ammodytes hexapterus), boreal smelt and saffron cod, respectively (excluding unidentified larval fish catches). The most striking observation made this season was the extremely large catch (16,913) of sand lance and the fact that all were taken by the Golovin Bay crew.

Flat Island Surveys

A total of 63 purse seine sets and 91 gillnet sets were made throughout the course of the season at Flat Island. A total of 704 fish were captured in 1,084 gillnet hours (both beach and drift sets). Duration of sets varied from two to 26 hours with an average of 11.9 hours per set. Fifteen percent of the gillnetting effort resulted in negative catches. An additional 180 fish were captured in the 63 purse seine sets for an average catch per effort of 2.9 fish per set. Twenty-two percent of the purse seine sets resulted in negative catches.

The most abundant and frequently occurring species captured at Flat Island in 1976 was Bering cisco. The second most abundant and frequently occurring fish captured was humpback whitefish while sheefish (Stenodus leucichthys) were the third most frequently encountered species. Four species of fish were captured at Flat Island that were not sampled throughout the remainder of Norton Sound in 1976. These species included: burbot (Lota lota leptura), northern pike (Esox lucius), northern sucker (Catostomus catostomus) and sheefish.

Offshore Pelagic Finfish Surveys

Gillnetting Studies

Twenty-two gillnet sets were made on Leg I (September 2-24) of the Miller Freeman cruise, in the Chukchi Sea and Norton Sound. A total of 190 gillnet hours produced a catch of 222 fish (Table 7). Approximately 23% of the gillnet sets produced negative catches. Twelve species were represented, of which, Pacific herring was the most abundant and frequently captured, being taken in 55% of the sets. Boreal smelt was the second most abundant species and occurred in 41% of the sets. Several salmonids, including juvenile king (Oncorhynchus tshawytscha) and pink salmon, maturing chum salmon and Arctic char were also taken. Gillnet sets near the shorelines and in Kotzebue Sound produced considerably greater catches than offshore sets. Gear damage reduced the number and size of shackles fished as the cruise progressed.

Eleven stations were fished from September 27 through October 9 in the North Bering Sea and remainder of Norton Sound left unsampled from Leg I. A total of 90 gillnet hours was fished of which 27% resulted in no catch. The small catch (15 fish) made during Leg II can be at least partially attributed to gear loss during Leg I. The smallest mesh net (21mm) was not replaced after its loss during Leg I and no replacements were available for the damaged 35mm and 42mm mesh nets. Only 16 fish (7%) were captured on Leg I in the four large mesh nets.

A total of 39% of all herring captured (Legs I and II) came from five gillnet sets inside Port Clarence made on September 9 and 16-17, while 37% were taken on September 8 in one set made about 30 km off the village of Kotzebue. Approximately 77% of the boreal smelt captured

Table 7 . Variable mesh gillnet catches for Leg I and II of the M/V Miller Freeman cruise from September 2 through October 9, 1976.

Species	Catch Leg I	Catch Leg II	Catch Total	Gillnet Set Number Captured In
King salmon	2*	1*	3*	1, 31
Pink salmon	6*1/	1*	7*1/	3, 4, 29
Chum salmon	52/	2	72/	1, 4, 8, 23, 32
Pacific herring	132	6	138	1, 3, 4, 5, 6, 7, 12, 33, 14, 15, 16, 18, 19, 32
Boreal smelt	47		47	1, 3, 6, 11, 12, 14, 15, 16
Bering cisco	3		3	6, 19, 22
Arctic char	8		8	8, 22
Pond smelt	4		4	14
Saffron cod	5		5	1, 3, 14
Starry flounder	2		2	3, 19
Gmnocanthus sp.	1		1	3
Myoxocephalus joak	7	2	9	1, 16, 19, 21, 22, 25, 26
Myoxocephalus verrucosis		3	3	25, 27, 33
Total Catch	222	15	237	
Total Hours Fished	190	90	280	

* All juveniles.
1/ One juvenile may have been a chum.
2/ Includes two juveniles.

were taken inside Port Clarence, with another 17% taken on September 3 near Cape Nome.

Trawling Studies

All results from the bottom and midwater trawling investigations are being prepared by NOAA (RU.175), Northwest and Alaska Fisheries Center (NWFC), Seattle. However, demersal trawl catches by location for Pacific herring and boreal smelt are shown in Figures 6 and 7 of this report. Excluding replicate trawls and gillnet catches herring occurred 54% of the time in the Chukchi Sea area and 38% in the Norton Sound area (Wolotira, 1977). Boreal smelt percent occurrence was 57% and 71% in the Chukchi Sea and Norton Sound areas, respectively. The density of both herring and boreal smelt was greatest in the Chukchi Sea area.

Biological Sampling

Detailed age-weight-length relationships for selected species captured during the trawling operations of the *Miller Freeman* cruise are being prepared by NOAA (Wolotira, 1977). Herring and boreal smelt are included among these target species. In addition, an examination of boreal smelt stomachs for subsequent analysis is scheduled.

The mean standard length (hypural) of herring males and females captured with gillnets during Legs I and II was 190mm and 192mm, respectively. The male to female sex ratio was 1.00:1.12. Mean fork lengths of boreal smelt were 170mm and 164mm for males and females, respectively, with a 1.00:0.91 sex ratio. Salmonid sampling is summarized in Table 8.

DISCUSSION

Subsistence Utilization

The level of herring use as a subsistence item by villagers throughout the study area appears to be a function of village location. It is also influenced by the number of dog teams per village, timing and abundance of herring spawners, occurrence of other fishery resources, occurrence of marine mammals and large game animals, commercial salmon fishing and other employment opportunities, such as firefighting. Villagers living in areas relatively close to important herring spawning areas tend to harvest more of that item for subsistence purposes. Stebbins and St. Michael are typical examples, having utilized herring as a subsistence item in 1976 to a greater extent than other residents throughout the study area. Commercial salmon fishing is restricted in this area.

Local residents in Unalakleet, Shaktoolik, Moses Point and Elim utilize herring for subsistence but most effort is devoted toward commercial salmon fishing, thereby, limiting the effort on herring. Subsistence fishing for herring also occurs in villages situated on the Seward Peninsula but use was quite limited in 1976. This was attributed to the lack of dog teams and occurrence of other fishery resources available for harvest, such as smelt, whitefish and sheefish. Also, much of the subsistence need in Kotzebue Sound is met from harvest of marine mammals and large game animals.

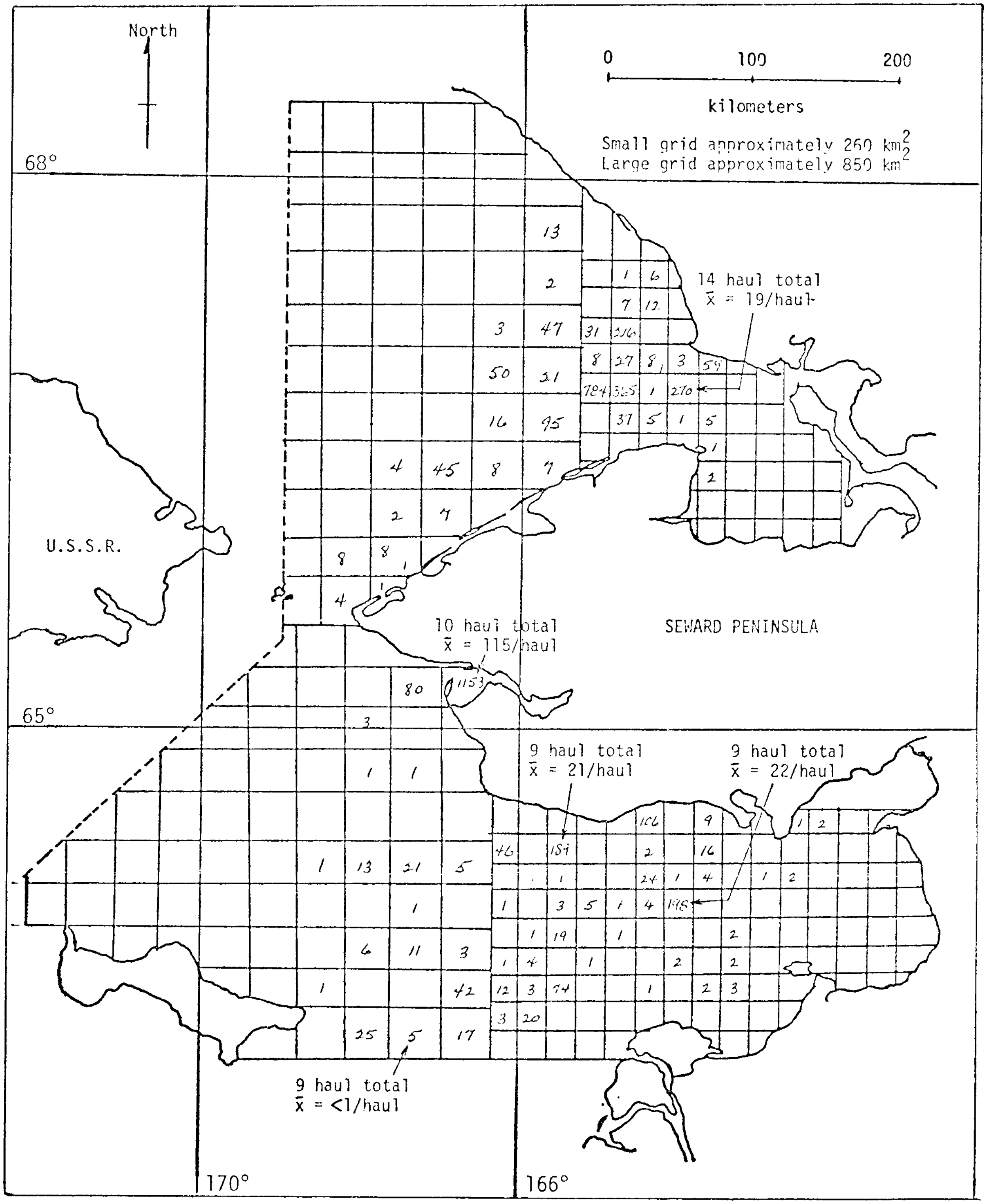

Figure 6. Location and size of Pacific herring 30 minute demersal trawl catches during the M/V Miller Freeman cruise from September 2 through October 9, 1976.

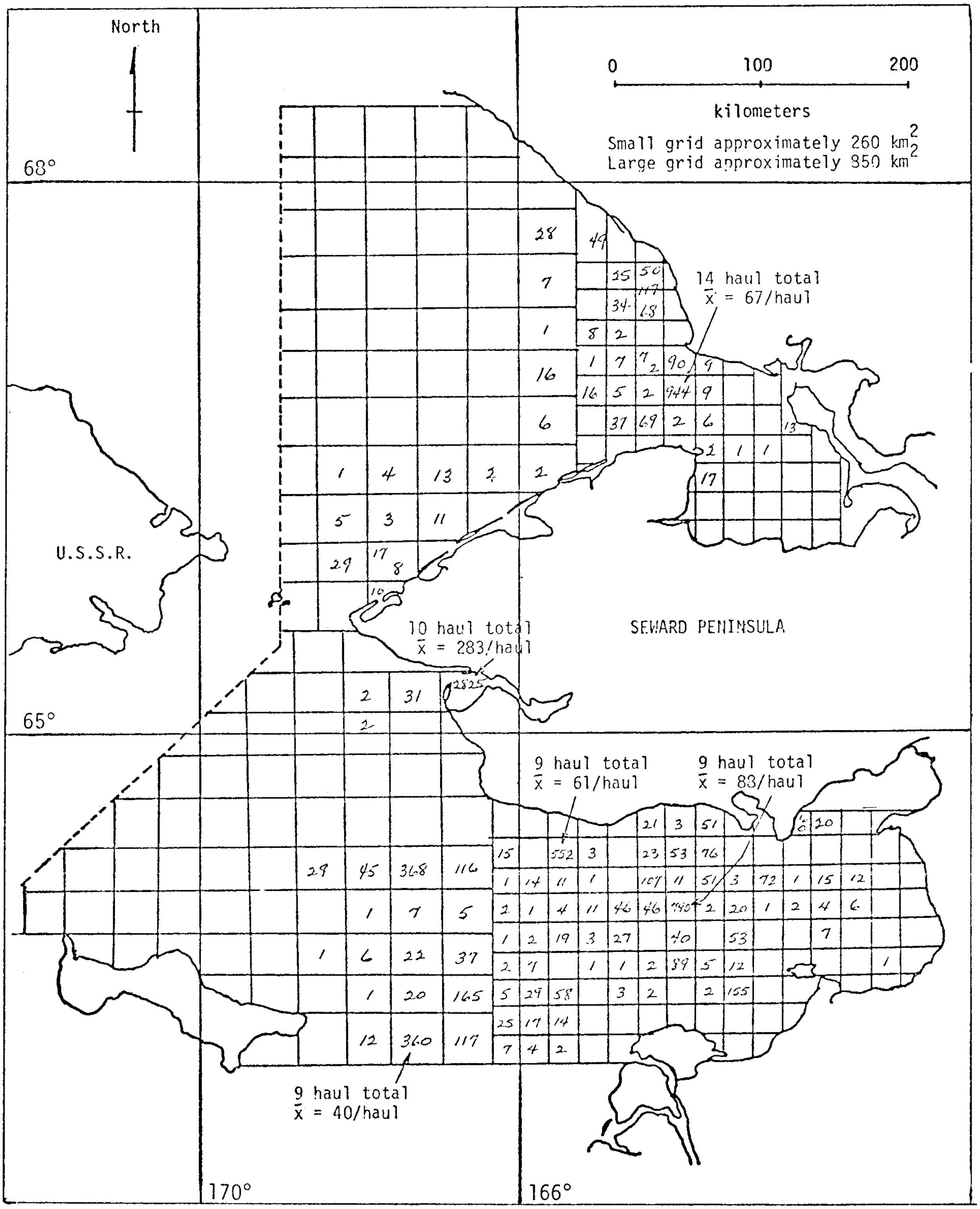

Figure 7. Location and size of boreal smelt 30 minute demersal trawl catches during the M/V Miller Freeman cruise from September 2 through October 9, 1976.

Table 8. Age, weight and length data collected for all salmon catches made aboard the Miller Freeman cruise (R.U.175) in the Northern Bering Sea and Southern Chukchi Sea, September 24 to October 9, 1976.

Species	Leg of Cruise	Capture Date	Station	Sex	Length 1/ (mm)	Weight (gms)	Age	Mesh Size (mm)
King	II	10/7	C-31 2/	F	779	6,700	1.3 (5_2)	Demersal Trawl
*King	I	9/3	1	-	183	53	1.0 (2_2)	35
*King	I	9/3	1	-	221	133	1.0 (2_2)	42
*King	II	10/5	31	-	226	121	2.0 (3_3)	42
Chum	I	9/3	1	F	560	2,800	0.2 (3_1)	64
Chum	I	9/6	4	F	605	3,550	0.3 (4_1)	133
Chum	I	9/13	8	M	610	3,600	0.3 (4_1)	133
Chum	II	9/29	23	F	610	3,600	0.3 (4_1)	114
Chum	II	10/8	32	M	636	4,200	0.4 (5_1)	114
*Chum	I	9/3	1	-	178	53	0.0 (1_1)	35
*Chum	I	9/6	4	-	188	72	0.0 (1_1)	42
*Pink 3/	I	9/3	1	-	168	56	0.0 (1_1)	35
*Pink	I	9/6	4	-	155	35	0.0 (1_1)	35
*Pink	I	9/6	4	-	195	77	0.0 (1_1)	35
*Pink	I	9/6	4	-	dismembered	59	0.0 (1_1)	35
*Pink	I	9/6	4	-	203	80	0.0 (1_1)	42
*Pink	I	9/5	3	-	105	11	0.0 (1_1)	21
*Pink	II	10/4	29	-	225	121	0.0 (1_1)	35

1/ Adults measured from mid-eye to fork of tail. Juveniles measured from tip of snout to fork of tail.

2/ Captured in demersal trawl. All other catches shown are from gillnets.

3/ May have been juvenile chum salmon.

* Signifies juvenile fish.

In general, herring were the most important as a subsistence item in 1976 in Norton Sound as opposed to Kotzebue Sound. Use by village appeared to decrease in a northerly direction, with greatest herring harvests occurring in the St. Michael area and utilization at Point Hope nil.

Most local residents throughout the study area indicated that herring subsistence utilization has decreased from previous years for three major reasons: 1) lack of dog teams, many of which have been replaced with snowmachines; 2) employment opportunities and 3) fewer numbers of herring. Most local residents agreed that foreign fishing effort has reduced herring populations from previous years. Barton (1977) states this view was also shared by coastal residents on the west coast residing below the Yukon River Delta. Barton also documented the use of herring as a subsistence item to local residents in that area in 1976. It is apparent that herring were more important as a subsistence item to local residents living below the Yukon River Delta than to those residents in Norton Sound and Kotzebue Sound. This difference in herring subsistence utilization may possibly be explained by the extensive marine mammal hunting conducted north of the Yukon River, particularly in Kotzebue Sound. A second factor which may explain the difference in use between areas north and south of the Yukon River is the lack of big game animals in the area of greatest herring subsistence use (i.e., between the Kuskokwim and Yukon Rivers) as well as commercial salmon fishing restrictions.

Herring Aerial Surveys

Problems Encountered

Barton (1977) discussed two problems encountered during aerial surveys conducted under R.U.19 in 1976. The same problems were encountered during these investigations (R.U.19E). The first stemmed from the requirement that latitudes and longitudes of individual fish schools be recorded onto the data management format. It was logistically impossible to record the latitude and longitude of each individual school when large concentrations of several schools were encountered in a given area. Therefore, the surface area of aggregate schools on many occasions was estimated from analysis of 35mm slides and thus entered as a single school (observation) along with a corresponding latitude and longitude.

A second problem of equal magnitude associated with aerial surveys was determining species idenity of many fish schools. This problem was especially realized during the course of this study as no float or amphibious plane service was available north of the Yukon River Delta, thus, eliminating the possibility of landing on many occasions to varify species idenity. This was expecially true on surveys conducted north of Nome, around the Seward Peninsula where no ground surveys were being conducted. Consequently, most fish schools observed in this vicinity were documented as forage fish species unknown (Figure 5).

Spatial and Temporal Considerations

Due to inclement weather conditions in 1976, all aerial surveys were flown on an opportunistic basis and thus timing of spawning activity and documentation of all spawning habitats throughout the study area from the Yukon River Delta to Point Hope was not obtained for all herring populations. However, it is felt that important herring spawning areas were documented through literature searches, aerial surveys, ground surveys and interviews with many local residents. This is particularly true in the Norton Sound area.

Results of OCS investigations revealed that herring spawn throughout most of Norton Sound during the spring and early summer (late May through July), with the greatest concentrations occurring along the southeastern shore from Stuart Island to Unalakleet. The first record of herring spawning in 1976 was reported in St. Michael Bay on June 15. Spawning has been recorded as early as May 30 in this area (ADF&G files), being greatly dependent upon ice breakup conditions. Alaska Department of Fish and Game files indicate that the greatest herring spawning activity in Norton Sound occurs usually from June 1-14.

A sample of sexually mature herring were taken in Golovin Bay in late May of 1976 by a commercial processor to be checked for oil content and egg quality. A 14.3 percent egg recovery rate was obtained. At least two waves of herring were documented to spawn at Cape Denbigh in 1976. Spawn was observed on June 20 and June 30 on the south side of the Cape. Observations made on herring between Bald Head and Cape Darby in 1976 revealed large concentrations present on July 15.

It is interesting to note that most subsistence fishing for herring in Norton Sound as well as areas below the Yukon River (Barton, 1977) occurs on spring spawning runs from late May through mid-July which usually appear immediately following ice breakup. However, a fall run of herring is known to occur in Golovin Bay, along the coast of the Seward Peninsula, and in Kotzebue Sound and may occur in other areas. Examination of fall herring specimens taken from Golovin Bay in mid-October, 1963, revealed that the reproductive organs were relatively undeveloped and it is suspected that this run does not spawn in the fall (ADF&G files). Herring of this run are of prime quality, the flesh being firm and of high oil content. A number of fishermen from Golovin Bay northwards to Kotzebue utilize herring of this run.

Over 100 schools of unidentified fish were observed from Nome to Grantley Harbor on July 21. No spawning was observed and the fish were believed to be herring based upon timing information obtained from local resident interviews and ADF&G files. Alt (1971) captured herring in July, 1970, in Imuruk Basis. A survey of the coastline from Nome to Shishmaref on July 25, 1976 resulted in no observations of herring south of Wales, but 23 unidentified schools were observed from Wales to Shishmaref Lagoon (believed to be herring).

Indications are that herring are widely distributed throughout the coastal and offshore waters of Norton Sound and Kotzebue Sound in the fall and early winter months. This is not only evident from local resident interviews, but also is supported from the demersal trawl catches of herring during the Miller Freeman cruise in September and October, 1976. Herring were found in the stomachs of sheefish captured in Hotham Inlet as late as November 25 in 1963 (ADF&G files).

Relative Abundance

It has already been stated that local residents reported that herring abundance has declined from previous levels. Results of aerial surveys conducted by ADF&G biologists also indicate a decline in spawning populations in Norton Sound. A total of 236 and 137 schools were observed along beaches between St. Michael and Unalakleet during 1968 and 1972, respectively (Table 9). During 1975 and 1976 aerial surveys were intensified, particularly in 1976 when OCS funding was made available. Not more than 10 schools were observed in either year in the same area. A similar trend is indicated for surveys made at Cape Denbigh. Similar comparative data is not available for other spawning areas in the study area.

Pelagic Finfish Surveys

Nearshore Sampling

Sampling the nearshore waters of Norton Sound from St. Michael to Cape Denbigh was initiated on June 17, and in Golovin Bay sampling did not begin prior to July 3. These late start-up difficulties stemmed from late funding of R.U.19E and consequently, more than three to four weeks of sampling the open water areas immediately following ice breakup was not accomplished. State of Alaska standard operational procedures in reference to receiving and spending Federal funds, purchase calendar deadlines and contract award vendors had to be adhered to. This in turn resulted in late arrival of boats and large quantities of sampling equipment and supplies. Boats had to be fabricated and all equipment purchased, assembled and shipped to remote locations. It is felt that valuable information, perhaps during the most critical time of the year, was not obtained, particularly in reference to movement patterns of juvenile salmon.

Both the Unalakleet and Golovin Bay crews fished beach seines as well as gillnets and the former proved vital for capturing juvenile salmonids as well as other small fish. Small catches of juvenile salmon (primarily pink followed in order by chum and king) were experienced by these crews, but only up until early to mid-July. The Unalakleet crew saw a peak in these catches about the first week in July while small catches were made in Golovin Bay from July 7 through about July 19. None were captured after these dates suggesting juveniles had migrated to other coastal areas or deeper water by this time.

Ice was still in the Yukon River on May 31 and did not move out until June 1. At that time Sheldon Point was iced in, but sampling could have begun on that date. The Flat Island OCS crew commenced sampling operations with gillnets on June 16, and sampling with the hand purse seines did not begin prior to its arrival in the first week of July. Consequently, several weeks of critical sampling was lost in this area, again due to late arrival of equipment. With the exception of one juvenile king salmon captured in a gill net, hand purse seines were the only gear fished which captured juvenile fish.

Large Vessel Sampling

Gillnet operations conducted during the Miller Freeman cruise were highly unproductive. Catches were small, ranging from about 55-60 fish

Table 9 . Aerial Survey counts of herring schools observed along Norton Sound beaches

Date	St. Michael to Unalakleet				
	Small 1/	Medium 2/	Large 3/	Total	Survey Conditions
6/18/68*	155	63	18	236	Fair
6/20/72*	99	35	3	137	Fair
6/7/74*	9	9	3	21	Poor - Fair
6/27/75*	0	0	0	0	Good
6/10/76* 4/	0	3	0	3	Fair
6/26/76*	7	3	0	10	Fair
	Cape Denbigh (Southside)				
6/16/72	6	7	5	18	Fair
6/10/75	6	0	1	7	Good
7/5/75	4	3	4	11	Good
6/20/76	0	0	0	0	-
6/26/76	1	1	1	3	Fair
6/30/76*	0	8	0	8	Fair

* Indicates spawning activity was observed in addition to herring schools.

1/ Estimate of school surface area: less than $50M^2$.

2/ $50\text{-}450M^2$.

3/ Greater than $450M^2$.

4/ Species of sighted schools unknown.

to no catch. The small catches can be at least partially attributed to two problems. The first stemmed from gear damage or loss arising from weakly constructed gillnets for high seas sampling. Float lines stretched under extreme tension upon retrieval, thus causing the webbing to rip, especially on the smaller mesh shackles. This gear damage reduced the number and sizes of shackles fished as the cruise progressed. The monofilament gillnets were extremely difficult to repair.

A second problem arose from differing total soak times of various mesh sizes due to collapsed sets (i.e., gear did not always remain completely stretched out).

These problems make a valid comparison of the relative efficiency for each gillnet mesh size and a statement on distribution or abundance of species collected impossible.

CONCLUSIONS

There are none at this time.

NEEDS FOR FURTHER STUDY

The needs for further study on the fishery resources in Norton Sound and Kotzebue Sound are many. Late funding of RU 19E in FY76 resulted in start-up difficulties in the inshore waters. A most critical time of year, the first few weeks of open water following ice breakup, was not sampled. Consequently, timing and routes of juvenile salmon migrations as well as age and growth information was not obtained. Temporal comparisons of fish species is not possible with only a single season of sampling effort. No inshore studies for pelagic fishes was conducted in Kotzebue Sound in FY76 due to the size of the study area and funding levels. Port Clarence and other sections along the Seward Peninsula were not included in the study area during 1976. Studies are desperately needed in Port Clarence, Grantley Harbor and the Imuruk Basin area as they potentially exist as a high impact area from oil development. Port Clarence is the only large vessel deep water harbor north of Dutch Harbor. Consequently, it exists as a potentially important staging or refueling stop for large vessels associated with oil activities.

More studies are needed to accurately document all primary spawning areas for herring and other forage fish populations. This could not be accomplished in a single season of sampling due to inclement weather conditions common throughout the study area, apparent annual fluctuations in herring abundance and timing of spawning activity. Large area synoptic surveys are still warranted, but continuing programs in specific areas of importance are also needed. Age structures should be monitored prior to oil activities in order to properly assess potential changes in herring population structures after development. Herring egg and larval development, distribution and migrations need to be studied and documented as well as the extent of any offshore spawning. Reid (undated) points out that environmental conditions during the early life stages of herring account for much of the fluctuations and population abundance. The effects of oil contaminants on primary herring spawning substrates e.g., *Fucus* and *Zosteria* species, should be assessed.

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APPENDIX TABLES

Table 1. Census areas from the Yukon River Delta to Point Hope, R.U. 19E, 1976.

Census Areas				Linear Shoreline Distance		Census Area 1/ Mid Point (km)
Area	No.	North* Latitude	West* Longitude	Miles	km	
Black River-North Mouth Yukon River	31	63°08'30"	164°33'50"	120.0	193.0	96.5
North Mouth Yukon River-Canal Point	32	63°12'30"	162°47'20"	40.9	65.8	32.9
Canal Point-Cape Stebbins	33	63°28'40"	162°18'00"	12.3	19.8	9.9
Stuart Island	34	63°33'05"	162°20'30"	41.9	67.5	Perimeter
Cape Stebbins-St. Michael	35	63°30'50"	162°08'00"	15.5	25.0	12.5
St. Michael- Klikitarik	36	63°27'05"	161°57'05"	18.3	29.5	14.8
Klikitarik-Unalakleet River	37	63°37'30"	161°01'00"	40.4	65.0	32.5
Unalakleet River-Cape Denbigh	38	64°13'45"	160°58'15"	52.8	85.0	42.5
Cape Denbigh-Bald Head	39	64°38'40"	160°47'30"	80.8	130.0	65.0
Bald Head-Cape Darby	40	64°41'10"	162°08'10"	70.5	113.5	56.8
Cape Darby-South Spit	41	64°36'10"	163°06'00"	55.9	90.0	45.0
South Spit-Topkok Head	42	64°30'20"	163°20'35"	36.0	58.0	29.0
Topkok Head-Point Spencer	43	64°30'00"	165°24'20"	94.4	152.0	76.0
Point Spencer-Cape Prince of Wales	44	65°18'40"	166°17'54"	124.3	200.0	100.0
Cape Prince of Wales-Cape Espenberg	45	66°15'50"	166°04'00"	149.1	240.0	120.0
Cape Espenberg-Kiwalik	46	66°07'10"	163°51'00"	127.4	205.0	102.5
Kiwalik-Point Garnet(Choris Pen.)	47	66°11'35"	160°59'30"	90.1	145.0	72.5
Point Garnet - Selawik Lake entrance	48	66°56'15"	162°31'20"	119.6	192.5	96.3
Selawik Lake entrance-Sheshalik	49	67°00'40"	161°38'50"	111.8	180.0	90.0
Sheshalik-Point Hope	50	67°43'25"	164°36'00"	149.1	240.0	120.0
Total	31-50			1,551.1	2,496.6	

1/ Linear shoreline distance on either side of census area mid point.

* Latitude and Longitude of mid point of census area.

Table 2. Sampling effort and catch results by area, gear type and sampling period in the nearshore waters of Norton Sound, 1976.

Area	Sample Period	Gear[1/] Type	Total Number Sample Stations	Total Number of Sets	Effort[2/] Negative	Effort[2/] Total	Total Catch	Total CPUE[3/]	Number of Species
Golovin Bay (AREA A)	I	GN							
	6/22-7/6	BS							
	II	GN	10	31	8.0	33.4	105	3.1	14
	7/7-7/21	BS	9	15	2	15	5,921	394.7	17
	III	GN	11	16	3.2	16.3	63	3.9	11
	7/22-8/6	BS	9	8	0	8	4,985	623.1	13
	IV	GN	10	26	8.0	26.0	63	2.4	11
	8/7-8/21	BS	9	13	0	13	3,989	306.8	18
	V	GN	13	28	9.8	29.8	67	2.2	9
	8/22-9/6	BS	9	16	1	16	6,314	394.6	16
	VI	GN	10	21	6.0	21.6	70	3.2	12
	9/7-9/21	BS	9	10	1	10	785	78.6	13
Cape Denbigh to Egavik (AREA B)	I	GN	6	9	1.5	12.2	260	21.3	13
	6/22-7/6	BS	6	3	0	3	58	19.3	5
	II	GN	6	14	1.1	15.1	88	5.8	11
	7/7-7/21	BS	6	7	0	7	145	20.7	10
	III	GN	6	12	0	13.6	162	11.9	14
	7/22-8/6	BS	6	6	0	6	478	79.7	13
	IV	GN	6	12	1.0	14.0	55	3.9	13
	8/7-8/21	BS	6	3	0	3	266	88.7	10
	V	GN	6	12	2.1	15.4	47	3.1	12
	8/22-9/6	BS	6	5	0	5	244	48.8	12
	VI	GN							
	9/7-9/21	BS							
Egavik to Tolstoi Point (AREA C)	I	GN	7	10	0	11.0	167	15.2	10
	6/22-7/6	BS	7	8	0	8	84	10.5	15
	II	GN	7	15	0	16.0	291	18.2	16
	7/7-7/21	BS	7	8	0	8	979	122.4	15
	III	GN	7	10	2.4	9.9	43	4.3	10
	7/22-8/6	BS	7	6	0	6	2,813	468.8	17
	IV	GN	7	14	2.8	18.1	193	10.7	12
	8/7-8/21	BS	7	5	0	5	527	105.4	12
	V	GN	7	14	1.4	20.1	58	2.9	13
	8/22-9/6	BS	7	7	0	7	852	121.7	14
	VI	GN	7	10	2.1	11.5	44	3.8	[illegible]
	9/7-9/21	BS	7	2	0	2	117	58.5	10
Tolstoi Point to Cape Stebbins (AREA D)	I	GN							
	6/22-7/6	BS							
	II	GN	11	26	7.0	26.0	115	4.4	14
	7/7-7/21	BS							
	III	GN	11	24	5.0	24.0	75	3.1	12
	7/22-8/6	BS							
	IV	GN	11	50	15.0	50.0	82	1.6	12
	8/7-8/21	BS							
	V	GN							
	8/22-9/6	BS							
	VI	GN							
	9/7-9/21	BS							

1/ GN - gillnet; BS - beach seine.
2/ Effort for gillnets is total number of hours fished; effort for beach seines is total number of good sets.
3/ CPUE for gillnets is number of fish per net hour; CPUE for beach seines is number of fish per good set.

Table 3. Total catch by species, gear type and area of finfish captured from Cape Stebbins to Bluff from June 17 through September 22, 1976.1/

Species	A		B		C		D		E		F		Totals	
	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN
Pink salmon	78	26	55	65	2	48	0	2	1	0	0	0	136	141
Chum salmon	7	8	0	5	15	5	0	2	0	0	0	0	22	20
King salmon	3	0	0	1	20	0	0	0	0	0	0	0	23	1
Coho salmon	0	1	0	3	0	2	0	2	2	0	0	0	2	8
Arctic char	5	30	4	21	1	44	0	14	4	1	0	2	14	112
Humpback whitefish	9	14	0	2	14	13	0	4	0	0	0	0	23	33
Broad whitefish	104	33	0	0	16	1	0	1	31	3	0	0	151	38
Round whitefish	0	0	0	0	21	1	0	0	0	0	0	0	21	1
Bering cisco	154	23	59	36	156	66	0	25	0	0	0	0	369	150
Least cisco	410	65	7	11	44	12	0	40	0	3	0	0	461	131
Saffron cod	959	81	121	59	634	57	0	46	0	0	3	9	1,717	252
Starry flounder	61	53	40	19	46	42	0	15	5	0	0	0	152	129
Arctic flounder	21	6	36	133	72	35	0	0	0	0	0	0	129	174
Alaska plaice	1	0	2	0	1	0	0	0	0	0	0	0	4	0
Longhead dab	0	0	1	2	0	1	0	0	0	0	0	0	1	3
Yellowfin sole	2	3	1	5	0	14	0	11	0	0	0	0	3	33
Sturgeon poacher	0	2	0	0	0	0	0	1	0	0	0	0	0	3
Tubenose poacher	48	0	5	0	8	0	0	0	0	0	0	0	61	0
Bering poacher	5	2	109	0	59	8	0	1	0	0	0	0	173	11
Pacific herring	0	3	97	168	2	131	0	75	0	0	0	0	99	377
Capelin	0	0	0	0	2	0	0	0	0	0	0	0	2	0
Boreal smelt	1,155	1	509	57	2,937	282	0	17	0	0	130	0	4,731	357
Sandlance	16,913	0	0	0	0	0	0	0	0	0	77	0	16,990	0
Pond smelt	0	0	57	7	1,196	1	0	1	0	0	0	0	1,253	9
Ninespine stickleback	46	0	36	1	23	1	0	0	179	0	0	0	284	2
Threespine stickleback	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Whitespotted greenling	1	16	0	1	0	1	0	0	0	0	0	0	1	18
Rock greenling	0	1	0	0	3	4	0	11	0	0	0	0	3	16
Ringtail snailfish	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Sculpins	11	0	11	1	32	1	0	3	2	0	0	0	56	5
Pricklebacks	0	0	13	14	65	26	0	1	0	0	6	0	84	41
Unidentified larval fish	2,001	0	25	1	0	0	0	0	1	0	0	0	2,027	1
Unidentified bony fish	0	0	3	0	1	0	0	0	509	0	0	0	513	0
TOTALS	21,995	368	1,191	612	5,371	796	0	272	734	7	216	11	29,507	2,066

1/ Sampling areas are as follows:
AREA A - Golovin Bay
AREA B - Cape Denbigh to Egavik
AREA C - Egavik to Tolstoi Point
AREA D - Tolstoi Point to Cape Stebbins
AREA E - Fish River mouth
AREA F - Cape Darby to Bluff

Table 4. Total catch by species, gear type and sampling period of finfish captured in Golovin Bay from July 3 through September 21, 1976.1/

Species	I		II		III		IV		V		VI		Totals	
	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN
Pink salmon			78	25	0	1	0	0	0	0	0	0	78	26
Chum salmon			7	8	0	0	0	0	0	0	0	0	7	8
King salmon			3	0	0	0	0	0	0	0	0	0	3	0
Coho salmon			0	0	0	0	0	1	0	0	0	0	0	1
Arctic char			0	1	0	8	1	10	4	7	0	4	5	30
Humpback whitefish			1	5	1	3	6	1	1	3	0	2	9	14
Broad whitefish			9	5	12	3	60	11	9	3	14	11	104	33
Round whitefish			0	0	0	0	0	0	0	0	0	0	0	0
Bering cisco			9	6	8	2	50	1	39	6	48	8	154	23
Least cisco			1	16	94	18	301	6	6	17	8	8	410	65
Saffron cod			25	24	22	16	480	4	384	16	48	21	959	81
Starry flounder			12	6	9	4	6	25	22	11	12	7	61	53
Arctic flounder			3	1	8	3	1	1	4	0	5	1	21	6
Alaska plaice			0	0	0	0	1	0	0	0	0	0	1	0
Longhead dab			0	0	0	0	0	0	0	0	0	0	0	0
Yellowfin sole			0	1	0	0	0	2	2	0	0	0	2	3
Sturgeon poacher			0	1	0	1	0	0	0	0	0	0	0	2
Tubenose poacher			12	0	5	0	15	0	14	0	2	0	48	0
Bering poacher			1	0	0	0	1	0	2	0	1	2	5	2
Pacific herring			0	1	0	0	0	0	0	0	0	2	0	3
Capelin			0	0	0	0	0	0	0	0	0	0	0	0
Boreal smelt			69	0	90	0	446	0	513	1	37	0	1,155	1
Sandlance			4,907	0	4,712	0	1,482	0	5,262	0	550	0	16,913	0
Pond smelt			0	0	0	0	0	0	0	0	0	0	0	0
Ninespine stickleback			1	0	17	0	16	0	9	0	3	0	46	0
Threespine stickleback			0	0	0	0	1	0	0	0	0	0	1	0
Whitespotted greenling			0	5	0	4	1	1	0	3	0	3	1	16
Rock greenling			0	0	0	0	0	0	0	0	0	1	0	1
Ringtail snailfish			0	0	0	0	0	0	0	0	0	0	0	0
Sculpins			1	0	3	0	2	0	4	0	1	0	11	0
Pricklebacks			0	0	0	0	0	0	0	0	0	0	0	0
Unidentified larval fish			782	0	4	0	1,119	0	39	0	57	0	2,001	0
Unidentified bony fish			0	0	0	0	0	0	0	0	0	0	0	0
TOTALS			5,921	105	4,985	63	3,989	63	6,314	67	786	70	21,995	368

1/ Sampling periods were as follows: Period I - June 22 thru July 6; Period II - July 7 thru July 21; Period III - July 22 thru August 6; Period IV - August 7 thru August 21; Period V - August 22 thru September 6; Period VI - September 7 thru September 21.

Table 5. Total catch by species, gear type and sampling period of finfish captured from Cape Denbigh to Egavik from June 17 through September 1, 1976. 1/

Species	I		II		III		IV		V		VI		Totals	
	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN
Pink slamon	39	63	16	2	0	0	0	0	0	0			55	65
Chum salmon	0	3	0	0	0	1	0	0	0	1			0	5
King salmon	0	0	0	0	0	0	0	1	0	0			0	1
Coho salmon	0	0	0	0	0	0	0	2	0	1			0	3
Arctic char	0	0	0	1	0	3	0	5	4	12			4	21
Humpback whitefish	0	0	0	1	0	0	0	1	0	0			0	2
Broad whitefish	0	0	0	0	0	0	0	0	0	0			0	0
Round whitefish	0	0	0	0	0	0	0	0	0	0			0	0
Bering cisco	6	8	18	10	7	4	7	7	21	7			59	36
Least cisco	0	0	0	0	6	1	0	5	1	5			7	11
Saffron cod	0	23	15	9	90	7	2	11	14	9			121	59
Starry flounder	0	5	8	7	16	2	4	2	12	3			40	19
Arctic flounder	0	1	8	4	11	125	8	2	9	1			36	133
Alaska plaice	0	0	0	0	2	0	0	0	0	0			2	0
Longhead dab	1	1	0	0	0	1	0	0	0	0			1	2
Yellowfin sole	0	3	1	1	0	1	0	0	0	0			1	5
Sturgeon poacher	0	0	0	0	0	0	0	0	0	0			0	0
Tubenose poacher	0	0	1	0	3	0	1	0	0	0			5	0
Bering poacher	0	0	0	0	26	0	83	0	0	0			109	0
Pacific herring	0	144	0	16	0	5	96	1	1	2			97	168
Capelin	0	0	0	0	0	0	0	0	0	0			0	0
Boreal smelt	10	6	72	36	296	8	58	5	73	2			509	57
Sandlance	0	0	0	0	0	0	0	0	0	0			0	0
Pond smelt	0	0	0	0	2	2	0	2	55	3			57	7
Ninespine stickleback	2	0	0	0	5	0	3	0	26	1			36	1
Threespine stickleback	0	0	0	0	0	0	0	0	0	0			0	0
Whitespotted greenling	0	0	0	0	0	1	0	0	0	0			0	1
Rock greenling	0	0	0	0	0	0	0	0	0	0			0	0
Ringtail snailfish	0	0	0	0	0	0	0	0	0	0			0	0
Sculpins	0	1	2	0	5	0	4	0	0	0			11	1
Pricklebacks	0	1	4	1	9	1	0	11	0	0			13	14
Unidentified larval fish	0	1	0	0	0	0	0	0	25	0			25	1
Unidentified bony fish	0	0	0	0	0	0	0	0	3	0			3	0
TOTALS	58	260	145	88	478	162	266	55	244	47			1,191	612

1/ Sampling periods were as follows: Period I - June 22 thru July 6; Period II - July 7 thru July 21; Period III - July 22 thru August 6; Period IV - August 7 thru August 21; Period V - August 22 thru September 6; Period VI - September 6 thru September 21.

Table 6. Total catch by species, gear type and sampling period of finfish captured from Egavik to Tolstoi Point from June 17 through September 1, 1976.1/

Species	I		II		III		IV		V		VI		Totals	
	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN
Pink salmon	0	0	2	48	0	0	0	0	0	0	0	0	2	48
Chum salmon	11	1	4	3	0	0	0	1	0	0	0	0	15	5
King salmon	19	0	1	0	0	0	0	0	0	0	0	0	20	0
Coho salmon	0	0	0	0	0	0	0	0	0	1	0	1	0	2
Arctic char	1	1	0	4	0	0	0	11	0	18	0	10	1	44
Humpback whitefish	9	0	0	10	1	2	0	0	0	1	4	0	14	13
Broad whitefish	2	0	1	1	0	0	3	0	10	0	0	0	16	1
Round whitefish	1	0	19	0	1	0	0	1	0	0	0	0	21	1
Bering cisco	1	8	7	34	17	4	27	7	96	10	8	3	156	44
Saffron cod	0	10	28	16	205	2	154	4	189	6	58	19	634	57
Starry flounder	4	5	7	27	11	7	8	3	6	0	10	0	46	42
Arctic flounder	1	9	25	7	25	2	5	5	5	6	11	6	72	35
Alaska plaice	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Longhead dab	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Yellowfin sole	0	0	0	3	0	0	0	9	0	2	0	0	0	14
Sturgeon poacher	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubenose poacher	1	0	0	0	5	0	1	0	1	0	0	0	8	0
Bering poacher	0	0	0	0	35	6	3	0	20	2	1	0	59	8
Pacific herring	0	87	0	38	1	6	0	0	1	0	0	0	2	131
Capelin	0	0	2	0	0	0	0	0	0	0	0	0	2	0
Boreal smelt	23	42	858	78	1,295	9	307	146	445	6	9	1	2,937	282
Sandlance	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pond smelt	0	0	0	0	1,182	0	4	0	10	0	0	1	1,196	1
Ninespine stickleback	8	0	0	0	5	0	0	0	9	1	1	0	23	1
Threespine stickleback	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Whitespotted greenling	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Rock greenling	1	0	0	1	2	0	0	0	0	2	0	1	3	4
Ringtail snailfish	0	0	0	0	0	0	1	0	0	0	0	0	1	0
Sculpins	0	1	1	0	7	0	5	0	7	0	12	0	32	1
Pricklebacks	0	0	4	17	19	3	9	3	33	2	0	1	65	26
Unidentified larval fish	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified bony fish	1	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	84	167	979	291	2,813	43	527	193	852	58	117	44	5,371	796

1/ Sampling periods were as follows: Period I - June 22 thru July 6; Period II - July 7 thru July 21; Period III - July 22 thru August 6; Period IV - August 7 thru August 21; Period V - August 22 thru September 6; Period VI - September 7 thru September 21.

Table 7. Total catch of finfish captured in variable mesh gillnets from Tolstoi Point to Cape Stebbins from June 17 through August 23, 1976.[1/]

Species	I		II		III		IV		V		VI		Totals	
	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN
Pink salmon				2		0		0						2
Chum salmon				2		0		0						2
King salmon				0		0		0						0
Coho salmon				0		0		2						2
Arctic char				0		6		8						14
Humpback whitefish				2		1		1						4
Broad whitefish				1		0		0						1
Round whitefish				0		0		0						0
Bering cisco				4		6		15						25
Least cisco				15		8		17						40
Saffron cod				26		11		9						46
Starry flounder				0		4		11						15
Arctic flounder				0		0		0						0
Alaska plaice				0		0		0						0
Longhead dab				0		0		0						0
Yellowfin sole				4		1		6						11
Sturgeon poacher				1		0		0						1
Tubenose poacker				0		0		0						0
Bering poacher				0		1		0						1
Pacific herring				42		27		6						75
Capelin				0		0		0						0
Boreal smelt				12		4		1						17
Sandlance				0		0		0						0
Pond smelt				1		0		0						1
Ninespine stickleback				0		0		0						0
Threespine stickleback				0		0		0						0
Whitespotted greenling				0		0		0						0
Rock greenling				1		5		5						11
Ringtail snailfish				0		0		0						0
Sculpins				2		0		1						3
Pricklebacks				0		1		0						1
Unidentified larval fish				0		0		0						0
Unidentified bony fish				0		0		0						0
TOTALS				115		75		82						272

1/ Sampling periods were as follows: Period I - June 22 thru July 6; Period II - July 7 thru July 21; Period III - July 22 thru August 6; Period IV - August 7 thru August 21; Period V - August 22 thru September 6; Period VI - September 7 thru September 21.

Table 8 . Total catch by species, gear type and sampling period of finfish captured from Cape Darby to Bluff from July 3 through September 21, 1976. 1/

Species	I		II		III		IV		V		VI		Totals	
	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN
Arctic char					0	2			0	0			0	2
Saffron cod					3	7			0	2			3	9
Boreal smelt					130	0			0	0			130	0
Sandlance					77	0			0	0			77	0
Pricklebacks					6	0			0	0			6	0
TOTALS					216	9			0	2			216	11

1/ Sampling periods were as follows: Period I - June 22 thru July 6; Period II - July 7 thru July 21; Period III - July 22 thru August 6; Period IV - August 7 thru August 21; Period V - August 22 thru September 6; Period VI - September 7 thru September 21.

Table 9 . Total catch by species, gear type and sampling period of finfish captured in Fish River from July 3 through September 21, 1976. 1/

Species	I		II		III		VI		V		VI		Totals	
	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN	BS	GN
Pink salmon			0	0	0	0	1	0					1	0
Coho salmon			0	0	0	0	2	0					2	0
Arctic char			0	0	0	0	4	1					4	1
Broad whitefish			0	2	0	0	31	1					31	3
Least cisco			0	3	0	0	0	0					0	3
Saffron cod			0	0	0	0	0	0					0	0
Starry flounder			0	0	2	0	3	0					5	0
Ninespine stickleback			0	0	13	0	166	0					179	0
Sculpins			0	0	0	0	2	0					2	0
Unidentified larval fish			0	0	1	0	0	0					1	0
Unidentified bony fish			0	0	0	0	509	0					509	0
TOTALS			0	5	16	0	718	2					734	7

1/ Sampling periods same as shown in above Table.

Table 10. Most frequently occurring species of finfish in percent captured in Norton Sound by sampling period, area and gear type, 1976.

Sample Period	GOLOVIN BAY species	%	CAPE DENBIGH - EGAVIK species	%	EGAVIK - TOLSTOI POINT species	%	TOLSTOI POINT - CAPE STEBBINS species	%
				BEACH SEINE				
I			pink salmon*	100	humpback whitefish	50		
6/22 -			Bering cisco	67	boreal smelt	50		
7/6			boreal smelt	67	9sp stickleback	38		
II	sandlance	60	boreal smelt	86	boreal smelt	88		
7/7 -	starry flounder	53	Bering cisco	57	saffron cod	75		
7/21	larval fish 1/	47	Arctic flounder	43	Arctic flounder	50		
III	Bering cisco	50	starry flounder	83	boreal smelt	100		
7/22 -	starry flounder	50	saffron cod	67	Bering cisco	100		
8/6	Arctic flounder	50	Bering cisco	67	saffron cod	100		
	larval fish 1/	50	boreal smelt	67				
IV	larval fish 1/	62	boreal smelt	100	saffron cod	100		
8/7 -	broad whitefish	54	Bering cisco	67	boreal smelt	100		
8/21	Bering cisco	54	Arctic flounder	67	starry flounder	80		
	boreal smelt	54	Bering poacher	67				
	sandlance	54						
V	Bering cisco	56	Bering cisco	60	boreal smelt	86		
8/22 -	starry flounder	50	Arctic flounder	40	saffron cod	71		
9/6	boreal smelt	44	boreal smelt	40	Bering cisco	71		
			9sp stickleback	40				
VI	Bering cisco	70			Bering cisco	100		
9/7 -	boreal smelt	60			saffron cod	100		
9/21	saffron cod	50			Arctic flounder	100		
	starry flounder	50			sculpins	100		
	sandlance	50						
				GILLNET				
I			Pacific herring	67	Pacific herring	60		
6/22 -			saffron cod	56	Bering cisco	50		
7/6			boreal smelt	44	boreal smelt	50		
			Bering cisco	44	saffron cod	50		
			pink salmon	44				
II	least cisco	35	boreal smelt	43	saffron cod	47	Pacific herring	35
7/7 -	saffron cod	29	Pacific herring	36	Bering cisco	40	least cisco	31
7/21	chum salmon	19	Bering cisco	36	boreal smelt	40	saffron cod	27
III	saffron cod	31	saffron cod	42	starry flounder	50	Pacific herring	42
7/22 -	least cisco	25	Bering cisco	33	Bering poacher	30	least cisco	25
8/6	Arctic char	19	Arctic char	25	boreal smelt	30	saffron cod	25
	starry flounder	19						
	Arctic flounder	19						
	wtsp. greenling	19						
IV	starry flounder	35	saffron cod	42	Arctic char	43	Bering cisco	22
8/7 -	Arctic char	19	least cisco	33	Bering cisco	29	least cisco	20
8/21	broad whitefish	15	pricklebacks	33	boreal smelt	29	starry flounder	16
V	least cisco	32	Bering cisco	42	Arctic char	36		
8/22 -	saffron cod	29	saffron cod	33	Bering cisco	29		
9/6	starry flounder	29	Arctic char	33	saffron cod	29		
					Arctic flounder	29		
VI	saffron cod	38			Arctic char	40		
9/7 -	Bering cisco	24			saffron cod	40		
9/21	broad whitefish	24			Bering cisco	20		

1/ unidentified larval fish.

* indicates juvenile fish.

Table 11. The three most abundant species of finfish captured in Norton Sound by sampling period, area and gear type, 1976.

Sample Period	GOLOVIN BAY species	cpue	CAPE DENBIGH - EGAVIK species	cpue	EGAVIK - TOLSTOI POINT species	cpue	TOLSTOI POINT - CAPE STEBBINS species	cpue
				BEACH SEINE 1/				
I 6/22 - 7/6			pink salmon*	12.7	boreal smelt	2.9		
			boreal smelt*	3.3	king salmon*	2.3		
			Bering cisco	2.0	chum salmon*	1.4		
II 7/7 - 7/21	sandlance	327.1	boreal smelt	10.3	boreal smelt	107.3		
	boreal smelt	4.6	Bering cisco	2.6	saffron cod	3.5		
	saffron cod	1.7	pink salmon*	2.3	Arctic flounder	3.1		
III 7/22 - 8/6	sandlance	589.0	boreal smelt	49.3	boreal smelt	215.8		
	least cisco	11.8	saffron cod	15.0	pond smelt	197.0		
	boreal smelt	11.3	Bering poacher	4.3	saffron cod	34.2		
IV 8/7 - 8/21	sandlance	114.0	Pacific herring	32.0	boreal smelt	61.4		
	saffron cod	36.9	Bering poacher	27.7	saffron cod	30.8		
	boreal smelt	34.3	boreal smelt	19.3	Bering cisco	5.4		
V 8/22 - 9/6	sandlance	328.9	boreal smelt	14.6	boreal smelt	63.6		
	boreal smelt	32.1	pond smelt	11.0	saffron cod	27.0		
	saffron cod	24.0	9sp stickleback	5.2	Bering cisco	13.7		
VI 9/7 - 9/21	sandlance	55.0			saffron cod	29.0		
	saffron cod	4.8			sculpins	6.0		
	Bering cisco	4.8			Arctic flounder	5.5		
				GILLNET 1/				
I 6/22 - 7/6			Pacific herring	11.8	Pacific herring	7.9		
			pink salmon	3.8	boreal smelt	3.8		
			saffron cod	1.9	saffron cod	0.9		
II 7/7 - 7/21	saffron cod	0.7	boreal smelt	2.4	boreal smelt	4.9	Pacific herring	1.6
	pink salmon	0.7	Pacific herring	1.1	pink salmon	3.0	saffron cod	1.0
	least cisco	0.5	Bering cisco	0.7	Pacific herring	2.4	least cisco	0.6
III 7/22 - 8/6	least cisco	1.1	Arctic flounder	9.2	boreal smelt	0.9	Pacific herring	1.1
	saffron cod	1.0	boreal smelt	0.6	starry flounder	0.7	saffron cod	0.5
	Arctic char	0.5	saffron cod	0.5	Pacific herring	0.6	least cisco	0.3
IV 8/7 - 8/21	starry flounder	1.0	saffron cod	0.8	boreal smelt	8.1	Bering cisco	0.3
	Arctic char	0.4	pricklebacks	0.8	Arctic char	0.6	least cisco	0.3
	broad whitefish	0.4	Bering cisco	0.5	yellowfin sole	0.5	Arctic char	0.2
V 8/22 - 9/6	least cisco	0.6	Arctic char	0.8	Arctic char	0.9		
	saffron cod	0.6	saffron cod	0.6	Bering cisco	0.5		
	starry flounder	0.4	Bering cisco	0.5	saffron cod	0.3		
VI 9/7 - 9/21	saffron cod	1.0			saffron cod	1.7		
	broad whitefish	0.5			Arctic char	0.9		
	Bering cisco	0.4			Arctic flounder	0.5		

1/ Beach seine CPUE equals number of fish captured per seine set; Gillnet CPUE equals number of fish captured per net hour.

* indicates juvenile fish.

Table 12. The three most frequently occurring and abundant species of finfish captured with gillnets and beach seines in the nearshore waters of Norton Sound from June 17 through September 21, 1976.

Gear Type	GOLOVIN BAY		CAPE DENBIGH - EGAVIK		EGAVIK - TOLSTOI POINT		TOLSTOI POINT - CAPE STEBBINS	
			MOST FREQUENTLY OCCURRING 1/					
GILLNET	saffron cod	27	saffron cod	39	saffron cod	34	least cisco	24
	least cisco	25	Bering cisco	34	Bering cisco	32	Pacific herring	23
	starry flounder	24	boreal smelt	29	boreal smelt	30	saffron cod	19
BEACH SEINE	Bering cisco	50	boreal smelt	71	boreal smelt	83		
	sandlance	47	Bering cisco	63	saffron cod	67		
	starry flounder	45	Arctic flounder	38	Bering cisco	50		
			starry flounder	38				
			MOST ABUNDANT 2/					
GILLNET	saffron cod	0.6	Pacific herring	2.4	boreal smelt	3.3	Pacific herring	0.8
	least cisco	0.5	Arctic flounder	1.9	Pacific herring	1.5	saffron cod	0.5
	starry flounder	0.4	pink salmon	0.9 3/	Bering cisco	0.8	least cisco	0.4
			saffron cod	0.8				
BEACH SEINE	sandlance	272.8	boreal smelt	20.8	boreal smelt	81.4		
	boreal smelt	18.6	saffron cod	5.0	pond smelt	33.2		
	saffron cod	15.5	Bering poacher	4.5	saffron cod	17.6		

1/ Shown with percentages.

2/ Shown with catch per effort indices.

3/ Pink salmon juveniles accounted for 22%.

Table 13. Total catch by gear type for 16 species of finfish captured at Flat Island, 1976.

Species	Catch		
	Gillnet	Purse Seine	Total
Bering cisco	225	119 1/	344
Humpback whitefish	162	20	182
Sheefish	88	4	92
Chum salmon	68	2*	70
Northern sucker	57	5	62
Northern pike	24	--	24
Least cisco	26	10	36
Starry flounder	21	--	21
Pink salmon	11	6*	17
Burbot	4	12 2/	16
Broad whitefish	10	--	10
Boreal smelt	3	--	3
Arctic char	3	--	3
Ninespine stickleback	0	2	2
King salmon	1*	--	1
Coho salmon	1	--	1
Total	704	180	884

1/ Includes four juveniles
2/ Includes one juvenile
* All juveniles

Table 14. Catch per unit effort for selected species of finfish by sample period and season taken in beach seines in Norton Sound, 1976.

Sample Area	Species	Sample Period I	II	III	VI	V	VI	Total
GOLOVIN BAY	*BC	NOT FISHED	0.6	1.0	3.8	2.4	4.8	2.5
	LC		0.1	11.8	23.2	0.4	0.8	6.6
	SC		1.7	2.8	36.9	24.0	4.8	15.5
	***SF		0.8	1.1	0.5	1.4	1.2	1.0
	PH		0.0	0.0	0.0	0.0	0.0	0.0
	BS		4.6	11.3	34.3	32.1	3.7	18.6
	**SL		327.1	589.0	114.0	328.9	55.0	272.8
CAPE DENBIGH - EGAVIK	**BC	2.0	2.6	1.2	2.3	4.2	NOT FISHED	2.5
	LC	0.0	0.0	1.0	0.0	0.2		0.3
	SC	0.0	2.1	15.0	0.7	2.8		5.0
	***SF	0.0	1.1	2.7	1.3	2.4		1.7
	PH	0.0	0.0	0.0	32.0	0.2		4.0
	*BS	3.3	10.3	49.3	19.3	14.6		21.2
	AF	0.0	1.1	1.8	2.7	1.8		5.5
EGAVIK - TOLSTOI POINT	***BC	0.1	0.9	2.8	5.4	13.7	4.0	4.3
	LC	0.1	2.4	0.2	0.0	2.9	1.5	1.2
	SC	0.0	3.5	34.2	30.8	27.0	29.0	17.6
	**SF	0.5	0.9	1.8	1.6	0.9	5.0	1.3
	PH	0.0	0.0	0.2	0.0	0.1	0.0	0.1
	*BS	2.9	107.3	215.8 1/	61.4	63.6	4.5	81.6
	HO	0.0	0.0	197.0 2/	0.8	1.4	0.0	33.2
TOLSTOI POINT - CAPE STEBBINS		NO BEACH SEINING WAS CONDUCTED IN THIS AREA						

1/ This figure is 55.4 when subtracting one beach seine haul made inside the lagoon at Unalakleet. A total of 997 boreal smelt were taken in this one haul. The remaining catch for the season was 1,940 boreal smelt with no significant catches taken inside the lagoon.

2/ This figure is 0.3 when subtracting one beach seine haul made inside the lagoon at Unalakleet. A total of 1,184 boreal smelt were taken in this one haul. The remaining catch for the season was 8 boreal smelt with no significant catches taken inside the lagoon.

* Indicates the most frequently occurring species for the season.
** Indicates the second most frequently occurring species for the season.
*** Indicates the third most frequently occurring species for the season.

BC Bering cisco; LC Least cisco; SC Saffron cod; SF Starry flounder; PH Pacific herring; BS Boreal smelt; SL Sandlance; AF Arctic flounder; HO Pond smelt.

Table 15. Catch per unit effort for selected species of finfish by sample period and season taken in variable mesh gillnets in Norton Sound, 1976.

Sample Area	Species	Sample Period I	II	III	VI	V	VI	Total
GOLOVIN BAY	BC	NOT FISHED	0.2	0.1	0.04	0.2	0.4	0.2
	**LC		0.5	1.1	0.2	0.6	0.4	0.5
	*SC		0.7	1.0	0.2	0.6	1.0	0.6
	***SF		0.2	0.2	1.0	0.4	0.3	0.4
	PH		0.03	0.0	0.0	0.0	0.1	0.02
	BS		0.0	0.0	0.0	0.04	0.0	0.01
CAPE DENBIGH - EGAVIK	**BC	0.7	0.7	0.3	0.5	0.5	NOT FISHED	0.5
	LC	0.0	0.0	0.1	0.4	0.3		0.2
	*SC	1.9	0.6	0.5	0.8	0.6		0.8
	SF	0.4	0.5	0.1	0.1	0.2		0.3
	PH	11.8	1.1	0.4	0.1	0.1		2.4
	***BS	0.5	2.4	0.6	0.4	0.1		0.8
	AF	0.1	0.3	9.2	0.1	0.1		1.9
EGAVIK - TOLSTOI POINT	**BC	0.7	2.1	0.4	0.4	0.5	0.3	0.8
	LC	0.3	0.2	0.2	0.1	0.05	0.1	0.1
	*SC	0.9	1.0	0.2	0.2	0.3	1.7	0.6
	SF	0.5	1.7	0.7	0.2	0.0	0.0	0.5
	PH	7.9	2.4	0.6	0.0	0.0	0.0	1.5
	***BS	3.8	4.9	0.9	8.1	0.3	0.1	3.3
TOLSTOI POINT - CAPE STEBBINS	BC	NOT FISHED	0.2	0.3	0.3	NOT FISHED	NOT FISHED	0.3
	*LC		0.6	0.3	0.3			0.4
	***SC		1.0	0.5	0.2			0.5
	SF		0.0	0.2	0.2			0.2
	**PH		1.6	1.1	0.12			0.8
	BS		0.5	0.2	0.02			0.2

BC Bering cisco; LC Least cisco; SC Saffron cod; SF Starry flounder; PH Pacific herring; BS Boreal smelt; AF Arctic flounder.

* Indicates the most frequently occurring species for the season.
** Indicates the second most frequently occurring species for the season.
***Indicates the third most frequently occurring species for the season.

Table 16. Sample size, range, standard deviation and mean lengths (millimeters) of pelagic finfish captured in beach seines in Norton Sound, 1976.

Species	GOLOVIN BAY				CAPE DENBIGH - EGAVIK				EGAVIK - TOLSTOI POINT				TOLSTOI POINT - CAPE STEBBINS			
	n	range	$\bar{x}$	s	n	range	$\bar{x}$	s	n	range	$\bar{x}$	s	n	range	$\bar{x}$	s
pink salmon	17	36-66	52	9	53	30-130	63	23	2	100-110	105	5				
chum salmon	4	53-71	59	7					21	42-117	59	25				
king salmon	3	37-113	87	36					19	83-110	98	9				
coho salmon																
Arctic char	5	115-446	321	123	4	250-260	255	4	1	152						
humpback whitefish	9	20-416	295	126					10	105-430	326	81				
broad whitefish	102	62-420	131	83					16	75-325	132	78				
round whitefish									21	75-158	107	16				
Bering cisco	148	39-296	127	46	57	67-345	170	86	132	68-380	128	59				
least cisco	93	131-330	219	36	7	52-150	79	30	24	100-300	163	67				
saffron cod	236	23-302	78	46	75	60-340	185	72	311	45-297	120	58				
starry flounder	60	23-345	110	48	40	70-245	141	39	36	85-450	163	66				
Arctic flounder	20	23-265	84	54	36	40-225	104	55	73	44-260	109	50				
Alaska plaice	1	63			2	65-80	73	8	1	120			NO BEACH SEINES WERE			
longhead dab																
yellowfin sole	2	45-69	57	12	1	175							FISHED IN THIS AREA			
sturgeon poacher																
tubenose poacher	46	25-115	67	17	4	50-102	79	21	8	35-147	109	35				
Bering poacher	4	25-99	67	27	4	25-124	64	41	64	30-155	97	28				
Pacific herring	1	44			1	175			2	60-225	143	83				
capelin									2	120&120						
boreal smelt	317	27-190	75	29	185	20-170	85	39	604	32-260	100	27				
pond smelt					3	55-62	59	3	39	65-105	85	10				
9-spine stickleback	56	21-55	32	7	35	27-55	42	7	14	25-61	40	11				
3-spine stickleback	1	75														
whitespotted greenling	1	63														
rock greenling									2	120-195	158	38				
ringtail snailfish									1	50						
sculpins	10	20-238	123	69	11	30-57	48	7	32	25-160	78	28				
pricklebacks					13	250-420	325	50	64	35-410	202	115				
sandlance	456	25-94	64	12												
unidentified larval fish	364	23-57	41	7												

Table 17. Sample size, range, standard deviation and mean lengths (millimeters) of pelagic finfish captured in variable mesh gillnets in Norton Sound, 1976.

Species	GOLOVIN BAY				CAPE DENBIGH - EGAVIK				EGAVIK - TOLSTOI POINT				TOLSTOI POINT - CAPE STEBBINS			
	n	range	$\bar{x}$	s	n	range	$\bar{x}$	s	n	range	$\bar{x}$	s	n	range	$\bar{x}$	s
pink salmon					18	104-132	115	8								
chum salmon																
king salmon																
coho salmon									1	520						
Arctic char	26	270-490	391	65	21	135-530	327	94	44	230-550	379	86	8	241-376	308	56
humpback whitefish	14	270-390	340	28	2	391-400	396	5	14	330-420	376	26	4	294-345	331	21
broad whitefish	29	125-385	306	71					1	400			1	405		
round whitefish																
Bering cisco	21	100-290	188	53	36	95-365	263	60	63	110-380	269	55	8	100-319	206	74
least cisco	61	183-310	242	28	10	180-305	260	37	12	175-315	259	48	38	157-373	269	57
saffron cod	82	82-345	246	44	59	132-290	253	29	55	104-359	248	44	43	112-342	229	44
starry flounder	50	78-450	194	70	20	105-480	228	83	39	100-430	253	67	10	113-336	190	57
Arctic flounder	5	64-221	144	55	10	100-250	145	47	24	72-264	161	53				
Alaska plaice																
longhead dab					1	125										
yellowfin sole	4	135-155	143	7	3	135-189	155	24	7	105-190	139	29	11	51-165	102	32
sturgeon poacher	2	143-150	147	4									1	136		
tubenose poacher																
Bering poacher									7	110-130	121	8	1	86		
Pacific herring	5	210-245	228	14	109	110-285	232	32	135	105-284	222	46	50	118-250	203	26
capelin																
boreal smelt	1	140			81	53-203	129	27	120	110-260	158	26	8	135-201	170	27
pond smelt					6	106-115	112	3	1	110						
9-spine stickleback																
3-spine stickleback																
whitespotted greenling	14	97-250	185	37	1	210							1	223		
rock greenling	1	275							3	210-290	237	38	11	151-214	185	17
ringtail snailfish																
sculpins					1	220							1	402		
pricklebacks					13	200-358	246	39	24	210-300	245	23	1	202		
sandlance																
unidentified lar al fish																

Table 18. Percent age classes of herring by sex captured in Norton Sound, 1976.

Area	Date	Sex	Sample Size	Age Class III	IV	V	VI	VII	VIII	IX	Mean Length 2/
St. Michael 1/ Bay	6/22	M	18		5.6	16.7	38.9	33.3	5.6		249
		F	14			21.4	21.4	50.0	7.1		246
		M+F			3.1	18.8	31.3	40.6	6.3		
St. Michael Bay	6/23	M	34	2.9	52.9	20.6	5.9	17.6			213
		F	18		61.1	22.2	11.1	5.6			209
		M+F		1.9	55.8	21.2	7.7	13.5			
Klikitarik & Black Point	7/10-21	M	20	5.0	60.0	15.0	10.0	10.0			207
		F	8		37.5	37.5	12.5	12.5			218
		M+F		3.6	53.6	21.4	10.7	10.7			
St. Michael Bay	7/17-30	M	13	7.7	69.2	15.4	7.7				201
		F	13	15.4	84.6						200
		M+F		11.5	76.9	7.7	3.8				
Blueberry Point	6/25	M	9				55.6	44.4			253
		F	7	28.6	28.6	14.3	28.6				237
		M+F		12.5	12.5	6.3	43.8	25.0			
Tolstoi Point	6/28	M	17	5.9		-	23.5	47.1	17.6	5.9	244
		F	17		17.6	5.9	11.8	41.2	11.8	11.8	239
		M+F		2.9	8.8	2.9	17.6	44.1	14.7	8.8	
Shaktoolik River	7/5	M	10		30.0	30.0	10.0	20.0	30.0		234
		F	17		64.7	17.6	5.9	5.9	5.9		226
		M+F			51.9	22.2	7.4	11.1	7.4		

1/ Sample was obtained from Kawerak commercial fishermen.

2/ Standard (hypural) length in millimeters.

Table 19 . Average standard (hypural) lengths in millimeters by sex and age for herring captured in Norton Sound, 1976.

AREA	DATE	SEX	III	IV	V	VI	VII	VIII	IX
St. Michael Bay 1/ n=38	6/22	Male		247	256	243	252	237	
		Female			231	250	254	252	
		Combined		247	243	245	253	245	
St. Michael Bay n=59	6/23	Male	180	205	201	242	243		
		Female		204	204	232	246		
		Combined	180	205	202	237	244		
Klikitarik - Black Point n=37	7/10-21	Male	200	202	203	233	236		
		Female		201	215	236	250		
		Combined	200	202	209	234	240		
St. Michael Bay n=32	7/17-30	Male	185	203	195	200			
		Female	181	203					
		Combined	182	203	195	200			
Blueberry Point n=33	6/25	Male				257	261		
		Female	226	233	235	248			
		Combined	226	233	235	255	261		
Tolstoi Point n=39	6/28	Male	185			243	241	263	260
		Female		215	250	233	251	235	270
		Combined	185	215	250	239	245	252	267
Shaktoolik River n=35	7/5	Male		210	227	266	250	280	
		Female		218	228	220	255	270	
		Combined		216	228	243	252	275	

1/ Sample was obtained from Kawerak commercial fishermen.

APPENDIX FIGURES

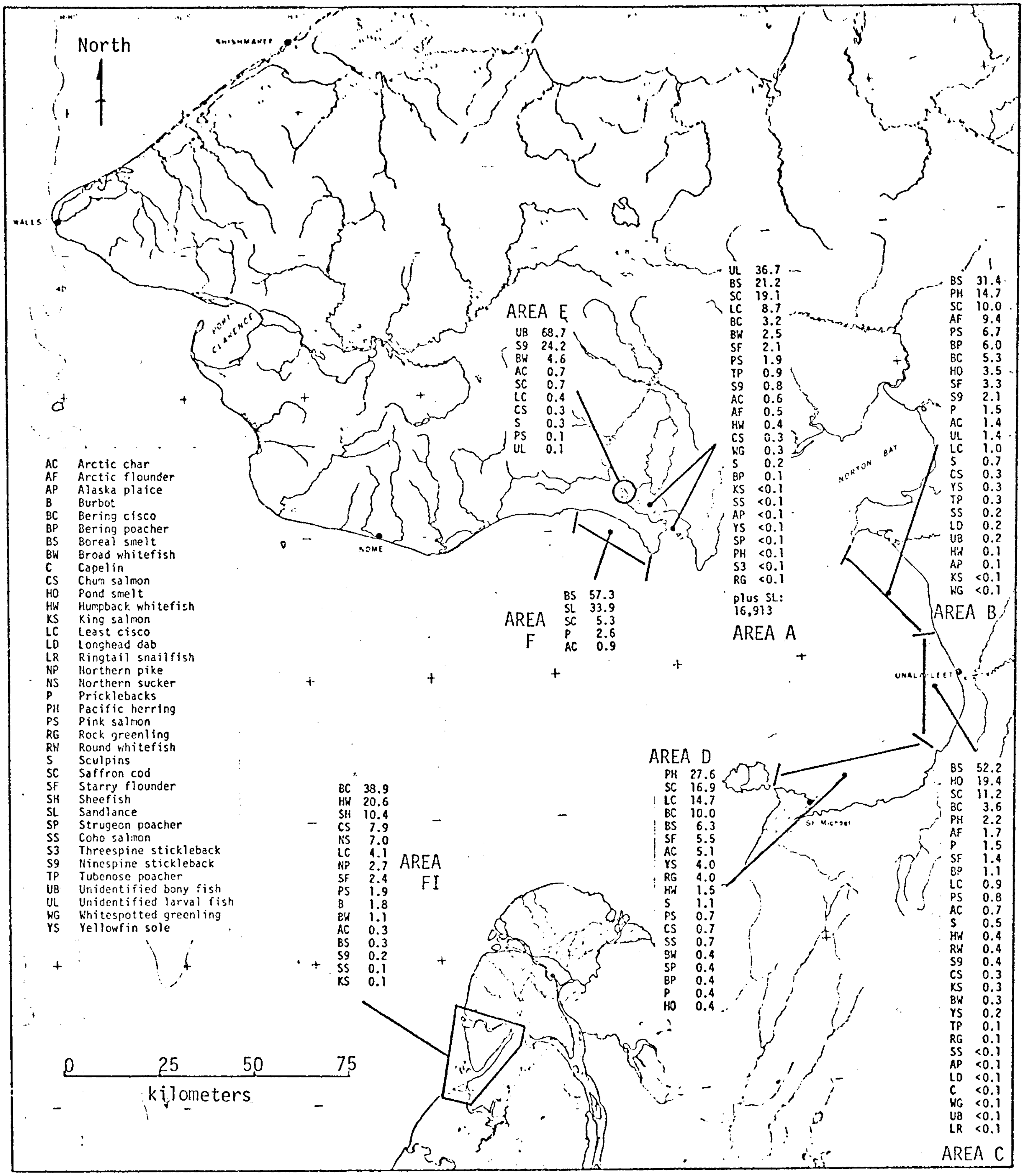

Figure 1. Relative abundance in percent composition by sampling area for finfish catches, early spring through early fall, 1976.

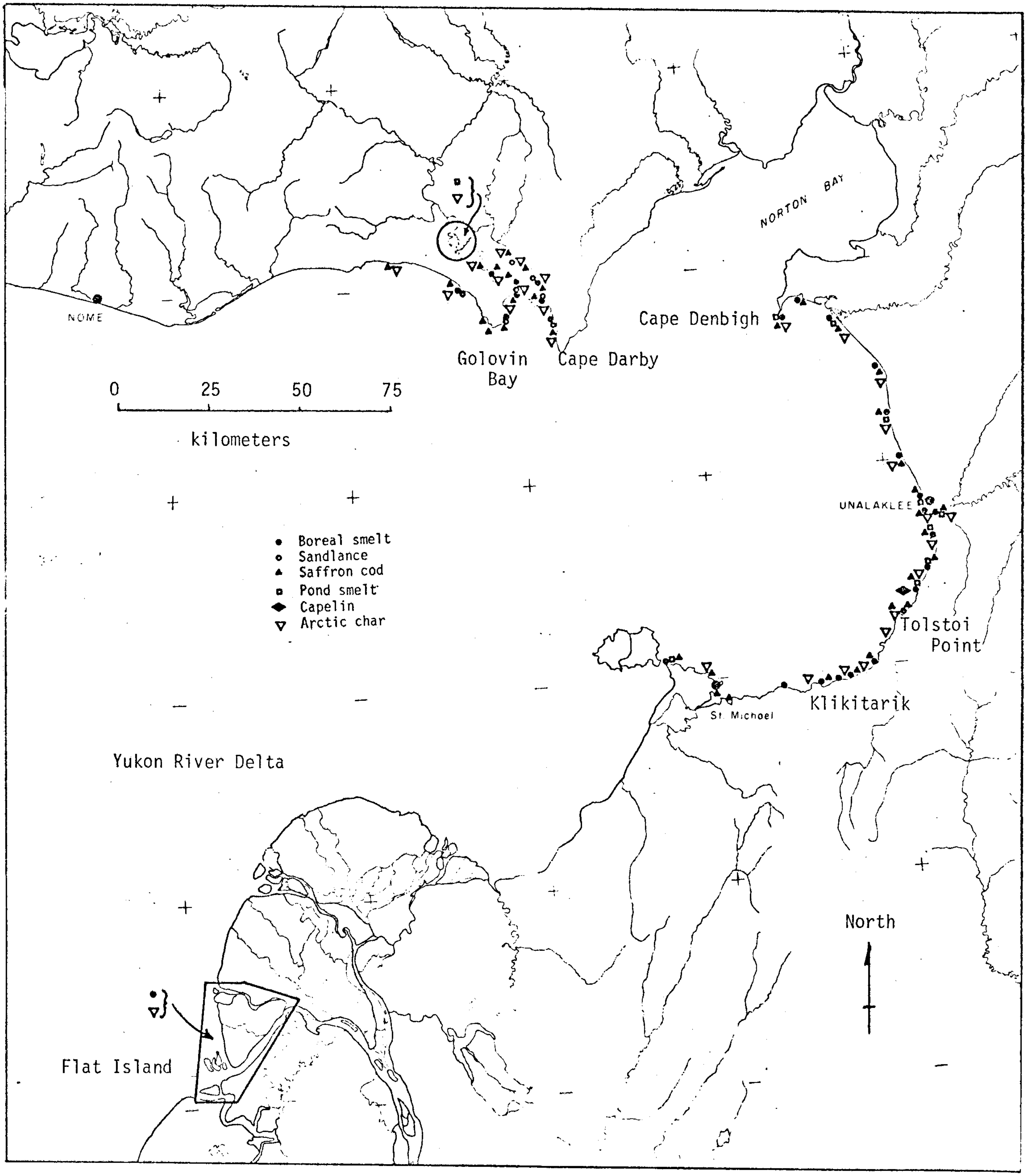

Figure 2. Catch distribution of selected species in the nearshore waters of Norton Sound, early spring through early fall, 1976.

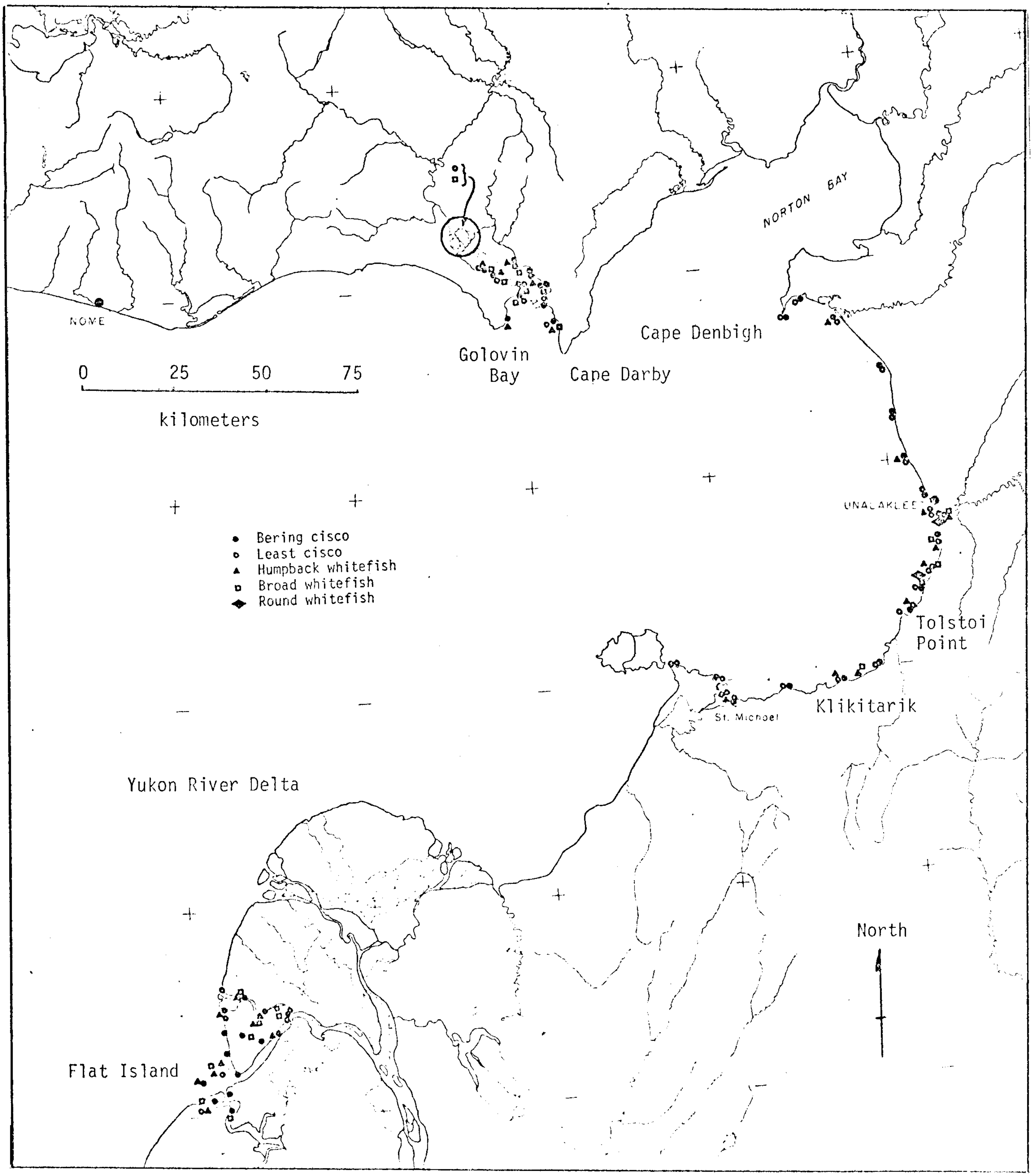

Figure 3. Catch distribution of selected species in the nearshore waters of Norton Sound, early spring through early fall, 1976.

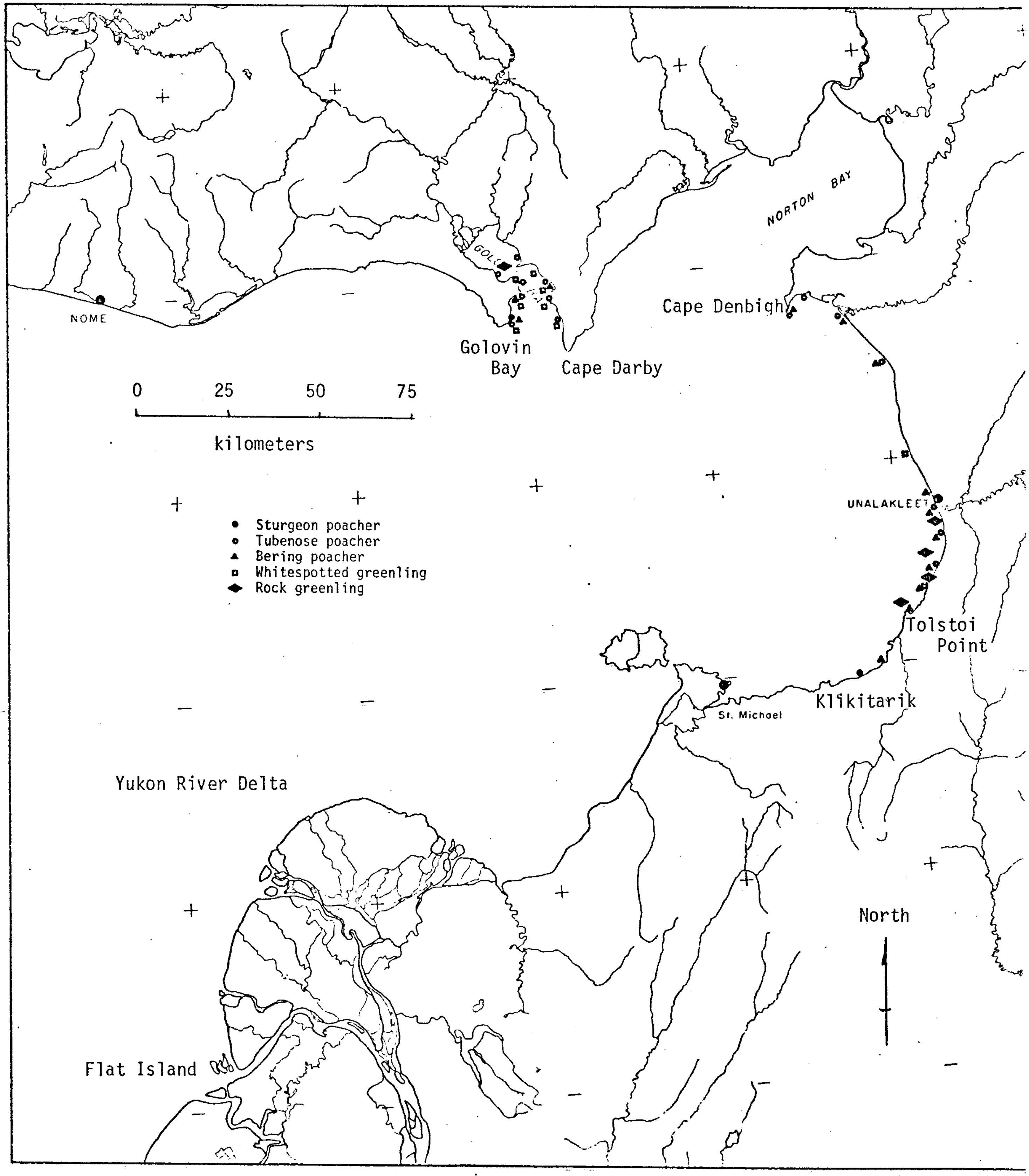

Figure 4 . Catch distribution of selected species in the nearshore waters of Norton Sound, early spring through early fall, 1976.

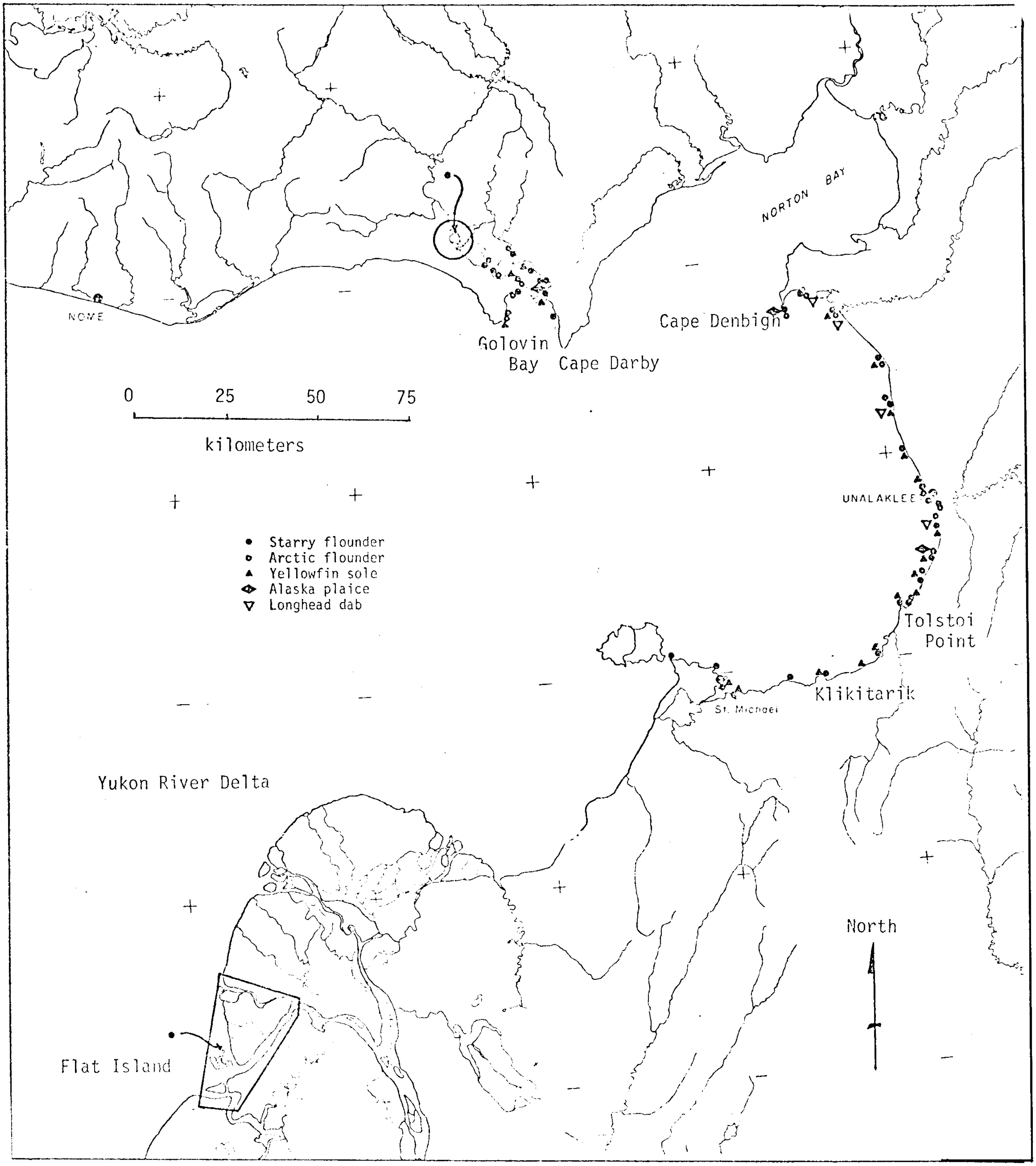

Figure 5. Catch distribution of selected species in the nearshore waters of Norton Sound, early spring through early fall, 1976.

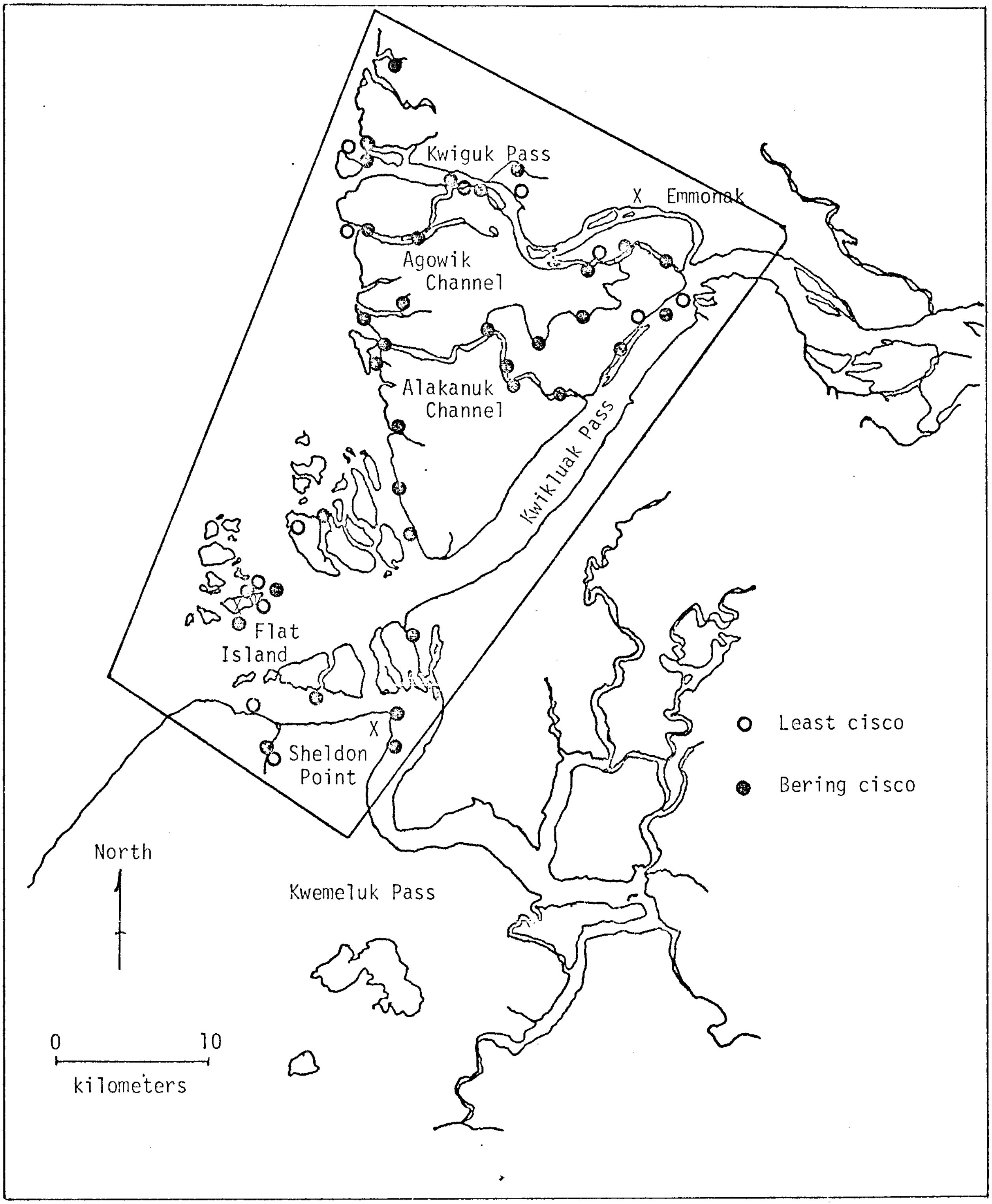

Figure 6 . Distribution of least cisco and Bering cisco catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

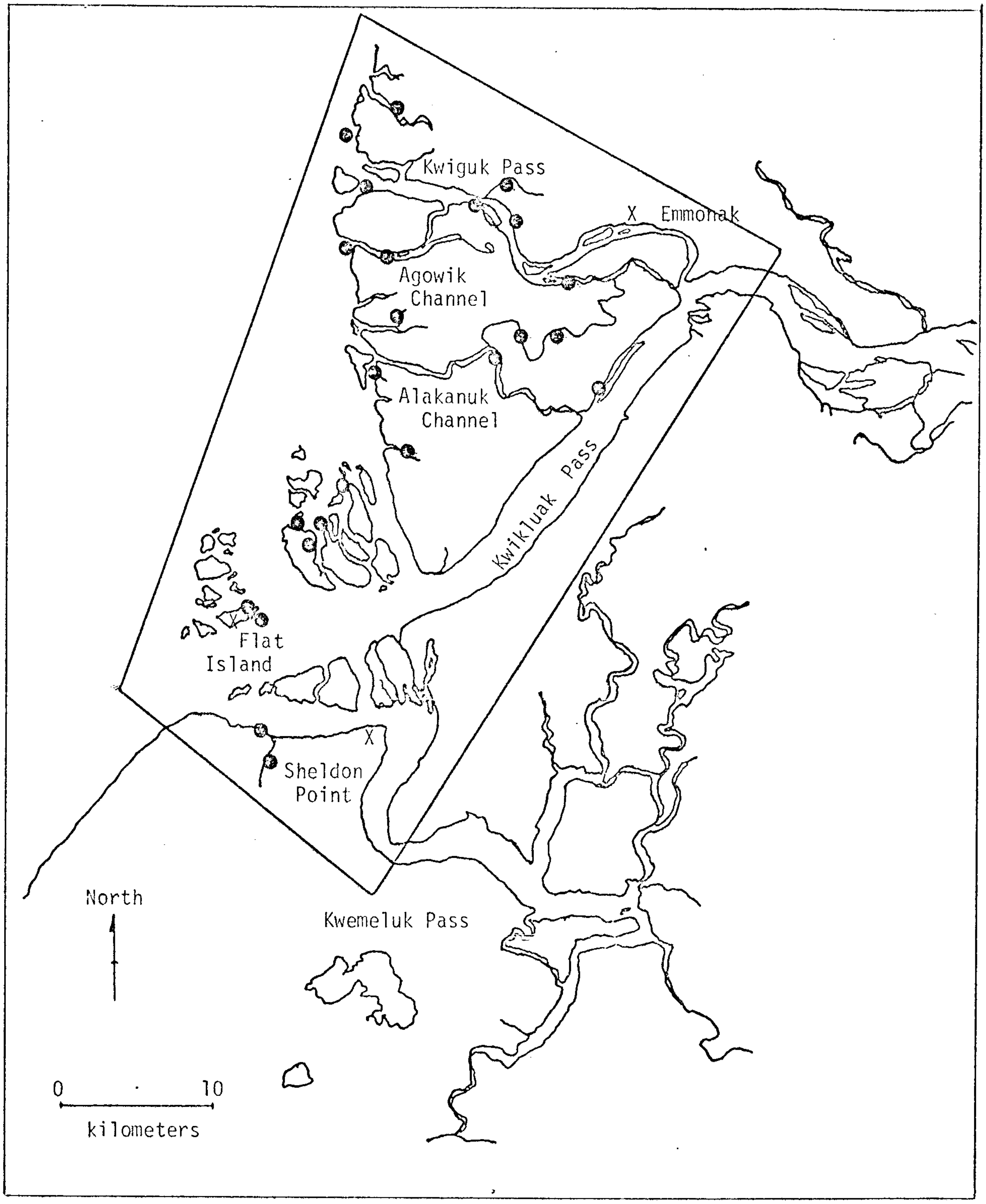

Figure 7 . Distribution of humpback whitefish catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

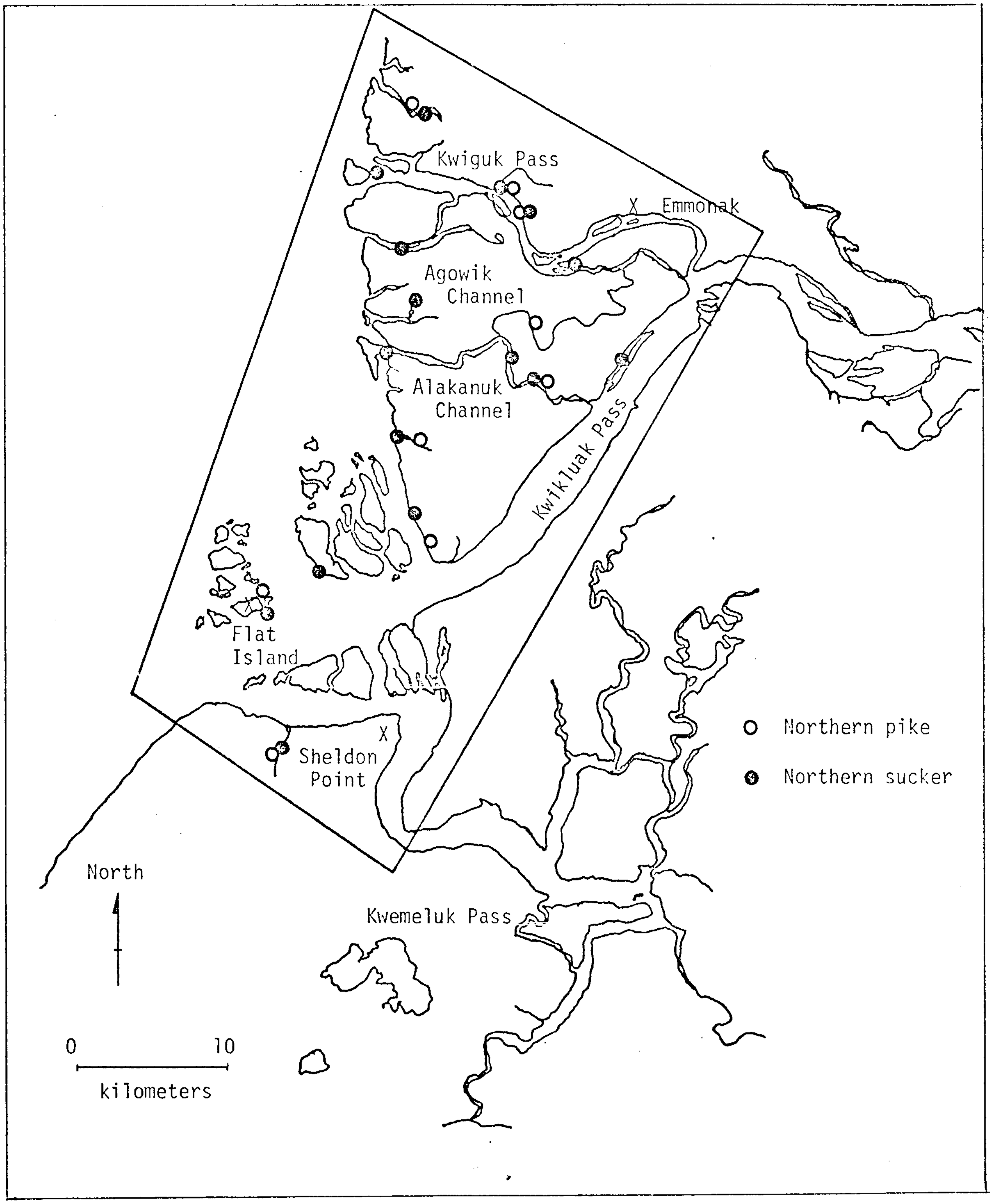

Figure 8 . Distribution of northern pike and northern sucker catches at the south mouth of the Yukon River, June 9 through August 5,1976.

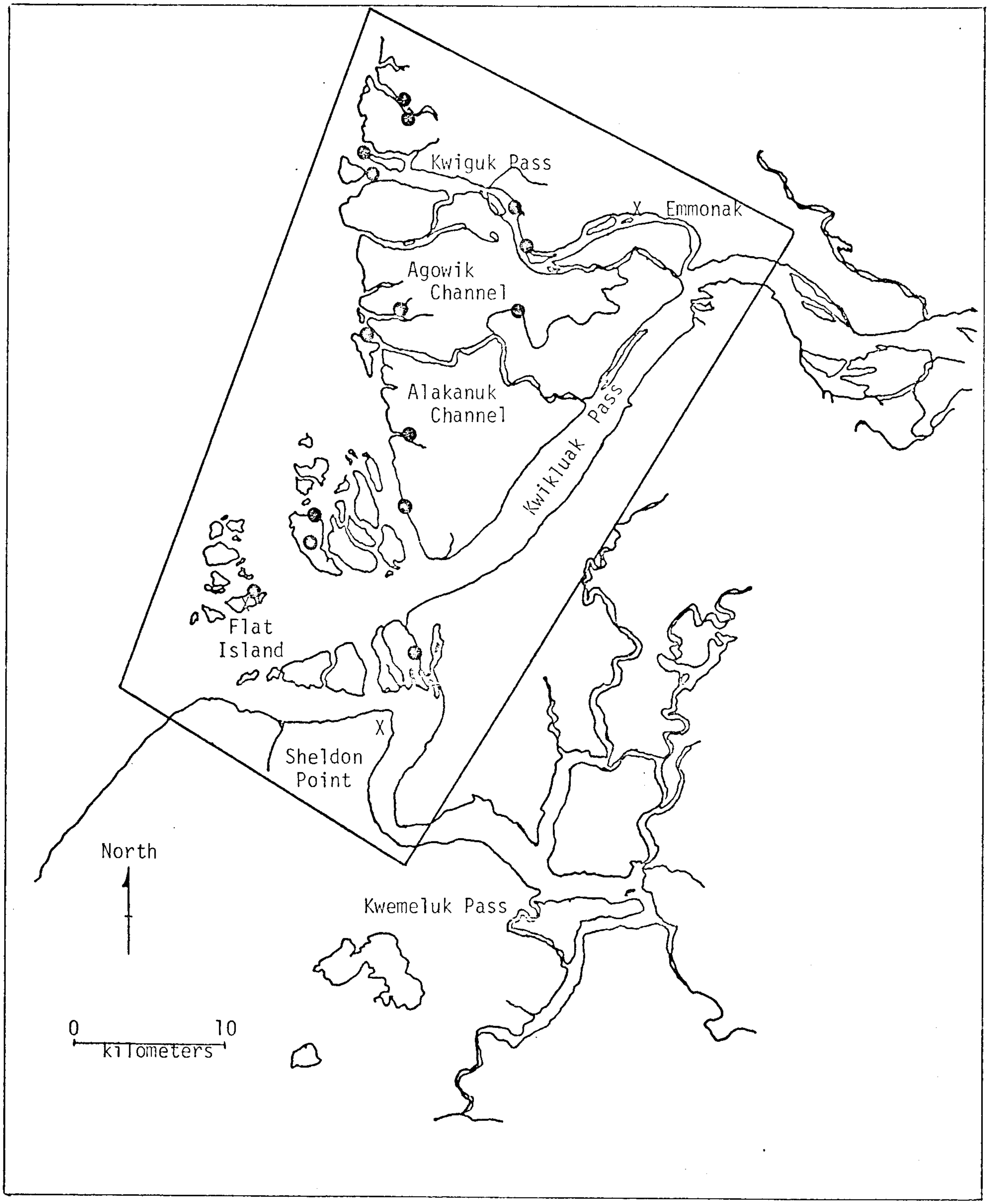

Figure 9. Distribution of sheefish (Inconnu) catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

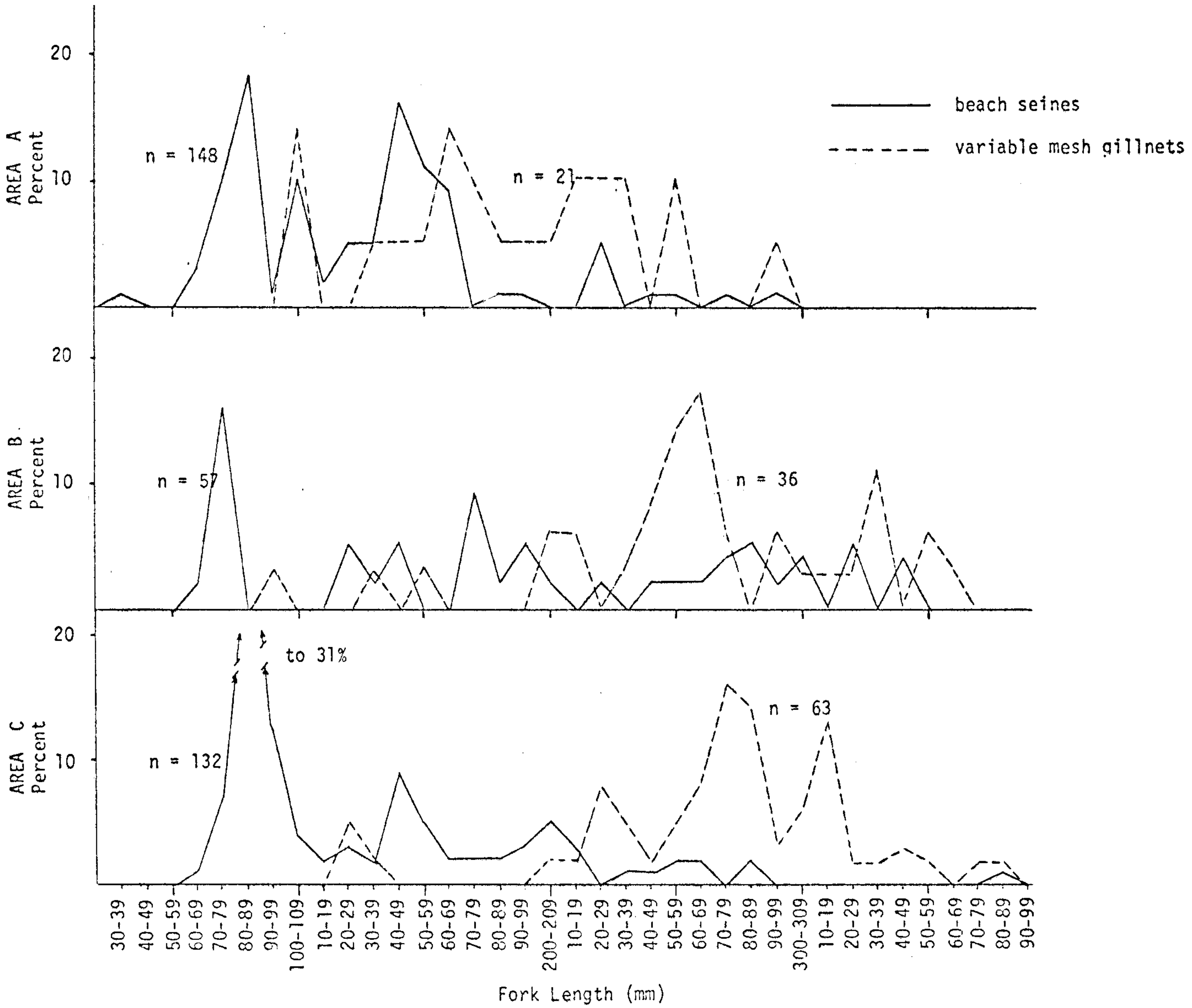

Figure 10. Length frequency distribution of Bering cisco sampled from Golovin Bay to Tolstoi Point in Norton Sound, 1976.

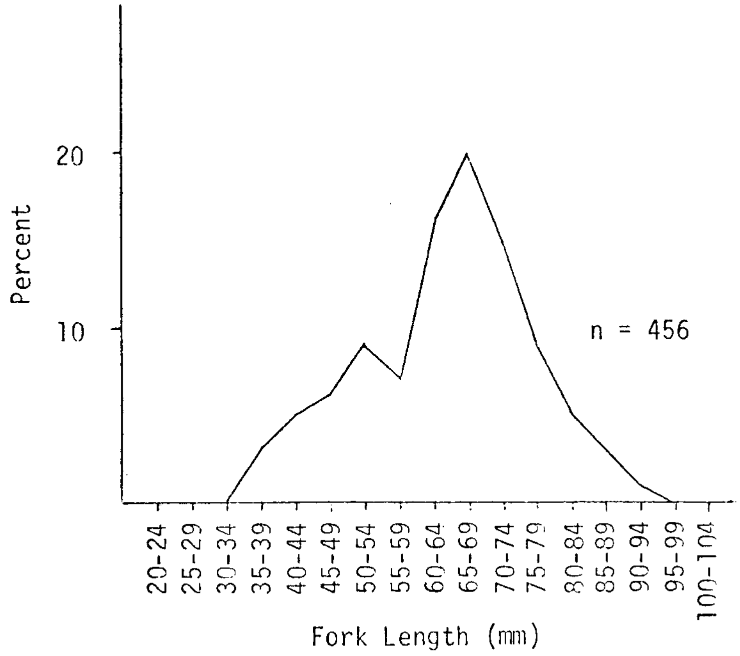

Figure 11. Percent length frequencies for sand lance captured in beach seines in Golovin Bay, 1976.

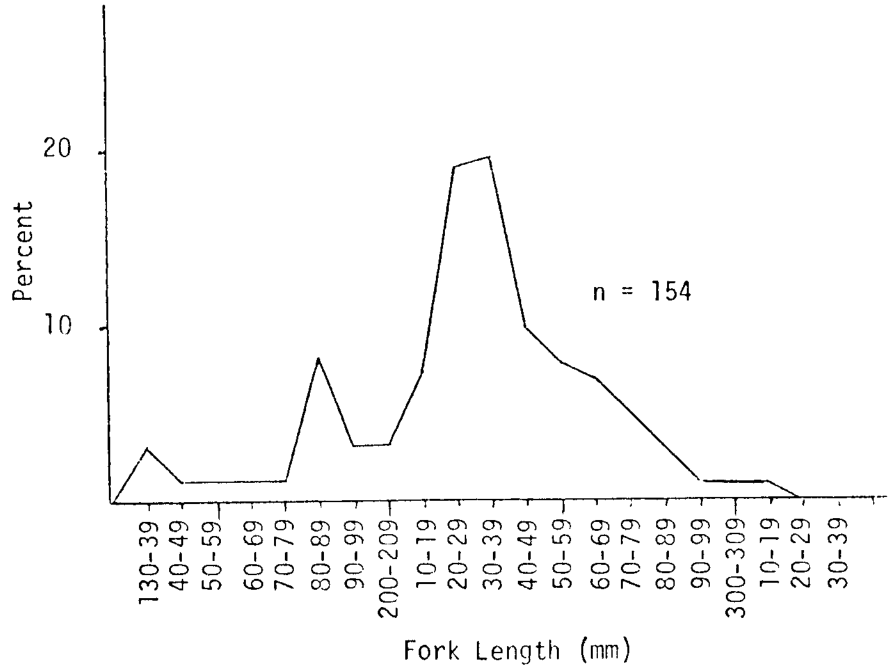

Figure 12. Percent length frequencies for least cisco captured in variable mesh gillnets and beach seines in Golovin Bay, 1976.

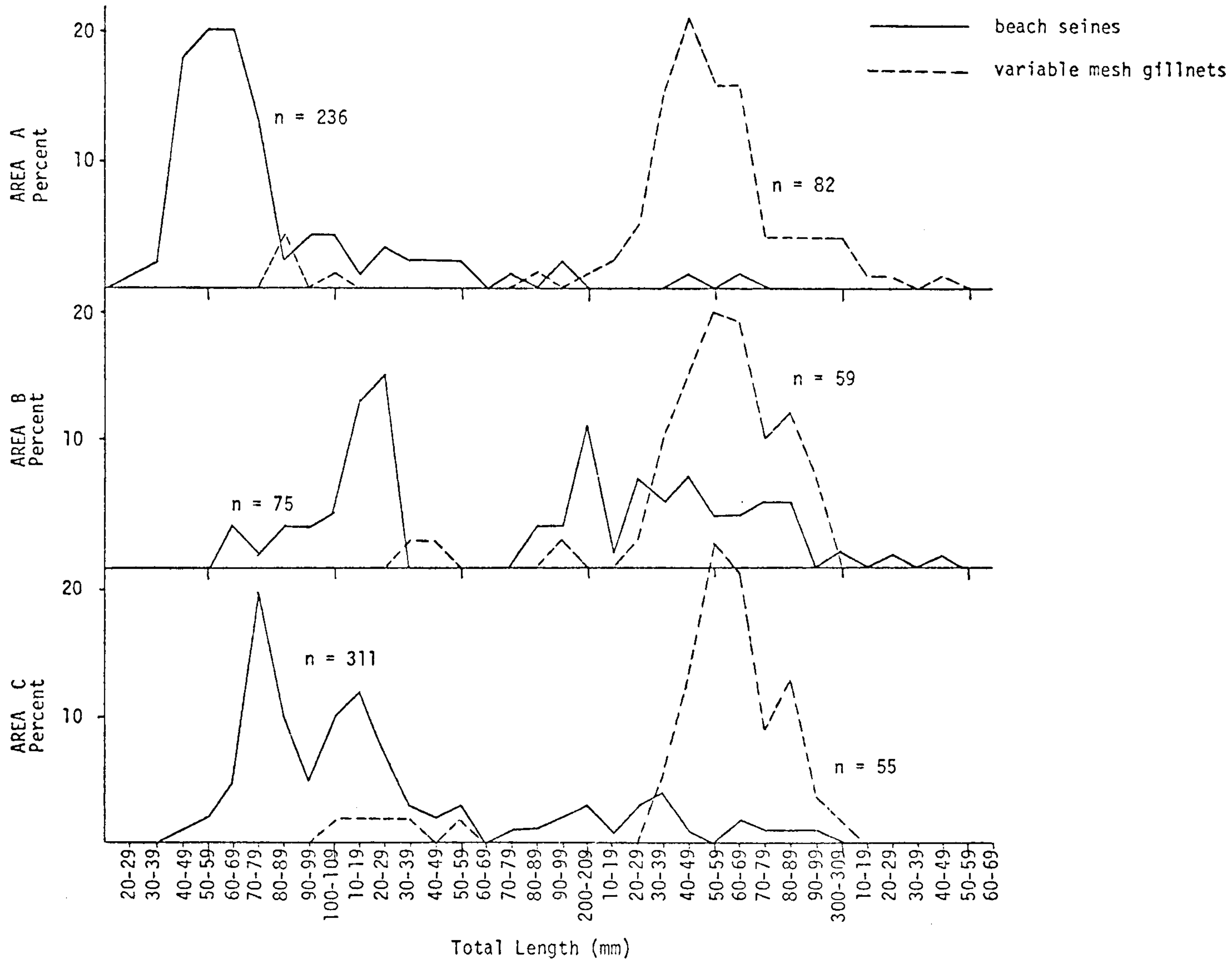

Figure 13. Length frequency distribution of saffron cod sampled from Golovin Bay to Tolstoi Point in Norton Sound, 1976.

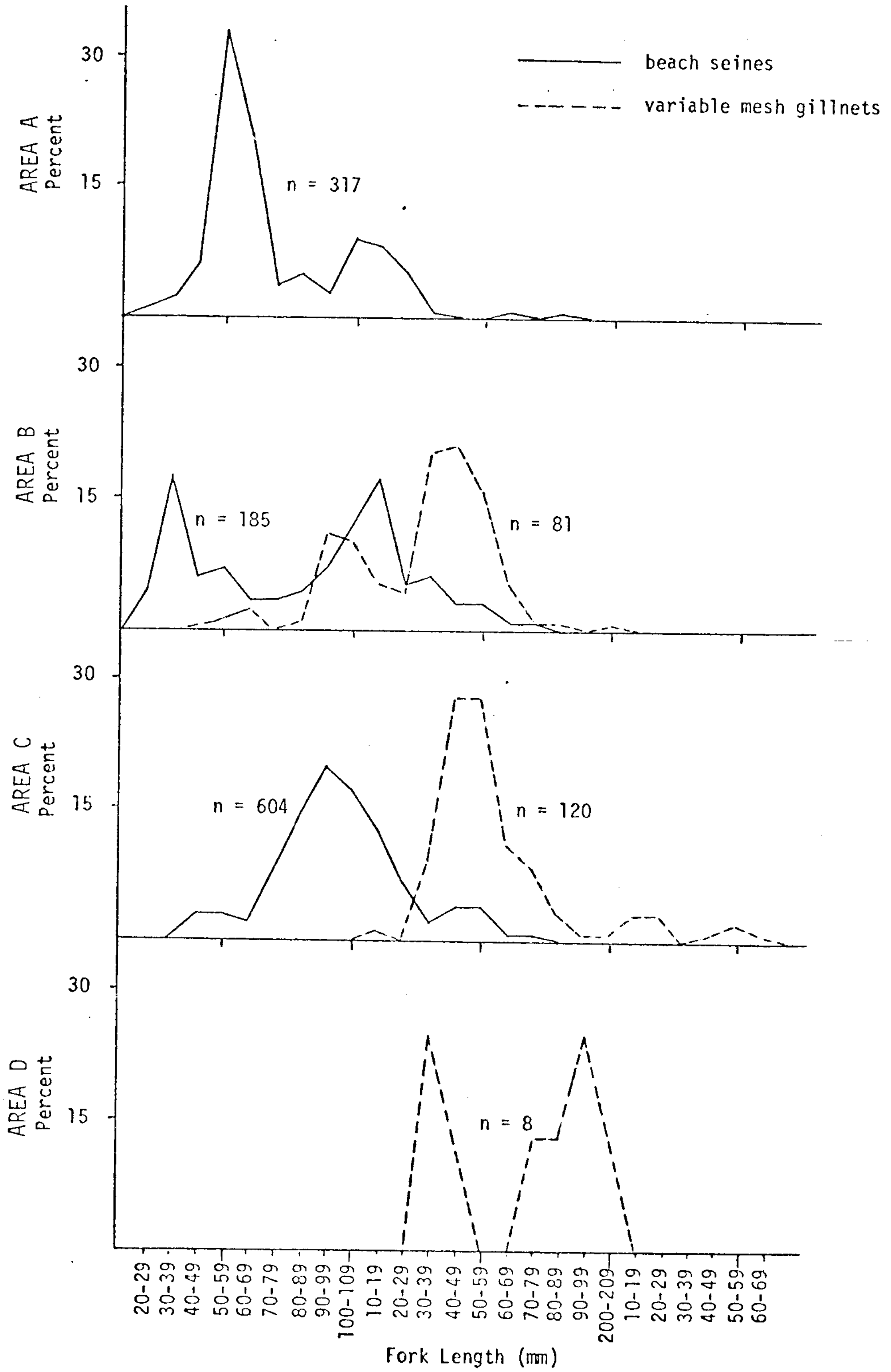

Figure 14. Length frequency distribution of boreal smelt sampled from Golovin Bay to Cape Stebbins in Norton Sound, 1976.

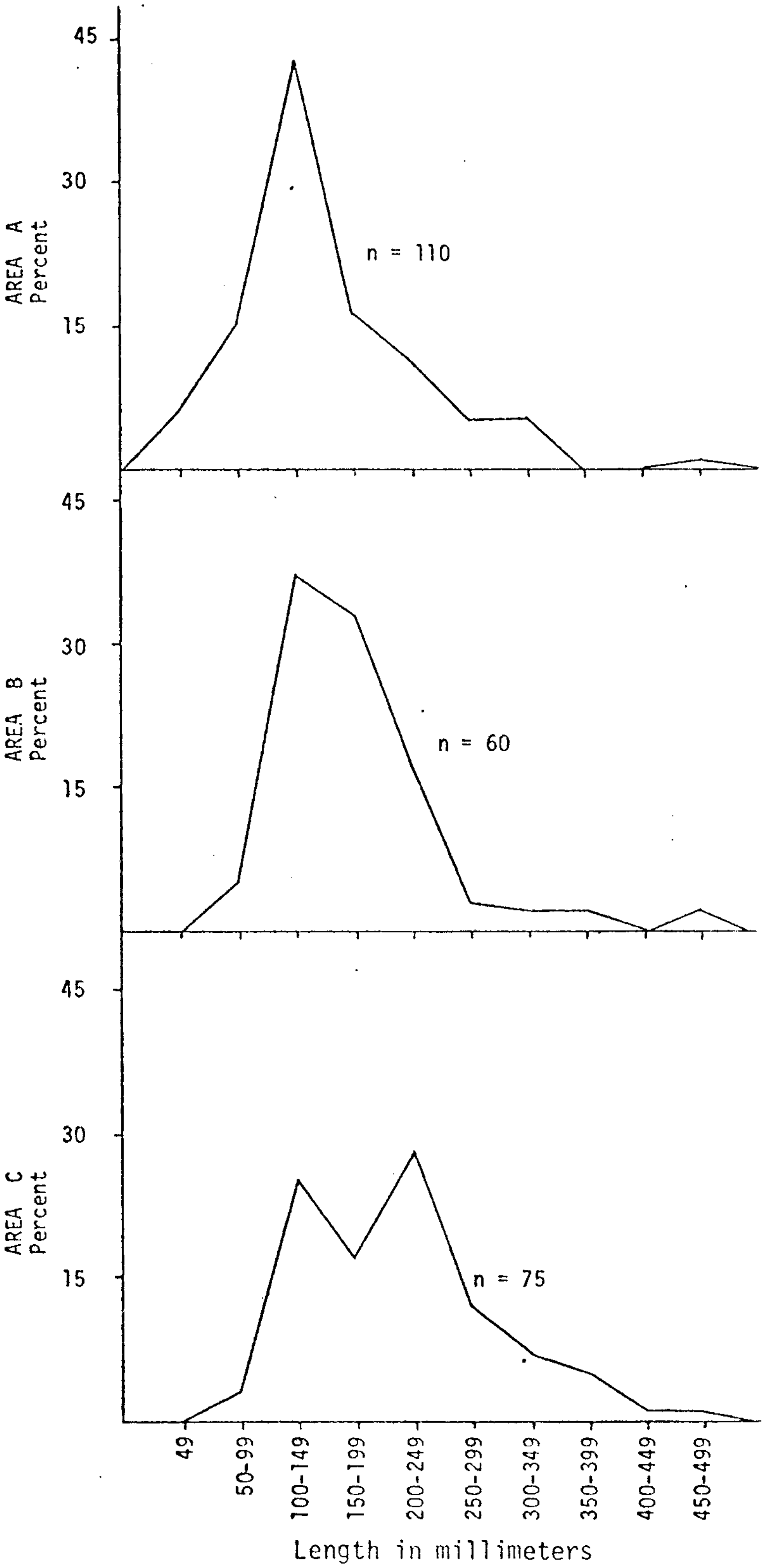

Figure 15. Length frequency distribution of starry flounder captured in beach seines and gillnets Norton Sound, 1976.

PROJECT COMPLETION REPORT

Contract No.: 03-5-022-69
Research Unit No.: 24
Reporting Period: April 1, 1976 - December 31, 197[illegible]
No. of Pages: 78

Razor Clam (*Siliqua patula*, Dixon) Distribution and Population Assessment Study

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April 15, 1977

SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

As the development of oil and gas reserves in the Gulf of Alaska proceeds toward production, petroleum related impact on the coastal, intertidal ecosystems will undoubtedly occur. The potential for negative effects on the marine organisms of this habitat will be significant at some locations. This study of the surf swept, sandy beach habitat of the Pacific razor clam (*Siliqua patula*, Dixon) was undertaken to achieve qualitative and quantitative baseline information on the mollusc and annelid invertebrate popualtions of this portion of the coastal intertidal zone. During the field season, twelve Kodiak Island and Alaska Peninsula area beaches were surveyed. Data gethered indicate that these relatively stable, non migrant species can be used as a critical monitor of change caused by oil pollution.

S. patula comprises the greatest percentage of the biomass of the bivalve molluscs in the beaches examined, and could be utilized as the target species for the ongoing monitoring of the oil related impact. The razor clam has been, and will continue to be, an important commercial and recreational resource as well as a vital part of the intertidal ecosystem. Personal field observations indicate that the razor clam is a significant part of the diet of brown bears (particularly for the sow with cubs), foxes, seagulls, ravens, an occasional eagle, seal, sea otter, crabs, and possibly bottom fish that also prey upon annelids.

Sandy beach habitat is clearly a productive and vulnerable facet of the marine coastal zone. The open, surf swept nature of this habitat makes the threat of harmful effects from oil pollution very real: wave action will cause the mixing of oil and its water soluble components which could then cause direct mortalities or narcotize the clams, making them more susceptible to predation and natural environmental stress (Rice & Karinen, 1976). Therefore, it is hoped that this study will aid in monitoring the anticipated petroleum impact on the habitat of *S. patula* by providing a profile of species composition and distribution prior to oil impact activities.

INTRODUCTION

This study originated to investigate a target species, *Siliqua patula*, from Unimak Bight to the 139° West Longitude south of Yakutat. A redefining of goals by OCSEAP planners in March, 1976, expanded project objectives to include reconnaisance and assessment of all bivalves and other invertebrates inhabiting the open, surf swept, sandy beach habitat in order to provide the baseline data necessary to evaluate changes of species occurrance and distribution as a result of oil development.

Specific Objectives

1) Determine the location and extent of all *S. patula* habitat within the study area through on site investigation, literature survey, and personal correspondence. Select beaches to be assessed during the current field season.

2) Collect and identify all bivalves and annelids captured at each location. Assess density, length and age (*S. patula* only) at each accessible integral tide level of the lowtide terrace.

3) Collect core samples of the substrate by tide level at each beach to determine substrate composition and grain size.

4) Record the following environmental parameters at each site: barometric pressure, air and water temperature, salinity, wind and general weather conditions.

5) Make incidental collections of *S. patula* for paralytic shellfish poisoning (PSP) studies conducted by the State of Alaska's Health Department in Juneau.

Relevance to Problems of Petroleum Development

Of the approximately fifty locations known to contain productive razor clam habitat in the Gulf of Alaska, research has been limited to the biology of *S. patula* at Swikshak Beach (Kaiser and Konigsberg, unpublished, 1976), Cordova (Nickerson, 1975), and the Cook Inlet area beaches (Nelson, 1971). It is important to gather comparable baseline data of the mollusc and annelid populations of the known razor clam habitat and to discover unrecorded habitat so that the impact of oil on this marine community may be monitored. Bivalve mollusc populations offer excellent indicators for assessing the effects of oil development as they are relatively long lived and can be monitored successively at the same location over a prolonged time period.

CURRENT STATE OF KNOWLEDGE

Distribution and Habitat

The Pacific razor clam is found in open, surf swept, sandy beaches from Pismo Beach in San Luis Obispo County, California (Weymouth, 1931) to the Aleutian Islands. In Alaska, there are approximately fifty known locations of productive *S. patula* habitat (Figure 1, Table 1). *Siliqua alta* is sympatric with *S. patula*, but occupies a zone comprised of finer substrate and is found only in the northwestern range from Cook Inlet down through the Alaska Peninsula including Kodiak Island (Nickerson, 1975). Of the two species, *S. patula* is by far the most abundant.[1]

The razor clam inhabits primarily the intertidal zone. Population density of the clams within a particular habitat is a function of the topography, substrate type and the tidal regimes. The majority of clams inhabit that area of the beach between the -0.91 meter and +0.91 meter tide levels, with density generally increasing outside of this range. Razor clams generally do not occur above the +1.52 meter tide level, but have been recovered by dredge at 54.86 M below mean lower low water (Nickerson, 1975). Little information exists as to the extent of the subtidal populations of *Siliqua*, but it is unlikely that they comprise more than a small percentage of the total population.

Biology

The life history of *S. patula* is typical of many bivalves: filter feeding, high fecundity and limited growing seasons which are marked by growth rings on the

[1] It is possible that some of the beaches on the Aleutian Islands and on the southern portion of the Alaska Peninsula may have major populations of *S. alta*.

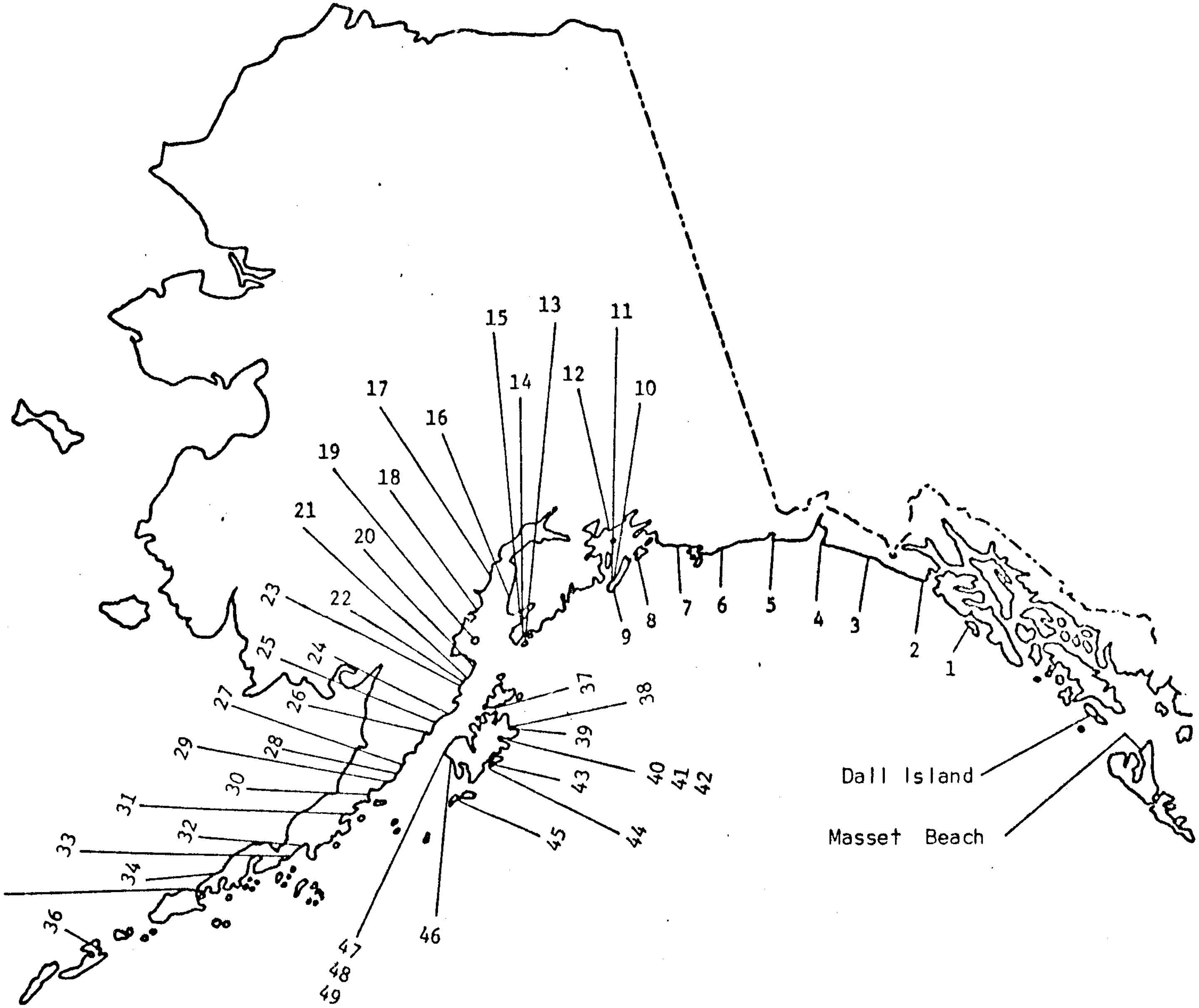


Figure 1. Geographic locations of known razor clam growing areas in Alaska. (from Nickerson - 1975)

Table 1. Known razor clam growing areas in Alaska

Number	Location of Clam Beds	Extent	Abundance	Historical Utilization
1	Kruzof Island	1/2 mile	fair	recreational
2	Dixon Harbor	1/2 mile	subsistance quantities	minimal
3	Lituya Bay to Ocean Cape	unknown	unknown	minimal
4	Small beach opposite Yakutat	20 yards	subsistance quantities	recreational
5	Icy Bay	unknown	unknown	minimal
6	Seal River	200 yards	subsistance quantities	none
7	Cape Suckling-Orca Inlet	140 miles	excellent	commercial/recreational
8	Nuchek, Hinchinbrook Island	1 mile	subsistance quantities	recreational
9	Jeanie Cove	1 mile	poor	minimal
10	Hanning Bay	1 mile	poor	minimal
11	Macleod Harbor	1 mile	poor	minimal
12	Eaglik Bay	1/2 mile	unknown	minimal
13	Nuka Island	1/2 mile	subsistance	recreational
14	Scattered beaches from Gore Point to Tonsina Bay	unknown	unknown	minimal
15	MacDonald Spit	1 mile	subsistance quantities	recreational
16	Homer Spit to Cape Kasilof	65 miles	poor to excellent	commercial/recreational
17	Kustatan to Tuxedine Bay	55 miles	poor to excellent	commercial
18	Chinitna Bay	2 miles	excellent	minimal

Table 1. (cont.)

Number	Location of Clam Beds	Extent	Abundance	Historical Utilization
19	Augustine Island	1000 yards	fair	minimal
20	Cape Douglas	25 miles	excellent	commercial
21	Swikshak, Big River & Village beaches	20 miles	excellent	commercial/recreational
22	Halo Bay	7 miles	good	commercial
23	Kukak Bay	10 miles	excellent	commercial
24	Dakavak Bay	3 miles	good	commercial
25	Kashvik Bay	2 miles	excellent	commercial
26	Alinchak Bay	4 miles	good	commercial
27	Imwya Bay	2 miles	excellent	commercial
28	Chiginagak	2 miles	good	commercial
29	Yantarni Bay	10 miles	excellent	commercial
30	Aniakchak Bay	5 miles	excellent	commercial
31	Hook Bay	1 mile	good	minimal
32	Humpback Bay	unknown	unknown	minimal
33	San Diego Bay	2 miles	good	minimal
34	Izembeck Bay	22 miles	good	minimal
35	Bechevin Bay	10 miles	good	minimal
36	Kalekta Bay	1 1/2 miles	fair	minimal

Table 1. (cont.)

Number	Location of Clam Beds	Extent	Abundance	Historical Utilization
37	Duck Bay	1/2 mile	fair	commercial/recreational
38	Buskin Beach	1 mile	poor	recreational
39	Middle Bay	1/2 mile	fair	recreational
40	Narrow Cape	5 miles	poor	minimal
41	Portage Bay	1/2 mile	poor	minor commercial/sport
42	Saltrey Cove	1/2 mile	poor	minimal
43	Ocean Beach	3 miles	fair	minimal
44	Rolling Bay	1 mile	fair	minimal
45	Tugidak	10 miles	fair	commercial
46	Cape Alitak-Low Cape	10 miles	fair	commercial
47	Bumble Bay	2 miles	fair	commercial
48	Halibut Bay	5 miles	good	commercial
49	Carmel	2 miles	fair	minimal

valves. Razor clams are dioecious, but it is not known if they exhibit protandric hermaphrodism. The female produces between 6-10 million eggs which are discharged into the ocean where fertilization occurs randomly by chance (McMillin 1924). A sustained sea water temperature of 42-48°F for a period of thirty days is apparently required for incubation prior to spawning which is apparently initiated by an abrupt increase in temperature above 47°F (Nickerson 1975).

Spawning activity increases with increasing temperature. Hot, clear and calm days during the low tide cycle allow the low tide terrace to accumulate a tremendous amount of heat which hastens the onset and intensity of spawning, thus enhancing the probability of fertilization and a resulting large set (Nickerson 1975). The resulting veligers are free swimming for a period of 8-10 weeks during which time they could be distributed elsewhere by ocean currents.

Razor clams are filter feeders, taking water and phytoplankton in through the incurrent siphon. Diatoms are filtered out and oxygen absorbed in the gills, with waste being discharged through the excurrent siphon. Clams grow by adding a new layer of inorganic material to the inside of the shell, creating annular growth rings which are used to determine age. The periods of rapid spring and summer growth are seen as wide bands bounded by winter annuli---distinct narrow concentric rings that result from this period of little growth. Growth is initially rapid and then markedly decreases with the onset of sexual maturity. Most clams do not reach sexual maturity until they have attained a size of 115 mm which corresponds to an age of 4.5 - 5.5 years in Alaska (Nickerson 1975).

The razor clams are active burrowers that move by pointing and projecting their foot into the sand, expanding it, and using it as an anchor as they draw their shell down or up. The young clams are often observed on top of the sand traversing brief distances before digging back into the sand, no doubt traveling horizontally within the top few inches of substrate. After approximately two years of age, clams undergo little horizontal motion and will probably remain at the same location unless moved by an outside agent.

Larval and juvenile mortality among razor clams is relatively high. Juveniles live in the top few inches of the substrate and are thus subjected to mortality from heavy surf conditions. Mortality among the adults has been estimated at 10% per annum (McMillin 1924). Nickerson estimates the survival rate for clams of age three and above at .4029 per year in the Cordova area.

Commercial History

Among bivalve clam species existing in the Gulf of Alaska, the razor clam is the most important commercial product historically, and constitutes an important recreational fishery. It is estimated that in 1975 a total of 39,970 man days of sport digging effort harvested 1.5 million razor clams in the Cook Inlet area alone (David Nelson, personal communication).

Initial discovery and development of razor clam beds in Alaska resulted as Washington-Oregon clam beds became depleted and industry sought new productive grounds for exploitation. The first commercial harvest of razor clams in Alaska occurred in 1916 in Prince William Sound near Cordova. Beginning in the 1920's, areas along the

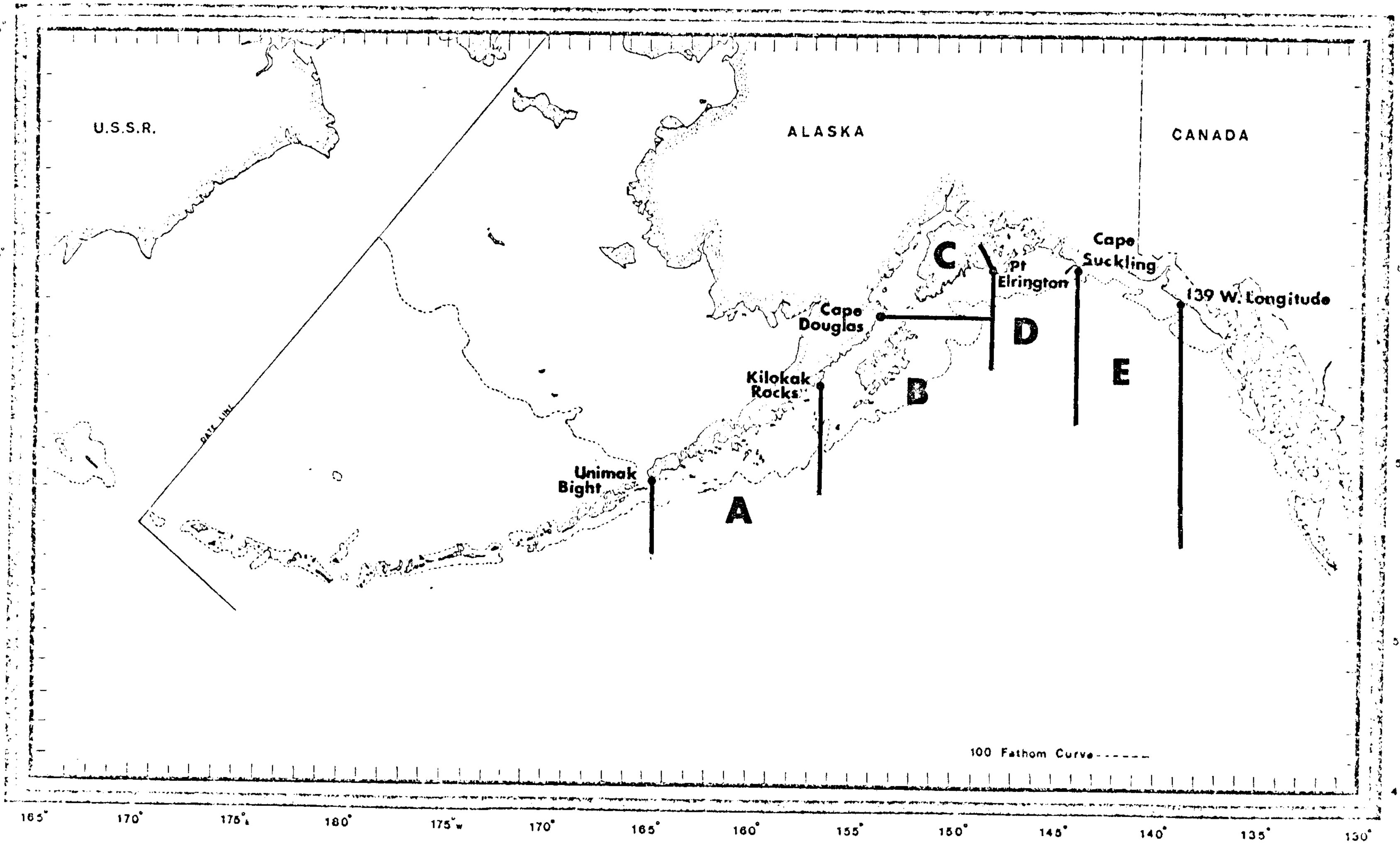


Figure 2 . Coastal zoning for razor clam research in the Gulf of Alaska.

Alaska Peninsula were explored; commercial quantities of razor clams were located and harvested primarily in Kukak, Hallo and Swikshak bays. Beaches of Polly Creek and Clam Gulch in Cook Inlet have also been commercially harvested. The following figures indicate the extent of these harvests (Nickerson 1975).

> From 1916 to 1973, 53 million pounds of clams have been harvested from the Cordova area with an average annual production of 880 thousand pounds of razor clams. Approximately 1.5 million cases (48½ lb. cans) of razor clam meat were produced over this 47 year period.
>
> From 1922-1971, approximately 314 thousand cases (48½ lb. cans) and 400 thousand pounds of whole clams have been produced from the Kodiak Island management area.
>
> From 1918-1971, approximately 80 cases (48½ lb. cans) of razor clam meat and 800 thousand pounds of whole clams were produced from the Cook Inlet area.

In recent years harvest in all three of the aforementioned areas has dwindled to only a fraction of its former level. In Cordova this is due, in part, to diminishing razor clam stocks brought on by the land mass shifts of the 1964 earthquake and a heavier siltation rate from the Copper River, (Nickerson, personal communication). This decrease in the Cook Inlet and Kodiak areas is primarily a result of new federal regulations and marketing factors. Interest in the Alaska clam resource is currently redeveloping as the east coast clam resources are declining.

STUDY AREA

The study area includes all sandy beach habitat of the Gulf of Alaska from the longitude of Cape Sarichef on Unimak Island east to 139 00'00"W. longitude. This coastline was divided into five major field work units early in 1976 to systematically approach the study of the razor clam habitat (Figure 2). Each unit was selected as a general geographic area with logistical considerations being a high priority. The anticipated timing of the oil lease sales in the Gulf of Alaska required that Field Unit B (Kodiak Island and the near Alaska Peninsula) be the first area of intensive study.

LOGISTICS AND PERSONNEL

The field survey crew consisted of three members: Daniel Konigsberg, biologist, Alaska Department of Fish and Game (ADF&G), Christopher Phillips, biologist, NMFS, Auke Bay, Jesus Briones, technician, ADF&G. Additional laboratory assistance came from Gayle Forrest and Claudia Mauro, fisheries technicians, ADF&G, Kodiak. Most logistical support came from Kodiak Western Airlines. The project required utilization of a Grumman Goose to land during high tide at each beach investigated. The pilots and personnel at Kodiak Western are to be commended for their invaluable assistance.

SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Beach Selection

The beaches to be surveyed were selected to provide a wide coverage of Zone B. Attempts were made to survey all beaches with significant populations of razor clams and then to survey the less productive beaches so that data could be obtained from both favorable and unfavorable habitats. United States Geological Survey maps, ADF&G sources and personal contacts were used as aids for determining study areas at each beach location.

Station Placement

Station selection on a purely random basis was not possible because of limitations on funding and manpower. Assessment at each station required a minimum of two minus tides (two days). Since the low tide cycles run for 5-10 days followed by a period of similar duration during which the tide is too high to conduct field studies, it was necessary to use only one station per beach. In this manner, two or three beaches per cycle could frequently be assessed. In order to obtain the most valid comparison between beaches, every station was located in an area of average density of *S. patula*.

The area of average density was determined by foot surveys. The beach was visually examined for topographical features and for density of clam "shows". At all beaches surveyed the majority of clams in the low tide terrace were *S. patula* and therefore the majority of "shows" were razor clam "shows". Operating under the assumption that the areas of average razor clam density will have average number of "shows", it was possible for the three field members to rapidly walk the beach, compare notes and determine the proper location for station placement. The senior scientist was led to believe (from two years of experience at Swikshak, Big River and Village beaches) that the areas of average density of the *Siliqua* population were located at or near the beach center and that the very low and/or dense populations are usually located at the ends of the beaches; "end" is defined as the mouth of a river or the actual termination of the sandy substrate against the rocky cliffs.

After the station location had been determined, a transit level was used to divide it into tide level sites. The low tide for the morning was determined by using the tide prediction and correction figures. At the time of the predicted low tide ebb, the water mark was staked (allowance was estimated for the wind conditions). Using transit, stadia rod and walkie talkies to direct the rod holder, each one foot increment in elevation was marked starting from an integral tide level. Each tide level site was marked with a 3 ft metal fence stake. The location of the lowest tide level site was determined by the daily tidal regimes; that of the highest tide level site sampled was determined by the upper limits of *S. patula* habitat.

After the station had been established, the sampling crew moved to the lowest site still exposed. The distance between each stake was paced to determined beach slope. A 21m x 3m tide level plot was established using heavy nylon twine (marked off at one meter increments) stretched between four corner stakes. This plot was aligned perpendicular to the beach exposure direction.

Sampling Techniques

Two sampling techniques were used at each station to study invertebrate populations. The first technique utilized three randomly placed sub-sampling frames in each tide level plot. To locate each sampling frame within the tide level plot, the one meter marks on the twine were used to generate grid coordinates. Each consecutive seven meters was designated as a subplot. Random coordinates were chosen for the first subplot and the same coordinates were used throughout the station subsampling procedure. A 1/3 meter square sampling frame, constructed from 1/4" iron rod was placed within a randomly selected one square meter grid. Once in place and held by four corner prongs, all sand within the frame was removed to a depth of 1 foot (.305 meters). This substrate (101.6 liters) was transported by three 5-gallon buckets to the sampling wagon which was specifically constructed for the sieving of subsamples.

The sampling wagon was fashioned out of aluminum with wide low pressure tires. The frame of the wagon unbolts from the rear axle and front steering assembly for transportation in aircraft. The wagon is 6 ft x 3 ft and has a collapsible 2 1/2 ft x 3 ft x 18 in tall sampling box mounted on the rear. The plywood sides of the box are bolted to the frame. The open bottom is supported by seven cross pieces of aluminum over which is fastened 1/2" galvanized wire mesh. A removable screen rests atop the 1/2" wire mesh.

Three 1/3 meter subsamples were collected within each tide level plot. Each subsample was deposited in the sampling box, washed and sieved with salt water from the pump mounted on the wagon. Sieving of the sand left all invertebrates exposed on the sampling screen for collection. Molluscs and other observable invertebrates were picked by hand or tweezers and placed in labeled "whirl-pacs". The remaining coarse gravel was bagged after removing big rocks and shells. This material was later sorted through for invertebrates that escaped unseen. The screen was then cleaned and replaced on the bottom of the box. All invertebrates caught were preserved for laboratory identification.

The second sampling technique involved digging the entire plot by shovel to capture all bivalves "showing". Bivalve molluscs greater than approximately 60 mm in length generally created distinct dimples or "shows" that indicated their presence. A "show" is a dimple or depression in the sand, created when the clams retract their siphons in response to a disturbance. Each species has a characteristic "show" which can be learned and identified under ideal conditions. All molluscs were dug with a standard clam shovel. All clams captured were then bagged, labeled and later identified and measured. All *S. patula* shells were retained for aging in the Kodiak laboratory.

After sampling of a given tide level plot was completed, the crew moved on to the next one that could be marked before being inundated by the incoming tide.

Substrate Sampling

Substrate core samples were collected at each tide level site examined. At the first two beaches surveyed, core samples were taken with a circular, copper core sampler approximately 25 mm in diameter and 20 cm in length equipped with a rubber tipped plunger to extricate the core. This sampler functioned only in very dry sand. Since a wide range of substrate consistency was encountered, a more efficient sampling device was designed that could be used to obtain a core even under water. This consisted of two pieces of aluminum bolted onto a standard clam shovel forming a channel 24 cm long, 44 mm wide and 22 mm deep. The shovel was pushed vertically into the sand and the core brought up in such a way that it was not displaced. All excess sand was scraped away, leaving a rectangular core of sand which was then bagged and labeled for laboratory analysis.

Environmental Parameters

Environmental parameters were taken after the sampling was completed. Salinity (in parts per thousand) and temperature of the sea water (°C) were taken using a Yellow Springs Instrument Co. Model 33 S-C-T (salinity, conductance, temperature) Meter. Air temperature (°F) was recorded using a standard precision thermometer. Barometric pressure (cm of Hg) was recorded using an Airguide barometer calibrated for sea level readings. Wind speed was approximated using a Dyer hand held wind gauge. Other parameters recorded were wind direction, breaker height, cloud amount, general weather conditions, beach and substrate type

Beach Mapping and Photo Documentation

Topographical charts were used as aids in mapping beaches in regard to the extent of *S. patula* habitat present. Photographs (black and white and color transparencies) were taken of each beach as well as sampling techniques as time permitted. Some black and white prints are included in the appendix of this report detailing various phases of the operation.

Laboratory Activities

A. Invertebrate analysis

All the molluscs and annelids captured in the subsamples were preserved at the beach in a 10 percent solution of formaldehyde. Notation was made of the presence of such organisms as the Pacific sand lance and amphipods. Systematic identification was done in the lab by Christopher Phillips using the facilities at the National Marine Fisheries Service laboratory in Kodiak. A voucher collection was verified by George Meuller at the University of Alaska in Fairbanks.

B. Age analysis

Age analysis was done in regard to *S. patula* only. All the meat was scraped off the valves in the field and, after drying, both valves were identically numbered in the laboratory. Valves were soaked overnight in a 50 percent solution of clorox to remove the periostracum. These valves were then rinsed in water and soaked four hours in a dark solution of Alizaren red dye. This solution stained the entire shell a dark purple. They were then briefly brushed in a 10 percent solution of nitric acid which left the annuli white against a purple background. Annular rings were then measured with calipers. Measurements were taken at the center of the anterior end of the annuli to the center of the posterior end. All valves from a particular beach were aged collectively.

C. Substrate analysis

Core samples were air dried on plastic plates and then run through a series of U.S.A. Standard Testing Sieves (Table 2) using a Tyler Mechanical Shaker. Weights of the sediment collected in each sieve were recorded.

RESULTS AND DISCUSSION

Beach Mapping

Salient physical characteristics of the beaches investigated (Figure 3) are listed in Table 3 and illustrated in Figures 4-5 and Appendix figures 1-10. The latitude and longitude of each station was determined so that it would be possible to return at a later date and transect the same area. Since adult bivalve populations, and to a lesser extent annelid populations are non-migrant and fairly stable, it would be possible to monitor these same populations successively over a period of years.

The visually observed extent of the razor clam habitat as determined by foot surveys was used to define the length of the particular beach investigated. The entire exposed sandy beaches of Swikshak, Village, Big River, Bumble Bay, Kashvik, and Alinchak were investigated and found to be favorable *Siliqua* habitat.

Two days were spent at Ocean Bay (Appendix figure 1), however, rough and stormy weather prevented the basic survey from being accomplished. High winds kept the tide from receeding below the 0 meter tide level and the atmospheric weather conditions kept clams from showing. Therefore, the extent of the *Siliqua* habitat at Ocean Bay was determined from topographical interpretations of the beach and personal conversations with the residents of Sitkalidak.

The sandy beach on the northeast section of Tanner Head (Appendix figure 2) was the only beach surveyed in the Alitak area. It is possible that some of the smaller sandy beaches on the southeast coast of Tanner Head have minor populations of *S. patula*. ADF&G literature indicates that there are sparse populations from Cape Alitak to Narrow Cape, west of the Alitak Lagoon.

The beach in the southwest corner of Halibut Bay (Appendix figure 3) was found to be favorable *Siliqua* habitat. The area north of the river was surveyed by foot for approximately two miles. The entire distance covered was favorable habitat, however, this *Siliqua* population appeared less dense than the southern beach population and samples collected indicated a wider distribution of age classes existed north of the river. How far this productive beach habitat extends is unknown.

The only beaches delineated in Hallo Bay were those southwest of the Ninagiak River (Appendix figure 5). The beach east of this river was found to be inhabitated by hard shell clams (*Saxidomus*). Within Hallo Bay there is a sandy beach habitat for *S. patula* stretching from Ninagiak Island north along the exposed reefs.

Time was available for exploration of only one bay within the Kukak Bay system (Appendix figure 6). The entire sandy beach within this particular bay was found to be *S. patula* habitat. The possibility exists that other bays within Kukak Bay may contain razor clams.

Table 2. Seive sizes used for sediment analysis.

ASTM E 11 Specification #	Opening in mm	Corresponding phi (ϕ) grain size retained in sieve	Definition of particle size
5	4.00	< -2	pebble
10	2.00	-2 to -1	granule
18	1.00	-1 to 0	very coarse sand
35	.50	0 to 1	coarse sand
60	.25	1 to 2	medium sand
120	.125	2 to 3	fine sand
230	.063	3 4	very fine sand
bottom pan	-	> 4	silt

Table 3. Location of station and some physical characteristics of fourteen Alaska Peninsula and Kodiak Island area sandy beaches studied May 13 - August 30, 1976.

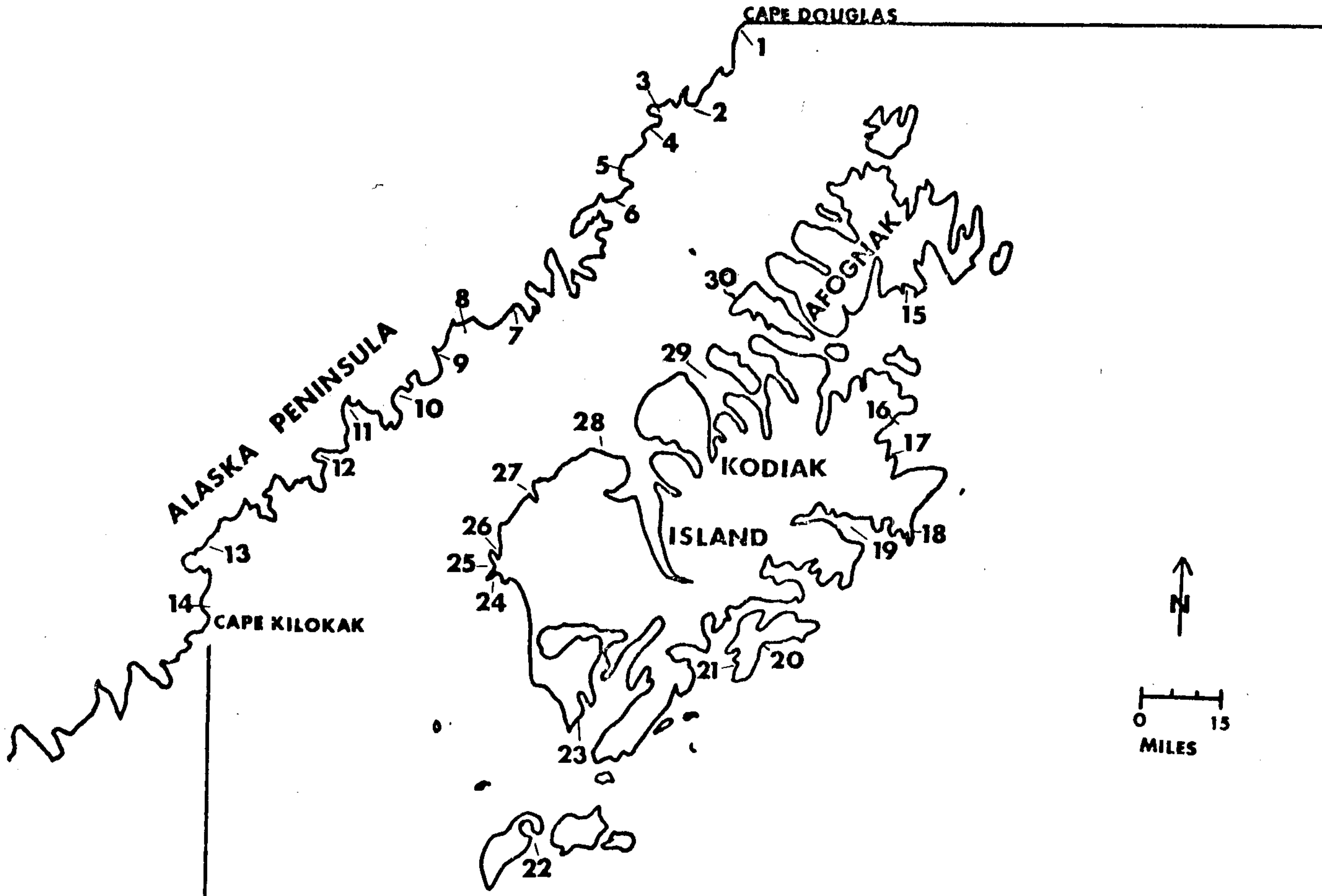
Beach	Station #	Approximate Lat - Long	Exposure direction of beach (magnetic degrees)	Estimated length of beach *Siliqua* habitat (km)	Width of beach at station (m)[1]	Slope distance from +1 to -1 foot tide level (m)
Ocean Bay	B1	57°06'40" N 153°10'00" W	148°	7.08	91.20 (-1)	23.79
Tanner Head	B2	56°52'50" N 154°13'20" W	114°	3.70	155.55 (-3)	22.88
Halibut Bay	B3	57°21'35" N 154°45'40" W	32°	7.61	114.38 (-1.7)	28.98
Swikshak[2]	B4	58°36'35" N 153°43'10" W	181°	7.24	201.91 (-2)	62.83
Village[3]	B5	58°34'10" N 153°50'30" W	102°	6.92	383.39 (-4)	234.24
Big River	B6	58°35'40" N 153°52'10" W	76°	3.22	900 (-4)	131.83
Hallo Bay[4]	B7	58°20'10" N 154°04'15" W	64°	6.84	676.66 (-3)	172.52
Kukak[5]	B8	58°21'20" N 154°06'10" W	90°	1.28	598.93 (-2)	51.82
Bumble Bay	B9	57°16'50" N 154°40'30" W	201°	1.61	108.97 (-1)	26.67

[1] Beach width measured from high tide swash to the low tide level indicated in feet within parenthesis.
[2] Measurements refer to that area of Swikshak beach from the mouth of the Swikshak River northeast to the first prominent rocky bluff.
[3] Steep embankment and rock cobble begins just above the zero (0.00') mean low water level.
[4] The beach studied and measured is that beach area between Hallo Creek and Hook Creek.
[5] Only one beach within an un-named bay within the Kukak Bay system was investigated.

Table 3. Cont.

Beach	Station #	Approximate Lat - Long	Exposure direction of beach (magnetic degrees)	Estimated length of beach *Siliqua* habitat (km)	Width of beach at station (m)[1]	Slope distance from +1 to -1 foot tide level (m)
Tugidak	B10	56°30'40" N 154°28'40" W	153°	?[6]	73.15 (-1)	23.62
Dakavak[7]	B11	58°03'40" N 154°41"10" W	150°	2.4	179.07 (-2)	20.57
Katmai[8]	B12	58°01'10" N 154°54'58" W	146°	4.02	-	-
Kashvik	B13	57°56'40" N 155°05'35" W	108°	2.01	1798.92 (-1)	917.75
Alinchak[9]	B14	57°49'50" N 155°20'10" W	106°	1.61	735.79 (-1)	156.06

[6] Extent of razor clam habitat is unknown.
[7] Measurements refer to the beach west of the major river in Dakavak Bay.
[8] No transect was established at Katmai Bay. Measurements refer to beach east of the Katmai river.
[9] Measurements refer to the northern most beach within Alinchak Bay.



1. Unnamed bay due south of Cape Douglas
2. Swikshak Beach*
3. Big River Beach*
4. Village Beach*
5. Hallo Bay*
6. Kukak Bay*
7. Dakavak Bay*
8. Katmai Bay*
9. Kashvik Bay*
10. Alinchak Bay*
11. Puale Bay
12. Dry Bay
13. Wide Bay
14. Imuya Bay
15. Duck Bay
16. Buskin Beach
17. Middle Bay
18. Narrow Cape
19. Ugak Bay
    a) Portage Bay
    b) Saltrey Cove
20. Ocean Bay*
21. Rolling Bay
22. Tugidak Island*
23. Tanner Head*
24. Bumble Bay*
25. Gurney Bay
26. Halibut Bay*
27. Sturgeon Head
28. Seven Mile Beach
29. Uganik Bay
30. Driver Bay

Figure 3. Beaches with known populations of Pacific razor clams within zone B. (* Denotes those beaches surveyed during the 1976 field season.)

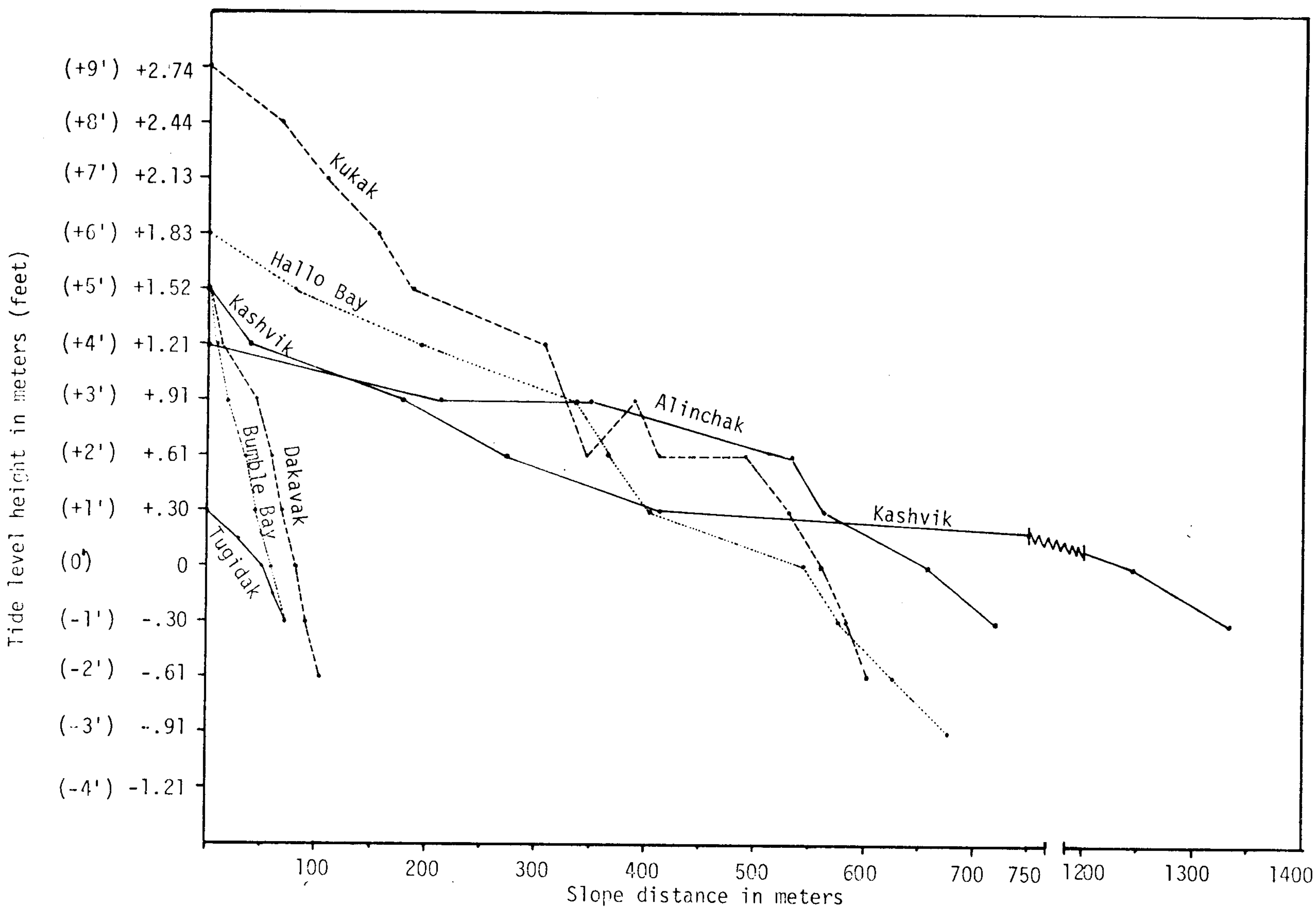


Figure 4. Slope and profile for seven beaches as determined at station site during July-August, 1976 on the Alaska Peninsula and Kodiak Island.

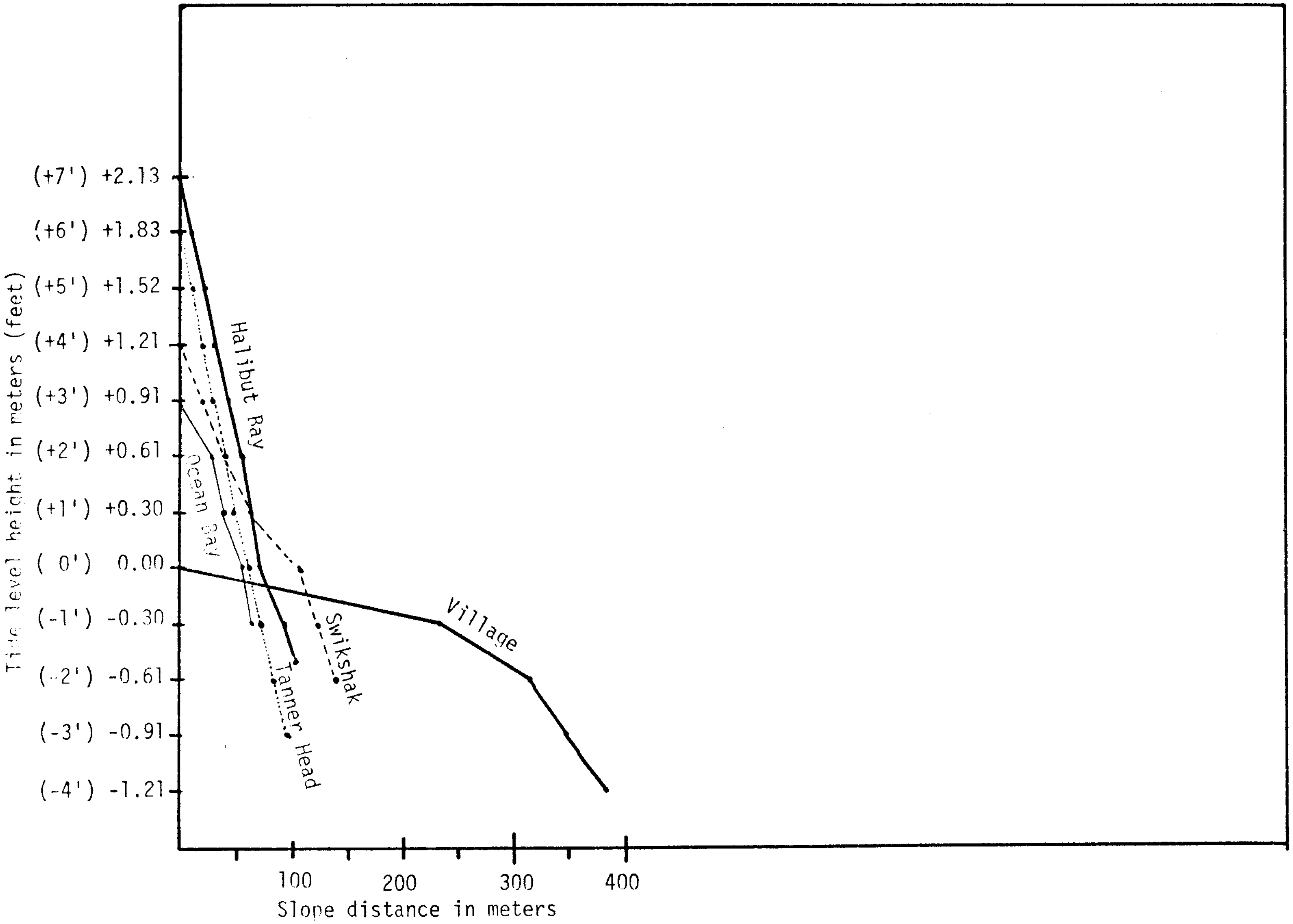


Figure 5. Slope and profile for five beaches as determined at station site during May - June, 1976 on the Alaska Peninsula and Kodiak Island.

Logistics were a limiting factor in the investigation of Tugidak Island (Appendix figure 7). It became apparent after preliminary foot surveys that the major razor clam populations were on sand bars located in the center of Tugidak passage. These bars, which were visible only at a low tide of -0.61 meters, were inaccessable as the Zodiac raft was not taken on this trip. Investigation of a small bar off the mouth of the lagoon, however, indicated dense populations of razor clams. It is therefore assumed that the remaining bars were similarly populated. The narrow beach transected and the relatively low density population found are of unknown length and perhaps circle this island.

The beach to the east of the Dakavak River on the Alaska Peninsula (Appendix figure 8) was found to be a totally unfavorable *Siliqua* habitat; no live razor clams were observed and no shell accumulation appeared in the drift zone. The beach to the west of the river was found to be favorable habitat. The eastern portion of Katmai beach (Appendix figure 8) was found to be very poor *Siliqua* habitat. Extremely rough seas and weather limited the work at this station to foot surveys. This particular beach had a steep slope (45^o) and had more volcanic ash (from the Mt. Katmai eruption) than any beach investigated. The habitable beach area was no more than 150 meters from a tide level of -0.91 meters to the high tide swash. Western Katmai beach appeared to be a more favorable habitat and commercial dungeness crab fishermen have indicated that this area has a "good" population of *Siliqua*.

Only the northern beach of Alinchak Bay was examined in detail because of continuing poor weather (Appendix figure 10). High winds kept the tide from receeding beyond the 0 meter tide level to the predicted low tide level. An adjacent beach just north of Little Alinchak Bay was briefly examined by foot survey and was observed to have a low density population of *S. patula*.

Bivalve Analysis

Bivalve molluscs were captured using the two previously discussed techniques (Table 4). Pinpoint digging with shovels produced primarily adults of *S. alta, Spisula polynyma, Clinicardium nuttallii* and *Mya arenaria* (Appendix table 1). Sieving techniques that washed approximately 101 liters of substrate per subplot generally captured juveniles of the same species and other bivalve species which had a length at maturity of 60 mm or less such as *Macoma balthica* (Appendix table 2). These juvenile and small molluscs were difficult to locate and capture by pinpoint digging unless the tide level station was very dry and there were not many large bivalves showing. The presence of numerous large bivalve "shows" made it difficult to identify the pinprick like "shows" of the smaller clams since effort was directed toward digging the readily observable "shows".

Of the 16 species captured, individuals from nine (*Macoma calcarea, Macoma loveni, Macoma nasuta, Macoma yoldiformis, Littorina sitkana* (washed ashore), *Brototheca staminae, Tellina nucleoides, Tressus capax* and *Mya arenaria*) were captured only once (Table 4). This does not mean, however, that these particular bivalves were restricted to the localities found: *Mya arenaria* was dug outside the study plot at Kashvik and Alinchak bays. Shells of *Tressus capax* were found at Bumble Bay, Tugidak and other beaches, but only one specimen was captured at Halibut Bay. An index of the relative abundance of these species at each is shown in Table 4.

Table 4. Identification and total numbers of bivalve molluscs by beach May 13-August 30, 1976 captured on the Alaska Peninsula and Kodiak Island.

Beach	# of tide level stations examined	*Siliqua patula*	*Siliqua alta*	*Spisula polynyma*	*Clinocardiom nuttallii*	*Macoma lama*	*Macoma balthica*	*Macoma calcarea*	*Macoma loveni*	*Macoma nasuta*	*Macoma yoldiformis*	*Littorina sitkana*	*Mya arenaria*	*Protothaca staminae*	*Tellina lutea alternidenta*	*Tellina nucleoides*	*Tressus capax*
Tanner Head	7	24	0	10	4	0	0	0	0	1	0	1	0	0	0	0	0
Halibut Bay	10	268	3	7	3	1	0	0	0	0	0	0	0	0	1	0	1
Swikshak	6	121	3	17	0	11	0	0	0	1	0	0	0	0	0	1	0
Village	5	208	26	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Big River	5	211	3	11	2	11	0	0	0	0	0	0	0	0	3	0	0
Hallo Bay	8	63	3	21	5	64	16	1	2	0	0	0	20	0	2	0	0
Kukak Bay	10	105	25	37	16	150	3	0	0	0	3	0	0	1	2	0	0
Bumble Bay	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tugidak	5	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dakavak	7	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kashvik	7	117	0	4	0	19	11	0	0	0	0	0	0	0	0	0	0
Alinchak	4	85	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Clearly the most abundant species encountered (as a result of project design) was *S. patula*. A total of 1,227 specimens were captured in the tide level station plots (Table 5) and 52 specimens in the subsampling plots for a total of 1,279 specimens. The largest specimens (in total length) came from the beaches of Big River, Village and Kukak. Approximately 90% of all razor clams captured were caught between the -0.91 meter tide level and the +0.91 meter tide level. The largest clams were found in the lower tide levels (Table 6 and Figure 6). Junenile razor clams (total length ≤60 mm) were found at the following beaches: Alinchak (42), Swikshak (26), Kashvik (16), Kukak (10), Halibut Bay (9), Big River (7) and Hallo Bay (6).

Forty-nine specimens of *S. alta* were captured in the tide level station plots and 16 were captured in the subsample plots for a total of 65 specimens (Tables 7-8 and Appendix Table 2). Juvenile *S. alta* (total length ≤60 mm) were found at Kukak (24), Village Beach (13), Hallo Bay (3), Halibut Bay (3), Swikshak (2), and Big River (2). A species of *Siliqua* was found at Hallo Bay which appeared to be a cross between *S. patula* and *S. alta*, however, positive identification of this specimen has not yet been made.

It is not possible to draw more than subjective evaluation of the relative abundance of *S. patula* at the beaches studied. Nickerson (1975) found in his research on razor clam stocks in Prince William Sound that the percentage of the resident *Siliqua* population that "shows" on a given day is dependent on the following environmental parameters:

1)	The water vapor deficit	(same day and day before)
2)	The air pressure	(" " " " ")
3)	Atmospheric pressure	(" " " " ")
4)	Low tide heights	(same day)
5)	Water surface conditions	(same day)
6)	Wind speed	(same day)

Nickerson devised a computer program which treated these parameters in conjunction with clam "shows". This analytical technique was designed to determine what percentage of a total population was represented by a given number of "shows". He found that the percentage of clams "showing" was highest on days that were wet, warm, had low atmospheric pressure, high low tide heights, small wave ranks and low windspeed (Nickerson 1975).

Lacking a computer program designed for the Kodiak area, the author offers the following ranking of beaches surveyed in terms of the total numbers of *Siliqua patula* at each beach: 1) Swikshak, 2) Big River, 3) Kashvik, 4) Village, 5) Kukak, 6) Alinchak, 7) Halibut Bay, 8) Hallo Bay, 9) Dakavak, 10) Tanner Head, 11) Tugidak, 12) Ocean Bay, 13) Bumble Bay, 14) Katmai east.

This ranking is a subjective interpretation of field observations and data presented in Tables 4 & 5. It should be noted that, while the Halibut Bay station yielded most razor clams, it was located in an area of high density and was representative of only the southern portion of the beach (Appendix figure 3). The Tugidak Island stocks, on the other hand, might have a significantly higher population of *Siliqua* than indicated in the above ranking once the Tugidak Passage bars are assessed. The beach drift zone near the Tugidak lagoon mouth had the greatest accumulation of *Siliqua* shells.

Table 5. Number of *Siliqua patula* dug from each tide level station plot, May 13 - August 30, 1976.

Beach	Tide level in feet (meters) -4 (1.22)	-3 (-0.91)	-2 (-0.61)	-1 (-0.30)	0 (0.00)	+1 (+0.30)	+2 (+0.61)	+3 (+0.91)	+4 (1.22)	+5 (+1.52)	+6 (+1.83)	+7 (+2.14)	+8 (+2.44)
Tanner Head	-*	-	-	7	10	5	0[1]	1	1	-	0	-	-
Halibut Bay	-	-	-	34	53	32	73	27	21	26	0	-	0[2]
Swikshak	-	-	-	32	34	13	12	17	3	-	-	-	-
Village	34	58	67	33	14	-	-	-	-	-	-	-	-
Big River	-	-	60	52	43	41	-	10	-	-	-	-	-
Hallo Bay	-	10	5	20	9	13	0	0	0	0	-	-	-
Kukak	-	-	-	6	4	10	19	23	26	9	0	0	0
Tugidak	-	-	-	8	12	1	-	-	-	-	-	-	-
Dakavak	-	-	-	4	12	16	11	5	1	0	-	-	-
Kashvik	-	-	-	43	36	26	2	0	0	0	-	-	-
Alinchak	-	-	-	-	-	29	51	0	-	-	-	-	-
Bumble Bay	-	-	-	-	1	2	1	0	0	0	-	-	-

*Dash indicates tide level not examined'

[1]Poor weather conditions kept bivalves from "showing."

[2]The +9' tide level station was also examined. No bivalves were found.

Table 6. Mean length in mm of *Siliqua patula* dug from each tide level station plot, May 13 - August 30, 1976.

Beach	Tide level in feet (meters) -4 (-1.22)	-3 (-0.91)	-2 (-0.61)	-1 (-0.30)	0 (0.00)	+1 (+0.30)	+2 (+0.61)	+3 (+0.91)	+4 (+1.22)	+5 (+1.52)
Tanner Head	-*	-	-	122	126	118	0	63	117	-
Halibut Bay	-	-	-	120	119	112	99	101	110	93
Swikshak	-	-	-	85	93	102	101	97	66	-
Village	133	140	140	132	130	-	-	-	-	-
Big River	-	-	142	143	157	124	-	129	-	-
Hallo Bay	-	128	131	110	127	125	-	-	-	-
Kukak	-	-	-	133	147	106	117	120	116	90
Bumble Bay	-	-	-	-	99	125	121	-	-	-
Tugidak	-	-	-	110	118	122	-	-	-	-
Dakavak	-	-	-	127	134	131	132	123	120	-
Kashvik	-	-	-	117	112	107	97	-	-	-
Alinchak	-	-	-	-	-	28	98	-	-	-

*Dash(-) Indicates tide level was not examined

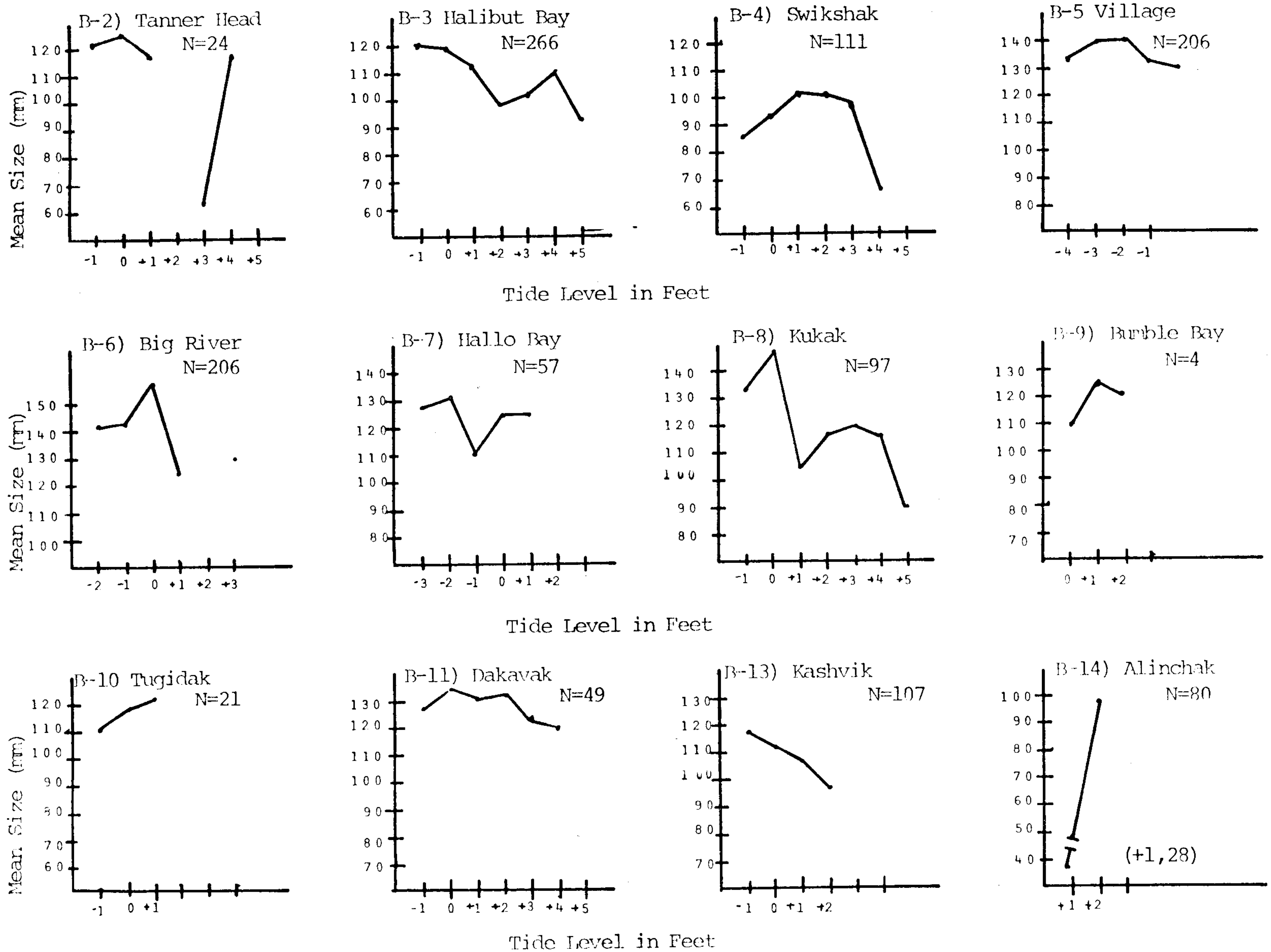


Figure 6. Comparison of tide levels and mean size of *Siliqua patula* captured in each tide level station plot.

Table 7. Number of all *Siliqua alta* dug from each tide level station plot, May 13-August 30, 1976.

	Tide level in feet (meters)												
Beach*	-4 (-1.22)	-3 (-0.91)	-2 (-0.61)	-1 (-0.30)	0 (0.00)	+1 (+0.30)	+2 (+0.61)	+3 (+0.91)	+4 (+1.22)	+5 (+1.52)	+6 (+1.83)	+7 (+2.14)	+8 (+2.44)
Swikshak	-	-	-	2	0	0	0	0	0	-	-	-	-
Village	24	0	1	1	0	-	-	-	-	-	-	-	-
Big River	-	-	1	0	1	0	-	0	-	-	-	-	-
Kukak	-	-	-	0	3	1	4	3	4	1	1	0	0
Alinchak	-	-	-	-	-	0	2	0	-	-	-	-	-

**Siliqua alta* found outside the study plots at Tanner Head, Dakavak, and Hallo Bay.

Table 8. Mean length in mm of all *Siliqua alta* dug from each tide level station plot, May 13 - August 30, 1976

	Tide level in feet (meters)										
Beach	-4 (-1.22)	-3 (-0.91)	-2 (-).61)	-1 (-0.30)	0 (0.00)	+1 (+0.30)	+2 (+0.61)	+3 (+0.91)	+4 (+1.22)	+5 (+1.52)	+6 (+1.83)
Swikshak	-	-	-	63	0	0	0	0	0	-	-
Village	49	0	104	99	0	-	-	-	-	-	-
Big River	-	-	12	0	51	0	-	0	-	-	-
Kukak	-	-	-	21	20	29	27	56	16	31	-
Alinchak	-	-	-	-	-	0	17	0	-	-	-

Dash (-) indicates tide level was not examined.

encountered. This accumulation of shells might, however, be the result of very high natural mortality of a small population, as until very recently the waters off the Tugidak Passage were prime dungeness fishing grounds (Guy Powell, personal communication); it seems possible, therefore, that a connection may exist between good dungeness fishing grounds and large clam populations. The fact that the numerous Aleut midden sites existing on Tugidak Island have vast accumulations of *S. patula* shells suggests that clam stocks have existed in this area for many years.

Hallo Bay had the most diverse populations of bivalves (a total of ten species) of the 14 studied. The beach on Ninagiak Island (Appendix figure 4) had abundant populations of *S. patula* and *alta, Tellina lutea alternidenta, Spisula polynyma* and *Mya elegans*. This small area, in fact, had a denser population of these than did that segment between Hallo and Cook creeks. It appeared at all beaches surveyed that populations of *S. patula* were of average density at or near the center of the beach and that the high and low density populations were located at or near the ends of a given beach.

Previous studies by ADF&G on clam stocks at Swikshak and Big River beaches resulted in estimations of the *S. patula* population size (Kaiser and Konigsberg, 1975 unpublished). Estimates were made of the number of clams ≤91 mm using Peterson's mark and recapture techniques. A total area of three million square meters was assessed at Swikshak beach which approximated the amount of habitat readily accessible to commercial hand diggers. A total of 1.4 million clams >115 mm and 1.1 million clams 91-114 mm in length were estimated in this habitat. Estimates at Big River beach, based on 707 thousand square meters of *Siliqua* habitat, were 1.3 million clams 115 mm and .3 million clams 91-114 mm in length. These estimates are conservative in that they assess only the clam populations between the -0.91 meter tide level and +1.22 meter tide level. A significant number of clams exist below the -0.91 meter tide level. Comparison of plot densities and habitat assessment surveys in current OCSEAP studies with those from the prior Swikshak beach investigation suggested that the portion of razor clam populations ≥91 mm ranged from approximately 2.5 million individuals at Swikshak beach to only several thousand at Bumble Bay and east Katmai beach.

Invertebrate Analysis (other than bivalve molluscs)

Polychaetes and nemeridians were captured exclusivley while sieving subsamples (Table 9). The number of annelids captured was dependent upon the density of the resident population and the number of subsamples taken. If the percentage of coarse sand and gravel was large, the sieving process was retarded. In order for the sampling crew to stay above an incoming tide in these cases it was often impossible for them to sieve the required 304.8 liters of sand from each tide level site. As a result of the high gravel content of the substrate at Bumble Bay, for instance, time was available for sieving only 33 liters of substrate. Therefore, special note should be paid to the volume of sand sieved before comparisons are drawn on the respective beach habitats.

The most frequently encountered annelids were *Scolelepis squamatus* (2966 specimens at 11 beaches), *Nephtys caeca* (254 specimens at 10 beaches), *Nephtys californiensis* (155 specimens at 9 beaches), *Haploscoloplos elongatus* (181 specimens at 9 beaches) and *Ophelia assimilis* (165 specimens at 8 beaches). One species of Nemertea was identified as *Cerebratulus californiensis*. Other unkeyable fragments were denoted

Table 9. Identification and total numbers of invertebrates (*polychaetes and nemeridians*) cantured May 13 - August 30, 1976 on the Alaska Peninsula and Kodiak Island.

Beach	Volume of sand sieved in thousands of liters	*Scolelepis squamatus*	*Haploscoloplos elongatus*	*Ophelia assimilis*	*Anaites groenlandica*	*Eteone longa*	*Glycinde picta*	*Cistenides brevicoma*	*Nephtys caeca*	*Nephtys californiensis*	*Nephtys ciliata*	phylum Nemertea	*Cerebratulus californiensis*
Tanner Head	2.1	137	0	14	0	0	0	0	20	0	0	0	0
Halibut Bay	2.1	231	42	13	0	2	4	0	11	3	0	5	0
Swikshak	1.8	359	18	0	0	7	0	0	20	13	3	0	1
Village	1.2	248	30	1	1	0	0	2	28	19	0	0	3
Big River	1.5	157	32	9	0	0	0	0	7	2	0	0	1
Hallo Bay	1.8	264	15	0	6	0	0	2	57	0	0	1	4
Kukak	3.0		10	0	1	1	1	0	71	1	0	5	3
Bumble Bay	.2	3	0	4	0	0	0	0	1	0	0	0	0
Tugidak	1.4	0	9	4	0	2	7	0	0	7	0	0	0
Dakavak	1.5	24	1	111	2	1	0	0	0	80	0	3	1
Kashvik	1.7	230	24	9	0	5	2	0	26	21	0	0	0
Alinchak	1.1	340	0	0	0	0	0	0	13	9	0	0	0

as Nemertea. In all, twelve species of annelids were encountered, identified and recorded in respect to tide level of capture (Appendix table 2).

Age Analysis

Aging of *S. patula* proved to be a tedious process. It was often impossible to interpret the first annuli. In these cases the first annuli recorded was at the second annular ring. As shells became brittle from cleaning in clorox and nitric acid baths, they broke easily. This limited the ability to consistently correlate the total length to a specific age class. To eliminate the effects of this breakage problem it would be prudent in future studies to attempt age determination of clams in the field and segregate their shells into age classes so each could be measured separately. In this way it would be possible to correlate environmental parameters to annular growth.

Razor clams from Bumble Bay appeared to have the slowest growth rate, and those from Kashvik Bay the most rapid. Razor clams at the beaches of Tugidak, Tanner Head, Halibut Bay and Alinchak beach had growth rates similar to that at Bumble Bay, while those at Big River, Kukak, Swikshak, Village, Hallo Bay and Dakavak had rates similar to that at Kashvik. In other words, it appeared that all of the Kodiak Island beaches investigated had a slower growth rate than the Alaska Peninsula beaches with the exception of Alinchak Bay. Mean lengths, standard deviations and standard errors of valve lengths at each annuli from all clams captured at each beach station are presented in Appendix table 3 and figure 7.

At all beaches investigated (except Dakavak, Village and Kashvik) the greatest increment of annular growth occurred during the clam's third growing season (between the second and third annuli). At Dakavak, Village and Kashvik beaches the greatest annular growth appeared to occur during the clam's fourth growing season (between the third and fourth annuli) (Figure 8).

Razor clam stocks at Swikshak, Village, Big River, Hallo Bay, Kukak, Dakavak, Kashvik and Alinchak beaches attained a length of 115 mm and presumed sexual maturity (Nickerson 1975) at an age of 4.5-5.5 years. Clams at Tanner Head, Halibut Bay, and Tugidak Island beaches attained a length of 115 mm at 5.5-6.5 years of age. Razor clams at Bumble Bay are apparently the latest group to mature sexually, not attaining a size of 115 mm until the 6.5-7.5th year. This difference in age at sexual maturity again implies that razor clam populations on Kodiak Island beaches developed more slowly than did those on Alaska Peninsula beaches studied.

A factor that might bear some relationship to this apparent difference in rate of development is the fact that razor clams from Halibut Bay and Tanner Head beaches on Kodiak Island (collected for P.S.P. studies over the past few years by the Department of Fish and Game) characteristically had considerably higher amounts of toxin than did those collected from Alaska Peninsula beaches. It is possible that the environmental factors in Halibut Bay and Tanner Head beaches that foster the growth of the *Gonyaulax* dinoflagelate are also responsible for the slower rate and is not as pronounced in the faster growing clams from the Alaska Peninsula.

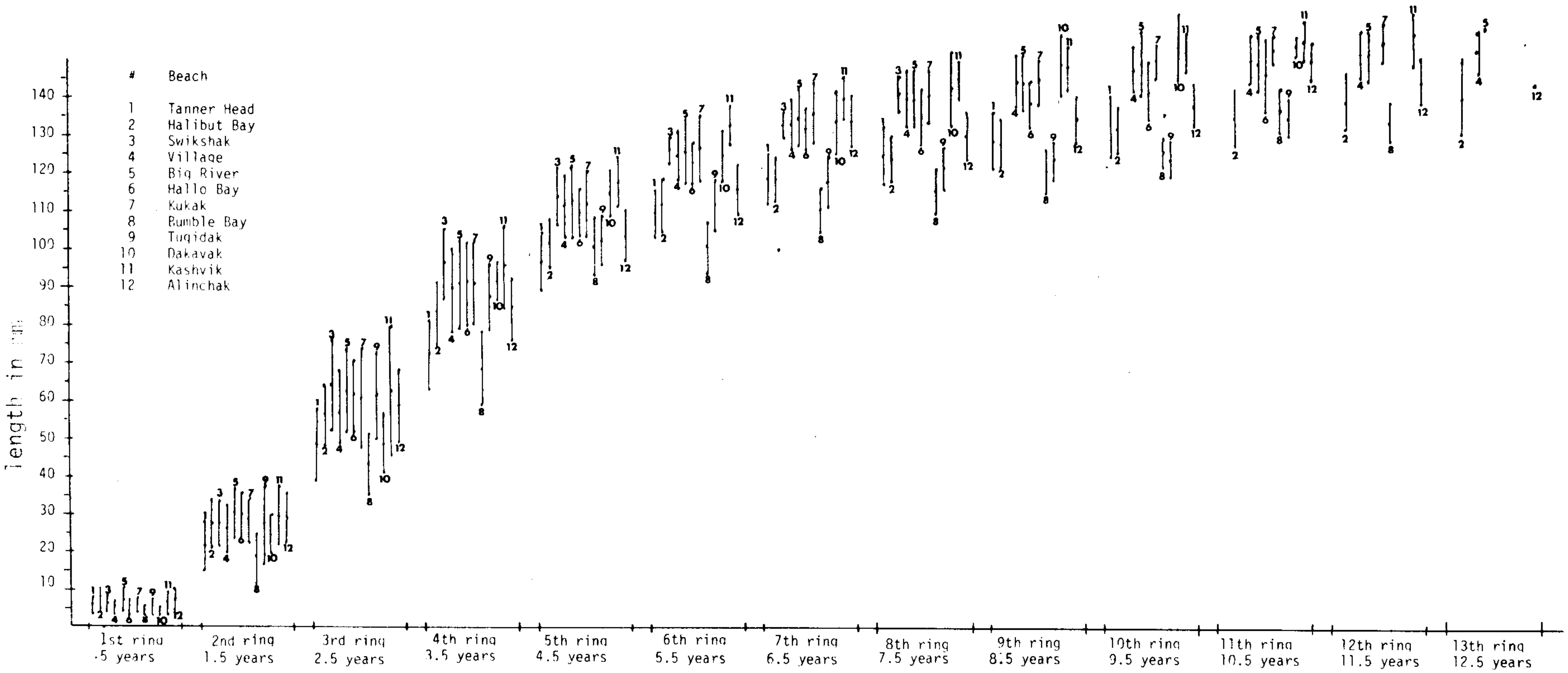


Figure 7. Comparison of the mean and one standard deviation of the cummulative annual growth increments from shells of *Siliqua patula* captured from areas of average density near the centers of twelve Kodiak Island and Alaska Peninsula area beaches.

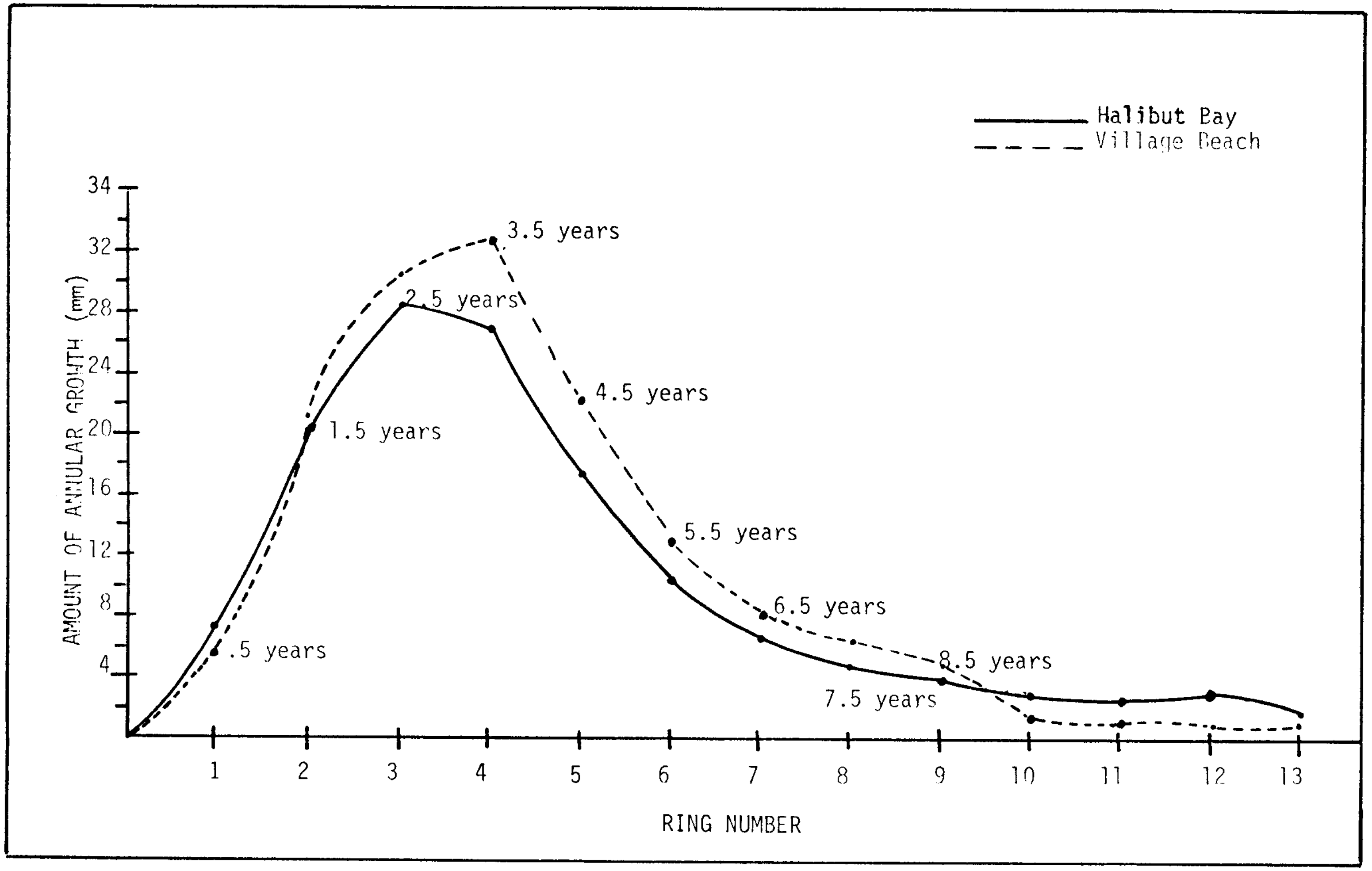


Figure 8. Profile of growth increments between consecutive annular rings of *Siliqua patula* from Halibut Bay and Village Beach, Alaska, 1976. Profile for Halibut Bay applicable to all beaches investigated except Dakavak, Village and Kashvik beaches which are represented by Village Beach.

Substrate Analysis

The predominant grain size within the favorable *Siliqua* habitat at the majority of the beaches investigated is fine sand which corresponds to a phi (ϕ) size designation of 2-3 (Table 2). The substrate at Swikshak beach (between the -0.61 and +1.22 meter tide levels) and Halibut Bay (between the -0.61 and +2.74 meter tide level stations) is predominantly fine. The substrate at all other beach stations (except Bumble Bay) is composed of fine and medium grain sand, generally progressing from fine sand to medium sand as the beach elevation increases. Only at Bumble Bay is the substrate predominantly coarse sand (Table 10, Appendix table 4).

An inverse relationship between grain size and the number of *S. patula* was apparent although not statistically proven (Figure 8). Fine and medium sand seemed to support a denser, more diverse population of invertebrates than does a substrate of predominantly coarse sand. This was particularly evident at the Bumble Bay station which had the least dense and diverse invertebrate populations and the coarsest substrate of the beach stations investigated. The Halibut Bay, Swikshak, and Kukak beach stations, which are characterized by a predominance of fine grained sand had dense and diverse invertebrate populations. It is possible that the physical factors which caused the sand to settle as it did also caused razor clam veligers to settle along with the fine sand: i.e. so that they are not in effect seeking out a fine sand substrate. It is known that silt, in a proportion greater than 2.2 percent of the substrate in the top four inches (10.16 cm) of the substrate surface, is potentially lethal to early life stages of razor clams (Nickerson 1975).

CONCLUSION

This paper has attempted to present some aspects of ecological baseline data for the surf swept, sandy beach *S. patula* habitat of the twleve Kodiak Island and Alaska Peninsula area beaches investigated in FY 1976. It is hoped that this project can be further developed to aid in the ongoing monitoring of the invertebrate populations of this sandy beach habitat using *S.patula* as a target species. Populations of this relatively stable, non-migrant bivalve could be used as a convenient monitoring vehicle to assess the impact of oil development on this portion of the marine intertidal ecosystem.

In the event this study is extended only to collect baseline data from unassessed *Siliqua* habitat, it is strongly recommended that beach station sites transect an area of high density of the *Siliqua* population rather than an area of average density. This would insure a large sample size and a subsample which would be more likely to contain the less commonly occurring bivalves and annelids than possible from a station of average density. Also, any impact from oil pollution could be more readily observed by monitoring an area of high species density and diversity.

Little work has been done to ascertain the mechanisms of oil toxicity on the razor clam. Research at the NMFS facilities at Auke Bay (Chris Brodersen, personal correspondence 1976) indicates that oil affects razor clams by causing direct mortalities. However, the effects might be so subtle as to only taint the taste of the meat. Even less is known about the mechanism of skin absorbtion by the annelids and the effects of oil on these invertebrate species----clearly more research is indicated in this regard.

Table 10. Mean sand grain diameter (mm) for each tide level investigated on 12 Alaska Peninsula and Kodiak Island area beaches.

Beach	Tide Level -4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9
Tanner Head*			.20	.20	.28	.30	.42	.47	.21	.20	.31	.19	.18	.18
Swikshak			.21	.24	.23	.20	.21	.22	.26					
Village	.20	.19	.23	.21	.21	.36	.39	.36	.37					
Big River		.24	.26	.25										
Halibut Bay*			.18	.19	.19	.20	.24	.23	.21	.21	.20	.22	.21	.20
Bumble Bay				.59	.52	.53	.59	.56	.64	.74				
Tugidak				.21	.23	.25								
Hallo Bay		.47	.42	.38	.34	.38	.28	.46						
Kukak			.25	.23	.22	.22	.22	.27	.22	.24	.23	.27	.31	.30
Dakavak			.24	.23	.25	.23	.27	.31	.28	.35				
Kashvik			.23	.25	.39	.58	.25	.43	.45	.64				
Alinchak					.35	.31	.30	.35						

*Not all standard seive sizes were available for sediment analysis.

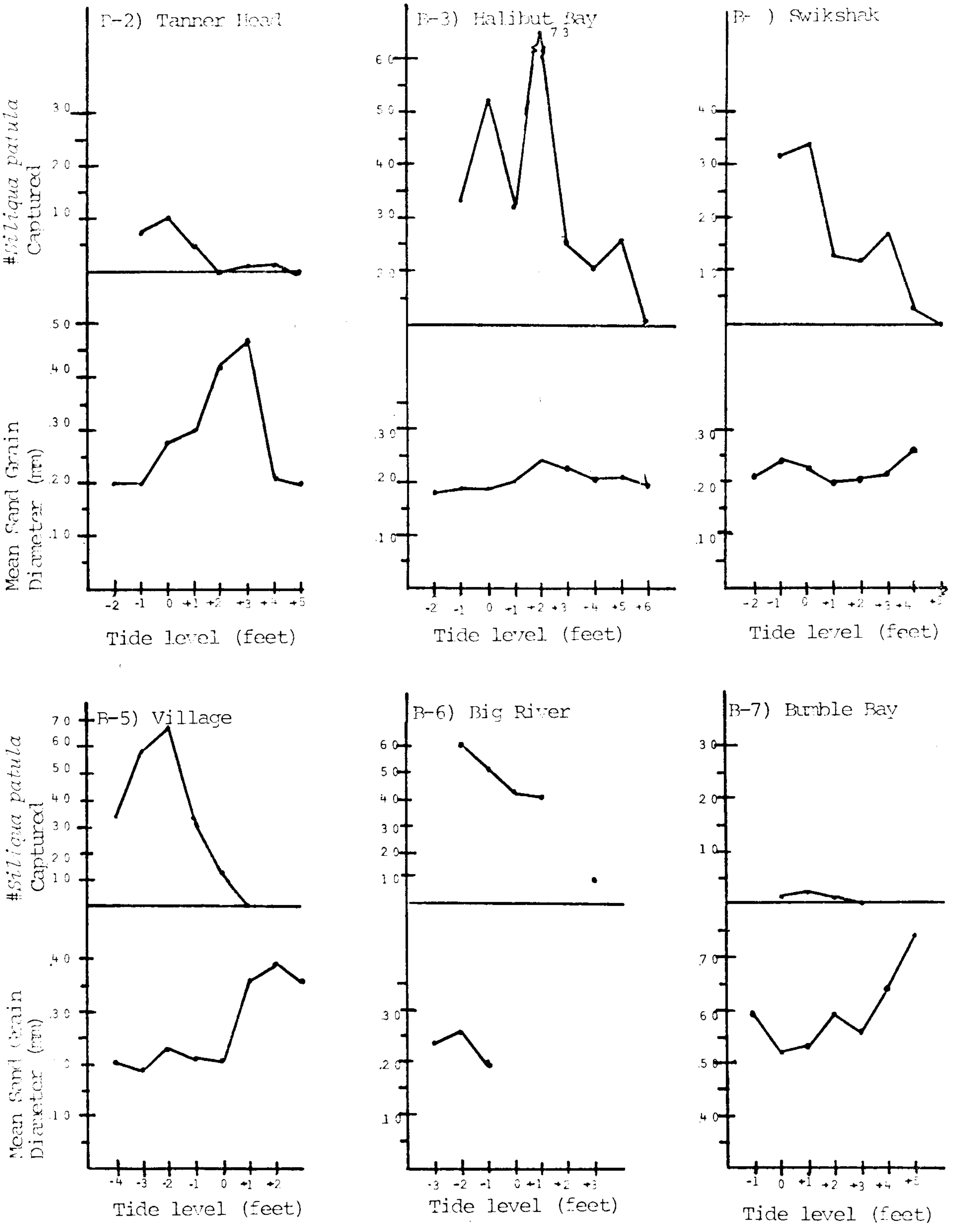


Figure 9. Comparison of sediment composition and the number of *Siliqua patula* captured in each tide level station plot.

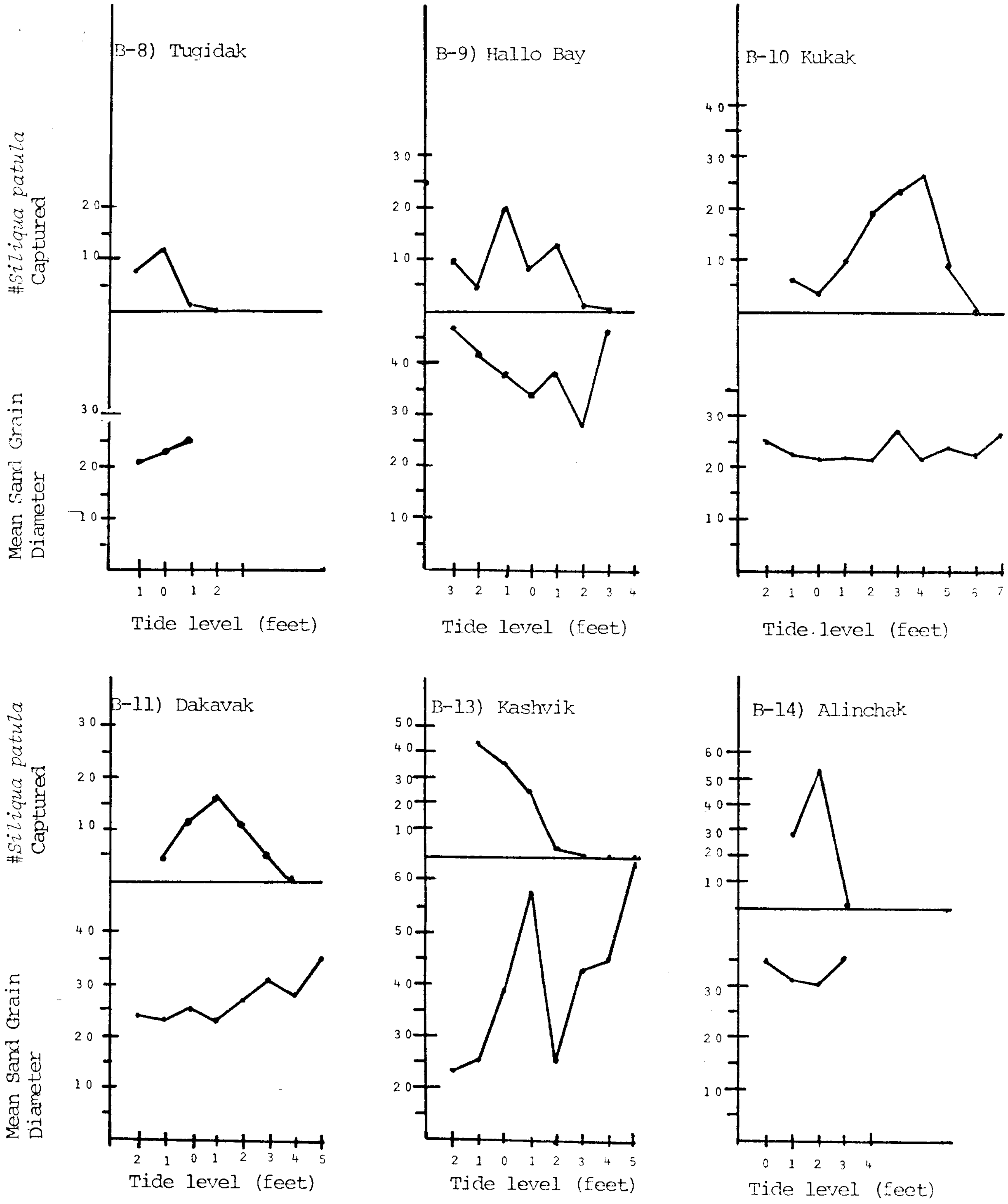


Figure 9. Continued.

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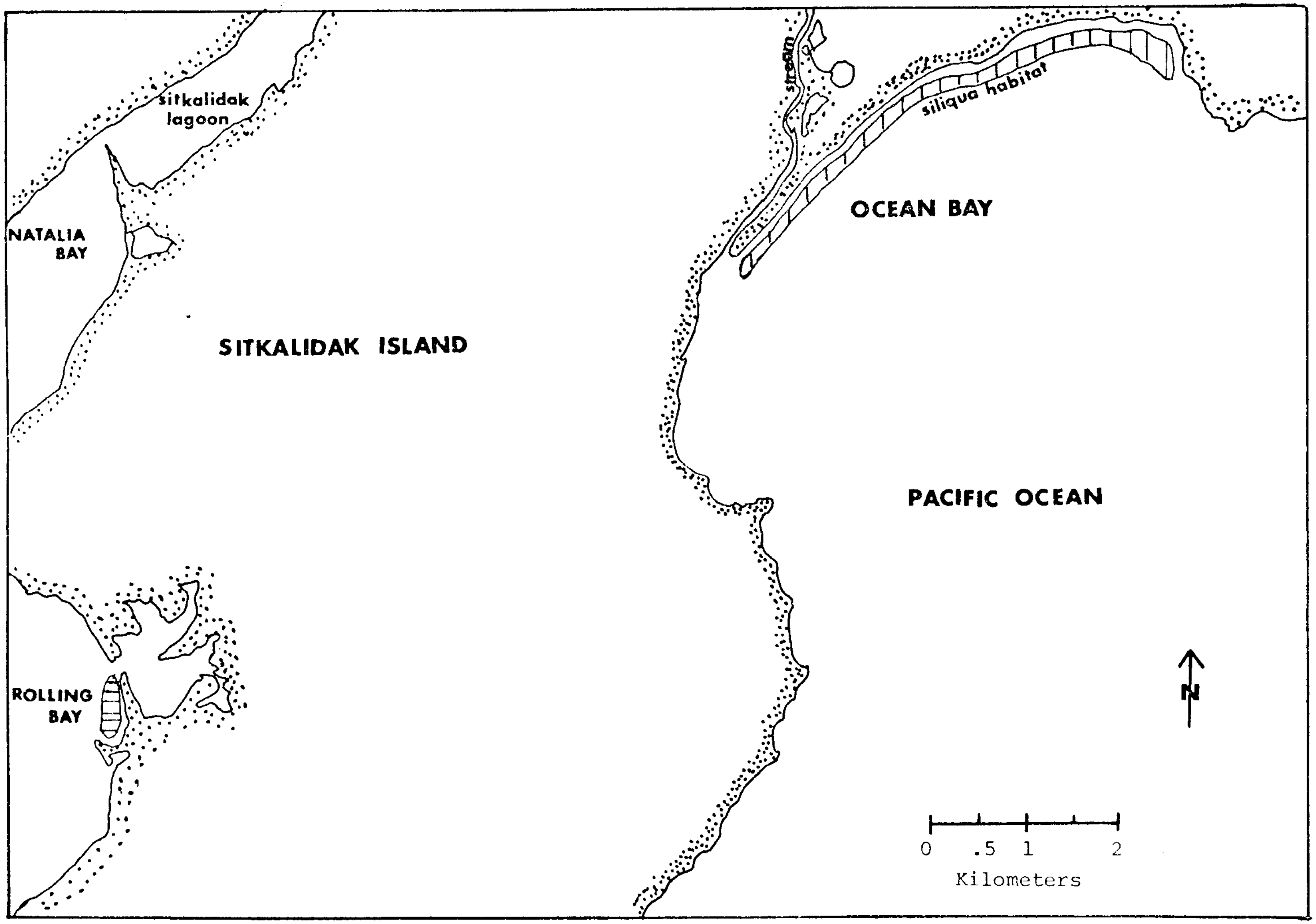
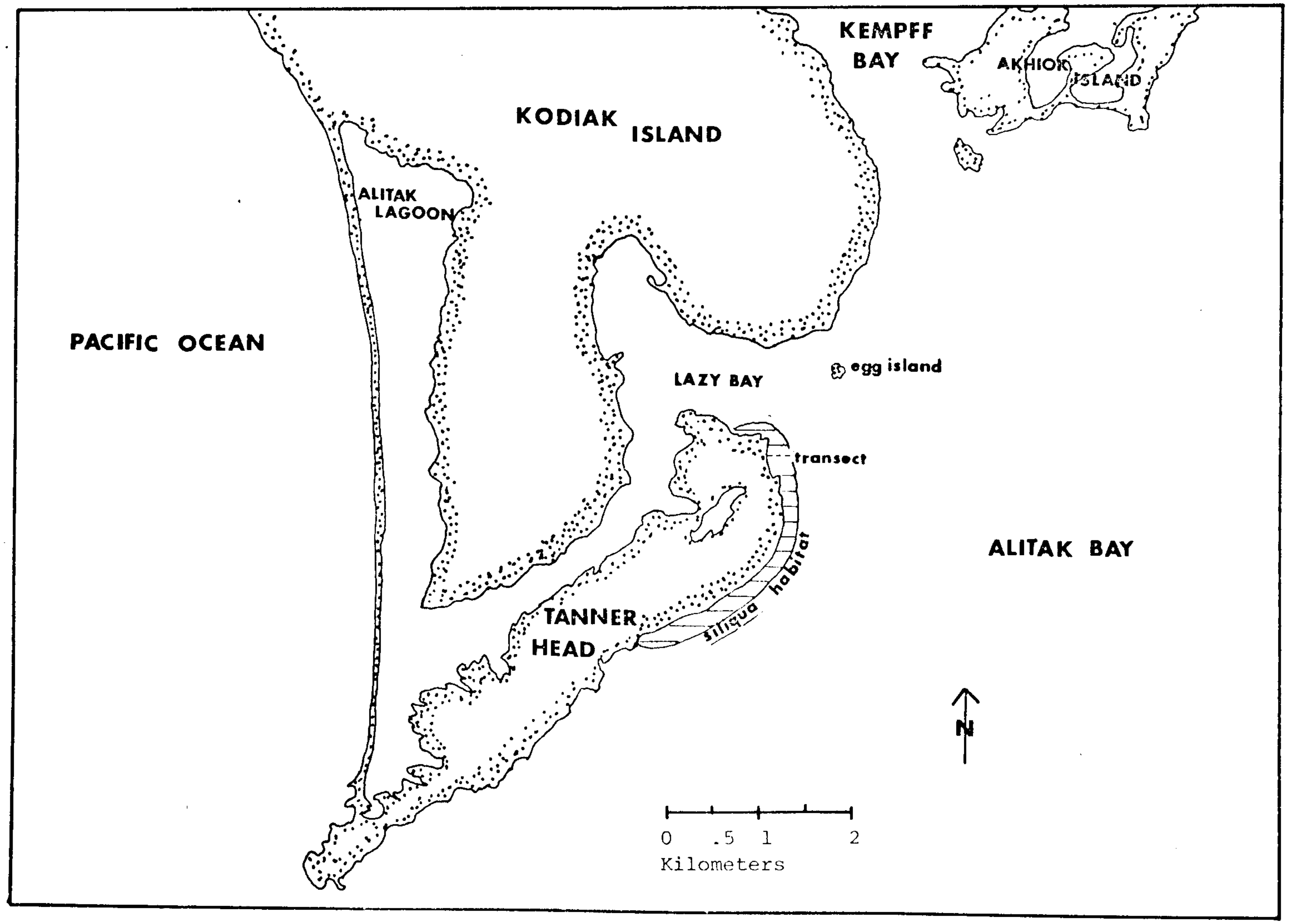
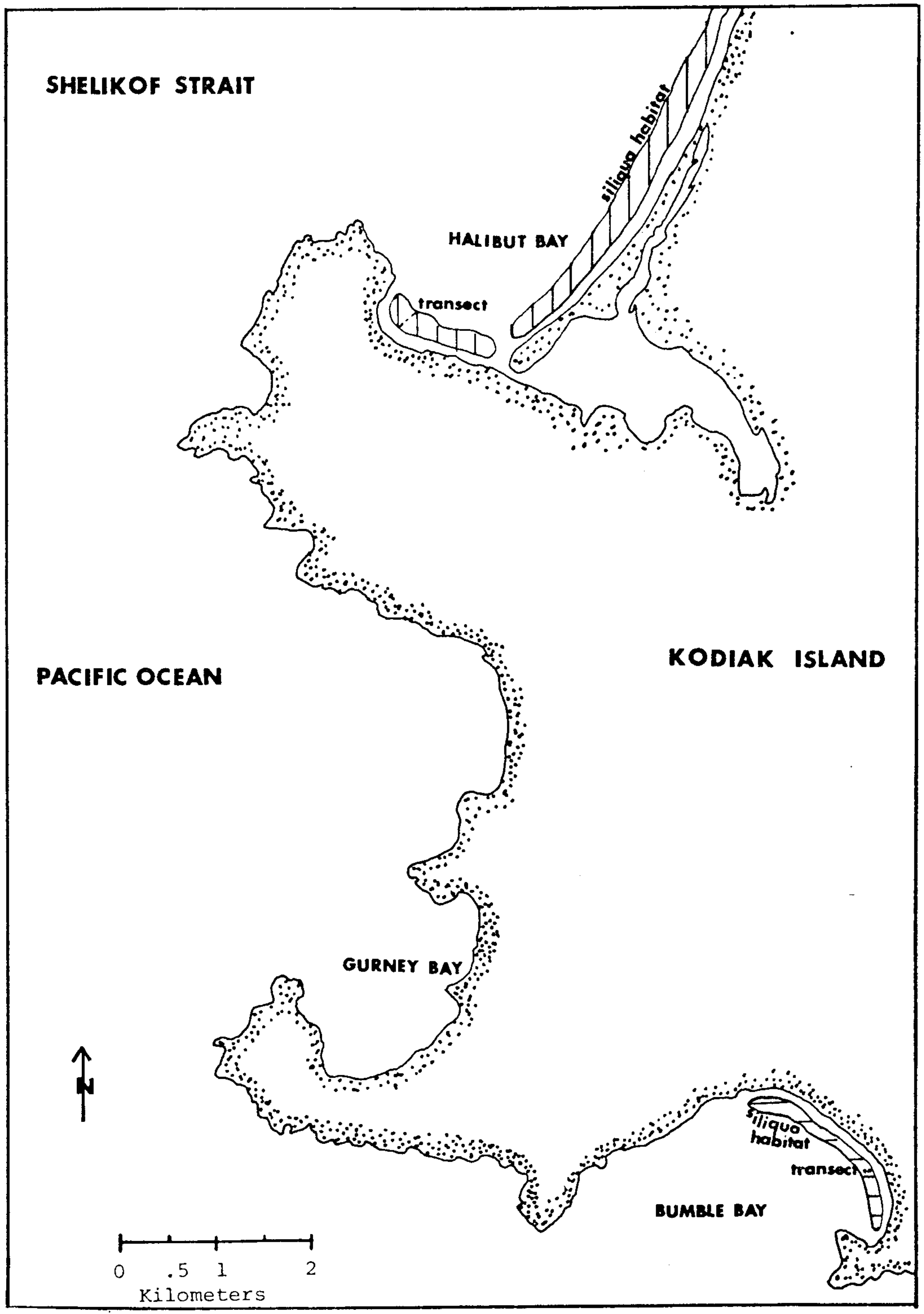


Appendix figure 1. Razor clam station B1 at 57°06'40"N. lat., 153°10'00"W. long., Kodiak Island, Alaska, 1976.



Appendix figure 2. Razor clam station B2 at 56°52'50"N. lat., 154°13'20"W. long., Kodiak Island, Alaska, 1976.



Appendix Figure 3. Razor clam station B3 (57°21'35"N. lat., 154°13'20"W. long., Kodiak Island, Alaska, 1976.

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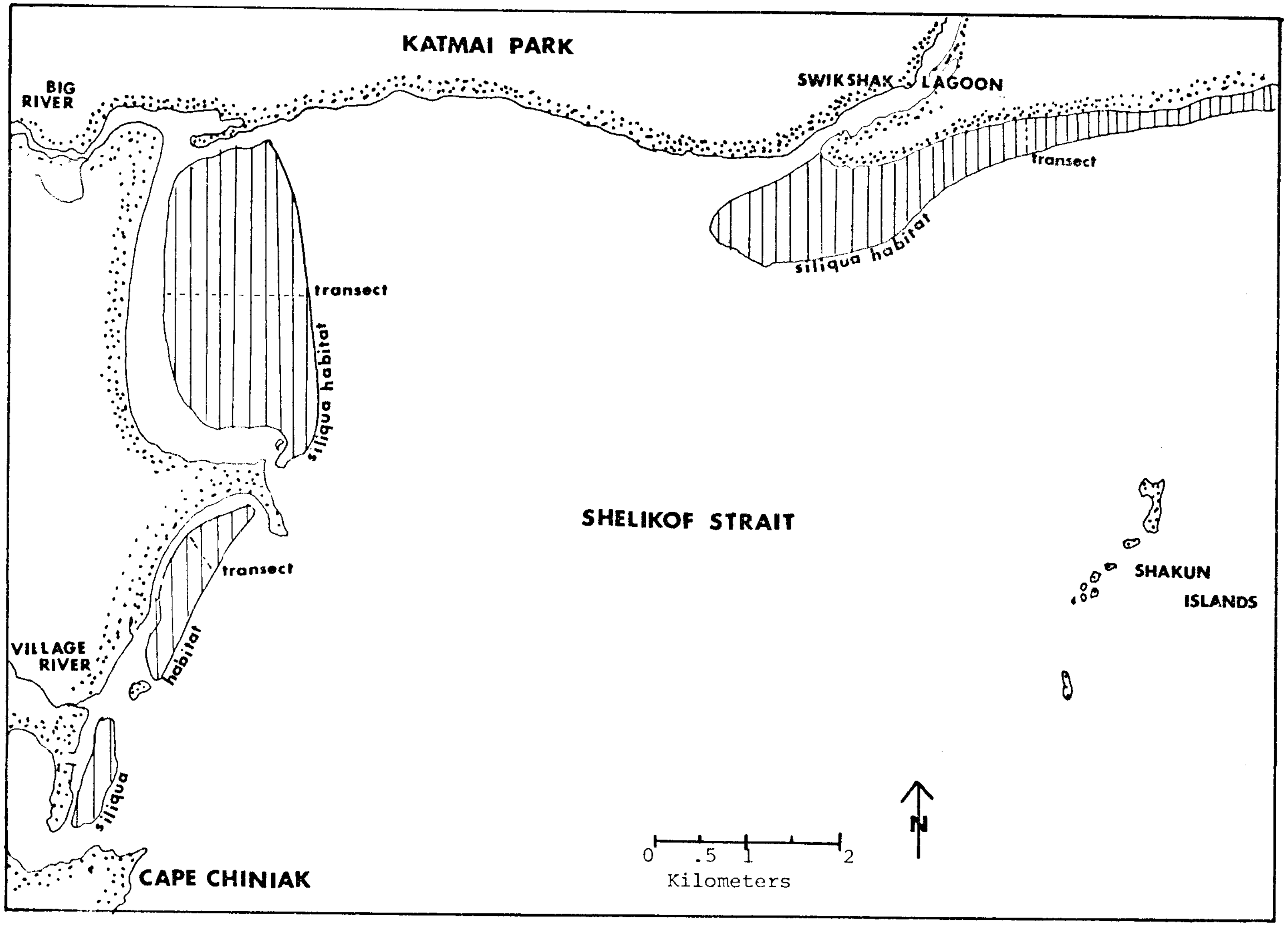
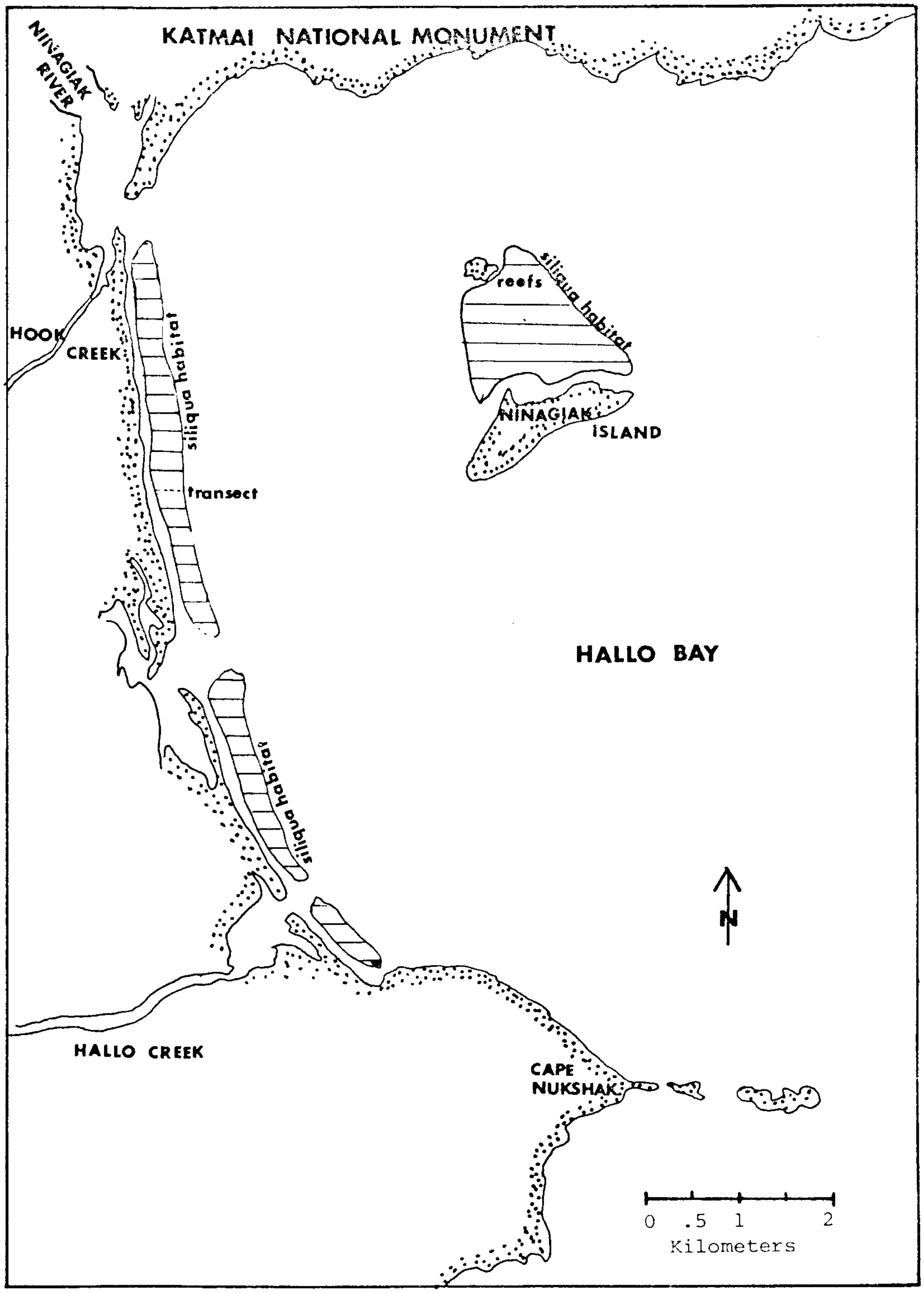
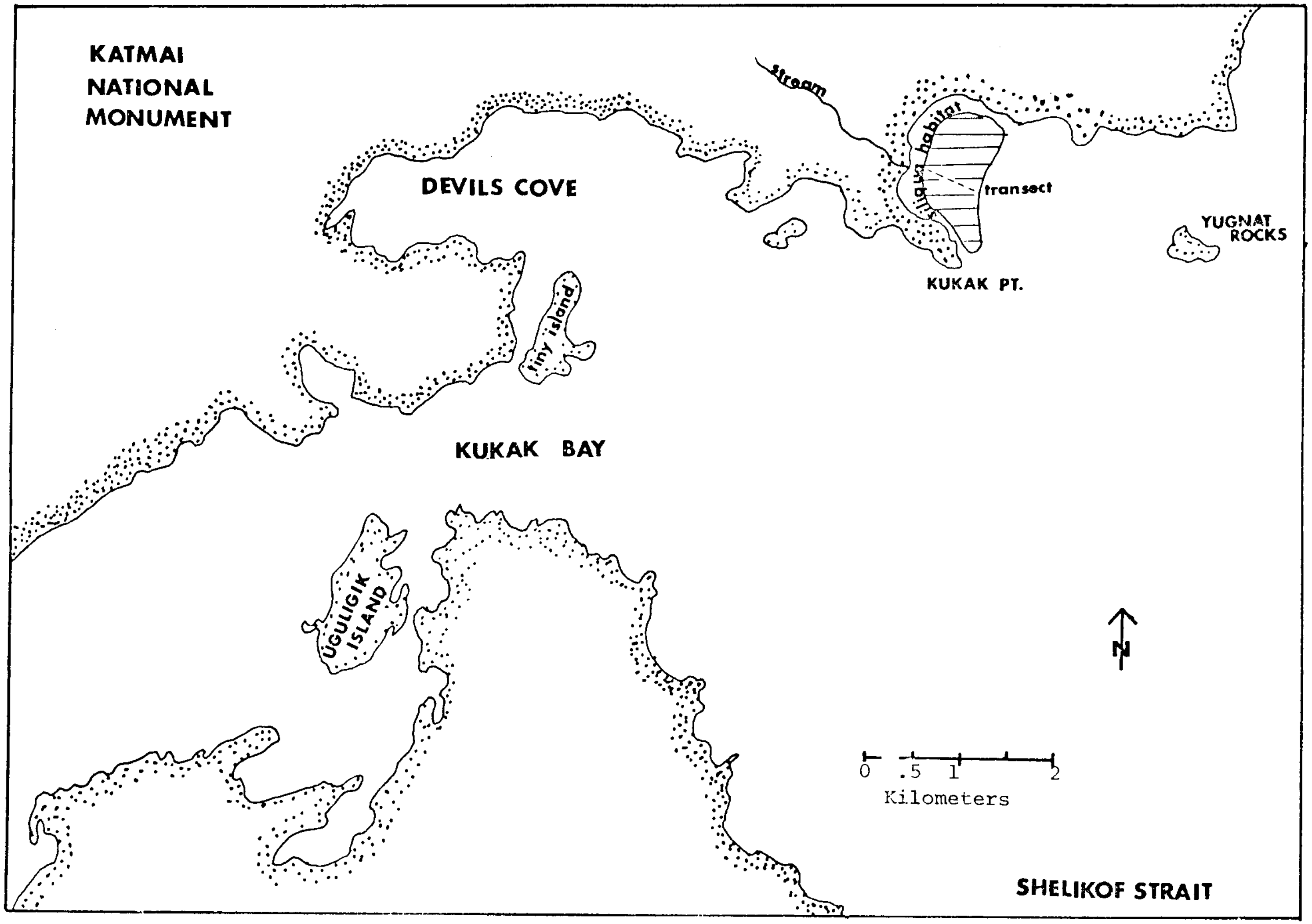


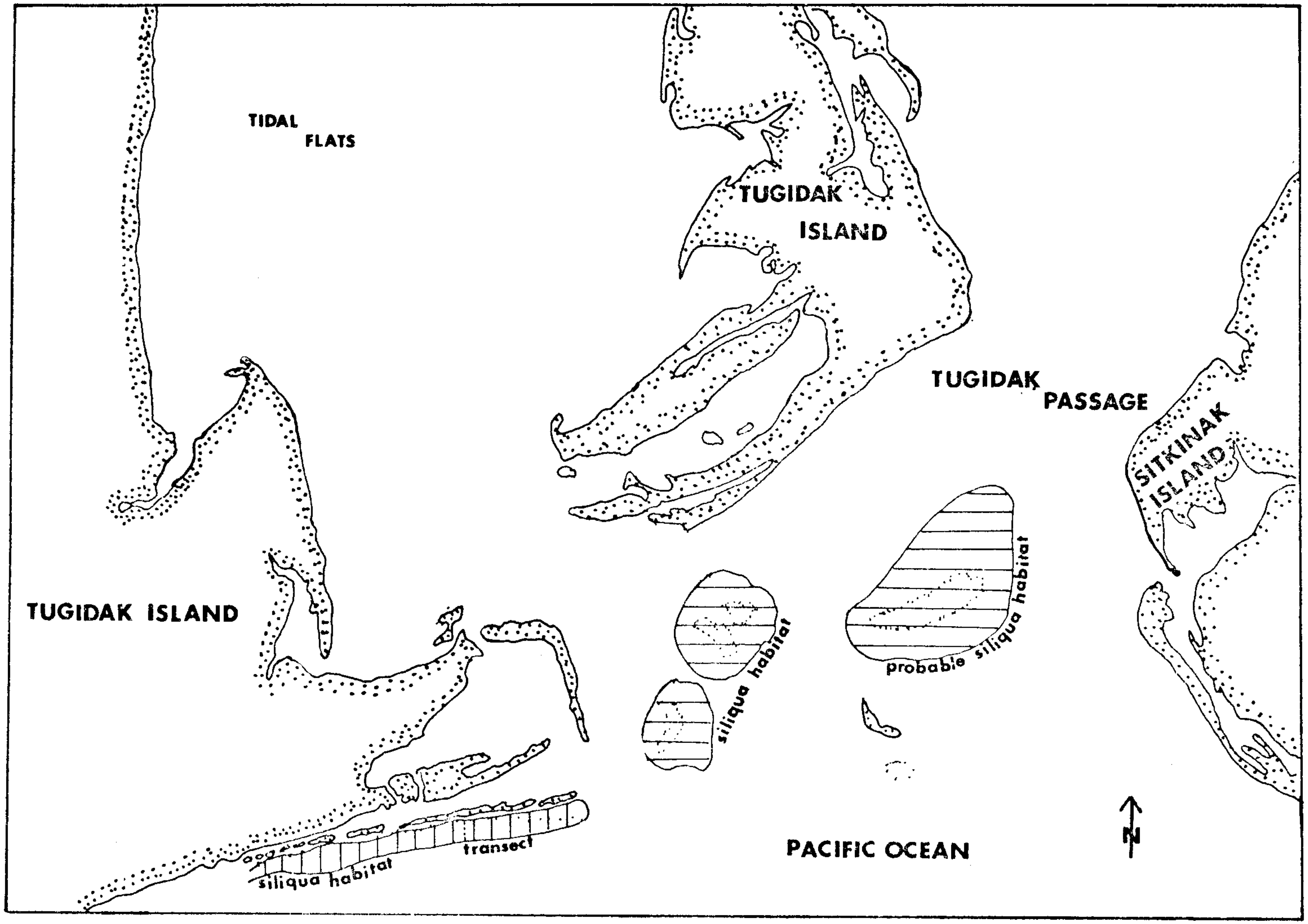
Appendix figure 4. Razor clam stations B4 (58°36'35"N. lat., 153°43'10"W. long. B5 (58°34'10"N. lat., 153°50'30"W. long.) and B6 (58°35'40"N. lat., 153°52'10"W. long.), Alaska Peninsula, Alaska, 1976.



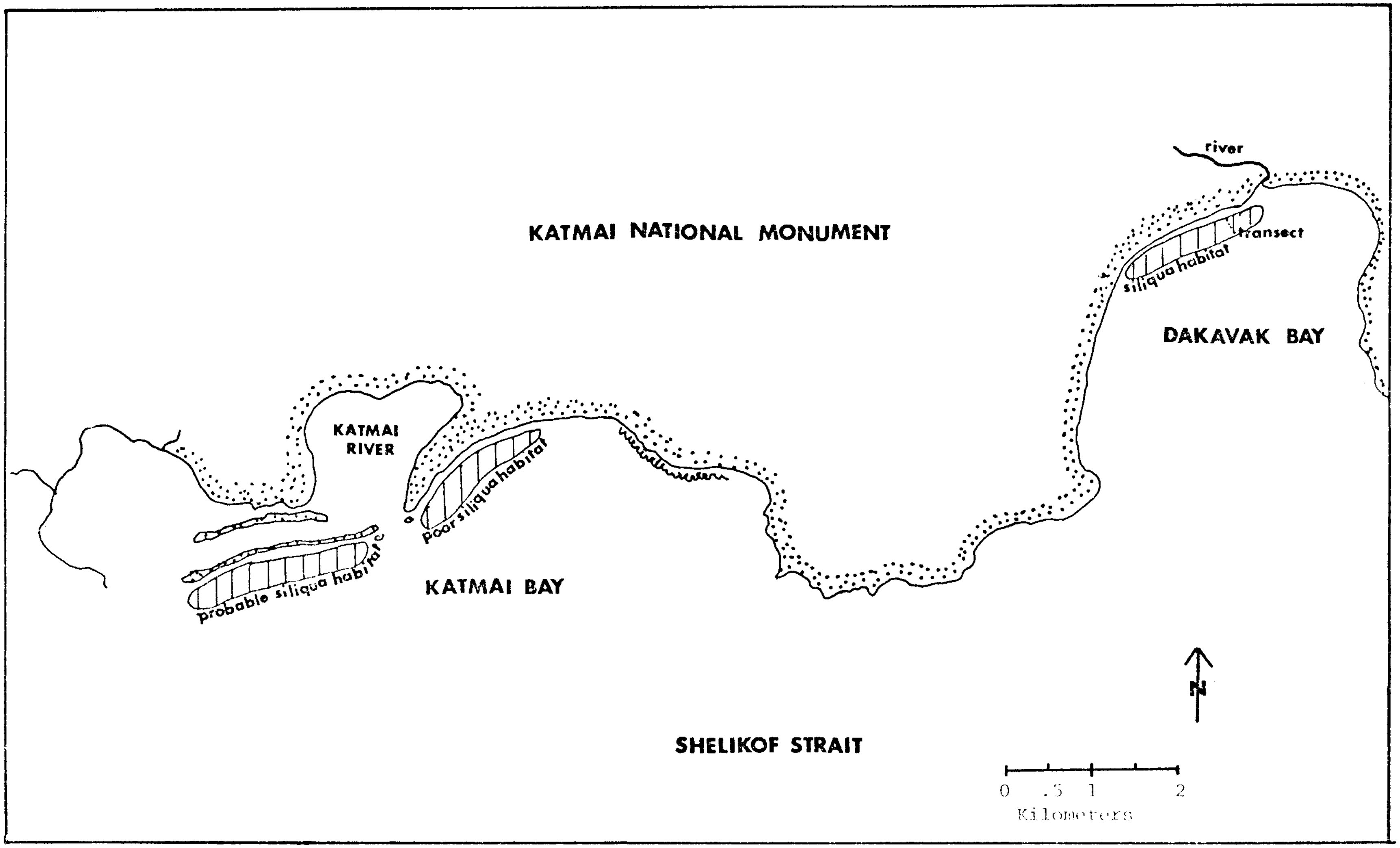
Appendix figure 5. Razor clam station B7 at 58°20'10"N. lat., 154°04'15" W. long., Alaska Peninsula, Alaska, 1976



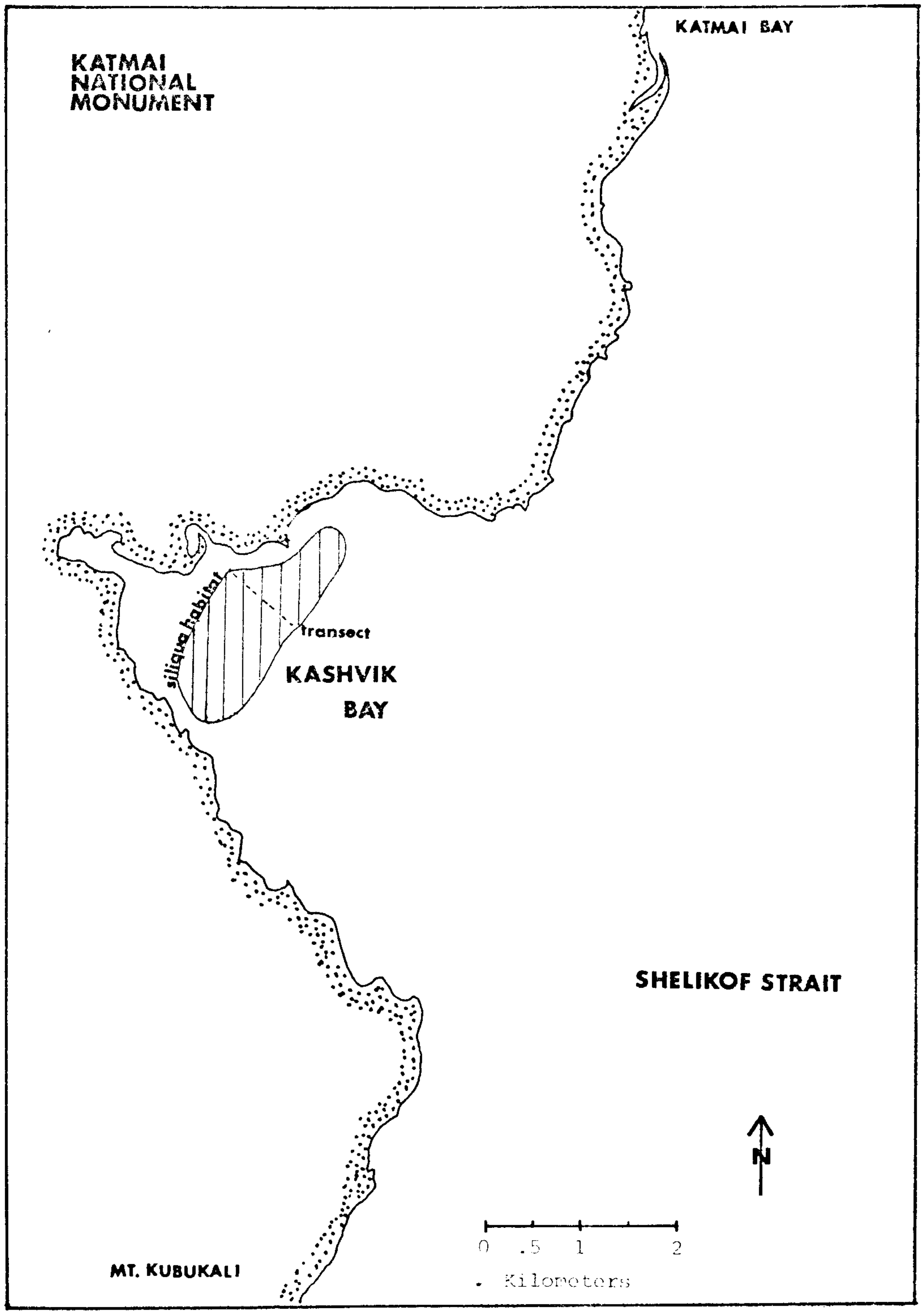
Appendix figure 6. Razor clam station B8 at 58°21'20"N. lat., 154°40'30"W. long., Alaska Peninsula, Alaska, 1976.



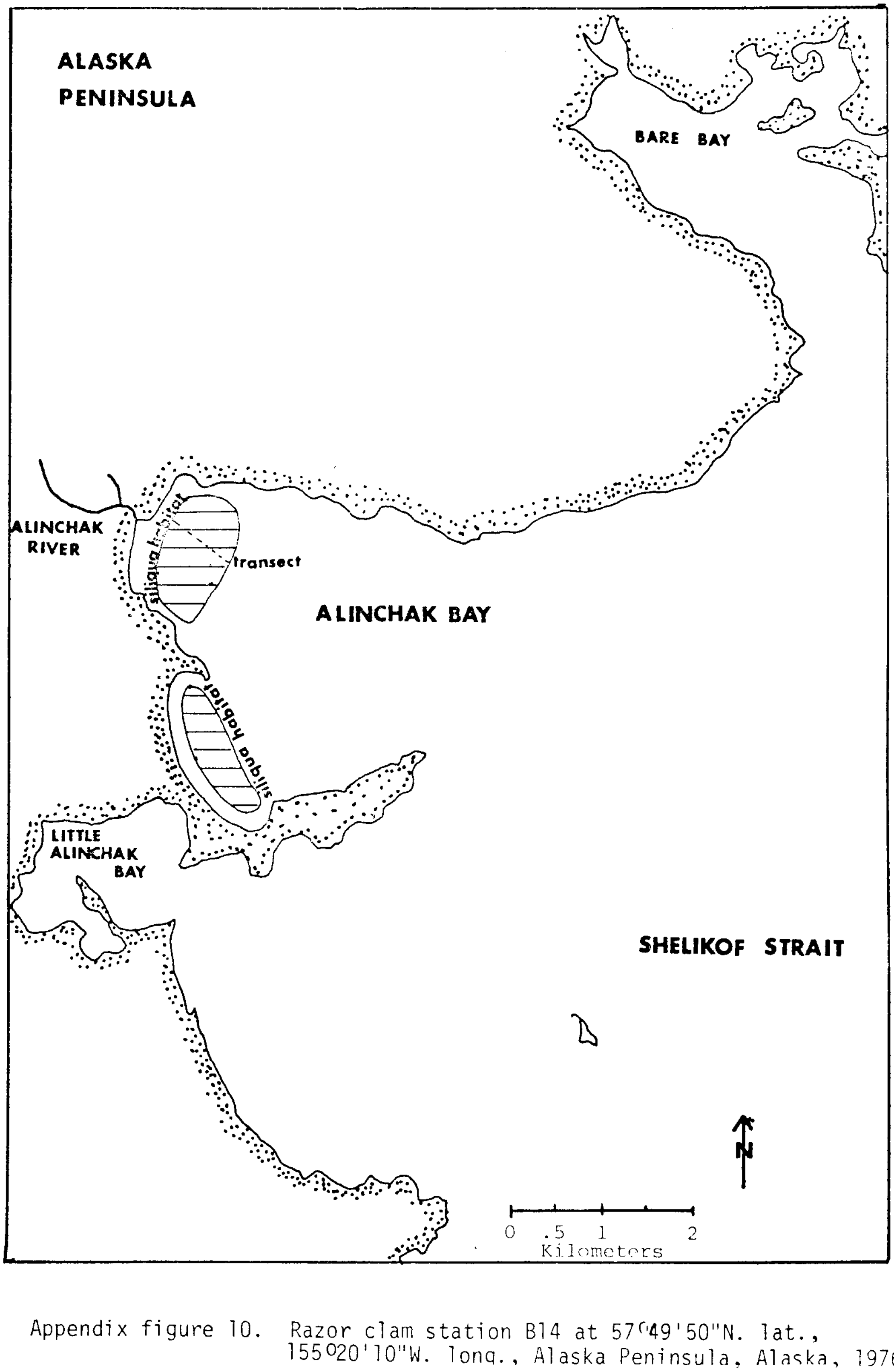
Appendix figure 7. Razor clam station B10 at 56°30'40"N. lat., 154°28'40"W. long., Kodiak Island Alaska, 1976.



Appendix figure 8. Razor clam stations B11 (58°03'40"N. lat., 154°41'10"W. long.) and B12 (58°01'10"N. lat., 154°54'58"W. long.), Alaska Peninsula, Alaska, 1976.



Appendix figure 9. Razor clam station B13 at 57°56'40"N. lat., 155°05'35"W. long., Alaska Peninsula, Alaska, 1976.



Appendix figure 10. Razor clam station B14 at 57°49'50"N. lat., 155°20'10"W. long., Alaska Peninsula, Alaska, 1976.

APPENDIX TABLES 1 - 4

Appendix table 1. Bivalve molluscs dug in tide level plots from Alaska Peninsula and Kodiak Island area beaches May 13 - August 30, 1976. (Does not include genus *Siliqua*.)

Beach	Organism (to species)	Tide Level[1] in feet	# Captured	Mean Length (mm)
Tanner Head	*Spisula polynyma*	-1 (-0.30)	4	130
	"	0 (0.00)	4	119
	Clinocardium nuttallii	-1 (-0.30)	3	68
Halibut Bay	*Spisula polynyma*	-1 (-0.30)	4	117
	"	0 (0.00)	1	78
	"	+2 (+0.61)	1	43
	"	+3 (+0.91)	1	13
	Clinocardium nuttallii	-1 (-0.30)	1	76
	"	0 (0.00)	2	111
	Tellina lutea alternidentata	+4 (+1.22)	1	60
	Tressus Capax	-1 (-0.30)	1	206
Swikshak	*Spisula polynyma*	-1 (-0.30)	7	43
	"	0 (0.00)	6	41
	"	+4 (+1.22)	2	19
	Macoma nasuta	-1 (-0.30)	1	21
Village	*Spisula polynyma*	-4 (-1.22)	1	126
	"	-3 (-0.91)	2	126
	"	-1 (-0.30)	5	105

Appendix Table 1. continued.

Beach	Organism (to species)	Tide Level[1] in feet	# Captured	Mean Length (mm)
Big River	*Spisula polynyma*	-2 (-0.61)	2	119
	"	+1 (+0.30)	1	57
	Clinocardium nuttallii	0 (0.00)	1	51
	"	+1 (+0.30)	1	55
Hallo Bay	*Spisula polynyma*	-3 (-0.91)	15	121
	"	-2 (-0.61)	3	120
	"	-1 (-0.30)	3	95
	Clinocardium nuttallii	-3 (-0.91)	1	67
	"	-1 (-0.30)	1	55
	Mya arenaria	-1 (-0.30)	1	112
	"	+1 (+0.30)	1	93
	"	+2 (+0.61)	5	65
	"	+4 (+1.22)	4	60
	"	+5 (+1.83)	9	85
	Tellina lutea alternidentata	+4 (+1.22)	1	60
Kukak	*Spisula polynyma*	-1 (-0.30)	8	130
	"	0 (0.00)	3	117
	"	+1 (+0.30)	2	116
	"	+2 (+0.61)	13	108
	"	+3 (+0.91)	1	126
	Clinocardium nuttallii	-1 (-0.30)	2	101
	"	0 (0.00)	1	106

Appendix Table 1. continued.

Beach	Organism (to species)	Tide Level[1] in feet	# Captured	Mean Length (mm)
Kukak (cont.)	*Clinocardium nuttallii*	+1 (+0.30)	2	46
	"	+2 (+0.61)	4	81
	"	+3 (+0.91)	3	55
	"	+5 (+1.52)	1	44
	Tellina lutea alternidentata	0 (0.00)	1	40
	"	+2 (+0.61)	1	68
Bumble Bay*				
Tugidak*				
Dakavak*				
Kashvik	*Spisula polynyma*	-1 (-0.30)	3	121
	"	0 (0.00)	2	18
Alinchak*				

[1]meters in parenthesis

*no molluscs other than *Siliqua* found at tide level plot

Appendix Table 2. All invertebrate organisms captured from tide level sub plots on Alaska Peninsula and Kodiak Island area beaches, May 13 - August 30, 1976.

Beach	Organism (to species)	Tide level in feet (meters)	# Captured	Mean Length (mm)
Tanner Head	*Clinocardium nuttallii*	+5 (+1.52)	1	40
	Littorina sitkana	+5 (+1.52)	1	-
	Macoma nasuta	+2 (+0.61)	1	17
	Spisula polynyma	-1 (-0.30)	1	60
	"	+3 (+0.91)	1	41
	Scolelepis squamatus	-1 (-0.30)	9	*
	"	0 (0.00)	10	*
	"	+1 (+0.30)	9	*
	"	+2 (+0.61)	14	*
	"	+3 (+0.91)	63	*
	"	+4 (+1.22)	16	*
	"	+5 (+1.52)	16	*
	Nephtys caeca	-1 (-0.30)	3	*
	"	0 (0.00)	2	*
	"	+1 (+0.30)	6	*
	"	+2 (+0.61)	3	*
	"	+3 (+0.91)	1	*
	"	+4 (+1.22)	1	*
	"	+5 (+1.52)	4	*
	Ophelia assimilis	+4 (+1.22)	14	*
	Eohaustoridae (sp)	+3 (+0.91)	Present	*
	Ammodytes hexapterus	-1 (-0.30)	1	76
Halibut Bay	*Siliqua alta*	-1 (-0.30)	1	29
	"	0 (0.00)	1	93

*Indicates no measurements available.

Appendix Table 2. Continued

Beach	Organism (to species)	Tide level in feet (meters)	# Captured	Mean Length (mm)
Halibut Bay Continued	*Siliqua alta*	+2 (+0.61)	1	60
	Siliqua patula	-1 (-0.30)	2	126
	Macoma lama	-1 (-0.30)	1	34
	Scolelepis squamatus	-1 (-0.30)	9	*
	"	0 (0.00)	27	*
	"	+1 (+0.30)	149	*
	"	+2 (+0.61)	31	*
	"	+5 (+1.52)	9	*
	"	+8 (+2.44)	6	*
	Haploscoloplos elongatus	-1 (+0.30)	9	*
	"	0 (0.00)	18	12
	"	+1 (+0.30)	14	*
	"	+2 (+0.61)	1	7
	Nephtys caeca	-1 (-0.30)	3	114
	"	0 (0.00)	3	130
	"	+1 (+0.30)	3	120
	"	+3 (+0.91)	2	112
	Nephtys californiensis	-1 (-0.30)	1	*
	"	+1 (+0.30)	1	51
	"	+3 (+0.91)	1	*
	Eteone longa	-1 (-0.30)	1	40
	"	+2 (+0.61)	1	80
	Glycinde picta	-1 (-0.30)	2	34
	"	+8 (+2.44)	2	34
	Nemertea	+3 (+0.91)	2	19

Appendix Table 2. Continued

Beach	Organism (to species)	Tide level in in feet (meters)	# Captured	Mean Length
Halibut Bay Continued	Nemertea	+8 (+2.44)	3	*
	Ophelia assimilis	+3 (+0.91)	8	*
	"	+5 (+1.52)	3	30
	"	+8 (+2.44)	2	34
	Eohaustoridae (sp)	-1 (-0.30)	Present	*
	"	0 (0.00)	"	*
	"	+1 (+0.30)	"	*
	"	+2 (+0.61)	"	*
	"	+3 (+0.91)	"	*
	"	+5 (+1.52)	"	*
Swikshak	*Siliqua alta*	+1 (+0.30)	1	21
	Siliqua patula	-1 (-0.30)	2	78
	"	0.(0.00)	2	56
	"	+1 (+0.30)	1	40
	"	+3 (+0.91)	5	45
	Spisula polynyma	+1 (+0.30)	1	24
	"	+4 (+1.22)	1	24
	Macoma lama	-1 (-0.30)	5	24
	"	0 (0.00)	2	18
	"	+2 (+0.61)	2	22
	"	+4 (+1.22)	2	19
	Tellina nucleoides	+2 (+0.61)	1	7
	Scolelepis squamatus	-1 (-0.30)	106	*
	"	0 (0.00)	81	*
	"	+1 (+0.30)	26	*
	"	+2 (+0.61)	55	*

Appendix Table 2. Continued.

Beach	Organism (to species)	Tide level in in feet (meters)	# Captured	Mean Length (mm)
Swikshak Continued	*Scolelepis squamatus*	+3 (+0.91)	Present	*
	"	+4 (1.22)	91	*
	Haploscoloplos elongatus	-1 (-0.30)	11	15
	"	+1 (+0.30)	3	*
	"	+2 (+0.61)	2	*
	"	+3 (+0.91)	2	*
	Nephtys caeca	-1 (-0.30)	5	*
	"	0 (0.00)	5	*
	"	+1 (+0.30)	5	*
	"	+2 (+0.61)	5	*
	Nephtys californiensis	-1 (-0.30)	9	41
	"	0 (0.00)	3	*
	"	+3 (+0.91)	1	*
	Nephtys ciliata	0 (0.00)	3	100
	Eteone longa	-1 (-0.30)	1	*
	"	0 (0.00)	2	50
	"	+1 (+0.30)	3	50
	"	+4 (+1.22)	1	*
	Cerebratulus californiensis	0 (0.00)	1	*
	Ammodytes hexapterus	-1 (-0.30)	1	90
Village	*Siliqua patula*	-4 (-1.22)	1	153
	"	-2 (-0.61)	1	159
	Spisula polynyma	-4 (-1.22)	1	99
	Scolelepis squamatus	-4 (-1.22)	111	*
	"	-3 (-0.91)	present	*
	"	-2 (-0.61)	128	*

Appendix Table 2. Continued.

Beach	Organism (to species)	Tide level in feet (meters	# Captured	Mean Length (mm)
Village Continued	*Scolelepis squamatus*	-1 (-0.30)	9	*
	Haploscoloplos elongatus	-4 (-1.22)	11	*
	"	-3 (-0.91)	14	*
	"	-2 (-0.61)	4	*
	"	-1 (-0.30)	1	*
	Nephtys caeca	-4 (-1.22)	8	132
	"	-3 (-0.91)	7	118
	"	-2 (-0.61)	8	120
	"	-1 (-0.30)	5	*
	Nephtys californiensis	-4 (-1.22)	4	*
	"	-3 (-0.91)	7	*
	"	-2 (-0.61)	5	*
	"	-1 (-0.30)	3	*
	Ophelia assimilis	-2 (-0.61)	1	20
	Cerebratulus californiensis	-4 (-1.22)	1	*
	"	-2 (-0.61)	1	*
	"	-1 (-0.30)	1	*
	Cistenides brevicoma	-4 (-1.22)	1	20
	"	-3 (-0.91)	1	25
	Anaitides groenlandica	-1 (-0.30)	1	180
	Eohaustoridae (sp)	-4 (-1.22)	Present	*
	"	-1 (-0.30)	"	*
	Ammodytes hexapterus	-3 (-0.91)	1	105
	"	-2 (-0.61)	1	*

Appendix Table 2. continued

Beach	Organism (to species)	Tide level in feet (meters)	# Captured	Mean Length (mm)
Big River	*Siliqua patula*	-2 (-0.61)	1	37
	"	-1 (-0.30)	3	54
	"	0 (0.00)	1	73
	Siliqua alta	+1 (+0.30)	1	18
	Spisula polynyma	-2 (-0.61)	4	12
	"	-1 (-0.30)	4	10
	Macoma lama	-2 (-0.61)	5	13
	"	-1 (-0.30)	4	15
	"	0 (0.00)	1	10
	"	+1 (+0.30)	1	12
	Tellina lutea alternidentata	-1 (-0.30)	3	18
	Scolelepis squamatus	-2 (-0.61)	36	*
	"	-1 (-0.30)	53	*
	"	0 (0.00)	25	*
	"	+1 (+0.30)	32	*
	"	+3 (+0.91)	11	*
	Haploscoloplos elongatus	-2 (-0.61)	8	*
	"	-1 (-0.30)	12	*
	"	0 (0.00)	4	*
	"	+1 +0.30)	8	*
	Nephtys caeca	-2 (-0.61)	4	74
	"	-1 (-0.30)	3	71

* Indicates no measurements available.

Appendix Table 2. continued

Beach	Organism (to species)	Tide level in feet (meters)	# Captured	Mean Length (mm)
Big River continued	*Nephtys californiensis*	+1 (+0.30)	1	*
	"	+3 (+0.91)	1	*
	Ophelia assimilis	0 (0.00)	3	54
	"	+1 (+0.30)	3	23
	"	+3 (+0.91)	3	64
	Nemertea	0 (0.00)	2	*
	Cerebratulus californiensis	0 (0.00)	1	*
	Eohaustoridae (sp)	-2 (-0.61)	present	*
	"	-1 (-0.30)	"	*
	"	0 (0.00)	"	*
	"	+1 (+0.30)	"	*
	"	+3 (+0.61)	"	*
	Ammodytes hexapterus	-2 (-0.61)	6	83
Hallo Bay	*Siliqua patula*	-1 (-0.30)	2	6
	"	0 (0.00)	4	7
	Siliqua alta	-2 (-0.61)	1	12
	"	-1 (-0.30)	2	7
	Clinocardium nuttallii	-3 (-0.91)	1	79
	"	-2 (-0.61)	2	5
	Macoma lama	-3 (-0.91)	40	12
	"	-1 (-0.30)	9	8
	"	0 (0.00)	1	6
	"	+1 (+0.30)	12	10
	"	+4 (+1.22)	2	11

Appendix Table 2. continued

Beach	Organism (to species)	Tide level in feet (meters)	# Captured	Mean Length (mm)
Hallo Bay continued	*Macoma balthica*	-2 (-0.61)	2	9
	"	-1 (-0.30)	2	7
	"	0 (0.00)	2	12
	"	+1 (+0.30)	6	10
	"	+2 (+0.61)	3	12
	"	+4 (+1.22)	1	13
	Macoma calcarea	+1 (+0.30)	1	7
	Macoma loveni	-3 (-0.91)	2	11
	Scolelepis squamatus	-3 (-0.91)	4	*
	"	-2 (-0.61)	35	*
	"	-1 (-0.30)	92	*
	"	0 (0.00)	5	*
	"	+1 (+0.30)	34	*
	"	+3 (+0.91)	94	*
	Haploscoloplos elongatus	-3 (-0.91)	1	*
	"	-2 (-0.61)	6	*
	"	-1 (-0.30)	3	*
	"	+1 (+0.30)	2	*
	"	+3 (+0.91)	3	*
	Nephtys caeca	-3 (-0.91)	12	*
	"	-2 (-0.61)	15	*
	"	-1 (-0.30)	12	*
	"	0 (0.00)	5	*
	"	+1 (+0.30)	10	*
	"	+3 (+0.91)	3	*

Appendix Table 2. continued

Beach	Organism (to species)	Tide level feet (meters)	# Captured	Mean Length (mm)
Hallo Bay continued	*Anaitides groenlandica*	-2 (-0.61)	3	*
	"	-1 (-0.30)	1	30
	"	+1 (+0.30)	1	*
	"	+3 (+0.91)	1	*
	Cistenides brevicoma	-1 (-0.30)	1	*
	"	+1 (+0.30)	1	*
	Nemertea	+3 (+0.91)	1	*
	Cerebratulus californiensis	-3 (-0.91)	1	*
	"	-2 (-0.61)	1	*
	"	-1 (-0.30)	1	*
	"	+1 (+0.30)	1	*
	Eohaustoridae (sp)	0 (0.00)	present	*
	"	+1 (+0.30)	present	*
	"	+3 (+0.91)	present	*
Kukak	*Siliqua patula*	-1 (-0.30)	2	92
	"	0 (0.00)	2	6
	"	+1 (+0.30)	2	11
	"	+2 (+0.61)	2	22
	Siliqua alta	-1 (-0.30)	2	14
	"	0 (0.00)	2	20
	"	+1 (+0.30)	2	19
	"	+2 (+0.61)	1	18
	"	+6 (+1.83)	1	26

Appendix Table 2. continued

Beach	Organism (to species)	Tide Level in feet (meters)	# Captured	Mean Length (mm)
Kukak continued	*Spisula polynyma*	-1 (-0.30)	2	9
	"	0 (0.00)	1	*
	"	+1 (+0.30)	4	9
	"	+2 (+0.61)	1	9
	"	+6 (+1.83)	1	21
	Clinocardium nuttallii	-1 (-0.30)	1	42
	"	+1 (+0.30)	1	29
	"	+3 (+0.91)	1	103
	Macoma balthica	0 (0.00)	1	6
	"	+5 (+1.52)	2	15
	Macoma lama	-1 (-0.30)	39	8
	"	0 (0.00)	65	7
	"	+1 (+0.30)	43	9
	"	+6 (+1.83)	1	17
	"	+7 (+2.13)	1	7
	Macoma yoldiformis	-1 (-0.30)	2	9
	"	0 (0.00)	1	11
	Protothaca stamenae	+2 (+0.61)	1	9
	Scolelepis squamatus	-1 (-0.30)	122	*
	"	0 (0.00)	35	*
	"	+1 (+0.30)	120	*
	"	+2 (+0.61)	94	*
	"	+3 (+0.91)	95	*
	"	+4 (+1.22	Present	*

Appendix Table 2. continued

Beach	Organism (to species)	Tide Level feet (meters)	# Captured	Mean Length (mm)
Kukak continued	*Scolelepis squamatus* continued	+5 (+1.52)	167	*
		+6 (+1.83)	140	*
	"	+7 (+2.13)	200	*
	Haploscoloplos elongatus	-1 (-0.30)	7	*
	"	0 (0.00)	1	55
	"	+3 (+0.91)	2	*
				*
	Nephtys caeca	-1 (-0.30)	8	108
	"	0 (0.00)	6	*
	"	+1 (+0.30)	4	80
	"	+1 (+0.30)	4	*
	"	+2 (+0.61)	7	74
	"	+2 (+0.61)	2	*
	"	+3 (+0.91)	13	97
	"	+4 (+1.22)	8	126
	"	+5 (+1.52)	14	121
	"	+7 (+2.13)	5	129
	Nephtys californiensis	+2 (+0.61)	1	*
	Anaitides groenlandica	-1 (-0.30)	1	90
	Eteone longa	+2 (+0.61)	1	*
	Glycinde picta	-1 (-0.30)	1	*
	Nemertea	+1 (+0.30)	1	*
	"	+5 (+1.52)	3	*
	"	+7 (+2.13)	1	*

Appendix Table 2. continued

Beach	Organism (to species)	Tide Level in feet (meters)	# Captured	Mean Length (mm)
Kukak continued	*Cerebratulus californiensis*	-1 (-0.30)	1	*
	"	+2 (+0.61)	1	*
	"	+4 (+1.22)	1	*
	Eohaustoridae (sp)	-1 (-0.30)	present	*
	"	0 (0.00)	present	*
	"	+2 (+0.61)	present	*
	"	+3 (+0.61)	present	*
	"	+4 (+1.22)	present	*
	"	+5 (+1.52)	present	*
Bumble Bay[1]	*Scolelepis squamatus*	0 (0.00)	1	*
	"	+3 (+0.91)	1	*
	"	+4 (+1.22)	1	*
	Nephtys caeca	0 (0.00)	1	*
	Ophelia assimilis	0 (0.00)	1	*
	"	+2 (+0.61)	1	*
	"	+3 (+0.91)	1	*
	"	+4 (+1.22)	1	*
Tugidak	*Siliqua patula*	+.5 (+.015)	2	74
	Haploscoloplos elongatus	-1 (-0.30)	1	22
	"	-.5 (-.015	1	36
	"	0 (0.00)	1	11
	"	+1 (+0.30)	6	*
	Eteone longa	+1 (+0.30)	2	*

[1] Only 33.83 liters of substrate examined at each tide level station.

Appendix Table 2. continued

Beach	Organism (to species)	Tide Level in feet (meters)	#Captured	Mean Length (mm)
Tugidak continued	*Glycinde picta*	-.5 (-.015)	1	*
	"	0 (0.00)	4	*
	"	+.5 (+.015)	2	*
	Nephtys californiensis	-1 (-0.30)	2	*
	"	0 (0.00)	1	*
	"	+.5 (+.015)	3	*
	"	+1 (+0.30)	1	*
	Ophelia assimilis	+.5 (+.015)	2	*
	"	+1 (+0.30)	2	*
Dakavak[1]	*Siliqua patula*	+1 (+0.30)	1	138
	Scolelepis squamatus	-1 (-0.30)	1	*
	"	0 (0.00)	6	*
	"	+1 (+0.30)	2	*
	"	+3 (+0.91)	8	*
	"	+4 (+1.22)	7	*
	Haploscoloplos elongatus	-1 (-0.30)	1	*
	Anaitedes groenlandica	+4 (+1.22)	2	*
	Eteone longa	+3 (+0.91)	1	*
	Nephtys californiensis	-1 (-0.30)	17	*
	"	0 (0.00)	1	*
	"	+1 (+0.30)	42	*
	"	+3 (+0.91)	17	*
	"	+4 (+1.22)	3	*

[1]Tide level station (+0.61) subsample lost as a result of improper preservation.

Appendix Table 2. continued

Beach	Organism (to species)	Tide Level in feet (meters)	# Captured	Mean Length (mm)
Dakavak continued	*Ophelia Assimilis*	-1 (-0.30)	40	*
	"	0 (0.00)	27	*
	"	+1 (+0.30)	20	*
	"	+3 (+0.91)	12	*
	"	+4 (+1.22)	12	*
	Nemertea	0 (0.00)	1	*
	"	+1 (+0.30)	2	*
	Cerebratulus californiensis	0 (0.00)	1	75
	Eohaustoridae (sp)	+1 (+0.30)	present	*
Kashvik	*Siliqua patula*	-1 (-0.30)	8	37
	"	0 (0.00)	1	23
	"	+2 (+0.61)	1	151
	Spisula polynyma	-1 (-0.30)	1	7
	Macoma balthica	+2 (+0.61)	3	16
	"	+3 (+0.91)	2	18
	"	+5 (+1.52)	6	16
	Macoma lama	-1 (-0.30)	8	19
	"	0 (0.00)	6	12
	"	+1 (+0.30)	3	13
	"	+2 (+0.61)	1	13
	"	+3 (+0.91)	1	14
	"	+4 (+1.22)	1	19

Appendix Table 2. continued

Beach	Organism (to species)	Tide Level in feet (meters)	# Captured	Mean Length (mm)
Kashvik continued	*Scolelepis squamatus*	-1 (-0.30)	27	*
	"	0 (0.00)	76	*
	"	+1 (+0.30)	80	*
	"	+3 (+0.91)	30	*
	"	+4 (+1.22)	17	*
	"	+5 (+1.52)	Present	*
	Haploscoloplos elongatus	-1 (-0.30)	3	*
	"	0 (0.00)	16	*
		+1 (+0.30)	3	*
		+2 (+0.61)	2	*
	Eteone longa	0 (0.00)	1	*
	"	+1 (+0.30)	3	*
	"	+2 (+0.61)	1	*
	Glycinde picta	-1 (-0.30)	2	*
	Nephtys caeca	-1 (-0.30)	6	*
	"	0 (0.00)	6	*
	"	+1 (+0.30)	3	*
	"	+2 (+0.61)	2	144
	"	+2 (+0.61)	2	*
	"	+3 (+0.91)	4	*
		+4 (+1.22)	2	*
		+5 (+1.52)	1	*
	Nephtys californiensis	-1 (-0.30)	14	*
	"	0 (0.00)	2	*
	"	+1 (+0.30)	2	*
	"	+2 (+0.61)	3	*

Appendix Table 2. continued

Beach	Organism (to species)	Tide Level in feet (meters)	# Captured	Mean Length (mm)
Kashvik continued	*Ophelia assimilis*	+3(+0.91)	9	*
	Eohaustoridae (sp)	-1 (-0.30)	present	*
	"	0 (0.00)	present	*
	"	+2 (+0.61)	present	*
	"	+3 (+0.91)	present	*
	"	+4 (+1.22)	present	*
	Ammodytes hexapterous	-1 (-0.30)	3	72
Alinchak	*Siliqua patula*	+1 (+0.30)	2	16
	"	+2 (+0.61)	2	18
	"	+3 (+0.91)	1	26
	Macoma lama	+2 (+0.61)	1	9
	Scolelepis squamatus	+1 (+0.30)	84	*
	"	+2 (+0.61)	223	*
	"	+3 (+0.91)	33	*
	Nephtys caeca	+1 (+0.30)	3	133
	"	+1 (+0.30)	3	*
	"	+2 (+0.61)	4	111
	"	+2 (+0.61)	2	*
	n"	+3 (+0.91)	1	143
	Nephtys californiensis	+1 (+0.30)	3	66
	"	+2 (+0.61)	5	51
	"	+3 (+0.91)	1	55
	Eohaustoridae (sp)	+2 (+0.61)	present	*
	Ammodytes hexapterus	+3 (+0.91)	1	100

Appendix Table 3. Growth rates of razor clams at beaches investigated on the Alaska Peninsula and Kodiak Island, May 13 - August 30, 1976.

Beach	Number in sample	Age years	Ring number	Mean length (mm)	Standard deviation (mm)	Standard error (mm)
Tanner Head	110	0.5	1	6.12	2.35	.22
	112	1.5	2	21.65	6.43	.61
	112	2.5	3	48.08	9.44	.89
	111	3.5	4	73.30	9.07	.86
	105	4.5	5	96.27	6.99	.68
	89	5.5	6	109.70	6.34	.67
	77	6.5	7	118.57	6.52	.74
	57	7.5	8	124.98	6.88	.91
	27	8.5	9	128.89	7.36	1.42
	5	9.5	10	132.60	8.17	3.66
Halibut Bay	64	0.5	1	7.48	2.74	.34
	184	1.5	2	27.99	6.06	.45
	185	2.5	3	56.28	8.49	.62
	141	3.5	4	83.66	8.05	.68
	128	4.5	5	101.35	6.44	.57
	113	5.5	6	111.72	5.68	.53
	86	6.5	7	118.50	5.52	.60
	67	7.5	8	123.50	5.60	.70
	45	8.5	9	127.64	5.97	.89
	26	9.5	10	131.30	6.50	1.27
	16	10.5	11	134.36	7.66	1.92
	11	11.5	12	138.20	7.11	2.14
	7	12.5	13	139.71	9.57	3.62
Swikshak	29	0.5	1	6.13	1.71	.32
	84	1.5	2	27.79	5.78	.63
	71	2.5	3	64.07	11.95	1.42
	57	3.5	4	96.63	9.22	1.22
	21	4.5	5	113.95	6.69	1.46
	9	5.5	6	126.33	3.39	1.13
	4	6.5	7	132.75	2.75	1.38
	3	7.5	8	141.00	4.00	2.31

Appendix Table 3. Continued

Beach	Number in sample	Age years	Ring number	Mean length (mm)	Standard deviation (mm)	Standard error (mm)
Village	70	0.5	1	5.79	1.72	.21
	156	1.5	2	26.55	6.67	.53
	160	2.5	3	56.63	11.30	.93
	148	3.5	4	89.57	10.91	.90
	136	4.5	5	111.59	7.78	.67
	104	5.5	6	124.29	6.69	.66
	81	6.5	7	132.82	6.63	.74
	60	7.5	8	139.35	7.12	.92
	48	8.5	9	144.00	6.81	.98
	37	9.5	10	147.95	6.94	1.14
	29	10.5	11	149.66	6.67	1.24
	18	11.5	12	151.22	6.39	1.51
	12	12.5	13	152.17	4.55	1.31
	4	13.5	14	154.00	6.66	3.33
Big River	62	0.5	1	7.65	3.04	.39
	161	1.5	2	30.46	6.98	.55
	167	2.5	3	62.92	11.51	.89
	158	3.5	4	91.92	10.87	.87
	140	4.5	5	112.73	9.30	.79
	119	5.5	6	125.83	7.94	.73
	99	6.5	7	134.54	7.19	.72
	83	7.5	8	139.33	7.13	.78
	69	8.5	9	143.77	7.10	.86
	32	9.5	10	147.50	7.62	1.35
	13	10.5	11	148.85	7.47	2.07
	5	11.5	12	150.60	6.31	2.82
	1	12.5	13	158.00	-	-
Hallo Bay	14	0.5	1	5.57	1.40	.37
	33	1.5	2	30.03	5.84	1.02
	33	2.5	3	61.61	9.89	1.72
	33	3.5	4	91.09	10.58	1.84
	18	4.5	5	109.06	5.74	1.35
	15	5.5	6	122.47	5.01	1.29
	13	6.5	7	131.39	5.32	1.47
	5	7.5	8	134.60	6.95	3.11
	4	8.5	9	138.00	5.72	2.86
	2	9.5	10	141.00	8.49	6.00
	2	10.5	11	145.50	9.19	6.50

Appendix Table 3. Continued

Beach	Number in sample	Age years	Ring number	Mean length (mm)	Standard deviation (mm)	Standard error (mm)
Kukak	18	0.5	1	6.33	1.68	.40
	67	1.5	2	28.81	6.17	.75
	67	2.5	3	60.25	12.05	1.47
	64	3.5	4	90.89	11.09	1.39
	43	4.5	5	111.16	7.67	1.17
	28	5.5	6	126.11	7.96	1.51
	23	6.5	7	135.09	7.28	1.52
	18	7.5	8	140.55	6.86	1.62
	14	8.5	9	144.64	5.93	1.59
	10	9.5	10	149.60	4.65	1.47
	5	10.5	11	152.60	3.36	1.50
	2	11.5	12	154.50	4.95	3.50
Bumble Bay	60	0.5	1	4.63	1.41	.18
	62	1.5	2	18.15	6.46	.83
	61	2.5	3	43.23	7.97	1.02
	60	3.5	4	68.17	9.26	1.20
	60	4.5	5	88.70	7.22	.93
	53	5.5	6	100.75	6.87	.94
	48	6.5	7	110.02	5.97	.86
	33	7.5	8	115.73	5.61	.98
	24	8.5	9	120.33	5.90	1.20
	5	9.5	10	125.40	3.78	1.69
	2	10.5	11	131.00	5.66	4.00
	2	11.5	12	133.50	4.95	3.50
Tugidak	82	0.5	1	5.78	2.31	.26
	82	1.5	2	27.70	10.66	1.18
	82	2.5	3	61.22	11.68	1.29
	81	3.5	4	87.20	8.39	.93
	71	4.5	5	102.37	6.68	.79
	60	5.5	6	111.41	5.87	.76
	46	6.5	7	117.67	5.84	.86
	28	7.5	8	121.43	5.43	1.03
	16	8.5	9	123.38	4.94	1.23
	6	9.5	10	123.29	4.15	1.57
	3	10.5	11	124.00	4.36	2.52

Appendix Table 3. Continued

Beach	Number in sample	Age years	Ring number	Mean length (mm)	Standard deviation (mm)	Standard error (mm)
Dakavak	45	0.5	1	4.44	.92	.14
	46	1.5	2	24.74	5.25	.77
	46	2.5	3	48.87	7.81	1.15
	46	3.5	4	91.48	5.55	.82
	43	4.5	5	114.65	5.39	.82
	12	5.5	6	124.83	5.49	1.58
	5	6.5	7	133.80	8.61	3.85
	4	7.5	8	142.25	9.81	4.91
	4	8.5	9	148.75	8.30	4.15
	4	9.5	10	153.50	9.47	4.74
	2	10.5	11	153.50	2.12	1.50
Kashvik	21	0.5	1	6.81	2.89	.63
	68	1.5	2	29.76	7.49	.91
	76	2.5	3	62.65	16.12	1.85
	65	3.5	4	95.91	11.10	1.38
	34	4.5	5	117.53	6.61	1.13
	17	5.5	6	132.29	4.74	1.15
	15	6.5	7	139.67	5.14	1.33
	12	7.5	8	144.42	4.96	1.43
	11	8.5	9	148.64	4.86	1.47
	10	9.5	10	151.50	4.79	1.52
	9	10.5	11	154.11	4.99	1.66
	3	11.5	12	156.33	7.23	4.18
Alinchak	51	0.5	1	7.94	2.46	.35
	105	1.5	2	29.00	6.21	6.21
	108	2.5	3	58.34	9.52	9.52
	108	3.5	4	84.56	7.46	7.46
	77	4.5	5	103.57	6.29	6.29
	64	5.5	6	115.11	5.96	5.96
	57	6.5	7	123.05	6.17	6.16
	43	7.5	8	129.47	5.66	5.66
	39	8.5	9	134.33	5.90	5.90
	29	9.5	10	137.55	5.10	5.10
	18	10.5	11	139.89	5.09	5.09
	6	11.5	12	143.33	5.13	5.13
	1	12.5	13	143.00	-	-

PHOTOGRAPHIC SUPPLEMENT

Appendix Table 4. Sediment analysis of core samples collected May 13 - August 30, 1976 on beaches on the Alaska Peninsula and Kodiak Island. Percentage composition expressed in phi (ϕ) grain size.

T = Trace amounts

	Big River Tide Level			Hallo Bay Tide Level						
phi (ϕ) size	-3	-2	-1	-3	-2	-1	0	+1	+2	+3
< -2	.15	.17	1.50	3.74	3.35	1.35	.46	.41	.72	2.86
-2 to -1	.07	.34	.00	4.11	2.16	2.94	1.18	.94	.86	10.26
-1 to 0	.26	.95	.23	6.41	8.21	6.09	2.32	2.72	1.51	11.93
0 to 1	1.57	2.38	1.19	8.89	6.16	6.78	4.04	7.86	4.60	6.95
1 to 2	18.65	22.28	29.65	11.46	12.93	22.48	32.33	42.10	19.30	33.01
2 to 3	77.57	71.34	66.31	57.36	58.64	56.60	56.09	38.65	57.01	32.45
3 to 4	1.91	2.28	1.73	5.68	7.32	3.63	3.07	3.47	14.37	2.83
> 4	.45	.41	.58	.41	1.33	.21	.21	.53	.93	.11

	Kukak Tide Level												
ϕ size	-2	-1	0	+1	+2	+2'	+3	+4	+5	+6	+7	+8	+9
< -2	.14	.20	.24	.00	.00	.00	.00	.00	.00	.00	.08	.00	.00
-2 to -1	.19	.56	.20	.04	.00	.04	.00	.22	.09	.00	.29	T	.22
-1 to 0	.14	.32	.24	.38	T	T	.23	.13	.09	.30	.54	.57	.75
0 to 1	7.29	2.43	2.82	2.79	4.42	1.77	9.33	2.23	5.07	4.29	5.80	7.03	5.15
1 to 2	11.65	6.20	7.09	6.42	8.09	5.23	14.09	6.91	10.74	10.08	17.66	39.52	33.67
2 to 3	72.71	82.94	82.65	84.53	80.41	86.59	71.95	83.11	81.44	82.59	73.44	50.57	56.08
3 to 4	7.24	6.76	6.76	5.16	6.28	5.71	3.51	5.77	2.10	2.27	1.46	1.22	1.94
> 4	.19	.12	.12	T	.18	.04	.14	.17	.23	.21	.21	.41	.45

Appendix Table 4. Cont.

phi (φ) size	Bumble Bay Tide Level -1	0	+1	+2	+3	+4	+5	Tugidak Tide Level -1	-.5	0	+.5	+1
< - 2	2.16	.16	1.03	.70	5.91	T	.56	.10	.11	.31	.35	.54
-2 to -1	1.36	1.79	.64	1.21	1.03	1.36	2.00	.59	.39	.45	.84	.87
-1 to 0	10.62	9.42	8.06	11.58	11.06	11.82	18.06	.59	.50	.45	.91	.94
0 to 1	29.75	19.79	27.84	28.79	23.68	35.17	35.82	.31	.82	1.07	.67	1.88
1 to 2	25.61	22.76	28.38	26.88	20.96	30.43	23.59	.70	10.12	8.46	8.94	6.65
2 to 3	29.64	43.28	32.64	29.48	34.71	20.40	19.24	89.97	83.96	85.91	83.60	85.90
3 to 4	1.33	2.59	1.13	1.27	2.16	.58	.62	3.81	3.96	3.78	4.33	3.07
>4	.03	.03	T	T	T	T	T	.03	.04	.10	.11	.14

φ size	Dakavak Tide Level -2	-1	0	+1	+2	+3	+4	+5	Alinchak Tide Level 0	+1	+2	+3	+3'
< -2	.00	.00	.00	.00	.00	T	.47	4.47	.33	T	.20	T	.12
-2 to -1	.12	T	T	T	T	T	.47	.73	1.05	.51	.47	.18	1.67
-1 to 0	.56	.19	.29	.17	.11	.17	1.42	2.09	2.28	1.31	1.38	.65	5.33
0 to 1	3.81	5.63	4.37	2.57	4.35	9.91	3.40	10.80	6.65	3.60	4.57	2.48	11.67
1 to 2	12.84	14.02	17.91	15.96	29.64	31.88	20.89	23.98	36.75	38.43	34.83	64.36	54.09
2 to 3	74.49	74.49	72.38	76.01	62.09	55.21	66.30	57.68	49.48	51.46	55.99	28.82	23.46
3 to 4	7.58	5.14	4.62	3.58	3.31	2.55	3.73	1.85	2.50	3.71	1.89	2.55	2.80
>4	.20	.10	.25	.26	.28	.34	.09	.19	.72	.98	.59	.72	.78

Appendix Table 4. Cont.

	Kashvik Tide Level							
ϕ size	-2	-1	0	+1	+2	+3	+4	+5
< -2	.17	.00	.00	6.06	.30	1.09	1.47	.98
-2 to -1	.21	.23	.33	6.64	.37	2.26	2.94	2.53
-1 to 0	.51	.34	.77	5.52	.75	3.24	3.43	1.43
0 to 1	1.51	1.43	6.84	7.01	2.96	7.58	8.19	17.22
1 to 2	15.38	23.53	72.01	36.71	17.77	54.41	45.81	45.59
2 to 3	75.55	71.08	19.06	35.18	66.23	29.26	36.53	30.61
3 to 4	5.41	2.60	.18	2.1	9.41	1.24	1.06	1.22
> 4	.99	.45	.11	.64	2.14	.84	.60	.82

	Swikshak Tide Level						
ϕ size	-2	-1	0	+1	+2	+3	+4
< -2	1.10	.03	1.74	0	.36	.34	.62
-2 to -1	.75	1.21	.8	T	.22	.40	.75
-1 to 0	.38	.77	.38	.07	.14	.34	.46
0 to 1	.38	.67	.24	.14	.22	.47	.46
1 to 2	3.84	6.85	8.45	5.92	7.83	11.89	21.85
2 to 3	78.53	80.84	82.50	88.30	86.79	81.46	73.04
3 to 4	14.37	8.86	5.56	5.08	4.08	4.55	2.26
> 4	.48	.34	.21	.42	.25	.47	.36

Appendix Table 4. Cont.

Tanner Head*

φsize	Tide Level -2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9
<-1	1.58	.61	.45	.53	1.46	1.99	.25	.04	.05	.15	0	0
-1 to +1	1.19	1.00	4.58	4.58	14.42	16.74	2.04	.52	1.49	.52	.06	.03
1 to 2	13.51	13.25	32.90	40.31	47.54	56.51	15.05	18.21	63.84	12.81	11.70	10.17
2 to 4	83.25	84.80	61.37	53.11	35.93	24.08	82.13	80.67	33.95	86.28	87.67	89.41
>4	.07	.03	.31	.16	T	T	T	T	T	T	T	T

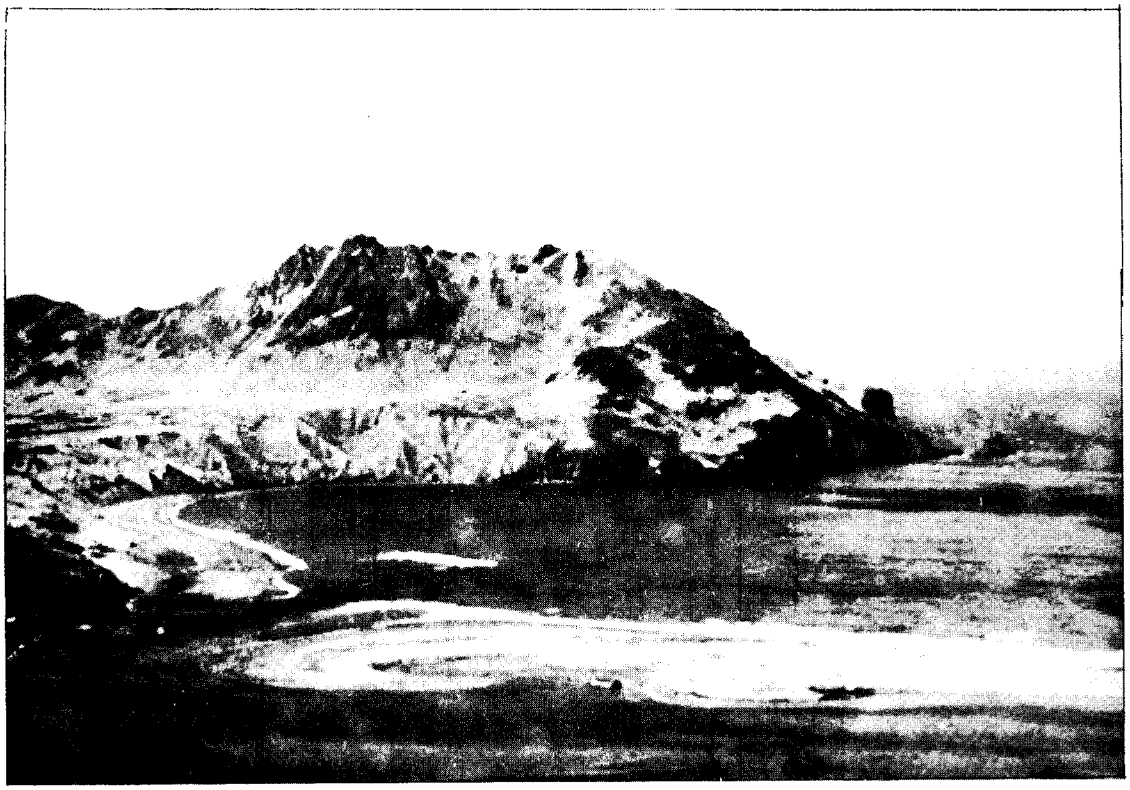
Halibut Bay*

φsize	Tide Level -1.7	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
<-1	4.93	.39	1.07	4.23	2.73	3.59	1.37	1.27	7.74	4.76	3.04	.49	1.63
-1 to +1	1.67	1.06	1.63	2.62	1.95	2.35	1.37	1.27	1.42	2.43	.73	.30	.31
1 to 2	7.31	10.02	8.35	12.08	24.67	23.93	21.37	20.75	15.19	19.91	19.71	15.57	10.47
2 to 4	86.32	87.89	88.81	80.70	69.51	69.07	75.57	76.46	75.30	72.68	76.35	83.15	87.39
>4	.13	T	.11	T	T	T	T	T	T	T	T	T	T

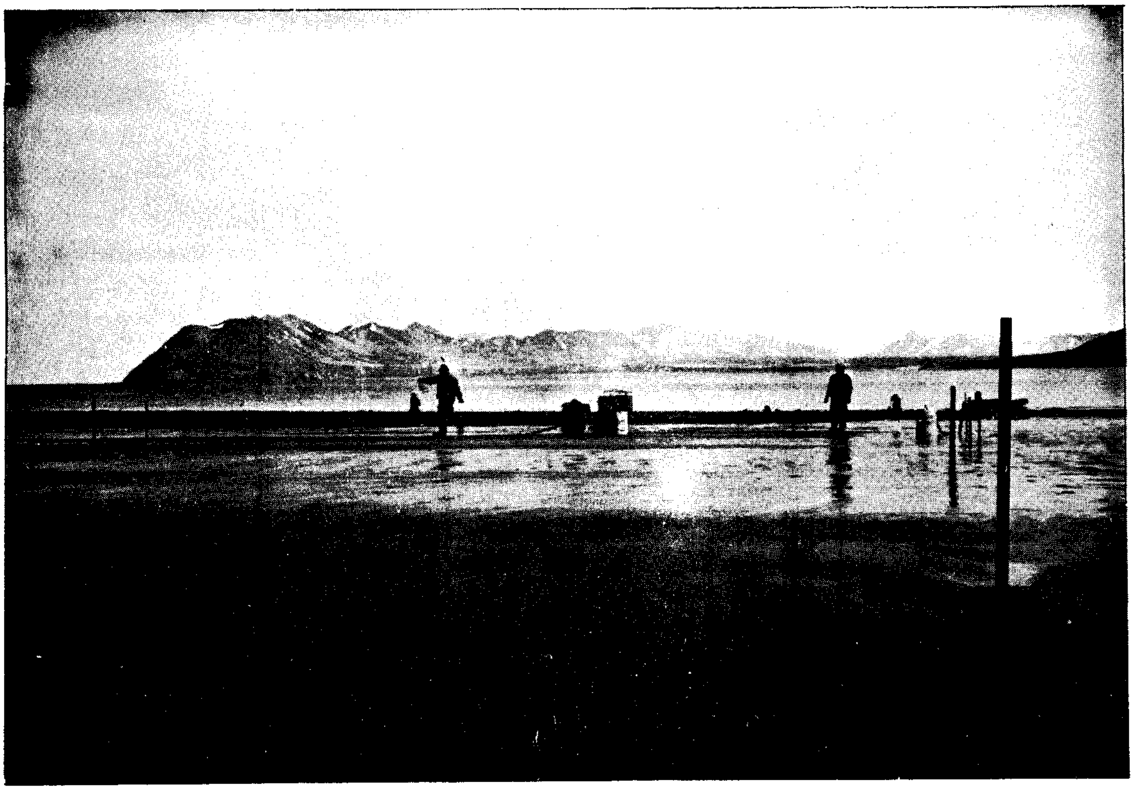
*Not all standard seive sizes were available for sediment analysis of Tanner Head and Halibut Bay.

Appendix Table 4. Cont.

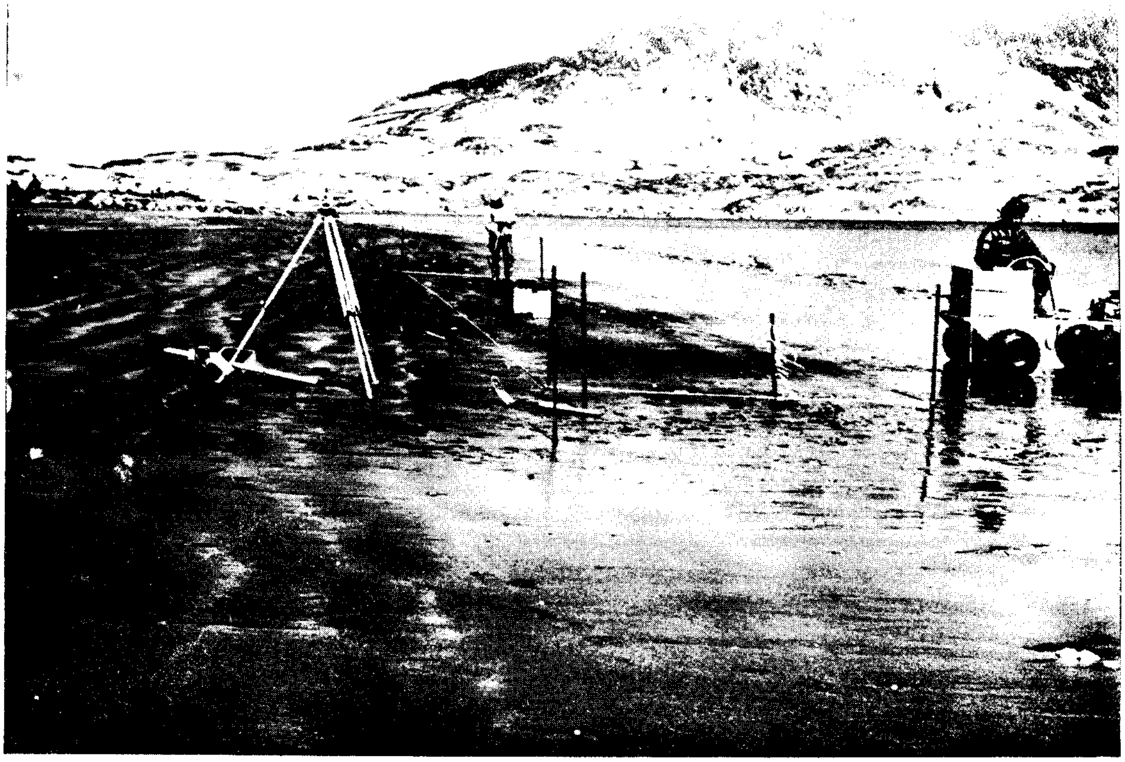
φ size	Village Tide Level -4	-3	-2	-1	0	+1	+2	+3	+4	0
<-2	0	.45	.11	0	.11	0	.61	T	.46	T
-2 to -1	T	.04	.11	.08	.04	.04	.37	.11	.16	T
-1 to 0	.18	.19	.48	.24	.37	.85	1.39	.71	1.64	.39
0 to 1	.55	.67	1.54	.55	2.39	4.25	7.35	2.92	3.76	1.08
1 to 2	6.10	2.13	11.19	8.94	1.66	72.48	69.83	73.67	68.02	66.55
2 to 3	86.10	86.92	83.56	82.95	88.45	21.33	20.06	18.92	21.01	29.17
3 to 4	6.40	4.93	2.61	4.84	4.63	.89	.81	.88	1.01	.96
>4	.84	.82	.15	.75	.81	.20	.12	.18	.20	.26



Photograph 1. Aerial view of Halibut Bay, south beach station site B–3.

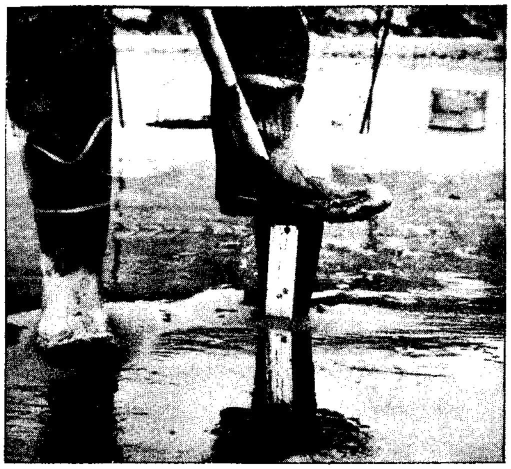


Photograph 2. Halibut Bay station B–3 looking north. Note Tide level station markers and technicians laying out the 3 X 21 meter tide level station plot.

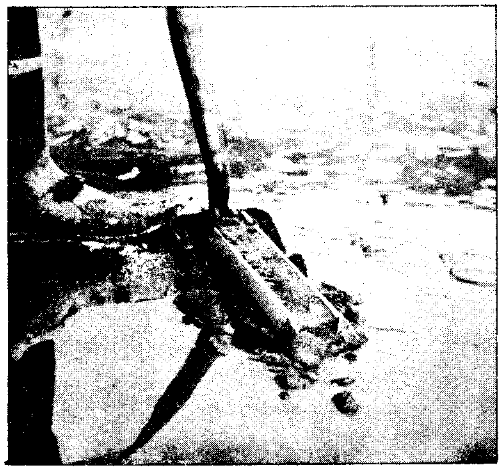


Photograph 3. Tanner Head tide level station plot at the +1.22 tide level. Note surveying transit at left used to locate tide levels; technician searching for bivalve molluscs in the plot and biologist washing subsamples in the wagon.

Photograph 4. Station B–7 at Hallo Bay looking southwest. Note the subplot and substrate in buckets waiting to be washed in the sampling wagon. Technician in background is looking for bivalve mollusc shows.



Photograph 5. The core sampler used to obtain sediment samples for grain size analysis.



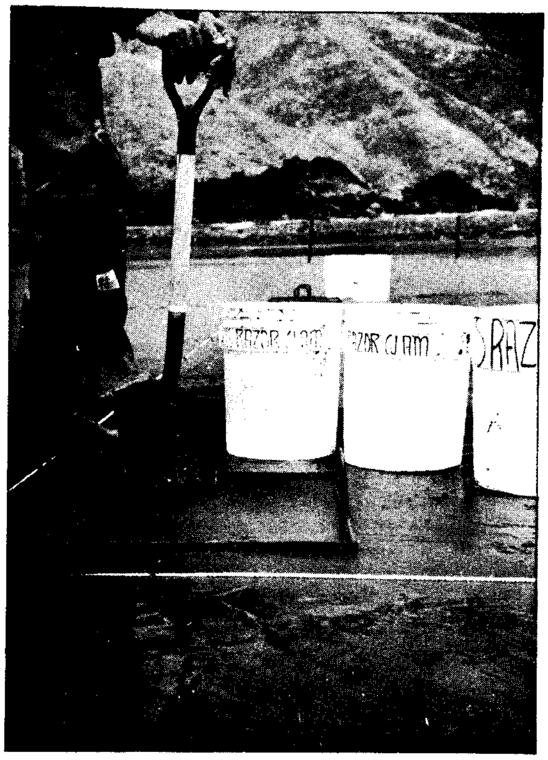
Photograph 6. The "core" after extraction which is then stored for later laboratory analysis.

Photograph 7. A typical *Siliqua* show caused by retraction of the siphon when the clam is disturbed.

Photograph 8. A rare *Siliqua* "show." The tip of the siphon is extended above the sand — like a flower in bloom.

Photograph 9. Technicians searching for bivalve mollusc shows at Tanner Head.

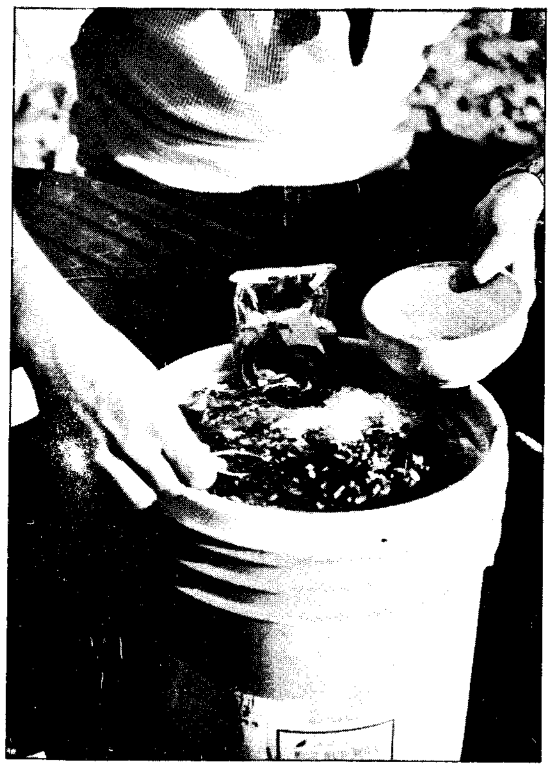
Photograph 10. Technician from photograph 9 with his captured *Siliqua patula*.



Photograph 11. Tide level station subplot sample being collected. All substrate is collected from within the 1/3 m^2 frame to a depth of one foot.

Photograph 12. Biologist using the Homelite pump mounted on the wagon to wash the subsample which is inside the box.

Photograph 13. Subsample from one tide level station at Swikshak Beach after the sand has been washed through the sample screen. Note annelids and juvenile *Siliqua patula.*



Photograph 14. Biologist sifting through the coarse gravel retained by the 1/16" mesh subsampling screen in order to find invertebrates.

COVER PAGE

FINAL REPORT

Contract No. 2655
Research Unit No. 27
July 1975 - August 1976
101 pp.

AN ECOLOGICAL ASSESSMENT OF THE LITTORAL ZONE ALONG THE OUTER COAST OF THE KENAI PENINSULA FOR STATE OF ALASKA, DEPARTMENT OF FISH & GAME

DENNIS C. LEES
RICHARD J. ROSENTHAL

DAMES & MOORE

JANUARY 24, 1977

January 24, 1977

State of Alaska
Department of Fish & Game
Homer, Alaska 99603

Attention: Mr. Loren Flagg

Gentlemen:

Final Report
An Ecological Assessment
of the Littoral Zone Along
the Outer Coast of the
Kenai Peninsula for
State of Alaska,
Department of Fish & Game

We submit herewith the final progress report and final discussion for the littoral and sublittoral studies on the outer Kenai Peninsula. This report contains the qualitative and quantitative descriptions of the biota obtained during the summer surveys conducted in July and August 1976.

A major conclusion of the study is that the intertidal and subtidal biotic assemblages are rich, pristine and productive. Primary productivity is high on both rocky and soft substrates and macrophytes apparently contribute sizable quantities of plant material to offshore systems. The time of maximum contribution (Fall) and the probable stability of the material at low temperatures combine to support a hypothesis that these plant materials are very important food sources to offshore and nearshore benthic assemblages during the winter, when phytoplankton production is low.

Assuming that a major crude oil spill is the main threat arising from oil development in this area, the greatest danger would probably be to salmon stocks, sea otters and marine birds. An important consequence of disturbing sea otter and marine bird populations would be to reduce predation pressures on several major herbivore species (sea urchins, limpets and chitons). This could result in serious problems in the macrophyte assemblages. The most serious long-term effects of a major oiling would probably occur in the lagoons and estuaries, however. Heavy oil contamination in these areas could reduce natural salmon stocks in affected watersheds and seriously reduce plant production and the contribution of plant materials to offshore assemblages. On the other hand, rocky plant assemblages are probably fairly resistant to the effects of major contamination by crude oil.

Participation in this study has been a pleasure. Your assistance and cooperation have been appreciated. If you have any questions, please contact us at the Homer (235-8494) or Anchorage (279-0673) office.

Very truly yours,

DAMES & MOORE

Richard C. Miller
Associate

Dennis C. Lees
Marine Biologist

Richard J. Rosenthal
Marine Biologist

RCM:DCL:RJR:sed
Enclosure

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LIST OF APPENDICES (Cont.)

I. TASK OBJECTIVES

The main objective of this study is to assess some of the marine plant and animal communities in intertidal and adjacent shallow subtidal areas along the southern, or outer, Kenai Peninsula. This is to be accomplished by:

1. Gathering baseline information on species composition and relationships within supporting "characteristic" biotic assemblages;

2. recording seasonal changes within the habitats; and

3. collecting information leading to an understanding of the ecological functions within these assemblages, including data on population structure, food web relationships, and factors influencing distribution and abundance.

The objective of this study was to collect data on distribution, size structure and biomass of the dominant organisms at each site and to assess the condition of the assemblages during the early spring.

II. FIELD

Field Trip Schedule

The surveys described herein were conducted from 30 June to 10 July and 30 and 31 August 1976. The M.V. Humdinger, chartered out of Cordova, was used to transport personnel and equipment to and from the stations. It served as a base of operations while in the field.

Scientific Party

The scientific party included:

1. Dennis Bishop, Dames & Moore, field assistant;
2. Dennis C. Lees, Dames & Moore, staff biologist;
3. Richard J. Rosenthal, Dames & Moore, staff biologist; and
4. Thomas M. Rosenthal, field assistant.

Methods

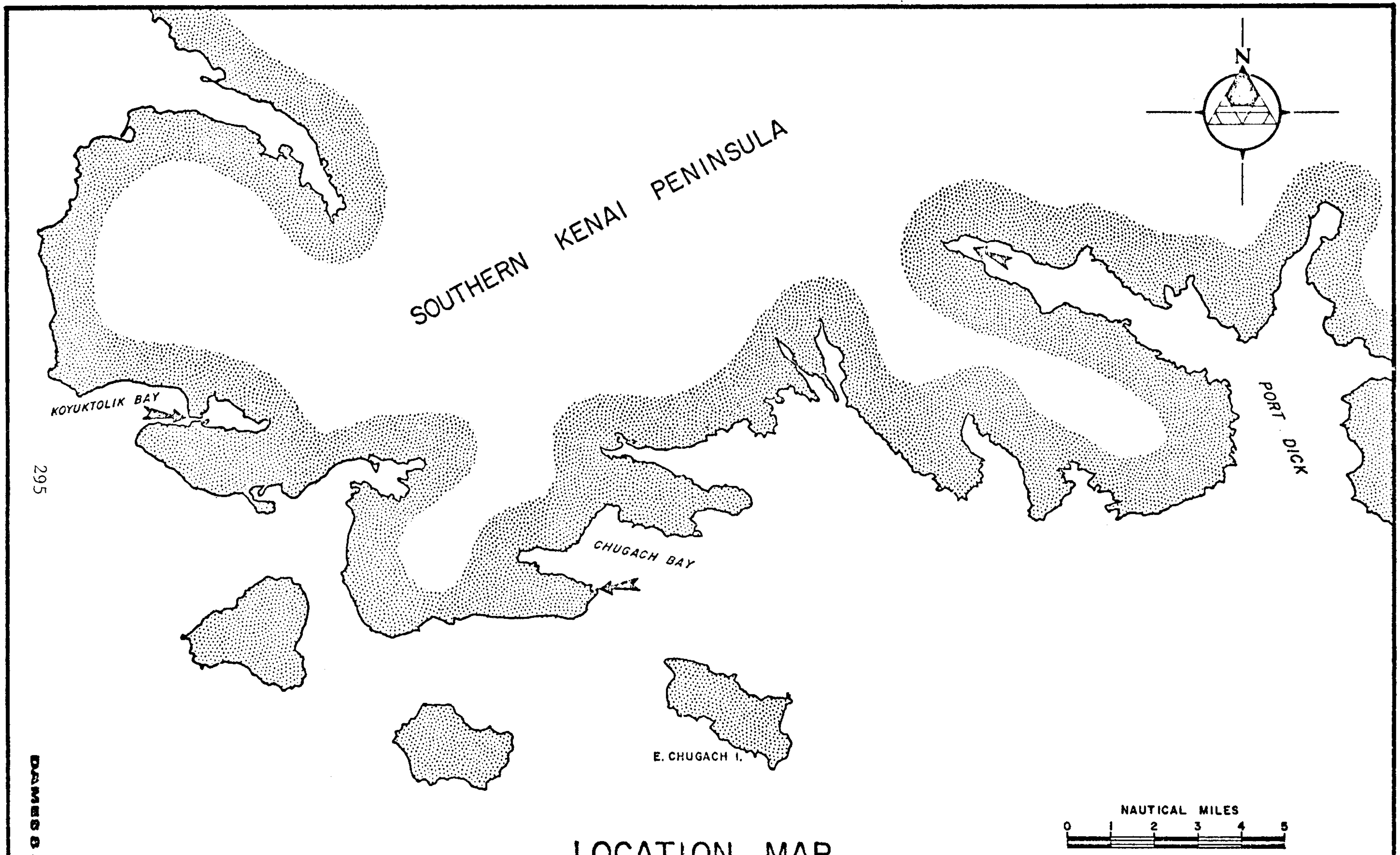
The mode of operation in the field was to combine qualitative and quantitative techniques in such a manner as to obtain a general description of the composition of the assemblages examined, the functional relationships characteristic of the sites surveyed, and the size structures, densities and biomasses of the organisms characterizing the various assemblages. This involved 1) taking random "nature walks" through the habitats, 2) examining large quadrats (25 m by 0.5, 1 or 2 m) for density estimates of macro-algae and large invertebrates such as starfish or gastropods, 3) medium quadrats (0.25 sq.m.) for species composition and relative cover estimates of smaller algae, encrusting and epifaunal forms, and 4) small quadrats (1/16 sq.m.) for density estimates and size distributions of dense organisms such as mussels and certain macrophytes (e.g., eelgrass). In cases of extreme density, smaller quadrats or covers are used to collect more practical samples.

Laboratory analysis included measuring the size, wet and dry weight of certain organisms to permit examination of size and weight distributions at the study sites and estimation of biomass of certain species. Measurements used are described herein. Regression lines relating linear measurements with whole, wet or dry tissue weights have been developed for several organisms. Macrophytes were dried at 90°C for 24 hours to obtain dry weights. Densities of Zostera were determined by counting the turions in haphazardly cast 1/16 m^2 quadrats. Only turions rooted within the quadrat were counted. Samples used for length and weight measurements were collected by hand by divers. Turions were collected either by removing all turions within the quadrats sampled, or by clearing small areas and placing all the turions in a bag. Length measurements were made from the uppermost node to the tip of the leaves. Turion heights were designated as the length of the longest leaf; turions were discarded if the tip of the longest leaf was broken off. Wet and dry weights were only measured for turions; roots and rhizomes were removed. Only turions on which the longest leaf was intact were utilized.

Densities of the blue mussel were estimated by counting the number of individuals in core samples (0.0046 m^2) or 1/16 m^2 quadrat samples. Sampling size depended upon the general density level of the area. Shell length is defined as the distance between the interior and the posterior margins, that is, the maximum length of the shell. Dry weights for mussels were obtained by drying 48 to 72 hours at 60°C. For larger specimens, wet tissue weights were obtained by removing the tissue from the shell and weighing it. For smaller specimens, the shell and tissue were dried and weighed, and then the meat was dissolved by Clorox and the empty shell weighed; dry tissue weight was obtained by subtraction.

Sample Localities

Specific habitats were examined at three locations on the outer Kenai Peninsula (Figure 1) during the summer of 1976. These are listed below:



LOCATION MAP
OF THE SOUTHERN KENAI PENINSULA

DAMES & MOORE

A. Koyuktolik (Dogfish) Bay and Lagoon (Figure 2)

1a. North side of Bay

1b. South side of Bay

2a. Mussel bed on north side of entrance channel to lagoon (outer bed)

2b. Mussel bed or bar separating entrance channel from lagoon (inner bed)

3. Rock pinnacle in outer lagoon

4. Outer lagoon

5. Inner lagoon

B. Chugach Bay (Figure 3)

a. Raft Cove

b. Shelf and slope north of Raft Cove

c. Northeast point of Raft Cove

d. West of Sea Otter Point

C. Port Dick (Figure 4)

a. Subtidal eelgrass bed

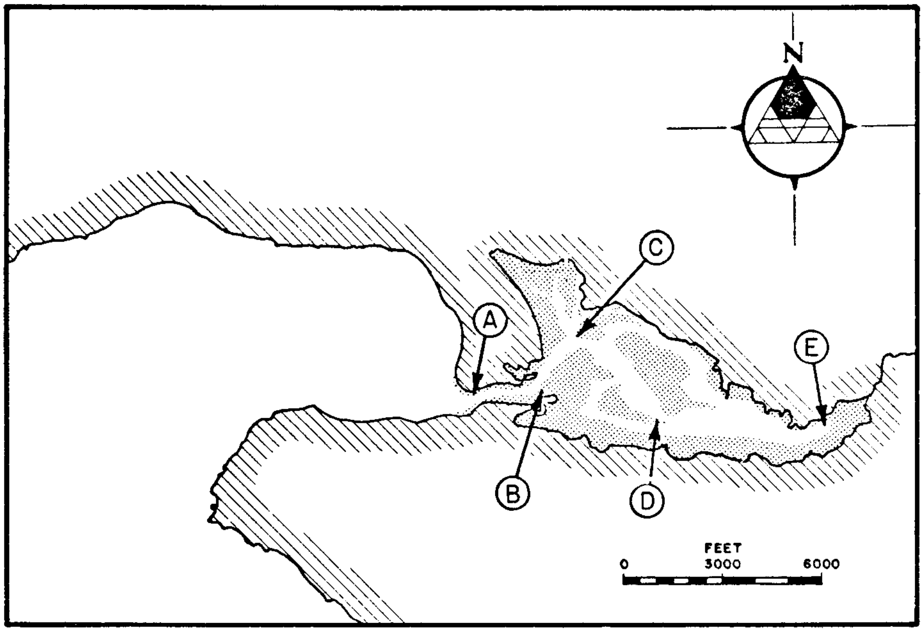
b. Intertidal mussel bed

c. Rockweed zone

d. Rock pinnacle (Dick's Head)

Data Collection and Analysis

The data collected are presented as tables, figures and appendices in this report. Analysis and interpretation of data are included in final discussion section of this report.



KEY:

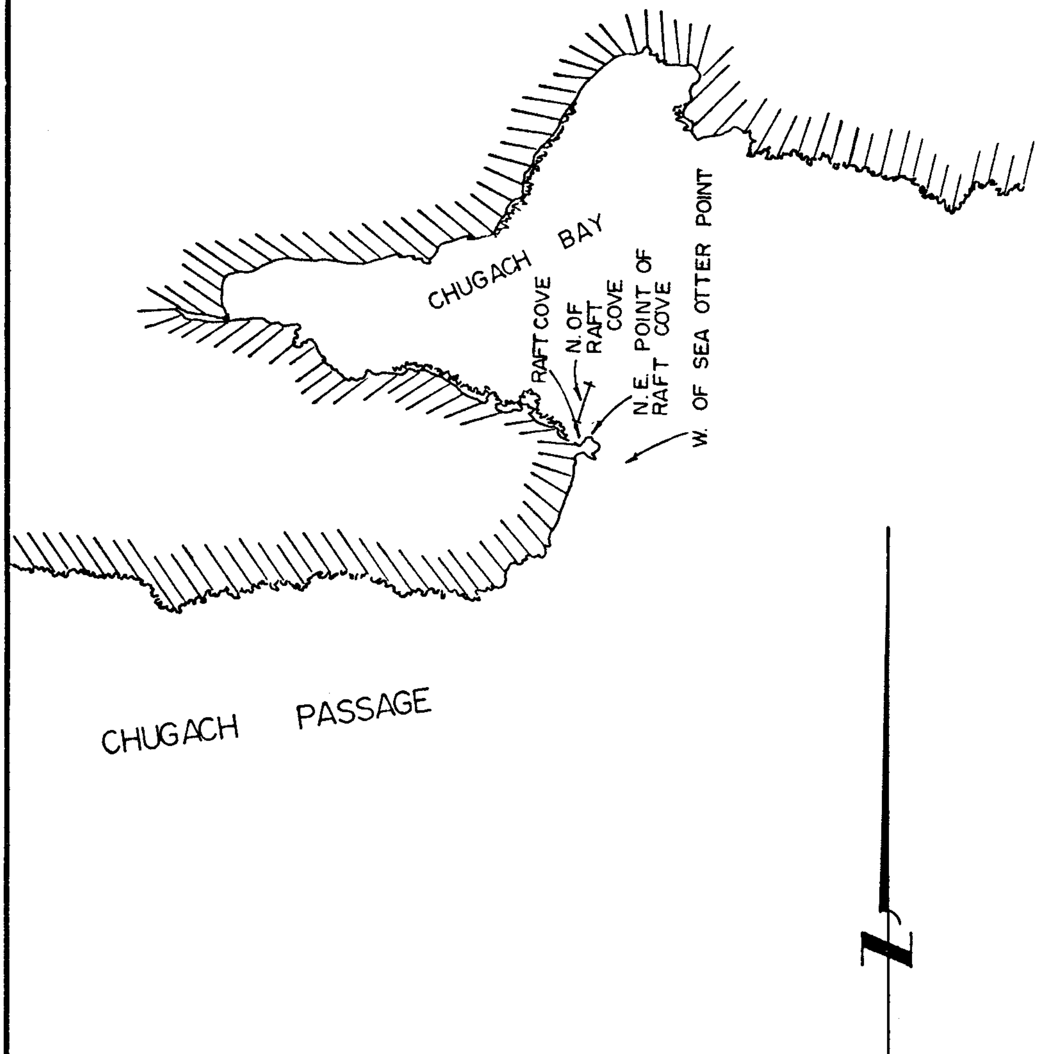
Ⓐ LETTERS CORRESPOND TO THOSE GIVEN IN THE TEXT

SHADED AREAS INDICATE MUD OR SAND FLATS

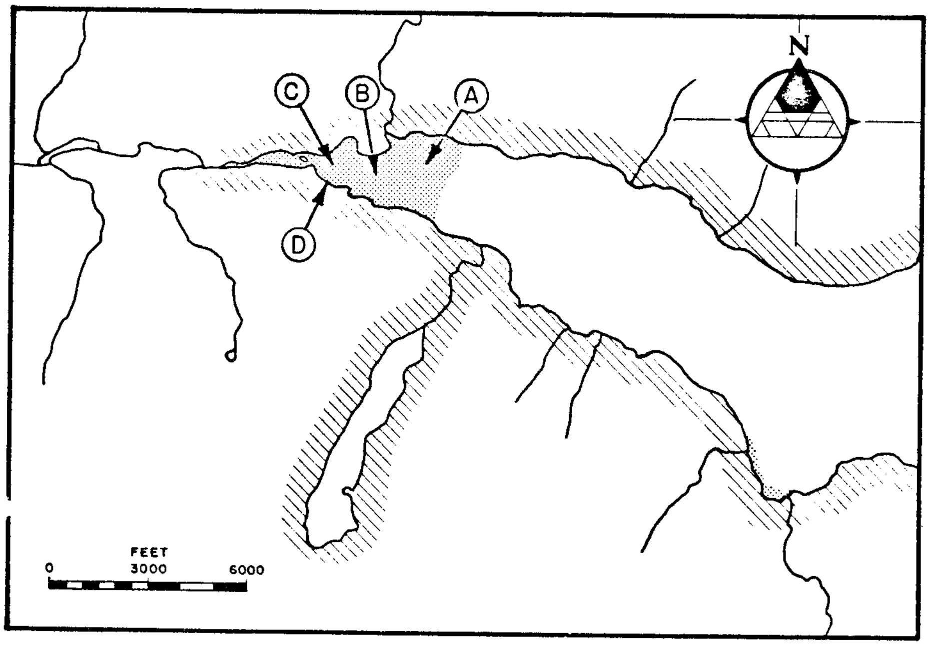
KOYUKTOLIK BAY AND LAGOON

DAMES & MOORE

FIGURE 2



LOCATION MAP FOR CHUGACH BAY



KEY:

(A) LETTERS CORRESPOND TO THOSE GIVEN IN THE TEXT

SHADED AREAS INDICATE MUD OR SAND FLATS

WEST ARM, PORT DICK

DAMES & MOORE

FIGURE 4

Types of Samples

Koyuktolik Bay - July

a. Qualitative diving observations from all sampling sites.

b. 0.0046 m^2 cores in mussel bed for estimating density, size structure and biomass - 12.

c. 1/16 m^2 quadrats for relative cover and abundance data for eelgrass from the transition zone and mid outer lagoon - 38.

d. Turion length, wet weight and dry weight data for estimating biomass and size structure of eelgrass from the inner lagoon, outer lagoon and transition zone - 210.

e. Food habit observations.

f. Relative cover of *Fucus* and *Mytilus* from 1/16 m^2 quadrats in the inner, outer and seaward mussel beds - 384.

g. Vertical series of 1/16 m^2 quadrats on rock pinnacle in entrance channel - 11.

h. 1/16 m^2 quadrats for density of *Katharina*, *Tonicella* and *Evasterias* on rock pinnacle in entrance channel - 22.

Koyuktolik Bay - August

a. Qualitative diving observations.

b. 1/16 m^2 quadrats for density and biomass estimates of eelgrass at the inner and outer edges of the eelgrass beds in the outer lagoon - 27.

c. Turion height and dry weight data for eelgrass from the eelgrass beds of the outer lagoon.

Chugach Bay - July

a. 1/4 m^2 quadrats for estimating abundance, density and relative cover of macrophytes and macrofauna - 50.

b. 5 x 1 m transects for Phaeophyta and grazers - 10.

c. 1/4 m^2 quadrats for estimating abundance of echinoids - 36.

d. Qualitative diving observations from all sampling sites.

e. Food habit observations.

Port Dick - July

a. 1/4 m^2 quadrats for estimating abundance and relative cover of macrophytes and macroinvertebrates - 80.

b. 1/4 m^2 quadrats for estimating relative cover of mussels - 60.

c. Size frequency data for Littorina sitkana - 333.

d. 1/4 m^2 quadrats for estimating abundance of limpets - 12.

e. Subtidal transects for estimating the abundance of asteriods:

5 x 1 m - 3

10 x 1 m - 6

30 x 1 m - 3

f. 30 m line intercept transects for estimating relative coverage of macrophytes - 9; of echinoids - 5.

g. Qualitative diving observations from all sampling sites.

h. Food habit observations.

i. Size, wet weight and dry weight of mussels for estimating biomass and size structure - 50.

j. 1/16 m^2 quadrats for mussel size frequency data - 8.

k. 1/16 m^2 quadrats for estimating biomass of macrophytes - 12.

Port Dick - August

a. 1/16 m^2 quadrats for estimating density of eelgrass.

b. Turion length and dry weights for estimating biomass and size structure of eelgrass - 163.

Intended Use for Size and Density Data

Several types of quantitative data may be collected for some conspicuous species apparently occupying important roles in the natural economy of each study site. These include relative abundance (density-number of individuals per square meter), and some measurements of linear size (length, width, aperture width, etc.) and weight (wet or dry weight of soft tissue). These data will assist in describing variations in conditions at the study sites and will permit examination of differences between them. Specifically, we want to be able to compare population structure among different areas, or at the same site under different conditions, and to generate accompanying biomass estimates for selected species at the study sites. These data will provide information on temporal variations in population structure at specific sites and allow assessment of the effects of unnatural phenomena.

We employed several statistical techniques in data analysis. Size-frequency data were compared with the Kolmogorov-Smirnov two-sample test (Siegel, 1956). Most of the biomass data was reconstructed by using the size-weight regressions. This only produces first approximations but in view of the nature of the study and the poor understanding of the qualitative features of the various systems, we decided that the major portion of our initial efforts would be more usefully spent in general endeavors such as describing species composition and the natural relationships (e.g., predator-prey and other trophic relationships).

Population structure was examined using a series of equations based on Brody-Bertalanffy growth curves (Ebert, 1973). This method, especially applicable to survey work, uses easily gathered size to produce useful first approximations of growth and mortality rates, and also generates a life table. The parameters required for computation are the means of the size distributions from two large samples (300 measurements; the means must closely estimate the parametric mean for the sampled population), times of sample collection relative to the time of "recruitment" in the sampled population, and maximum (asymptotic) size attained by the species at the collecting site.

III. RESULTS

KOYUKTOLIK LAGOON

Description of the Areas Examined

In July, five types of habitats were examined at Koyuktolik Bay. These included: (1) the sand bottom on the north side of the Bay, (2) the intertidal portion of the entrance channel, (3) a rock pinnacle in the entrance channel, (4) the outer lagoon and (5) the inner lagoon (Figure 2). These habitats differ significantly in hydrographical, geological, and biological characteristics. The north side of the Bay is exposed to moderate wave action, judging from the large ripplemarks in the well-sorted sand substrate. The south side and lagoon areas, however, appear well protected. Although the outer portion of the entrance channel may be exposed to considerable wave action from lower Cook Inlet, the lagoon areas are well protected. The entrance channel is swept four times daily by strong tidal currents. Geologically, it appears that the lagoon was formed behind a moraine left by the glacier that excavated the Koyuktolik Bay and canyon complex. The narrow entrance channel winds through the moraine, permitting water movement into and from the Bay. The area of the lagoon is approximately 1,690,000 sq.m.

The substrate of the Bay, on its north side, was characterized by clean, gray medium sand with little shell debris. Wave action had created a microrelief of large ripple marks at a depth of 9.8 m (Appendix A-1). The biota was dominated by a maldanid polychaete (a deposit feeder), the clam *Tellina nuculoides* (a suspension feeder), and a sand dollar *Echinarachnius parma* (a suspension feeder). Major predators appeared to be sea ducks (probably scoters and common eiders), the olive shell (Olivella baetica) and the sunstar (Pyncopodia helianthoides; Appendix A-1).

On the south side of the Bay, the substrate was predominantly a cobble/sand matrix overlain with a thin dusting of silt. A large quantity of organic debris of terrestrial and marine origin was present (Appendix A-2). Although shell debris was common, living clams were not observed. The most conspicuous alga was elephant ear kelp (Laminaria saccharina), but it appeared possibly imported from shallower water. The predominant invertebrates were a chiton (Tonicella lineata), a hermit crab (Pagurus ochotensis) and the sunstar (Pycnopodia helianthoides).

The intertidal margins of the entrance channel to the lagoon was strongly dominated by two extensive beds of the blue mussel (Mytilus edulis). One bed was at the north side of the mouth and the other was on the gravel bar separating the entrance channel from the outer lagoon. Each mussel bed covered nearly four acres and comprised a considerable biomass of mussels. Additionally, outside the mussel beds, dense patches of the periwinkle (Littorina sitkana) were scattered throughout the intertidal zone in the entrance channels (Appendix A-3).

The flora of the mussel beds was dominated by rockweed (Fucus distichus), but several other species were conspicuous. A large ribbon-like kelp (Alaria fistulosa) was a conspicuous dominant in the shallow subtidal zone. Another common intertidal form was the thin red alga Porphyra sp., which appeared to be an important pioneer species. In the ice-scoured furrows, it almost completely covered the exposed cobbles by mid-July, whereas in May these same furrows had been completely devoid of vegetation.

A large rock outcrop is located where the entrance channel joins the outer lagoon. The flora and fauna of this area is quite robust and diverse (Appendix A-4). The sides of this pinnacle supported moderate quantities of several large algae such as Fucus, Alaria sp. and Agarum cribrosum. The boulders around the pinnacle were heavily covered with a three-layered algal assemblage. The upper layer was dominated by Laminaria groenlandica and Alaria sp.; over much of the area, coverage by L. groenlandica was complete. Under the laminarian canopy, several foliose species of red algae were abundant, notably Rhodymenia palmata, Opuntiella californica and Iridaea lineare. Encrusting coralline algae formed a thin veneer on the rocks under the overlying algal canopy.

Vertical zonation on the pinnacle is indicated in Table 1. Rock-weed and barnacles dominated the upper zone which is also occupied by several subdominants. These were mainly browsing molluscs (Littorina sitkana), some limpet species, a chiton (Katharina tunicata) and the blue mussel. Another chiton, Tonicella insignis, was common from mid-intertidal into the subtidal zone, under the kelp canopy (Table 1; Appendix A-5). The lower intertidal zone was largely dominated by algae (Table 1). Katharina was a dominant grazer in the mid-intertidal zone, and probably has a considerable influence on algal cover and the floral composition. Based on data collected in that zone, the estimated density for Katharina was about 44 individuals/m^2 (Appendix A-5).

Table 1. Distribution of organisms observed in a vertical series of 1/16 m^2 quadrats on a rock pinnacle in entrance channel to Koyuktolik Lagoon, 7/10/76.

	Upper Intertidal				QUADRAT ORDER				Low Intertidal		
Species	1	2	3	4	5	6	7	8	9	10	11
Fucus distichus (C)	100%	20%	0	5%	5%	100%	100%	0	0	0	0
Balanus ? glandula (N)	0	5	46	0	0	0	0	0	0	0	0
Balanus ? glandula (C)	0	0	0	0	40%	75%	75%	50%	0	0	0
Littorina sitkana (N)	0	0	25	70	15	0	0	0	0	0	0
Acmaeidae, unid. (N)	0	0	0	6	5	0	0	0	0	0	0
Mytilus edulis (N)	0	0	0	20	0	0	0	0	0	0	0
Mytilus edulis (C)	0	0	0	5%	20%	0	0	0	0	0	0
Katharina tunicata (N)	0	0	0	0	0	2	3	0	0	0	0
Elassochirus gilli (N)	0	0	0	0	0	1	1	0	0	0	0
Serpulidae, unid. (N)	0	0	0	0	0	0	0	Numerous	0	Numerous	0
Encrusting bryozoan (N)	0	0	0	0	0	0	0	P	0	[illegible]	0
Alaria sp. (N)	0	0	0	0	0	0	0	0	3	0	Dom
Alaria sp. (C)	0	0	0	0	0	0	0	0	100%	0	0
? Monostroma sp. (C)	0	0	0	0	0	0	0	0	75%	50%	0
Encrusting coralline alga (C)	0	0	0	0	0	0	0	0	50%	25%	0
Pycnopodia helianthoides (N)	0	0	0	0	0	0	0	0	1	0	0
Tonicella ? insignis (N)	0	0	0	0	0	0	0	0	0	6	0
Laminaria sp.	0	0	0	0	0	0	0	0	0	0	Dom

(N) - Number
(C) - Relative cover
Dom - Dominant

Several mobile crustaceans were common on the sides of the pinnacle. These included the hermit crab Elassochirus gilli and two decorator crabs (Hyas lyratus and Oregonia gracilis).

The fauna on and under the boulders surrounding the pinnacle was dominated by suspension feeders such as the hydroid Abietinaria turgida, the sponge Halichondria panicea, the sea cucumber Cucumaria miniata and the brittlestar Ophiopholis aculeata. Two herbivores, Tonicella lineata and Strongylocentrotus drobachiensis were common. The starfish Pycnopodia helianthoides and Evasterias troschelii were common. The discovery that juvenile king crab (Paralithodes camtschatica) were common under rocks was surprising in this estuarine habitat. Specimens with carapace widths of about 1 cm were observed under at least a third of the large boulders overturned during examination.

The outer lagoon was strongly dominated by macrophytes, mainly eelgrass (Zostera marina), and the seaweeds, Laminaria ? saccharina, Alaria sp., and Ahnfeltia plicata. The quantity of marine vegetation in the outer lagoon was very high. Major invertebrates included clams (Mya spp., Saxidomus gigantea and Tresus capax) and a crab (Telmessus cheiragonus; Appendix A-6). A total of 31 species was recorded in July.

The epibiota of the inner lagoon was generally representative of an impoverished area. Only three species were recorded during a cursory examination, but extended observations probably would not have increased the number of macroscopic forms appreciably. Eelgrass was the dominant plant and the deposit feeding polychaete, Abarenicola ? pacifica was a common animal (Appendix A-7).

Biology of Eelgrass

The dominant primary producer in Koyuktolik Lagoon was eelgrass. The bed was best developed in the outer lagoon. Overall vegetative cover in the lagoon by eelgrass was not examined, but cover and density of turions (bundles of leaves) were measured in the transition zone between the inner and outer lagoon, and toward the middle of the outer lagoon. Turion density estimates are based on replicate counts in 0.0625 m^2 quadrats. In July, the density of eelgrass in the middle of the lagoon averaged about 485 turions per m^2; relative cover averaged 81 percent (Appendix A-8). Plant height ranged from 38 to 142 cm, and averaged 107.9 ± 24.1 cm (Appendix A-9; Table 2). The distribution of plant height was unimodal, the mode being above the mean. In August, the estimated density of eelgrass in the same general area was about 612 turions/m^2; relative cover was not measured (Appendix A-10). Plant height at that time ranged from 31.5 to 248.0 cm, and averaged 160.0 ± 46.3 cm (Appendix A-11; Table 3); the distribution of plant height was again unimodal, but rather flatter than in July; the mode was again somewhat above the mean.

In the transition zone (Figure 2), eelgrass and a mat-forming red alga *Ahnfeltia plicata* co-dominated. Large patches of eelgrass were separated by wide channels of *Ahnfeltia*. In the area examined in July, relative cover by *Ahnfeltia* was about 54 percent. Relative cover by eelgrass was about 40 percent and the estimated overall density was 182 turions/m^2 (Appendix A-8). Density within the eelgrass bed was about 456 turions/m^2. Plant height ranged from 28-173 cm and averaged 95.5 ± 30.6 cm (Appendix A-12; Table 2). The distribution of plant height was basically bimodal in this location with the major mode located slightly above the

Table 2 . Turion height-frequency distributions of eelgrass (Zostera marina) in Koyuktolik Lagoon, 7/9/76.

Turion Height (cm) [1]	Inner Lagoon Frequency	%	Transition Zone Inner & Outer Lagoon Frequency	%	Middle of Outer Lagoon Frequency	%
20.0-29.9	1	2	1	1.6	0	0
30.0-39.9	10	20	0	0	1	1
40-0.49.9	8	16	6	10.0	2	2
50.0-59.9	1	2	2	3.3	3	3
60.0-69.9	4	8	5	8.3	2	2
70.0-79.9	4	8	2	3.3	3	3
80.0-89.9	5	10	6	10.0	10	10
90.0-99.9	4	8	9	15.0	10	10
100.0-109.9	6	12	11	18.3	12	12
110.0-119.9	2	4	6	10.0	15	15
120.0-129.9	2	4	3	5.0	27	27
130.0-139.9	3	6	4	6.7	13	13
140.0-149.9	0	0	3	5.0	2	2
150.0-159.9	0	0	0	0	0	0
160.0-169.9	0	0	0	0	0	0
170.0-179.9	0	0	1	1.6	0	0
n	50		60		100	
$\bar{x}$ (cm) [2]	73.0		95.5		107.9	
s (cm) [2]	33.2		30.0		24.1	

[1] Length of longest leaf from upper node.
[2] Based on unclassed data in Appendices A-9, A-12 and A-14.

mean. In August the estimated density of eelgrass within the bed in the same general area was 440 turions/m^2. Plant height ranged from 28.5-217.0 cm and averaged 130.5 ± 53.2 cm (Appendix A-13; Table 3). The distribution of plant height was irregularly bimodal with the major mode somewhat higher than the mean.

In the inner lagoon (Figure 2), although poorly developed and sparsely distributed, eelgrass was the dominant plant cover. Relative cover was probably less than 5 percent over the entire area, and density was estimated at less than 50 turions/m^2. Plant height ranged from 27.5-136.0 cm and averaged 7.30 ± 33.2 cm (Appendix A-14; Table 2). The distribution of plant height was basically bimodal with the major mode located somewhat below the mean. This area was not sampled in August.

Samples were collected for estimation of wet and dry weight of the standing stocks of eelgrass in July and August. The relationships between turion height and wet weight are shown for three locations in the lagoon in Figure 5; the basic data are included in Appendices A-12, A-14 and A-15. The relationships between turion height and dry weight for samples from the transition zone are shown in Figure 6 and the basic data are included in Appendices A-15 and A-16.

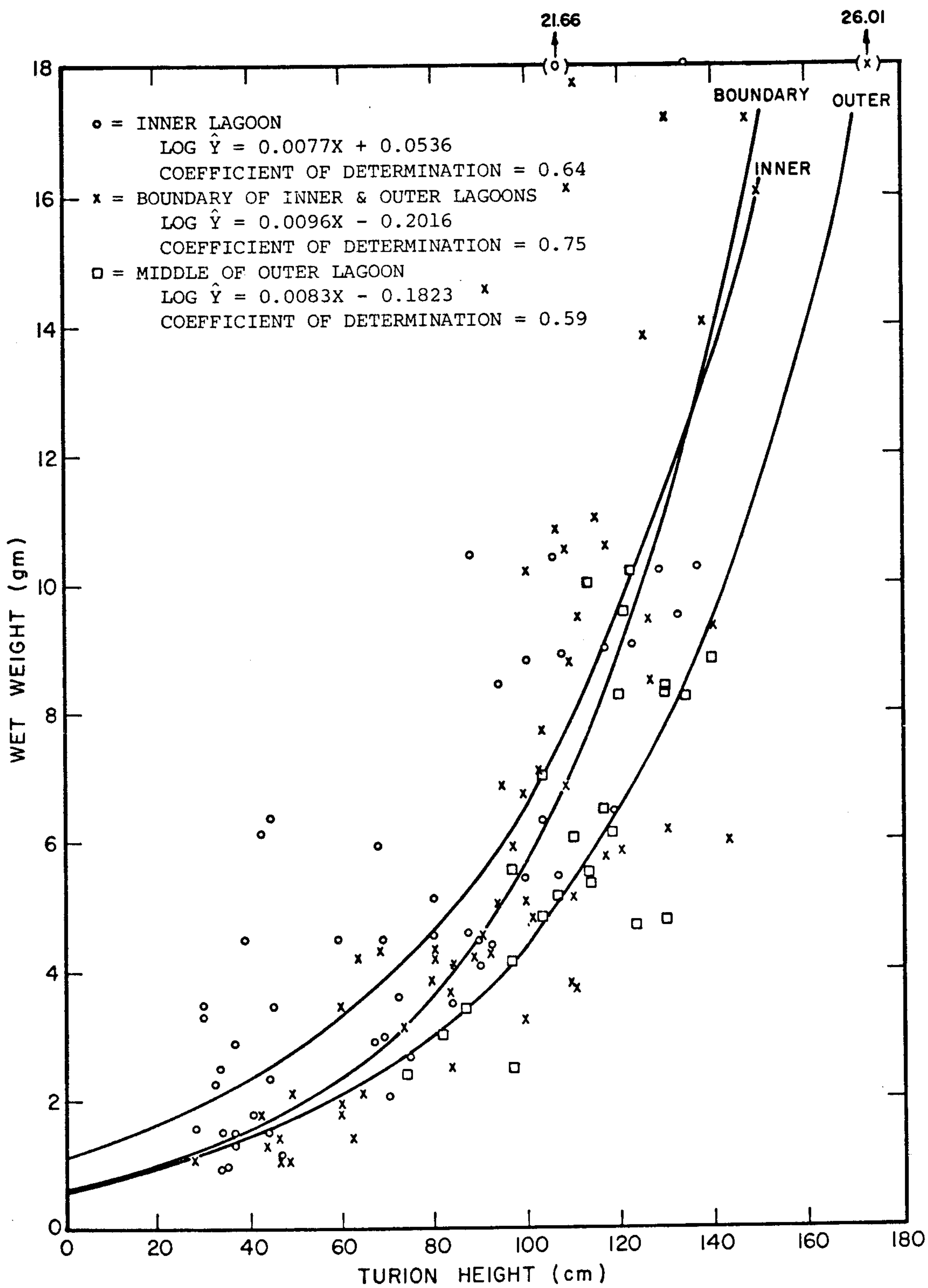
The turion height-wet weight regressions are fairly similar for all three beds sampled in July (Figure 5). However, it appears that the plants in the outer lagoon have a tendency to be lighter than plants of the same size from the inner beds. This is possible because the somewhat lower turion densities and relative cover within the beds of the transition

Table 3 . Turion height frequency distributions for eelgrass (Zostera marina in Koyuktolik Lagoon, 8/30/76.

Turion Height (cm)[1/]	Transition Zone Between Inner & Outer Lagoon Frequency	%	Middle of Outer Lagoon Frequency	%	Total	Percent
20.0-29.9	1	1.5	0	0.0	1	0.6
30.0-39.9	2	3.0	2	2.0	4	2.4
40.0-49.9	2	3.0	0	0.0	2	1.2
50.0-59.9	2	3.0	0	0.0	2	1.2
60.0-69.9	2	3.0	1	1.0	3	1.8
70.0-79.9	6	9.0	2	2.0	8	4.8
80.0-89.9	5	7.5	1	1.0	6	3.6
90.0-99.0	3	4.5	4	4.0	7	4.2
100.0-109.9	5	7.5	4	4.0	9	5.4
110.0-119.9	2	3.0	7	7.1	9	5.4
120.0-129.9	1	1.5	7	7.1	8	4.8
130.0-139.9	5	7.5	3	3.0	8	4.8
140.0-149.9	1	1.5	7	7.1	8	4.8
150.0-159.9	6	9.0	6	6.1	12	7.2
160.0-169.9	3	4.5	9	9.1	12	7.2
170.0-179.9	5	7.5	7	7.1	12	7.2
180.0-189.9	7	10.4	10	10.1	17	10.2
190.0-199.9	2	3.0	9	9.1	11	6.6
200.0-209.9	4	6.4	7	7.1	11	6.6
210.0-219-9	3	4.5	6	6.1	9	5.4
220.0-229.9	0	0.0	2	2.0	2	1.2
230.0-239.9	0	0.0	4	4.0	4	2.4
240.0-249.9	0	0.0	1	1.0	1	0.6
n	67		99		166	
$\bar{x}$ (cm)[2/]	130.5		160.0		148.1	
s (cm)[2/]	53.2		46.3		49.0	

[1/] Length of longest leaf from upper node.

[2/] Based on unclassed data in Appendices A-11 and A-13.

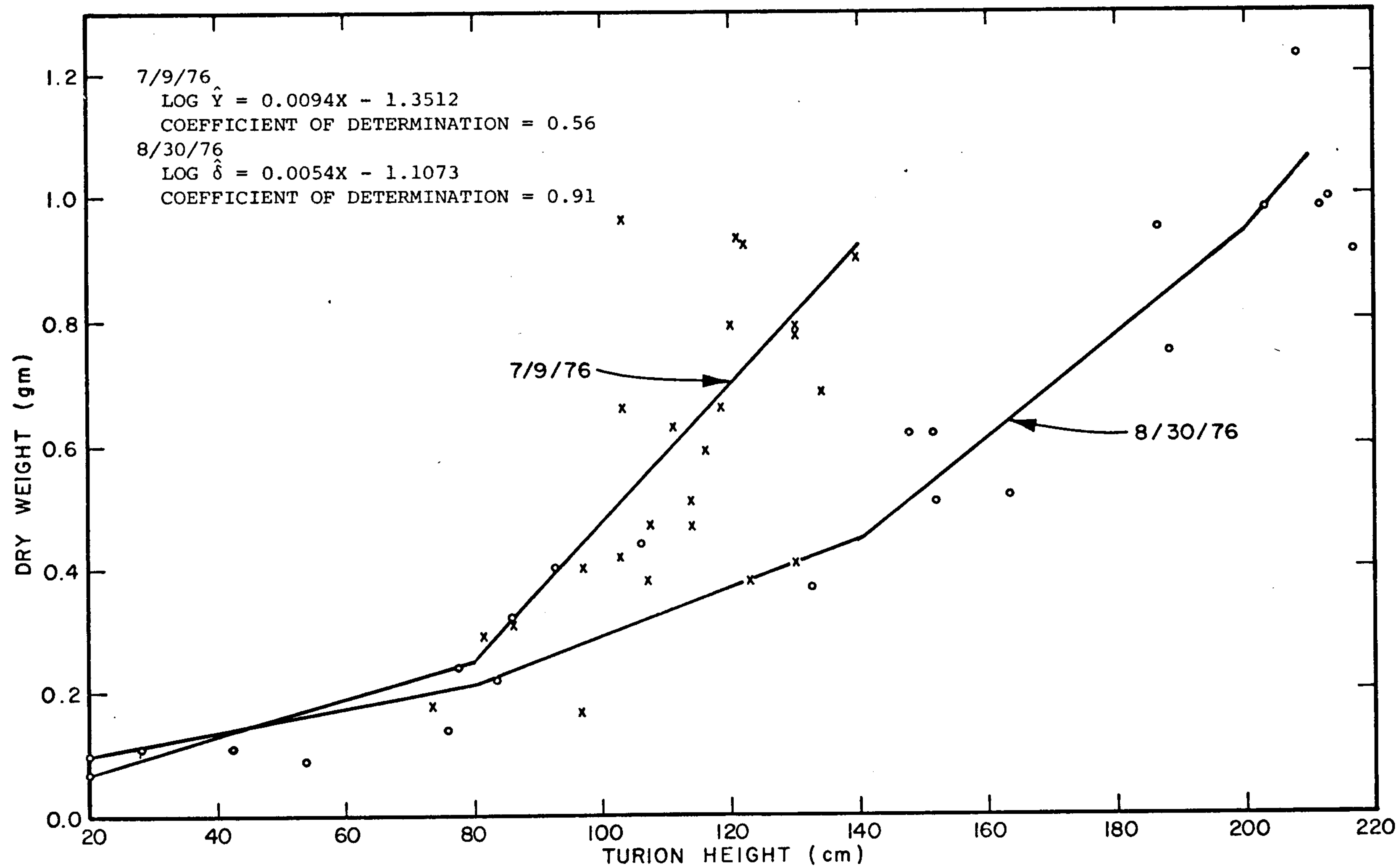


RELATIONSHIP BETWEEN TURION HEIGHT AND WET WEIGHT FOR EELGRASS (*ZOSTERA MARINA*) AT KOYUKTOLIK LAGOON, 7/9/76.

zone permit the plants to become more robust. However, it may also be a consequence of experimental error.

In August while examining the samples from the eelgrass meadows in Koyuktolik Lagoon, it seemed that the physical appearance of the plants was poorer than those observed in July. The plants were also somewhat poorer than those observed at Port Dick the next day. The characteristics of the plants that led to the initial subjective opinion were the number of frayed and broken leaves and the amount of deterioration and apparently dead tissue on the leaves. The first part of this hypothesis is supported by the data presented in Figure 6. A comparison of the regressions for turion height and dry weight suggests that, although average length was considerably lower in August (Tables 2 and 3), turions of equal size were considerably heavier in July (Figure 6). For example, the estimated dry weight of 140 cm long turion in July was 0.92 gm, but in August it had decreased to 0.45 gm. Furthermore, a comparison of the turion height-dry weight relationships for eelgrass from Port Dick and Koyuktolik Lagoon produced the same conclusion, namely plants of equal length were lighter at Koyuktolik (Figure 7). In fact, the details are quite similar; the estimated dry weight of a 140 cm long turion at Port Dick in August is about 0.88 gm, only slightly less than in the transition zone at Koyuktolik in July. These factors, in addition to a large quantity of loose and drifting leaves, made it appear that the eelgrass beds in Koyuktolik Lagoon had already peaked by late August. No flowering plants were observed during either survey.

To estimate biomass, the size distribution for each area was utilized to divide the number of turions per m^2 into size classes; then



RELATIONSHIP BETWEEN TURION HEIGHT AND DRY WEIGHT FOR EELGRASS (*ZOSTERA MARINA*) IN THE TRANSITION ZONE BETWEEN THE INNER AND OUTER LAGOONS, KOYUKTOLIK LAGOON, SUMMER 1976.

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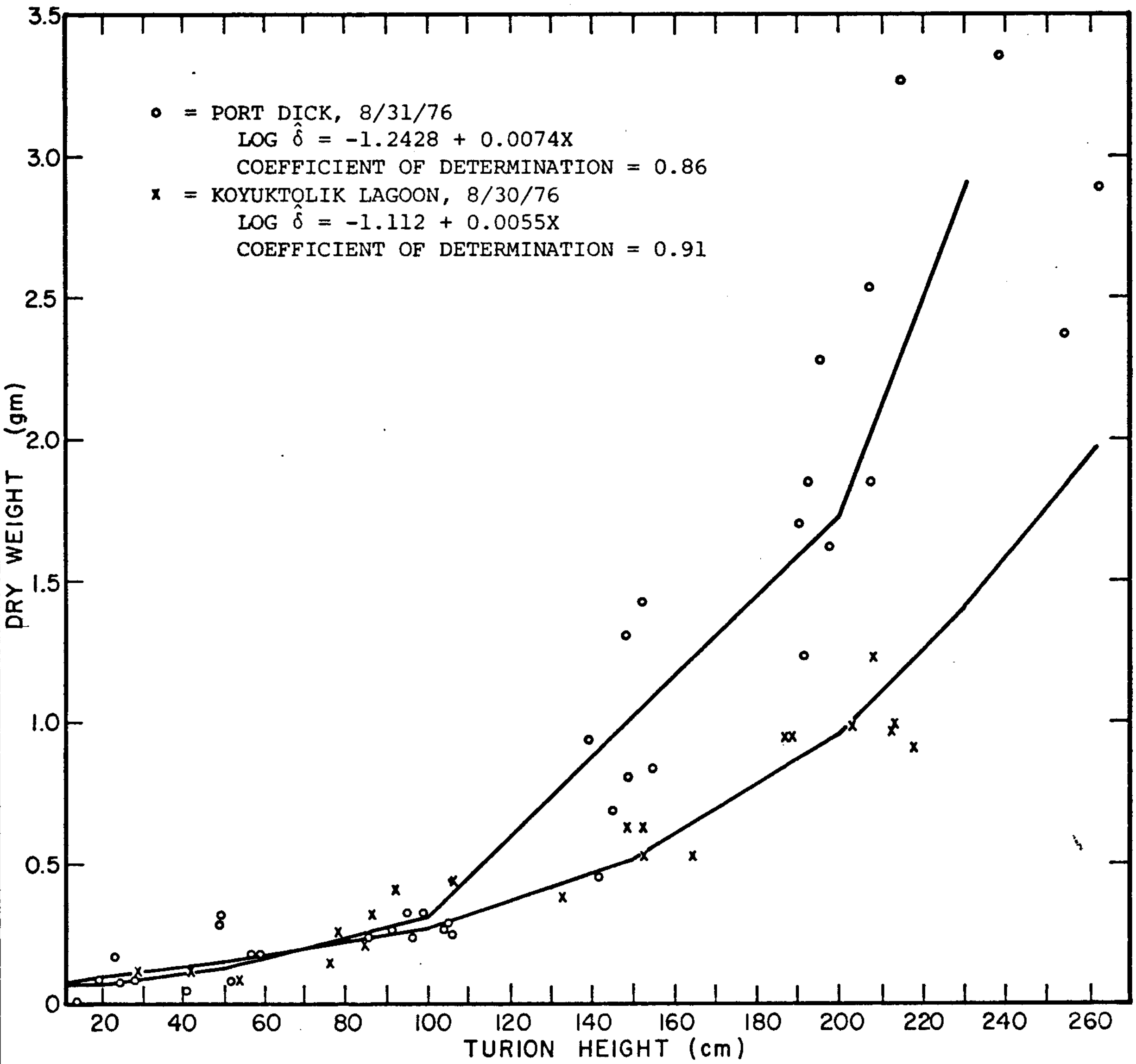


COMPARISON OF TURION HEIGHT-DRY WEIGHT RELATIONSHIPS FOR EELGRASS (*ZOSTERA MARINA*) FROM PORT DICK AND KOYUKTOLIK LAGOON, AUGUST 1976.

DAMES & MOORE

FIGURE 7

the number of individuals in each class was multiplied by the estimated weight of a turion of the average size for that class. The component weights were summed for the estimated biomass/m^2. These data are presented in Table 4.

Standing stocks of eelgrass are considerably lower in the inner lagoon than elsewhere (Table 4). In July the biomass of the beds of the outer lagoon and the transition zone were at least ten times greater than the biomass of the bed in the inner lagoon. Estimated wet weight at the outer areas averaged about 2,800 gm per m^2.

Because of the paucity of data, the main value of these data is that they provide general estimates of standing stocks of eelgrass and its distribution in the lagoon. It cannot be determined if the increase in density and biomass indicated for the middle of the outer lagoon are real or are due to sampling variation. Clearly, however, the outer lagoon supports a considerable standing crop. The poor condition of the plants and the large quantity of drifting eelgrass observed in August indicate that maximum values were not obtained.

Biology of the Mussel Beds

Beds of the blue mussel *Mytilus edulis* are an important and conspicuous feature in the ecology of the entrance channel and nearby lagoon system. These beds cover, in varying densities, at least 7.5 acres of the intertidal. All of the mussel beds examined here have been formed on a gravel/cobble substrate. With maturity, these beds incorporate a sizable quantity of cobble, gravel, sand and silt into the matrix formed by

Table 4. Estimates of size and weight distributions, density and biomass of eelgrass beds in Koyuktolik Lagoon in summer 1976.

	7/9/76						8/30/76			
	Inner Lagoon		Transition Zone		Outer Lagoon		Transition Zone		Outer Lagoon	
Turion Height (cm)	Approx. Frequency	Estimated Wet Tissue Weight (gm)	Approx. Frequency	Wet Tissue	Approx. Frequency	Wet Tissue	Approx. Frequency	Dry Tissue	Approx. Frequency	Dry Tissue 1/
20.0- 29.9	1	1.8	8	8.3	0	0	7	0.7	0	0
30.0- 39.9	10	21.0	0	0	5	6.2	12	1.6	12	1.5
40.0- 49.9	8	20.1	46	77.5	9	15.1	13	1.8	0	0
50.0- 59.9	1	3.0	16	32.2	14	27.4	13	2.0	0	0
60.0- 69.9	4	14.3	39	100.5	9	22.1	13	2.3	6	1.1
70.0- 79.9	4	17.1	16	50.1	14	40.1	39	7.8	12	2.5
80.0- 89.9	5	25.5	46	187.7	49	161.8	33	7.4	6	1.4
90.0- 99.9	4	24.4	68	351.1	49	195.9	20	5.0	25	6.3
100.0-109.9	6	43.7	85	535.3	58	284.5	33	9.5	25	7.1
110.0-119.9	2	17.4	46	364.2	73	430.6	13	4.3	43	14.1
120.0-129.9	2	20.8	24	227.2	132	938.2	7	2.4	43	16.0
130.0-139.9	3	37.2	30	377.8	64	546.9	33	13.7	20	7.8
140.9-149.9	0	0	24	353.5	9	101.9	7	3.1	43	20.5
150.0-159.9	0	0	0	0	0	0	39	21.1	37	19.9
160.0-169.9	0	0	0	0	0	0	20	12.0	56	33.8
170.0-179.9	0	0	8	228.7	0	0	33	22.6	43	29.8
180.0-189.9	0	0	0	0	0	0	46	35.8	62	48.2
190.0-199.9	0	0	0	0	0	0	13	11.6	56	49.1
200.0-209.9	0	0	0	0	0	0	26	26.3	43	43.2
210.0-219.9	0	0	0	0	0	0	20	22.3	37	42.0
220.0-229.9	0	0	0	0	0	0	0	0	12	15.8
230.0-239.9	0	0	0	0	0	0	0	0	25	35.9
240.0-249.9	0	0	0	0	0	0	0	0	6	10.2
Approx. No. per m^2	<50		456		485		440		612	
Estimated Biomass (gm wet wt./m^2) (gm dry wt./m^2)		<246 <25 2/		2894 289 2/		2770 277 2/		2133 2/ 213		4061 2/ 406

1/ Calculated using the regression equation developed from the data for the transition zone eelgrass bed, which may cause an overestimate of biomass.

2/ Based on an average wet weight/dry weight ratio of 10:1.

the shells and byssus masses. Thickness of this mat ranged from about 1 cm near the upper edge of the beds to about 20 cm in some locations near the low tide mark. All beds examined have been located in areas subjected to fast tidal currents. The upper and lower margins are rather sharply defined. Connell (1961) pointed out that many intertidal organisms are limited by physical factors at their upper limits, and by biotic factors on their lower limits. The factors imposing upper limits for mussels in these beds are probably harsh temperatures, desiccation and limited feeding time. In some locations, the lower limits are probably imposed by the predatory activities of the slender starfish Evasterias troschelii, but overall, the rather sharp demarcation at the lower limit is unexplained at present. Other predators include glaucous-winged gulls, northwestern crows, sea ducks, and sea otters. To date, we have seen no evidence of other species competing strongly with mussels for food or space.

As indicated above, the majority of the mussels are concentrated into two beds. Within these beds, mean shell length seems largest near the lower edge of the bed and smaller at the top; densities are greater toward the middle of the bed and lowest near the lower edge; this numerical difference is probably a function of crowding and size.

Mussels and rockweed were the dominant organisms in both the outer and inner mussel beds. Relative cover by mussels in the outer bed averaged 80 percent (Table 5). Rockweed (Fucus distichus) averaged less than 2 percent (Appendix A-17), and was generally common only along the lower edge of the bed near MLLW. Mussel density and size structure varied

Table 5. Summary of relative cover data for the blue mussel (*Mytilus edulis*) in mussel beds in the entrance to the lagoon, Koyuktolik Bay, 7/10/76.

Percent Cover*	Outer Bed	Inner Bed
0	0	15
1	0	1
5	1	4
10	2	4
15	3	1
20	1	3
25	4	4
30	3	1
35	2	1
40	9	7
45	3	6
50	8	11
55	1	9
60	5	18
65	5	11
70	11	14
75	14	17
80	11	13
85	13	8
90	24	10
95	25	9
97	3	0
98	10	0
99	4	0
100	47	10
Number of quadrats	209	177
Mean cover ($\bar{x} \pm s$):	79.6 ± 23.9	58.9 ± 29.2

* In 1/16 m^2 quadrats

considerably with position within the bed. Near the channel (about 150 m from the upper edge of the bed), mussel density approached 13,000/m^2, but 80 m from the upper edge, density was about 9,000/m^2 (Appendix A-18). Size structures at these two levels were statistically similar. Average shell lengths were 25.5 ± 8.8 mm and 23.8 ± 7.4 mm, respectively, for the channel and the 80 m areas (Appendix A-18; Table 6). The size structures were basically unimodal; the modes were located very close to the means (Table 6). Unfortunately, samples for the upper levels of the bed were lost, but field observations indicated that the patterns were still similar to those reported previously. Generally, the density was very high but average shell length was small.

Relative coverage of substrate by mussels averaged about 60 percent (Table 5), and Fucus averaged about 11 percent in the inner bed (Appendix A-19). The mussels were most dense in a 20 m wide band extending along the channel for approximately 200 m. Fucus was most abundant along the entrance channel, but was also abundant around several pools and drainage channels located within the bed. Mussel density and size structure varied considerably with position within the bed. At the southwestern corner of the bed, near the confluence of the entrance channel and a moderate sized feeder channel, densities were high, ranging from 18,000 to 22,000/m^2. Moving north along the main channel, densities declined to about 12,500 at 30 m, and 7,000 at 75 m (Appendix A-20). Average shell length generally increased in the same direction, ranging from 16.7 mm at the southwest tip of the bed to 26.2 mm, 75 m north of that point (Appendix A-20; Table 7). Size generally appeared to decrease with increased distance from the channel (or increased tidal elevation). The size structures were basically unimodal in all samples except from 75 m north of the southwest tip; the modes were all

Table 6 . Size distributions for blue mussels (*Mytilus edulis*) from outer bed on entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	150 m from Upper Edge 10 m from Lower Edge Frequency	%	80 m from Upper Edge Frequency	%
1-4	1	0.9	0	0.0
5-8	4	3.4	1	1.2
9-12	2	1.7	4	4.8
13-16	9	7.6	11	13.1
17-20	20	17.0	12	14.3
21-24	15	12.7	14	16.7
25-28	23	19.5	18	21.4
29-32	20	17.0	16	19.1
33-36	12	10.2	5	6.0
37-40	7	5.9	3	3.6
41-44	4	3.4	0	0.0
45-48	0	0.0	0	0.0
49-52	1	0.9	0	0.0
n	118		84	
$\bar{x} \pm s$*	25.5		23.8	

* Based on unclassed data in Appendix A-18.

Table 7. Size distributions for blue mussels (*Mytilus edulis*) from inner bed on entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	5 m from South End Frequency	%	10 m from South End Frequency	%	30 m from South End Frequency	%	75 m from South End Frequency	%
1-4	0	0.0	0	0.0	0	0.0	0	0.0
5-8	18	11.0	6	3.0	5	4.3	0	0.0
9-12	38	23.2	32	15.8	24	20.5	10	15.2
13-16	46	28.1	58	28.7	31	26.5	7	10.6
17-20	23	14.0	44	21.8	16	13.7	6	9.1
21-24	17	10.4	17	8.4	12	10.3	7	10.6
25-28	6	3.7	10	5.0	6	5.1	11	16.7
29-32	4	2.4	9	4.5	7	6.0	7	10.6
33-36	6	3.7	7	3.5	6	5.1	2	3.0
37-40	3	1.8	9	4.5	5	4.3	7	10.6
41-44	1	0.6	4	2.0	4	3.4	4	6.1
45-48	2	1.2	4	2.0	1	0.9	4	6.1
49-52	0	0.0	1	0.5	0	0.0	1	1.5
n	164		202		117		66	
$\bar{x} \pm s$*	16.7 ± 8.1 mm		19.7 ± 9.6 mm		19.6 ± 9.6 mm		26.2 ± 11.6	

* Based on unclassed data in Appendix .

fairly close to the means. The size distribution of the 75 m sample was somewhat bimodal but, because of the small sample size, the pattern is suspect.

Estimates of mussel biomass were developed for all sampling areas. These were generated utilizing the site specific density and size data and a shell length-wet weight regression equation for mussels from Port Dick in the same time period. Comparison of regression data collected from both Koyuktolik Bay and Port Dick in May indicated a close similarity and was considered as justification for this application (Dames & Moore, 1976).

The biomass of wet tissue in the outer bed was highest along the channel, where the estimate exceeded 9 kg/m^2. Although the size structure at the 80 m level was very similar, the lower density resulted in a biomass of only 5.5 kg/m^2 (Table 8). Biomass was generally higher in the inner bed, ranging from 6.6 to 11.5 kg/m^2 (Table 9). The average biomass for both beds was about 7.7 kg/m^2. The overall biomass of the two mussel beds, adjusting for relative cover in both beds, is therefore estimated in the vicinity of 165,000 kg (about 165 metric tons).

Several feeding observations were made in the Bay, the mussel beds and the lagoon (Appendix A-21). Several species of birds were important predators on pelecypods. Evidence of sea otter predation was also common in the lagoon.

Table 8. Estimates of size and weight distributions, density and biomass of blue mussel (Mytilus edulis) for outer mussel bed, Koyuktolik Bay, 7/10/76.

	80 m from upper edge		150 m from upper edge	
Shell Length (mm)	Approximate Frequency	Estimated Wet Tissue Weight (gm)	Approximate Frequency	Estimated Wet Tissue Weight (gm)
1- 4	0	0	109	12.2
5- 8	109	16.2	434	65.0
9-12	435	86.8	217	43.4
13-16	1196	319.0	979	261.1
17-20	1304	465.2	2175	775.6
21-24	1522	725.4	1631	777.5
25-28	1956	1246.6	2501	1593.4
29-32	1739	1481.0	2175	1851.9
33-36	543	618.6	1305	1485.2
37-40	326	496.1	761	1158.0
41-44	0	0	434	884.4
45-48	0	0	0	0
49-52	0	0	109	395.0
Approx. No. per m^2	9130		12830	
Estimated Biomass: (gm wet weight/m^2)		5455		9303

Table 9. Estimates of size and weight distributions, density and biomass of blue mussels (*Mytilus edulis*) for inner mussel bed, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	5 m from South End		10 m from South End		30 m from South End		75 m from South End	
	Frequency	Wet Tissue Wt.	Frequency	Wet Tissue Wt.	Frequency	Wet Tissue Wt.	Frequency	Wet Tissue Wt.
1 - 4	0	0	0	0	0	0	0	0
5 - 8	2002	292.2	655	156.1	543	81.2	0	0
9 - 12	3789	737.8	3496	694.4	2609	520.8	1079	217.0
13 - 16	5124	1334.2	6336	1682.3	3370	800.1	755	203.0
17 - 20	2463	891.6	4807	1705.8	1739	620.3	647	232.6
21 - 24	1895	880.9	1857	880.9	1304	621.8	755	362.7
25 - 28	669	415.5	1092	692.6	652	415.5	1188	761.8
29 - 32	446	370.3	983	833.1	761	648.0	755	648.0
33 - 36	669	642.4	765	866.1	652	742.3	269	247.5
37 - 40	334	496.1	982	1488.4	543	826.8	755	1157.6
41 - 44	112	221.0	437	884.2	435	884.1	432	884.2
45 - 48	223	590.9	437	1181.8	109	295.4	431	1181.8
49 - 52	0	0	110	394.9	0	0	108	394.9
Approx. No. per m^2	17,826		21,957		12,717		7,174	
Estimated Biomass: (gm Wet Tissue Wt./m^2)		6,972.9		11,460.6		6,555.3		6,711.1

CHUGACH BAY

Five general locations were examined near the southern shoreline of Chugach Bay. The principal substrate in the sublittoral zone was bedrock with scattered boulders and patches of coarse sand. Depths surveyed ranged from 7.5-21 m. The general locations indicated in Figure 3 are 1) inside Raft Cove (9.1-10.7 m), 2) north of Raft Cove (7.5-16 m), 3) near the northeast point of Raft Cove (8-11.5 m), 4) south of the southeast point of Chugach Bay (12-12.5 m) and 5) east of that point (21 m).

In all locations, the bottom was visually dominated by kelp species. However, the species composition, density and relative cover, varied markedly with location and depth. Inside Raft Cove, bull kelp (Nereocystis luetkeana) and elephant ear kelp (Laminaria groenlandica) were dominants (Table 10). Ribbon kelp (Alaria sp.) and Cymathere triplicata were common and only observed at this site. Juvenile kelps were abundant (Appendix B-1). North of Raft Cove, on a rock shelf and slope, Pleurophycus gardneri and elephant ear dominated (Table 11). Sieve kelp (Agarum cribrosum) became important at the deeper locations (Appendix B-2). Off the northeast point of Raft Cove, and south and east of the southeast point of Chugach Bay, elephant ear and sieve kelp dominated (Table 12, Appendices B-3 through B-10).

Algal density and relative cover were generally higher at the shallower stations (Table 13, Appendix B-10), but this pattern was not clear-cut throughout the area. In general, Laminaria, Nereocystis, Pleurophycus and Alaria were most abundant between the intertidal zone and 10 m depths. Agarum is most abundant between 10 m and 25 m. However, this varied greatly with microhabitat differences, turbulence and water clarity being particularly important factors.

Table 10 . Average density of principal macrophyte species in Raft Cove, Chugach Bay, 7/6/76.

	No. of plants per m^2	
Depth (m)	9.1	10.7
SPECIES		
Agarum cribrosum	0	0
Alaria sp.	0	5.6
Cymathere triplicata	6.7	4.8
Laminaria ? groenlandica	5.3	32.8
Nereocystis luetkeana	14.7	9.6

Table 11 . Average density and relative cover of principal macrophytes on the shelf and slope north of Raft Cove, 7/6 and 7/8/76.

	No. of plants per m^2 or relative cover (%)						
Depth (m)	7.5-9	9	10.5-11.5	12	12-13.5	15-16.5	16
SPECIES							
Agarum cribrosum	0	0	3.4	4.0	6.7	3.2	14.6
Constantinea sp.	-*	0.3%	-	2.3%	-	0	-
Encrusting coralline alga	-	58.3%	-	78.3%	-	16%	-
Laminaria ? groenlandica	21.2	5.2	3.4	5.3	0	1.6	16.9
L. yezoensis	0	0	0.6	0	0	0	0
Opuntiella californica	-	0.7%	-	9.7%	-	0	-
Pleurophycus gardneri	20.0	10.8	5.7	6.7	4.0	4.0	0.8
	38.3%	48.3%	17.1%	45%	26.7%	11%	-
Rhodymenia pertusae	-	0	-	6.7%	-	2%	-

* A dash (-) indicates that sampling method excluded that species in the respective sample.

Table 12 . Average density and relative cover of principal macrophytes of the northeast point of Raft Cove, Chugach Bay, 7/5/76.

	No. of plants per m^2 or relative cover (%)			
Depth (m)	8-8.5	9-9.5	10.5	10.5-11.5
SPECIES				
Agarum cribrosum	5.2 12.3%	7.0 38.8%	2.0 15%	0.3 16.5%
Constantinea sp.	-*	-	-	5.6%
Encrusting coralline alga	-	-	-	21.5%
Hildenbrandia sp.	-	-	-	7%
Laminaria ? *groenlandica*	30.7	3.0	0	5.6
L. saccharina	0	0	40%	5.5%
L. yezoensis	0 0	0 0	0 0	0.8 2%
Pleurophycus gardneri	1.3 3.3%	0 0	0 0	0 0
Rhodymenia pertusae	-	-	-	3.4%

* A dash (-) indicates that sampling method excluded that species in the respective sample.

Table 13 . Relationship between depth, relative cover and density of major kelps in the vicinity of Raft Cove, Chugach Bay, July 1976.

Depth (mm)	Percent Cover	Moving Average for % Cover	No. of Plants per m^2	Moving Average for No./m^2	Location
7.5-9	8.3	--	41.2	--	North of Raft Cove
8-8.5	85.6	--	37.0	--	Northeast point of Raft Cove
9	101.6	79.9	16.0	26.2	North of Raft Cove
9-9.5	73.8	71.0	10.0	18.3	Northeat point of Raft Cove
9.1	--		26.7	12.3	In Raft Cove
10.5	55.0	68.9	2.0	11.7	Northeast point of Raft Cove
10.5-11.5	39	68.9	6.7	20.4	Northeast point of Raft Cove
10.5-11.5	75.0	64.3	13.1	18.1	North of Raft Cove
10.7	--		52.8	19.4	Raft Cove
12	101.7	66.2	16.0	20.2	North of Raft Cove
12-12.5	50.7	66.4	8.6	19.4	South of Point
12-13.5	66.7	54.4	10.7	15.3	North of Raft Cove
15-16.5	38	--	8.8	12.9	North of Raft Cove
16	--	--	32.3	--	North of Raft Cove
21	15	--	4.0	--	East of Point
Averages		65.5%		19.1 Plants/m^2	

The epifauna in the study site is quite rich; it was mainly dominated by a broad variety of suspension feeders. The general paucity of large clams and other large fleshy forms possibly reflects the predatory influence of the sea otters that inhabit Raft Cove. However, despite the presence of otters, sea urchins were common under rocks; even in Raft Cove, sea urchin density averaged 2 individuals/m^2 (Appendix B-1).

A broad variety of epifaunal forms was observed on the shelf and slope north of Raft Cove (Appendices B-3 through B-5). The macroherbivores included the sea urchins Strongylocentrotus drobachiensis and S. franciscanus. The former ranged in diameter from 7 to 40 mm and averaged 22.3 ± 7.2 mm (Table 14), and the latter ranged from 7 to 33 mm and averaged 19.9 ± 8.7 mm (Appendix B-11). These averages indicate small animals, particularly for S. franciscanus, suggesting rather young populations. The microherbivores included the snails Calliostoma ligatum and Margarites pupillus and the chitons Tonicella spp. (Table 15); combined densities approaches 13.5 individuals/m^2. Major epifaunal suspension feeders included the tunicate ? Distaplia sp., the bryozoan Microporina borealis and hydroids of the family Sertulariidae; combined cover was over 20 percent. Hermit crabs (Paguridae) considered as scavengers and predators, were common. Three predatory species of starfish were common, namely, an unidentified species of Leptasterias (possibly L. leptalea), Crossaster papposus and Tosiaster arcticus. Average radii for these species were 17.0 ± 6.0 mm, 39.3 ± 17.7 mm and 23.3 ± 4.3 mm, respectively. The genus Henricia was also common in the area, but individuals were not identified to species. As a consequence, feeding type cannot be identified. The average size of the specimens observed was 29.6 ± 18.3 mm. Size data for several other asteroids in the area are presented in Appendix B-11.

Table 14 . Size distribution for the green sea urchin (*Strongylocentrotus drobachiensis*) from Raft Cove, Chugach Bay, 7/7/76.

Test Diameter (mm)	Frequency
6-10	4
11-15	6
16-20	17
21-25	17
26-30	13
31-35	3
36-40	1

$n = 61$
$\bar{x} \pm s = 22.3 \pm 7.2$ mm
Range = 7-40 mm

* Based on unclassed data in Appendix B-11.

Table 15. Abundance and relative cover of several common invertebrates north of Raft Cove, Chugach Bay, summer 1976.

	No. per m^2 or percent cover		
Date	7/6	7/8	7/6
Depth (m)	7.4-13.5	9.1	12-16.5
SPECIES			
Calliostoma ligatum	-	0	5.5
Crossaster papposus	0.4	0	0
? *Distaplia* sp.	-	0	6.3%
Henricia spp.	1.2	0	0.5
Leptasterias ? *leptalea*	0	2.7	0
Margarites pupillus	-	2.7	2.0
Microporina borealis	-	6.7%	11.9%
Paguridae, unid.	-	14.7	2.5
Sertulariidae, unid.	-	8.7%	3.0%
Strongylocentrotus drobachiensis	2.0	0	2.5
S. franciscanus	0.8	0	0.5
Tonicella spp.	-	2.7	6.0
Tosiaster arcticus	0.8	0	0.5

Appendix B-11. Most numerous among these was Orthasterias koehleri, an active predator in the entire area.

Additional density data for echinoderm from depths between 12.2 and 18.3 m on the shelf and slope north of Raft Cove are presented in Appendix B-12. The green sea urchin S. drobachiensis was most common; its average density was 5.6 individuals/m^2. Most of the individuals were relatively small and lived under boulders. The brittle star Ophiopholis aculeata, also found under rocks, averaged 3.7/m^2, but this is probably a considerable underestimate.

Vertical faces usually support a broad variety of organisms, particularly suspension feeders. A detailed examination of a 2.5 m high pinnacle exemplifies this; over 50 percent of the species were suspension feeders (Appendix B-13). Dominant forms were the bryozoan Microporina borealis, and several species of hydroids and tunicates.

The epifaunal mat was not well developed under the algal canopy off the northeast point of Raft Cove (Appendix B-7). Only three species were common, namely the colonial tunicate ? Distaplia sp., hermit crabs (Paguridae) and chitons (Tonicella sp.). The olive snail (Olivella baetica) was common on sand (Appendix B-7).

The rock finger extending east of the southern headland of Chugach Bay supported an extremely rich, lush epibiota. An average of 19 species was observed per quadrat. A total of 71 taxa was observed in a single dive (about 1/2 hour). However, because of the small number of quadrats, the cover and density estimates are poor. The dominant species were the hydroids Abietinaria spp., Obelia ? loveni and Tubularia sp., an unidentified starfish (possibly Leptasterias leptalea), the bryozoan Microporina borealis, an orange encrusting tunicate, two species of hermit crabs, and the snail Trichotropis cancellata. Seventeen species of hydroids were particularly abundant, with a combined coverage of over 25%. Suspension feeders, with 56% of the species, dominated the epifauna.

A broad variety of feeding observations was recorded during this sampling period. The more active predators included the sea otter, and the starfish Dermasterias imbricata and Crossaster papposus (Table 16). The most remarkable observation was of the predatory chiton Placiphorella sp. feeding on a juvenile fish, which it had apparently captured. Three species appeared to be responding to reproductive maturity of their prey. Hermit crabs were eating the tops out of colonial tunicates to obtain the large eggs inside. The starfish Orthasterias koehleri was feeding on a small tunicate packed with numerous large eggs. The leather star Dermasterias imbricata was feeding on reproductively mature sertulariid hydroids, and possibly the bryozoans Microporina and Dendrobeania, upon which it was feeding, was mature also. The interesting aspect of this is the fact that these prey species, particularly hydroids, are not considered frequent prey species. However, the suspected pattern emerging from similar feeding observations is that some predators are able to sense reproductive maturity of potential prey species and that by preying on these species during such periods, they can capitalize on the concentrated nutrients available to them.

Table 16 . Observations of predation of Chugach Bay on 7/5 and 7/8/76.

Predator	Prey	Depth (mm)	No. of Feeding	Type of Evidence
Placiphorella sp.	Juvenile fish	9.1	1	Direct
Fusitriton oregonensis	Juvenile fish	--	1	Direct
Pagurus sp.	Orange, social, colonial tunicate ? (tops eaten out of groups)	--	1	Direct
Enhydra lutris	Molluscus	12.0	Numerous	Indirect
Orthasterias koehleri	Can-of-corn tunicate	15.8	1	Direct
Leptasterias ? leptalea	Musculus vernicosus	18.3	1	Direct
Dermasterias imbricata	Microporina borealis	15.8	1	Direct; gut out
Dermasterias imbricata	Dendrobeania ? murrayana	15.2	1	Direct; gut out
Dermasterias imbricata	Sertulariid hydroids	16.8	Numerous	Direct; gut out
Crossaster papposus	Calliostoma ligatum	16.8	1	Direct; gut out
Crossaster papposus	Placiphorella sp.	--	1	Direct

PORT DICK

General Description of Areas Examined

The areas examined at the head of the West Arm of Port Dick included the outer edge of the shelf, a small rock islet near the slope on the southern side of the shelf, and the slope at the outer edge of the shelf. The shelf is a depositional mudflat at the mouth of Port Dick Creek. Quantitative data were collected in the rockweed and mussel assemblages, the eelgrass bed and on the slope (Figure 4).

Intertidal Zone

The rocky intertidal zone on Dick's Head was dominated by rockweed, sea lettuce and blue mussels (Table 17). Rockweed dominated in the high, middle and low intertidal zones on the north side. The high zone was characterized by barnacles and mussels, the middle zone by sea lettuce and a rope-like green alga (Spongomorpha sp.), and the low zone by sea lettuce and a ribbon-like brown alga (Alaria sp.; Table 17). With the exception of the species mentioned, most of the organisms observed in the intertidal zone were relatively uncommon (Appendix C-1). The biota was fairly diverse (Appendix C-2).

Plant biomass in the intertidal zone was quite high, averaging about 5.5 kg/m^2; rockweed (Fucus) composed over 90% of the wet weight (Appendix C-3). The estimated biomass of rockweed in the 12 m location is extraordinary and probably is a consequence of sampling variability. Even adjusting for relative cover at that level (68%) reduces the biomass to 12.6 kg/m^2. However, it is apparent from these data that the intertidal zone on Dick's Head supports a high algal standing crop.

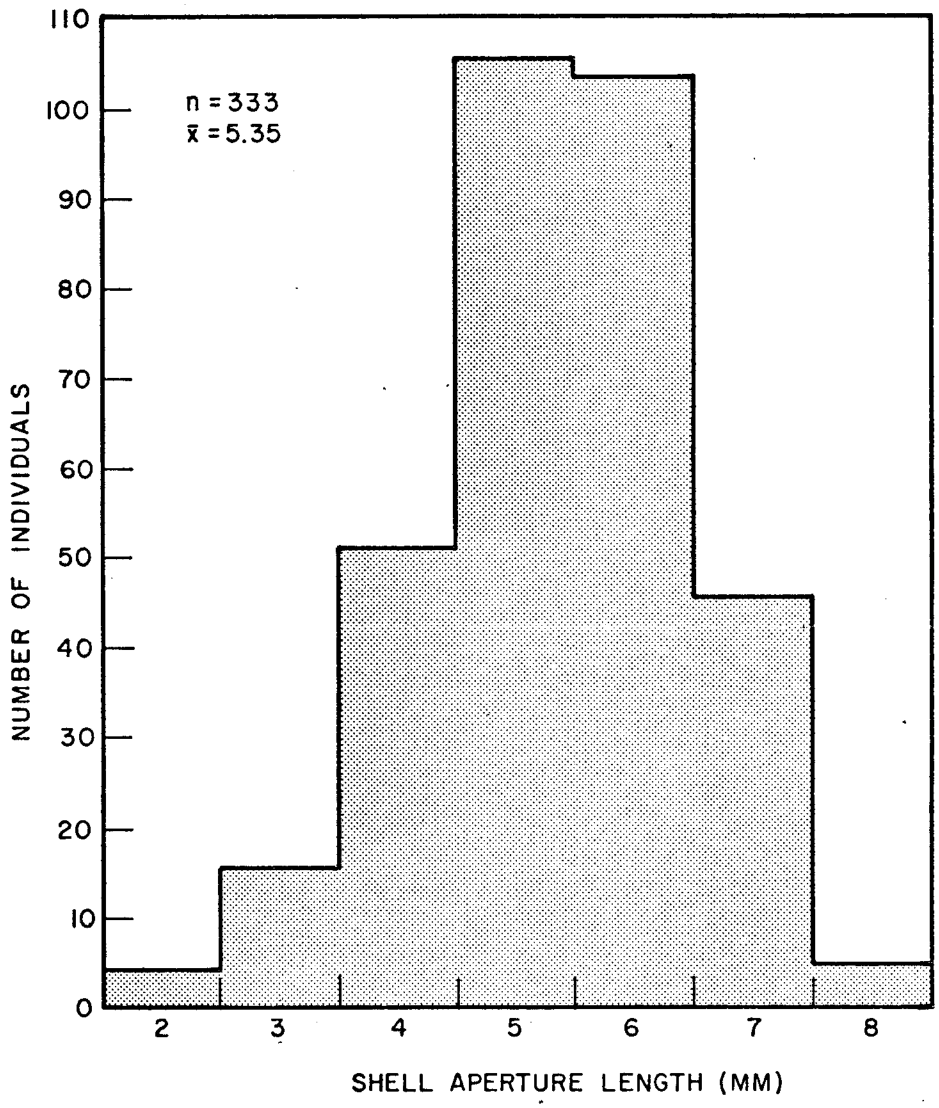
Table 17 . Relative cover by major organisms in intertidal zones on Dick's Head, at the head of West Arm, Port Dick, 6/30/76.

Species	PERCENT COVER Lower Intertidal	Middle Intertidal	Upper Intertidal	Mean Cover $\bar{x} \pm s$
Alaria sp.	8.2	1.3	0	3.8 ± 12.8
Balanus ? glandula	0	3.8	10.4	4.6 ± 9.7
Callophyllis sp.	0	0.2	0	0.1 ± 0.4
Costaria costata	0.5	0	0	0.2 ± 1.2
Cryptosiphonia woodii	0.3	0.5	0	0.3 ± 1.4
Enteromorpha sp.	0.4	0.2	1.7	0.8 ± 3.3
Fucus distichus	66.4	38.8	68.2	57.8 ± 32.1
Gigartina papillata	0	2.4	0	1.0 ± 3.2
Gloiopeltis furcata	0	1.2	0.1	0.4 ± 2.5
Halosaccion glandiforme	1.5	4.7	0	2.0 ± 5.6
Littorina sitkana	0	0.1	1.7	0.6 ± 1.3
Mytilus edulis	0	6.6	18.5	8.5 ± 23.8
Rhodophyta, unid. (Filamentous)	7.6	3.2	1.9	4.2 ± 10.1
Rhodymenia palmata	0.1	0.5	0.1	3.7 ± 4.8
Scytosiphon lomentaria	0	0.2	0	0.1 ± 0.3
Spongomorpha sp.	5.2	10.4	0.2	5.3 ± 10.5
? Ulva sp.	24.9	11.4	2.3	12.8 ± 16.9

Several herbivores were common in this area. The periwinkle Littorina sitkana, a microherbivore, was abundant in the high intertidal (Table 17). Aperture length, used as a measure of size, averaged 5.4 ± 1.2 mm (Figure 8). The size structure was strongly unimodal. Limpets (family Acmaeidae) were another microherbivore common in the intertidal zone. Highest densities were observed in the mid-intertidal zone (Appendix C-4).

On the south side of Dick's Head, the blue mussel strongly dominated the intertidal zone. Relative cover exceeded 70% (Table 18) and overall density was over 4,600 mussels/m^2. Density was generally higher at the lower levels (Table 19). However, at the highest level sampled, the elevated density appears to be due to a strong 0-year class there. Average shell length was generally larger at the lower levels, except for the population at the lowest level (Table 19; Appendix C-5). The modes of the size distributions follow the same general pattern. All except the upper population had basically unimodal distribution; while the upper population was clearly bimodal. Young mussels (0-year class) were uncommon in the mid-intertidal populations, but dominated in the highest population and common in the lowest population. The abundance of young mussels in the lower population is not completely responsible for its smaller average size; however, the mode for that population is also considerably smaller than for the population at the next higher level (Table 19).

A series of mussels were weighed and measured to determine the relationship between shell length, whole wet weight, wet tissue weight and dry tissue weight. On the average, wet weight was about 44% of whole wet weight and dry weight is about 19% of wet tissue weight (Appendix C-6). The



SIZE FREQUENCY HISTOGRAM FOR THE PERIWINKLE LITTORINA SITKANA FROM DICK'S HEAD, WEST ARM, PORT DICK, 6/30/76.

FIGURE 8

Table 18. Relative cover data for the blue mussel (*Mytilus edulis*) in 1/4 m^2 quadrats on Dick's Head, at the head of West Arm, Port Dick, 7/1/76.

Percent Cover	Number of Quadrats
30	2
35	2
40	2
45	0
50	2
55	0
60	2
65	4
70	6
75	9
80	7
85	6
90	7
95	1
Total	50

Mean Percent Cover: $\bar{x} \pm s = 71.6 \pm 17.0\%$

Table 19 . Summary of size distribution data for the blue mussel (*Mytilus edulis*) from the intertidal zone, on Dick's Head at the head of West Arm, Port Dick, July 1976.

Shell Length (mm)	0 m Zone Frequency	%	3 m Zone Frequency	%	9 m Zone Frequency	%	12 m Zone Frequency	%
1-4	6	1.2	1	0.4	0	0.0	0	0.0
5-8	101	19.7	0	0.0	1	0.2	28	2.6
9-12	111	21.6	2	0.8	7	1.5	56	5.2
13-16	63	12.3	7	2.7	9	2.0	97	8.9
17-20	75	14.6	13	5.0	20	4.3	107	9.9
21-24	81	15.8	23	8.8	19	4.1	109	10.0
25-28	43	8.4	49	22.3	29	6.3	168	15.5
29-32	15	2.9	65	25.0	23	5.0	140	12.9
33-36	10	1.9	39	15.0	58	12.6	148	13.6
37-40	7	1.4	33	12.7	93	20.1	128	11.8
41-44	1	0.2	10	4.0	101	21.9	58	5.3
45-48	0	0.0	7	2.7	74	16.0	40	3.7
49-52	0	0.0	2	0.8	24	5.2	6	0.6
53-56	0	0.0	0	0.0	4	0.9	1	0.1
n	513		260		462		1,086	
$\bar{x}$ (cm)*	16.0		30.4		37.3		27.7	
s (cm)*	8.0		7.4		9.4		10.1	
No./m^2	4,104		2,080		3,696		8,688	

* Based on unclassed data in Appendix C-5.

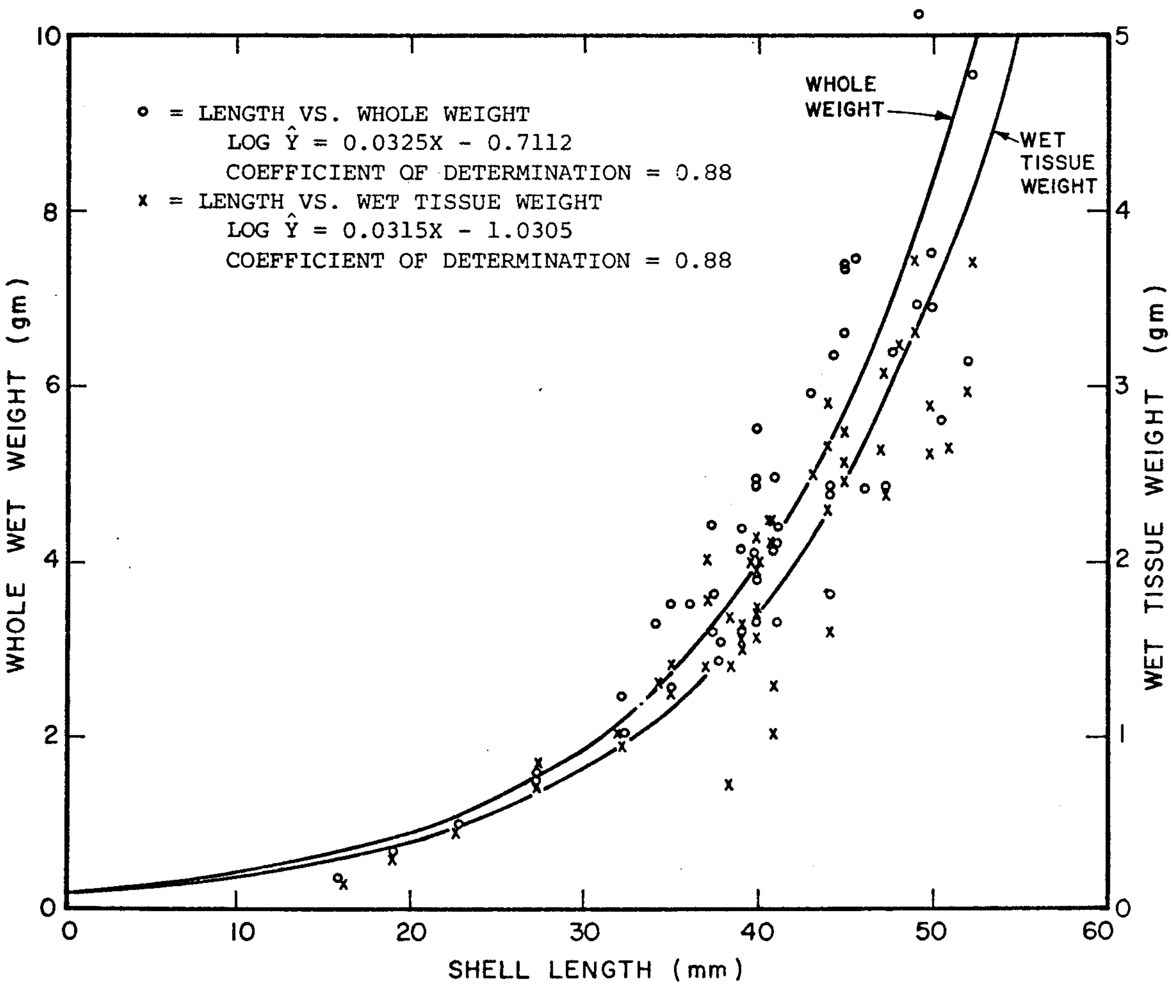
relationship between shell length, whole wet weight and wet tissue weight are shown in Figure 9, along with the respective regression equations.

The data for density, size distributions and the length-weight regressions were used to develop biomass estimates for the mussel populations at the various tidal levels. Wet tissue weight increased dramatically from the higher to the lower levels (Table 20). The overall average was about 4.4 kg/m^2.

Subtidal Areas

The subtidal area in the vicinity of Dick's Head was no more diverse than the intertidal zone (Appendix C-7). The rocky portions were dominated by Laminaria spp. and Alaria sp. and the soft substrate by eelgrass (Zostera marina). Few macroinvertebrates were observed on the rock substrate (Appendix C-7). These were limited mainly to the green sea urchin (Strongylocentrotus drobachiensis) and the slender star (Evasterias troschelii) (Appendix C-8). Macrophytes covered about 75% of the soft substrate in the vicinity of Dick's Head; ? Ulva was the dominant plant, but eelgrass, distributed in small patches, was somewhat important (Appendix C-9). Mussels covered nearly 25% of the soft substrate.

The slender star (Evasterias troschelii) was an important predator around Dick's Head, feeding mainly on Mytilus edulis and Littorina sitkana (Table 21). Its density averaged about $1.1/m^2$. Radius averaged 41.2 ± 27.0 mm; the size structure was basically unimodal with the mode located substantially below the mean (Table 22). Sizes ranged from 15-130 mm (Appendix C-10). These data indicate that the population is dominated by relatively young individuals, and that recruitment has been successful recently. Sea otters also seemed to be feeding in the area (Table 21).



RELATIONSHIP BETWEEN SHELL LENGTH, WHOLE WET WEIGHT AND WET TISSUE WEIGHT FOR BLUE MUSSELS (MYTILUS EDULIS) FROM DICK'S HEAD, PORT DICK, 7/1/76.

FIGURE 9

Table 20. Estimates of size and weight distribution, density and biomass for blue mussels (*Mytilus edulis*) from the intertidal zone of Dick's Head at the head of West Arm, Port Dick, July 1976.

	0 m Zone		3 m Zone		9 m Zone		12 m Zone	
Shell Length (mm)	Frequency	Wet Tissue Wt.	Frequency	Wet Tissue Wt.	Frequency	Wet Tissue Wt.	Frequency	Wet Tissue Wt.
1- 4	48	5.4	8	1.1	0	0	0	0
5- 8	808	120.7	0	0	8	1.2	224	33.4
9-12	888	177.3	16	3.2	56	11.2	448	89.4
13-16	504	134.5	56	14.9	72	19.2	776	207.1
17-20	600	214.0	104	37.1	160	57.1	856	305.3
21-24	648	308.9	184	87.7	152	72.5	872	415.7
25-28	344	219.2	464	295.6	232	147.8	1344	856.3
29-32	120	102.2	520	442.8	184	156.7	1120	953.8
33-36	80	91.1	312	355.1	464	528.2	1184	1347.7
37-40	56	85.2	264	401.7	744	1131.9	1024	1557.9
41-44	8	16.3	80	162.7	808	1643.1	456	927.3
45-48	0	0	56	152.2	592	1609.1	320	869.8
49-52	0	0	16	58.1	192	697.5	56	203.4
53-56	0	0	0	0	32	155.4	8	38.8
Density	4104		2080		3696		8688	
Estimated Biomass: (gm wet weight/m^2)		1475		2012		6231		7809

Table 21. Observations for predation at Port Dick 7/1-7/3/76.

Predator	Prey	No. of Feedings	Type of Evidence
Evasterias troschelii	*Mytilus edulis*	7	Direct
Hexagrammos stelleri-juv.	Juv. *Mytilus* on eelgrass	-	Direct
Hermissenda crassicornis	Hydroid	1	Direct
Telmessus cheiragonus	*Zostera marina*	1	Direct
Enhydra lutris	Clams	Numerous	Indirect
Phalacrocorax auritus	Fish	4	Direct

Table 22. Size distribution for the slender star (Evasterias troschelii) near outer edge of shelf at head of West Arm, Port Dick, 7/1/76.

Radius (mm)[1/]	Frequency
10-19	12
20-29	38
30-39	19
40-49	14
50-59	9
60-69	3
70-79	3
80-89	2
90-99	6
100-109	0
110-119	4
120-129	1
130-139	1

n = 112
Mean radius[2/] = 41.2 ± 27.0 mm
Range = 15-130 mm

[1/]Measured from center of mouth to tip of longest arm.
[2/]Based on unclassed data in Appendix C-10.

Closer to the center of the shelf, the flora was more diverse and covered about 65% of the bottom (Table 23). Dominant species were Laminaria saccharina, Zostera marina and Desmarestia viridis. Laminaria and Desmarestia were more abundant in the shallower areas examined. All species were distributed in a patchy manner (Appendix C-11). Algal debris, composed largely of sea lettuce, was common throughout most of the area. Epibenthic invertebrates were uncommon.

Eelgrass formed a more uniform bed toward the middle of the shelf. Estimated densities at the inner and outer edges of the bed were 109 and 108 turions/m^2, respectively (Appendix C-12). Turion height ranged from 35.5 - 274.0 cm, at the inner edge, and averaged 164.1 ± 58.3 cm (Appendix C-13). The shape of the size distribution is not clear, but may be bimodal (Table 24). The major mode is somewhat higher than the mean. At the outer edge of the bed, turion height ranged from 13.5 - 267.0 cm and averaged 126.4 ± 63.9 cm (Appendix C-14). The shape of the distribution is basically unimodal with the mode fairly close to the mean (Table 24). Except for the conspicuous mode, the distribution is rather flat; a broad range of sizes are well represented.

The relationship between turion height and dry weight (Appendix C-15), shown for August in Figure 7, indicates that the plants are in good condition. As discussed previously, the condition of the plants from Port Dick was superior to that of those from Koyuktolik Lagoon. Flowering plants were common in the bed.

Table 23. Relative cover and abundance of major epibiotic organisms on the outer edge of the shelf at the head of West Arm, Port Dick, 6/30/76.

SPECIES	6 m	8-9 m	12.5-13.0 m	Overall $\bar{x} \pm s$
Algal debris (C)	10%	0	23%	13.5 ± 24.3%
Costaria costata (C)	10%	0.8%	0	2.3 ± 8.0%
Desmarestia viridis (C)	5%	36.2%	1.5%	12.6 ± 23.7%
Laminaria saccharina (N)	0	0.3	0	0.1 ± 0.3
Laminaria saccharina (N)	31.2%	41.7%	10%	23.8 ± 25.1%
Pycnopodia helianthoides (N)	0	0	0.1	0.05; 0.2/m^2
Rhodophyta, unid. (Filamentous) (C)	0	0	1%	0.5%
Telmessus cheiragonus (N)	0	0	0.2	0.1; 0.4/m^2
? *Ulva* sp. (C)	0	0	5%	2.5 ± 7.2%
Zostera marina (C)	0	5%	47%	13.8 ± 12.1%
Total percent cover by attached macrophytes	56.2%	83.7%	64.5%	

Table 24. Turion height-frequency data for eelgrass (*Zostera marina*) from West Arm, Port Dick, 8/31/76.

Turion Height (cm)[1]	Inner Edge of Bed	Outer Edge of Bed	Total	Percent
10.0 - 19.9	0	3	3	1.5
20.0 - 29.9	0	6	6	3.0
30.0 - 39.9	0	5	5	2.5
40.0 - 49.9	2	3	5	2.5
50.0 - 59.9	2	5	7	3.5
60.0 - 69.9	0	6	6	3.0
70.0 - 79.9	2	5	7	3.5
80.0 - 89.9	4	5	9	4.5
90.0 - 99.9	4	8	12	6.0
100.0 - 109.9	2	3	5	2.5
110.0 - 119.9	1	5	6	3.0
120.0 - 129.9	3	4	7	3.5
130.0 - 139.9	1	13	14	7.0
140.0 - 149.9	7	7	14	7.0
150.0 - 159.9	4	5	9	4.5
160.0 - 169.9	3	4	7	3.5
170.0 - 179.9	1	10	11	5.4
180.0 - 189.9	7	1	8	4.0
190.0 - 199.9	8	7	15	7.4
200.0 - 209.9	8	3	11	5.4
210.0 - 219.9	8	4	12	6.0
220.0 - 229.9	5	2	7	3.5
230.0 - 239.9	5	3	8	4.0
240.0 - 249.9	0	0	0	0.0
250.0 - 259.9	1	2	3	1.5
260.0 - 269.9	0	2	2	1.0
270.0 - 279.9	1	0	1	0.5
n	81	121	202	
$\bar{x}$ (cm)[2]	164.1	126.4	141.5	
s (cm)[2]	48.3	63.9	61.6	

[1] Length of longest leaf from upper node.
[2] Based on unclassed data in Appendices C-13 and C-14.

Estimates of standing stocks were computed using the information for density, the distribution of turion heights and the length-weight regression from late August. Biomass was higher near the inner edge of the bed, mainly as a consequence of the larger average turion size. The overall average was about 120 gms dry weight/m^2 (Table 25). Based on an estimate that eelgrass covers about 300,000 m^2 on this shelf, the dry weight of this plant may approach 35 metric tons.

The slope between the shallow shelf at the head of West Arm, and the deeper basin was dominated by the brown alga Laminaria saccharina. Highest density was observed along the lip (Appendix C-16). Overall density exceeded 2.0 plants/m^2.

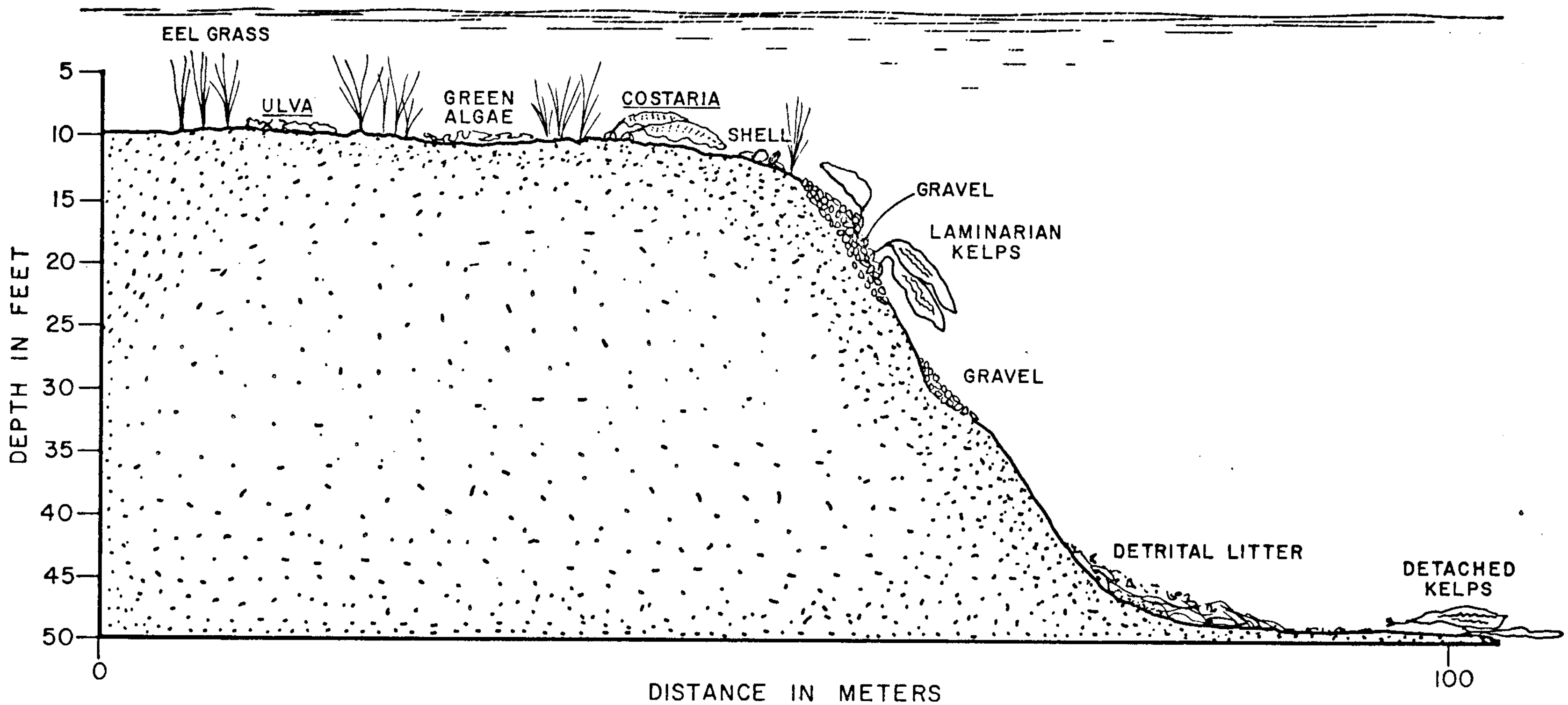
The sunstar (Pyncopodia helianthoides) was a dominant predator on the slope, its overall density was 0.14/m^2. The population was composed of moderate sized individuals with an average radius of 141.7 ± 85.8 mm (Appendix C-17). Other less common species observed on the slope are listed in Appendix C-18.

A considerable quantity of plant material is produced in the rocky intertidal zone and on the shallow subtidal shelf, but attached plants are not common more than a short distance down the outer slope (Figure 10). A great deal of the plant material produced in shallow water is torn loose and transported into the basin by tidal activity and storm induced turbulence. The resulting large accumulations of detrital material in the basin are probably very important to the food budget of organisms that generally remain in the deeper portions of the fjord.

Table 25. Estimate of size and weight distribution, density and biomass for eelgrass (*Zostera marina*) from West Arm, Port Dick, 8/31/76.

Turion Size Class (cm)	Inner Edge of Bed		Outer Edge of Bed	
	Frequency	Dry Weight	Frequency	Dry Weight
10.0- 19.9	0	0	3	0.20
20.0- 29.9	0	0	4	0.47
30.0- 39.9	0	0	4	0.46
40.0- 49.9	3	0.33	3	0.33
50.0- 59.9	3	0.39	4	0.65
60.0- 69.9	0	0	5	0.93
70.0- 79.9	3	0.55	4	0.92
80.0- 89.9	6	1.31	4	1.09
90.0- 99.9	6	1.55	7	2.06
100.0-109.9	3	0.92	3	0.92
110.0-119.9	1	0.55	4	1.81
120.0-129.9	4	1.94	4	1.72
130.0-139.9	1	0.77	11	6.62
140.0-149.9	10	6.37	6	4.23
150.0-159.9	6	4.32	4	3.58
160.0-169.9	4	3.84	4	3.40
170.0-179.9	1	1.52	9	10.07
180.0-189.9	10	12.60	1	1.19
190.0-199.9	10	17.07	6	9.91
200.0-209.9	11	20.24	3	5.03
210.0-219.9	11	24.00	4	7.96
220.0-229.9	7	17.79	2	4.72
230.0-239.9	7	21.09	3	8.39
240.0-249.9	0	0	0	0
250.0-259.9	1	5.93	2	7.87
260.0-269.9	0	0	2	9.33
270.0-279.9	1	8.34	0	0
No./m^2	109		108	
Estimated biomass:				
(gm dry weight/m^2)		151.42		93.63
(gm wet weight/m^2)		1514*		936*

* Estimate wet weight based on an estimated wet weight/dry weight ratio of 10:1.



PROFILE OF VEGETATIVE PATTERNS AT THE OUTER EDGE OF WEST ARM, PORT DICK, JUNE 1976.

FIGURE 10

DISCUSSION

The importance of nearshore assemblages to marine systems and, specifically, to ocean fisheries, is due in large part to their plant production. This appears to be particularly true of nearshore areas on the southern Kenai Peninsula. Macrophyte production of the kelp and eelgrass beds contributes large quantities of plant material to the benthic assemblages of both the north Gulf of Alaska and lower Cook Inlet. The timing of the major contribution of plant material to nearshore waters is important. The main plant assemblages shed a large proportion of their biomass during autumnal storms, at a time when phytoplankton stocks are declining rapidly. Drifting plant materials from macrophyte assemblages are distributed widely within Cook Inlet. Dense mats of macerated algal debris are frequently observed in the middle Inlet, at least 60 miles from appreciable algal stocks (personal communication, Rick Wright, State of Alaska). Large quantities of bull kelp have been observed stranded at Amakdedori Beach, in Kamishak Bay, at least 40 miles from the nearest bed (personal communication, Tina Cunnings, ADF&G). In fact, it appears from the paucity of large herbivorous species that most of the plant material produced in the nearshore assemblages is exported and utilized elsewhere.

Macerated kelp is apparently a relatively stable food material. Zobell (1959) showed that, "for finely chopped seaweeds, about half of the organic content is oxidized within 5 days at 20°C ...; [they are] almost completely mineralized within a month." Furthermore, "decomposition takes place only about half as fast at 10°C." Assuming an average temperature of about 5°C in deeper waters in this area, one can extrapolate that the organic content of finely chopped seaweeds would be half oxidized in about 20 days. Zobell (1959) also stated that decomposition rates are much slower for living plants or larger pieces, so algal debris from fall shedding may remain available for several months during the winter.

Nearshore areas are also important as forage and nursery areas for numerous important sport and commercial species. Rocky areas are important for juvenile king crab, some shrimp species, herring and probably salmon. The areas of soft substrate are important to the fry of several species of salmon, dungeness crabs, and as feeding areas to several species of ducks and geese. Such areas also support important clam resources.

GENERAL COMPOSITION OF MAJOR BIOTIC ASSEMBLAGES

One of the major objectives of this study was to begin to describe major features in the ecology of nearshore assemblages of the outer Kenai Peninsula. Three general areas, each representing an important nearshore assemblage, were selected as study sites. Exposed rocky shoreline is the dominant substrate of the coastline along the southern Kenai Peninsula. This type of habitat, typified by offshore beds of bull (Nereocystis) and ribbon kelp (Alaria), was examined at Chugach Bay and E. Chugach Island. Protected rocky areas and soft substrates are also important substrate types, especially in the numerous bays and fiords penetrating into the Peninsula. Such habitats, characterized by beds of mussels and eelgrass, were examined at Koyuktolik Bay and in the West Arm of Port Dick. Data from surveys in summer 1975 and spring 1976 are presented in earlier reports (Dames & Moore 1975 and 1976).

Hard Substrates

The rock habitats supported more diverse benthic assemblages than the soft substrates, regardless of whether they were protected from or exposed to waves and strong currents. The stability of the substrate allows organisms to attach firmly. On rock habitats, exposure generally acted to increase diversity; this is a response to several factors. Exposed rocky habitats are generally free of resuspendable inorganic deposits which act to discourage development of lush epibenthic assemblages. The turbulent nature of exposed areas has additional beneficial effects. By causing the resuspension of organic particles, it increases food availability to suspension feeders and also, by macerating organic debris, it accelerates the decomposition process upon which suspension feeders depend. Finally, by agitating the upper algal canopies, turbulence increases light penetration through them, thus promoting better development of vegetative undergrowth.

At Chugach Bay, the degree of exposure of the sites examined varies moderately. The most exposed sites were west of "Sea Otter" Point (Figure 3). The structural complexity and species diversity of the epibenthic assemblage off this site was great, particularly with regard to the suspension feeders. At locations farther inside the Bay, complexity was somewhat reduced. Also, algal species characteristic of less turbulent, darker habitats were found in shallower water.

The species composition of the nearshore assemblage at Chugach Bay was typically diverse; approximately 200 species were identified (Appendix D-1). Hydroids, bryozoans, tunicates and starfish were disproportionately abundant (Table 26). This reflects the diversity of the suspension feeding assemblage

Table 26. Comparison by major taxa of the species observed on the southern Kenai Peninsula.

	Chugach Bay	E. Chugach Bay	Koyuktolik Bay	Port Dick
ALGAE-total	45	26	39	47
Chlorophyta	1	-	7	6
Rhodophyta	27	17	18	25
Phaeophyta	17	9	14	16
ANGIOSPERMAE	0	0	1	1
PROTOZOA	0	-	-	1
PORIFERA	7	1	3	1
CNIDARIA-total	29	17	8	3
Hydrozoa	25	15	3	1
Anthozoa	4	2	5	2
SIPUNCULA	-	1	-	-
ANNELIDA-Polychaeta	4	-	7	6
ARTHROPODA-Crustacea	14	9	17	17
MOLLUSCA-total	40	21	37	34
Pelecypoda	11	4	13	15
Gastropoda	21	13	19	19
Polyplacophora	8	4	5	-
ECTOPROCTA	15	8	5	1
BRACHIOPODA	1	-	1	-
ECHINODERMATA-total	20	10	11	5
Holothuroidea	2	0	3	1
Echinoidea	3	1	2	1
Asterozoa	15	9	6	3
CHORDATA				
Tunicata	12	5	1	-
Pisces	10	4	8	22
Aves	-	-	4	5
Mammalia	1	2	2	2
Total	198	104	144	145

and the concomitant diversification of predators. Twelve species of large kelps were observed (Appendix D-1); six of these were dominant in one or more areas during the summer. Elephant ear kelp (Laminaria groenlandica) dominated the bottom between low intertidal and 6 m deep. Between 6 m and 12 m, bull kelp (Nereocystis luetkeana) formed a dense surface canopy. This was particularly well developed in the vicinity of Raft Cove and on its outlying shelf. Under the canopy was a dense mixed stand of L. groenlandica and Pleurophycus gardneri. Several other species of Laminaria were also commonly encountered within this lower canopy. At about 12 m, sieve kelp (Agarum cribrosum) began to appear in the lower canopy and, at about 17 m, was the dominant alga, replacing Laminaria spp. and Pleurophycus which had gradually disappeared. Sieve kelp was abundant on down past 23 m deep.

The major herbivores were the green sea urchin (Strongylocentrotus drobachiensis), several chitons (Tonicella spp. and Mopalia spp.) and snails (Margarites pupillus and Callistoma ligatum). The densities and sizes of the sea urchin species indicate that their influence on the plant community was small. Densities of microherbivores such as chitons and small snails, that feed on gametophytes and juvenile sporophytes of the kelps, were great enough to suggest that they may have had an influence on the composition and density of the algal assemblages. About 20 species of herbivores were identified.

The appearance of the suspension feeding assemblage was dominated by bryozoans (Microporina borealis), hydroids (Abietinaria spp. and Campanularia verticillata) and colonial tunicates (? Aplidium spp., ? Distaplia sp., ? Synoicum sp., and Didemnum sp.). This epifaunal assemblage was not well developed under the dense algal canopies. However, where the algal canopy thinned out, the epifaunal mat was well developed, commonly covering more than 50% of the available substrate. About 90 species of suspension feeders were identified.

The major predators at Chugach Bay appeared to be sea otters and starfish, particularly Orthasterias koehleri, Dermasterias imbricata, Crossaster papposus and Leptasterias ? leptalea. A group of additional species that act equally well as predators or scavengers was particularly characterized by crustaceans (Appendix D-1). About 50 species of predators and scavengers were identified at Chugach Bay. These included several common fish species, namely white-spotted, kelp and rock greenling, northern ronquil, and some unidentified cottids and flatfish. Also, although marine birds were not surveyed, several species were common and active in the area.

Generally, the size data collected suggests that the fauna was composed of young to moderately old animals. None of the species measured were very large for their species, implying either slow growth, high mortality, or both. Because of the abundance of food, slow growth does not seem too probable. A high mortality rate seems fairly predictable, however, considering the density and variety of predators and the exposure of the area to winter storms.

Seasonal changes at Chugach Bay were not examined, but can be predicted based on observation in similar locations (Kachemak Bay and western Prince William Sound). The most obvious and important changes concern the algal assemblages. Bull kelp is an annual, germinating in late winter and early spring and forming dense surface canopies by late spring or early summer. The plants are senescent by late summer so that fall storms induce drastic shedding of fronds. The surface canopy is essentially absent during the remainder of the year. The major kelp species in the lower canopy are perennials. At least two species (Laminaria groenlandica and Agarum cribrosum) exhibit maximum growth during late winter and early spring. The lower canopy is consequently best developed during that period. Major shedding, is generally synchronized with shedding in the surface canopy, and apparently induced by the same causes.

Seasonal changes in the epifauna are also conspicuous and species composition of this assemblage may vary considerably on a long-term basis. However, several major epifaunal species are distinctly annual and exhibit substantial seasonal variation in cover and abundance. During 1975-76, the bryozoan Microporina borealis, several hydroids (Campanularia verticillata, Abietinaria turgida and A. variabilis) and several species of tunicates were important epifaunal forms that exhibited clear seasonal changes in abundance in several locations on the north Gulf of Alaska. Generally, these groups were most abundant in spring and summer.

The small mytilid Musculus vernicosus also displayed strong seasonal variation. This small mussel frequently encrusts large portions of the blades of seaweeds in the lower canopy. It, therefore, is strongly affected by changes in the condition of the canopy. Because of predation pressures, adult specimens of Musculus are rarely successful on the bottom and so adult abundance declines sharply after fall shedding. Possibly synchronized with shedding, however, extraordinary numbers of juvenile Musculus appear. As juveniles Musculus generally are brooded by the adults, it is possible that they are released when the shed kelp blades and attached adults are on the bottom. The juveniles form dense encrustations on many short-statured seaweeds and invertebrates. However, their growth during the winter is very slow; rapid growth probably commences concurrently with spring plankton blooms.

Brief surveys were made at the east end and near the west end of E. Chugach Island. The areas examined were rock and supported epibenthic assemblages similar to those described for Chugach Bay. The surface canopy of bull kelp was well-developed all along the north side of the island. The species forming the lower canopy were quite similar. In fact, comparison of the species list compiled for these surveys (Appendices D-1 and D-2) reveals that most of the species observed at E. Chugach Island were also found in Chugach Bay. It is probably fairly safe to assume that the systems operate similarly and that most of the remarks made for Chugach Bay are also pertinent for E. Chugach Island.

In summary, the nearshore environments at Chugach Bay and E. Chugach Island are robust, pristine and appear highly productive. The plant materials that they contribute to offshore areas undoubtedly play a role in sustaining several important shellfish resources through winter, when other food supplies are low. The areas also are nursery areas for such commercially important species as herring and king crab. Finally, they have intangible value as true wilderness environments.

Soft Substrates

Although the physical characteristics in Koyuktolik Lagoon and the West Arm of Port Dick differ somewhat, especially in respect to velocities of tidal currents, the composition of the intertidal and shallow subtidal assemblages was rather similar, and appeared fairly representative of estuarine conditions in southern Alaska. The substrate is predominantly sandy gravel, gravel and cobble. The upper intertidal zone was characterized by Fucus distichus and Littorina sitkana. Fucus was also abundant in the mid-intertidal zone, where blue mussels (Mytilus edulis) became abundant. Mussels dominated heavily in the lower intertidal. In many areas, Fucus was also abundant along the lower edge of the mussel beds (Appendices D-3 and D-4). Species diversity in these intertidal areas is low, but the species that live there are very successful. Littorines are the major herbivore and the major predators are probably sea birds such as gulls, northwestern crows, surf scoters and harlequin ducks.

The substrate in the shallow subtidal zones of both locations are predominantly sandy silt or silty sand. These areas were characterized mainly by eelgrass (Zostera marina) and various densities of several species of marine algae such as Laminaria saccharina, Alaria sp., ? Ulva sp. and Ahnfeltia plicata. Species diversity was higher than in the intertidal zone, except in dense eelgrass meadows. Eelgrass was generally the dominant form, occupying considerable area and contributing great quantities of plant material to nearshore and offshore areas.

A fairly constant assemblage of animals was associated with these major plant species. The larger, more conspicuous forms were crustaceans, pelecypods and starfish. Principal among these are barnacles (Balanus ? glandula and B. rostratus alaskensis), crabs (Telmessus cheiragonus, Cancer magister and Oregonia gracilis), clams (Saxidomus giganteus, Tresus capax, Astarte spp., Hiatella arctica, Macoma balthica, Macoma spp., Mya arenaria and M. truncata) and sea stars (Evasterias troschelii and Pycnopodia helianthoides). The ice cream cone worm (Cistenides brevicomis) is often common in gravelly sand. Approximately 150 species were identified in both locations (Table 26; Appendices D-3 and D-4).

The fauna was dominated by suspension feeders, but scavengers and predators were common. Herbivores appeared unimportant. The major resident forms are Margarites helicinus and Lacuna spp., small snails that mainly graze on epiphytes growing on the eelgrass leaves. Seasonally, several species of ducks and geese are known to stop in these areas to browse on the eelgrass (personal communication, Dave Erickson, ADF&G).

Size data collected for two major predators, the starfish Evasterias troschelii and Pycnopodia helianthoides, indicate that most of the animals are fairly young. Specimens of both species are relatively small. In view of the fairly rich supply of mussels and several species of clam, it appears that the mortality rate of the starfish must be fairly high. Fresh water is probably an important factor in this.

On their way to and from the spawning streams, large numbers of salmon pass through Port Dick, Koyuktolik Lagoon and several other estuarine areas on the outer Kenai. The major species entering Port Dick Creek is pink salmon. The ADF&G estimate of the adult pink salmon stocks in this area during the summer season range from 1,000 to 150,000 fish; variation is substantial between years (personal communication, Loren Flagg, ADF&G). Other species that are abundant in Port Dick are chum salmon, with a range from about 10,000 to 100,000 fish, and a few silvers. Residence time in the estuary for adults is approximately 8 weeks; juvenile salmon move into the estuarine areas around the end of March and remain until late August. The major species in Koyuktolik Lagoon is the chum salmon. The ADF&G estimate of the adult salmon stocks in this area during the summer 1971 season was over 100,000 chum, and approximately 10,000 pinks. A surprising comparison is that the Koyuktolik streams have only about one-third the spawning area of those at Port Dick. It is very possible that the large and productive Koyuktolik Lagoon plays an important part in increasing fry survival, thus allowing a disproportionately larger return of adults.

BIOLOGY OF THE EELGRASS BEDS

Development of the eelgrass beds is strongly seasonal. This was observed mainly in the size of the turions, but also was reflected in the condition of the beds; turion density may show some seasonal variation in some locations. Data comparing density, turion height and estimated wet weight for all collections are presented in Table 27.

The density of the bed in Koyuktolik Lagoon is considerably higher than the bed at Port Dick. Additionally, the Koyuktolik bed is considerably larger (approximately 1.14×10^6 m^2 vs. 0.3×10^6 m^2). According to McRoy's data (1972), this would make Koyuktolik Lagoon about the fifth largest eelgrass bed in Alaska. However, the largest, Izembek Lagoon on the Alaska Peninsula, is more than 100 times larger (170×10^6 m^2).

Because size structure of the Port Dick and Koyuktolik Lagoon beds were not examined throughout the growing season, and the probability that population growth is synchronized at these sites, it would be improper to compare size distributions between them. However, size comparisons within each area are valid.

Table 27. Comparison of population parameters for eelgrass samples from the southern Kenai Peninsula, 1976.

Location	Date	Density (#/m^2)	Turion Height (cm) $\bar{x}$	s	Estimated Wet Weight per m^2 (gm)	Estimated Dry Weight per m^2 (gm)
Koyuktolik Lagoon						
Inner Lagoon	5/6	∿ 0	--	--	∿ 0	--
	7/9	∿50	73.0	33.2	<246	∿25
Transition Zone	7/9	456	95.5	30.6	2894	289
	8/30	440*	130.5	53.2	2133	213
Outer Lagoon	7/9	486	107.9	24.1	2770	277
	8/30	612*	160.0	46.3	4061	406
Port Dick-Head of West Arm						
Subtidal Bed	5/4	95	40.9	19.8	228	23
Inner Edge of Bed	8/31	109	164.1	58.3	1514	151
Outer Edge of Bed	8/31	108	126.4	63.9	936	94

*Difference between densities in the transitional zone and outer bed of 8/30 are significant ($p < 0.02$).

In Koyuktolik Lagoon, size data were collected from three general areas; lowest densities and smallest plants were observed in the inner lagoon (Table 27). Here plants were virtually absent in May, but small patches were present in July. In the transition zone between the inner and outer lagoon, density of turions (leaf bundles) within the bed was much higher, and the turions were significantly larger (Kolmogorov-Smirnov two sample test, $p < 0.05$). However, the bed did not completely cover the bottom, but rather co-dominated with the red alga *Ahnfeltia plicata*, which formed a low mat reminiscent of plastic scouring pads. Coverage by *Zostera* probably ranged between 50 and 75%. In the middle of the outer lagoon, toward the outer edge of the eelgrass bed, the density of the turions within the bed may be slightly higher. The bed is certainly more solidly distributed, occupying over 90% of the bottom. Turions here were significantly larger than in the transition zone ($p < 0.01$ both in July and August; Table 27).

The difference in density between the transition zone and outer lagoon in August, although statistically significant (Mann-Whitney U Test, $p < 0.05$), was probably due more to a difference in sampling locations in the outer lagoon than to real increases in the number of plants. This is supported by the size data. A large increase in density would be accompanied by the addition of numerous small plants to the population, which would, in turn, be reflected in the size structure and by a reduction of the mean size. Such changes were not apparent in the size structure of the population in August and the mean height was significantly larger than in July ($p \ll 0.001$).

Biomass patterns basically reflect density and size patterns. Wet biomass in the inner lagoon in July was less than 10% of that found in the outer areas. Unfortunately, the data presented are only useful in indicating general standing stocks. Even preliminary estimates of primary production based on increases in biomass are invalid because the plants had started shedding before the sampling period in August. This is exemplified by data from the transition zone. Despite a rather substantial increase in mean turion height between July and August, estimates of biomass decreased considerably and to a much greater extent than justified by the slight (statistically insignificant) reduction in density (Table 27). Physical examination of the turions indicated a loss of leaves on the turions and a generally poor condition (Figure 7). These factors acted to reduce the ratio of wet weight to turion height, which in turn, resulted in a lower biomass.

On the shelf at the head of West Arm, Port Dick, size data for eelgrass were collected at three locations. The first sample (May 1976) was collected at an unspecified location within the bed, but the August samples were collected near the inner and outer edges of the bed. Densities for all samples were similar, averaging around 100 turions/m^2. Turion height was significantly greater in August ($p << 0.001$) and the size of the plants at the inner edge of the bed was significantly larger than at the outer edge ($p << 0.001$). The plants had grown approximately 100 cm in four months (Table 27). The bed appeared in peak condition in late August. Leaves were robust, turgid and generally unblemished; reproductive turions were scattered throughout the bed and had flowered. Wet biomass increased considerably during the summer and, because of the sampling times and apparent synchrony with peak summer condition, may provide a very preliminary, conservative estimate of primary productivity by eelgrass. Using the May estimate as the minimum biomass for the year, and the August estimate as the maximum, the difference of about 1,000 gm/m^2 wet weight is a conservative estimate of plant production by eelgrass during the summer of 1976. The confidence level of this estimate is low. This amounts to an increase of about 500%. Obviously, the number of samples and the coverage of the bed is low. The estimate does not take into account loss from grazing or leaf shedding. Additionally, it is based on the assumption that the biomass estimates available are the lowest and highest for the year; any changes in these values would only act to increase the estimated production of the bed. The overall estimate of primary production for this area is definitely too low, because the contribution of the algae has not been included. Several species, most notably sea lettuce (? Monostroma sp.), elephant ear kelp (Laminaria saccharina), rockweed (Fucus distichus) and several small epiphytes on Zostera contribute a substantial quantity of plant material to the overall production of the intertidal and subtidal areas in Port Dick.

It appears that the majority of the plant material produced in the eelgrass beds is exported to nearshore and offshore areas for utilization by benthic assemblages. Herbivores were generally uncommon within the eelgrass beds. The most important grazing probably occurs in the spring and fall, when geese visit these sites during their migrations. After a great deal of physical reworking, some of the eelgrass becomes available to local detritivores in the form of plant debris.

BIOLOGY OF THE MUSSEL BEDS

The physical environments at Koyuktolik Lagoon and Port Dick strongly influence the development at these two sites. Foremost among the important factors is tidal current, which is responsible for the great differences in density between the mussel beds in the two areas. Mussel densities in the entrance channel beds at Koyuktolik exceeded maximum densities at Port Dick by about 300%. Ice scouring appears to be an important factor at Koyuktolik; ice blocks gouge broad furrows through the beds, clearing considerable portions of substrate and causing substantial mortality. This phenomenon acts to open up large tracts of substrate for dense recruitment by juvenile mussels. At Port Dick, the major causes of mortality are unclear. A major kill involving both mussels and the starfish _Evasterias_ _troschelii_ appears to have occurred between August 1975 and May 1976. The cause is unknown. The major area of influence was in the low intertidal and shallow subtidal areas. Possible causes include red tide (summer 1975), low temperatures (winter 1976) and fresh water run-off (spring and summer 1976). In August 1975, however, _Evasterias_ appeared to exert a strong predatory influence in those beds.

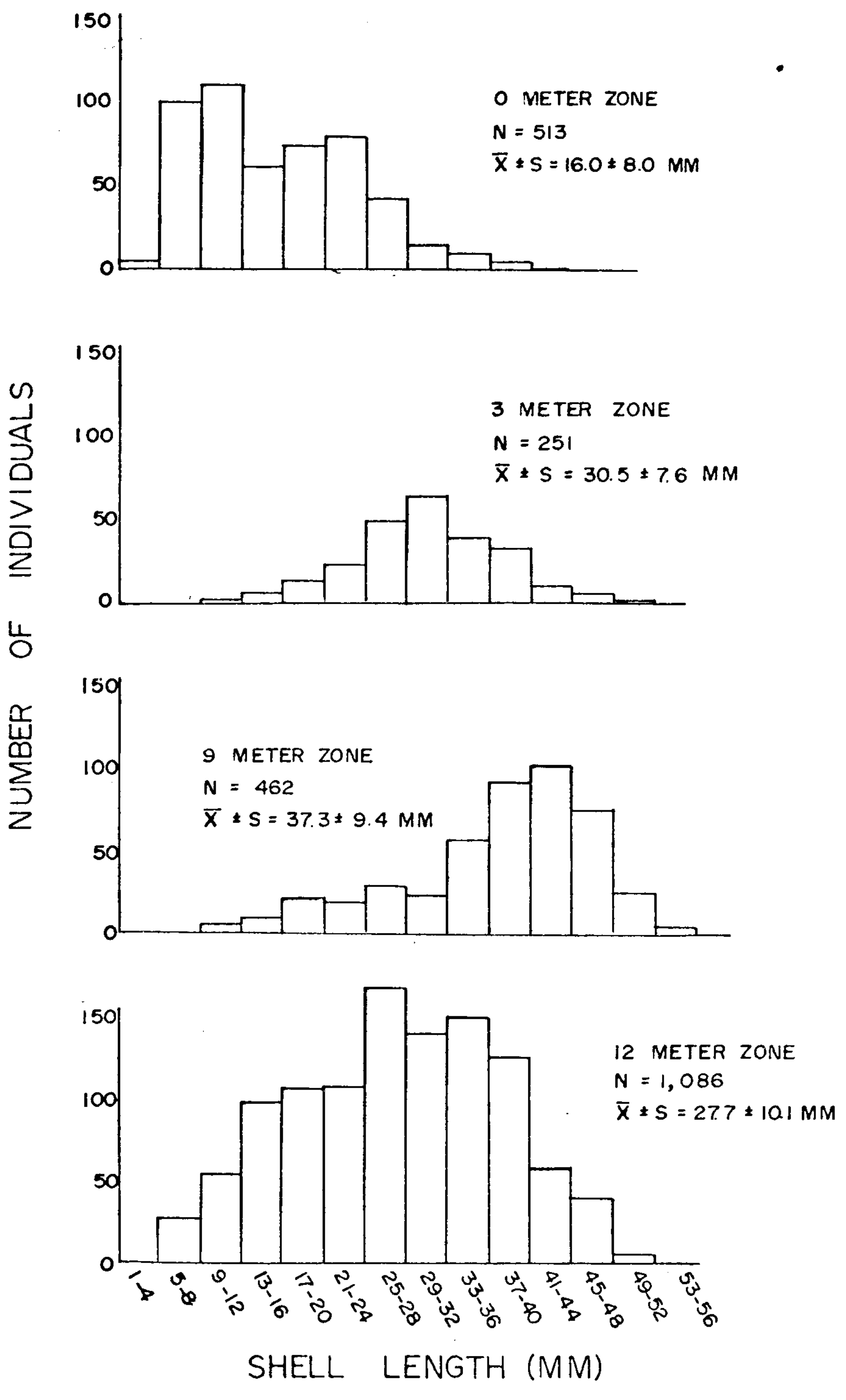
The average size of the mussels within a bed varies significantly with tidal elevation (Table 28), but since elevations were not determined accurately it would be improper to attempt size comparisons between Port Dick and Koyuktolik beds. Overall, however, the largest mussels were collected at Port Dick (Table 28).

Generally, the average size of the mussels was smaller at higher elevations at both Koyuktolik and Port Dick (Table 28; Figure 11). In nearly all cases, the differences in mean sizes between elevations in the same sampling period were highly significant when tested with the Kolmogorov-Smirnov two-sample test ($p < 0.01$). The main factors responsible for these

Table 28. Comparison of population parameters for blue mussel samples from the southern Kenai Peninsula, 1975-76.

Location	Date	Density (#/m2)	Shell Length (mm) $\bar{x}$	s	Estimated Wet Weight per m2 (gm)
Koyuktolik Lagoon Entrance Channel					
Outer Mussel Bed					
10 m from upper edge	9/9/75	12,384	19.3	11.1	5,026*
	5/7/76	19,006	13.0	8.1	3,424
20 m from upper edge	9/9/75	24,680	17.9	10.4	7,400*
	5/7/76	29,167	14.6	9.3	7,228
80 m from upper edge	7/10/76	9,130	23.8	7.4	5,455
150 m from upper edge, 10 m from lower	9/9/75	6,968	27.6	8.6	5,504*
	5/7/76	12,865	24.3	8.7	5,976
	7.10/76	12,830	25.5	8.8	9,303
60 m from seaward edge, 10 m from lower	5/7/76	12,061	22.0	8.1	4,435
Inner Mussel Bed					
5 m from south end of bed	5/8/76	34,649	13.7	7.1	6,519
	7/10/76	17,826	16.7	8.1	6,973
10 m from south end of bed	7/10/76	21,957	19.7	9.6	11,461
30 m from south end of bed	7/10/76	12,717	19.6	9.6	6,555
75 m from south end of bed	5/8/76	4,751	30.0	13.8	5,483
	7/10/76	7,174	26.2	11.6	6,711
Port Dick					
Middle Shoal	5/3/76	507	21.1	9.4	223*
Subtidal Bed	5/3/76	--	23.1	11.2	
Dick's Head					
0 m	7/1/76	4,104	16.0	8.0	1,475
3 m	7/1/76	2,080	30.5	7.6	2,012
9 m	7/1/76	3,696	37.3	9.4	6,231
12 m	7/1/76	8,680	27.7	10.1	7,809

* Estimate based on whole wet weight: wet tissue weight ratio of 1:0.35.



COMPARISON OF SIZE DISTRIBUTIONS FROM INTERTIDAL SITES ON DICK'S HEAD, AT THE HEAD OF WEST ARM, PORT DICK

DAMES & MOORE

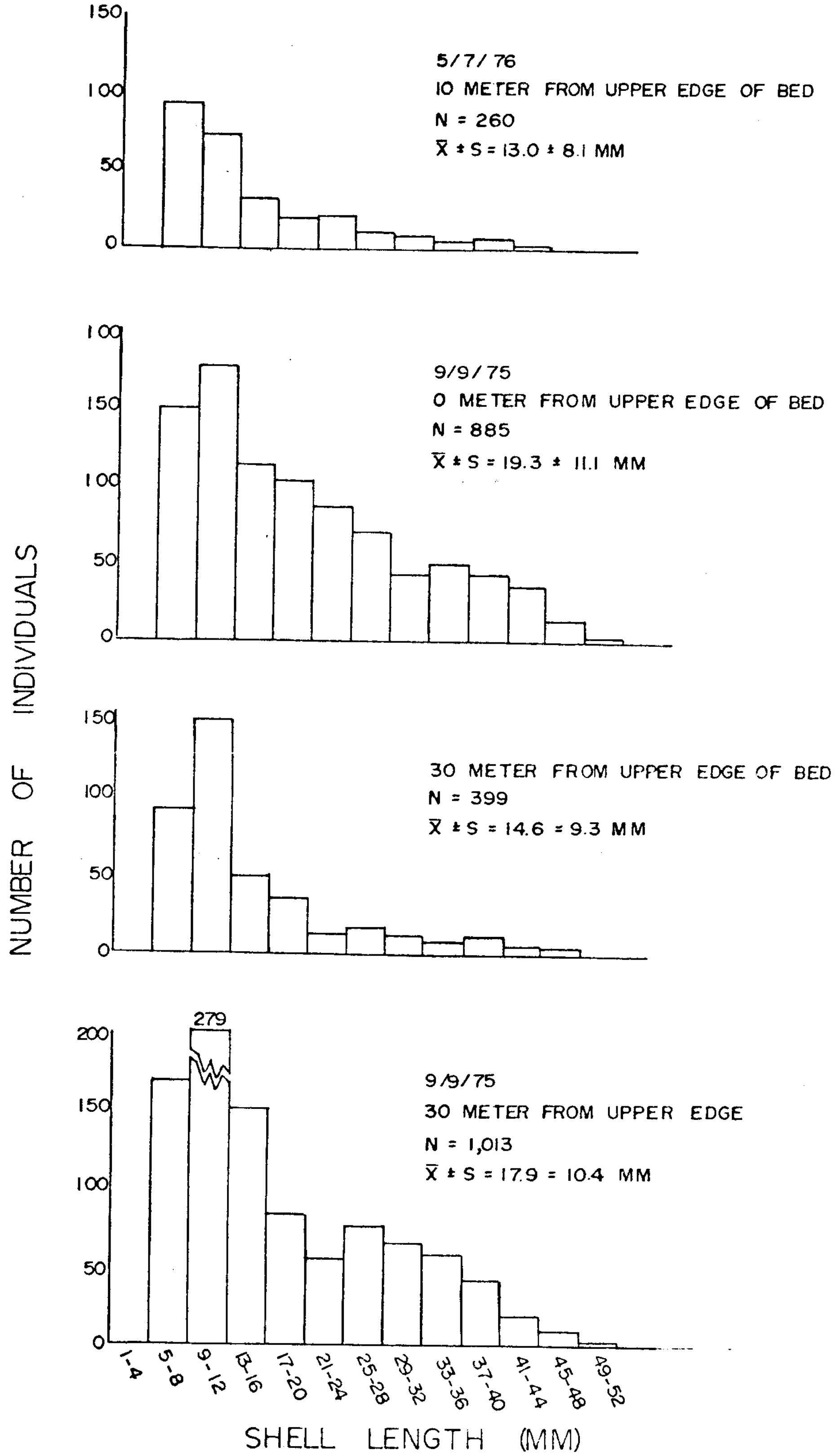
FIGURE 11

differences probably relate to the ratio of immersion and emersion periods. This controls duration of feeding periods and exposure to extremes in temperature, factors that are very important to growth and mortality rates.

Density patterns varied considerably between beds. In the outer bed at Koyuktolik Bay, density was highest near its upper edge and was uniformly lower along the main channel. In the inner bed, density declined with higher elevation and varied considerably along the main channel (Table 28); there was no distinct upper edge here. On Dick's Head, in Port Dick, density generally was lower at the higher elevations and greatest at the lowest level sampled (Table 28).

Examination of size structures for different sites provides insight into prevailing conditions. Populations near the upper edge of the outer bed at Koyuktolik are strongly dominated by small individuals (Figure 12). The strongly skewed distributions indicate a high mortality rate and heavy recruitment. A similar size structure was observed near the lower edge of the inner bed, 5 meters from its southern end (Figure 13). This area is at the confluence of the main channel and a major drainage channel from the lagoon. Evidence of ice scour is obvious and widespread. It appears that both areas are characterized by highly stressful conditions.

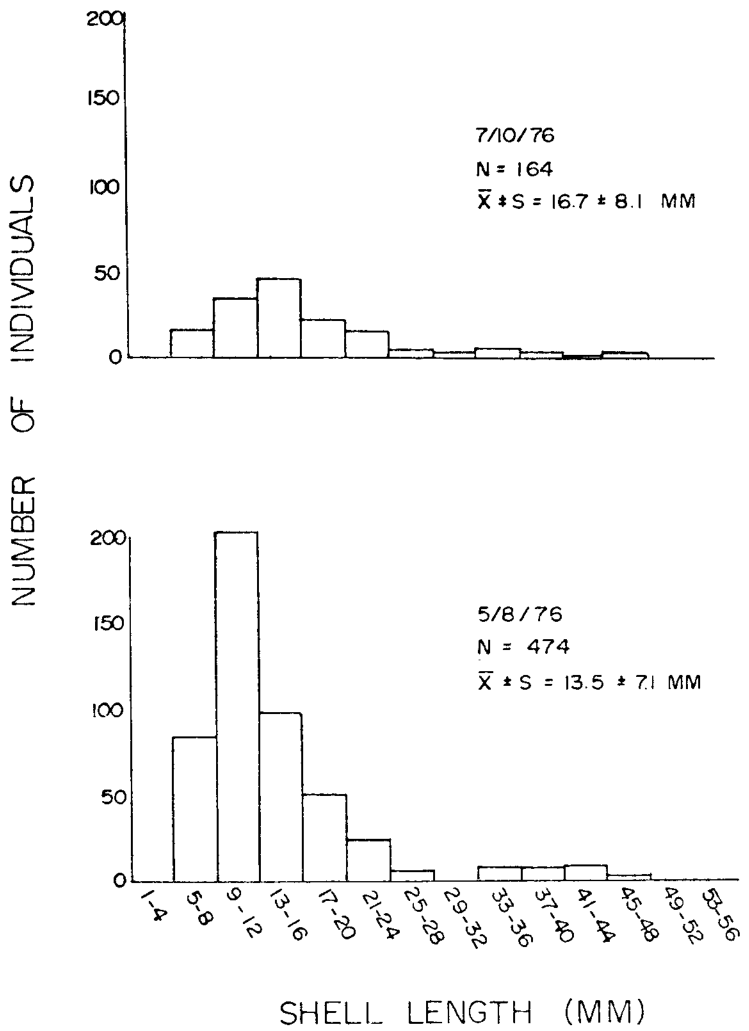
More favorable conditions are indicated by the size distributions from populations near the lower edge of the outer bed at Koyuktolik Bay and near the lower edge of the bed on Dick's Head, at Port Dick (Figures 11 and 14). These populations are strongly dominated by larger mature animals. It appears that recruitment and mortality rates are lower than in the areas previously discussed. Recruitment by larvae is probably strongly inhibited by the filtering influence of the adults (Thorson, 1950).



COMPARISON OF SIZE DISTRIBUTION FOR BLUE MUSSELS FROM NEAR THE UPPER EDGE OF THE OUTER MUSSEL BED, KOYUKTOLIK BAY

DAMES & MOORE

FIGURE 12



COMPARISON OF SIZE DISTRIBUTIONS FOR BLUE MUSSELS 5 m FROM THE SOUTH END OF THE INNER MUSSEL BED, KOYUKTOLIK BAY

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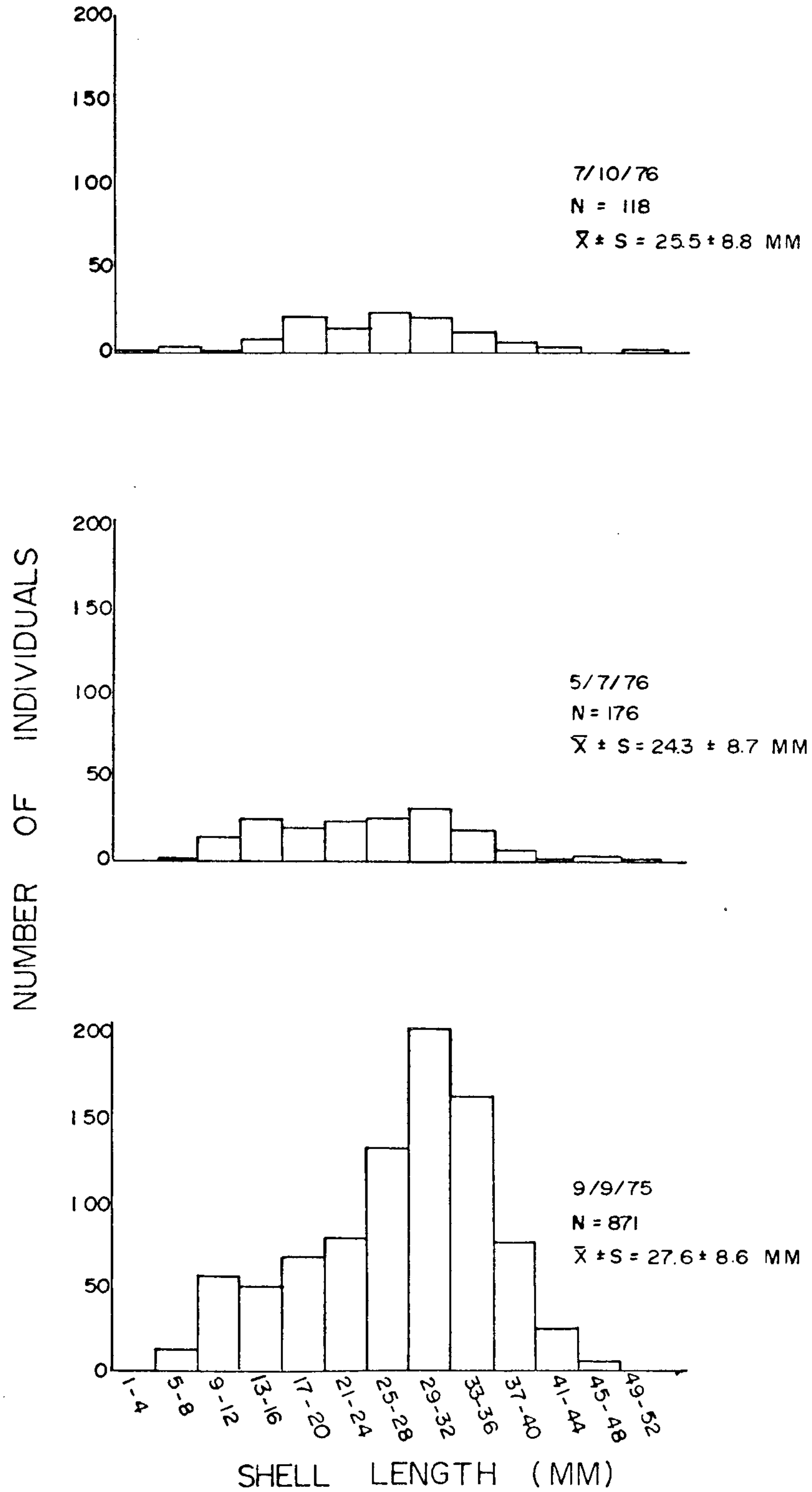
FIGURE 13



COMPARISON OF SIZE DISTRIBUTIONS FOR BLUE MUSSELS FROM NEAR THE LOWER EDGE OF THE OUTER MUSSEL BED, KOYUKTOLIK BAY

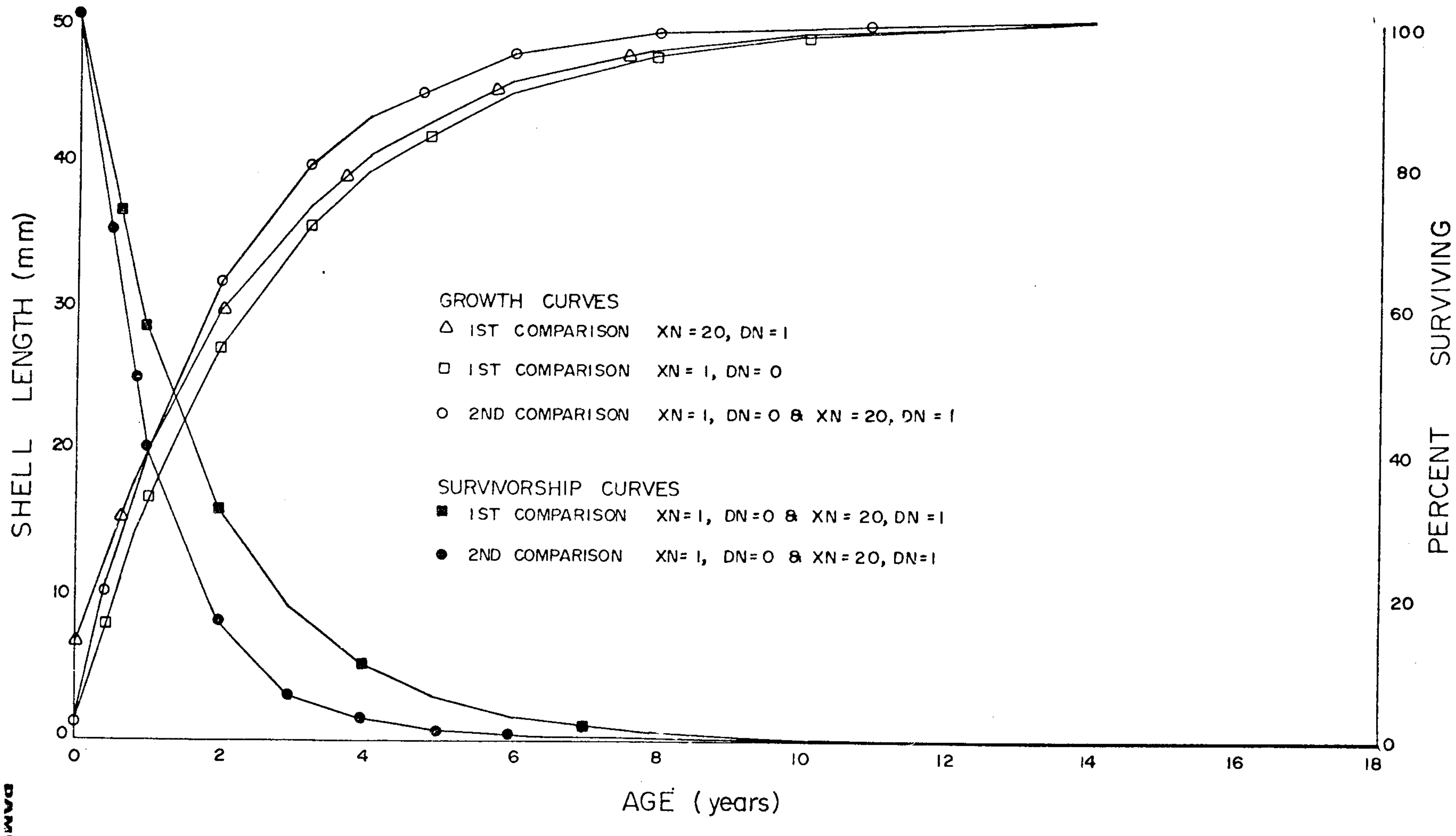
FIGURE 14

Using a technique described by Ebert (1973), attempts were made to estimate growth and mortality rates for mussels for specific sites at Koyuktolik. The results were not completely satisfactory, but nevertheless, are of interest. The data that are used to compute these curves are 1) mean sizes for a population at two times of the year (Table 28), 2) the time of year the population was sampled in relation to the suspected time of recruitment (October), 3) the asymptotic size for a population (50 mm), 4) size at the time of recruitment to the sample (i.e., the smallest size that will be sampled by the collection technique utilized (4 mm); and finally, 5) the known size of individuals (XN) at a known age (DN).

Best estimates were obtained for the population at the lower edge of the outer bed. Samples were collected from this location three times during the year. Using two combinations of these data (May:July and May:September) and two sets of knowns (XN = 1 mm, DN = 0 years, and XN = 20 mm and DN = 1 year), four sets of survivorship and growth curves were generated (Figure 15).

All combinations generated rather similar curves. Survivorship becomes negligible after about 5 years; 50% of the recruits are dead about 1 year after settlement, and 75% after about 2 years. Some specimens may live over 20 years, but only about 1% survive past 8 years. Rate of growth is fairly rapid in the first 4 years, after which it declines quickly. Size becomes asymptotic (50 mm) after about 14 years. The animals attain mean size about 2 years after settlement.

For several reasons, the accuracy or reliability of these curves must be evaluated. All of the basic assumptions of the model may not be



ESTIMATED GROWTH AND SURVIVORSHIP CURVES FOR THE BLUE MUSSEL POPULATION FROM THE LOWER EDGE OF THE OUTER MUSSEL BED AT KOYUKTOLIK LAGOON

FIGURE 15

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satisfied by the population being sampled. Of particular concern, are the assumptions of constant growth and mortality rates during the year and the requirement that most recruitment occur during a single month. It is possible that growth nearly ceases during the winter, and fairly probable that the mortality rate increases dramatically during winter and early spring, especially during spring breakup. Finally, the estimated time of maximum recruitment is a guess based on several pieces of indirect evidence, but no direct observations; the duration of this period is unknown. However, Ebert states that the method is sufficiently robust "to withstand some violations of assumptions and still produce reasonable estimates". Also, the standard errors for the samples utilized are within the range utilized by Ebert in his published examples. Basically, the curves do not suggest conclusions that deviate strongly from those suggested by field observations. We have therefore concluded that the curves generated are reasonable estimates for growth and survivorship for the mussels near the lower edge of the outer mussel bed at Koyuktolik.

It is not safe to conclude that these curves are representative for other parts of that bed, or other beds. In fact, the computer program "blew up" on all other runs attempted. A suspected reason for this problem is the spatial heteogeneity of size structures resulting from the temporal instability of the populations in most of the other areas sampled. Replicate samples from such populations provide a mixture of size and age distributions, which violates a major assumption of a stable population with a stationary age distribution.

Biomass for mussels in the two beds examined at Koyuktolik was fairly equal. Wet tissue weight in the dense areas averaged approximately 6.5 kg/m^2 (Table 28). Using an estimate of 7.5 acres of mussels, an overall coverage of 70% and the average biomass of 6.5 kg wet tissue/m^2, the estimated tissue weight for the two beds exceeds 135 metric tons. Over 50% of the tissue weight is contributed by individuals with shell lengths less than 2 years old (Figure 15). The survivorship curves indicate that 99% of a year class have died by year 7, so that a previous estimate of a turnover period of 10 years (Dames & Moore, 1976) was not unreasonable. Assuming a 10% annual turnover rate, mussel production would have to equal about 445 gm wet mussel tissue/m^2 if the population is stable.

Biomass in the mussel beds at Port Dick is generally somewhat lower than at Koyuktolik. Wet weights were lowest on the intertidal mudflats near the mouth of Port Dick (Table 28). Dick's Head supported greater stocks, approaching an average wet tissue weight of 4.5 kg/m^2. However, the size of this bed was quite small in comparison with the beds at Koyuktolik. Biomass clearly became greater moving downward across the intertidal zone. The major factors causing the differences observed between the intertidal flats and the several levels on Dick's Head are probably the intensity of the tidal currents and availability of suitable substrate. The influence of fresh water at both sites may have a slight effect.

During the study we have developed an impression of the natural history of the mussel beds. The major recruitment period is probaly in the fall, based on size distributions and other observations. Growth rates are probably fairly slow during the winter because of temperature induced reductions in feeding rates and reduction in food concentrations in the water. Major mortality is probably due mainly to low temperatures and, at Koyuktolik, ice scouring. An additional source of winter mortality is predation by sea otters, gulls, crows and overwintering sea ducks, all of which are major predators all year. During spring and summer, feeding rates, food supply and predation rates increase considerably. Additional predators in the mussel bed areas included the slender star *Evasterias troschelii*, which moves up from deeper water. The adult mussels themselves are probably quite efficient consumers of mussel larvae. Thorson (1949) estimated that a medium-sized mussel could ingest about 100,000 pelecypod larvae per day.

RECOMMENDATIONS FOR MONITORING STUDIES

The predictability of the changes that would occur following catastrophes at some future date is extremely restricted because of the limited nature of the existing data base. The small amount of information presently available for lower Cook Inlet and the north Gulf of Alaska indicates that substantial changes in the composition of the epibenthic assemblages are routine, long-term occurrences. However, no information regarding the range of variation exists, and so inferences concerning what is "normal" following a major disturbance would necessarily be weak. The information necessary to improve interpretation could be produced by a long-term monitoring program.

The experience of this study is useful in designing such a program. Generally, the nature of the studies should remain unchanged, but greater emphasis should be placed on obtaining useful estimates of plant and animal production. Furthermore, the objectives should be clearly and specifically stated in a manner conducive to standardized, quantitative examination.

A major problem encountered was the difficulty of sampling at Port Dick and Chugach Bay because of their inaccessibility, especially during fall and winter. Because of these difficulties, future studies would be more effective if monitoring sites were established at more accessible locations. A major necessity is accessibilty by boat or plane during the fall and winter. Sites that may be suitable for intensive study are Port Graham, Koyuktolik Bay and Perl Island. Surveys should be conducted once during winter, fall and spring and three times during summer.

POTENTIAL PROBELMS OF OIL DEVELOPMENT

The impetus for funding this study was the proposal by Dept. of Interior to lease offshore areas in the Gulf of Alaska for development of suspected petroleum resources. Recent history provides abundant evidence that such development can be accompanied by several types of activities disruptive to natural systems (Anonymous, 1975; Smith, 1968; Nelson-Smith, 1973). This knowledge created concerns over ignorance concerning the composition and distribution of the assemblages that might be affected by potential development and the processes crucial to the well-being of these assemblages.

In the marine environment, the most conspicuous consequences of oil development occur in intertidal and shallow subtidal assemblages. Effects in these areas are most noticeable for several reasons. First, man's maritime activities are concentrated in that area. Second, the proportion of observations and familiarity with these assemblages is greater, so that sudden changes are more obvious. Third, petroleum products are lighter than water and therefore often remain near the sea surface, at least initially. Wind can then drive conspicuous quantities of oil onshore. Finally, turbidity, often a consequence of petroleum related development can have strong detrimental effects on the visually dominant macrophyte assemblages, which are restricted to intertidal and shallow subtidal areas.

Basically, the kinds of problems encountered fall into three major categories. These include: 1) catastrophic spills resulting from blowouts of offshore wells, shipping accidents or severe damage to storage facilities or pipelines, 2) chronic, low-level contamination resulting from routine shipping operations and release of co-product brines, and 3) increased turbidity in the water column from disposal of dredge spoils produced by installation of port facilities, pipelines, wells, etc.

In view of the development scenarios generated by the Bureau of Land Management for the Kodiak Shelf and lower Cook Inlet, the most probable type of pollution to be experienced by the area from Gore Point to Koyuktolik Bay is a catastrophic spill. The probability of damage from chronic, low-level pollutants or turbidity is low because of circulation patterns and the remoteness of the area from potential platform sites and onshore facilities. As a consequence, the prospects for continued high plant production are good. However, prospects are also fairly high that the faunal assemblages could be appreciably perturbed. Two major features characterizing the ecology of intertidal and nearshore assemblages of the outer Kenai Peninsula , and apparently many other northern areas, lead to this conclusion. First, two of the most important groups of predators on the benthos of nearshore and intertidal areas are sea otters and several species of marine birds. A major spill in nearshore areas would certainly have a severe effect on local sea otter populations, regardless of the time of year, because they are non-migratory. Spills in nearshore areas in spring and summer would additionally kill large numbers of marine birds and could severely disrupt their populations. The long-term effects of a reduction in the predation pressures from these two groups cannot be predicted clearly, but both groups consume large numbers of herbivores (Ebert, 1968; Cottam, 1939). Uncontrolled herbivore populations frequently cause depletion of algal resources (Paine and Vadas, 1969; Kitching and Ebling, 1967).

The next feature, indicated by the patchy distribution and age structure of many invertebrate populations, is their apparently slow rate of recruitment to established populations or establishment of new populations. In particular, mature subtidal epifaunal assemblages such as Modiolus beds could perhaps require decades to recover from catastrophic damage.

An additional, but lesser, concern is that disruption of the possible pattern of food supply could affect offshore productivity. Seagrasses are quite sensitive to oil contamination (Straughan, 1971) and heavy contamination could severely reduce their production for many years. Kelps and other seaweeds are generally not as sensitive to oil contamination as seagrasses, but are definitely affected by refined products (Clendenning and North, 1960). If a major spill hit the intertidal and nearshore areas at a time when it disrupted reproduction or germination of such important "annuals" as Nereocystis, the subsequent reduction in plant production could have a substantial impact on the condition of offshore organisms.

Of major importance in determining the magnitude and nature of the damage caused by a catastrophic oil spill are the volume and type of petroleum. The recent grounding of the tanker Sealift Pacific clearly demonstrated that both crude and refined petroleum products are potential sources of contamination in lower Cook Inlet. The physical and chemical properties of refined products differ considerably from those of crudes and their effects on living organisms are considerably more severe. However, the probability of a major spill of refined petroleum products on the outer Kenai Peninsula is fairly low.

Many of the larger and more highly publicized spills have involved crude oil. The major physical effects of crude oil contamination include smothering and dislocation of organisms and alteration of substrate. Smothering is particularly pertinent to sedentary invertebrate forms such as barnacles, mussels and limpets. It generally only occurs in the intertidal zone as a consequence of very heavy oiling and is most damaging to small specimens. Dislocation can occur in several ways and affect both seaweeds and animals. Smaller seaweeds such as rockweed become heavily fouled and may be torn from the substrate as a consequence. Sessile intertidal forms such as limpets and littorine snails retract into their shells and release their hold on the substrate. Wave action subsequently washes them into subtidal areas where they die. Motile forms such as crabs and fish can sometimes move from contaminated areas, but often those in embayments and estuaries cannot, and are subsequently killed (Blumer, 1972). Oiling can also render substrates unsuitable for recruitment by the forms normally encountered. This is particularly important in areas where heavy oiling leaves an asphaltic coating not suitable for recruitment by most intertidal forms. Major spills where these types of effects have been observed include the Torrey Canyon spill on the Cornish coast (Smith, 1968), the Santa Barbara blow-out (Straughan, 1971), and the Metula accident, in the Straits of Magellan (personal communication, Dr. Miles O. Hayes, University of South Carolina).

Direct poisoning by crude oil has been poorly documented and studied but appears relatively uncommon (Boesch, Hershner and Milgram, 1971). It may be important to fish, however, by disturbing membrane permeability in the gills (Morrow, 1974). Ingestion of crude oil apparently has little immediate harmful effects on invertebrates but may damage marine birds. Food chain effects, particularly sublethal forms such as decreased reproductive potential or reduced fitness resulting from altered behavioral patterns, have been insufficiently investigated (Blumer, 1972).

Clean-up methods, particularly use of chemical emulsifiers and dispersants, have actually caused more damage than the spilled oil (Smith, 1968). However, this is probably not a serious concern on the outer Kenai Peninsula. It is probably fairly safe to predict that because of its remoteness and physical inhospitality, clean-up efforts would not be attempted.

It is difficult to predict the overall effects of a large spill of crude oil on the outer Kenai Peninsula. Numerous variables are very important in influencing the magnitude of damage. Among these are time of year, sea state and position in the monthly tide cycle. These factors determine composition and development of the intertidal and shallow subtidal assemblages, rates of evaporation, emulsification and decomposition of the oil, and the amount of sea floor contacted by it.

The predominance of evidence from recent spills indicates that major damage to the rocky shore would be to barnacles, limpets and chitons. Damage to seaweeds would be only temporary. Later, because of the absence of the major grazers, seaweeds would probably develop luxuriant, diverse assemblages. The period of time necessary for complete recovery is not predictable, but in the case of the Tampico Maru, which spilled diesel oil in Baja California, recovery was not complete seven years later (North, Neushul and Clendenning, 1964). The length of the recovery period would be considerably lengthened, however, if a spill caused high mortality among major predators such as sea otters and marine birds.

The potential consequences of a spill entering the lagoons c estuaries of the outer Kenai are much more serious. Dominant species such as eelgrass and marsh grasses, are more sensitive to oil contamination than the algal species (Straughan, 1971). Furthermore, the probability of contact is higher because of the flatness and greater extent of the intertidal zone in estuaries. The high concentrations of silt and organic debris would act to increase the quantity of oil retained in the system and the time necessary for flushing to occur. However, because of the well-developed microbial flora, degradation may occur more rapidly. Greatest damage would be to eelgrass, the dominant primary producer, but unfortunate timing could also cause severe damage to salmon stocks if adults or juveniles were trapped and killed, or if migrations into spawning streams were inhibited (Dept. of Interior, 1976).

Juvenile pink salmon are quite sensitive to low level exposures of crude oil (Rice, 1973). Highest sensitivity of fry was in salt water, where about 50% were killed by a 96 hour exposure to crude oil concentrations of 0.04 ml/l. Significant mortalities occurred in young coho salmon when concentrations of crude oil poured on the surface of the water reached 500 ppm (Morrow, 1974). Further discussion of the problems and evidence supporting these projections are available in the environmental impact statement for lower Cook Inlet (Dept. of Interior, 1976).

The systems examined during this study are robust, pristine and quite productive. They appear to contribute significant quantities of food material to the offshore systems and may be particularly important in satisfying winter food requirements. This point of interaction appears to be a crucial consideration in planning for oil development because the loss or contamination of a large proportion of that food source could cause significant losses in valuable offshore fisheries resources. The estuarine systems are also very important to salmonid stocks, which are highly susceptible to contamination. Heavy oiling of a lagoon such as Koyuktolik could seriously reduce natural salmon runs (Dept. of Interior, 1976). However, evidence from other areas indicates that exposed intertidal and shallow subtidal systems are generally resilient and recover fairly well following major spills. Furthermore, it appears that the local systems occasionally sustain widespread damage from natural catastrophes (earthquakes, red tides), but most recover quickly. Disturbances of salmon stocks are not quickly resolved, however (National Research Council, 1971). In contrast, the effects of an oil spill on sea otters and marine birds are not analogous to those of natural catastrophes. Damage to populations could be severe and recovery would be slow. This is justifiable cause for great concern over the well-being of these important animals.

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Appendix A-1. Species observed on sand bottom on north side of Koyuktolik Bay, 7/9/76. Corrected depth - 32'.

Invertebrates

Echinarachnius parma - common
Elassochirus gilli
Maldanidae, unid. - ∿ 50/m^2
Olivella baetica - abundant
Pagurus ochotensis - common
Pycnopodia helianthoides - sparse
Tellina nuculoides - common

Fishes

Leptocottus armatus
Pleuronectiformes, unid. - juveniles, abundant

Substrate: Clean gray medium sand with little shell derbis, moderate organic debris, large ripple marks (5 x 45 cm); shell piles (egesta) common.

Appendix A-2. Species observed along south side of Koyuktolik Bay, 8/30/76. Water depth 18.9 m.

Macrophytes

Constantinea simplex
Cymathere triplicata
Fucus distichus
Laminaria saccharina-dominant; about 75% cover

Invertebrates

Elassochirus tenuimanus-uncommon
? *Hermissenda crassicornis*-uncommon
Hydractinia sp.-uncommon
Metridium senile-uncommon
Pagurus ochotensis-common
Pycnopodia helianthoides-common
Tonicella lineata-common

Fishes

Hexagrammos stelleri-common
Stichaeidae, unid.-common

Substrate: silty cobble/sand bottom, no ripple marks, with a considerable quantity of vegetative debris of marine and terrestrial origin. *Laminaria*, *Cymathere* and *Fucus* appeared to have been imported. Terrestrial debris included alder leaves and conifer leaves and branches.

Appendix A-3. Species observed in the mussel beds along the entrance channel to the lagoon, Koyuktolik Bay, 7/10/76.

Macrophytes

Chlorophyta

Cladophora sp.
? Monostroma sp.
Spongomorpha sp.

Rhodophyta

Callophyllis sp.
Halosaccion glandiforme
Iridaea lineare
Odonthalia floccosa
Porphyra sp.

Phaeophyta

Alaria fistulosa
Alaria spp.
Cymathere triplicata
Fucus distichus

Invertebrates

Balanus cariosus
B. glandula
Collisella pelta
Cucumaria sp.
Gnorimosphaeroma oregonensis
Leptasterias ? hexactis
Littorina sitkana
Mytilus edulis
Nucella lima

Birds

Corvus caurinus (northwestern crow)
Larus spp. (seagulls)

Appendix A-4. Organisms observed in vicinity of rock pinnacle, entrance channel to Koyuktolik Lagoon, 7/10/76.

Side of Pinnacle
Invertebrates

Abietinaria turgida-reprod.

Acmaea mitra
Anthopleura sp., small
Balanus ? glandula

Chthamalus dalli
Diaulula sandiegensis

? Diadumene sp.
Diestothyrus frontalis
Diodora aspera

Elassochirus gilli
E. tenuimanus
Eudistylia ? vancouveri
Evasterias troschelii
Flustrella corniculata-on alga
Halichondria panicea
Hippothoa hyalina
Hyas lyrata
Katharina tunicata
Metridium senile
Oregonia gracilis

Serpulidae, unid.
Tealia crassicornis
Tonicella insignis

Under Rocks
Invertebrates

Alcyonidium polyoum
Cancer oregonensis

Cucumaria miniata

Elassochirus gilli-abundant

E. tenuimanus-abundant

Fusitriton oregonensis

Lebbeus sp.

Leptasterias hexactis-sparse

Paralithodes camtschatica

Strongylocentrotus ? drobachiensis

Tedania sp.

Bottom on Boulders
Algae

Agarum cribrosum-on sides
Alaria sp.
Costaria costata
Desmarestia viridis
Laminaria groenlandica-much of area with 100% coverage

L. setchellii-much of area with 100% coverage

Under Laminarian Canopy
Algae

Constantinea simplex
Corallina vancouveriensis
Delesseria decipiens
Encrusting coralline alga
Iridaea lineare

Opuntiella californica

Ptilota filicina
Rhodymenia palmata

Invertebrates

Abietinaria turgida
Acmaea mitra
Alcyonidium pedunculatum
Cucumaria miniata
Diaulula sandiegensis
Elassochirus spp.
Evasterias troschelii
Halichondria panicea

Modiolus modiolus-uncommon
Ophiopholus aculeata
Oregonia gracilis
Pagurus sp.
Porifera, syconid
Porifera, yellow, encrusting
Pugettia gracilis
Pycnopodia helianthoides-very common
Serpulidae, unid.
Tealia crassicornis
Tonicella lineata
Volutharpa ampullacea

Appendix A-5. Abundance of major macroinvertebrates in 1/16 m^2 quadrats from mid-intertidal zone on rock pinnacle in entrance to Koyuktolik Lagoon, 7/10/76.

	Katharina tunicata	*Tonicella insignis*	*Evasterias troschelii*
	3	0	0
	1	0	0
	2	0	0
	5	0	0
	2	0	0
	1	0	5
	2	0	0
	2	0	0
	0	1	0
	1	0	0
	4	0	0
	2	1	0
	4	0	1
	6	0	0
	1	0	0
	2	0	0
	5	1	0
	4	0	0
	7	2	0
	1	0	0
	6	1	0
	0	0	0
$\bar{x}$	2.8	0.3	0.3
s	2.0	0.6	1.1
Estimated No./m^2	44.4	4.6	4.4

Appendix A-6. Species observed in outer lagoon, Koyuktolik Bay, 7/9/76.

Macrophytes

Chlorophyta

? *Monostroma* sp.

Rhodophyta

Ahnfeltia plicata
Halosaccion glandiforme

Phaeophyta

Alaria sp.
Costaria costata
Cymathere triplicata
Laminaria ? *saccharina*

Angiospermae

Zostera marina

Invertebrates

Astarte sp.
Clinocardium nuttalli
Evasterias troschelii
Haliclystis sp.-common
Lucuna sp.
Macoma sp.
Margarites helicinus
Mopalia sp.
Musculus ? *vernicosus*
Mya ? *arenaria*
Mya truncata
Natica sp.
Oregonia gracilis
Protothaca staminea
Pycnopodia helianthoides
Saxidomus gigantea
Syconidae, unid.
Telmessus cheiragonus
Tresus capax

Fishes

Ammodytes hexapterus (Pacific sand lance)
Hexagrammos stelleri (White spotted greenling)
Salvelinus malma (Dolly Varden trout)

Marine Mammals

Euhydra lutris (Sea otter)

Subtrate: mud and sand/gravel patches with heavy shell debris.

Appendix A-7. Species observed in the inner lagoon, Koyuktolik Bay, 7/9/76.

Macrophytes

Zostera marina - about 10/m^2, in sparse patches.
? Monstroma sp. - sparse

Invertebrates

Abarenicola ? pacifica - common.

Substrate: Silt with some shell debris.

Appendix A-8. Relative cover and abundance data for <u>Zostera marina</u> and <u>Ahnfeltia plicata</u> in 1/16 m^2 quadrats in eelgrass bed in the lagoon at Koyuktolik Bay, 7/9/76.

Transition Zone of Inner and Outer Lagoon

Zostera													
No. of turions	0	0	0	0	0	0	0	0	0	41	27	37	36
Percent cover	0	0	0	0	0	0	0	0	0	90	100	90	100
Ahnfeltia-Percent cover	100	100	100	100	100	100	100	100	100	0	0	0	0

Zostera												$\bar{x} \pm s$	No. per m^2
No. of turions	21	34	0	0	6	26	0	0	0	0	0	11.4 ± 15.9	182
Percent cover	90	100	0	0	40	60	10	90	95	35	50	39.6 ± 43.2%	
Ahnfeltia - Percent cover	0	0	100	100	60	40	90	0	0	0	0	53.8 ± 48.4%	

Middle of Outer Lagoon

Zostera												
No. of turions	31	42	24	33	64	23	35	21	0	45	36	43
Percent cover	100	100	75	100	100	100	100	80	5	100	100	95

Zostera			$\bar{x} \pm s$	No. per m^2
No. of turions	5	23	30.4 ± 16.4	485.7
Percent cover	20	60	8.11 ± 31.7%	

Appendix A-9. Turion height data, *Zostera marina* from middle of outer lagoon, Koyuktolik Bay, 7/9/76.

Maximum Leaf Length* (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)
61.0	127.0	121.0	122.0	81.0
95.0	100.0	50.0	75.0	104.0
104.0	134.0	99.0	100.0	123.0
63.0	136.0	120.5	43.0	138.0
128.0	46.0	38.0	126.0	89.0
93.0	129.0	128.0	141.0	103.0
110.0	127.0	137.0	122.0	130.0
124.0	112.0	121.0	123.0	89.0
129.0	139.0	131.0	54.0	97.0
118.0	92.0	129.0	58.0	90.0
139.5	111.0	73.5	128.0	125.5
118.5	114.0	103.0	91.0	103.0
122.0	107.0	134.0	106.0	80.0
130.0	123.0	97.0	129.5	113.0
103.0	107.5	103.0	120.0	123.5
130.0	130.0	118.0	121.5	142.0
120.0	86.0	88.0	120.0	133.0
113.0	81.5	112.0	70.0	84.0
116.0	97.0	113.0	82.5	119.0
121.0	114.0	111.0	98.0	85.0

$n = 100$
$\bar{x} \pm s = 107.9 \pm 24.1$ cm
Range = 38.0 - 142.0 cm

* Length of longest leaf from upper node.

Appendix A-10. Number of turions of *Zostera marina* in 1/16 m^2 quadrats in eelgrass beds of outer lagoon, Koyuktolik Bay, 8/30/76.

INNER EDGE

23	24	27	19	21
6	18	23	44	42
20	19	36	54	36

Average number per 1/16 m^2 quadrat: $\bar{x} \pm s = 27.5 \pm 12.5$

Estimated density = 440 plants/m^2

Note: area interspersed with broad channels of *Ahnfeltia plicata*

OUTER EDGE

22	59	35	44	39
42	34	39	30	49
37	29			

Average number per 1/16 m^2 quadrat: $\bar{x} \pm s = 38.3 \pm 9.7$

Estimated density = 612 plants/m^2

Appendix A-11. Turion height data; Zostera marina from middle of outer lagoon, Koyuktolik Bay, 8/30/76.

Maximum Leaf Length* (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)
231.5	236.0	75.0	178.0	194.0
90.5	144.0	121.0	115.0	160.5
33.0	162.0	164.0	149.0	194.5
171.5	185.0	154.0	212.5	121.5
226.0	194.0	96.0	197.0	89.0
214.0	137.5	162.5	120.0	91.0
222.5	178.0	184.5	117.5	31.5
120.5	206.0	161.0	171.5	146.5
111.0	155.0	168.0	203.0	121.0
187.0	189.5	201.5	186.0	191.0
140.5	179.5	123.5	151.5	182.0
131.0	73.0	169.5	109.0	209.5
173.0	207.0	100.5	96.5	195.5
230.0	61.0	215.5	157.5	117.5
181.0	166.5	214.0	248.0	196.5
153.0	149.5	208.0	231.0	177.0
148.5	167.0	218.0	219.0	116.5
183.0	194.0	196.5	149.5	100.0
202.0	152.5	109.0	116.0	
120.0	188.5	139.0	113.0	

n = 99
$\bar{x} \pm s = 160.0 \pm 46.3$ cm
Range: 31.5 - 248.0 cm

* Length of longest leaf from upper node.

Appendix A-12. Turion height and wet weight data for Zostera marina from the transition zone between the inner and outer lagoons, Koyuktolik Bay, 7/9/76.

Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight (gm)
98.5	6.73	109.5	5.15	79.0	3.89	117.0	10.62
130.0	17.21	116.0	5.80	103.5	7.73	115.0	11.00
137.0	14.02	120.5	5.85	80.0	4.20	49.0	2.10
83.0	3.65	108.0	6.81	110.0	17.75	106.0	10.82
90.0	4.53	125.5	8.45	109.0	3.79	108.0	10.51
149.0	16.02	120.5	9.47	67.0	4.35	111.0	9.48
111.0	3.75	48.0	1.12	43.0	1.30	146.0	17.23
64.0	2.08	62.0	1.44	97.0	5.06	59.0	3.48
130.0	6.18	99.0	3.24	73.0	3.13	109.0	16.10
92.0	4.33	143.0	6.00	60.0	1.97	42.0	1.80
99.0	5.13	83.0	2.52	92.0	14.62	94.0	6.85
139.5	9.43	59.0	1.80	84.0	4.08	102.0	7.07
101.0	4.87	100.0	10.16	63.0	4.21	46.5	1.13
173.0	26.01	88.0	4.21	28.0	1.07	97.0	5.90
109.0	8.75	80.0	4.32	46.0	1.44	125.0	13.86

n = 60

Mean Plant Height: $\bar{x} \pm s = 95.5 \pm 30.6$ cm

Mean Plant Weight: $\bar{x} \pm s = 6.9 \pm 5.2$ gm

Turion Height range: 28.0 - 173.0 cm

Appendix A-13. Turion height data; Zostera marina from inner edge of ıter lagoon, Koyuktolik Bay, 8/30/76.

Maximum Leaf Length* (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)
75.5	107.0	94.0
137.0	28.5	186.5
97.0	108.5	104.0
165.5	92.5	54.0
181.5	188.5	217.0
150.5	79.0	152.5
179.5	184.5	132.0
170.0	177.0	88.0
199.0	137.0	125.5
77.0	152.0	169.0
200.0	187.0	37.0
157.5	148.0	52.0
208.0	116.5	151.5
132.5	135.5	152.0
106.0	175.0	184.0
172.5	87.0	37.0
61.0	190.0	111.0
200.0	83.5	86.0
163.5	103.5	47.0
76.0	42.5	213.0
77.5	78.0	189.5
212.0	203.0	
87.0	67.5	

n = 67

$\bar{x} \pm s = 130.5 \pm 53.2$ cm

Range: 28.5 - 217.0 cm

* Length of longest leaf from upper node

Appendix A-14. Turion height and wet weight data for *Zostera marina* from inner lagoon, Koyuktolik Bay, 7/9/76.

Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight (gm)
90.0	4.12	103.0	6.36	44.0	6.35	80.0	5.16
118.5	6.47	67.0	2.97	42.0	6.18	107.0	8.88
87.0	10.42	30.0	3.28	35.0	0.98	106.0	5.48
99.5	5.42	84.0	3.51	33.0	2.49	32.0	2.28
134.0	18.02	67.0	5.91	45.0	3.46	30.0	3.48
122.0	9.07	100.0	8.83	36.0	1.52	36.0	2.86
87.0	4.60	44.0	1.56	41.0	1.86	27.5	1.59
128.0	10.21	68.0	2.95	34.0	1.57	42.0	4.50
68.0	4.49	58.0	4.54	33.0	0.92	92.0	4.40
106.0	21.66	47.0	1.19	36.0	1.30	89.0	4.49
136.0	10.28	75.0	2.67	44.0	2.33	132.0	9.52
91.0	8.45	70.0	2.06	116.0	8.99		
79.0	4.61	72.0	3.60	105.0	10.36		

n = 50
Mean Plant Height: $\bar{x} \pm s = 73.0 \pm 33.2$ cm
Mean Plant Wet Weight: $\bar{x} \pm s = 5.4 \pm 4.1$ gm
Range: 27.5 - 13.60 cm

Appendix A-15. Turion height, wet weight and dry weight data for _Zostera marina_ from middle of outer lagoon, Koyuktolik Bay, 7/9/76.

Maximum Leaf Length (cm	Wet Weight (gm)	Dry Weight (gm)	Dry Weight Wet Weight Ratio	Maximum Leaf Length (cm)	Wet Weight (gm)	Dry Weight (gm)	Dry Weight Wet Weight Ratio
139.5	8.82	0.90	0.102	107.0	4.15	0.38	0.092
118.5	6.19	0.66	0.106	123.0	4.69	0.38	0.081
122.0	10.21	0.92	0.090	107.5	5.13	0.47	0.092
130.0	8.32	0.78	0.094	130.0	4.78	0.41	0.086
103.0	7.03	0.66	0.094	86.0	3.43	0.31	0.090
130.0	8.38	0.79	0.094	81.5	3.06	0.29	0.095
120.0	8.29	0.79	0.095	97.0	5.59	0.40	0.072
113.0	9.97	0.96	0.096	114.0	5.35	0.47	0.088
116.0	6.49	0.59	0.091	73.5	2.36	0.18	0.076
121.0	9.57	0.93	0.097	103.0	4.82	0.42	0.087
111.0	6.06	0.63	0.104	134.0	8.21	0.69	0.084
114.0	5.63	0.51	0.091	97.0	2.53	0.17	0.067

Average Dry Weight/Wet Weight Ratio: $\bar{x} \pm s = 0.09 \pm 0.01$

Appendix A-16. Data on relationship between turion height and dry weight for *Zostera marina* from inner edge of outer lagoon, Koyuktolik Bay, 8/30/76.

Maximum Leaf Length (cm)	Dry Weight (gm)
208.0	1.23
132.5	0.37
106.0	0.44
163.5	0.52
76.0	0.14
77.5	0.24
212.0	0.98
28.5	0.11
92.5	0.40
188.5	0.95
152.0	0.51
148.0	0.62
83.5	0.22
42.5	0.11
203.0	0.98
186.5	0.95
54.0	0.09
217.0	0.91
151.5	0.62
86.0	0.32
213.0	0.99

Appendix A-17. Relative cover data for <u>Mytilus edulis</u> and <u>Fucus distichus</u> in outer mussel bed, entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

% Cover*		% Cover		% Cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
At east end of bed		Moving toward northwest corner bed		0	85	0	100
				0	90	0	100
0	20	30	50	0	90	0	100
5	70	5	40	0	95	0	100
0	80	0	70	At northwest corner, moving south		0	100
0	75	0	5	0	95	0	100
0	75	0	40	0	85	0	99
0	50	0	55	0	95	0	95
0	90	0	95	0	100	0	90
0	100	0	95	0	99	0	100
0	95	0	15	0	100	0	100
0	90	0	90	0	100	0	100
0	25	0	90	0	100	0	100
0	60	0	90	0	40	0	100
0	65	0	10	0	25	0	95
0	90	0	15	0	50	0	99
1	85	0	95	0	99	0	100
0	30	0	60	0	60	0	0
0	95	0	80	0	85	0	0

% Cover		% Cover		% Cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
At east corner moving to southwest corner		25	90	0	98	0	100
0	85	0	100	0	75	0	100
0	50	0	100	0	100	0	95
0	75	25	85	0	75	0	95
0	80	0	75	0	80	0	100
0	40	0	90	0	85	0	100
40	95	0	97	0	85	0	100
60	75	At southwest corner moving north and through center		0	95	0	45
50	70	0	50	0	100	0	90
0	90	0	75	0	85	0	100
0	100	5	75	0	98	0	70
0	95	2	97			0	90

Appendix A-17 (Cont.). Relative cover data to Mytilus edulis and Fucus distichus in outer mussel bed, entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

% Cover		% Cover		% Cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
10	100	0	85	0	85	0	90
10	80	0	100	0	90	0	65
0	95	0	98	0	100	0	85
0	100	0	98	0	90	0	90
0	90	0	98	0	60	0	80
0	90	0	95	0	90	0	97
0	90	0	95	0	95	0	100
0	50	0	100	0	75	0	65
80	100	0	100	0	70	0	95
0	70	0	100	0	98	0	95
25	70	0	98	0	75	0	95
5	70	0	80	0	15	0	60
0	65	0	40	0	40	0	70
0	75	0	95	0	25	0	75
0	100	0	95	0	65	0	35
0	90	0	98	0	35	0	10
0	80	0	100	0	40	0	30
0	100	0	95	0	25	0	45
0	100	0	98	0	45	0	50
0	100	0	100	0	50	0	30
0	100	0	98	0	40	0	65
0	100	0	90	0	70	0	100
0	80	0	75	0	70	0	100
0	80	0	80	0	40	0	0

Relative cover by Fucus: $\bar{x} \pm s = 1.8 \pm 8.9\%$
Relative cover by Mytilus: $\bar{x} \pm s = 79.6 \pm 23.9\%$

* Visual estimates based on haphazard casts with 1/16 m^2 quadrat

Appendix A-18. Size data, Mytilus edulis from outer bed on entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

80 m from upper edge

Shell Length (mm)	Sample No. 1 Frequency	Sample No. 2 Frequency	Total	Percent
5	0	1	1	1.2
6	0	0	0	0.0
7	0	0	0	0.0
8	0	0	0	0.0
9	0	0	0	0.0
10	2	0	2	2.4
11	0	0	0	0.0
12	0	2	2	2.4
13	2	0	2	2.4
14	4	2	6	7.1
15	1	1	2	2.4
16	1	0	1	1.2
17	2	1	3	3.6
18	4	3	7	8.3
19	1	0	1	1.2
20	0	1	1	1.2
21	0	0	0	0.0
22	2	1	3	3.6
23	3	3	6	7.1
24	2	3	5	6.0
25	2	1	3	3.6
26	0	2	2	2.4
27	3	2	5	6.0
28	4	4	8	9.5
29	1	2	3	3.6
30	3	6	9	10.7
31	2	0	2	2.4
32	2	0	2	2.4
33	1	0	1	1.2
34	0	0	0	0.0
35	1	2	3	3.6
36	1	0	1	1.2
37	1	1	2	2.4
38	0	0	0	0.0
39	0	0	0	0.0
40	0	1	1	1.2
$\bar{x} \pm s$ (mm)	23.3 ± 7.4	24.5 ± 7.5	23.8 ± 7.4	
n	45	39	84	

Appendix A-18 (Cont.). Size data, *Mytilus edulis* from outer bed on entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

150 m from upper edge, 10 m from lower edge

Shell Length (mm)	Sample No. 1 Frequency	Sample No. 2 Frequency	Total	Percent
4	0	1	1	0.8
5	1	1	2	1.7
6	0	0	0	0.0
7	0	0	0	0.0
8	1	1	2	1.7
9	0	1	1	0.8
10	0	0	0	0.0
11	0	0	0	0.0
12	0	1	1	0.8
13	0	2	2	1.7
14	1	1	2	1.7
15	1	3	4	3.4
16	0	1	1	0.8
17	1	5	6	5.1
18	4	4	8	6.7
19	0	2	2	1.7
20	3	1	4	3.4
21	1	0	1	0.8
22	0	5	5	4.2
23	4	3	7	5.9
24	0	2	2	1.7
25	4	2	6	5.1
26	1	3	4	3.4
27	4	2	6	5.1
28	4	3	7	5.9
29	0	1	1	0.8
30	3	3	6	5.1
31	4	2	5	5.1
32	5	2	7	5.9
33	3	1	4	3.4
34	2	1	3	2.5
35	1	3	4	3.4
36	0	1	1	0.8
37	0	2	2	1.7
38	2	2	4	3.4
39	0	0	0	0.0
40	1	0	1	0.8
41	0	0	0	0.0
42	3	0	3	2.5
43	0	1	1	0.8
44	0	0	0	0.0
45	0	0	0	0.0
46	0	0	0	0.0
47	0	0	0	0.0
48	0	0	0	0.0
49	0	0	0	0.0
50	0	1	1	0.8
$\bar{x} \pm s$ (mm)	27.2 ± 8.0	24.1 ± 9.3	25.5 ± 8.8	
n	54	64	118	

Appendix A-19. Relative cover data for Mytilus edulis and Fucus distichus in inner mussel bed, entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

% Cover		% Cover		% Cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
75 m north of		0	0	0	25	100	80
southern tip,		At upper edge of		0	5	0	80
moving ENE		bed, moving due		0	5	80	70
across bed		south		0	10	0	85
100	100	0	40	Moving SSW		0	85
100	100	0	0			0	90
10	90	0	0	0	20	0	95
20	60	0	90	0	90	0	0
0	20	0	0	0	75	0	40
0	95	0	70	2	95	0	100
0	50	0	10	0	100	0	100
0	75	0	0			Moving west	
0	50	40	60	Moving west			
0	75	0	95	0	100	0	85
0	30	60	60	5	50	0	0
0	70	0	25	0	65	0	90
0	75	0	70	0	70	2	95
1	95	0	25	0	90	0	0
0	60	0	5	0	90	0	25
0	10	0	85	20	90	0	100
0	10	At SE corner of		40	85	10	65
		bed					
0	5	Moving WSW		0	50	Ended at SW	
0	1	0	75	Back at 75 m		corner of bed	
0	0	0	20	location, moving			
				south			

% Cover		% Cover		% Cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
5	75	15	50	2	55	0	65
5	100	5	40	2	65	0	80
70	100	0	80	15	75	0	75
65	75	60	60	5	70	0	50
75	70	2	55	2	50	0	0
15	60	10	60	0	40	0	35
0	70	0	15	0	50	0	70

Appendix A-19 (Cont.). Relative cover data for *Mytilus edulis* and *Fucus distichus* in inner mussel bed, entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

% Cover		% Cover		% Cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
0	40	0	85	10	65	80	75
0	75	15	60	2	65	2	55
0	60	2	90	60	75	2	60
0	40	20	40	0	45	60	60
0	80	0	60	0	45	20	80
0	75	100	80	0	55	0	95
0	60	60	60	0	75	0	75
0	75	10	55	0	85	25	70
0	65	15	50	0	75	20	95
0	50	2	45	15	70	2	70
0	80	50	70	0	60	75	80
0	80	35	55	0	50	0	65
0	65	30	45	0	55	0	100
0	60	50	80	0	70	0	95
2	45	20	60	0	55	0	0
0	0	80	65	0	80	65	65
0	80	40	60	0	45	0	0
0	90	75	85	2	55	0	0

Relative cover by *Fucus*: $\bar{x} \pm s = 11.2 \pm 24.1\%$
Relative cover by *Mytilus*: $\bar{x} \pm s = 58.9 \pm 29.2\%$

* Visual estimates based on haphazard casts with 1/16 m^2 quadrat.

Appendix A-20a. Size data, *Mytilus edulis*, 5 m from south end of the inner bed in entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	Station No. 1 Frequency	Station No. 2 Frequency	Total	%
5	0	1	1	0.6
6	0	2	2	1.2
7	0	5	5	3.1
8	4	6	10	6.1
9	2	4	6	3.7
10	1	7	8	4.9
11	2	4	6	3.7
12	4	14	18	11.0
13	5	9	14	8.5
14	8	5	13	7.9
15	6	5	11	6.7
16	6	2	8	4.9
17	5	3	8	4.9
18	5	0	5	3.1
19	2	1	3	1.8
20	4	3	7	4.3
21	3	3	6	3.7
22	5	2	7	4.3
23	2	0	2	1.2
24	1	1	2	1.2
25	0	2	2	1.2
26	0	3	3	1.8
27	0	1	1	0.6
28	0	0	0	0.0
29	0	0	0	0.0
30	0	1	1	0.6
31	0	1	1	0.6
32	1	1	2	1.2
33	1	2	3	1.8
34	0	1	1	0.6
35	1	0	1	0.6
36	1	0	1	0.6
37	0	2	2	1.2
38	1	0	1	0.6
39	0	0	0	0.0
40	0	0	0	0.0
41	1	0	1	0.6
42	0	0	0	0.0
43	0	0	0	0.0
44	0	0	0	0.0
45	1	0	1	0.6
46	0	0	0	0.0
47	1	0	1	0.6
n	73	91	164	
$\bar{x} \pm s$ (mm)	18.3 ± 8.3	15.3 ± 7.7	16.7 ± 8.1	

Approx. No./m^2 = 17,826

Appendix A-20b. Size data, *Mytilus edulis*, 10 m from south end of the inner bed in entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	Sample No. 1	Sample No. 2	Total	Shell Length (mm)	Sample No. 1	Sample No. 2	Total
7	0	1	1	29	0	1	1
8	1	4	5	30	3	2	5
9	1	2	3	31	0	0	0
10	0	7	7	32	2	1	3
11	0	5	5	33	0	0	0
12	4	13	17	34	1	2	3
13	6	18	24	35	1	1	2
14	2	15	17	36	0	2	2
15	1	7	8	37	2	0	2
16	5	4	9	38	3	2	5
17	4	14	18	39	1	0	1
18	3	9	12	40	1	0	1
19	2	4	6	41	0	0	0
20	3	5	8	42	0	1	1
21	2	2	4	43	1	2	3
22	1	1	2	44	0	0	0
23	2	3	5	45	1	0	1
24	2	4	6	46	0	0	0
25	1	4	5	47	0	1	1
26	0	1	1	48	0	2	2
27	0	2	2	49	0	0	0
28	0	2	2	50	2	0	2

n	58	144	202
$\bar{x}$	23.2	18.3	
s	10.9	8.7	9.6

Appendix A-20c. Size data, *Mytilus edulis* 30 m from south end of the inner bed in entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	Sample No. 1 Frequency	Sample No. 2 Frequency	Total	%
7	1	1	2	1.7
8	2	1	3	2.6
9	4	3	7	6.0
10	3	4	7	6.0
11	3	1	4	3.4
12	1	5	6	5.1
13	3	6	9	7.7
14	1	2	3	2.6
15	2	7	9	7.7
16	6	4	10	8.6
17	1	1	2	1.7
18	4	3	7	6.0
19	2	1	3	2.6
20	3	1	4	3.4
21	5	1	6	5.1
22	1	2	3	2.6
23	0	2	2	1.7
24	0	1	1	0.9
25	0	1	1	0.9
26	1	1	2	1.7
27	1	1	2	1.7
28	1	0	1	0.9
29	0	0	0	0.0
30	2	1	3	2.6
31	0	0	0	0.0
32	0	4	4	3.4
33	1	1	2	1.7
34	1	1	2	1.7
35	0	1	1	0.9
36	0	1	1	0.9
37	0	1	1	0.9
38	4	0	4	3.4
39	0	0	0	0.0
40	0	0	0	0.0
41	0	0	0	0.0
42	0	2	2	1.7
43	0	1	1	0.9
44	0	1	1	0.9
45	0	0	0	0.0
46	0	0	0	0.0
47	0	0	0	0.0
n	53	64	117	
$\bar{x} \pm s$ (mm)	18.6 ± 8.6	20.3 ± 10.4	19.6 ± 9.6	

Approx. No./m^2 = 12,717

Appendix A-20d. Size data, Mytilus edulis 75 m from south end of the inner bed in entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	Station No. 1 Frequency	Station No. 2 Frequency	Total	%
9	3	1	4	6.1
10	2	0	2	3.0
11	0	0	0	0.0
12	3	1	4	6.1
13	0	2	2	3.0
14	0	2	2	3.0
15	0	0	0	0.0
16	1	2	3	4.6
17	1	1	2	3.0
18	1	0	1	1.5
19	1	0	1	1.5
20	1	1	2	3.0
21	0	1	1	1.5
22	1	3	4	6.1
23	2	0	2	3.0
24	0	0	0	0.0
25	1	0	1	1.5
26	0	1	1	1.5
27	2	3	5	7.6
28	0	4	4	6.1
29	0	0	0	0.0
30	2	2	4	6.1
31	1	1	2	3.0
32	1	0	1	1.5
33	0	0	0	0.0
34	1	0	1	1.5
35	1	0	1	1.5
36	0	0	0	0.0
37	0	2	2	3.0
38	0	0	0	0.0
39	0	1	1	1.5
40	1	3	4	6.1
41	0	0	0	0.0
42	2	2	4	6.1
43	0	0	0	0.0
44	0	0	0	0.0
45	1	0	1	1.5
46	0	0	0	0.0
47	0	1	1	1.5
48	2	0	2	3.0
49	0	0	0	0.0
50	0	1	1	1.5
n	31	35	66	
$\bar{x} \pm s$ (mm)	25.1 ± 12.4	27.3 ± 10.9	26.2 ± 11.6	
Approximate No./m^2	7,174			

Appendix A-21. Observations of predation at Koyuktolik Bay, 7/9 and 7/10/76.

Predator	Prey	Depth (m)	Number	Type of Evidence
BAY				
Pycnopodia helianthoides	*Echinarachinus parma*	12	1	Direct
Melanitta sp.	Small clams	12	Numerous	Indirect
ENTRANCE CHANNEL				
Salvelinus malma (Dolly Varden)	Gammarid amphipods	2	Numerous	Direct
Corvus caurinus (Northwestern crow)	*Mytilus edulis*	Intertidal	Numerous	Indirect
Larus spp. (Gulls)	*Mytilus edulis*	Intertidal	Numerous	Indirect
Evasterias troschelii	*Mytilus edulis*	2	4	Direct
LAGOON				
Enhydra lutris (Sea otter)	*Saxidomus gigantea*	2	Numerous	Indirect
	Mya truncata	2	Numerous	Indirect

Appendix B-1. Abundance of macrophytes and echinoids in 1/4 m^2 quadrats in Raft Cove, Chugach Bay, 7/6/76.

	Quadrat 1	2	3	4	5	6	7	8	$\bar{x} \pm s$	No. per m^2
Alaria sp.	0	0	0	3	4	0	0	0	0.9 ± 1.6	3.5
Cymathere triplicata	0	0	0	4	2	0	5	0	1.4 ± 2.1	5.5
Desmarestia spp.	2	0	0	6	0	0	4	0	1.5 ± 2.3	6.0
Laminaria ? groenlandica	5	15	11	4	6	0	4	0	5.6 ± 5.2	22.5
Nereocystis luetkeana	1	0	0	11	0	0	10	1	2.9 ± 4.7	11.5
Phaeophyta, unid. (juveniles)	6	0	0	25	0	15	21	19	10.8 ±10.4	43.0
Strongylocentrotus drobachiensis	0	0	2	0	0	0	2	0	0.5 ± 0.9	2.0
Depth (m)	10.7	10.7	10.7	10.7	10.7	9.1	9.1	9.1		

Appendix B-2. Abundance of macrophytes and echinoids in 5 x 1 m quadrats off Raft Cove, Chugach Bay, 7/6/76.

Species	Quadrats 1	2	Total	No. per m^2
Agarum cribrosum	104	42	146	14.6
Laminaria groenlandica	123	46	169	16.9
Pleurophycus gardneri	3	5	8	0.8
Strongylocentrotus drobachiensis	1	0	1	0.1

Habitat Notes:		
Depth (m)	15.8	16.1
Substrate	Rock	Sand w/rock patches

Appendix B-3. Abundance and relative cover of macrophytes and echinoderms in 1/4 m^2 quadrats off Raft Cove, Chugach Bay in 7.5-13.5 m depths, 7/16/76.

	Quadrats														
	1	2	3	4	5	6	7	8	9	10	11	12	13	$\bar{x} \pm s$	No. Per m^2
Agarum cribrosum (N)	2	3	0	0	0	0	0	3	0	3	0	0	0	0.8 ± 1.3	3.2
Agarum cribrosum (C)	0	0	0	0	0	0	0	40%	0	40%	0	0	0	6.2 ± 15.0%	0.0
Laminaria groenlandica (N)	0	0	0	0	2	0	0	2	0	2	4	5	7	1.7 ± 2.3	6.8
Laminaria groenlandica (C)	70%	0	50%	50%	20%	70%	70%	10%	75%	10%	50%	20%	65%	43.1 ± 27.3%	0.0
L. yezoensis (N)	0	0	0	1	0	0	0	0	0	0	0	0	0	0.1	0.4
Pleurophycus gardneri (N)	0	2	1	2	4	0	4	0	0	0	3	7	2	1.9 ± 2.1	7.6
Pleurophycus gardneri (C)	0	40%	40%	30%	60%	0	30%	0	0	0	40%	60%	15%	24.2 ± 23.1%	0.0
Crossaster papposus (N)	0	0	0	1	0	0	0	0	0	0	0	0	0	0.1	0.4
Henricia sp. (N)	0	0	1	0	0	0	0	3	0	0	0	0	0	0.3 ± 0.9	1.2
Strongylocentrotus droebach-	0	0	0	0	0	1	0	3	1	0	2	0	0	0.5 ± 1.0	2.0
S. franciscanus	0	0	0	0	0	0	0	2	0	0	0	0	0	0.2	0.8
Tosiaster arcticus (N)	0	0	0	0	1	0	0	0	0	0	0	1	0	0.2	0.8
Depth (m)	13.5	13.0	12.0	11.0	11.5	10.5	10.5	10.5	10.5	10.5	9.0	9.0	7.5		

Appendix B-4. Abundance and relative cover of organisms in 1/4 m^2 quadrats at 30 feet off Raft Cove, Chugach Bay, 7/8/76.

Species	Quadrats 1	2	3	x̄ ± s
Constantinea simplex (C)	0	0	1%	0.3% ± 0.6
Corallina vancouveriensis (C)	5%	2%	0	2.3% ± 2.5
encrusting coralline alga (C)	50%	70%	55%	58.3% ± 10.4
Delesseria decipiens (C)	0	0	1%	0.3% ± 0.6
Laminaria ? setchellii (adult) (C)	75%	25%	60%	53.3% ± 25.7
Laminaria ? setchellii (adult) (N)	0	0	4	1.3 ± 2.3
Laminaria ? setchellii (juvenile) (N)	0	8	8	5.3 ± 4.6
Opuntiella californica (C)	0	2%	0	0.7% ± 1.2
Phaeophyta, unid. (juvenile) (N)	0	3	0	1.0 ± 1.7
Pleurophycus gardneri (C)	50%	75%	20%	48.3% ± 27.5
Pleurophycus gardneri (adult) (N)	0	4	4	2.7 ± 2.3
Pleurophycus gardneri (juvenile) (N)	0	1	1	0.7 ± 0.6
Abietinaria sp. (C)	1%	10%	15%	8.7 ± 7.1
? Aplidium solidum (C)	0	6%	1%	2.3% ± 3.2
Asteriidae, unid. (small) (N)	0	1	1	0.7 ± 0.6
Dendrobeania murrayana (C)	0	1%	1%	0.7% ± 0.6
Heteropora sp. (C)	0	1%	0	0.3% ± 0.6
Margarites pupillus (N)	0	0	2	0.7 ± 1.2
Microciona sp. (C)	2%	1%	2%	1.7 ± 0.6
Microporina borealis (C)	0	15%	5%	6.7% ± 7.6
Notoacmaea instabilis (N)	0	1	0	0.3 ± 0.6
Ophiopholis aculeata (N)	0	0	P	
Paguridae, unid. (N)	3	2	6	3.7 ± 2.1
? Rhabdodermella sp. (C)	0	0	2%	0.7 ± 1.2
Bryozoa (unid. brown encruster) (C)	3%	3%	0	2.0% ± 1.7
Crucigera sp. (N)	1	0	0	0.3 ± 0.6
Synoicum sp. (C)	0	1	0	0.3 ± 0.6
Tonicella insignis (N)	2	0	0	0.6 ± 1.2
Trichotropis cancellata (N)	0	0	1	0.3 ± 0.6
Trophon multicostatus (N)	0	1	0	0.3 ± 0.6
Tunicate, encrusting orange, social (C)	0	0	2	0.6 ± 1.2

Extralimital species: Musculus vernicosus sparse on kelps.

Habitat Notes: Bottom of boulders from 2' to 8' in diameter, up to 10' relief, extending to intertidal nearby.

Bottom dominated by Laminaria ? setchellii and Pleurophycus gardneri.

Appendix B-5. Abundance and relative cover of organisms in 1/4 m^2 quadrats off Raft Cove, Chugach Bay, 7/6/76.

	1	2	3	4	5	6	7	8	$\bar{x} \pm s$	No. per m^2
Agarum cribrosum (C)	20%	0	15%	0	20%	30%	0	60%	18.1 ± 20.3%	
Agarum cribrosum (N)	0	0	0	0	4	1	0	2	0.9 ± 1.5	3.5
Callophyllis sp. (C)	0	0	0	0	10%	2%	0	5%	2.1 ± 3.6%	
Constantinea sp. (C)	0	0	0	0	0	5%	0	2%	0.9 ± 1.8%	
encrusting coralline alga (C)	0	0	0	0	80%	70%	80%	85%	39.4 ± 42.3%	
Hildenbrandia sp. (C)	0	0	0	0	0	5%	10%	0	1.9 ± 3.7%	
Laminaria groenlandica (C)	40%	25%	15%	0	0	40%	0	40%	20.0 ± 18.7%	
Laminaria groenlandica (N)	0	0	2	0	0	2	0	2	0.8 ± 1.0	3.0
Laminaria sp. (C)	0	0	0	0	0	5%	5%	2%	. 1.5 ± 2.3%	
Laminaria sp. (N)	0	0	0	0	0	2	3	6	1.4 ± 2.2	5.5
Odonthalia kamschatica (C)	0	0	0	0	0	0	0	2%	0.3%	
Opuntiella californica (C)	0	0	0	0	0	5%	2%	0	0.9 ± 1.8%	
Pleurophycus gardneri (C)	0	0	0	15%	40%	60%	75%	0	23.8 ± 30.6%	
Pleurophycus gardneri (N)	0	0	0	1	4	1	4	0	1.3 ± 1.8	5.0
Ptilota sp. (C)	0	0	10%	0	0	2%	0	0	2.5 ± 4.6%	
Rhodophyta, unid. (filamentous) (C)	0	0	0	0	0	6%	0	0	0.8 ± 2.1%	
Rhodymenia pertusae (C)	0	0	10%	0	0	10%	10%	0	3.8 ± 5.2%	
Acmaea mitra (N)	0	0	0	0	1	0	0	0	0.1	0.5
Amphissa columbiana (N)	0	0	0	0	0	1	0	0	0.1	0.5
Calliostoma ligatum (N)	0	0	0	0	P	3	7	0	1.4 ± 2.5	5.5
Campanularia verticillata (C)	0	0	0	0	15%	0	0	0	1.9%	
Cliona celata (C)	0	0	0	0	0	0	0	2%	0.3%	
Dendrobeania ? murrayana (C)	0	0	0	0	5%	0	2%	2%	1.1 ± 1.8%	
Didemnum sp. (C)	0	0	0	0	0	0	0	2%	0.3%	
Distaplia sp. (C)	0	0	0	0	20%	25%	5%	0	6.3 ± 10.3%	
Distaplia sp. (N)	0	0	0	0	0	0	0	2	0.3	1.0
Flustrella gigantea (C)	0	0	0	0	5%	5%	10%	0	2.5 ± 3.8%	
Fusitriton oregonensis (N)	0	0	0	0	0	1	0	1	0.3 ± 0.5	1.0
Henricia sp. (N)	0	0	0	0	0	1	0	0	0.1	0.5
Heteropora sp. (C)	0	0	0	0	8%	0	5%	2%	1.9 ± 3.0%	
Margarites pupillus (N)	0	0	0	0	0	0	2	2	0.5 ± 0.9	2.0
Microcladia sp. (C)	0	0	0	0	0	20%	25%	15%	7.5 ± 10.7%	
Microporina borealis (C)	0	0	0	0	0	25%	50%	20%	11.9 ± 18.5%	
Musculus vernicosus (N)	0	0	0	0	P	0	0	0	P	
Pagurus sp. (N)	0	0	0	0	3	1	0	1	0.6 ± 1.1	2.5
Placiphorella sp. (N)	0	0	0	0	0	0	0	1	0.1	0.5
Polyplacophora, unid. (N)	0	0	0	0	0	0	0	1	0.1	0.5
Porifera, unid. (orange) (C)	0	0	0	0	0	0	0	5%	0.6%	
Puncturella multistriata (N)	0	0	0	0	0	0	1	0	0.1	0.5
Searlesia dira (N)	0	0	0	0	0	1	0	1	0.3 ± 0.5	1.0
Serpulidae, unid. (C)	0	0	0	0	0	2%	2%	2%	0.8 ± 1.0%	
Sertulariidae, five spp. (C)	0	0	0	0	10%	2%	10%	2%	3.0 ± 4.4	
Strongylocentrotus droebachiensis (N)	0	0	1	0	0	2	0	2	0.6 ± 0.9	2.5
Strongylocentrotus franciscanus (N)	0	0	0	0	0	0	1	0	0.1	0.5
Tonicella sp. (N)	0	0	0	0	3	3	3	3	1.5 ± 1.6	6.0
Tosiaster arcticus (N)	0	0	0	0	0	0	1	0	0.1	0.5
Tricellaria sp. (C)	0	0	0	0	0	2%	0	0	0.3%	
Trichotropis cancellata	0	0	0	0	P	P	P	0	P	

Habitat Notes

Substrate Type: Rock/Gravel/Gravel/Gravel/Rock/Rock/Rock/Rock
Gravel/Shell/Shell/ Shell
Shell

Depth (m) 16.5 16.5 16.5 16.5 15.5 12.0 12.0 12.0

Extralimital species: Abietinaria filicina (reproductive), Abietinaria turgida, Alaria crispa, Bonneviella grandis (reproductive), Calliostoma annulatum, Campanularia verticillata (mature), Odonthalia lyallii, Halecium labrosum (immature), Ptilosarcus gurneyi, Sertularella polyzonias (immature), Clupea harengus (juv., var 1-2" long), schooling 10'-15' above algal canopy, Sertularella polyzonias var. gigantea (immature), Sertularella tricuspidata (reproductive), Sertularella sp., Nassarius ? mendicus, Nucella lima

Appendix B-6. Abundance and relative cover of macrophytes in 1/4 m^2 quadrats at northeast point of Raft Cove, Chugach Bay, 7/5/76.

Species	Quadrats 1	2	3	4	5	6	7	8	9	10	$\bar{x} \pm s$
Agarum cribrosum (N)	1	0	0	0	2	1	4	0	1	3	1.2 ± 1.4
Agarum cribrosum (C)	30%	0	0	20%	60%	60%	15%	2%	25%	10%	22.2 ±22.4%
Laminaria groenlandica (N)	0	0	0	1	0	0	2	12	5	6	2.6 ± 4.0
Laminaria groenlandica (C)	0	0	0	60%	10%	10%	60%	80%	50%	80%	3.5 ±34.1%
Laminaria saccharina (C)	0	80%	0	0	0	0	0	0	0	0	8.0%
Pleurophycus gardneri (N)	0	0	0	0	0	0	0	0	0	1	0.1
Pleurophycus gardneri (C)	0	0	0	0	0	0	0	0	0	10%	1.0%
Depth (m)	10.5	10.5	-	9.0	9.5	9.0	9.0	8.5	8.5	8.0	9.2 m

Appendix B-7. Abundance and relative cover of rock substrate in 0.25 m^2 quadrats at northeast point of Raft Cove, Chugach Bay, 7/5/76.

Species	Quadrats 1	2	3	4	5	6	7	8	9	10	$\bar{x} \pm s$
Agarum cribrosum(N)[1/]			1				3		2	1	0.7 ± 1.1
Agarum cribrosum(C)[2/]		20%	10%		15%		70%		30%	20%	16.5 ± 21.6%
Bossiella sp.(C)			4%				5%	2%			1.1 ± 1.9%
Callophyllis sp.(C)										2%	0.2%
Constantinea sp.(C)			2%		2%	15%	15%	5%	2%	15%	5.6 ± 6.7%
Delesseria decipiens(C)							2%				0.2%
Desmarestia munda(N)			1								0.1
Desmarestia munda(C)			5%								0.5%
Encrusting coralline alga(C)			25%			70%	60%	30%		30%	21.5 ± 26.5%
Hildenbrandia sp.(C)						20%	30%	20%			7.0 ± 11.6%
Laminaria groenlandica(N)			1			2		5	2	4	1.4 ± 1.8
Laminaria groenlandica(C)			25%			15%		40%	30%	40%	15.0 ± 17.3%
L. saccharina(C)	25%			30%							5.5 ± 11.7%
L. yezoensis(N)							2				0.2
L. yezoensis(C)							20%				2.0%
Laminaria sp.(N)							2	3			0.5 ± 1.1
Laminaria sp.(C)							2%	2%			0.4 ± 0.8%
Microcladia sp.(C)										2%	0.2%
Ralfsia pacifica(C)							5%				0.5%
Rhodymenia pertusae(C)			2%	10%	10%	10%			2%		3.4 ± 4.6%
Acmaea mitra(N)							2		1	1	0.4 ± 0.7
Calliostoma ligatum(N)										1	0.1
Dendrobeania ? murrayana(C)								2%		2%	0.4 ± 0.8%
Diodora aspera(N)										1	0.1
Distaplia sp.(C)						5%	5%				1.0 ± 2.1%
Evasterias troschelii(N)										1	0.1
Flustrella gigantea(C)							2%				0.2%
Fusitriton oregonensis(N)										1	0.1
Heteropora sp.(C)						2%					0.2%
Microporina borealis(C)							2%			2%	0.4 ± 0.8%
Mopalia sp.(N)							1				0.1
Myriozoum ? tenue(C)										5%	0.5%
Musculus discors(N)									1		0.1
M. vernicosus						P					
Olivella baetica(N)		8									0.8
Paguridae, unid.(N)		1				2					0.3 ± 0.7
Placiphorella sp.(N)								1			0.1
Searlesia dira(N)							2				0.2
Strongylocentrotus droebachiensis(N)						1					0.1
Tonicella sp.(N)			3				4	3	1		1.1 ± 1.6
Trichotropis cancellata(N)							P	P			

1/ N = Number
2/ C = Relative cover

Habitat Notes:	1	2	3	4	5	6	7	8	9	10	$\bar{x} \pm s$
Substrate	S & SH	S & R	S & R	S	S, R & SH	R & Sh	R	R & S	R & S	R & S	
Depth (m)	11.5	11.5	11.5	11.5	11.5	10.5	10.5	10.5	10.5	10.5	11.0 ± 0.5

S = Sand
R = Rock
Sh= Shell

Appendix B-8. Density and relative cover of macrophytes in 1/4 m^2 quadrats inside south point at Chugach Bay, 7/5/76.

Species	Quadrats 1	2	3	4	5	6	7	$\bar{x} \pm s$	No. per m^2
Agarum cribrosum (N)	3	0	0	1	0	0	0	0.6 ± 1.1	2.3
Agarum cribrosum (C)	35%	10%	0	25%	0	0	45%	16.4 ± 18.6%	
Constantinea sp. (C)	20%	20%	0	20%	3%	10%	10%	11.9 ± 8.4%	
Encrusting coralline alga (C)	0	0	0	20%	10%	5%	15%	7.1 ± 8.1%	
Laminaria groenlandica (N)	2	1	0	2	3	0	0	1.1 ± 1.2	4.6
Laminaria groenlandica (C)	55%	20%	0	10%	75%	10%	0	24.3 ± 29.2%	
Laminaria saccharina (C)	0	0	15%	0	0	0	0	2.1%	
Laminaria yezoensis (N)	0	0	1	0	0	1	0	0.3 ± 0.5	1.1
Laminaria yezoensis (C)	0	0	75%	0	0	25%	0	14.3 ± 28.3 %	
Pleurophycus gardneri (N)	0	0	0	0	1	0	0	0.1	0.6
Pleurophycus gardneri (C)	0	0	0	0	25%	0	0	3.6%	
Rhodymenia pertusae (C)	0	0	0	10%	0	0	0	1.4%	
Rhodymenia pertusae (N)	0	0	0	0	0	0	0		
Rhodymenia sp. (C)	5%	0	0	0	0	0	0	0.7%	

Habitat Notes:	1	2	3	4	5	6	7
Depth (m):	12.5	12.5	12.0	12.0	12.0	12.0	12.0
Substrate:	Sand, scattered, rock	Sand, scattered, rock	Sand	Rock	Rock	Sand, rock	Sand, rock

Extralimital intertebrate species: Evasterias troschelii, Dermasterias imbricata, Fusitriton oregonensis (spawning), Paguridae, unid.

Appendix B-9. Abundance, relative cover and composition of organisms on rocks in 1/4 m^2 quadrats on western finger off southern headland, Chugach Bay, 7/8/76.

Depth: 21 m

Species	Quadrats 1	2	$\bar{x}$
Agarum cribrosum (N)	0	2	1.0
Agarum cribrosum (C)	0	30%	15.0%
Encrusting coralline alga (C)	30%	35%	32.5%
Hildenbrandia sp. (C)	2%	10%	6.0%
Membranoptera sp. (C)	0	5%	2.5%
Ptilota sp. (C)	2%	5%	3.5%
Abietinaria sp. (C)	15%	10%	12.5%
Alcyonidium ? pedunculatum (C)	0	1%	0.5%
Campanularia verticillata (C)	2%	0	1.0%
Cryptochiton stelleri (N)	1	0	0.5
Dendrobeania murrayana (C)	5%	2%	3.5%
Entoprocta, unid. (C)	1%	0	0.5%
Flustrella gigantea (C)	0	5%	2.5%
Henricia leviuscula (N)	1	0	0.5
Heteropora sp. (C)	2%	0	1.0%
Leptasterias leptalea	1	1	1.0
Margarites pupillus (N)	1	0	0.5
Microporina borealis (C)	20%	15%	17.5%
Obelia ? loveni (C)	0	10%	5.0%
Pagurus spp. (2 species) (N)	4	3	3.5
Placiphorella sp. (N)	1	0	0.5
Sertularia cupressoides (C)	0	5%	2.5%
Sertulariidae, (5 species) (C)	5%	0	2.5%
Strongylocentrotus droebachiensis (N)	1	0	0.5 (juvenile)
Trichotropis cancellata (N)	3	2	2.5
Tubularia sp. (N)	4	5	4.5 (reproductive)
Tunicate, orange enc. (C)	10%	5%	7.5%

Extralimital Species

Algae

Cryptonemia sp.
Rhodymenia palmata
R. pertusae

Invertebrates

Abietinaria turgida-reproductive
A. ? variabilis
Amphissa columbiana
Bougainvilliidae, unid.
Bryozoans, encrusting brown and encrusting orange
Hippothoa hyalina
Humilaria kennerlyi (Shell only)
Lafoea fruticosa
Leucosolenia sp.
Mopalia sp.
Musculus discors
Myriozoella plana
Myriozoum ? tenue
Orthasterias koehleri
Orthopyxis caliculata-reproductive
Oweniidae, unid.
Pagurus ? caurinus-juvenile
P. ? confragosus-juvenile
Pugettia gracilis

Appendix B-9 (Cont.). Abundance, relative cover and composition of organisms on rocks in 1/4 m^2 quadrats on western finger off southern headland, Chugach Bay, 7/8/76.

Calycella syringa
Campanularia speciosa-reproductive
C. volubilis-reproductive
Cancer oregonensis
Costazia ventricosa
Crossaster papposus
Dendrobeania ? murrayana
Dermasterias imbricata
Eudendrium vaginatum-reproductive
Garveia annulata-reproductive
Halecium ? labrosum-imm
Sabellidae, unid.
Serpulidae, unid.
Sertularella albida-reproductive
S. polyzonias var. gigantea-reproductive
Strongylocentrotus ? pallidus
Tonicella lineata
Trophon multicostatus

Vertebrates

Cottidae, unid.
Hexagrammos decagrammus

Habitat Notes: Bottom of low undulating rock fingers with boulders shale, shell sand and debris interspersed Agarum, Rhodymenia ? palmata, an encrusting orange colonial tunicate and hydroids dominated by cover. Fauna very complex.

Appendix B-10. Summary of density and relative cover data for the principal macrophyte species in the vicinity of Raft Cove, Chugach Bay, July 1976.

Location	N. of Raft Cove	N.E. Pt. of Raft Cove	N. of Raft Cove	N.E. Pt. of Raft Cove	Raft Cove	N.E. Pt. of Raft Cove	N.E. Pt. of Raft Cove	N. of Raft Cove	Raft Cove	N. of Raft Cove	S. of Point	N. of Raft Cove	N. of Raft Cove	N. of Raft Cove	E. of Point
Species Depth (m)	7.5 -9	8- 8.5	9	9- 9.5	9.1	10.5	10.5- 11.5	10.5- 11.5	10.7	12	12- 12.5	12- 13.5	15- 16.5	16	21
Agarum cribrosum (N)*	0	5.2	0	7.0	0	2.0	0.3	3.4	0	4.0	2.3	6.7	3.2	14.6	4.0
Agarum cribrosum (C)	0	12.3%	0	38.8%	-	15%	16.5%	14.3%	-	30%	16.4%	0	11%	-	15%
Alaria sp. (N)	0	0	0	0	0	0	0	0	5.6	0	0	0	0	0	0
Constantinea sp. (C)	-	-	0.3%	-	-	-	5.6%	-	-	2.3%	11.9%	-	0	-	0
Cymathere triplicata (N)	0	0	0	0	6.7	0	0	0	4.8	0	0	0	0	0	0
Encrusting coralline alga (C)	-	-	58.3%	-	-	-	21.5%	-	-	78.3%	7.1%	-	16%	-	32.5%
Hildenbrandia sp. (C)	-	-	-	-	-	-	7%	-	-	0	0	-	0	-	6%
Laminaria ? groenlandica (N)	21.2	30.7	5.2	3.0	5.3	0	5.6	3.4	32.8	5.3	4.6	0	1.6	16.9	0
Laminaria ? groenlandica (C)	45%	70%	53.3%	35%	-	0	15%	43.6%	-	26.7%	24.3%	40%	16%	-	0
L. saccharina (C)	0	0	0	0	-	40%	5.5%	0	-	0	2.1%	0	0	-	0
L. yezoensis (N)	0	0	0	0	0	0	0.8	0.6	0	0	1.1	0	0	0	0
L. yezoensis (C)	0	0	0	0	-	0	2%	0	-	0	14.3%	0	0	-	0
Nereocystis luetkeana (N)	0	0	0	0	14.7	0	0	0	2.6	0	0	0	0	0	0
Opuntiella californica (C)	-	-	0.7%	-	-	-	0	-	-	9.7	0	-	0	-	0
Pleurophycus gardneri (N)	20.0	1.3	10.8	0	0	0	0	5.7	0	6.7	0.6	4.0	4.0	0.8	0
Pleurophycus gardneri (C)	38.3%	3.3%	48.3%	0	-	0	0	17.1%	-	45%	3.6%	26.7%	11%	-	0
Rhodymenia pertusae (C)	-	-	0	-	-	-	3.4%	-	-	6.7%	1.4%	-	2%	-	0

* N = number of individuals
C = relative cover

Appendix B-11. Size data for echinoderms off Raft Cove, Chugach Bay in 7.5-16.8 depths, 7/6/76.

Strongylocentrotus droebachiensis - test diameter (mm): 30, 28, 18, 25, 21, 35, 23, 19, 29, 25, 17, 25, 30, 26, 18, 25, 25, 20, 30, 17, 20, 22, 20, 30, 25, 25, 20, 30, 30, 28, 25, 25, 25, 25, 25, 30, 12, 8, 8, 7, 7, 12, 30, 18, 12, 18, 18, 15, 16, 18, 40, 15, 23, 32, 20, 20, 30, 15, 35, 20, 22, $\bar{x} \pm s$ = 21.9 ± 7.7 mm.

S. franciscanus - test diameter (mm): 20, 33, 22, 28, 22, 18, 9, 7, $\bar{x} \pm s$ = 19.9 ± 8.7 mm.

Asteriidae, unid. - maximum radius (mm): 16, 27, 12, 13, 17, $\bar{x} \pm s$ = 17.0 ± 6.0 mm.

Henricia sp. - maximum radius (mm): 18, 18, 24, 26, 16, 72, 20, 35, 18, 19, 20, 22, 39, 68, $\bar{x} \pm s$ = 29.6 ± 18.3.

Crossaster papposus - maximum radius (mm): 28, 27, 37, 65, $\bar{x} \pm s$ = 39.3 ± 17.7 mm.

Pteraster tesselatus - maximum radius (mm): 30

Tosiaster arcticus - maximum radius (mm): 19, 20, 27, 27, $\bar{x} \pm s$ = 23.3 ± 4.3 mm.

Orthasterias koehleri - maximum radius (mm): 115, 119, 65, 143, 122, 126, 75, 92, 115, 120, 70, 100, $\bar{x} \pm s$ = 105.2 ± 24.7 mm.

Dermasterias imbricata - maximum radius (mm): 80, 120, 115, 85, 109, $\bar{x} \pm s$ = 101.8 ± 18.1 mm.

Pycnopodia helianthoides - maximum radius (mm): 22, 105, $\bar{x}$ = 63.5 mm

Evasterias troschelii - maximum radius (mm): 92.

Appendix B-12. Abundance of echinoderms in 1/4 m^2 quadrats off Raft Cove, Chugach Bay, 7/6/76.

Quadrat	Depth (ft)	Ophiopholis[1] aculeata	Asteriidae unid. (small)	Strongylocentrotus[1] droebachiensis	S.[1] franciscanus	Henricia sp.	Crossaster papposus	Pteraster tesselatus
1	55	5	1					
2	55	3						
3	50	5		4				
4	50							
5	50							
6	50	16		7	2			
7	48					2		
8	48			1				
9	45							
10	45							
11	45						2	
12	45			2			1	
13	45							
14	45							
15	45				1			
16	45			5				
17	43	2						
18	43							
19	42							1
20	42				$\bar{x}$±s = 0.1±0.4			
21	40			16	No. per m^2=0.3			
22	60		1					
23	60							Eupentacta
24	60			4				? quinquesemita
25	58	2		4				1
26	55					1		
27	55							
28	55			2				
29	55			1	Dermasterias			
					imbricata			
30	52			2	1			
31	52							Orthasterias
								koehleri
32	50							1
33	50				1			1
34	52			2				1
35	55							
36	55						1	
$\bar{x}$ ± s		0.9 ± 2.9	0.1 ± 0.2	1.4 ± 3.1	0.1 ± 0.2	0.1 ± 0.4	0.1 ± 0.4	0.1 ± 0.3
No. per m^2		3.7	0.2	5.6	0.2	0.3	0.4	0.3

Appendix B-13. Species observed on vertical face of 8 foot high pinnacle off Raft Cove, Chugach Bay, 7/8/76.

ALGAE-Rhodophyta

Encrusting coralline alga-sparse
Rhodymenia pertusae

PORIFERA

Leucosolenia sp.
? Scypha sp.-common
White saccate sponge-common
Gray globose sponge-common

CNIDARIA-Hydrozoa

Abietinaria spp.-abundant
Campanularia verticillata-common
C. integra
Garveia annulata-common
Tubularia sp.-common

CNIDARIA-Anthozoan

Tealia crassicornis

ANNELIDA-Polychae'a

Crucigera sp.

MOLLUSCA

Cadlina luteomarginata-sparse
Calliostoma ligatum-common
Crepidula nummaria
Cryptochiton stelleri-sparse
Fusitriton oregonensis-sparse
Lepidozona mertensii
Margarites sp.-common
Musculus discors
Placiphorella sp.-common
Tonicella insignis
T. lineata

ARTHROPODA-Crustacea

Balanus nubilis-common, large
Elassochirus gilli-common
E. tenuimanus-common
Oregonia gracilis
Pagurus beringanus
P. kennerlyi
Pugettia gracilis

ECHINODERMATA

Dermasterias imbricata
Henricia leviuscula-common
Ophiopholis aculeata
Orthasterias koehleri-sparse

BRYOZOA

Crisia sp.
Costazia ventricosa
Heteropora sp.
Microporina borealis-75% cover
Myriozoella plana
Encrusting brown bryozoan

CHORDATA-Tunicata

Boltenia ? villosa-common
Didemnum sp.-common
Metandrocarpa taylori
Orange social colonial tunicate

CHORDATA-Pisces

Hexagrammos decagrammus

Appendix C-1. Relative cover for epibiotic organisms in 1/16 m^2 quadrats on Dick's Head, near the outer edge of the shelf, at the head of West Arm, Port Dick, 6/30/76.

	Low Intertidal												Quadrats												
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Alaria sp.	30	0	0	0	5	5	0	0	0	0	0	0	80	0	0	0	0	35	25	0	0	0	5	0	0
Costaria costata	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptosiphonia woodii	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Enteromorpha sp.	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Fucus distichus	20	75	80	85	30	50	50	75	100	100	75	25	0	25	75	100	100	95	25	100	100	75	80	30	15
Gigartina papillata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	5
Halosaccion glandiforme	5	0	0	0	5	0	10	0	0	0	0	0	2	3	0	0	0	2	0	0	0	0	2	2	0
Rhodophyta, unid. (filamentous)	60	25	10	5	0	30	0	15	0	0	0	0	0	0	15	0	0	0	0	0	2	5	0	0	5
Rhodymenia palmata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Scytosiphon lomentaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Spongomorpha sp.	0	0	0	0	5	10	5	0	0	5	0	2	2	35	20	0	0	10	15	0	0	5	0	0	5
? Ulva sp.	10	2	20	75	25	20	35	75	40	40	50	5	25	15	10	15	10	0	15	20	25	15	20	30	20
Balanus ? glandula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	2
Callophyllis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gloiopeltis furcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mytilus edulis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Littorina sitkana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C-1 (Cont.). Relative cover for epibiotic organisms in 1/16 m^2 quadrats on Dick's Head, near the outer edge of the shelf, at the head of West Arm, Port Dick, 6/30/76.

Species	Quadrats 26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	40	50
Alaria sp.	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Costaria costata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptosiphonia woodii	0	10	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enteromorpha sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fucus distichus	25	30	10	75	75	60	50	60	50	75	40	20	3	6	25	0	50	30	45	25	20	100	60	95	80
Gigartina papillata	5	10	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halosaccion glandiforme	30	10	25	2	0	0	20	2	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhodophyta, unid. (filamentous)	0	5	3	15	0	0	0	30	0	0	0	0	0	0	0	7	5	0	0	0	0	0	0	25	0
Rhodymenia palmata	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scytosiphon lomentaria	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spongomorpha sp.	50	0	30	25	5	30	30	25	10	2	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
? Ulva sp.	35	35	10	25	20	3	0	15	30	5	0	0	0	0	0	0	0	0	2	0	0	2	0	5	0
Balanus ? glandula	0	0	2	2	0	0	5	2	2	2	5	2	2	2	15	0	10	5	5	2	3	3	3	0	5
Callophyllis sp.	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gloiopeltis furcata	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	20	0	0	2	0	0	0	3	0	0
Mytilus edulis	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	75	60	95	90	0	0	0	0
Littorina sitkana	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	2	0	0

Appendix C-1 (Cont.). Relative cover for epibiotic organisms in 1/16 m^2 quadrats on Dick's Head, near the outer edge of the shelf, at the head of West Arm, Port Dick, 6/30/76.

	Quadrats												High Intertidal				
Species	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	$\bar{x} \pm s$
Alaria sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.8 ± 12.8%
Costaria costata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2 ± 1.2%
Cryptosiphonia woodii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3 ± 1.4%
Enteromorpha sp.	0	0	0	0	0	0	0	5	5	0	25	2	0	0	0	0	0.8 ± 3.3%
Fucus distichus	75	100	100	100	100	80	70	30	30	25	35	70	100	30	75	100	57.8 ± 32.1%
Gigartina papillata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0 ± 3.2%
Halosaccion glandiforme	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.0 ± 5.6%
Rhodophyta, unid. (filamentous)	0	0	0	0	0	2	15	0	0	0	0	0	0	0	0	0	4.2 ± 10.1%
Rhodymenia palmata	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3.7 ± 4.8%
Scytosiphon lomentaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1 ± 0.3%
Spongomorpha sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3 ± 10.5%
? *Ulva* sp.	0	0	0	15	7	15	0	5	0	2	0	0	0	0	0	0	12.8 ± 16.9%
Balanus ? *glandula*	20	5	5	2	10	50	40	5	10	2	5	2	7	0	5	45	4.6 ± 9.7%
Callophyllis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1 ± 0.4%
Gloiopeltis furcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4 ± 2.5%
Mytilus edulis	0	5	15	2	10	10	2	5	0	95	2	2	5	0	0	0	8.4 ± 23.8%
Littorina sitkana	5	0	5	3	3	0	2	0	0	0	2	2	2	2	2	5	0.6 ± 1.3%

Appendix C-2. Species observed intertidally on Dick's Head at the head of West Arm, Port Dick, 6/30/76.

MACROPHYTES

CHLOROPHYTA

Cladophora sp.
Enteromorpha intestinalis
Spongomorpha sp.
? *Ulva* sp.
Urospora ? *penicilliformis*

RHODOPHYTA

Agardhiella tenera
Cryptosiphonia woodii
Gigartina papillata
Gloiopeltis furcata
Halosaccion glandiforme
Odonthalia floccosa
Polysiphonia ? *pacifica*
Porphyra sp.
Rhodymenia palmata

PHAEOPHYTA

Alaria ? *crispa*
Costaria costata
Desmarestia aculeata
D. viridis
Fucus distichus
Laminaria saccharina
Scytosiphon lomentaria
Soranthera ulvoidea

INVERTEBRATES

Balanus ? *glandula*
Collisella pelta
Gnorimosphaeroma oregonensis
Halichondria panicea
Lacuna ? *variegata*
Littorina scutulata
L. sitkana
Modiolus modiolus
Mytilus edulis
Nereis sp.
Notoacmaea scutum
Protothaca staminea
Telmessus cheiragonus

FISHES

High cockscomb (*Anoplarchus purpurescens*)
Crescent gunnel (*Pholis laeta*)
Ribbon prickleback (*Phytichtys chirus*)

SEA BIRDS

Double-crested cormorant (*Phalacrocorax auritus*
Black-legged kittiwake (*Rissa tridactyla*)
White winged scoter (*Melanitta deglandi*)

MARINE MAMMALS

Sea otter (*Enhydra lutris*)
Harbor seal (*Phoca vitulina*)

Appendix C-3. Wet weights of marcophytes in 1/16 m^2 quadrats from a transect around Dick's Head, at the head of West Arm, Port Dick, 6/30/76 and 7/1/76.

	Low *Fucus* Zone 0 m		3 m		6 m[1]	9 m		12 m		12 m High *Fucus* Zone		
	a	b	a	b		a	b	a[1]	b	a	b	$\bar{x} \pm s$ (gm)
Chlorophyta, unid. (filamentous)	46.6	10.3[1]	0	14.1	79.9	0	0	0	0	5.4	0	14.2 ± 25.8
Fucus distichus	257.7	11.4	201.3	134.0[2]	83.4[3]	36.0	340.7	1099.0	1217.0	33.7	32.1	313.4 ± 431.3
? *Ulva* sp.	17.0	31.7	30.8	26.1	0	0	0	0	0	2.8	0	9.8 ± 13.6
Rhodophyta, unid. (foliose)	∿ 1.0	3.2	5.3	8.0	0	0	0	0	0	0	0	1.6 ± 2.7
Rhodophyta, unid. (filamentous)	0	trace	1.0	0	trace	0	0	0	0	0	0	trace
Phaeophyta, unid. (ribbob-like)	0	trace	0	0	0	0	0	0	0	0	0	trace
Paheophyta, unid. (filamentous)	0	0	29.1	18.8	0	0	0	0	0	0	0	4.4 ± 10.0
Total Wet Weight (gm)	322.3	56.6	267.5	202.0	163.3	36.0	340.7	1099.0	1217.0	41.9	32.1	343.5 ± 419.2
Mean Wet Weight per Quadrat (gm)		189.4		234.8			188.4		1158.0		37.0	
Mean Wet Weight Quadrat (gm)		3,030		3,757	2,613		3,014		18,528		592	

[1] With numerous small *Mytilus*, perwinkles or limpets included.
[2] Small plants, heavy algae growth.
[3] Small plants, covered with heavy filamentous algal growth.

Appendix C-4. Abundance of limpets (Acmaeidae) in 1/4 m^2 quadrats in *Fucus* zone, Dick's Head, West Arm, Port Dick, 7/1/76.

	Low *Fucus* Zone	Mid *Fucus* Zone	High *Fucus* Zone
	4	21	5
	4	7	9
	6	8	4
	3	24	3
$\bar{x} \pm s$:	4.3 ± 1.3	15.0 ± 8.8	5.3 ± 2.6
No. per m^2:	17	60	21

Appendix C-5a. Size data for *Mytilus edulis* from Dick's Head, West Arm, Port Dick, July 1976.

Shell Length (mm)	0 m Zone (High Intertidal) No. 1	No. 2	Total	%
2	1	0	1	0.2
3	1	0	1	0.2
4	2	2	4	0.8
5	9	4	13	2.5
6	17	6	23	4.5
7	28	8	36	7.0
8	21	8	29	5.7
9	17	16	33	6.4
10	15	13	28	5.5
11	16	5	21	4.1
12	19	10	29	5.7
13	7	10	17	3.3
14	7	10	17	3.3
15	6	14	20	3.9
16	3	6	9	1.8
17	12	7	19	3.7
18	9	6	15	2.9
19	10	8	18	3.5
20	15	8	23	4.5
21	9	9	18	3.5
22	9	12	21	4.0
23	8	12	20	3.9
24	11	11	22	4.3
25	11	10	21	4.1
26	4	7	11	2.1
27	2	2	4	0.8
28	3	4	7	1.4
29	2	0	2	0.4
30	2	4	6	1.2
31	0	7	7	1.4
32	0	0	0	0.0
33	0	1	1	0.2
34	2	1	3	0.6
35	1	1	2	0.4
36	0	4	4	0.8
37	0	3	3	0.6
38	1	1	2	0.4
39	0	2	2	0.4
40	0	0	0	0.0
41	0	1	1	0.2
n	280	233	513	
$\bar{x} \pm s$ (mm)	14.4 ± 7.3	18.0 ± 8.4	16.0 ± 8.0	
Relative cover	50%	35%		
No./m^2			4,104	

Appendix C-5b (Cont.). Size data for *Mytilus edulis* from Dick's Head, West Arm, Port Dick, July 1976.

Shell Length (mm)	3 m Zone (High Intertidal) No. 1	No. 2	Total	%
3	1	0	1	0.4
4	0	0	0	0.0
5	0	0	0	0.0
6	0	0	0	0.0
7	0	0	0	0.0
8	0	0	0	0.0
9	0	0	0	0.0
10	0	0	0	0.0
11	1	0	1	0.4
12	1	0	1	0.4
13	1	0	1	0.4
14	2	0	2	0.8
15	1	2	3	1.2
16	1	0	1	0.4
17	3	0	3	1.2
18	3	3	6	2.3
19	1	1	2	0.8
20		2	2	0.8
21	2	2	4	1.6
22	2	5	7	2.7
23	1	4	5	1.9
24	5	2	7	2.7
25	6	9	15	5.8
26	3	4	7	2.7
27	6	12	18	6.9
28	11	7	18	6.9
29	3	2	5	1.9
30	5	17	22	8.5
31	13	3	16	6.2
32	8	14	22	8.5
33	1	4	5	1.9
34	6	3	9	3.5
35	6	8	14	5.4
36	7	4	11	4.2
37	6	7	13	5.0
38	3	4	7	2.7
39	1	3	4	1.6
40	0	9	9	3.4
41	1	0	1	0.4
42	2	3	5	1.9
43	2	2	4	1.6
44	0	0	0	0.0
45	0	5	5	2.0
46	0	0	0	0.0
47	1	1	2	0.8
48	0	0	0	0.0
49	0	0	0	0.0
50	1	0	1	0.4
51	0	0	0	0.0
52	0	1	1	0.4
n	117	143	260	
$\bar{x} \pm s$ (mm)	29.3 ± 7.8	31.3 ± 7.0	30.4 ± 7.4	
Relative cover	45%	50%		
No./m^2			2,080	

Appendix C-5c (Cont.). Size data for *Mytilus edulis* from Dick's Head, West Arm, Port, Dick, July 1976.

Shell Length (mm)	3 m Zone (High Intertidal) No. 1	No. 2	Total	%
8	1	0	1	0.2
9	0	1	1	0.2
10	1	1	2	0.4
11	1	1	2	0.4
12	1	1	2	0.4
13	1	0	1	0.2
14	2	1	3	0.6
15	1	2	3	0.6
16	2	0	2	0.4
17	3	3	6	1.3
18	3	0	3	0.6
19	1	1	2	0.4
20	4	5	9	2.0
21	2	1	3	0.6
22	5	4	9	2.0
23	1	2	3	0.6
24	2	2	4	0.9
25	5	4	9	2.0
26	3	4	7	1.5
27	5	4	9	2.0
28	2	2	4	0.9
29	2	3	5	1.1
30	2	3	5	1..
31	1	3	4	0.9
32	6	3	9	2.0
33	5	12	17	3.7
34	1	5	6	1.3
35	10	8	18	3.9
36	7	10	17	3.7
37	12	12	24	5.2
38	7	14	21	4.5
39	3	6	9	2.0
40	12	27	39	8.4
41	5	13	18	3.9
42	19	13	32	6.9
43	22	10	32	6.9
44	6	13	19	4.1
45	15	17	32	6.9
46	6	6	12	2.6
47	12	7	19	4.1
48	5	6	11	2.4
49	2	3	5	1.1
50	5	4	9	2.0
51	0	4	4	0.9
52	2	4	6	1.3
53	1	2	3	0.6
54	1	0	1	0.2
n	215	247	462	
$\bar{x} \pm s$ (mm)	36.9 ± 10.0	36.7 ± 8.9	37.3 ± 9.4	
Relative cover	80%	90%		
No./m^2			2,696	

Appendix C-5d (Cont.). Size data for *Mytilus edulis* from Dick's Head, West Arm, Port, Dick, July 1976.

Shell Length (mm)	12 m Zone (High Intertidal) No. 1	No. 2	Total	%
5	3	1	4	0.4
6	2	2	4	0.4
7	2	3	5	0.5
8	7	8	15	1.4
9	10	7	17	1.6
10	4	12	16	1.5
11	1	5	6	0.6
12	6	11	17	1.6
13	8	12	20	1.8
14	4	14	18	1.7
15	6	21	27	2.5
16	6	26	32	3.0
17	20	15	35	3.2
18	3	21	24	2.2
19	2	10	12	1.1
20	10	26	36	3.3
21	4	18	22	2.0
22	12	20	32	3.0
23	13	17	30	2.8
24	6	19	25	2.3
25	17	29	46	4.2
26	17	25	42	3.9
27	21	14	35	3.2
28	25	20	45	4.1
29	9	5	14	1.3
30	33	25	58	5.3
31	14	8	22	2.0
32	33	13	46	4.2
33	26	12	38	3.5
34	13	14	27	2.5
35	40	17	57	5.2
36	12	14	26	2.4
37	31	15	46	4.2
38	22	9	31	2.9
39	3	11	14	1.3
40	14	23	37	3.4
41	1	14	15	1.4
42	11	13	24	2.2
43	3	7	10	0.9
44	3	6	9	0.8
45	4	13	17	1.6
46	4	8	12	1.1
47	1	5	6	0.6
48	3	2	5	0.5
49	0	2	2	0.2
50	1	1	2	0.2
51	0	2	2	0.2
52	0	0	0	0.0
53	0	0	0	0.0
54	0	0	0	0.0
55	0	1	1	0.1
n	490	596	1,086	
$\bar{x} \pm s$ (mm)	28.8 ± 9.3	26.7 ± 10.6	27.7 ± 10.1	
Relative cover	95%	95%		
No./m^2			8,688	

Appendix C-6. Data for relationship between shell length, whole wet weight, and wet and dry tissue weights for *Mytilus edulis* from Dick's Head, West Arm, Port Dick, 7/1/76.

Shell Length (mm)	Whole Wet Weight (gm)	Wet Tissue Weight (gm)	Dry Tissue Weight (gm)	Wet Weight: Whole Weight Ratio	Dry Weight: Wet Weight Ratio	Shell Length (mm)	Whole Wet Weight (gm)	Wet Tissue Weight (gm)	Dry Tissue Weight (gm)	Wet Weight: Whole Weight Ratio	Dry Weight: Wet Weight Ratio
44.0	3.58	1.59	0.34	0.44	0.21	52.0	9.63	3.71	0.65	0.39	0.18
51.0	5.69	2.65	0.53	0.47	0.20	44.0	4.82	2.32	0.38	0.48	
46.0	7.49	3.09	0.49	0.41	0.16	45.0	7.38	2.73	0.37	0.37	0.14
40.0	3.31	1.65	0.34	0.50	0.21	50.0	7.55	2.87	0.43	0.38	0.15
32.0	2.18	0.93	0.26	0.43	0.28	41.0	4.17	2.00	0.40	0.48	0.20
41.0	4.45	2.21	0.39	0.50	0.18	40.0	3.89	1.95	0.37	0.50	0.19
49.0	6.91	3.29	0.59	0.48	0.18	45.0	6.65	2.56	0.52	0.39	0.20
41.0	3.26	1.27	0.29	0.39	0.22	40.0	4.85	2.12	0.38	0.44	0.18
52.0	6.26	2.95	0.55	0.47	0.19	44.0	6.34	2.90	0.40	0.46	0.14
40.0	4.91	1.66	0.24	0.34	0.15	49.0	10.24	3.69	0.57	0.36	0.15
50.0	6.87	2.60	0.51	0.38	0.20	41.0	4.12	2.11	0.38	0.51	0.18
34.0	3.27	1.31	0.25	0.40	0.19	44.0	4.76	2.64	0.41	0.56	0.16
39.0	4.36	1.62	0.29	0.37	0.18	43.0	5.90	2.48	0.42	0.42	0.17
37.0	3.62	1.39	0.28	0.38	0.20	39.0	3.22	1.54	0.30	0.48	0.19
48.0	6.36	3.21	0.53	0.51	0.17	39.5	4.09	1.99	0.37	0.49	0.19
41.0	4.42	2.22	0.43	0.50	0.19	32.0	2.05	1.01	0.21	0.49	0.20
47.0	4.80	2.38	0.37	0.50	0.16	37.0	4.42	1.99	0.33	0.45	0.17
40.0	3.79	1.56	0.30	0.41	0.19	35.0	3.53	1.39	0.24	0.39	0.17
38.0	3.10	1.40	0.22	0.45	0.16	36.0	3.53	1.79	0.29	0.57	0.16
45.0	7.38	2.45	0.35	0.33	0.14	27.0	1.51	0.72	0.13	0.48	0.18
39.0	4.16	1.50	0.23	0.36	0.15	38.0	3.20	1.66	0.31	0.52	0.19
46.0	4.82	2.64	0.44	0.55	0.17	22.5	0.91	0.47	0.10	0.52	0.21
38.0	2.80	0.73	0.22	0.26	0.30	27.0	1.63	0.80	0.14	0.49	0.18
40.0	5.50	2.01	0.37	0.36	0.18	16.0	0.37	0.18	0.06	0.49	0.33
35.0	2.59	1.26	0.28	0.49	0.22	19.0	0.72	0.28	0.06	0.39	0.25
									$\bar{x}$	0.44	0.19
									s	0.06	0.04

Appendix C-7. Species observed subtidally around Dick's Head at the head of West Arm, Port Dick, 7/3/76.

MACROPHYTES

RHODOPHYTA	PHAEOPHYTA	ANGIOSPERMAE
Constantinea simplex	*Agarum cribrosum*	*Zostera marina*
C. subulifera	*Alaria* sp.	
Corallina sp.	*Fucus distichus*	
Gigartina spp.	*Laminaria groenlandica*	
? *Lithotham ium* sp.	*L. yezoensis*	
Phycodrys sp.		
? *Prionitis* sp.		
Rhodoglossum affine		
Rhodophyta, unid.		
Rhodymenia sp.		

INTERTEBRATES

Clinocardium nuttalli	*Mya arenaria*	Serpulidae, unid.
Coryphella sp.	*M. truncata*	*Saxidomus gigantea*
Hydroida, unid.	*Mytilus edulis*	*Telmessus cheiragonus*
Macoma spp.	*Protothaca staminea*	*Tresus capax*
Musculus vernicosus		

FISHES

Ammodytes hexapterus (Pacific sand lance)
Hexagrammos stelleri (white-spotted greenling)
Microgadus proximus (Pacific tomcod)
Pholididae, unid. (light brown)
Pholis laeta (crescent gunnel)
Pleuronectiformes, unid. (flatfish)
Stichaeidae, unid. (Prickleback)

Appendix C-8. Abundance of some dominant macroinvertebrates in subtidal quadrats on Dick's Head, Port Dick, 7/1/76.

Species	Number per Quadrat				Total	No. per m^2
Evasterias troschelii	46	20	17	29	112	1.12
Chiridota sp.	13	--*	--	7	20	0.50
Cancer magister	4	0	0	0	4	0.04
Strongylocentrotus drobachiensis	--	--	--	53	53	5.30
Quadrat area (m^2)	30	30	30	10	100	

* -- indicates the spaces was not counted.

Appendix C-9 (Cont.). Line contact data from shell at head of West Arm, Port Dick, 7/1/76.

Transect No. and Length	*Zostera marina* Line Contact (m)	*Zostera marina* Distance (m)	? *Ulva* sp. Line Contact (m)	? *Ulva* sp. Distance (m)	*Mytilus edulis* Line Contact (m)	*Mytilus edulis* Distance (m)	Gravel Line Contact (m)	Gravel Distance (m)
9 - 30 m	15.4-16.1	0.5	3.2- 6.2	3.0	0.0- 3.2	3.2	None	
			7.5-11.0	3.5	6.2- 7.5	1.3		
			14.4-15.4	1.0	11.0-14.4	3.4		
			16.1-17.5	1.4	17.5-23.0	5.5		
			23.0-26.0	3.0	26.0-29.2	3.2		
			29.2-30.0	0.8				
	Total	0.5		12.7		16.6		
	% Cover	1.7		42.3		55.3		
Overall Cover:		10.7%		65.5%		23.4%		0.4%

Appendix C-9. Line contact data from shell at head of West Arm, Port Dick, 7/1/76.

Transect No. and Length	*Zostera marina* Line Contact (m)	*Zostera marina* Distance (m)	? *Ulva* sp. Line Contact (m)	? *Ulva* sp. Distance (m)	*Mytilus edulis* Line Contact (m)	*Mytilus edulis* Distance (m)	Gravel Line Contact (m)	Gravel Distance (m)
1 - 30 m	1.4- 2.0	0.6	0.0- 1.4	1.4	None		None	
	7.2- 8.2	1.0	2.0- 7.2	5.2				
	16.0-17.0	1.0	8.2-16.0	7.8				
	19.0-19.8	0.8	17.0-19.0	2.0				
			19.8-30.0	10.2				
	Total	3.4		26.6				
	% Cover	11.3		88.7				
2 - 30 m	2.0- 2.8	0.8	0.0- 2.0	2.0	None		None	
	7.3- 7.9	0.6	2.8- 7.3	4.5				
	10.5-11.0	0.5	7.9-10.5	2.6				
	15.7-17.0	1.3	11.0-15.7	4.7				
	19.8-19.9	0.1	17.0-19.8	2.8				
	28.5-29.2	0.7	19.9-28.5	8.6				
			29.2-30.0	0.8				
	Total	4.0		26.0				
	% Cover	13.3		86.7				
3 - 30 m	7.0- 8.0	1.0	0.0- 7.0	7.0	None		None	
	14.8-16.1	1.3	8.0-14.8	6.8				
	26.0-30.0	4.0	16.1-26.0	9.9				
	Total	6.3		23.7				
	% Cover	21.0		79.0				
4 - 30 m	12.2-13.3	1.1	0.0- 9.0	9.0	None		9.0-10.00	1.0
	20.3-22.4	2.1	10.0-12.2	2.2				
			13.3-20.3	7.0				
			22.4-30.0	7.6				
	Total	3.2		25.8				1.0
	% Cover	10.7		86.0				3.3
5 - 30 m	5.6- 6.5	0.9	3.5- 5.6	2.1	0.0- 3.5	3.5	None	
	8.9- 9.3	0.4	6.5- 8.9	2.4	17.0-20.8	3.8		
	23-5-24.8	1.3	9.3-17.0	7.7	27.2-30.0	2.8		
			20.8-23.5	2.7				
			24.8-27.2	2.4				
	Total	2.6		17.3		10.1		
	% Cover	8.7		57.7		33.7		
6 - 30 m	14.1-15.0	0.9	0.0-11.0	11.0	11.0-12.0	1.0	None	
	20.2-23.4	3.2	12.0-14.1	2.1	23.4-26.0	2.6		
			15.0-20.2	5.2				
			26.0-30.0	4.0				
	Total	4.1		22.3		3.6		
	% Cover	13.7		74.3		12.0		
7 - 30 m	14.6-15.9	1.3	5.3-10.0	4.7	0.0- 5.3	5.3	None	
			12.3-14.6	2.3	10.0-12.3	2.3		
			15.9-24.5	8.6	24.5-30.0	5.5		
	Total	1.3		15.6		13.1		
	% Cover	4.3		52.0		43.7		
8 - 30 m	3.8- 5.7	1.0	2.3- 3.8	1.5	0.0- 2.3	2.3	None	
	18.0-19.6	1.6	5.7- 7.3	1.6	7.3-17.0	9.7		
			17.0-18.0	1.0	22.1-29.8	7.7		
			19.6-22.1	2.5				
			29.8-30.0	0.2				
	Total	3.5		6.8		19.7		
	% Cover	11.7		22.7		65.7		

Appendix 10. Size data, <u>Evasterias troschelii</u> from outer edge of shelf at head of West Arm, Port Dick, 7/1/76.

Radius (mm)*	Radius (mm)	Radius (mm)	Radius (mm)	Radius (mm)
35	30	50	30	25
35	35	84	92	90
30	30	40	55	112
25	20	125	18	40
18	40	32	28	38
22	30	22	50	57
25	22	30	36	88
25	25	38	17	28
45	90	58	92	28
30	70	28	90	28
35	42	30	15	20
28	40	25	52	16
40	25	25	52	18
60	43	15	90	40
23	19	20	130	115
20	20	22	111	28
25	40	20	72	40
70	30	23	44	18
20	15	20	20	28
48	25	25	50	57
60	45	30	20	
30	17	18	118	
25	22	25	63	

$n = 112$
$\bar{x} \pm s = 41.2 \pm 27.0$ mm

* Mouth to tip of longest ray

Appendix C-11. Abundance and relative cover of major epibiotic organisms in 1/4 m^2 quadrats on the outer edge of the shelf at the head of West Arm, Port Dick, 6/30/76.

Species	Quadrat Numbers 1	2	3	4	5	6	7	8	9	10	11
Costaria costarum (C)	0	0	0	0	0	0	0	0	0	0	0
Desmarestia viridis (C)	0	0	0	0	15%	0	0	0	0	0	2%
Laminaria saccharina (N)	0	0	0	0	0	0	0	0	0	0	0
Laminaria saccharina (C)	25%	0	0	25%	20%	0	30%	0	0	0	60%
Rhodophyta, unid. (filamentous) (C)	0	0	10%	0	0	0	0	0	0	0	0
? Ulva sp. (C)	0	10%	0	0	10%	0	0	30%	0	0	0
Zostera marina (C)	90%	95%	90%	70%	40%	10%	15%	20%	10%	30%	30%
Pycnopodia helianthoides (N)	0	0	0	0	0	0	1	0	0	0	0
Telmessus cheiragonus (N)	2	0	0	0	0	0	0	0	0	0	0
Algal debris (C)	0	0	0	5%	0	80%	60%	0	60%	25%	0
Substrate:	Soft	Soft light shell	Soft	Soft	Soft	Soft	Soft	Soft silt	Soft silt light shell de-ris	Silt, light shell	Silt
Depth (m):	12.5	12.5	12.5	12.5	12.5	12.5	12.5	13	13	13	9

Appendix C-11 (Cont.). Abundance and relative cover of major epibiotic organisms in 1/4 m^2 quadrats on the outer edge of the shelf at the head of West Arm, Port Dick, 6/30/76.

Species	Quadrat Numbers 12	13	14	15	16	17	18	19	20	$\bar{x} \pm s$
Costaria costarum (C)	5%	0	0	0	0	40%	0	0	0	2.3 ± 8.0%
Desmarestia viridis (C)	75%	60%	0	60%	20%	0	0	20%	0	12.6 ± 23.7%
Laminaria saccharina (N)	0	0	0	1	1	0	0	0	0	0.1 ± 0.3
Laminaria saccharina (C)	20%	25%	40%	25%	80%	0	20%	80%	25%	23.8 ± 25.1%
Rhodophyta, unid. (filamentous) (C)	0	0	0	0	0	0	0	0	0	0.5%
? *Ulva* sp. (C)	0	0	0	0	0	0	0	0	0	2.5 ± 7.2%
Zostera marina (C)	0	0	0	0	0	0	0	0	0	13.8 ± 12.1%
Pycnopodia helianthoides (N)	0	0	0	0	0	0	0	0	0	0.05; 0.2/m^2
Telmessus cheiragonus (N)	0	0	0	0	0	0	0	0	0	0.1; 0.4/m^2
Algal debris (C)	0	0	0	0	0	10%	10%	0	20%	13.5 ± 24.3 %
Substrate:	Silt	Silt	Silt gravel shell	Silt	Silt	Silt/shell	Sand shell	Gravel/ sand	Gravel	
Depth (m):	9	9	9	8	8	6	6	6	5	

Appendix C-12. Number of turions of *Zostera marina* in 1/16 m^2 quadrats in the eelgrass bed at the head of West Arm, Port Dick, 8/31/76.

Turions per Quadrat	Frequency at Inner Edge of Bed	Frequency at Outer Edge of Bed
0	8	5
1	5	1
2	2	5
3	7	2
4	12	14
5	11	7
6	9	11
7	12	12
8	4	12
9	4	3
10	3	4
11	1	4
12	2	1
13	5	1
14	1	1
15	1	0
16	1	0
17	0	1
18	1	0
19	1	0
20	0	1
21	2	1
22	1	0
23	0	0
24	1	0
25	0	1

Average No. per 1/16 m^2: $\bar{x} \pm s$	6.8 ± 5.2	6.7 ± 4.3
Estimated Density	109/m^2	108/m^2
No. of quadrats	94	87

Appendix C-13. Turion height data, *Zostera marina*, inner edge of bed, West Arm, Port Dick, 8/31/76.

Maximum Leaf Length* (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)
142.0	216.5	152.5	234.5
111.0	121.5	200.5	224.5
51.5	165.0	194.5	197.0
44.5	217.5	200.0	207.0
101.0	182.5	81.0	198.0
97.0	191.0	209.0	227.0
198.0	193.5	151.5	92.0
158.5	145.5	211.5	201.0
235.5	182.5	99.0	125.0
169.0	214.5	81.5	145.0
206.5	189.0	85.0	186.0
201.0	35.5	187.5	188.0
59.0	144.0	77.5	186.5
220.0	144.0	202.0	70.5
214.0	143.0	103.0	145.5
225.0	127.5	170.5	87.0
214.5	274.0	38.5	230.0
233.5	250.5	198.0	236.0
97.0	198.0	44.0	218.0
210.5	227.5	134.0	167.5
153.5	233.5	97.0	144.0

$n = 81$

$\bar{x} \pm s = 164.1 \pm 58.3$ cm

* Length of longest leaf from upper node.

Appendix C-14. Turion height data, Zostera marina from outer edge of bed, West Arm, Port Dick, 8/31/76.

Maximum Leaf Length* (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)
23.5	154.0	55.5	90.5	118.5
98.0	238.5	132.5	134.5	64.5
196.5	28.0	179.0	88.5	137.0
190.5	141.5	164.5	137.0	119.5
145.0	214.0	174.5	110.0	137.0
192.0	178.0	104.5	88.5	64.5
170.0	120.0	73.5	216.5	66.0
147.5	221.5	126.0	112.5	145.0
191.0	48.0	76.0	23.5	155.0
253.5	206.5	60.0	34.0	152.5
99.0	175.0	135.5	56.0	155.0
40.5	85.0	23.0	33.0	191.5
103.5	176.5	73.5	138.0	213.5
168.5	206.0	152.0	142.5	224.5
118.5	13.5	147.5	126.5	230.5
96.0	164.5	94.0	60.0	267.0
138.5	91.5	73.0	149.0	208.5
23.0	35.0	26.0	136.5	262.0
132.0	104.0	13.5	86.5	176.5
139.5	125.0	87.5	55.5	232.5
179.5	69.0	51.5	134.0	255.0
194.5	175.5	31.5	94.0	
167.0	36.5	19.5	186.0	
170.5	213.5	59.5	196.0	
49.0	135.5	76.5	91.0	

$n = 121$
$\bar{x} \pm s = 126.4 \pm 63.9$ cm

* Length of longest leaf from upper node.

Appendix C-15. Turion height and dry weight data for _Zostera marina_ from outer edge of bed, West Arm, Port Dick, 8/31/76.

Maximum Leaf Length (cm)	Dry Weight (gm)	Maximum Leaf Length (cm)	Dry Weight (gm)
23.5	0.08	141.5	0.45
196.5	1.61	48.0	0.29
190.5	1.70	206.5	1.85
145.0	0.68	85.0	0.24
192.0	1.85	206.0	2.54
147.5	0.80	13.5	0.01
191.0	1.24	91.5	0.39
253.5	2.36	35.0	0.18
99.0	0.31	104.0	0.25
40.5	0.05	213.5	3.26
103.5	0.26	55.5	0.18
96.0	0.24	104.5	0.29
23.0	0.17	152.0	1.43
139.5	0.94	147.5	1.30
194.5	2.27	94.0	0.33
49.0	0.32	51.5	0.08
154.0	0.84	19.5	0.09
238.5	3.35	59.5	0.17
28.0	0.09	90.5	0.26
		262.0	2.89

Appendix C-16. Abundance of *Laminaria saccharina* and *Pycnopodia helianthoides* in quadrats on slope at outer edge of shelf, West Arm, Port Dick, 7/1/76.

Depth (m)	Quadrat Size (m^2)	*Laminaria saccharina*	*Pycnopodia helianthoides*
12.2	10	4	2
10.7	10	3	1
7.6	10	13	0
6.1	5	3	0
4.6	5	19	2
3.7	5	57	2
7.6	10	--*	2
6.1	10	--	0
Total		99	9
No. per m^2		2.20	0.14

* No data

Appendix C-17. Size data for *Pycnopodia helianthoides* from slope at edge of shelf at head of West Arm, Port Dick, 7/1/76.

Radius (mm)*	Radius (mm)	Radius (mm)
130	90	110
65	140	300
270	60	110

$\bar{x} \pm s = 141.7 \pm 85.8$ mm

* Mouth to tip of longest ray.

Appendix C-18. Extralimital species observed on the outer slope of the shelf at the head of West Arm, Port Dick, 6/30/76.

Invertebrates

Cancer magister
Macoma sp.

Metridium senile
Protothaca staminea
Pycnopodia helianthoides
Telmessus cheiragonus - mated pair

Fishes

Cottidae, unid.
Snake prickleback (*Lumpenus sagitta*)

Appendix D-1. Species observed at Chugach Bay.

Species	Dates Observed				
	9/11/75[1/]	9/12/75	7/5/76	7/6/76	7/8/76
ALGAE-Chlorophyta					
? Monostroma sp.	X	X			
ALGAE-Phaeophyta					
Agarum cribrosum (adults)	X	X	X	X	X
Agarum cribrosum (juv.)		X			
Alaria crispa				X	
A. marginata	X	X			
Alaria sp.	X[1/]	X[1/]		X	
Costaria costata		X			
Cymathere triplicata	X	X		X	
Desmarestia munda			X		
D. viridis	X	X			
Desmarestia sp.				X	
Fucus distichus		X			
Laminaria groenlandica (adults)	X	X	X	X	
Laminaria groenlandica (juv.)		X			
L. saccharina			X		
L. setchelii					X
L. ? sinclairii		X			
L. yezoensis			X	X	
Laminaria sp.			X	X	
Nereocystis luetkeana	X	X		X	
Pleurophycus gardneri	X	X	X	X	X
Ralfsia pacifica			X		
Phaeophyta, unid. (juv.)				X	
ALGAE-Rhodophyta					
Bossiella sp.			X		
Callophyllis edentata		X			
Callophyllis sp.	X	X	X	X	
Constantinea simplex	X	X			X
C. subulifera	X	X			
Constantinea sp.			X	X	
Corallina ? officinalis	X	X			
C. vancouveriensis	X	X			X
Coralline spp., encrusting	X	X	X	X	X
Cryptonemia sp.	X	X			X
Delesseria decipiens		X	X		X
Halosaccion glandiforme		X			
Hildenbrandia sp.	X	X	X	X	X
Iridea lineare		X			

Appendix D-1 (Cont.). Species observed at Chugach Bay.

Species	Dates Observed 9/11/75[1]	9/12/75	7/5/76	7/6/76	7/8/76
Membranoptera		X			X
Microcladia sp.	X	X	X	X	
Odonthalia floccosa	X	X			
O. kamchatica	X	X		X	
O. lyallii				X	
Opuntiella californica	X	X		X	X
Polysiphonia sp.		X			
Porphyra sp.	X	X[1]			
Ptilota filicina	X	X			
Ptilota sp.	X	X		X	X
Rhodophyta, unid. (filamentous)				X	
Rhodymenia palmata	X	X			X
R. pertusae	X	X	X	X	X
Rhodymenia sp.			X		
Schizymenia sp.	X	X			
PORIFERA					
Cliona celata	X			X	
Leucosolenia sp.					X
Microciona sp.					X
Porifera, unid.				X	
Rhabdodermella sp.					X
Porifera, gray globose					X
Porifera, white saccate					X
Porifera, yellow, osculate		X			
? Scypha sp.					X
CNIDARIA-Hydrozoa					
Abietinaria filicula				X	
A. turgida (adults)					X[2]
A. turgida (juveniles)				X	
A. variabilis					X[2]
Abietinaria sp.	X[3]	X			X
Bonneviella grandis				X[2]	
Bougainvilliidae, unid.		X			X
Calycella syringa (immature)					X
Campanularia integra					X[2]
C. speciosa					X[2]
C. verticillata		X		X	X
C. volubilis					X[2]
Eudendrium vaginatum					X[2]
Garveia annulata					X[2]
Halecium ? labrosum (immature)				X	X
Lafoea fruticosa					X

Appendix D-1 (Cont.). Species observed at Chugach Bay.

Species	9/11/75[1]	9/12/75	7/5/76	7/6/76	7/8/76
	Dates Observed				
MOLLUSCA-Polyplacophera					
Cryptochiton stelleri					X
Katharina tunicata		X			
Lepidozona mertensii					X
Mopalia sp.			X		X
Placiphorella sp.			X	X	X
Polyplacophora, unid.				X	
Tonicella insignis					X
T. lineata				X	X
Tonicella sp.	X	X	X		
MOLLUSCA-Pelecypoda					
Astarte sp.	X	X[5]			
? *Chlamys* sp.		X			
Clinocardium californiense		X[5]			
Entodesma saxicola		X			
Humilaria kennerlyi	X	X			X
Musculus discors	X	X	X		X
M. vernicosus	X[6]	X[6]	X	X	X
Mya truncata	X[7]				
Mytilus edulis		X			
Protothaca staminea	X				
Saxidomus gigantea	X[7]				
MOLLUSCA-Gastropoda					
Acmaea mitra	X	X	X	X	
Amphissa columbiana	X	X		X	X
Cadlina luteomarginata		X			X
Calliostoma annulatum				X	
C. ligatum	X	X	X	X	X
Crepidula nummaria					X
Crepipatella lingulata	X				
Diodora aspera	X		X		
Fusitriton oregonensis	X	X	X[9]	X	X
Margarites pupillus				X	X
Margarites sp.					X
Nassarius ? *mendicus*				X	
Notoacmaea instabilis	X[8]	X			X
Nucella lamellosa	X	X			
N. lima				X	
Olivella baetica			X		
Puncturella multistriata		X		X	
Searlesia dira	X	X	X	X	
Trichotropis cancellata	X	X	X	X	X
Trophon multicostatus	X				X
Volutharpa ampullacea	X				

Appendix D-1 (Cont.). Species observed at Chugach Bay.

Species	Dates Observed 9/11/75[1]	9/12/75	7/5/76	7/6/76	7/8/76
ECTOPROCTA					
Alcyonidium pedunculatum					X
Costazia ventricosa					X
Crisia sp.					X
Dendrobeania ? *murrayana*			X	X	X
Flustrella gigantea			X	X	X
Heteropora sp.	X	X	X	X	X
Hippothoa hyalina					X
Lichenopora sp.	X	X			
? *Membranipora* sp.		X			
Microporina borealis	X	X	X	X	X
Myriozoella plana					X
Myriozoum ? *tenue*			X		X
Tricellaria sp.				X	
Bryozoa, unid., brown, encrusting					X
Bryozoa, orange, encrusting					X
Bryozoa, unid, encrusting	X				
ENTOPROCTA, unid.					X
BRACHIPODA					
Terebratalia transversus	X				
ECHINODERMATA					
Crossaster papposus	X	X		X	X
Dermasterias imbricata	X	X	X		X
Eupentacta quinquesemita	X	X			
Evasterias troschelii	X	X	X		
Henricia leviuscula	X	X			X
H. sanguinoleuta				X	
Leptasterias? *hexactis*		X			
L. ? *leptalea* (= Asterias, sm)		X			X
Ophiopholis aculeata	X	X			X
Orthasterias koehleri	X	X			X
Parastichopus californicus (juvenile)		X			
Pisaster ochraceus		X			
Pteraster tesselatus	X	X			
Pycnopodia helianthoides	X	X			
Solaster dawsoni	X				
S. stimpsoni		X			
Strongylocentrotus drobachiensis	x	x[10]	x	x	x

Appendix D-1 (Cont.). Species observed at Chugach Bay.

Species	Dates Observed				
	9/11/75[1]	9/12/75	7/5/76	7/6/76	7/8/76
S. franciscanus	X	X		X	
S. ? *pallidus*					X
Strongylocentrotus sp.		X			
Ceramaster (= *Tosiaster*) *arcticus*				X	
CHORDATA-Tunicata					
? *Aplidlium solidum*					X
Ascidians, unid., small orange, social		X			
Boltenia villosa	X	X			
B. ? *villosa*					X
Didemnum sp.	X			X	X
Distaplia sp.			X	X	
Halocynthia aurantia	X	X			
H. igaboja	X	X			
Metandrocarpa taylori	X	X			X
Styela montereyensis	X	X			
Synoicum sp.					X
Tunicata, unid., orange, encrusting					X
CHORDATA-Pisces					
Ammodytes hexapterus	X	X			
Clupea harengus (adults)				X[11]	
Clupea harengus (juv.)	X[12]	X[12]			
Cottidae, unid.	X	X			X
Hemilepidotus sp.	X	X			
Hexagrammos decagrammus	X				X
H. stelleri	X				
H. superciliosus	X				
Microgadus proximus	X	X			
Ronquilus jordani	X	X			
Sebastes melanops	X	X			
CHORDATA-Mammalia					
Enhydra lutris	X	X			

Appendix D-1 (Cont.). Species observed at Chugach Bay.

1/ Locations examined on specified dates:

9/11/75
Off Sea otter Pt - 10-23 m
West of Sea Otter Pt -10-13 m
Off West Pt, 2nd Cove - 14 m

9/12/75
NE of Sea Otter Pt - 13-23 m
Outer point of Raft Cove - 6.5-10 m
2nd Cove - 5.0-0.0 m

7/5/76
NE point of Raft Cove - 10.5-11.5 m
South Point - 12.0-12.5 m

7/6/76
In Raft Cove - 9.1-10.7 m
Off Raft Cove - 7.5-16.8 m

7/8/76
West finger off south headland - 70 ft
Off Raft Cove - 30 ft
8' pinnacle off Raft Cove - 30 ft

2/ On *Nereocystis*
3/ Reproductive
4/ 3 species
5/ 5 species
6/ In shell debris
7/ On laminarians
8/ Shell only
9/ On stipes of *Laminaria* and *Pleurophycus*
10/ Spawning
11/ On shell debris and rock
12/ Schooling above algal canopy
13/ Schooling

Appendix D-2. Species observed at East Chugach Island, 8/1/75.

SPECIES

ALGAE-Phaeophyta
- Agarum cribrosum
- Alaria fistulosa
- A. ? praelonga
- Cymathere triplicata
- Desmarestia ligulata
- D. viridis
- Laminaria groenlandica
- Nereocystis luetkeana
- Pleurophycus gardneri

ALGAE-Rhodophyta
- Bossiella sp.
- Constantinea sp.
- Corallina sp.
- Coralline spp., encrusting
- Cryptonemiales, unid.
- Delesseria decipiens
- Membranoptera sp.
- Microcladia sp.
- Odonthalia kamschatica
- Opuntiella californica
- Polyneura latissima
- Polysiphonia sp.
- Porphyra sp.
- Ptilota sp.
- Rhodymenia palmata
- R. pertusae
- Schizymenia sp.

PORIFERA
- Porifera, unid.

CNIDARIA-Hydrozoa
- Abietinaria filicula
- A. turgida - reprod.
- A. ? variabilis - reprod.
- Abietinaria sp.
- Campanularia speciosa - reprod.
- C. volubilis - reprod.
- Eudendrium vaginatum - reprod.
- Garveia annulata - reprod.
- Halecium beani - imm
- Hydractinia ? armata - on Nereocystis
- Orthopyxis caliculata
- Sertularella pinnata -imm
- S. tricuspidata - reprod.
- S. turgida - reprod.
- Sertulariidae, unid.

CNIDARIA-Anthozoa
- Gersemia rubriformis
- Tealia crassicornis

SIPUNCULA
- Phascolosoma agassizii

ARTHROPODA-Crustacea
- Balanus nubilis
- Elassochirus gilli
- E. tenuimanus
- Metacaprella kennerlyi
- Oregonia gracilis
- Pagurus beringanus
- P. ? caurinus
- Paguridae, unid.
- Pugettia gracilis

MOLLUSCA-Polyplacophora
- Lepidozona mertensii
- Mopalia sp.
- Tonicella insignis
- Tonicella sp.

MOLLUSCA-Pelecypoda
- Humilaria kennerlyi - juv.
- Modiolus modiolus - juv.
- Musculus vernicosus - on Laminarians
- Mytilus californianus
- Pododesmus macroschisma

MOLLUSCA-Gastropoda
- Acmaea mitra
- Calliostoma ligatum
- Crepidula nummaria
- Fusitriton oregonensis
- Lepeta sp.
- Margarites helicinus
- Notoacmaea scutum

Appendix D-2 (Cont.). Species observed at East Chugach Island, 8/1/75.

SPECIES

Nucella canaliculata
Trophon multicostatus
Trophonopsis sp.
Velutina sp.

ECHINODERMATA
Crossaster papposus
Dermasterias imbricata
Evasterias troschelii
Henricia leviusculus
? Lethasterias nanimensis
Ophiopholis aculeata
Orthasterias koehleri
Pycnopodia helianthoides
Strongylocentrotus drobachiensis
Ceramaster (= Tosiaster) arcticus

ECTOPROCTA
Caulibugula sp.
Filicrisia sp.
Flustrella corniculata
Hippothoa hyalina
Membranipora sp.
Microporella sp. (nr. californica)
Microporina borealis
Tricellaria sp.

CHORDATA-Tunicata
Ascidians, unid. (compound, social)
? Didemnum sp.
Halocynthia aurantia
Styela montereyensis
Synoicum sp.

CHORDATA-Pisces
Hemilepidotus hemilepidotus
Hexagrammos decagrammus
Microgadus proximus - juv.
Pleuronectiformes, unid.

CHORDATA-Mammalia
Eumetopias jubatus
Enhydra lutris

Appendix D-3. Species observed at Port Dick.

	Creek Mouth	Fucus Zone	Mussel Bed, mud flat	Zostera Bed, mud flat	Shelly Slope	Dick's Head
ALGAE-Chlorophyta						
Chlorophyta, unid. (filamentous)						X
Cladophora sp.			X	X		X
Enteromorpha sp.						X
? *Monostroma* sp.			X	X[1]		X
Spongomorpha sp.						X
? *Ulva* sp.					X	X
Urospora ? *penicilliformis*						X
ALGAE-Phaeophyta						
Agarum cribrosum						X
Alaria ? *crispa*						X
A. marginata		X[1/]	X	X		
Alaria sp.			X[1/]			X
Costaria costata					X[1/]	X
Cymathere triplicata			X	X		
Desmarestia aculeata				X		X
D. ? *viridis*			X	X	X	X
? *Ectocarpus* sp.			X	X		
Fucus distichus	X	X	X		X[1/]	X
Laminaria groenlandica						X
L. saccharina			X	X	X	X
L. yezoensis						X
Phaeophyta, unid. (ribbon-like)						
Phaeophyta, unid. (filamentous)						X
Nereocystis luetkeana		X[1/]				
Scytosiphon lomentaria						X
Soranthera ulvoidea						X
ALGAE-Rhodophyta						
Agardhiella tenera						X
Callophyllis sp.						X
Constantinea simplex				X		X
C. subulifera						X
Corallina sp.						X
Cryptosiphonia woodii						X
Gigartina papillata						X
Gigartina spp.						X
Gloiopeltis furcata						X
Gloiosiphonia verticillaris				X		
Halosaccion glandiforme			X	X		X
Iridaea lineare			X	X		
? *Lithothamnium* sp.						X
Odonthalia floccosa						X

Appendix D-3 (Cont.). Species observed at Port Dick.

	Creek Mouth	Fucus Zone	Mussel Bed, mud flat	Zostera Bed, mud flat	Shelly Slope	Dick's Head
Phycodrys sp.						X
Polysiphonia ? *pacifica*						X
Porphyra sp.		X[1/]	X	X		X
? *Prionitis* sp.						X
Rhodoglossum affine						X
Rhodomela larix				X		
Rhodophyta, unid. (filamentous)			X	X	X	X
Rhodophyta, unid. (foliose)						X
Rhodophyta, unid. (saccate)	X					
Rhodymenia palmata			X	X		X
Rhodymenia sp.						X
ANGIOSPERMAE						
Zostera marina		X[1/]	X	X	X	X
PROTOZOA						
Gromia oviformis				X		
PORIFERA						
Halichondria panicea						X
CNIDARIA-Hydrozoa						
Hydroida, unid.						X
CNIDARIA-Anthozoa						
Anthopleura ? *artemisia*			X			
Metridium senile					X	
ANNELIDA-Polychaeta						
Cirratulidae, unid.					X	
Cistenides brevicomis				X		
Crucigera sp.				X		
Nereis sp.						X
Serpulidae, unid.						X
Terebellidae, unid.			X	X		
ARTHROPODA-Crustacea						
Balanus cariosus			X[2/]			
B. ? *glandula*		X	X			X
B. hesperius laevidomus			X	X		
B. rostratus alaskensis				X		
Balanus spp.		X				
Cancer magister				X	X	X

Appendix D-3 (Cont.). Species observed at Port Dick.

	Creek Mouth	Fucus Zone	Mussel Bed, mud flat	Zostera Bed, mud flat	Shelly Slope	Dick's Head
Caridae, unid.				X		
Chthamalus dalli	X					
Cirripedia-Rhizocephala				X[3]		
Elassochirus tenuimanus (juvenile)				X		
Eualus townsendi[5]						
Gnorimosphaeroma oregonensis				X		X
Paguridae, unid.			X	X		
Pagurus hirsutiusculus			X	X		
Pandalidae, unid.					X	
Pandalus hypsinotus[5]						
Pentidotea wosnesenskii				X		
Telmessus cheiragonus				X	X	X
MOLLUSCA-Pelecypoda						
Clinocardium nuttalli			X	X		X
Hiatella arctica				X		
Macoma balthica			X	X		
M.? inconspiqua					X	
M. ? *inquinata*			X			
M. nasuta					X[4]	
Macoma spp.						X
Modiolus modiolus						X
Musculus vernicosus						X
Mya arenaria			X	X		X
M. truncata					X	X
Mya sp.			X			
Mytilus edulis	X		X			X
Pododesmus ? *macroschisma*					X	
Protothaca staminea				X	X	X
Saxidomus gigantea			X	X	X	X
Tresus capax						X
MOLLUSCA-Gastropoda						
Acmaea asmi			X	X		
A. pelta			X	X		
A. ? *triangularis*			X	X		
Acmaea spp.	X					
Acmaeidae, unid.						X
Aeolidida, unid.				X		
Collisella pelta						X
Coryphella sp.						X
? *Cryptobranchia concentrica*				X		

Appendix D-3 (Cont.). Species observed at Port Dick.

	Creek Mouth	Fucus Zone	Mussel Bed, mud flat	Zostera Bed, mud flat	Shelly Slope	Dick's Head
Hermissenda crassicornis				X		X
Lacuna ? variegata						X
L. vincta				X		
Lacuna sp.				X		
Littorina scutulata			X			X
L. sitkana	X	X	X	X		X
Margarites helicinus				X		
M. pupillus				X		
Margarites sp.				X		
Mitrella gouldi[5]						
Natica clausa					X	
Notoacmaea scutum						X
Nucella ? canaliculata			X			
ECTOPROCTA						
Membranipora sp.					X	
ECHINODERMATA						
Chiridota sp.						X
Dermasterias imbricata					X	
Evasterias troschelii			X	X	X	X
Pycnopodia helianthoides				X	X	
Strongylocentrotus drobachiensis						X
CHORDATA-Pisces						
Ammodytes hexapterus				X		X
Anoplarchus purpurescens						X
Bathymaster sp.					X	
Blepsias cirrhosus				X		
Cottidae, unid.	X				X	
Hexagrammos decagrammus					X	
Hexagrammos stelleri						X
Hippoglossus stenolepis					X	
? Lamna ditropis					X	
Limanda aspera[5]					X	
Lumpenus sagitta					X	
Microgadus proximus						X
Myoxocephalus ? polyacanthocephalus				X		
Oncorhynchus gorbuscha	X		X			
Oncorhynchus sp. (fry)	X					
Pholididae, unid., light brown						X
Pholis laeta						X

Appendix D-3 (Cont.). Species observed at Port Dick.

	Creek Mouth	Fucus Zone	Mussel Bed, mud flat	Zostera Bed, mud flat	Shelly Slope	Dick's Head
Phytichtys chirus						X
Platichthys stellatus					X	
Pleuronectiformes, unid. (adults)						X
Pleuronectiformes, unid. (juveniles)					X	
Ronquilus jordani				X		
Stichaeidae, unid.						X
CHORDATA-Aves						
Anas platyrhynchos			X			
Larus spp.			X			
Melanitta deglandi						X
Phalacrocorax auritus						X
Rissa tridactyla						X
CHORDATA-Mammalia						
Enhydra lutris						X
Phoca vitulina			X	X		X

1/ Drift
2/ Brooding
3/ Parasitic
4/ Shell only
5/ Caught in shrimp trap at 60 fathoms 7/31/75

Appendix D-4. Species observed in Koyuktolik Bay and Lagoon.

	Bay	Outer Lagoon	Inner Lagoon	Subtidal Entrance Channel	Pinnacle	Intertidal Mussel Beds
ALGAE-Chlorophyta						
Cladophora sp.						X
Enteromorpha sp.		X				
? Monostroma sp.		X	X	X	X	X
Rhizoclonium ? tortuosam						X
Spongomorpha sp.		X		X		X
Ulothrix sp.						X
? Urospora sp.					X	
ALGAE-Phaeophyta						
Agarum cribrosum					X	
Alaria fistulosa						X
A. ? marginata		X			X	
A. tenuifolia				X		X
Alaria sp.		X	X		X	X
Costaria costata		X			X	
Cymathere triplicata	X	X		X		X
Desmarestia ? viridis				X	X	X
Fucus distichus	X	X	X	X	X	X
Laminaria groenlandica		X		X	X	X
L. saccharina	X				X	
L. setchellii					X	
Laminaria sp.					X	
Nereocystis luetkeana		X		X		X
Phaeophyta, unid. (saccate)					X	
Scytosiphon lomentaria					X	
ALGAE-Rhodophyta						
Ahnfeltia plicata		X	X			
Callophyllis sp.						X
Constantinea simplex	X				X	
Corallina vancouveriensis					X	
Delesseria decipiens					X	
Encrusting coralline algae					X	
Halosaccion glandiforme		X		X	X	X
Iridaea lineare		X			X	X
Microcladia sp.					X	
Odonthalia floccosa						X
O. kamschatica					X	
Opuntiella californica					X	
Porphyra sp.		X	X	X		X
Ptilota filicina					X	
Ptilota sp.					X	
Rhodymenia palmata					X	
R. pertusae					X	
Schizymenia sp.		X		X	X	X

Appendix D-4 (Cont.). Species observed in Koyuktolik Bay and Koyuktolik Bay Lagoon.

	Bay	Outer Lagoon	Inner Lagoon	Subtidal Entrance Channel	Pinnacle	Intertidal Mussel Beds
ANGIOSPERMAE						
Zostera marina		X	X[1/]	X		X
PORIFERA						
Halichondria panicea (encrusting)					X	
Porifera, unid., syconid					X	
Tedania sp.		X			X	
CNIDARIA-Hydrozoa						
Abietinaria turgida					X	
Hydractinia sp.	X					
Sertulariidae, unid.					X	
CNIDARIA-Scyphozoa						
Haliclystus sp.		X[3/]				
CNIDARIA-Anthozoa						
Anthopleura ? *artemesia*					X	
Anthopleura sp.					X	
? *Diadumene* sp.					X	
Metridium senile	X				X	
Tealia crassicornis					X	
ANNELIDA-Polychaeta						
Abarenicola sp.			X			
Eudistylia ? *vancouveri*					X	
Myxicola infundibulum					X	
Polychaeta, unid. (tubicolous)	X					
? *Serpula vermicularis*					X	
Serpulidae, unid.					X	
Terebellidae, unid.					X	
ARTHROPODA-Crustacea						
Balanus cariosus					X	X
B. ? *glandula*		X			X	X
Brachyura, unid.		X			X	
Cancer oregonensis					X	
Chthamalus dalli					X	
Elassochirus gilli	X				X	
E. tenuimanus	X				X	
Gammaridea, unid.					X	
Gnorimosphaeroma oregonensis						X
Hyas lyrata					X	

Appendix D-4 (Cont.). Species observed in Koyuktolik Bay and Koyuktolik Bay Lagoon.

	Bay	Outer Lagoon	Inner Lagoon	Subtidal Entrance Channel	Pinnacle	Intertidal Mussel Beds
Lebbeus sp.					X	
Oregonia gracilis					X	
Pagurus ochotensis	X					
Pagurus sp.					X	
Paralithodes camtschatica					X	
Pugettia gracilis					X	
Telmessus cheiragonus		X		X	X	X
MOLLUSCA-Polyplacophora						
Katharina tunicata					X	
Mopalia sp.					X	
Polyplacophora, unid.		X				
Tonicella insignis					X	
T. lineata					X	
MOLLUSCA-Pelecypoda						
Astarte sp.		X			X[4/]	
Clinocardium nuttalli		X				
Humilaria kennerlyi		X[4/]			X[4/]	
Macoma sp.		X				
Modiolus modiolus					X	
Musculus vernicosus		X				
Mya arenaria		X				
Mya truncata		X[4/]				
Mytilus edulis		X		X	X	X
Protothaca staminea		X				
Saxidomus gigantea		X				
Tellina nuculoides	X					
Tresus capax		X			X[4/]	
MOLLUSCA-Gastropoda						
Acmaea mitra					X	X
Acmaea sp.				X	X	X
Acmaeidae, unid.					X	X
Collisella pelta						X
Diaulula sandiegensis					X	
Diodora aspera					X	
Fusitriton oregonensis					X	
Hermissenda crassicornis						
Lacuna sp.		X			X	
Littorina sitkana		X		X	X	X
Margarites helicinus		X[4/]				
Margarites sp.					X	
Natica clausa		X			X	
Natica sp.					X	
Notoacmaea persona						X

Appendix D-4 (Cont.). Species observed in Koyuktolik Bay and Koyuktolik Bay Lagoon.

	Bay	Outer Lagoon	Inner Lagoon	Subtidal Entrance Channel	Pinnacle	Intertidal Mussel Beds
N. scutum					X	
Nucella lima						X
Olivella baetica	X					
Volutharpa ampullacea					X	
ECTOPROCTA						
Alcyonidium pedunculatum					X	
A. polyoum					X	
Ectoprocta, unid.					X	
Flustrella corniculata					X	
Hippothoa hyalina					X	
BRACHIPODA						
Diestothyrus frontalis					X	
ECHINODERMATA						
Cucumaria miniata					X	
Cucumaria sp.					X	X[5]
Echinarachnius parma	X					
Eupentacta quinquesemita						X
Evasterias troschelii		X			X	
Henricia leviusculus					X	
Leptasterias ? *hexactis*		X			X	X
Ophiopholis aculeata					X	
Pycnopodia helianthoides (adults)	X	X			X	
Pycnopodia helianthoides (juveniles)				X		X
Strongylocentrotus drobachiensis					X	
CHORDATA-Tunicata						
Ascidians, social, colonial	X					
CHORDATA-Pisces						
Ammodytes hexapterus		X				
Cottidae, unid.		X				
Hexagrammos decagrammus	X					
H. stelleri						
Hexagrammos sp.		X				
Leptocottus armatus	X					
Microgadus prodimus		X				
Pleuronectiformes, unid. (adults)					X	
Pleuronectiformes, unid. (juveniles)	X					

Appendix D-4 (Cont.). Species observed in Koyuktolik Bay and Koyuktolik Bay Lagoon.

	Bay	Outer Lagoon	Inner Lagoon	Subtidal Entrance Channel	Pinnacle	Intertidal Mussel Beds
Salvelinus malma				X		
Stichaeidae, unid.	X					
CHORDATA-Aves						
Corvus caurinus						X
Larus glaucescens						X
Larus sp.						X
Melanitta perspicillata						X
CHORDATA-Mammalia						
Phoca vitulina		X	X			
Enhydra lutris			X	X		X

1/ Drift
2/ Orange-yellow, in Ahnfeltia
3/ On eelgrass
4/ Shell only
5/ Black and white species

NOAA03-5-022-67

Research Unit #58

9/1/75 - 4/1/77

FINAL REPORT

A Description and Numerical Analysis of the Factors Affecting the Processes of Production in the Gulf of Alaska

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Special Report No. 76
Reference M-77-40

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Figure

Figure

Figure

Acknowledgments

Thanks are due to the following persons who participated in this study. Linda Olund wrote and ran the productivity sorting program, Donna Bendiner wrote and ran the phytoplankton program. Ken Seymour wrote the programs for and prepared the magnetic tapes. Jim Postel and Willis Peterson assisted with the graphic presentation. Discussions with Dr. T. S. English and Michael MacCauley have been helpful with regard to the statistical analyses.

SUMMARY

Objective 1. To conduct a search and present a compilation of available baseline biological and associated physical and chemical data from the Gulf of Alaska (planktonic realm).

Conclusion: The data have been compiled and submitted to NODC on magnetic tape.

Implications: Measurement of the effects of petroleum development will depend upon comparison of data with pre-development figures (i.e., those of this study).

Objective 2. To use the compiled data for a description of the temporal and geographic variation in phytoplankton standing stock (and species), production, and related physical and chemical factors.

Conclusion: Annual, seasonal, geographic, and vertical variation of biological and associated factors has been described in the pelagic realm of the eastern Subarctic Pacific. Annual and seasonal features are dominant. Geographic variation is limited to differences between coastal and oceanic regimes.

Implications: Evidence of natural fluctuations in plant biomass and production are now available for comparison with changes related to petroleum development. Grazing and circulation patterns indicate the possibility of long-term toxins (hydrocarbons) in the food chain leading to salmon.

Objective 3. To use the data from Station "P" in a model of phytoplankton productivity and to test the sensitivity of the model to changes in physiological constants and external parameters.

Conclusion: A model has been completed and the results are sensitive to more of the inputs during the winter than during periods of high grazing pressure in the spring.

Implications: The model may be used to relate natural and oil-related changes in the environment to plant production.

INTRODUCTION

A. General nature and scope of study

A study of the potential impact of modifications to an ecological system must determine both the quantity and distribution of organisms and the relationship between these various organisms. Baseline studies are necessary in order to assess the average stocks in an area and the natural variations within these stocks. Knowledge of the energetics which relate the different organisms is also necessary in order to estimate changes which might be expected from modifications of the system. Even more important, a general understanding of the gross processes controlling the ecological system, when applied to a simple model, is an invaluable tool in designing and implementing the baseline studies. This study encompasses the pelagic ecosystem in the Gulf of Alaska, concentrating on the first step of the food chain.

B. Specific objectives

The specific objectives of this study are:

1. To search the existing literature and unpublished data in order to compile baseline information on factors of importance to phytoplankton production.
2. To synthesize the baseline information into a description of the seasonal and geographic distribution of phytoplankton standing stock, production and related physical and chemical factors insofar as the existing data are suitable.
3. To use the data to initialize a numerical model and to determine the combinations of process submodels which lead to distributions in the dependent variables that are in agreement with observations.

4. To test the sensitivity of the results of the "standard" run to changes in the submodels and independent variables; identify those variables and processes which strongly influence the results.

C. Relevance to problems of petroleum development

The results of this study are relevant to petroleum development in two ways: First, the baseline information which we have compiled may be used (where the existing data are suitable) to compare effects after petroleum development with the natural range of values in the pelagic ecosystem. Second, we can suggest the types of modifications to the plant community which might be associated with a large scale oil spill.

This study describes the "normal" state of the ecosystem in the Gulf of Alaska, as well as any natural fluctuations of plant populations that have occurred in the past. Where the data are adequate, comparisons with this norm should be the basis of any future study of the actual impact of petroleum development on the pelagic ecosystem. We can now point out areas in which we feel the data are lacking. The model results from Station "P" indicate the variables which most strongly influence primary production. It would stand to reason that these variables should also be gathered in any further studies in the Gulf of Alaska if they are not already available.

It is obvious that, with the exception of the area around Station "P", there are insufficient data in the Gulf of Alaska to describe quantitative cause and effect relationships. Individual species of phytoplankton are likely to be most sensitive to chemical changes in the environment so that changes in species distribution may be good indicators of changes in the ecosystem. This study describes those species distributions that have been found in the past.

To actually predict the effects of an oil spill on the primary producers is a task far beyond the capabilities of the present study. To do this, one would need supporting information on the effect of oil on the physical properties of the water column and on the physiology of the plants and animals. Still, we can suggest the nature of the changes which might occur. For instance, a layer of oil on the sea surface may be expected to decrease the transmission of light and the transfer of turbulent energy across the air-sea interface. This can be modeled by decreasing the incident radiation and by reducing the vertical mixing. This same layer of oil might affect the plant community by decreasing the maximum production rate and by increasing the respiration rate (an artificial means of increasing mortality). We have tried the above demonstrations in order to evaluate the value of this scientific model as a management tool.

The effects of an oil spill on the productivity of underlying waters would be, for the most part, short term effects. There is also a possibility of long term effects of petroleum development in the Gulf of Alaska. One such long term effect would be the introduction of different oil fractions into the food chain. Some of these fractions may not be toxic to organisms low on the food chain, but could be toxic to man. For instance, high boiling aromatic hydrocarbons are suspected as long-term poisons, perhaps carcinogenic ones, and the nonhydrocarbon fractions of crude oil behave in a similar manner (Blumer, 1969).

In the Gulf of Alaska during the spring bloom, it has been reported that grazing by a large stock of herbivores keeps the phytoplankton standing stock at a constant level (McAllister *et al.*, 1960). If an oil spill were dispersed into tiny droplets either chemically or by wave action, these droplets would likely be consumed along with the living cells. Circulation patterns described in the literature we have reviewed show, in addition to the counterclockwise flow around the Gulf of Alaska, that currents flow north from the Alaskan stream through the Aleutians to Bristol Bay (Figure 24). Thus, hydrocarbons consumed by zooplankters would be distributed to one of the main feeding ground of salmon, and chemicals of unknown but suspected toxicity to man could become concentrated in a major food source.

PHYTOPLANKTON PRODUCTIVITY MODEL

A. Abstract

The objectives of this numerical study of primary productivity at Ocean Station "Papa" (Station "P") are:

1) to provide a quantitative synthesis of the ideas which have been advanced concerning plant production;
2) to assess the relative importance of the various processes which contribute to net plant production; and
3) to speculate about the consequences of environmental changes to the standing stock of the plants.

We synthesized one combination of biological concepts to simulate the observed chlorophyll distributions and plant productivity over the course of one year. This model was then used to study the sensitivity of the results to changes in some of the model inputs. It was also used to simulate the effects of environmental changes on the plant community. With the present uncertainty about the input values and the processes which govern phytoplankton distribution, there may be other, equally valid models. Two of the least-known independent variables, the carbon-to-chlorophyll ratio and the zooplankton feeding threshold, both exert a major influence on the results throughout the year and are exceedingly important for part of the year.

B. Current state of knowledge

Observations which have been made concerning primary production at Station "P" indicate that: 1) chlorophyll concentrations show very little change throughout the year (Parsons and LeBrasseur, 1968); 2) nutrients (nitrogen) are available in sufficient quantity so as not to limit plant growth (Anderson *et al.*, 1969); 3) plant production in the water column, however, peaks during the early summer (McAllister, 1969); and 4) this excess production must be cropped down by the grazers (McAllister, *et al.*, 1960).

Figure 1 is a composite of the surface chlorophyll data (McAllister, 1962; Stephens, 1964, 1966, 1968, 1970) for the years from 1959 to 1970. All of the data are plotted against the day of the year, regardless of the actual year. In this and all other figures, day 1 corresponds to January 1. All chlorophyll concentrations measured before 1963 were assumed to be over-estimates. These values had been computed using the formulae of Richards with Thompson (1952) or Strickland and Parsons (1960). We multiplied these values by 0.76 to make them compatible with the equations of Parsons and Strickland (1963) and UNESCO (1966). The correction factor is taken from Banse and Anderson (1967). It is obvious from these data that there is considerable variation in the surface chlorophyll values at any given time of the year. The mean chlorophyll concentration, however, may not change much throughout the year.

Not only do the chlorophyll concentrations vary at the surface, but there is also considerable scatter in their values at depth. Because of this, the data for these 12 years were averaged into blocks covering 30 days and 10 m in depth in order to present a mean description of the chlorophyll-depth profile as it changes throughout the year. Figure 2 shows the average data and the standard deviation of the data. Values which are enclosed by a dotted circle are each derived from only one data point and, therefore, have no standard deviations associated with them. There are also no data for certain depth intervals. In Figure 2, we also pass a hand-fit curve through the mean data.

Figure 3 shows the seasonal, depth variation of the mean chlorophyll distribution. The twelve smoothed curves from Figure 2 were used in generating Figure 3. The top figure illustrates the time and depth dependence of

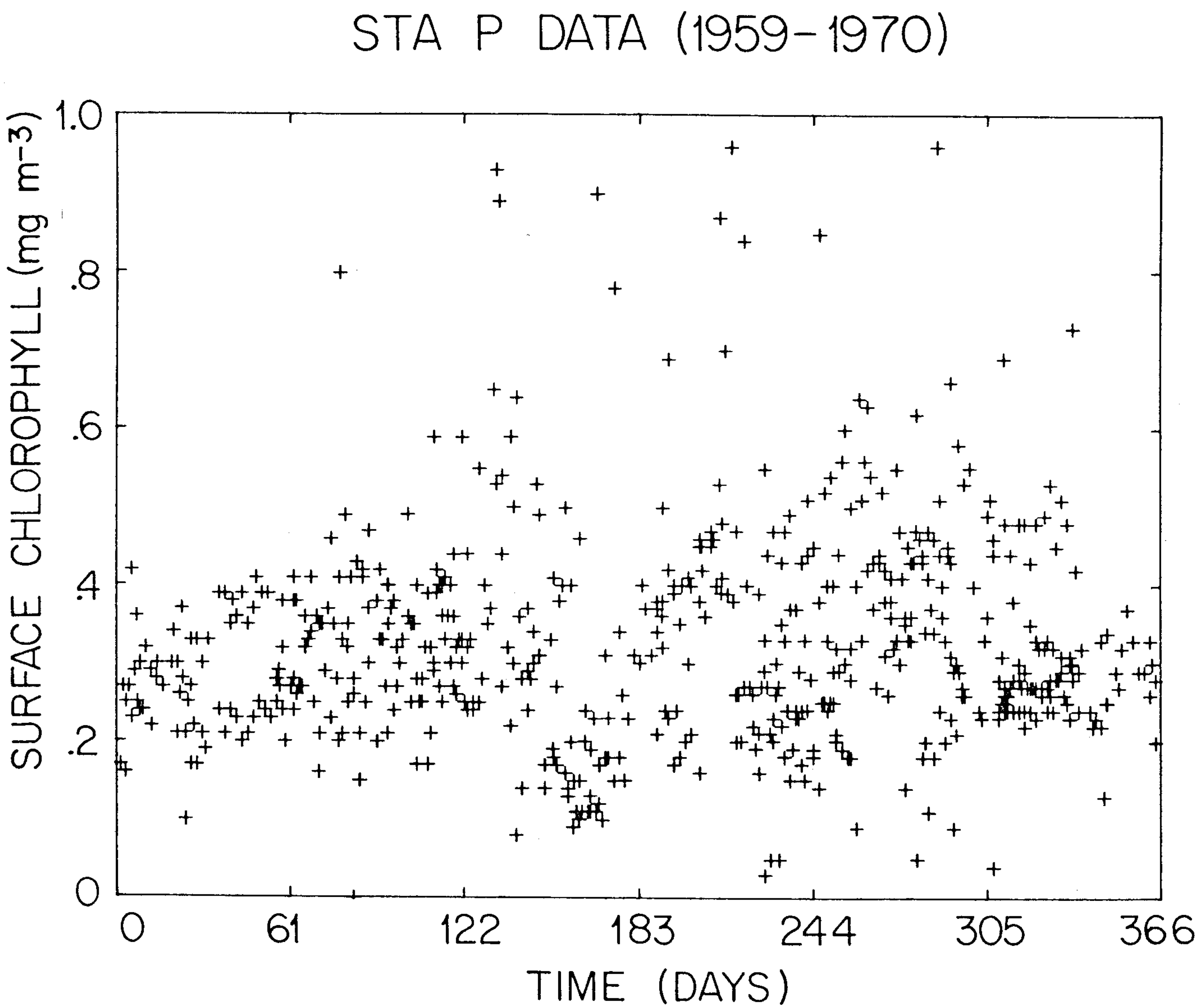


Figure 1. Surface chlorophyll values at Station P. Data from all the years are combined.

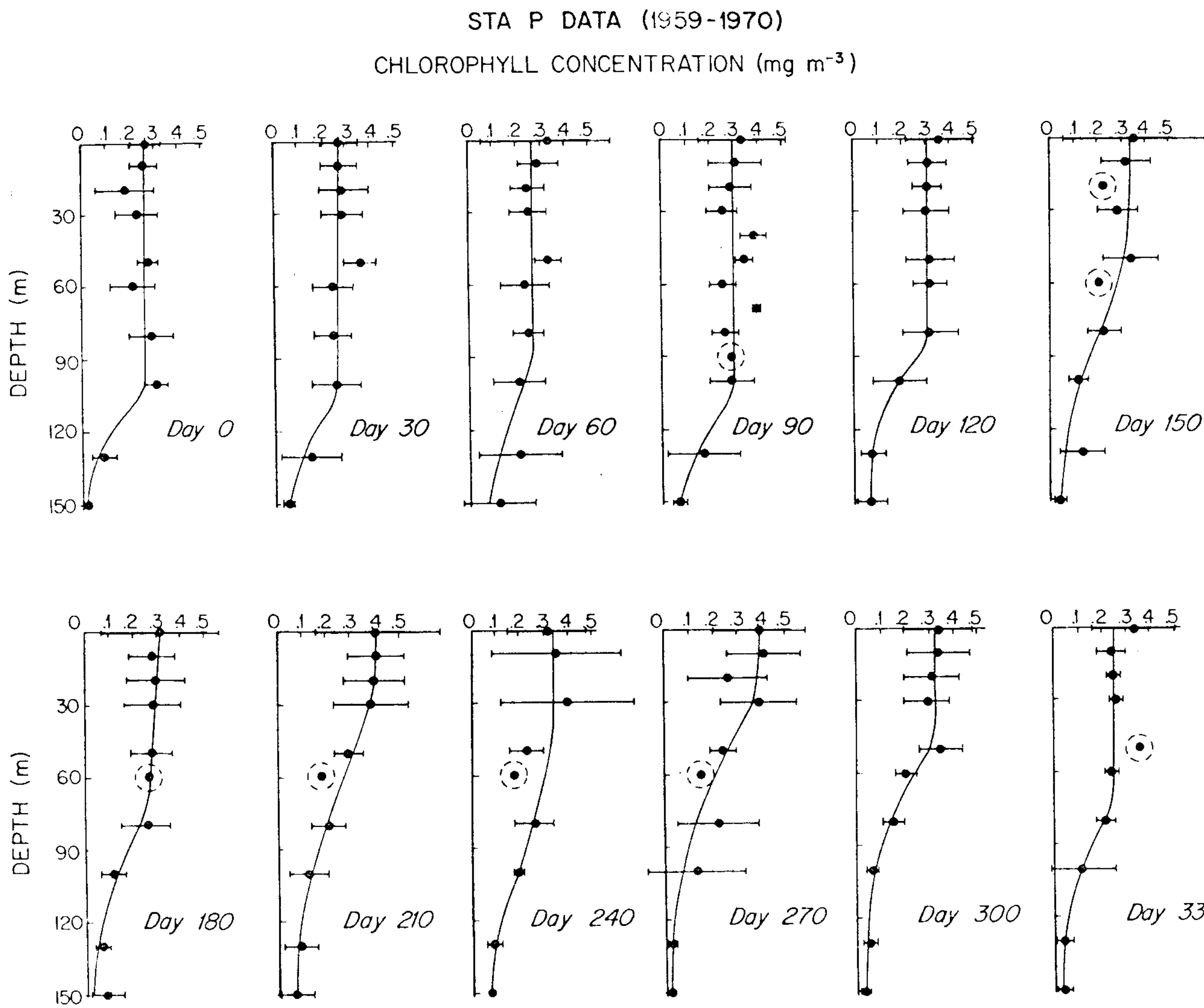
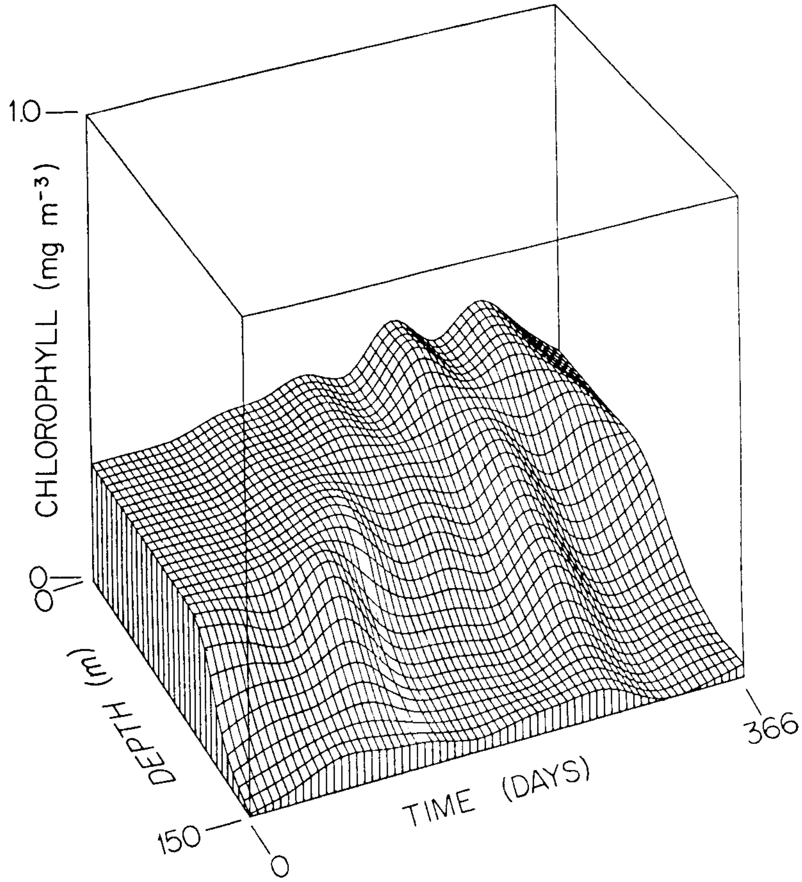
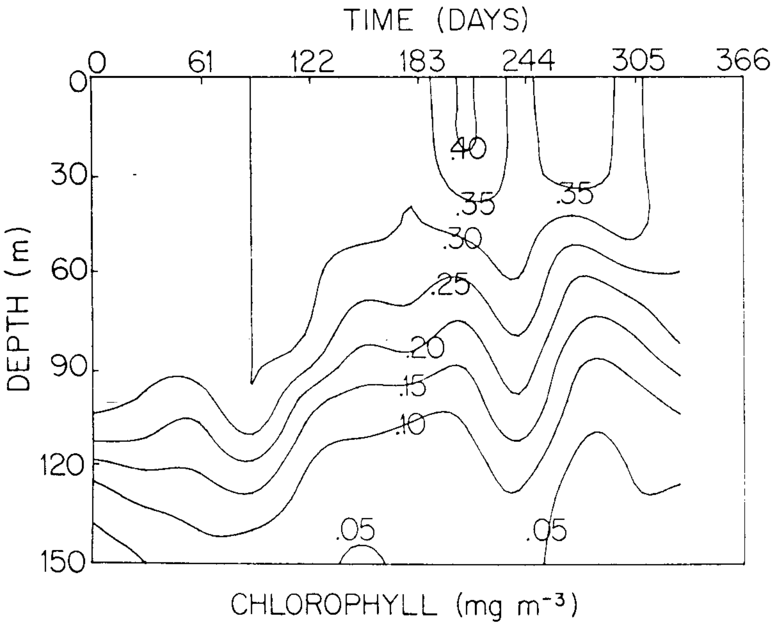


Figure 2. Mean (30 day-10 m blocks) chlorophyll concentration. Error bars indicate standard deviations. Dotted circle surrounds the "mean" values when only one data point is available. Hand-fit curves are shown for these data.

Figure 3. Mean, seasonal and depth variation in chlorophyll concentration. Data from hand-fit curves in Figure 2. Top, 3-dimensional representation. Bottom, contour plot.


1.0
CHLOROPHYLL (mg m^{-3})
0
0
DEPTH (m)
150
0
TIME (DAYS)
366


TIME (DAYS)
0
61
122
183
244
305
366
0
30
60
90
120
150
DEPTH (m)
.40
.35
.35
.30
.25
.20
.15
.10
.05
.05
CHLOROPHYLL (mg m^{-3})

chlorophyll concentration. The bottom figure presents the same information in a contour plot. Here the contours are for values of constant chlorophyll. It may be seen from either of these figures that the change in chlorophyll concentration with season is relatively small in the near surface waters. The chlorophyll concentrations in the mid-depths do show more variation as the mixed layer depth changes from summer to winter.

Nitrate data for Station "P" are available for the six years from 1965-1970 (same source as chlorophyll data). Figures 4 and 5 show the mean profiles and the seasonal depth variation for this nutrient. Surface nitrate reaches a high of about 17 μg-at ℓ^{-1} in the winter and is reduced to a low of about 7 μg-at ℓ^{-1} in the late summer. Even the minimum value encountered in the summer is sufficiently high so that nitrate is not limiting phytoplankton growth. It is interesting to note that nutrients are being removed from the near surface waters throughout the year and that the minimum surface nutrients in the summer occur at about the same time as the maximum surface chlorophyll concentrations.

Values for the integrated carbon production in the water column are only reported for the three years, 1961 to 1963. The depth to which production was measured and hence integrated varied somewhat throughout the data. That depth, however, was not less than 50 m and the small amount of production which was neglected below the integration depth would not have greatly changed the reported values. The time variation of production in the water column is shown in Figure 6. This composite description shows a peak in production about the end of June.

Station "P" has a very complete coverage of the seasonal variation in zooplankton biomass (LeBrasseur, 1965). The data on the zooplankton wet weight were obtained by net hauls from 150 meters to the surface. The values, however,

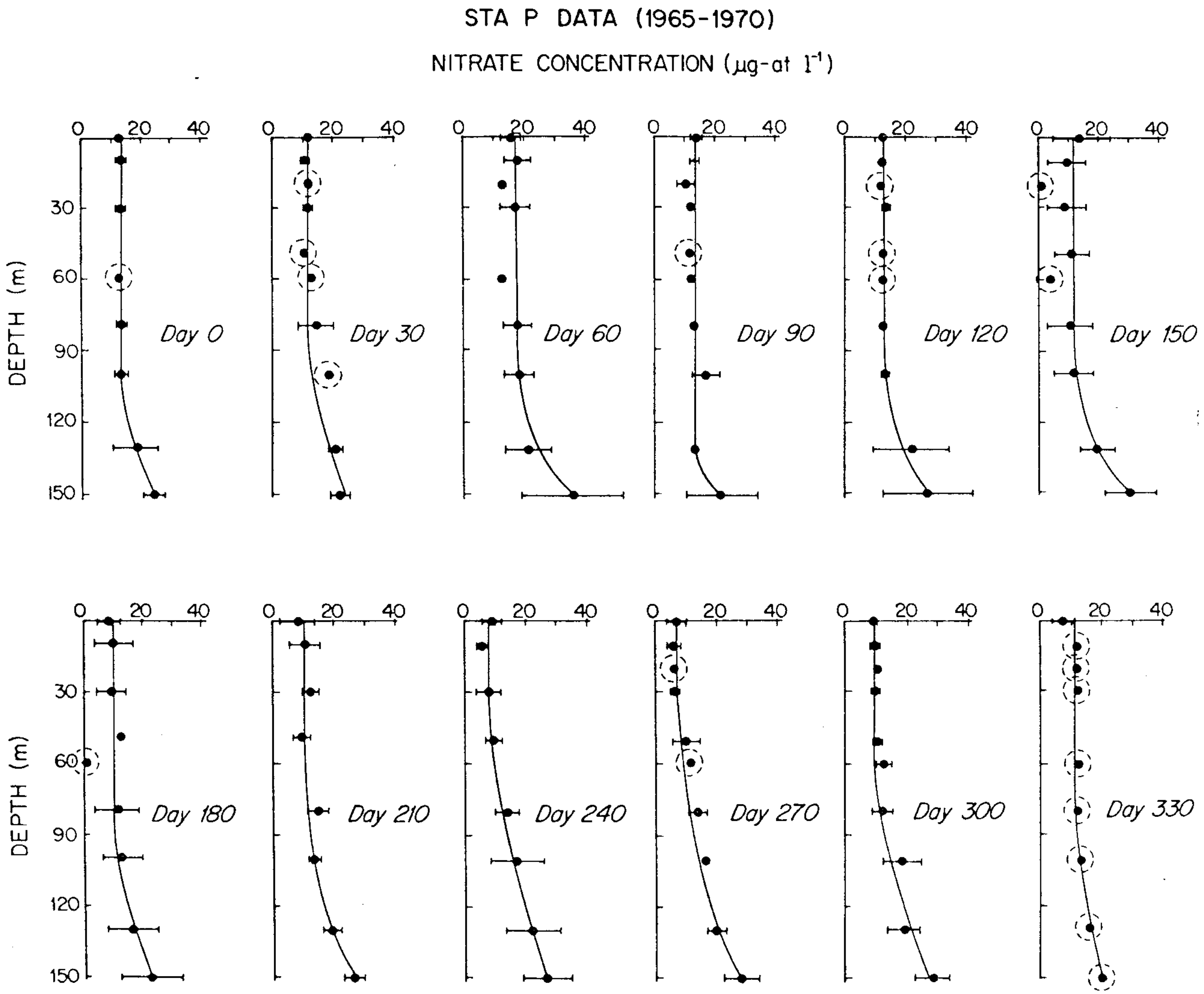
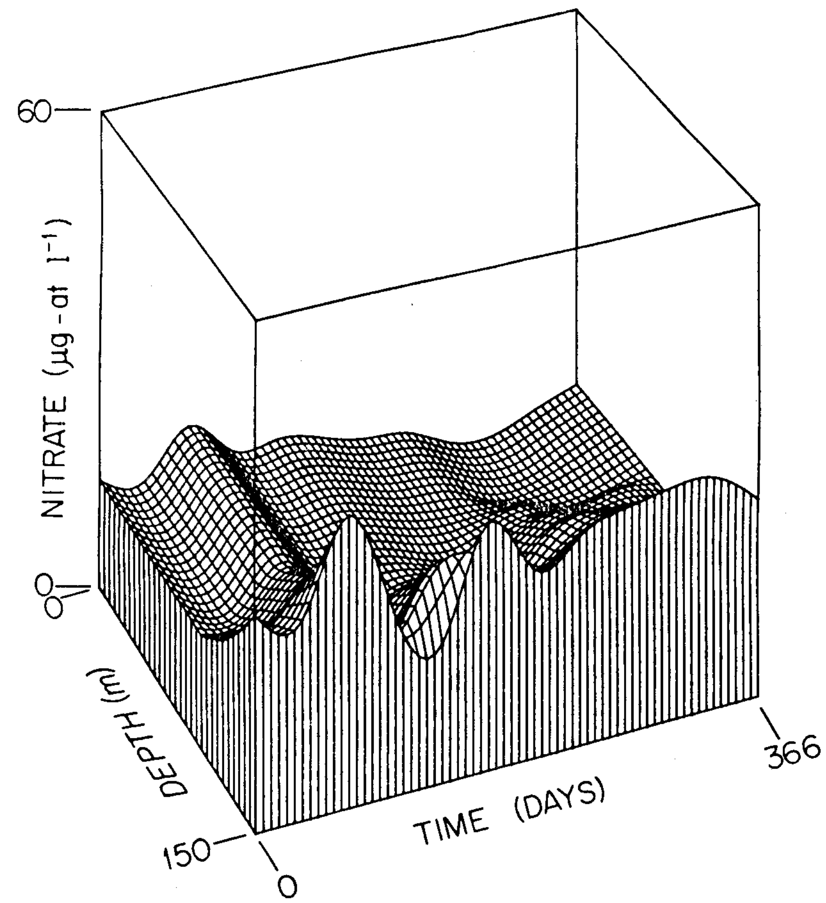
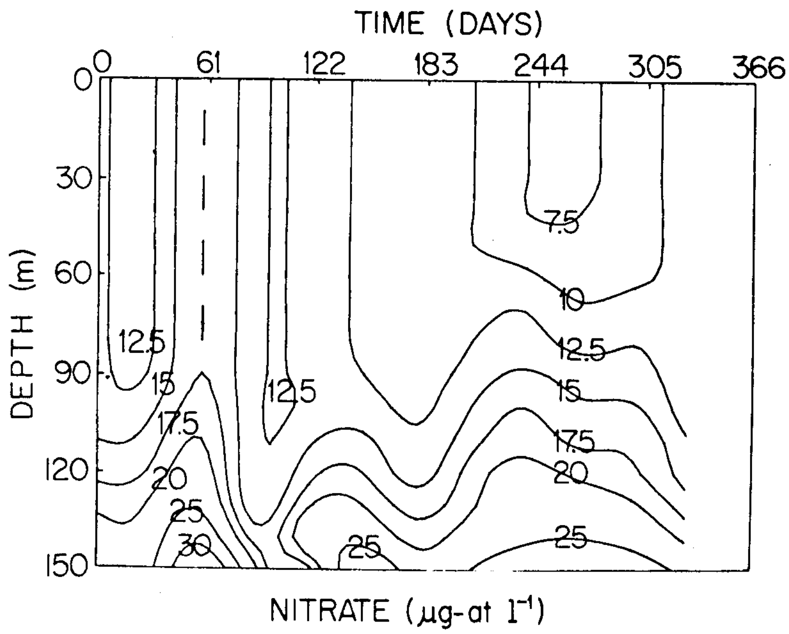


Figure 4. Mean (30 day-10 m blocks) nitrate concentration. Error bars indicate standard deviations. Dotted circle surrounds the "mean" values when only one data point is available. Hand-fit curves are shown for these data.

Figure 5. Mean, seasonal and depth variation in nitrate concentration. Data from hand-fit curves in Figure 4. Top, 3-dimensional representation. Bottom, contour plot.


60
NITRATE (µg-at l⁻¹)
0
0
DEPTH (m)
150
0
TIME (DAYS)
366


TIME (DAYS)
0
61
122
183
244
305
366
0
30
60
90
120
150
DEPTH (m)
7.5
10
12.5
12.5
15
12.5
15
17.5
17.5
20
20
25
30
25
25
NITRATE (µg-at l⁻¹)

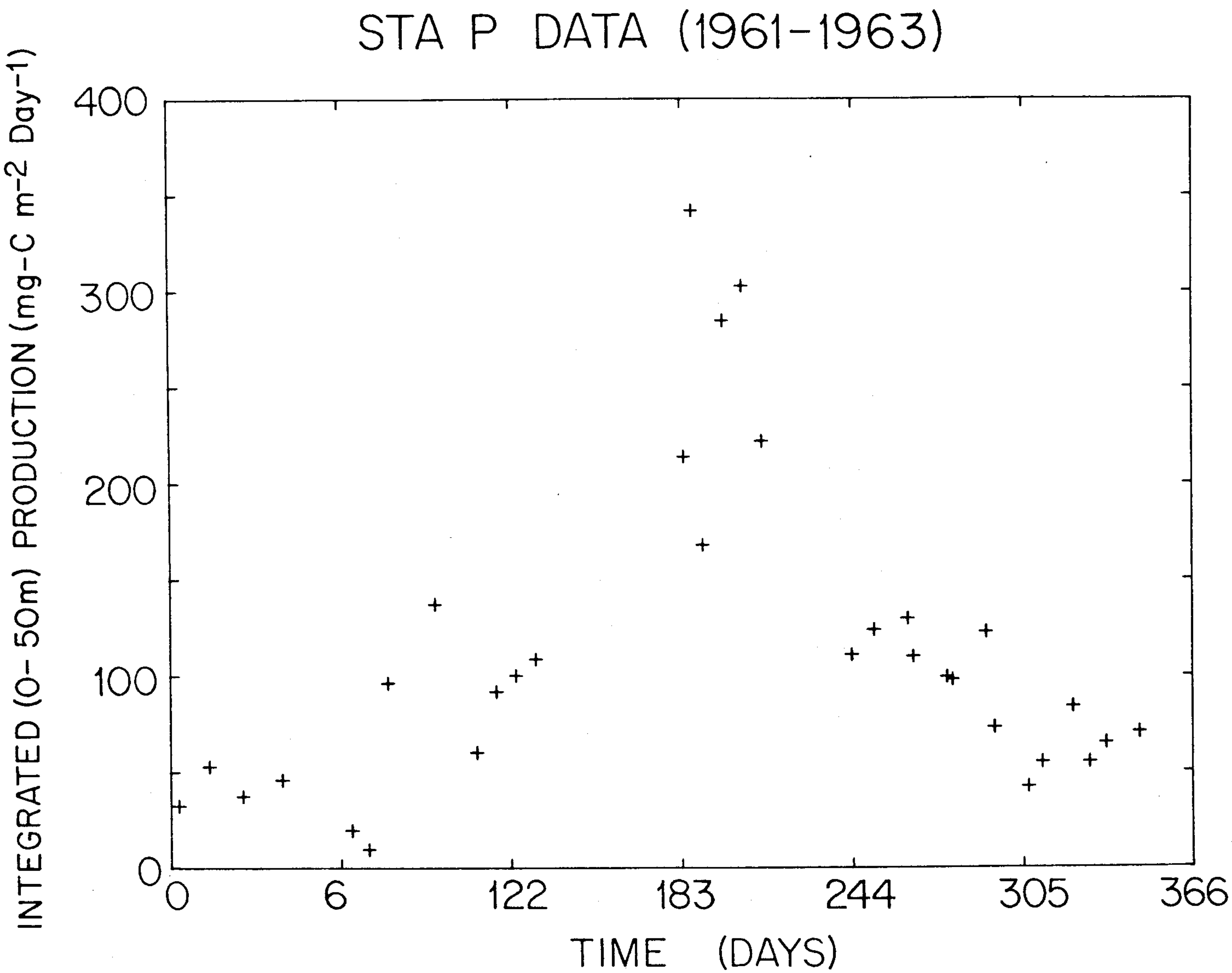


Figure 6. Daily production in the water column.

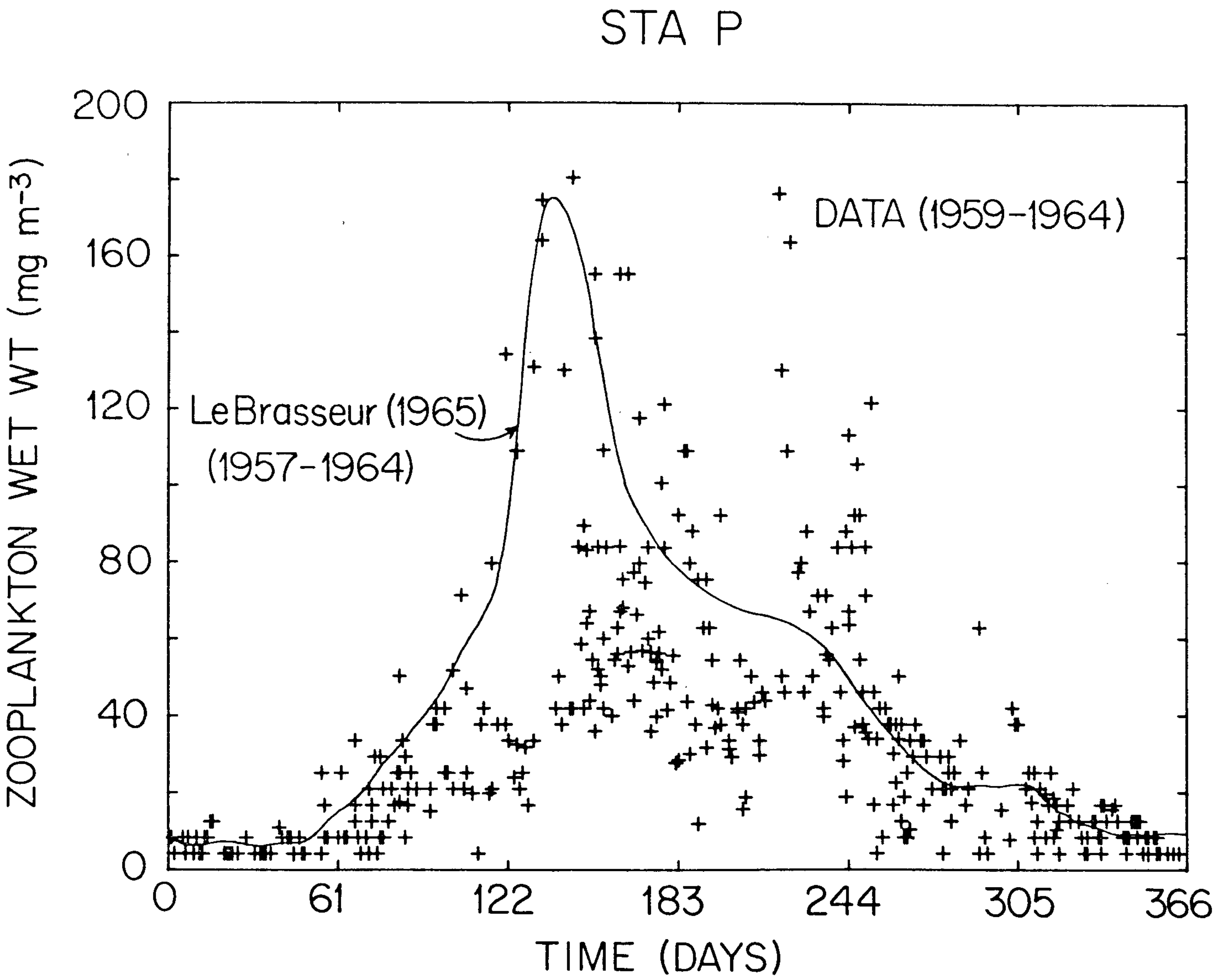


Figure 7. Seasonal zooplankton wet weight data and an averaged curve. Values given are means in the top 150 m of the water column.

are reported as concentrations per unit volume so that those values must be multiplied by the volume of the 150 m deep water column in order to arrive at the zooplankton biomass of the water column Figure 7 shows both the data (1959 to 1964) and an average curve for 1957 to 1964 (LeBrasseur, 1965) for zooplankton wet weight.

C. Study area

Weather Station "P" has been chosen as the study area because of the extensive time series of biological and physical data collected there.

D. Model equations and inputs

It is one goal of this study to combine the observations at Station "P" with theories concerning plant production in order to study the processes of primary production which are occurring at that location. To that end, we will construct a model to describe chlorophyll concentrations and check our theories by comparing the results of this model with observations. In the model, we begin with an initial chlorophyll-depth profile and simulate the change in that profile with time. The time rate of change in chlorophyll depends on processes such as mixing and sinking, on net production, and on grazing. In general, net production and grazing both depend, in turn, on the chlorophyll concentration. For instance, production depends on the supply of limiting nutrients, which is governed, itself, by the uptake and regeneration due to the phytoplankton. Similarly, the grazing pressure is proportional to the number of herbivorous zooplankters and that zooplankton population depends on the availability of plant food. Thus, a description of plant production should consist of three coupled equations: one describing the rate of change of the plants, one the rate of change of the nutrients, and one the rate of change of the population of grazers. However, because nutrients do not limit production at Station "P", they may be eliminated from the model. Also, because of the large amount of zooplankton biomass data and because of the uncertainties associated with trying to describe zooplankton growth, we feel that it is better to use the zooplankton data as an independent input in place of the zooplankton growth equation.

This simplifies the model to one equation describing the rate of change of plant material (chlorophyll), which does not depend on the external nutrient concentration and which includes zooplankton biomass as one of the independent inputs. While this simplification is justified by the observations at Station "P", it does limit the generality of the model. For instance, it is unrealistic to allow this model to produce a massive phytoplankton bloom since we know that such a situation would deplete the available nutrients and necessitate a consideration of the effects of low nutrients on production. Likewise, if the plant population were to drop to very low levels in the model, it is unlikely that the system would be able to support the observed zooplankton population. So, this would violate our assumption that zooplankton grazing pressure may be modeled by the measured zooplankton biomass.

The advantage of this simplified model is that it allows us to simulate the biological system at Station "P" with a minimum of assumptions concerning biological processes, many of which are poorly understood at present. The disadvantage, as mentioned in the previous paragraph, is that we cannot apply this model to extreme situations. In the following sections, we will present the equations governing the rate of plant production and the constants and independent variables used in those equations.

The rate of change of chlorophyll depends on mixing and sinking, on gross production, and on grazing by the herbivorous zooplankton. Thus, it may be expressed as:

$$\partial_t A = \partial_z (K \partial_z A) - w \partial_z A + \left[P_{max} \tanh\left(\frac{I\alpha}{P_{max}\gamma}\right) - R\right] A - \frac{G}{\gamma}\left(1 - e^{-\beta(A\gamma - P_o)}\right) \quad (1)$$

where:

$A(z,t)$ - chlorophyll concentration [mg m^{-3}]

$K(z,t)$ - vertical eddy diffusion coefficient [$m^2 s^{-1}$]

w - sinking speed [ms^{-1}]

P_{max} - maximum photosynthetic rate [s^{-1}]

$I(z,t)$ - light intensity [cal cm^{-2} hr^{-1} $\equiv$ ly hr^{-1}]

$\gamma(z,t)$ - carbon to chlorophyll ratio [mg-C (mg chl)$^{-1}$]

α - initial slope of photosynthesis vs. light curve [mg-C (mg-chl)$^{-1}$ ly^{-1}]

R - respiration rate [s^{-1}]

G(z,t) - grazing pressure [mg-C m^{-3} s^{-1}]

β - normalized initial slope of grazing curve [m^3 mg-C^{-1}]

$P_o(t)$ - feeding threshold [mg-C m^{-3}]

t - time [s]

z - depth [m]

The boundary conditions on the chlorophyll concentration are that there is no flux at the top (z = 0) and zero gradient at the bottom of the modeled water column ($z = z_{btm}$).

$$K \partial_z A - wA = 0 \qquad z = 0 \tag{2}$$

$$\partial_z A = 0 \qquad (z = z_{btm}) \tag{3}$$

Furthermore, it is assumed that there is a "near-surface"mixed layer, the depth of which (d_{mix}) varies with the time of year. Within the mixed layer, the governing equation for the rate of change of chlorophyll becomes:

$$\partial_t A = \frac{1}{d_{mix}} \left\{ [K \partial_z A - wA]_{d_{mix}} - [K \partial_z A - wA]_o + \int_o^{d_{mix}} \left(\left[P_{max} \tanh\left(\frac{I \alpha}{P_{max} \gamma} \right) - R \right] A - \frac{G}{\gamma} \left[1 - e^{-\beta(A\gamma - P_o)} \right] \right) dz \right\}$$

Invoking the surface boundary condition, this becomes:

$$\partial_t A = \frac{1}{d_{mix}} \left\{ (K \partial_z A - wA)_{d_{mix}} + \int_o^{d_{mix}} \left[P_{max} A \tanh\left(\frac{I \alpha}{P_{max} \gamma} \right) - RA - \frac{G}{\gamma} \left(1 - e^{-\beta(A\gamma - P_o)} \right) \right] dz \right\}; \qquad z \le d_{mix} \tag{4}$$

In both equations 1 and 4, the grazing pressure is zero when $A < P_o\gamma^{-1}$.

Light intensity at depth in the water column depends on the amount of light at the surface of the water and the extinction of that light as it passes through the water column. So:

$$I(z,t) = I_o(t)e^{-c_1 z - c_2 \int_o^z A(z',t)dz'} \tag{5}$$

where:

$I_o(t)$ - light at the sea surface [ly]

c_1 - extinction coefficient of the water [m^{-1}]

c_2 - extinction due to self shading by the plants [m^2 (mg-chl)$^{-1}$]

The light penetrating through the sea surface depends on the amount of light reaching the top of the atmosphere, the amount which is lost in transmission through the atmosphere and the reflective losses at the sea surface. Thus:

$$I_o(t) = I_a(t)\ \tau_s^{\sec\lambda}\ \tau_c^{\sec\lambda}\ \delta \tag{6}$$

where the solar radiation reaching a unit horizontal and at the top of the atmosphere is given by:

$$I_a(t) = J_o \cos\lambda \tag{7}$$

where:

$$\cos\lambda \equiv \sin\phi \sin\theta + \cos\phi \cos\theta \cos h \tag{8}$$

$\sec\lambda = (\cos\lambda)^{-1}$

τ_s - transmission coefficient of the atmosphere

τ_c - transmission coefficient of the clouds

δ - fraction of solar radiation penetrating through the sea surface

J_o = 1.94 [ly min^{-1}] - solar constant

ϕ = 50 [deg] - latitude

h - sun's hour angle [deg]

$$\theta \quad = 23.433 \cos \left[\frac{(d-174)\pi}{182.5}\right] \text{- sun's declination [deg]} \qquad (9)$$

d - day of the year

Sunrise and sunset are assumed to occur when $\cos \lambda = 0$.

This model of chlorophyll standing stock includes six independent variables: $K(z,t)$, $d_{mix}(t)$, $\tau_c(t)$, $\gamma(z,t)$, $G(t)$, $P_o(t)$, which must be specified. There are also 9 constants which must be supplied: w, P_{max}, α, R, β, τ_s, c_1, c_2, δ. In the following paragraphs, we will describe the choice of independent variables and constants which are used in the standard run.

Mixing Coefficient, K, and mixed layer depth, d_{mix}

The first term on the right-hand side of equation (1) is the contribution of turbulent mixing to the change in chlorophyll concentration at any depth. That mixing is parameterized by the vertical eddy diffusion coefficient, a value which is very poorly known for the oceans. Models of primary production have usually assumed constant values for this coefficent or have guessed at its time and depth variations. Station "P" is unique in having numerous measurements of physical and chemical parameters in addition to a large set of biological data which have been acquired over the years. If we assume that chlorophyll and temperature are both "mixed" by the same processes, then the temperature data may be used to calculate an apparent mixing coefficient for use in the biological model. Because of the extensive amount of temperature data which is available, we restricted ourselves to the data for 1970 (deJong *et al.*, 1971; Minkley, 1971; Garrett, *et al.*, 1971; Linggard, *et al.*, 1971; Gantzer and Healey, 1971) instead of averaging data from many years. That year was chosen because it was one of the earlier ones for which temperature measurements were available every month.

All of the temperature casts which reached a depth of 300 m were used in our analysis. Those data were blocked into monthly average values for certain depth intervals (see Table 1). The averaged temperatures were then fit by the functions:

$$T = T_0 + T_1 \left(e^{-a_1 z^m} - 1\right) - T_2 z; \qquad z \leq z_m \tag{10}$$

$$T = T_3 + T_4 e^{-a_2 z} - T_5 z \quad ; \qquad z \geq z_m \tag{11}$$

where T and $\partial_z T$ are continuous at $z = z_m$.

Values for T_3, T_4, and T_5 and a_2 were estimated from all of the temperature data since the temperature-depth profiles of the deep waters did not change significantly over the course of the year. z_m, T_0 , T_1 , a_1 , m, T_2 were then chosen each month such that the continuity conditions at $z = z_m$ were satisfied and so that the curve best fit the monthly averaged temperature data. The temperature-depth profiles, as described by equations 10 and 11, for each month are given in Figure 8.

In order to calculate the mixing coefficient for heat (and by assumption also for chlorophyll), we start with an equation describing the rate of change of temperature in a diffusive medium (Carslaw and Jaeger, 1959);

$$\rho c \, \partial_t T = \partial_z (k \partial_z T) \tag{12}$$

where:

T - temperature [°C]

ρ - density [g cm^{-3}]

c - specific heat [cal g^{-1}°C^{-1}]

k - thermal conductivity [cal cm^{-1}sec^{-1}°C^{-1}]

Equation 12 may be rewritten as (assuming ρ and c do not vary with depth)

$$\partial_t T = \partial_z \left(\frac{k}{\rho c} \partial_z T\right)$$

$$= \partial_z (K \partial_z T)$$

Table 1. Monthly Average Temperature (°C), 1970

Month	Jan.	Feb.	Mar.	Apr.	May	June	July*	July†	Aug.	Sept.	Oct.	Nov.	Dec.
Number of cases	7	10	8	6	9	8	9	16	9	10	11	3	9
Depth (m)													
0	5.71	5.34	5.33	5.37	6.01	7.70	8.89	9.62	10.62	11.65	11.15	9.02	6.89
10	5.71	5.34	5.31	5.37	5.98	7.68	8.67	9.59	10.60	11.64	11.12	8.97	6.80
20	5.72	5.34	5.29	5.36	5.95	7.56	8.48	9.39	10.47	11.62	11.12	8.98	6.89
30	5.71	5.33	5.28	5.35	5.93	7.34	8.26	8.85	10.18	11.48	10.90	8.90	6.85
50	5.70	5.33	5.26	5.28	5.75	6.65	7.49	7.50	7.85	7.78	8.15	8.97	6.80
75	5.68	5.32	5.20	5.20	5.38	5.48	5.58	5.60	5.78	5.68	5.50	5.08	6.38
100	5.02	5.10	5.02	5.03	5.04	5.01	4.93	4.94	5.06	4.93	4.92	--	4.89
125	4.02	4.10	4.18	4.20	4.34	4.46	4.48	4.57	4.59	4.57	4.67	4.36	4.49
150	4.02	4.08	4.07	4.05	4.10	4.26	4.12	4.16	4.19	4.26	4.33	4.25	4.32
175	3.91	3.97	3.99	3.96	3.99	4.12	3.97	4.01	4.04	4.09	4.18	4.17	4.19
200	3.79	3.85	3.88	3.85	3.88	3.98	3.86	3.91	3.95	3.98	4.07	4.09	4.05
225	3.73	3.77	3.80	3.77	3.81	3.89	3.79	3.82	3.86	3.90	3.99	--	3.97
250	3.70	3.72	3.75	3.73	3.77	3.83	3.74	3.77	3.81	3.84	3.92	3.92	3.93
300	3.66	3.68	3.71	3.68	3.71	3.74	3.69	3.71	3.72	3.75	3.83	3.81	3.80

* First half of month

† Second half of month

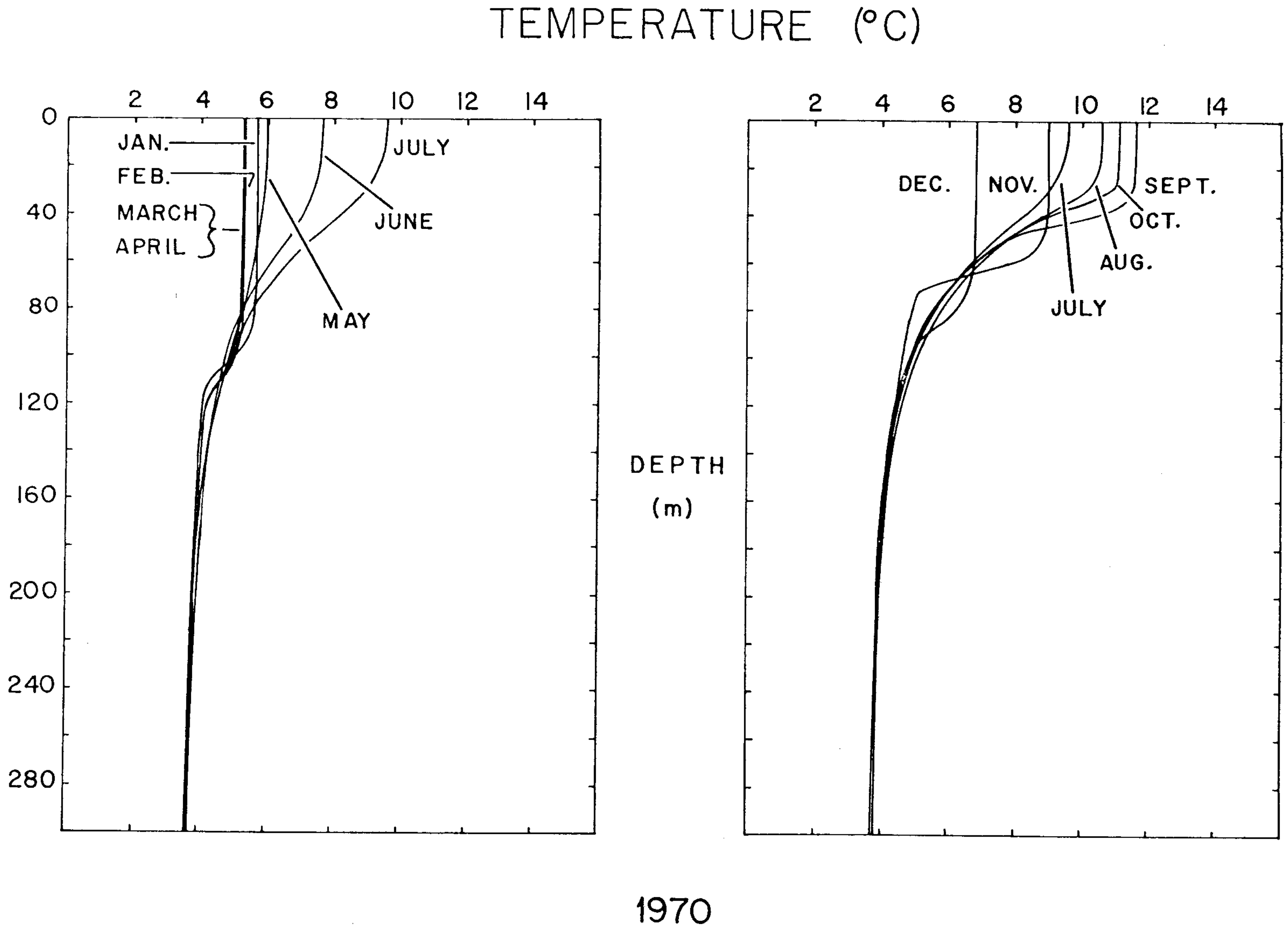


Figure 8. Temperature profiles from an analytical fit to the averaged, monthly temperature data for 1970.

where $K = k\rho^{-1}c^{-1}$ has the units of the eddy diffusion coefficient. For simplicity, we assume that the temperature distribution in the water column is at steady state so that:

$$\partial_z (K\partial_z T) = 0 \qquad (13)$$

Equation 13 is satisfied if K is proportional to $(\partial_z T)^{-1}$:

$$K \propto (\partial_z T)^{-1}$$

The averaged temperature profiles (Figure 8 and equations 10 and 11) were used to calculate $\partial_z T$ for each month and equation 14 was then applied in order to get the functional form for K (Figure 9). The proportionality constant in equation 14 was estimated by 1) comparing our mixing coefficients (Figure 9) for the months of May through October with those of Vo Van Lanh (1974) and 2) comparing our results with heat flux measurements at Station "P" (Tabata, 1961). The values for the diffusion coefficient which we used for the deep waters is presented in Figure 10.

The temperature data suggested that the near surface waters were subjected to convective overturn so that a diffusive description of mixing was incorrect for those waters. Thus equation 4 was developed for this near surface, mixed layer. The mixed layer depth changed with the season, and we estimated it from the temperature data. During the summer months, the surface waters would warm up during the day but would be mixed to some depth upon cooling during the night. This latter depth was taken as the mixed layer depth. The mixed layer depth is also shown in Figure 10, and no values of eddy diffusion are shown for the mixed layer.

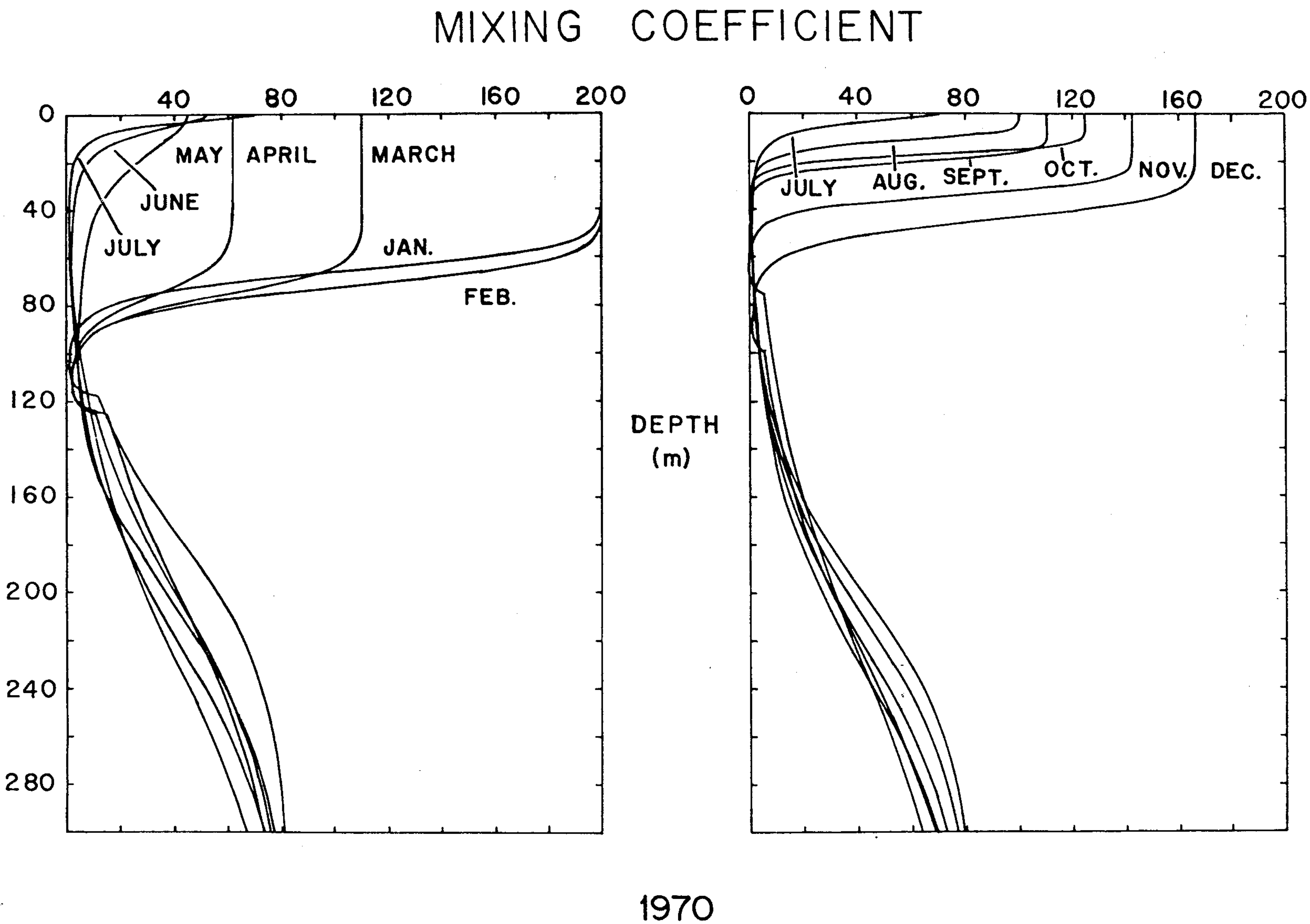


Figure 9. Vertical eddy diffusion coefficient profiles. The actual values are proportional to these curves and are shown in Figure 10.

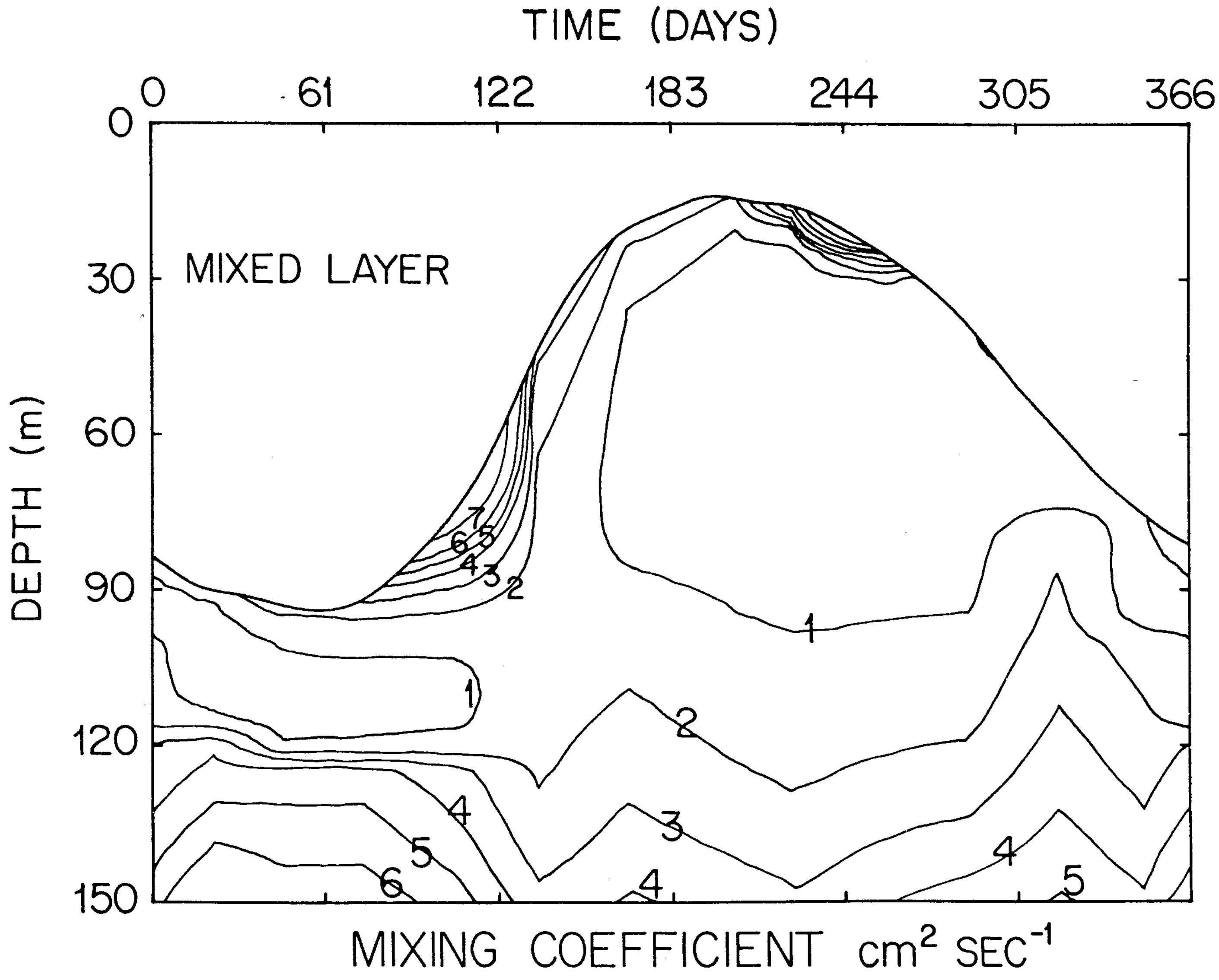


Figure 10. Vertical eddy diffusion coefficients and the mixed layer depths for one year.

Cloud transmission τ_c

Monthly radiation data for the years 1960 to 1967 were obtained from Monthly Radiation Summary, Meteorological Branch, Department of Transportation, Canada. Figure 11 is a plot of the average daily radiation and the standard deviation in that value for each month of the year. In most cases, the standard deviation is no more than the size of the dot which was used to mark the mean values. These data were interpolated to every day of the year and the cloud transmission coefficients were adjusted so that the daily radiation in the model matched the data.

Carbon to chlorophyll ratio, γ

The carbon-to-chlorophyll ratio is difficult to measure (Banse, personal communication); yet, it is known to vary with both depth and season. Furthermore, we will show later that the modeled chlorophyll distribution is quite sensitive to changes in this ratio. For purposes of the standard run, we assumed that the carbon-to-chlorophyll ratio at the surface, $\gamma(0,t)$ varied as (McAllister, 1969):

$$\gamma(0,t) = 0.5 \left\{ 65 - 35 \cos \left(\frac{2\pi}{365} (d-15) \right) \right\}$$

This results in a minimum surface value of 15 on the 15th day of the year and a maximum value of 50 on the 197th day. In addition, we assumed that the carbon-to-chlorophyll ratio at 150 m was always 10. $\gamma(z,t)$ was assumed to be uniform throughout the mixed layer and to approach a value of 10 at 150 m:

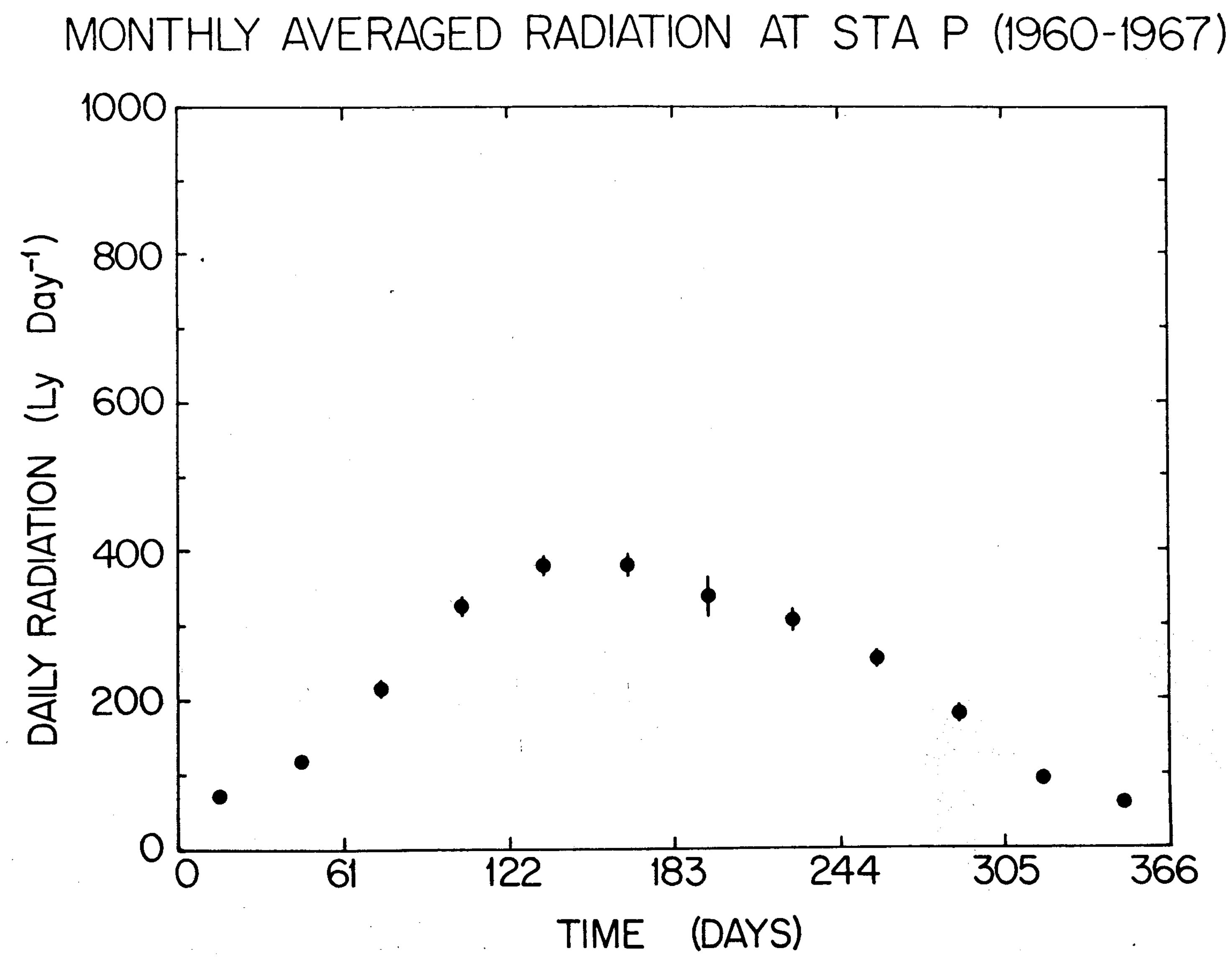


Figure 11. Average daily radiation received at Station P for each month of the year. The vertical lines give the standard deviation.

$$\gamma(z,t) = \gamma(0,t) \;; \qquad z \leq d_{mix}$$

$$= 10 + (\gamma(0,t) - 10)e^{-b_1(\Delta z)^2} \;; \qquad z \geq d_{mix}$$

where $\Delta z = z - d_{mix}$ and $b_1 = \frac{6.91}{(150 - d_{mix})^2}$ is chosen so that $e^{-b_1(z')^2} = .001$

when $z' = 150m - d_{mix}$. The depth dependence of $\gamma(z,t)$ is shown schematically in Figure 12, while Figure 13 is a contour plot of the depth and time dependence of the carbon-to-chlorophyll ratio which was used in the standard run.

Grazing pressure, G, and feeding threshold, P_0

The seasonal variation of zooplankton biomass is based on the average wet weights reported by LeBrasseur (1965)(Figure 7). These values were increased by a factor of 2.6 to correct for undersampling and the loss of small animals through the mesh (LeBrasseur and Kennedy, 1972). For most of the year, much of the zooplankton biomass consists of copepods, and we use a conversion factor of .6 mg-C/1.5 mg animal wet weight (Frost, personal communication), which would be appropriate for C. Plumchrus, Stage IV, in order to convert the biomass data to units of zooplankton carbon. It was necessary to assume that each animal exerted a maximum grazing pressure of twice its weight in carbon during a day. The resulting seasonal distribution of grazing pressure, G, is shown in Figure 14.

At any given time, the zooplankton are assumed to have a depth distribution which corresponds to that of their food, the phytoplankton. A comparison of the zooplankton depth distribution for 1957 (McAllister, 1961) with chlorophyll depth profiles suggests that the animals do tend to be distributed as assumed.

The feeding threshold, P_0 , was adjusted to produce a standard run where the chlorophyll concentration and primary production are reasonal approximations to the observations. Those P_0 values are shown in Figure 15. A

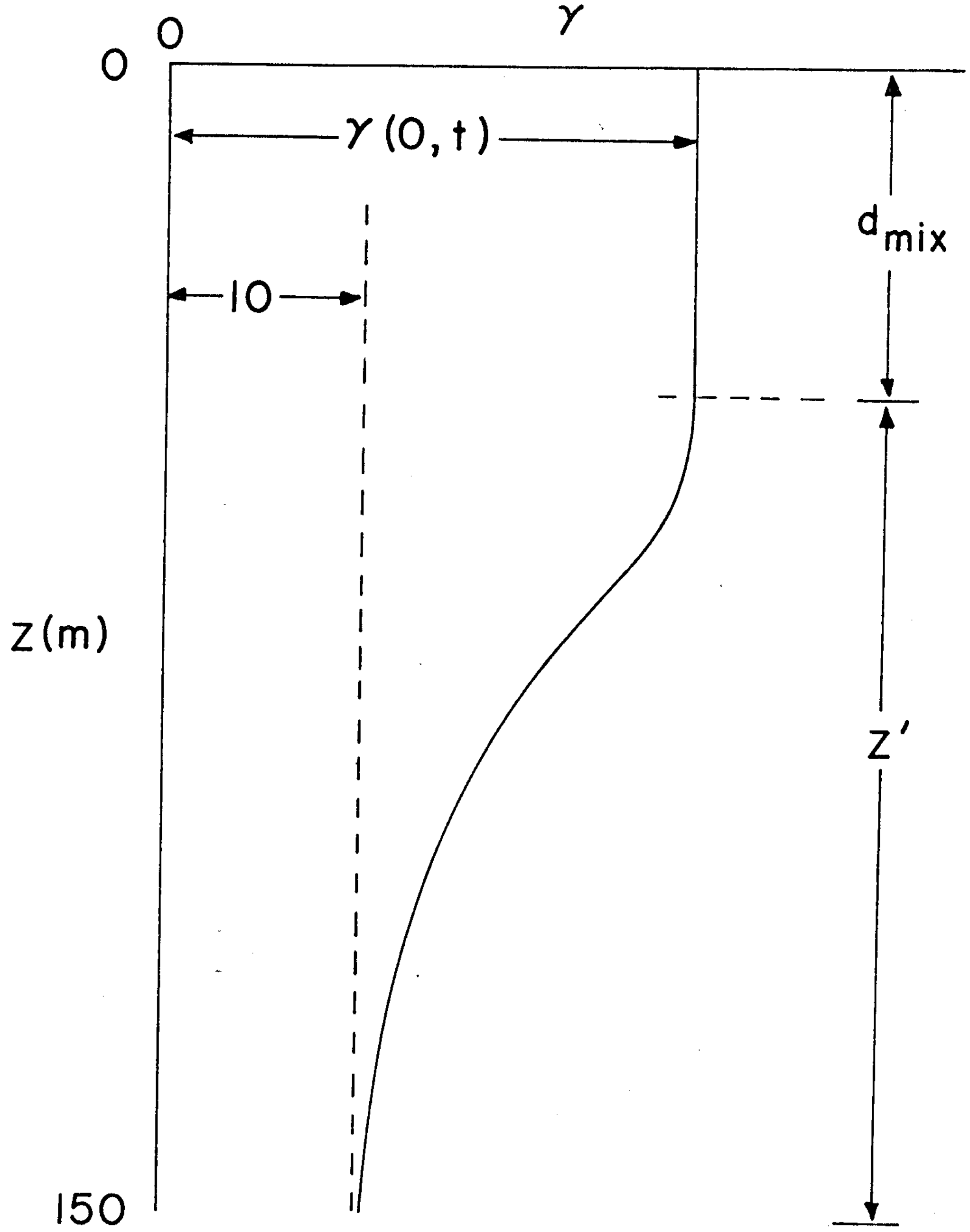


Figure 12. Depth dependence of the carbon-to-chlorophyll ratio.

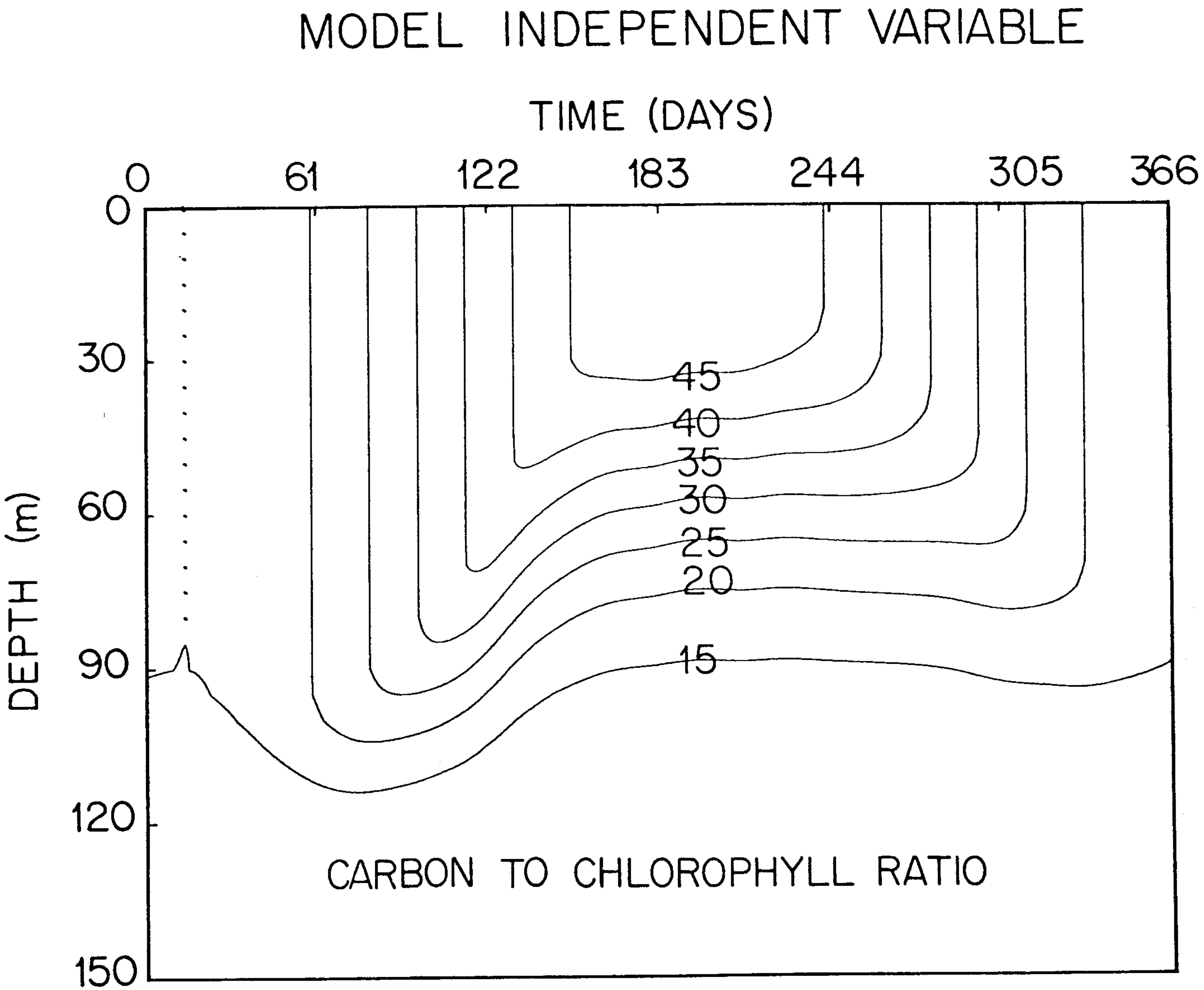


Figure 13. Carbon to chlorophyll values for one year.

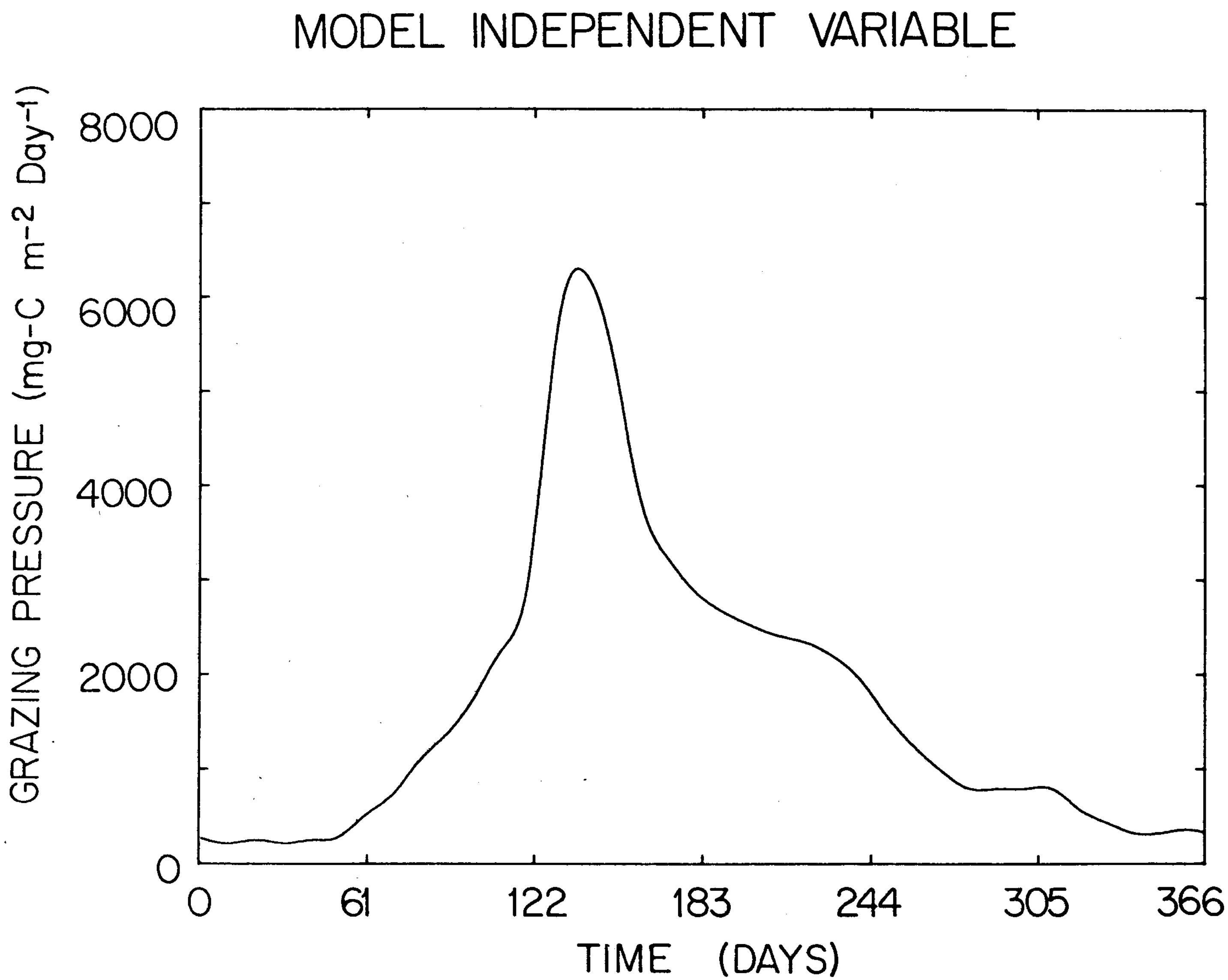


Figure 14. Seasonal variation in grazing pressure.

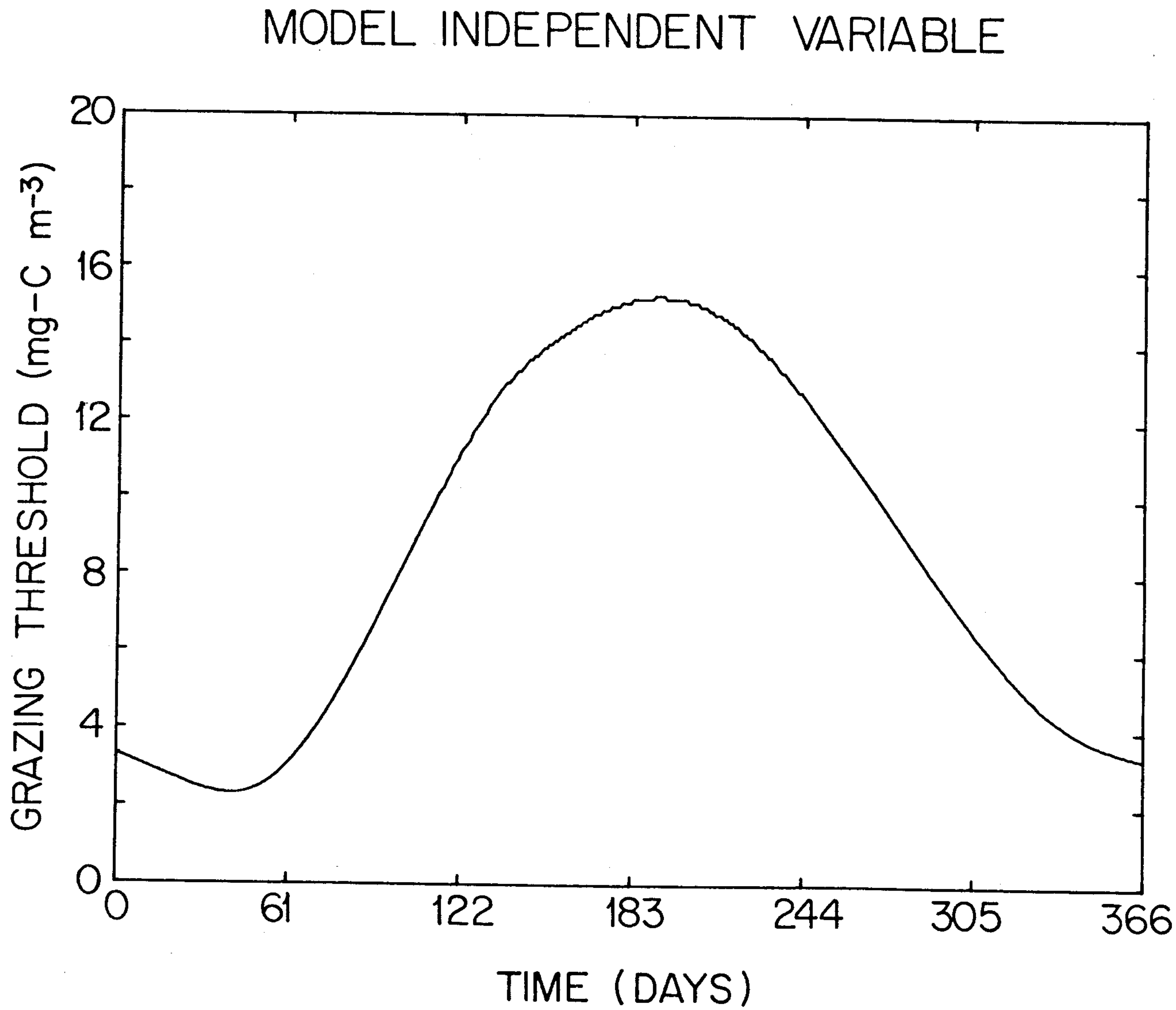


Figure 15. Seasonal variation in zooplankton feeding threshold.

minimum feeding threshold in the winter and a maximum threshold in the summer is consistent with the idea that the threshold increases with increasing animal size (Lam and Frost, 1976) and with the expected seasonal variations in zooplankton size distribution.

Constants in the standard run

As mentioned previously, nine physical and physiological constants must be specified in the model. These include w, the sinking speed of the algae; τ_s, c_1, c_2, and δ which affect the in situ light intensity; terms in the description of net production, P_{max}, α, and R; and β which occurs in the description of grazing.

A constant value of $w = 0.5$ m day^{-1} was chosen for the sinking speed. This is the sinking speed for an actively growing unicellular alga in the 10-20 μ size range (Smayda, 1970).

An atmospheric transmission coefficient, $\tau_s = 0.95$ and a sea surface penetration fraction of 0.85 (Parsons and Takahashi, 1973) were chosen for the model. Self shading by the plants results in $c_2 = 0.14$ m^2 (mg-chl)$^{-1}$ (Lorenzen, 1972) and a value of $c_1 = .071$ m^{-1} was taken so as to place the 1% light level at a depth of approximately 60 m (Lorenzen, personal communication). In the model, we assumed that only one half of the measured radiation contributes to photosynthesis (Strickland, 1958).

Values for P_{max} and α were based on production rate data obtained near Station "P" and on considerations of the temperature-dependence of P_{max} (Eppley, 1972). These data included two cruises taken by the University of Washington in 1971 and 1973 and data taken near Station "P" in 1969 (Takahashi, *et al.*, 1972). The P vs I curves reported for 1969 were from 3-4 hour incubations with daylight fluorescent lamps using the C^{14} method. Photosynthesis was given as mg-C (mg-chl hr)$^{-1}$ and light intensity was reported in Klux. The light intensities for the different data sets were converted to ly hr^{-1} using conversion factors given by Strickland (1958) for photosynthetically active radiation. These factors are:

$$1 \text{ ly hr}^{-1} = 2.8 \text{ Klux}$$
$$= 0.25 \text{ K foot candles}$$

The values for the initial slope ranged from a high of 2.8 to a low of 0.44 with a mean of 1.55 and an adjusted standard error of 0.25. The data give maximum production rates as carbon produced per unit chlorophyll whereas P_{max} is the specific production rate. It was necessary, therefore, to multiply the maximum production rates found in this data by the carbon-to-chlorophyll ratio, γ, in order to obtain P_{max}. γ, however, was not reported for the productivity experiments so we used the γ values from Figure 13. Resulting P_{max} values range from 0.02 to 0.22 and have a mean of 0.09 and an adjusted standard error of 0.02. The values of P_{max}, α, and the assumed C:chl values for the data are summarized in Table 2. A value of $\alpha = 1.6$, the mean data value, is chosen for the standard run. This is consistent with the range of α from 1.12 to 1.68, reported by Steemann-Nielsen and Jorgensen (1968). Eppley (1972) showed that laboratory cultures of algae grown under continuous light have:

$$P_{max} = .851 \times 10^{0.0275T}$$

where T is the temperature in °C and P_{max} is given in doublings per day. Thus, for $T = 5°C$, $P_{max} = 0.049$ and for $T = 11°C$, $P_{max} = 0.071$ An average of these two values, $P_{max} = 0.06$, was chosen for the standard run. This value is lower than the average P_{max} from the data but still within the range of P_{max} values "measured" at Station P.

Table 2.

Identifier	Depth (m)	P_{max} (hr^{-1})	α $\frac{mg\ C}{mg\ Chl\text{-}ly}$	Assumed C/Chl	Date
TT059 Sta. 51	3	---	.67	47	6/71
	15	.09	.79	47	"
TT082 Sta. 35	0	.14	2.0	49	8/73
	30	.08	2.0	49	"
Sta. 36	0	.22	2.3	49	"
	20	.22	2.3	49	"
Sta. 37	10	.02	.47	49	"
	50	.03	.47	35	"
Sta. 38	10	.07	2.8	49	"
	75	.06	2.8	22	"
Sta. 41	10	.14	2.5	49	"
	75	.11	2.5	22	"
Takahashi, *et al.* (1972)	10	.04	.72	46	8/69
	40	.03	.44	40	"
	70	.04	.44	25	"
Average		.09	1.55		
σ		.07	.98		
$\sigma/\sqrt{n}$		.02	.25		

Respiration rate, R , was taken as 0.07 x P_{max} (i.e., R = 0.0042) for the model runs. Steemann Nielsen and Jorgensen (1968) state that respiration rate is 5 to 10% of light saturated photosynthesis, while Talling (1960) gives a value for respiration of 5 to 20% of maximum photosynthetic rate. In reality, respiration rate, like photosynthesis, is temperature dependent (Riley, Stommel & Bumpus, 1949) where the specific respiration rate per day is given by:

$$R = 0.0175\ e^{0.069T} \qquad (15)$$

It is consistent with our choise of an average, constant value for P_{max} that the respiration rate is also taken to be a constant. The value chosen is close to the lower limit of that suggested by Steemann Nielsen & Jorgensen as well as Talling but is considerably larger than the value suggested by Equation 15.

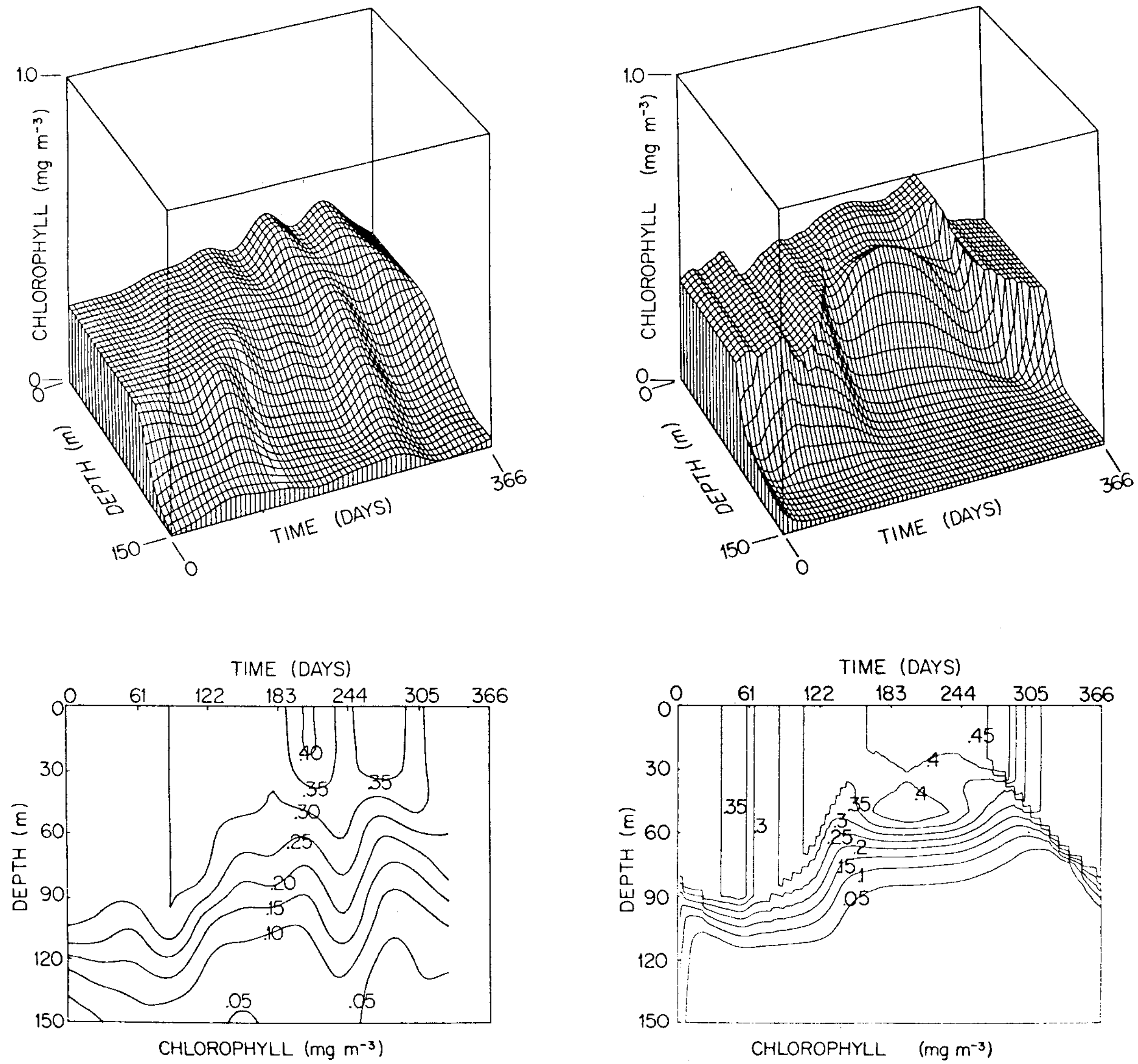
Method of solution

The Crank-Nicholson method was used to solve the production equation (Jamart, *et al.*, in press). Time steps of one half hour and five meter depth intervals were used in all of the numerical simulations.

E. Model results

Standard run

Using the independent variables and constants which were just presented, the model was started on the first day of the year with an intial chlorophyll profile and allowed to run for one full year. The evolution of the chlorophyll concentration through time is presented in Figure 16b. Observed chlorophyll data (Figure 3) is reproduced in Figure 16a for comparison. General features such as the seasonal variation in the depth of the uniform, near-surface concentrations and the maximum standing stock in late summer compare well. Differences in the details like the double surface



(a) (b)

Figure 16. Comparison of modeled chlorophyll concentration (b) with average concentration data from Figure 3 (a).

chlorophyll peaks in the data or the spring chlorophyll minimum in the model are to be expected. We find from the large standard deviation in the chlorophyll data (Figure 2) that the observed double peak is not statistically significant. Likewise, details of the modeled chlorophyll concentrations are influenced by misrepresentations of the independent variables. Since the model run used averaged data to generate the independent variables and since these averages were often for different time periods, we should not place much emphasis on the smaller details of the model.

Figure 17 compares the modeled chlorophyll concentrations in the mixed layer with the data for the surface chlorophyll. From this comparison, because of the large scatter in the data, we can only say that the model results are not inconsistent with the measurements. The integrated values for net production from the model are plotted, along with the observed values, in Figure 18. Both the model and the data show a peak in production at the beginning of the summer.

Sensitivity analysis

While creating the standard run, we found that the relative importance of the different inputs and coefficients on the chlorophyll distribution changes with time. We also discovered that, in the mixed layer, turbulent mixing and algal sinking were relatively unimportant when compared with net production and zooplankton grazing. In this case, for the mixed layer, the production equation (equation 4) may be approximated by:

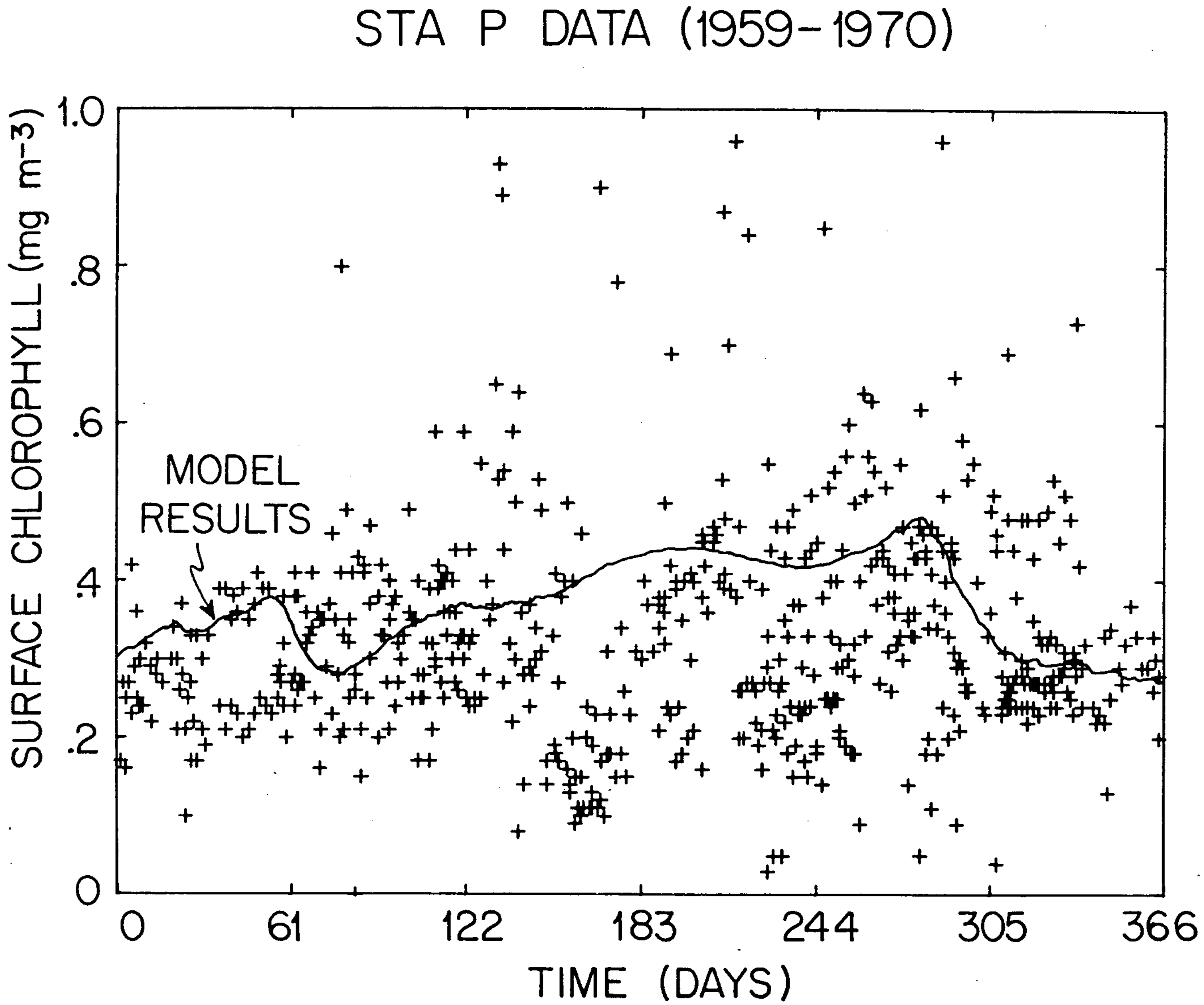


Figure 17. Comparison of modeled, mixed-layer chlorophyll with surface chlorophyll data from Figure 1.

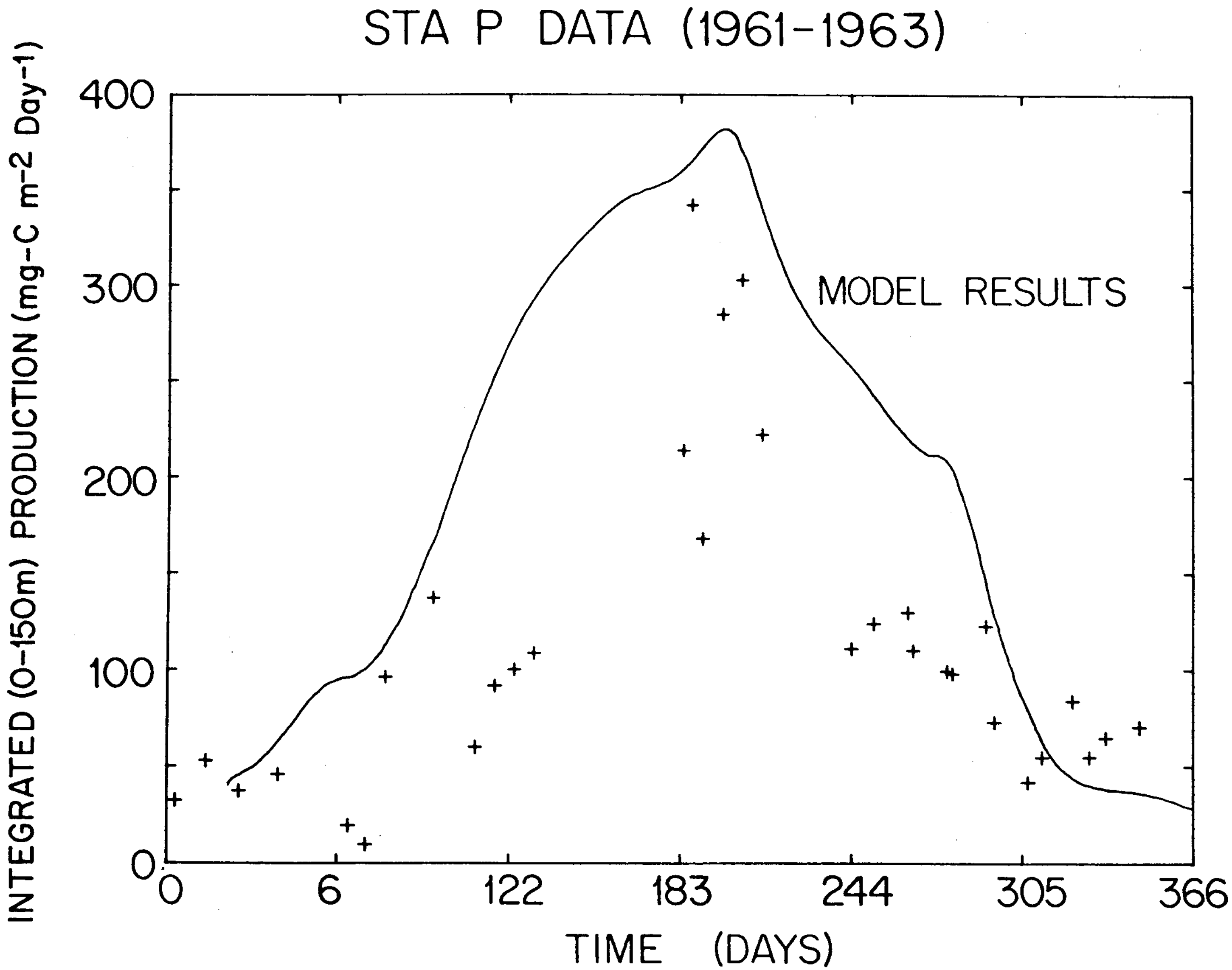


Figure 18. Comparison of modeled, integrated (0-150 m) net production with observed values from Figure 6.

$$\partial_t A = \left[P_{max} \tanh \left(\frac{I\alpha}{P_{max}\,\gamma} \right) - R \right] A - \frac{G}{\gamma} \left[1 - e^{-\beta(A\gamma - P_0)} \right] \qquad (16)$$

At any given time, the independent variables and the constants may be specified so that equation 16 may be further simplified to:

$$\begin{aligned} \partial_t A &= Q_1 A - Q_2 \left(1 - e^{-\beta(A\gamma - P_0)} \right); \quad A\gamma > P_0 \\ &= Q_1 A \qquad\qquad\qquad\qquad\quad ; \quad A\gamma \leq P_0 \qquad (17) \end{aligned}$$

Here Q_1 represents the net production rate and Q_2 represents the grazing pressure. In figures 19 and 20, we plot equation 17, showing the time rate of change in chlorophyll concentration against the chlorophyll concentration for various times of the year. For low chlorophyll concentrations ($A \leq P_0/\gamma$), the rate of change is proportional to the concentration. At higher values, the change is due to both a linear term and a grazing loss. For very high concentrations, the grazing loss approaches its asymptotic limit and we have:

$$\partial_t A = Q_1 A - Q_2 \qquad ; \quad A \to \infty$$

At each time of the year, the coefficients, Q_1 and Q_2, are calculated from the known independent variables and coefficients and from the average net production over 24 hours. Most of the rate curves in Figures 19 and 20 show increasing chlorophyll concentrations for both very high and very low chlorophyll concentrations and decreasing concentrations for the values in between. In these cases, there are two points where the rate of change in

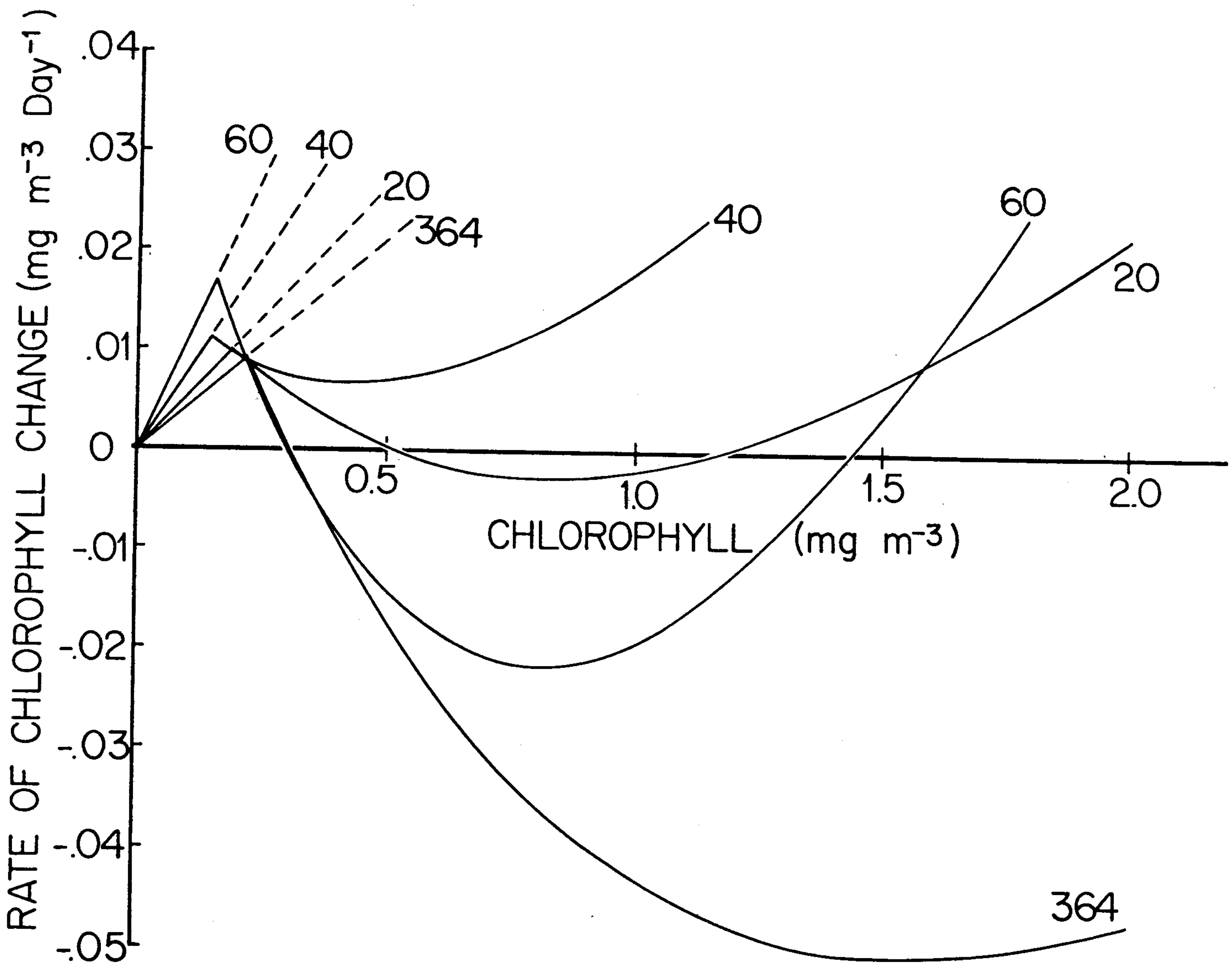


Figure 19. Plot of rate of change in the mixed layer chlorophyll concentration versus the chlorophyll concentration for days 20, 40, 60, and 364.

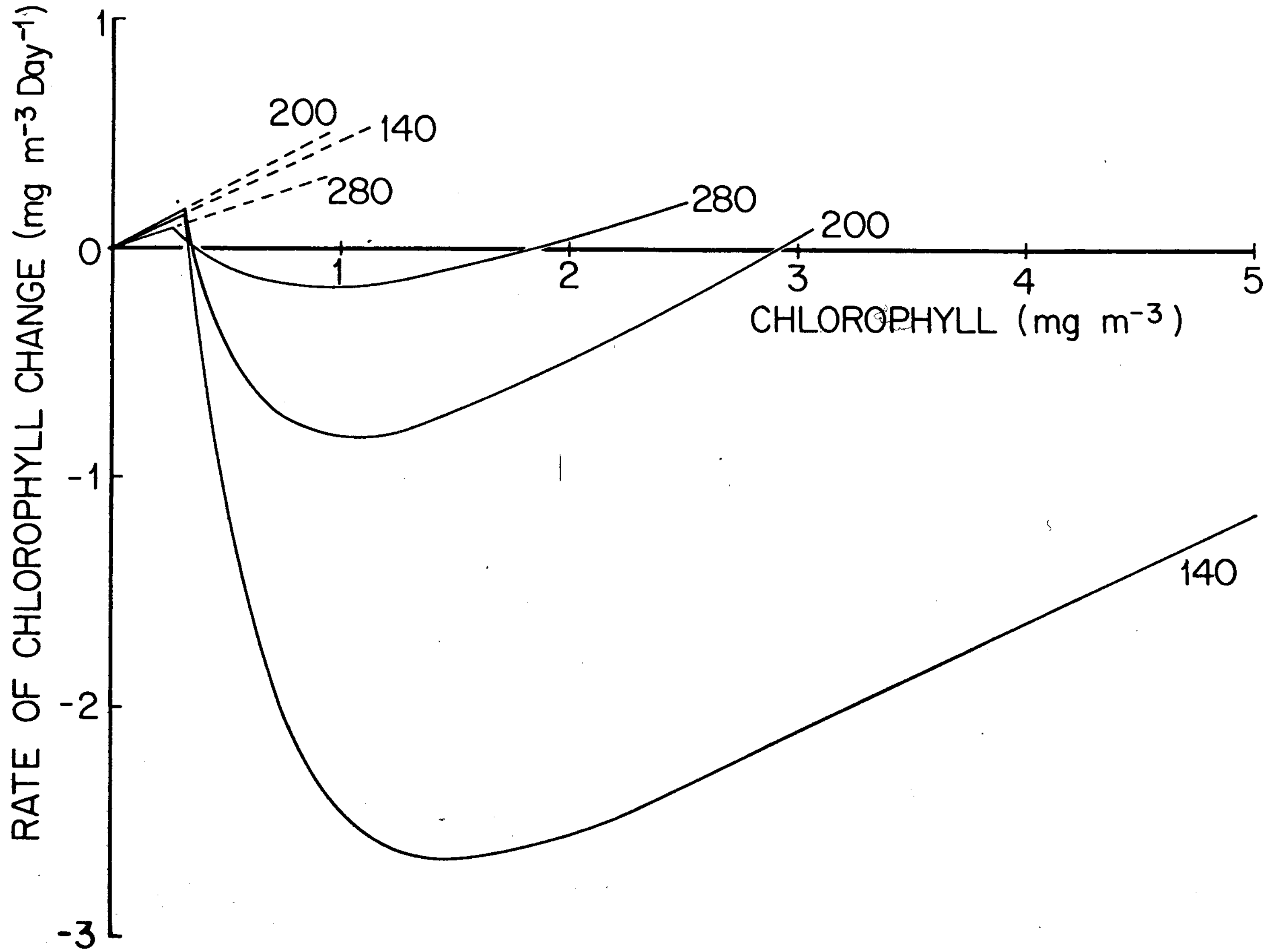


Figure 20. Plot of rate of change in the mixed layer chlorophyll concentration versus the chlorophyll concentration for days 140, 200, and 280.

plant material is zero, the zero crossings of the curve. For chlorophyll concentrations below the higher zero crossings, the biological system is stable and the chlorophyll concentrations will evolve toward the value at the smaller zero crossing. If concentrations had started out below this value, the rate of change would be positive and the chlorophyll concentrations would increase until the rate of change became zero. Likewise, if the plant concentrations were between the two zero crossings, the rate of change would be negative and the concentrations would decrease until the rate of change reached zero.

In this model, there are some situations which could cause the chlorophyll concentration to either grow unchecked or to approach zero. If chlorophyll concentrations are above the higher zero crossing, they will continue to increase with time at an ever accelerating rate. Another case where the plants might grow unchecked is illustrated by the case for day 40 in Figure 19. There, the combination of net production and grazing loss is such that the zooplankton can never keep the plants cropped down and the chlorophyll production rate is always positive. If net production, Q_1, were negative, possibly caused by an extremely deep mixed layer, the rate of change in chlorophyll content would always be negative so that the plants would disappear from the water column. In nature, unchecked plant growth is impossible and complete depletion of plant material is unlikely. In the model, these two extreme cases either violate the assumptions or are poorly approximated by the model. In the first case, as the plant concentrations become very large, nutrients would certainly be depleted to the point where there would be nutrient limitation to growth. On the other hand, if conditions are unfavorable and net production becomes negative, plant respiration often decreases. This is not simulated in the model.

We see in Figures 19 and 20 that days 20 and 140 represent the cases where there are barely enough zooplankters to keep plant production in control and where there is a superabundance of zooplankters. These two time periods were chosen for sensitivity studies because they represent extreme cases. Equilibrium chlorophyll concentrations ($\partial_t A = 0$) were found for each of these periods by iteration from equation 17. Some of the inputs were then increased and decreased by 10% and new equilibrium values calculated. Table 3 lists the inputs which were changed along with the percentage change in the equilibrium chlorophyll concentrations for each of the two time periods. For day 20 in the early winter, the chlorophyll values changed by at least 10% in response to changes of any of the inputs. In many cases, a 10% change in inputs caused an imbalance between net production and grazing such that the chlorophyll values increased continuously and no equilibrium value was reached. In contrast, the equilibrium chlorophyll concentration on day 140 showed very little response to changes in the variables other than the feeding threshold and the carbon-to-chlorophyll ratio. The equilibrium concentrations changed by about 10% when those two inputs were altered. The response of the chlorophyll concentration to changes in the inputs should fall somewhere between these two extremes during the rest of the year.

The results which are summarized in Table 3 were verified by doing the same experiments on the computer model. Changing the inputs caused changes in the mixed layer chlorophyll concentrations which were very close to those predicted by Table 3.

Table 3. Percent change in equilibrium chlorophyll concentration (from standard run) as the inputs are changed by ± 10%.

Day 20

γ	P_0	β	Q_2	Q_1	A
10					-25
-10					*
	10				15
	-10				-13
		10			-17
		-10			*
			10		-18
			-10		*
				10	*
				-10	-19

* No equilibrium ($\partial_t A > 0$)

Day 140

γ	P_0	β	Q_2	Q_1	A
10					-9
-10					12
	10				10
	-10				-10
		10			- 0.3
		-10			0.6
			10		- 0.3
			-10		0.6
				10	0.6
				-10	- 0.6

Simulated response to an oil spill

In this section, we show how the model might be used to simulate the effects of an oil spill on the standing stock of chlorophyll. Oil pollution has been postulated to cause a 50% reduction in the growth rate of marine phytoplankton at oil concentrations greater than 10 ppm (Mills and Ray 1977, Vaughn 1973, Kauss *et al.*, 1973, Strand *et al.*, 1971) and a 25% increase in growth rate at oil concentrations of 30 to 100 ppb (Prouse *et al.*, 1976, Gordon and Prouse 1973). Oil pollution is also likely to inhibit zooplankton feeding rates. The feeding rate of lobster larvae was reduced at oil concentrations greater than 1 ppm (Forns 1977). Lobster feeding was reduced in the presence of a 10 ppm crude oil emulsion (Atema and Stein 1974). Locomotory inhibition of an arctic amphipod occurred at oil concentrations of 400 ppm (Percy 1977). Prouse *et al.* (1976) found 16-41 ppb oil in the water column 3 months after the Arrow spill.

Guided by the above literature, we performed three sets of simulation experiments. In the first one, P_{max} was increased by 25%, decreased by 25%, and decreased by 50% in order to simulate the effects of increasing amounts of pollution. In the second set, grazing pressure was decreased by 10%, 25%, and 50%. Finally, both P_{max} and the grazing pressure were reduced by 50% to simulate the combined response of the biological system. In all cases, the model was run for two 60-day periods, days 20 to 80 and days 120 to 180. These two periods were chosen to include the times of low and high zooplankton pressure, the ones which were examined in the sensitivity analysis. Each simulation run started with the chlorophyll distribution from the appropriate day of the standard run. Then P_{max} and/or the grazing pressure was changed and the model was allowed to run for 60 days with all other inputs unchanged.

In Figure 21, the mixed layer chlorophyll concentrations from the standard run and from the simulation runs where P_{max} was changed are shown together. As expected, the concentrations increased when P_{max} was increased and decreased when it was lowered. Changes in chlorophyll standing stock changed more during the first period of the year than in the second in response to changes in P_{max}. This too is consistent with the results of our sensitivity analysis. During the period beginning with day 20, the perturbed concentration values first diverged from those of the standard run but then converged towards them again towards the end of the 60 days.

Figure 22, illustrates the case where grazing pressure is reduced. When that pressure is reduced by 10% or 25%, the results are qualitatively similar to those of Figure 21: changes during the second period are less than those of the first and the perturbed values during the first period diverge from and then reconverge towards the standard values. When grazing pressure is halved, chlorophyll blooms occur for both time periods. In the second period, however, that bloom does not begin immediately and is only initiated (sometime after day 140) when the grazing pressure has dropped. Further computer simulations showed that even when grazing was reduced 50%, the blooms did not go unchecked and chlorophyll values did decrease at some later time.

Finally, Figure 23 illustrates the combined effects of decreasing both P_{max} and grazing pressure by 50%.

These three simulation exercises are only meant to illustrate one possible use of a model; the results must be interpreted with great caution. For instance:

- The results illustrate only the effects on plant biomass and do not address questions concerning long-term, low-level effects or influences on other trophic levels.

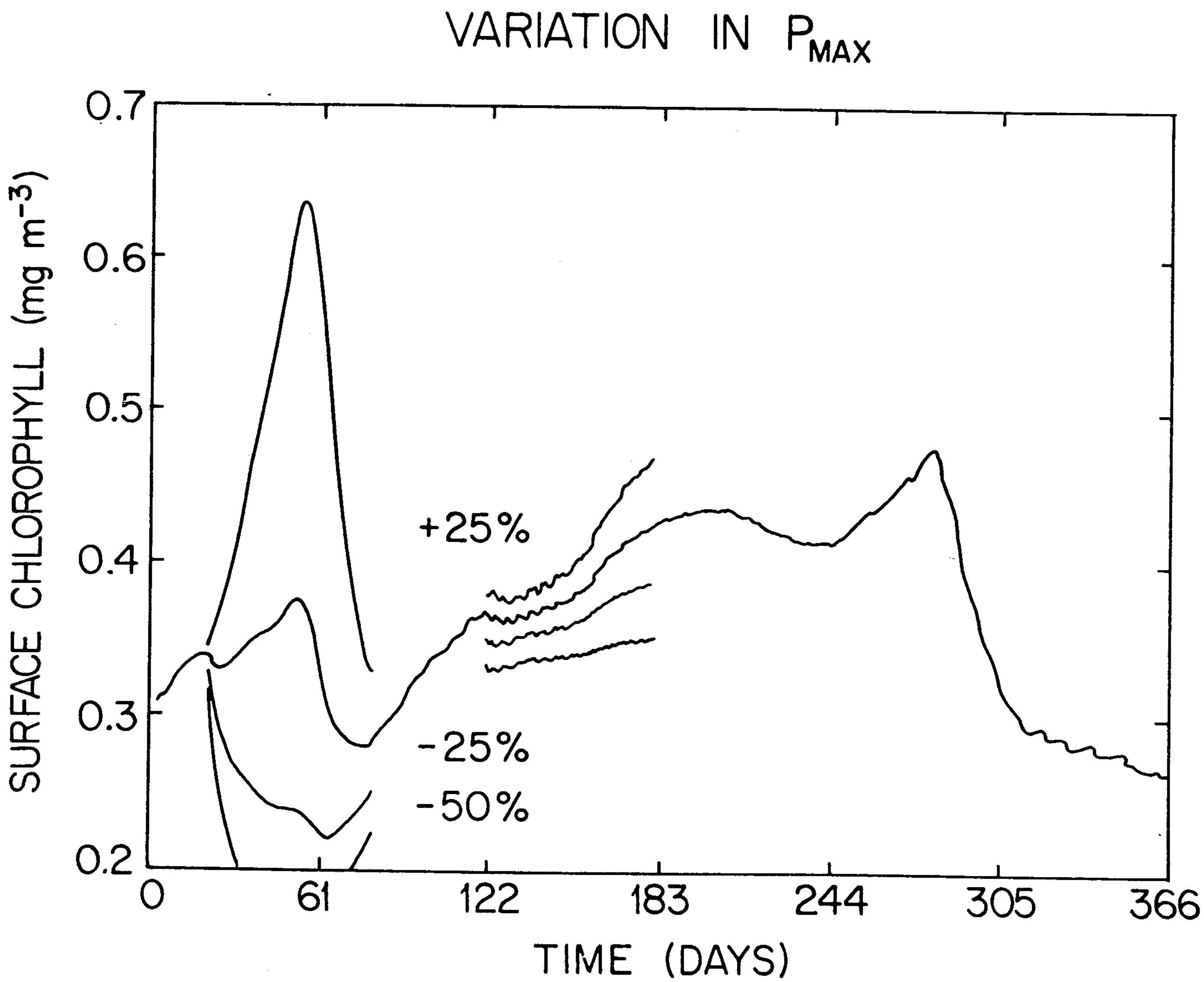


Figure 21. Mixed layer chlorophyll concentration for the standard run and for variations where P_{max} is changed, as indicated. The variations are run from days 20-80, and days 120-180.

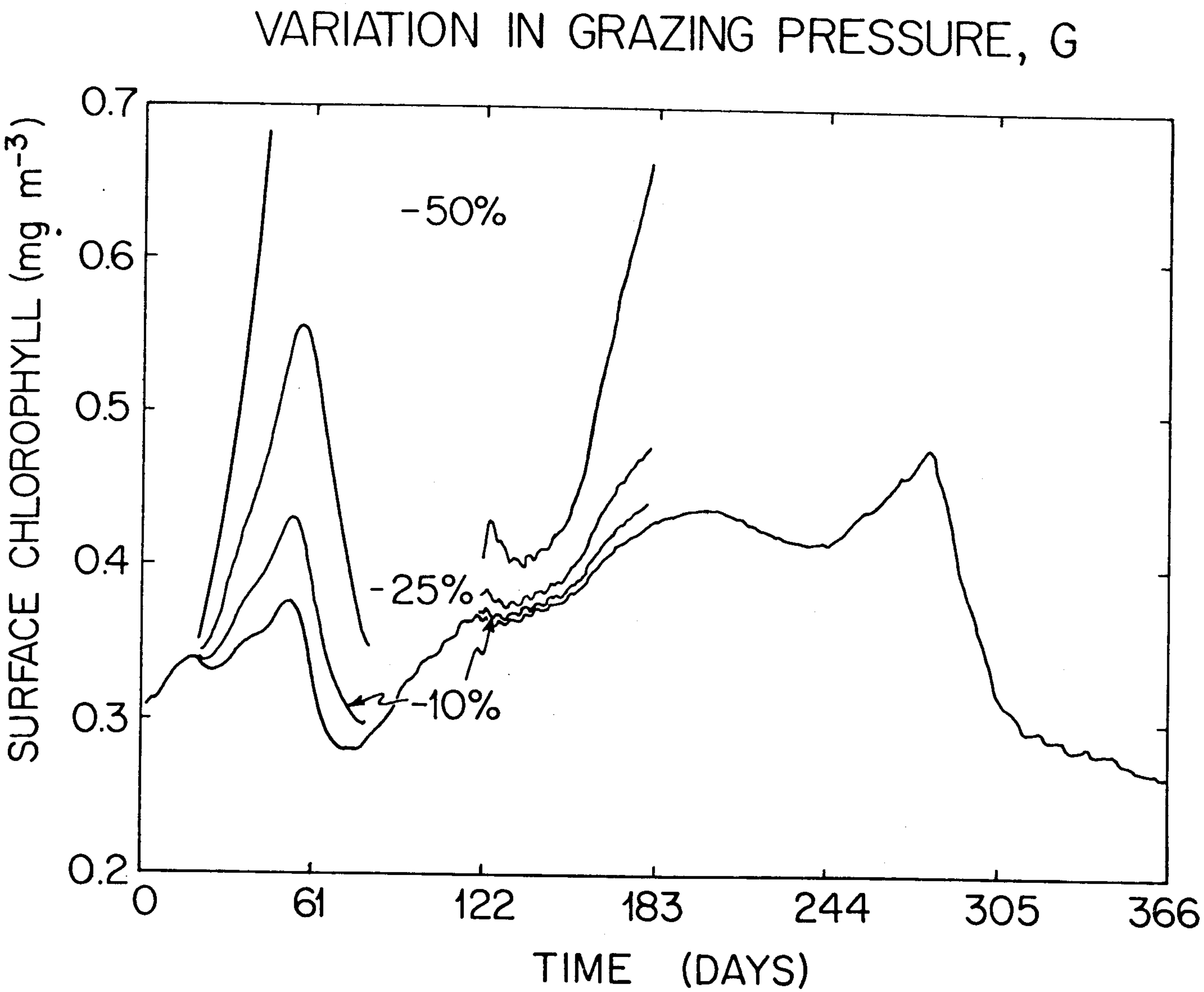


Figure 22. Mixed layer chlorophyll concentration for the standard run and for variations where grazing pressure is changed, as indicated. The variations are run from days 20-80 and days 120-180.

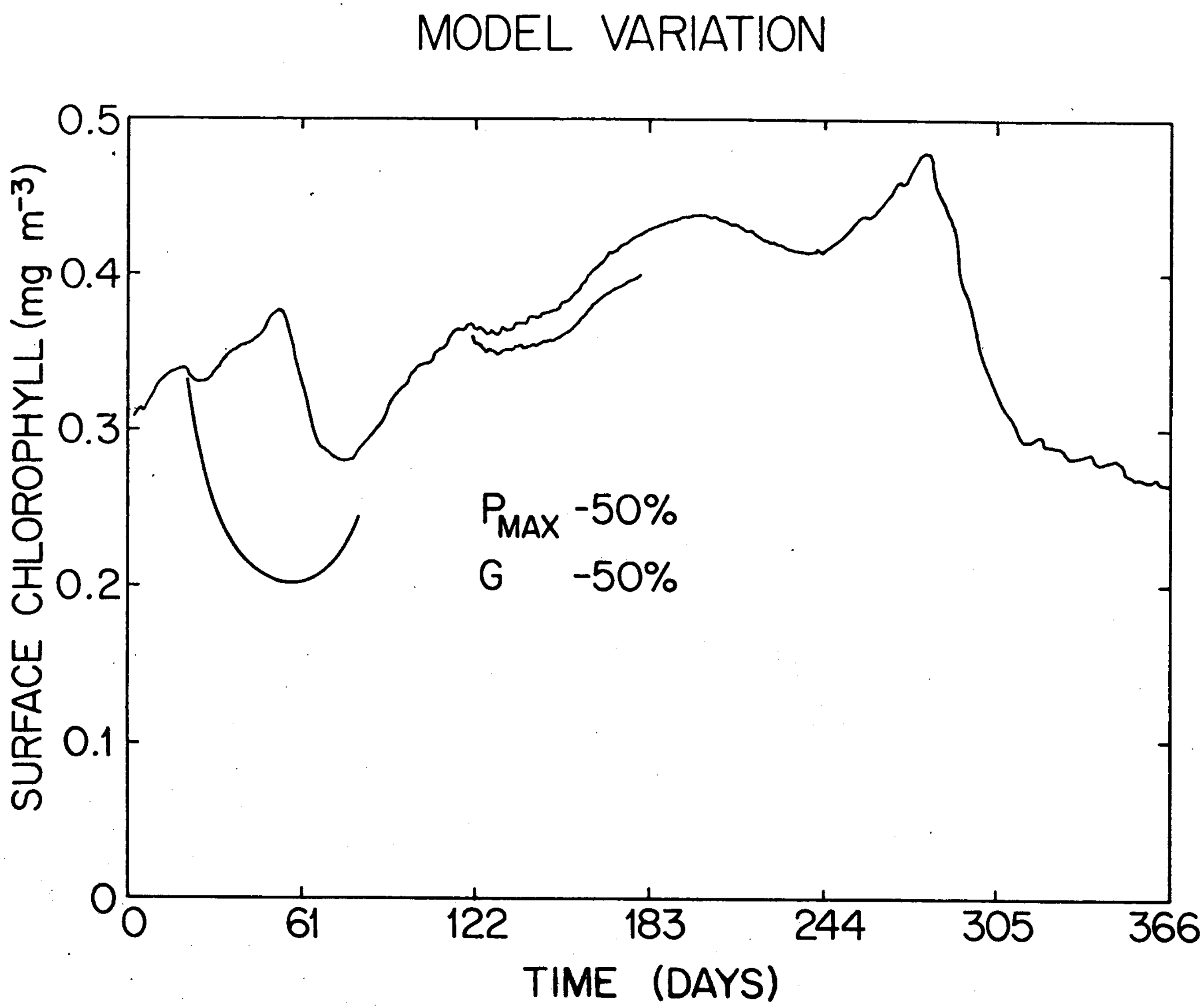


Figure 23. Mixed layer chlorophyll concentration for the standard run and for variations where P_{max} and grazing pressure are changed, as indicated. The variations are run from days 20-80 and days 120-180.

- Effects of oil on other than P_{max} and the grazing pressure have not been considered.
- A different model (different standard run) might produce very dissimilar results.

F. Summary and conclusions

We have synthesized a relatively uncomplicated model of primary productivity at Station "P". When we apply biologically and physically reasonable inputs to this model, the results are in agreement with observations for that location. The model is more sensitive to change in the inputs during the winter months when zooplankton biomass is low than during the spring time with greater zooplankton grazing pressure. Whereas the results were sensitive to net production, zooplankton biomass, carbon-to-chlorophyll ratio, and the feeding threshold during the winter, the model was only sensitive to the last two variables during the high biomass period. Unfortunately, both the time variation in the feeding threshold and the time-depth structure of the carbon-to-chlorophyll ratio are very poorly known. Because of this and since there is a wide latitude in the choice of many of the other inputs, we can only assert that this is one model which is applicable to Station "P". Other combinations of processes and inputs may also be able to explain the data.

There are reasons to include two equations to describe the time rate of change in zooplankters and in nutrients in future work. Including a zooplankton equation may very well degrade the results and introduce more uncertainties. However, that would be more useful in simulating a perturbed system since the plants and animals do interact and change together. When we perturb the system now, we allow the chlorophyll content to change but do not allow the zooplankton biomass to adjust accordingly. Since nutrients do not appear to be limiting, introducing a nutrient equation should not alter the results of the standard run. However, it would provide a description of nutrient concentrations which could be compared to the data for another check on the model. Also, a model which includes nutrients would be more applicable for those perturbations which now cause large phytoplankton blooms.

BASELINE DATA

A. Current state of knowledge

The first studies of the lower trophic levels of the eastern Subarctic ecosystem (Holmes, 1958; McAllister *et al.*, 1960; Parsons, 1965) were limited by a small data base. The data base has been expanded both geographically and temporally over the last twelve years.

Some of the readily available information on the physical oceanography of the Subarctic Pacific Ocean has been described by a number of authors (e.g., Tully and Barber, 1960; Uda, 1963; Dodimead, Favorite and Hirano, 1963; Tully, 1964; Tabata, 1965; and references cited therein). Similarly, some of the major publications of biological data for the same area include the works of McAllister, Parsons and Strickland, 1960; Anderson, Parsons and Stephens, 1969; Parsons and LeBrasseur, 1969; Parsons and Anderson, 1970; Larrance, 1971a; and Anderson and Munson, 1972. Other relevant biological information from the area are contained in the north-south sections made through the Gulf in past years, e.g., Ursa Major and Zetes expeditions in 1964 and 1965 (University of California, 1967, 1970), the HAKUKŌ MARU in 1969 (Marumo, 1970), and the R/V T.G. THOMPSON in 1972. Also, a winter cruise in February 1967 by the R/V THOMPSON covering a large area of the Gulf of Alaska has produced a unique set of data on primary production, plant nutrients, and hydrography at a time when observations are most difficult to obtain.

One of the largest blocks of existing data was obtained through several decades of study carried out by Canadian oceanographers at Ocean Weather Station "P", the results of which are reported in various papers and technical reports. A second very large block of data was obtained during a five-year study (January-June, 1968-1972) made from commercial vessels crossing from North America to Japan via the Gulf of Alaska and near to the Aleutian Islands (Anderson and Munson, 1972; Munson, in preparation). In these Ships of Opportunity studies, enumeration of phytoplankton species and measurements of surface chlorophyll and nutrient concentrations, productivity, zooplankton volume, depth of mixed layer, temperature, and insolation were made at frequent intervals during the period of the spring bloom. In addition to the measurements made from the commercial vessels, more sophisticated sampling from research vessels including measurements of the vertical distribution of parameters was carried out from a number of oceanographic cruises taken over similar cruise tracks. In March and April 1969, studies were conducted by the Fisheries Research Board of Canada, Nanaimo (T. R. Parsons) aboard the ENDEAVOUR (Anon, 1970); in June and July 1970, samples were collected by Hokkaido University (S. Motoda) aboard the OSHORO MARU (Faculty of Fisheries, 1972) and the University of Washington (G. Anderson) made similar measurements from the T.G. THOMPSON in the spring of 1971. Other biological cruises aboard the R/V THOMPSON were made during the summers of 1973 and 1974.

Coastal areas which have received intensive investigation are the Aleutian chain (McAlister, 1971), the inland waters of Alaska (Bruce, 1969; Iverson *et al.*, 1974; Curl, 1972; Iverson, 1972; DeManche, 1974; Kirk, 1973; Schell, 1974; Iverson, Curl, and Saugen, 1974; Goering *et al.*, 1973; Horner *et al.*, 1973), and British Columbia (Parsons, 1965; Gilmartin, 1964; Parsons *et al.*, 1969, 1970; Strickland, 1959, 1961; Waldichuck, 1956; Stockner and Cliff, 1975, 1976; Takahashi *et al.*, 1973). Some of the above data have been summarized to describe features of the distribution of biological parameters in the Northeast Pacific:

<u>Seasonal variation</u>

Evidence of seasonal variation has been derived from long-term monitoring at Station "P" (145°W50°N). In contrast to the marked phytoplankton blooms over the Continental Shelf, phytoplankton biomass in the open ocean region of 145°W50°N remains relatively constant throughout the year. In this area primary production increases in the spring months, and grazing is assumed to keep the plant biomass constant (McAllister, *et al.*, 1960).

The investigations show that there are high nutrient concentrations in the waters of the Gulf of Alaska during the winter, and in the summer the nutrients in the coastal waters are substantially reduced while the nutrients in the oceanic waters, though reduced, remain in fairly high concentration. Nevertheless, surface concentrations of phytoplankton in oceanic waters remain quite uniform throughout the year. Parsons and LeBrasseur (1969) have hypothesized from the relationship between thermocline depth and incident radiation that the spring increase in primary production should begin in March around the edge of the Gulf of Alaska but not until May in the central portion of the Gulf. This shorter period of plant growth from the coast outward is offered as an explanation for the reduced level of nutrient removal from offshore oceanic waters as compared with coastal waters. It is further suggested (McAllister *et al.*, 1960) that secondary production in the offshore waters also contributes to limting the standing stock of phytoplankton during spring and to recycling nutrients. In the winter, high vertical mixing in combination with low light intensities result in higher nutrient concentrations in the surface waters.

Annual variation

Large-scale, non-seasonal fluctuations of biological parameters have been observed in the vicinity of Station "P". Intrusion of mixed Transition waters from 1958 to 1960 brought warmer temperatures with lower oxygen concentration than in Subarctic waters which normally occur there (Parsons and LeBrasseur, 1967; Marlow and Miller, 1975). The presence of Transition waters at the surface produced biological differences in underlying waters (Geynrikh, 1968). For example, while the zooplankter *Calanus pacificus* occurred in all

Subarctic waters, *Parathemisto japonica* was not found in Subarctic water overlain by Transition water (Beklemishev, 1969). From 1962 to 1964, zooplankton biomass at Station "P" decreased to one fifth its normal level (Longhurst, *et al.*, 1972). The decrease was not correlated with any other parameter, biological or physical. Other unexplained non-seasonal variations in salinity and oxygen content have also been observed at Station "P" (Marlow and Miller, 1975; Tabata, 1965). Intrusion of deep water below the halocline from the western into the eastern Subarctic Pacific has been documented for the years 1955 to 1962 (Favorite, person communication). The intrusion has not been correlated with any biological events above the halocline.

Geographic variation

Fewer studies have dealt with geographic variation of biological features in the eastern Subarctic Pacific. Venrick (1969) found the neritic phytoplankton to be markedly distinct from the oceanic species, and the boundary between oceanic and neritic to be very sharp. Larrance (1971a) found productivity and chlorophyll a substantially higher in coastal waters of the Aleutian chain than in the Alaskan Stream. Beklemishev and Nakonechnaya (1972) found discrete phytoplankton blooms in both Subarctic and Transition Zone waters. The smallest patches had dimensions of 150 x 420 nautical miles. The patches in the Subarctic water coincided with the area of high phytoplankton biomass described by Parsons and Anderson (1970).

Many of the problems encountered in studies of variation within large scale ecosystems have been discussed by Kerr and Neal (1976). They point out the difficulty of distinguishing patterns within a system containing excess "noise". They note that physical and chemical processes are ultimately responsible for biological variation but that the relationships are not direct and are therefore difficult to discern. One of the main problems of large scale ecosystem studies, therefore, is that the very process of organizing and grouping data for descriptive analysis obscures many causative features and quantitative relationships.

In this paper we describe a large-scale ecosystem study of the eastern Subarctic Pacific using a variety of data from both published and unpublished sources. We adopt the idea put forward by Kerr and Neal (1976) that an ecosystem can be defined as a list of variables.

B. Study area

In order to obtain as much baseline data as possible, the study area covers the Gulf of Alaska expanded west to 180° and south to 42°N. This area includes the entire eastern Subarctic (excluding the Bering Sea) as well as part of the Transition Zone. For the numerical model, Weather Station "P" has been chosen as the study area because of the extensive time series of biological and physical data collected there.

C. Materials and methods

Data collection and adjustment

Source of data: Biological oceanographic data collected from the eastern Subarctic Pacific between 1958 and 1974 were compiled from published and unpublished sources (Table 4). The study area was bounded by the 180° meridian, the 42° N parallel, and the Alaskan, British Columbian, and Washington coasts. The major types of data collected on each cruise are listed in Table 4. To ensure comparability, only data from selected methods were compiled; and some systematic corrections which are described below were made. The data have been filed with National Oceanographic Data Center, Rockville, Maryland.*

Chlorophyll *a*: Chlorophyll *a* concentration may be used as an index of phytoplankton standing stock. The laboratory technique for the spectrophotometric method has remained essentially the same since its development (Richards

* OCSEAP RU 58 Tapes #1 and #2.

Table 4. List of operations in the eastern subarctic Pacific between June 1958 and July 1974 which yielded biological oceanographic data.

[C = chlorophyll a/m^3, C' = chlorophyll a/m^2, Ph = phaeopigments/m^3, Ph' = phaeopigments/m^2, P = primary productivity/m^3, P' = primary productivity/m^2, Z = zooplankton, Sp = phytoplankton species, O = oxygen, N = nitrate, N' = nitrite, N" = ammonia, Pp = phosphate, S = silicate, D = mixed layer depth, R = total incident radiation]

Operation	Period	Zones	Type of Data	Source
Weather Station "P"				
cruises 593 to 614	1959 to 1961	33	C C' P P' Z O S R	McAllister, 1962
cruises 615 to 634	1961 to 1963	33	C C' P P' Z O S R	Stephens, 1964
cruises 635 to 655	1964 to 1966	33	C P Z O N R	Stephens, 1966
cruises 661 to 674	1966 to 1967	33	C P O N R	Stephens, 1968
cruises 681 to 706	1968 to 1970	33	C P N R	Stephens, 1970
Ships of Opportunity cruises 02 to 43	1968 to 1972	15,19,20,22-34,36-42	C P Sp N Pp S D R	Anderson, unpubl.
	1958			
BROWN BEAR 199	June to July	20,32,37	O Pp D	Fleming, 1959
H.M. SMITH 46	Aug. to Sept.	24,25,29,30,31,38,39, 40	C P Z O	McGary and Graham, 1960
VITYAZ 29	Oct. to Dec.	19-21,24,27,29,30,32, 35,37,41,42	P Z N Pp R	Koblentz-Mishke, 1969
	1959			
OSHORO MARU 44	June	22,25,29	Z O Pp	Faculty of Fisheries, 1960
BROWN BEAR 235	July to Aug.	15,19,20,23,24,27,28, 34,36	C O Pp	Stephens, 1964
	1960			
OSHORO MARU 46	June to Aug.	18-20,22-24,29-32,35, 37,38	Sp Z O Pp S	Faculty of Fisheries, 1961. Motoda and Kawamura, 1963
	1961			
OSHAWA 1961	June	19,33,36,37	C O N S	Antia et al., 1962
OSHORO MARU 048	June	22,29	Z	Faculty of Fisheries, 1962
PIONEER 66	Sept. to Oct.	22,23,26,29,30,38,39, 42	C P Z	Doty, 1964
	1962			
OSHAWA 1962	April	42	C N S	Antia et al., 1962
	1964			
G. B. REED 164	Jan. to Feb.	19,20,21,24,27,28, 31-37,42	C	Stephens, 1964
AGASSIZ Ursa Major	Aug. to Sept.	16,24,27,31,40	C Sp Z O N' Pp S	University of California, 1967. Venrick, 1969.
	1965			
OSHORO MARU 014	June	22,24,25,29	Z	Faculty of Fisheries, 1966
	1966			
ARGO Zetes I	January	16,24,27,31,40	C Ph Sp Z O N N' Pp S	University of California, 1970. Venrick, 1969.
Straits of Georgia	Feb. to Sept.	20	C P N N' N" Pp S	Fulton, et al., 1967
KELEZ 166	March	22,25,29	C C' P P' Z Pp S D R	Larrance, 1971b
Saanich Inlet	May to July	20	C P Z N N' Pp S	Stephens, et al., 1967

Table 4. (continued)

	1966 (cont.)			
PARAGON 266	June	22,25,29	C C' P P' Z Pp S D R	Larrance, 1971b
KELEZ 366	September	20,22,29-32,37,38	C C' P P' Z N Pp S D R	Larrance, 1971b
	1967			
KELEZ 167	Jan. to Feb.	23,26,30	C C' P P' Z N Pp S D R	Larrance, 1971b
T.G. THOMPSON 012	Feb. to Mar.	17-19,24,27,28,34-36	C C' P P' O N Pp S	Anderson, unpubl.
KELEZ 367	April	19,20,36,37	C D	Larrance, 1971b
KELEZ 567	June to July	16,22-25,29	C C' P P' Z N Pp S D R	Larrance, 1971b
KELEZ 667	July	22	C C' P P' Z N Pp S D R	Larrance, 1971b
KELEZ 767	August	22,25,29	C C' P P' Z N Pp S D R	Larrance, 1971b
	1968			
KELEZ 268	May	23,26,30	C C' Pp S D	Larrance, 1971b
OSHORO MARU 028	June to July	17,18,22	Z O Pp	Faculty of Fisheries, 1969
	1969			
ENDEAVOUR Trans Pacific	March to April	20,29-32,37	C P P' Z Pp N S D R	Anon, 1970
VITYAZ 045	May to June	17,18,23,35	C P P'	Anon, 1973
HAKUHŌ MARU 694	August	31	C SP	Takahashi *et al.*, 1972 Asaoka, unpubl.
	1970			
HAKUHŌ MARU 702	May	19,32,34,37,41	O N N' Pp S	Horibe, 1971
OSHORO MARU 037	June to July	16,17,18,22-24,27, 31-34,36,37	C Z Pp N N' S	Faculty of Fisheries, 1972
	1971			
T.G. THOMPSON 059	May to June	20,22,23,25,26,27	C C' O N N" Pp S	Anderson, unpubl.
ACONA cruises 113,117, 122,125	May to Dec.	17	C C' P P' Ph Ph' Sp O N N" Pp S	Goering, Shiels, and Patton (1973) Goering, Patton, and Shiels (1973) Hood and Patton (1973)
	1972			
ACONA 128, 131	March to April	17	C C' P P' Ph Ph' Sp O N N" Pp S	Muench and Nebert (1973) Horner *et al.*, 1973.
T.G. THOMPSON 072	September	24,27,31,40	C C' P P' Ph Ph' O N N' N" Pp S R	Anderson, unpubl.
	1973			
T.G. THOMPSON 082	August	32,33,41	C C' Ph Ph' O N N' N" Pp S R	Anderson, unpubl.
	1974			
HAKUHŌ MARU 742	May	29	C O N N' N" Pp S	Kuroki, 1975
T.G. THOMPSON 091	July	36	C Ph	Anderson, unpubl.

with Thompson, 1952). Conversion of laboratory values to chlorophyll a concentration is based on equations which correct for interference from chlorophylls b and c. Revised equations by UNESCO (1966) produce chlorophyll a concentrations which are 24% lower than values derived from the original equations (Banse and Anderson, 1967). To obtain comparable data, we have reduced all data (prior to 1962) based on the equations of Richards with Thompson (1952) or Strickland and Parsons (1960) by 24%. Data based on the equations of Parsons and Strickland (1963) were assumed compatible with data based on the UNESCO equations (Banse and Anderson, 1967). Although later editions of Strickland and Parsons (1965, 1968, 1972) printed both the Richards equations and the Parsons-Strickland equations, in all cases the original data were based on the Parsons-Strickland equations so that data obtained after 1963 did not need reduction.

Chlorophyll a concentrations derived from the fluorometric technique (Lorenzen, 1966) were assumed to be comparable with those derived from the spectrophotometric technique.

In the cases where chlorophyll data were reported at depth but integration over the water column was not performed, we have performed that integration. Chlorophyll a was integrated down to the one percent light depth by the least squares method. A minimum of two chlorophyll values per station was required for integration. If there were data above and below the one percent light depth, the program interpolated the chlorophyll value at the one percent light depth. If there were no data at or below the one percent light depth, chlorophyll at this depth was set equal to zero.

Phaeopigments were determined fluorometrically using the method of Lorenzen (1966).

Phytoplankton species: All cell counts compiled were observed in samples collected from water bottles. Counts and proportions taken from net samples were not compiled. All cell counts were obtained using the inverted microscope method of Utermöhl (1931) which depends upon sedimentation to concentrate the cells. Biomass estimates for individual species were computed from cell carbon using the following conversion from plasma volume (Strathmann, 1967):

$$\log C \text{ (pg)} = 0.610 + 0.892 \log \text{ (plasma vol} + 0.1 \text{ vacuole vol).}$$

Plasma volume was derived from cell measurements and geometric formulae for 18 cell shapes (Larrance, 1964) assuming a standard plasma thickness of 1 mμ.

Primary production: Primary production is most commonly measured using the radioactive carbon uptake method of Steemann Nielsen (1952). Steemann Nielsen's original method involved incubation of phytoplankton samples under standardized (fluorescent)light conditions. Many researchers in the subarctic have continued to use this method (Faculty of Fisheries, 1960, 1961, 1969, 1972). The "in situ" and "simulated in situ" incubation methods are modifications of Steemann Nielsen's method. According to Koblentz-Mishke (1961) data from the standardized light incubation method ("tank" method) are not comparable with those from "in situ" and "simulated in situ" incubations. Therefore, we have compiled only productivity values which have been obtained from incubation in daylight either "in situ" or using neutral density filters on matched depth samples. Productivity values obtained from incubation in an artificial light source (tank method) from composite samples, from depth samples incubated without filters, and from surface samples incubated with filters have not been included.

Carbon assimilation rates which were originally reported as mg C/m^3/day (RV VITYAZ 029) were converted to mg C/m^3/hr by dividing by the number of hours between sunrise and sunset. Hours of daylight were taken from the 1976 Nautical Almanac.

Nutrients: Reactive nitrate was commonly reduced to nitrite, the concentration of which was then determined colorimetrically. Reduction methods [Mullin and Riley, 1955a; Morris and Riley (Strickland and Parsons, 1972); Wood, Armstrong and Richards, 1967] have varied to improve sensitivity and ease of measurement. We have compiled values from all methods without adjustment.

Because the nitrite concentration is usually a small proportion of the nitrate concentration, we have included the early nitrate data with later data from which nitrite concentrations have been subtracted. Both early and later measurements have been averaged to analyze geographic and temporal variation in nitrate concentrations.

Reactive nitrite was determined colorimetrically according to the method of Benschneider and Robinson (Strickland and Parsons, 1972).

Ammonia was oxidized to nitrite according to the method of Richards and Keltsch (Strickland and Parsons, 1972). This method measures amino acids along with the ammonia.

Reactive phosphate was determined using four methods [Robinson and Thompson (Strickland and Parsons, 1969); Wooster and Rakestraw, 1951; King *et al.*, 1957; Murphy and Riley, 1962]. All four methods utilize a phosphomolybdate complex but differ in rapidity and speed of analysis.

Silicate was determined using two methods [Mullin and Riley, 1955b; Chow *et al.* (Strickland and Parsons, 1972)]. Concentrations of phosphate reported from the VITYAZ 029 cruise were converted from mg m^{-3} to μgm. at. ℓ^{-1} during compilation.

One percent light depth: In cases where the one percent light depth was not reported with the original data, it was calculated from secchi depth by the following formula:

$$I_z = I_o e^{-kz}$$

$$I_z/I_o = .01$$

$k = 1.7/\text{secchi depth}$ (Poole and Atkins, 1929)

$z_{1\%} = 2.7 \times \text{secchi depth}$

Secchi depth: For stations which included chlorophyll profiles but not integrated chlorophyll values or one percent light depths, it was necessary to assign a one percent light depth so that the chlorophyll data could be integrated. This was accomplished by locating the station closest in space and time from another cruise and assigning that secchi depth. One percent light depth was then calculated from the secchi depth.

Mixed layer depth: Mixed layer depth, if it was not originally recorded, was taken to be the depth to the top of the major thermocline for thermoclines with a gradient >1°C/15 meters (Giovando and Robinson, 1965). In most cases, the thermocline could be determined from a visual inspection of the temperature profile. If it was not clear, a graph was drawn. When no temperature gradient greater than 1°C/15 meters was observed, mixed layer depth was taken to be the depth to the top of the halocline. In a few cases where temperature inversions were observed (TGT 059 sts. 41, 38, 53) mixed layer depth was taken to be the depth to the top of the pycnocline.

Light level: Light levels which were originally presented as Langleys/ half day (VITYAZ 029) were multiplied by 2 to obtain Langleys/day.

Data analysis

The study area was defined as the Subarctic Pacific east of 180°W and north of 42°N, not including the Bering Sea. The area was divided into 28 geographic zones (Figure 25) based on the work of Dodimead *et al.* (1963). Dodimead *et al.* (1963) divided the Subarctic into domains on the basis of temperature, salinity, and flow characteristics, not on the basis of water masses. The domains exhibited consistent structure and oceanographic behavior. The Central Subarctic Domain displays a permanent halocline at about 100 meters and salinities of 32.4 to 32.8 °/₀₀ in the upper zone. The Transition Domain is warmer and separated

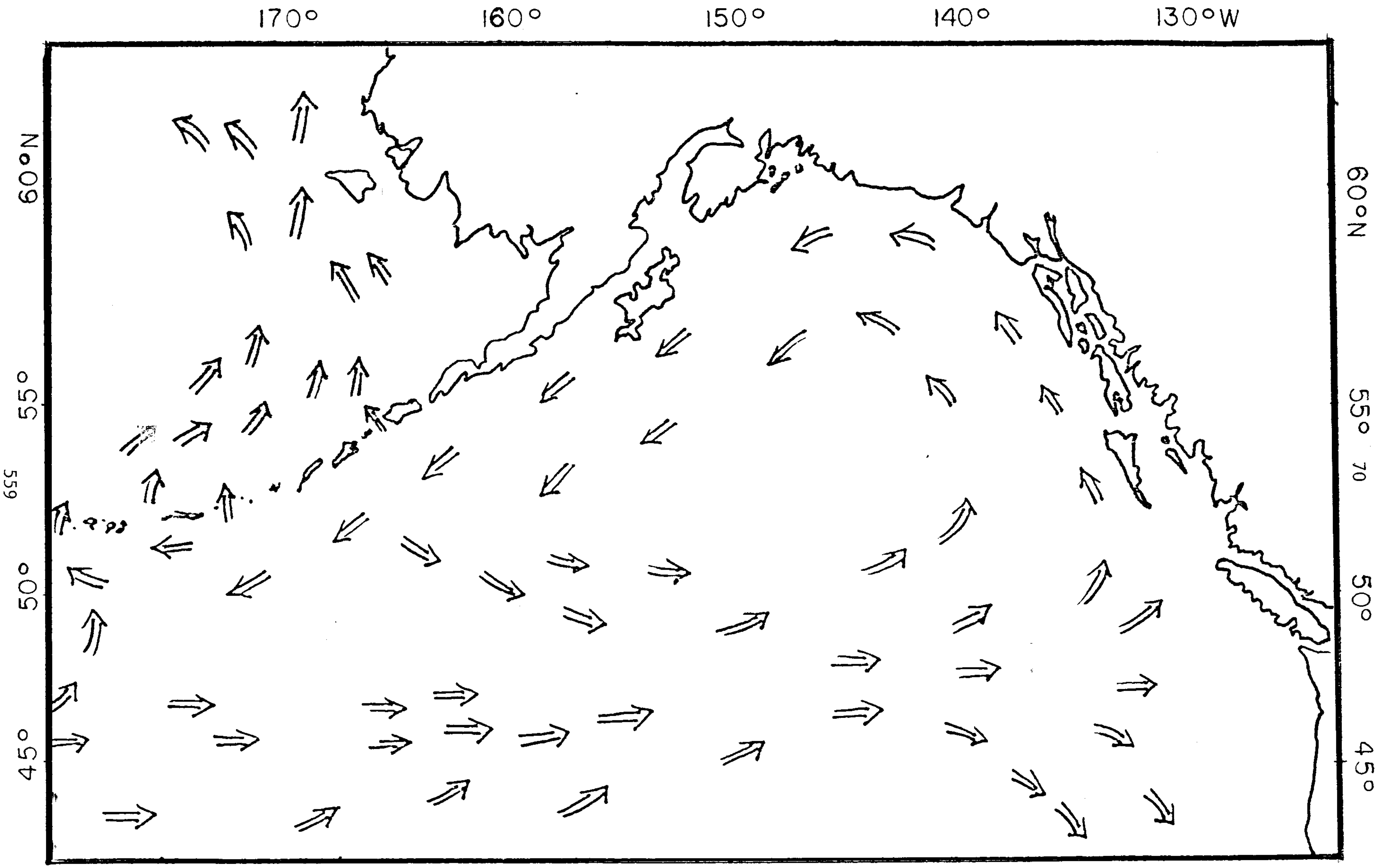


Figure 24. Persistent circulation in the eastern Subarctic Pacific (after Uda, 1963).

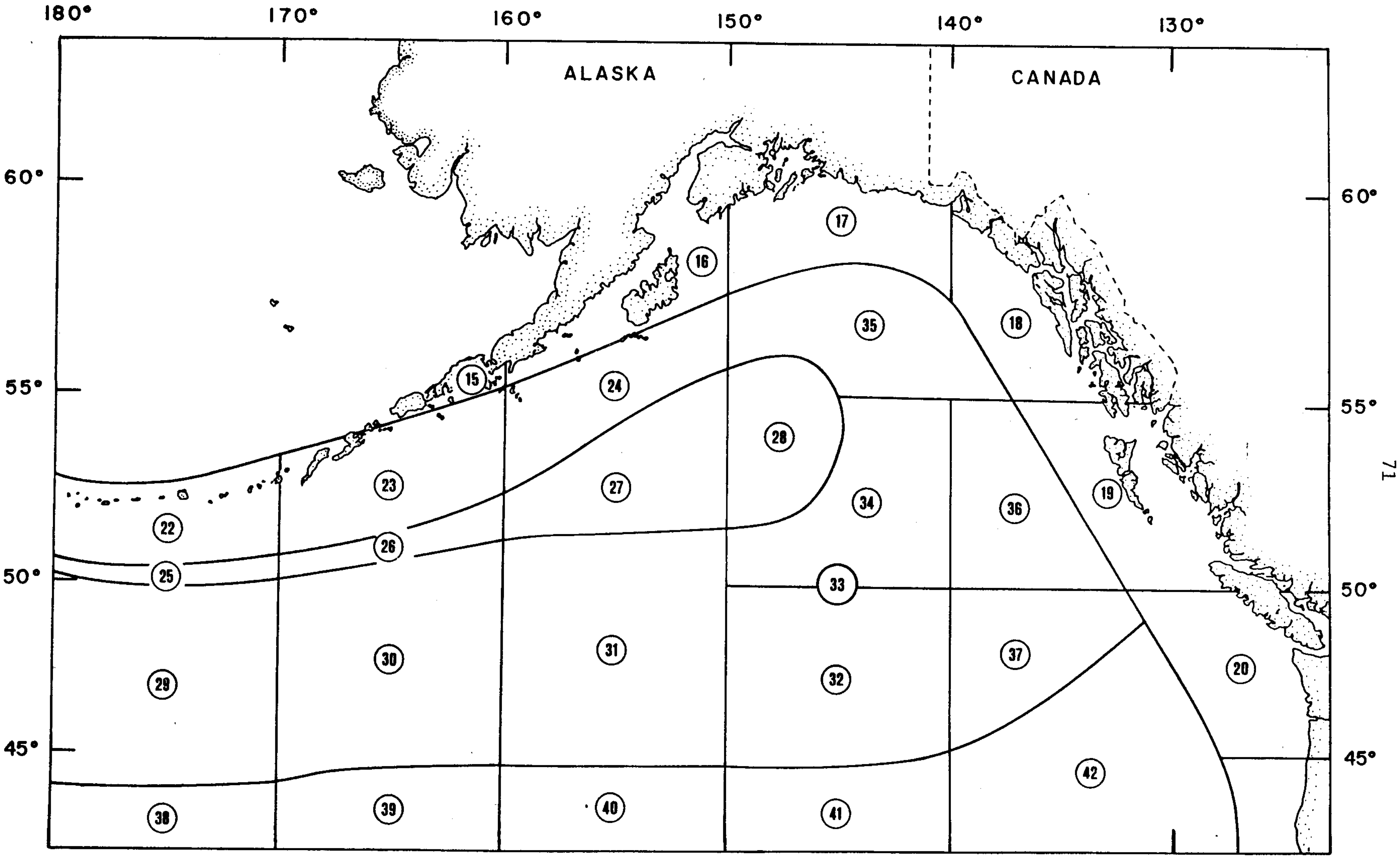


Figure 25. The geographical zones of the eastern Subarctic Pacific. The circled number in each zone is the number by which that zone is identified in the text and in the following figures and tables. Zone 33 is Ocean Weather Station 'P' and its near environs.

from the Central Subarctic Domain by the 7°C isotherm at the bottom of the upper zone. The Coastal Domain is less saline and separated from the Central Subarctic Domain by the isohaline of 32.4 °/₀₀ at the surface. The Alaskan Stream Domain is both warmer and less saline than the Central Subarctic Domain, comprising waters with salinities less than 32.6 °/₀₀. The Alaskan Gyre is differentiated by flow characteristics and a salinity maximum of 32.8 to 33.1 °/₀₀ at the surface. The extensions of the three peripheral domains on the Central Subarctic Domain vary annually. Figure 216 in Dodimead *et al.* (1963), which represents the average positions of the boundaries between domains, was used to define the geographic zones in the present study. Zones 15-21 in the Coastal Domain (Figure 25) include the continental shelf as well as oceanic areas in close proximity to the shelf. Zones 22-24 in the Alaskan Stream Domain include the Alaskan Stream as well as the neritic area of the Aleutian chain. Zones 27-28 define the center of the Alaskan Gyre. Zones 29-31 comprise the Central Subarctic. Zone 33 includes Ocean Weather Station "P". Zones 32-37 include waters of mixed origin within the Central Subarctic Domain. Zones 29-42 include Transition waters.

The data were divided by season. According to Parsons and LeBrasseur (1968), during March the depth of the mixed layer at Station "P" equals the critical depth as defined by Sverdrup (1953). Parsons and LeBrasseur (1969) predict from physical data that the spring increase in phytoplankton production will occur in March in zones 16, 20, 24, and 42 of Figure 25. Therefore, spring was not defined astronomically in the present study but as the period from March to May. Similarly, summer included June to August; autumn included September to November, and winter included December to February. Station locations for each season are plotted in Figures 26 to 29.

The data were grouped into six depth ranges: 0-10 m, 10.1-25 m, 25.1-50 m, 50.1-100 m, 100.1-150 m, >150 m.

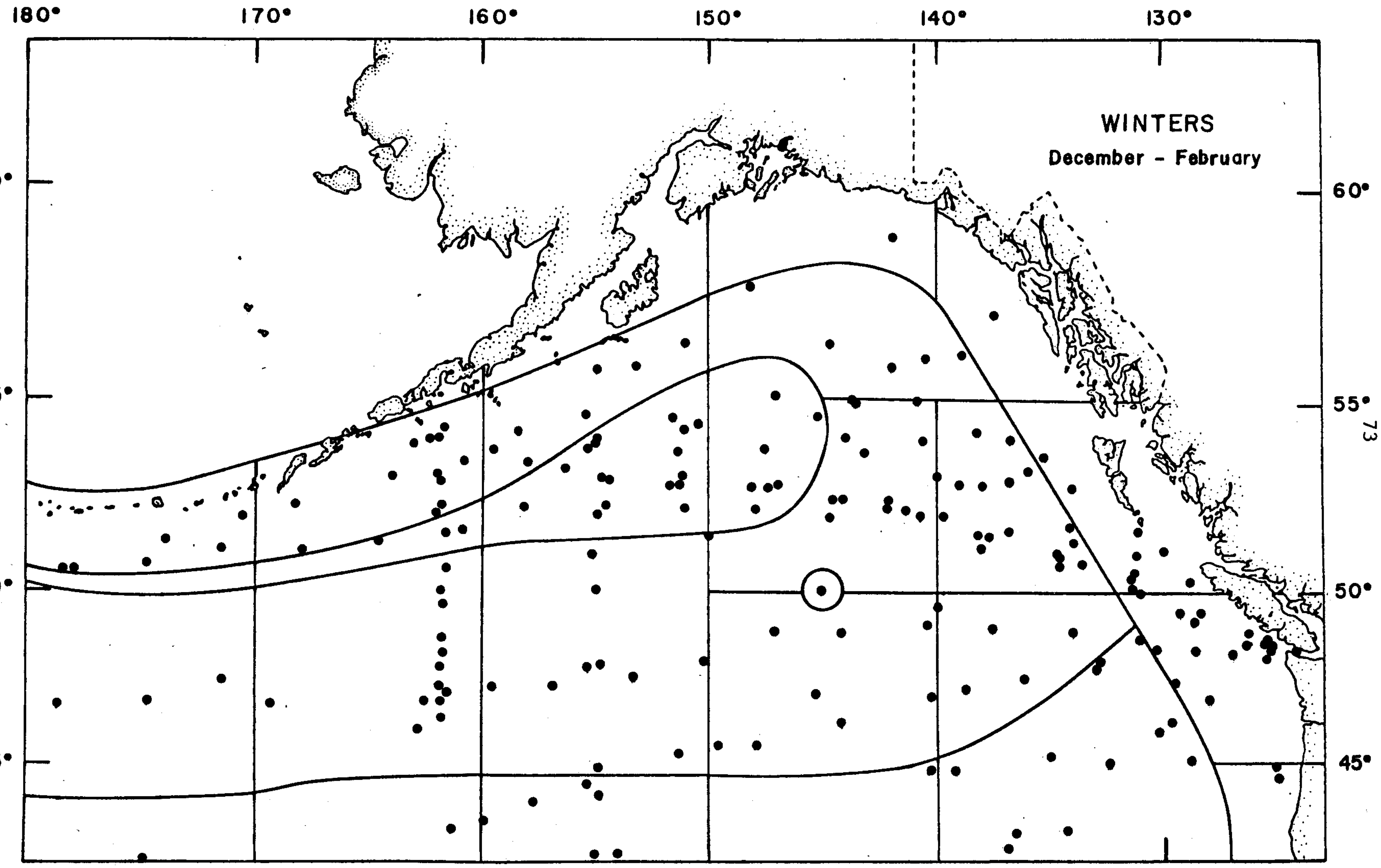


Figure 26. The distribution of stations in the eastern Subarctic Pacific from which data were collected during one or more winters from 1958 through 1974.

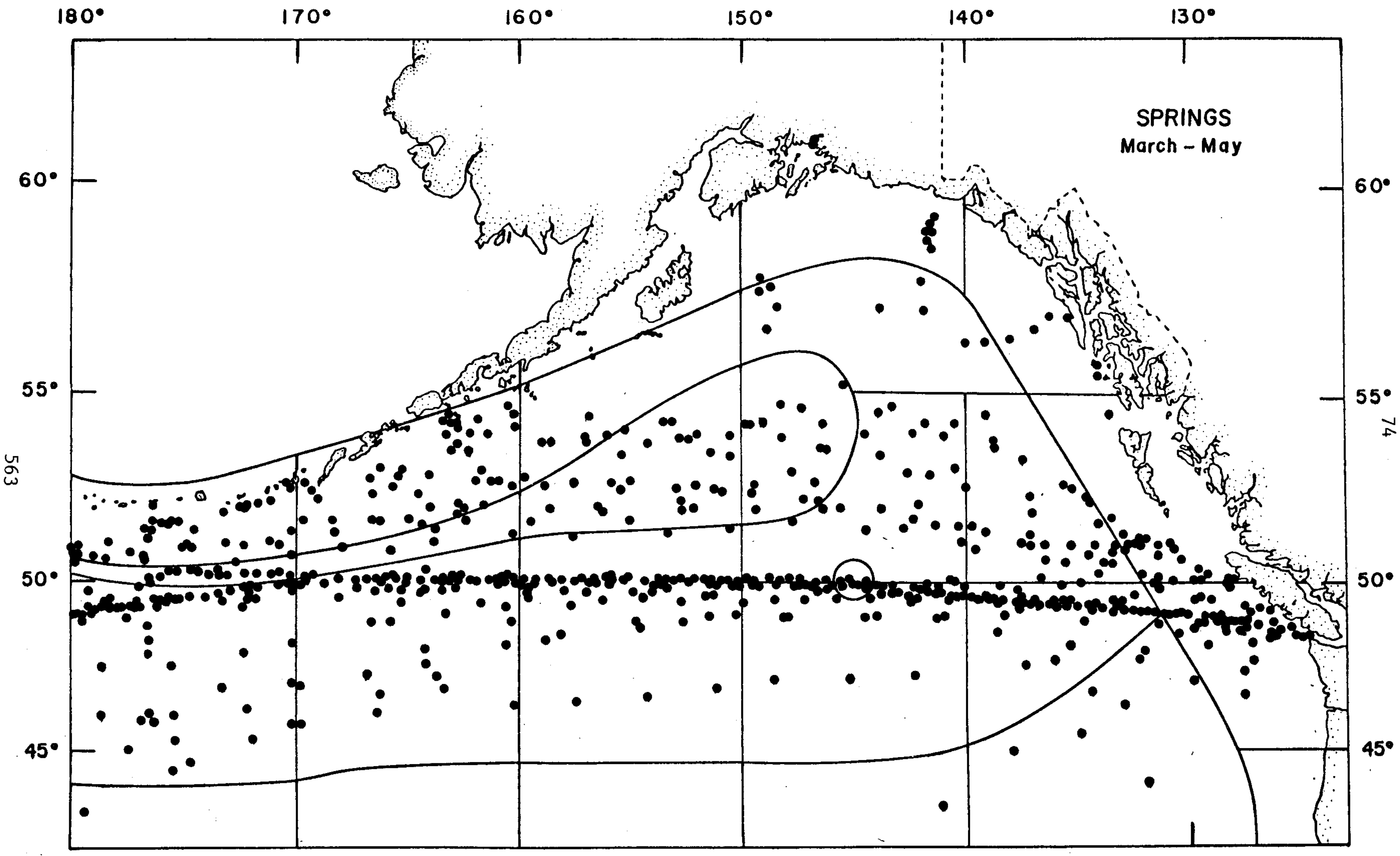


Figure 27. The distribution of stations in the eastern Subarctic Pacific from which data were collected during one or more springs from 1958 through 1974.

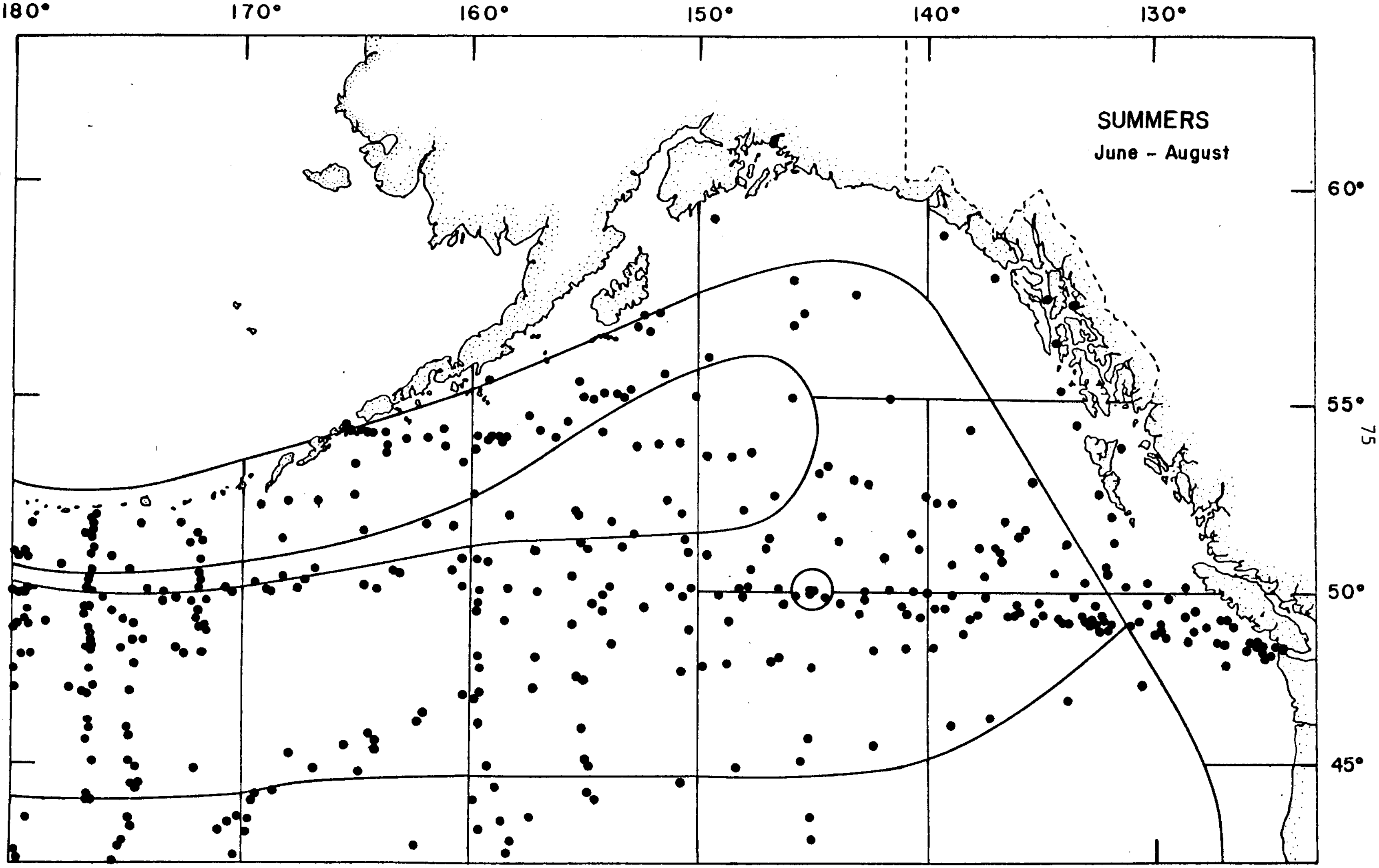


Figure 28. The distribution of stations in the eastern Subarctic Pacific from which data were collected during one or more summers from 1958 through 1974.

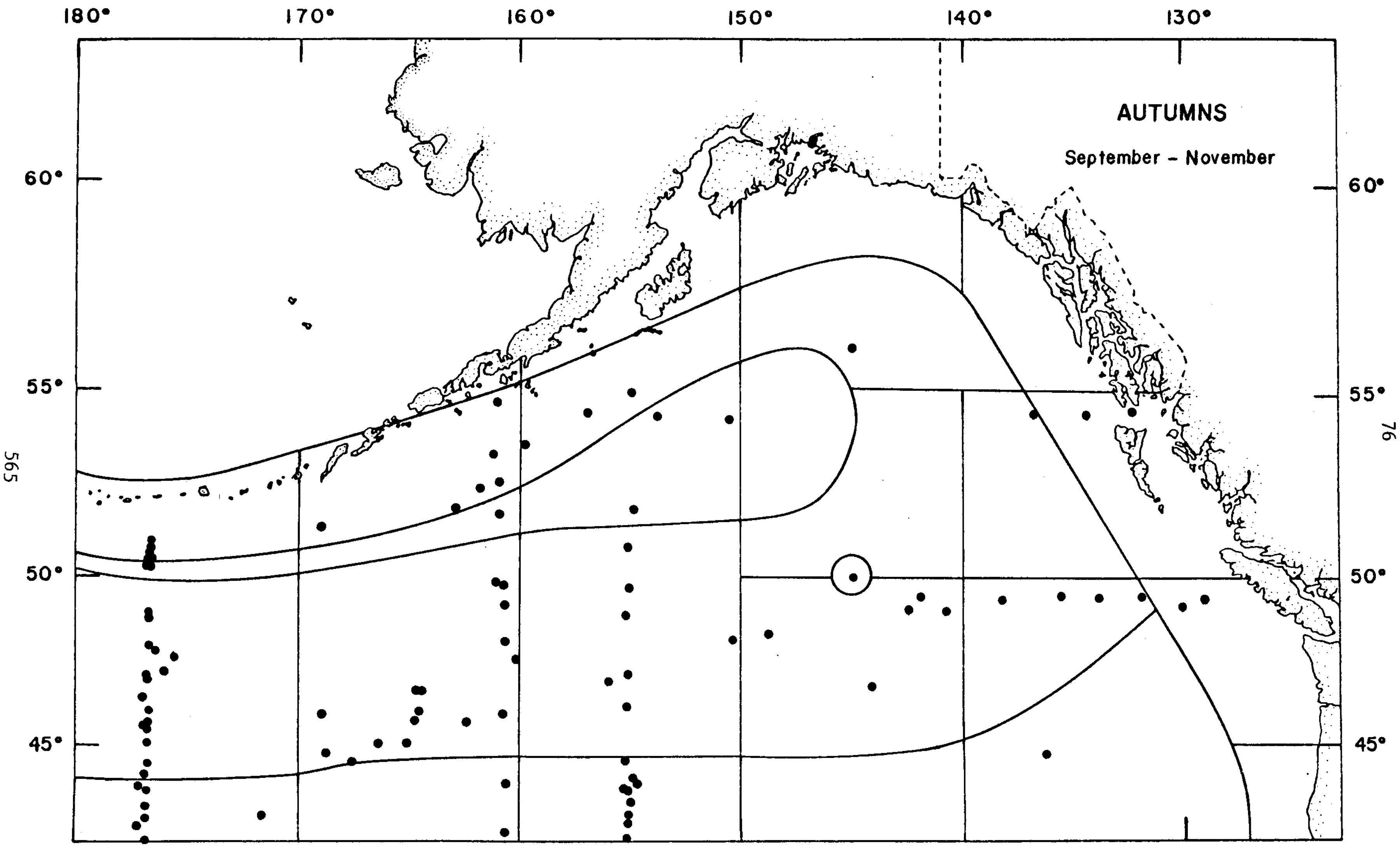


Figure 29. The distribution of stations in the eastern Subarctic Pacific from which data were collected during one or more autumns from 1958 through 1974.

Productivity data: Within each cell formed by one geographic zone, one year, one season, and one depth, the range, mean, and standard deviation for each variable were computed:

$$\text{mean: } \overline{X} = X_{i\cdot}/n_i$$

$$\text{standard deviation: } s = \frac{\Sigma X_{ij}^{2} - X_{i\cdot}^{2}/n_i}{n_i - 1}$$

One-way analysis of variance (ANOVA) was used to test the difference between years. The generalized ANOVA table for samples of unequal sizes (Snedecor and Cochran, 1967) is as follows:

Source of Variation	SS	Degrees of Freedom	Mean Square	Expected Mean Square
Between years	$\Sigma\frac{X_{i\cdot}^{2}}{n_i} - \frac{X_{\cdot\cdot}^{2}}{N}$	a - 1	Sc^2	$\sigma^2 + n_o\sigma_A^2$
Within years	$\Sigma\Sigma X_{ij}^{2} - \Sigma\frac{X_{i\cdot}^{2}}{n_i}$	a(N - 1)	S^2	σ^2
Total	$\Sigma\Sigma X_{ij}^{2} - X_{\cdot\cdot}^{2}/N$	N - 1		

where X_{ij} denotes the jth observation from the ith year, $X_{i\cdot}$ denotes the cell total of the X_{ij}, $X_{\cdot\cdot} = \Sigma X_{i\cdot}$ denotes the grand total, a denotes the number of years, n_i denotes the size of the sample in the ith cell, and $N = \Sigma n_i$ denotes the total size of all cells. The F ratio, Sc^2/s^2 has (a - 1) and (N - a) degrees of freedom. Mathematically, the model may be written:

$$X_{ij} = \mu + \alpha_i + \varepsilon_{ij}, \quad i = 1....a, \; j = 1....n,$$

Equal cell sizes were impossible to achieve because of the nature of the sampling process. To achieve equal cell size, zonal boundaries would have had to be adjusted. Because each cruise measured different variables (Table 4), the boundaries would have to be different for each variable, a premise which violated the experimental design. Therefore, unequal cell size was accepted as an undesirable but necessary part of the program.

Although equal cell size is not essential for the performance of single factor ANOVA (Zar, 1974), independence of error and variance homogeneity are essential (Sokal and Rohlf, 1969). With unequal cell size, the F-test and t-tests are more affected by non-normality and heterogeneity of variances than with equal cell size (Snedecor and Cochran, 1967). To evaluate independence of error, the variance of each cell was plotted against the mean of the cell for each variable. The Student-t test was used to determine if the resulting regression line differed significantly from zero:

$$t = \frac{b - 0}{S_b}, \text{ d.f.} = n - 2$$

where b = the slope of the regression line, S_b = sample standard deviation of the regression coefficient. Regression was tested at the 95% level for 14 variables (Table 5).

In the cases where the slope of the regression line differed significantly from zero (i.e., the variance was dependent upon the mean), various transformations of the original data were made and the significance of the regression tested again at the 95% level. Transformations which removed dependence are listed in Table 6. The $\sqrt{X}$ transformation was performed on phaeopigments (mg/m^3), ammonia, mixed depth, total radiation. The $\sqrt{X+1}$ transformation was performed on nitrate. The $\log_{10}(X+1)$ transformation was performed on integrated chlorophyll a (mg/m^2). No transformation was necessary for phosphate, silicate, nitrite, integrated phaeopigments, integrated productivity, or integrated zooplankton. No transformation could be found for chlorophyll a (mg/m^3), primary productivity ($mg\ C/m^3/hr$) or oxygen which would achieve independence.

Table 5. Regression of cell variance on cell mean for 14 variables in the Eastern Subarctic Pacific

Variable	b[1)]	S_b[2)]	b/S_b	d.f.	t_{95}
Chlorophyll *a*	3.76	0.23	16.64**[3)]	167	1.98
Integrated chlorophyll *a*	128.83	20.22	6.37**	57	2.00
Phaeopigments	0.77	0.07	10.35**	3	3.18
Integrated phaeopigments	4.06	3.00	1.36	30	2.04
Nitrate	1.07	0.52	2.04*[4)]	142	1.98
Phosphate	-0.06	0.13	-0.45	181	1.98
Silicate	0.57	0.45	1.25	157	1.98
Nitrite	0.16	0.19	0.85	18	2.10
Ammonia	0.56	0.20	2.82*	15	2.13
Oxygen	-0.08	0.03	-2.37*	57	2.00
Depth of mixed layer	5.11	1.96	2.61*	198	1.98
Incident radiation	29.45	6.93	4.25**	209	1.98

1) b = slope of regression line

2) S_b = sample standard deviation of the regression coefficient

3) significant at the 99% level

4) significant at the 95% level

Table 6. Regression of cell variance on cell mean for 7 transformed variables in the Eastern Subarctic Pacific

Variable	Transformation	$b^{1)}$	$S_b^{\,2)}$	b/S_b	d.f.	t
Integrated chlorophyll *a*	$\log_{10}(X+1)$	0.02	0.16	0.13	57	$t_{50} = 0.68$
Phaeopigments	$\sqrt{X}$	0.81	0.30	2.68	3	$t_{95} = 3.18$
Nitrate	$\sqrt{X+1}$	0.0003	0.05	0.007	142	$t_{50} = 0.68$
Ammonia	$\sqrt{X}$	0.042	0.09	0.48	15	$t_{50} = 0.69$
Depth of mixed layer	$\sqrt{X}$	0.096	0.13	0.74	198	$t_{60} = 0.84$
Incident radiation	$\sqrt{X}$	0.32	0.17	1.93	209	$t_{95} = 1.97$

1) b = slope of regression line

2) S_b = sample standard deviation of the regression coefficient

After the appropriate transformations were made, the ANOVA program was run and the difference between years evaluated. The results are outlined in Tables 7 and 8. F-ratios based on samples from 2 or more years where only one year had more than 2 samples were considered invalid, and the results were left out of the analysis.

When a large number of ANOVA tests are performed at the 95% level, 5% of the tests are expected to be positive (i.e., the null hypothesis is rejected) when in fact the null hypothesis is true. This is termed a Type I error; it overestimates a difference. The proportion of positive F-tests to the total valid tests performed was computed for each variable at each depth range (Table 9). The proportions for each variable far exceed 5/100, thereby indicating real differences between years. Type II errors cause an underestimation of real differences and so do not need to be considered here.

Finally, all the years were averaged, and the range, mean, and standard deviation were computed for each variable in each geographic zone at each depth for each season. The results are plotted in Figure 27 to 74 and listed in Appendix A.

<u>Phytoplankton species data</u>: Phytoplankton species data were insufficient to allow analysis of seasonal variation; therefore, samples collected between January and June for all years were analyzed for geographic variation. Only surface samples were analyzed to provide comparability with the large body of Ships-of-Opportunity data. Stations within each geographic zone were grouped together. The number of stations sampled in each zone are indicated in Figure 75. For each species occurring within each zone, six statistics were computed:

1) Mean number of cells per liter. The cell concentration of the species was averaged over the samples in which that species occurred.

Table 7. Geographic zones in the Eastern Subarctic Pacific which show significant variation between years (tested at the 95% level).

Variable	Season	0-10m	10-25m	25-50m	50-100m	100-150m	>150m
Nitrate[1)]	Winter	20[2)],27,31,32,36	--	--	27	33	--
	Spring	19,20,22,25,29-34,37	33	--	20,33	33	33
	Summer	20,23,27,31-34,37	33,37	20,32,33	20,32,33	33	33
	Autumn	33	--	--	--	--	33
Phosphate	Winter	20,27,31,32,36	--	--	--	--	--
	Spring	20,22,25,29-32,36,37	22,25	20,22	20	--	--
	Summer	23,25,29,31,32,33,38	20,22,29,32	20,29,33,37,38	22,29	29,33	24,27,29,31,38
	Autumn	--	--	--	40	--	--
Silicate	Winter	20,32,34,36,40	--	--	27	--	--
	Spring	20,22,25,29-32,34,37	22,30	20,22,29,30	20,29,30	--	--
	Summer	20,22,23,25,27,29,31-34	19	20,29,31-33	20,29,31,33	--	22,29
	Autumn	40	--	40	--	--	--

1) ANOVA performed on $\sqrt{X+1}$ transformation of data

2) Zone 20 (see Figure 25)

Table 8. Geographic zones in the Eastern Subarctic Pacific which show significant variation between years (tested at the 95% level).

Season	Integrated chlorophyll a[1)]	Depth of Mixed Layer[2)]	Incident Radiation[2)]
Winter	33[3)]	--	30, 33
Spring	23, 33	20, 22	22, 33
Summer	33	20, 22, 29, 32	--
Autumn	29, 33	--	33

1) ANOVA performed on $\log_{10}(X+1)$ transformation of data

2) ANOVA performed on $\sqrt{X}$ transformation of data

3) Zone 33 (see Figure 25)

Table 9. Ratio of positive F-tests to total tests performed for analysis of variance between years in the Eastern Subarctic Pacific.

Variable	0-10m	10-25m	25-50m	50-100m	100-150m	>150m
Nitrate	25*/39**	3/5	3/4	6/10	2/4	3/4
Phosphate	21/38	6/10	7/13	4/11	2/3	5/7
Silicate	25/27	3/6	10/12	8/11	0/3	2/3
Integrated chlorophyll a	6/7					
Depth of mixed layer	6/24					
Incident radiation	5/10					

* 23 instances of significant difference between years

** 39 valid ANOVA tests performed

2) Maximum percentage of total cells. In each sample the percentage contribution of the species to the total phytoplankton cell count was determined. The maximum percentage within each zone was the highest percent contribution at any one station.

3) Mean carbon per liter. In each sample the cell concentration of the species was multiplied by the estimated amount of carbon per cell to produce an estimate of the biomass (in nanograms carbon per liter) of the species. The mean for each zone was the biomass of the species averaged over the samples in which the species occurred.

4) Maximum percentage of total carbon. In each sample the percentage contribution of the species to the phytoplankton biomass was determined. The maximum percentage within each zone was the highest percent contribution at any one station.

5) Number of stations present. The number of occurrences of the species within the zone was counted.

6) Percentage occurrence. The number of occurrences of the species was divided by the total number of samples within the zone and multiplied by 100.

Phytoplankton species were ranked in importance according to the number of occurrences, according to the maximum cell concentration at any one station, according to the maximum percent contribution to cell numbers at any one station, according to the maximum biomass at any one station, and according to the maximum percent contribution to biomass at any one station. All neritic stations were omitted so that the rankings would indicate the relative importance of species in the oceanic Subarctic.

D. Results

Productivity data

Annual variation: Significant annual variation during all seasons was observed for every variable on which valid ANOVA tests could be performed (Tables 7 and 8). Annual variation of nitrate, silicate, and phosphate was most frequent in the upper 10 meters and for the spring and summer seasons. The results indicate, however, only zones where annual variation could be demonstrated. Not all the blank spaces in Tables 7 and 8 indicate annual homogeneity; for many of them the sample number was insuffficent for analysis of variance. Zones where valid ANOVA tests supported annual homogeneity are listed in Tables 10 and 11.

Preliminary analysis of variance tests performed on untransformed chlorophyll *a* data indicate extensive annual variation. Chlorophyll *a* variation is best documented in zone 33 (Figure 30). A general upward trend of average chlorophyll *a* concentrations occurs from 1965 to 1969. Variation of chlorophyll *a* within years is greatest in the summer months. Annual variation between 1960 and 1965 at Station "P" has been described by Wickett (1973).

Chlorophyll *a*: Mean chlorophyll *a* concentrations show little seasonal change in the surface layer of the eastern oceanic Subarctic Pacific, in contrast to the marked seasonal variation of neritic zones (15, 17, 18, 20)(Figure 27). The neritic influence extends well beyond the shelf break, however, as evidenced by an average spring chlorophyll *a* concentration of over 2 mg m^{-3} in zone 25 and a summer average over 1 mg m^{-3} in zone 36. In most zones spring averages were higher than summer averages with the exception of zones 20, 26, 32, and 36, where summer averages were higher. A summer maximum is also suggested in Transition waters (zones 38, 41, 42), but the data are too few to be conclusive. Comparison of seasonal means within the oceanic area (zones 26 to 42) shows a small but significant difference (at the 99 percent level) between winter and spring, between spring and autumn, and between summer

Table 10. Geographic zones in the Eastern Subarctic Pacific which show no significant variation between years (tested at the 95% level)

Variable	Season	0-10m	10-25m	25-50m	50-100m	100-150m	>150m
Nitrate[1)]	Winter	22,23,30,33,34,40	33	--	33	33	3
	Spring	23,27,28,36,42	--	32	29,32	--	--
	Summer	22,29,36	--	--	--	--	--
	Autumn	--	23	--	33	33	--
Phosphate	Winter	22,23,30,34,40	--	--	27	--	--
	Spring	19,23,27,28,34	23,30	29,32	29,30,32	--	--
	Summer	20,22,27,34,36,37	31,37	22,24,31	31,32,33,38	--	22,25
	Autumn	40	--	40	--	40	--
Silicate	Winter	22,23,27,30,31	--	--	--	--	--
	Spring	19,23,27,28,36,42	23	32	32	32	--
	Summer	36,37	22,29	22	22	29,32	27
	Autumn	--	--	--	40	40	--

1) ANOVA performed on $\sqrt{X+1}$ transformation data

2) Zone 20 (see Figure 25)

Table 11. Geographic zones in the Eastern Subarctic Pacific which show no significant variation between years (tested at the 95% level).

Season	Integrated Chlorophyll _a_	Mixed Depth Layer	Incident Radiation
Winter	--	30,36	--
Spring	--	19,22,23,27,28,29, 30,31,32,34,36,37	23,29
Summer	31	31,33,34	29,33
Autumn	--	29	29

Table 12. Seasonal variation in average surface chlorophyll _a_ concentrations in the eastern oceanic Subarctic Pacific (zones 26 to 42*).

Season	Number of Observations	Maximum (mg m^{-3})	Mean (mg m^{-3})	σ^2	t'
winter	291	1.37	0.305	0.0165	
					9.69 ($p < .01$)
spring	532	2.16	0.424	0.0506	
					3.28 ($p < .01$)
summer	561	1.97	0.370	0.1022	
					3.18 ($p < .01$)
autumn	360	1.25	0.316	0.0354	

* See Figure 25

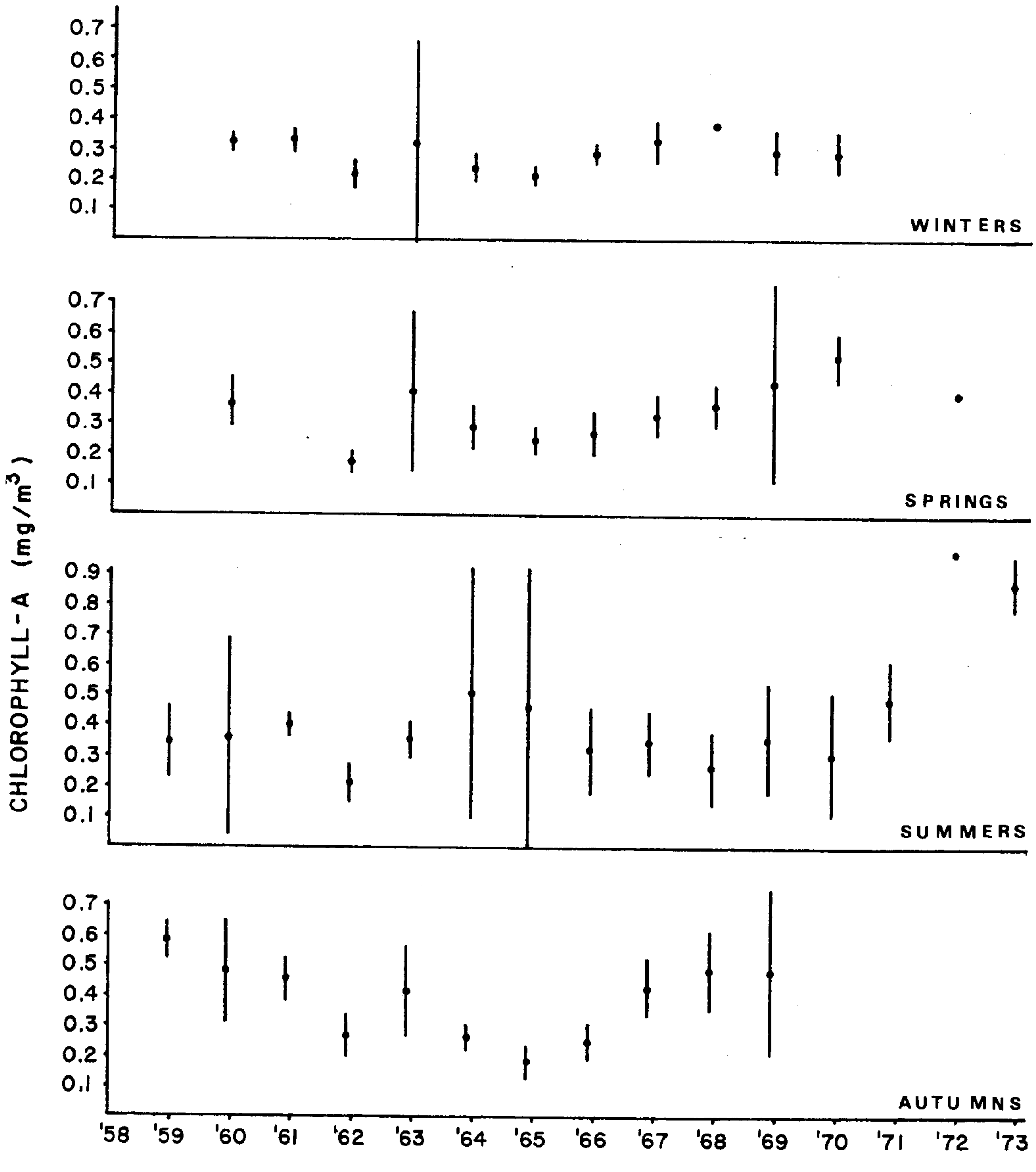


Figure 30. Chlorophyll a (mean seasonal concentration ± standard deviation) at Ocean Weather Station 'P' (145°W, 50°N) from 1959 to 1973.

and autumn (Table 12). Surface characteristics in all zones are constant (uniform) to 50 m (Figures 28, 29) except in zone 17, where consistently low chlorophyll a values occur below 25 m. The summer maximum in zone 20 is consistent in all three depth intervals to 50 m. Below 50 m, chlorophyll a concentrations are lower than those above 50 m, and no seasonal variation is apparent with the exception of zones 20 and 22 (Figures 30, 31, 32). The variation of surface chlorophyll a over an eleven year period at Station "P" is plotted in Figure 1. Intra seasonal variation of chlorophyll a at depth is greatest during summer months and the first month of autumn in zone 33 (Figure 2).

The seasonal and geographic distribution of chlorophyll a integrated over the euphotic zone is similar to that of discrete chlorophyll a concentrations in the upper 50 m (Figure 33). Seasonal variation occurs in neritic areas (zones 17, 20, 22, 23, 24) and in oceanic areas south of the Aleutians (zone 25). The summer maximum in integrated chlorophyll a in zone 24 (Figure 33), which is indicated also in discrete chlorophyll a concentrations between 10 and 50 m (Figures 28, 29) is based on too few data to be conclusive. Zone 24 includes neritic stations which may produce a seasonal pattern similar to zone 20.

Primary production: Primary production in surface waters peaks in summer in oceanic zones (Figure 34) and in spring in neritic zones where high production is maintained throughout the summer. A similar contrast of oceanic and neritic zones occurs at 10 to 25 meters depth (Figure 35). Below 25 m production is low in spring in neritic zones and in summer in oceanic zones (Figure 36) when standing stock increases in the upper layers reduce the depth of the photic layer. Productivity below 50 meters was negligible in all zones and was not plotted; the values are available in Appendix A. Productivities integrated over the euphotic zone demonstrate patterns similar to the discrete values in zones 17 and 33. Other zones contain too few data to warrant any conclusions.

Nutrients: Surface nitrate concentrations in the oceanic Subarctic build up during winter and spring and decrease between spring and summer (Figure 38). In contrast, nitrate concentrations in neritic areas (zones 17, 19, 20) peak in winter and decrease steadily from winter to summer. The difference can be attributed to a delayed phytoplankton growth period caused by late formation of a seasonal thermocline in the oceanic areas (Parsons and LeBrasseur, 1969). Oceanic areas experience another decrease in nitrate concentrations between summer and fall, while neritic areas (zones 17, 20) experience an increase. The neritic increase can be explained by regeneration and mixing in shallow water.

Average nitrate concentrations approach zero values in neritic areas in summer (Figure 38) but remain well above limiting concentrations in oceanic areas. The difference has been attributed to the shorter growth period in oceanic areas (Parsons and LeBrasseur, 1969) and to low oceanic phytoplankton biomass resulting from grazing (McAllister *et al.*, 1960) as discussed in Anderson *et al.*, (1969). Discrete nitrate concentrations of zero do appear in summer in neritic zones (see Appendix A for minimum values). Average values are consistently higher in all seasons in the Alaskan Gyre (zones 27, 28) and lower in Transition waters (zones 38 to 42). Mixed waters (zone 37) are intermediate between Central waters (zones 29-33) and Transition waters.

Surface concentrations of phosphate and silicate duplicate both the seasonal and geographic distributions of nitrate (Figures 44, 50). Average phosphate concentrations do not drop as low as nitrate concentrations even in the neritic and Transition areas, suggesting that nitrate probably is a limiting nutrient in those areas. Discrete summer concentrations of phosphate do, however, drop to zero in zone 17 (see Appendix A). Silicate concentrations are low in zone 17 at all seasons, decreasing to limiting amounts in spring. Zero values of silicate occur in spring in zone 17 and in summer in zones 20, 23, 36, 37, and 40 (see Appendix A). Spring silicate concentrations in zone 29 are not as high as those described by Park *et al.* (1968) who found values to 30 μgm at ℓ^{-1}, while phosphate concentrations are in the range they found.

Nitrate concentrations at depth follow surface patterns, both seasonally and geographically to 100 meters (Figures 39, 40, 41). Some zones (27, 31) develop a summer nitrate maximum which is intensified below 100 meters (Figure 42). This subsurface nitrate maximum can be explained by regeneration in the waters lying between the seasonal thermocline and the halocline (50-150 m). Concentrations below 100 m are higher in all zones including Transition waters (Figure 46). The autumn increase in zone 20 is greatest from 10 to 100 m. Intra seasonal variation in nitrate in zone 33 is greatest between 100 and 150 m (Figure 4).

Phosphate concentrations at depth follow surface patterns to 25 meters (Figure 45). Below 25 meters, seasonal variation is reduced in the central zones (Figures 46, 47, 48, 49) and a summer phosphate maximum develops in zone 17, which contrasts with the seasonal pattern in other neritic zones. This effect is explained by the fact that most zone 17 data were collected well inshore in Port Valdez, whereas other neritic zones were sampled over the shelf. Between 100 and 150 meters, a summer maximum also occurs in zone 20, suggesting regeneration at depth. Below 150 meters, phosphate concentrations in Transition and mixed waters (zones 32, 34, 37, 38, 40, 41) show a sizable decrease between spring and autumn (Figure 49) in contrast to the 100-150 meter interval. General levels of phosphate are higher below 150 meters.

Silicate concentrations at depth resemble the nitrate pattern (Figures 51 to 55). Concentrations in zone 17 drop to zero in summer between 10 and 50 meters (Figures 51, 52). The summer decrease in mixed waters below 150 meters follows nitrate and phosphate patterns (Figure 55).

Oxygen concentrations above 100 m show little seasonal change in oceanic zones (Figures 56 to 59). Decreased oxygen solubilities due to temperature increases are balanced by photosynthetic increases in spring resulting in little change from winter to spring. A summer reduction due to reduced solubility is seen in most zones. A spring maximum caused by photosynthesis and a summer minimum in zone 17 are found at all depths. The spring maxima found below 100 meters in zones 24 and 27 (Figure 60) are anomalous values based on only 2 samples. Sizeable changes in oxygen concentrations from spring to autumn in zones 29 to 40 are based on too few data to be conclusive (Figure 61).

Ammonia concentrations rise in the spring (Figures 62, 63) and increase or decrease in summer and autumn in zones 17 and 20. Transition waters (zones 40, 41) have low ammonia concentrations above 25 meters and greater amounts from 25 to 100 meters (Figures 62 to 67). Below 50 meters, ammonia falls to zero in zones 20, 24, 27, 31.

Nitrite data (Figures 68-72) are too few and too conflicting (compare the upper depth intervals in zones 17, 20) to provide useful conclusions. Nitrite concentrations seem to become negligible below 150 m (Figure 72).

<u>Physical factors</u>: The seasonal pattern of daily radiation is best documented in zone 33 (Figure 73). Light limitation in autumn months is apparent. Oceanic areas in the central Subarctic demonstrate the same pattern. Increased cloud cover in summer (Dodimead and Tully, 1958) can explain the low summer radiation values in zones 22 and 29. No north-south variation can be

demonstrated, verifying Dodimead and Tully (1958), but the southern zones show higher incident radiation in autumn and winter.

Seasonal variation in the depth of the mixed layer is best documented in zone 33 (Figure 74) where the maximum occurs in winter (85.8 meters) and the minimum in summer (18.5 meters). An autumn increase occurs in the areas east of 150°W but not west of 150°W. Because the seasonal thermocline decays between September and November, early autumn samples would bias an average depth. It it probable that the western areas show such a bias. The deepest winter mixing depth occurs in the western area (zone 30) and the shallowest in the Alaskan gyre (zone 28). These conclusions are in agreement with those of Giovando and Robinson (1965).

Discussion: Despite the broad scope of the experimental design, which averages across three month periods and wide depth intervals, the results are consistent within variables and between variables. For instance, surface patterns in nutrient concentrations are consistent for several depth intervals within individual zones (i.e., nitrate in the upper 50 meters in zone 17). Furthermore, three principal nutrients (nitrate, phosphate, silicate) show similar patterns within individual zones (i.e., surface values in zone 24) and inverse patterns when compared with oxygen (i.e., zone 27 at 100 to 150 meters). These consistent patterns point to real events as opposed to artifacts of the sampling and averaging programs. Seasonal patterns which are based on few data points can be confirmed by comparison with patterns in adjacent zones which were sampled more thoroughly (i.e., compare the mixing depth in zones 32 and 33 (Figure 74).

Respectively higher nutrient concentrations at all depths in the Alaskan gyre demonstrate the doming or upwelling process described by Uda (1963) and Anderson *et al.* (1969). Uda (1963) furthermore notes high transparencies in the gyre which indicate lack of plant growth. The present study does not confirm any difference between the Alaskan gyre (zones 27 to 28) and other Central Subarctic areas with respect to chlorophyll a concentrations (Figure 27) or primary production (Figure 34). Shoaler mixed depths are demonstrated for both the Alaskan gyre and Station "P" which is close to the gyre axis. Venrick (1969) found low nutrient, phytoplankton, and zooplankton concentrations at the gyre axis as well as high diatom equitability. She suggests a stable regime which is in contradiction to the hydrography. The present study finds physical and chemical affirmation of upwelling with no apparent effect on biological features.

Phytoplankton species data

Out of 121 Ships-of-Opportunity samples, *Thalassiosira lineata* occurred 118 times. *Nitzschia* sp. (Pseudonitzschia group), *Fragilariopsis pseudonana*, *Denticula seminae*, and *Coccolithus huxleyi* were found in over 75% of the samples (Table 13).

Cell concentrations of over 100,000 cells/liter were achieved by *Nitzschia pseudonana*, while *Denticula seminae*, *Rhizosolenia alata* f. *inermis*, *Nitzschia* sp. (*Pseudonitzschia* group), *Corethron hystrix*, *Cylindrotheca closterium*, *Cyclococcolithus* sp. B, *Coccolithus huxleyi* occurred in concentrations over 10,000 cell/liter (Table 14). The same species contributed over 20% to total cell numbers (Table 14), but the rank order differed from that based on maximum cell numbers.

A maximum biomass over 10 μgm carbon/liter was reported for *Corethron hystrix*, *Rhizosolenia alata* f. *inermis*, *Ethmodiscus rex*, *Asteromphalus* spp., and *Denticula seminae* (Table 14). Over 50% of total phytoplankton carbon at some stations was contributed by *Gyrodinium* spp., *Corethron hystrix*, *Ethmodiscus rex*, *Rhizosolenia alata* F. *inermis*, *Ceratium pentagonum*, and *Cyclococcolithus* sp. B (Table 14).

Table 13. Phytoplankton species rankings according to five criteria using data from 121 Ships-of-Opportunity Samples.

Species	No. of Occurrences	Mean no. cells/ℓ	Max. % of total cells	Mean carbon/ℓ	Max % of total carbon
Centric diatoms					
Actinoptychus undulatus	60[1)]	69	56	70	53
Asteromphalus spp.	12	12	4	14	20
Bacteriastrum mediterraneus	50	48	50	42	57
Biddulphia spp.	59	54	23	62	27
Cerataulina sp.	53	61	63	59	64
Chaetoceros atlanticus	16	14	22	17	34
C. convolutus	10	15	8	10	12
C. peruvianus	36	40	46	46	63
Corethron hystrix	11	5	1	5	2
Coscinodiscus centralis	42	51	47	61	59
C. curvatulus	37	49	31	48	49
C. lineatus	17	33	43	25	46
C. oculus iridis	38	58	10	54	43
C. radiatus	30	53	41	44	32
C. stellaris	30	34	11	31	17
Dactyliosolen mediterraneus	32	25	36	20	38
Ditylum brightwellii	44	16	19	40	25
Ethmodiscus rex	62	75	3	72	3
Eucampia zoodiacus	57	72	64	69	61
Hemiaulus sinensis	62	77	70	74	68
Lauderia borealis	48	73	32	63	26
Leptocylindrus danicus	62	39	61	39	66
Planktoniella sol	57	76	62	75	65
Rhizosolenia alata	29	50	45	53	36
R. alata f. curvirostris	24	29	26	26	16
R. alata f. inermis	22	3	2	4	4
R. hebetata f. hiemalis	31	63	37	64	44
R. hebetata f. semispina	35	25	40	33	50
R. stolterfothii	43	30	20	41	30
R. styliformis	46	23	18	29	21

1) Species is 60th on list ranked by number of occurrences, where 1st occurs most often.

Table 13 continued

Species	No. of Occurrences	Mean no. cells/ℓ	Max. % of total cells	Mean carbon/ℓ	Max. % of total carbon
Skeletonema costatum	55	17	54	18	48
Stephanopyxis nipponica	49	64	51	49	58
Thalassiosira condensata	61	45	53	47	56
T. decipiens	21	21	28	22	42
T. eccentrica	21	38	12	27	15
T. lineata	1	10	25	15	24
T. nordenskioeldii	45	9	17	11	23
T. pacifica	56	31	35	38	51
T. rotula	48	13	21	13	29
T. subtilis	62	47	67	50	75
Pennate diatoms					
Asterionella japonica	56	67	73	68	74
Cylindrotheca closterium	19	6	34	7	11
Denticula seminae	4	2	5	3	7
Licmophora abbreviata	62	44	52	60	69
Navicula spp.	15	43	60	35	40
Nitzschia longissima	32	35	59	28	45
Nitzschia pseudonana	3	1	25	1	18
Nitzschia sp. (*Fragilariopsis* group)	9	16	58	12	60
Nitzschia sp. (*Pseudonitzschia* group)	2	4	27	6	37
Pseudoeunotia doliolus	54	19	68	71	73
Rhabdonema arcuatum	18	27	55	34	62
Thalassionema nitzschioides	26	36	48	32	52
Thalassiothrix longissima	13	22	6	16	22
Tropidoneis antarctica polyplasta	14	20	13	21	14
Dinoflagellates					
Ceratium fusus	39	68	38	57	33
C. longipes	50	62	29	73	31
C. macroceros	47	70	33	65	28
C. pentagonum	28	65	15	56	5
C. tripos	48	71	39	66	35

Table 13 continued

Species	No. of Occurrences	Mean no. Cells/ℓ	Max. % of total cells	Mean carbon/ℓ	Max. % of total carbon
Dinophysis acuta	41	52	42	43	47
Gymnodinium spp.	7	28	30	24	19
Gyrodinium spp.	5	18	14	19	1
Miniscule bipes	40	74	72	67	71
Peridinium depressum	25	37	16	37	10
P. cerasus	22	41	44	36	41
Coccolithophorids					
Calyptrosphaera spp.	36	55	71	55	70
Coccolithophorid "C"[3]	45	56	65	30	55
Coccolithus huxleyi	6	8	9	8	8
C. pelagicus	8	11	25	9	13
Cyclococcolithus sp. A[1]	33	32	49	23	39
C. sp. B[2]	29	7	24	2	6
Syracosphaera spp.	52	66	69	58	72
Rhabdosphaera tignifer	51	60	66	52	67
Silicoflagellates					
Dictyocha fibula	20	26			
Distephanus octangulatus	34	59			
Other groups					
Pterosperma sp.	27	57	57	45	54
Halosphaera viridis	23	42	7	51	9

1) *Cyclococcolithus* sp. 'A' resembles *Cyclococcolithus leptoporus*

2) *Cyclococcolithus* sp. 'B' resembles *Cyclococcolithus fragilis*

3) *Coccolithophorid* 'C' resembles *Michaelsarsia* sp.

Table 14. Phytoplankton species from 121 Eastern Subarctic stations (neritic stations omitted) ranked according to 4 criteria.

Rank	Species	Max. no. cells/ℓ	Rank	Species	Max. carbon/ℓ
1	*Nitzschia pseudonana*	7.06×10^{5}	1	*Corethron hystrix*	7.73×10^{4}
2	*Denticula seminae*	8.26×10^{4}	2	*Rhizosolenia alata f. inermis*	4.37×10^{4}
3	*Rhizosolenia alata f. inermis*	5.12×10^{4}	3	*Ethmodiscus rex*	1.59×10^{4}
4	*Nitzschia* sp. (*Pseudonitzschia* group)	4.29×10^{4}	4	*Asteromphalus* sp.	1.21×10^{4}
5	*Corethron hystrix*	4.16×10^{4}	5	*Denticula seminae*	1.00×10^{4}
6	*Cylindrotheca closterium*	3.34×10^{4}	6	*Thalassithrix longissima*	7.75×10^{3}
7	*Cyclococcolithus* sp.B	2.84×10^{4}	7	*Halosphaera viridis*	6.62×10^{3}
8	*Coccolithus huxleyi*	1.74×10^{4}	8	*Chaetoceros convolutus*	5.36×10^{3}
9	*Thalassiosira nordenskioeldii*	1.14×10^{4}	9	*Coccolithus huxleyi*	4.83×10^{3}
10	*Thalassiosira lineata*	9.33×10^{3}	10	*Coscinodiscus oculis iridis*	3.38×10^{3}
11	*Coccolithus pelagicus*	7.77×10^{3}	11	*Coscinodiscus stellaris*	3.12×10^{3}
12	*Asteromphalus* spp.	6.22×10^{3}	12	*Thalassiosira eccentrica*	2.98×10^{3}
13	*Thalassiosira rotula*	5.72×10^{3}	13	*Tropidoneis antarctica polyplasta*	2.74×10^{3}
14	*Chaetoceros atlanticus*	5.26×10^{3}	14	*Gyrodinium* spp.	2.58×10^{3}
15	*Chaetoceros convolutus*	5.07×10^{3}	15	*Ceratium pentagonum*	2.48×10^{3}
16	*Nitzschia* sp (*Fragilariopsis* group)	4.37×10^{3}	16	*Peridinium depressum*	2.33×10^{3}
17	*Skeletonema costatum*	3.33×10^{3}	17	*Thalassiosira nordenskioeldii*	2.12×10^{3}
18	*Gyrodinium* spp.	2.91×10^{3}	18	*Rhizosolenia styliformis*	1.92×10^{3}
19	*Pseudoeunotia doliolus*	2.58×10^{3}	19	*Ditylum brightwelli*	1.70×10^{3}
20	*Tropidoneis antarctica* var. *polyplasta*	2.42×10^{3}	20	*Rhizosolenia stolterfothii*	1.62×10^{3}

Table 14 continued

Rank	Species	Max. % of total cells/ℓ	Rank	Species	Max. % of total carbon/ℓ
1	*Nitzschia pseudonana*	85.4	1	*Gyrodinium* spp.	85.7
2	*Cyclococcolithus* sp. B	54.2	2	*Corethron hystrix*	75.5
3	*Denticula seminae*	38.5	3	*Ethmodiscus rex*	64.4
4	*Rhizosolenia alata f. inermis*	32.2	4	*Rhizosolenia alata f. inermis*	61.4
5	*Corethron hystrix*	24.9	5	*Ceratium pentagonum*	57.2
6	*Nitzschia* sp. (*Pseudonitzschia* group)	24.8	6	*Cyclococcolithus* sp. B	50.5
7	*Cylindrotheca closterium*	24.3	7	*Denticula seminae*	44.7
8	*Coccolithus huxleyi*	21.5	8	*Coccolithus huxleyi*	44.2
9	*Coccolithus pelagicus*	10.7	9	*Halosphaera viridis*	42.8
10	*Chaetoceros convolutus*	10.4	10	*Peridinium depressum*	41.3
11	*Thalassiosira nordenskioeldii*	9.8	11	*Cylindrotheca closterium*	40.5
12	*Nitzschia* sp. (*Fragilariopsis* group)	5.3	12	*Chaetoceros convolutus*	40.0
13	*Thalassiosira notula*	4.9	13	*Coccolithus pelagicus*	40.0
14	*Asteromphalus* spp.	3.7	14	*Tropidoneis antarctica* var. *polyplasta*	32.3
15	*Thalassiosira lineata*	2.6	15	*Thalassiosira eccentrica*	30.8
16	*Thalassiothrix longissima*	2.5	16	*Rhizosolenia alata f. curvirostris*	29.3
17	*Chaetoceros atlanticus*	2.4	17	*Coscinodiscus stellaris*	27.0
18	*Skeletonema costatum*	2.0	18	*Nitzschia pseudonana*	24.3
19	*Gyrodinium* spp.	1.8	19	*Gymnodinium* spp.	21.5
20	*Dactyliosolen mediterraneous*	1.5	20	*Asteromphalus* spp.	21.3
21	*Tropidoneis antarctica* var. *polyplasta*	1.5			

Geographic variation: The geographic distributions of phytoplankton species which occurred in more than 10% of the total surface samples collected in the Eastern Subarctic Pacific are presented in Figures 81 to 142. Generalizations based on each figure would be too lengthy to include here. Taken as a whole, the figures demonstrate the widespread distribution of all members of the Subarctic phytoplankton community. In each major phytoplankton group (i.e., the diatoms, the dinoflagellates, the coccolithphorids, and the silicoflagellates) are a few species which are major contributors to the Subarctic community.

The species distributions do not show any clear and consistent biological differences between Subarctic water, mixed water, Alaska gyre water, and Alaskan stream water. Certain species were not found in Transition waters (for example, *Ceratium pentagonum*, Figure 123, and *Thalassiosira nordenskioeldii*, Figure 107); these species differ, however, from those so defined by Venrick (1971).

A distinction between oceanic and neritic species cannot be made on the basis of the figures because no obligatorily neritic species have been mapped, a feature which is the result of the very limited number of neritic stations sampled. Many of the neritic species are listed in Table 15. The Hyalochaete group of the genus Chaetoceros (Figure 84) includes a number of species which are neritic (*Chaetoceros debilis, decipiens, lacinosus, didymus, radicans, affinis, brevis, pelagicus, socialis, subsecundus, teres.*). The Ships-of-Opportunity data do not differentiate these species; hence, they could not be mapped separately.

Another group of major importance which was not differentiated into species in the Ships-of-Opportunity data is the microflagellates. This group of organisms, primarily chrysophytes and cryptophytes, occurred in every sample in dominant numbers (Figure 142).

Table 15. Phytoplankton species occurring infrequently in the eastern oceanic Subarctic Pacific.

Species	Zones of Occurrence	Maximum cells/ℓ	Maximum carbon/ℓ (nanograms)	Maximum % cells/ℓ	Maximum % carbon/ℓ
Actinoptychus undulatus	19*,31,36	50	89	0.04	3.40
Asterionella japonica	15,20,36,37	63	0.62	0.05	0.02
Bacteriastrum mediterraneous	15,19,20,36,37	289	113	0.34	2.35
Biddulphia spp.	15,36,37	204	1570	0.10	15.40
Cerataulina sp.	19,20,24,27,28,36	96	23	0.13	0.78
Ethmodiscus rex	29	18	15900	0.02	64.40
Eucampia zoodiacus	20,31,34,36	41	22	0.05	1.06
Hemiaulus sinensis	36	8	7	0.01	0.47
Leptocylindrus danicus	17,22	49	27	0.46	0.56
Licmophora abbreviata	20	424	100	0.12	0.31
Planktoniella sol	22,29,34,37	17	25	0.007	0.66
Pseudoeunotia doliolus	31,37,40	2580	13	0.03	0.12
Stephanopyxis nipponica	15,20,22,24,34,36,37	82	110	0.19	2.18
Syracosphaera sp.	19,20,24,29,30,31,36	71	8	0.14	0.25
Thalassiosira condensata	20,36	385	97	0.22	2.86
Thalassiosira pacifica	15,19,20,32,37	1230	388	0.47	3.80
Thalassiosira subtilis	37	303	14	0.19	0.02

*Zone 19, see Figure 25.

The widespread occurrence of *Coccolithus huxleyi* (syn. *Emiliania huxleyi)* demonstrated in Figure 133, is supported by Okada and Honjo (1973). The distribution of *Chaetoceros atlanticus* as well as several other species is in accord with Koblents Mishke (1969).

Species which occur infrequently in the oceanic Subarctic are either warm water species or neritic species. The warm water species on Table 15 are *Ethmodiscus rex, Eucampia zoodiacus, Hemiaulus sinensis, Plantoniella sol, Pseudoeunotia doliolus.* It can be observed that these species occurred in Transition waters or mixed water to the north of the Transition Zone. *Rhizosolenia styliformis* is also a warm water species. Its occurrence around the outside of the gyre (Figure 102) suggests a confirmation of the hypothesis of Ohwada and Asaoka (1963) that traces of warm water are carried along the outer edge of the gyre. The occurrence of *Planktoniella sol* in zone 22 carried the hypothesis to its limit. The remaining species listed in Table 15 are neritic species. Their occurrence in zones 36 and 37 (mixed waters) suggests that these waters can be distinguished from the Central Subarctic zones to the west (Tully *et al.*, 1960). Oceanic species abundant in coastal waters are *Corethron hystrix, Coscinodiscus oculis iridis, Chaetoceros concavicornis,* and *Rhizosolenia hebatata* (Williamson, 1974).

A list of species recorded from the eastern Subarctic Pacific is presented in Table 16.

Discussion: Past studies of phytoplankton species in the Eastern Subarctic Pacific have either defined specific areas dominated by certain species (for instance the work of Japanese scientists) or grouped species into recurrent groups (Venrick, 1971). Ohwada and Kon (1963) describe the cold water species, *Corethron hystrix* and *Denticula seminae,* flowing south out of the Bering Sea in 1960 through western Aleutian passes, and *Nitzschia seriata* flowing in mixed waters north through eastern passes. The relative positions of the "Denticula"

Table 16. Phytoplankton species reported from the Eastern Subarctic Pacific north of 42°N and east of 180°W.

Diatoms

Achnanthes longipes Ag.	O*
A. sp.	N**
Actinocyclus curvatulus Janisch	O
A. sp.	O
Actinoptychus undulatus (Bail.) Ralfs	O
Amphiprora sp.	N
Asterionella japonica Cl.	O
Asterolampra marylandica Ehr.	O
A. flabellatus (Brèb.) Grev.	O
A. hepactus (Brèb.) Ralfs	O
A. robustus Castr.	O
Bacteriastrum delicatulum Cl.	O
Bacteriosira fragilis Gran.	N
Biddulphia aurita (Lyng.) Brèb. and God.	N
B. longicruris Grev.	O
B. sp.	O
Cerataulina sp.	O
C. bergonii H. Pér.	O
Chaetoceros atlanticus Cl.	O
C. convolutus Castr.	O
C. concavicornis Mang.	O
C. peruvianus Brightw.	O
C. debilis Cl.	N
C. decipiens Cl.	N
C. didymus Ehr.	N
C. lacinosus Schütt	N
C. radicans Schütt	N
C. affinis Laud.	N
C. brevis Schütt	N
C. mitra (Bail.) Cl.	N
C. pelagicus Cl.	N
C. socialis Laud.	N
C. subsecundus (Grun.) Hust.	N
C. teres Cl.	N
Cocconeis sp.	O
Corethron hystrix Hen.	O
Coscinodiscus lineatus Ehr.	O
C. curvatulus Grun.	O
C. centralis Ehr.	O
C. radiatus Ehr.	O
C. stellaris Rop.	O
C. oculis iridis Ehr.	O
C. tabularis Grun.	O
C. marginatus Ehr.	O
C. wailesii Gran and Angst	O
C. granii Gough	N
C. perforatus Ehr.	O
Cylindrotheca closterium Reiman and Lewin	O
Cyclotella stelligera Cl. and Grun.	O
Cymbella sp.	O
Dactyliosolen meditterraneus H. Pér.	O
Denticula seminae (Semina) Simon and Kanaya	O
Ditylum brightwellii (West) Grun.	O
Ethmodiscus rex (Wall.) Hendey	O
Eucampia zoodiacus Ehr.	O
Gyrosigma sp.	N
Grammatophora marina (Lyng.) Kütz	O
Hemiaulus sinensis Grev.	O
H. membranaceous Cl.	O
Hemidiscus cuneiformis Wall.	O
Lauderia borealis Gran.	O
Leptocylindrus danicus Cl.	O
Licmophora abbreviata Ag.	O
Melosira moniliformis (Müll.) Ag.	N
M. sulcata (Ehr.) Kütz	N
Navicula sp.	O
Nitzschia seriata Cl.	O
N. sicula (Castr.) Hustedt	O
N. bilobata Wm. Smith	O
N. bicapitata Cl.	O
N. heimii Manguin	O
N. turgiduloides Hasle	O
N. longissima (Brèb.) Ralfs	O
N. pungens Hasle	N
N. paradoxa (Gmel.) Grun.	N
N. pseudonana (Steeman Nielsen) Hasle	O
N. sp.	O
Planktoniella sol (Wall.) Schütt	O
Pleurosigma directum Grun.	O
Podosira sp.	O
Pseudoeunotia dolidus (Wall.) Grun.	O
Rhabdonema arcuatum Kützing	O
Rhizosolenia alata Brightw.	O
R. alata f. curvirostris Gran	O
R. alata f. inermis (Castr.) Hust.	O
R. hebetata f. hiemalis Gran	O
R. hebetata f. seimspina (Hen.) Gran	O
R. styliformis Brightw.	O
R. styliformis f. longispina Hust.	O

* oceanic
** neritic

Table 16 continued

Diatoms

R. stolterfothii H. Pér.	O*
R. fragilissima Berg.	O
R. imbricata shrubsolei (Cl.) Schröd.	O
R. obtusa Hensen	O
Roperia tesselata (Roper) Grun.	O
Skeletonema costatum (Grev.) Cl.	O
Stephanopyxis nipponica Gran and Yendo	O
S. turris (Grev. and Arn.) Ralfs	N**
Striatella unipuntata (Lyng.) Ag.	N
Surirella sp.	N
Synedra vaucheriae Kutz. var. *capitellata* Grun.	O
Thalassionema nitzschioides Grun.	O
Thalassiosira decipiens (Grun.) Jørg.	O
T. angstii (Gran.) Makarova	O
T. nordenskiöldii Cl.	O
T. rotula Meun.	O
T. pacifica Gran and Angst	O
T. subtilis (Osten.) Gran	O
T. condensata Cl.	O
T. lineata Jousé	O
T. antiqua (Grun) A. Cl. var. *septata* Prosh. Lavr.	O
T. oestrupii (Ostf.) Hasle	O
T. eccentrica (Ehr.) Cleve	O
T. polychorda (Gran) Jørg.	O
Thalassiothrix longissima Cl. and Gran	O
Triceratium arcticum Brightw.	N
Tropidoneis antarctica Grun. var. *polyplasta* Gran and Angst	O

Dinoflagellates

Ceratium fusus (Ehrenb.) Dujardin	O
C. longipes (Bailey) Gran	O
C. tripos O. F. Müller	O
C. macroceros (Ehr.) Vanhöffen	O
C. pentagonum Gourret	O
C. lineatum (Ehr.) Cl.	N
C. intermedium (Jörg.) Jörg.	O
Dinophysis acuta Ehr.	O
Exuviella baltica Lohmann.	O
Gymnodinium sp.	O
Gyrodinium sp.	O
Miniscule bipes Lebour	O
Peridinium depressum Bailey	O
P. cerasus Paulsen	O
P. conicum (Gran) Ost. and Schmidt	N
P. pallidum Ost.	N

Coccolithophorids

Calyptrosphaera sp.	O
Coccolithus huxleyi (Lohm.) Kpt.	O
C. pelagicus (Wallick) Schiller	O
Cyclococcolithus leptoporus (Murr. et. Blackm.) Schiller	O
C. fragilis (Lohm.) Gaarder	O
Michaelsarsia sp.	O
Rhabdosphaera tignifer Sch.	O
Syracosphaera sp.	O

Other groups

Pterosperma sp.	O
Halosphaera viridis Schmitz	O
mμ flagellates	O
Phaeocystis pouchetii (Hariot) Lagerheim	N
Ebria tripartita (Schum.) Lemmerman	O
Dictyocha fibula Ehr.	O
Distephanus speculum (Ehr.) Haeckel	O
D. octangulatus Wailes	O

* O = oceanic
** N = neritic

and "Nitzschia" communities were different in 1957 (Iizuka and Tamura, 1958) reflecting annual variation. Figures 110 and 115 show dominance of these two species in all the Central Subarctic zones. Cupp (1937) documents annual variation in the species *Asterionella japonica*, which was completely absent at Scotch Cap, Alaska (near eastern Aletuian passes) for two years. Two studies distinguish the *Nitzschia* (Pseudonitzschia group) community from the Subarctic community (Ohwada and Kon, 1963; Marumo, 1967) while Venrick (1971) defines three Subarctic communities, one of which includes *Nitzschia*. [This is not a semantic problem. The *Nitzschia seriata* of Japanese works is surely the same species as Venrick's *Nitzschia turgiduloides*. The present study has labelled this species *Nitzschia* sp. (Pseudonitzschia group).]

Recurrent group analysis was performed on the Ships-of-Opportunity data upon which the present study is based. No recurrent groups could be defined within the surface layer (Munson, personal communication). The present study demonstrates that each of the earlier generalizations applies only to the specific time period studied, a conclusion similar to that drawn by Allen (1943) after 20 years of phytoplankton research off southern California.

Distributions of individual species can also be shown to be specific in time and not general for all years. Venrick (1971) found *Denticula seminae*, *Corethron criophilum*, (syn. *Corethron hystrix*), and *Fragilariopsis pseudonana* (syn. *Nitzschia pseudonana*) restricted to the Central Subarctic north of 46°N. Figures 110, 86, and 113 show all three to occur south of 43°N. [Figures 99 and 117 confirm Venrick's report that *Rhizosolenia hebatata* f. *hiemalis*, and *Thalassionema nitzschioides* do not occur in Transition water.] The distributions of *Thalassiothrix longissima* (Figure 118) and *Tropidoneis antarctica* var. *polyplasta* (Figure 119) are not restricted to the southern Subarctic in contrast to Venrick (1971). Venrick states that the *Nitzschia closterium/longissima* complex (syn. *Cylindrotheca closterium/Nitzschia longissima*) is rare near the axis of the Alaska gyre. Figures 109 and 112 show uniform distribution of this species across the Subarctic.

The widespread occurrence of *Thalassiosira lineata* across the eastern Subarctic in concentrations of 10000-10000 cells/ℓ is of interest. From her own observations and the work of others, Hasle (1976) describes this species as a warm-water species, although she indicates its occurrence to 55°N. The present study (Figure 106) documents *Thalassiosira lineata* as a major member of the Subarctic community, not a warm-water accidental. Another species, *Pseudoeunotia doliolus*, does seem to be a warm water introduction as described by Hasle (1976). This species was recorded once in the Ships-of-Opportunity data in zone 17, confirming its rare occurrence in the Subarctic Pacific. The sizeable concentrations of *Pseudoeunotia doliolus* found by Venrick (1969) to extend to 50°N must have been a rare event.

E. Discussion

The relatively narrow range of variation, both seasonal and geographic, of biological and chemical parameters in the oceanic eastern Subarctic is in contrast to the wide range of annual variation. Phytoplankton species distributions as well as chlorophyll a concentrations, primary production, and nutrient concentrations support this generalization. Annual variation in this context is not seen as a general trend but as a series of biological "events". The "events" do not stand out in averaged data but do appear in the tables of ranges (Appendix A). For instance, the averaged data show a small seasonal change in primary production in surface waters at Station "P" (zone 33), with a summer mean of 3.37 mg C/m^3/hr. However, a maximum production rate of 38.20 mg C/m^3/hr has been recorded at Station "P". Such an event cannot mean a low standing stock, growing rapidly, but must mean a sizeable population, growing fast. In fact, high chlorophyll a concentrations have been reported from Station "P" (maximum: 2.08 mg chl a/m^3). Phytoplankton species distributions indicate that such "events" are not caused by a few species but that a number of species can grow to high cell densities. Nor are the events more likely in any one subdivision of the oceanic area. The data indicate that there are in each phytoplankton group a number of species most successful in the Subarctic Pacific; which species dominates the event must be dependent upon a series of advantageous circumstances prior to the event. Beklemishev and Nakonechnaya (1972) describe blooms of diatoms south of the Aleutians with dimensions of 150 x 420 nautical miles. The factors responsible for the "events" cannot be nutrients, although computing nutrient concentration changes is a good way of monitoring such events. Factors responsible could be a number of sunny days in succession in combination with a shallow mixed layer and grazing pressure lessened due to patch zooplankton distributions or to migrating zooplankton populations. Study of unusual biological events in the eastern Subarctic should be undertaken.

F. Conclusions

Significant annual variation was found at most seasons and depths in most zones for all the variables tested. The fact that annual variation occurs in zone 33 (Station "P") where a standardized technique and sampling program produces a more balanced experimental design argues against the conclusion that the variation observed was an artifact of the experimental program.

Seasonal variation was also demonstrated for all variables tested, and it was more apparent in neritic zones than oceanic zones. Seasonal variation was least in phytoplankton standing stock (as measured by chlorophyll a concentrations) in oceanic areas.

Geographic variation was most apparent between coastal and oceanic areas. Coastal regimes were found to extend well beyond the shelf break south of the Aleutian chain and west of Vancouver Island. Geographic variation within the Central Subarctic Domain could not be distinguished from annual variation except in the gyre axis, which was chemically and physically separate from other Central Subarctic zones. Transition waters were distinct from those of the Central Subarctic for biological and chemical factors as well as for some phytoplankton species.

G. Needs for future study

The scale of the experiment was too broad to delineate any but the most general relationships between physical and biological parameters. Future studies should be concentrated on the biological "events" when phytoplankton standing stock and production rise well above average values. Because nutrients are not limiting in the oceanic Subarctic, upwelling does not explain the "events". The combination of physical and biological factors preceding "events" should be described.

The paucity of data from inshore areas is striking. Now that new OCSEAP data are available, they should be included in the program developed in the present study to fill in some of the gaps.

Annual variation in the boundaries of the principal Subarctic domains should be related to biological parameters, and the unusual characteristics of the axis of the Alaskan gyre system should be considered.

Key to Figures 31 to 79

These figures show the northeast Subarctic Pacific divided into zones as in Figure 25. The graph drawn within the boundaries of each zone shows the variation of a variable within that zone. Some graphs were too large for the boundaries of their zones and were drawn above the zone in the margin. The circled number adjacent to a graph in the margin indicates the zone which it represents. The graph for zone 33, Ocean Weather Station "P", is always located in the upper right corner of the map and is labelled with the units and scale for each map.

A point on a graph represents the mean of all measurements for that season, that zone, and that depth range.

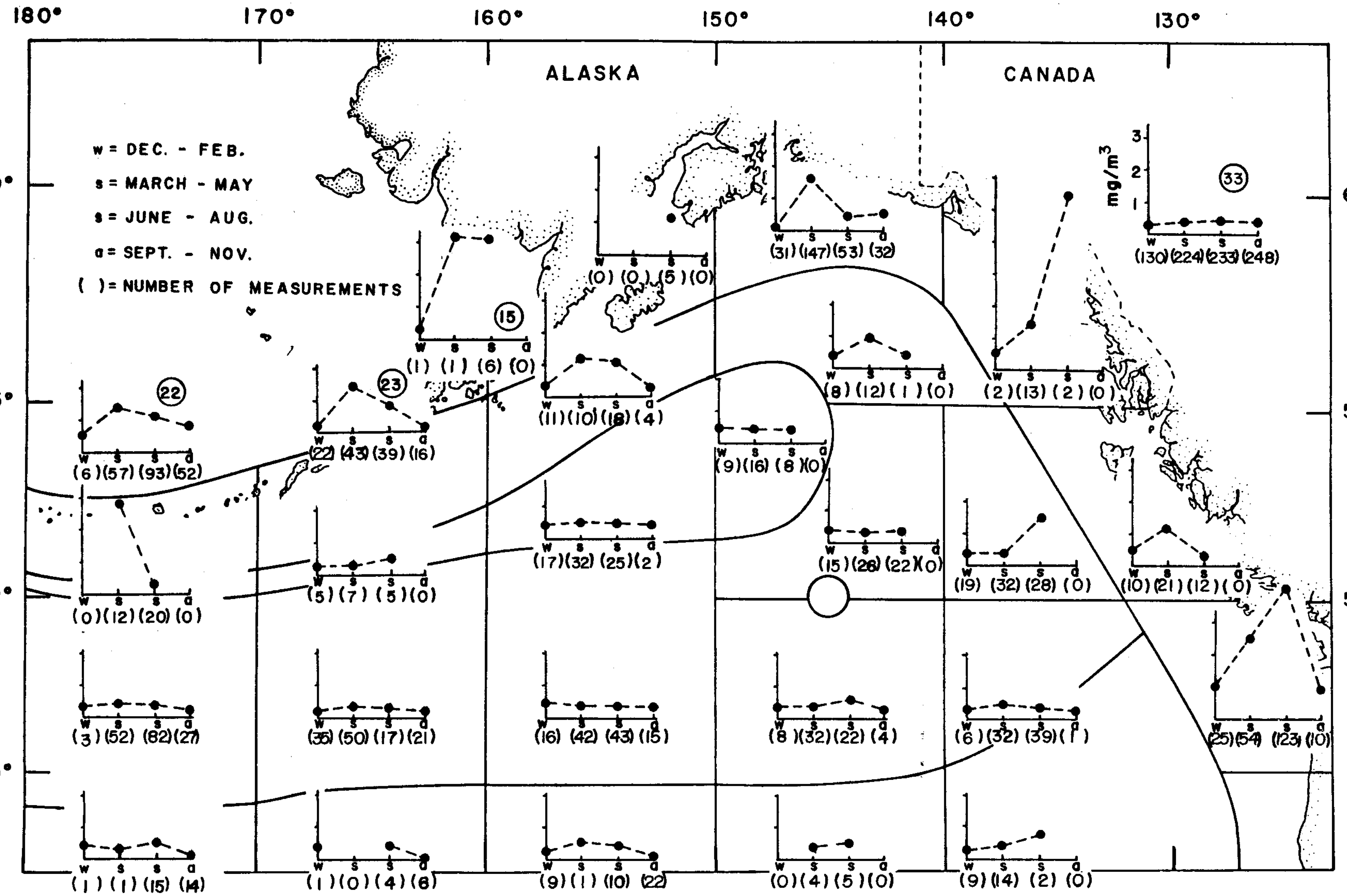


Figure 31. The distribution of chlorophyll a (seasonal means, milligrams chlorophyll a per cubic meter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 0 to 10 meters.

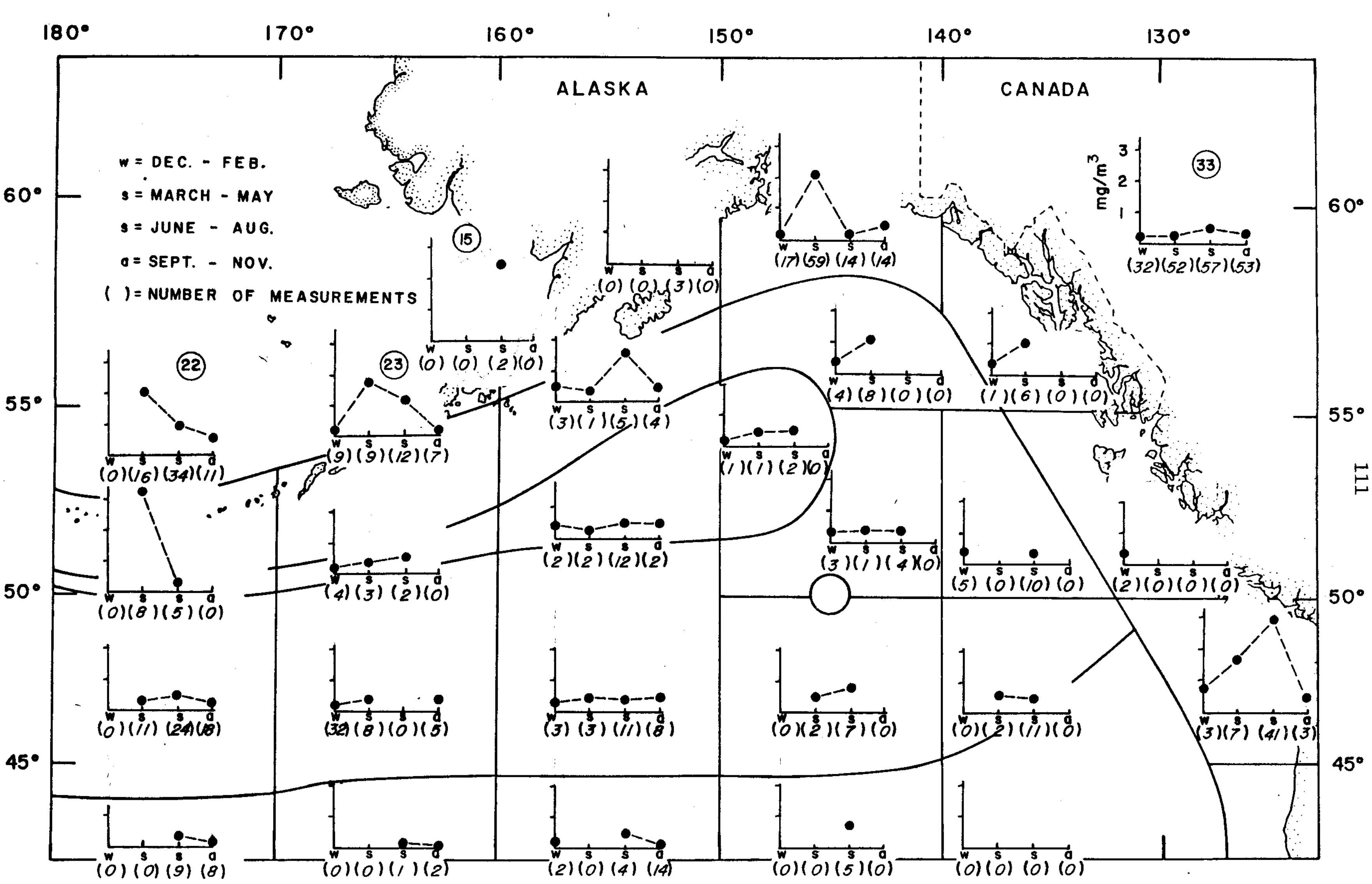


Figure 32. The distribution of chlorophyll a (seasonal means, milligrams chlorophyll a per cubic meter) in the eastern Subarctic Pacific for the years 1953 through 1974, and the depth range 10.1 to 25 meters.

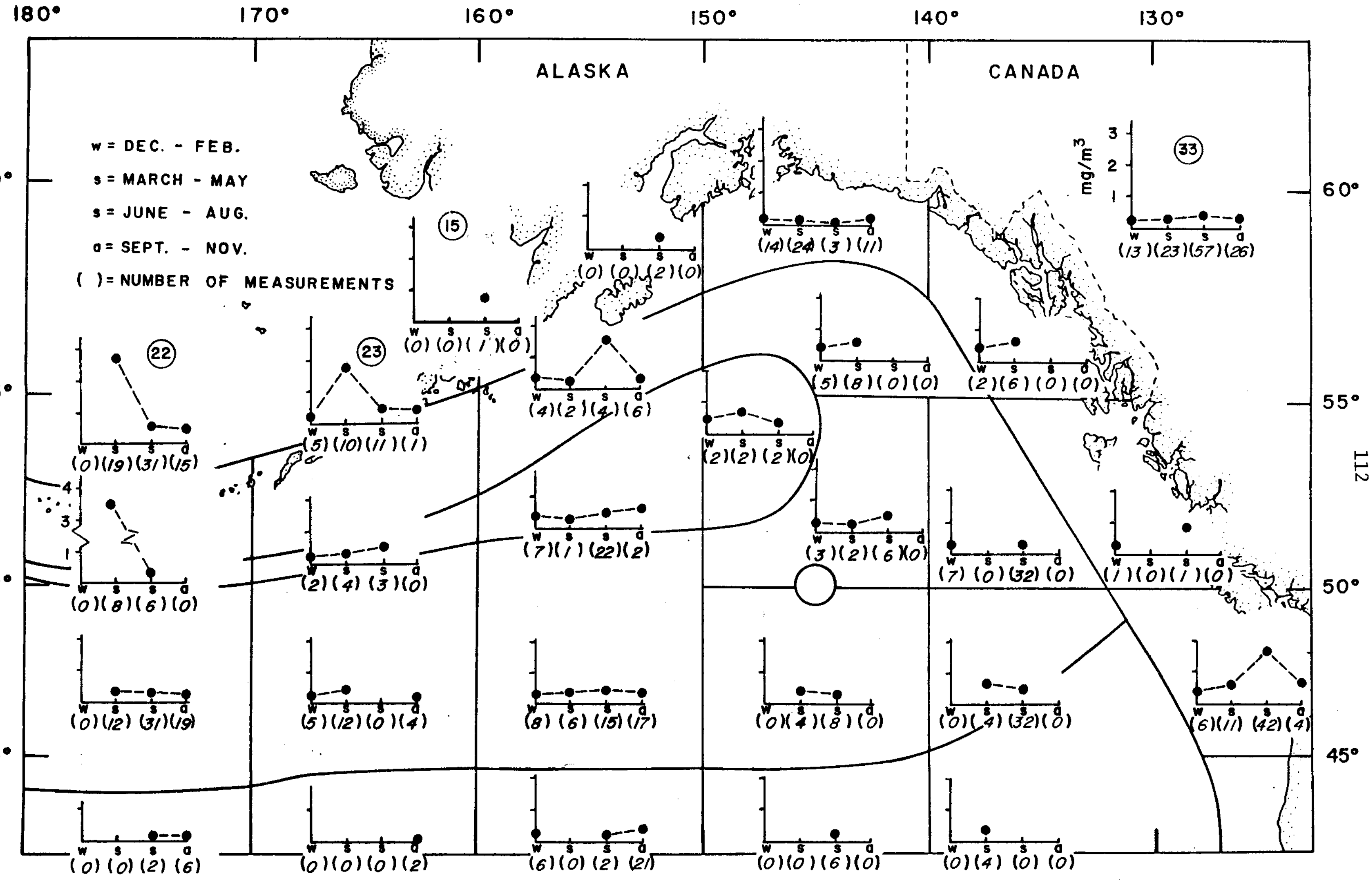


Figure 33. The distribution of chlorophyll a (seasonal means, milligrams chlorophyll a per cubic meter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 25.1 to 50 meters.

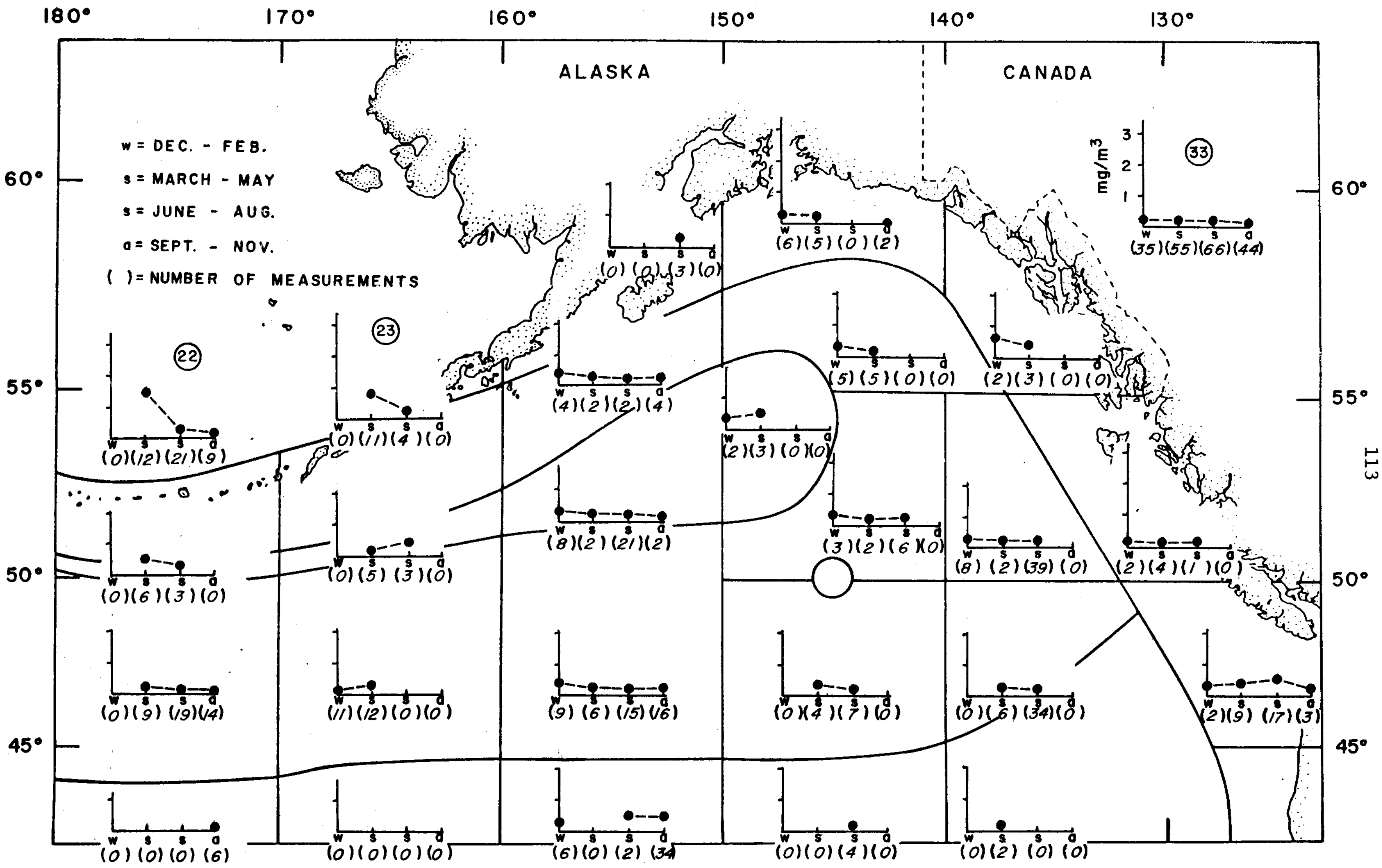


Figure 34. The distribution of chlorophyll a (seasonal means, milligrams chlorophyll a per cubic meter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 50.1 to 100 meters.

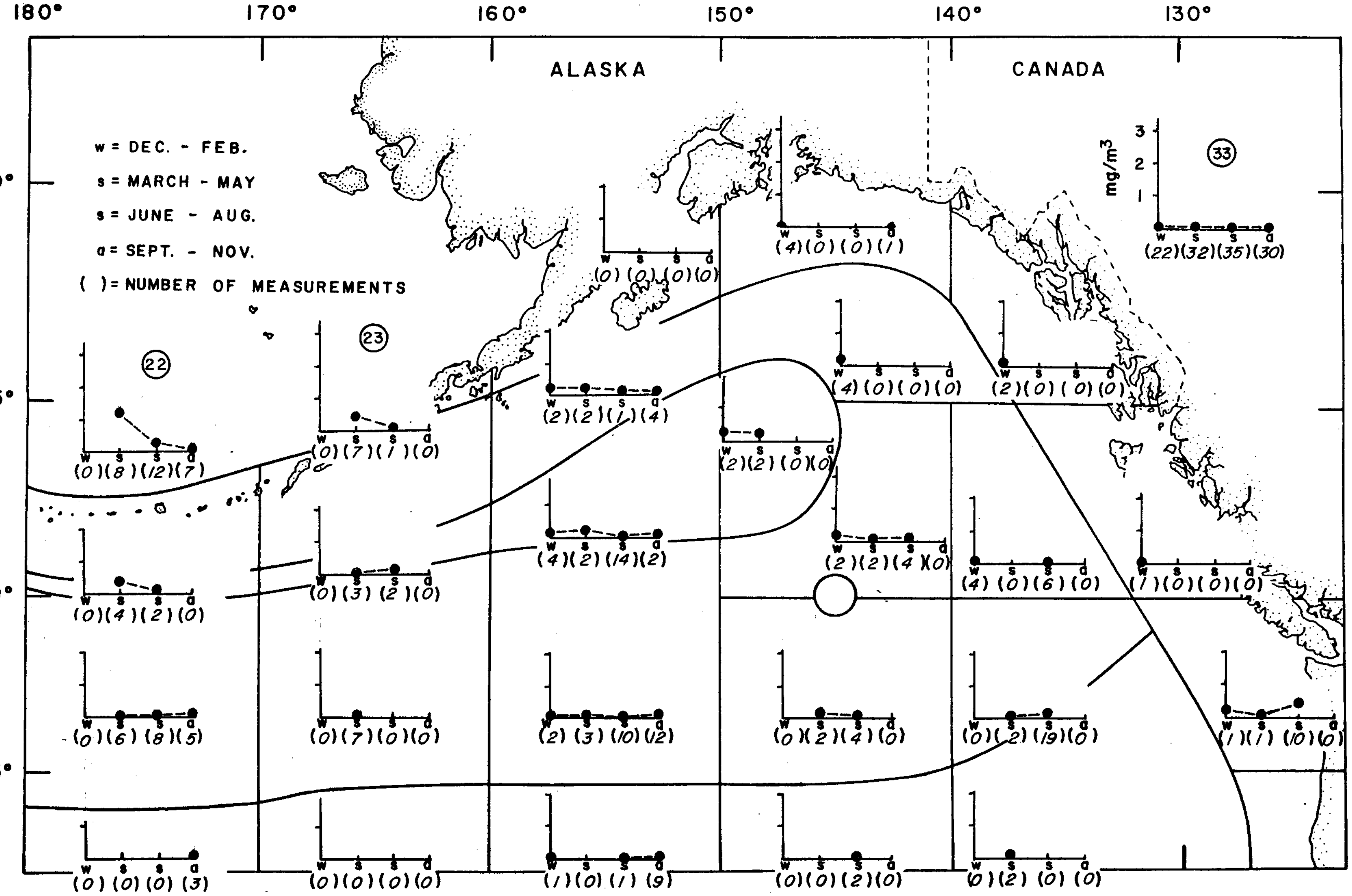


Figure 35. The distribution of chlorophyll a (seasonal means, milligrams chlorophyll a per cubic meter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 100.1 to 150 meters.

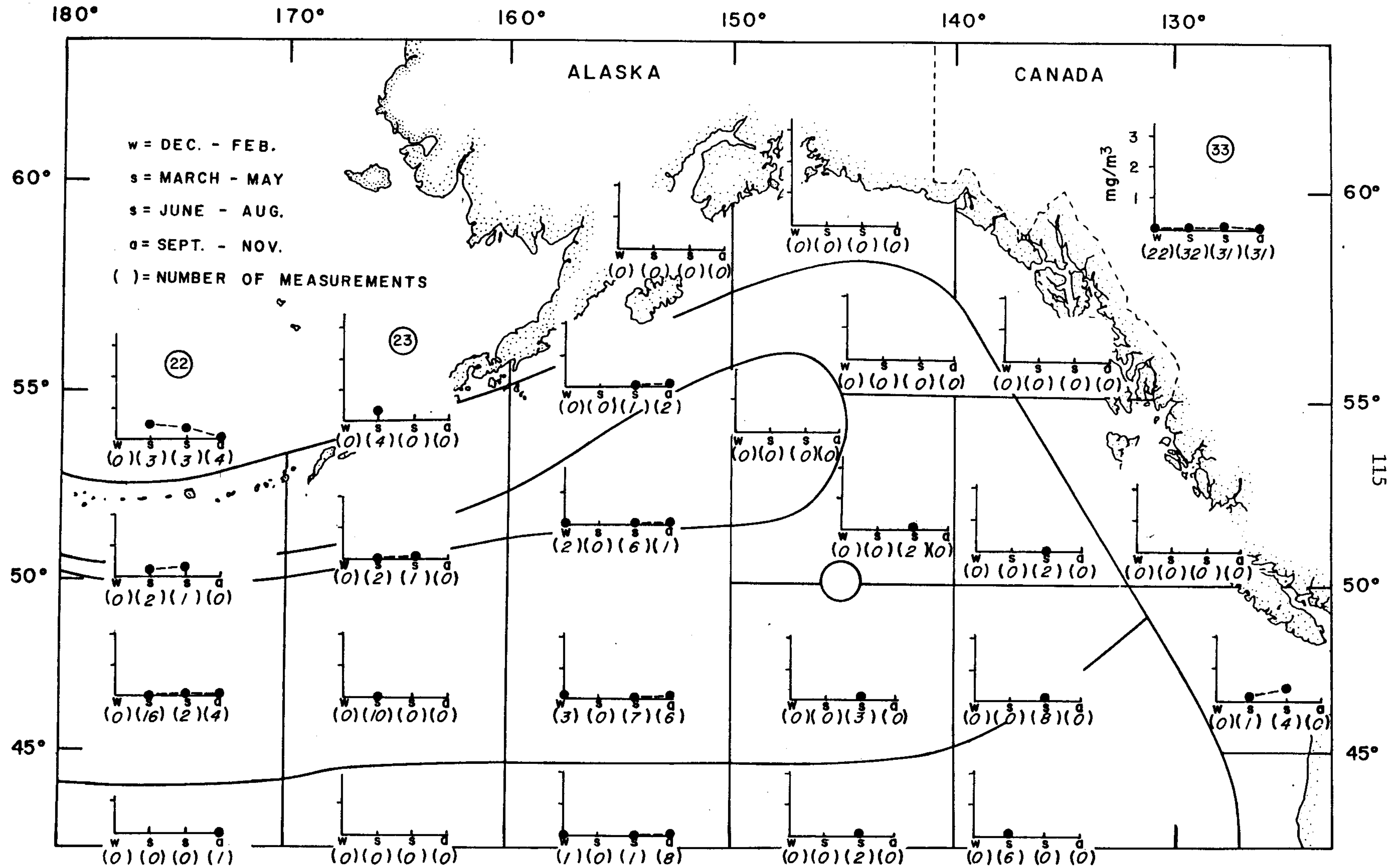


Figure 36. The distribution of chlorophyll a (seasonal means, milligrams chlorophyll a per cubic meter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 150.1 meters to the deepest sampling depth.

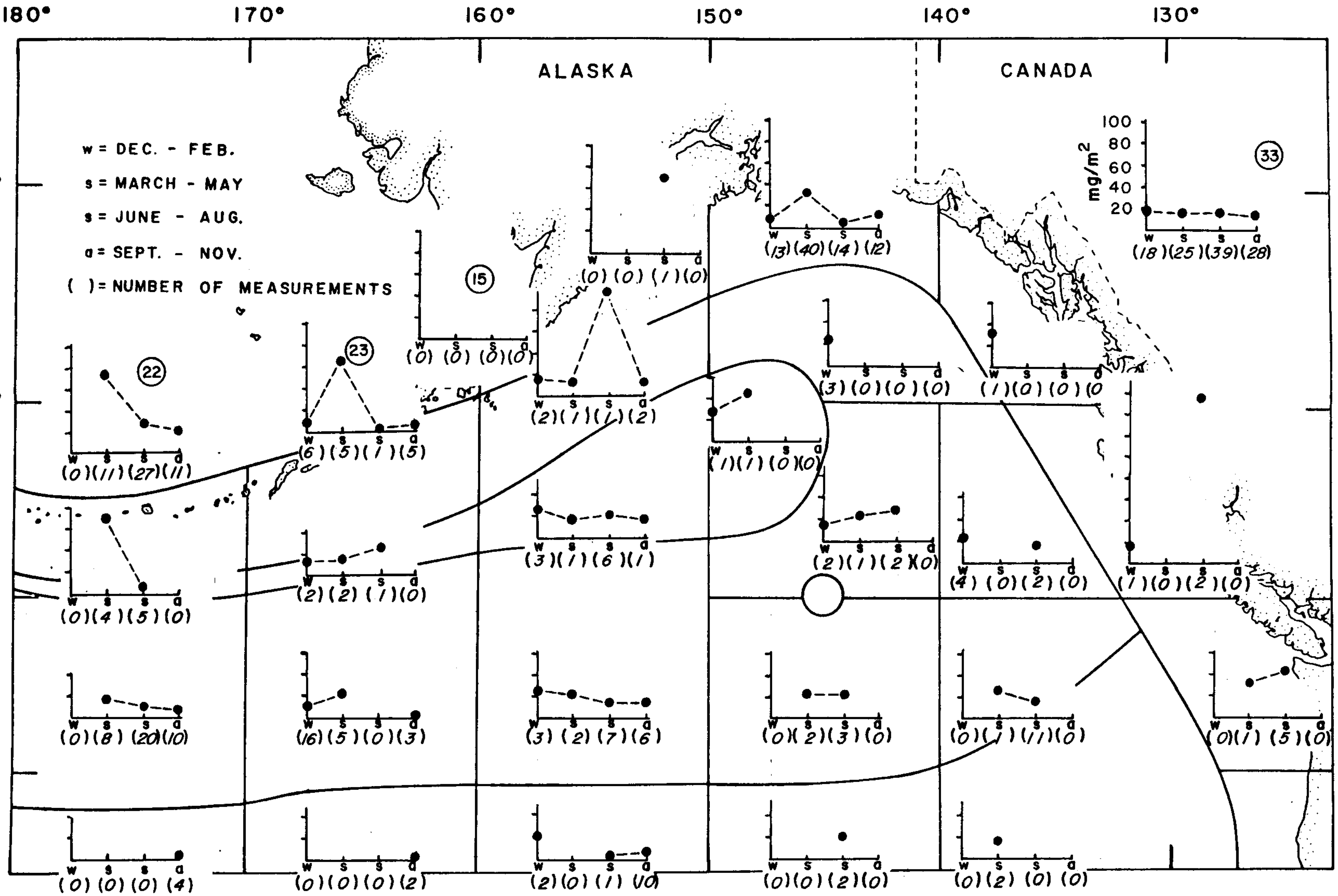


Figure 37. The distribution of integrated chlorophyll a (seasonal means for the euphotic layer, milligrams per square meter) in the eastern Subarctic Pacific for the years 1958 through 1974.

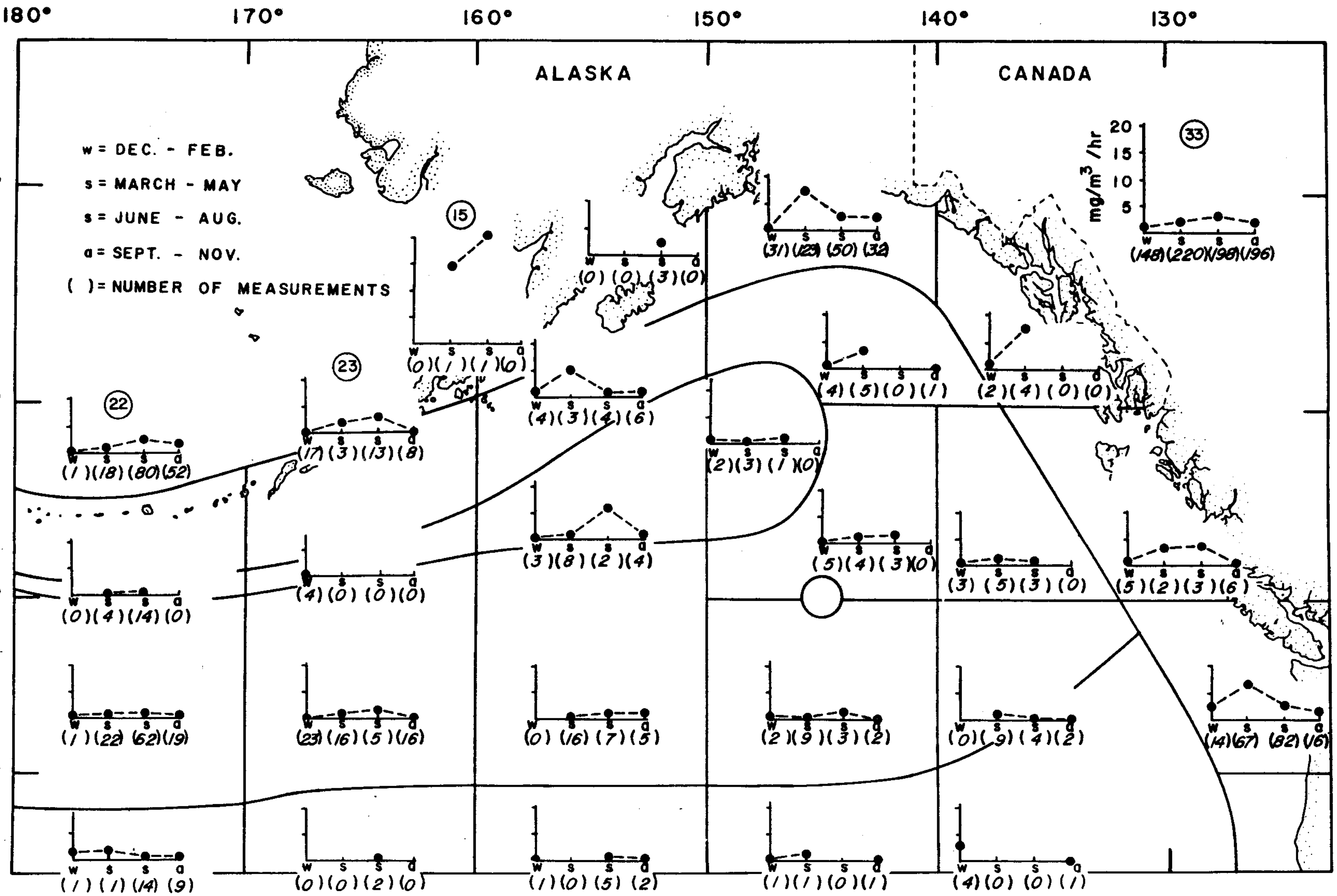


Figure 38. The distribution of primary production (seasonal means, milligrams carbon per cubic meter per hour) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 0 to 10 meters.

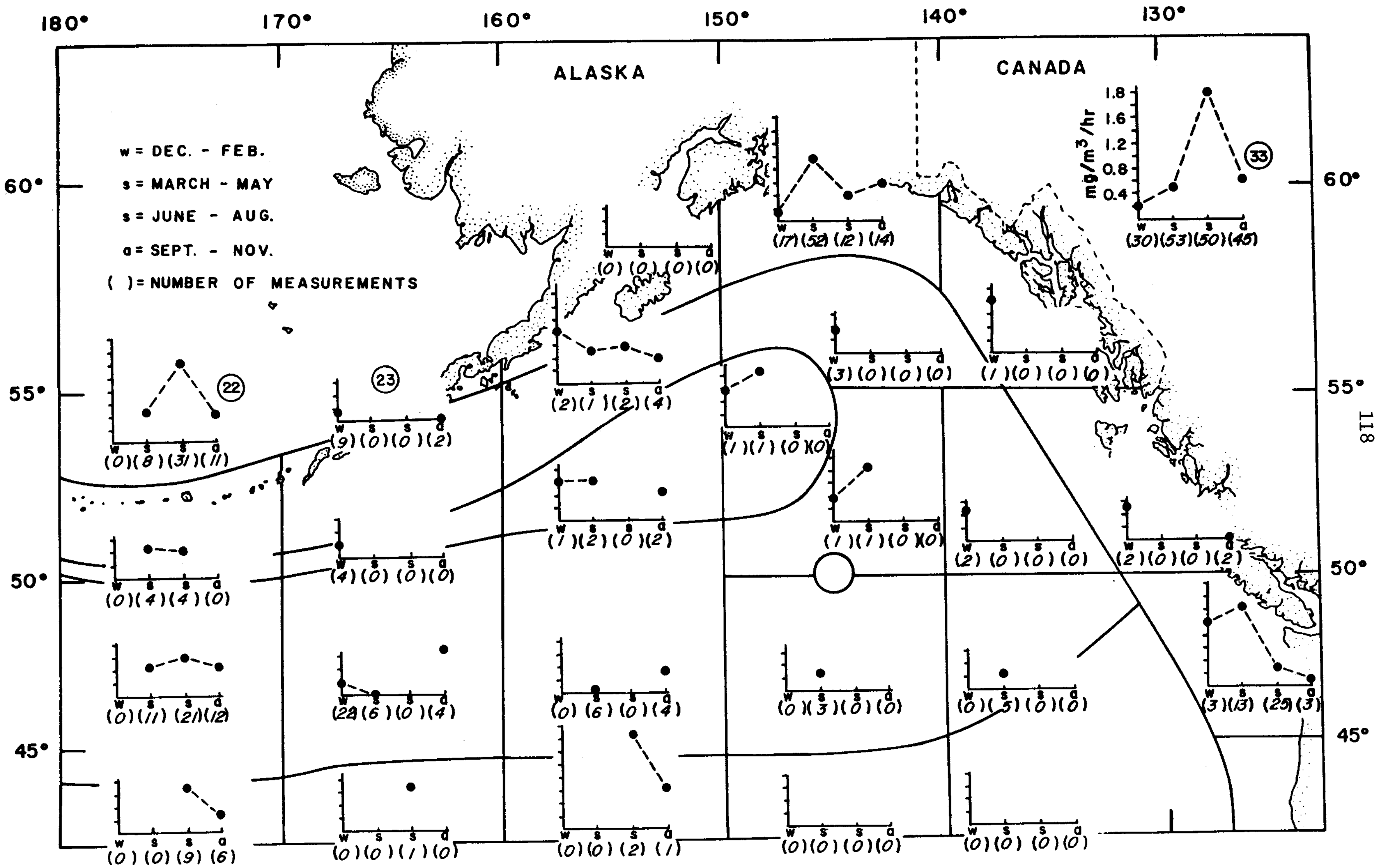


Figure 39. The distribution of primary production (seasonal means, milligrams carbon per cubic meter per hour) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 10.1 to 25 meters.

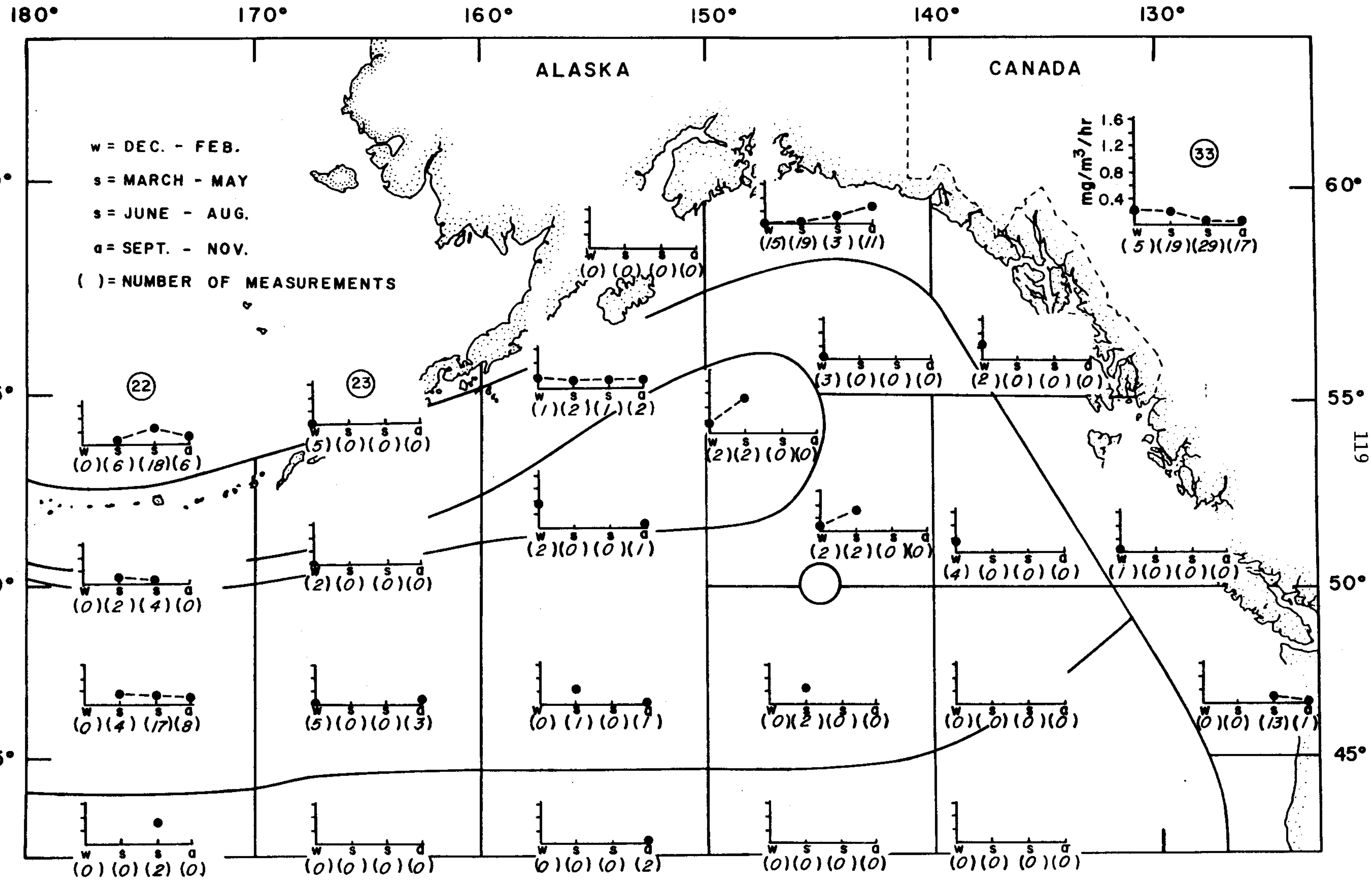


Figure 40. The distribution of primary production (seasonal means, milligrams carbon per cubic meter per hour) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 25.1 to 50 meters.

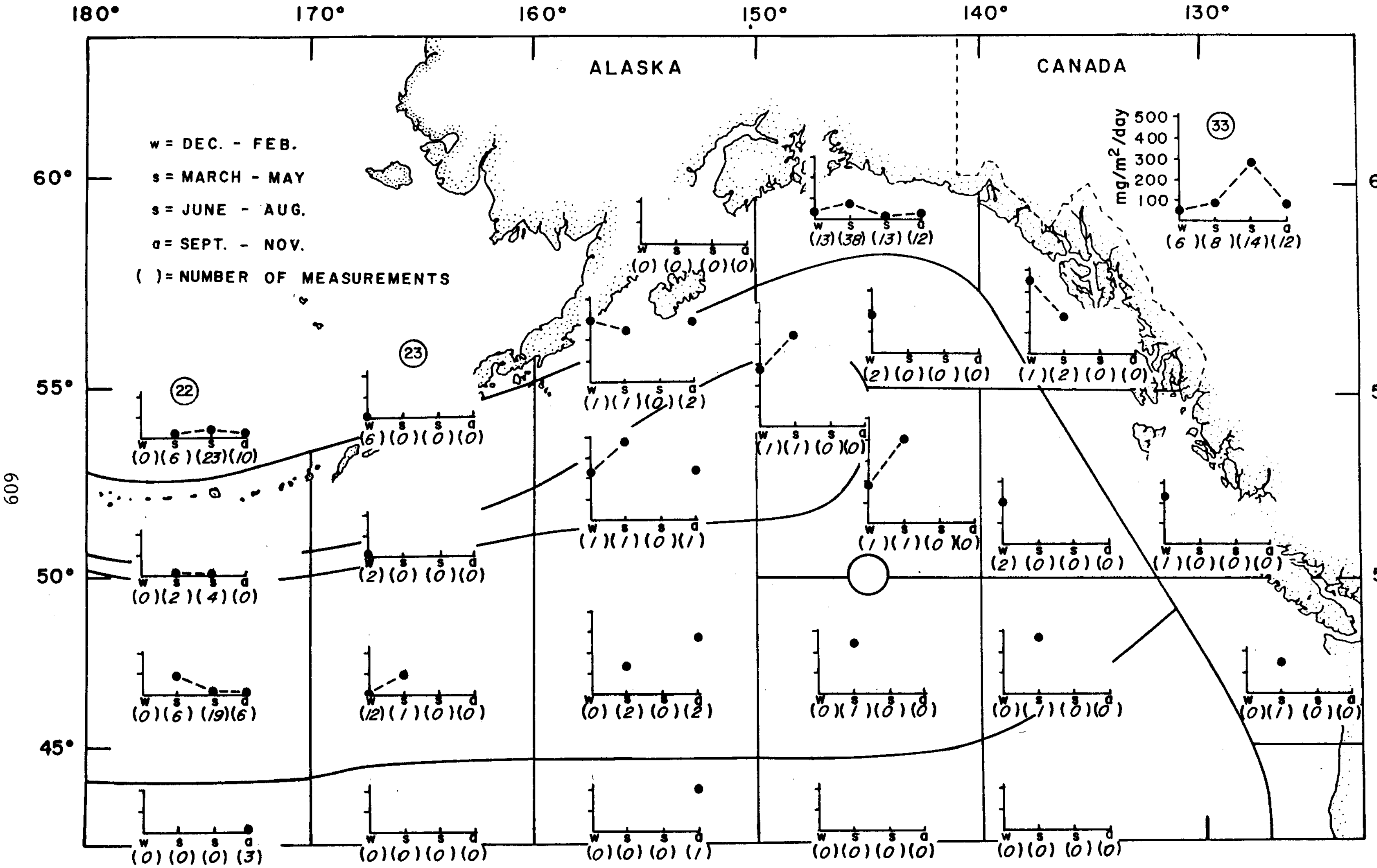


Figure 41. The distribution of integrated primary productivity (seasonal means for the euphotic zone, milligrams carbon per square meter per day) in the eastern Subarctic Pacific for the years 1958 through 1974.

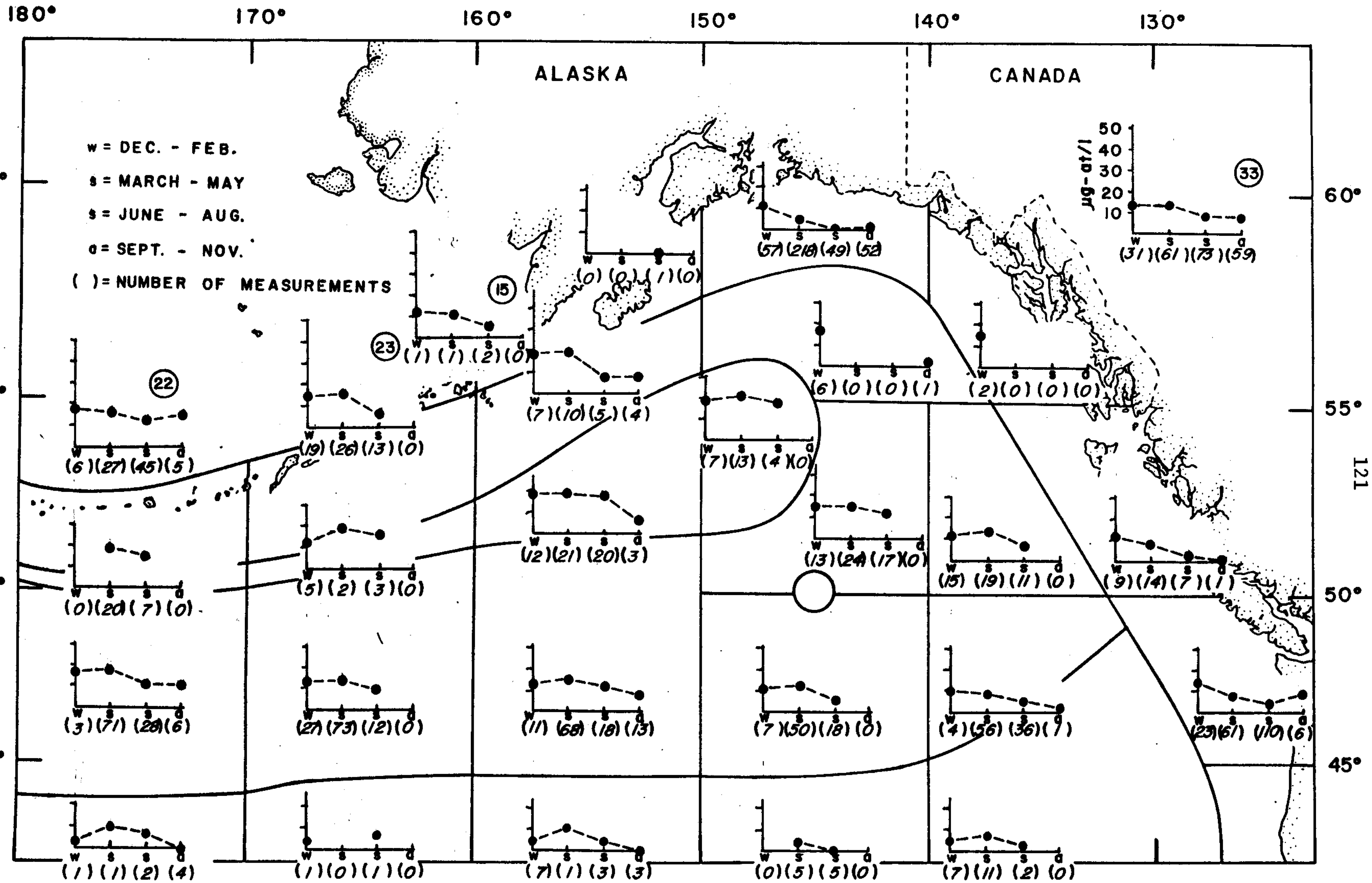


Figure 42. The distribution of nitrate (NO_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 0 to 10 meters.

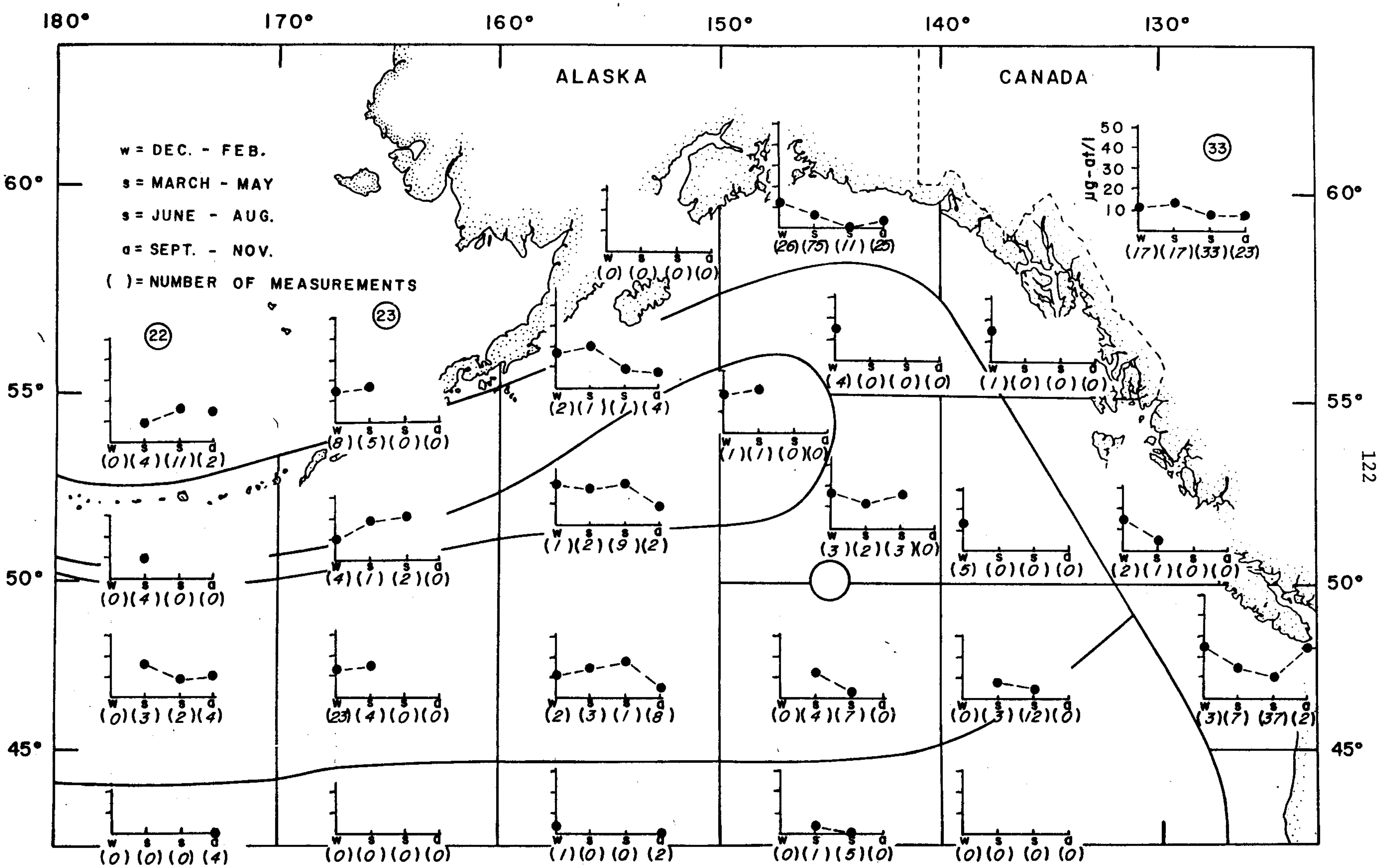


Figure 43. The distribution of nitrate (NO_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 10.1 to 25 meters.

612

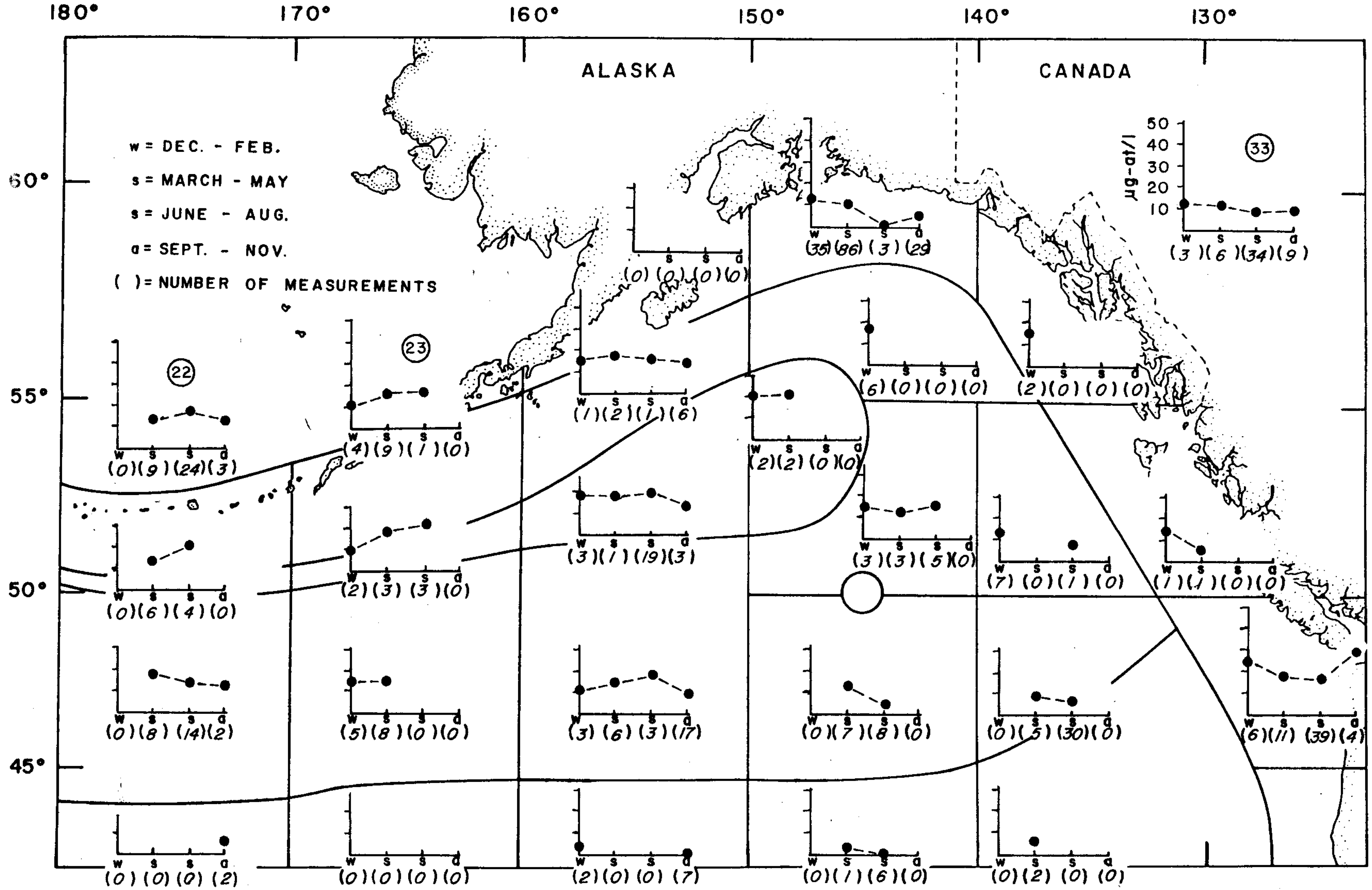


Figure 44. The distribution of nitrate (NO_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 25.1 to 50 meters.

123

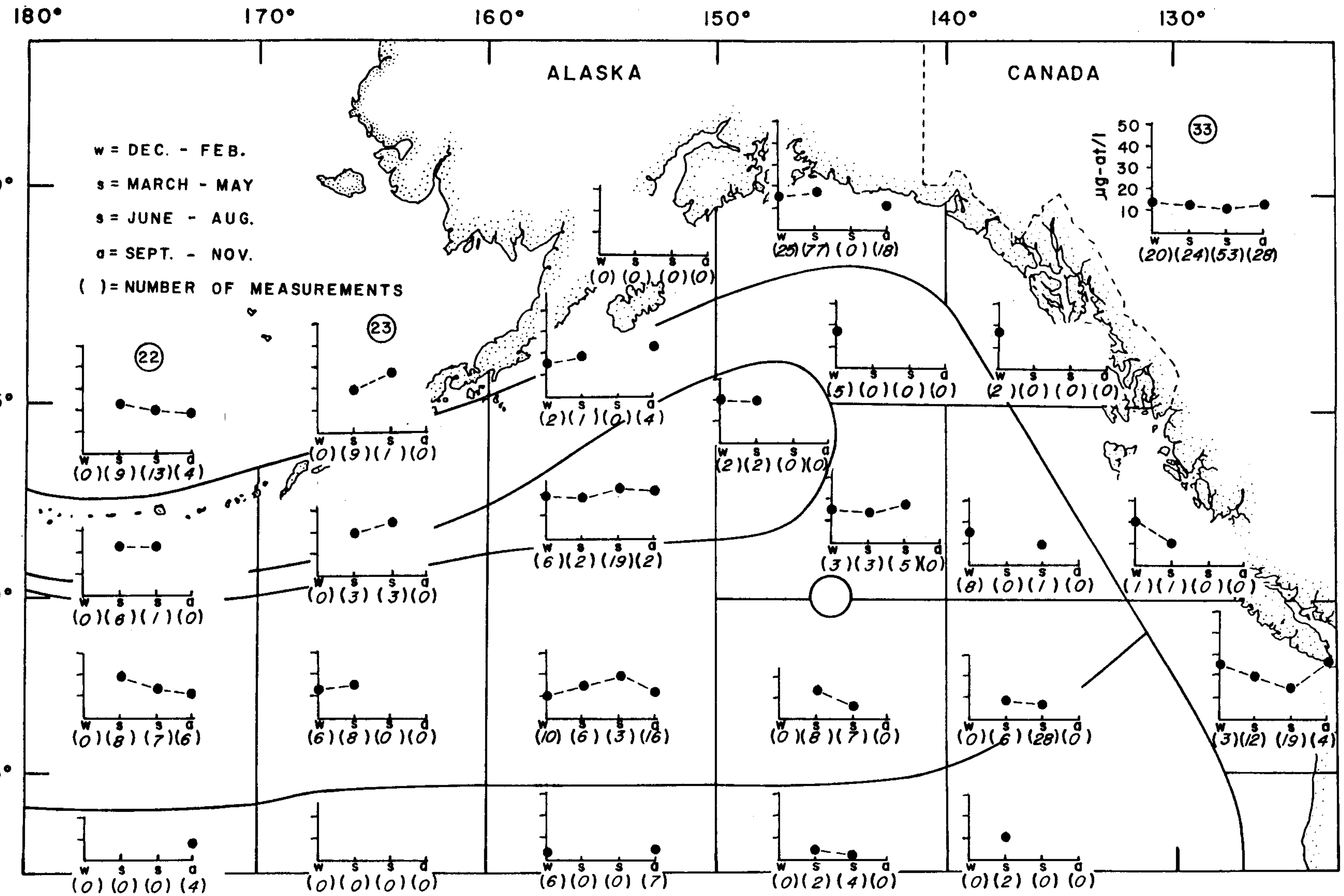


Figure 45. The distribution of nitrate (NO_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 50.1 to 100 meters.

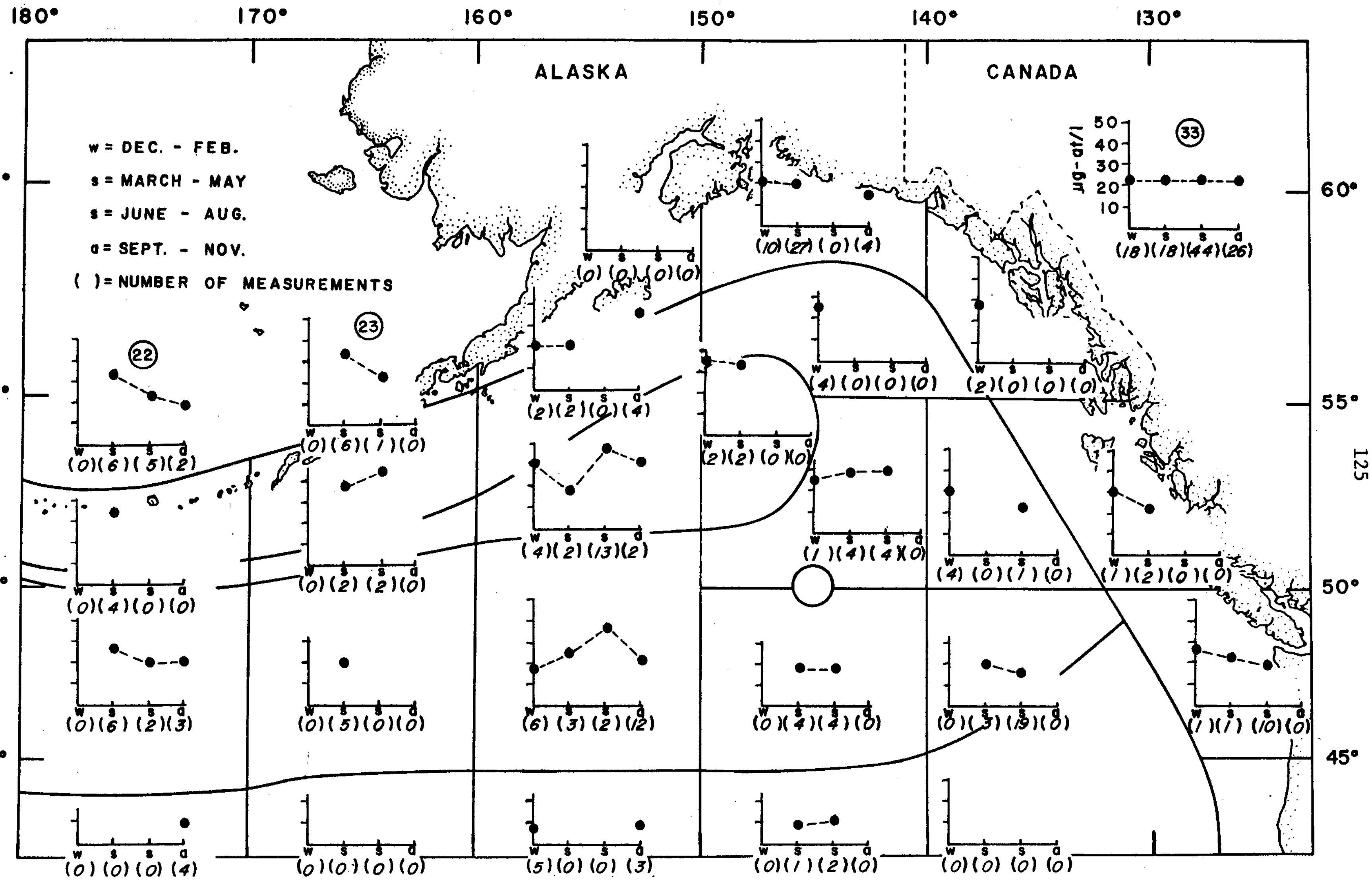


Figure 46. The distribution of nitrate (NO_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 100.1 to 150 meters.

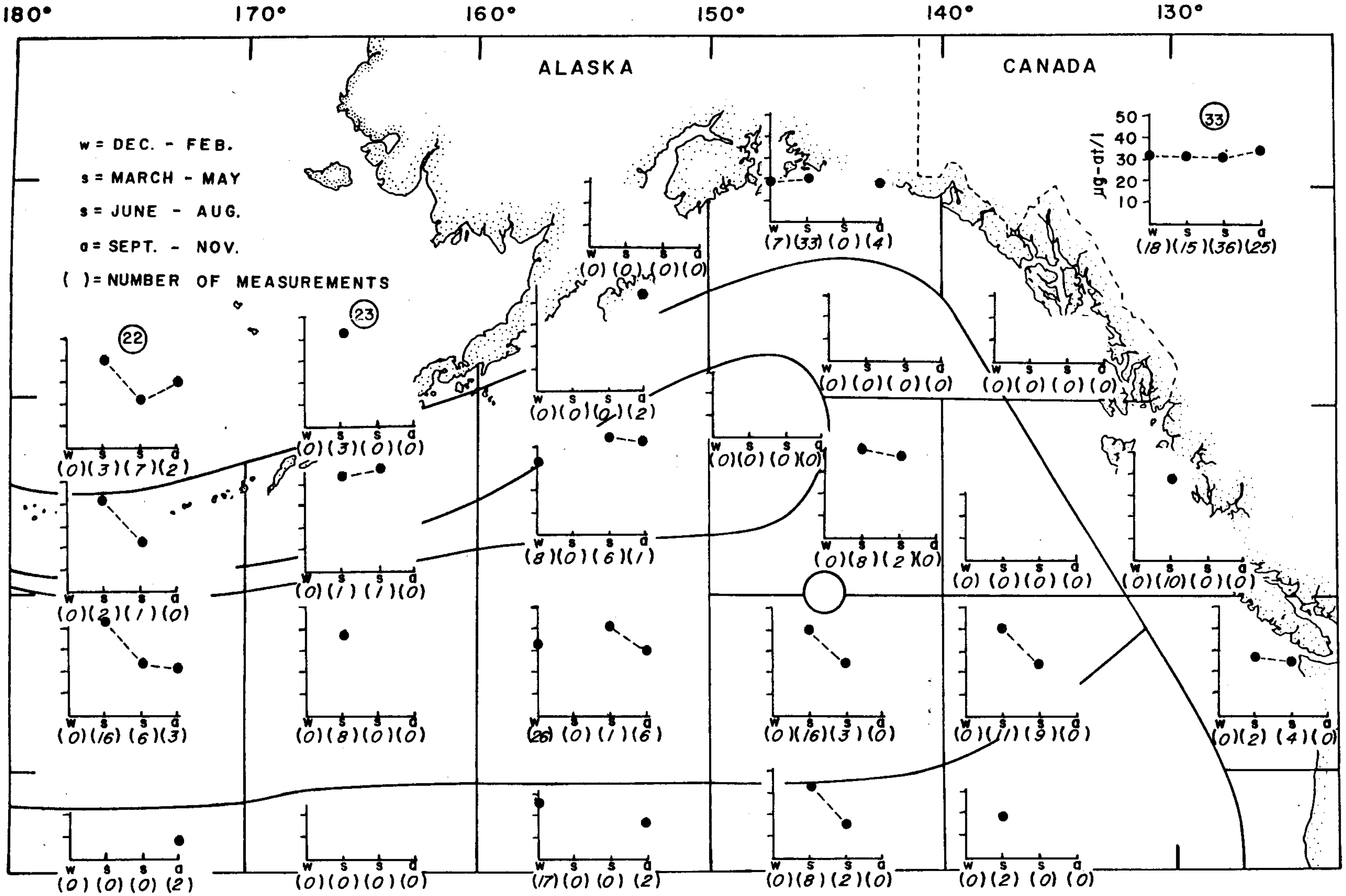


Figure 47. The distribution of nitrate (NO_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 150.1 meters to the deepest sampling depth.

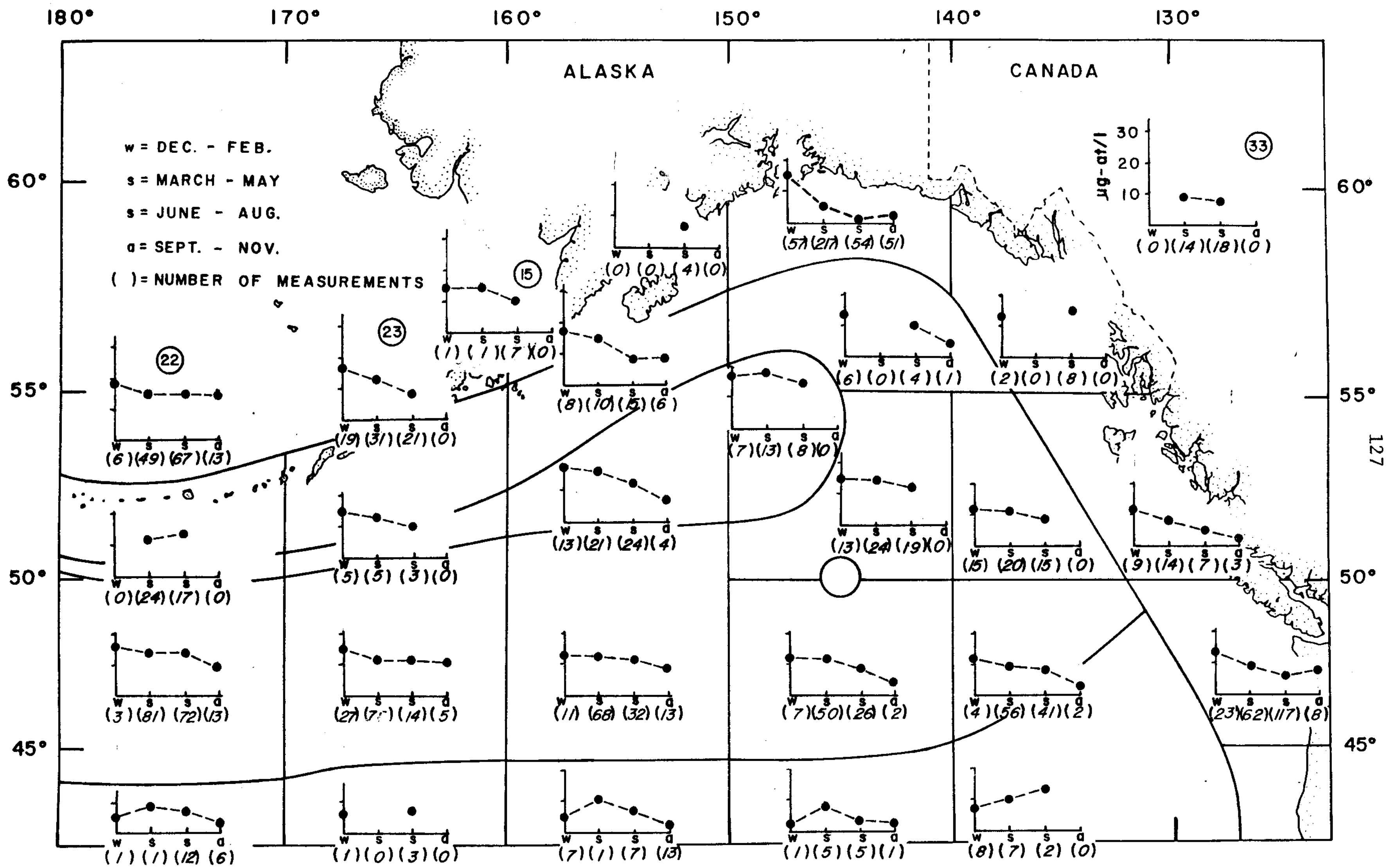


Figure 48. The distribution of phosphate (PO_4, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 0 to 10 meters.

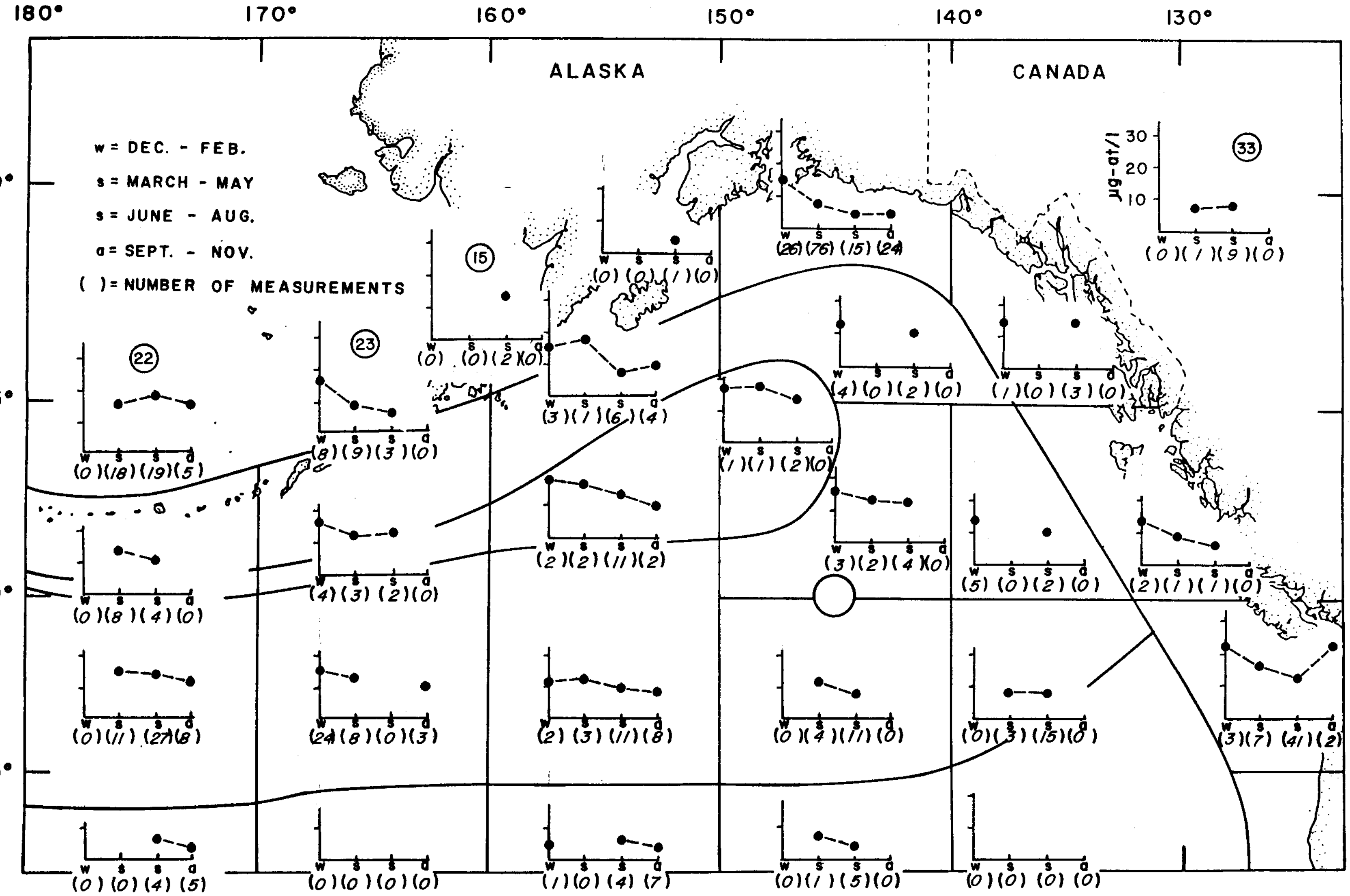


Figure 49. The distribution of phosphate (PO_4, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 10.1 to 25 meters.

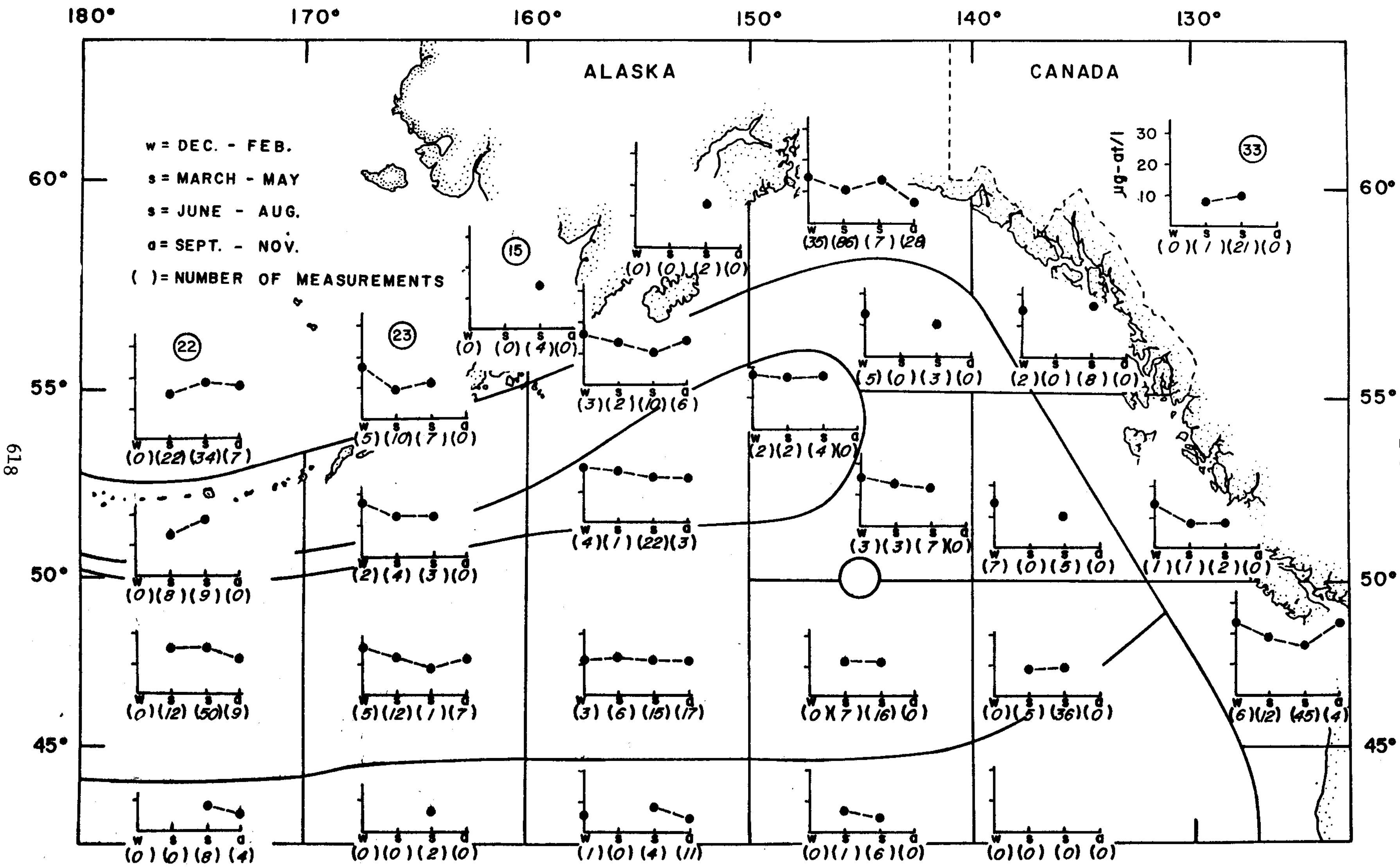


Figure 50. The distribution of phosphate (PO_4, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 25.1 to 50 meters.

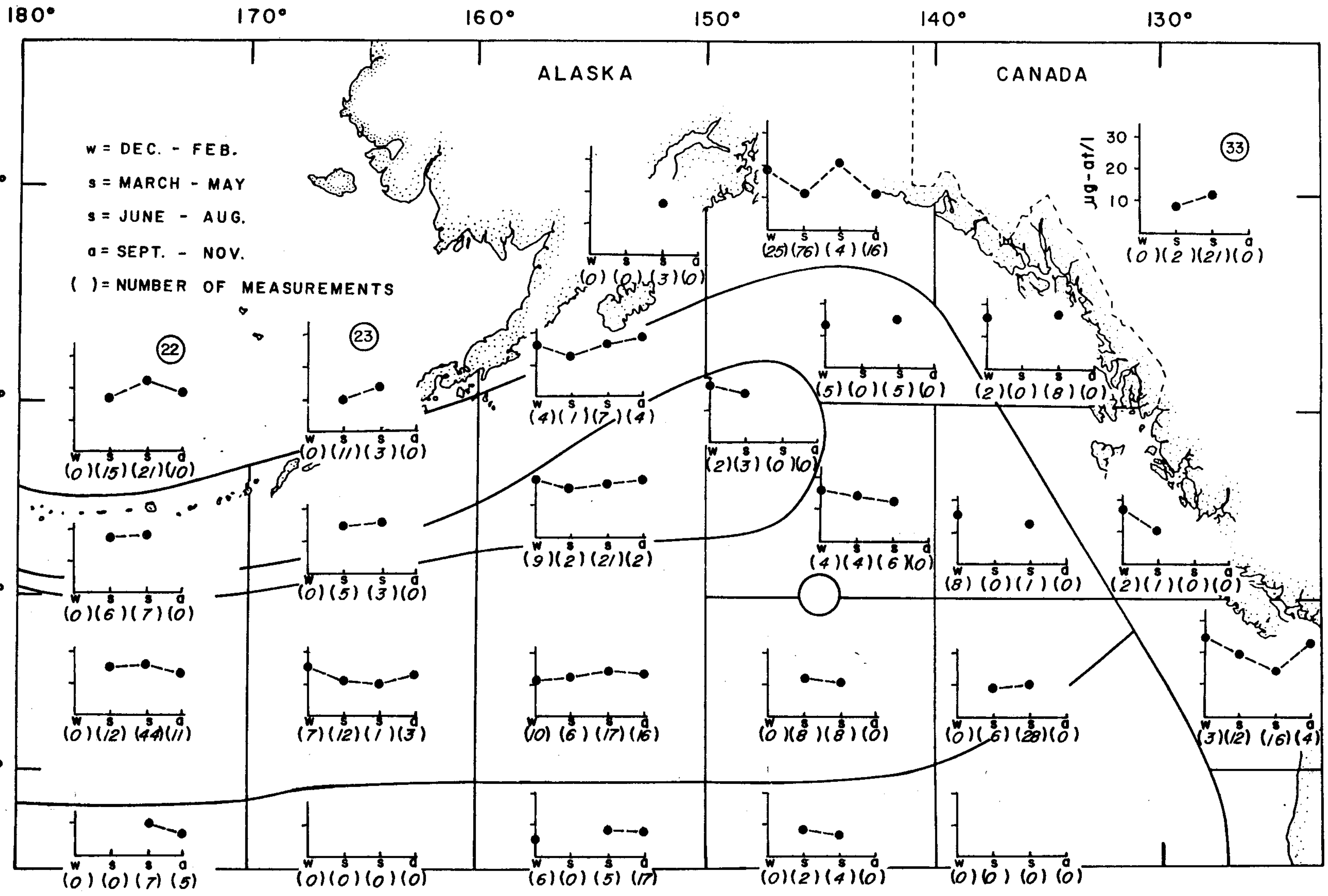


Figure 51. The distribution of phosphate (PO_4, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 50.1 to 100 meters.

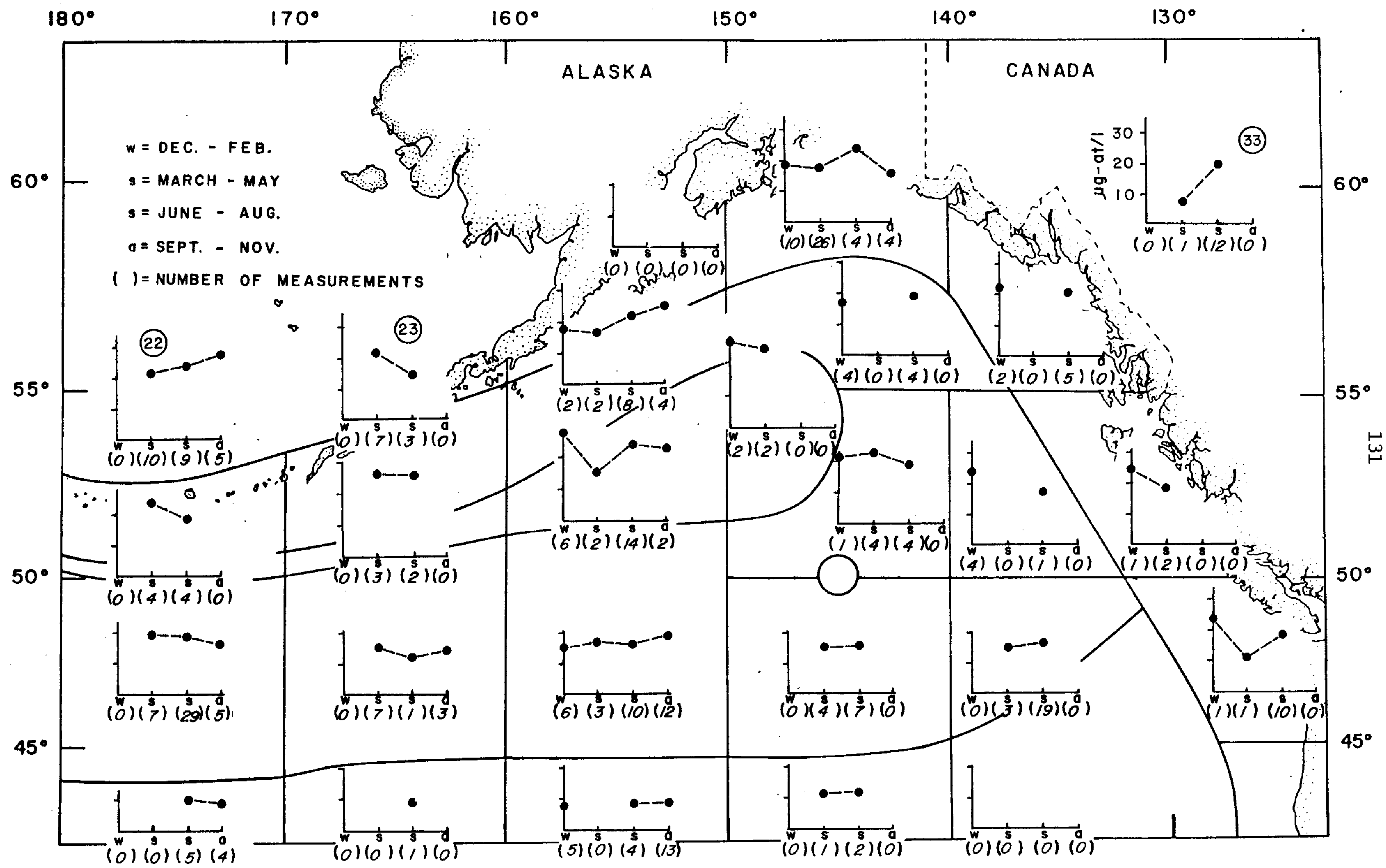


Figure 52. The distribution of phosphate (PO_4, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 100.1 to 150 meters.

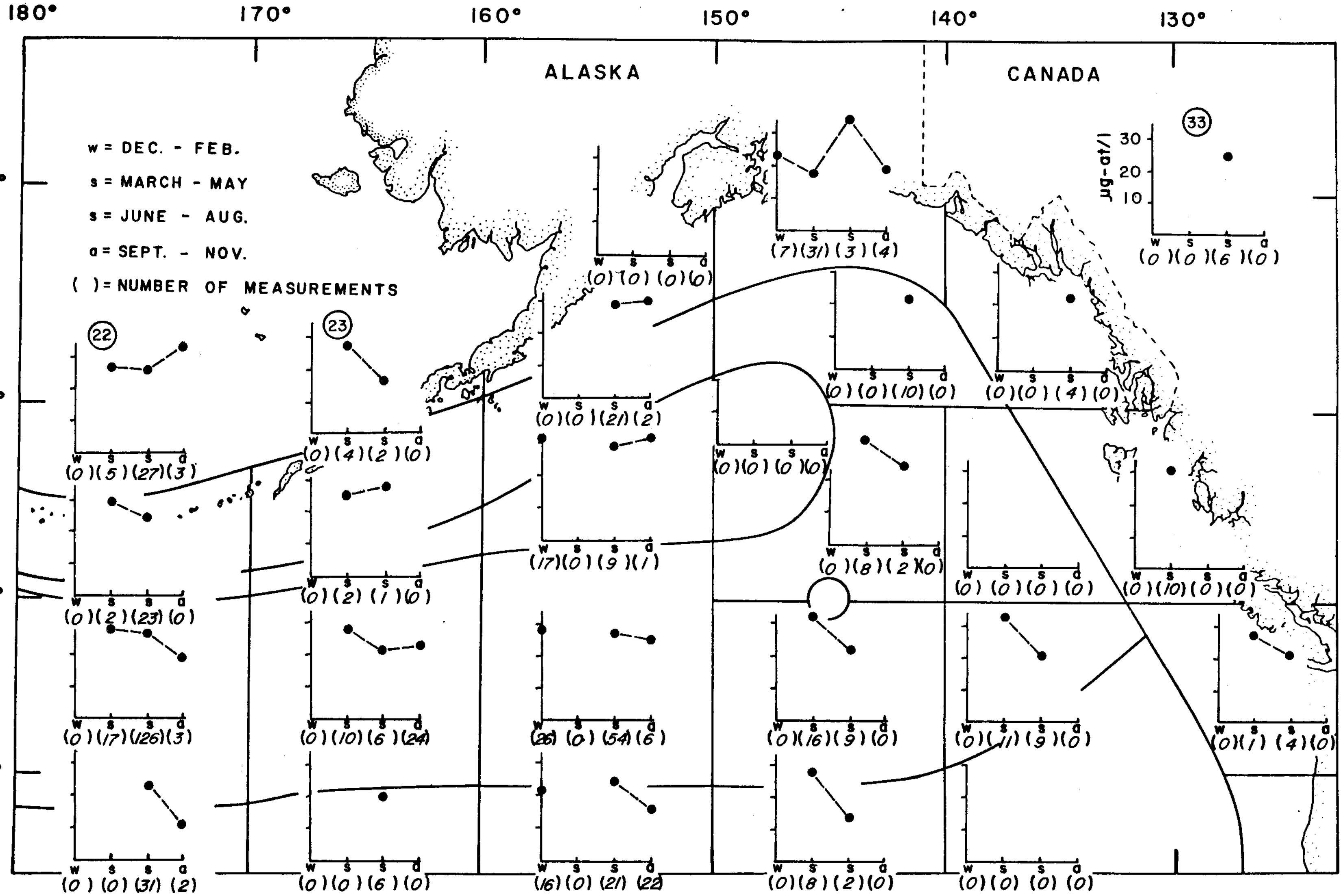


Figure 53. The distribution of phosphate (PO_4, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 150.1 meters to the deepest sampling depth.

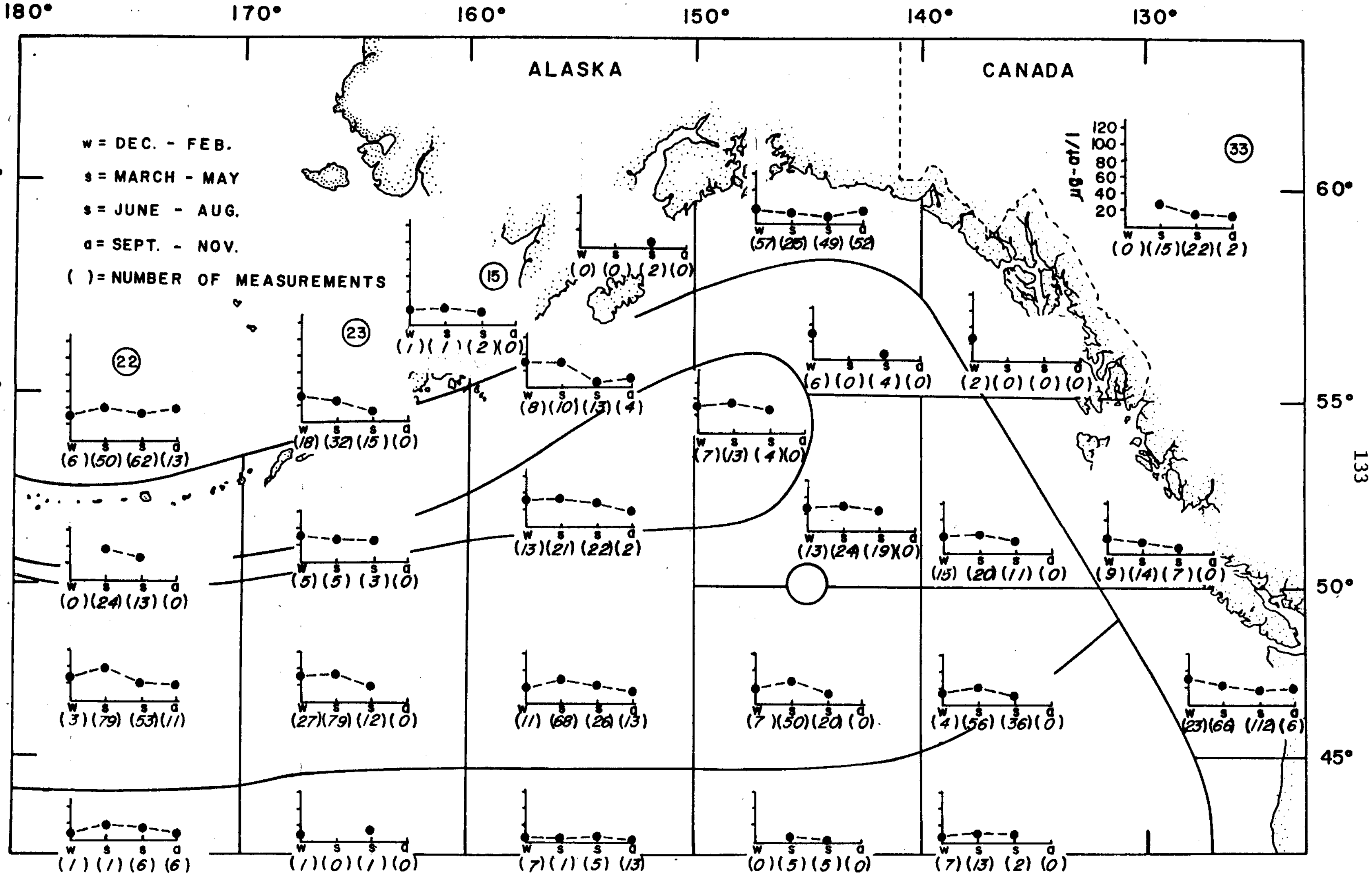


Figure 54. The distribution of silicate (SiO_3, seasonal means, micrograms - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 0 to 10 meters.

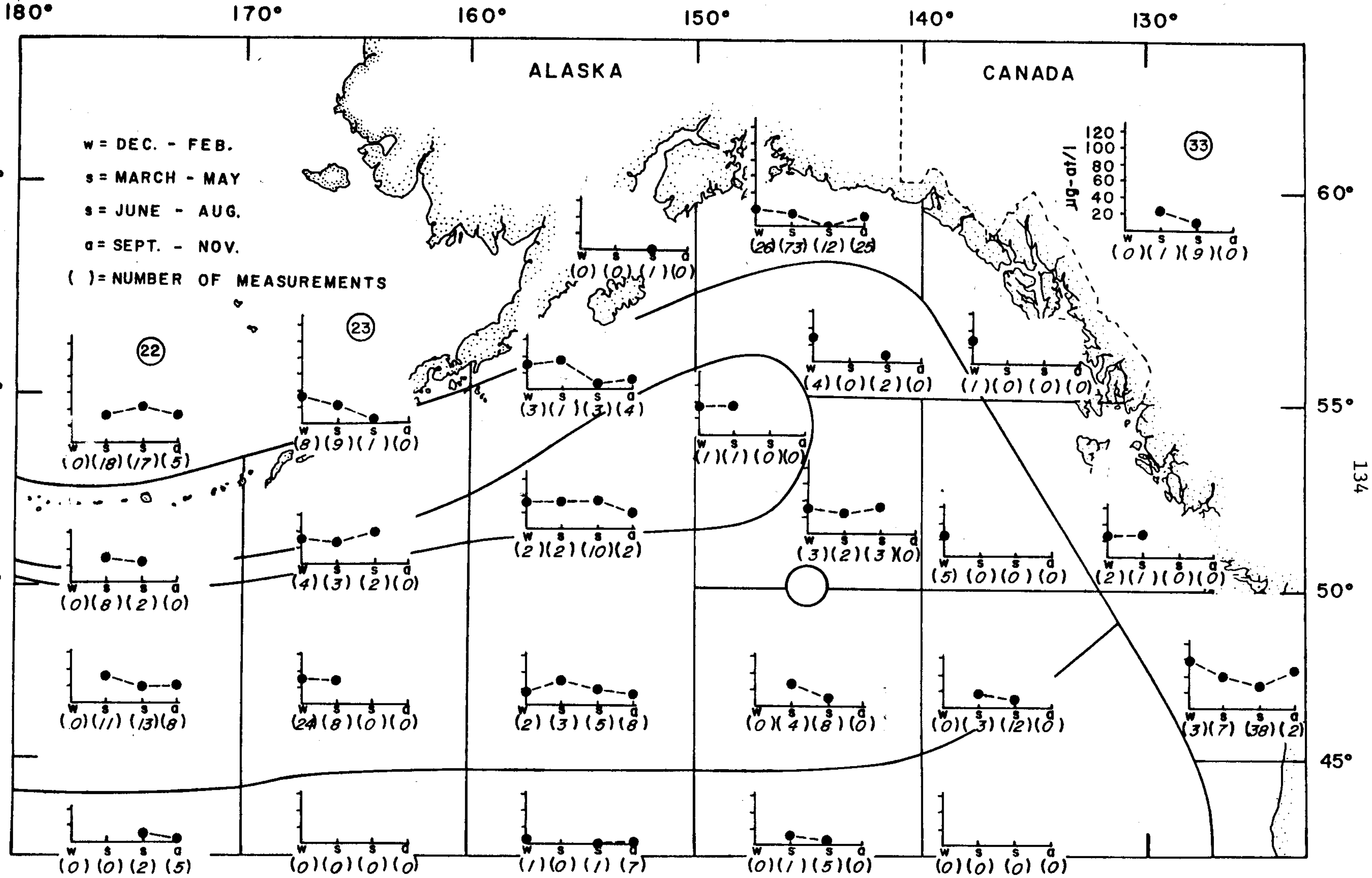


Figure 55. The distribution of silicate (SiO_3, seasonal means, micrograms - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 10.1 to 25 meters.

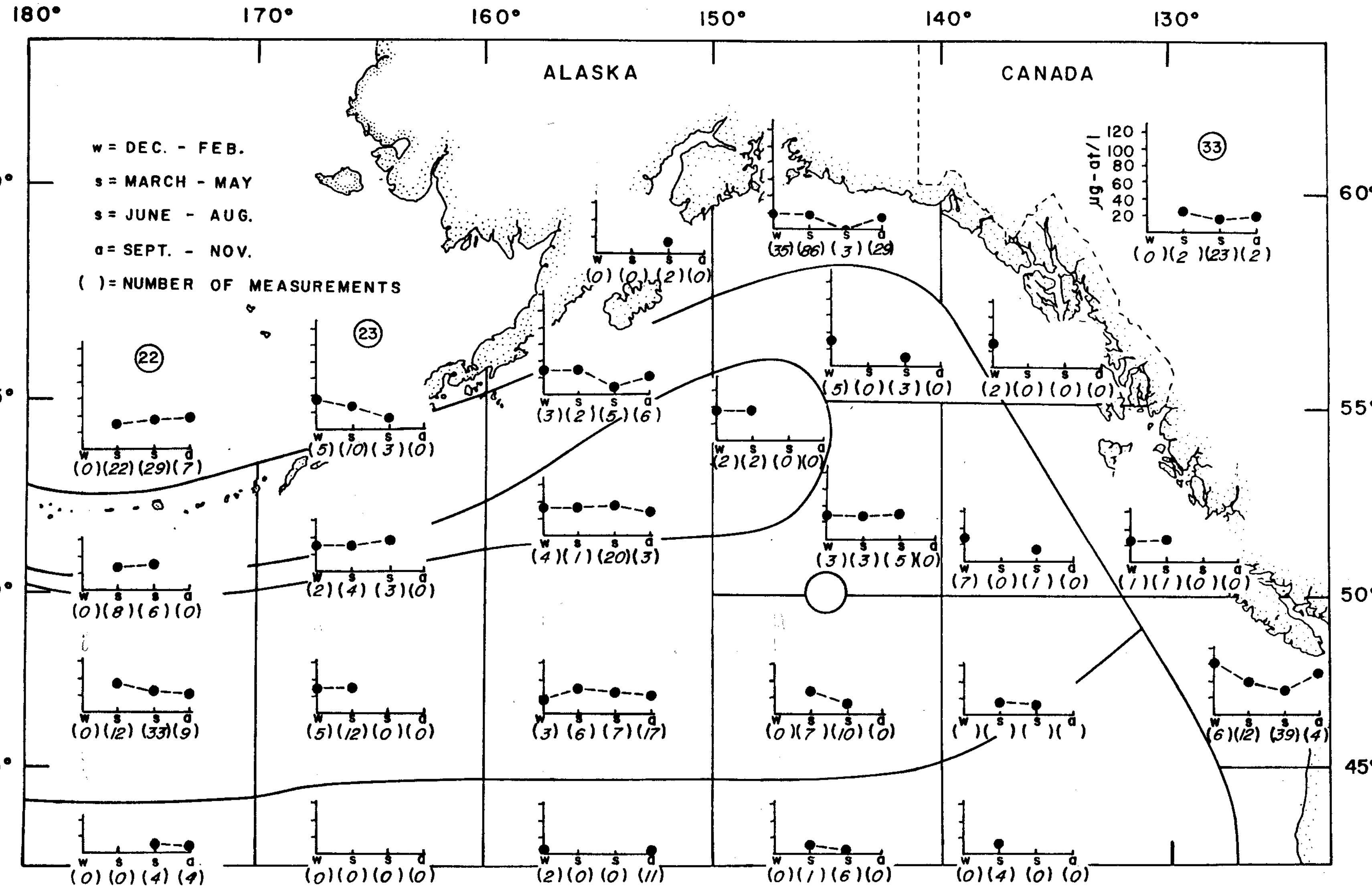


Figure 56. The distribution of silicate (SiO_3, seasonal means, micrograms - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 25.1 to 50 meters.

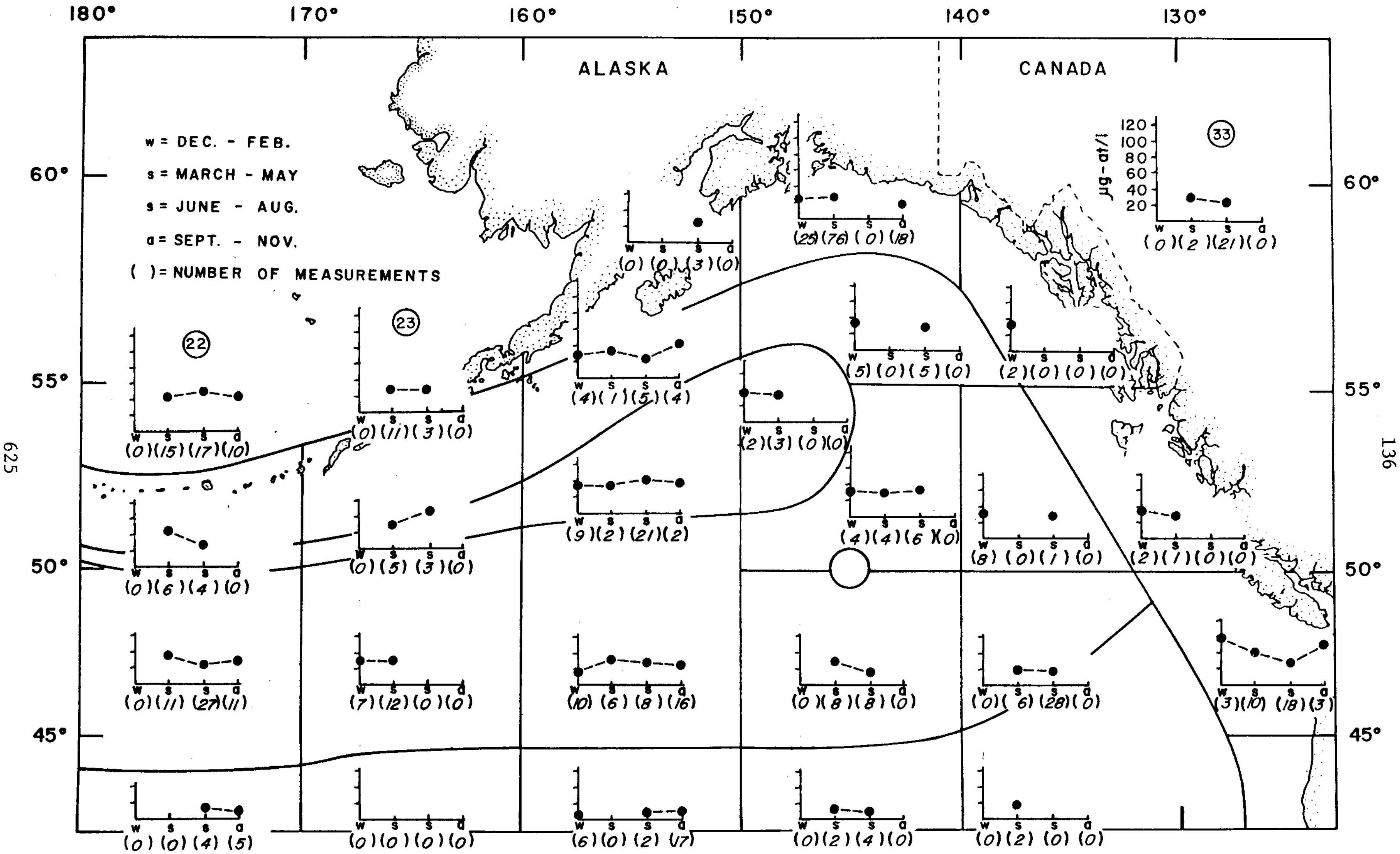


Figure 57. The distribution of silicate (SiO_3, seasonal means, micrograms - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 50.1 to 100 meters.

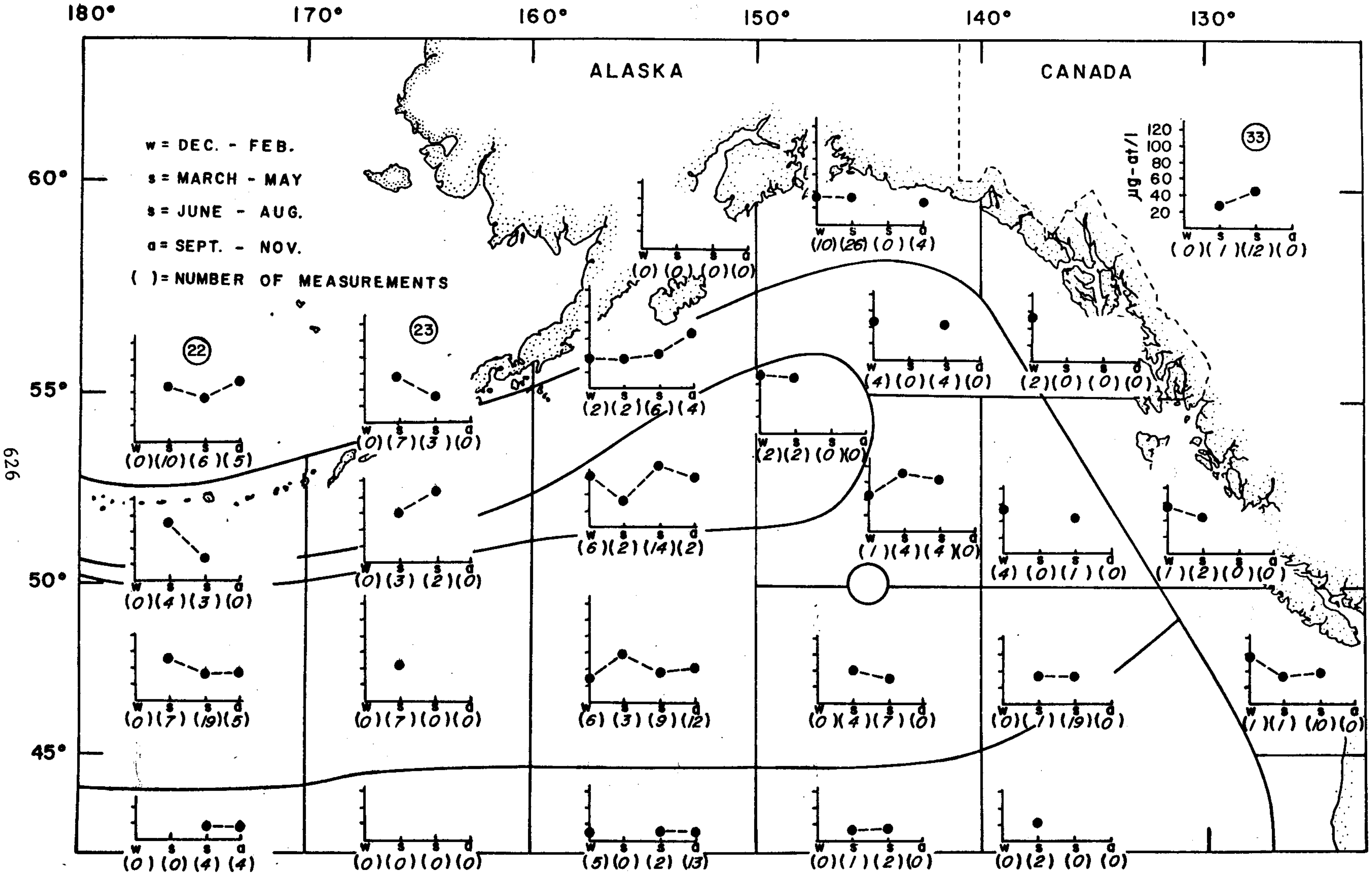


Figure 58. The distribution of silicate (SiO_3, seasonal means, micrograms - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 100.1 to 150 meters.

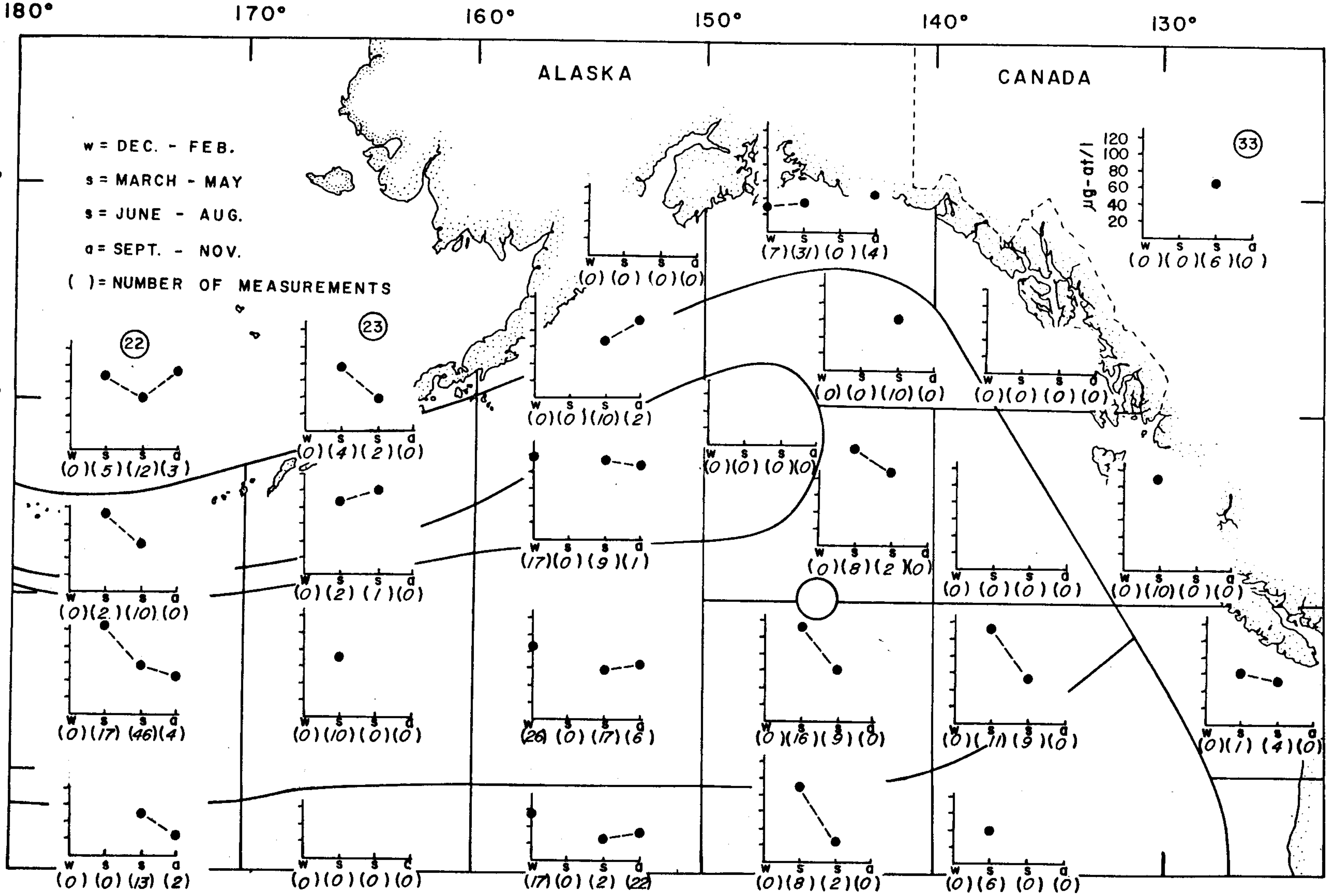


Figure 59. The distribution of silicate (SiO_3, seasonal means, micrograms - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 150.1 meters to the deepest sampling depth.

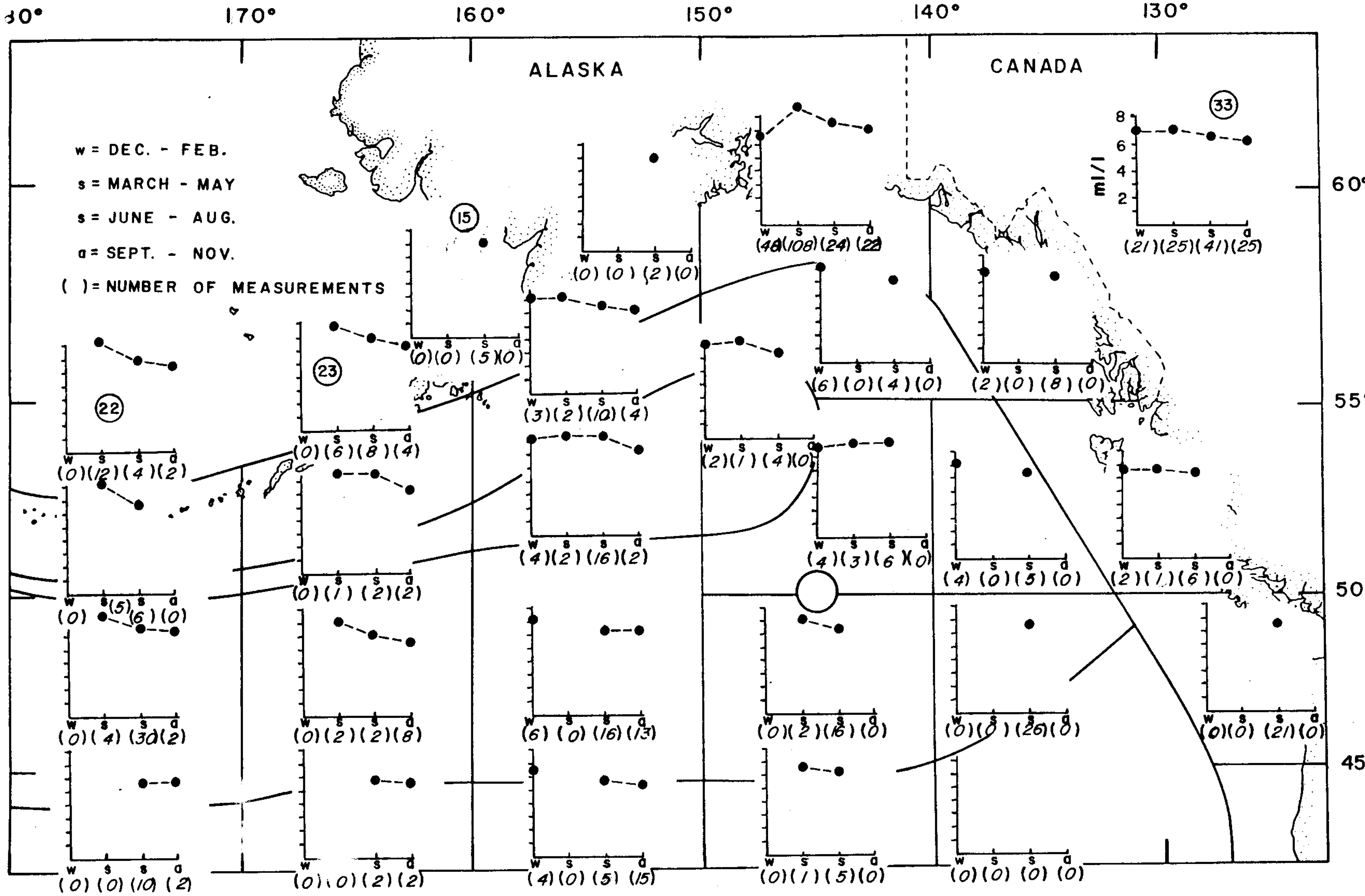


Figure 60. The distribution of oxygen (seasonal means, milliliters per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 0 to 10 meters.

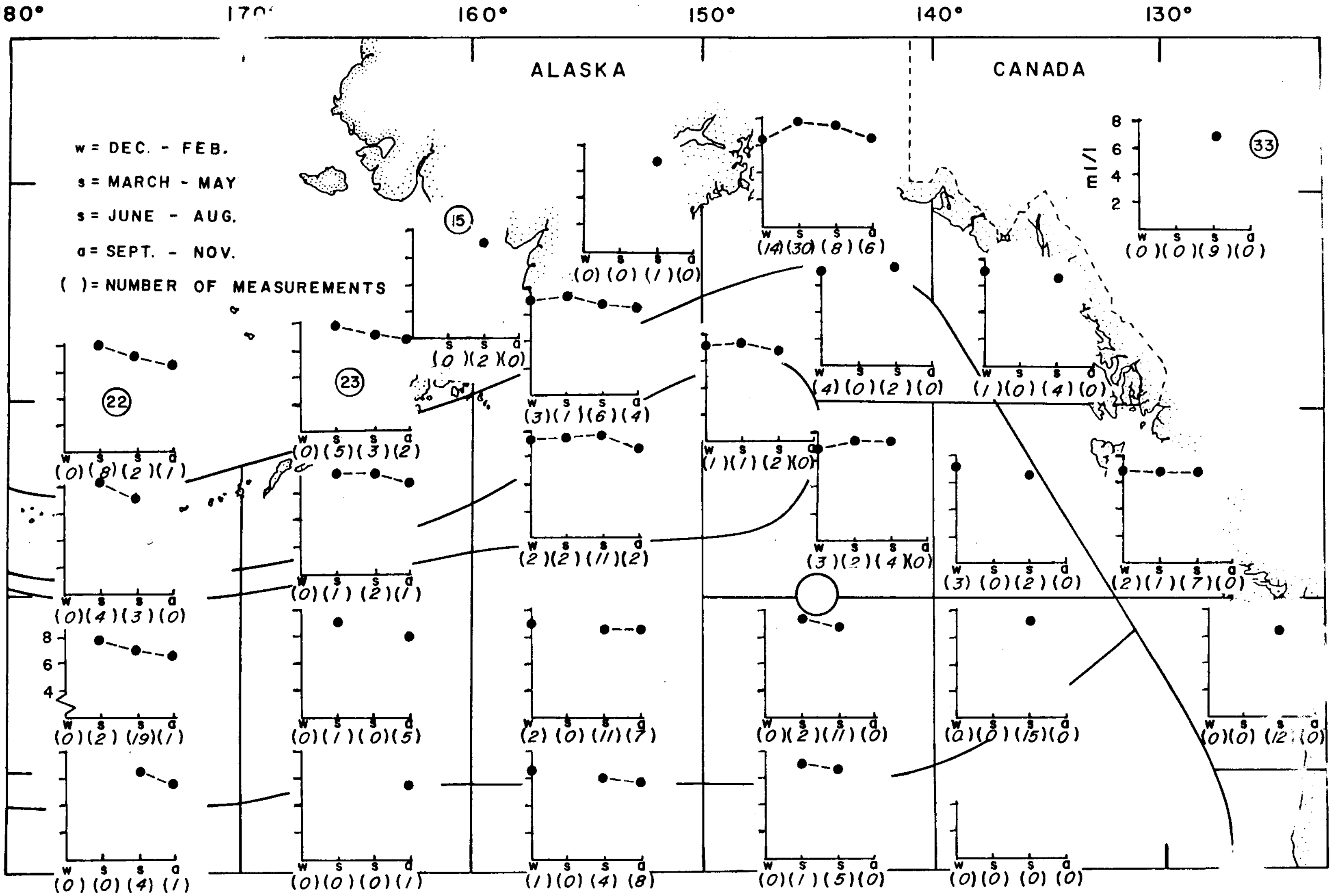


Figure 61. The distribution of oxygen (seasonal means, milliliters per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 10.1 to 25 meters.

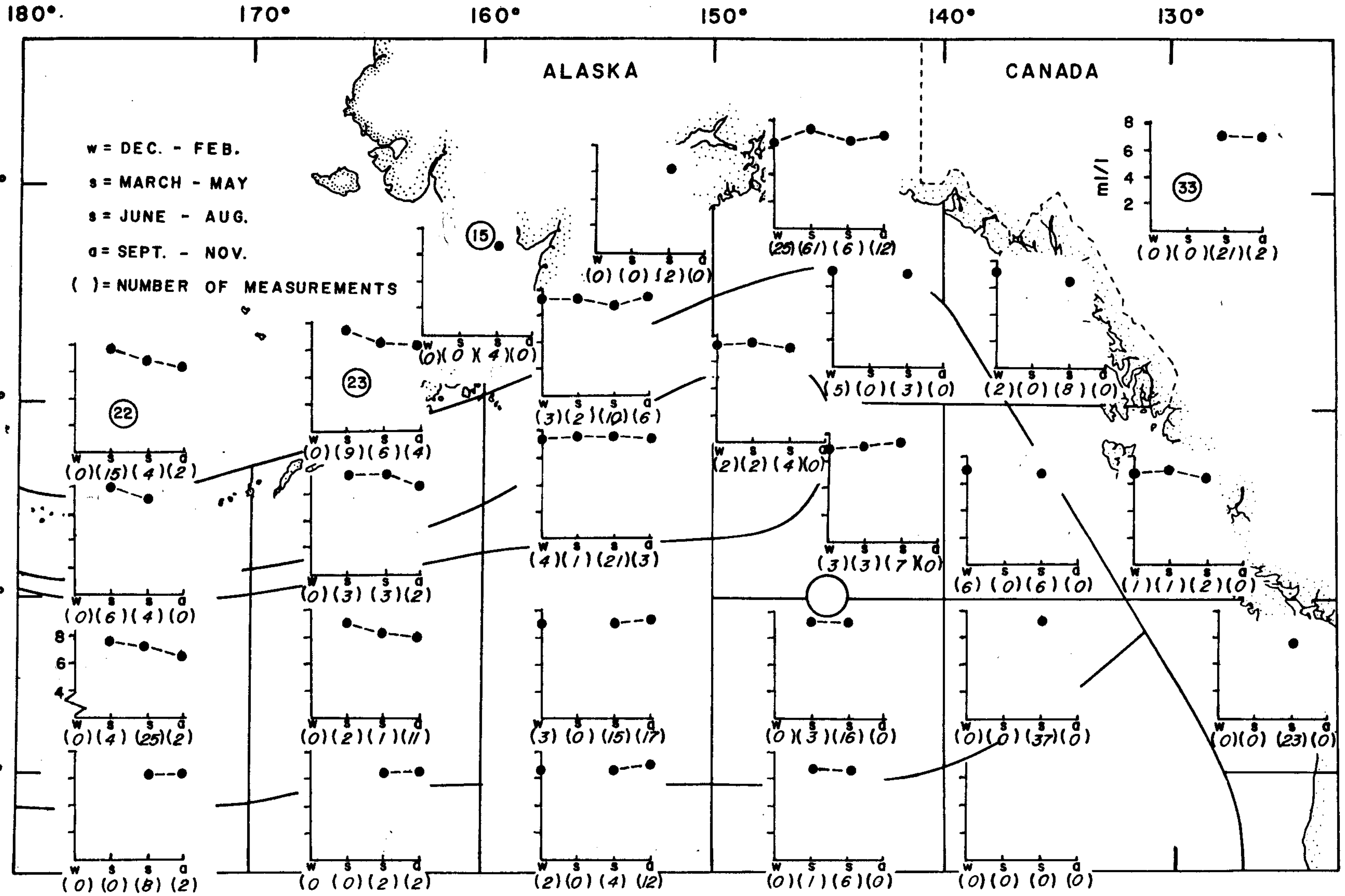


Figure 62. The distribution of oxygen (seasonal means, milliliters per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 25.1 to 50 meters.

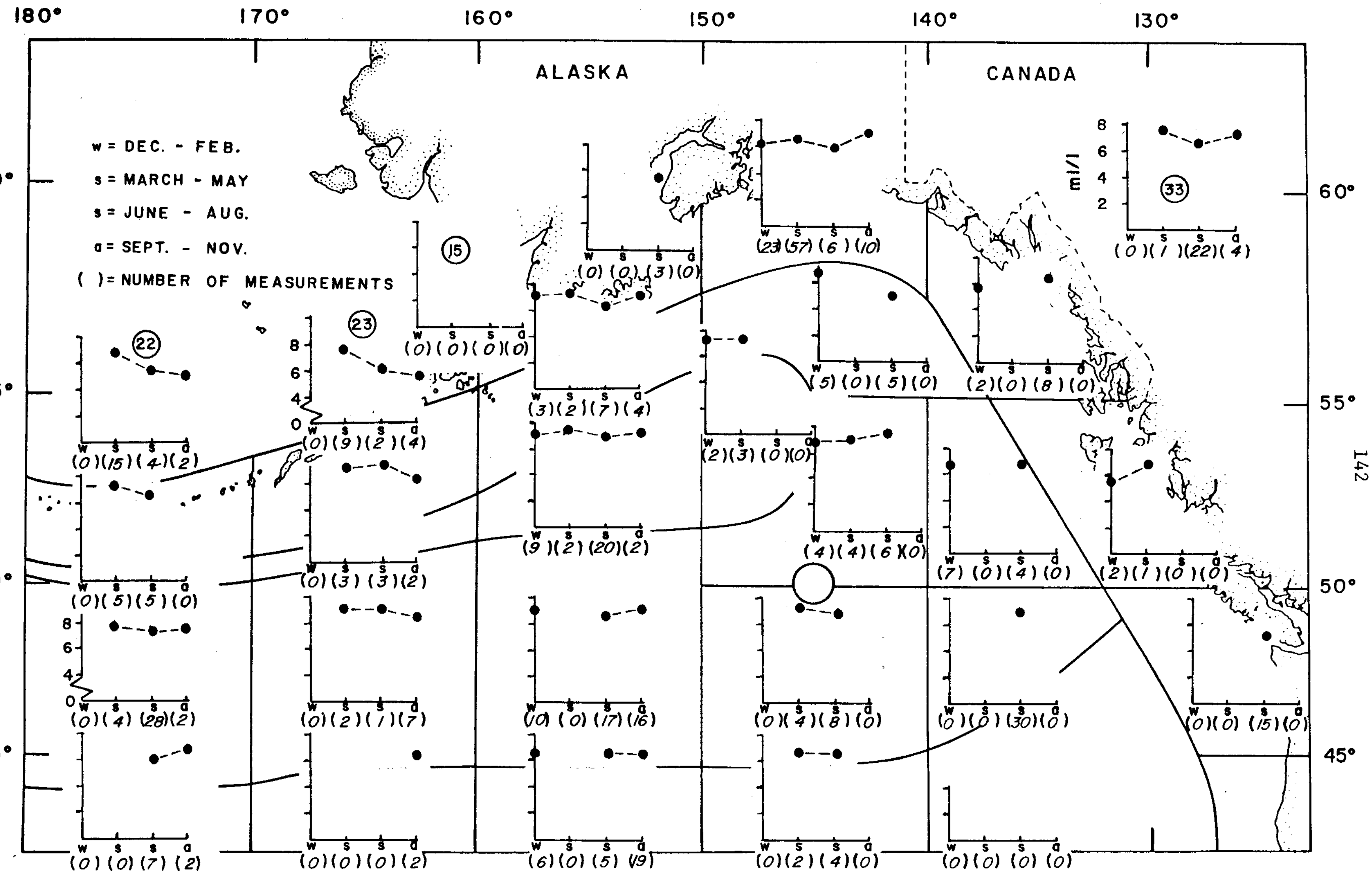


Figure 63. The distribution of oxygen (seasonal means, milliliters per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 50.1 to 100 meters.

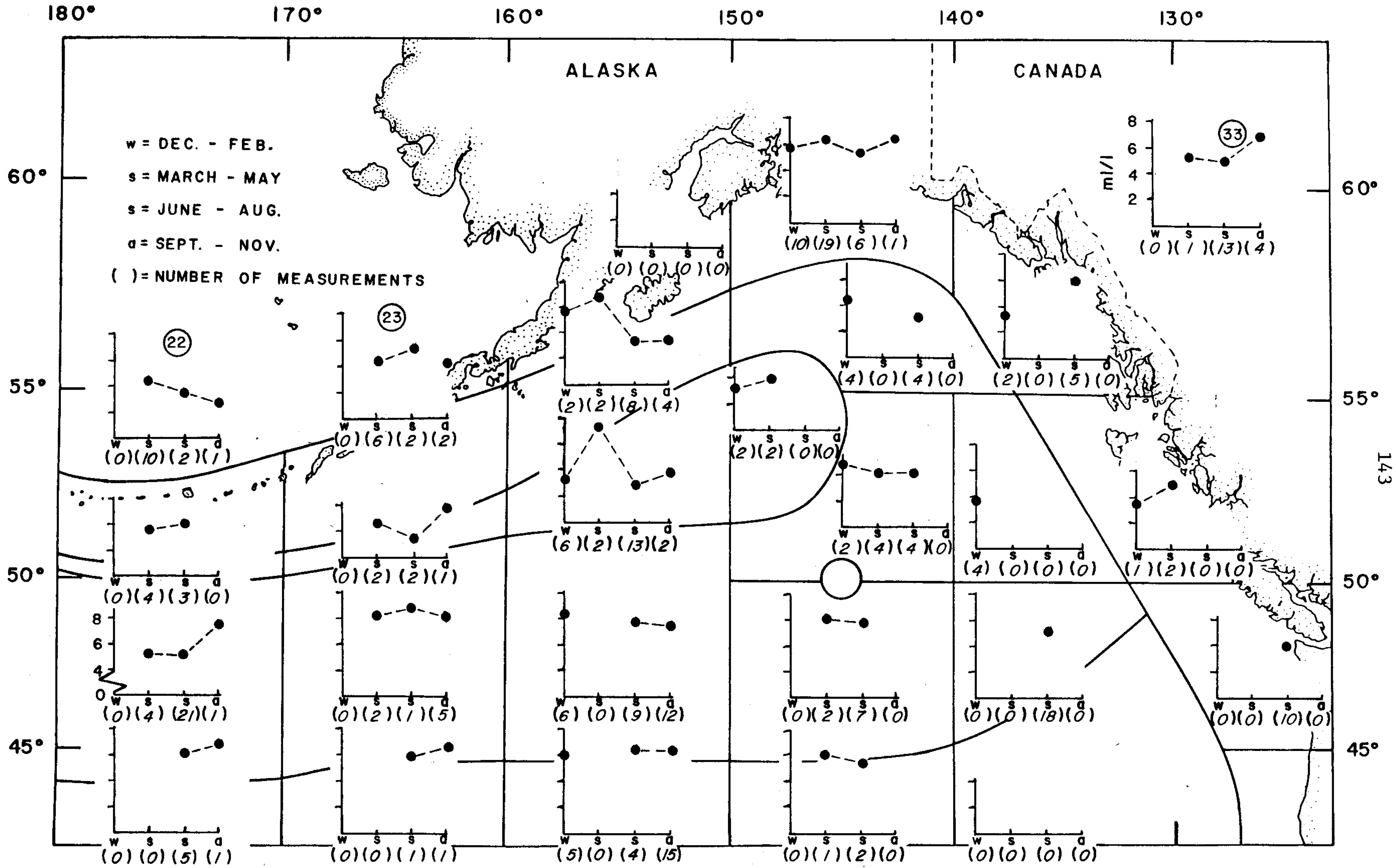


Figure 64. The distribution of oxygen (seasonal means, milliliters per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 100.1 to 150 meters.

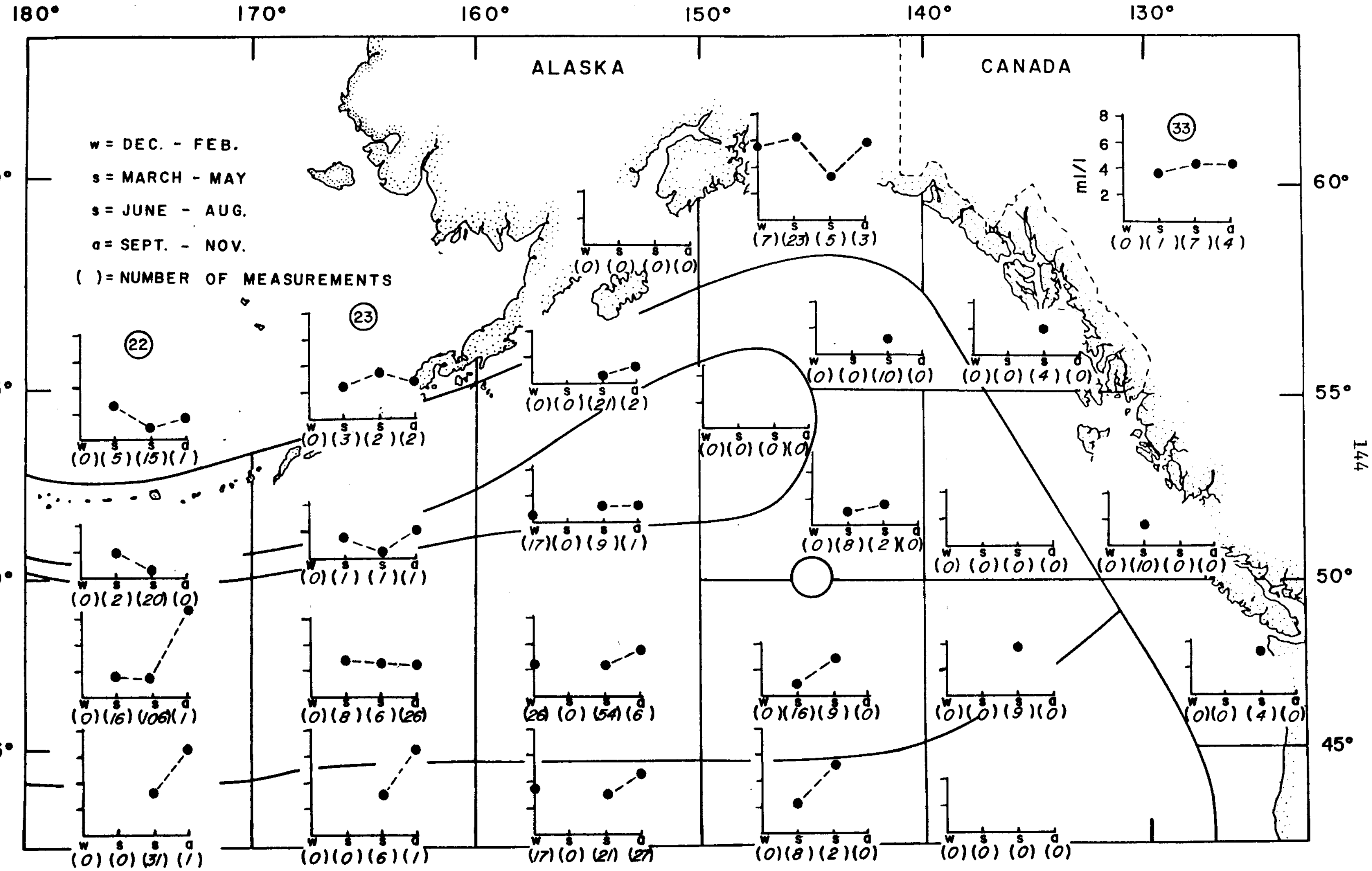


Figure 65. The distribution of oxygen (seasonal means, milliliters per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 150.1 meters to the deepest sampling depth.

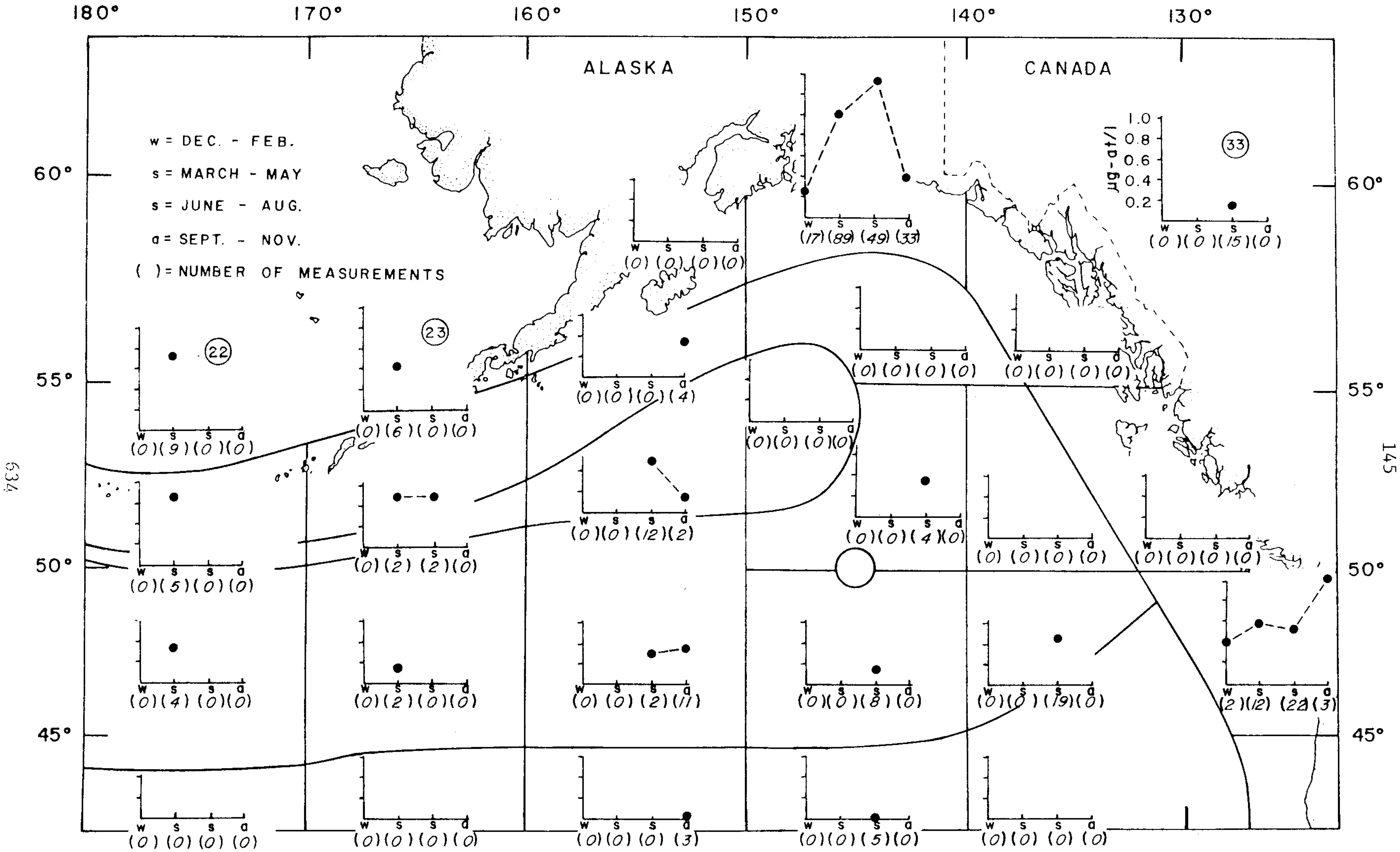


Figure 66. The distribution of ammonia (NH_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 0 to 10 meters.

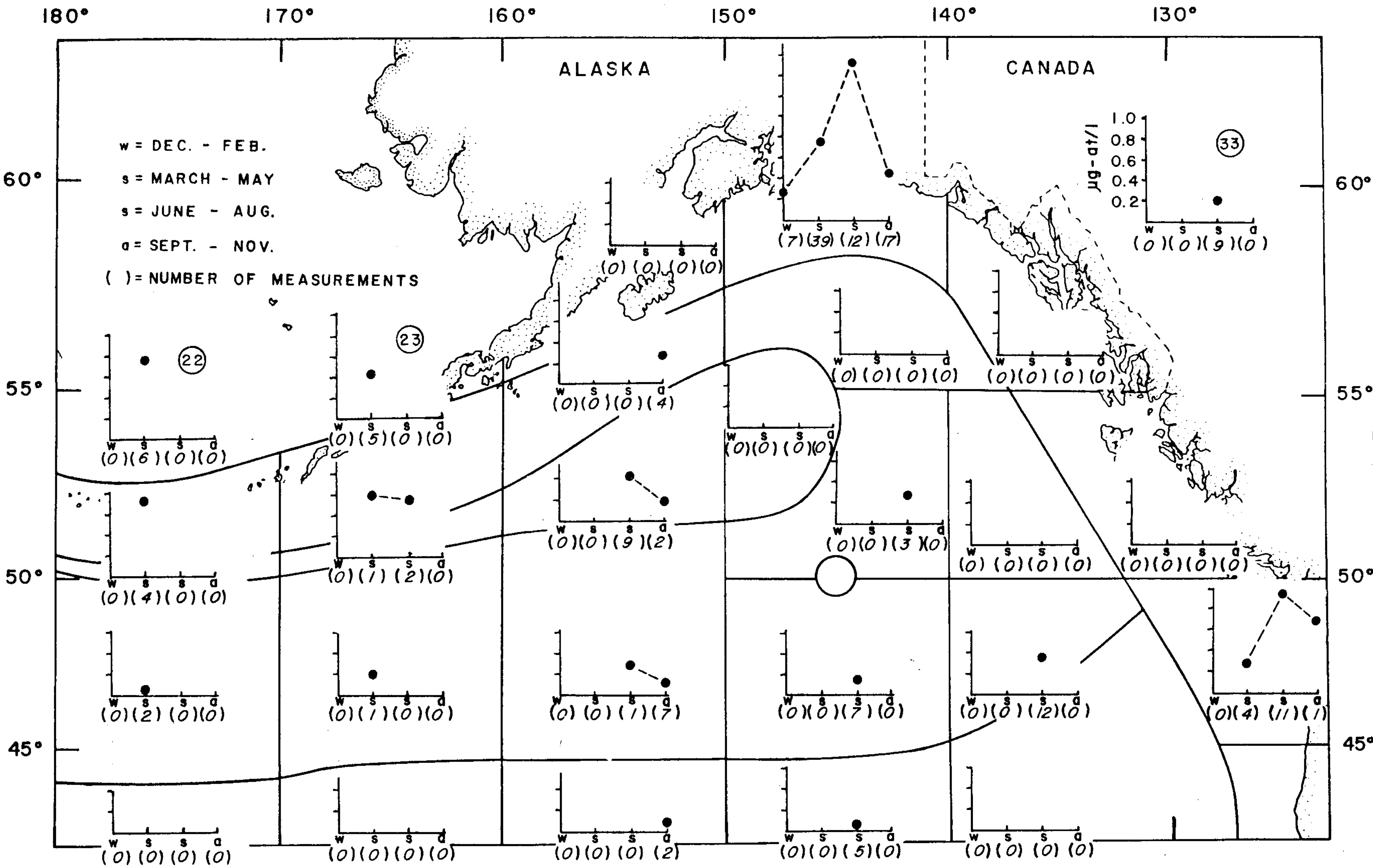


Figure 67. The distribution of ammonia (NH_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 10.1 to 25 meters.

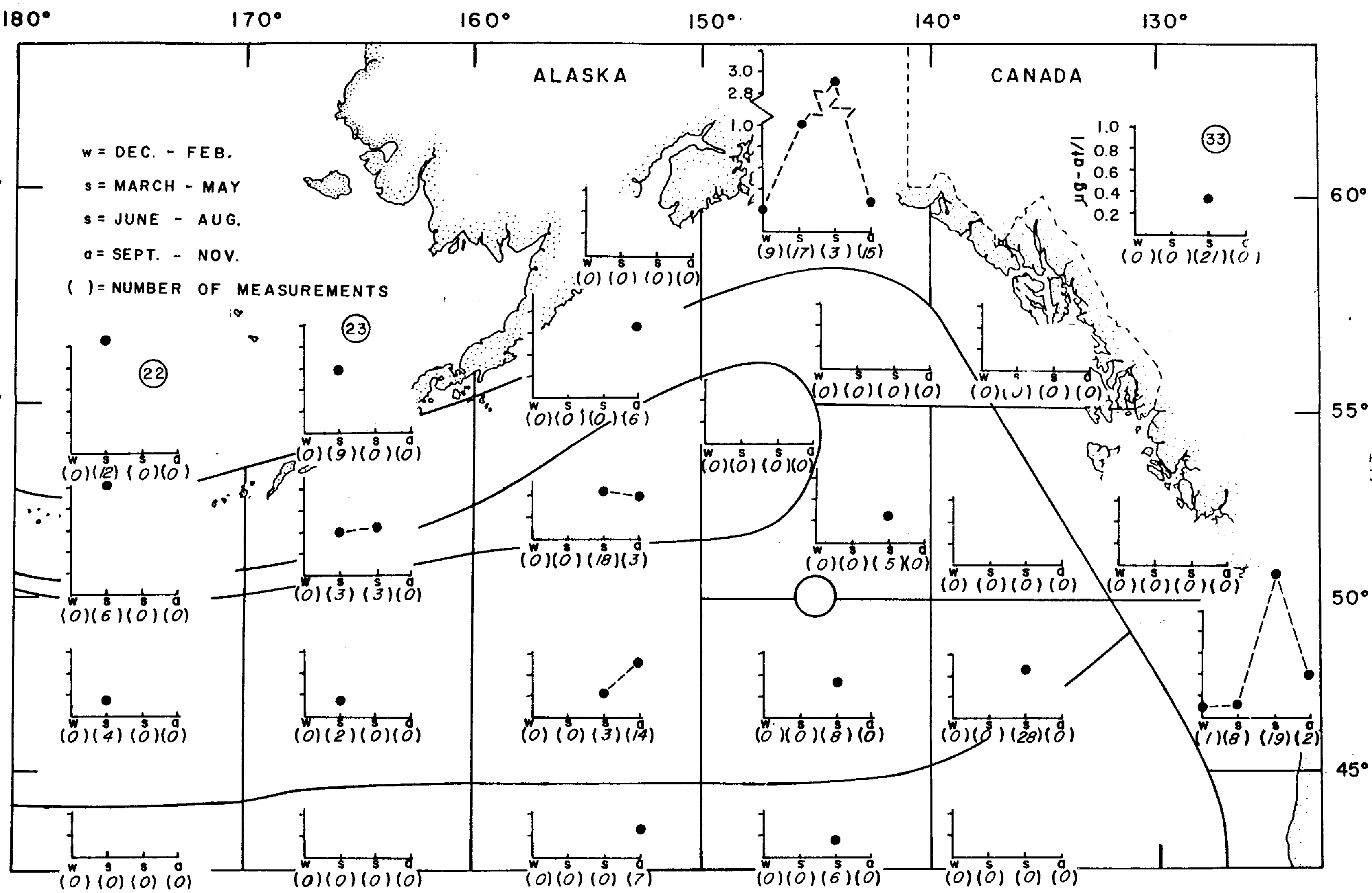


Figure 68. The distribution of ammonia (NH_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 25.1 to 50 meters.

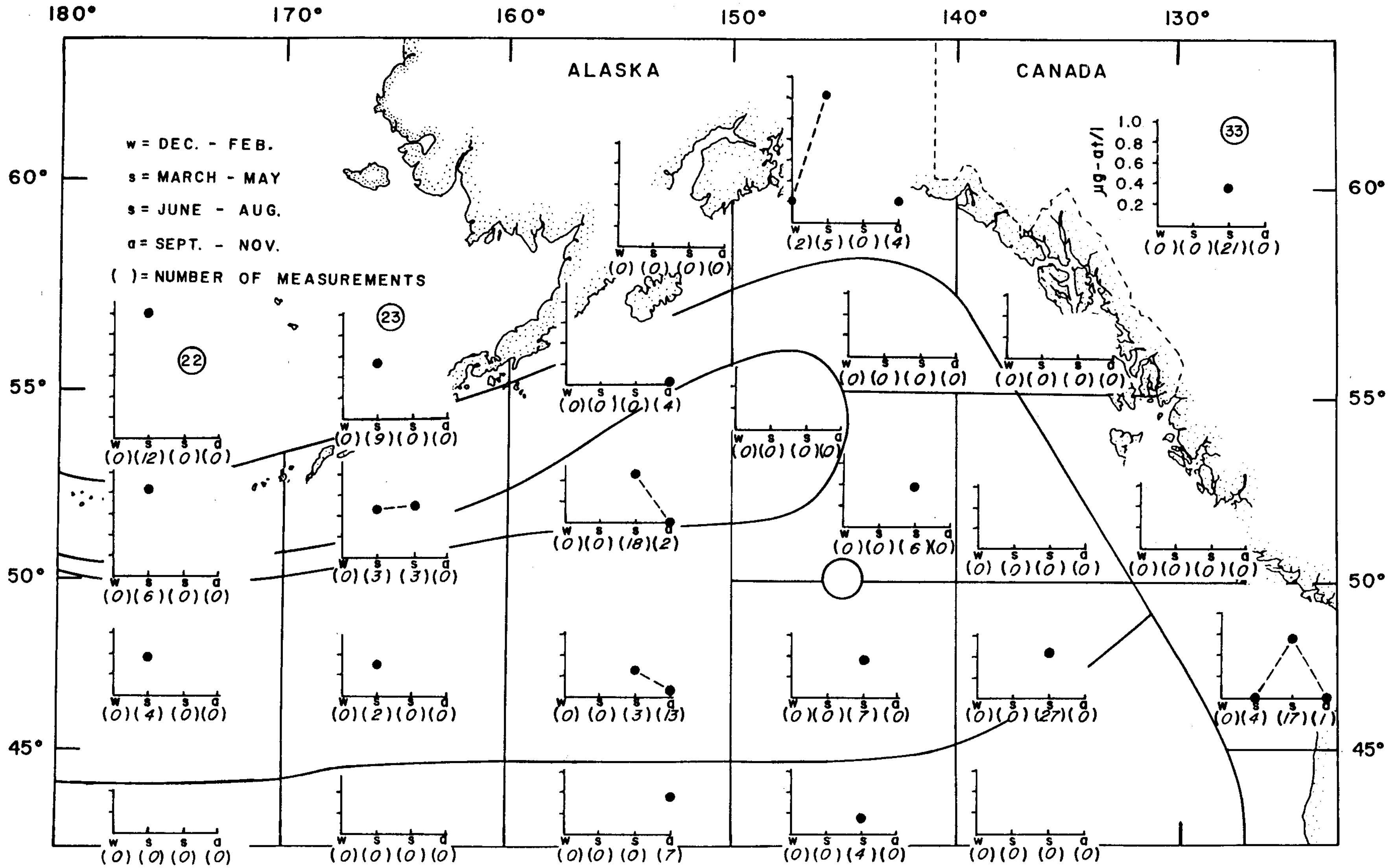


Figure 69. The distribution of ammonia (NH_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 50.1 to 100 meters.

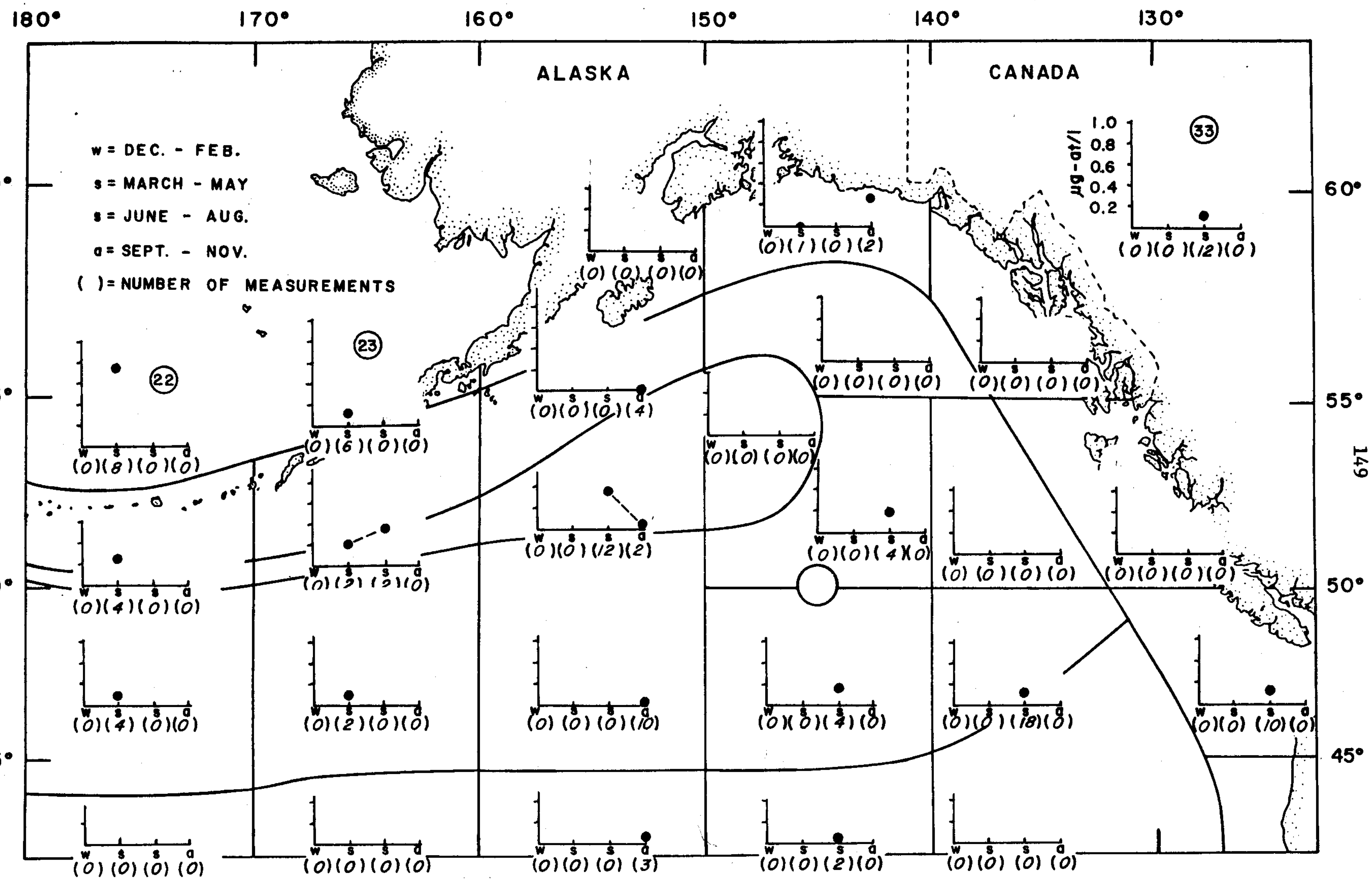


Figure 70. The distribution of ammonia (NH_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 100.1 to 150 meters.

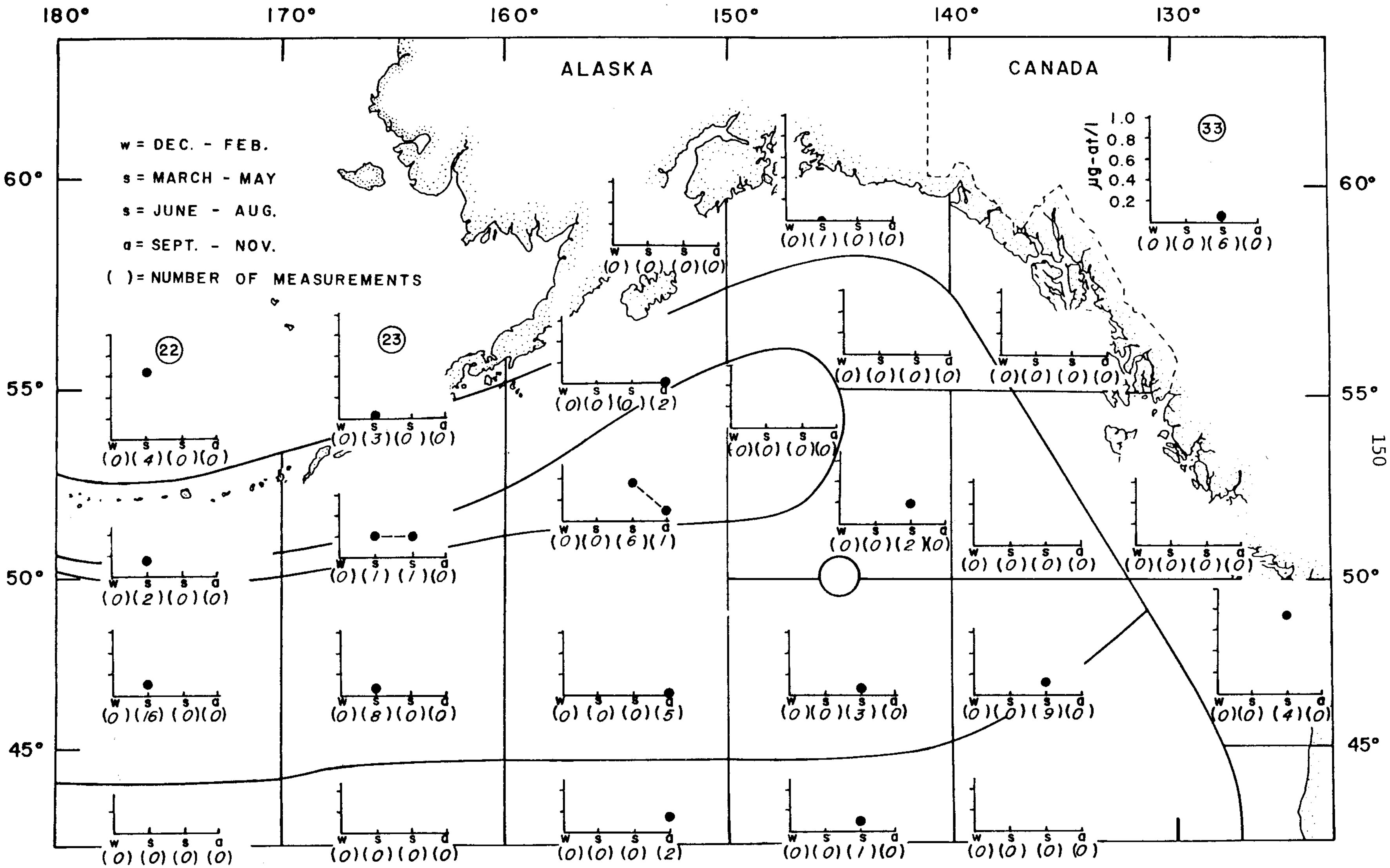


Figure 71. The distribution of ammonia (NH_3, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 150.1 meters to the deepest sampling depth.

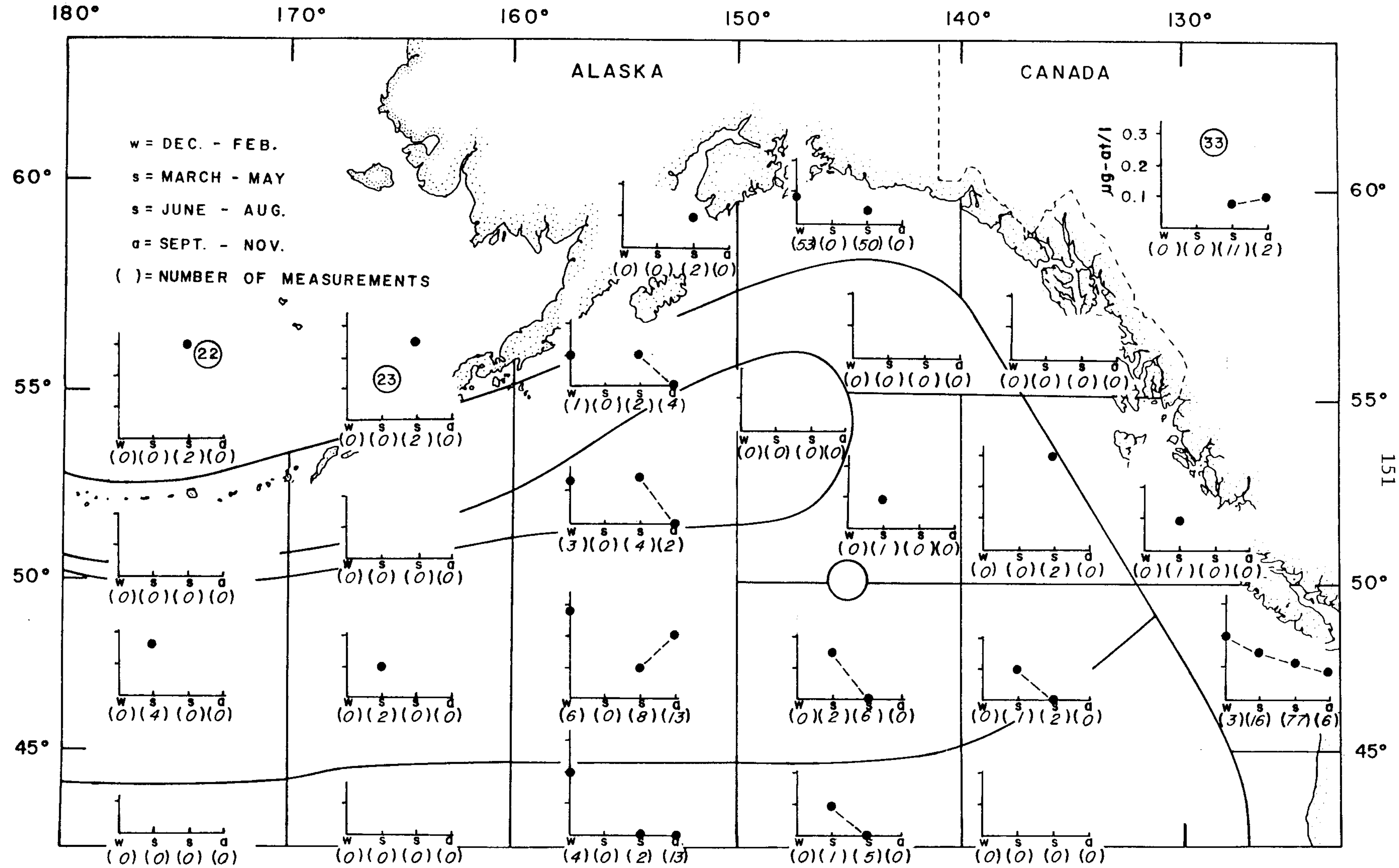


Figure 72. The distribution of nitrite (NO_2, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 0 to 10 meters.

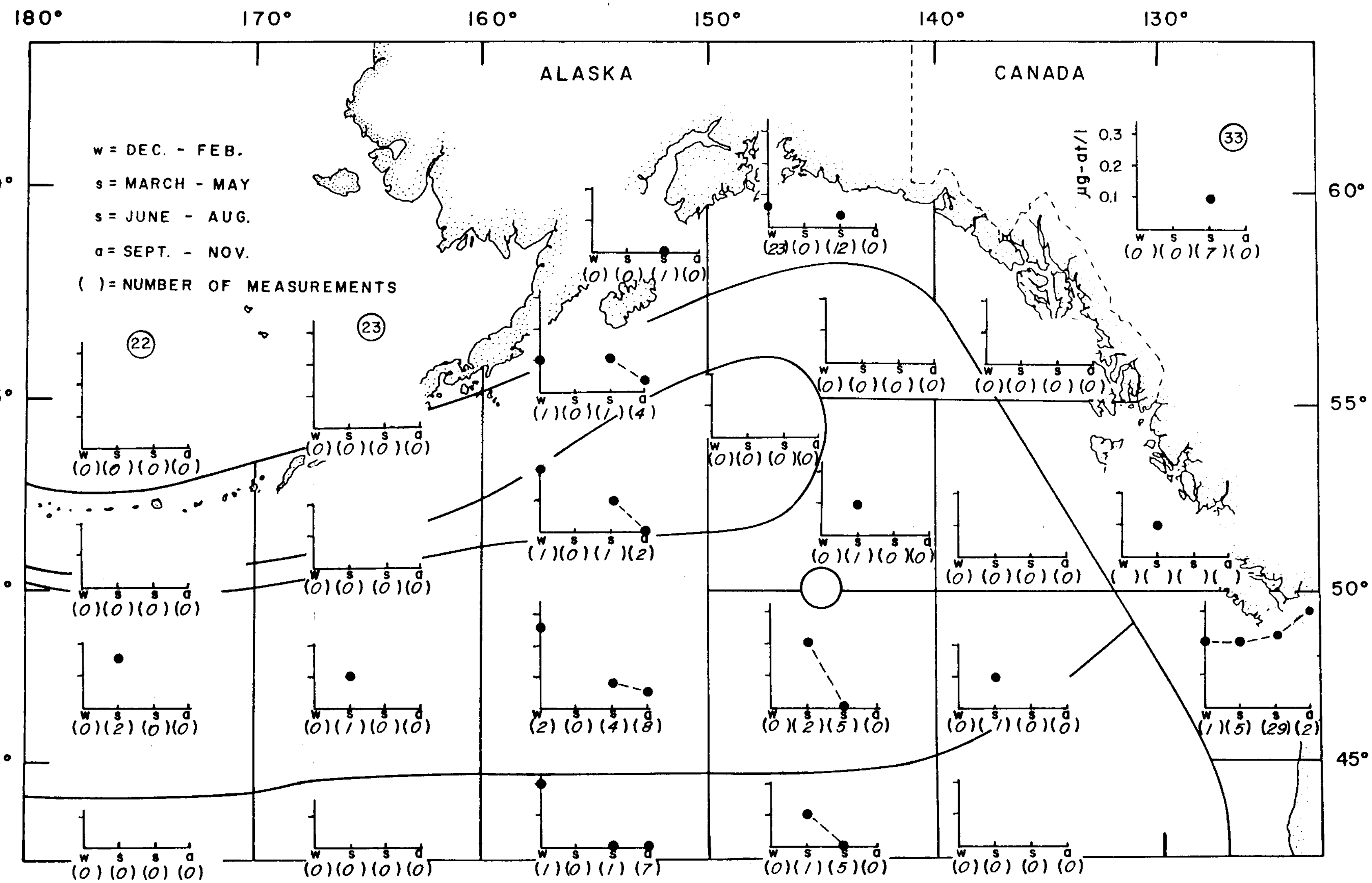


Figure 73. The distribution of nitrite (NO_2, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 10.1 to 25 meters.

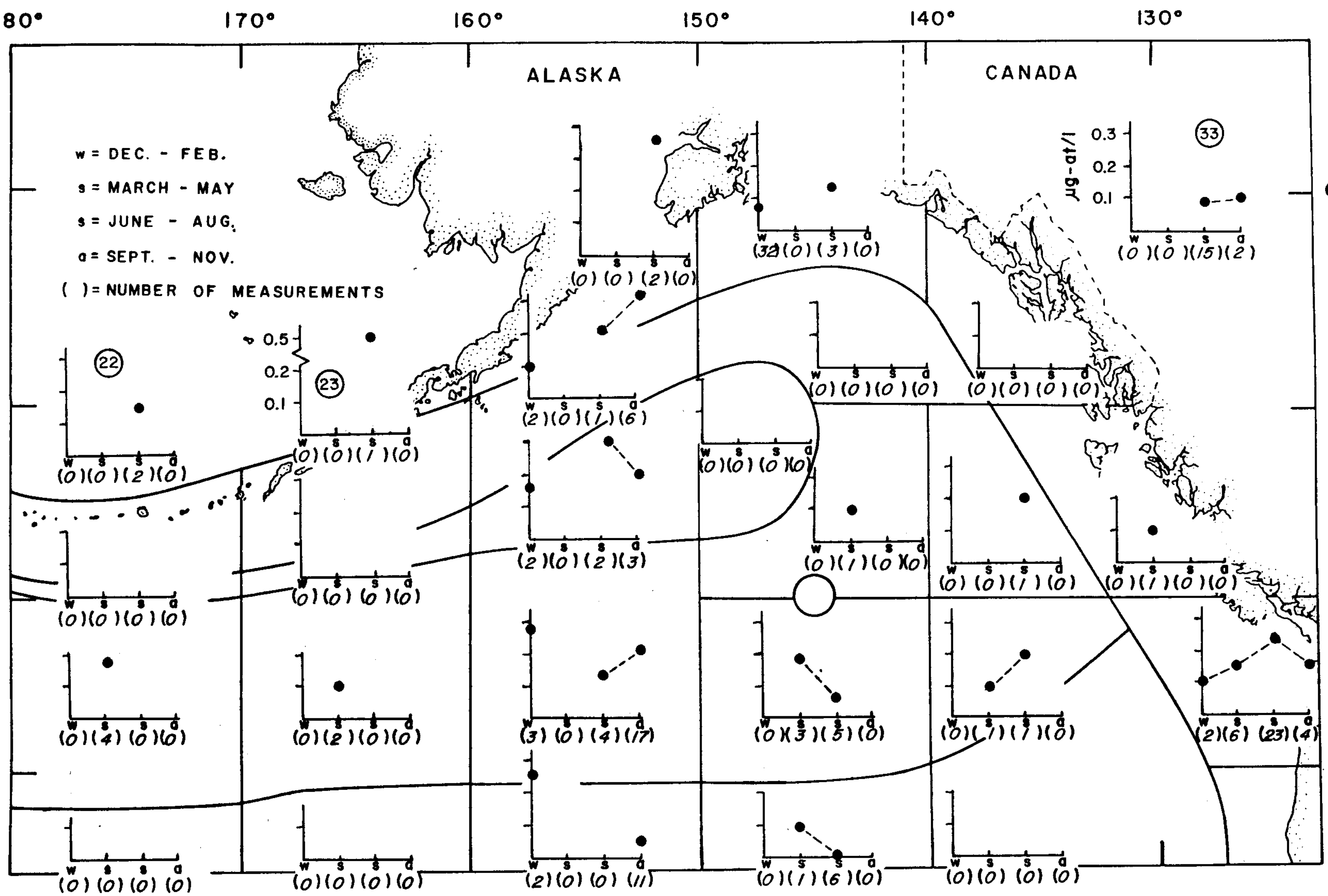


Figure 74. The distribution of nitrite (NO_2, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 25.1 to 50 meters.

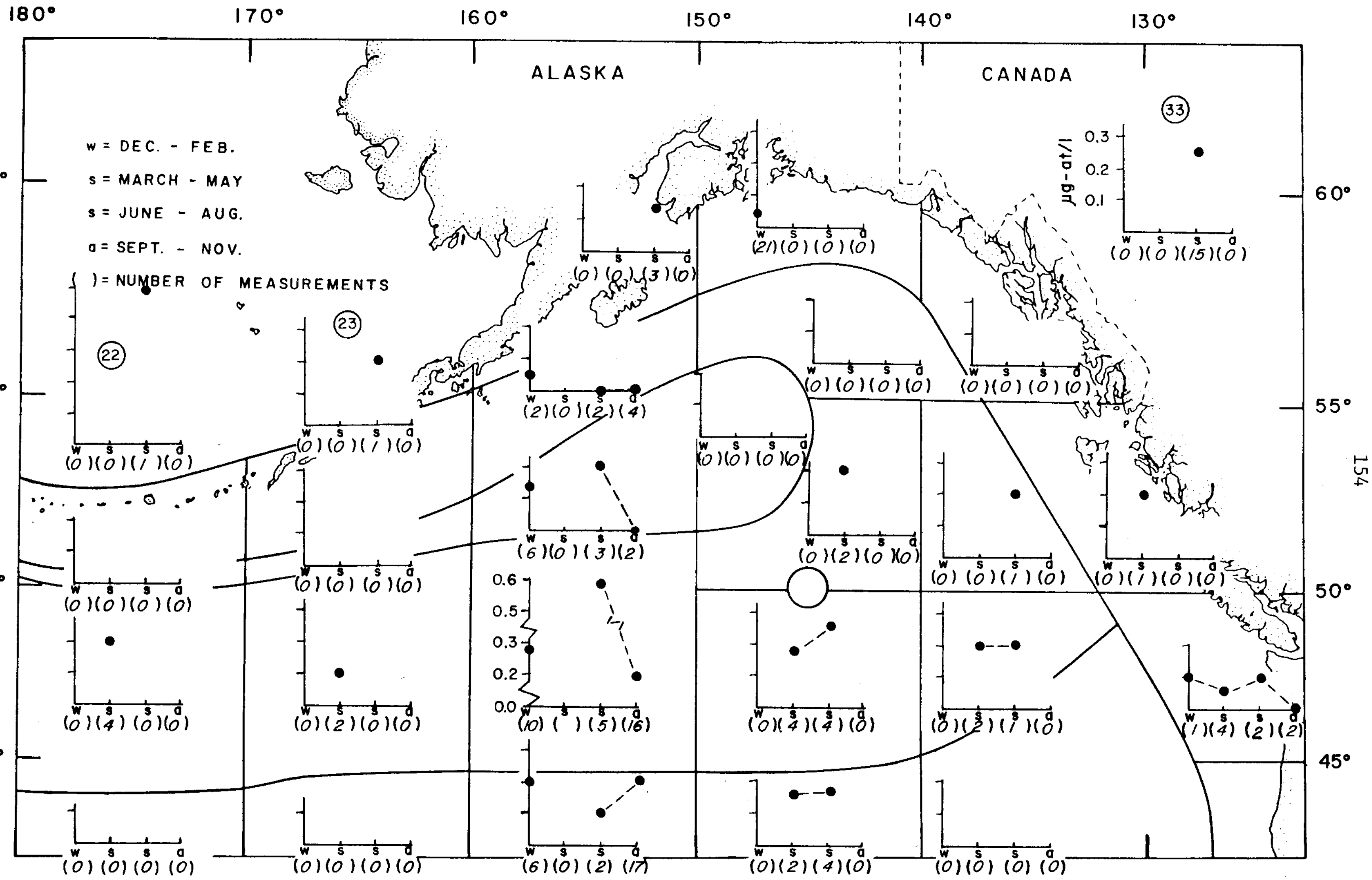


Figure 75. The distribution of nitrite (NO_2, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 50.1 to 100 meters.

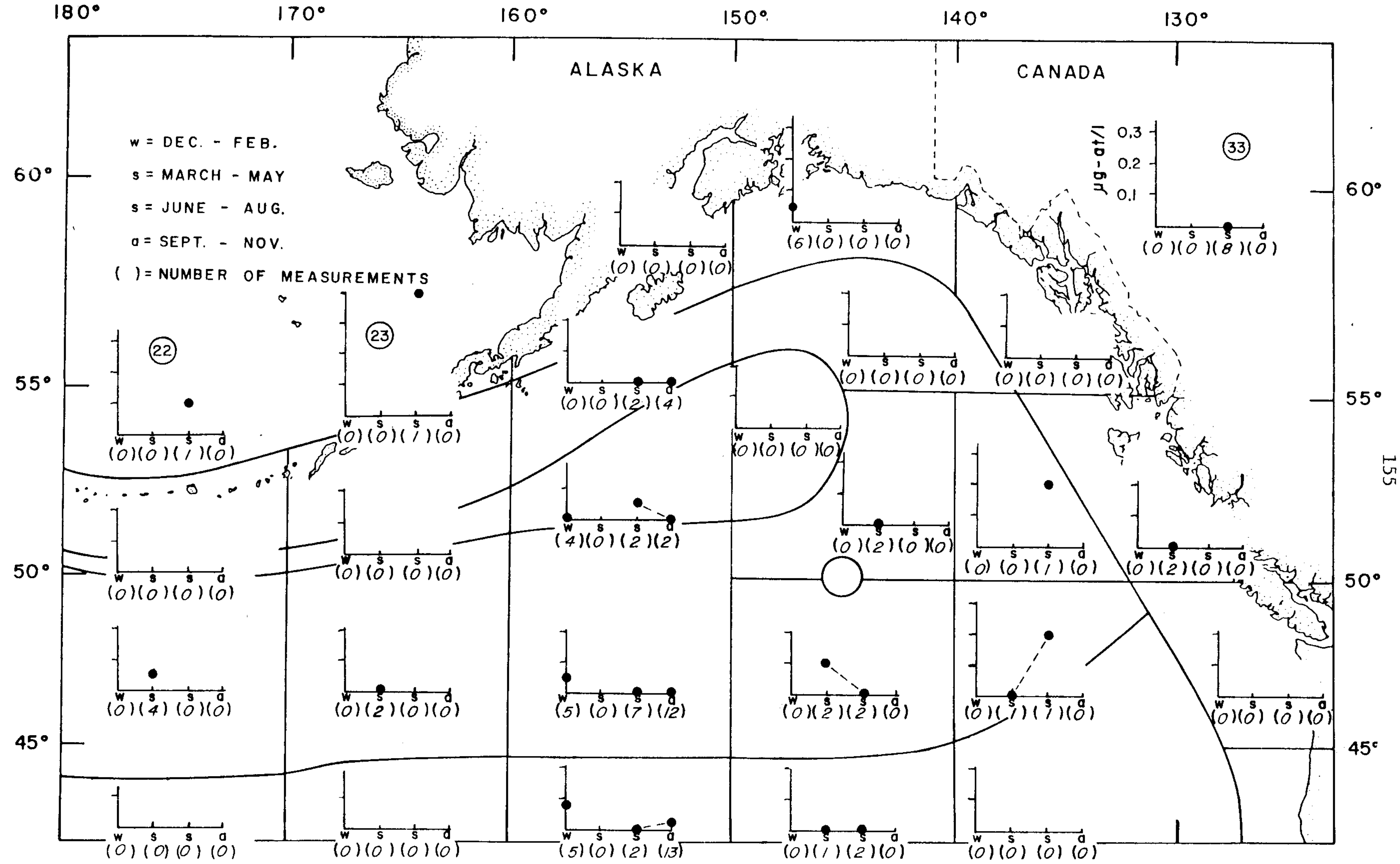


Figure 76. The distribution of nitrite (NO_2, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 100.1 to 150 meters.

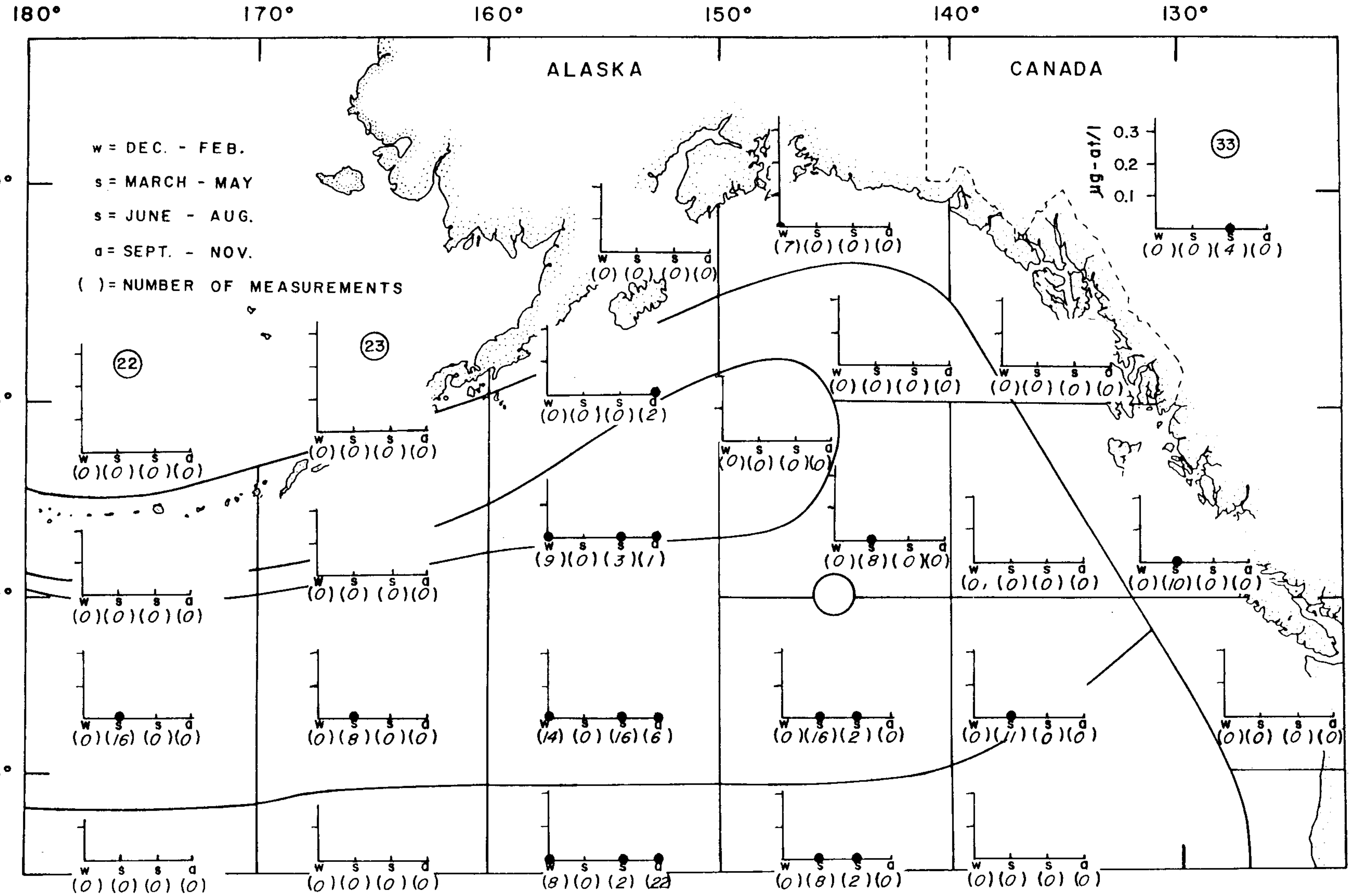


Figure 77. The distribution of nitrite (NO_2, seasonal means, microgram - atoms per liter) in the eastern Subarctic Pacific for the years 1958 through 1974, and the depth range 150.1 meters to the deepest sampling depth.

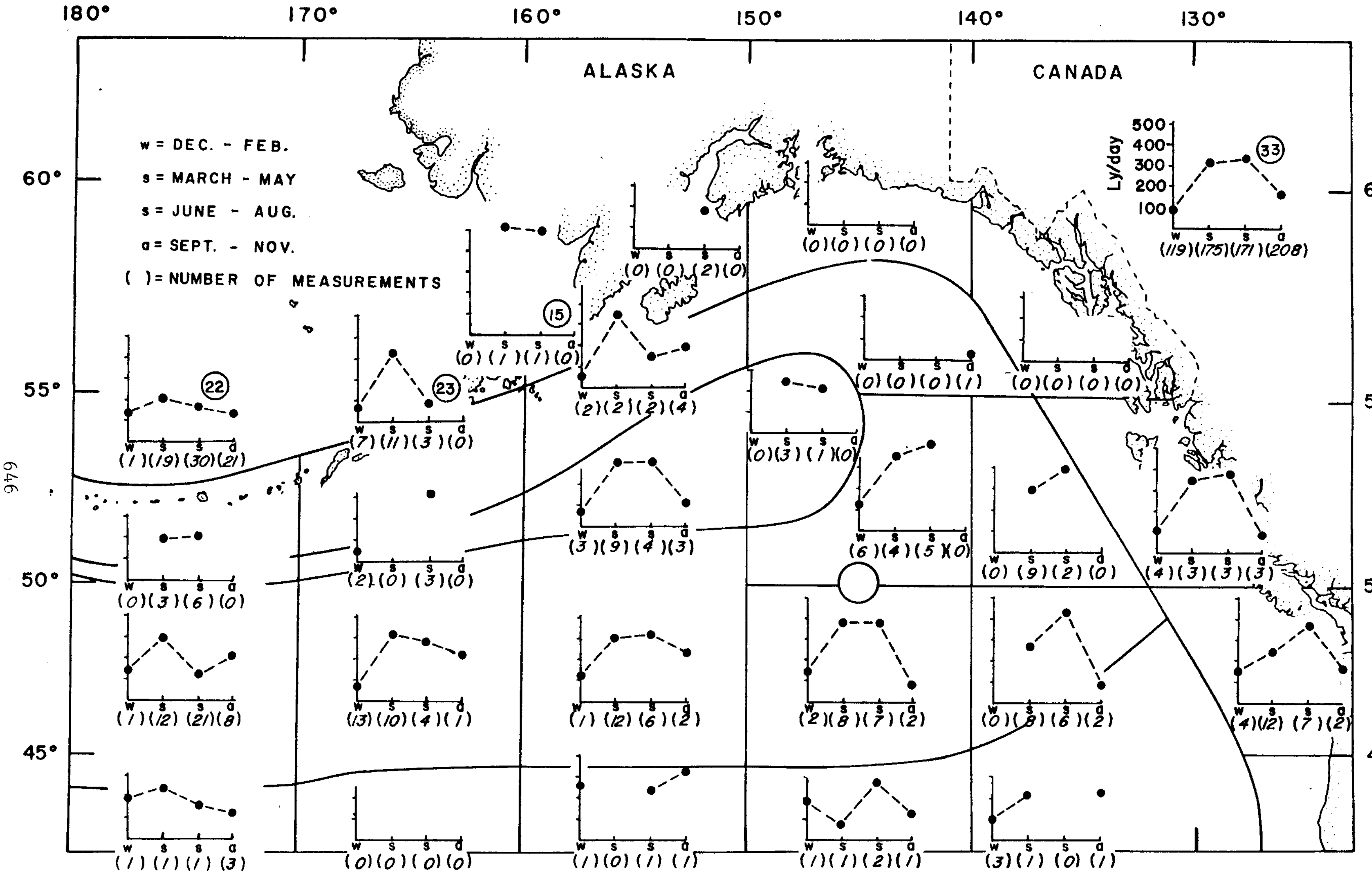


Figure 78. The distribution of incident solar radiation (seasonal means, Langleys per day) in the eastern Subarctic Pacific for the years 1958 through 1974.

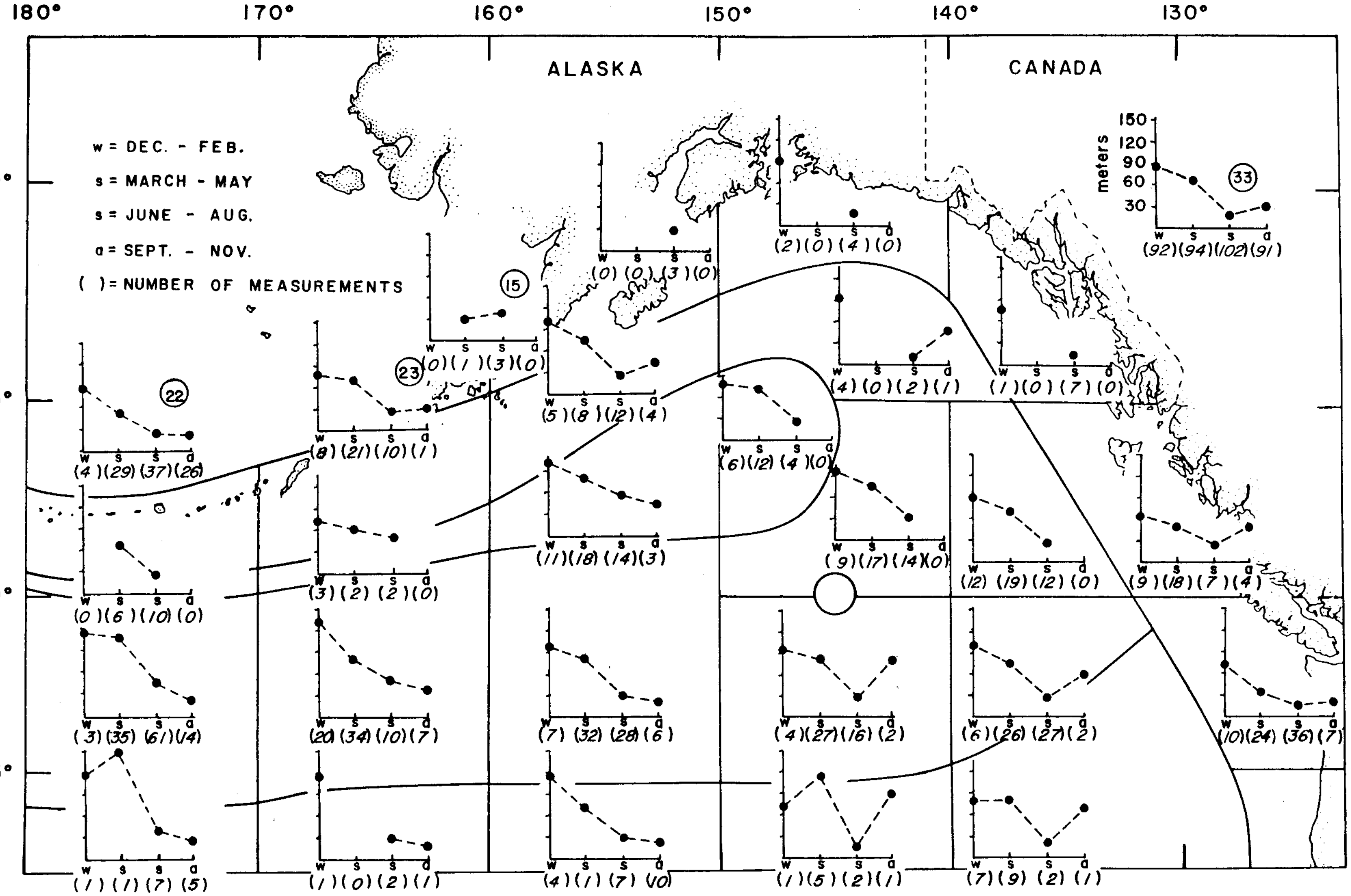


Figure 79. The distribution of the depth of the mixed layer (seasonal means in meters) in the eastern Subarctic Pacific for the years 1958 through 1974.

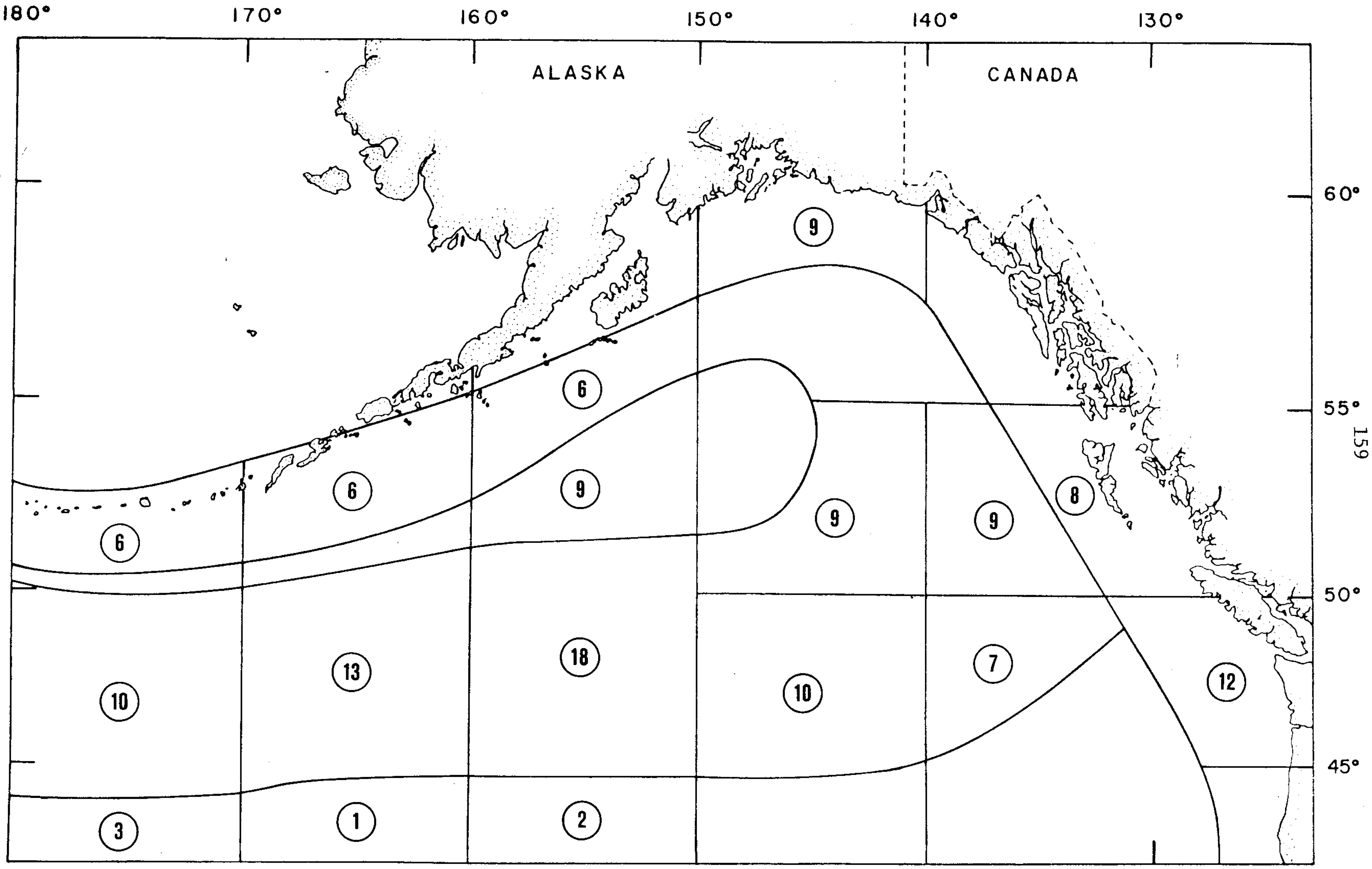


Figure 80. The number of stations within each zone at which phytoplankton species data were collected in the upper 10 meters of the water column from January to July, 1966, and 1969 to 1972.

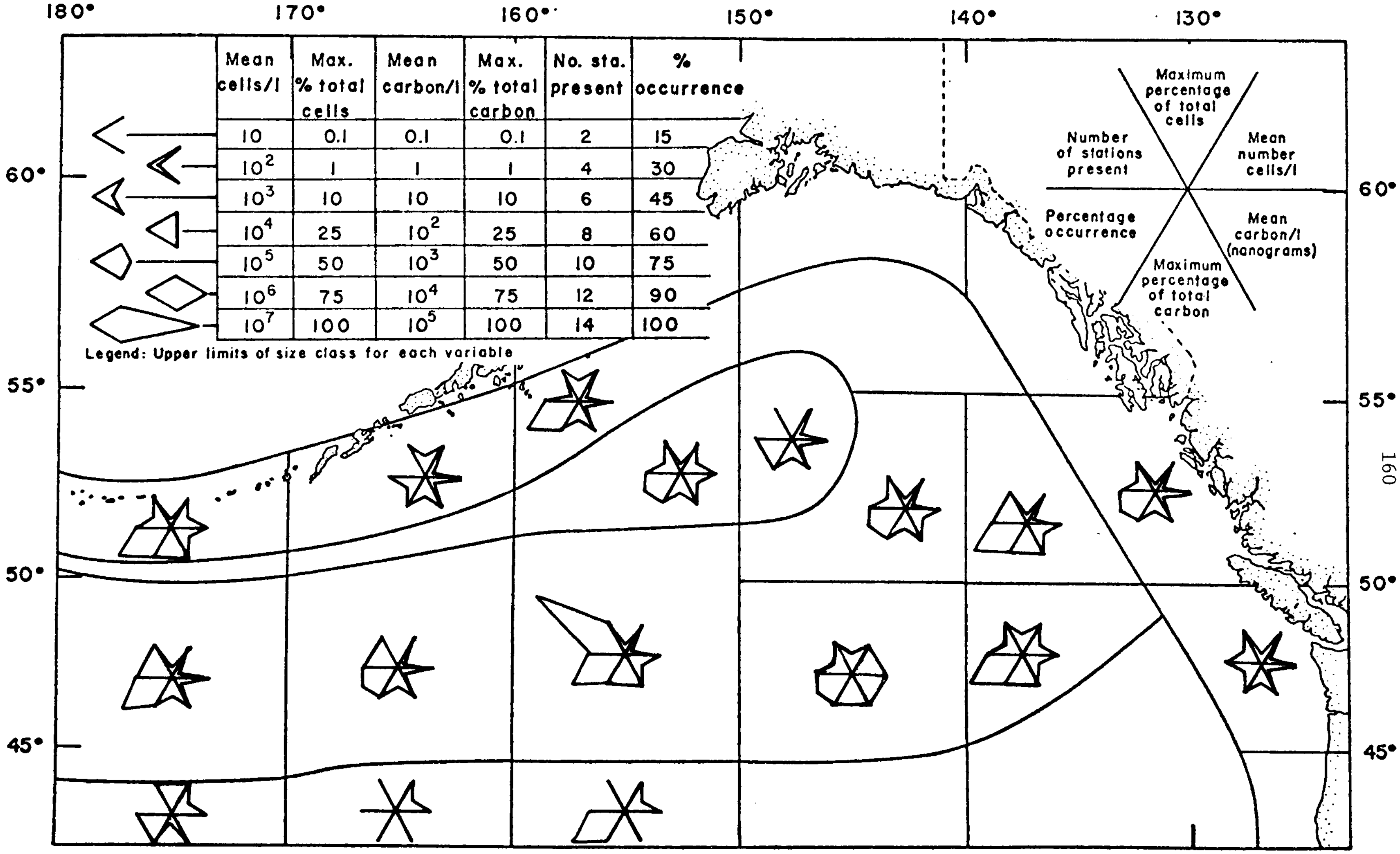


Figure 81. The distribution of *Asteromphalus* spp. in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

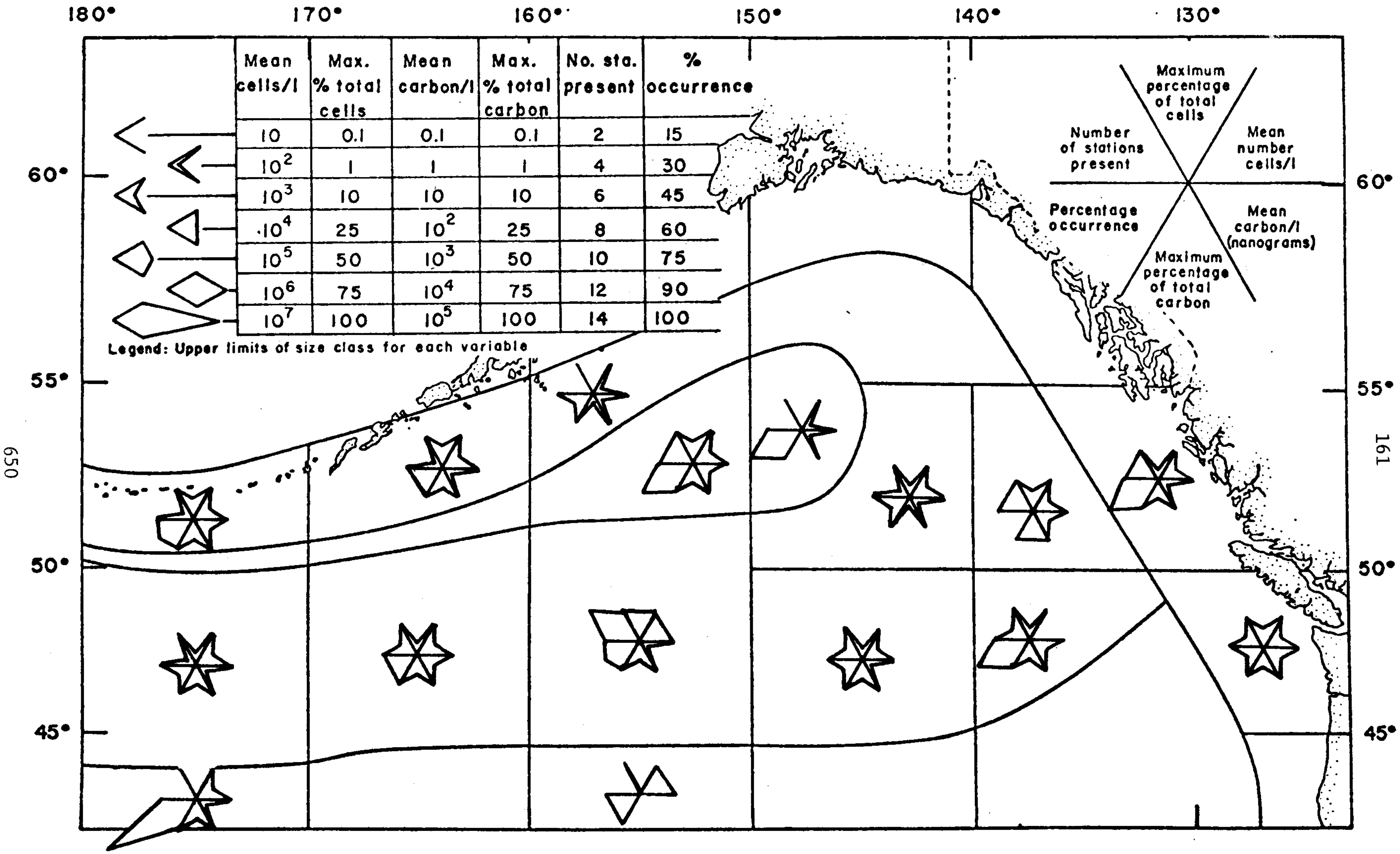


Figure 82. The distribution of *Chaetoceros atlanticus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

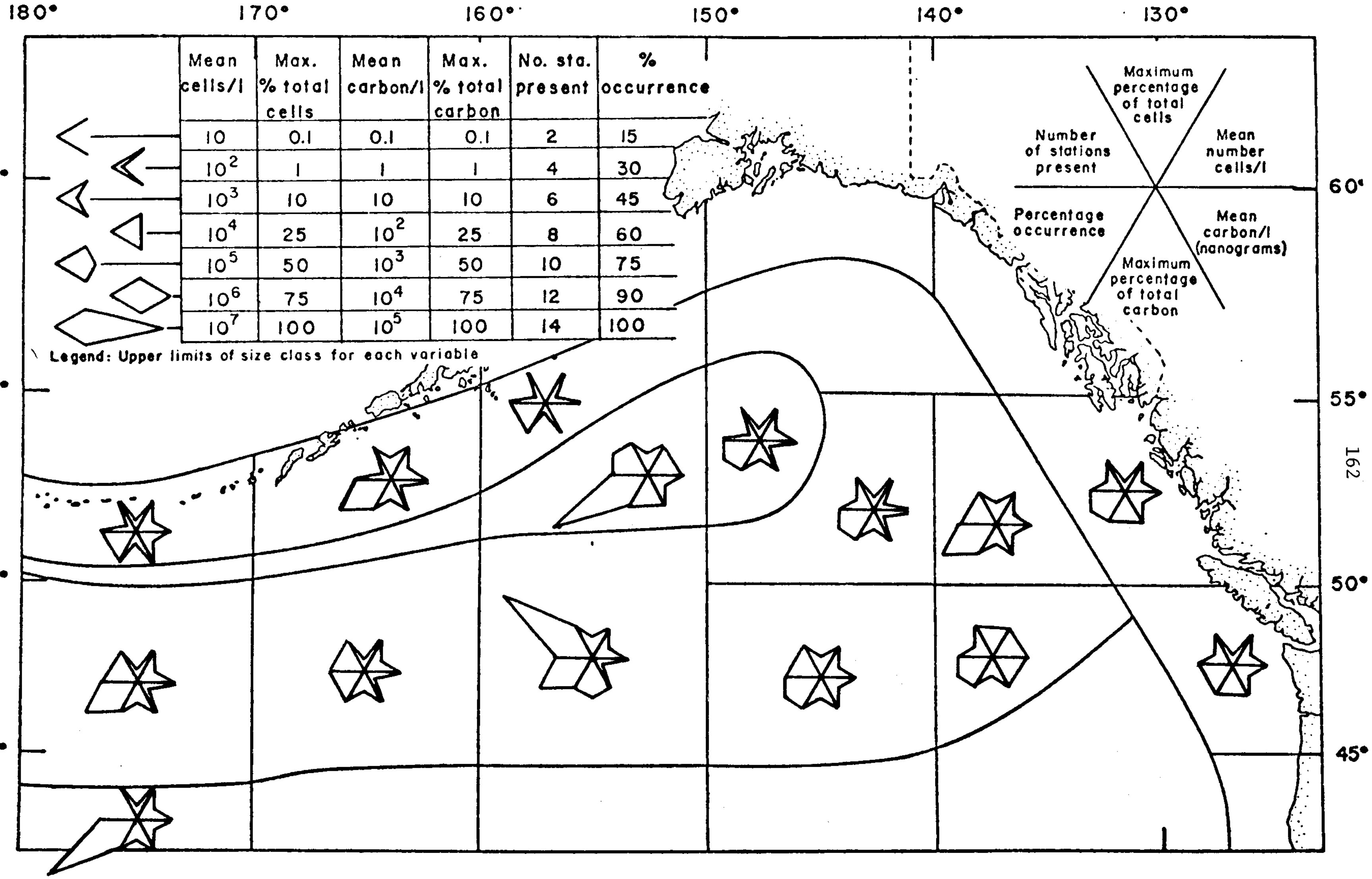


Figure 83. The distribution of *Chaetoceros convolutus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

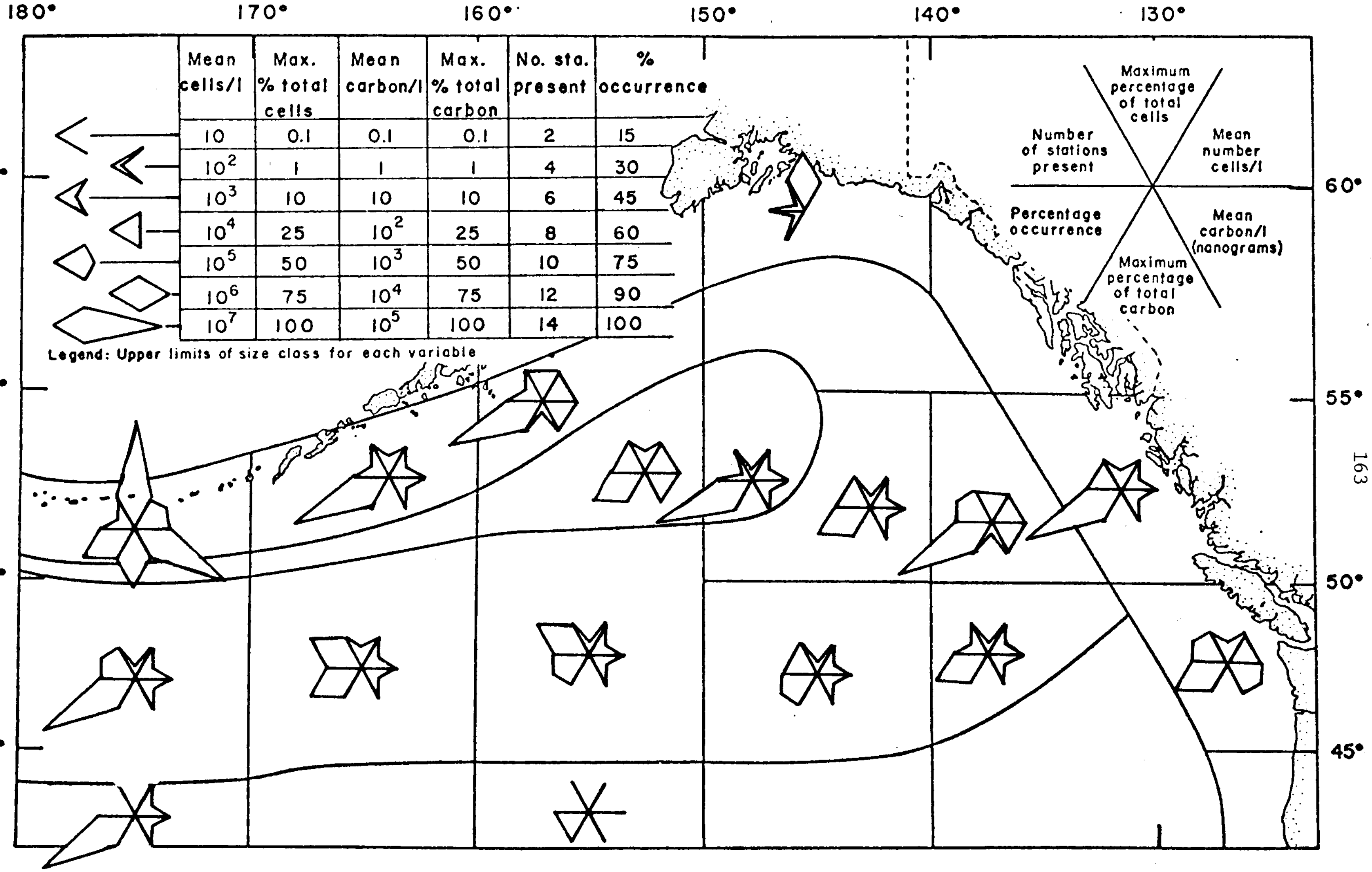


Figure 84. The distribution of *Chaetoceros* hyalochaete spp. in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

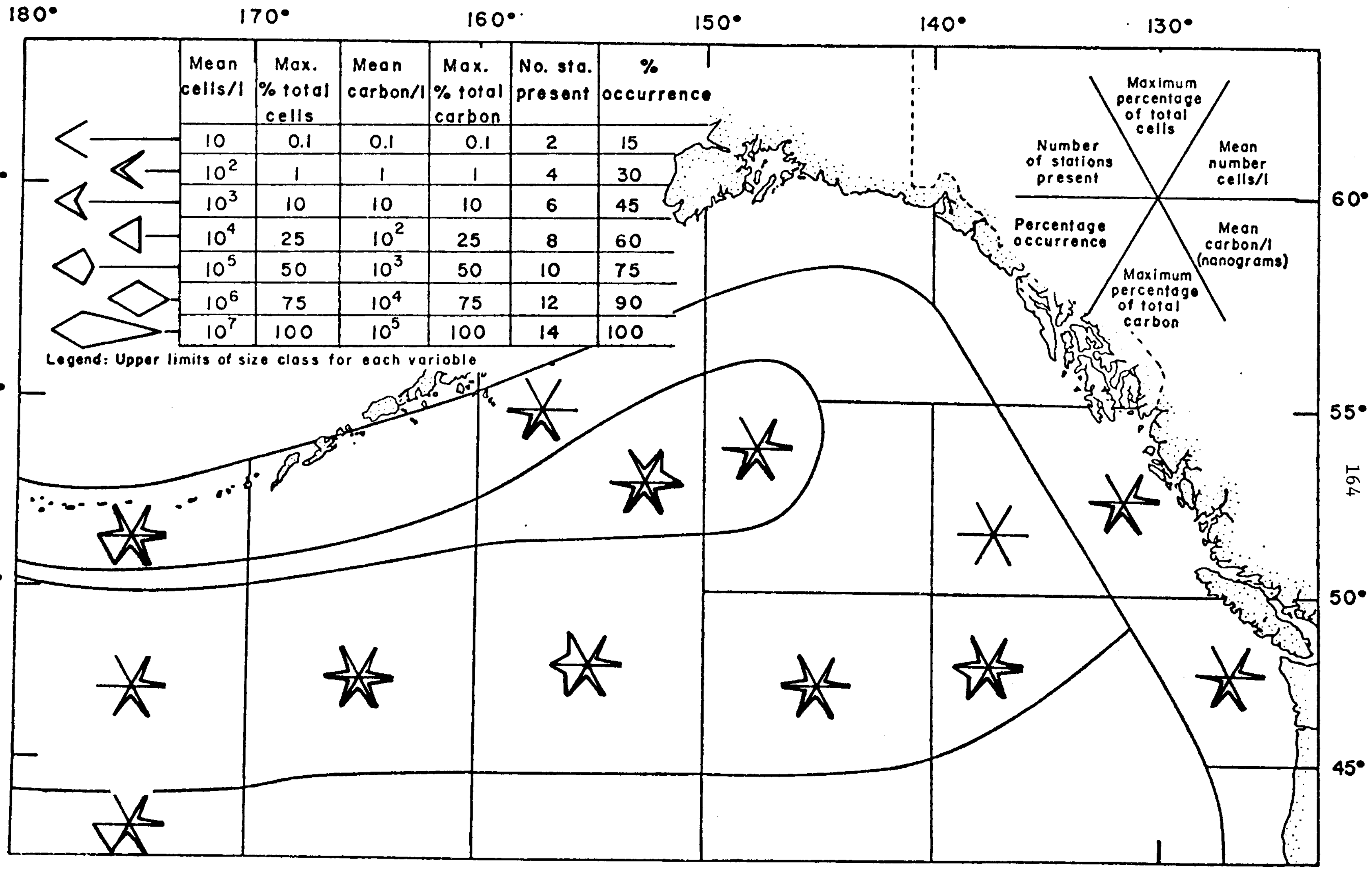


Figure 85. The distribution of *Chaetoceros peruvianus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

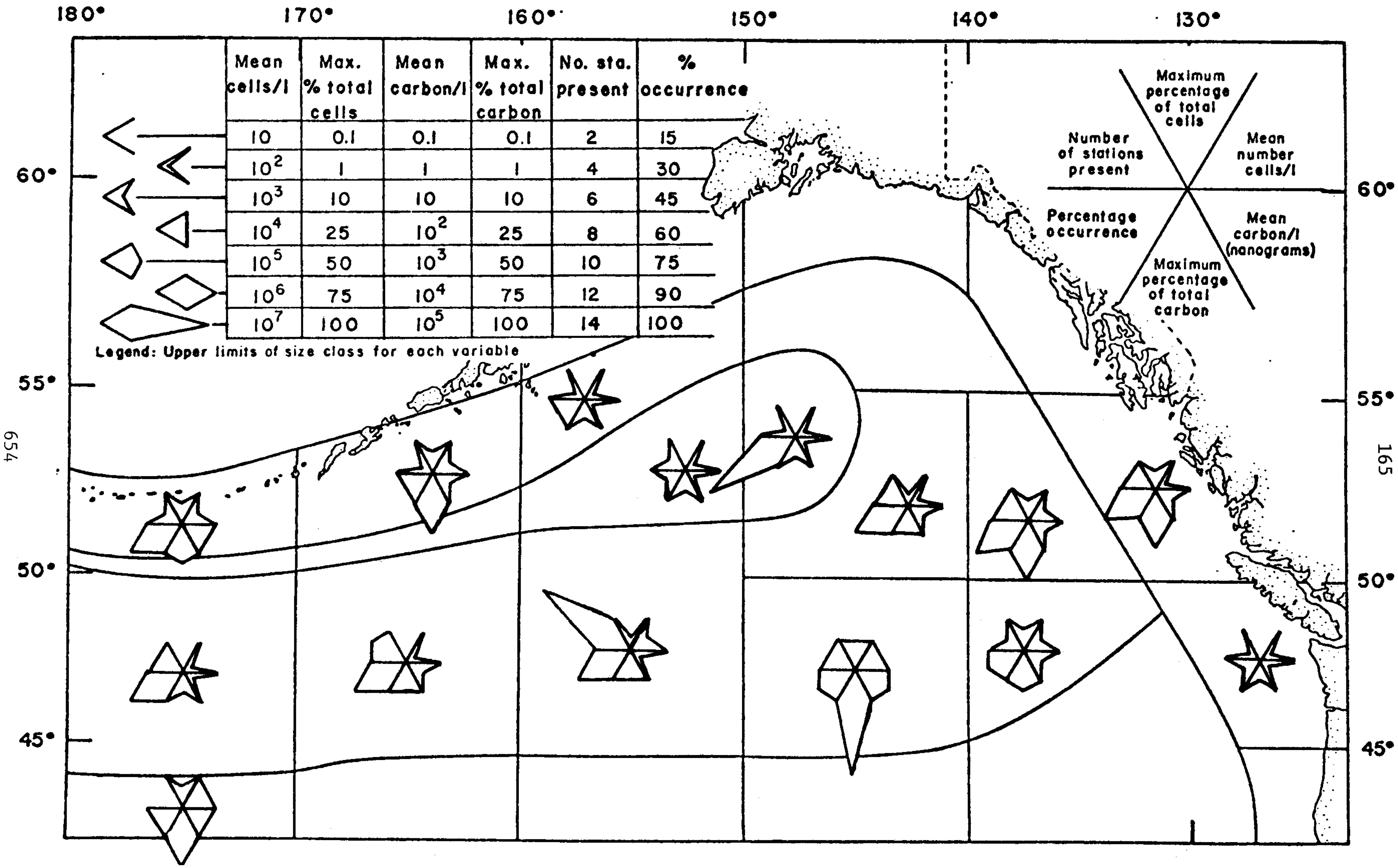


Figure 86. The distribution of *Corethron hystrix* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

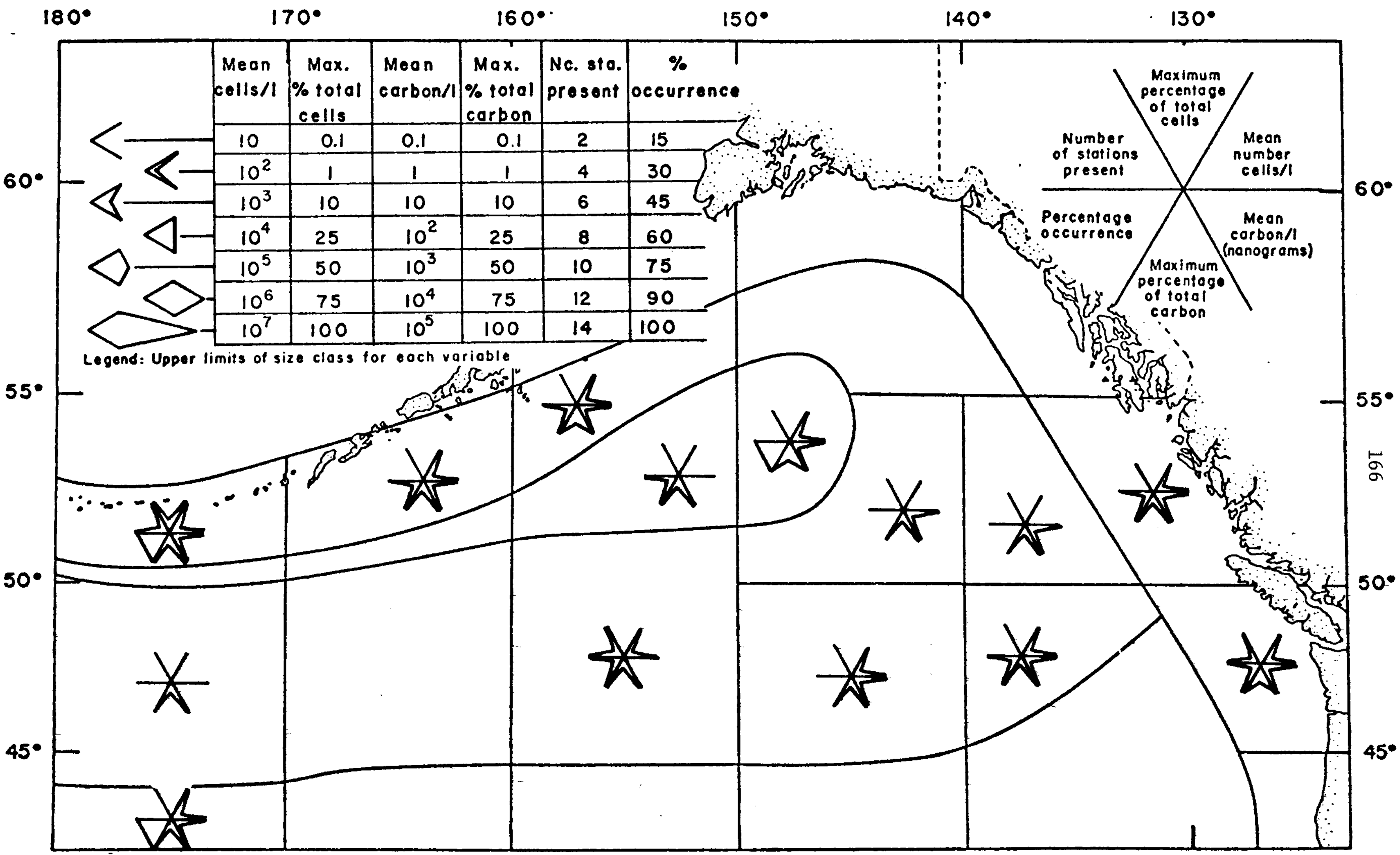


Figure 87. The distribution of *Coscinodiscus centralis* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

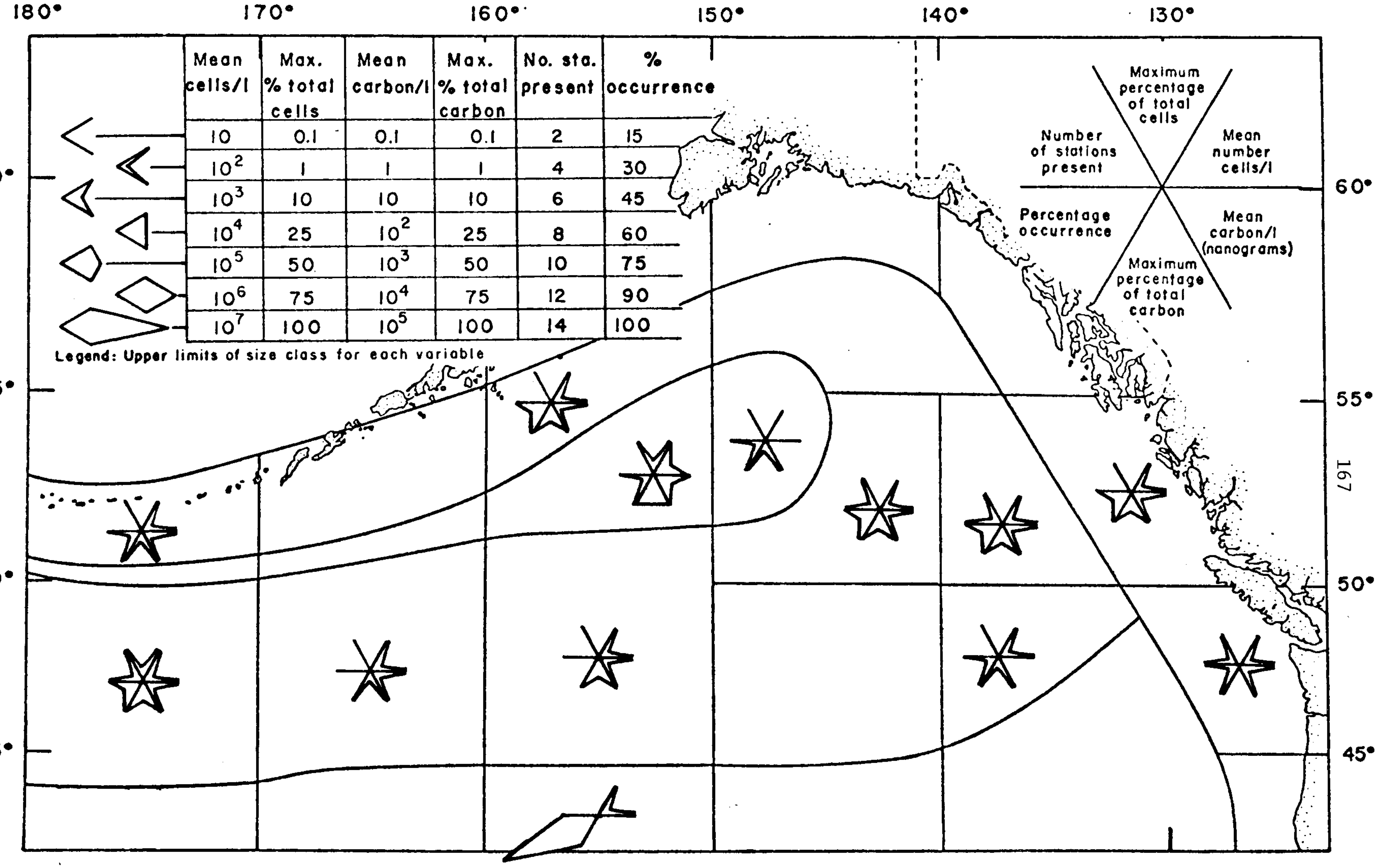


Figure 88. The distribution of *Coscinodiscus curvatulus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

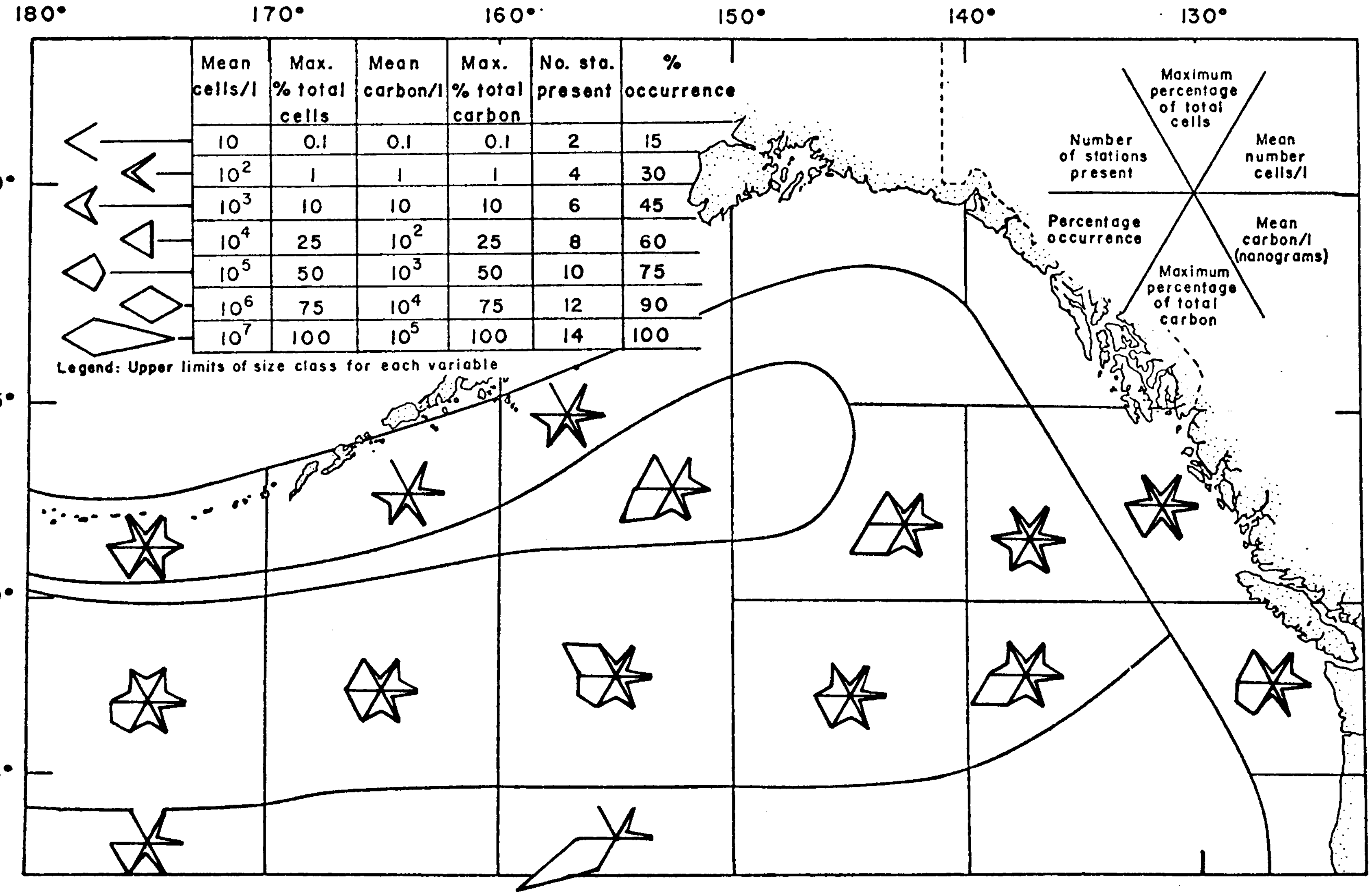


Figure 89. The distribution of *Coscinodiscus lineatus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

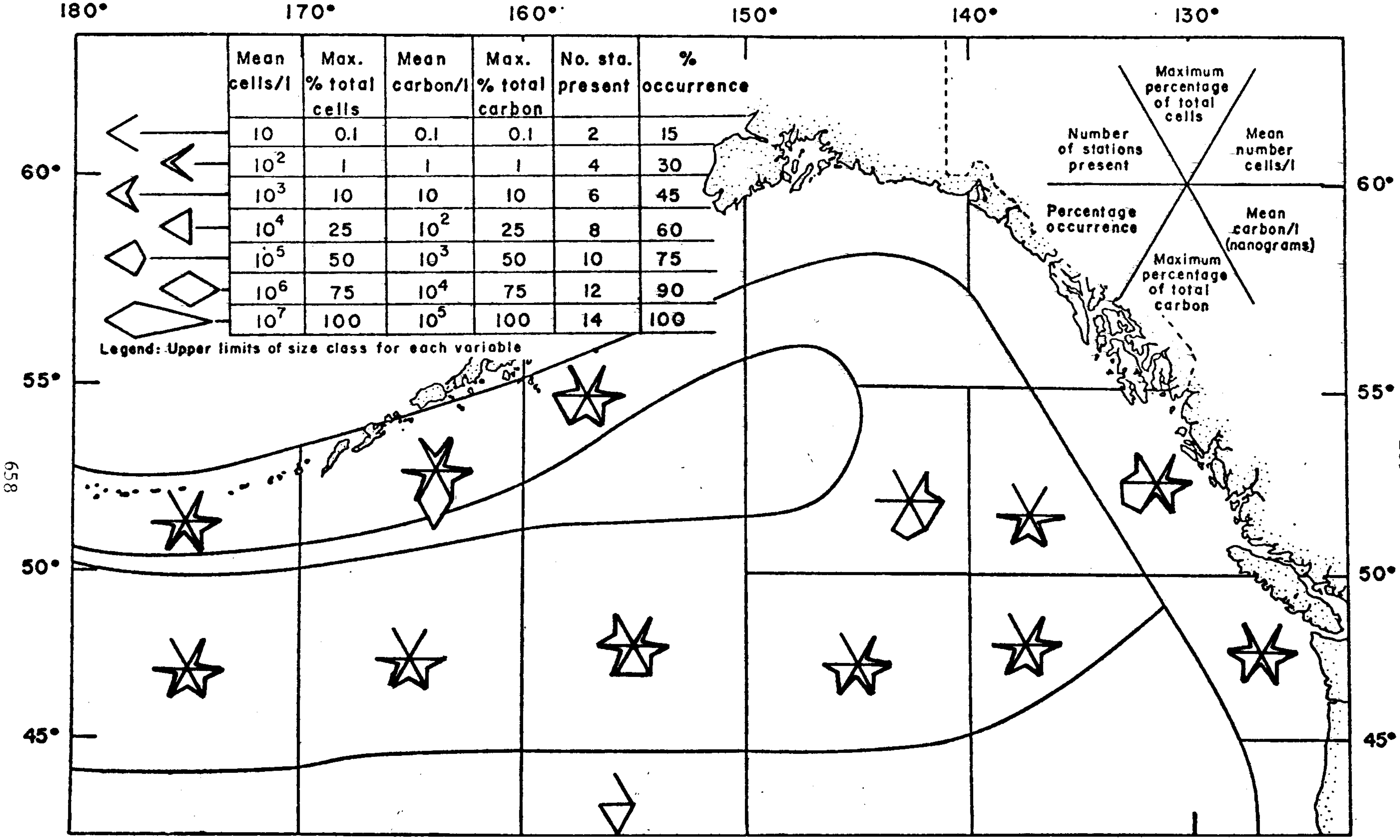
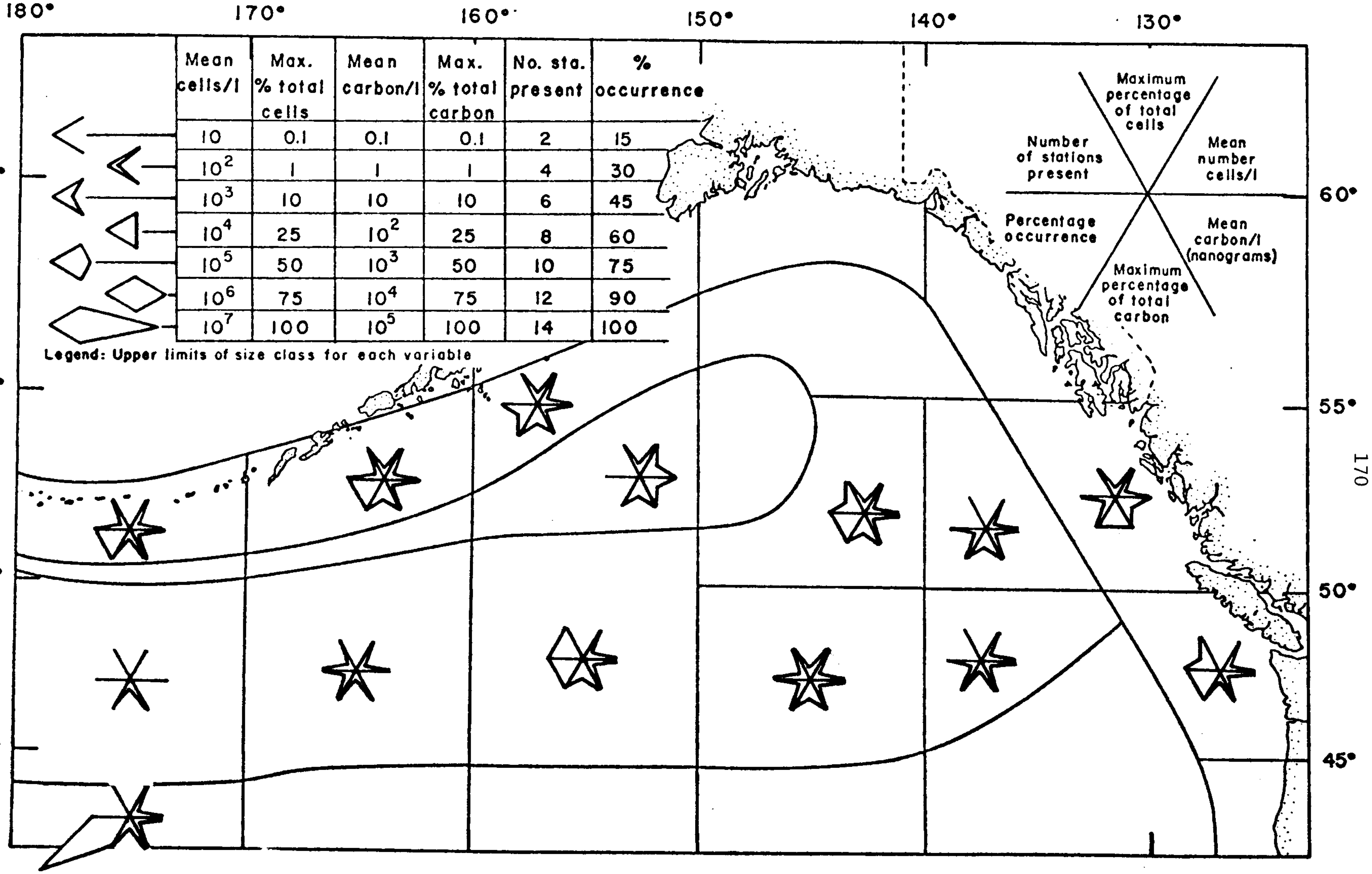


Figure 90. The distribution of *Coscinodiscus oculus iridis* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 91. The distribution of *Coscinodiscus radiatus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

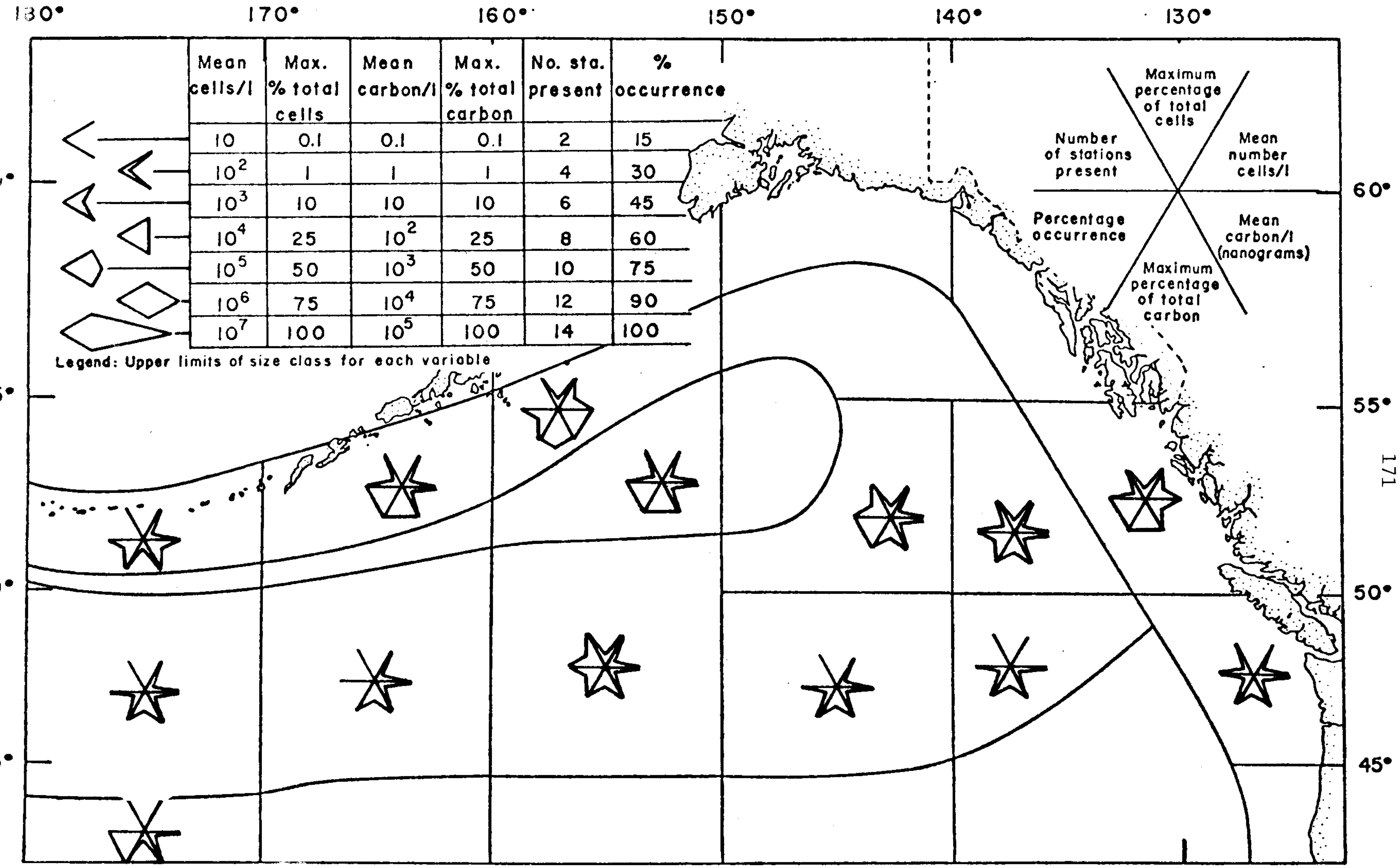
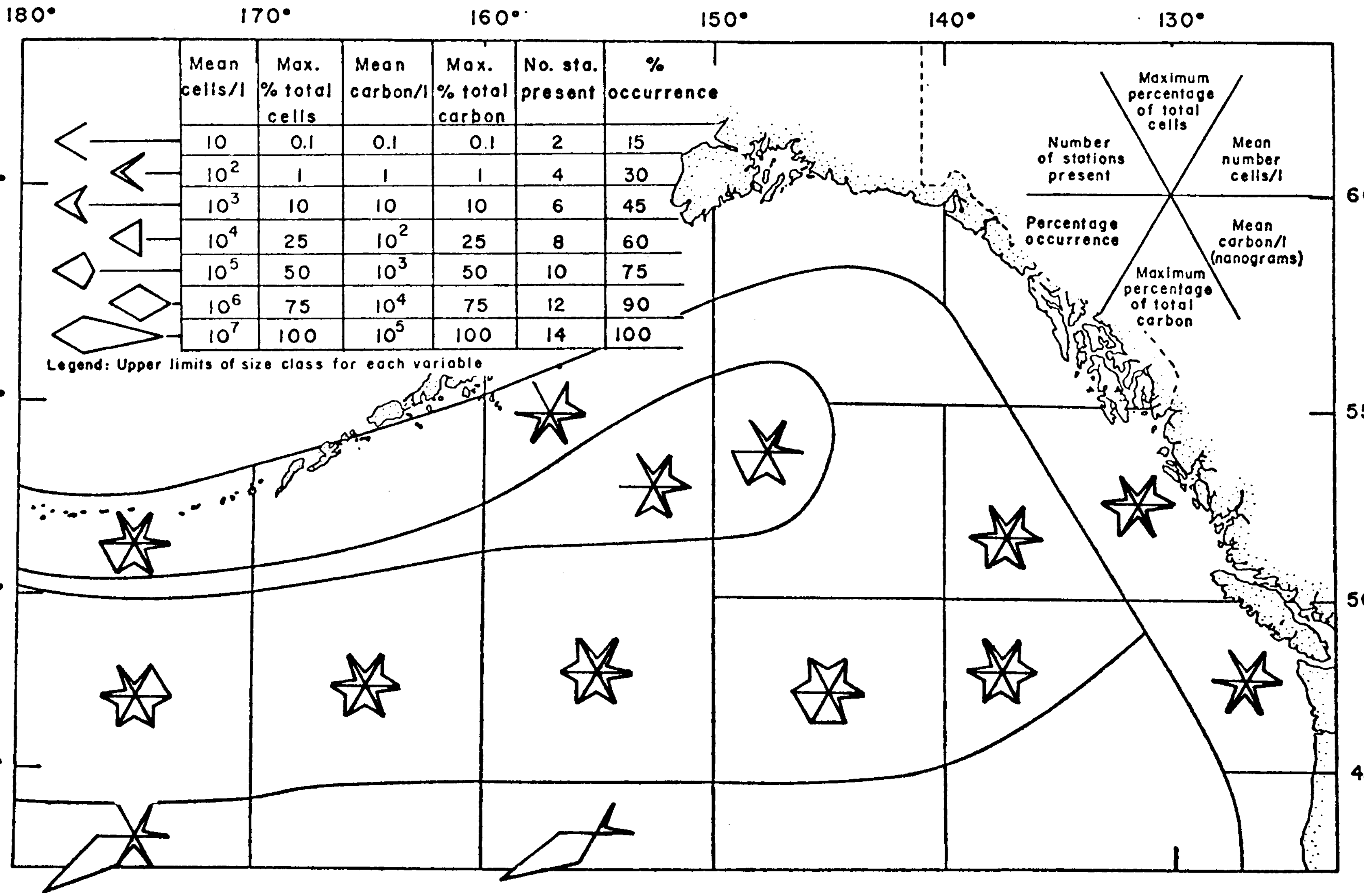


Figure 92. The distribution of *Coscinodiscus stellaris* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 93. The distribution of *Dactyliosolen mediterraneus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

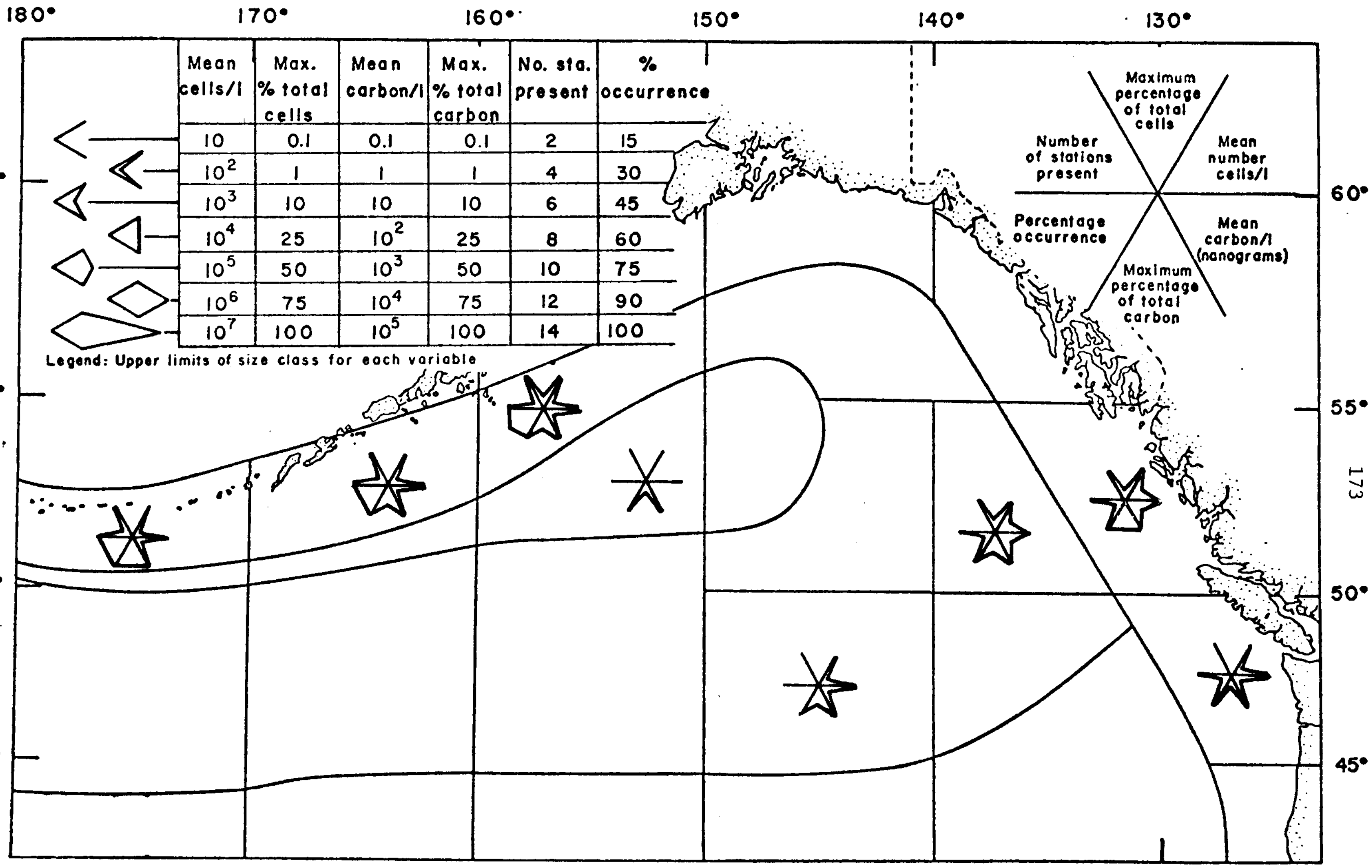
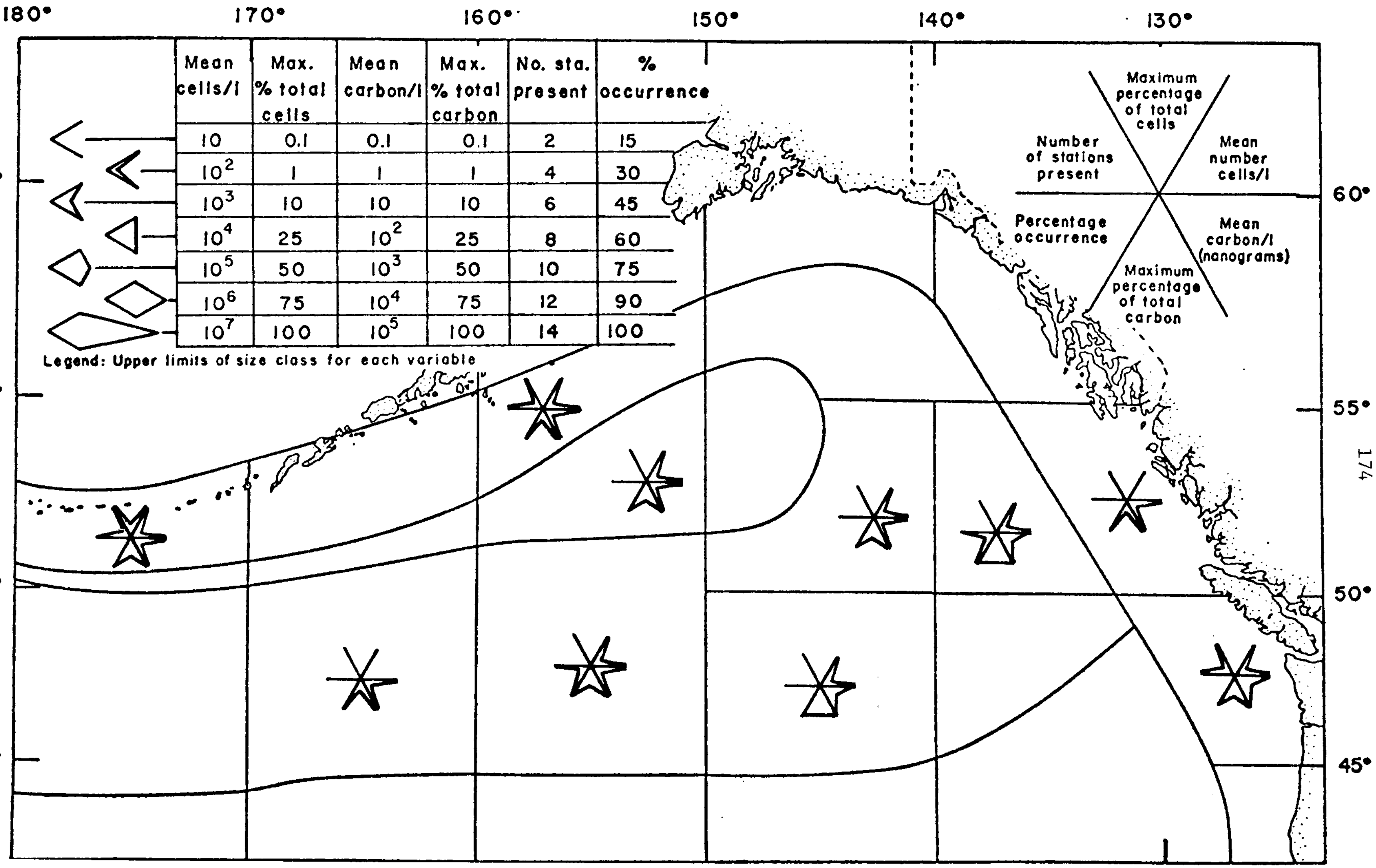


Figure 94. The distribution of *Ditylum brightwellii* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 95. The distribution of *Lauderia borealis* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

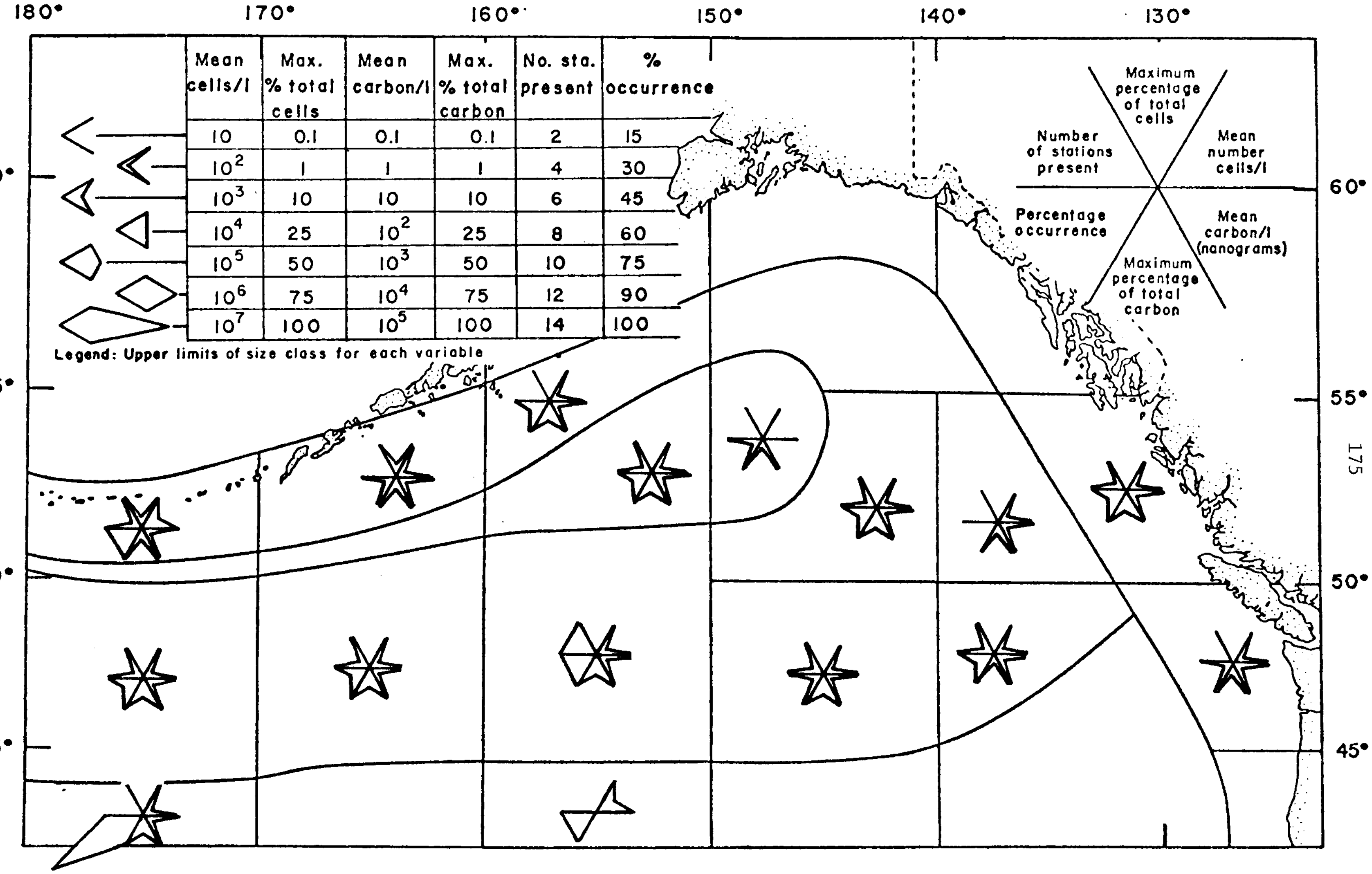
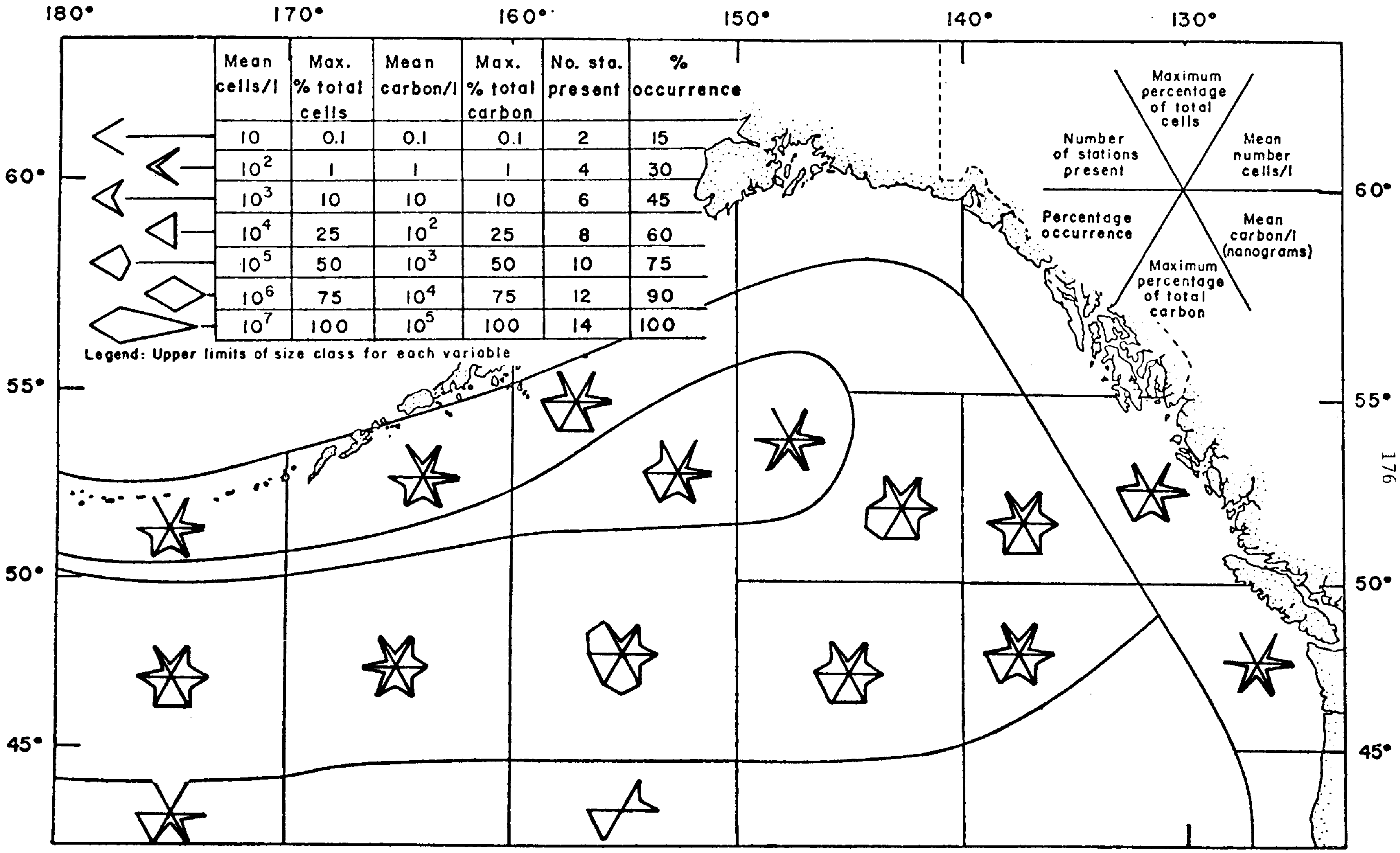


Figure 96. The distribution of *Rhizosolenia alata* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 97. The distribution of *Rhizosolenia alata f. curvirostris* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

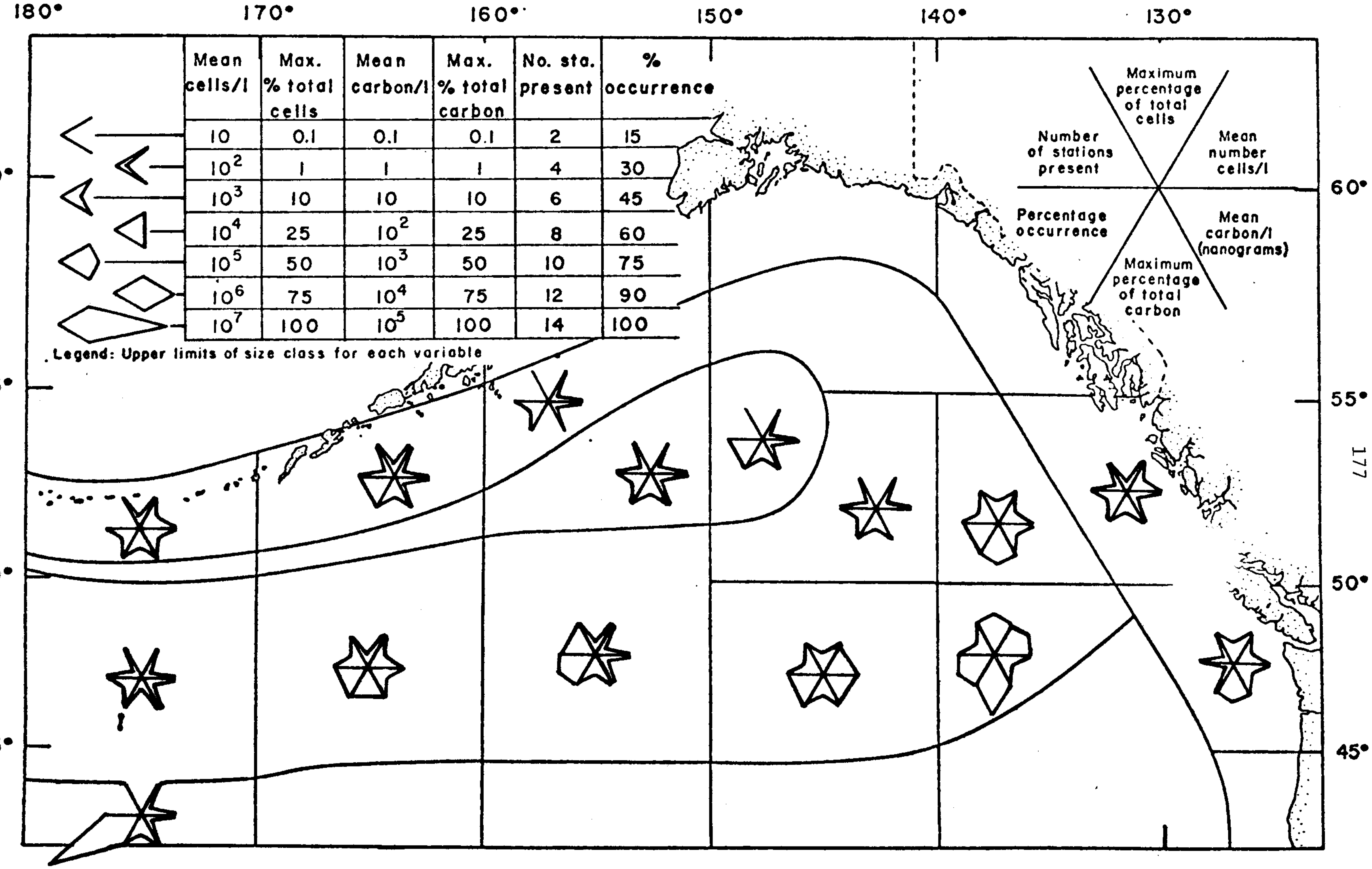
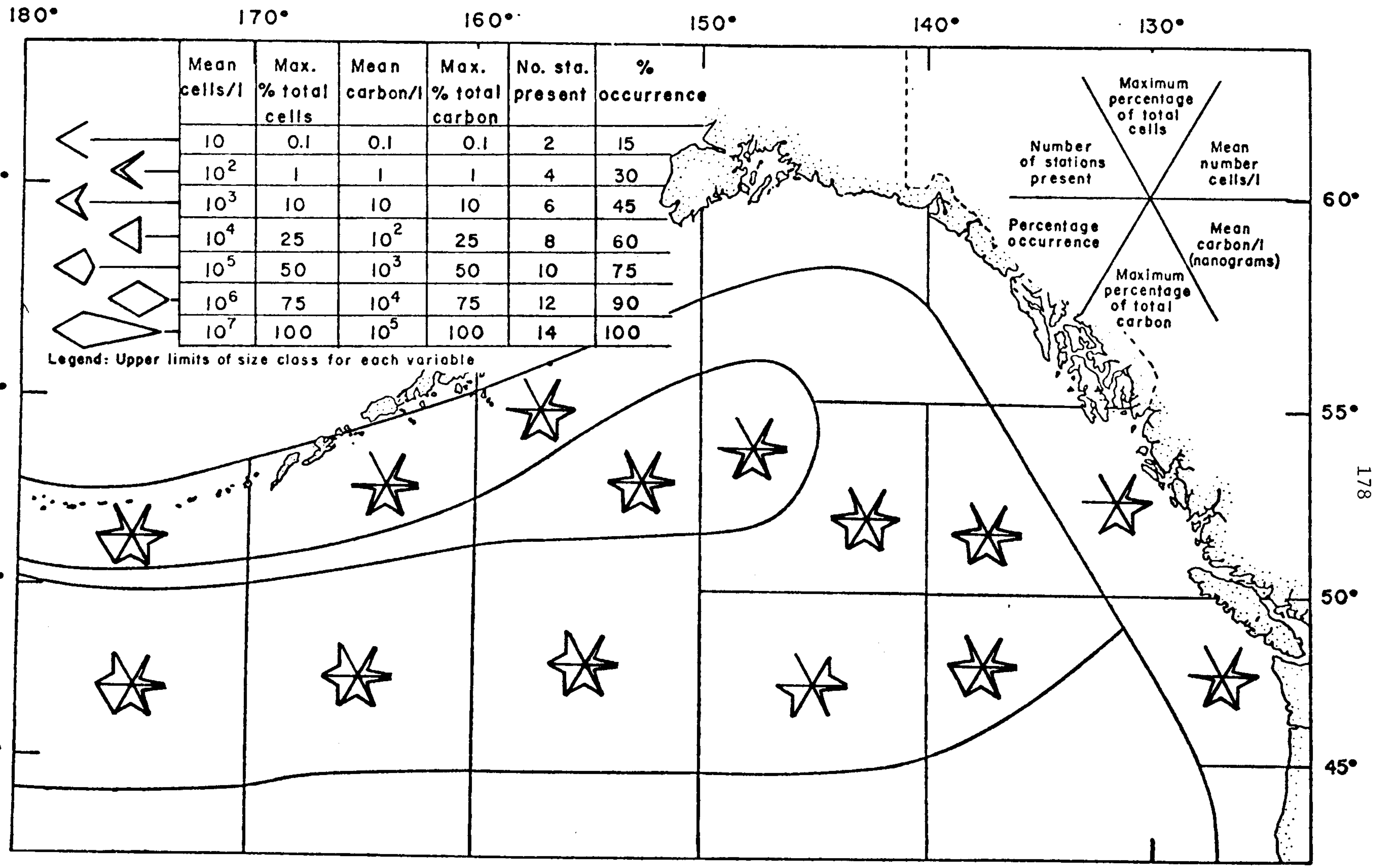


Figure 98. The distribution of *Rhizosolenia alata f. inermis* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 99. The distribution of *Rhizosolenia hebetata f. hiemalis* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

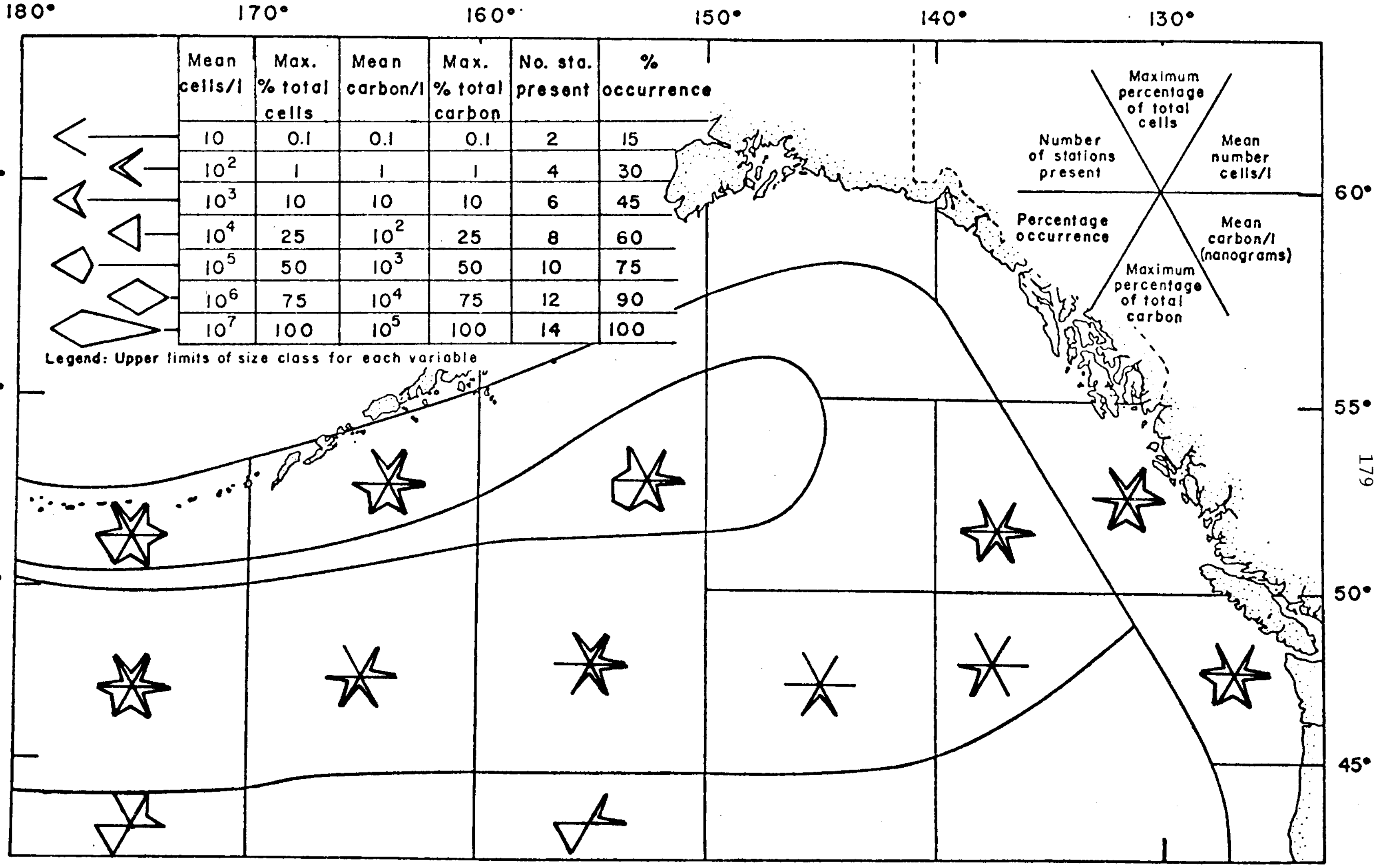
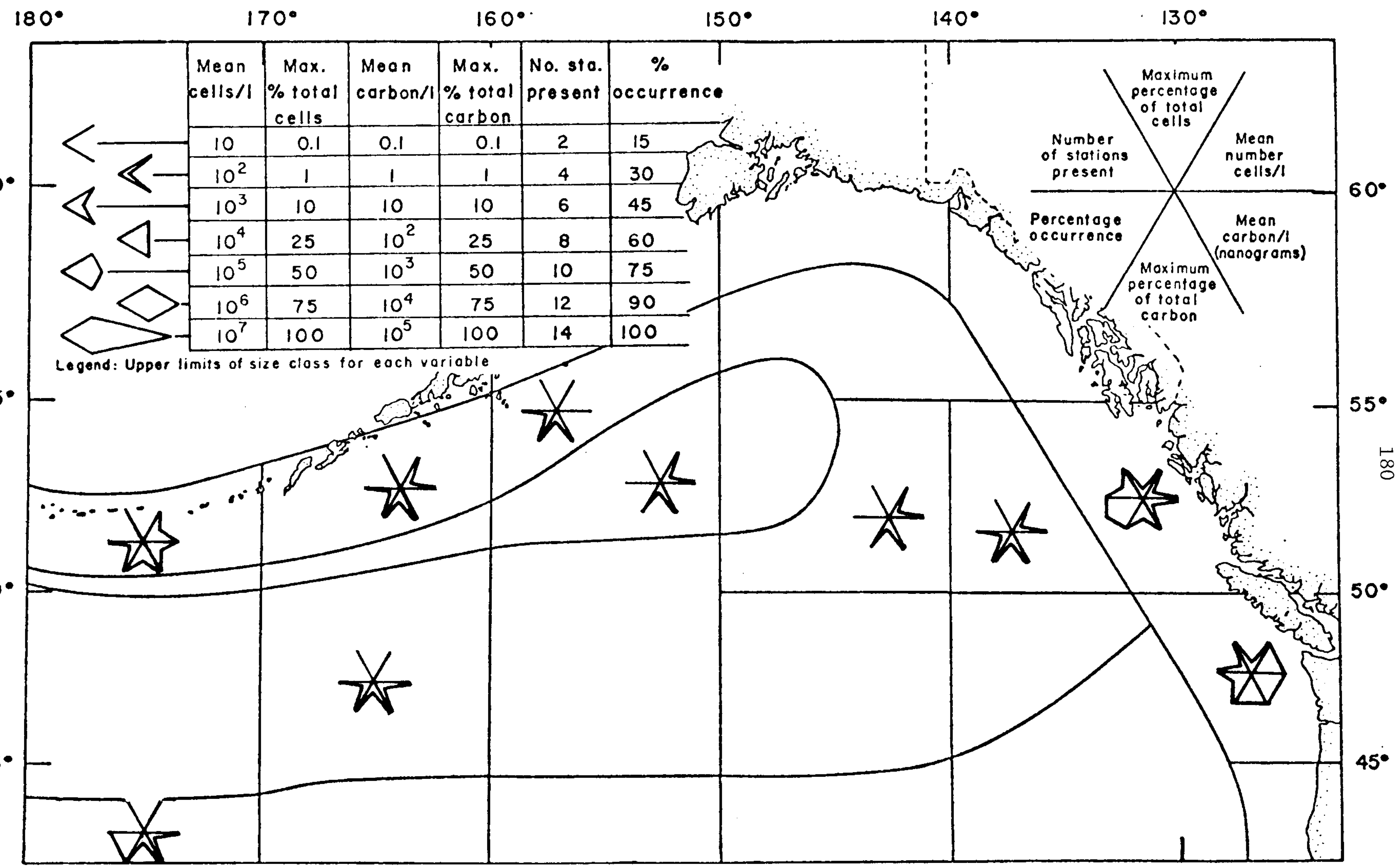
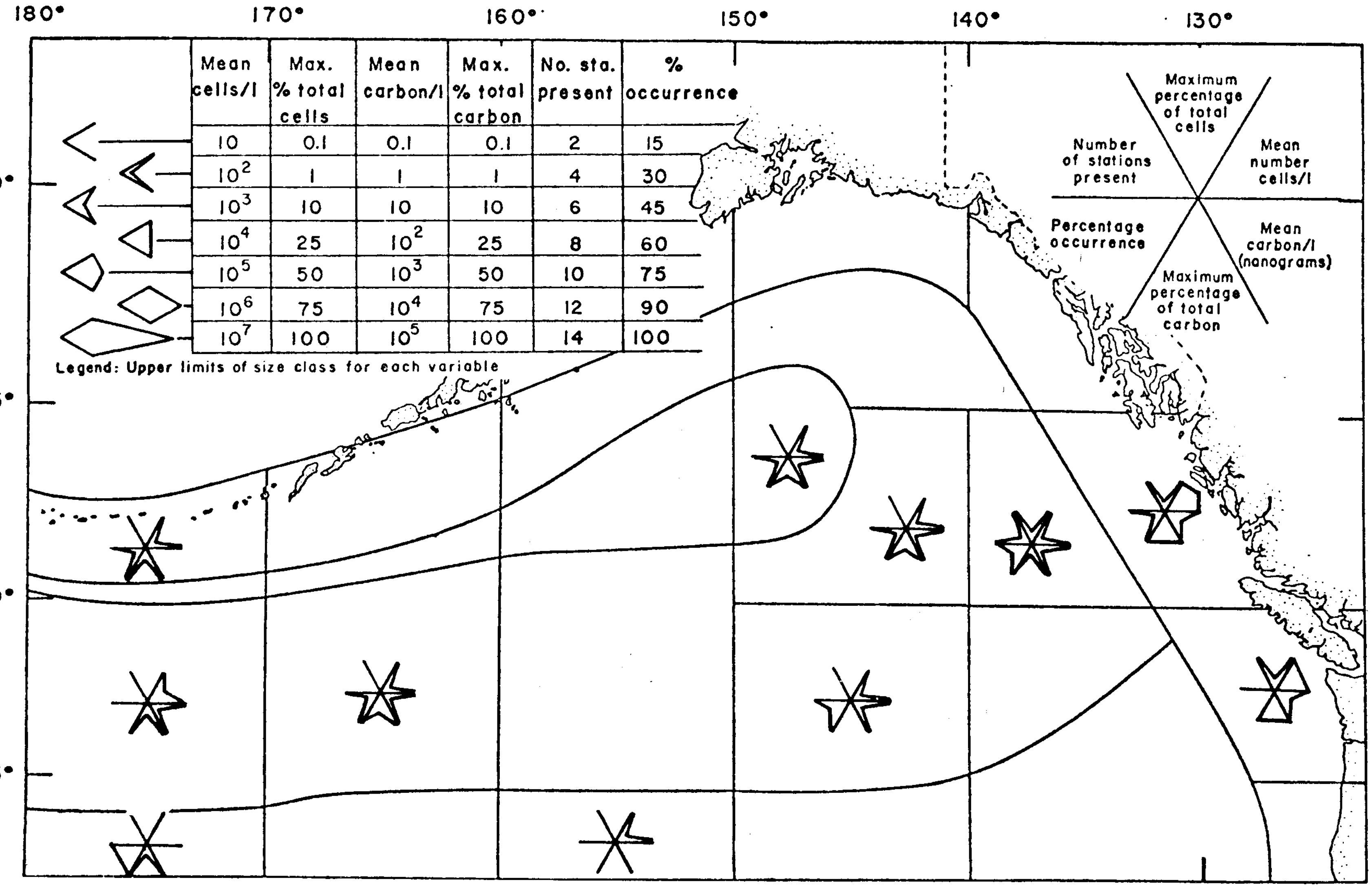


Figure 100. The distribution of *Rhizosolenia hebetata f. semispina* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 101. The distribution of *Rhizosolenia stolterfothii* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 102. The distribution of *Rhizosolenia styliformis* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

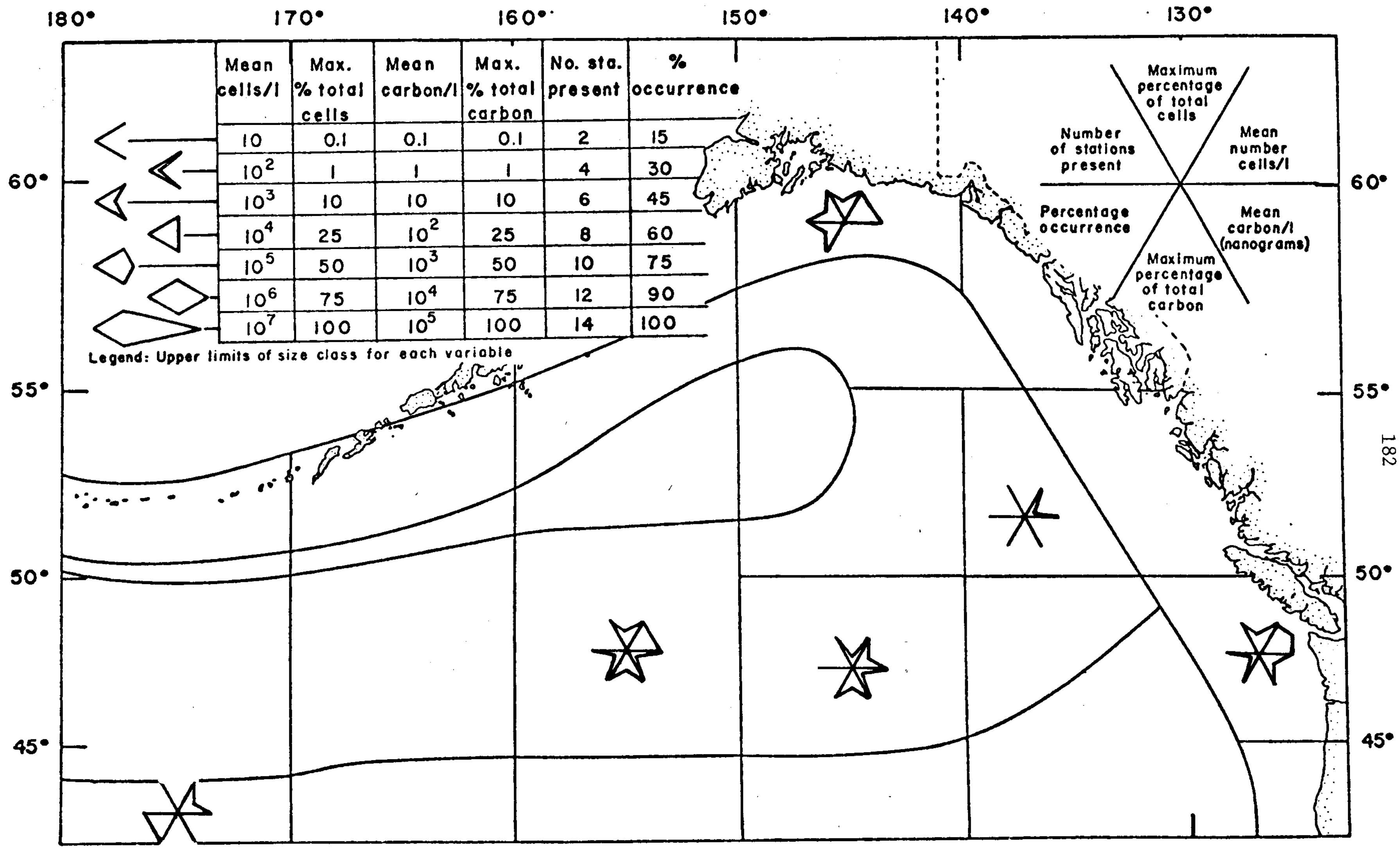


Figure 103. The distribution of *Skeletonema costatum* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

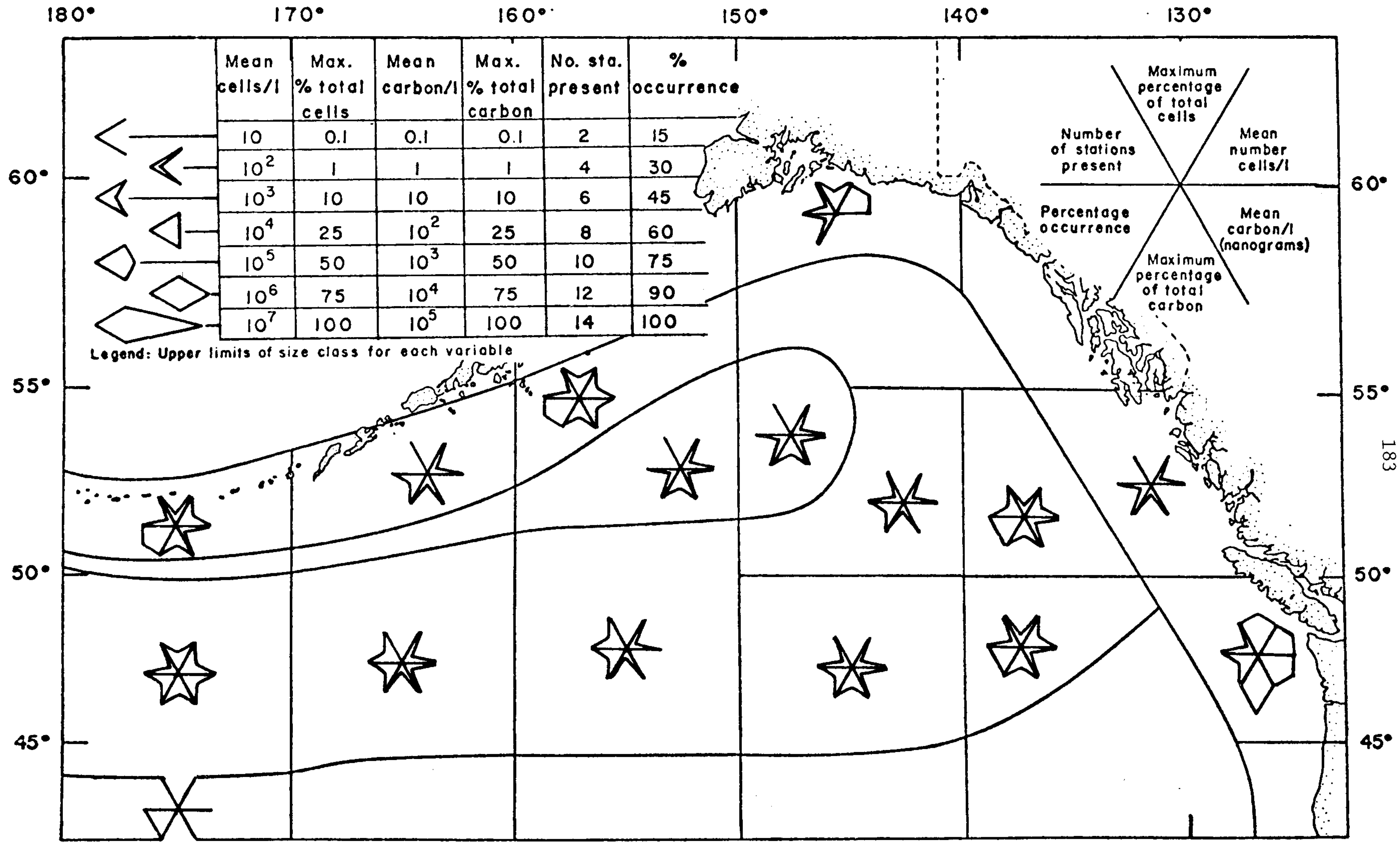


Figure 104. The distribution of *Thalassiosira decipiens* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

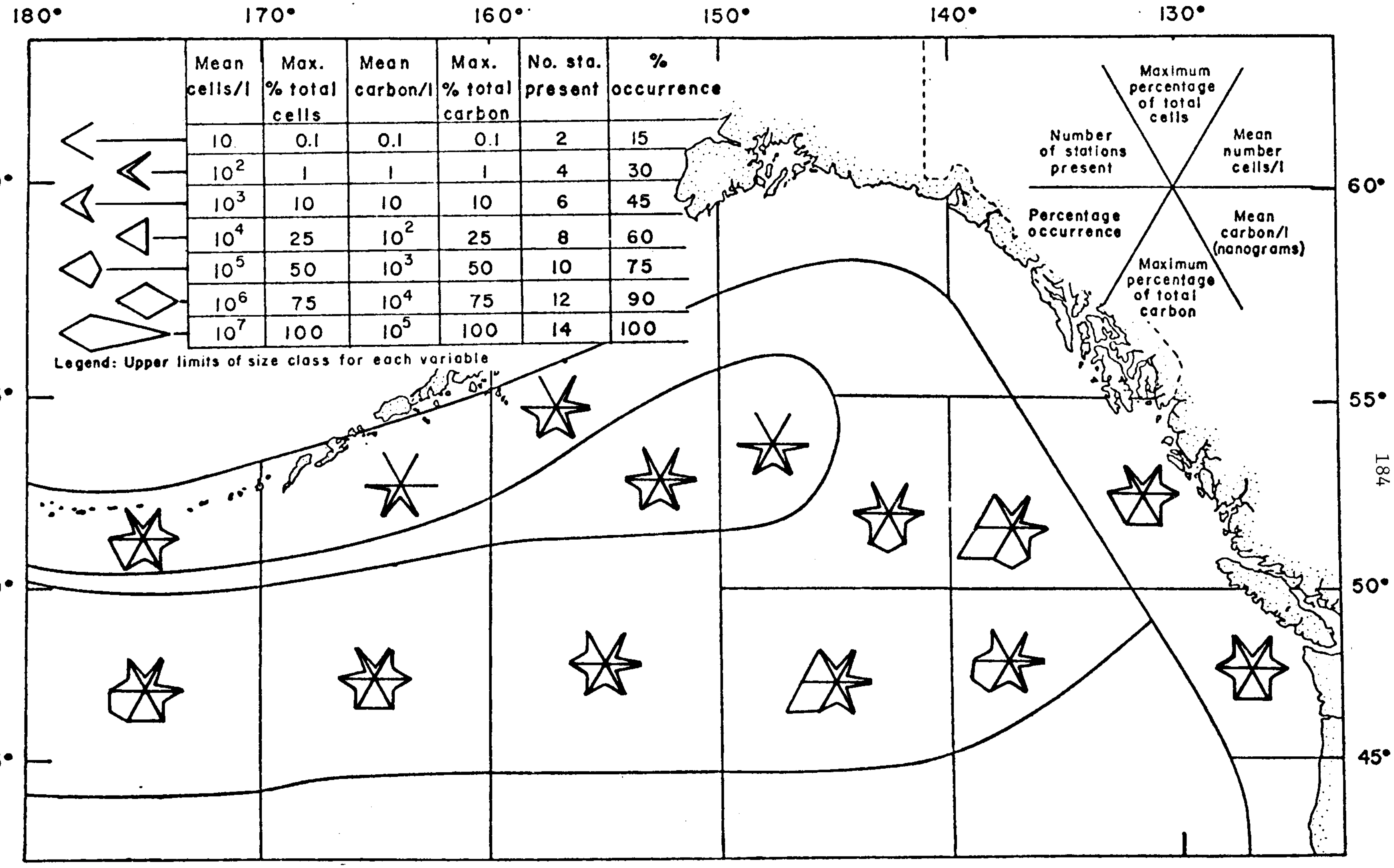


Figure 105. The distribution of *Thalassiosira eccentrica* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

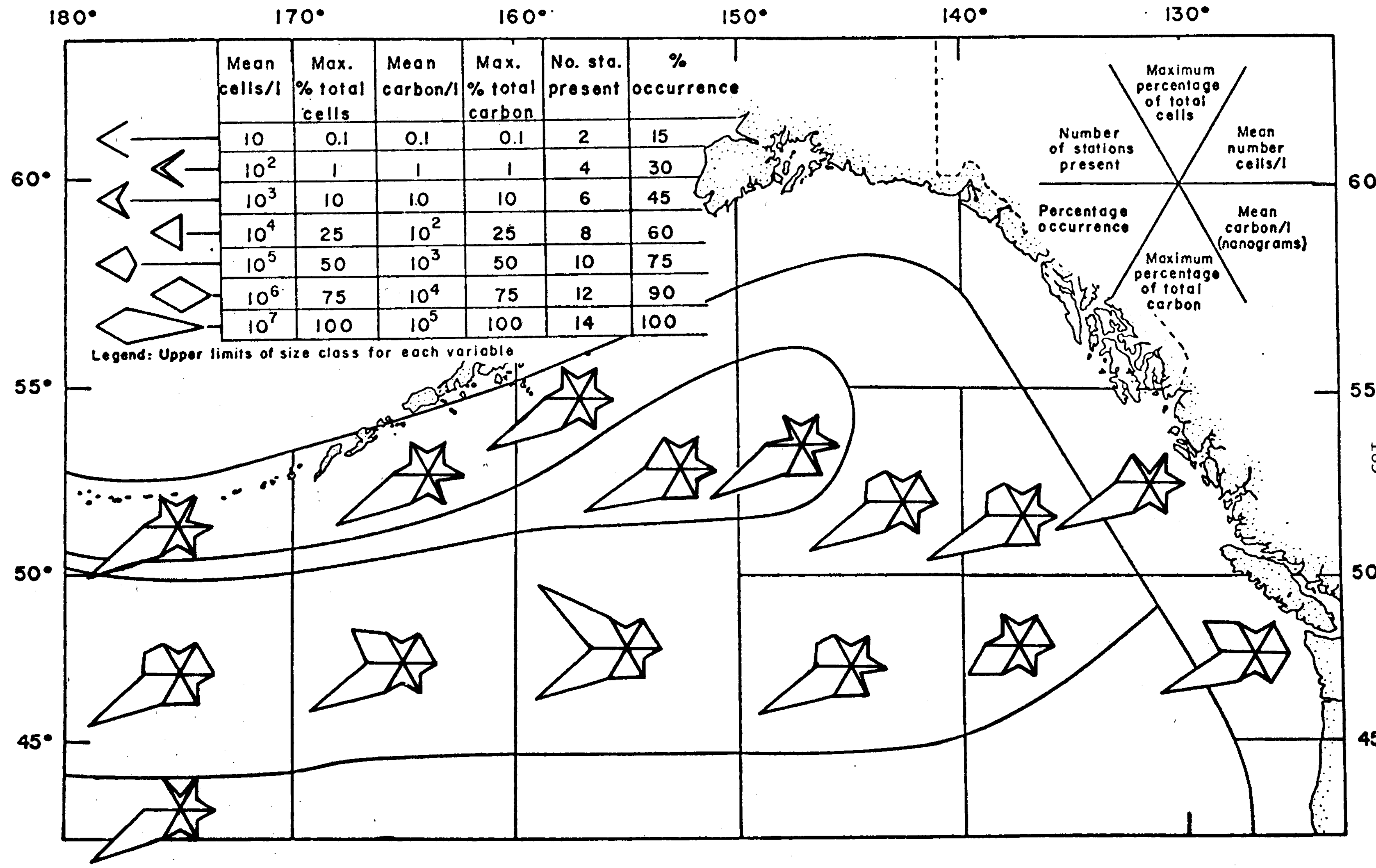


Figure 106. The distribution of *Thalassiosira lineata* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

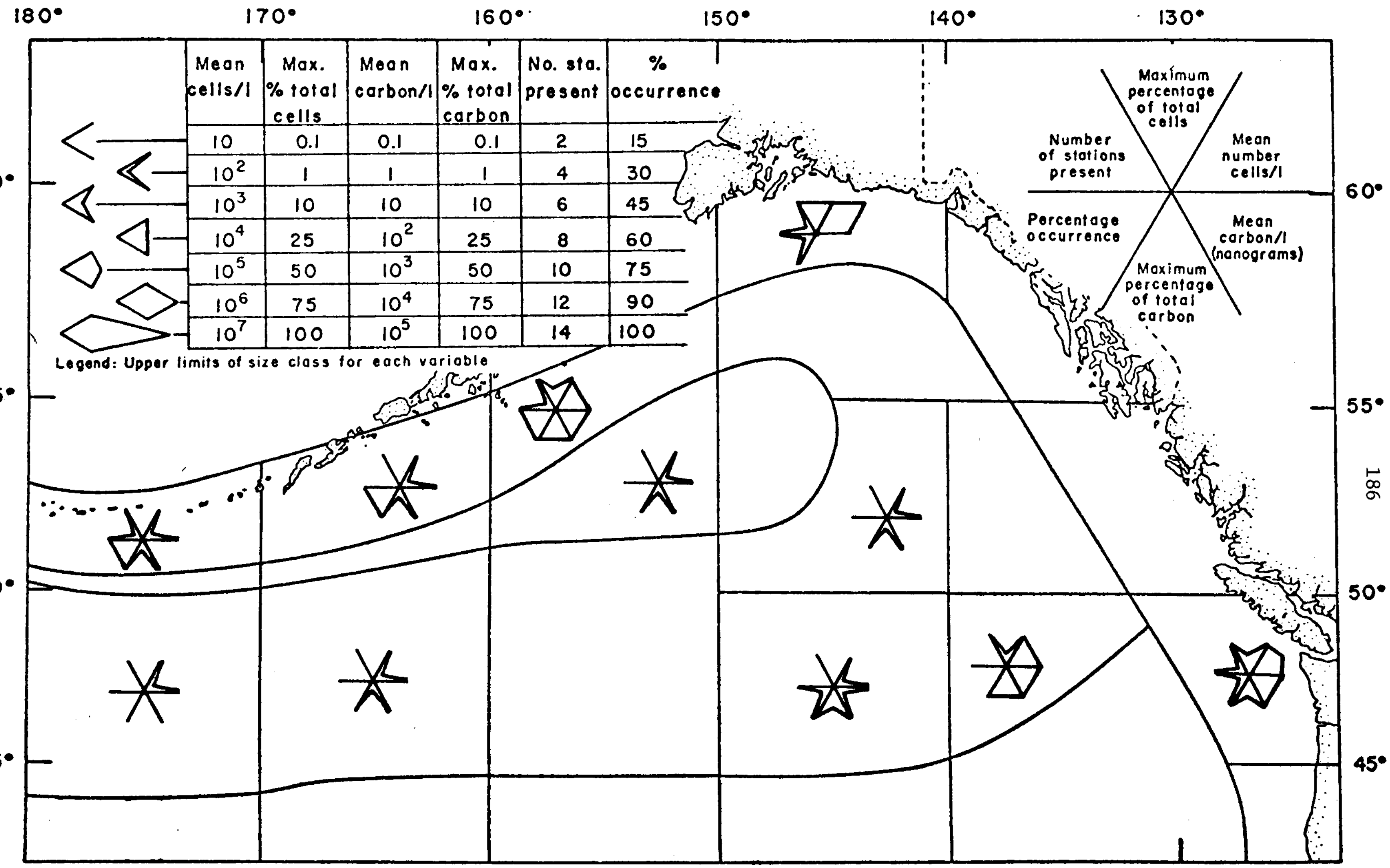


Figure 107. The distribution of *Thalassiosira nordenskioeldii* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

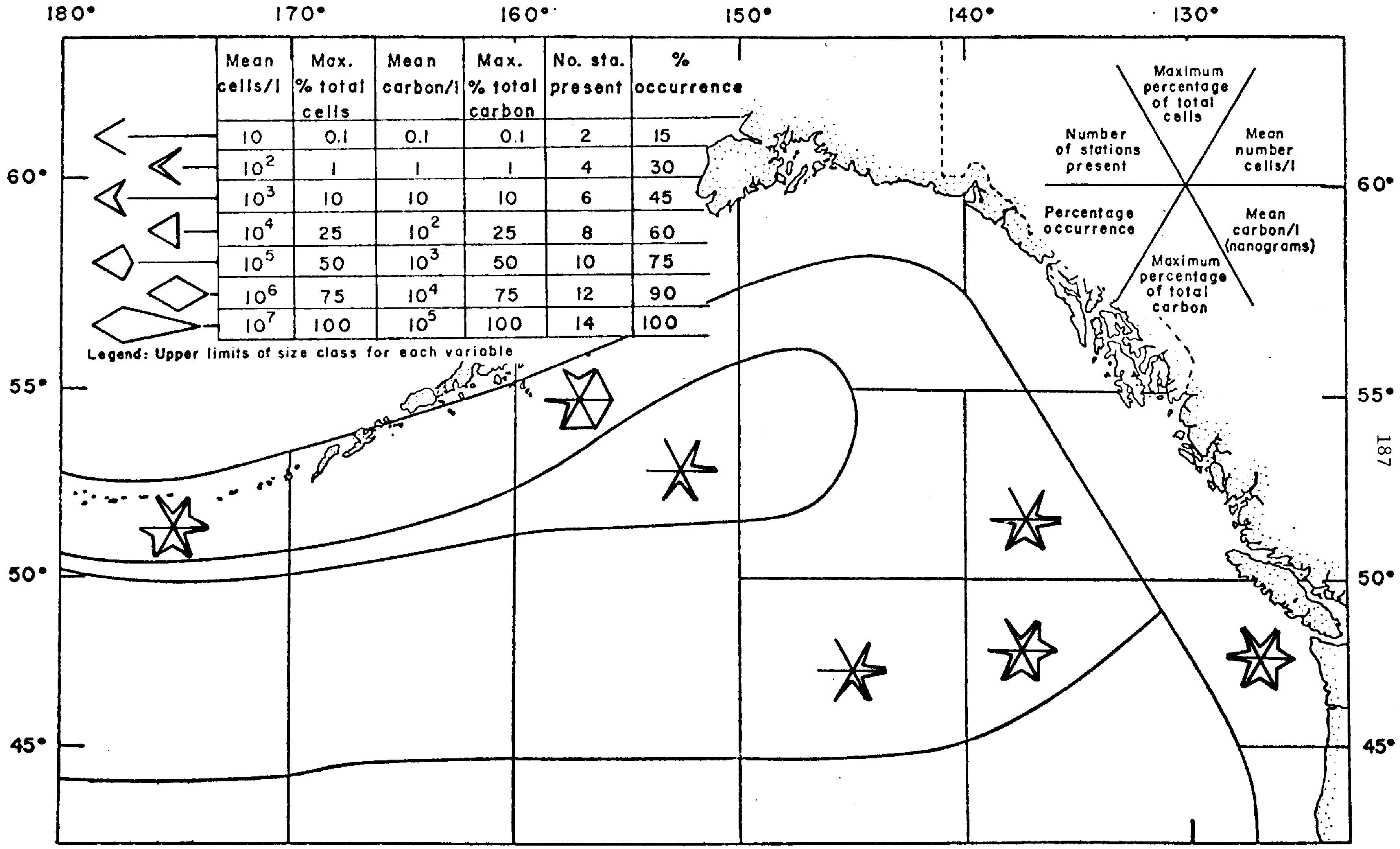


Figure 108. The distribution of *Thalassiosira rotula* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

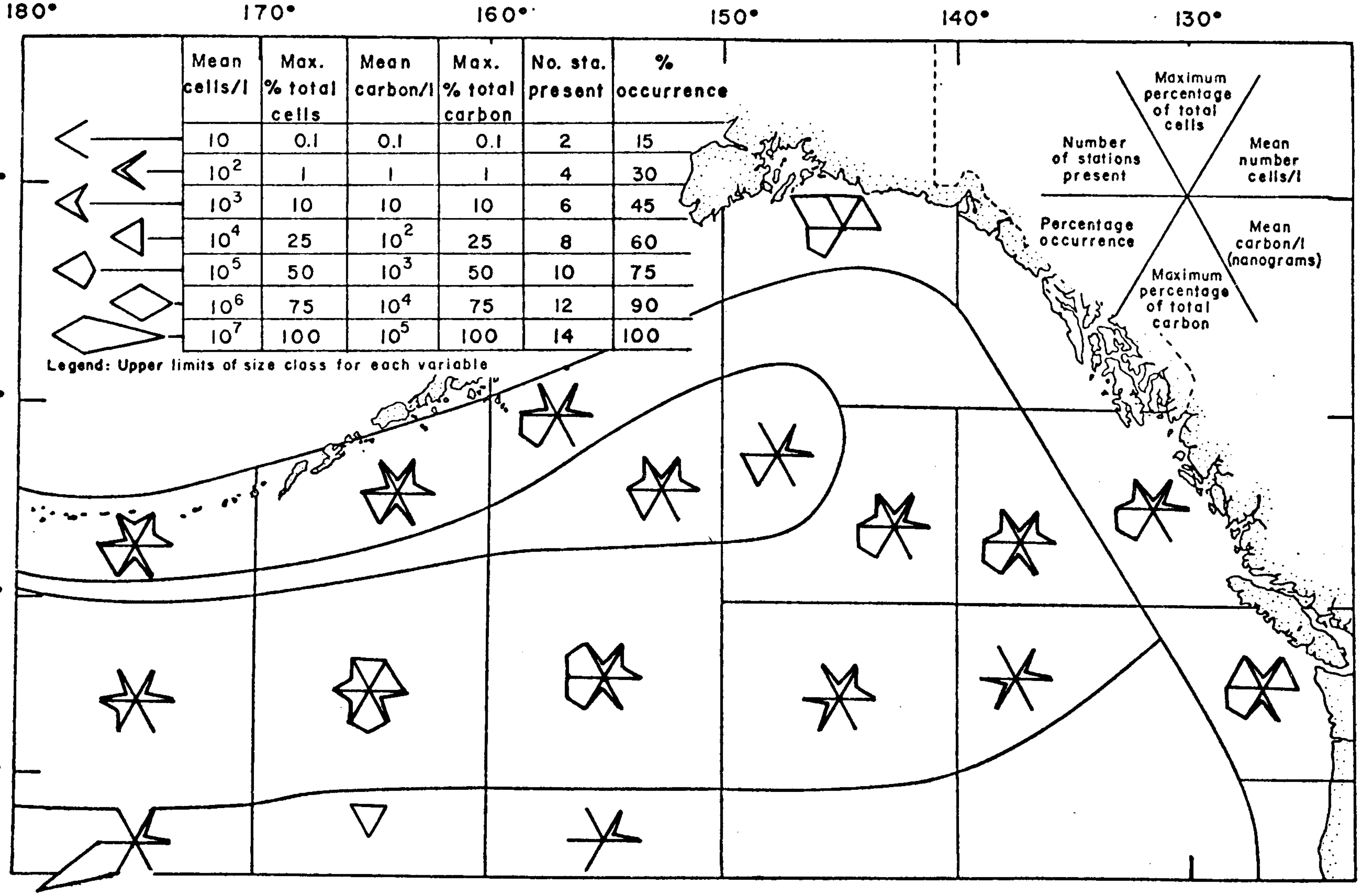


Figure 109. The distribution of *Cylindrotheca closterium* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

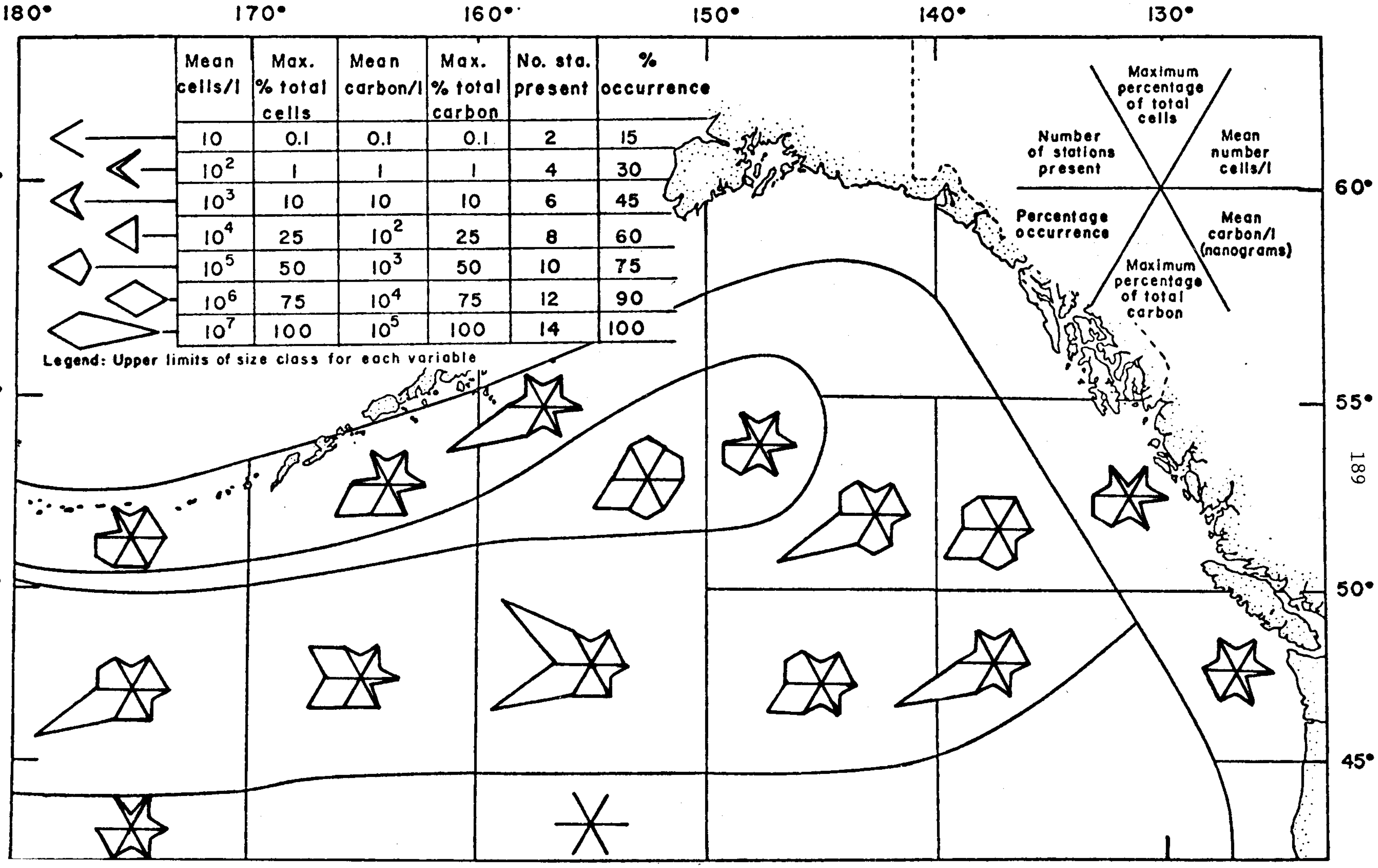


Figure 110. The distribution of *Denticula seminae* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

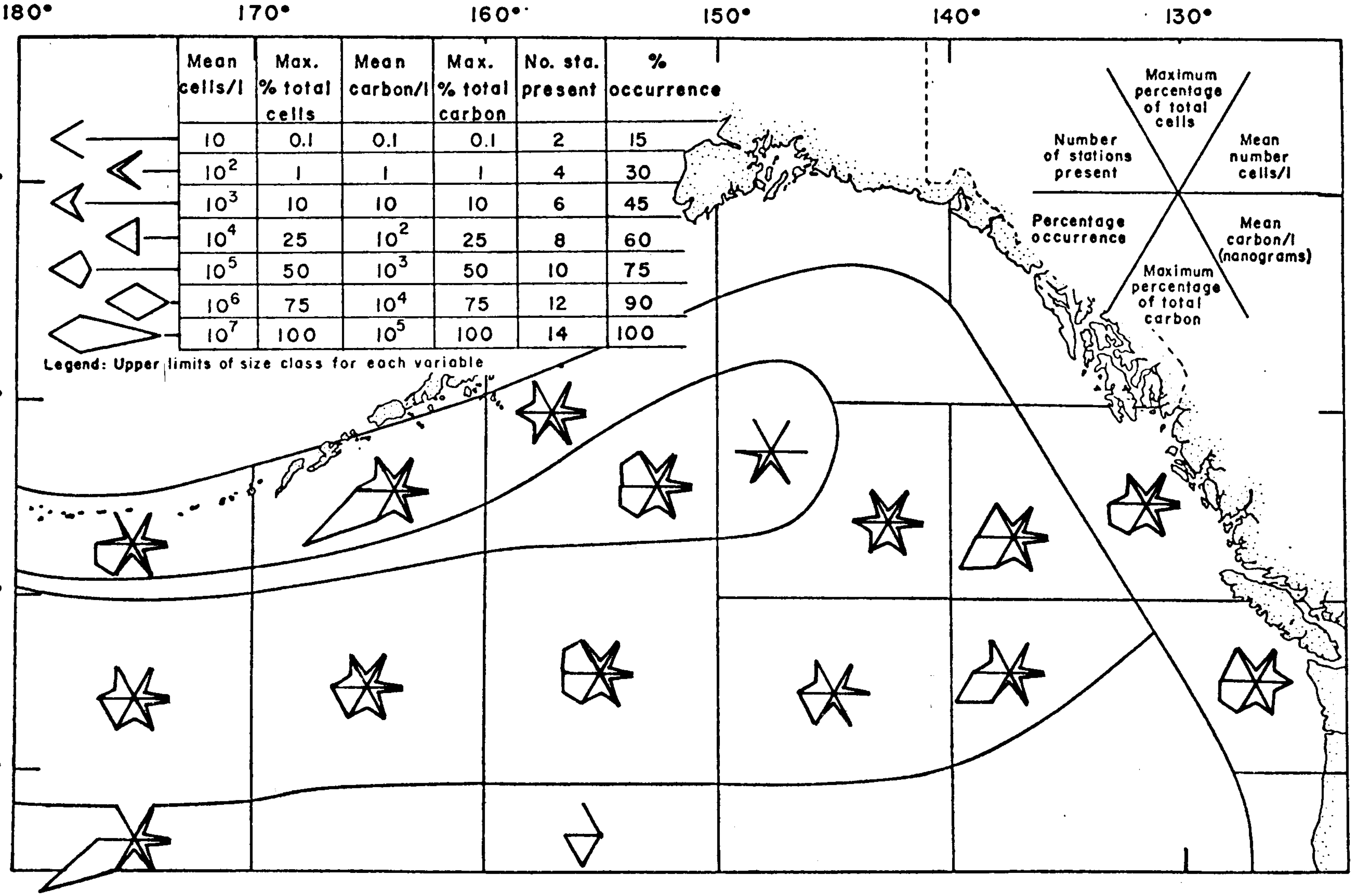
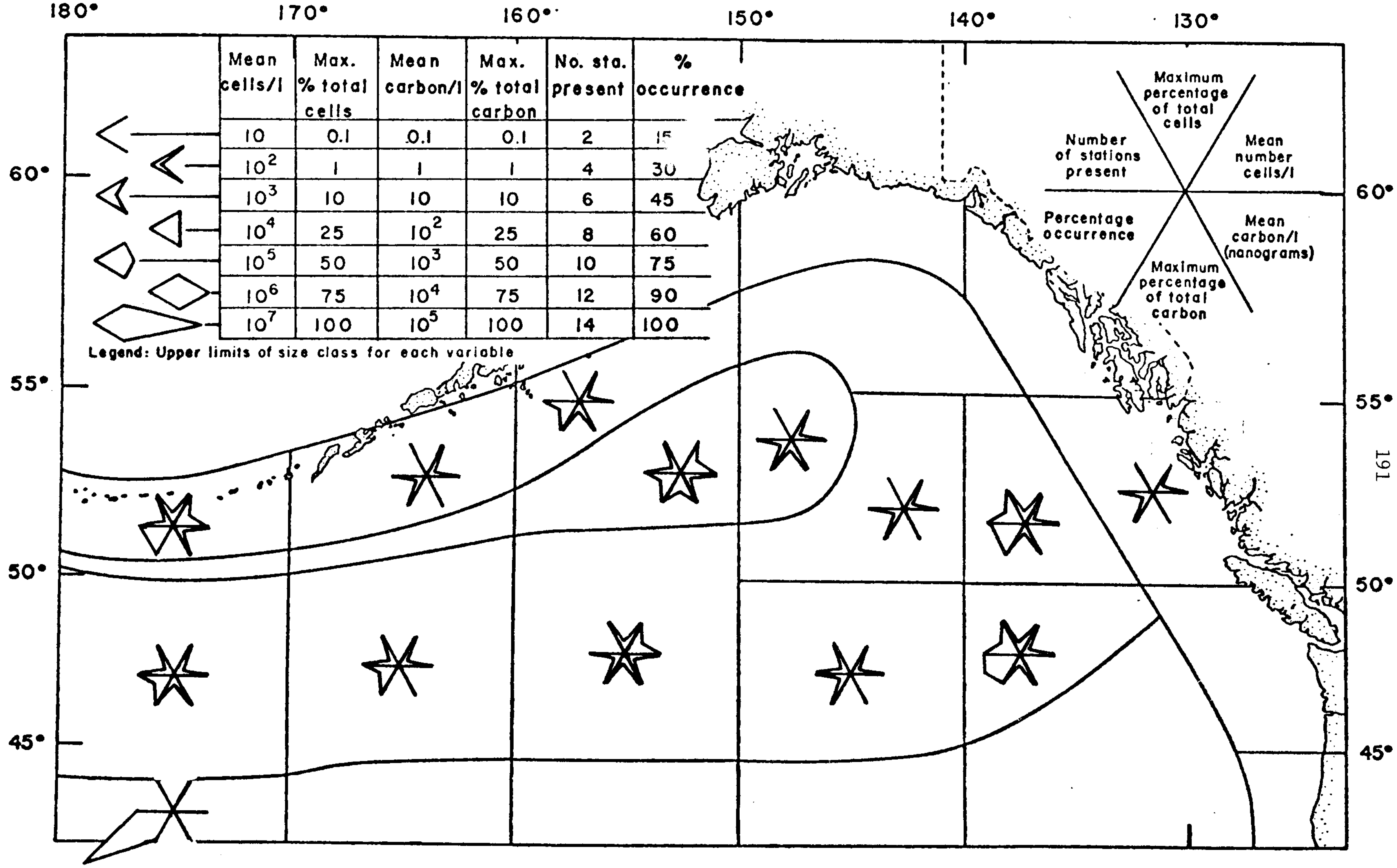


Figure 111. The distribution of *Navicula* spp. in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 112. The distribution of *Nitzschia longissima* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

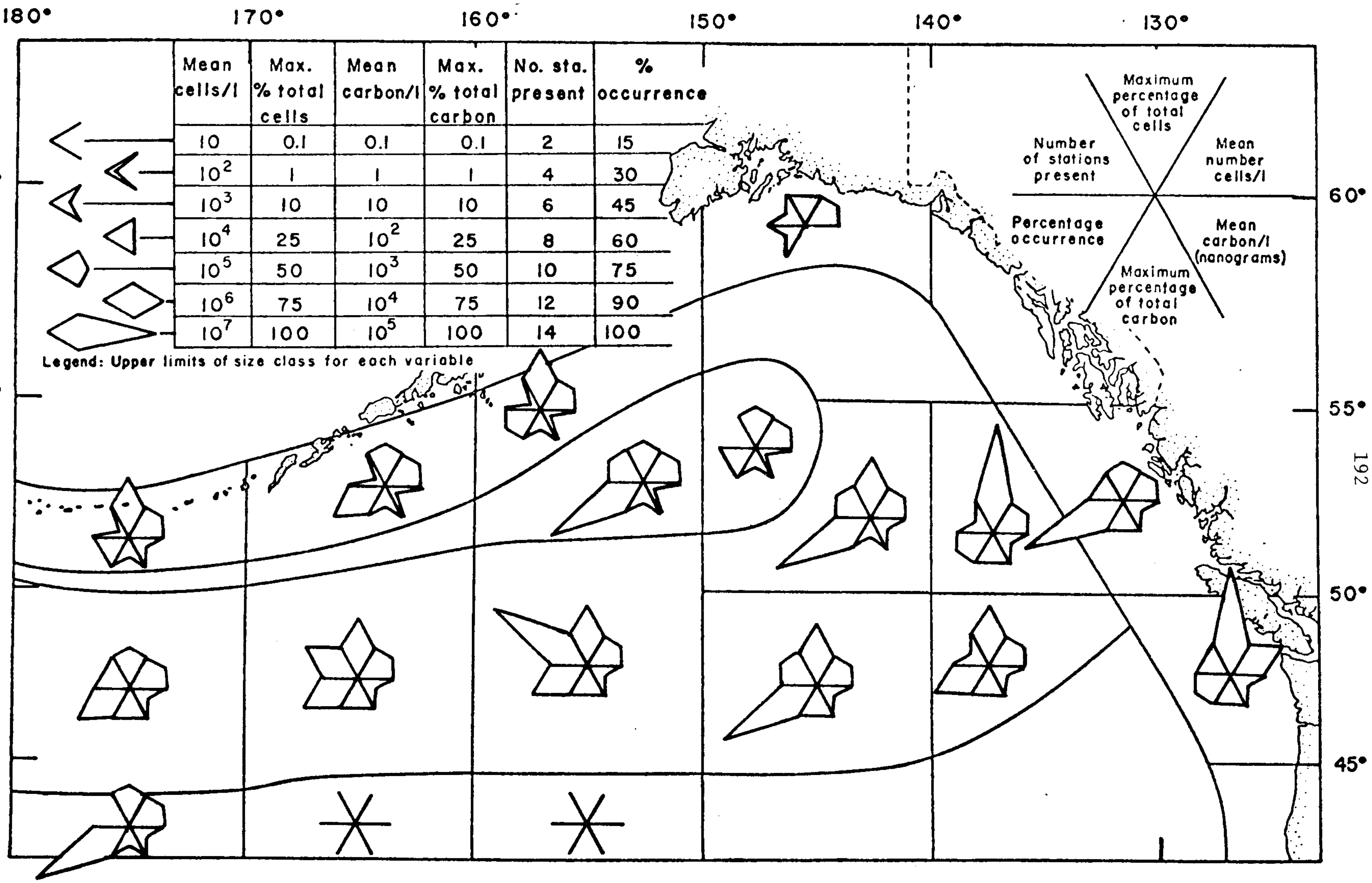


Figure 113. The distribution of *Nitzschia pesudonana* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

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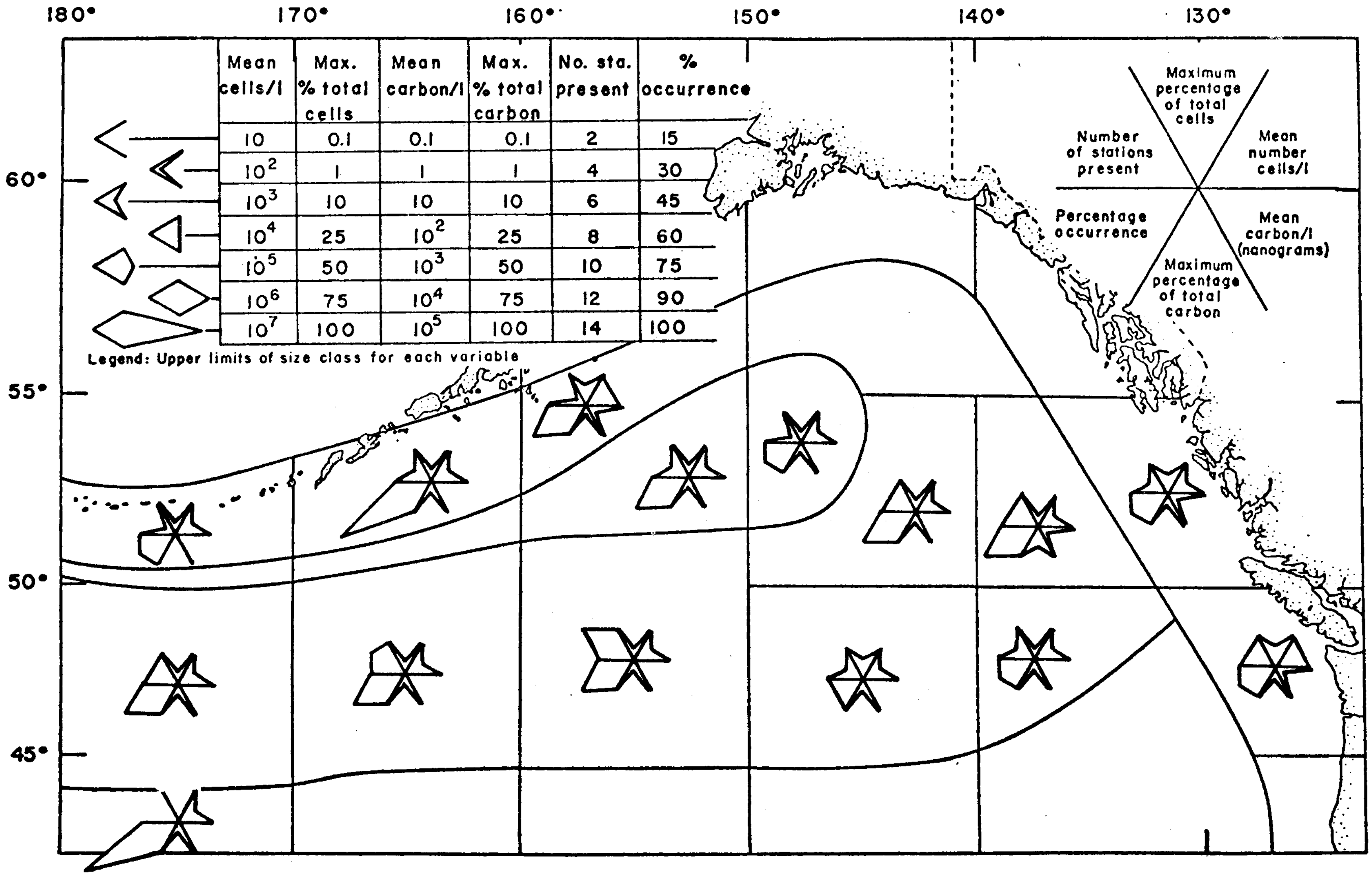


Figure 114. The distribution of *Nitzschia* sp. (*Fragilariopsis* group) in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

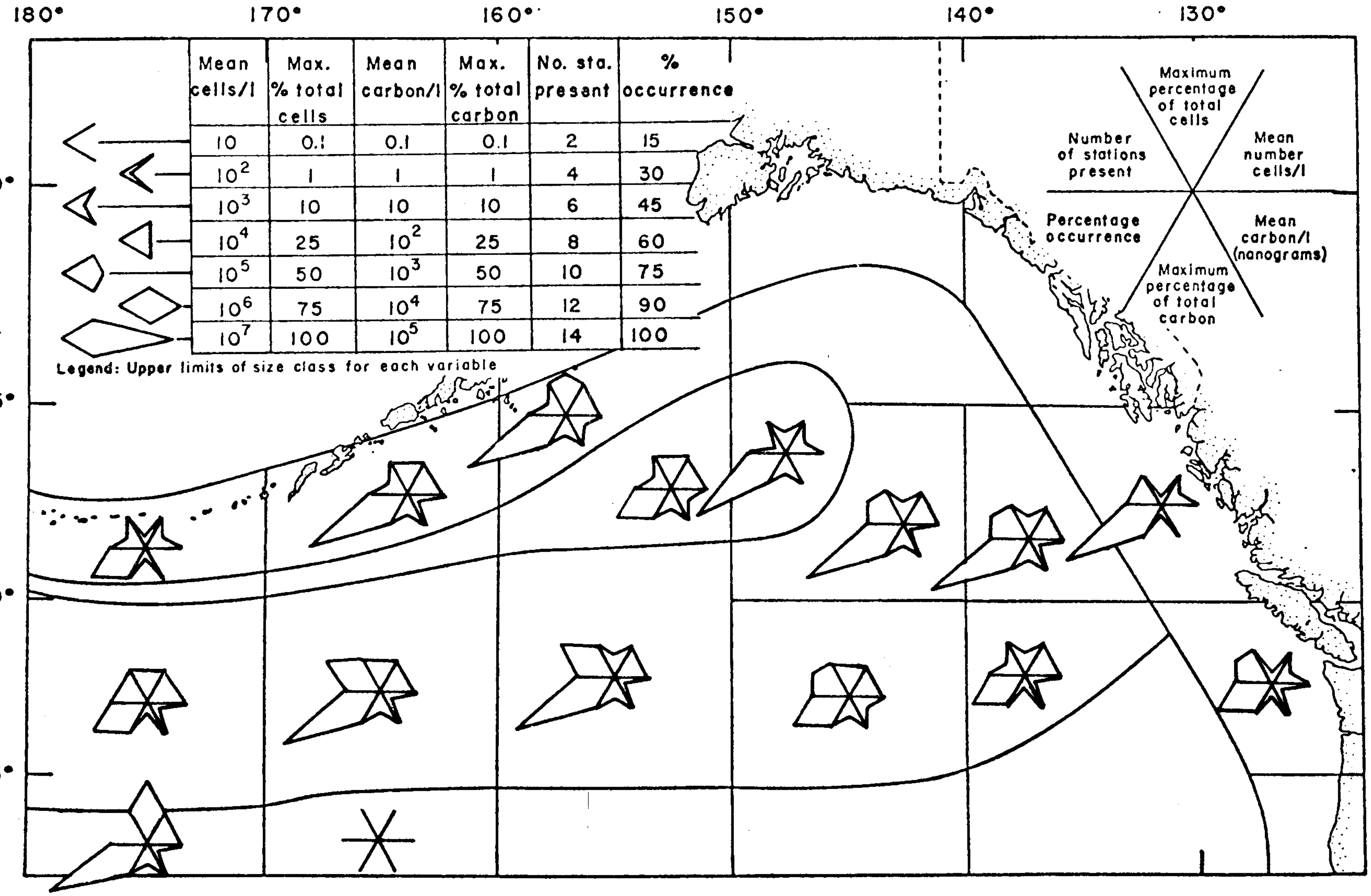


Figure 115. The distribution of *Nitzschia* sp. (*Pesudonitzschia* group) in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

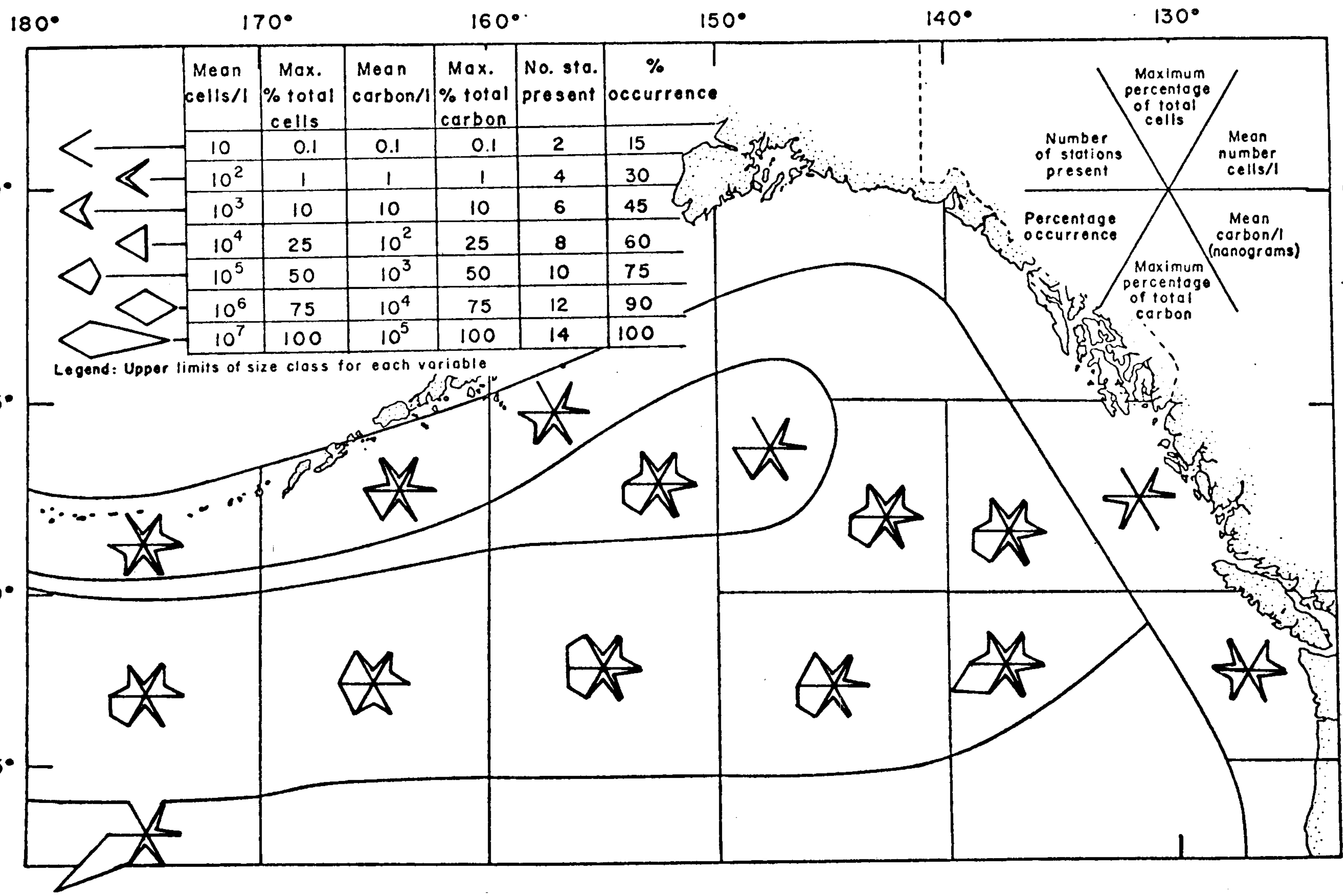


Figure 116. The distribution of *Rhabdonema arcuatum* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

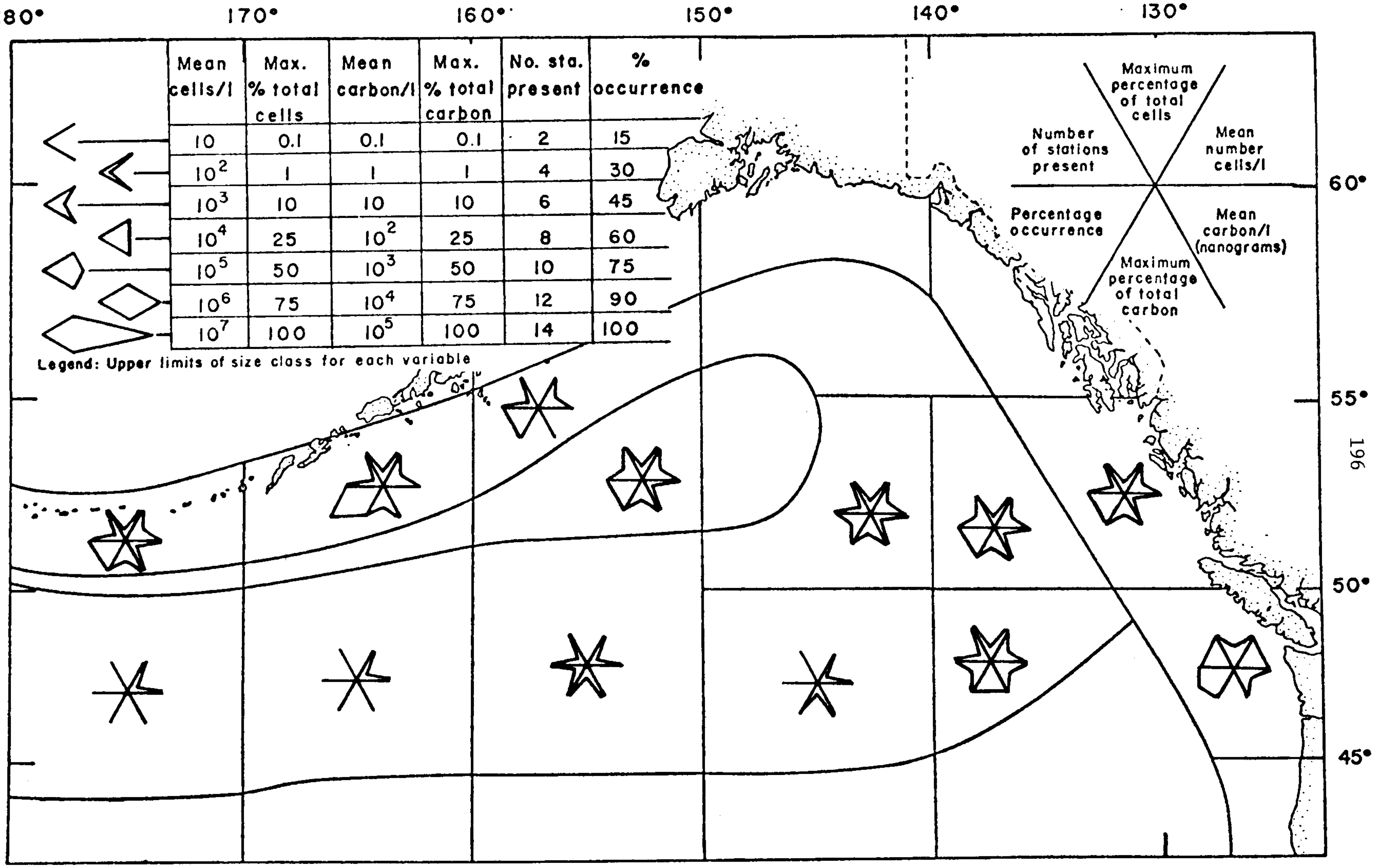


Figure 117. The distribution of *Thalassionema nitzschioides* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

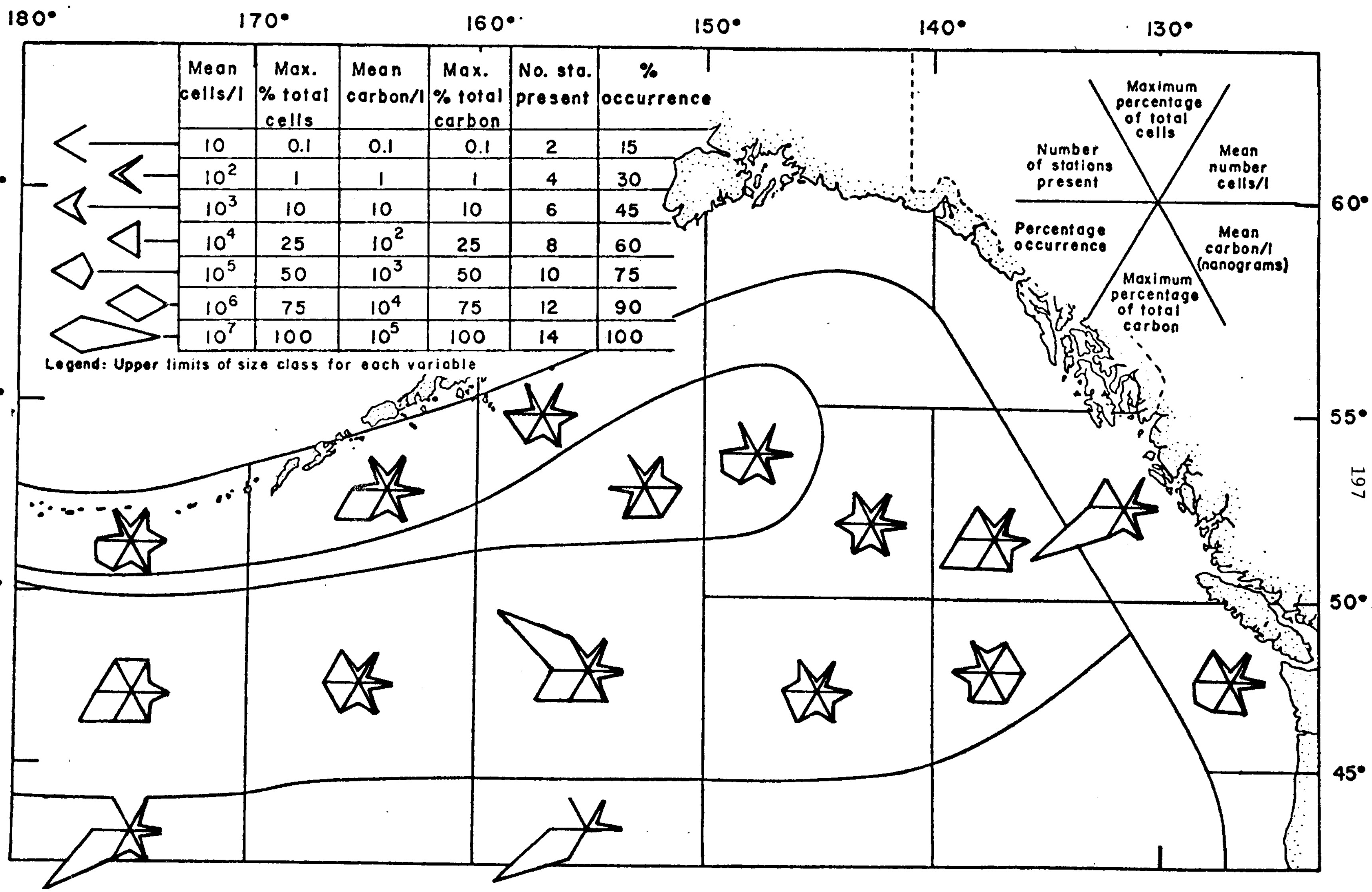


Figure 118. The distribution of *Thalassiothrix longissima* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

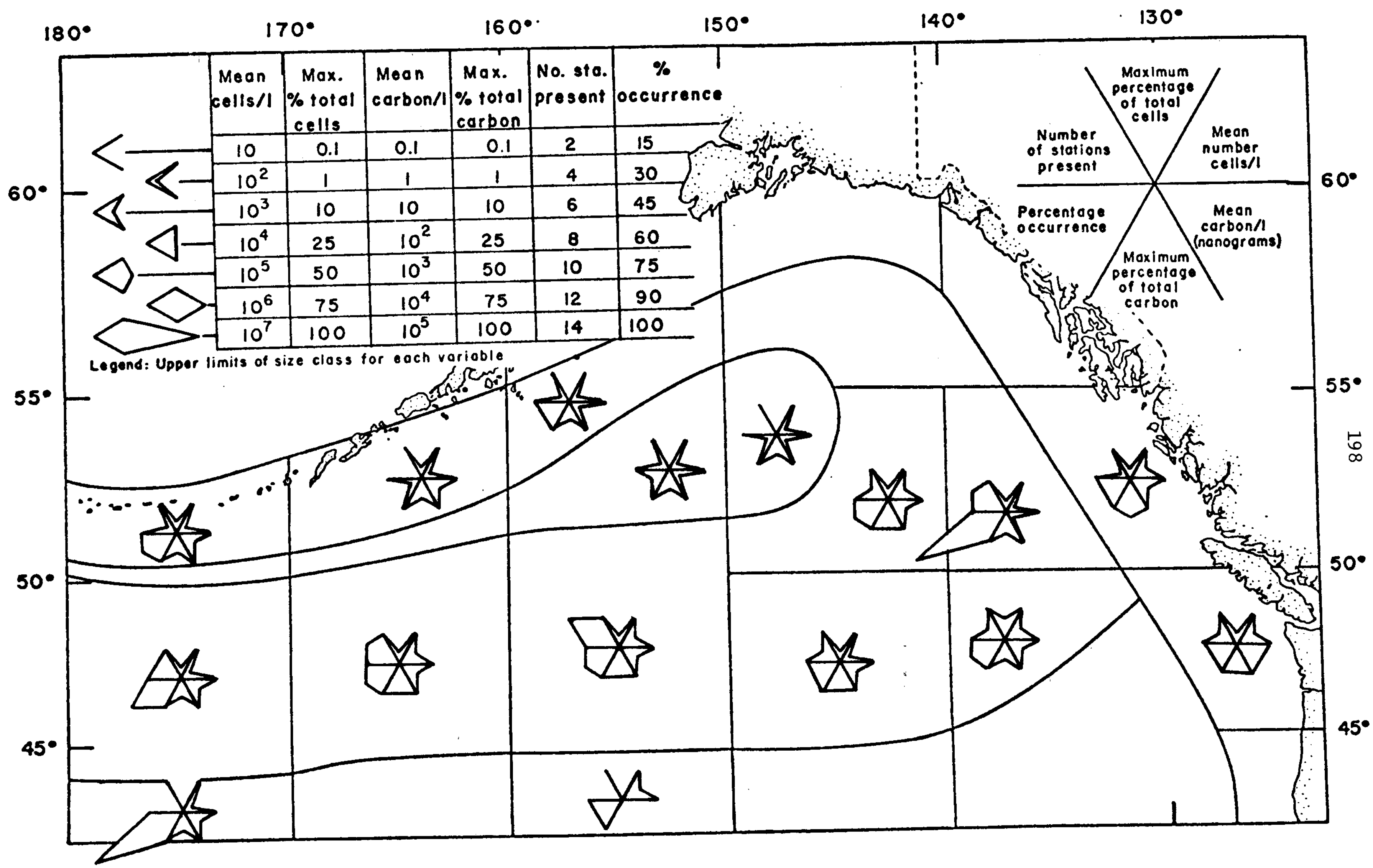


Figure 119. The distribution of *Tropidoneis antarctic polyplasta* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

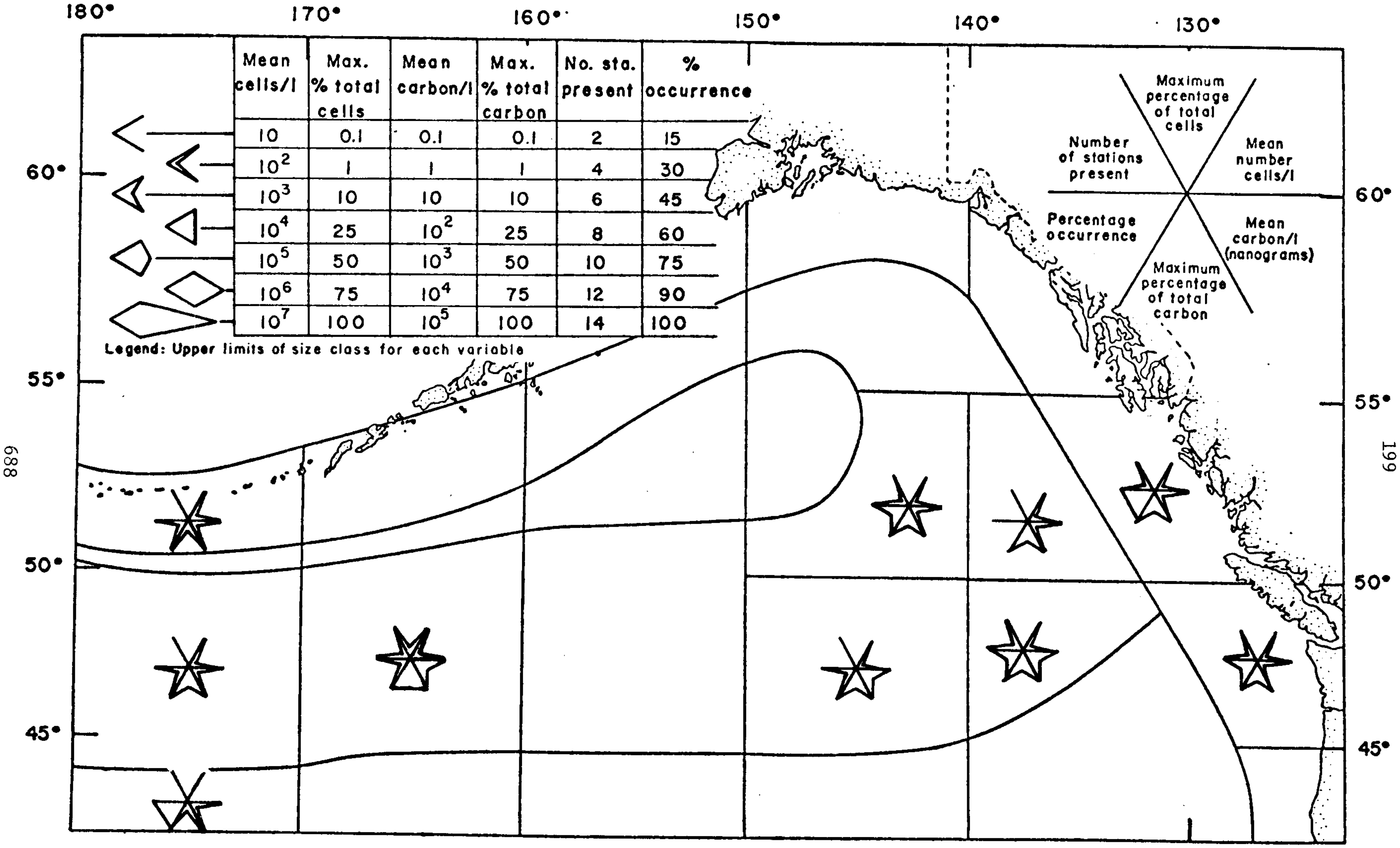


Figure 120. The distribution of *Ceratium fusus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

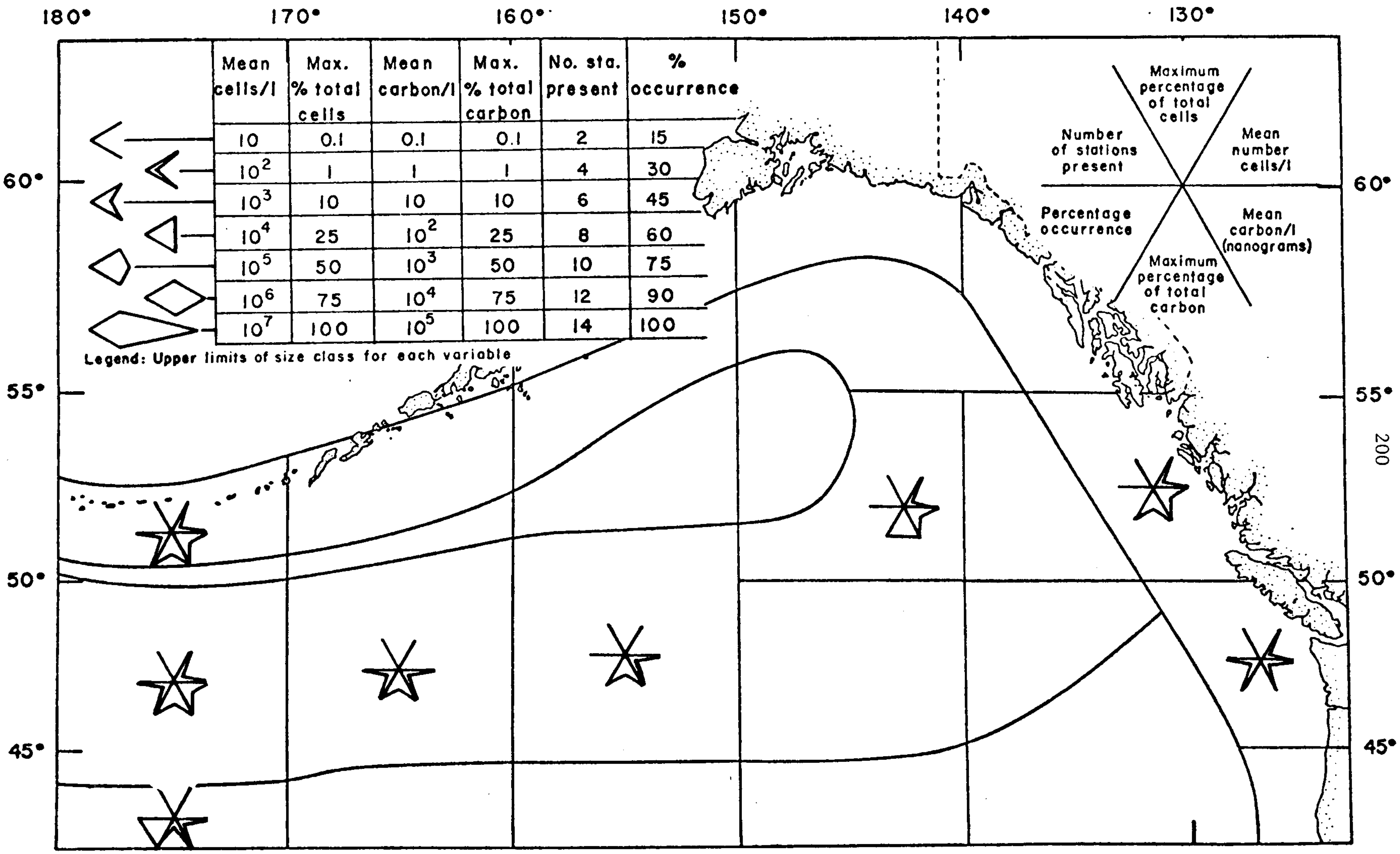


Figure 121. The distribution of *Ceratium longipes* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

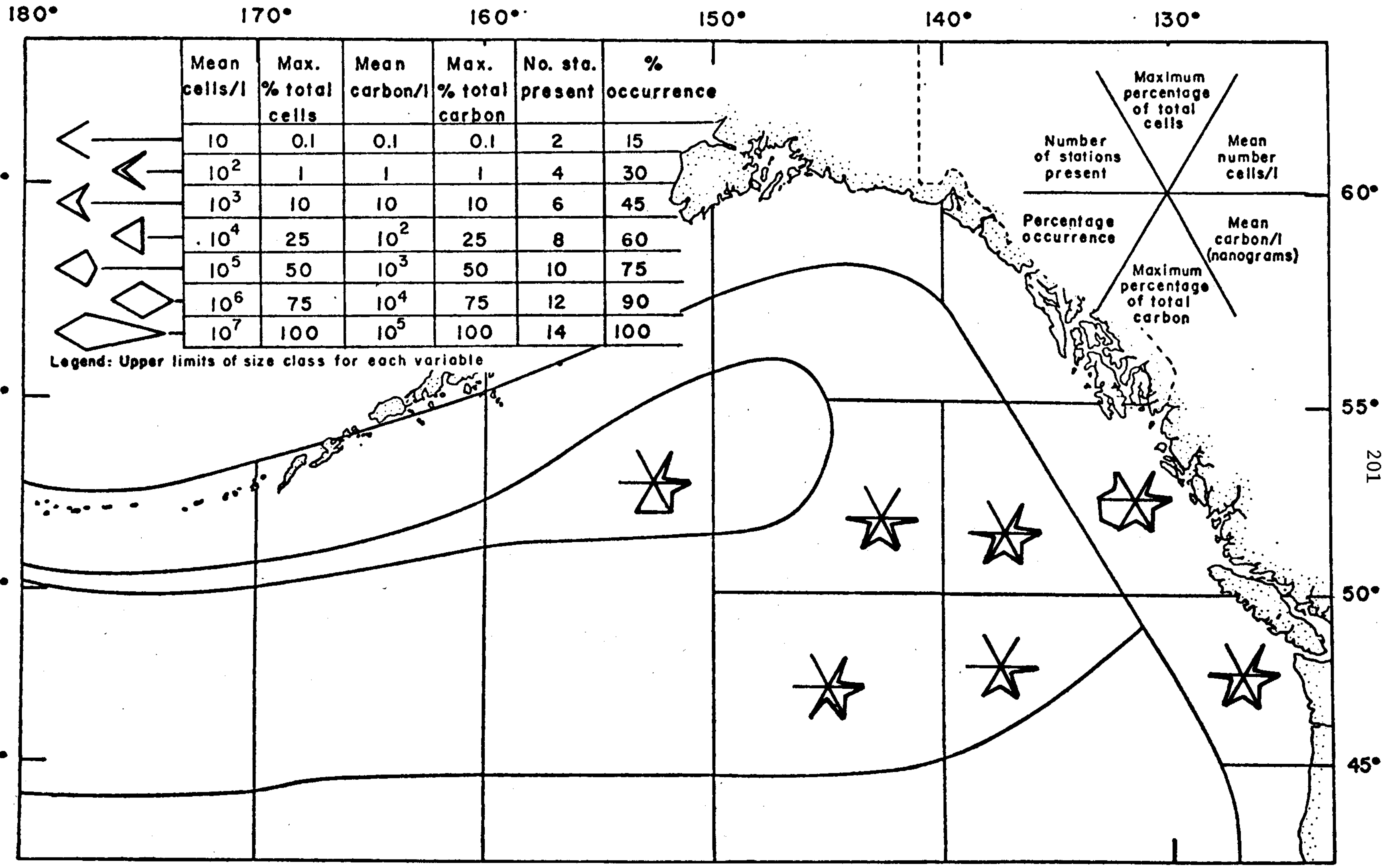


Figure 122. The distribution of *Ceratium macroceros* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

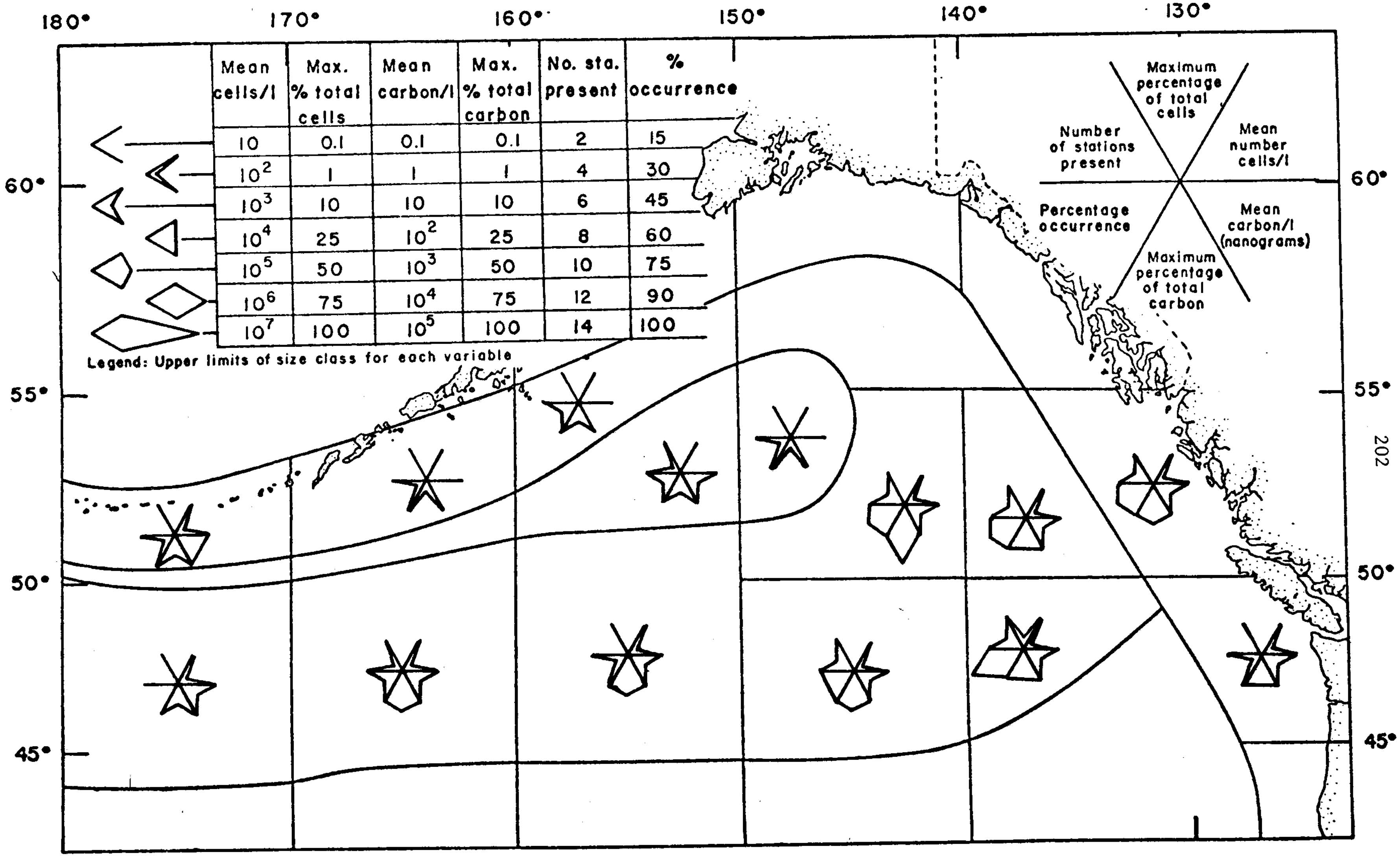


Figure 123. The distribution of *Ceratium pentagonum* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

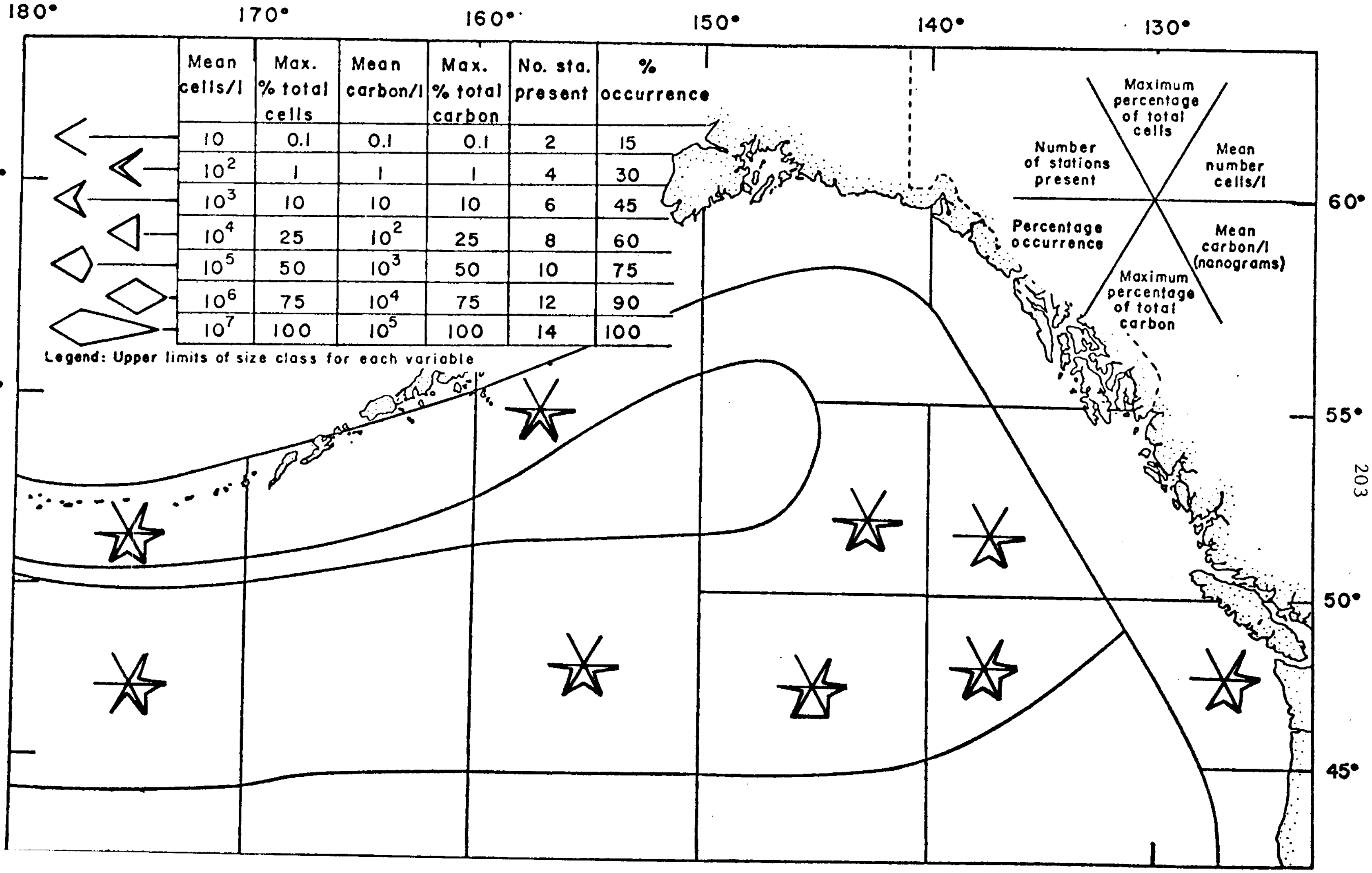


Figure 124. The distribution of *Ceratium tripos* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

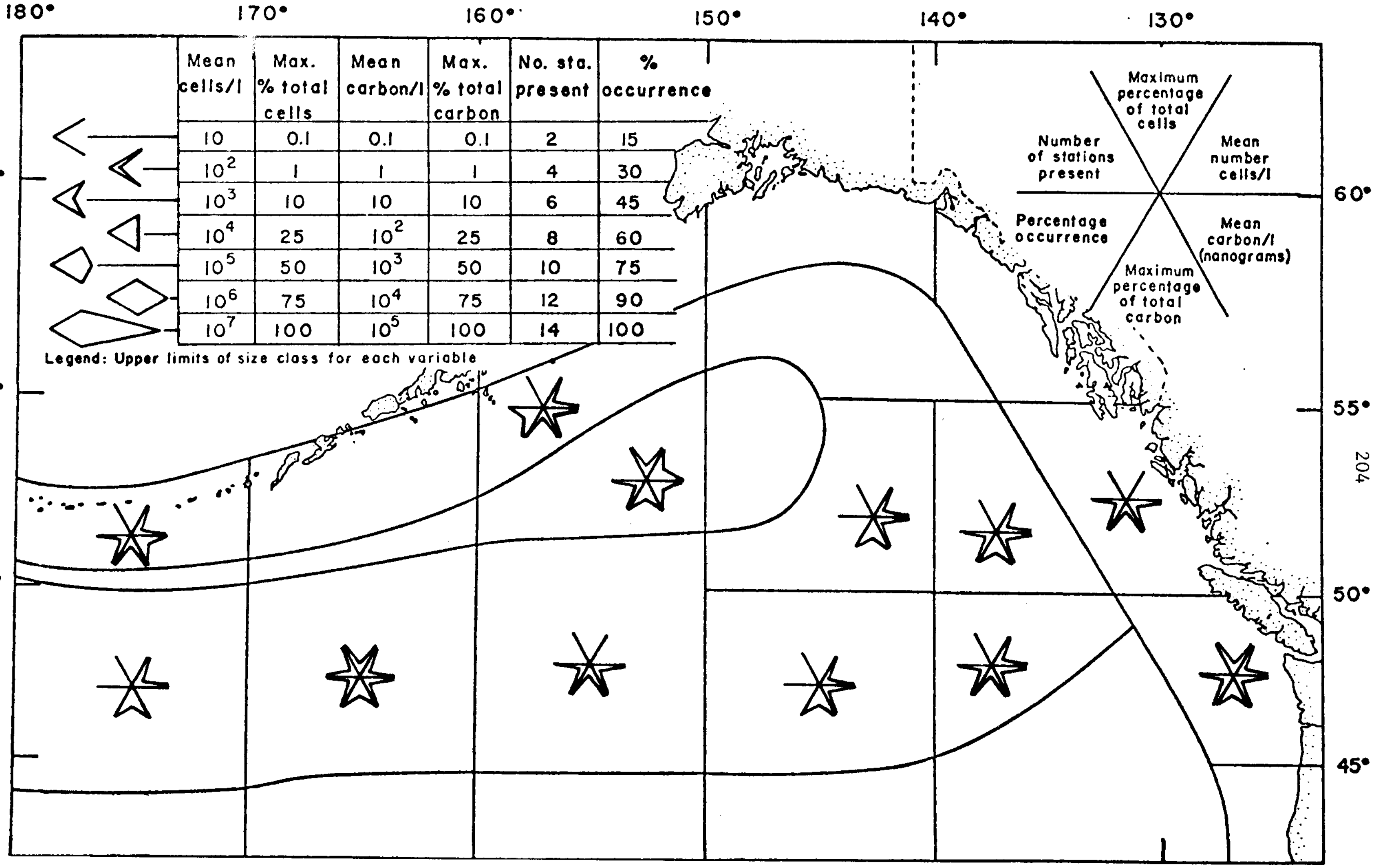


Figure 125. The distribution of *Dinophysis acuta* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

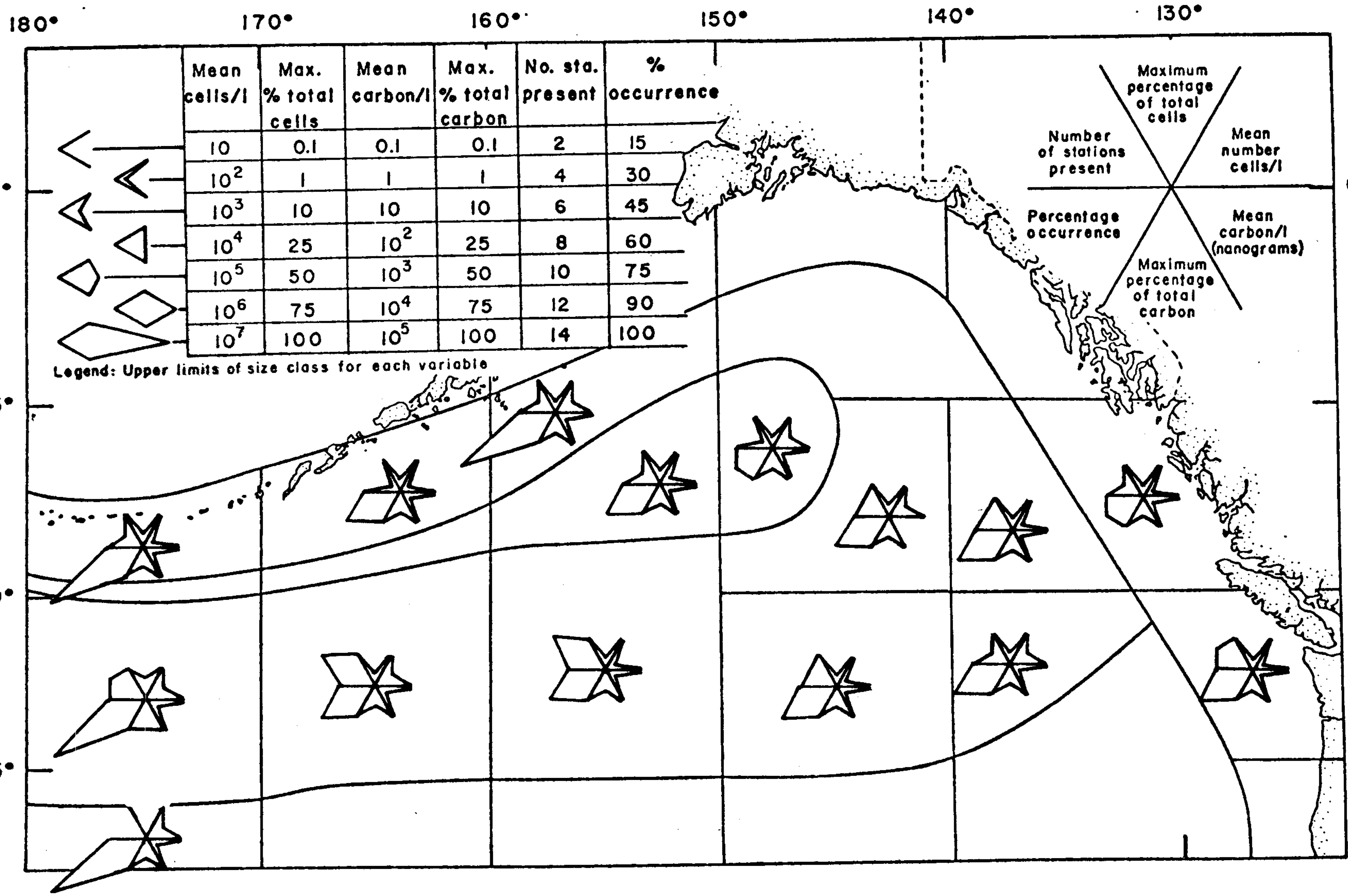
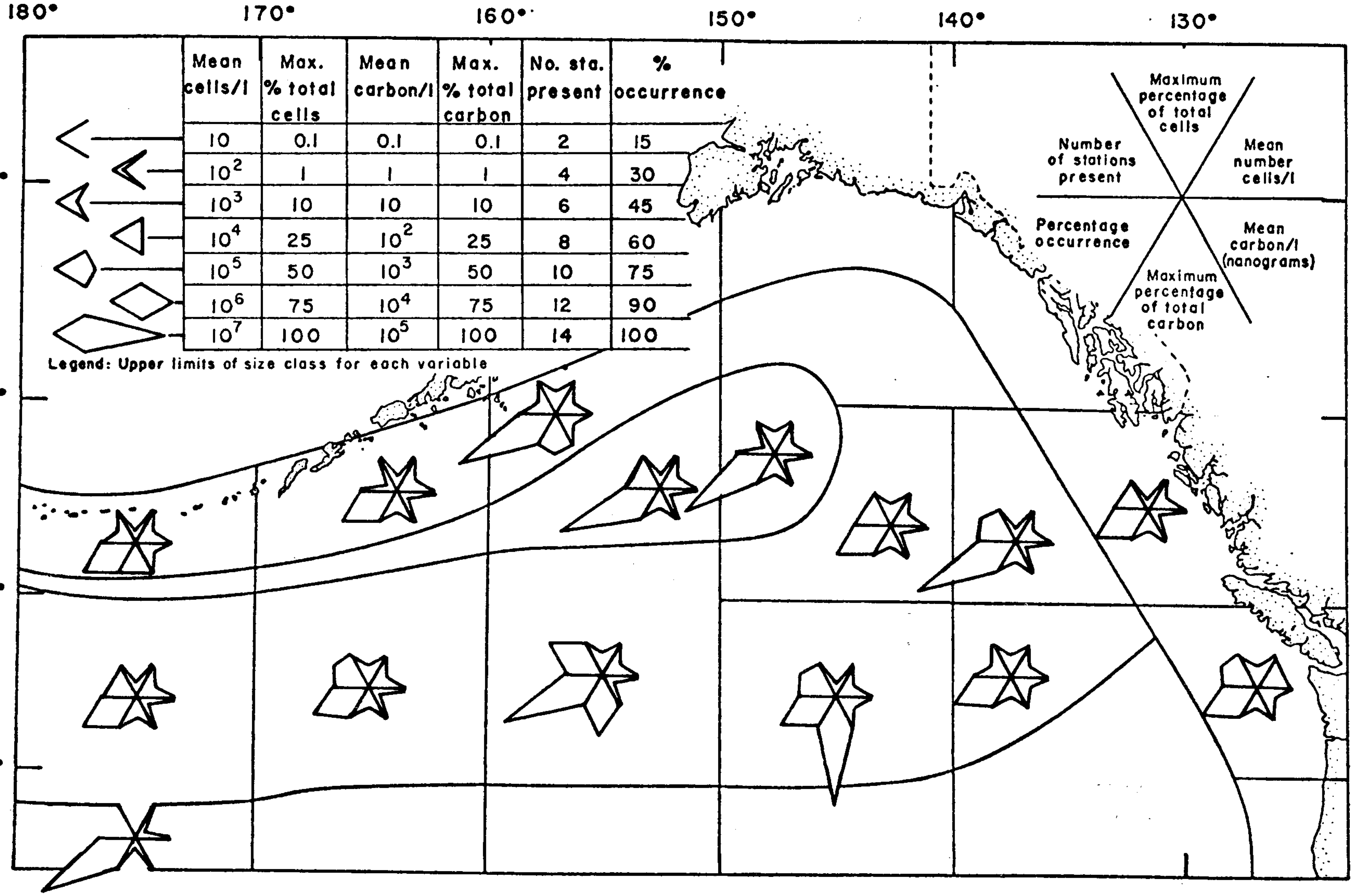


Figure 126. The distribution of *Gymnodinium* spp. in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 127. The distribution of *Gyrodinium* spp. in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

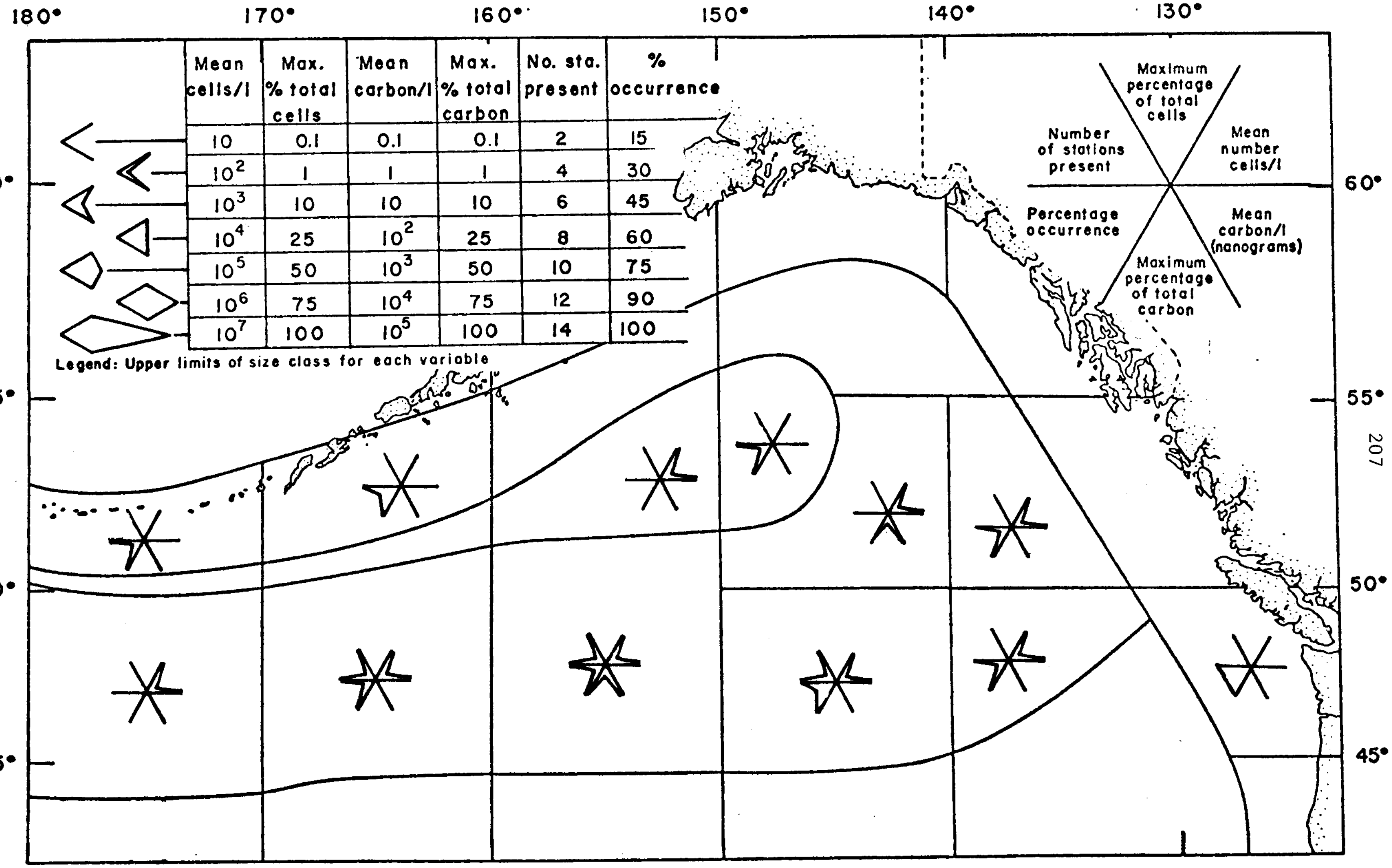
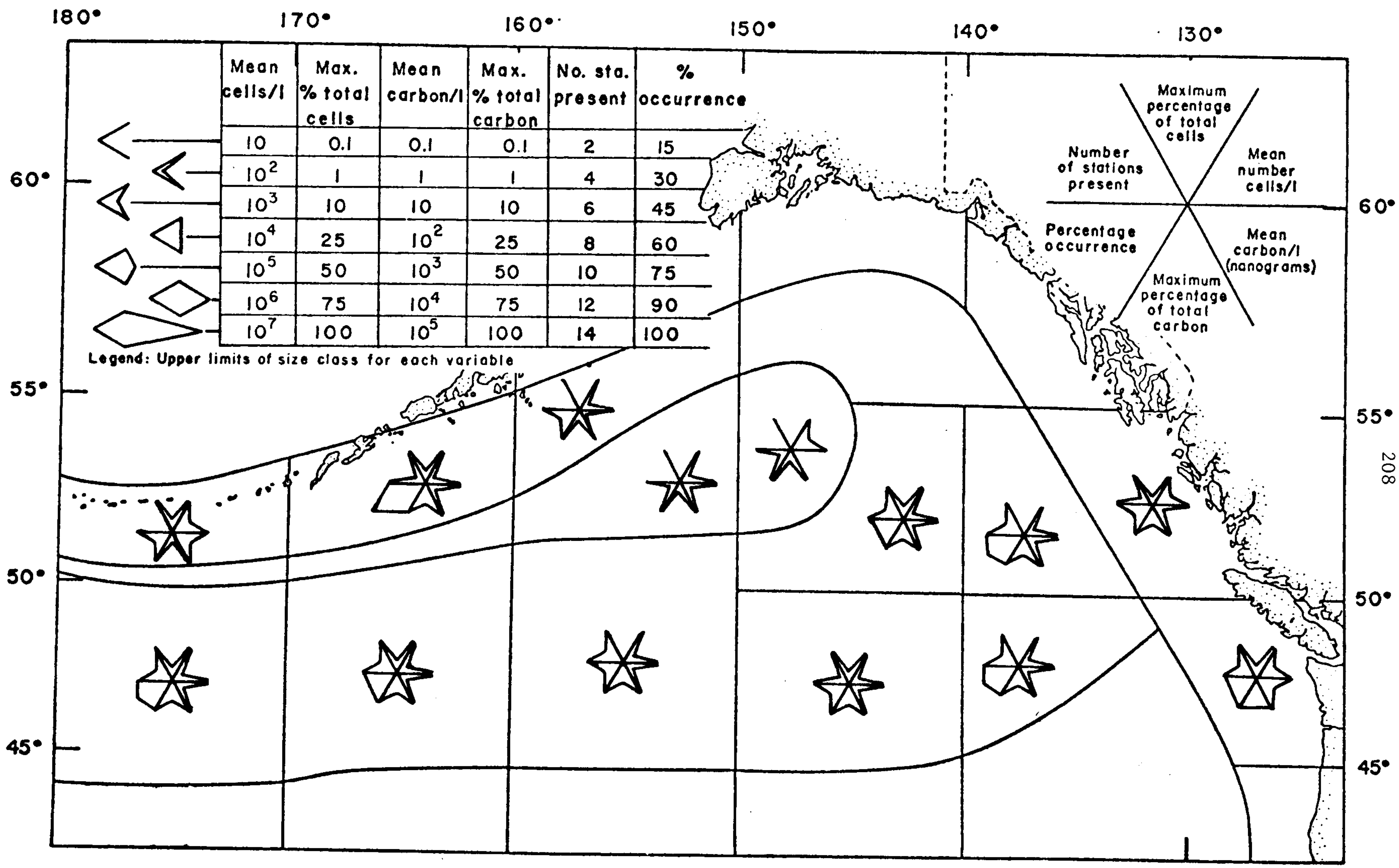


Figure 128. The distribution of *Miniscule bipes* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 129. The distribution of *Perdinium cerasus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

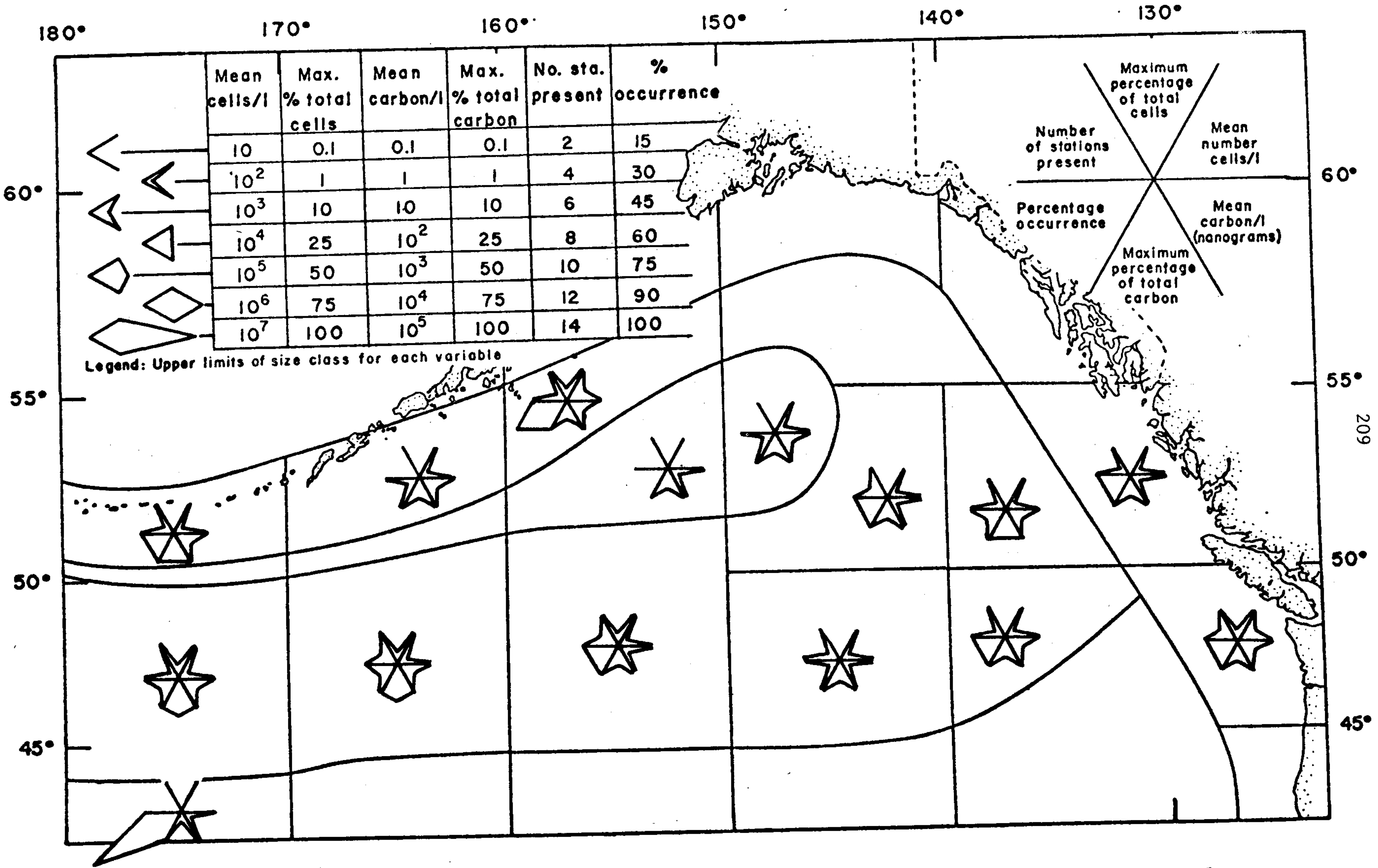


Figure 130. The distribution of *Peridinium depressum* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

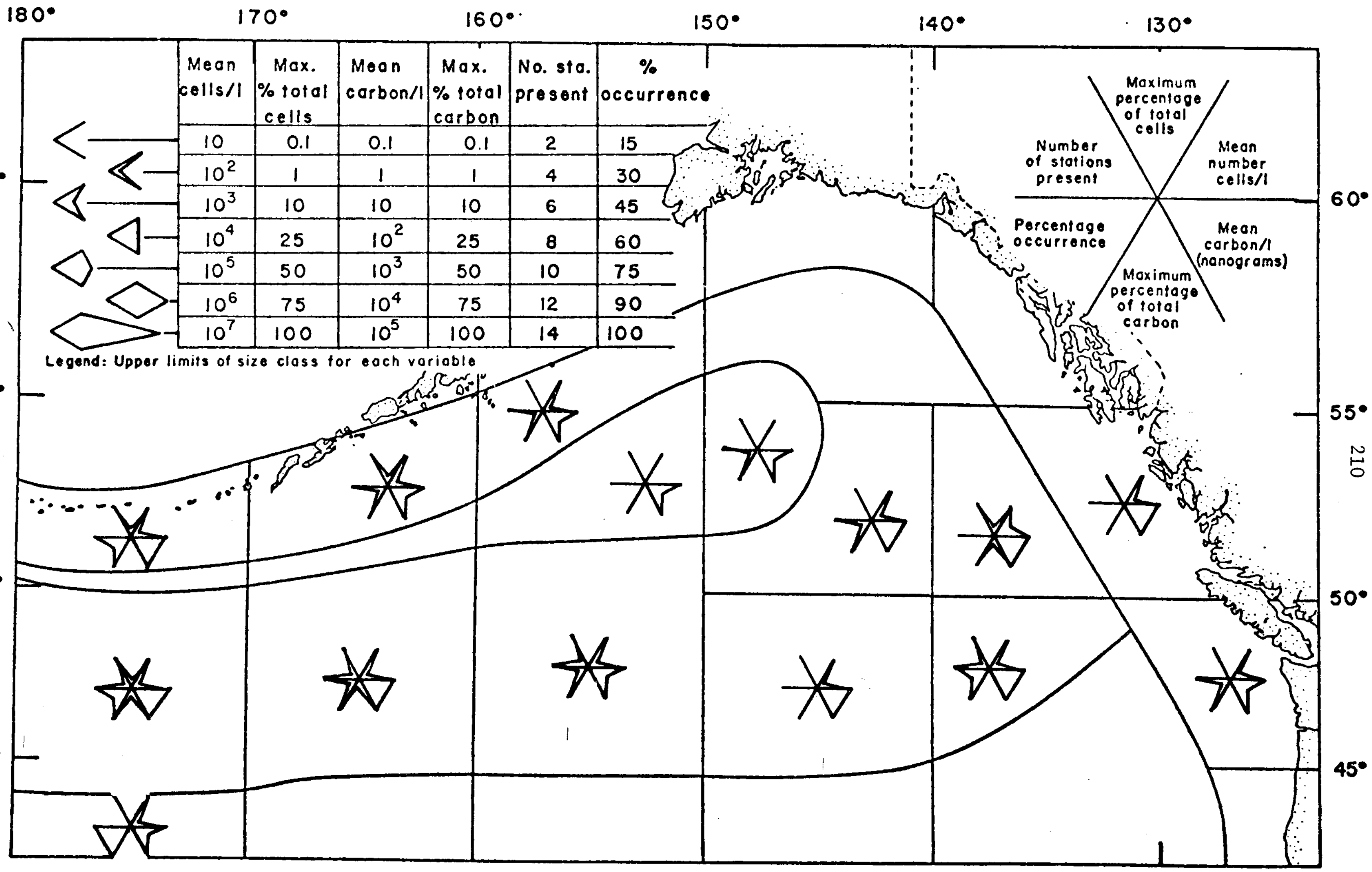


Figure 131. The distribution of *Calyptrosphaera* spp. in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

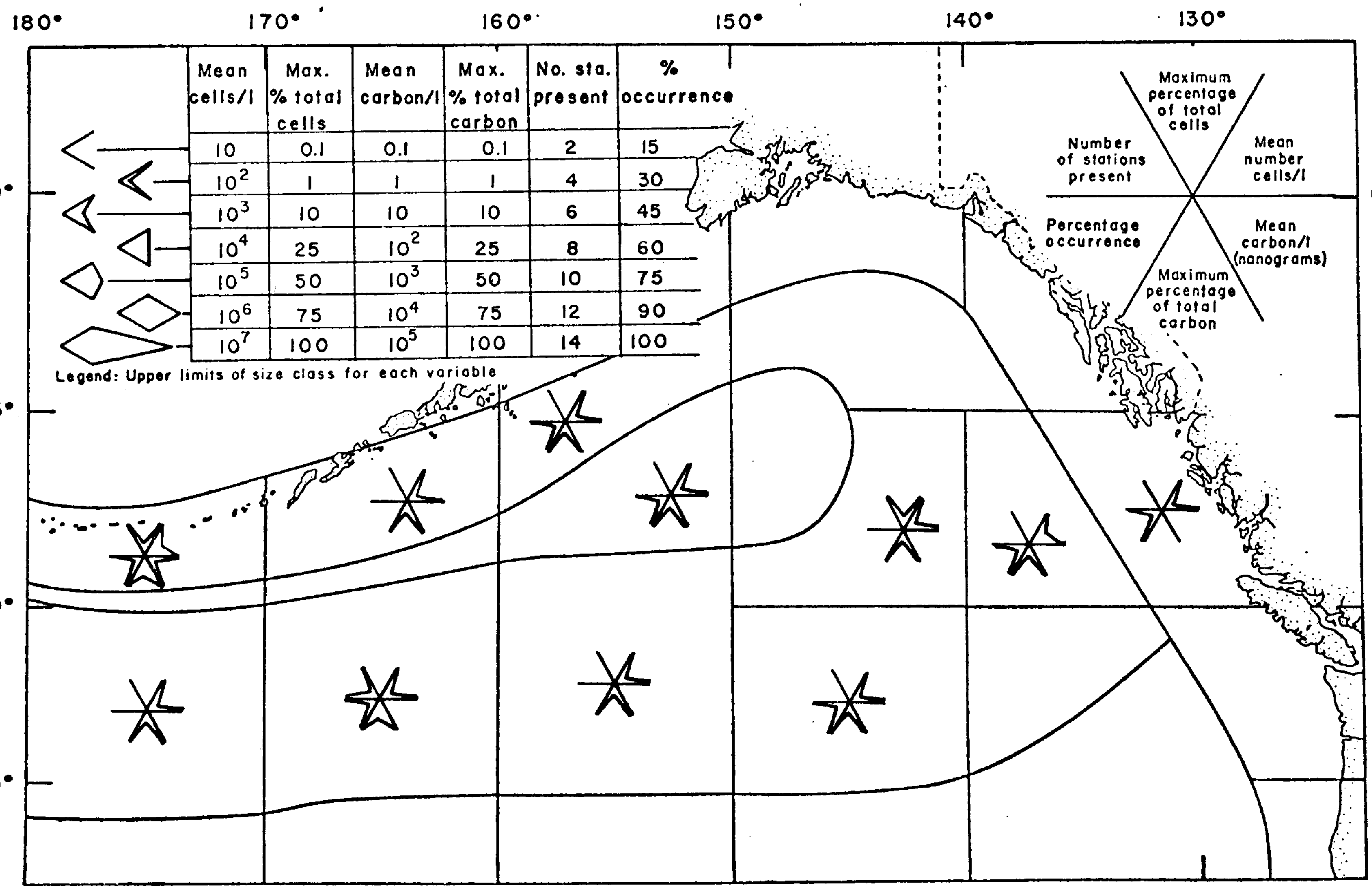


Figure 132. The distribution of *Coccolithophorid "C"* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

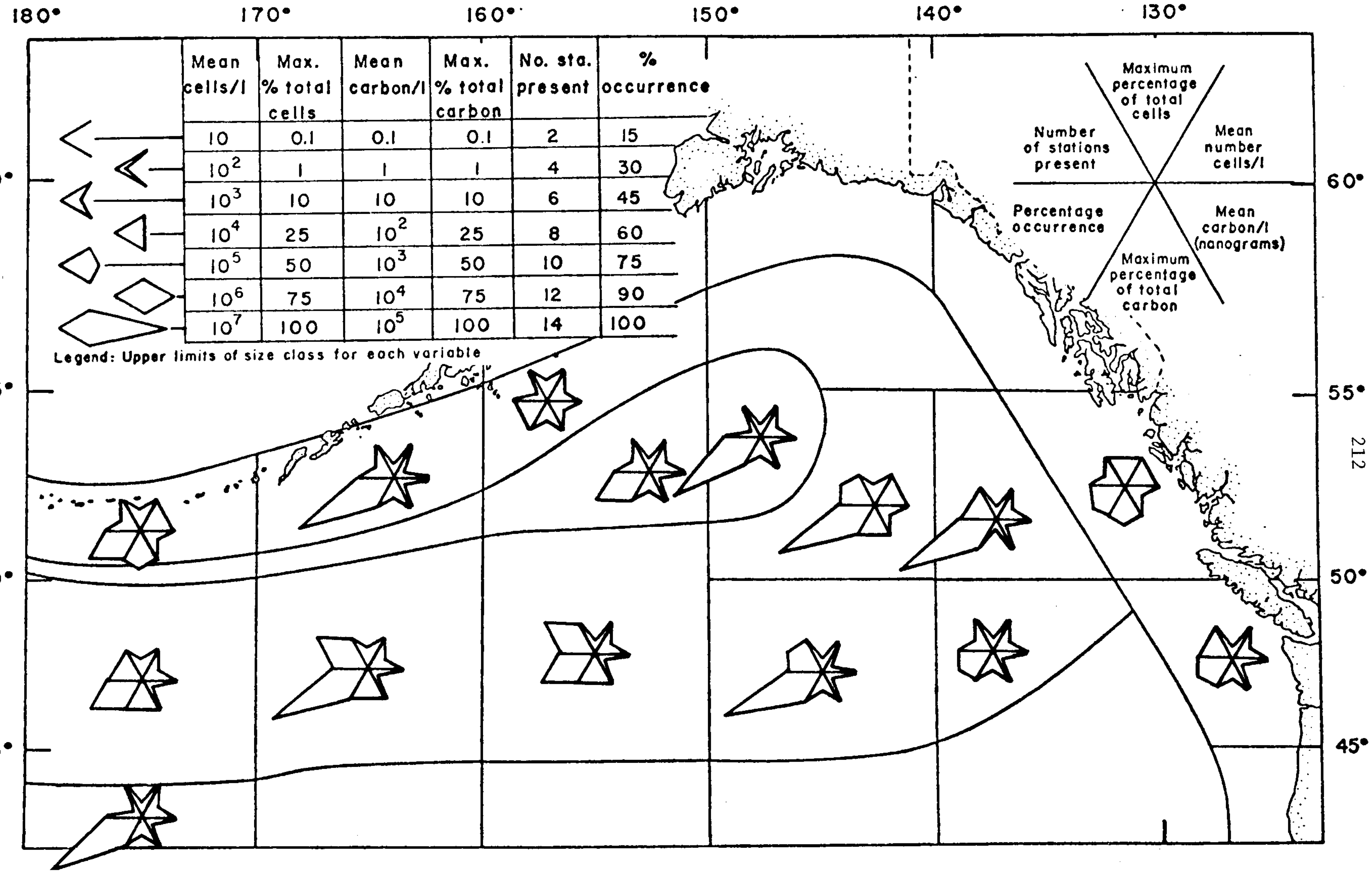


Figure 133. The distribution of *Coccolithus huxleyi* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

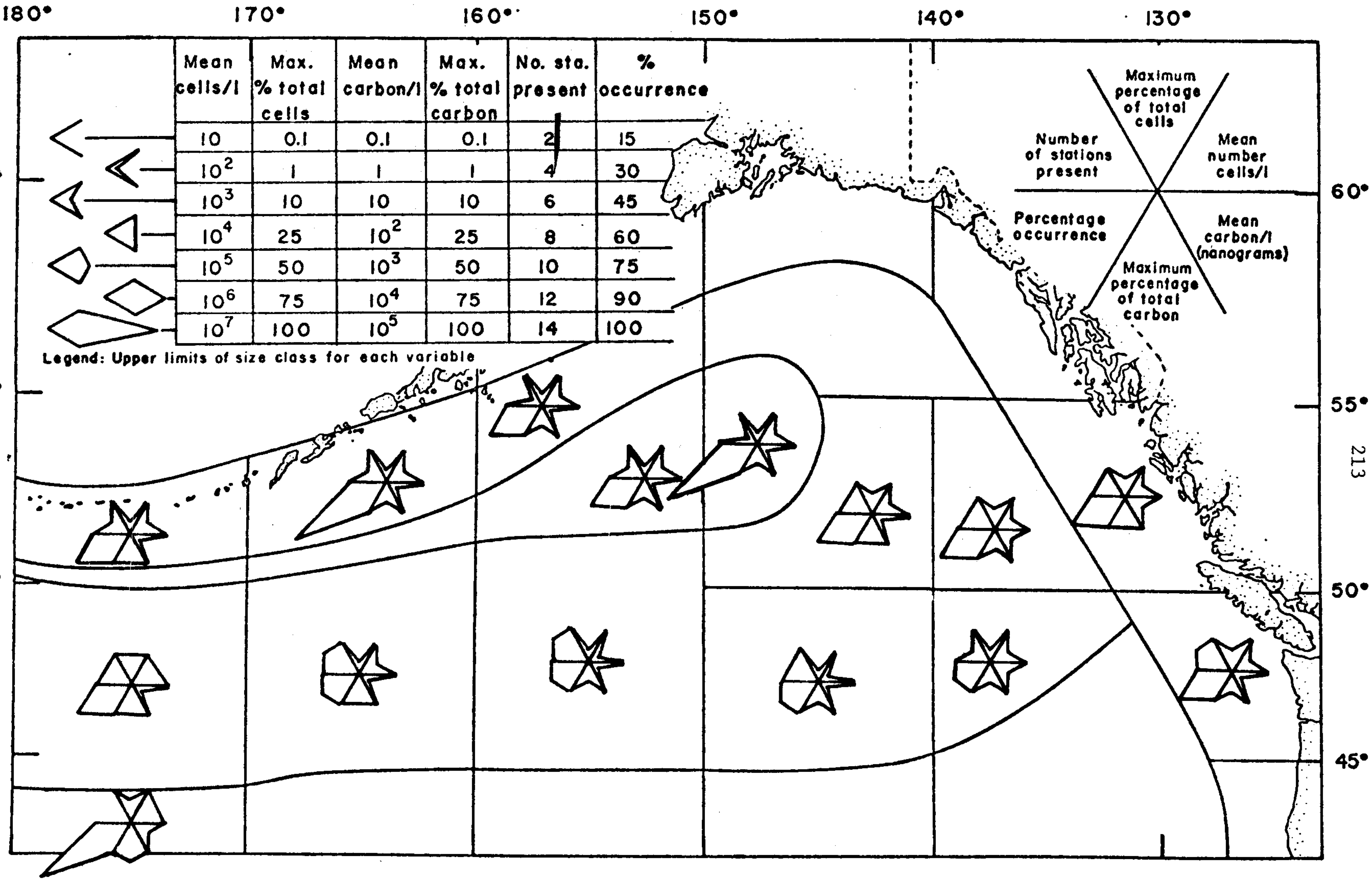


Figure 134. The distribution of *Coccolithus pelagicus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

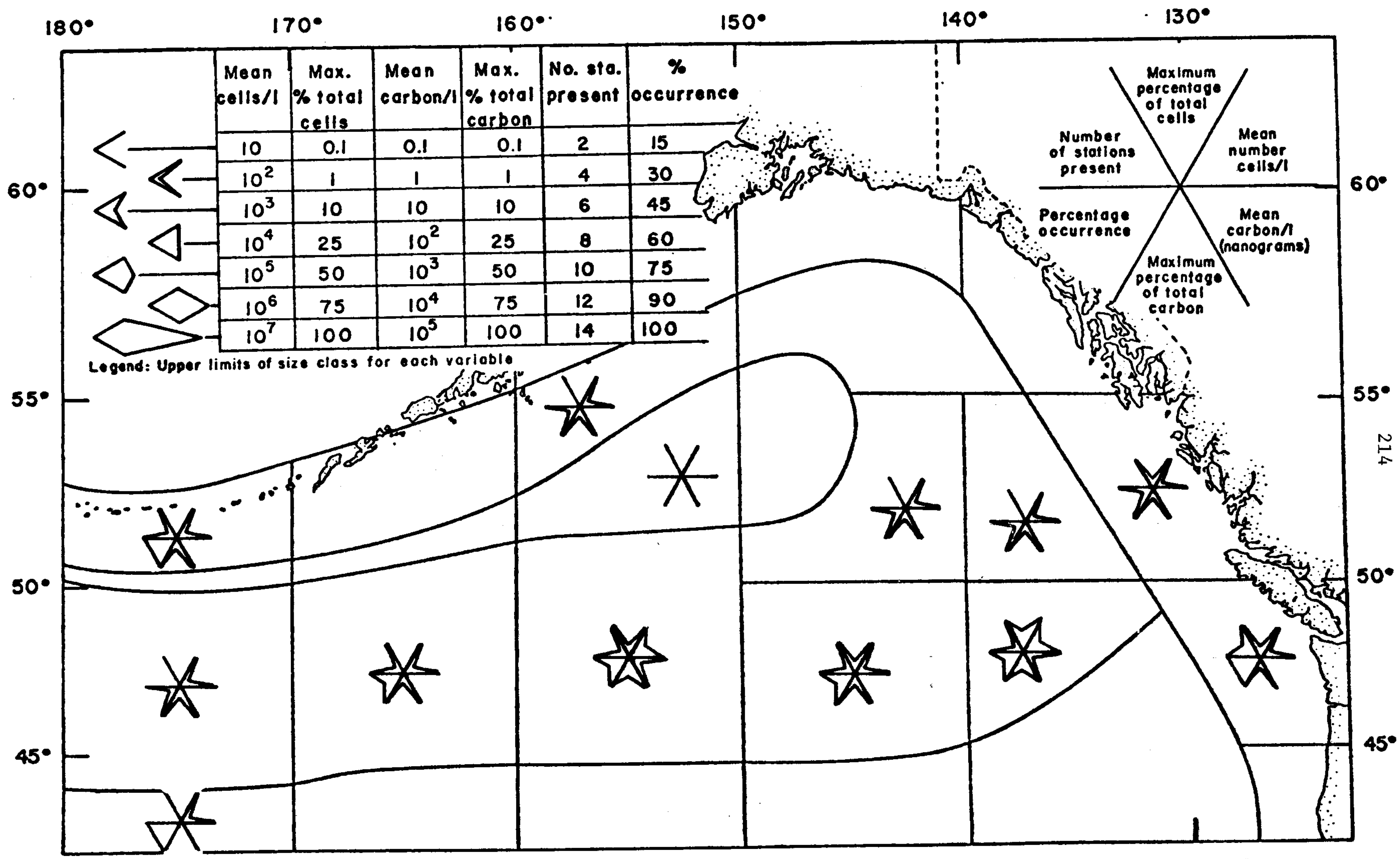
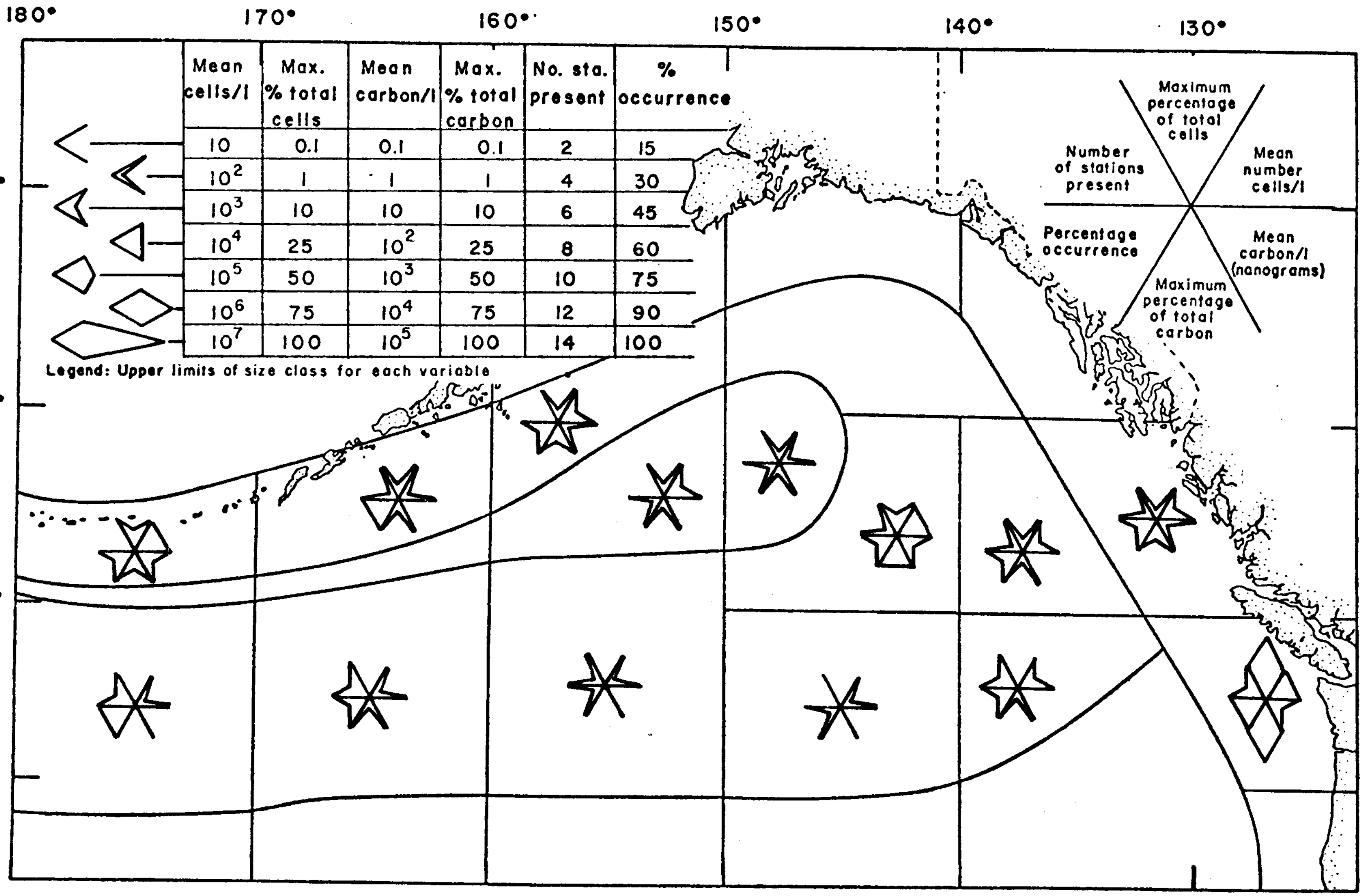


Figure 135. The distribution of *Cyclococcolithus* sp. A in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.



Mean cells/l	Max. % total cells	Mean carbon/l	Max. % total carbon	No. sta. present	% occurrence
10	0.1	0.1	0.1	2	15
10^2	1	1	1	4	30
10^3	10	10	10	6	45
10^4	25	10^2	25	8	60
10^5	50	10^3	50	10	75
10^6	75	10^4	75	12	90
10^7	100	10^5	100	14	100

Figure 136. The distribution of *Cyclococcolithus* sp. B in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

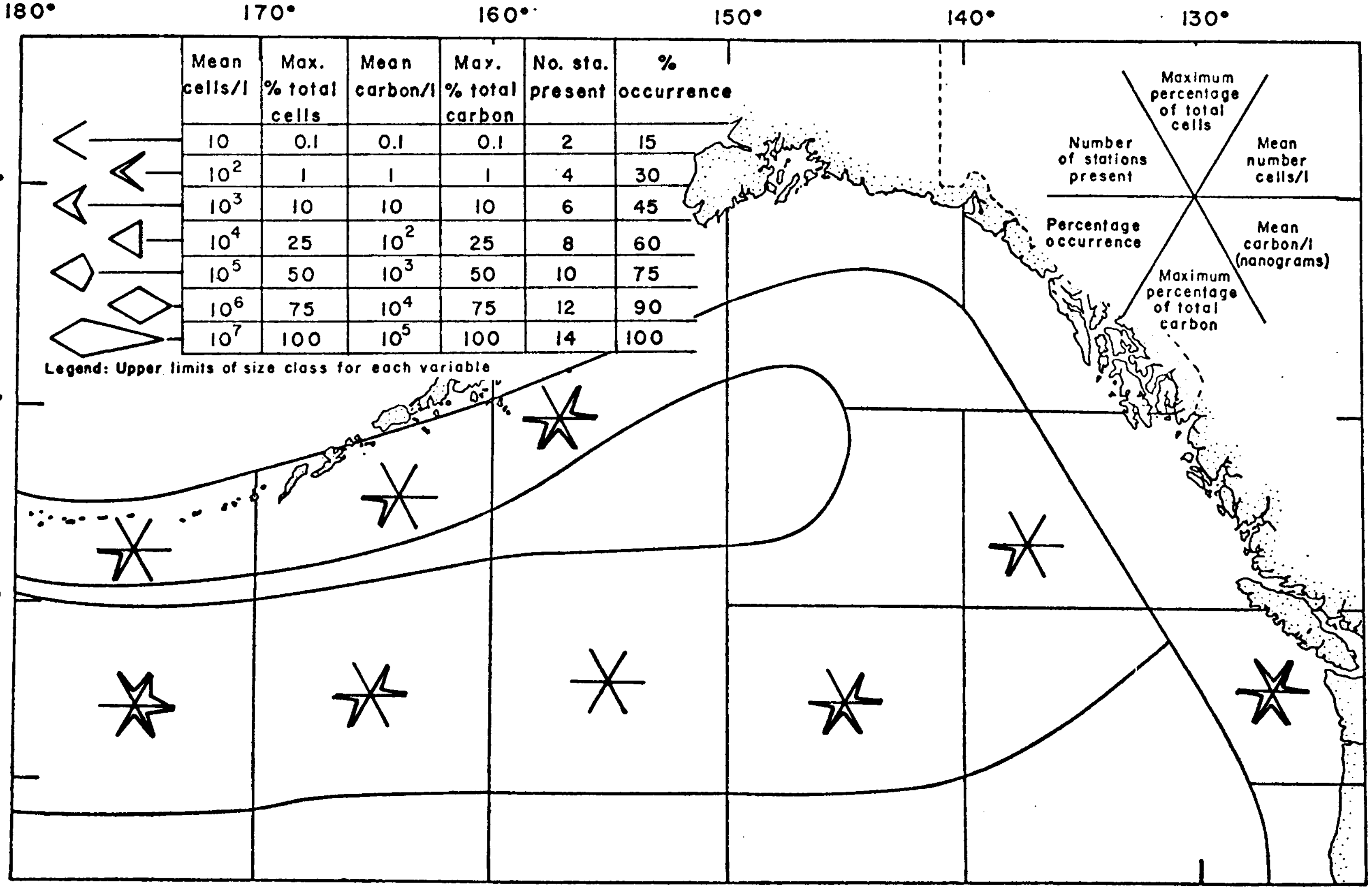


Figure 137. The distribution of *Rhabdosphaera tignifer* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

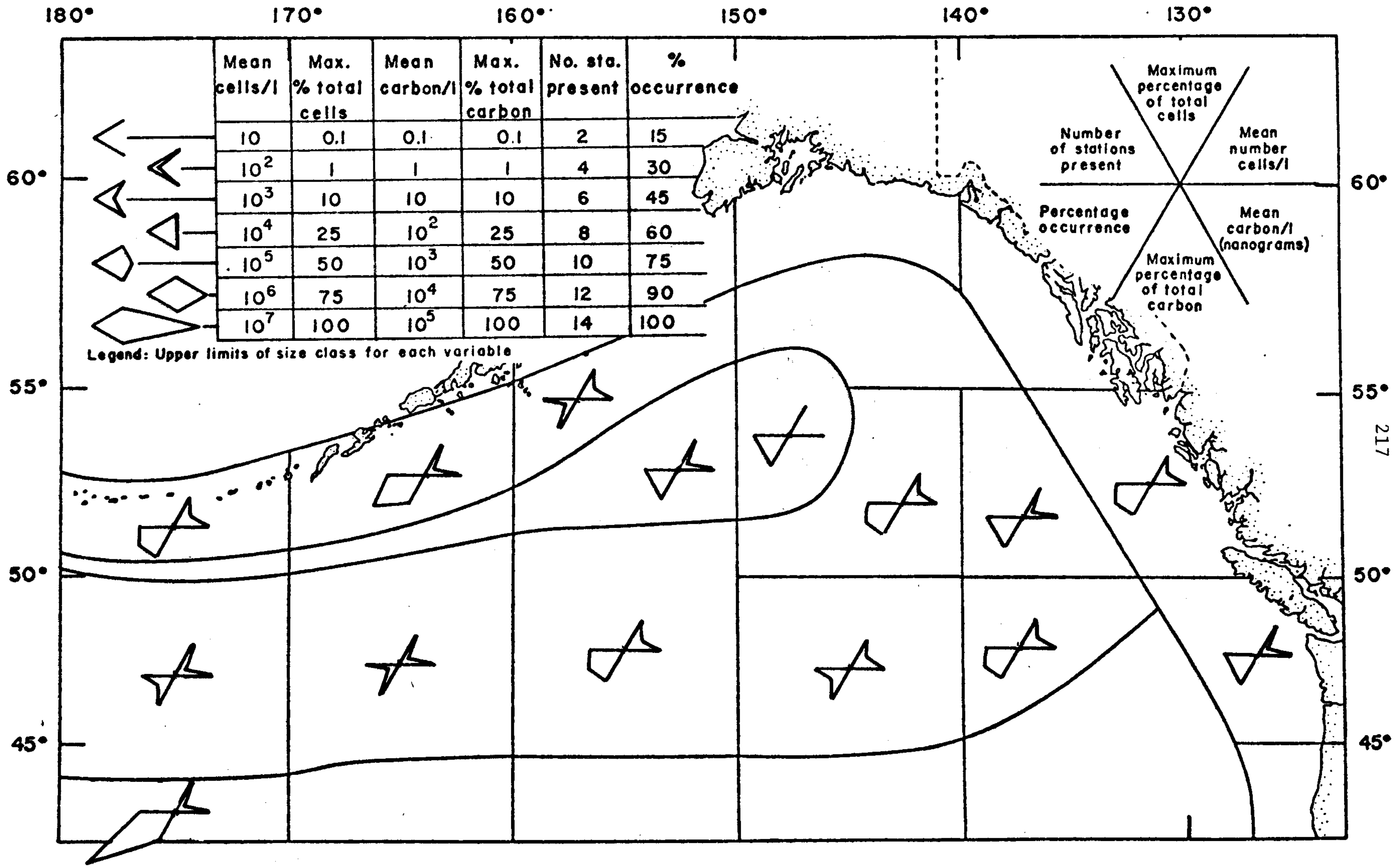


Figure 138. The distribution of *Dictyocha fibula* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

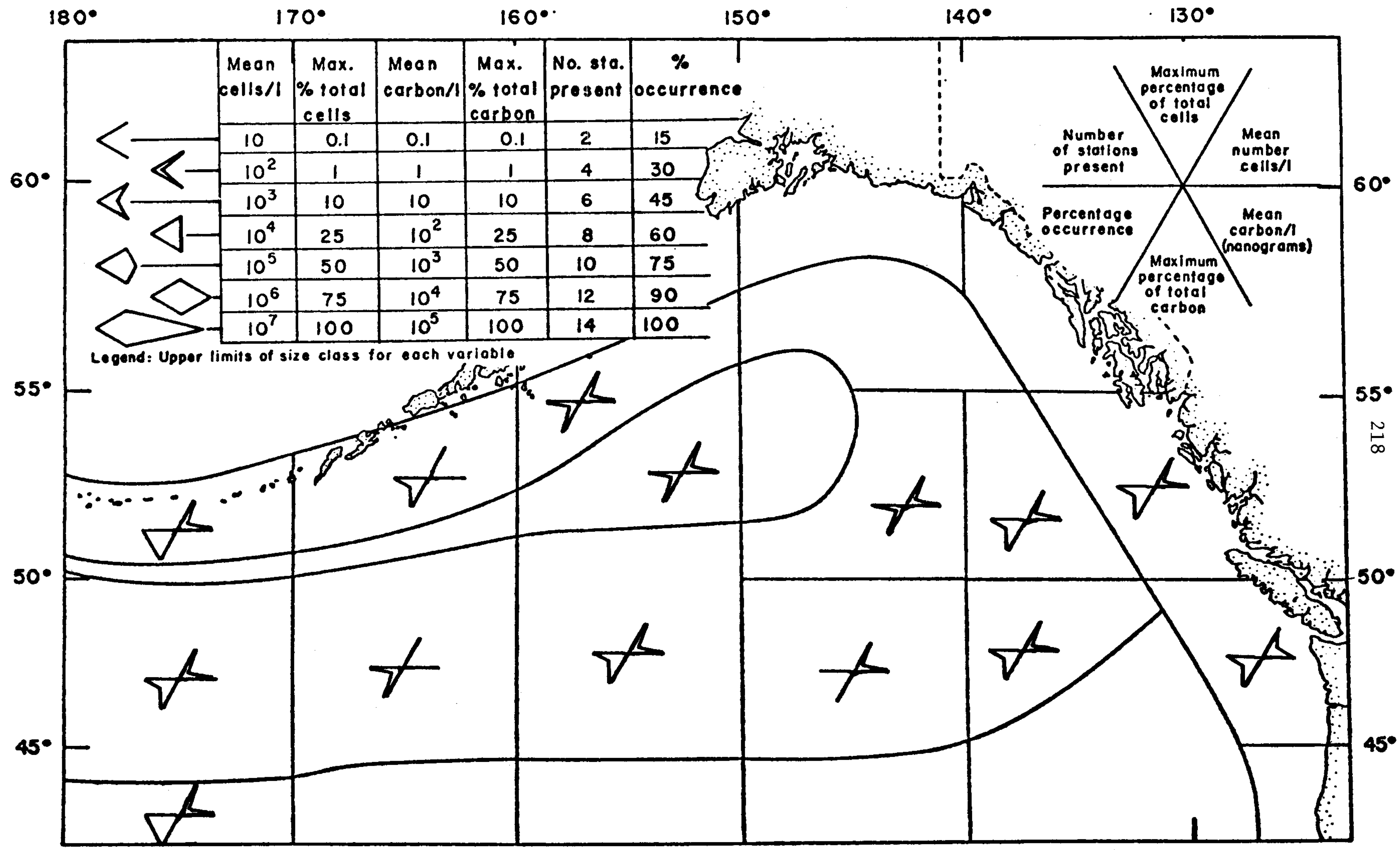


Figure 139. The distribution of *Distephanus octangulatus* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

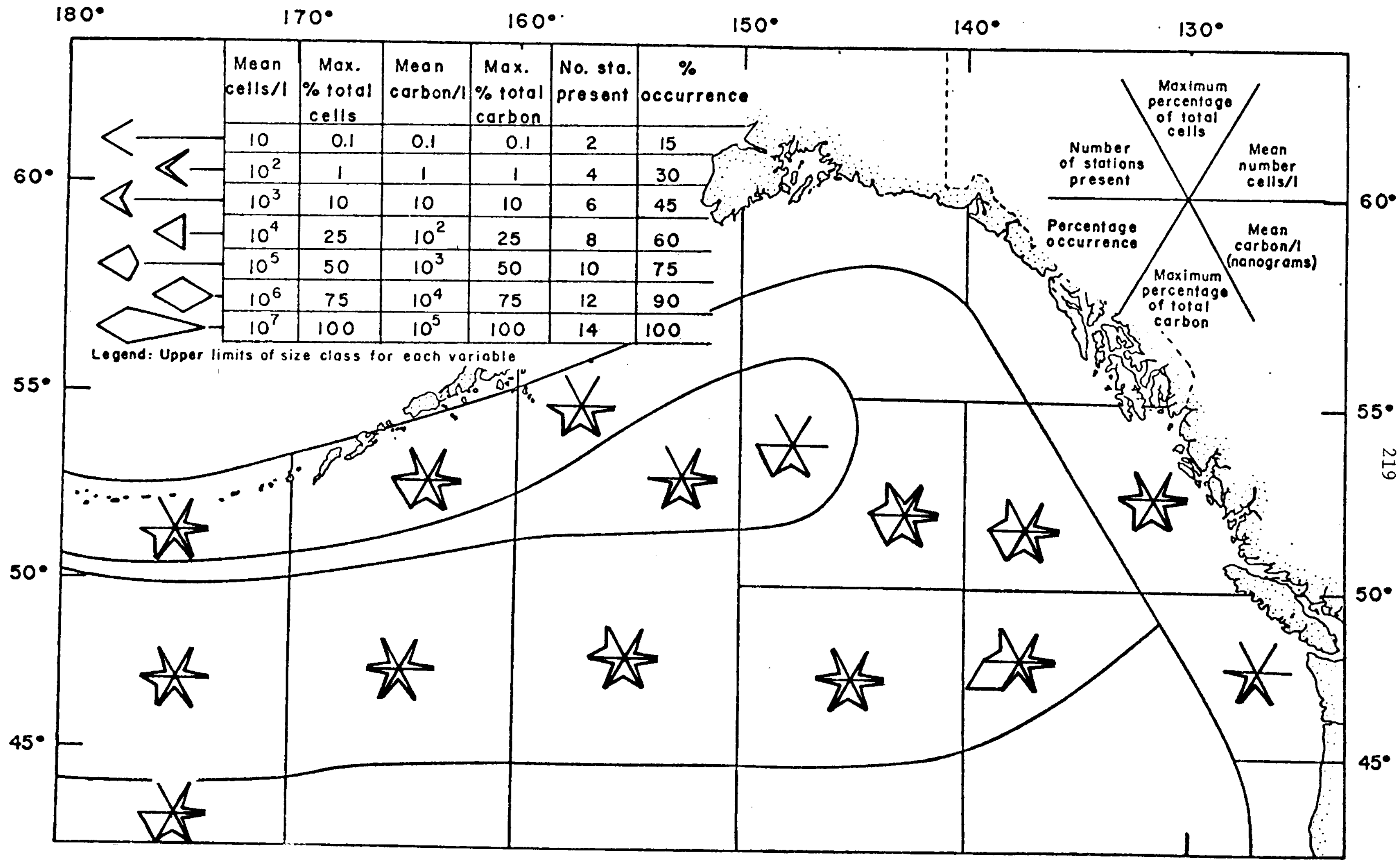


Figure 140. The distribution of *Pterosperma* sp. in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

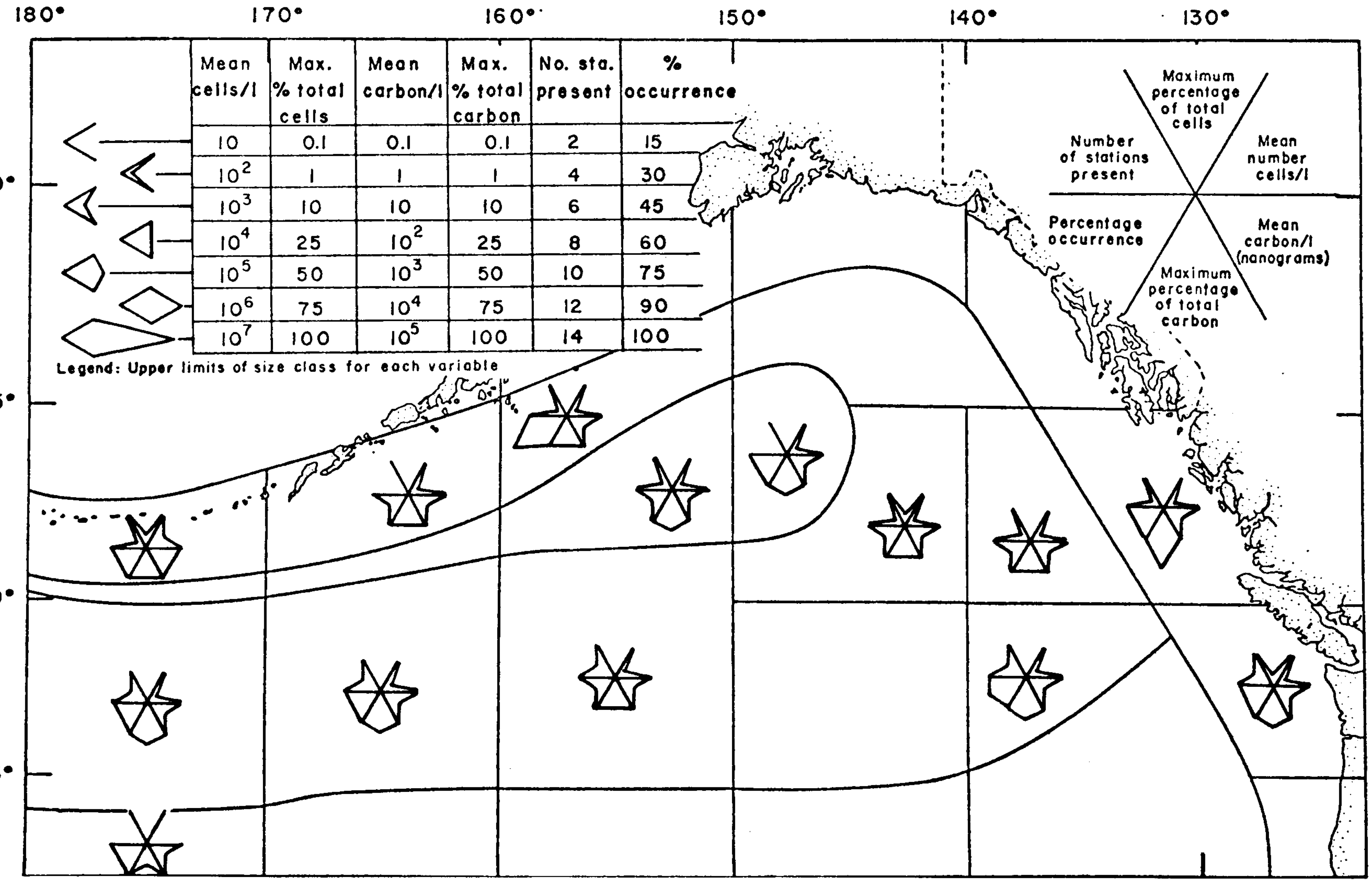


Figure 141. The distribution of *Halosphaera viridis* in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

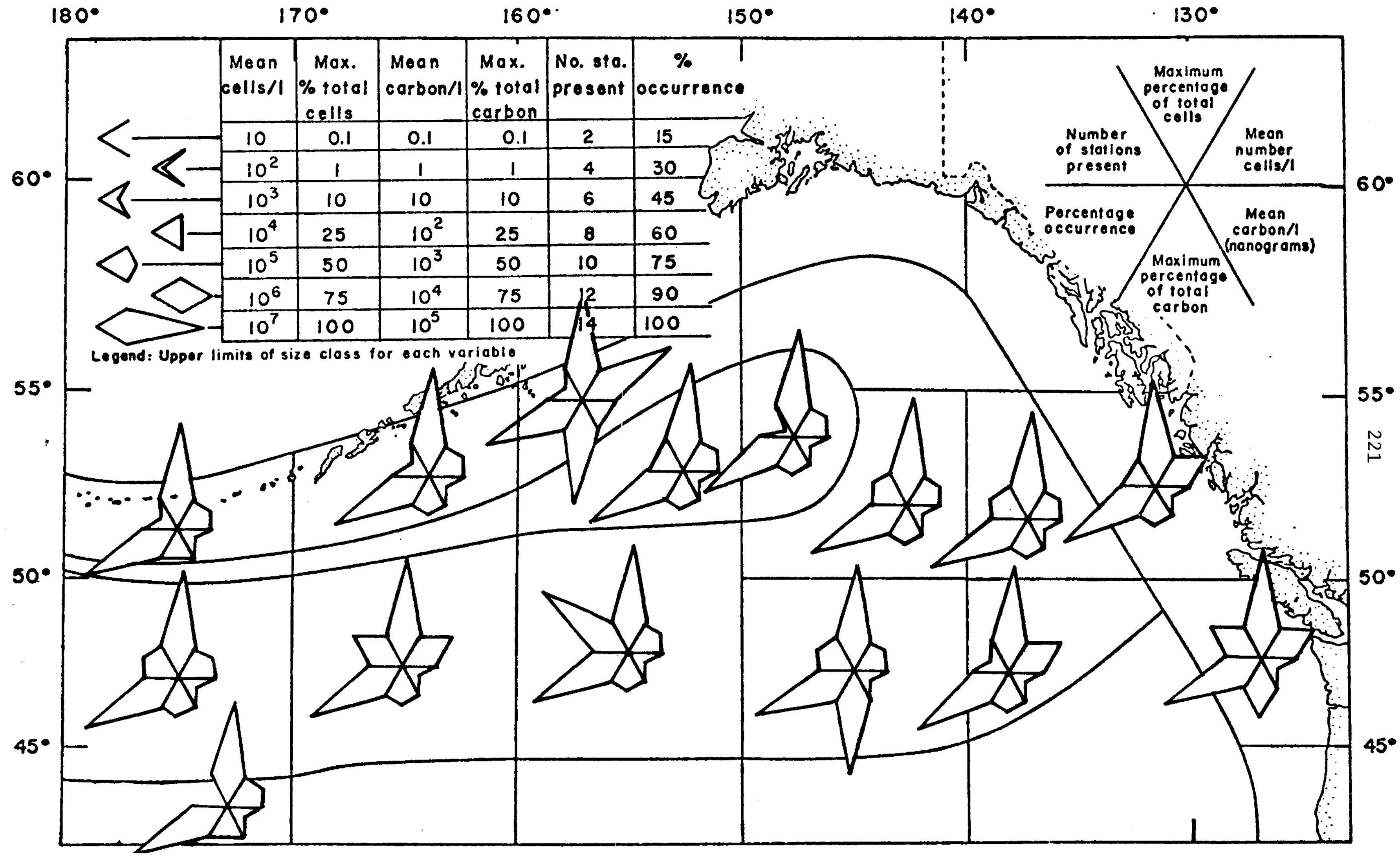


Figure 142. The distribution of Micro-flagellates in the upper 10 meters of the water column from January to July 1966 and 1969 to 1972.

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Appendix A

The following tables contain the data represented by Figure 31 through 79. Each page presents the data for one variable, all zones and seasons for the years 1958 through 1974 for the depth range written at the upper right corner.

The tables show the oceanic zone number in the left-most column under each season, followed by the various parameters for that zone and season.

MAX is the maximum value measured.

MIN is the minimum value measured.

MEAN is the arithmetic mean of all the data.

SD is the standard deviation.

N is the number of measurements made.

-00.99 and -99.9 and -99 indicate that there was no data for that zone and season.

Depth range 150.0-*99 meters includes all samples below 150 meters.

Total chlorophyll-a is integrated over the euphotic zone.

Total production (mg C/m^2/day is integrated over the euphotic zone.

Total phaeopigments are integrated over the euphotic zone.

Table 1. Chlorophyll a
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m
- e. 100.1-150 m
- f. > 150 m

Table 2. Total chlorophyll a

Table 3. Primary productivity
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m

Table 4. Total productivity

Table 5. Nitrate
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m
- e. 100.1-150 m
- f. > 150 m

Appendix A (cont'd.)

Table 6. Phosphate
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m
- e. 100.1-150 m
- f. > 150 m

Table 7. Silicate
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m
- e. 100.1-150 m
- f. > 150 m

Table 8. Oxygen
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m
- e. 100.1-150 m
- f. > 150 m

Table 9. Phaeopigments
- a. 0-10 m
- b. 10.1-25
- c. 25.1-50 m
- d. 50.1-100 m
- e. 100.1-150 m
- f. > 150 m

Table 10. Total phaeopigments

Table 11. Nitrite
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m
- e. 100.1-150 m
- f. > 150 m

Table 12. Ammonia
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m
- e. 100.1-150 m
- f. > 150 m

Table 13. Depth of Mixed Layer

Table 14. Light

TABLE 1a

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 .0 - 10.0 METERS

WINTER ZONE	MAX	MIN	MEAN	SD	N	SPRING ZONE	MAX	MIN	MEAN	SD	N
15	.33	.33	.33	.0	1	15	3.22	3.22	3.22	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	.61	.00	.16	.2	31	17	13.08	.00	2.65	3.6	147
18	.60	.56	.58	.0	2	18	2.22	.99	1.45	.4	13
19	.65	.30	.48	.1	10	19	4.90	.11	1.17	1.3	21
20	3.28	.18	1.05	.8	25	20	14.18	.15	2.44	3.1	54
21	.71	.71	.71	.0	1	21	-99.99	-99.99	-99.99	-99.9	-99
22	.58	.37	.48	.1	6	22	12.03	.17	1.32	2.4	57
23	.58	.13	.25	.1	22	23	12.57	.16	1.41	2.3	43
24	.54	.23	.33	.1	11	24	5.17	.25	1.18	1.7	10
25	-99.99	-99.99	-99.99	-99.9	-99	25	9.09	.33	2.77	3.4	12
26	.46	.16	.25	.1	5	26	.44	.21	.31	.1	7
27	.66	.26	.40	.1	17	27	1.60	.17	.51	.4	32
28	.74	.33	.44	.1	9	28	2.16	.12	.46	.5	16
29	.38	.36	.37	.0	3	29	1.28	.09	.43	.3	52
30	.40	.00	.19	.1	35	30	.76	.05	.39	.2	50
31	1.06	.26	.40	.2	16	31	.74	.05	.37	.2	42
32	.42	.24	.33	.1	9	32	.64	.14	.36	.1	32
33	1.37	.10	.28	.1	130	33	2.08	.00	.35	.2	224
34	.55	.28	.38	.1	15	34	.58	.16	.34	.1	26
35	.43	.29	.37	.0	3	35	1.89	.23	.91	.7	12
36	.72	.22	.38	.1	19	36	.74	.13	.37	.1	32
37	.34	.25	.31	.0	6	37	.75	.20	.41	.2	32
38	.41	.41	.41	.0	1	38	.30	.30	.30	.0	1
39	.36	.36	.36	.0	1	39	-99.99	-99.99	-99.99	-99.9	-99
40	.38	.17	.29	.1	9	40	.52	.52	.52	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99	41	.38	.29	.35	.0	4
42	.38	.19	.27	.1	9	42	.48	.14	.36	.1	14

SUMMER ZONE	MAX	MIN	MEAN	SD	N	AUTUMN ZONE	MAX	MIN	MEAN	SD	N
15	6.22	.62	3.09	2.9	6	15	-99.99	-99.99	-99.99	-99.9	-99
16	2.03	.05	1.18	1.0	5	16	-99.99	-99.99	-99.99	-99.9	-99
17	1.81	.00	.40	.5	53	17	1.15	.00	.53	.3	32
18	9.50	1.40	5.45	5.7	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	.68	.19	.41	.2	9	19	-99.99	-99.99	-99.99	-99.9	-99
20	24.04	.15	4.10	4.9	123	20	1.88	.12	.94	.6	10
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	5.34	.00	1.11	1.4	93	22	2.63	.09	.78	.6	52
23	3.87	.05	.80	.9	39	23	.45	.02	.17	.1	16
24	3.72	.07	1.06	1.2	18	24	.47	.30	.36	.1	4
25	1.47	.00	.34	.3	29	25	-99.99	-99.99	-99.99	-99.9	-99
26	.94	.33	.55	.2	5	26	-99.99	-99.99	-99.99	-99.9	-99
27	1.35	.11	.43	.2	25	27	.42	.41	.41	.0	2
28	.58	.13	.41	.2	9	28	-99.99	-99.99	-99.99	-99.9	-99
29	1.58	.09	.36	.3	82	29	.40	.07	.23	.1	27
30	.66	.21	.33	.1	17	30	1.25	.00	.25	.3	21
31	.78	.16	.36	.2	43	31	.54	.08	.36	.1	15
32	1.97	.11	.60	.6	22	32	.55	.12	.28	.2	4
33	1.83	.03	.37	.3	233	33	1.49	.04	.36	.2	248
34	.74	.12	.36	.2	22	34	-99.99	-99.99	-99.99	-99.9	-99
35	.40	.40	.40	.0	1	35	-99.99	-99.99	-99.99	-99.9	-99
36	37.10	.00	1.58	6.8	29	36	-99.99	-99.99	-99.99	-99.9	-99
37	.68	.09	.35	.1	39	37	.23	.23	.23	.0	1
38	1.56	.21	.51	.4	15	38	.25	.02	.14	.1	14
39	.48	.25	.36	.1	4	39	.16	.04	.08	.0	6
40	1.05	.08	.44	.3	10	40	.94	.01	.13	.2	22
41	.65	.30	.49	.2	5	41	-99.99	-99.99	-99.99	-99.9	-99
42	1.01	.64	.82	.3	2	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 1b

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 10.1 - 25.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.51	.03	.17	.1	17
18	.37	.37	.37	.0	1
19	.37	.32	.34	.0	2
20	.86	.60	.74	.1	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	.25	.14	.19	.0	9
24	.64	.28	.52	.2	3
25	-99.99	-99.99	-99.99	-99.9	-99
26	.20	.17	.18	.0	4
27	.40	.32	.36	.1	2
28	.17	.17	.17	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99
30	.24	.12	.18	.0	32
31	.38	.24	.31	.1	3
32	-99.99	-99.99	-99.99	-99.9	-99
33	.37	.10	.26	.1	32
34	.39	.32	.35	.0	3
35	.50	.27	.42	.1	4
36	.50	.20	.36	.1	5
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.34	.16	.25	.1	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	14.02	.00	2.16	3.8	59
18	1.17	.66	1.00	.2	6
19	-99.99	-99.99	-99.99	-99.9	-99
20	3.22	.64	1.71	1.2	7
21	-99.99	-99.99	-99.99	-99.9	-99
22	10.98	.32	2.09	2.9	16
23	4.76	.23	1.71	1.6	9
24	.30	.30	.30	.0	1
25	6.89	.30	3.18	3.1	8
26	.39	.26	.33	.1	3
27	.29	.26	.27	.0	2
28	.45	.45	.45	.0	1
29	.58	.11	.31	.1	11
30	.71	.06	.36	.2	8
31	.49	.27	.41	.1	3
32	.48	.48	.48	.0	2
33	.52	.13	.30	.1	52
34	.38	.38	.38	.0	1
35	1.89	.39	1.10	.7	8
36	-99.99	-99.99	-99.99	-99.9	-99
37	.69	.51	.60	.1	2
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	3.14	1.69	2.41	1.0	2
16	3.42	1.95	2.49	.8	3
17	.65	.04	.26	.2	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	13.90	.31	2.99	3.0	41
21	-99.99	-99.99	-99.99	-99.9	-99
22	4.16	.11	.97	.9	34
23	2.76	.35	1.11	.9	12
24	3.03	.19	1.55	1.3	5
25	.47	.06	.27	.2	5
26	.54	.50	.52	.0	2
27	.68	.29	.46	.1	12
28	.63	.43	.53	.1	2
29	2.96	.10	.47	.6	24
30	-99.99	-99.99	-99.99	-99.9	-99
31	.66	.20	.37	.2	11
32	2.05	.19	.76	.7	7
33	1.04	.10	.42	.2	57
34	.47	.25	.36	.1	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	.54	.15	.34	.1	10
37	.61	.24	.42	.1	11
38	.46	.17	.34	.1	9
39	.15	.15	.15	.0	1
40	.89	.08	.48	.5	4
41	1.62	.34	.74	.5	5
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	1.08	.27	.51	.2	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.71	.25	.45	.2	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	1.20	.11	.57	.3	11
23	.43	.00	.16	.2	7
24	.43	.33	.38	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.47	.46	.46	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	.37	.03	.22	.1	18
30	.81	.14	.36	.3	5
31	.59	.21	.40	.1	8
32	-99.99	-99.99	-99.99	-99.9	-99
33	.93	.14	.33	.1	53
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.21	.05	.14	.0	8
39	.12	.07	.09	.0	2
40	.27	.05	.11	.1	14
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 1c

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 25.1 - 50.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	.54	.00	.18	.2	14	17	.65	.02	.16	.2	24
18	.45	.41	.43	.0	2	18	.98	.29	.64	.3	6
19	.29	.29	.29	.0	1	19	-99.99	-99.99	-99.99	-99.9	-99
20	.72	.12	.37	.2	6	20	1.29	.37	.65	.3	11
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	9.66	.33	2.67	2.9	19
23	.25	.17	.21	.0	5	23	4.65	.23	1.77	1.5	10
24	.45	.27	.34	.1	4	24	.28	.17	.22	.1	2
25	-99.99	-99.99	-99.99	-99.9	-99	25	7.37	.30	3.44	2.8	8
26	.24	.17	.21	.0	2	26	.35	.28	.33	.0	4
27	.46	.28	.37	.1	7	27	.29	.29	.29	.0	1
28	.52	.42	.47	.1	2	28	.75	.60	.68	.1	2
29	-99.99	-99.99	-99.99	-99.9	-99	29	.61	.08	.33	.2	12
30	.25	.18	.21	.0	5	30	.74	.06	.39	.2	12
31	.38	.15	.30	.1	8	31	.51	.17	.35	.2	6
32	-99.99	-99.99	-99.99	-99.9	-99	32	.46	.35	.41	.0	4
33	.41	.08	.31	.1	13	33	.49	.12	.31	.1	23
34	.34	.29	.32	.0	3	34	.35	.30	.32	.0	2
35	.58	.24	.39	.2	5	35	1.89	.27	.63	.5	8
36	.41	.20	.30	.1	7	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	.70	.64	.66	.0	4
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.56	.17	.32	.1	6	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	.38	.30	.35	.0	4

	SUMMER						AUTUMN				
15	.70	.70	.70	.0	1	15	-99.99	-99.99	-99.99	-99.9	-99
16	.42	.28	.35	.1	2	16	-99.99	-99.99	-99.99	-99.9	-99
17	.09	.05	.07	.0	3	17	.73	.06	.25	.2	11
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	.84	.84	.84	.0	1	19	-99.99	-99.99	-99.99	-99.9	-99
20	11.60	.14	1.67	1.9	42	20	1.25	.19	.69	.5	4
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	1.93	.13	.56	.5	31	22	1.09	.14	.46	.2	15
23	.77	.02	.47	.2	11	23	.38	.38	.38	.0	1
24	2.78	.64	1.53	1.0	4	24	.43	.17	.29	.1	6
25	.43	.15	.29	.1	6	25	-99.99	-99.99	-99.99	-99.9	-99
26	.57	.49	.54	.0	3	26	-99.99	-99.99	-99.99	-99.9	-99
27	.63	.26	.44	.1	22	27	.69	.60	.64	.1	2
28	.49	.25	.37	.2	2	28	-99.99	-99.99	-99.99	-99.9	-99
29	.92	.10	.29	.2	31	29	.49	.05	.23	.1	19
30	-99.99	-99.99	-99.99	-99.9	-99	30	.46	.05	.17	.2	4
31	.98	.20	.40	.2	15	31	.49	.17	.35	.1	17
32	.42	.24	.32	.1	8	32	-99.99	-99.99	-99.99	-99.9	-99
33	1.01	.09	.36	.2	57	33	.66	.14	.31	.1	26
34	.64	.28	.54	.1	6	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	.65	.00	.33	.1	32	36	-99.99	-99.99	-99.99	-99.9	-99
37	.67	.14	.43	.1	32	37	-99.99	-99.99	-99.99	-99.9	-99
38	.24	.11	.17	.1	2	38	.33	.02	.17	.1	6
39	-99.99	-99.99	-99.99	-99.9	-99	39	.11	.08	.09	.0	2
40	.22	.17	.19	.0	2	40	.75	.07	.39	.2	21
41	.47	.19	.31	.1	6	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 1d

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 50.1 - 100.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	.61	.00	.29	.2	6	17	.39	.02	.18	.1	5
18	1.08	.27	.67	.6	2	18	.84	.14	.41	.4	3
19	.26	.13	.19	.1	2	19	.46	.03	.16	.2	4
20	.33	.31	.32	.0	2	20	.84	.12	.38	.3	9
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	3.63	.29	1.42	1.3	12
23	-99.99	-99.99	-99.99	-99.9	-99	23	2.06	.07	.80	.7	11
24	.51	.23	.35	.1	4	24	.44	.13	.28	.2	2
25	-99.99	-99.99	-99.99	-99.9	-99	25	1.10	.26	.50	.3	6
26	-99.99	-99.99	-99.99	-99.9	-99	26	.38	.04	.17	.1	5
27	.46	.09	.33	.1	8	27	.27	.26	.26	.0	2
28	.36	.34	.35	.0	2	28	.56	.44	.50	.1	3
29	-99.99	-99.99	-99.99	-99.9	-99	29	.59	.01	.20	.2	9
30	.22	.10	.15	.0	11	30	.64	.00	.31	.2	12
31	.55	.20	.35	.1	9	31	.43	.14	.27	.1	6
32	-99.99	-99.99	-99.99	-99.9	-99	32	.42	.23	.34	.1	4
33	.37	.04	.24	.1	35	33	.44	.06	.25	.1	55
34	.36	.31	.34	.0	3	34	.26	.23	.25	.0	2
35	.58	.00	.34	.2	5	35	.28	.08	.15	.1	5
36	.47	.03	.31	.1	8	36	.36	.17	.26	.1	2
37	-99.99	-99.99	-99.99	-99.9	-99	37	.66	.10	.31	.2	6
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.45	.21	.32	.1	6	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	.29	.04	.16	.2	2

	SUMMER						AUTUMN				
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	.29	.20	.26	.0	3	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	.05	.00	.03	.0	2
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	.20	.20	.20	.0	1	19	-99.99	-99.99	-99.99	-99.9	-99
20	1.65	.18	.57	.5	17	20	.51	.00	.24	.3	3
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	.64	.08	.28	.2	21	22	.26	.09	.16	.1	9
23	.22	.14	.19	.0	4	23	-99.99	-99.99	-99.99	-99.9	-99
24	.26	.12	.19	.1	2	24	.31	.12	.22	.1	4
25	.42	.10	.27	.2	3	25	-99.99	-99.99	-99.99	-99.9	-99
26	.56	.24	.41	.2	3	26	-99.99	-99.99	-99.99	-99.9	-99
27	.49	.02	.27	.1	21	27	.19	.14	.17	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	.18	.00	.13	.0	19	29	.31	.00	.14	.1	14
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	.38	.10	.18	.1	15	31	.48	.04	.21	.1	16
32	.29	.12	.20	.1	7	32	-99.99	-99.99	-99.99	-99.9	-99
33	.42	.04	.21	.1	66	33	.62	.01	.16	.1	44
34	.45	.16	.28	.1	6	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	.38	.03	.21	.1	39	36	-99.99	-99.99	-99.99	-99.9	-99
37	.60	.03	.26	.1	34	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	.27	.07	.13	.1	6
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.97	.12	.54	.6	2	40	1.41	.07	.50	.4	34
41	.20	.13	.17	.0	4	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 1e

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 100.1 - 150.0 METERS

ZONE	WINTER MAX	MIN	MEAN	SD	N	ZONE	SPRING MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	.25	.09	.14	.1	4	17	-99.99	-99.99	-99.99	-99.9	-99
18	.16	.13	.14	.0	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	.06	.06	.06	.0	1	19	-99.99	-99.99	-99.99	-99.9	-99
20	.27	.27	.27	.0	1	20	.10	.10	.10	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	3.32	.20	1.24	1.3	8
23	-99.99	-99.99	-99.99	-99.9	-99	23	1.13	.06	.45	.5	7
24	.30	.24	.27	.0	2	24	.22	.15	.18	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99	25	.68	.21	.41	.2	4
26	-99.99	-99.99	-99.99	-99.9	-99	26	.10	.02	.05	.0	3
27	.27	.01	.15	.1	4	27	.26	.18	.22	.1	2
28	.39	.19	.29	.1	2	28	.36	.12	.24	.2	2
29	-99.99	-99.99	-99.99	-99.9	-99	29	.09	.00	.02	.0	6
30	-99.99	-99.99	-99.99	-99.9	-99	30	.20	.00	.07	.1	7
31	.05	.04	.04	.0	2	31	.19	.01	.08	.1	3
32	-99.99	-99.99	-99.99	-99.9	-99	32	.29	.01	.15	.2	2
33	.35	.02	.10	.1	22	33	.48	.02	.11	.1	32
34	.30	.20	.25	.1	2	34	.18	.03	.10	.1	2
35	.33	.11	.23	.1	4	35	-99.99	-99.99	-99.99	-99.9	-99
36	.17	.02	.09	.1	4	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	.11	.01	.06	.1	2
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.05	.05	.05	.0	1	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	.10	.09	.09	.0	2

ZONE	SUMMER MAX	MIN	MEAN	SD	N	ZONE	AUTUMN MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	.01	.01	.01	.0	1
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	1.28	.10	.42	.5	10	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	1.31	.00	.31	.4	12	22	.20	.00	.07	.1	7
23	.09	.09	.09	.0	1	23	-99.99	-99.99	-99.99	-99.9	-99
24	.12	.12	.12	.0	1	24	.11	.07	.09	.0	4
25	.21	.07	.14	.1	2	25	-99.99	-99.99	-99.99	-99.9	-99
26	.20	.14	.17	.0	2	26	-99.99	-99.99	-99.99	-99.9	-99
27	.15	.00	.07	.1	14	27	.11	.10	.10	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	.09	.00	.05	.0	8	29	.31	.02	.09	.1	5
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	.04	.01	.02	.0	10	31	.14	.00	.09	.0	12
32	.15	.06	.09	.0	4	32	-99.99	-99.99	-99.99	-99.9	-99
33	.20	.02	.07	.0	35	33	.12	.00	.04	.0	30
34	.13	.06	.10	.0	4	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	.05	.01	.03	.0	6	36	-99.99	-99.99	-99.99	-99.9	-99
37	.41	.00	.12	.1	19	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	.10	.02	.05	.0	3
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.03	.03	.03	.0	1	40	.16	.02	.07	.0	9
41	.09	.06	.07	.0	2	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 1f

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 150.1 - *99.0 METERS

WINTER						SPRING					
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99	20	.14	.14	.14	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	1.03	.26	.54	.4	3
23	-99.99	-99.99	-99.99	-99.9	-99	23	1.10	.04	.35	.5	4
24	-99.99	-99.99	-99.99	-99.9	-99	24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99	25	.22	.16	.19	.0	2
26	-99.99	-99.99	-99.99	-99.9	-99	26	.02	.01	.02	.0	2
27	.05	.05	.05	.0	2	27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	.00	.00	.00	.0	16
30	-99.99	-99.99	-99.99	-99.9	-99	30	.10	.00	.01	.0	10
31	.20	.02	.11	.1	3	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	-99.99	-99.99	-99.99	-99.9	-99
33	.10	.02	.05	.0	22	33	.38	.00	.07	.1	32
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.01	.01	.01	.0	1	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	.14	.04	.08	.0	6

SUMMER						AUTUMN					
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	1.35	.07	.41	.6	4	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	.55	.16	.35	.2	3	22	.09	.00	.04	.0	4
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	.04	.04	.04	.0	1	24	.11	.04	.07	.0	2
25	.33	.33	.33	.0	1	25	-99.99	-99.99	-99.99	-99.9	-99
26	.05	.05	.05	.0	1	26	-99.99	-99.99	-99.99	-99.9	-99
27	.11	.00	.06	.0	6	27	.08	.08	.08	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	.04	.01	.03	.0	2	29	.06	.00	.03	.0	4
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	.15	.01	.04	.1	7	31	.16	.00	.08	.1	6
32	.11	.05	.08	.0	3	32	-99.99	-99.99	-99.99	-99.9	-99
33	.74	.01	.09	.1	31	33	.08	.00	.03	.0	31
34	.07	.07	.07	.0	2	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	.02	.00	.01	.0	2	36	-99.99	-99.99	-99.99	-99.9	-99
37	.31	.03	.12	.1	8	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	.00	.00	.00	.0	1
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.01	.01	.01	.0	1	40	.12	.01	.04	.0	8
41	.07	.03	.05	.0	2	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 2

TOTAL CHLOROPHYLL-A (MG/M**2) 1958 - 1974

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	33.60	2.00	8.95	9.7	13
18	31.40	31.40	31.40	.0	1
19	18.50	18.50	18.50	.0	1
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	13.20	6.40	9.72	2.8	6
24	21.40	13.30	17.35	5.7	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	13.50	10.90	12.20	1.8	2
27	32.90	19.50	24.30	7.5	3
28	27.00	27.00	27.00	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99
30	14.90	8.30	11.17	2.2	16
31	26.10	21.20	24.10	2.6	3
32	-99.99	-99.99	-99.99	-99.9	-99
33	64.60	10.50	19.16	14.7	18
34	21.60	12.20	16.90	6.6	2
35	29.20	18.90	23.27	5.3	3
36	30.70	14.00	22.52	7.9	4
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	25.10	16.00	20.55	6.4	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	177.30	1.10	35.05	48.1	40
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	32.10	32.10	32.10	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	288.40	18.00	76.95	87.9	11
23	180.60	10.20	66.78	69.8	5
24	14.50	14.50	14.50	.0	1
25	134.80	18.60	71.12	61.2	4
26	17.10	11.60	14.35	3.9	2
27	17.20	17.20	17.20	.0	1
28	46.50	46.50	46.50	.0	1
29	29.70	4.00	17.16	9.0	8
30	35.20	9.40	22.84	11.6	5
31	22.80	21.80	22.30	.7	2
32	24.60	21.40	23.00	2.3	2
33	22.20	7.00	14.14	3.6	25
34	22.90	22.90	22.90	.0	1
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	29.50	29.50	29.50	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	18.60	15.90	17.25	1.9	2

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	72.20	72.20	72.20	.0	1
17	18.00	.30	6.16	6.1	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	311.60	.00	155.80	220.3	2
20	102.40	21.10	43.74	33.7	5
21	-99.99	-99.99	-99.99	-99.9	-99
22	126.30	6.40	31.56	30.1	27
23	2.50	2.50	2.50	.0	1
24	98.60	98.60	98.60	.0	1
25	11.50	4.30	8.82	3.3	5
26	28.10	28.10	28.10	.0	1
27	31.10	10.30	21.32	8.6	6
28	-99.99	-99.99	-99.99	-99.9	-99
29	17.50	4.40	11.31	3.9	20
30	-99.99	-99.99	-99.99	-99.9	-99
31	23.00	7.50	14.34	6.4	7
32	36.90	13.50	21.50	13.3	3
33	30.80	4.50	15.44	6.6	39
34	30.80	28.10	29.45	1.9	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	23.60	10.00	16.80	9.6	2
37	23.40	6.80	16.59	4.7	11
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	4.10	4.10	4.10	.0	1
41	22.80	20.40	21.60	1.7	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	27.70	9.00	15.87	5.3	12
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	44.90	4.90	21.24	11.8	11
23	13.90	1.20	5.92	4.9	5
24	12.20	9.90	11.05	1.6	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	17.50	17.50	17.50	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	15.50	2.80	8.65	4.4	10
30	4.50	1.70	2.73	1.5	3
31	22.50	7.80	14.77	5.6	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	25.80	6.40	14.51	5.4	28
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	6.30	1.10	4.17	2.2	4
39	3.50	2.60	3.05	.6	2
40	23.30	2.30	8.51	7.2	10
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 3a

PRIMARY PRODUCTIVITY (MG/M**3/HR) 1958-1974 .0 - 10.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	14.83	14.83	14.83	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	1.24	.02	.24	.3	31	17	35.24	.03	7.84	8.8	123
18	1.28	1.06	1.17	.2	2	18	11.00	4.75	7.34	3.0	4
19	1.80	.34	.88	.6	5	19	5.09	.93	3.01	2.9	2
20	6.05	.38	2.54	1.6	14	20	32.90	.18	7.16	7.8	67
21	.67	.67	.67	.0	1	21	-99.99	-99.99	-99.99	-99.9	-99
22	.38	.38	.38	.0	1	22	1.51	.48	.91	.3	18
23	.52	.17	.35	.1	17	23	3.93	.61	2.01	1.7	3
24	1.34	.50	.98	.4	4	24	14.05	.65	5.16	7.7	3
25	-99.99	-99.99	-99.99	-99.9	-99	25	.82	.28	.50	.2	4
26	.38	.31	.34	.0	4	26	-99.99	-99.99	-99.99	-99.9	-99
27	.46	.02	.28	.2	3	27	1.43	.36	.93	.4	8
28	.75	.75	.75	.0	2	28	.75	.45	.55	.2	3
29	.40	.40	.40	.0	1	29	3.29	.28	.83	.6	22
30	1.11	.21	.36	.2	23	30	4.31	.20	.96	1.0	16
31	-99.99	-99.99	-99.99	-99.9	-99	31	1.24	.00	.60	.3	16
32	.97	.66	.81	.2	2	32	1.62	.07	.60	.5	9
33	6.90	.02	1.13	1.3	148	33	38.20	.08	2.04	3.9	220
34	.83	.29	.54	.2	5	34	1.68	.66	1.13	.4	4
35	.92	.58	.80	.2	4	35	8.56	.79	3.68	3.6	5
36	.76	.54	.67	.1	3	36	2.85	.49	1.10	1.0	5
37	-99.99	-99.99	-99.99	-99.9	-99	37	1.72	.56	1.24	.4	9
38	1.43	1.43	1.43	.0	1	38	1.92	1.92	1.92	.0	1
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.37	.37	.37	.0	1	40	-99.99	-99.99	-99.99	-99.9	-99
41	.02	.02	.02	.0	1	41	1.38	1.38	1.38	.0	1
42	9.19	.20	2.88	4.2	4	42	-99.99	-99.99	-99.99	-99.9	-99

	SUMMER						AUTUMN				
15	20.58	20.58	20.58	.0	1	15	-99.99	-99.99	-99.99	-99.9	-99
16	3.38	.87	2.15	1.3	3	16	-99.99	-99.99	-99.99	-99.9	-99
17	11.71	.00	2.14	3.0	50	17	7.83	.06	2.01	1.4	32
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	8.43	.00	3.66	4.3	3	19	2.06	.05	.77	.8	6
20	14.73	.00	2.81	3.1	82	20	4.23	.17	1.78	1.3	16
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	9.97	.25	2.28	2.3	80	22	4.92	.19	1.53	1.0	52
23	10.15	.42	3.09	3.0	13	23	.52	.11	.29	.1	8
24	8.77	.26	2.56	4.1	4	24	1.12	.22	.86	.3	6
25	1.23	.37	.70	.3	14	25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99	26	-99.99	-99.99	-99.99	-99.9	-99
27	12.55	.08	6.31	8.8	2	27	1.75	.04	.90	.8	4
28	1.01	1.01	1.01	.0	1	28	-99.99	-99.99	-99.99	-99.9	-99
29	4.47	.14	.93	.9	62	29	1.26	.05	.66	.3	19
30	5.80	.25	1.79	2.3	5	30	1.02	.03	.42	.3	16
31	4.41	.34	1.34	1.4	7	31	1.63	1.13	1.38	.2	5
32	1.90	.38	1.34	.8	3	32	.30	.13	.21	.1	2
33	26.36	.05	3.37	5.8	198	33	20.01	.00	2.63	3.4	196
34	2.39	1.16	1.71	.6	3	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	.03	.03	.03	.0	1
36	1.74	.17	.83	.8	3	36	-99.99	-99.99	-99.99	-99.9	-99
37	1.02	.34	.68	.3	4	37	.46	.18	.32	.2	2
38	1.94	.12	.72	.4	14	38	1.26	.37	.79	.3	9
39	.93	.35	.64	.4	2	39	-99.99	-99.99	-99.99	-99.9	-99
40	1.39	.31	.97	.5	5	40	.91	.52	.71	.3	2
41	-99.99	-99.99	-99.99	-99.9	-99	41	.03	.03	.03	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99	42	.04	.04	.04	.0	1

TABLE 3b

PRIMARY PRODUCTIVITY (MG/M**3/HR) 1958-1974 10.0-25.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.99	.00	.14	.2	17
18	.84	.84	.84	.0	1
19	.71	.35	.53	.3	2
20	2.97	.00	.99	1.7	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	.25	.03	.15	.1	9
24	.99	.67	.83	.2	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	.24	.17	.20	.0	4
27	.60	.60	.60	.0	1
28	.58	.58	.58	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99
30	.34	.04	.20	.1	22
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	1.06	.01	.20	.3	30
34	.38	.38	.38	.0	1
35	.46	.16	.34	.2	3
36	.56	.35	.45	.1	2
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	9.33	.01	.99	1.9	52
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	6.55	.08	1.26	1.9	13
21	-99.99	-99.99	-99.99	-99.9	-99
22	.74	.28	.52	.2	8
23	-99.99	-99.99	-99.99	-99.9	-99
24	.52	.52	.52	.0	1
25	.75	.20	.47	.3	4
26	-99.99	-99.99	-99.99	-99.9	-99
27	.93	.31	.62	.4	2
28	.89	.89	.89	.0	1
29	.66	.24	.44	.1	11
30	.22	.00	.07	.1	6
31	.31	.00	.12	.1	6
32	.48	.07	.26	.2	3
33	3.67	.02	.50	.8	53
34	.86	.86	.86	.0	1
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	.63	.11	.24	.2	5
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	2.47	.05	.43	.7	12
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	2.92	.00	.32	.6	25
21	-99.99	-99.99	-99.99	-99.9	-99
22	5.66	.14	1.21	1.2	31
23	-99.99	-99.99	-99.99	-99.9	-99
24	.69	.45	.57	.2	2
25	.63	.24	.43	.2	4
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	1.61	.08	.61	.4	21
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	14.80	.00	2.02	3.7	50
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	1.06	.31	.69	.3	9
39	.72	.72	.72	.0	1
40	1.89	1.07	1.48	.6	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	2.17	.01	.62	.7	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	.07	.07	.07	.0	2
20	.23	.04	.12	.1	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	1.22	.04	.47	.4	11
23	.05	.00	.03	.0	2
24	.90	.01	.43	.5	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.85	.10	.47	.5	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	.85	.08	.45	.3	12
30	1.17	.28	.74	.4	4
31	1.28	.06	.37	.6	4
32	-99.99	-99.99	-99.99	-99.9	-99
33	3.87	.00	.68	.9	45
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.75	.04	.30	.3	6
39	-99.99	-99.99	-99.99	-99.9	-99
40	.72	.72	.72	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 3c

PRIMARY PRODUCTIVITY (MG/M**3/HR) 1958-1974 25.1-50.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.07	.00	.01	.0	15
18	.42	.05	.23	.3	2
19	.04	.04	.04	.0	1
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	.08	.01	.03	.0	5
24	.17	.17	.17	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99
26	.01	.01	.01	.0	2
27	.47	.26	.37	.1	2
28	.28	.02	.15	.2	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	.05	.00	.03	.0	5
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.45	.01	.23	.2	5
34	.17	.01	.09	.1	2
35	.09	.00	.04	.0	3
36	.25	.04	.15	.1	4
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.41	.00	.06	.1	19
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	.13	.04	.07	.0	6
23	-99.99	-99.99	-99.99	-99.9	-99
24	.25	.04	.14	.1	2
25	.15	.09	.12	.0	2
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	.66	.40	.53	.2	2
29	.48	.08	.18	.2	4
30	-99.99	-99.99	-99.99	-99.9	-99
31	.23	.23	.23	.0	1
32	.12	.01	.06	.1	2
33	1.18	.00	.20	.3	19
34	.57	.11	.34	.3	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.17	.03	.11	.1	3
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.84	.00	.08	.2	13
21	-99.99	-99.99	-99.99	-99.9	-99
22	1.10	.00	.24	.3	18
23	-99.99	-99.99	-99.99	-99.9	-99
24	.11	.11	.11	.0	1
25	.16	.02	.09	.1	4
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.43	.00	.14	.1	17
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	6.98	.00	.72	1.4	29
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.37	.34	.35	.0	2
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	2.37	.00	.32	.7	11
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.04	.04	.04	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	.20	.01	.11	.1	6
23	-99.99	-99.99	-99.99	-99.9	-99
24	.24	.02	.13	.2	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.06	.06	.06	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	.23	.03	.10	.1	8
30	.21	.01	.08	.1	3
31	.04	.04	.04	.0	1
32	-99.99	-99.99	-99.99	-99.9	-99
33	5.00	.01	.67	1.2	17
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.12	.03	.07	.1	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 3d

PRIMARY PRODUCTIVITY (MG/M**3/HR) 1958-1974 50.1-100.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.02	.00	.01	.0	2
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	.05	.01	.03	.0	6
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.36	.00	.06	.1	12
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	.70	.02	.36	.5	2
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.02	.01	.02	.0	2
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	.05	.05	.05	.0	1
29	.09	.09	.09	.0	1
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.65	.00	.07	.2	16
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.73	.01	.14	.3	7
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.02	.00	.01	.0	2
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.47	.00	.08	.1	11
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 4

TOTAL PRODUCTIVITY (MG/M**2/DAY) 1958 - 1974

ZONE	WINTER MAX	MIN	MEAN	SD	N	ZONE	SPRING MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	335.20	.70	39.22	97.5	13	17	253.30	1.30	70.15	73.9	38
18	357.50	357.50	357.50	.0	1	18	199.60	173.40	186.50	18.5	2
19	232.00	232.00	232.00	.0	1	19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99	20	148.00	148.00	148.00	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	22.30	13.40	18.12	3.3	6
23	8.80	5.00	7.12	1.5	6	23	-99.99	-99.99	-99.99	-99.9	-99
24	292.40	292.40	292.40	.0	1	24	259.10	259.10	259.10	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99	25	16.60	15.90	16.25	.5	2
26	9.10	8.50	8.80	.4	2	26	-99.99	-99.99	-99.99	-99.9	-99
27	227.90	227.90	227.90	.0	1	27	377.50	377.50	377.50	.0	1
28	274.60	274.60	274.60	.0	1	28	442.80	442.80	442.80	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99	29	260.00	20.70	94.90	111.8	6
30	14.60	5.00	9.48	2.9	12	30	94.00	94.00	94.00	.0	1
31	-99.99	-99.99	-99.99	-99.9	-99	31	183.00	77.00	130.00	75.0	2
32	-99.99	-99.99	-99.99	-99.9	-99	32	242.00	242.00	242.00	.0	1
33	70.50	32.40	50.73	15.1	6	33	137.50	9.60	78.11	44.7	8
34	176.30	176.30	176.30	.0	1	34	410.30	410.30	410.30	.0	1
35	232.20	140.30	186.25	65.0	2	35	-99.99	-99.99	-99.99	-99.9	-99
36	236.20	171.90	204.05	45.5	2	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	276.00	276.00	276.00	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	18.60	15.90	17.25	1.9	2

ZONE	SUMMER MAX	MIN	MEAN	SD	N	ZONE	AUTUMN MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	67.40	.80	23.15	23.8	13	17	103.50	9.80	33.57	26.0	12
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	144.10	5.60	39.42	33.0	23	22	65.10	12.20	26.55	15.9	10
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99	24	310.60	270.00	290.30	28.7	2
25	17.60	8.30	13.20	3.8	4	25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99	26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99	27	260.50	260.50	260.50	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	41.10	7.40	18.28	11.4	19	29	25.50	11.10	16.62	6.1	6
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99	31	314.40	237.20	275.80	54.6	2
32	-99.99	-99.99	-99.99	-99.9	-99	32	-99.99	-99.99	-99.99	-99.9	-99
33	810.20	55.00	284.91	186.6	14	33	129.70	42.00	92.02	29.9	12
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	17.30	10.30	12.97	5.8	3
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	212.80	212.80	212.80	.0	1
41	22.80	20.40	21.60	1.7	2	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 5a

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 .0 - 10.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	11.90	11.90	11.90	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99
17	15.90	10.50	11.91	1.1	57
18	15.00	14.60	14.80	.3	2
19	14.70	8.40	10.87	2.2	9
20	25.60	3.30	13.36	8.7	23
21	-99.99	-99.99	-99.99	-99.9	-99
22	19.90	16.50	17.72	1.3	6
23	20.80	6.10	14.45	4.1	19
24	20.90	16.90	18.23	1.4	7
25	-99.99	-99.99	-99.99	-99.9	-99
26	16.20	7.30	12.74	4.3	5
27	23.50	14.00	18.51	3.3	12
28	22.80	11.40	18.84	3.7	7
29	17.30	16.20	16.67	.6	3
30	18.40	5.20	12.80	3.0	27
31	18.00	6.90	12.91	3.5	11
32	14.70	6.80	10.63	3.0	7
33	20.60	1.10	13.15	3.5	31
34	18.60	13.00	15.59	1.6	13
35	17.40	14.40	16.23	1.1	6
36	14.70	8.10	11.77	2.2	15
37	11.40	7.90	9.72	1.4	4
38	3.80	3.80	3.80	.0	1
39	4.50	4.50	4.50	.0	1
40	6.00	3.00	4.16	1.3	7
41	-99.99	-99.99	-99.99	-99.9	-99
42	9.00	1.70	5.34	2.8	7

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	11.10	11.10	11.10	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99
17	20.50	.00	4.46	7.5	218
18	-99.99	-99.99	-99.99	-99.9	-99
19	40.30	1.60	8.81	9.5	14
20	24.30	.00	7.51	5.9	61
21	-99.99	-99.99	-99.99	-99.9	-99
22	31.80	7.80	16.37	5.8	27
23	33.30	.20	15.38	5.7	26
24	44.60	6.90	19.06	10.1	10
25	20.80	6.90	17.05	4.7	20
26	19.00	19.00	19.00	.0	2
27	34.50	11.80	18.81	4.9	21
28	30.10	14.40	20.58	4.8	13
29	21.50	1.40	17.29	4.3	71
30	20.30	.40	14.48	3.3	73
31	19.30	7.90	14.46	2.3	68
32	17.40	7.70	12.20	2.0	50
33	27.20	2.10	13.95	4.4	61
34	23.40	9.80	15.40	3.8	24
35	-99.99	-99.99	-99.99	-99.9	-99
36	62.20	4.40	13.88	12.5	19
37	13.70	2.70	8.80	2.2	56
38	10.30	10.30	10.30	.0	1
39	-99.99	-99.99	-99.99	-99.9	-99
40	10.10	10.10	10.10	.0	1
41	4.40	3.00	3.86	.5	5
42	12.70	3.50	6.55	2.8	11

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	7.60	1.60	4.60	4.2	2
16	.40	.40	.40	.0	1
17	3.30	.00	1.28	1.1	49
18	-99.99	-99.99	-99.99	-99.9	-99
19	6.60	.00	2.63	2.3	7
20	22.60	.00	4.43	5.5	110
21	-99.99	-99.99	-99.99	-99.9	-99
22	25.20	2.70	12.04	6.6	45
23	13.60	.70	6.60	4.7	13
24	9.50	5.10	7.36	2.1	5
25	18.10	11.40	14.40	2.9	7
26	21.50	6.30	16.43	8.8	3
27	21.60	8.80	17.27	4.2	20
28	21.20	12.90	17.10	4.3	4
29	18.10	4.50	11.46	4.1	28
30	13.00	5.30	9.45	2.1	12
31	18.20	7.70	11.60	3.0	18
32	11.60	.00	5.02	4.5	18
33	30.00	.00	8.02	5.4	73
34	17.40	3.30	11.68	3.8	17
35	-99.99	-99.99	-99.99	-99.9	-99
36	12.30	.80	6.19	3.7	11
37	9.40	.00	4.91	2.7	36
38	7.10	6.70	6.90	.3	2
39	6.60	6.60	6.60	.0	1
40	6.70	2.60	4.83	2.1	3
41	.20	.00	.12	.1	5
42	4.50	1.10	2.80	2.4	2

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	15.00	.30	2.14	2.3	52
18	-99.99	-99.99	-99.99	-99.9	-99
19	1.40	1.40	1.40	.0	1
20	23.10	.20	8.20	9.9	6
21	-99.99	-99.99	-99.99	-99.9	-99
22	19.70	6.70	14.82	5.2	5
23	-99.99	-99.99	-99.99	-99.9	-99
24	8.00	6.50	7.22	.8	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	8.80	2.60	6.73	3.6	3
28	-99.99	-99.99	-99.99	-99.9	-99
29	17.00	3.00	11.03	5.3	6
30	-99.99	-99.99	-99.99	-99.9	-99
31	19.60	1.60	7.09	4.1	13
32	-99.99	-99.99	-99.99	-99.9	-99
33	11.20	1.10	7.85	2.4	59
34	-99.99	-99.99	-99.99	-99.9	-99
35	3.10	3.10	3.10	.0	1
36	-99.99	-99.99	-99.99	-99.9	-99
37	1.70	1.70	1.70	.0	1
38	.60	.00	.25	.3	4
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	3
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 5b

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 10.1 - 25.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	16.10	10.80	12.26	1.4	26
18	15.20	15.20	15.20	.0	1
19	14.40	14.10	14.25	.2	2
20	26.10	24.20	25.17	1.0	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	17.40	12.00	15.27	1.8	8
24	16.80	16.70	16.75	.1	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	13.90	5.60	10.37	3.5	4
27	19.20	19.20	19.20	.0	1
28	18.20	18.20	18.20	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99
30	18.60	9.80	13.50	2.2	23
31	14.00	8.00	11.00	4.2	2
32	-99.99	-99.99	-99.99	-99.9	-99
33	20.50	9.80	12.84	2.3	17
34	17.00	15.50	16.47	.8	3
35	16.50	14.60	15.27	.9	4
36	14.20	12.70	13.52	.7	5
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	4.00	4.00	4.00	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	20.60	.00	6.34	7.6	75
18	-99.99	-99.99	-99.99	-99.9	-99
19	4.80	4.80	4.80	.0	1
20	24.90	5.60	15.91	8.6	7
21	-99.99	-99.99	-99.99	-99.9	-99
22	11.40	8.00	9.45	1.6	4
23	19.10	10.70	16.24	3.4	5
24	20.90	20.90	20.90	.0	1
25	15.10	6.90	9.20	3.9	4
26	19.00	19.00	19.00	.0	1
27	18.60	18.50	18.55	.1	2
28	20.00	20.00	20.00	.0	1
29	19.20	14.20	16.47	2.5	3
30	17.90	10.40	15.02	3.2	4
31	16.20	11.30	14.50	2.8	3
32	14.40	10.10	12.42	1.8	4
33	22.30	2.70	12.02	4.5	17
34	14.20	9.40	11.80	3.4	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	10.20	6.20	8.10	2.0	3
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	3.20	3.20	3.20	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.50	.00	.19	.2	11
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	25.60	.00	11.74	7.8	37
21	-99.99	-99.99	-99.99	-99.9	-99
22	24.70	5.70	16.58	5.4	11
23	-99.99	-99.99	-99.99	-99.9	-99
24	9.60	9.60	9.60	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99
26	21.50	21.50	21.50	.0	2
27	21.30	18.40	19.82	1.0	9
28	-99.99	-99.99	-99.99	-99.9	-99
29	14.00	4.10	9.05	7.0	2
30	-99.99	-99.99	-99.99	-99.9	-99
31	18.50	18.50	18.50	.0	1
32	7.40	.00	2.49	3.4	7
33	25.50	.90	7.52	5.7	33
34	17.50	14.30	16.37	1.8	3
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	9.30	2.20	4.70	2.2	12
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.30	.00	.18	.1	5
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	4.80	1.40	2.80	.8	25
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	25.20	25.20	25.20	.0	2
21	-99.99	-99.99	-99.99	-99.9	-99
22	23.50	6.40	14.95	12.1	2
23	-99.99	-99.99	-99.99	-99.9	-99
24	8.00	6.50	7.27	.8	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	9.50	8.80	9.15	.5	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	13.60	8.00	10.72	2.9	4
30	-99.99	-99.99	-99.99	-99.9	-99
31	8.20	1.50	5.76	2.1	8
32	-99.99	-99.99	-99.99	-99.9	-99
33	11.30	3.10	7.61	2.2	23
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.50	.00	.25	.3	4
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 5c

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 25.1 - 50.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	22.50	10.70	12.84	2.2	35
18	15.60	15.50	15.55	.1	2
19	14.20	14.20	14.20	.0	1
20	26.10	23.30	24.80	1.2	6
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	16.90	4.00	10.67	6.7	4
24	15.30	15.30	15.30	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99
26	9.90	8.60	9.25	.9	2
27	21.50	14.00	18.87	4.2	3
28	20.50	20.30	20.40	.1	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	16.90	10.30	14.02	2.4	5
31	14.00	8.00	11.00	3.0	3
32	-99.99	-99.99	-99.99	-99.9	-99
33	15.20	10.70	12.27	2.1	4
34	16.90	12.20	14.73	2.4	3
35	17.40	13.90	16.34	1.4	5
36	14.60	11.10	13.59	1.2	7
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	4.00	3.00	3.50	.7	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	20.70	.80	10.73	7.1	86
18	-99.99	-99.99	-99.99	-99.9	-99
19	5.80	5.80	5.80	.0	1
20	27.30	5.20	18.80	9.8	11
21	-99.99	-99.99	-99.99	-99.9	-99
22	22.90	8.20	12.77	4.7	9
23	19.10	11.20	16.47	2.8	9
24	16.40	16.20	16.30	.1	2
25	17.40	7.50	12.27	4.5	6
26	19.00	18.80	18.90	.1	3
27	18.20	18.20	18.20	.0	1
28	20.30	20.30	20.30	.0	2
29	20.00	16.10	18.01	1.6	8
30	17.80	10.30	14.81	2.8	8
31	16.20	11.60	14.62	2.1	6
32	14.40	10.30	12.59	1.8	7
33	15.60	4.00	11.77	4.2	6
34	14.40	10.70	12.80	1.9	3
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	10.30	6.50	8.66	1.6	5
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	3.00	3.00	3.00	.0	1
42	9.00	4.70	6.85	3.0	2

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	3.00	.60	1.50	1.3	3
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	37.00	.60	16.09	9.0	39
21	-99.99	-99.99	-99.99	-99.9	-99
22	25.30	4.10	16.30	6.4	24
23	16.90	16.90	16.90	.0	1
24	15.10	15.10	15.10	.0	1
25	21.90	18.30	19.60	1.6	4
26	21.60	21.50	21.53	.1	3
27	21.30	11.30	19.33	2.2	19
28	-99.99	-99.99	-99.99	-99.9	-99
29	22.20	5.30	13.42	5.7	14
30	-99.99	-99.99	-99.99	-99.9	-99
31	18.80	18.60	18.70	.1	3
32	8.50	.80	3.90	3.3	8
33	16.10	1.60	8.49	4.5	34
34	17.60	14.30	15.68	1.7	5
35	-99.99	-99.99	-99.99	-99.9	-99
36	7.20	7.20	7.20	.0	1
37	11.50	2.50	5.58	2.4	30
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.70	.30	.50	.2	6
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	21.30	3.30	6.05	3.8	29
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	29.90	27.00	27.97	1.3	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	17.00	6.60	12.23	5.3	3
23	-99.99	-99.99	-99.99	-99.9	-99
24	21.00	9.70	14.37	4.0	6
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	17.70	11.10	14.20	3.3	3
28	-99.99	-99.99	-99.99	-99.9	-99
29	16.00	9.60	12.80	4.5	2
30	-99.99	-99.99	-99.99	-99.9	-99
31	14.60	1.90	8.89	3.6	17
32	-99.99	-99.99	-99.99	-99.9	-99
33	14.60	5.50	9.54	2.9	9
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	7.50	3.70	5.60	2.7	2
39	-99.99	-99.99	-99.99	-99.9	-99
40	2.50	.00	.64	1.0	7
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 5d

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 50.1 - 100.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	25.10	11.60	15.73	3.7	25	17	20.90	2.10	17.18	3.6	77
18	22.10	14.40	18.25	5.4	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	26.20	14.60	20.40	8.2	2	19	10.40	10.40	10.40	.0	1
20	26.20	23.40	25.27	1.6	3	20	28.00	5.40	20.28	9.9	12
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	35.20	17.00	23.46	6.8	9
23	-99.99	-99.99	-99.99	-99.9	-99	23	26.70	16.40	19.50	3.4	9
24	16.60	13.90	15.25	1.9	2	24	18.40	18.40	18.40	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99	25	29.20	18.50	22.20	4.1	6
26	-99.99	-99.99	-99.99	-99.9	-99	26	22.80	18.80	20.27	2.2	3
27	22.10	14.00	19.08	3.6	6	27	19.20	18.60	18.90	.4	2
28	21.50	18.90	20.20	1.8	2	28	20.30	18.10	19.57	1.3	3
29	-99.99	-99.99	-99.99	-99.9	-99	29	21.90	16.50	18.65	2.1	8
30	15.50	9.10	12.42	2.1	6	30	18.00	10.40	14.89	2.8	8
31	14.00	8.00	10.90	2.2	10	31	17.00	12.20	15.08	2.2	6
32	-99.99	-99.99	-99.99	-99.9	-99	32	16.70	10.70	13.60	2.3	8
33	21.00	10.60	14.46	3.2	20	33	21.60	2.40	13.57	4.1	24
34	16.90	15.80	16.10	.5	4	34	14.70	11.90	14.00	1.4	4
35	19.40	14.80	17.42	1.7	5	35	-99.99	-99.99	-99.99	-99.9	-99
36	26.90	12.20	15.69	4.6	8	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	10.70	7.40	9.12	1.4	6
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	5.00	3.00	4.00	1.1	6	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	4.30	3.70	4.00	.4	2
42	-99.99	-99.99	-99.99	-99.9	-99	42	15.00	5.80	10.40	6.5	2

	SUMMER						AUTUMN				
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	25.30	5.80	10.51	5.5	18
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	27.30	3.40	14.63	8.8	19	20	28.20	24.40	27.15	1.8	4
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	32.10	7.00	20.70	6.5	13	22	29.00	6.10	18.92	9.5	4
23	27.60	27.60	27.60	.0	1	23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99	24	32.30	15.90	23.90	7.9	4
25	22.60	22.60	22.60	.0	1	25	-99.99	-99.99	-99.99	-99.9	-99
26	34.40	21.50	25.80	7.4	3	26	-99.99	-99.99	-99.99	-99.9	-99
27	35.60	18.40	22.56	5.6	19	27	22.20	20.00	21.10	1.6	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	16.30	10.80	13.46	2.4	7	29	18.00	3.10	10.62	5.2	6
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	23.50	18.80	20.40	2.7	3	31	18.90	3.30	12.83	4.3	16
32	12.10	1.30	6.39	4.1	7	32	-99.99	-99.99	-99.99	-99.9	-99
33	32.40	.90	12.10	5.8	53	33	27.70	6.40	14.50	3.7	28
34	20.80	14.60	17.12	2.1	6	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	9.90	9.90	9.90	.0	1	36	-99.99	-99.99	-99.99	-99.9	-99
37	14.30	3.70	7.66	2.7	28	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	13.00	.20	7.92	5.5	4
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	6.60	1.70	4.79	1.9	7
41	3.10	1.00	2.00	.9	4	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 5e

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 100.1 - 150.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	32.00	16.10	20.71	6.1	10
18	29.40	26.10	27.75	2.3	2
19	30.30	30.30	30.30	.0	1
20	26.40	26.40	26.40	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	24.10	16.40	20.25	5.4	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	39.10	23.00	30.35	6.7	4
28	39.80	30.70	35.25	6.4	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	24.00	14.00	17.67	3.5	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	48.20	13.70	22.66	7.7	18
34	24.00	24.00	24.00	.0	1
35	29.60	19.40	25.75	4.4	4
36	32.10	27.80	30.27	2.0	4
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	12.00	4.00	7.20	3.1	5
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	21.30	17.70	19.61	1.0	27
18	-99.99	-99.99	-99.99	-99.9	-99
19	23.50	20.90	22.20	1.8	2
20	23.60	23.60	23.60	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	40.30	20.10	33.62	7.2	6
23	42.30	27.90	33.93	5.1	6
24	22.60	19.70	21.15	2.1	2
25	40.90	29.40	35.07	4.8	4
26	41.00	36.10	38.55	3.5	2
27	18.80	18.60	18.70	.1	2
28	38.40	28.40	33.40	7.1	2
29	41.20	16.60	27.08	9.2	6
30	22.10	16.00	19.44	2.4	5
31	29.90	16.60	25.13	7.4	3
32	28.80	12.60	18.37	7.2	4
33	51.50	10.30	21.92	11.5	18
34	43.10	16.20	28.67	11.1	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	22.50	17.30	19.90	2.6	3
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	9.10	9.10	9.10	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	29.70	10.60	19.80	5.4	10
21	-99.99	-99.99	-99.99	-99.9	-99
22	29.00	14.20	22.98	6.1	5
23	23.00	23.00	23.00	.0	1
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	46.10	43.30	44.70	2.0	2
27	43.30	28.90	38.26	3.8	13
28	-99.99	-99.99	-99.99	-99.9	-99
29	22.00	17.00	19.50	3.5	2
30	-99.99	-99.99	-99.99	-99.9	-99
31	38.60	35.90	37.25	1.9	2
32	21.90	13.80	17.62	3.4	4
33	39.30	2.30	23.63	7.2	44
34	35.60	18.50	29.20	7.5	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	22.20	22.20	22.20	.0	1
37	29.10	8.20	16.91	5.6	19
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	11.30	11.00	11.15	.2	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	18.90	11.70	15.20	3.5	4
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	28.90	8.40	18.65	14.5	2
23	-99.99	-99.99	-99.99	-99.9	-99
24	48.00	22.30	36.05	11.4	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	36.30	28.40	32.35	5.6	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	36.20	9.40	20.87	13.8	3
30	-99.99	-99.99	-99.99	-99.9	-99
31	28.30	15.80	21.36	4.3	12
32	-99.99	-99.99	-99.99	-99.9	-99
33	36.90	12.20	23.81	6.4	26
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	13.00	3.90	9.80	4.2	4
39	-99.99	-99.99	-99.99	-99.9	-99
40	11.90	6.50	10.03	3.1	3
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 5f

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 150.1 - *99.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	22.70	11.30	18.77	3.5	7
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	35.00	32.00	33.00	.9	8
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	41.00	19.00	32.15	6.0	26
32	-99.99	-99.99	-99.99	-99.9	-99
33	61.20	20.30	32.37	11.0	18
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	42.00	10.00	26.59	10.9	17
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	24.10	17.70	20.40	1.5	33
18	-99.99	-99.99	-99.99	-99.9	-99
19	42.70	26.40	38.58	6.1	10
20	28.00	26.60	27.30	1.0	2
21	-99.99	-99.99	-99.99	-99.9	-99
22	44.10	38.70	40.83	2.9	3
23	47.10	39.90	42.70	3.9	3
24	-99.99	-99.99	-99.99	-99.9	-99
25	43.90	39.80	41.85	2.9	2
26	44.40	44.40	44.40	.0	1
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	55.40	27.00	44.40	6.6	16
30	48.10	20.00	37.04	10.0	8
31	-99.99	-99.99	-99.99	-99.9	-99
32	43.80	27.00	40.59	4.6	16
33	57.50	13.00	31.96	11.8	15
34	43.10	32.30	40.79	3.6	8
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	43.10	31.50	40.74	3.3	11
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	43.00	16.80	33.45	9.9	8
42	23.00	13.70	18.35	6.6	2

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	33.30	19.40	25.70	5.9	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	31.40	13.70	23.49	5.9	7
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	21.90	21.90	21.90	.0	1
26	47.00	47.00	47.00	.0	1
27	44.70	41.50	43.12	1.4	6
28	-99.99	-99.99	-99.99	-99.9	-99
29	36.40	7.80	24.18	10.4	6
30	-99.99	-99.99	-99.99	-99.9	-99
31	41.00	41.00	41.00	.0	1
32	29.20	19.30	24.30	5.0	3
33	44.90	12.60	31.41	7.0	36
34	38.80	38.50	38.65	.2	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	31.00	14.10	23.70	6.4	9
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	16.10	15.90	16.00	.1	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	20.60	15.60	18.15	2.5	4
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	45.80	14.60	30.20	22.1	2
23	-99.99	-99.99	-99.99	-99.9	-99
24	49.00	39.10	44.05	7.0	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	42.00	42.00	42.00	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	30.40	16.20	21.17	8.0	3
30	-99.99	-99.99	-99.99	-99.9	-99
31	38.30	22.10	29.92	6.5	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	46.90	24.90	35.16	5.7	25
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	9.70	6.60	8.15	2.2	2
39	-99.99	-99.99	-99.99	-99.9	-99
40	17.90	17.00	17.45	.6	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 6a

PHOSPHATE (MICROGRAM-AT/L) 1958 - 1974 .0 - 10.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	14.30	14.30	14.30	.0	1	15	13.90	13.90	13.90	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	25.00	12.90	15.45	2.5	57	17	16.70	.00	4.94	5.6	217
18	13.40	12.70	13.05	.5	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	13.60	9.80	11.71	1.2	9	19	13.00	3.30	8.74	2.6	14
20	22.20	5.30	13.30	6.3	23	20	23.20	3.00	9.20	4.9	62
21	3.10	3.10	3.10	.0	1	21	-99.99	-99.99	-99.99	-99.9	-99
22	20.90	17.50	18.93	1.5	6	22	27.20	5.10	15.93	5.4	49
23	19.90	13.70	16.97	2.0	19	23	19.80	2.90	13.03	4.2	31
24	20.50	15.20	17.60	1.8	8	24	18.40	5.60	14.98	3.5	10
25	-99.99	-99.99	-99.99	-99.9	-99	25	18.90	6.80	11.89	3.8	24
26	17.10	12.90	15.90	1.7	5	26	15.70	10.20	13.22	2.0	5
27	21.90	14.30	17.49	2.2	13	27	22.40	11.00	16.61	2.4	21
28	20.40	13.90	17.37	2.4	7	28	21.10	11.30	17.68	3.0	13
29	17.10	15.20	16.03	1.0	3	29	19.30	2.70	13.56	3.1	81
30	18.40	10.90	15.04	1.8	27	30	18.60	1.40	11.49	3.8	78
31	15.90	8.80	12.70	2.6	11	31	17.60	4.30	12.25	3.4	68
32	15.30	9.10	12.30	2.3	7	32	20.00	4.50	11.18	3.2	50
33	-99.99	-99.99	-99.99	-99.9	-99	33	12.50	6.60	9.22	1.8	14
34	17.70	14.10	15.51	1.0	13	34	19.50	4.90	14.45	3.1	24
35	14.40	11.70	13.58	1.1	6	35	-99.99	-99.99	-99.99	-99.9	-99
36	15.30	8.80	12.73	1.8	15	36	18.20	7.20	11.76	3.1	20
37	12.40	10.70	11.67	.7	4	37	17.50	4.60	9.29	2.5	56
38	5.30	5.30	5.30	.0	1	38	8.70	8.70	8.70	.0	1
39	6.30	6.30	6.30	.0	1	39	-99.99	-99.99	-99.99	-99.9	-99
40	8.10	4.20	5.97	1.3	7	40	10.80	10.80	10.80	.0	1
41	2.70	2.70	2.70	.0	1	41	8.70	7.40	7.76	.5	5
42	12.40	1.40	7.07	4.2	8	42	15.20	7.60	10.03	2.6	7

	SUMMER						AUTUMN				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	14.80	5.70	10.20	2.9	7	15	-99.99	-99.99	-99.99	-99.9	-99
16	10.90	4.60	6.72	2.8	4	16	-99.99	-99.99	-99.99	-99.9	-99
17	12.40	.00	1.83	2.9	54	17	4.20	.10	2.22	.9	51
18	22.40	10.80	14.92	3.7	8	18	-99.99	-99.99	-99.99	-99.9	-99
19	7.90	2.50	5.34	2.1	7	19	3.30	2.70	2.97	.3	3
20	21.40	.20	6.03	4.9	117	20	21.10	2.50	7.92	7.5	8
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	25.10	6.20	15.14	4.9	67	22	18.80	12.00	14.83	2.6	13
23	13.50	4.40	7.74	3.0	21	23	-99.99	-99.99	-99.99	-99.9	-99
24	12.80	3.20	8.39	2.3	15	24	10.50	3.30	8.27	2.7	6
25	23.40	8.30	13.65	5.2	17	25	-99.99	-99.99	-99.99	-99.9	-99
26	12.10	9.70	10.80	1.2	3	26	-99.99	-99.99	-99.99	-99.9	-99
27	25.20	8.30	12.95	3.5	24	27	9.90	3.50	6.82	3.6	4
28	24.90	12.50	15.44	4.0	8	28	-99.99	-99.99	-99.99	-99.9	-99
29	21.80	6.40	13.71	3.1	72	29	15.80	4.20	9.28	3.5	13
30	15.10	8.20	11.46	2.3	14	30	13.20	5.00	10.28	3.2	5
31	18.20	4.30	11.73	3.4	32	31	22.50	7.00	9.66	4.0	13
32	15.60	3.30	8.63	3.6	26	32	4.50	3.50	4.00	.7	2
33	13.50	5.70	8.10	2.8	18	33	-99.99	-99.99	-99.99	-99.9	-99
34	17.30	7.10	11.92	2.4	19	34	-99.99	-99.99	-99.99	-99.9	-99
35	10.80	9.50	10.20	.6	4	35	4.00	4.00	4.00	.0	1
36	16.10	4.50	9.04	3.1	15	36	-99.99	-99.99	-99.99	-99.9	-99
37	16.60	3.40	8.30	2.5	41	37	3.20	2.70	2.95	.4	2
38	8.30	3.50	6.45	1.7	12	38	5.70	1.70	3.00	1.8	6
39	8.90	5.90	6.90	1.7	3	39	-99.99	-99.99	-99.99	-99.9	-99
40	11.80	3.50	6.89	3.0	7	40	4.60	2.00	2.93	.9	13
41	3.80	2.50	3.32	.6	5	41	2.40	2.40	2.40	.0	1
42	18.10	8.40	13.25	6.9	2	42	1.70	1.70	1.70	.0	1

TABLE 6b

PHOSPHATE (MICROGRAM-AT/L) 1958 - 1974 10.1 - 25.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	24.10	13.40	15.27	2.2	26	17	16.60	1.30	7.97	5.5	76
18	14.10	14.10	14.10	.0	1	18	-99.99	-99.99	-99.99	-99.9	-99
19	13.80	13.70	13.75	.1	2	19	9.00	9.00	9.00	.0	1
20	22.20	21.70	21.93	.3	3	20	23.50	5.40	16.41	6.7	7
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	22.70	6.50	14.46	4.8	18
23	17.90	14.10	16.20	1.3	8	23	12.70	3.30	9.06	3.6	9
24	17.40	14.60	15.70	1.5	3	24	17.50	17.50	17.50	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99	25	19.00	6.50	13.69	5.9	8
26	17.50	13.70	15.87	1.7	4	26	14.00	11.50	12.60	1.3	3
27	17.70	16.90	17.30	.6	2	27	16.40	16.30	16.35	.1	2
28	16.30	16.30	16.30	.0	1	28	17.40	17.40	17.40	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99	29	16.60	10.20	14.44	2.0	11
30	18.40	12.00	15.03	1.5	24	30	17.30	7.50	11.77	4.0	8
31	13.80	9.10	11.45	3.3	2	31	15.30	8.50	12.30	3.5	3
32	-99.99	-99.99	-99.99	-99.9	-99	32	14.30	4.90	10.82	4.1	4
33	-99.99	-99.99	-99.99	-99.9	-99	33	7.00	7.00	7.00	.0	1
34	16.80	14.70	15.80	1.1	3	34	14.50	12.00	13.25	1.8	2
35	14.20	9.70	12.07	2.4	4	35	-99.99	-99.99	-99.99	-99.9	-99
36	14.80	12.70	13.78	.9	5	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	10.00	6.70	8.47	1.7	3
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	4.40	4.40	4.40	.0	1	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	7.30	7.30	7.30	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

	SUMMER						AUTUMN				
15	14.20	12.20	13.20	1.4	2	15	-99.99	-99.99	-99.99	-99.9	-99
16	4.20	4.20	4.20	.0	1	16	-99.99	-99.99	-99.99	-99.9	-99
17	15.20	1.20	3.87	4.6	15	17	5.80	2.90	4.33	.7	24
18	14.60	13.50	14.00	.6	3	18	-99.99	-99.99	-99.99	-99.9	-99
19	5.90	5.90	5.90	.0	1	19	-99.99	-99.99	-99.99	-99.9	-99
20	22.50	2.80	12.75	5.8	41	20	24.10	21.20	22.65	2.1	2
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	24.70	8.90	17.65	5.1	19	22	18.50	12.30	14.34	2.5	5
23	6.80	5.30	6.07	.8	3	23	-99.99	-99.99	-99.99	-99.9	-99
24	10.50	4.20	7.13	2.2	6	24	10.00	8.10	9.00	1.0	4
25	14.40	8.50	10.70	2.7	4	25	-99.99	-99.99	-99.99	-99.9	-99
26	13.10	12.90	13.00	.1	2	26	-99.99	-99.99	-99.99	-99.9	-99
27	14.10	8.60	13.19	1.6	11	27	10.60	10.20	10.40	.3	2
28	14.80	13.10	13.95	1.2	2	28	-99.99	-99.99	-99.99	-99.9	-99
29	18.30	6.70	12.77	3.4	27	29	15.80	5.70	10.96	3.4	8
30	-99.99	-99.99	-99.99	-99.9	-99	30	13.20	7.00	10.07	3.1	3
31	18.20	4.10	9.72	4.0	11	31	10.10	7.10	8.67	1.3	8
32	11.30	3.90	7.74	2.5	11	32	-99.99	-99.99	-99.99	-99.9	-99
33	11.30	5.90	7.60	1.8	9	33	-99.99	-99.99	-99.99	-99.9	-99
34	12.30	11.40	11.97	.4	4	34	-99.99	-99.99	-99.99	-99.9	-99
35	11.00	9.30	10.15	1.2	2	35	-99.99	-99.99	-99.99	-99.9	-99
36	12.20	6.70	9.45	3.9	2	36	-99.99	-99.99	-99.99	-99.9	-99
37	10.40	6.90	7.96	1.0	15	37	-99.99	-99.99	-99.99	-99.9	-99
38	7.00	3.80	5.57	1.5	4	38	5.10	1.90	2.84	1.3	5
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	8.30	2.90	5.60	2.5	4	40	4.30	2.10	3.04	.8	7
41	4.30	2.90	3.68	.6	5	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 6c

PHOSPHATE (MICROGRAM-AT/L) 1958 - 1974 25.1 - 50.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	29.70	13.40	16.28	3.4	35
18	14.50	14.40	14.45	.1	2
19	14.00	14.00	14.00	.0	1
20	24.90	21.60	23.68	1.2	6
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	18.00	14.70	16.28	1.2	5
24	17.80	15.10	16.90	1.6	3
25	-99.99	-99.99	-99.99	-99.9	-99
26	17.50	15.70	16.60	1.3	2
27	18.00	15.90	17.32	1.0	4
28	17.90	17.60	17.75	.2	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	17.90	11.20	15.14	2.5	5
31	14.00	9.10	11.63	2.5	3
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	15.40	13.50	14.47	1.0	3
35	14.40	12.40	13.66	.8	5
36	14.40	12.00	13.63	.8	7
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	4.50	4.50	4.50	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	18.90	3.30	11.65	4.5	86
18	-99.99	-99.99	-99.99	-99.9	-99
19	8.40	8.40	8.40	.0	1
20	25.30	4.80	18.47	8.0	12
21	-99.99	-99.99	-99.99	-99.9	-99
22	23.30	6.40	13.96	4.1	22
23	13.40	4.00	8.96	3.6	10
24	15.10	11.80	13.45	2.3	2
25	17.70	7.20	12.72	4.2	8
26	13.90	12.70	13.57	.6	4
27	16.20	16.20	16.20	.0	1
28	17.30	15.70	16.50	1.1	2
29	16.30	11.70	14.42	1.7	12
30	17.10	7.10	11.87	3.4	12
31	15.40	8.80	12.10	2.9	6
32	14.50	5.30	10.54	3.6	7
33	7.70	7.70	7.70	.0	1
34	14.00	12.60	13.43	.7	3
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	10.00	6.20	8.22	1.8	5
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	6.90	6.90	6.90	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	19.40	10.30	13.97	4.0	4
16	13.20	10.70	11.95	1.8	2
17	22.50	3.50	13.66	8.7	7
18	18.10	13.70	16.42	1.8	8
19	13.10	3.80	8.45	6.6	2
20	29.70	4.50	15.94	7.0	45
21	-99.99	-99.99	-99.99	-99.9	-99
22	27.80	5.60	18.20	5.4	34
23	15.90	5.00	10.87	3.6	7
24	14.80	5.30	10.26	3.1	10
25	27.10	10.40	17.63	5.7	9
26	13.50	13.40	13.47	.1	3
27	17.20	10.30	14.21	1.3	22
28	18.50	15.20	17.02	1.4	4
29	23.40	6.60	14.71	3.2	50
30	8.30	8.30	8.30	.0	1
31	14.80	4.20	11.21	3.6	15
32	14.40	6.10	10.76	2.5	16
33	12.00	7.00	9.85	1.2	21
34	14.40	11.20	12.19	1.1	7
35	12.00	9.50	10.93	1.3	3
36	12.60	7.10	10.04	2.4	5
37	13.40	6.90	9.08	1.6	36
38	10.00	4.00	7.11	2.3	8
39	6.40	5.90	6.15	.4	2
40	10.00	5.40	8.10	2.3	4
41	4.90	4.30	4.50	.3	6
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	19.80	3.80	7.36	3.3	28
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	25.50	21.80	23.67	1.5	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	20.10	12.60	16.19	3.1	7
23	-99.99	-99.99	-99.99	-99.9	-99
24	16.90	11.40	13.67	1.9	6
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	16.20	12.30	14.20	2.0	3
28	-99.99	-99.99	-99.99	-99.9	-99
29	16.50	6.90	11.00	3.3	9
30	13.20	10.00	11.60	1.6	7
31	14.60	7.50	11.45	2.1	17
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	6.90	3.90	5.17	1.3	4
39	-99.99	-99.99	-99.99	-99.9	-99
40	6.00	2.90	4.06	1.0	11
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 6d

PHOSPHATE (MICROGRAM-AT/L) 1958 - 1974 50.1 - 100.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	33.60	10.60	18.66	5.9	25
18	18.10	13.50	15.80	3.3	2
19	21.00	14.00	17.50	4.9	2
20	24.60	23.90	24.13	.4	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	17.60	13.50	15.90	2.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	19.70	15.90	17.82	1.2	9
28	17.90	17.50	17.70	.3	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	18.60	13.20	15.43	1.7	7
31	13.90	8.90	11.37	2.1	10
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	15.80	15.00	15.47	.4	4
35	15.90	10.10	13.60	2.2	5
36	21.60	12.40	14.69	2.9	8
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	6.40	4.30	5.38	1.0	6
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	20.20	6.10	15.96	2.2	76
18	-99.99	-99.99	-99.99	-99.9	-99
19	10.50	10.50	10.50	.0	1
20	25.40	7.70	19.52	7.0	12
21	-99.99	-99.99	-99.99	-99.9	-99
22	22.50	12.30	16.13	2.5	15
23	14.10	4.60	10.02	3.4	11
24	12.20	12.20	12.20	.0	1
25	20.60	15.70	17.45	2.2	6
26	17.80	13.90	15.42	1.6	5
27	16.50	14.10	15.30	1.7	2
28	17.30	11.50	15.07	3.1	3
29	17.60	12.10	15.30	2.0	12
30	15.90	7.10	11.26	3.0	12
31	15.80	8.80	12.00	3.0	6
32	15.60	5.10	11.84	4.2	8
33	8.80	8.20	8.50	.4	2
34	14.80	13.50	14.07	.6	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	11.80	6.30	9.08	2.4	6
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	8.60	8.40	8.50	.1	2
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	19.70	14.40	16.40	2.9	3
17	22.60	21.40	22.02	.6	4
18	18.60	15.10	17.09	1.3	8
19	-99.99	-99.99	-99.99	-99.9	-99
20	23.10	7.20	14.02	4.9	16
21	-99.99	-99.99	-99.99	-99.9	-99
22	27.60	12.40	21.91	4.2	21
23	20.10	9.50	13.37	5.9	3
24	20.10	11.30	16.00	3.5	7
25	28.20	10.50	17.99	7.3	7
26	20.00	13.60	15.77	3.7	3
27	23.80	13.40	16.43	3.5	21
28	-99.99	-99.99	-99.99	-99.9	-99
29	21.30	8.70	15.94	2.9	44
30	10.00	10.00	10.00	.0	1
31	24.20	7.60	13.91	3.8	17
32	14.00	6.90	10.75	2.2	8
33	15.40	9.90	12.14	1.6	21
34	14.70	11.10	12.38	1.2	6
35	19.00	12.00	15.10	2.5	5
36	12.10	12.10	12.10	.0	1
37	13.70	8.00	10.46	1.3	28
38	13.20	4.50	10.20	3.7	7
39	-99.99	-99.99	-99.99	-99.9	-99
40	10.80	5.90	8.52	2.2	5
41	6.90	5.90	6.30	.4	4
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	23.80	6.30	12.02	4.8	16
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	23.90	20.80	23.00	1.5	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	23.50	14.80	18.87	2.5	10
23	-99.99	-99.99	-99.99	-99.9	-99
24	20.60	14.80	17.80	2.6	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	19.10	17.50	18.30	1.1	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	20.00	9.60	13.71	3.4	11
30	14.90	10.80	12.97	2.1	3
31	16.70	9.40	13.57	2.4	16
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	8.20	2.70	6.16	2.2	5
39	-99.99	-99.99	-99.99	-99.9	-99
40	10.60	4.40	7.80	1.8	17
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 6e

PHOSPHATE (MICROGRAM-AT/L) 1958 - 1974 100.1 - 150.0 METERS

WINTER						SPRING					
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	23.00	8.70	18.49	4.7	10	17	20.30	14.70	17.30	1.3	26
18	21.80	21.30	21.55	.4	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	24.30	24.30	24.30	.0	1	19	18.20	16.70	17.45	1.1	2
20	23.60	23.60	23.60	.0	1	20	10.90	10.90	10.90	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	25.90	17.20	21.89	2.6	10
23	-99.99	-99.99	-99.99	-99.9	-99	23	25.10	17.00	21.26	2.5	7
24	19.80	15.30	17.55	3.2	2	24	18.10	14.70	16.40	2.4	2
25	-99.99	-99.99	-99.99	-99.9	-99	25	27.60	22.10	24.72	2.3	4
26	-99.99	-99.99	-99.99	-99.9	-99	26	39.80	15.90	26.13	12.3	3
27	31.10	22.10	27.02	3.7	6	27	16.30	15.50	15.90	.6	2
28	30.20	24.40	27.30	4.1	2	28	28.80	22.10	25.45	4.7	2
29	-99.99	-99.99	-99.99	-99.9	-99	29	28.80	12.90	19.30	5.5	7
30	-99.99	-99.99	-99.99	-99.9	-99	30	22.20	8.80	14.80	5.0	7
31	21.00	12.10	15.20	3.2	6	31	20.70	10.80	16.70	5.2	3
32	-99.99	-99.99	-99.99	-99.9	-99	32	21.80	4.30	14.55	7.6	4
33	-99.99	-99.99	-99.99	-99.9	-99	33	7.10	7.10	7.10	.0	1
34	20.70	20.70	20.70	.0	1	34	33.00	14.90	22.82	7.5	4
35	22.80	10.20	16.85	6.2	4	35	-99.99	-99.99	-99.99	-99.9	-99
36	25.10	21.30	23.65	1.7	4	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	20.00	10.40	14.23	5.1	3
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	9.50	5.70	7.56	1.5	5	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	11.10	11.10	11.10	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER						AUTUMN					
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	28.00	21.80	24.52	2.6	4	17	16.60	14.20	15.25	1.0	4
18	26.00	15.70	19.62	3.8	5	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	22.00	12.00	18.42	3.2	10	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	27.60	19.30	23.57	2.7	9	22	30.60	23.00	27.48	3.2	5
23	17.60	11.50	14.37	3.1	3	23	-99.99	-99.99	-99.99	-99.9	-99
24	31.70	14.50	22.22	5.3	8	24	29.20	18.90	24.85	4.3	4
25	21.30	15.00	17.65	2.7	4	25	-99.99	-99.99	-99.99	-99.9	-99
26	26.90	26.10	26.50	.6	2	26	-99.99	-99.99	-99.99	-99.9	-99
27	30.40	19.80	25.01	2.5	14	27	27.40	19.70	23.55	5.4	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	25.80	12.20	18.68	4.0	29	29	24.50	10.10	15.80	6.5	5
30	11.60	11.60	11.60	.0	1	30	14.80	13.20	13.73	.9	3
31	24.60	7.00	15.99	5.7	10	31	25.30	14.40	18.88	3.7	12
32	17.00	12.20	15.43	1.6	7	32	-99.99	-99.99	-99.99	-99.9	-99
33	22.10	13.10	18.90	3.0	12	33	-99.99	-99.99	-99.99	-99.9	-99
34	23.80	12.80	19.05	4.8	4	34	-99.99	-99.99	-99.99	-99.9	-99
35	21.50	17.80	19.02	1.7	4	35	-99.99	-99.99	-99.99	-99.9	-99
36	16.40	16.40	16.40	.0	1	36	-99.99	-99.99	-99.99	-99.9	-99
37	19.20	12.50	15.66	2.0	19	37	-99.99	-99.99	-99.99	-99.9	-99
38	13.20	7.00	10.36	3.0	5	38	9.50	8.10	8.85	.6	4
39	9.10	9.10	9.10	.0	1	39	-99.99	-99.99	-99.99	-99.9	-99
40	10.00	6.40	8.57	1.5	4	40	10.50	6.50	8.98	1.2	13
41	11.70	11.10	11.40	.4	2	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 6f

PHOSPHATE (MICROGRAM-AT/L) 1958 - 1974 150.1 - *99.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	26.40	19.50	22.93	2.9	7
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	33.40	31.40	32.76	.4	17
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	33.10	14.30	28.29	5.3	26
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	32.40	9.80	20.87	8.4	16
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	20.50	14.90	17.68	1.5	31
18	-99.99	-99.99	-99.99	-99.9	-99
19	34.90	19.70	30.27	5.5	10
20	27.20	27.20	27.20	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	30.50	23.70	26.54	2.6	5
23	30.60	23.70	27.05	3.0	4
24	-99.99	-99.99	-99.99	-99.9	-99
25	29.50	28.80	29.15	.5	2
26	32.90	17.50	25.20	10.9	2
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	33.70	18.50	29.91	5.2	17
30	34.90	16.00	28.09	7.0	10
31	-99.99	-99.99	-99.99	-99.9	-99
32	34.30	20.50	31.81	3.6	16
33	-99.99	-99.99	-99.99	-99.9	-99
34	34.30	25.30	32.20	3.1	8
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	34.30	23.80	31.99	3.1	11
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	34.30	14.30	27.41	7.2	8
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	35.50	33.70	34.60	.9	3
18	26.50	20.90	22.70	2.6	4
19	-99.99	-99.99	-99.99	-99.9	-99
20	23.50	17.80	20.80	2.8	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	30.70	17.70	25.69	3.4	27
23	18.50	14.00	16.25	3.2	2
24	38.10	21.00	28.67	6.0	21
25	37.20	5.00	24.20	7.3	23
26	27.90	27.90	27.90	.0	1
27	33.10	26.10	29.20	2.8	9
28	-99.99	-99.99	-99.99	-99.9	-99
29	42.50	9.30	26.87	6.8	126
30	29.10	14.80	21.88	4.9	6
31	40.00	5.00	26.83	7.0	54
32	26.50	17.80	22.30	3.0	9
33	25.90	20.50	24.28	1.9	6
34	25.70	22.90	24.30	2.0	2
35	22.50	20.50	21.55	.7	10
36	-99.99	-99.99	-99.99	-99.9	-99
37	22.70	18.90	20.57	1.3	9
38	42.50	9.30	22.99	8.6	31
39	26.30	10.80	20.33	6.2	6
40	41.00	1.20	24.39	10.2	21
41	14.00	13.70	13.85	.2	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	21.40	16.90	18.95	2.1	4
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	33.30	32.60	32.90	.4	3
23	-99.99	-99.99	-99.99	-99.9	-99
24	30.00	29.60	29.80	.3	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	31.90	31.90	31.90	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	27.90	14.60	19.37	7.4	3
30	31.70	14.80	23.22	5.4	24
31	29.70	17.50	24.68	5.6	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	11.40	10.60	11.00	.6	2
39	-99.99	-99.99	-99.99	-99.9	-99
40	28.80	9.50	16.32	5.2	22
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 7a

SILICATE (MICROGRAM-AT/L) 1958 - 1974 .0 - 10.0 METERS

WINTER						SPRING					
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	18.30	18.30	18.30	.0	1	15	20.50	20.50	20.50	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	29.00	15.00	18.89	2.9	57	17	44.00	.00	12.20	12.4	215
18	27.00	26.00	26.50	.7	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	25.00	13.40	17.60	4.5	9	19	24.00	5.40	13.54	4.4	14
20	62.00	5.40	31.49	23.8	23	20	60.20	1.20	22.38	16.0	66
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	34.80	25.90	31.67	3.8	6	22	85.30	9.60	37.19	15.7	50
23	39.00	20.00	30.43	5.5	18	23	46.00	.89	26.51	9.1	32
24	35.20	27.10	31.55	2.3	8	24	40.00	11.80	31.11	8.9	10
25	-99.99	-99.99	-99.99	-99.9	-99	25	48.40	13.40	37.08	10.7	24
26	39.00	27.00	32.94	5.0	5	26	35.93	21.00	28.68	6.7	5
27	40.00	26.60	32.46	5.1	13	27	41.40	20.40	33.60	6.0	21
28	40.90	21.10	32.31	6.7	7	28	47.10	27.80	36.86	5.6	13
29	29.40	27.00	27.93	1.3	3	29	52.90	8.10	39.20	10.0	79
30	45.00	22.00	30.81	4.9	27	30	53.90	2.90	33.42	9.3	79
31	28.10	7.00	19.72	8.4	11	31	36.90	16.60	30.60	4.5	68
32	25.10	8.70	16.96	6.0	7	32	43.70	17.40	27.66	4.6	50
33	-99.99	-99.99	-99.99	-99.9	-99	33	37.80	24.30	28.87	4.8	15
34	33.60	22.00	27.51	4.0	13	34	41.80	16.70	30.88	5.8	24
35	33.00	27.00	30.17	2.2	6	35	-99.99	-99.99	-99.99	-99.9	-99
36	28.00	12.50	19.99	4.8	15	36	57.40	12.80	21.97	9.0	20
37	16.40	12.10	14.40	1.9	4	37	33.90	3.60	19.86	6.3	56
38	8.30	8.30	8.30	.0	1	38	19.20	19.20	19.20	.0	1
39	8.60	8.60	8.60	.0	1	39	-99.99	-99.99	-99.99	-99.9	-99
40	7.40	4.00	5.53	1.4	7	40	4.70	4.70	4.70	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99	41	12.00	3.50	6.64	3.3	5
42	11.30	5.00	7.56	2.1	7	42	28.50	5.20	10.57	6.3	13

SUMMER						AUTUMN					
15	27.00	3.50	15.25	16.6	2	15	-99.99	-99.99	-99.99	-99.9	-99
16	8.00	7.00	7.50	.7	2	16	-99.99	-99.99	-99.99	-99.9	-99
17	18.00	2.00	8.06	3.7	49	17	54.00	10.00	14.87	6.9	52
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	14.40	2.20	7.16	4.1	7	19	-99.99	-99.99	-99.99	-99.9	-99
20	53.30	.00	16.12	14.9	112	20	54.70	.00	19.00	23.7	6
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	67.00	.30	32.30	18.3	62	22	54.00	29.00	38.69	10.1	13
23	30.40	.00	11.56	9.1	15	23	-99.99	-99.99	-99.99	-99.9	-99
24	20.80	1.00	6.58	5.7	13	24	18.70	2.94	10.77	9.0	4
25	39.00	14.00	28.17	7.6	13	25	-99.99	-99.99	-99.99	-99.9	-99
26	39.27	1.00	26.40	22.0	3	26	-99.99	-99.99	-99.99	-99.9	-99
27	38.98	2.40	27.72	13.7	22	27	19.79	19.77	19.78	.0	2
28	37.60	7.60	27.52	13.9	4	28	-99.99	-99.99	-99.99	-99.9	-99
29	47.00	3.00	22.77	10.4	53	29	34.00	16.00	20.27	6.7	11
30	26.40	4.90	19.93	5.4	12	30	-99.99	-99.99	-99.99	-99.9	-99
31	36.34	1.00	21.22	8.4	26	31	20.73	2.36	14.79	5.1	13
32	32.80	1.40	12.47	8.4	20	32	-99.99	-99.99	-99.99	-99.9	-99
33	28.24	5.20	14.85	9.5	22	33	14.50	13.30	13.90	.8	2
34	36.52	11.60	23.96	6.9	17	34	-99.99	-99.99	-99.99	-99.9	-99
35	8.00	3.00	5.50	2.9	4	35	-99.99	-99.99	-99.99	-99.9	-99
36	25.90	.00	14.72	7.6	11	36	-99.99	-99.99	-99.99	-99.9	-99
37	21.95	.00	10.54	6.3	36	37	-99.99	-99.99	-99.99	-99.9	-99
38	18.00	9.00	13.65	4.0	6	38	13.00	2.00	6.33	5.2	6
39	15.80	15.80	15.80	.0	1	39	-99.99	-99.99	-99.99	-99.9	-99
40	18.90	.00	6.28	8.1	5	40	6.47	.00	2.14	2.3	13
41	5.03	2.33	3.93	1.4	5	41	-99.99	-99.99	-99.99	-99.9	-99
42	13.80	6.50	10.15	5.2	2	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 7b

SILICATE (MICROGRAM-AT/L) 1958 - 1974 10.1 - 25.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	29.00	16.00	19.38	3.6	26
18	27.00	27.00	27.00	.0	1
19	25.00	25.00	25.00	.0	2
20	60.00	58.60	59.23	.7	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	39.00	31.00	34.00	3.3	8
24	32.00	30.00	31.33	1.2	3
25	-99.99	-99.99	-99.99	-99.9	-99
26	37.00	19.00	31.75	8.6	4
27	36.00	28.00	32.00	5.7	2
28	35.00	35.00	35.00	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99
30	39.00	22.00	30.79	4.9	24
31	26.00	8.00	17.00	12.7	2
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	31.00	28.00	30.00	1.7	3
35	30.00	27.00	28.00	1.4	4
36	28.00	22.00	24.40	2.6	5
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	5.00	5.00	5.00	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	35.00	.00	14.52	13.8	73
18	-99.99	-99.99	-99.99	-99.9	-99
19	27.00	27.00	27.00	.0	1
20	55.60	11.20	40.17	18.7	7
21	-99.99	-99.99	-99.99	-99.9	-99
22	64.00	15.32	35.17	13.2	18
23	33.18	.93	21.55	12.1	9
24	37.00	37.00	37.00	.0	1
25	45.00	12.92	30.16	15.4	8
26	35.87	22.00	26.96	7.7	3
27	34.00	34.00	34.00	.0	2
28	37.00	37.00	37.00	.0	1
29	46.30	18.00	34.25	7.8	11
30	38.70	17.00	29.99	7.5	8
31	34.80	32.00	33.03	1.5	3
32	31.70	21.00	28.48	5.0	4
33	24.90	24.90	24.90	.0	1
34	27.00	25.00	26.00	1.4	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	20.90	15.30	18.40	2.8	3
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	13.00	13.00	13.00	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	.00	.00	.00	.0	1
17	6.00	2.00	3.58	1.3	12
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	57.40	1.09	27.03	16.8	38
21	-99.99	-99.99	-99.99	-99.9	-99
22	62.00	9.00	43.12	17.0	17
23	4.00	4.00	4.00	.0	1
24	11.00	2.00	6.00	4.6	3
25	32.00	15.00	23.50	12.0	2
26	39.70	39.48	39.59	.2	2
27	38.92	4.00	34.37	10.7	10
28	-99.99	-99.99	-99.99	-99.9	-99
29	39.00	2.00	21.08	10.1	13
30	-99.99	-99.99	-99.99	-99.9	-99
31	36.85	1.00	19.57	13.4	5
32	16.17	4.33	9.64	5.4	8
33	28.41	6.08	12.15	8.9	9
34	36.36	30.93	34.49	3.1	3
35	9.00	3.00	6.00	4.2	2
36	-99.99	-99.99	-99.99	-99.9	-99
37	22.49	7.13	11.30	4.8	12
38	13.00	10.00	11.50	2.1	2
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	1
41	5.51	2.25	4.47	1.3	5
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	17.00	10.00	12.84	1.9	25
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	57.60	38.50	48.05	13.5	2
21	-99.99	-99.99	-99.99	-99.9	-99
22	51.00	29.00	34.80	9.2	5
23	-99.99	-99.99	-99.99	-99.9	-99
24	18.49	2.97	10.73	8.9	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	20.98	19.75	20.37	.9	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	34.00	16.00	22.12	7.6	8
30	-99.99	-99.99	-99.99	-99.9	-99
31	20.82	10.52	15.50	3.9	8
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	13.00	2.00	5.00	4.6	5
39	-99.99	-99.99	-99.99	-99.9	-99
40	7.16	.00	2.15	2.8	7
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 7c

SILICATE (MICROGRAM-AT/L) 1958 - 1974 25.1 - 50.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	36.00	1.90	19.57	5.2	35
18	29.00	28.00	28.50	.7	2
19	24.00	24.00	24.00	.0	1
20	61.80	59.00	60.23	1.1	6
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	42.00	31.00	36.40	4.4	5
24	31.00	26.00	29.00	2.6	3
25	-99.99	-99.99	-99.99	-99.9	-99
26	33.00	29.00	31.00	2.8	2
27	41.00	27.00	34.00	7.5	4
28	38.00	37.00	37.50	.7	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	36.00	22.00	28.80	5.5	5
31	26.00	7.00	17.00	9.5	3
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	31.00	24.00	27.67	3.5	3
35	32.00	26.00	30.40	2.5	5
36	28.00	19.00	25.57	3.0	7
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	6.00	4.00	5.00	1.4	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	35.00	1.00	18.49	14.2	86
18	-99.99	-99.99	-99.99	-99.9	-99
19	26.00	26.00	26.00	.0	1
20	61.00	11.10	41.51	20.8	12
21	-99.99	-99.99	-99.99	-99.9	-99
22	64.00	15.45	33.68	11.9	22
23	33.51	15.00	28.12	6.9	10
24	30.00	30.00	30.00	.0	2
25	48.00	13.16	28.03	13.0	8
26	36.36	24.00	33.18	6.1	4
27	34.00	34.00	34.00	.0	1
28	38.00	37.00	37.50	.7	2
29	49.40	28.00	37.38	7.1	12
30	38.50	14.00	32.07	7.5	12
31	35.20	30.70	32.78	1.8	6
32	33.10	23.00	29.49	4.5	7
33	25.60	25.40	25.50	.1	2
34	27.00	26.00	26.67	.6	3
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	20.90	15.40	18.38	2.7	5
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	12.00	12.00	12.00	.0	1
42	23.20	6.20	12.92	8.2	4

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	20.00	15.00	17.50	3.5	2
17	3.00	2.00	2.67	.6	3
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	60.20	5.33	30.59	17.2	39
21	-99.99	-99.99	-99.99	-99.9	-99
22	66.00	5.00	39.35	18.0	29
23	30.46	5.00	13.82	14.4	3
24	17.00	3.00	7.80	5.4	5
25	40.00	15.00	32.83	9.4	6
26	39.81	39.65	39.73	.1	3
27	39.25	15.11	35.97	5.3	20
28	-99.99	-99.99	-99.99	-99.9	-99
29	47.00	2.00	25.79	11.8	33
30	-99.99	-99.99	-99.99	-99.9	-99
31	37.61	8.00	26.62	11.7	7
32	19.00	5.59	13.57	4.3	10
33	29.16	8.42	18.50	6.7	23
34	36.55	31.13	33.29	2.9	5
35	17.00	5.00	11.00	6.0	3
36	17.52	17.52	17.52	.0	1
37	25.31	7.80	14.92	4.2	30
38	12.00	10.00	11.25	1.0	4
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	6.06	4.70	5.46	.5	6
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	42.00	8.00	14.55	6.5	29
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	59.00	48.30	52.87	4.5	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	58.00	30.00	40.00	10.3	7
23	-99.99	-99.99	-99.99	-99.9	-99
24	34.79	8.45	21.91	8.8	6
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	31.71	25.60	28.46	3.1	3
28	-99.99	-99.99	-99.99	-99.9	-99
29	36.00	16.00	22.00	6.8	9
30	-99.99	-99.99	-99.99	-99.9	-99
31	28.31	15.45	21.58	3.8	17
32	-99.99	-99.99	-99.99	-99.9	-99
33	28.40	12.50	20.45	11.2	2
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	12.00	9.00	9.75	1.5	4
39	-99.99	-99.99	-99.99	-99.9	-99
40	8.22	1.00	4.23	2.6	11
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 7d

SILICATE (MICROGRAM-AT/L) 1958 - 1974 50.1 - 100.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	43.00	19.00	25.20	7.6	25	17	38.00	1.00	28.59	7.7	76
18	40.00	26.00	33.00	9.9	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	45.00	25.00	35.00	14.1	2	19	29.00	29.00	29.00	.0	1
20	59.60	57.00	58.40	1.3	3	20	60.00	16.20	41.72	19.9	10
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	65.40	28.76	42.84	8.1	15
23	-99.99	-99.99	-99.99	-99.9	-99	23	45.14	11.00	30.48	9.1	11
24	31.00	26.00	27.75	2.4	4	24	34.00	34.00	34.00	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99	25	54.90	39.28	44.51	6.7	6
26	-99.99	-99.99	-99.99	-99.9	-99	26	41.63	25.00	33.37	7.1	5
27	42.00	27.00	34.11	6.5	9	27	35.00	34.00	34.50	.7	2
28	40.00	35.00	37.50	3.5	2	28	37.00	34.00	36.00	1.7	3
29	-99.99	-99.99	-99.99	-99.9	-99	29	48.20	30.00	37.45	5.8	11
30	34.00	25.00	29.71	3.3	7	30	42.20	14.00	32.08	8.8	12
31	26.00	7.00	16.20	7.7	10	31	37.60	31.60	34.13	2.1	6
32	-99.99	-99.99	-99.99	-99.9	-99	32	35.60	21.00	30.71	5.0	8
33	-99.99	-99.99	-99.99	-99.9	-99	33	29.90	29.30	29.60	.4	2
34	31.00	28.00	29.25	1.3	4	34	32.00	28.00	29.00	2.0	4
35	37.00	27.00	32.60	3.8	5	35	-99.99	-99.99	-99.99	-99.9	-99
36	48.00	21.00	28.62	8.1	8	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	22.20	16.00	19.87	2.3	6
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	6.00	4.00	4.83	.8	6	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	14.00	13.00	13.50	.7	2
42	-99.99	-99.99	-99.99	-99.9	-99	42	26.30	11.30	18.80	10.6	2

	SUMMER						AUTUMN				
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	36.00	23.00	28.00	7.0	3	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	54.00	8.00	19.61	12.0	18
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	63.70	9.80	30.02	17.5	13	20	58.40	47.10	51.83	5.9	3
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	69.00	25.00	52.44	11.7	17	22	61.00	32.00	44.20	8.0	10
23	52.44	16.00	28.48	20.8	3	23	-99.99	-99.99	-99.99	-99.9	-99
24	41.00	11.00	24.20	13.2	5	24	61.64	27.95	43.20	16.0	4
25	47.00	15.00	27.00	15.0	4	25	-99.99	-99.99	-99.99	-99.9	-99
26	62.27	39.90	47.47	12.8	3	26	-99.99	-99.99	-99.99	-99.9	-99
27	69.01	35.00	42.71	10.4	21	27	39.31	35.41	37.36	2.8	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	50.00	2.00	25.19	10.7	27	29	47.00	21.00	29.09	8.3	11
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	45.56	17.00	29.23	10.4	8	31	33.54	16.40	25.68	5.4	16
32	23.00	6.82	17.12	5.9	8	32	-99.99	-99.99	-99.99	-99.9	-99
33	29.70	14.11	22.49	5.5	21	33	-99.99	-99.99	-99.99	-99.9	-99
34	41.60	31.23	34.94	4.0	6	34	-99.99	-99.99	-99.99	-99.9	-99
35	38.00	22.00	29.00	6.8	5	35	-99.99	-99.99	-99.99	-99.9	-99
36	26.38	26.38	26.38	.0	1	36	-99.99	-99.99	-99.99	-99.9	-99
37	28.52	12.83	18.78	3.3	28	37	-99.99	-99.99	-99.99	-99.9	-99
38	22.00	12.00	14.75	4.9	4	38	16.00	4.00	12.00	4.6	5
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	13.00	2.00	7.50	7.8	2	40	13.00	3.00	9.46	2.6	17
41	9.08	5.07	7.06	2.0	4	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 7e

SILICATE (MICROGRAM-AT/L) 1958 - 1974 100.1 - 150.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	60.00	21.00	34.20	13.9	10	17	36.00	29.00	32.85	1.9	26
18	58.00	49.00	53.50	6.4	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	55.00	55.00	55.00	.0	1	19	45.00	45.00	45.00	.0	2
20	57.00	57.00	57.00	.0	1	20	33.60	33.60	33.60	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	77.75	46.14	63.73	10.1	10
23	-99.99	-99.99	-99.99	-99.9	-99	23	76.91	44.00	57.53	11.6	7
24	44.00	30.00	37.00	9.9	2	24	41.00	35.00	38.00	4.2	2
25	-99.99	-99.99	-99.99	-99.9	-99	25	80.60	62.33	71.59	7.9	4
26	-99.99	-99.99	-99.99	-99.9	-99	26	79.37	33.00	60.08	24.1	3
27	79.00	48.00	61.50	11.8	6	27	35.00	35.00	35.00	.0	2
28	80.00	59.00	69.50	14.8	2	28	78.00	54.00	66.00	17.0	2
29	-99.99	-99.99	-99.99	-99.9	-99	29	82.80	28.50	52.37	19.0	7
30	-99.99	-99.99	-99.99	-99.9	-99	30	55.00	29.00	45.57	9.4	7
31	42.00	20.00	27.33	7.9	6	31	75.90	33.80	58.73	22.1	3
32	-99.99	-99.99	-99.99	-99.9	-99	32	56.90	24.00	40.80	15.3	4
33	-99.99	-99.99	-99.99	-99.9	-99	33	26.00	26.00	26.00	.0	1
34	44.00	44.00	44.00	.0	1	34	157.00	30.00	72.25	57.4	4
35	57.00	37.00	45.50	9.7	4	35	-99.99	-99.99	-99.99	-99.9	-99
36	62.00	46.00	54.50	6.6	4	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	38.00	32.90	35.80	2.6	3
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	16.00	5.00	9.20	4.7	5	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	15.00	15.00	15.00	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99	42	25.80	19.60	22.70	4.4	2

	SUMMER						AUTUMN				
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	33.00	30.00	31.50	1.3	4
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	57.63	21.91	40.18	10.4	10	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	68.00	32.00	54.32	13.6	6	22	88.00	58.00	75.40	12.8	5
23	39.98	25.00	29.99	8.6	3	23	-99.99	-99.99	-99.99	-99.9	-99
24	53.00	28.00	43.17	8.7	6	24	85.54	40.46	65.28	19.5	4
25	34.00	24.00	27.33	5.8	3	25	-99.99	-99.99	-99.99	-99.9	-99
26	93.56	85.39	89.47	5.8	2	26	-99.99	-99.99	-99.99	-99.9	-99
27	85.36	52.91	76.26	8.7	14	27	71.54	52.33	61.93	13.6	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	63.00	3.00	34.42	15.6	19	29	63.00	21.00	37.20	18.7	5
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	82.16	16.00	39.20	25.1	9	31	61.02	29.39	41.64	10.6	12
32	38.49	25.00	31.47	5.0	7	32	-99.99	-99.99	-99.99	-99.9	-99
33	59.83	30.33	45.53	8.7	12	33	-99.99	-99.99	-99.99	-99.9	-99
34	81.67	35.17	62.37	20.0	4	34	-99.99	-99.99	-99.99	-99.9	-99
35	49.00	41.00	44.00	3.6	4	35	-99.99	-99.99	-99.99	-99.9	-99
36	42.04	42.04	42.04	.0	1	36	-99.99	-99.99	-99.99	-99.9	-99
37	47.78	24.23	35.74	7.1	19	37	-99.99	-99.99	-99.99	-99.9	-99
38	24.00	11.00	17.50	7.0	4	38	19.00	16.00	17.75	1.5	4
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	13.00	12.00	12.50	.7	2	40	17.97	10.00	12.60	2.6	13
41	20.17	13.67	16.92	4.6	2	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 7f

SILICATE (MICROGRAM-AT/L) 1958 - 1974 150.1 - *99.0 METERS

WINTER						SPRING					
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	39.00	26.00	31.43	4.8	7	17	42.00	29.00	34.48	2.9	31
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	150.00	54.00	108.90	34.3	10
20	-99.99	-99.99	-99.99	-99.9	-99	20	61.40	61.40	61.40	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	97.37	75.69	86.18	7.8	5
23	-99.99	-99.99	-99.99	-99.9	-99	23	93.71	63.00	78.22	12.7	4
24	-99.99	-99.99	-99.99	-99.9	-99	24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99	25	95.47	93.43	94.45	1.4	2
26	-99.99	-99.99	-99.99	-99.9	-99	26	92.38	82.00	87.19	7.3	2
27	128.00	75.00	97.35	17.6	17	27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	158.60	43.00	106.15	35.7	17
30	-99.99	-99.99	-99.99	-99.9	-99	30	135.40	35.00	73.71	32.7	10
31	133.00	26.00	85.15	31.5	26	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	153.00	49.00	111.50	28.9	16
33	-99.99	-99.99	-99.99	-99.9	-99	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	148.00	64.00	113.87	28.3	8
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	145.00	62.00	111.45	24.5	11
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	119.00	12.00	55.76	36.2	17	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	141.00	32.00	90.25	37.9	8
42	-99.99	-99.99	-99.99	-99.9	-99	42	57.20	23.50	40.42	13.2	6

SUMMER						AUTUMN					
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	55.00	37.00	45.00	8.1	4
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	68.19	44.84	54.04	10.3	4	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	86.00	33.00	60.08	18.9	12	22	98.00	87.00	94.00	6.1	3
23	46.00	33.00	39.50	9.2	2	23	-99.99	-99.99	-99.99	-99.9	-99
24	94.00	52.00	69.20	13.1	10	24	103.19	81.39	92.29	15.4	2
25	85.00	29.00	58.40	17.4	10	25	-99.99	-99.99	-99.99	-99.9	-99
26	99.94	99.94	99.94	.0	1	26	-99.99	-99.99	-99.99	-99.9	-99
27	105.00	87.00	93.50	5.5	9	27	86.96	86.96	86.96	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	97.00	12.00	59.80	21.0	46	29	77.00	31.00	46.25	21.0	4
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	90.82	23.00	59.05	20.9	17	31	83.57	42.87	65.35	17.0	6
32	87.00	39.14	60.56	17.0	9	32	-99.99	-99.99	-99.99	-99.9	-99
33	71.05	61.21	67.77	3.8	6	33	-99.99	-99.99	-99.99	-99.9	-99
34	91.28	84.56	87.92	4.8	2	34	-99.99	-99.99	-99.99	-99.9	-99
35	85.00	45.00	60.60	13.7	10	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	64.56	47.07	55.90	5.6	9	37	-99.99	-99.99	-99.99	-99.9	-99
38	85.00	15.00	50.92	24.1	13	38	23.00	22.00	22.50	.7	2
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	30.00	20.00	25.00	7.1	2	40	78.00	12.00	34.18	17.4	22
41	28.34	18.85	23.60	6.7	2	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 8a

OXYGEN (ML/L) 1958 - 1974 .0 - 10.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	7.12	6.29	6.61	.2	48
18	6.91	6.90	6.91	.0	2
19	6.83	6.70	6.76	.1	2
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	7.18	7.08	7.11	.1	3
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	7.36	6.98	7.15	.2	4
28	7.11	7.10	7.10	.0	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	7.28	6.86	7.05	.2	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	7.40	6.79	7.07	.1	21
34	7.04	6.66	6.86	.2	4
35	7.12	6.98	7.06	.1	6
36	7.15	6.96	7.02	.1	4
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	6.66	6.48	6.54	.1	4
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	11.15	6.89	8.50	1.3	108
18	-99.99	-99.99	-99.99	-99.9	-99
19	6.75	6.75	6.75	.0	1
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	8.74	7.64	8.19	.3	12
23	8.19	7.51	7.87	.3	6
24	7.26	7.19	7.22	.0	2
25	8.36	7.87	8.15	.3	5
26	7.55	7.55	7.55	.0	1
27	7.24	7.23	7.23	.0	2
28	7.19	7.19	7.19	.0	1
29	7.58	7.39	7.48	.1	4
30	7.07	7.07	7.07	.0	2
31	-99.99	-99.99	-99.99	-99.9	-99
32	7.16	7.08	7.12	.1	2
33	7.61	6.58	7.18	.2	25
34	7.15	6.93	7.06	.1	3
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	6.91	6.91	6.91	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	6.77	6.77	6.77	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	7.39	6.80	7.11	.3	5
16	7.03	6.99	7.01	.0	2
17	9.04	4.80	7.64	1.1	24
18	7.41	6.42	6.71	.3	8
19	6.94	6.14	6.55	.3	6
20	7.98	5.93	6.78	.6	21
21	-99.99	-99.99	-99.99	-99.9	-99
22	7.23	6.89	7.00	.2	4
23	7.51	6.84	7.01	.2	8
24	7.44	6.21	6.68	.4	10
25	7.31	6.45	6.93	.4	6
26	7.51	7.51	7.51	.0	2
27	7.53	6.54	7.27	.4	16
28	6.52	6.48	6.50	.0	4
29	7.67	6.06	6.90	.4	30
30	6.15	6.12	6.13	.0	2
31	7.45	5.77	6.42	.5	16
32	7.04	6.03	6.51	.4	16
33	7.36	6.19	6.68	.3	41
34	7.45	6.44	7.07	.5	6
35	6.41	6.30	6.37	.0	4
36	6.91	6.34	6.47	.2	5
37	7.25	6.13	6.78	.3	26
38	6.11	5.72	5.86	.1	10
39	5.97	5.93	5.95	.0	2
40	6.14	5.59	5.88	.2	5
41	6.33	6.13	6.25	.1	5
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	8.60	6.74	7.09	.4	22
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	6.75	6.23	6.49	.4	2
23	6.52	6.26	6.38	.1	4
24	6.45	6.27	6.36	.1	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	6.32	6.27	6.29	.0	2
27	6.46	6.46	6.46	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	6.56	6.53	6.54	.0	2
30	6.23	4.25	5.73	.7	8
31	6.48	6.26	6.38	.1	13
32	-99.99	-99.99	-99.99	-99.9	-99
33	7.11	5.95	6.49	.3	25
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	6.05	5.91	5.98	.1	2
39	5.78	5.71	5.75	.0	2
40	5.97	5.17	5.45	.3	15
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 8b

OXYGEN (ML/L) 1958 - 1974 10.1 - 25.0 METERS

	WINTER					SPRING				
ZONE	MAX	MIN	MEAN	SD	N	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	-99.99	-99.99	-99.99	-99.9	-99
17	7.15	6.31	6.66	.3	14	8.99	6.88	7.81	.7	30
18	6.95	6.95	6.95	.0	1	-99.99	-99.99	-99.99	-99.9	-99
19	6.77	6.75	6.76	.0	2	6.76	6.76	6.76	.0	1
20	-99.99	-99.99	-99.99	-99.9	-99	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	8.32	7.61	7.91	.3	8
23	-99.99	-99.99	-99.99	-99.9	-99	8.20	7.53	7.80	.3	5
24	7.12	7.06	7.08	.0	3	7.19	7.19	7.19	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99	8.35	7.89	8.22	.2	4
26	-99.99	-99.99	-99.99	-99.9	-99	7.53	7.53	7.53	.0	1
27	7.21	7.12	7.16	.1	2	7.24	7.23	7.23	.0	2
28	7.10	7.10	7.10	.0	1	7.23	7.23	7.23	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99	7.60	7.43	7.51	.1	2
30	-99.99	-99.99	-99.99	-99.9	-99	7.09	7.09	7.09	.0	1
31	7.22	6.86	7.04	.3	2	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	7.29	7.25	7.27	.0	2
33	-99.99	-99.99	-99.99	-99.9	-99	-99.99	-99.99	-99.99	-99.9	-99
34	7.04	6.66	6.82	.2	3	7.14	7.09	7.11	.0	2
35	7.08	6.91	7.01	.1	4	-99.99	-99.99	-99.99	-99.9	-99
36	6.95	6.88	6.92	.0	3	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	7.03	7.03	7.03	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	-99.99	-99.99	-99.99	-99.9	-99
40	6.39	6.39	6.39	.0	1	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	6.92	6.92	6.92	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99	-99.99	-99.99	-99.99	-99.9	-99

	SUMMER					AUTUMN				
ZONE	MAX	MIN	MEAN	SD	N	MAX	MIN	MEAN	SD	N
15	6.97	6.86	6.91	.1	2	-99.99	-99.99	-99.99	-99.9	-99
16	6.76	6.76	6.76	.0	1	-99.99	-99.99	-99.99	-99.9	-99
17	8.48	6.16	7.48	.9	8	6.91	6.45	6.74	.2	6
18	7.36	5.96	6.48	.6	4	-99.99	-99.99	-99.99	-99.9	-99
19	6.98	6.24	6.72	.3	7	-99.99	-99.99	-99.99	-99.9	-99
20	8.56	4.23	6.76	1.2	12	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	-99.99	-99.99	-99.99	-99.9	-99
22	7.08	6.95	7.01	.1	2	6.38	6.38	6.38	.0	1
23	7.25	6.86	7.01	.2	3	6.52	6.32	6.42	.1	2
24	7.51	6.46	6.74	.4	6	6.45	6.26	6.37	.1	4
25	7.39	6.48	6.96	.5	3	-99.99	-99.99	-99.99	-99.9	-99
26	7.52	7.51	7.51	.0	2	6.30	6.30	6.30	.0	1
27	7.53	6.52	7.30	.3	11	6.66	6.47	6.56	.1	2
28	6.51	6.44	6.47	.0	2	-99.99	-99.99	-99.99	-99.9	-99
29	7.33	6.26	6.91	.4	19	6.64	6.64	6.64	.0	1
30	-99.99	-99.99	-99.99	-99.9	-99	6.32	5.03	5.97	.5	5
31	7.46	6.00	6.47	.4	11	6.45	6.33	6.41	.1	7
32	7.08	6.23	6.71	.3	11	-99.99	-99.99	-99.99	-99.9	-99
33	7.40	6.54	6.84	.3	9	-99.99	-99.99	-99.99	-99.9	-99
34	7.44	6.38	7.15	.5	4	-99.99	-99.99	-99.99	-99.9	-99
35	7.19	7.19	7.19	.0	2	-99.99	-99.99	-99.99	-99.9	-99
36	6.41	6.36	6.38	.0	2	-99.99	-99.99	-99.99	-99.9	-99
37	7.20	6.46	6.92	.2	15	-99.99	-99.99	-99.99	-99.9	-99
38	7.56	5.81	6.32	.8	4	5.65	5.65	5.65	.0	1
39	-99.99	-99.99	-99.99	-99.9	-99	5.78	5.78	5.78	.0	1
40	6.11	5.74	5.95	.2	4	6.18	5.52	5.80	.2	8
41	6.78	6.32	6.53	.2	5	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	-99.99	-99.99	-99.99	-99.9	-99

TABLE 8c

OXYGEN (ML/L) 1958 - 1974 25.1 - 50.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	7.18	4.13	6.35	.6	25	17	8.74	5.91	7.39	.6	61
18	6.94	6.89	6.91	.0	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	6.76	6.76	6.76	.0	1	19	6.91	6.91	6.91	.0	1
20	-99.99	-99.99	-99.99	-99.9	-99	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	8.31	6.67	7.76	.4	15
23	-99.99	-99.99	-99.99	-99.9	-99	23	8.15	7.51	7.74	.2	9
24	7.14	7.05	7.11	.1	3	24	7.19	7.18	7.19	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99	25	8.31	7.65	8.00	.3	6
26	-99.99	-99.99	-99.99	-99.9	-99	26	7.54	7.52	7.53	.0	3
27	7.31	7.07	7.17	.1	4	27	7.29	7.29	7.29	.0	1
28	7.10	7.09	7.09	.0	2	28	7.23	7.23	7.23	.0	2
29	-99.99	-99.99	-99.99	-99.9	-99	29	7.66	7.30	7.48	.2	4
30	-99.99	-99.99	-99.99	-99.9	-99	30	7.08	7.07	7.07	.0	2
31	7.30	6.82	7.04	.2	3	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	7.18	7.08	7.12	.1	3
33	-99.99	-99.99	-99.99	-99.9	-99	33	-99.99	-99.99	-99.99	-99.9	-99
34	7.00	6.71	6.90	.2	3	34	7.13	7.00	7.08	.1	3
35	7.09	6.95	7.05	.1	5	35	-99.99	-99.99	-99.99	-99.9	-99
36	7.03	6.95	6.97	.0	6	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	6.93	6.93	6.93	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	6.59	6.42	6.50	.1	2	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	6.72	6.72	6.72	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

	SUMMER						AUTUMN				
15	6.84	6.06	6.56	.4	4	15	-99.99	-99.99	-99.99	-99.9	-99
16	6.27	5.99	6.13	.2	2	16	-99.99	-99.99	-99.99	-99.9	-99
17	7.12	6.31	6.56	.3	6	17	7.50	5.05	6.78	.6	12
18	7.62	5.63	6.46	.6	8	18	-99.99	-99.99	-99.99	-99.9	-99
19	6.37	6.04	6.20	.2	2	19	-99.99	-99.99	-99.99	-99.9	-99
20	7.08	2.27	5.85	1.3	23	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	7.11	6.27	6.80	.4	4	22	6.35	6.04	6.19	.2	2
23	6.91	6.55	6.65	.1	6	23	6.48	5.70	6.23	.4	4
24	7.26	6.46	6.79	.3	10	24	7.48	7.13	7.33	.1	6
25	7.36	6.68	7.05	.3	4	25	-99.99	-99.99	-99.99	-99.9	-99
26	7.51	7.47	7.50	.0	3	26	6.56	6.23	6.39	.2	2
27	7.59	6.52	7.40	.2	21	27	7.33	7.23	7.27	.1	3
28	7.24	6.56	6.93	.3	4	28	-99.99	-99.99	-99.99	-99.9	-99
29	7.53	6.57	7.12	.3	25	29	6.84	6.62	6.73	.2	2
30	6.32	6.32	6.32	.0	1	30	6.98	4.31	6.07	.7	11
31	7.71	6.26	6.92	.5	15	31	7.45	6.88	7.22	.2	17
32	7.63	6.64	7.02	.3	16	32	-99.99	-99.99	-99.99	-99.9	-99
33	7.33	6.77	7.06	.2	21	33	7.08	6.95	7.01	.1	2
34	7.43	6.51	7.22	.3	7	34	-99.99	-99.99	-99.99	-99.9	-99
35	7.24	6.56	6.95	.3	3	35	-99.99	-99.99	-99.99	-99.9	-99
36	7.16	6.39	6.68	.3	6	36	-99.99	-99.99	-99.99	-99.9	-99
37	7.53	6.89	7.17	.1	37	37	-99.99	-99.99	-99.99	-99.9	-99
38	6.72	5.73	6.25	.4	8	38	6.84	5.82	6.33	.7	2
39	6.46	6.12	6.29	.2	2	39	6.50	6.35	6.42	.1	2
40	6.72	6.22	6.48	.2	4	40	7.81	6.19	7.01	.6	12
41	6.76	6.48	6.59	.1	6	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 8d

OXYGEN (ML/L) 1958 - 1974 50.1 - 100.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	7.10	3.61	6.15	.8	23
18	6.73	4.91	5.82	1.3	2
19	6.79	3.72	5.25	2.2	2
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	7.09	6.98	7.05	.1	3
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	7.31	5.99	6.97	.5	9
28	7.10	7.02	7.06	.1	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	7.24	6.85	7.03	.2	10
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	7.05	6.43	6.87	.3	4
35	7.10	6.21	6.87	.4	5
36	6.99	4.50	6.60	.9	7
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	6.62	6.38	6.50	.1	6
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	7.42	5.57	6.68	.4	57
18	-99.99	-99.99	-99.99	-99.9	-99
19	6.47	6.47	6.47	.0	1
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	7.61	3.95	6.52	1.2	15
23	7.78	6.59	7.35	.4	9
24	7.18	7.16	7.17	.0	2
25	7.43	6.13	7.11	.6	5
26	7.52	6.81	7.28	.4	3
27	7.19	7.19	7.19	.0	2
28	7.19	7.16	7.18	.0	3
29	7.47	7.24	7.34	.1	4
30	7.00	6.88	6.94	.1	2
31	-99.99	-99.99	-99.99	-99.9	-99
32	7.18	7.02	7.10	.1	4
33	7.44	7.44	7.44	.0	1
34	7.10	6.77	6.99	.1	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	6.90	6.83	6.87	.0	2
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	6.73	6.68	6.70	.0	2
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	5.93	4.92	5.52	.5	3
17	6.65	4.44	5.86	1.0	6
18	6.81	5.39	6.30	.5	8
19	-99.99	-99.99	-99.99	-99.9	-99
20	6.93	3.21	5.42	1.5	15
21	-99.99	-99.99	-99.99	-99.9	-99
22	6.33	4.90	5.63	.8	4
23	6.12	5.88	6.00	.2	2
24	6.60	5.32	6.13	.4	7
25	7.25	4.67	6.54	1.1	5
26	7.48	7.15	7.36	.2	3
27	7.51	3.40	6.70	1.4	20
28	-99.99	-99.99	-99.99	-99.9	-99
29	7.75	5.60	6.99	.4	28
30	6.89	6.89	6.89	.0	1
31	7.46	2.30	6.56	1.2	17
32	7.12	6.33	6.79	.3	8
33	7.33	4.70	6.73	.6	22
34	7.42	6.83	7.25	.2	6
35	6.05	4.01	5.14	1.0	5
36	6.89	6.69	6.77	.1	4
37	7.25	5.81	6.90	.3	30
38	6.44	5.50	5.98	.3	7
39	-99.99	-99.99	-99.99	-99.9	-99
40	7.21	6.13	6.55	.4	5
41	6.59	6.40	6.49	.1	4
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	7.97	4.30	6.79	1.2	10
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	5.36	4.96	5.16	.3	2
23	6.82	4.29	5.70	1.1	4
24	7.27	6.13	6.91	.5	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	6.62	5.55	6.09	.8	2
27	7.20	6.94	7.07	.2	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	7.20	7.17	7.18	.0	2
30	6.92	5.35	6.29	.7	7
31	7.32	6.08	7.01	.3	16
32	-99.99	-99.99	-99.99	-99.9	-99
33	7.25	7.09	7.19	.1	4
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	6.78	6.55	6.66	.2	2
39	6.49	6.39	6.44	.1	2
40	7.00	6.21	6.41	.2	19
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 8e

OXYGEN (ML/L) 1958 - 1974 100.1 - 150.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	6.63	3.54	5.73	1.0	10
18	3.94	2.85	3.39	.8	2
19	3.65	3.65	3.65	.0	1
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	6.83	4.51	5.67	1.6	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	5.25	1.36	3.19	1.5	6
28	4.34	1.84	3.09	1.8	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	6.88	5.40	6.22	.5	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	5.26	4.39	4.82	.6	2
35	6.15	3.23	4.22	1.3	4
36	3.92	3.46	3.72	.2	4
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	6.57	5.80	6.05	.3	5
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	6.97	6.00	6.50	.3	19
18	-99.99	-99.99	-99.99	-99.9	-99
19	5.23	4.78	5.00	.3	2
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	6.74	2.32	4.38	1.3	10
23	5.75	2.18	4.38	1.3	6
24	7.15	6.58	6.87	.4	2
25	4.97	2.40	3.67	1.1	4
26	3.33	2.06	2.69	.9	2
27	7.22	7.19	7.20	.0	2
28	5.10	2.38	3.74	1.9	2
29	6.86	2.90	5.09	1.8	4
30	6.10	6.03	6.06	.0	2
31	-99.99	-99.99	-99.99	-99.9	-99
32	6.99	4.95	5.97	1.4	2
33	5.65	5.65	5.65	.0	1
34	6.93	.45	4.08	2.7	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	5.25	5.25	5.25	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	6.00	6.00	6.00	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	6.25	4.12	5.40	.8	6
18	6.66	5.04	5.98	.6	5
19	-99.99	-99.99	-99.99	-99.9	-99
20	5.73	2.72	3.92	1.0	10
21	-99.99	-99.99	-99.99	-99.9	-99
22	3.87	3.12	3.50	.5	2
23	5.81	4.73	5.27	.8	2
24	5.12	.68	3.16	1.4	8
25	5.51	2.92	4.03	1.3	3
26	1.50	.99	1.24	.4	2
27	5.33	1.58	2.57	1.0	13
28	-99.99	-99.99	-99.99	-99.9	-99
29	7.31	1.53	5.04	2.1	21
30	6.61	6.61	6.61	.0	1
31	7.32	2.09	5.67	2.0	9
32	7.02	4.87	5.84	.9	7
33	7.20	4.01	5.16	1.1	13
34	7.00	1.91	4.00	2.2	4
35	3.45	2.73	3.02	.3	4
36	-99.99	-99.99	-99.99	-99.9	-99
37	6.28	4.16	5.27	.6	18
38	6.39	5.53	6.02	.4	5
39	5.86	5.86	5.86	.0	1
40	6.53	5.90	6.25	.3	4
41	5.58	5.52	5.55	.0	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	6.51	6.51	6.51	.0	1
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	2.79	2.79	2.79	.0	1
23	4.42	3.89	4.15	.4	2
24	5.95	.91	3.34	2.1	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	3.70	3.70	3.70	.0	1
27	5.17	2.63	3.90	1.8	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	7.11	7.11	7.11	.0	1
30	6.85	3.86	6.00	1.2	5
31	7.16	3.59	5.47	1.1	12
32	-99.99	-99.99	-99.99	-99.9	-99
33	7.25	5.48	6.66	.8	4
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	6.53	6.53	6.53	.0	1
39	6.46	6.46	6.46	.0	1
40	6.45	5.68	6.14	.2	15
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 8f

OXYGEN (ML/L) 1958 - 1974 150.1 - *99.0 METERS

WINTER						SPRING					
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	6.03	5.12	5.65	.3	7	17	6.84	5.31	6.24	.4	23
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	4.34	.35	1.61	1.5	10
20	-99.99	-99.99	-99.99	-99.9	-99	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	3.24	1.30	2.42	.9	5
23	-99.99	-99.99	-99.99	-99.9	-99	23	2.90	1.05	2.27	1.1	3
24	-99.99	-99.99	-99.99	-99.9	-99	24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99	25	2.18	1.71	1.95	.3	2
26	-99.99	-99.99	-99.99	-99.9	-99	26	1.53	1.53	1.53	.0	1
27	1.62	.32	.57	.3	17	27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	5.33	.57	1.73	1.5	16
30	-99.99	-99.99	-99.99	-99.9	-99	30	5.34	.79	2.75	1.7	8
31	5.94	.49	2.22	1.5	26	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	4.34	.48	1.15	1.0	16
33	-99.99	-99.99	-99.99	-99.9	-99	33	3.80	3.80	3.80	.0	1
34	-99.99	-99.99	-99.99	-99.9	-99	34	3.25	.46	1.12	1.0	8
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	3.30	.39	1.06	.9	11
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	5.82	.66	3.51	1.9	17	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	5.12	.43	2.16	1.7	8
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER						AUTUMN					
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	5.86	2.33	3.33	1.5	5	17	6.31	5.30	5.93	.5	3
18	3.02	1.13	2.10	.8	4	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	4.20	2.16	3.20	1.0	4	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	2.25	.59	1.05	.5	15	22	1.58	1.58	1.58	.0	1
23	3.73	3.09	3.41	.5	2	23	2.83	2.72	2.77	.1	2
24	2.26	.36	.68	.5	21	24	1.99	.51	1.25	1.0	2
25	3.04	.47	.89	.6	20	25	-99.99	-99.99	-99.99	-99.9	-99
26	.67	.67	.67	.0	1	26	2.03	2.03	2.03	.0	1
27	1.91	.76	1.19	.3	9	27	1.23	1.23	1.23	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	6.26	.43	1.49	1.3	106	29	6.52	6.52	6.52	.0	1
30	5.14	.73	2.40	1.6	6	30	6.68	.73	2.32	1.6	26
31	6.04	.22	2.32	1.7	54	31	5.13	1.79	3.28	1.6	6
32	5.12	.60	2.70	1.7	9	32	-99.99	-99.99	-99.99	-99.9	-99
33	13.30	2.22	4.51	3.9	7	33	5.88	3.49	4.59	1.0	4
34	1.97	1.02	1.49	.7	2	34	-99.99	-99.99	-99.99	-99.9	-99
35	2.60	.44	1.30	.7	10	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	4.03	3.28	3.72	.3	9	37	-99.99	-99.99	-99.99	-99.9	-99
38	5.99	.79	3.13	1.7	31	38	6.38	6.38	6.38	.0	1
39	5.76	.85	2.99	1.8	6	39	6.33	6.33	6.33	.0	1
40	6.08	.69	2.99	1.7	21	40	6.21	2.34	4.60	1.0	27
41	5.34	5.31	5.32	.0	2	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 9a

PHAEOPIGMENTS (MG/M**3) 1958 - 1974 .0 - 10.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	.22	.00	.04	.1	27	17	1.58	.00	.15	.3	85
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99	24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99	26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99	27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	.09	.01	.06	.0	9	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.05	.00	.03	.0	6	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

	SUMMER						AUTUMN				
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	4.49	.00	.61	1.0	53	17	2.08	.00	.39	.4	32
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	.00	.00	.00	.0	1	22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99	24	.30	.00	.08	.1	4
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99	26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99	27	.71	.00	.36	.5	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99	31	.24	.00	.06	.1	10
32	.20	.00	.08	.1	6	32	-99.99	-99.99	-99.99	-99.9	-99
33	.39	.00	.10	.1	11	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	.04	.00	.02	.0	12	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	.00	.00	.00	.0	2
41	.14	.00	.05	.1	5	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 9b

PHAEOPIGMENTS (MG/M**3) 1958 - 1974 10.1 - 25.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.07	.00	.02	.0	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.07	.03	.05	.0	3
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.03	.01	.02	.0	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.25	.00	.04	.1	41
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	1.50	.08	.36	.4	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	.25	.04	.12	.1	5
33	.12	.00	.04	.1	7
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	.05	.00	.02	.0	8
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.27	.00	.09	.1	5
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.48	.00	.17	.1	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.64	.00	.23	.3	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.10	.00	.05	.1	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.10	.00	.03	.0	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 9c

PHAEOPIGMENTS (MG/M**3) 1958 - 1974 25.1 - 50.0 METERS

WINTER					
ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.15	.00	.02	.0	11
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.15	.06	.10	.0	5
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.08	.00	.05	.0	6
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING					
ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.12	.00	.02	.0	20
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER					
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.06	.01	.03	.0	3
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	.11	.11	.11	.0	1
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	.00	.00	.00	.0	5
33	.14	.00	.04	.0	16
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	.16	.02	.08	.0	26
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.07	.00	.02	.0	6
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN					
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.40	.00	.11	.1	11
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.47	.00	.09	.2	6
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.19	.00	.04	.1	16
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.27	.07	.14	.1	3
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 9d

PHAEOPIGMENTS (MG/M**3) 1958 - 1974 50.1 - 100.0 METERS

WINTER / SPRING

ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	.08	.00	.04	.1	2	17	.12	.00	.08	.1	3
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99	24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99	26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99	27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	.09	.05	.07	.0	6	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.07	.01	.04	.0	6	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER / AUTUMN

ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	.02	.00	.01	.0	2
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99	24	.12	.00	.04	.1	4
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99	26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99	27	.00	.00	.00	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99	31	.25	.00	.05	.1	14
32	.08	.00	.02	.0	4	32	-99.99	-99.99	-99.99	-99.9	-99
33	.08	.00	.01	.0	13	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	.18	.04	.10	.0	31	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	.02	.00	.01	.0	3
41	.00	.00	.00	.0	4	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 9e

PHAEOPIGMENTS (MG/M**3) 1958 - 1974 100.1 - 150.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.04	.03	.03	.0	2
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.03	.03	.03	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	.00	.00	.00	.0	2
33	.00	.00	.00	.0	8
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	.06	.03	.05	.0	5
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.00	.00	.00	.0	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.05	.05	.05	.0	1
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.00	.00	.00	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.00	.00	.00	.0	10
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 9f

PHAEOPIGMENTS (MG/M**3) 1958 - 1974 150.1 - *99.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.02	.02	.02	.0	2
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.03	.03	.03	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	.08	.00	.04	.1	2
33	.02	.00	.01	.0	4
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	.02	.02	.02	.0	2
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.00	.00	.00	.0	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.04	.00	.02	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.05	.00	.01	.0	5
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 10

TOTAL PHAEOPIGMENTS (MG/M**2) 1958 - 1974

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	2.20	.00	.99	.8	11
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	5.30	.00	1.55	1.6	28
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	18.60	15.90	17.25	1.9	2

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	26.90	.10	7.60	8.8	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	3.90	.70	2.30	2.3	2
33	5.10	.00	1.27	2.5	4
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	1.70	.90	1.30	.6	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	20.60	2.70	7.81	5.7	12
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	12.50	.00	6.25	8.8	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	1.40	1.40	1.40	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	3.10	.00	.96	1.4	5
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	2.20	2.20	2.20	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 11a

NITRITE (NO2) (MICROGRAM-AT/L) 1958 - 1974 .0 - 10.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	.20	.00	.08	.0	53	17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	.10	.10	.10	.0	1
20	.20	.20	.20	.0	3	20	.30	.00	.15	.1	16
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	.10	.10	.10	.0	1	24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99	26	-99.99	-99.99	-99.99	-99.9	-99
27	.20	.10	.13	.1	3	27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	.20	.10	.17	.1	4
30	-99.99	-99.99	-99.99	-99.9	-99	30	.10	.10	.10	.0	2
31	.30	.20	.28	.0	6	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	.20	.10	.15	.1	2
33	-99.99	-99.99	-99.99	-99.9	-99	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	.10	.10	.10	.0	1
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	.10	.10	.10	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.20	.20	.20	.0	4	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	.10	.10	.10	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

	SUMMER						AUTUMN				
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	.10	.10	.10	.0	2	16	-99.99	-99.99	-99.99	-99.9	-99
17	.10	.00	.04	.1	50	17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	.60	.00	.12	.1	77	20	.30	.00	.10	.1	6
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	.30	.30	.30	.0	2	22	-99.99	-99.99	-99.99	-99.9	-99
23	.30	.20	.25	.1	2	23	-99.99	-99.99	-99.99	-99.9	-99
24	.10	.10	.10	.0	2	24	.00	.00	.00	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99	26	-99.99	-99.99	-99.99	-99.9	-99
27	.20	.10	.15	.1	4	27	.00	.00	.00	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	.10	.10	.10	.0	8	31	2.00	.00	.21	.5	13
32	.00	.00	.00	.0	6	32	-99.99	-99.99	-99.99	-99.9	-99
33	.10	.00	.08	.0	11	33	.10	.10	.10	.0	2
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	.30	.30	.30	.0	2	36	-99.99	-99.99	-99.99	-99.9	-99
37	.00	.00	.00	.0	2	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	2	40	.00	.00	.00	.0	13
41	.00	.00	.00	.0	5	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 11b

NITRITE (NO2) (MICROGRAM-AT/L) 1958 - 1974 10.1 - 25.0 METERS

WINTER						SPRING					
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	.20	.00	.07	.1	23	17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	.10	.10	.10	.0	1
20	.20	.20	.20	.0	1	20	.40	.00	.20	.1	5
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	.10	.10	.10	.0	1	24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99	26	-99.99	-99.99	-99.99	-99.9	-99
27	.20	.20	.20	.0	1	27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	.20	.10	.15	.1	2
30	-99.99	-99.99	-99.99	-99.9	-99	30	.10	.10	.10	.0	1
31	.30	.20	.25	.1	2	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	.20	.20	.20	.0	2
33	-99.99	-99.99	-99.99	-99.9	-99	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	.10	.10	.10	.0	1
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	.10	.10	.10	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.20	.20	.20	.0	1	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	.10	.10	.10	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER						AUTUMN					
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	.00	.00	.00	.0	1	16	-99.99	-99.99	-99.99	-99.9	-99
17	.10	.00	.03	.0	12	17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	.50	.10	.22	.1	29	20	.40	.20	.30	.1	2
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	.10	.10	.10	.0	1	24	.10	.00	.03	.1	4
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99	26	-99.99	-99.99	-99.99	-99.9	-99
27	.10	.10	.10	.0	1	27	.00	.00	.00	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	.10	.00	.07	.1	4	31	.10	.00	.04	.1	8
32	.00	.00	.00	.0	5	32	-99.99	-99.99	-99.99	-99.9	-99
33	.10	.00	.09	.0	7	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	1	40	.00	.00	.00	.0	7
41	.00	.00	.00	.0	5	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 11c

NITRITE (NO2) (MICROGRAM-AT/L) 1958 - 1974 25.1 - 50.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.20	.00	.07	.1	32
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.10	.10	.10	.0	2
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.10	.10	.10	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.20	.10	.15	.1	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.30	.20	.27	.1	3
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.30	.20	.25	.1	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	.10	.10	.10	.0	1
20	.40	.00	.15	.2	6
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.20	.10	.17	.1	4
30	.10	.10	.10	.0	2
31	-99.99	-99.99	-99.99	-99.9	-99
32	.20	.10	.17	.1	3
33	-99.99	-99.99	-99.99	-99.9	-99
34	.10	.10	.10	.0	1
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	.10	.10	.10	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.10	.10	.10	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	.40	.30	.35	.1	2
17	.20	.10	.13	.1	3
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.80	.00	.24	.2	23
21	-99.99	-99.99	-99.99	-99.9	-99
22	.30	.00	.15	.2	2
23	.50	.50	.50	.0	1
24	.20	.20	.20	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.30	.30	.30	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.20	.10	.13	.0	4
32	.10	.00	.06	.1	5
33	.10	.00	.09	.0	15
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	.20	.20	.20	.0	1
37	.20	.20	.20	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.00	.00	.00	.0	6
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.30	.00	.15	.1	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.80	.00	.30	.3	6
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.50	.00	.20	.3	3
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.80	.00	.21	.2	17
32	-99.99	-99.99	-99.99	-99.9	-99
33	.10	.10	.10	.0	2
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.20	.00	.05	.1	11
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 11d

NITRITE (NO2) (MICROGRAM-AT/L) 1958 - 1974 50.1 - 100.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.10	.00	.04	.0	21
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.10	.10	.10	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.10	.00	.05	.1	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.20	.10	.13	.1	6
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.30	.20	.27	.0	10
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.20	.20	.20	.0	6
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	.20	.20	.20	.0	1
20	.10	.00	.05	.1	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.20	.20	.20	.0	4
30	.10	.10	.10	.0	2
31	-99.99	-99.99	-99.99	-99.9	-99
32	.20	.10	.17	.1	4
33	-99.99	-99.99	-99.99	-99.9	-99
34	.20	.20	.20	.0	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	.20	.20	.20	.0	2
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.20	.10	.15	.1	2
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	.30	.00	.13	.2	3
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.10	.10	.10	.0	2
21	-99.99	-99.99	-99.99	-99.9	-99
22	.50	.50	.50	.0	1
23	.20	.20	.20	.0	1
24	.00	.00	.00	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.60	.00	.20	.3	3
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	1.10	.00	.58	.5	5
32	.40	.00	.25	.2	4
33	.70	.00	.25	.3	15
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	.20	.20	.20	.0	1
37	.20	.20	.20	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.20	.00	.10	.1	2
41	.50	.00	.17	.2	4
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.00	.00	.00	.0	2
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.00	.00	.00	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	1.30	.00	.19	.4	16
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	1.00	.00	.21	.3	17
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 11e

NITRITE (NO2) (MICROGRAM-AT/L) 1958 - 1974 100.1 - 150.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.10	.00	.05	.1	6
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	4
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.10	.00	.04	.1	5
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.20	.00	.08	.1	5
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	.00	.00	.00	.0	2
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.10	.00	.05	.1	4
30	.00	.00	.00	.0	2
31	-99.99	-99.99	-99.99	-99.9	-99
32	.20	.00	.10	.1	2
33	-99.99	-99.99	-99.99	-99.9	-99
34	.00	.00	.00	.0	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	.00	.00	.00	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.00	.00	.00	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	.10	.10	.10	.0	1
23	.40	.40	.40	.0	1
24	.00	.00	.00	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.10	.00	.05	.1	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.00	.00	.00	.0	7
32	.00	.00	.00	.0	2
33	.00	.00	.00	.0	8
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	.20	.20	.20	.0	1
37	.20	.20	.20	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	2
41	.00	.00	.00	.0	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.00	.00	.00	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.00	.00	.00	.0	12
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.10	.00	.02	.0	13
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 11f

NITRITE (NO2) (MICROGRAM-AT/L) 1958 - 1974 150.1 - *99.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.00	.00	.00	.0	7
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	9
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.00	.00	.00	.0	14
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	8
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	.00	.00	.00	.0	10
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.00	.00	.00	.0	16
30	.00	.00	.00	.0	8
31	-99.99	-99.99	-99.99	-99.9	-99
32	.00	.00	.00	.0	16
33	-99.99	-99.99	-99.99	-99.9	-99
34	.00	.00	.00	.0	8
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	.00	.00	.00	.0	11
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.00	.00	.00	.0	8
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	3
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.00	.00	.00	.0	16
32	.00	.00	.00	.0	2
33	.00	.00	.00	.0	4
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	2
41	.00	.00	.00	.0	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.00	.00	.00	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.00	.00	.00	.0	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.10	.00	.00	.0	22
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 12a

AMMONIA (MICROGRAM-AT/L) 1958 - 1974 .0 - 10.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	.50	.00	.24	.1	17	17	40.00	.00	1.02	4.2	89
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	.50	.30	.40	.1	2	20	2.20	.00	.62	.6	12
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	1.20	.40	.73	.3	9
23	-99.99	-99.99	-99.99	-99.9	-99	23	.50	.30	.43	.1	6
24	-99.99	-99.99	-99.99	-99.9	-99	24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99	25	.80	.60	.68	.1	5
26	-99.99	-99.99	-99.99	-99.9	-99	26	.50	.50	.50	.0	2
27	-99.99	-99.99	-99.99	-99.9	-99	27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	.70	.00	.35	.3	4
30	-99.99	-99.99	-99.99	-99.9	-99	30	.20	.10	.15	.1	2
31	-99.99	-99.99	-99.99	-99.9	-99	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

	SUMMER						AUTUMN				
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	2.90	.70	1.35	.5	40	17	1.00	.00	.39	.3	33
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	3.50	.00	.56	.8	22	20	1.60	.70	1.07	.5	3
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99	24	.40	.20	.35	.1	4
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	.60	.40	.50	.1	2	26	-99.99	-99.99	-99.99	-99.9	-99
27	.80	.30	.50	.2	12	27	.20	.10	.15	.1	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	.30	.30	.30	.0	2	31	1.80	.10	.35	.5	11
32	.40	.00	.14	.2	8	32	-99.99	-99.99	-99.99	-99.9	-99
33	.30	.00	.15	.1	15	33	-99.99	-99.99	-99.99	-99.9	-99
34	.50	.20	.35	.2	4	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	1.10	.20	.48	.2	19	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	.10	.00	.03	.1	3
41	.10	.00	.02	.0	5	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 12b

AMMONIA (MICROGRAM-AT/L) 1958 - 1974 10.1 - 25.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	.60	.10	.26	.2	7	17	2.30	.00	.77	.6	39
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99	20	.50	.00	.30	.2	4
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	1.00	.40	.77	.2	6
23	-99.99	-99.99	-99.99	-99.9	-99	23	.50	.40	.42	.0	5
24	-99.99	-99.99	-99.99	-99.9	-99	24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99	25	.90	.60	.72	.1	4
26	-99.99	-99.99	-99.99	-99.9	-99	26	.60	.60	.60	.0	1
27	-99.99	-99.99	-99.99	-99.9	-99	27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	.10	.00	.05	.1	2
30	-99.99	-99.99	-99.99	-99.9	-99	30	.20	.20	.20	.0	1
31	-99.99	-99.99	-99.99	-99.9	-99	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

	SUMMER						AUTUMN				
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	4.20	.60	1.48	.9	12	17	1.00	.20	.45	.2	17
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	3.20	.00	.97	1.1	11	20	.70	.70	.70	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99	24	.40	.10	.27	.2	4
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	.60	.50	.55	.1	2	26	-99.99	-99.99	-99.99	-99.9	-99
27	.60	.30	.41	.1	9	27	.20	.20	.20	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	.30	.30	.30	.0	1	31	.20	.10	.11	.0	7
32	.30	.00	.14	.1	7	32	-99.99	-99.99	-99.99	-99.9	-99
33	.50	.10	.21	.1	9	33	-99.99	-99.99	-99.99	-99.9	-99
34	.30	.20	.27	.1	3	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	.60	.20	.35	.2	12	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	.20	.00	.10	.1	2
41	[illegible]	.00	.06	.1	5	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 12c

AMMONIA (MICROGRAM-AT/L) 1958 - 1974 25.1 - 50.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.40	.10	.21	.1	9
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.10	.10	.10	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	2.20	.20	.99	.8	17
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.60	.00	.12	.2	8
21	-99.99	-99.99	-99.99	-99.9	-99
22	2.00	.40	1.07	.4	12
23	1.00	.30	.60	.3	9
24	-99.99	-99.99	-99.99	-99.9	-99
25	1.60	.70	1.03	.3	6
26	.40	.40	.40	.0	3
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.20	.10	.15	.1	4
30	.20	.10	.15	.1	2
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	5.30	1.30	2.87	2.1	3
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	3.30	.10	1.39	1.3	19
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	.50	.40	.47	.1	3
27	.70	.20	.43	.1	18
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.30	.20	.23	.1	3
32	.40	.10	.32	.1	8
33	.60	.20	.35	.1	21
34	.40	.20	.26	.1	5
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	1.10	.10	.46	.2	28
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.30	.00	.15	.1	6
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	1.10	.00	.31	.3	15
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.70	.10	.40	.4	2
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	1.10	.10	.67	.4	6
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.60	.00	.40	.3	3
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	1.00	.10	.51	.2	14
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	1.20	.00	.27	.4	7
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 12d

AMMONIA (MICROGRAM-AT/L) 1958 - 1974 50.1 - 100.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.30	.10	.20	.1	2
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	2.80	.00	1.26	1.2	5
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.00	.00	.00	.0	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	2.60	.40	1.21	.7	12
23	1.00	.00	.52	.4	9
24	-99.99	-99.99	-99.99	-99.9	-99
25	1.60	.10	.83	.6	6
26	.60	.30	.47	.2	3
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.50	.20	.37	.2	4
30	.40	.20	.30	.1	2
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	2.00	.10	.58	.6	17
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	.90	.30	.50	.3	3
27	1.30	.10	.47	.3	18
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.30	.20	.27	.1	3
32	.70	.10	.37	.2	7
33	.90	.30	.37	.3	21
34	.50	.20	.37	.1	6
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	.70	.10	.42	.2	27
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.40	.00	.15	.2	4
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.50	.10	.27	.2	4
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.00	.00	.00	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.10	.00	.03	.1	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.20	.00	.06	.1	13
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	1.00	.00	.36	.3	7
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 12e

AMMONIA (MICROGRAM-AT/L) 1958 - 1974 100.1 - 150.0 METERS

WINTER					
ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING					
ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.00	.00	.00	.0	1
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	1.30	.10	.74	.5	8
23	.30	.00	.12	.1	6
24	-99.99	-99.99	-99.99	-99.9	-99
25	.40	.10	.25	.2	4
26	.20	.20	.20	.0	2
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.20	.00	.10	.1	4
30	.20	.00	.10	.1	2
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER					
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.20	.10	.12	.0	10
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	.40	.30	.35	.1	2
27	1.20	.10	.36	.4	12
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	.30	.10	.17	.1	4
33	.30	.00	.12	.1	12
34	.30	.10	.20	.1	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	.20	.00	.11	.0	18
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.10	.00	.05	.1	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN					
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.30	.20	.25	.1	2
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.00	.00	.00	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.10	.00	.05	.1	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.10	.00	.03	.0	10
32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.20	.00	.07	.1	3
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 12f

AMMONIA (MICROGRAM-AT/L) 1958 - 1974 150.1 - *99.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	.00	.00	.00	.0	1
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	1.20	.10	.65	.6	4
23	-99.99	-99.99	-99.99	-99.9	-99	23	.10	.00	.03	.1	3
24	-99.99	-99.99	-99.99	-99.9	-99	24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99	25	.20	.10	.15	.1	2
26	-99.99	-99.99	-99.99	-99.9	-99	26	.20	.20	.20	.0	1
27	-99.99	-99.99	-99.99	-99.9	-99	27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	.20	.00	.10	.0	16
30	-99.99	-99.99	-99.99	-99.9	-99	30	.10	.00	.07	.0	8
31	-99.99	-99.99	-99.99	-99.9	-99	31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99	32	-99.99	-99.99	-99.99	-99.9	-99
33	-99.99	-99.99	-99.99	-99.9	-99	33	-99.99	-99.99	-99.99	-99.9	-99
34	-99.99	-99.99	-99.99	-99.9	-99	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

	SUMMER						AUTUMN				
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	2.70	.10	.75	1.3	4	20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99	23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99	24	.00	.00	.00	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99	25	-99.99	-99.99	-99.99	-99.9	-99
26	.20	.20	.20	.0	1	26	-99.99	-99.99	-99.99	-99.9	-99
27	1.10	.10	.35	.4	6	27	.10	.10	.10	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99	29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99	31	.10	.00	.02	.0	5
32	.20	.00	.07	.1	3	32	-99.99	-99.99	-99.99	-99.9	-99
33	.30	.00	.07	.1	6	33	-99.99	-99.99	-99.99	-99.9	-99
34	.30	.10	.20	.1	2	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	-99.99	-99.99	-99.99	-99.9	-99
37	.20	.10	.13	.1	9	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	.20	.10	.15	.1	2
41	.10	.10	.10	.0	1	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 13

DEPTH OF MIXED LAYER (METERS) 1958 - 1974

WINTER						SPRING					
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	27.00	27.00	27.00	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	100.00	75.00	87.50	17.7	2	17	-99.99	-99.99	-99.99	-99.9	-99
18	75.00	75.00	75.00	.0	1	18	-99.99	-99.99	-99.99	-99.9	-99
19	85.00	38.00	65.67	13.0	9	19	99.00	9.00	47.67	30.8	18
20	145.00	11.00	72.40	33.0	10	20	116.00	5.00	32.75	28.5	24
21	60.00	22.00	41.00	26.9	2	21	-99.99	-99.99	-99.99	-99.9	-99
22	107.00	68.00	84.75	16.3	4	22	107.00	10.00	52.00	30.1	29
23	110.00	28.00	78.25	33.9	8	23	116.00	12.00	66.86	29.8	21
24	125.00	76.00	99.40	19.7	5	24	150.00	15.00	74.50	41.3	8
25	-99.99	-99.99	-99.99	-99.9	-99	25	143.00	38.00	63.00	39.5	6
26	105.00	11.00	72.00	52.9	3	26	70.00	50.00	60.00	14.1	2
27	165.00	79.00	101.00	22.6	11	27	150.00	12.00	77.72	33.2	18
28	117.00	9.00	77.83	37.6	6	28	146.00	6.00	71.42	47.2	12
29	122.00	106.00	116.67	9.2	3	29	162.00	15.00	104.03	34.7	35
30	159.00	107.00	130.90	13.6	20	30	137.00	9.00	80.09	41.0	34
31	113.00	70.00	97.14	14.1	7	31	150.00	6.00	81.28	34.9	32
32	119.00	75.00	96.50	24.3	4	32	146.00	6.00	81.15	32.5	27
33	110.00	69.05	85.78	7.77	92	33	93.97	29.24	69.41	20.83	94
34	137.00	67.00	96.67	22.7	9	34	134.00	15.00	75.06	32.0	17
35	100.00	85.00	92.50	8.7	4	35	-99.99	-99.99	-99.99	-99.9	-99
36	113.00	53.00	87.33	15.4	12	36	114.00	15.00	69.53	25.1	19
37	125.00	69.00	99.83	19.7	6	37	140.00	6.00	75.69	40.2	26
38	116.00	116.00	116.00	.0	1	38	150.00	150.00	150.00	.0	1
39	114.00	114.00	114.00	.0	1	39	-99.99	-99.99	-99.99	-99.9	-99
40	122.00	110.00	115.50	5.0	4	40	98.00	98.00	98.00	.0	1
41	72.00	72.00	72.00	.0	1	41	122.00	100.00	111.40	8.3	5
42	115.00	40.00	80.29	27.3	7	42	122.00	24.00	81.56	31.8	9

SUMMER						AUTUMN					
15	50.00	30.00	37.00	11.3	3	15	-99.99	-99.99	-99.99	-99.9	-99
16	45.00	15.00	28.33	15.3	3	16	-99.99	-99.99	-99.99	-99.9	-99
17	28.00	10.00	17.00	8.7	4	17	-99.99	-99.99	-99.99	-99.9	-99
18	20.00	10.00	12.71	4.6	7	18	-99.99	-99.99	-99.99	-99.9	-99
19	38.00	15.00	24.71	9.4	7	19	70.00	5.00	47.50	29.6	4
20	76.00	1.00	14.33	15.8	36	20	66.00	5.00	20.14	26.3	7
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	95.00	2.00	25.65	26.0	37	22	33.00	6.00	22.42	7.9	26
23	47.00	10.00	24.80	13.7	10	23	30.00	30.00	30.00	.0	1
24	40.00	15.00	24.25	7.6	12	24	65.00	17.00	41.25	24.7	4
25	97.00	2.00	25.80	29.0	10	25	-99.99	-99.99	-99.99	-99.9	-99
26	75.00	20.00	47.50	38.9	2	26	-99.99	-99.99	-99.99	-99.9	-99
27	100.00	20.00	56.21	29.3	14	27	60.00	19.00	44.67	22.4	3
28	30.00	20.00	26.75	4.7	4	28	-99.99	-99.99	-99.99	-99.9	-99
29	143.00	10.00	48.08	32.9	61	29	50.00	5.00	23.43	11.3	14
30	104.00	6.00	51.30	40.8	10	30	65.00	30.00	38.43	13.8	7
31	72.00	6.00	30.11	15.9	28	31	23.00	20.00	20.50	1.2	6
32	61.00	15.00	27.62	13.2	16	32	80.00	80.00	80.00	.0	2
33	50.00	13.92	18.54	3.53	102	33	68.53	20.63	42.11	14.84	91
34	74.00	6.00	31.57	17.8	14	34	-99.99	-99.99	-99.99	-99.9	-99
35	10.00	10.00	10.00	.0	2	35	50.00	50.00	50.00	.0	1
36	61.00	6.00	26.83	16.8	12	36	-99.99	-99.99	-99.99	-99.9	-99
37	100.00	6.00	26.70	19.3	27	37	60.00	52.00	56.00	5.7	2
38	85.00	17.00	41.14	30.4	7	38	32.00	20.00	25.80	5.6	5
39	33.00	24.00	28.50	6.4	2	39	20.00	20.00	20.00	.0	1
40	46.00	20.00	29.29	8.4	7	40	28.00	15.00	21.30	3.3	10
41	15.00	15.00	15.00	.0	2	41	90.00	90.00	90.00	.0	1
42	26.00	15.00	20.50	7.8	2	42	62.00	62.00	62.00	.0	1

TABLE 14

LIGHT (LY/DAY) 1958 - 1974

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	517.00	517.00	517.00	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	248.00	39.00	109.25	96.8	4	19	470.00	173.00	353.00	158.2	3
20	339.00	16.00	150.00	152.9	4	20	475.00	79.00	247.42	145.0	12
21	68.00	68.00	68.00	.0	1	21	-99.99	-99.99	-99.99	-99.9	-99
22	131.00	131.00	131.00	.0	1	22	825.00	26.00	203.74	191.6	19
23	102.00	18.00	56.29	28.5	7	23	567.00	83.00	320.18	137.4	11
24	65.00	33.00	49.00	22.6	2	24	572.00	121.00	346.50	318.9	2
25	-99.99	-99.99	-99.99	-99.9	-99	25	297.00	136.00	201.67	84.5	3
26	62.00	40.00	51.00	15.6	2	26	-99.99	-99.99	-99.99	-99.9	-99
27	79.00	60.00	70.67	9.7	3	27	521.00	85.00	300.67	131.8	9
28	-99.99	-99.99	-99.99	-99.9	-99	28	409.00	134.00	243.33	145.9	3
29	143.00	143.00	143.00	.0	1	29	439.00	156.00	297.00	89.6	12
30	167.00	24.00	71.92	35.7	13	30	476.00	100.00	318.40	102.2	10
31	116.00	116.00	116.00	.0	1	31	590.00	68.00	299.58	169.7	12
32	192.00	88.00	140.00	73.5	2	32	620.00	225.00	386.62	116.8	8
33	279.00	13.00	98.25	54.8	119	33	750.00	65.00	313.39	144.3	175
34	229.00	44.00	123.33	80.1	6	34	482.00	185.00	354.00	139.9	4
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99	36	574.00	19.00	298.44	195.3	9
37	-99.99	-99.99	-99.99	-99.9	-99	37	440.00	121.00	274.87	122.9	8
38	184.00	184.00	184.00	.0	1	38	233.00	233.00	233.00	.0	1
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	258.00	258.00	258.00	.0	1	40	-99.99	-99.99	-99.99	-99.9	-99
41	187.00	187.00	187.00	.0	1	41	69.00	69.00	69.00	.0	1
42	142.00	67.00	105.00	37.5	3	42	214.00	214.00	214.00	.0	1

	SUMMER						AUTUMN				
15	501.00	501.00	501.00	.0	1	15	-99.99	-99.99	-99.99	-99.9	-99
16	228.00	140.00	184.00	62.2	2	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	494.00	225.00	380.67	139.4	3	19	130.00	17.00	90.67	63.8	3
20	681.00	137.00	373.14	187.0	7	20	196.00	128.00	162.00	48.1	2
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	350.00	54.00	164.43	71.1	30	22	268.00	42.00	130.57	55.5	21
23	108.00	50.00	81.33	29.3	3	23	-99.99	-99.99	-99.99	-99.9	-99
24	198.00	100.00	149.00	69.3	2	24	298.00	82.00	190.00	89.7	4
25	378.00	128.00	212.00	90.3	6	25	-99.99	-99.99	-99.99	-99.9	-99
26	461.00	215.00	324.67	125.1	3	26	-99.99	-99.99	-99.99	-99.9	-99
27	480.00	235.00	302.50	118.5	4	27	186.00	70.00	108.67	67.0	3
28	212.00	212.00	212.00	.0	1	28	-99.99	-99.99	-99.99	-99.9	-99
29	250.00	44.00	124.10	55.6	21	29	439.00	94.00	206.87	104.4	8
30	355.00	196.00	279.00	68.8	4	30	223.00	223.00	223.00	.0	1
31	573.00	147.00	310.17	166.3	6	31	250.00	222.00	236.00	19.8	2
32	468.00	240.00	384.00	75.3	7	32	125.00	38.00	81.50	61.5	2
33	746.00	64.00	347.56	129.7	171	33	448.00	4.00	163.32	100.2	208
34	512.00	271.00	405.20	99.2	5	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	26.00	26.00	26.00	.0	1
36	571.00	228.00	399.50	242.5	2	36	-99.99	-99.99	-99.99	-99.9	-99
37	731.00	127.00	436.50	264.3	6	37	60.00	14.00	37.00	32.5	2
38	159.00	159.00	159.00	.0	1	38	224.00	56.00	126.00	87.4	3
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	245.00	245.00	245.00	.0	1	40	330.00	330.00	330.00	.0	1
41	275.00	275.00	275.00	.0	2	41	125.00	125.00	125.00	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99	42	226.00	226.00	226.00	.0	1

Appendix B

The data for total chlorophyll-a (integrated chlorophyll-a), chlorophyll-a (discrete samples), carbon-14 (discrete productivity samples), and nitrate (discrete samples) were transformed, and range, mean, and standard deviation of the transformed data were computed. The results of the analysis are contained in these tables. The different variables were transformed as follows:

Chlorophyll-a (x): $\log_{10}(x+1)$

Total chlorophyll-a (x): $\log_{10}(x+1)$

Primary productivity (x): $\log_{10}(x+1)$

Nitrate (x): $\sqrt{x+1}$

Table 1. Chlorophyll a (mg/m^3)
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m
- e. 100.1-150 m
- f. > 150 m

Table 2. Total chlorophyll a (mg/m^2)

Table 3. Primary productivity ($mg/m^3/hr$)
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m

Table 4. Nitrate (μg m at/l)
- a. 0-10 m
- b. 10.1-25 m
- c. 25.1-50 m
- d. 50.1-100 m
- e. 100.1-150 m
- f. > 150 m

TABLE 1a

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 .0 - 10.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	.12	.12	.12	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99
17	.21	.00	.06	.1	31
18	.20	.19	.20	.0	2
19	.22	.11	.17	.0	10
20	.63	.07	.29	.1	25
21	.23	.23	.23	.0	1
22	.20	.14	.17	.0	6
23	.20	.05	.10	.0	22
24	.19	.09	.12	.0	11
25	-99.99	-99.99	-99.99	-99.9	-99
26	.16	.06	.10	.0	5
27	.22	.10	.14	.0	17
28	.24	.12	.16	.0	9
29	.14	.13	.14	.0	3
30	.15	.00	.07	.0	35
31	.31	.10	.14	.1	16
32	.15	.09	.12	.0	8
33	.37	.04	.11	.0	130
34	.19	.11	.14	.0	15
35	.16	.11	.14	.0	8
36	.24	.09	.14	.0	19
37	.13	.11	.12	.0	6
38	.15	.15	.15	.0	1
39	.13	.13	.13	.0	1
40	.14	.07	.11	.0	9
41	-99.99	-99.99	-99.99	-99.9	-99
42	.14	.08	.10	.0	9

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	.63	.63	.63	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99
17	1.15	.00	.38	.4	147
18	.51	.30	.38	.1	13
19	.77	.05	.28	.2	21
20	1.18	.06	.42	.3	54
21	-99.99	-99.99	-99.99	-99.9	-99
22	1.11	.07	.27	.2	57
23	1.13	.06	.29	.3	43
24	.79	.10	.26	.2	10
25	1.00	.12	.42	.4	12
26	.16	.08	.12	.0	7
27	.41	.07	.17	.1	32
28	.50	.05	.15	.1	16
29	.36	.04	.15	.1	52
30	.25	.02	.14	.1	50
31	.24	.02	.13	.1	42
32	.21	.06	.13	.0	32
33	.49	.00	.13	.1	224
34	.20	.06	.13	.0	26
35	.46	.09	.26	.2	12
36	.24	.05	.14	.0	32
37	.24	.08	.15	.0	32
38	.11	.11	.11	.0	1
39	-99.99	-99.99	-99.99	-99.9	-99
40	.18	.18	.18	.0	1
41	.14	.11	.13	.0	4
42	.17	.06	.13	.0	14

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	.86	.21	.56	.2	6
16	.48	.02	.30	.2	5
17	.45	.00	.12	.1	53
18	1.02	.38	.70	.5	2
19	.23	.08	.15	.1	9
20	1.40	.06	.56	.3	123
21	-99.99	-99.99	-99.99	-99.9	-99
22	.80	.00	.26	.2	93
23	.69	.02	.22	.2	39
24	.67	.03	.25	.2	18
25	.39	.00	.12	.1	20
26	.29	.12	.19	.1	5
27	.37	.05	.15	.1	25
28	.20	.05	.15	.1	8
29	.41	.04	.13	.1	82
30	.22	.08	.12	.0	17
31	.25	.06	.13	.0	43
32	.47	.05	.18	.1	22
33	.45	.01	.13	.1	233
34	.24	.05	.13	.0	22
35	.15	.15	.15	.0	1
36	1.58	.00	.16	.3	29
37	.23	.04	.13	.0	39
38	.41	.08	.17	.1	15
39	.17	.10	.13	.0	4
40	.31	.03	.15	.1	10
41	.22	.11	.17	.0	5
42	.30	.21	.26	.1	2

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.33	.00	.18	.1	32
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.46	.05	.27	.1	10
21	-99.99	-99.99	-99.99	-99.9	-99
22	.56	.04	.23	.1	52
23	.16	.01	.07	.0	16
24	.17	.11	.13	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.15	.15	.15	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	.15	.03	.09	.0	27
30	.35	.00	.09	.1	21
31	.19	.03	.13	.0	15
32	.19	.05	.10	.1	4
33	.40	.02	.13	.0	248
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	.09	.09	.09	.0	1
38	.10	.01	.05	.0	14
39	.06	.02	.03	.0	6
40	.29	.00	.05	.1	22
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 1b

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 10.1 - 25.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.18	.01	.07	.0	17
18	.14	.14	.14	.0	1
19	.14	.12	.13	.0	2
20	.27	.20	.24	.0	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	.10	.06	.08	.0	9
24	.21	.11	.18	.1	3
25	-99.99	-99.99	-99.99	-99.9	-99
26	.08	.07	.07	.0	4
27	.15	.12	.13	.0	2
28	.07	.07	.07	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99
30	.09	.05	.07	.0	32
31	.14	.09	.12	.0	3
32	-99.99	-99.99	-99.99	-99.9	-99
33	.14	.04	.10	.0	32
34	.14	.12	.13	.0	3
35	.18	.10	.15	.0	4
36	.18	.08	.13	.0	5
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.13	.06	.10	.0	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	1.18	.00	.28	.4	59
18	.34	.22	.30	.0	6
19	-99.99	-99.99	-99.99	-99.9	-99
20	.63	.21	.40	.2	7
21	-99.99	-99.99	-99.99	-99.9	-99
22	1.08	.12	.37	.3	16
23	.76	.09	.37	.3	9
24	.11	.11	.11	.0	1
25	.90	.11	.49	.4	8
26	.14	.10	.12	.0	3
27	.11	.10	.11	.0	2
28	.16	.16	.16	.0	1
29	.20	.05	.12	.0	11
30	.23	.03	.13	.1	8
31	.17	.10	.15	.0	3
32	.17	.17	.17	.0	2
33	.18	.05	.11	.0	52
34	.14	.14	.14	.0	1
35	.46	.14	.30	.1	8
36	-99.99	-99.99	-99.99	-99.9	-99
37	.23	.18	.20	.0	2
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	.62	.43	.52	.1	2
16	.65	.47	.54	.1	3
17	.22	.02	.09	.1	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	1.17	.12	.51	.3	41
21	-99.99	-99.99	-99.99	-99.9	-99
22	.71	.05	.26	.2	34
23	.58	.13	.29	.2	12
24	.61	.08	.36	.2	5
25	.17	.03	.10	.1	5
26	.19	.18	.18	.0	2
27	.23	.11	.16	.0	12
28	.21	.16	.18	.0	2
29	.60	.04	.15	.1	24
30	-99.99	-99.99	-99.99	-99.9	-99
31	.22	.08	.13	.0	11
32	.48	.08	.22	.2	7
33	.31	.04	.15	.1	57
34	.17	.10	.13	.0	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	.19	.06	.13	.0	10
37	.21	.09	.15	.0	11
38	.16	.07	.13	.0	9
39	.06	.06	.06	.0	1
40	.28	.03	.15	.1	4
41	.42	.13	.23	.1	5
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.32	.10	.18	.1	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.23	.10	.16	.1	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	.34	.05	.19	.1	11
23	.16	.00	.06	.1	7
24	.16	.12	.14	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.17	.16	.17	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	.14	.01	.08	.0	18
30	.26	.06	.13	.1	5
31	.20	.08	.15	.0	8
32	-99.99	-99.99	-99.99	-99.9	-99
33	.29	.06	.12	.0	53
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.08	.02	.06	.0	8
39	.05	.03	.04	.0	2
40	.10	.02	.04	.0	14
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 1c

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 25.1 - 50.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.19	.00	.07	.1	14
18	.16	.15	.16	.0	2
19	.11	.11	.11	.0	1
20	.24	.05	.13	.1	6
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	.10	.07	.08	.0	5
24	.16	.10	.13	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	.09	.07	.08	.0	2
27	.16	.11	.14	.0	7
28	.18	.15	.17	.0	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	.10	.07	.08	.0	5
31	.14	.06	.11	.0	8
32	-99.99	-99.99	-99.99	-99.9	-99
33	.15	.03	.12	.0	13
34	.13	.11	.12	.0	3
35	.20	.09	.14	.0	5
36	.15	.08	.11	.0	7
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.19	.07	.12	.0	6
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.22	.01	.06	.0	24
18	.30	.11	.21	.1	6
19	-99.99	-99.99	-99.99	-99.9	-99
20	.36	.14	.21	.1	11
21	-99.99	-99.99	-99.99	-99.9	-99
22	1.03	.12	.45	.3	19
23	.75	.09	.38	.2	10
24	.11	.07	.09	.0	2
25	.92	.11	.55	.3	8
26	.13	.11	.12	.0	4
27	.11	.11	.11	.0	1
28	.24	.20	.22	.0	2
29	.21	.03	.12	.1	12
30	.24	.02	.14	.1	12
31	.18	.07	.13	.0	6
32	.16	.13	.15	.0	4
33	.17	.05	.12	.0	23
34	.13	.11	.12	.0	2
35	.46	.10	.20	.1	8
36	-99.99	-99.99	-99.99	-99.9	-99
37	.23	.21	.22	.0	4
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	.14	.11	.13	.0	4

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	.23	.23	.23	.0	1
16	.15	.11	.13	.0	2
17	.04	.02	.03	.0	3
18	-99.99	-99.99	-99.99	-99.9	-99
19	.26	.26	.26	.0	1
20	1.10	.06	.36	.2	42
21	-99.99	-99.99	-99.99	-99.9	-99
22	.47	.05	.18	.1	31
23	.25	.01	.16	.1	11
24	.58	.21	.38	.2	4
25	.16	.06	.11	.0	6
26	.20	.17	.19	.0	3
27	.21	.10	.16	.0	22
28	.17	.10	.14	.1	2
29	.23	.04	.11	.0	31
30	-99.99	-99.99	-99.99	-99.9	-99
31	.30	.08	.14	.1	15
32	.15	.09	.12	.0	8
33	.30	.04	.13	.1	57
34	.21	.11	.17	.0	6
35	-99.99	-99.99	-99.99	-99.9	-99
36	.22	.00	.12	.0	32
37	.22	.06	.15	.0	32
38	.09	.05	.07	.0	2
39	-99.99	-99.99	-99.99	-99.9	-99
40	.09	.07	.08	.0	2
41	.17	.08	.12	.0	6
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.24	.03	.09	.1	11
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.35	.08	.21	.1	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	.32	.06	.16	.1	15
23	.14	.14	.14	.0	1
24	.16	.07	.11	.0	6
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.23	.20	.22	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	.17	.02	.09	.0	19
30	.15	.02	.07	.1	4
31	.17	.07	.13	.0	17
32	-99.99	-99.99	-99.99	-99.9	-99
33	.22	.06	.12	.0	26
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.12	.01	.07	.0	6
39	.05	.03	.04	.0	2
40	.24	.03	.14	.1	21
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 1d

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 50.1 - 100.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.21	.00	.11	.1	6
18	.32	.10	.21	.2	2
19	.10	.05	.08	.0	2
20	.12	.12	.12	.0	2
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.18	.09	.13	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.16	.04	.12	.0	8
28	.13	.13	.13	.0	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	.09	.04	.06	.0	11
31	.19	.08	.13	.0	9
32	-99.99	-99.99	-99.99	-99.9	-99
33	.14	.02	.09	.0	35
34	.13	.12	.13	.0	3
35	.20	.00	.12	.1	5
36	.17	.01	.11	.0	8
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.16	.08	.12	.0	6
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.14	.01	.07	.1	5
18	.26	.06	.14	.1	3
19	.16	.01	.06	.1	4
20	.26	.05	.13	.1	9
21	-99.99	-99.99	-99.99	-99.9	-99
22	.67	.11	.33	.2	12
23	.49	.03	.23	.2	11
24	.16	.05	.11	.1	2
25	.32	.10	.17	.1	6
26	.14	.02	.07	.1	5
27	.10	.10	.10	.0	2
28	.19	.16	.18	.0	3
29	.20	.00	.07	.1	9
30	.21	.00	.11	.1	12
31	.16	.06	.10	.0	6
32	.15	.09	.13	.0	4
33	.16	.03	.09	.0	55
34	.10	.09	.10	.0	2
35	.11	.03	.06	.0	5
36	.13	.07	.10	.0	2
37	.22	.04	.11	.1	6
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	.11	.02	.06	.1	2

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	.11	.08	.10	.0	3
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	.08	.08	.08	.0	1
20	.42	.07	.18	.1	17
21	-99.99	-99.99	-99.99	-99.9	-99
22	.21	.03	.11	.1	21
23	.09	.06	.07	.0	4
24	.10	.05	.07	.0	2
25	.15	.04	.10	.1	3
26	.19	.09	.15	.1	3
27	.17	.01	.10	.1	21
28	-99.99	-99.99	-99.99	-99.9	-99
29	.07	.00	.05	.0	19
30	-99.99	-99.99	-99.99	-99.9	-99
31	.14	.04	.07	.0	15
32	.11	.05	.08	.0	7
33	.15	.02	.08	.0	66
34	.16	.06	.11	.0	6
35	-99.99	-99.99	-99.99	-99.9	-99
36	.14	.01	.08	.0	39
37	.20	.01	.10	.0	34
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.29	.05	.17	.2	2
41	.08	.05	.07	.0	4
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.02	.00	.01	.0	2
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.18	.00	.09	.1	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	.10	.04	.07	.0	9
23	-99.99	-99.99	-99.99	-99.9	-99
24	.12	.05	.09	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.08	.06	.07	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	.12	.00	.05	.0	14
30	-99.99	-99.99	-99.99	-99.9	-99
31	.17	.02	.08	.0	16
32	-99.99	-99.99	-99.99	-99.9	-99
33	.21	.00	.06	.0	44
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.10	.03	.05	.0	6
39	-99.99	-99.99	-99.99	-99.9	-99
40	.38	.03	.16	.1	34
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 1e

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 100.1 - 150.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.10	.04	.06	.0	4
18	.06	.05	.06	.0	2
19	.03	.03	.03	.0	1
20	.10	.10	.10	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	.11	.09	.10	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.10	.00	.06	.1	4
28	.14	.08	.11	.0	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.02	.02	.02	.0	2
32	-99.99	-99.99	-99.99	-99.9	-99
33	.13	.01	.04	.0	22
34	.11	.08	.10	.0	2
35	.12	.05	.09	.0	4
36	.07	.01	.04	.0	4
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.02	.02	.02	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.04	.04	.04	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	.64	.08	.29	.2	8
23	.33	.03	.14	.1	7
24	.09	.06	.07	.0	2
25	.23	.08	.15	.1	4
26	.04	.01	.02	.0	3
27	.10	.07	.09	.0	2
28	.13	.05	.09	.1	2
29	.04	.00	.01	.0	6
30	.08	.00	.03	.0	7
31	.08	.00	.03	.0	3
32	.11	.00	.06	.1	2
33	.17	.01	.04	.0	32
34	.07	.01	.04	.0	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	.05	.00	.02	.0	2
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	.04	.04	.04	.0	2

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.36	.04	.14	.1	10
21	-99.99	-99.99	-99.99	-99.9	-99
22	.36	.00	.10	.1	12
23	.04	.04	.04	.0	1
24	.05	.05	.05	.0	1
25	.08	.03	.06	.0	2
26	.08	.06	.07	.0	2
27	.06	.00	.03	.0	14
28	-99.99	-99.99	-99.99	-99.9	-99
29	.04	.00	.02	.0	8
30	-99.99	-99.99	-99.99	-99.9	-99
31	.02	.00	.01	.0	10
32	.06	.03	.04	.0	4
33	.08	.01	.03	.0	35
34	.05	.03	.04	.0	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	.02	.00	.01	.0	6
37	.15	.00	.05	.0	19
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.01	.01	.01	.0	1
41	.04	.03	.03	.0	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.00	.00	.00	.0	1
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	.08	.00	.03	.0	7
23	-99.99	-99.99	-99.99	-99.9	-99
24	.05	.03	.04	.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.05	.04	.04	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	.12	.01	.04	.0	5
30	-99.99	-99.99	-99.99	-99.9	-99
31	.06	.00	.04	.0	12
32	-99.99	-99.99	-99.99	-99.9	-99
33	.05	.00	.02	.0	30
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.04	.01	.02	.0	3
39	-99.99	-99.99	-99.99	-99.9	-99
40	.06	.01	.03	.0	9
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 1f

CHLOROPHYLL-A (MG/M**3) 1958 - 1974 150.1 - *99.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.02	.02	.02	.0	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	.08	.01	.04	.0	3
32	-99.99	-99.99	-99.99	-99.9	-99
33	.04	.01	.02	.0	22
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.06	.06	.06	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	.31	.10	.18	.1	3
23	.32	.02	.11	.1	4
24	-99.99	-99.99	-99.99	-99.9	-99
25	.09	.06	.08	.0	2
26	.01	.00	.01	.0	2
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.00	.00	.00	.0	16
30	.04	.00	.00	.0	10
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.14	.00	.03	.0	32
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	.06	.02	.03	.0	6

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.37	.03	.12	.2	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	.19	.06	.13	.1	3
23	-99.99	-99.99	-99.99	-99.9	-99
24	.02	.02	.02	.0	1
25	.12	.12	.12	.0	1
26	.02	.02	.02	.0	1
27	.05	.00	.03	.0	6
28	-99.99	-99.99	-99.99	-99.9	-99
29	.02	.00	.01	.0	2
30	-99.99	-99.99	-99.99	-99.9	-99
31	.06	.00	.01	.0	7
32	.05	.02	.03	.0	3
33	.24	.00	.03	.0	31
34	.03	.03	.03	.0	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	.01	.00	.00	.0	2
37	.12	.01	.05	.0	8
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.00	.00	.00	.0	1
41	.03	.01	.02	.0	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	.04	.00	.02	.0	4
23	-99.99	-99.99	-99.99	-99.9	-99
24	.05	.02	.03	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.03	.03	.03	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	.03	.00	.01	.0	4
30	-99.99	-99.99	-99.99	-99.9	-99
31	.06	.00	.03	.0	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	.03	.00	.01	.0	31
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.00	.00	.00	.0	1
39	-99.99	-99.99	-99.99	-99.9	-99
40	.05	.00	.02	.0	8
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 2

TOTAL CHLOROPHYLL-A (MG/M**2) 1958 - 1974

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	1.54	.48	.85	.3	13
18	1.51	1.51	1.51	.0	1
19	1.29	1.29	1.29	.0	1
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	1.15	.87	1.02	.1	6
24	1.35	1.16	1.25	.1	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	1.16	1.08	1.12	.1	2
27	1.53	1.31	1.39	.1	3
28	1.45	1.45	1.45	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99
30	1.20	.97	1.08	.1	16
31	1.43	1.35	1.40	.0	3
32	-99.99	-99.99	-99.99	-99.9	-99
33	1.82	1.06	1.24	.2	18
34	1.35	1.12	1.24	.2	2
35	1.48	1.30	1.38	.1	3
36	1.50	1.18	1.35	.2	4
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	1.42	1.23	1.32	.1	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	2.25	.32	1.14	.6	40
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	1.52	1.52	1.52	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	2.46	1.28	1.69	.4	11
23	2.26	1.05	1.63	.5	5
24	1.19	1.19	1.19	.0	1
25	2.13	1.29	1.69	.5	4
26	1.26	1.10	1.18	.1	2
27	1.26	1.26	1.26	.0	1
28	1.68	1.68	1.68	.0	1
29	1.49	.70	1.19	.3	8
30	1.56	1.02	1.33	.2	5
31	1.38	1.36	1.37	.0	2
32	1.41	1.35	1.38	.0	2
33	1.37	.90	1.17	.1	25
34	1.38	1.38	1.38	.0	1
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	1.48	1.48	1.48	.0	1
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	1.29	1.23	1.26	.0	2

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	1.86	1.86	1.86	.0	1
17	1.28	.11	.69	.4	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	2.49	.00	1.25	1.8	2
20	2.01	1.34	1.58	.3	5
21	-99.99	-99.99	-99.99	-99.9	-99
22	2.10	.87	1.36	.4	27
23	.54	.54	.54	.0	1
24	2.00	2.00	2.00	.0	1
25	1.10	.72	.97	.2	5
26	1.46	1.46	1.46	.0	1
27	1.51	1.05	1.32	.2	6
28	-99.99	-99.99	-99.99	-99.9	-99
29	1.27	.73	1.07	.2	20
30	-99.99	-99.99	-99.99	-99.9	-99
31	1.38	.93	1.15	.2	7
32	1.58	1.16	1.31	.2	3
33	1.50	.74	1.18	.2	39
34	1.50	1.46	1.48	.0	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	1.39	1.04	1.22	.2	2
37	1.39	.89	1.23	.1	11
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.71	.71	.71	.0	1
41	1.38	1.33	1.35	.0	2
I	I	I	I	I	I

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	1.46	1.00	1.21	.1	12
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	1.66	.77	1.29	.2	11
23	1.17	.34	.75	.3	5
24	1.12	1.04	1.08	.1	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	1.27	1.27	1.27	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	1.22	.58	.93	.2	10
30	.74	.43	.55	.2	3
31	1.37	.94	1.17	.2	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	1.43	.87	1.17	.2	28
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.86	.32	.67	.2	4
39	.65	.56	.60	.1	2
40	1.39	.52	.88	.3	10
41	-99.99	-99.99	-99.99	-99.9	-99
I	I	I	I	I	I

TABLE 3a

PRIMARY PRODUCTIVITY (MG/M**3/HR) 1958-1974 0-10.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.35	.01	.09	.1	31
18	.36	.31	.34	.0	2
19	.45	.13	.26	.1	5
20	.85	.14	.51	.2	14
21	.22	.22	.22	.0	1
22	.14	.14	.14	.0	1
23	.18	.07	.13	.0	17
24	.27	.18	.29	.1	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	.14	.12	.13	.0	4
27	.16	.01	.10	.1	3
28	.24	.24	.24	.0	2
29	.15	.15	.15	.0	1
30	.32	.08	.13	.1	23
31	-99.99	-99.99	-99.99	-99.9	-99
32	.29	.22	.26	.1	2
33	.90	.01	.26	.2	148
34	.26	.11	.18	.1	5
35	.28	.20	.25	.0	4
36	.25	.19	.22	.0	3
37	-99.99	-99.99	-99.99	-99.9	-99
38	.39	.39	.39	.0	1
39	-99.99	-99.99	-99.99	-99.9	-99
40	.14	.14	.14	.0	1
41	.01	.01	.01	.0	1
42	1.01	.08	.43	.4	4

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	1.20	1.20	1.20	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99
17	1.56	.01	.70	.5	123
18	1.08	.76	.90	.2	4
19	.78	.29	.54	.4	2
20	1.53	.07	.73	.4	67
21	-99.99	-99.99	-99.99	-99.9	-99
22	.40	.17	.28	.1	18
23	.69	.21	.43	.2	3
24	1.18	.22	.55	.5	3
25	.26	.11	.17	.1	4
26	-99.99	-99.99	-99.99	-99.9	-99
27	.39	.13	.28	.1	8
28	.24	.16	.19	.0	3
29	.63	.11	.25	.1	22
30	.73	.08	.26	.2	16
31	.35	.00	.20	.1	16
32	.42	.03	.19	.1	9
33	1.59	.03	.33	.3	220
34	.43	.22	.32	.1	4
35	.98	.25	.56	.3	5
36	.59	.17	.29	.2	5
37	.43	.19	.34	.1	9
38	.47	.47	.47	.0	1
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	.38	.38	.38	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	1.33	1.33	1.33	.0	1
16	.64	.27	.47	.2	3
17	1.10	.00	.35	.3	50
18	-99.99	-99.99	-99.99	-99.9	-99
19	.97	.00	.51	.5	3
20	1.20	.00	.47	.3	82
21	-99.99	-99.99	-99.99	-99.9	-99
22	1.04	.10	.44	.2	80
23	1.05	.15	.52	.3	13
24	.99	.10	.38	.4	4
25	.35	.14	.23	.1	14
26	-99.99	-99.99	-99.99	-99.9	-99
27	1.13	.03	.58	.8	2
28	.30	.30	.30	.0	1
29	.74	.06	.26	.1	62
30	.83	.10	.35	.3	5
31	.72	.13	.32	.2	7
32	.46	.14	.35	.2	3
33	1.44	.02	.41	.4	198
34	.52	.33	.43	.1	3
35	-99.99	-99.99	-99.99	-99.9	-99
36	.44	.07	.23	.2	3
37	.31	.13	.22	.1	4
38	.47	.05	.22	.1	14
39	.29	.13	.21	.1	2
40	.38	.12	.23	.1	5
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.95	.03	.44	.2	32
18	-99.99	-99.99	-99.99	-99.9	-99
19	.49	.02	.21	.2	6
20	.72	.07	.39	.2	16
21	-99.99	-99.99	-99.99	-99.9	-99
22	.77	.08	.38	.2	52
23	.18	.05	.11	.0	8
24	.33	.09	.26	.1	6
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.44	.02	.25	.2	4
28	-99.99	-99.99	-99.99	-99.9	-99
29	.35	.02	.21	.1	19
30	.31	.01	.14	.1	16
31	.42	.33	.37	.0	5
32	.11	.05	.08	.0	2
33	1.32	.00	.42	.3	196
34	-99.99	-99.99	-99.99	-99.9	-99
35	.01	.01	.01	.0	1
36	-99.99	-99.99	-99.99	-99.9	-99
37	.16	.07	.12	.1	2
38	.35	.14	.25	.1	9
39	-99.99	-99.99	-99.99	-99.9	-99
40	.28	.18	.23	.1	2
41	.01	.01	.01	.0	1
42	.02	.02	.02	.0	1

TABLE 3b

PRIMARY PRODUCTIVITY (MG/M**3/HR) 1958-1974 10.1-25.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.30	.00	.05	.1	17
18	.26	.26	.26	.0	1
19	.23	.13	.18	.1	2
20	.60	.00	.20	.3	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	.10	.01	.06	.0	9
24	.30	.22	.26	.1	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	.09	.07	.08	.0	4
27	.20	.20	.20	.0	1
28	.20	.20	.20	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99
30	.13	.02	.08	.0	22
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.31	.00	.07	.1	30
34	.14	.14	.14	.0	1
35	.16	.06	.12	.1	3
36	.19	.13	.16	.0	2
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	1.01	.00	.20	.3	52
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.88	.03	.27	.3	13
21	-99.99	-99.99	-99.99	-99.9	-99
22	.24	.11	.18	.1	8
23	-99.99	-99.99	-99.99	-99.9	-99
24	.18	.18	.18	.0	1
25	.24	.08	.16	.1	4
26	-99.99	-99.99	-99.99	-99.9	-99
27	.29	.12	.20	.1	2
28	.28	.28	.28	.0	1
29	.22	.09	.16	.0	11
30	.09	.00	.03	.0	6
31	.12	.00	.05	.1	6
32	.17	.03	.10	.1	3
33	.67	.01	.14	.2	53
34	.27	.27	.27	.0	1
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	.21	.05	.09	.1	5
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.54	.02	.12	.2	12
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.59	.00	.09	.1	25
21	-99.99	-99.99	-99.99	-99.9	-99
22	.82	.06	.30	.2	31
23	-99.99	-99.99	-99.99	-99.9	-99
24	.23	.16	.19	.0	2
25	.21	.09	.15	.0	4
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.42	.03	.20	.1	21
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	1.20	.00	.28	.4	50
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.31	.12	.22	.1	9
39	.24	.24	.24	.0	1
40	.46	.32	.39	.1	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.50	.00	.18	.2	14
18	-99.99	-99.99	-99.99	-99.9	-99
19	.03	.03	.03	.0	2
20	.09	.02	.05	.0	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	.35	.02	.15	.1	11
23	.02	.00	.01	.0	2
24	.28	.00	.14	.1	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.27	.04	.15	.2	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	.27	.03	.15	.1	12
30	.34	.11	.23	.1	4
31	.36	.03	.11	.2	4
32	-99.99	-99.99	-99.99	-99.9	-99
33	.69	.00	.18	.2	45
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.24	.02	.11	.1	6
39	-99.99	-99.99	-99.99	-99.9	-99
40	.24	.24	.24	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 3c

PRIMARY PRODUCTIVITY (MG/M**3/HR) 1958-1974 25.1-50.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.03	.00	.01	.0	15
18	.15	.02	.09	.1	2
19	.02	.02	.02	.0	1
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	.03	.00	.01	.0	5
24	.07	.07	.07	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99
26	.00	.00	.00	.0	2
27	.17	.10	.13	.0	2
28	.11	.01	.06	.1	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	.02	.00	.01	.0	5
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.16	.00	.08	.1	5
34	.07	.00	.04	.0	2
35	.04	.00	.02	.0	3
36	.10	.02	.06	.0	4
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.15	.00	.02	.0	19
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	.05	.02	.03	.0	6
23	-99.99	-99.99	-99.99	-99.9	-99
24	.10	.02	.06	.1	2
25	.06	.04	.05	.0	2
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	.22	.15	.18	.1	2
29	.17	.03	.07	.1	4
30	-99.99	-99.99	-99.99	-99.9	-99
31	.09	.09	.09	.0	1
32	.05	.00	.03	.0	2
33	.34	.00	.07	.1	19
34	.20	.05	.12	.1	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.07	.01	.04	.0	3
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.26	.00	.03	.1	13
21	-99.99	-99.99	-99.99	-99.9	-99
22	.32	.00	.08	.1	18
23	-99.99	-99.99	-99.99	-99.9	-99
24	.05	.05	.05	.0	1
25	.06	.01	.04	.0	4
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	.16	.00	.05	.1	17
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.90	.00	.17	.2	29
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	.14	.13	.13	.0	2
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.53	.00	.09	.2	11
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	.02	.02	.02	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	.08	.00	.05	.0	6
23	-99.99	-99.99	-99.99	-99.9	-99
24	.09	.01	.05	.1	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.03	.03	.03	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	.09	.01	.04	.0	8
30	.08	.00	.03	.0	3
31	.02	.02	.02	.0	1
32	-99.99	-99.99	-99.99	-99.9	-99
33	.78	.00	.17	.2	17
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	.05	.01	.03	.0	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 3d

PRIMARY PRODUCTIVITY (MG/M**3/HR) 1958-1974 50.1-100.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.01	.00	.00	.0	2
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	.00	.00	.00	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	.02	.00	.01	.0	6
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.13	.00	.02	.0	12
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	.23	.01	.12	.2	2
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.01	.00	.01	.0	2
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	.02	.02	.02	.0	1
29	.04	.04	.04	.0	1
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.22	.00	.03	.1	16
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.24	.00	.05	.1	7
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	.01	.00	.00	.0	2
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	-99.99	-99.99	-99.99	-99.9	-99
32	-99.99	-99.99	-99.99	-99.9	-99
33	.17	.00	.03	.1	11
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 4a

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 .0 - 10.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	3.59	3.59	3.59	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99
17	4.11	3.39	3.59	.1	57
18	4.00	3.95	3.97	.0	2
19	3.96	3.07	3.43	.3	9
20	5.16	2.07	3.62	1.2	23
21	-99.99	-99.99	-99.99	-99.9	-99
22	4.57	4.18	4.32	.1	6
23	4.67	2.66	3.89	.6	19
24	4.68	4.23	4.38	.2	7
25	-99.99	-99.99	-99.99	-99.9	-99
26	4.15	2.88	3.67	.6	5
27	4.95	3.97	4.40	.4	12
28	4.88	3.52	4.44	.4	7
29	4.28	4.15	4.22	.1	3
30	4.40	2.49	3.69	.4	27
31	4.36	2.81	3.70	.5	11
32	3.96	2.79	3.38	.5	7
33	4.65	1.45	3.72	.5	31
34	4.43	3.74	4.07	.2	13
35	4.29	3.92	4.15	.1	6
36	3.96	3.02	3.56	.3	15
37	3.52	2.98	3.27	.2	4
38	2.19	2.19	2.19	.0	1
39	2.35	2.35	2.35	.0	1
40	2.65	2.00	2.26	.3	7
41	-99.99	-99.99	-99.99	-99.9	-99
42	3.16	1.54	2.46	.6	7

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	3.48	3.48	3.48	.0	1
16	-99.99	-99.99	-99.99	-99.9	-99
17	4.64	1.00	1.94	1.3	218
18	-99.99	-99.99	-99.99	-99.9	-99
19	6.43	1.61	2.93	1.1	14
20	5.93	1.00	2.76	.9	51
21	-99.99	-99.99	-99.99	-99.9	-99
22	5.73	2.97	4.11	.7	27
23	5.86	1.10	3.97	.8	26
24	6.75	2.81	4.37	1.0	10
25	4.67	2.81	4.21	.6	20
26	4.47	4.47	4.47	.0	2
27	5.96	3.58	4.42	.5	21
28	5.58	3.92	4.62	.5	13
29	4.74	1.55	4.23	.6	71
30	4.62	1.18	3.90	.5	73
31	4.51	2.98	3.92	.3	69
32	4.29	2.95	3.62	.3	50
33	5.31	1.76	3.82	.6	61
34	4.94	3.29	4.02	.5	24
35	-99.99	-99.99	-99.99	-99.9	-99
36	7.95	2.32	3.68	1.2	19
37	3.83	1.92	3.11	.4	56
38	3.36	3.36	3.36	.0	1
39	-99.99	-99.99	-99.99	-99.9	-99
40	3.33	3.33	3.33	.0	1
41	2.32	2.00	2.20	.1	5
42	3.70	2.12	2.71	.5	11

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	2.93	1.61	2.27	.9	2
16	1.18	1.18	1.18	.0	1
17	2.97	1.00	1.47	.4	49
18	-99.99	-99.99	-99.99	-99.9	-99
19	2.76	1.00	1.81	.6	7
20	4.86	1.00	2.08	1.1	110
21	-99.99	-99.99	-99.99	-99.9	-99
22	5.12	1.92	3.49	.9	45
23	3.82	1.30	2.62	.9	13
24	3.24	2.47	2.87	.4	5
25	4.37	3.52	3.91	.4	7
26	4.74	2.70	4.06	1.2	3
27	4.75	3.13	4.24	.5	20
28	4.71	3.73	4.23	.5	4
29	4.37	2.35	3.48	.6	28
30	3.74	2.51	3.22	.3	12
31	4.38	2.95	3.53	.4	18
32	3.55	1.00	2.24	1.0	10
33	5.57	1.00	2.85	1.0	73
34	4.29	2.07	3.52	.6	17
35	-99.99	-99.99	-99.99	-99.9	-99
36	2.65	1.34	2.59	.7	11
37	3.22	1.00	2.36	.6	36
38	2.85	2.77	2.81	.1	2
39	2.76	2.76	2.76	.0	1
40	2.77	1.90	2.39	.4	3
41	1.10	1.00	1.06	.1	5
42	2.35	1.45	1.90	.6	2

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	4.00	1.14	1.72	.5	52
18	-99.99	-99.99	-99.99	-99.9	-99
19	1.55	1.55	1.55	.0	1
20	4.91	1.10	2.63	1.6	6
21	-99.99	-99.99	-99.99	-99.9	-99
22	4.55	2.77	3.73	.7	5
23	-99.99	-99.99	-99.99	-99.9	-99
24	3.00	2.74	2.87	.1	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	3.13	1.90	2.72	.7	3
28	-99.99	-99.99	-99.99	-99.9	-99
29	4.24	2.00	3.39	.8	6
30	-99.99	-99.99	-99.99	-99.9	-99
31	4.54	1.61	2.78	.6	13
32	-99.99	-99.99	-99.99	-99.9	-99
33	3.49	1.45	2.94	.4	59
34	-99.99	-99.99	-99.99	-99.9	-99
35	2.02	2.02	2.02	.0	1
36	-99.99	-99.99	-99.99	-99.9	-99
37	1.64	1.64	1.64	.0	1
38	1.26	1.00	1.11	.1	4
39	-99.99	-99.99	-99.99	-99.9	-99
40	1.00	1.00	1.00	.0	3
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 4b

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 10.1 - 25.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	4.14	3.44	3.64	.2	26
18	4.02	4.02	4.02	.0	1
19	3.92	3.89	3.91	.0	2
20	5.21	5.02	5.11	.1	3
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	4.29	3.61	4.03	.2	8
24	4.22	4.21	4.21	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	3.86	2.57	3.34	.5	4
27	4.49	4.49	4.49	.0	1
28	4.38	4.38	4.38	.0	1
29	-99.99	-99.99	-99.99	-99.9	-99
30	4.43	3.29	3.80	.3	23
31	3.87	3.00	3.44	.6	2
32	-99.99	-99.99	-99.99	-99.9	-99
33	4.64	3.29	3.71	.3	17
34	4.24	4.06	4.18	.1	3
35	4.18	3.95	4.03	.1	4
36	3.90	3.70	3.81	.1	5
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	2.24	2.24	2.24	.0	1
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	4.65	1.00	2.38	1.3	75
18	-99.99	-99.99	-99.99	-99.9	-99
19	2.41	2.41	2.41	.0	1
20	5.09	2.57	3.98	1.1	7
21	-99.99	-99.99	-99.99	-99.9	-99
22	3.52	3.00	3.23	.3	4
23	4.48	3.42	4.13	.4	5
24	4.68	4.68	4.68	.0	1
25	4.01	2.81	3.15	.6	4
26	4.47	4.47	4.47	.0	1
27	4.43	4.42	4.42	.0	2
28	4.58	4.58	4.58	.0	1
29	4.49	3.90	4.17	.3	3
30	4.35	3.38	3.99	.4	4
31	4.15	3.51	3.93	.4	3
32	3.92	3.33	3.66	.2	4
33	4.83	1.92	3.54	.7	17
34	3.90	3.22	3.56	.5	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	3.35	2.68	3.00	.3	3
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	2.05	2.05	2.05	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	1.22	1.00	1.09	.1	11
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	5.16	1.00	3.33	1.3	37
21	-99.99	-99.99	-99.99	-99.9	-99
22	5.07	2.59	4.14	.7	11
23	-99.99	-99.99	-99.99	-99.9	-99
24	3.26	3.26	3.26	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99
26	4.74	4.74	4.74	.0	2
27	4.72	4.40	4.56	.1	9
28	-99.99	-99.99	-99.99	-99.9	-99
29	3.87	2.26	3.07	1.1	2
30	-99.99	-99.99	-99.99	-99.9	-99
31	4.42	4.42	4.42	.0	1
32	2.90	1.00	1.70	.8	7
33	5.15	1.38	2.75	1.0	33
34	4.30	3.91	4.16	.2	3
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	3.21	1.79	2.35	.5	12
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	1.14	1.00	1.08	.1	5
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	2.41	1.55	1.94	.2	25
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	5.12	5.12	5.12	.0	2
21	-99.99	-99.99	-99.99	-99.9	-99
22	4.95	2.72	3.84	1.6	2
23	-99.99	-99.99	-99.99	-99.9	-99
24	3.00	2.74	2.87	.1	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	3.24	3.13	3.19	.1	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	3.82	3.00	3.40	.4	4
30	-99.99	-99.99	-99.99	-99.9	-99
31	3.03	1.58	2.56	.5	8
32	-99.99	-99.99	-99.99	-99.9	-99
33	3.51	2.02	2.91	.4	23
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	1.22	1.00	1.11	.1	4
39	-99.99	-99.99	-99.99	-99.9	-99
40	1.00	1.00	1.00	.0	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 4c

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 25.1 - 50.0 METERS

	WINTER						SPRING				
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	4.85	3.42	3.71	.3	35	17	4.66	1.34	3.24	1.1	86
18	4.07	4.06	4.07	.0	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	3.90	3.90	3.90	.0	1	19	2.61	2.61	2.61	.0	1
20	5.21	4.93	5.08	.1	6	20	5.32	2.49	4.29	1.2	11
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	4.89	3.03	3.67	.6	9
23	4.23	2.24	3.30	1.0	4	23	4.48	3.49	4.17	.3	9
24	4.04	4.04	4.04	.0	1	24	4.17	4.15	4.16	.0	2
25	-99.99	-99.99	-99.99	-99.9	-99	25	4.29	2.92	3.60	.6	6
26	3.30	3.10	3.20	.1	2	26	4.47	4.45	4.46	.0	3
27	4.74	3.87	4.44	.5	3	27	4.38	4.38	4.38	.0	1
28	4.64	4.62	4.63	.0	2	28	4.62	4.62	4.62	.0	2
29	-99.99	-99.99	-99.99	-99.9	-99	29	4.58	4.14	4.36	.2	8
30	4.23	3.36	3.87	.3	5	30	4.34	3.36	3.96	.4	8
31	3.87	3.00	3.45	.4	3	31	4.15	3.55	3.94	.3	6
32	-99.99	-99.99	-99.99	-99.9	-99	32	3.92	3.36	3.68	.2	7
33	4.02	3.42	3.64	.3	4	33	4.07	2.24	3.52	.7	6
34	4.23	3.63	3.96	.3	3	34	3.92	3.42	3.71	.3	3
35	4.29	3.86	4.16	.2	5	35	-99.99	-99.99	-99.99	-99.9	-99
36	3.95	3.48	3.82	.2	7	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	3.36	2.74	3.10	.3	5
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	2.24	2.00	2.12	.2	2	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	2.00	2.00	2.00	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99	42	3.16	2.39	2.77	.5	2

	SUMMER						AUTUMN				
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	2.00	1.26	1.55	.4	3	17	4.72	2.07	2.60	.6	29
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	6.16	1.26	3.94	1.3	39	20	5.56	5.29	5.38	.1	4
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	5.13	2.26	4.07	.9	24	22	4.24	2.76	3.58	.8	3
23	4.23	4.23	4.23	.0	1	23	-99.99	-99.99	-99.99	-99.9	-99
24	4.01	4.01	4.01	.0	1	24	4.69	3.27	3.89	.5	6
25	4.79	4.39	4.54	.2	4	25	-99.99	-99.99	-99.99	-99.9	-99
26	4.75	4.74	4.75	.0	3	26	-99.99	-99.99	-99.99	-99.9	-99
27	4.72	3.51	4.50	.3	19	27	4.32	3.48	3.88	.4	3
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	4.82	2.51	3.72	.8	14	29	4.12	3.26	3.69	.6	2
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	4.45	4.43	4.44	.0	3	31	3.95	1.70	3.08	.6	17
32	3.08	1.34	2.10	.7	8	32	-99.99	-99.99	-99.99	-99.9	-99
33	4.14	1.61	2.99	.8	34	33	3.95	2.55	3.22	.5	9
34	4.31	3.91	4.08	.2	5	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	2.86	2.86	2.86	.0	1	36	-99.99	-99.99	-99.99	-99.9	-99
37	3.54	1.87	2.53	.5	30	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	2.92	2.17	2.54	.5	2
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	1.87	1.00	1.24	.3	7
41	1.30	1.14	1.22	.1	6	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 4d

NITRATE (NO3) (MICROGRAM-AT/L) 1959 - 1974 50.1 - 100.0 METERS

WINTER						SPRING					
ZONE	MAX	MIN	MEAN	SD	N	ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	5.11	3.55	4.07	.4	25	17	4.69	1.76	4.24	.5	77
18	4.81	3.92	4.37	.6	2	18	-99.99	-99.99	-99.99	-99.9	-99
19	5.22	3.95	4.58	.9	2	19	3.38	3.38	3.38	.0	1
20	5.22	4.94	5.12	.2	3	20	5.39	2.53	4.46	1.2	12
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99	22	6.02	4.24	4.90	.7	9
23	-99.99	-99.99	-99.99	-99.9	-99	23	5.26	4.17	4.52	.4	9
24	4.20	3.86	4.03	.2	2	24	4.40	4.40	4.40	.0	1
25	-99.99	-99.99	-99.99	-99.9	-99	25	5.50	4.42	4.80	.4	6
26	-99.99	-99.99	-99.99	-99.9	-99	26	4.88	4.45	4.61	.2	3
27	4.81	3.87	4.47	.4	6	27	4.49	4.43	4.46	.0	2
28	4.74	4.46	4.60	.2	2	28	4.62	4.37	4.53	.1	3
29	-99.99	-99.99	-99.99	-99.9	-99	29	4.79	4.18	4.43	.2	8
30	4.06	3.18	3.65	.3	6	30	4.36	3.38	3.97	.4	8
31	3.87	3.00	3.44	.3	10	31	4.24	3.63	4.00	.3	6
32	-99.99	-99.99	-99.99	-99.9	-99	32	4.21	3.42	3.81	.3	8
33	4.69	3.41	3.91	.4	20	33	4.75	1.94	3.77	.6	24
34	4.23	4.10	4.13	.1	4	34	3.96	3.59	3.87	.2	4
35	4.52	3.97	4.29	.2	5	35	-99.99	-99.99	-99.99	-99.9	-99
36	5.28	3.63	4.06	.5	8	36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99	37	3.42	2.90	3.17	.2	6
38	-99.99	-99.99	-99.99	-99.9	-99	38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	2.45	2.00	2.22	.2	6	40	-99.99	-99.99	-99.99	-99.9	-99
41	-99.99	-99.99	-99.99	-99.9	-99	41	2.30	2.17	2.24	.1	2
42	-99.99	-99.99	-99.99	-99.9	-99	42	4.00	2.61	3.30	1.0	2

SUMMER						AUTUMN					
15	-99.99	-99.99	-99.99	-99.9	-99	15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99	16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99	17	5.13	2.61	3.32	.7	18
18	-99.99	-99.99	-99.99	-99.9	-99	18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99	19	-99.99	-99.99	-99.99	-99.9	-99
20	5.32	2.10	3.79	1.2	19	20	5.40	5.04	5.30	.2	4
21	-99.99	-99.99	-99.99	-99.9	-99	21	-99.99	-99.99	-99.99	-99.9	-99
22	5.75	2.83	4.60	.8	13	22	5.48	2.66	4.34	1.2	4
23	5.35	5.35	5.35	.0	1	23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99	24	5.77	4.11	4.94	.8	4
25	4.86	4.86	4.86	.0	1	25	-99.99	-99.99	-99.99	-99.9	-99
26	5.95	4.74	5.15	.7	3	26	-99.99	-99.99	-99.99	-99.9	-99
27	6.05	4.40	4.83	.5	19	27	4.82	4.58	4.70	.2	2
28	-99.99	-99.99	-99.99	-99.9	-99	28	-99.99	-99.99	-99.99	-99.9	-99
29	4.16	3.44	3.79	.3	7	29	4.36	2.02	3.33	.8	6
30	-99.99	-99.99	-99.99	-99.9	-99	30	-99.99	-99.99	-99.99	-99.9	-99
31	4.95	4.45	4.62	.3	3	31	4.46	2.07	3.67	.7	16
32	3.62	1.52	2.62	.8	7	32	-99.99	-99.99	-99.99	-99.9	-99
33	5.78	1.38	3.51	.9	53	33	5.36	2.72	3.91	.5	28
34	4.67	3.95	4.25	.2	6	34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99	35	-99.99	-99.99	-99.99	-99.9	-99
36	3.30	3.30	3.30	.0	1	36	-99.99	-99.99	-99.99	-99.9	-99
37	3.91	2.17	2.91	.5	28	37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99	38	3.74	1.10	2.81	1.2	4
39	-99.99	-99.99	-99.99	-99.9	-99	39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99	40	2.76	1.64	2.37	.4	7
41	2.02	1.41	1.72	.3	4	41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99	42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 4e

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 100.1 - 150.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	5.74	4.14	4.62	.6	10
18	5.51	5.21	5.36	.2	2
19	5.59	5.59	5.59	.0	1
20	5.23	5.23	5.23	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	5.01	4.17	4.59	.6	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	6.33	4.90	5.58	.6	4
28	6.39	5.63	6.01	.5	2
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	5.00	3.87	4.31	.4	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	7.01	3.83	4.81	.7	18
34	5.00	5.00	5.00	.0	1
35	5.53	4.52	5.16	.4	4
36	5.75	5.37	5.59	.2	4
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	3.61	2.24	2.82	.5	5
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	4.72	4.32	4.54	.1	27
18	-99.99	-99.99	-99.99	-99.9	-99
19	4.95	4.68	4.81	.2	2
20	4.96	4.96	4.96	.0	1
21	-99.99	-99.99	-99.99	-99.9	-99
22	6.43	4.59	5.85	.7	6
23	6.58	5.38	5.90	.4	6
24	4.86	4.55	4.70	.2	2
25	6.47	5.51	6.00	.4	4
26	6.48	6.09	6.29	.3	2
27	4.45	4.43	4.44	.0	2
28	6.28	5.42	5.85	.6	2
29	6.50	4.20	5.24	.9	6
30	4.81	4.12	4.51	.3	5
31	5.56	4.20	5.07	.8	3
32	5.46	3.69	4.35	.9	4
33	7.25	3.36	4.66	1.1	18
34	6.64	4.15	5.38	1.0	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	4.85	4.28	4.57	.3	3
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	3.18	3.18	3.18	.0	1
42	-99.99	-99.99	-99.99	-99.9	-99

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	5.54	3.41	4.53	.6	10
21	-99.99	-99.99	-99.99	-99.9	-99
22	5.48	3.90	4.86	.7	5
23	4.90	4.90	4.90	.0	1
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	6.86	6.66	6.76	.1	2
27	6.66	5.47	6.26	.3	13
28	-99.99	-99.99	-99.99	-99.9	-99
29	4.80	4.24	4.52	.4	2
30	-99.99	-99.99	-99.99	-99.9	-99
31	6.29	6.07	6.18	.2	2
32	4.79	3.85	4.30	.4	4
33	6.35	1.82	4.89	.8	44
34	6.05	4.42	5.46	.7	4
35	-99.99	-99.99	-99.99	-99.9	-99
36	4.82	4.82	4.82	.0	1
37	5.49	3.03	4.18	.7	19
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	3.51	3.46	3.49	.0	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	4.46	3.56	4.01	.4	4
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	5.47	3.07	4.27	1.7	2
23	-99.99	-99.99	-99.99	-99.9	-99
24	7.00	4.83	6.03	1.0	4
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	6.11	5.42	5.76	.5	2
28	-99.99	-99.99	-99.99	-99.9	-99
29	6.10	3.22	4.52	1.5	3
30	-99.99	-99.99	-99.99	-99.9	-99
31	5.41	4.10	4.71	.4	12
32	-99.99	-99.99	-99.99	-99.9	-99
33	6.16	3.63	4.94	.6	26
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	3.74	2.21	3.23	.7	4
39	-99.99	-99.99	-99.99	-99.9	-99
40	3.59	2.74	3.30	.5	3
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

TABLE 4f

NITRATE (NO3) (MICROGRAM-AT/L) 1958 - 1974 150.1 - *99.0 METERS

WINTER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	4.87	3.51	4.43	.4	7
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	-99.99	-99.99	-99.99	-99.9	-99
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	6.00	5.74	5.83	.1	8
28	-99.99	-99.99	-99.99	-99.9	-99
29	-99.99	-99.99	-99.99	-99.9	-99
30	-99.99	-99.99	-99.99	-99.9	-99
31	6.48	4.47	5.73	.5	26
32	-99.99	-99.99	-99.99	-99.9	-99
33	7.89	4.62	5.72	.9	18
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	6.56	3.32	5.15	1.1	17
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99

SPRING

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	5.01	4.32	4.62	.2	33
18	-99.99	-99.99	-99.99	-99.9	-99
19	6.61	5.23	6.27	.5	10
20	5.39	5.25	5.32	.1	2
21	-99.99	-99.99	-99.99	-99.9	-99
22	6.72	6.30	6.47	.2	3
23	6.94	6.40	6.61	.3	3
24	-99.99	-99.99	-99.99	-99.9	-99
25	6.70	6.39	6.54	.2	2
26	6.74	6.74	6.74	.0	1
27	-99.99	-99.99	-99.99	-99.9	-99
28	-99.99	-99.99	-99.99	-99.9	-99
29	7.51	5.29	6.72	.5	16
30	7.01	4.58	6.12	.9	8
31	-99.99	-99.99	-99.99	-99.9	-99
32	6.69	5.29	6.44	.4	16
33	7.65	3.74	5.65	1.1	15
34	6.64	5.77	6.46	.3	8
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	6.64	5.70	6.46	.2	11
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	6.63	4.22	5.81	.9	8
42	4.90	3.83	4.37	.8	2

SUMMER

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	-99.99	-99.99	-99.99	-99.9	-99
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	5.86	4.52	5.14	.6	4
21	-99.99	-99.99	-99.99	-99.9	-99
22	5.69	3.83	4.92	.6	7
23	-99.99	-99.99	-99.99	-99.9	-99
24	-99.99	-99.99	-99.99	-99.9	-99
25	4.79	4.79	4.79	.0	1
26	6.93	6.93	6.93	.0	1
27	6.76	6.52	6.64	.1	6
28	-99.99	-99.99	-99.99	-99.9	-99
29	6.12	2.97	4.91	1.1	6
30	-99.99	-99.99	-99.99	-99.9	-99
31	6.48	6.48	6.48	.0	1
32	5.50	4.51	5.01	.5	3
33	6.77	3.69	5.65	.7	36
34	6.31	6.28	6.30	.0	2
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	5.66	3.89	4.93	.7	9
38	-99.99	-99.99	-99.99	-99.9	-99
39	-99.99	-99.99	-99.99	-99.9	-99
40	-99.99	-99.99	-99.99	-99.9	-99
41	4.14	4.11	4.12	.0	2
42	-99.99	-99.99	-99.99	-99.9	-99

AUTUMN

ZONE	MAX	MIN	MEAN	SD	N
15	-99.99	-99.99	-99.99	-99.9	-99
16	-99.99	-99.99	-99.99	-99.9	-99
17	4.65	4.07	4.37	.3	4
18	-99.99	-99.99	-99.99	-99.9	-99
19	-99.99	-99.99	-99.99	-99.9	-99
20	-99.99	-99.99	-99.99	-99.9	-99
21	-99.99	-99.99	-99.99	-99.9	-99
22	6.84	3.95	5.40	2.0	2
23	-99.99	-99.99	-99.99	-99.9	-99
24	7.07	6.33	6.70	.5	2
25	-99.99	-99.99	-99.99	-99.9	-99
26	-99.99	-99.99	-99.99	-99.9	-99
27	6.56	6.56	6.56	.0	1
28	-99.99	-99.99	-99.99	-99.9	-99
29	5.60	4.15	4.66	.8	3
30	-99.99	-99.99	-99.99	-99.9	-99
31	6.27	4.81	5.53	.6	6
32	-99.99	-99.99	-99.99	-99.9	-99
33	6.92	5.09	5.99	.5	25
34	-99.99	-99.99	-99.99	-99.9	-99
35	-99.99	-99.99	-99.99	-99.9	-99
36	-99.99	-99.99	-99.99	-99.9	-99
37	-99.99	-99.99	-99.99	-99.9	-99
38	3.27	2.76	3.01	.4	2
39	-99.99	-99.99	-99.99	-99.9	-99
40	4.35	4.24	4.30	.1	2
41	-99.99	-99.99	-99.99	-99.9	-99
42	-99.99	-99.99	-99.99	-99.9	-99