Environmental Assessment of the Alaskan Continental Shelf

Final Reports of Principal Investigators

Volume 1. Biological Studies

Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado 80302

June 1978

MSC xellograph noted

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

Environmental Research Laboratories
Wilmot Hess, Director

The facts, conclusions and issues appearing in these reports are based on interim results of an Alaskan environmental studies program managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) of the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, and primarily funded by the Bureau of Land Management (BLM), U.S. Department of the Interior, through interagency agreement.

CONTENTS

LETHAL AND SUBLETHAL EFFECTS ON SELECTED ALASKAN MARINE SPECIES AFTER ACUTE AND LONG-TERM EXPOSURE TO OIL AND OIL COMPONENTS

by

Stanley D. Rice

Sid Korn

and

John F. Karinen

Research Unit 72

Submitted as part of the Final Report
for Contract #R7120822

OUTER CONTINENTAL SHELF ENERGY ASSESSMENT PROGRAM
Sponsored by
U. S. Department of the Interior
Bureau of Land Management

April 1, 1978

Northwest and Alaska Fisheries Center, Auke Bay Laboratory
National Marine Fisheries Service, NOAA
P.O. Box 155, Auke Bay, AK 99821

Annual Report

(For the Period April 1, 1977 to March 31, 1978)

Table of Contents

Summary and Implications of Research

Progress on FY 77 studies for research unit #72 was generally good except for a few studies requiring considerable chemical expertise. Loss of three chemists (GS-11, GS-9, GS-7) from the program mid-way through the fiscal year followed by a delay of 2 months before replacement with one permanent chemist (GS-9) and a temporary chemist (GS-5) required rescheduling of some projects. Chemical support is now nearly back to normal with the exception that the GS-11 chemist has not been replaced, reducing our capacity for chemical R&D and manuscript preparation. Contract support from the NOAA National Analytical Facility, including co-authorship of some chemically oriented studies has helped to relieve this problem of chemical support.

Progress on FY 78 studies is going well and is generally on schedule. Progress on studies requiring chemical R&D is satisfactory with no major problems encountered.

A number of manuscripts are in preparation but a significant back-log of manuscripts exists. Progress on manuscripts is returning to normal, assisted by the fact that several junior scientists within our research unit have developed professionally to the level of competent writers. An up-grading of professional competence in oil research is common throughout the research unit, which is paradoxical in light of the recent indications of reduced funding for effects studies and the continued need for such studies.

A substantial base of oil effects data has been accumulated. Implications are that

(1) Oil effects and responses of organisms to oil are complex, species dependent, and variably modified by environmental factors (temperature, salinity etc).

(2) Effects studies are producing a number of observations useful in evaluating the impact of oil in the real environment.

(3) There is a need to test laboratory findings in the field.

(4) Several research findings indicate the need for further effects research, especially with long-term chronic exposures.

(5) Extremely low concentrations of hydrocarbons reduce survival of marine organisms.

(6) Immediate or delayed death is not necessarily a prerequisite to impact on a life stage; behavioral changes of larvae (nonswimming response) may be just as effective in eliminating the individual (predators) as outright death from oil.

(7) Much of the research data generated in this program has had immediate application and use by regulatory agencies, e.g. Alaska Governor's Office, legislative committees, and Federal and State Agencies.

Introduction

General Nature and Scope of Study

The research is addressed to the general question, "What are the effects of petroleum hydrocarbons on arctic and subarctic biota"? It involves physiological and bioassay tests of applied research on species indigenous to the Gulf of Alaska, Bering Sea, and Beaufort Sea. The major emphasis of research has shifted from strictly descriptive acute toxicity determinations to mechanistic studies and sublethal tests that will eventually allow prediction of oil impact on the biota.

Our studies can be broken down into two basic themes. (1) Toxicity challenge experiments, where we attempt to identify sensitive species, life stages, factors that affect toxicity, or components that are most responsible for toxicity, and (2) sublethal physiological response, where we attempt to identify, measure, and characterize physiological responses that are indicative of oil stress. Eventually these sublethal studies will provide information useful in identifying exposed animals in the field, an evaluation of how stressed the exposed animals are, and possibly the mode or mechanism of toxic action. We often conduct uptake-depuration studies in parallel to the above tests, to correlate tissue concentrations with effects, which will aid in the interpretation of results.

OCSEAP funding on effects studies at Auke Bay began in the last 2 months of FY 75, continued at significant funding levels through FY 76, 77, and will continue through at least FY 78. This report describes progress associated with OCSEAP funding only, and draws from published or drafted manuscripts and unwritten but completed studies up to April 1978.

Specific Program Objectives

General program objectives have remained relatively constant throughout the life of this research unit, although emphasis has changed as information on various aspects of oil impact has accumulated. A list of current and recent past objectives follows. Objectives which have significant data accumulation are indicated with an asterisk *.

1. Toxicity challenge experiments

A*. Determine the comparative sensitivity of Alaskan marine organisms to oil and oil components.

B*. Compare static and flow-through tests--determine the validity and reliability of static tests for comparing animal sensitivities to oil.

C*. Determine whether Alaskan species are more sensitive to oil than animals from warmer climates.

D. Determine the effect of temperature on toxicity and sensitivity.

E*. Determine the sensitivity of comparative life stages of fish to oil.

F*. Determine the sensitivity of comparative life stages of crustaceans to oil.

G*. Identify the major toxic compounds or fractions in the water-soluble fraction (WSF) of oil.

H. Determine whether the major toxic components have similar modes of action, metabolic rates, uptake-depuration rates and if they are synergistic or antagonistic to each other.

2. Sublethal effects experiments

A. Determine behavioral responses of organisms to oil and the effect on survival.

B*. Determine the effects of aromatic hydrocarbons on byssal thread formation in mussels.

C*. Determine the effects of aromatic hydrocarbons on oxygen consumption and breathing rates in pink salmon fry.

D. Determine the pathway of elimination from fish of aromatic hydrocarbons.

E*. Determine the effect of aromatic hydrocarbons exposures on crab heart rates and oxygen consumption.

F. Determine the effect of aromatic hydrocarbons on growth of fish and invertebrates.

Revelance to Problems of Petroleum Development

The above objectives when answered will allow an evaluation of the relative contribution of each important oil component to the toxicity of oil WSF. This information will allow some prediction of effects of oil contamination on the biota by relating chemical analyses of the water (amount of each important oil component) to the toxicity of each component. In addition, the other objectives will evaluate comparative sensitivities of Alaskan organisms, effects of temperature on toxicity, and effects on sublethal physiological parameters.

Uptake-depuration information relating tissue burdens with particular exposure regimes, with observed sublethal effects, and with measured stress factors is of particular value in understanding the impact of hydrocarbons in the environment. Coincident with this is the need for information on the duration that a particular physiological pertubation exists in an animal following exposure. In other words, can we identify animals in the field which have been exposed to oil for short durations or chronic levels of oil? Do they recover rapidly? Information collected is expected to have considerable value in detecting, predicting, and monitoring oil impacts in the environment when coupled with hydrocarbon baseline information, information on concentrations achieved in the field following spills, and the persistence of oil in arctic environments.

The research completed on a number of spills indicating that oil from spills in temperate and Arctic regions is much more persistent than oil spilled in warmer waters shows the value of research on the effects of temperature on oil toxicity, sublethal effects, metabolism, etc. Our data indicate that temperature and salinity affects the sensitivity of marine organisms to oil and these effects are species dependent, therefore the need for more information on temperature and salinity effects is apparent.

Current State of Knowledge

Prior to this research, information on acute and chronic toxicity to Alaskan organisms was limited to certain commercial species. Beyond acute toxicity determinations little was known about sublethal effects or the relative toxicity of important oil components. A base of information has now begun to accumulate on acute toxicity, sublethal effects, behavioral responses, and the effects of various factors on these parameters, but it is only a small part of the information needed to predict and evaluate the major impacts of hydrocarbons in the marine environment. Essentially little is yet known about the effects of temperature, salinity, and pressure (depth) on the ability of arctic organisms to metabolize, eliminate or recover from petroleum exposure.

A recent (December 1977) review of RU #72 prepared for OCSEAP discusses the current status of knowledge and research needs relevant to research objectives of this project. The list of completed and in-progress publications at the end of this report forms part of the information base for that discussion.

A considerable amount of information has been generated in this effects study and in other effects studies throughout the scientific community. There is a need to review the current status of knowledge, take a close look at information gaps, and the direction of future research. In our opinion there is still a great need for effects research information, especially the correlation of effects observed in the laboratory with effects noted in field exposures, and the determination of exposure regimes and tissue burdens in field and laboratory exposures.

Progress on FY-77 Studies

Situation

The progress in FY 77 was generally good, except in a few studies requiring chemical expertise. The death in late FY 77 of a competent chemist spearheading two projects was a severe blow to the entire program. The transfer of one chemist and the resignation of a second chemist for personal reasons, created additional voids during the same time period. A replacement chemist was finally hired after a delay of 2 months and by mid-summer we had added a temporary chemist to carry us through the fiscal year.

This series of events, especially the death of a colleague and a friend, created an emotional atmosphere which undoubtably affected our performance and resulted in the loss of two positions, one permanent and one part-time permanent from the program.

Accomplishment (Study Title, Objectives, Methods, Status, Results, and Significance)

1. Determination of the acute toxicity of the water-soluble fraction WSF of crude oil:

Objective 1A: Determine the acute toxicity to species not tested previously.

Methods: Acute static 96 h bioassays were conducted before being phased out and flow-through tests substituted. Animals were retained in clean water for observation of delayed mortality.

Status: The manuscript "Toxicity of Cook Inlet Crude Oil and No. 2 Fuel Oil to Several Alaskan Marine Fishes and Invertebrates" was presented at the AIBS meeting in Washington, D.C. 1976, but included no GC measurements. Some of these tests had GC measurements, but were not included, while many of the earlier tests with sensitive and commercial species were conducted prior to our ability to analyze WSF's by GC. Consequently, we have conducted a few more static bioassays with crude and No. 2 fuel oil to several new species that represent groups we have not tested and several old species that we had tested before, but lacked GC analysis. Except for a study comparing static and flow-through tests with sensitive and tolerant species, this is the last study containing static tests and is intended to be a final study comparing sensitivities based on GC and IR measurements of over 30 subarctic species from several phyla and environments. With only 2 species remaining to be tested (availability is limited by season), the drafting of a final manuscript is in progress now. A summary of bioassays completed by species follows in Table 1.

Results: We found fish and shrimp to be the more sensitive animals tested with oil, with some exceptions, like starry flounder. Most subtidal invertebrates such as shrimp, crabs, and sea urchins were also moderately sensitive. Intertidal animals were quite tolerant to 96 h static exposures, probably because they are adapted to environmental stress and can "close-up" during brief static exposures to oil solutions which are declining in concentrations over time. The sensitivities to 96 h static exposures, with declining doses, vary considerably between various animal groups, much more so than sensitivities during 96 h flow-through exposures (see next objective #1B).

Significance of Results: These results simulate brief exposure to oil from a point source and give environmental managers information on the types of animals that are most sensitive to short-term, acute oil exposures.

Objective 1B: Compare sensitivites of tolerant and sensitive species to toluene and naphthalene when exposed in static and flow-through tests.

Methods: Pink salmon, the black sea cucumber *Cucumaria vegae*, the shore crab *Hemigrapsus*, *Eualus* shrimp, and a subtidal snail *Colus* sp. were tested with naphthalene and toluene using both static and continuous-flow bioassay methods. In the static bioassays, the concentrations decline with time, while in flow-through tests, the concentrations remain stable.

Table 1. Status of static crude oil and No. 2 fuel oil bioassays Species tested using 96 h static bioassays with Cook Inlet Crude oil (CI) and No. 2 fuel oil (FO).

Species	Completed by FY 77		Completed or scheduled[1/] in FY 78	
Fish				
1. *Oncorhynchus gorbuscha*	CI	FO		
2. *Salvelinus malma*		FO	(CI)	
3. *Theragra chalcogramma*	CI	FO		
4. *Clupea pallasi*	CI	FO		
5. *Platicthys stellatus*	CI			(FO)
6. *Myoxocephalus polyacanthocephalus*	CI	FO		
Crustacea				
7. *Orchomene pinguis*	CI	FO		
8. *Acanthomysis pseudomacropsis*	CI	FO		
Crustacea-shrimp				
9. *Pandalus borealis*			CI	FO
10. *Eualus suckleyi*	CI			FO
11. *Crago alaskensis*	CI	FO		
Crustacea-crabs				
12. *Pagurus* sp.			CI	FO
13. *Hemigrapsus nudus*	CI	FO		
14. *Paralithodes camtschatica*			CI	FO
Echinoderms				
15. *Strongylocentrotus drobachiensis*			CI	FO
16. *Leptasterias hexactis*			CI	FO
17. *Eupentacta quinquesimita*	CI	FO		
18. *Cucumaria vega*	CI	FO		
Mollusks - Limpets and Chitons				
19. *Collisella scutum*	CI	FO		
20. *Notoacmaea pelta*	CI	FO		
21. *Katharina tunicata*	CI			FO
22. *Tonicella lineata*	CI			FO
23. *Mopalia cilliata*	CI			FO
Mollusks-clams				
24. *Chlamys hericus*	CI			FO
25. *Mytilus edulis*		FO	CI	
26. *Protothaca staminea*	CI	FO		
Mollusks-snails				
27. *Margarites pupillus*	CI			FO
28. *Littorina sitkana*	CI	FO		
29. *Nucella lima*	CI	FO		
30. *Colus halli*		FO	CI	
31. *Buccinum plectrum*	CI			FO

1/ Those in parentheses are scheduled and will be completed by June 1978.

Status: All tests are complete. The manuscript "Comparative sensitivities of five marine organisms exposed to toluene and naphthalene by static and flow-through tests" is in preparation.

Results: The differences between static and flow-through tests for a given species have been insignificant with the sensitive fish and shrimp, and dramatically different with tolerant species. The differences between animal response to the static and flow-through exposures is probably caused by the rate of toxicity. The "so called" sensitive species take up hydrocarbons quickly, effects are noted within a few hours, and deaths appear in 12 h or so. The tolerant species do not show signs of stress (except the slowing down and lack of movement), and deaths are not noted for at least 24-48 h. These animals have the ability to "hold up" and wait for the static concentrations to decline to sublethal concentrations.

Significance: These tests tell environmental managers that some animals can be tolerant to short-term exposure to WSF's of oil, and can have better survival rates if the concentrations decline within 24-48 h. If the concentrations continue at relatively high concentrations, all animals appear vulnerable.

Objective 1C: Determine acute toxicity of WSF and aromatic hydrocarbons to (a) larvae of new species, previously untested, and (b) crustacean larvae; before, during, and after molting.

Methods: Tests will be static. Larvae of previously untested species (such as mussels, barnacles, snails, and sea urchins) will be tested with WSF, toluene, and naphthalene. Massive cultures of daily released crustacean larvae will be reared on phytoplankton until tested.

Status: (a) Tests with several species were cancelled because of hiring freezes that caused administrative delays in hiring key personnel.

(b) Toxicity tests with coonstripe shrimp larvae before, during, and after molting from Stage I to II were completed with both toluene and naphthalene. A manuscript that compares toxicity data and uptake data (see objective 4A) is in progress. "Acute toxicity and uptake-depuration of toluene and naphthalene by coonstripe shrimp larvae exposed before, during, and after molting from Stage I to II".

Results: Molting animals were more sensitive than nonmolting animals when exposed to toluene, but little difference was observed for naphthalene.

Significance of Results: Molting larvae seem to be the most sensitive stage ever tested to oil. Mortality to toluene was found at ppb levels which could occur in the environment after an oil spill.

Objective 1D: Determine sensitivity changes of several salmonid species when transferred to seawater at time of normal seaward migration.

Method: Salmon smolts were tested (static bioassay) in fresh water and after acclimation to salt water.

Status: Data acquisition and analyses have been completed. The data on out-migrant smolt tests in seawater has been included in the manuscript "Sensitivity of Alaskan Freshwater and Anadromous Fishes to Prudhoe Bay Crude Oil and Benzene". The manuscript will be submitted to a journal in April 1978.

Results: The sensitivity of three species of salmonid smolts in seawater (after rapid acclimation-3 days) was about twice the sensitivity of out-migrant smolts tested in freshwater, to toluene, naphthalene, and WSF of Prudhoe Bay crude oil. Even though the out-migrant smolts are "pre-adapted" for the normal migration to seawater, the initial introduction is stressful, resulting in a lowered tolerance to oil.

Significance of Results: Salmon are most sensitive to oil pollution at the time of smolt migration from fresh- to seawater. Environmental managers will want to minimize the risk of oil pollutants in estuaries that first receive out-migrant smolts.

2. Determine which components of oil account for toxicity:

Objective 2A: Assess the toxicity role of phenols and heterocycles by determining quantities available in oil and WSF's, determining the acute toxicity of the major compounds found in the WSF to two species and determining the persistent compounds in the tissues of exposed organisms.

Method: Standard 96 h static assays were used. Oil and WSF samples were analyzed by GC-MS. Labeled compounds were used in uptake-depuration tests.

Status: All bioassay and uptake tests have been completed. Detailed analyses by National Analytical Laboratory at Seattle are completed. The manuscript "Occurrence of toxicity, accumulation, and depuration of phenol and cresol in salmon and shrimp" is in preparation.

Results: Phenols and cresols were found in low concentrations in oil and oil WSF. Cresol was more toxic than phenol (TLm's were in the low ppm range). Salmon were more sensitive to both compounds than shrimp. Phenol and cresol accumulate in both species and the retention was longer in shrimp than salmon.

Significance: The relatively low toxicity, low accumulation, and low concentration (low availability) of the compounds in oil WSF indicates that phenol and cresol are not major contributors to the toxicity of un-aged oil WSF.

Objective 2B: Determine toxicity of natural WSF and a synthetic WSF to three species with flow-through tests to determine whether the synthetic WSF accounts for all the toxicity.

Method: A synthetic WSF will be created by combining the most important aromatic oil components (as determined by GC) in the same ratio that they are found in the natural WSF. Flow-through bioassays will compare the toxicity of the synthetic and natural WSF's. Compounds will be added or deleted as needed to account for toxicity.

Status: This study was delayed by the death of Loren Cheatham, chemist, and resignation of chemist Sue Way, who operated the GC. The new chemist, Steve Lindsay, has received specific GC training for WSF hydrocarbons; and GC analyses have been calibrated with standards from NOAA analytical facility at Seattle. Some R&D was started in FY 77, but R&D for WSF generation was not completed until early FY 78 and this project is currently in progress in FY 78.

Objective 2C: Determine the magnitude of synergistic action of mono- and dinuclear aromatic hydrocarbons by conducting time-dependent toxicity recovery curves with mono- and dinuclear aromatics to three species with flow-through tests.

Methods: Tests will be with individual compounds and combined mixtures. Standard flow-through assays with stable concentrations will be used. This will be a beginning effort to assess the relative importance of mono- and dinuclear aromatics.

Status: This study was also delayed by the loss of two chemists. The project was re-evaluated and included as FY 78 goal and is currently in progress (see section 4).

3. Effects of oil on survival of animals in the field:

Objective 3A: Determine the effects of short-term exposures to WSF's on the survival of tagged scallops that are returned to the natural environment.

Methods: Scallops will be tagged, exposed, and returned to pens in Auke Bay, with exposed and nonexposed starfish (*Pycnopodia helianthodes*) also being introduced into the pens. Their survival will be monitored for up to 3 months. Tests with pure aromatic fractions will also be used.

Status: Preliminary tests with scallops exposed to sublethal doses of oil and returned to pens in the natural environment indicated that oil exposure reduced survival. Control and exposed scallops were preyed upon by the sunflower star Pycnopodia helianthodes which entered the pens. A follow-up study with scallops and Pycnopodia was completed; however, reduced feeding by both control and oil exposed starfish made the results of the experiment inconclusive. Handling of starfish is believed to have disrupted their incentive to feed. As we have found previously, field studies are unpredictable and often require large samples, difficult logistics, and much R&D due to the many uncontrollable variables.

4. Determine the tissue burden of several species exposed to oil or labeled aromatics, and their ability to rid themselves of hydrocarbons.

Objective 4A: Determine the accumulation in larvae of WSF's spiked with labeled isotopes.

Method: Larvae were exposed for varying lenths of time to radiolabeled compounds and analyzed by liquid scintillation counting. The form of the isotope (parent compound vs metabolite) were determined by the method of Roubal (1976). No attempt was made to identify metabolites.

Status: Data acquisition completed. Coonstripe shrimp larvae (stages I, II, and I molting to II) were exposed to labeled toluene and naphthalene. Analyses of live vs dead larvae (killed with O_2 deprivation) and of molted skins and bodies of stage II, were completed. Roubal samples for metabolites were taken. The manuscript "Accumulation and depuration of ^{14}C toluene and naphthalene in stage I, stage II, and molting coonstripe shrimp larvae" is being prepared.

Results: Larvae accumulated oil components very rapidly (equilibrium levels in 20-60 minutes), probably because of the high surface area to volume ratio. We showed that labeled hydrocarbons were taken up, rather than adsorbed on the carapace surface, by finding essentially all the isotope in Stage II larvae that had been exposed only as Stage I, prior to molting (and no isotope was found in the cast exoskeleton). Depuration of naphthalene was slow (96 h), but toluene depuration was even slower (most remaining after 96 h). Live larvae accumulated more rapidly than dead larvae.

Significance: Shrimp larvae accumulate oil components very rapidly. Even a brief exposure will cause the maximum amount of accumulation. The observation of rapid toxicity and rapid uptake have been used by oil discharge permit reviewers to justify the implementation of lower discharges during the spring in Cook Inlet.

The slow depuration, especially toluene, indicates low or nonexistant metabolic potential. Shrimp larvae would transfer accumulated residues to their predators (next trophic level).

Objective 4B: Determine the aromatic hydrocarbon uptake depuration pattern in salmonid smolts when exposed in seawater and in fresh water.

Methods: Effects of salinity on uptake, metabolism and depuration were investigated by exposing pink and chum salmon out-migrant fry (fresh water and salt water simultaneously) to the toxicants for 24 h and sampling for isotopic content and percent metabolite (by the method of Roubal) in whole animals during exposure and during the clean water depuration phase. Isotope counting was by liquid scintillation.

Status: The uptake, metabolism, and depuration of radio-labeled toluene, naphthalene, and methyl naphthalene were determined with pink salmon and chum salmon fry acclimated to fresh water and to seawater. The comparison of uptake in fresh and seawater is included in a manuscript currently in progress "uptake and depuration of ^{14}C toluene and naphthalene by different life stages of salmon".

Results: Salinity did not affect accumulation or depuration of labeled compounds in whole animals. The increased sensitivity of salmon in seawater vs fresh water cannot be explained by different uptake patterns between fresh and seawater exposures. A small follow-up study to look at other parameters to explain this difference is currently in progress in FY 78.

Objective 4C: Determine the pathway and rate of elimination of labeled mono- and dinuclear aromatics in fish; identify the labeled compounds as "parent" or "metabolite".

Methods: Salmon were fed ^{14}C naphthalene or toluene. The fish were placed in partitioned chambers which separated the gill area from the anal area, and with the ureters catheterized. Samples of water from the gill and anal chambers were analyzed periodically during the 24 h experiments. Samples of urine and tissue were analyzed radiometrically at the end of 24 h. Metabolite percentage was determined for each sample.

Status: Data collection was completed. The manuscript "Excretion of labeled toluene and naphthalene by gills vs gut of Dolly Varden trout" is in review.

Results: Toluene was eliminated more rapidly than naphthalene, primarily from the gill as parent hydrocarbon. There was less metabolism of toluene than naphthalene. Very little naphthalene was excreted in 24 h. Small percentages of the total amount ingested appeared in liver, gall bladder, intestine, but was almost entirely metabolite.

Significance: These results explain the mechanisms of oil hydrocarbon elimination, and the differences observed in the retention of mono- and dinuclear aromatic hydrocarbons.

Objective 4D: Determine the uptake, metabolism, distribution and elimination of naphthalene in intertidal Hemigrapsus crabs.

Methods: Adult crabs were exposed to ^{14}C naphthalene and the blood, hepatopancreas, muscle, gut, and nerve ganglion sampled periodically during exposure and a depuration period. The Roubal method was used to determine metabolite level. Crabs were exposed to naphthalene in their bath then divided into three groups for depuration in water, in air, or normal tidal cycle.

Status: The study was completed. Results from this study are to be combined with another test with toluene scheduled for this spring 1978.

Results: Hepatopancreous accumulated the most, followed by nerve ganglion, green gland and muscle. The most metabolism occurred in the green gland. Residues are depurated at a slower rate than in fish. Depuration was slowed considerably during air exposures.

Significance: Understanding the pathways and metabolic rates of aromatics in invertebrates brings us closer to the point of predicting the impact of oil on this species. This is some of the first work ever on this type of intertidal invertebrate.

5. Effects of oil and oil components on byssal thread formation in mussels.

Objective 5A: Determine the rate of byssal thread extrusion of mussels exposed to WSF, toluene and naphthalene.

Method: Mussels were exposed to oil, toluene, and naphthalene for 48 h under static conditions. The rate of byssal thread extrusion was monitored during and after exposure.

Status: The study was completed and the manuscript "Effects of crude oil WSF, toluene, and naphthalene on byssal thread extrusion rates of mussels" is in preparation.

Results: The byssal thread extrusion rate was reduced by exposure to oil components at sublethal levels. The reduction was linearly related to oil concentration for each of the toxicants.

Significance: Reduction of byssal thread extrusion could have major implications in the field. The success of juvenile mussel attachment could be lowered, and adults could have reduced survival due to their inability to replace damaged byssal threads and subsequent loss from the substrate.

6. Temperature effects on oil toxicity and metabolism.

Objective 6A: Determine the effect of temperature on fish and shrimp sensitivity to toluene and naphthalene, and the effect on uptake-depuration.

Method: Uptake tests and bioassays were flow-through. Samples were taken during the uptake tests to determine percent of metabolite (Roubal method). During the uptake studies, viscera, muscle and whole body residues were determined.

Status: Flow-through assays and uptake studies were completed at 4°, 8°, and 12°C with toluene and naphthalene exposures to pink salmon juveniles and Eualus shrimp. The manuscript "Effects of temperature or accumulation and depuration of aromatic oil components in pink salmon and Eualus shrimp" is in preparation.

Results: No effects of temperature were found on oil component accumulation and depuration. Flow-through tests supported previous results of the earlier static temperature study in that toluene was more toxic to fish at lower temperatures and naphthalene was more toxic to shrimp at high temperatures. These results were expected because both species are relatively sensitive, with rapid uptake, and effects are observed quickly after beginning exposure; indicating that most of the "action" is in the first few hours, when there is little difference between static and flow-through exposures. Effects of temperature on uptake would probably be noted on "slow" species, such as sessile molluscs.

Significance: Effects of temperature on toxicity vary with species. Certain animals are more sensitive at cold Alaskan temperatures indicating the need for more study. Toxicity mechanisms differ between fish and shrimp.

Progress on FY 78 Studies

Situation

In FY 78, our studies are generally going well, and are on schedule. The preparation of manuscripts is increasing, probably about normal now, although the finished-reviewed products are some time away.

Accomplishments (study, title, objectives, methods, and status

1. Toxic components and synergism of toxic components:

Objective 1A: Compare the toxicity of water-soluble fractions (WSF's) of crude oil with synthetically produced WSF's.

Methods: Exposures are flow-through, analyses by GC, and test animals are pink salmon fry and shrimp (*Eualus*). Synthetic mix contains the most important aromatics in the same amounts as oil WSF.

Status: Experimental design is complete. The apparatus has been constructed, and is being tested, and tests on shrimp are scheduled to begin in spring 1978. GC analytical equipment has been upgraded (automatic sample changer and integrator) and is functional.

2. Synergistic effects of toluene and naphthalene:

Objective 2A: Determine if toluene and naphthalene have synergistic toxicities to pink salmon fry, snails (*Colus* sp), *Mytilus*, and *Eualus* shrimp under flow-through conditions.

Methods: Flow-through bioassays will be used with both compounds individually and simultaneously.

Status: The assays testing toluene and naphthalene with *Eualus* shrimp were completed in December 1977 and data analyses are in progress. Tests with the snails, *Colus jordani* and the mussel, *Mytilus edulis* have been completed (March 1978). Final tests with pink salmon fry are scheduled for spring 1978, when they are available.

Objective 2B: Determine if toluene and naphthalene have synergistic effects on uptake and/or depuration in pink salmon fry, snails (*Colus* sp) and *Eualus* shrimp.

Methods: Uptake studies (2-4 days) will be run to determine the equilibrium levels of each toxicant alone, then together. Static solutions are changed as needed to keep the concentration stable (above 90% of initial). Liquid scintillation counting is used for residue analyses, and some samples are analyzed for percent metabolite (Roubal et al. 1974).

Status: Synergistic uptake studies with *Eualus* shrimp were completed, and will be followed by tests in April with snails, and in May with pink salmon fry.

3. Larval Studies

Objective 3A: Determine the sensitivity of eggs and larvae from several noncommercial species, e.g. barnacles, mussels, snails, and sea urchins.

Methods: Static exposures will be used for these microscopic larvae, and will include tests with WSF's, toluene, and naphthalene.

Status: Larval bioassays are scheduled for spring and summer 1978 when wild test organisms will be available. Eggs have been collected from several species and are being incubated.

Objective 3B: Determine what concentrations impair swimming ability of larvae.

Methods: Several species will be tested with WSF's, toluene, and naphthalene. Inability to swim will be interpreted as equivalent to death in the natural environment.

Status: This study is scheduled for spring and summer 1978 when larvae become available.

4. Accumulation Studies

Objective 4A: Determine the uptake and retention of hydrocarbons into gonads, new eggs, and old eggs carried by *Eualus* shrimp.

Methods: Exposures will be WSF's and isotopes, and analyses by GC and liquid scintillation. Isotope exposures are 24 h at each stage. Shrimp carrying new eggs are exposed continuously for 10 days to oil WSF. Shrimp gonad, muscle, and hepatopancreas will be sampled and analysed by liquid scintillation or GC.

Status: All studies are finished. GC analyses of tissues is in progress. Data work-up of isotope exposures is in progress.

Objective 4B: Determine the uptake of isotopes into tissues of fresh water and seawater adapted salmonid smolts.

Methods: Fresh water and salt water adapted smolts will be simultaneously exposed to ^{14}C aromatics for 24 h. Brain, liver, muscle, gill and intestine will be analyzed by liquid scintillation.

Status: This study is scheduled for summer 1978. Dr. R. Thomas, Chico State University will be co-investigator for this project.

5. Effects of salinity on oil toxicity

Objective 5A: Determine the osmotic and ionic composition of blood in fresh water and seawater adapted smolts exposed to toluene and naphthalene.

Methods: Salmon smolt will be exposed under flow-through conditions to toluene and naphthalene while their blood osmotic pressure and ionic composition is monitored. Dr. W. Stickle, Louisiana State University, will be co-investigator for this experiment.

Status: Osmotic studies are scheduled for May-June 1978 when wild smolts normally migrate from fresh water to salt water.

6. Long-term Exposures

<u>Objective 6A</u>: Determine the effects of flow-through toluene and naphthalene exposures on growth and survival of pink salmon fry exposed at different temperatures.

<u>Methods</u>: Tests will be 40 days long, with samples of fish taken at 10-day intervals to assess effects on growth, fat content and caloric content. Tests will be replicated at two temperatures to determine the influence of temperature on toxicity in long-term exposures.

<u>Status</u>: Design of the apparatus is complete with experiments scheduled for spring and summer 1978.

<u>Objective 6B</u>: Determine the sensitivity of several intertidal species to toluene and naphthalene exposures, with and without intermittent exposures to air.

<u>Method</u>: Flow-through bioassays will be used with animals in water and animals exposed on a tidal cycle (air and water).

<u>Status</u>: Bioassay with <u>Hemigrapsus nudus</u> to toluene and naphthalene are scheduled for spring 1978.

7. Dispersant testing

Literature review and R&D on methods of analysis and exposure will be probed. This will be a trial exercise in preparation for expanded testing in FY 79. We will conduct a literature survey and identify the dispersants of interest, and conduct some preliminary tests with dispersants on fish and shrimp in the summer of FY 78.

Status: Literature review has started. New information was learned at the recent ASTM Conference on dispersants. Five dispersants are now approved by EPA for uses that include "minimizing environmental damage". New dispersants are relatively non-toxic, effective even at ratios of 1/50. Exposures scheduled for summer 1978.

Recent preliminary information on FY 79 indicate a substantial reduction in funds, eliminating the continued effort in dispersants. If this is true, perhaps the remaining dispersant effort should be cancelled and reprogrammed into the current studies and the manuscript backlog.

8. Writing-up of previous results:

Manuscripts describing FY 77 research projects will be completed.

Status: Robert Thomas and Stan Rice presented a paper "The significance of exposure temperatures on the sensitivity and respiration of pink salmon fry exposed to toluene and naphthalene" at the symposium on Pollution and Physiology of Marine Organisms, at Georgetown, South Carolina in November 1977. The manuscript is being reviewed for publication.

The manuscript "Effects of temperature on median tolerance limits of pink salmon fry and shrimp exposed to toluene, naphthalene, and Cook Inlet crude oil" was revised and resubmitted for publication.

Several manuscripts have been worked on, but progress has been less than hoped for. A reduction from $500k in FY 77 to $300k in FY 78 has eliminated several personnel from the staff who contributed in the writing of manuscripts. Some manuscripts are being co-authored by co-investigators working for other agencies in other parts of the country. As for three manuscripts, the senior author is deceased, however, completion by junior authors is in progress.

Problems Encountered

No major problems have been encountered in research activities. Functionally, however, the present funding level is below optimum for the research unit.

MILESTONE CHART

▽ Technique development
□ Experiment in progress
○ Data collected
△ Data analysis
Proposed - Open
Actual - Darkened

RU #: 72 PI: Karinen, Rice, and Korn

25

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

27

MAJOR MILESTONES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
A. Toxic components & synergism (flow-thru)															
1. Comparison of natural & synthetic WSF															
a. pink salmon fry			▽			▼			□						
b. Eualus shrimp			▽			▼ □		□							
2. Synergism of toluene, naphthalene															
a. Toxicity bioassay			▼												
(1) pink salmon fry			▼						□			□			
(2) Eualus shrimp			▼			■									
b. Uptake/depuration															
(1) fry									□						
(2) shrimp						■									
B. Larvae															
1. Sensitivity of non-commercial species to static exposure of WSF, toluene & naphthalene.									□			□			
2. Failure to swim after WSF, toluene, naphthalene									□						
a crustacean															

MILESTONE CHART

▽ Technique development
□ Experiment in progress
○ Data collected
△ Data analysis
Proposed - Open
Actual - Darkened

RU #: 72

PI: Karinen, Rice, and Korn

26

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

28

MAJOR MILESTONES	1977			1978											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
b. non-crustacean															
3. Uptake and retention of labeled WSF into new and old shrimp eggs			■			●	△		□			□			
C. Sensitivity increase to smolts in sea H_2O															
1. Isotope uptake into tissues								□				□			
2. Osmotic and ionic composition of blood								□				□			
D. Long-term exposure (flow-thru)															
1. Effect of toluene, naphthalene (40d exposure) on pink salmon fry, f(T)						▽			□						
2. Survival of tolerant and sensitive species to toluene, naphthalene, WSF			▽	▼		■			□			□			
E. Effect of intermittent air exposure on sensitivity of intertidal species to															
1. Sensitivity						▼			□			□			
2. Uptake/depuration of labeled compounds												□			
F. Dispersant testing															
1. Literature review			▼												
2. R&D on methods and exposure												▽			

Estimate of Funds Expended for FY 78

	Annual Plan	Costs to Feb. 28, 1978
Salary Costs (base pay + benefits & COLA)	$150.3	$150.3 1/
Travel	9.7	7.8
Contracts	18.5	8.3
Equipment and Supplies	42.3	30.1
Other Direct & Indirect Costs	79.2	79.2 1/
Total	$300.0K	$275.7K

1/ Salary costs projected through September 30.

BIBLIOGRAPHY

Rice, Stanley D. 1973. Toxicity and avoidance test with Prudhoe Bay oil and pink salmon fry. In: Proceedings of Joint Conference on Prevention and Control of Oil Spills, p. 667-670. American Petroleum Institute, Environmental Protection Agency, and U.S. Coast Guard, Washington, D.C.

Karinen, John F., and Stanley D. Rice. 1974. Effects of Prudhoe Bay crude oil on molting tanner crabs, Chionoecetes bairdi. U.S. Natl. Mar. Fish. Serv., Mar Fish. Rev. 36(7):31-37.

Evans, Dale R., and Stanley D. Rice. 1974. Effects of oil on marine ecosystems: a review for administrators and policy makers. Fish. Bull., U.S. 72:625-638.

Rice, Stanley D., D. Adam Moles, and Jeffrey W. Short. 1975. The effect of Prudhoe Bay crude oil on survival and growth of eggs, alevins, and fry of pink salmon, Oncorhynchus gorbuscha. In: Proceedings, 1975 Conference on Prevention and Control of Oil Pollution, p. 503-507. American Petroleum Institute, Environmental Protection Agency, and U.S. Coast Guard.

Thomas, Robert E., and Stanley D. Rice. 1975. Increased opercular rates of pink salmon (O. gorbuscha) fry after exposure to the water-soluble fraction of Prudhoe Bay crude oil. J. Fish. Res. Board Can. 32(11):2221-2224.

Rice, S.D., J.W. Short, C.C. Brodersen, T.A. Mecklenburg, D.A. Moles, C.J. Misch, D.L. Cheatham, and J.F. Karinen. 1976. Acute toxicity and uptake-depuration studies with Cook Inlet crude oil, Prudhoe Bay crude oil, No. 2 fuel oil, and several subarctic marine organisms. Northwest Fish. Cent. Auke Bay Fish. Lab., NMFS, NOAA, Processed Rep., 90p.

*Rice, Stanley D., Jeffrey W.Short, and John F. Karinen. 1976. Toxicity of Cook Inlet crude oil and No. 2 fuel oil to several Alaskan marine fishes and invertebrates. In: Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment, pp. 394-406. American Institute of Biological Sciences, Washington, D. C.

Short, Jeffrey W., Stanley D. Rice, and D. Loren Cheatham. 1976. Comparison of the standard method for oil and grease determination with an infrared spectrophotometric method on known toxic water-soluble fractions of oils. In: D.W. Hood and D.C. Burrell (editors), Assessment of the Arctic Marine Environment: Selected Topics, pp. 451-462.

*Mecklenburg, T. Anthony, Stanley D. Rice, and John F. Karinen. 1977. Molting and survival of king crab (Paralithodes camtschatica) and coonstripe shrimp (Pandalus hypsinotus) larvae exposed to Cook Inlet crude oil water-soluble fraction. In: D.A. Wolfe (ed.), Fate and effects of petroleum hydrocarbons in marine ecosystems and organisms, p. 221-228. Oxford, Pergamon Press.

*Rice, Stanley D., Jeffrey W. Short, and John F. Karinen. 1977. Comparative oil toxicity and comparative animal sensitivity. In: D.A. Wolfe (ed.), Fate and effects of petroleum hydrocarbons in marine ecosystems and organisms, p. 78-94. Oxford, Pergamon Press.

*Taylor, Tamra L., and John F. Karinen. 1977. Response of the clam, Macoma blathica (linnaeus), exposed to Prudhoe Bay crude oil as unmixed oil, water-soluble fraction, and oil-contaminated sediment in the laboratory. In: D.A. Wolfe (ed.), Fate and effects of petroleum hydrocarbons in marine ecosystems and organisms, p. 229-237. Oxford, Pergamon Press.

*Brodersen, C.C., S.D. Rice, J.W. Short, T.A. Mecklenburg, and J.F. Karinen. 1977. Sensitivity of larval and adult Alaskan shrimp and crabs to acute exposures of the water-soluble fraction of Cook Inlet crude oil. In: Proceedings, 1977 Oil Spill Conference (Prevention, Behavior, Control, Cleanup), March 8-10, 1977, New Orleans, Louisiana, pp. 575-578. American Petroleum Institute.

*Rice, S.D., R.E. Thomas, and J.W. Short. 1977. Effect of petroleum hydrocarbons on breathing and coughing rates and hydrocarbon uptake-depuration in pink salmon fry. In: Physiological Responses of Marine Biota to Pollutants, pp. 259-277. Academic Press, New York.

*Borchek, Mary Ann, and Malin M. Babcock. Effects of crude oil exposure on king crab (Paralithodes camtschatica) gill morphology. In Lab. Review, target journal: J. of Invertebrate Pathology.

*Korn, S., S.D. Rice, and D.A. Moles. The effect of temperature on the toxicity of Cook Inlet crude oil water-soluble fraction to scallops, shrimp, and pink salmon fry. Submitted to journal.

Short, Jeffrey W., and Stanley D. Rice. Accumulation, retention, and depuration of petroleum-derived hydrocarbons by four species of Alaskan marine animals (scallops, shrimp, king crab, and salmon). Submitted to journal.

Moles, Adam, Sid Korn, and Stanley D. Rice. Sensitivity of Alaskan freshwater fishes to Prudhoe Bay crude oil and benzene. In Laboratory Review.

*Cheatham, D.L., R.S. McMahon, S.J. Way, J.W. Short, and S.D. Rice. Effects of temperature, volatility, and biodegradation on the persistence of aromatic hydrocarbons in seawater. In preparation.

*Mecklenburg, T.A., and S.D. Rice. Heart rate and oxygen consumption in Alaskan king crab, Paralithodes camtschatica, exposed to Cook Inlet crude oil, benzene, and naphthalene. To be submitted to Journal of Comparative Biochemistry and Physiology. (Awaiting services of Technical Publications Editor and Laboratory Editor). In preparation.

Babcock, Malin M. Scanning electron microscopy of olfactory epithelium of pink salmon (Oncorhynchus gorbuscha) fry exposed to sublethal concentrations of benzene. In Laboratory Review, target journal; Marine Biology.

*Thomas, R.E. and S.D. Rice. In preparation. Excretion of labeled toluene and naphthalene by gills vs gut of Dolly Varden trout.

*Rice, S.D., C.C. Brodersen, S.Korn, and T.A. Mecklenburg. In preparation. Sensitivity and uptake of naphthalene and toluene by molting and non-molting coonstripe shrimp larvae.

*Brodersen, C. C. In preparation. Comparative sensitivities of four marine organisms exposed to toluene and naphthalene by static and flow-through tests.

*Taylor, T. and S.D. Rice. In preparation. Effect of crude oil WSF, toluene, and naphthalene on byssal thread extrusion rates of mussels.

*Rice, S.D., D.L. Cheatham, and D. Brown. In preparation. The toxicity, uptake, and availability of phenol, substituted phenols, naphthols, and heterocycles compounds from crude oil WSF.

---

* Indicates OCSEAP funded.

FINAL REPORT

Contract: #03-5-022-56
Task Order: #21
Research Unit: #284
Reporting Period: 4/1/77-3/31/78
Number of Pages: 70

FOOD AND FEEDING RELATIONSHIPS IN THE BENTHIC AND DEMERSAL FISHES OF THE GULF OF ALASKA AND BERING SEA

Ronald L. Smith, Principal Investigator

With

Alan C. Paulson

and

John R. Rose

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

March 1978

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONT'D)

LIST OF FIGURES

I. SUMMARY OF OBJECTIVES AND IMPLICATIONS

Our ultimate goal was to construct a detailed picture of the food and feeding relationships of the fishes in these two study areas. This should include analyses of predator size vs. prey composition; bottom type, temperature and location vs. prey composition; prey composition in diets vs. prey abundance; prey composition vs. season. The rationale behind this study was to develop an ability to predict the impact of oil development activities on the fishes in these two areas. Clearly, for example, activities which affect benthic invertebrates will directly affect those fish species which feed on them. This study, coupled with others designed to study acute and chronic toxic effects on the fish populations, will help establish the predictive base necessary to make management decisions. It is already known that certain specific geographic areas are fairly critical as overwintering areas or feeding areas for some of the fishes. Exploration and drilling activity could have a much greater impact in these areas than in others. Again, one of the ultimate goals of this study is to elucidate some of these area effects.

The relevance of these considerations should be obvious. The fishing industry is one of the most important in the state of Alaska. Commercial fishing in Alaskan waters has, in the past, contributed heavily to the landings of foreign countries such as Japan, Korea and the U.S.S.R. To an unknown extent, oil exploration and development on the outer continental shelf will impact these fisheries. Impacts other than economic will also occur but will be difficult to assess. The relevance of this project is that it adds to the total fund of information available on the risks of oil development. Other information will be provided, hopefully, on the benefits of development. With the risks and benefits of a particular course of action clearly defined, the politicians will have some firm ground upon which to base their decisions.

II. CURRENT STATE OF KNOWLEDGE

This section includes the discussion of our research findings when possible in the context of previous studies on the same species. Nine of the species we report on are ones for which we have contributed original research. They are: pollock, rex sole, rock sole, dover sole, flathead sole, arrowtooth flounder, Greenland halibut, capelin and shortfin eelpout. In addition, we were asked to summarize existing information on Pacific cod, yellowfin sole and Pacific halibut. Each of these twelve species is treated below, in a section of its own. An exception is that the rex, rock, dover and flathead soles are treated in a single chapter since their analysis has been integrated.

Walleye pollock, *Theragra chalcogramma*, southeast Bering and northeast Gulf of Alaska

Several previous studies have dealt with food habits of the pollock. Young British Columbia pollock, from 4-22 mm standard length, feed on copepods and their eggs (Barraclough, 1967) while adults feed on shrimps, sand lance and herring (Hart, 1949). Armstrong and Winslow (1968) report Alaska pollock feeding on young pink, chum and coho salmon. Suyehiro (1942) reported small shrimps, benthic amphipods, euphausiids and copepods in the stomachs of pollock from the Aleutians. Andriyashev (1964) listed mysids and amphipods as the major foods of Bering pollock with *Chionoecetes opilio* (tanner crab) also present. He also reports that pollock from Peter the Great Bay and Sakhalin feed on surf smelt and capelin in the spring and shift to planktonic crustaceans in the summer. Nikolskii (1961) lists pollock food organisms from Asian waters as mysids, euphausiids, silver smelt and capelin. The purpose of this study is to add information on the food habits of Alaska pollock, with special reference to the effect of predator size.

A summary of stomach contents of pollock from the southeast Bering Sea is presented in Table I. That summary presents information on percent frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and Index of Relative Importance (IRI).

Identifiable euphausiids represented the genera *Euphausia* and *Thysanoessa*. Crabs in the family Majidae, when identifiable, were usually *Chionoecetes* sp. but *Hyas* sp. also occurred. All the Majids were in the megalops stage. The Amphipoda contributing to the food of Bering Sea pollock were all pelagic Hyperiidae.

Table II is an analysis of the same feeding data as above, but divided into six size categories. Data presented are F, V, and IRI for each pollock size interval.

Table III summarizes the stomach contents from pollock sampled from the northeast Gulf of Alaska. The molluscan prey organisms consisted of small benthic clams and snails and larval cephalopods. Amphipods were predominantly the pelagic hyperiids but several benthic forms were present. All the Majidae were megalops larvae.

An analysis of the Gulf of Alaska food habits by pollock size category is presented in Table IV. As in Table II, F, V and IRI are presented.

TABLE I

A SUMMARY OF STOMACH CONTENTS FROM ALL SIZE CATEGORIES OF POLLOCK CAUGHT IN THE SOUTHEAST BERING SEA

Standard lengths ranged from 85 to 526 mm ($\bar{x}$ = 270 ± 145 mm). Results are reported as frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and index of relative importance (IRI). Number of feeding individuals examined was 163.

Prey taxon	F	N	V	IRI
Polychaeta	0.6	0.1	0.1	0.1
Crustacea	87	95	30	10799
Copepoda	6	2	0.02	15
Amphipoda	15	7	0.7	124
Mysidae	2	0.3	0.2	1
Euphausiidae	60	77	10	5211
Hippolytidae	0.6	0.1	0.02	0.1
Pandalidae	3	1	2	10
Crangonidae	4	6	16	82
Majidae	1	0.2	0.03	0.2
Unident. Crust.	21	3	0.4	80
Teleostei	12	2	70	886
Unident. Anim. Mat.	12	3	0.2	-

TABLE II

FEEDING HABITS OF POLLOCK IN SIX SIZE CATEGORIES FROM THE SOUTHEAST BERING SEA

Results are reported as percent frequency of occurrence (F), percent volumetric contribution (V), and index of relative importance (IRI). Mean length ($\bar{x}$) and sample size (n) are reported for each interval.

Prey taxon	0-99 mm $\bar{x}$=93, n=22	100-199 mm $\bar{x}$=159, n=55	200-299 mm $\bar{x}$=228, n=25	300-399 mm $\bar{x}$=343, n=17	400-499 mm $\bar{x}$=438, n=36	500-1000 mm $\bar{x}$=615, n=8
Polychaeta			4,1.3,6.5			
Crustacea	86,92,13441	95,100,18831	88,51,13189	82,52,12382	75,28,9313	88,24,9855
Copepoda	32,4,1243	5.5,0,4.5				
Amphipoda	31,4,871	16,0,59	12,0.8,33	18,0,32		
Mysidae						38,0.3,158
Euphausiidae	68,80,8199	64,92,11537	56,47,7821	76,52,11286	56,19,4650	13,0.02,25
Hippolytidae		1.8,0.5,1.5				
Crangonidae						75,20,7030
Pandalidae			4,2.1,11			75,3,634
Majidae			4,0.3,2.3		3,0.2,2.1	
Teleostei			12,47,579	18,48,876	22,69,1637	63,76,5395
Unident. Animal Material	4,8,-	9.1,0,-	4,0.3,-		11,2,-	

TABLE III

A SUMMARY OF STOMACH CONTENTS FROM ALL SIZE CATEGORIES OF POLLOCK CAUGHT IN THE NORTHERN GULF OF ALASKA

Standard lengths ranged from 139 to 560 mm ($\bar{x}$ = 344 ± 84 mm). Results are reported as frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and index of relative importance (IRI). Number of feeding individuals examined was 253.

Prey taxon	F	N	V	IRI
Polychaeta	2	0.01	0.2	0.4
Mollusca	2	0.08	0.6	1.4
Pelecypoda	1.2	0.03	0.5	0.6
Gastropoda	0.4	0.01	0	0.04
Cephalopoda	0.8	0.03	0.06	0.07
Crustacea	90	99.6	90	17064
Copepoda	1.2	0.14	0.02	0.2
Amphipoda	9	0.6	0.1	6
Euphausiidae	83	95.5	87	15148
Pandalidae	6	0.2	2.5	16
Crangonidae	1.2	0.03	0.2	0.3
Majidae	16	2.8	0.5	53
Unident. Crustacea	2	-	0.04	-
Teleostei	9	0.3	7.5	70
Unident. Anim. Mat.	19	-	0.5	-

TABLE IV

FEEDING HABITS OF POLLOCK IN FIVE SIZE CATEGORIES FROM THE NORTHERN GULF OF ALASKA

Results are reported as percent frequency of occurrence (F), percent volumetric contribution (V), and index of relative importance (IRI). Mean length ($\bar{x}$) and sample size (n) are reported for each interval.

Prey taxon	100-199 mm $\bar{x}$=158, n=24	200-299 mm $\bar{x}$=276, n=19	300-399 mm $\bar{x}$=357, n=151	400-499 mm $\bar{x}$=426, n=56	500-1000 mm $\bar{x}$=540, n=3
Polychaeta	17, 27, 464		0.7, 0.02, 0.01		
Mollusca			3, 1, 3		
Crustacea	75, 59, 11888	89, 98, 17739	94, 90, 17766	88, 90, 16540	67, 97, 13104
Copepoda		5, 0, 2.4	1.3, 0.03, 0.3		
Amphipoda	8, 3, 49	25, 0.8, 121	7, 0.08, 3	9, 0.1, 4.2	33, 0.2, 26
Euphausiidae	21, 38, 2146	84, 97, 15863	91, 86, 16380	86, 87, 15822	67, 97, 13052
Pandalidae	4, 2, 9	5, 0.3, 2.5	7, 3, 23	5, 2, 13	
Crangonidae	8, 3, 35			2, 0.5, 1	
Majidae	63, 11, 2334	26, 0.8, 109	11, 0.6, 45	7, 0.2, 7	
Teleostei			9, 8.1, 82	18, 8, 152	33, 3, 115
Unident. Animal Material	21, 14, -	32, 2, -	13, 1, -	32, 2, -	33, 0, -

This study reports the same types of food organisms in pollock as were found in other studies. Our results differ markedly from those of Nikolskii (1961) and Andriyashev (1964) in that we found mysids to be of very little importance in the southeast Bering Sea and were completely absent from northern Gulf pollock stomachs.

In examining Table I and Table III, it is clear that euphausiids are the predominant food organisms (in terms of F, N and IRI) in pollock from both the geographic regions considered. The second most important food category is Teleostei, based on IRI, both in the Gulf and the Bering Sea. However, in terms of volumetric contribution in the stomachs sampled, fishes were very important in the Bering Sea (V=70%) and much less so in the Gulf (V=7.5%).

In examining food habits versus size in pollock from the Bering Sea (Table II) several trends appear. The smallest food organisms, the copepods, are present only in the two smallest size intervals and are only important (IRI) in the smallest size interval. Conversely, fishes, large sized food organisms, are absent from the first two size intervals and become progressively more important in the remaining four size intervals. This suggests an increased emphasis on fishes in the diets with increasing size in Bering Sea pollock. In terms of IRI, amphipods decline in importance with increased predator size. Euphausiids are the most important food organisms in all but the largest size interval. Sample size in that interval is small suggesting that the results we found may not be completely representative of natural populations. The largest interval was the only one in which mysids and crangonid shrimps appear in the diet. Majid crabs appear very infrequently in Bering Sea pollock stomachs sampled.

Analysis of Gulf of Alaska pollock foods by size intervals reveals some similarities to the Bering Sea results. Again, euphausiids are the most important food organisms (IRI) in all size intervals except one. Only in the 100-199 mm interval are euphausiids overshadowed by majid crabs. Another similarity to the Bering Sea findings is the presence of fishes in the stomachs of only the larger pollock. The Gulf results contrast with the Bering Sea results in several respects, however. As noted above, fishes are much less important in pollock diets in the Gulf than in the southeast Bering as evidenced by comparisons of IRI and V values. Also, in the Gulf specimens examined, copepods are much less prevalent and majid megalops larvae are much more prevalent. The majid crabs are the most important food organisms (F, IRI) in the smallest predator interval and progressively decline in frequency of occurrence and relative importance with increased size. Pandalid shrimps are much more prevalent in the various size intervals of Gulf pollock than Bering Sea. The same is true of benthic organisms in general.

Insufficient data were obtained to speculate about diurnal periodicity in feeding, seasonality in feeding intensity, or food composition versus season. Larger sample sizes could confirm the tentative conclusions reached concerning food habits in Alaskan pollock.

Rex, flathead, rock and dover soles

The rex sole, *Glyptocephalus zachirus*, occurs from southern California to the eastern Bering Sea. Needler (1954) reported that this species grows slowly with a lifespan of at least 24 years. Females grow faster and live longer than males (Hosie and Horton, 1977). Mineva (1968) noted that 75%

of fish captured in the Bering Sea were between 12 and 16 years of age. Hart (1973) reports females more abundant in Pacific Ocean catches while Mineva (1968) found males more abundant in the Bering Sea. As juveniles grow, they move out of shallow water down to 150 m, and as adults are most abundant from 200 to 550 m. The rex sole has been reported down to 1100 m (Grinols, 1965).

The flathead sole, *Hippoglossoides elassodon*, occurs from northern California to the Bering Sea, at depths ranging from the surface to 550 m. While maximum abundance tends to occur at depths of 91-181 m in the Gulf of Alaska and 2-90 m in the Bering Sea (Alderdice and Forrester, 1974), geographic and bathymetric migrations have been described with respect to season and maturity (Hughes, 1974). The possibility of flathead sole rising to the surface at night, and returning to the bottom during the day was proposed by Cooney (1967).

Limited information on feeding in this species has been reported by Suyehiro (1934), Smith (1936), and Skalkin (1963). These studies suggested that the flathead sole feeds on both benthic organisms such as polychaetes, molluscs, and brittle stars, and nektonic organisms such as fishes and shrimps. Mineva (1968) found that the flathead sole feeds in winter, unlike allied species. Miller (1970) discussed changes in the diet of the flathead sole with size and season in Washington waters.

The rock sole, *Lepidopsetta bilineata*, ranges from southern California through the Bering Sea to the Sea of Japan. Hart (1973) states that females may attain a length of 60 cm and males 53 cm. A maximum lifespan of 22 years for females and 15 years for males is suggested by Forrester (1964). While the rock sole occurs from the surface to 366 m, it is rare below 100 m in the Gulf of Alaska and British Columbia. In the eastern Bering Sea, the rock sole is rare below 300 m (Pereyra *et al.*, 1976). A summer movement into shallower water has been reported throughout the range (Forrester, 1969; Shubnikov and Lisovenko, 1964).

Little is known about the feeding habits of the rock sole. Skalkin (1963) and Shubnikov and Lisovenko (1964) report that the Bering Sea diet consists chiefly of polychaetes followed by molluscs and crustaceans. Kravitz *et al.* (1976) found that rock sole in Oregon waters fed mainly on ophiuroids. Feeding is much reduced during the winter, and is most intense in June and July.

The dover sole, *Microstomus pacificus*, is found from northern Baja California to the Bering Sea. Individuals may attain a length of 71 cm, and have been found from the surface to 1100 m (Hart, 1973). Little is known about the habits of this species in Alaskan waters. Hagerman (1952) stated that the dover sole feeds on molluscs, polychaetes and echinoderms in Californian waters.

Rex sole were captured by otter trawl from May through July 1975. Gulf of Alaska trawl stations occupied in this study are from among those used by the International Pacific Halibut Commission in their yearly surveys (Fig. 1). Abdomens were slit and the whole fishes were packed in 10% formalin (per total volume of water and fish), buffered with 20 g of hexamethylenetetramine per liter. Upon return to the lab, specimens were measured for standard length to the nearest millimeter. Sex and maturity were recorded.

Flathead sole were captured at six stations in the Gulf of Alaska from May through July 1975. Five trawls in the Bering Sea were made in August

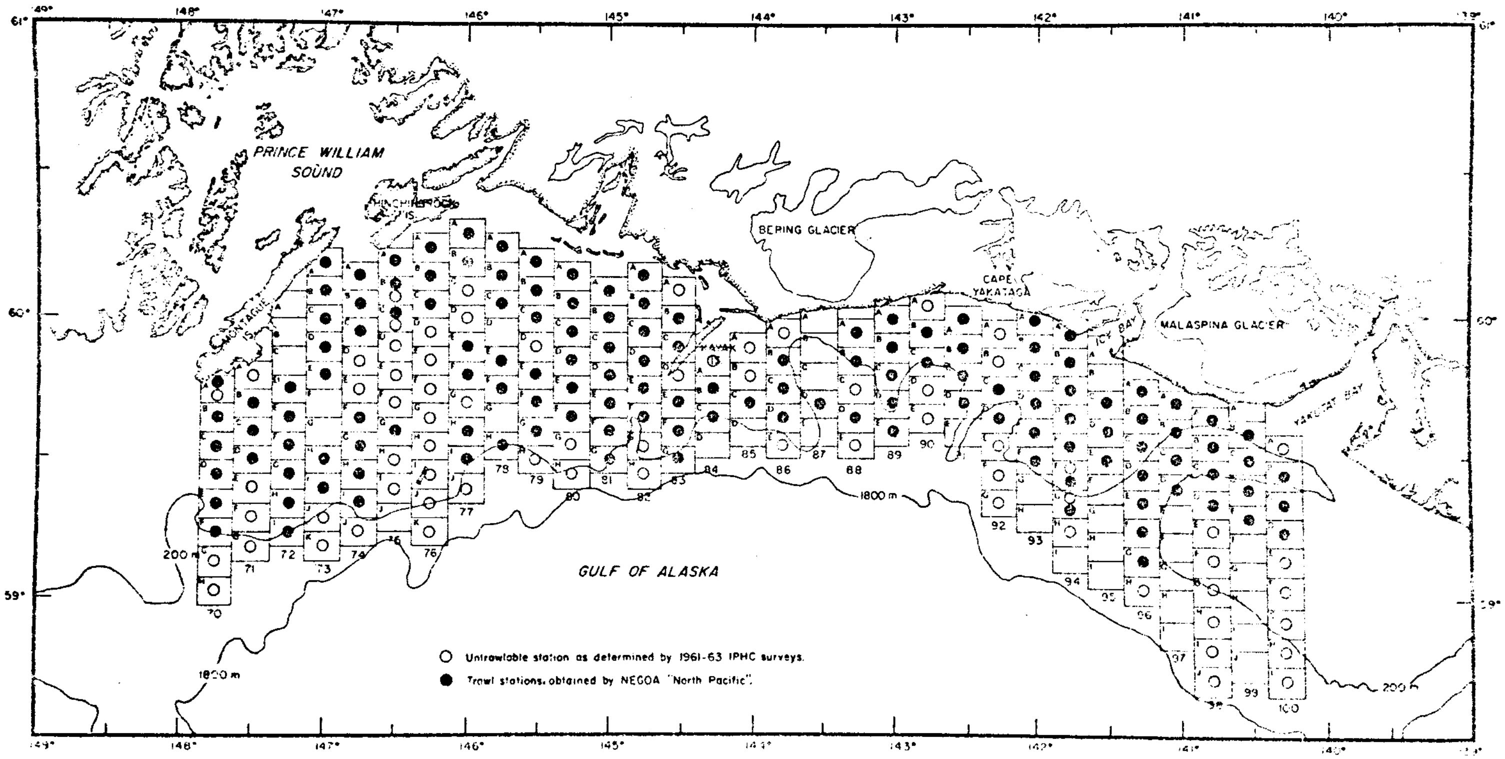


Figure 1. Trawl stations occupied during 1975 in the Gulf of Alaska.

1975, October 1975 and May 1976, representing summer, autumn and spring, respectively.

Dover sole were taken at seven Gulf of Alaska stations during the same period as the rex sole. Nine Bering Sea stations occupied from August through October 1975 provided the rock sole. It was impossible to influence when or where any trawls were made in this study, so collections were opportunistic rather than according to a particular sampling plan.

Prey were identified to the most specific taxa permitted by their state of preservation. Counts were made of all items, and volumes were measured for each taxon to the nearest 0.1 ml. The frequency of prey occurrence (F), the percent contribution by volume (V), the percent by number (N), and an Index of Relative Importance (IRI) were calculated for each station and for all stations combined. The index was developed by Pinkas *et al.* (1971) using the formula IRI = (N + V)F. It should be noted that values reported for consumption of a prey taxon may be conservative. This is reflected in partially unidentifiable material being assigned to a higher taxon; for example, the importance of the Amphipoda in the rex sole diet (Table VI) is far greater than suggested by values for amphipods identified to lower taxa.

An index of stomach fullness was recorded for each predator such that 0 = no information, 1 = empty, 2 = trace, 3 = 25%, 4 = 50%, 5 = 75%, 6 = 100%, and 7 = distended. Mean stomach fullness was calculated for each prey taxon at a station, for all taxa at a station, for each taxon combining all stations, and for all taxa combining all stations. Mean predator length was calculated in the same fashion. It was hoped that these last two criteria might elucidate possible changes in food preference with stomach fullness (i.e., satiation) or with predator size. The fortran program developed for this study is highly machine specific for the Honeywell 66/40.

Prey availability data came from Best (1964), Feder *et al.* (1976), and R. T. Cooney (personal communication). Biologically important taxa (BIT) in terms of prey availability were determined using the method of Feder *et al.* (1976). To qualify as a BIT, a taxon must be distributed in 50% or more of total stations sampled, comprise over 10% of population numbers or biomass at any one station, or satisfy a population density or biomass criterion. These density and biomass criteria are based upon a percentage calculated for each taxon, with the sum of the population density or biomass of all taxa equaling 100%. These percentages are ranked in descending order. The percentages of each taxon are then summed in descending order until a cut-off point of 50% is reached. BIT by these population density or biomass criteria are those taxa whose percentages are used to reach the 50% cut-off point.

Diets were statistically compared using 2-tailed (α:0.005) Spearman's rank correlation coefficients (Zar, 1974).

Of 300 rex sole stomachs collected in 1975, seven were empty and 293 contained food (Table V). Ten families of polychaetes contributed most of the food consumed. Pelecypods, cumaceans, amphipods, euphausiids, and decapods (especially *Pandalus borealis* and postlarval *Chionoecetes bairdi*) were also common in the diet (Table VI; Fig. 2). Table VII compares feeding in the rex sole according to three predator size classes. Using the Spearman's rank correlation coefficient (SRCC), no significant changes in diet were found with predator size.

TABLE V

STATION DATA FOR REX SOLE COLLECTIONS IN THE GULF OF ALASKA

Variable	Station 81C	98B	77I	78H	100B	82D	Combined Gulf of Alaska
Latitude (°N)	59°88	59°53	59°55	59°73	59°45	59°88	59°67
Longitude (°W)	144°95	140°73	145°98	145°73	140°23	144°73	143°73
Time of day (1-24 h)	23	1	22	6	22	21	21
Date	7-14	7-4	7-27	5-14	6-3	5-15	-
Depth (m)	111	149	76	89	122	63	102
Number feeding	106	65	3	36	16	67	293
Number empty	4	1	1	0	0	1	7
Mean fullness of feeding individuals	60	59	8	46	77	82	63
Mean length of predator (mm)	240	267	121	250	251	261	228

TABLE VI

PREY CONSUMED BY REX SOLE FOR ALL GULF OF ALASKA STATIONS

Data are expressed as percent frequency of occurrence (F), percent by number (N), percent by volume (V), and by index of relative importance (IRI). Biologically important taxa in terms of prey availability are noted by an asterisk under BIT. Mean predator length in mm (MPL) and mean fullness of stomach in percent (MFS) are given for each prey taxon consumed.

Taxon	MPL	MFS	F	N	V	IRI	BIT
POLYCHAETA	231	68	79.7	42.3	54.6	7722	*
Phyllodocidae	207	84	3.9	1.1	0.3	5	
Anaitides sp.	250	100	0.7	0.2	0.0	0.2	
Eulalia sp.	174	25	0.4	0.1	0.0	0.0	
Notophyllum sp.	228	100	0.4	0.1	0.0	0.1	
Nephtyidae	241	100	0.7	0.1	0.8	0.6	*
Goniadidae	245	76	6.6	1.3	1.1	16	*
Glycinde picta	182	100	0.4	0.1	0.0	0.0	
Goniada annulata	247	74	5.9	1.2	1.1	13	*
Onuphidae	231	87	28.7	18.8	21.9	1166	*
Onuphis iridescens	232	89	25.5	18.0	21.0	996	
Lumbrineridae	210	79	6.3	1.4	1.5	18	*
Lumbrinereis sp.	253	38	0.7	0.1	0.2	0.2	
Sternaspidae	261	88	5.2	1.0	0.7	9	*
Sternaspis scutata	261	88	5.2	1.0	0.7	9	*
Sabellariidae	222	0	0.4	0.1	0.2	0.1	
Pectinaridae	278	100	0.7	0.1	0.1	0.2	
Ampharetidae	217	100	0.7	0.1	0.1	0.1	*
Sabellidae	326	100	0.4	0.1	0.1	0.0	*
MOLLUSCA							*
Pelecypoda	265	71	16.8	6.3	3.1	157	*
CRUSTACEA	160	83	95.5	74.3	21.6	9148	*
Copepoda	214	38	0.7	0.1	0.0	0.1	
Calanus sp.	214	38	0.7	0.1	0.0	0.1	
Cumacea	196	74	26.6	6.0	0.2	164	*
Eudorella sp.	198	60	4.6	1.5	0.2	8	
Eudorella emarginata	187	56	2.8	1.2	0.2	4	*
Diastylis sp.	174	100	0.4	0.1	0.0	0.0	
Campylaspis sp.	194	69	3.2	0.4	0.2	2	
Amphipoda	190	75	27.3	14.2	0.8	408	*
Haploops tubercula	250	100	0.7	0.3	0.0	0.2	*

TABLE VI

CONTINUED

Taxon	MPL	MFS	F	N	V	IRI	BIT
Amphipoda (cont'd)							
Ampithoidae	273	50	0.4	0.1	0.2	0.1	
Neohela sp.	232	100	0.4	0.1	0.0	0.0	
Gammaridae	251	25	0.4	0.1	0.0	0.0	
Hyperia sp.	256	100	0.4	0.1	0.0	0.0	
Caprellidae	230	88	2.1	0.4	0.0	0.9	
Euphausiacea	228	78	16.8	3.7	4.3	134	*
Euphausia pacifica	265	81	1.4	0.3	0.6	1.2	*
Thysanoessa sp.	174	80	1.8	0.2	0.2	0.8	
Thysanoessa rashii	205	100	0.4	0.1	0.1	0.1	
Decapoda	219	70	52.1	20.4	16.7	1933	*
Pandalidae	258	84	9.1	3.3	7.5	98	
Pandalus borealis	264	79	4.6	1.9	6.3	37	
Hippolytidae	205	88	6.3	1.8	2.1	24	
Spirontocaris sp.	284	50	0.4	0.5	0.4	0.3	
Callionassidae	289	88	0.7	0.1	0.4	0.3	
Majidae	214	70	39.5	13.9	4.7	734	*
Hyas sp.	139	100	0.7	0.1	0.0	0.1	
Chionoecetes bairdi	214	70	38.8	13.6	4.8	709	*
Xanthidae	262	25	0.4	0.1	0.1	0.1	
ECHINODERMATA							
Ophiuroidea	266	82	3.9	0.5	0.4	4	*
TELEOSTEI	258	75	1.4	0.2	1.0	2	*
Zoarcidae	225	100	0.4	0.1	0.1	0.0	
Unidentified animal material			38.8	0.0	15.8	-	

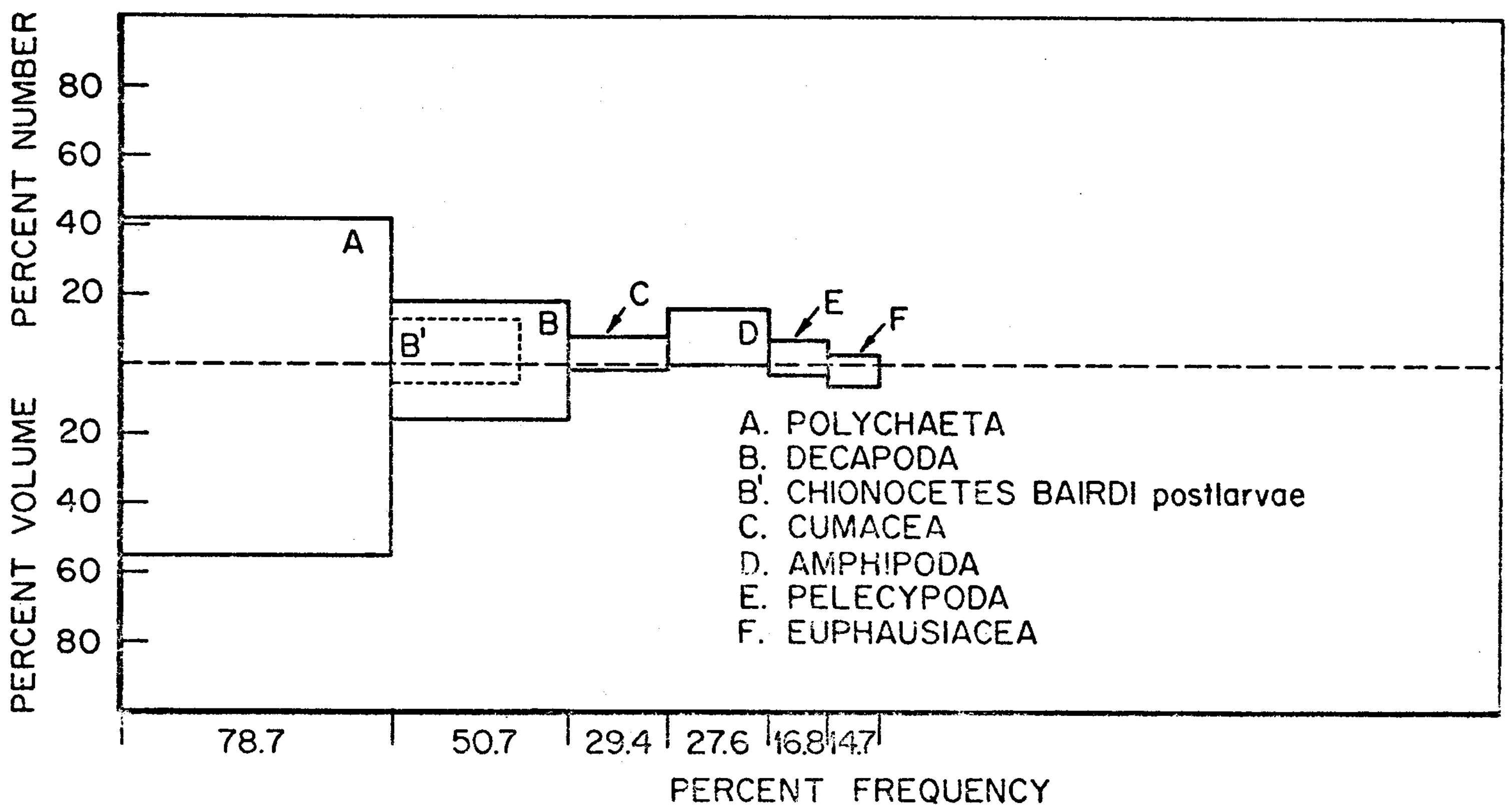


Figure 2. Feeding habits of the rex sole in the Gulf of Alaska.

TABLE VII

REX SOLE - FEEDING HABITS BY SIZE

Taxon	0-200 mm IRI	201-300 mm IRI	301-600 mm IRI
POLYCHAETA	6021	6597	14307
Phyllodocidae	13	5	0
Goniadidae	13	20	10
Onuphidae	914	574	4552
Lumbrineridae	54	6	28
Sternaspidae	2	11	21
PELECYPODA	1	298	354
CRUSTACEA	9237	6111	1536
Cumacea	764	220	2
Amphipoda	1688	454	37
Euphausiacea	106	225	10
Decapoda	2688	1946	889
Pandalidae	55	70	425
Hippolytidae	67	26	0
Majidae	1210	741	136
OPHIUROIDEA	0.2	10	1
TELEOSTEI	0	8	0

Of 129 dover sole stomachs collected in the Gulf of Alaska, 8 were empty and 121 contained food. Ten families of polychaetes contributed most of the food consumed (Table VIII). Ophiuroids, pelecypods, amphipods and decapods were also important.

Table IX shows dover sole feeding habits by predator size category. Paired comparisons using SRCC show that there is no difference between the feeding habits of the two largest categories, while all other combinations are different.

Prey consumption by 247 flathead sole in the Gulf of Alaska is listed in Table X. Euphausiids (probably all *Thysanoessa* spp.) and the brittle star, *Ophiura sarsi*, contributed most of the diet of the 139 feeding individuals. Only 39 flathead sole were collected in the Bering Sea (Table XI). These limited data suggest that the shrimp *Pandalus borealis* is the most important spring prey, while mysids, amphipods, and *Ophiura sarsi* dominated summer feeding. Crangonid shrimps and juvenile pollock were the most important autumn prey in the Bering Sea.

Table XII compares the diet of flathead sole according to predator size. Paired tests using SRCC demonstrate no significant difference between the diets of the two largest categories, but all other combinations are different.

Of 166 rock sole stomachs collected in the Bering Sea, 80 were empty. Eleven families of polychaetes contributed most of the food consumed (Table XIII). Crustaceans, pelecypods, fishes, and ophiuroids were also important.

Feeding habits by predator size are found in Table XIV. Using SRCC all paired comparisons were different. Thus feeding habits of the rock sole change significantly with increasing size. Crustaceans (chiefly

TABLE VIII

DOVER SOLE - STOMACH CONTENTS ALL STATIONS

Taxa	MPL	MFS	F	N	V	IRI
POLYCHAETA	277	62	71.1	59.6	72.2	9369
Glyceridae	239	0	0.8	0.1	0.0	0.1
Goniadidae	321	75	0.8	0.1	0.1	0.1
Goniada annulata	321	75	0.8	0.1	0.1	0.1
Onuphidae	292	81	17.4	18.6	42.7	1063
Onuphis iridescens	303	87	14.9	18.1	41.9	892
Lumbrineridae	263	32	5.8	4.6	0.2	28
Sternaspidae	328	56	3.3	0.5	0.3	3
Sternaspis scutata	328	56	3.3	0.5	0.3	3
Maldanidae	232	100	0.8	0.9	0.5	1.2
Sabellariidae	301	75	0.8	0.2	0.1	0.2
Ampharetidae	249	78	8.3	1.3	0.7	17
Ampharete sp.	249	78	8.3	1.3	0.7	17
Terebellidae	227	83	8.3	7.9	6.1	116
Aphroditidae	287	50	1.7	0.2	1.1	2
Aphrodita parva	287	50	1.7	0.2	1.1	2
MOLLUSCA	290	49	26.5	5.3	2.0	192
Pelecypoda	288	47	24.0	4.6	1.9	156
Nuculidae	278	57	5.8	1.1	0.2	8
Nucula tenuis	278	57	5.8	1.1	0.2	8
Nuculanidae	310	46	10.7	1.7	1.0	27
Nuculana fossa	329	75	1.7	0.5	0.4	1.5
Yoldia sp.	325	100	0.8	0.2	0.1	0.2
Y. montereyensis	307	41	9.1	1.1	0.5	14
Mytilidae	315	88	1.7	0.2	0.5	1.1
Musculus discors	315	88	1.7	0.2	0.5	1.1
Gastropoda	217	75	0.8	0.1	0.0	0.1
Scaphopoda	365	50	1.7	0.6	0.1	1.0
Cadulus sp.	365	50	1.7	0.6	0.1	1.0
Cephalopoda	329	100	0.8	0.1	0.0	0.1
CRUSTACEA	267	57	26.5	8.6	4.1	334
Cumacea	290	67	5.0	1.2	0.0	6
Eudorella sp.	325	100	0.8	0.2	0.0	0.2

TABLE VIII

CONTINUED

Taxa	MPL	MFS	F	N	V	IRI
CRUSTACEA (cont'd)						
Amphipoda	262	53	14.9	5.1	2.8	116
Corophiidae	252	42	2.5	2.0	0.3	6
Erichthonius hunteri	227	34	1.7	1.8	0.1	3
Neohila sp.	301	50	0.8	0.2	0.3	0.4
Kuriidae	297	75	0.8	0.4	0.9	1.1
Caprellidae	341	88	1.7	1.1	1.4	4
Euphausiacea	271	55	4.1	0.6	0.5	5
Euphausiidae	264	33	2.5	0.5	0.4	2
Thysanoessa sp.	281	88	1.7	0.2	0.1	0.4
Decapoda	264	53	7.4	1.4	0.9	17
Pandalidae	237	100	0.8	0.3	0.4	0.6
Pandalus borealis	237	100	0.8	0.3	0.4	0.6
Majidae	266	43	5.8	1.1	0.4	8
Hyas sp.	260	50	1.7	0.2	0.1	0.4
Chionoecetes bairdi	285	35	4.1	0.8	0.3	4
ECHINODERMATA	314	48	40.5	26.3	18.1	1800
Asteroidea	381	63	1.7	0.2	0.3	0.7
Ctenodiscus crispatus	381	63	1.7	0.2	0.3	0.7
Ophiuroidea	314	48	40.5	26.2	17.8	1782
Ophiopenia disacantha	341	88	1.7	0.2	0.1	0.4
Ophiopenia vacina	217	75	0.8	0.1	0.0	0.1
Ophiura sarsi	320	48	33.1	22.8	15.9	1280
TELEOSTEI	325	100	0.8	0.1	0.8	0.7
Lycodes diapterus	325	100	0.8	0.1	0.8	0.7
Unidentified Animal Material	273	42	18.2	-	2.8	55

TABLE IX

DOVER SOLE - FEEDING HABITS BY SIZE

Taxon	0-200 mm IRI	201-300 mm IRI	301-600 mm IRI
POLYCHAETA	19087	12461	6148
Onuphidae	0	1018	1178
Lumbrineridae	238	47	7
Sternaspidae	0	3	3
Ampharetidae	119	57	0
Terebellidae	9232	313	0
Aphroditidae	0	9	0
MOLLUSCA	0	138	274
Pelecypoda	0	126	204
Nuculanidae	0	10	64
Nuculidae	0	8	8
Mytilidae	0	0	5
Scaphopoda	0	0	5
CRUSTACEA	119	458	226
Cumacea	0	4	9
Amphipoda	119	137	87
Euphausiacea	0	13	0.5
Decapoda	0	31	8
ECHINODERMATA	0	538	4235
Ophiuroidea	0	538	4183
TELEOSTEI	0	0	3

TABLE X

PREY CONSUMED BY FLATHEAD SOLE FOR ALL GULF OF ALASKA STATIONS (n=247)

Data are expressed as percent frequency of occurrence (F), percent by number (N), percent by volume (V), and by index of relative importance (IRI). Biologically important taxa in terms of prey availability are noted by an asterisk under BIT. Mean predator length (MPL) in mm and mean fullness of stomach in percent (MFS) are given for each prey taxon consumed.

Taxon	MPL	MFS	F	N	V	IRI	BIT
MOLLUSCA	240	100	1.4	0.1	0.1	0.3	*
Pelecypoda	253	100	0.7	0.0	0.0	0.0	*
Gastropoda	227	100	0.7	0.0	0.0	0.0	*
Cephalopoda	227	100	0.7	0.1	0.0	0.0	
CRUSTACEA	210	77	51.1	73.8	38.2	5718	*
Euphausiidae	209	78	49.6	73.7	37.9	5537	*
Thysanoessa sp.	201	82	20.1	37.6	18.3	1125	*
T. spinifera	177	104	13.0	33.4	18.0	665	*
Decapoda	243	50	2.2	0.1	0.3	0.9	*
Majidae	263	63	1.4	0.1	0.2	0.4	*
Hyas sp.	248	75	0.7	0.0	0.0	0.0	
OPHIUROIDEA	263	53	61.9	26.1	59.6	5297	*
Ophiura sarsi	263	57	56.8	26.0	58.4	4793	*
TELEOSTEI	258	50	1.4	0.1	1.8	2.6	*
Unident. Animal Material			3.6	0.0	0.4	-	

TABLE XI

SEASONAL PREY CONSUMPTION BY FLATHEAD SOLE
IN THE BERING SEA

Data are expressed as index of relative importance (IRI), and biologically important taxa in terms of prey availability are noted by an asterisk under BIT. Probable BIT are noted by a question mark.

Taxon	Spring 1976	Summer 1975	Autumn 1975	BIT
POLYCHAETA	381	-	-	*
PELECYPODA	116	-	108	*
Nuculana fossa	70	-	-	
CRUSTACEA	7936	7645	11651	*
Neomysis rayii	55	1031	-	?
Amphipoda	-	2700	69	*
Rhachatropis oculatus	-	2700	-	
Decapoda	6561	159	11234	*
Crangon dalli	-	-	11234	?
Majidae	23	-	-	?
Pandalus borealis	5485	159	-	?
OPHIUROIDEA	68	1946	35	?
Ophiopenia disacantha	35	-	-	
Ophiura sarsi	-	1946	-	?
Ophiuroidae	-	-	35	
TELEOSTEI	235	157	416	*
Theragra chalcogramma	-	-	416	*

TABLE XII

FLATHEAD SOLE - FEEDING HABITS BY SIZE

Taxon	0-200 mm IRI	201-300 mm IRI	301-600 mm IRI
CRUSTACEA	17098	3582	1437
Amphipoda	44	0.2	0
Mysidae	19	0.4	0
Euphausiidae	12261	2393	46
Decapoda	25	106	760
Pandalidae	16	30	73
Crangonidae	0.5	1.6	351
OPHIUROIDEA	102	7313	9997
Ophiura sarsi	102	6456	8594
Ophiopenia disacantha	0	0.2	0
TELEOSTEI	5	19	36

TABLE XIII

ROCK SOLE STOMACH CONTENTS - ALL STATIONS FROM THE BERING SEA

Taxa	MPL	MFS	F	N	V	IRI
POLYCHAETA	237	40	74.4	48.2	36.9	6332
Phyllodocidae	300	100	1.2	0.1	0.1	0.2
Spionidae	174	25	1.2	0.2	0.1	0.4
Nereidae	332	25	1.2	0.1	0.6	0.7
Nephtyidae	212	88	2.3	0.2	1.3	4
Nephtys sp.	185	100	1.2	0.1	1.2	1.5
Onuphidae	205	42	3.5	0.2	1.1	4
Lumbrineridae	288	100	1.2	0.7	4.5	6
Paraonidae	300	75	1.2	0.4	0.2	0.7
Anaspio sp.	174	25	1.2	0.2	0.1	0.4
Opheliidae	270	67	3.5	0.3	0.9	4
Travisia sp.	270	67	3.5	0.3	0.9	4
Maldanidae	311	67	3.5	0.4	0.1	2
Ampharetidae	315	25	1.2	0.1	0.1	0.3
Ampharete sp.	315	25	1.2	0.1	0.1	0.3
Sabellidae	341	50	1.2	0.1	0.3	0.4
MOLLUSCA	245	43	17.4	2.0	9.2	196
Pelecypoda	250	45	12.3	1.9	9.2	180
Nuculanidae	199	33	3.5	0.2	0.0	0.6
Nuculana sp.	199	33	3.5	0.2	0.0	0.6
Cariidae	238	125*	1.2	0.9	7.9	10
Serripes sp.	238	125*	1.2	0.9	7.9	10
Gastropoda	198	38	2.3	0.1	0.1	0.4
CRUSTACEA	229	40	29.1	48.4	7.9	1635
Cumacea	201	42	7.0	1.3	0.0	9
Eudorella sp.	192	25	1.2	0.1	0.0	0.1
Diastylidae	182	25	2.3	0.3	0.0	0.7
Diastylis bidentata	172	25	2.3	0.2	0.0	0.5
Isopoda	190	25	1.2	0.1	0.0	0.1
Amphipoda	229	39	26.7	46.7	5.3	1389
Ampeliscidae	199	42	3.5	3.8	0.3	14
Ampelisca sp.	241	50	1.2	0.1	0.1	0.2
Bylilus sp.	179	38	2.3	3.8	0.2	9
Calliopiidae	172	25	1.2	3.0	0.2	4
Calliopius sp.	172	25	1.2	0.7	0.0	0.8

TABLE XIII

CONTINUED

Taxa	MPL	MFS	F	N	V	IRI
Corophiidae	185	50	1.2	3.0	0.2	4
Ericthonius sp.	185	50	1.2	3.0	0.2	4
Gammaridae	258	25	1.2	1.4	0.8	3
Melita sp.	258	25	1.2	1.4	0.8	3
Isaeidae	183	33	3.5	18.8	1.4	70
Photis sp.	172	25	1.2	0.7	0.0	0.8
Protomedeia sp.	183	33	3.5	15.9	1.4	60
Podoceropsis sp.	179	38	2.3	2.2	0.1	5
Lysianassidae	222	25	4.7	2.2	0.5	12
Anonyx nugax	239	25	3.5	1.5	0.5	7
Orchomene sp.	172	25	1.2	0.7	0.0	0.8
Phoxocephalidae	172	25	1.2	0.7	0.1	0.8
Paraphoxus sp.	172	25	1.2	0.7	0.1	0.8
Euphausiacea	207	50	2.3	0.1	0.0	0.3
Decapoda	231	25	3.5	0.2	2.5	9
Pandalidae	202	50	1.2	0.1	1.9	2
Hyas sp.	229	25	1.2	0.1	0.1	0.2
OPHIUROIDEA	265	58	3.5	1.0	4.3	19
Ophiolebes pavcispina	289	38	2.3	0.2	0.5	2
Ophiura atacta	218	100	1.2	0.8	3.8	5
TELEOSTEI	360	90	5.8	0.4	36.3	213
Ammodytidae	427	108	3.5	0.3	33.2	117
Unidentified Animal Material	227	42	7.0	-	5.4	-

* indicates distended stomachs

TABLE XIV

ROCK SOLE - FEEDING HABITS BY SIZE

Taxon	0-200 mm IRI	201-300 mm IRI	301-600 mm IRI
POLYCHAETA	4827	10957	5165
Spionidae	8	0	0
Nereidae	0	0	30
Nephtyidae	50	1.1	0
Onuphidae	69	1.4	0
Lumbrineridae	0	21	0
Opheliidae	13	3	41
Maldanidae	0	4	20
Ampharetidae	0	0	41
Sabellidae	0	0	25
MOLLUSCA	72	238	436
Pelecypoda	43	237	436
CRUSTACEA	4823	474	119
Cumacea	50	0.3	0
Amphipoda	4722	258	19
Decapoda	0	32	0
OPHIUROIDEA	0	40	64
TELEOSTEI	0	3	3294

amphipods) become less important as predator size increases, while fishes become more important.

Rock sole diets from this study were compared with Skalkin's (1963) limited Bering Sea data and the Oregon data of Kravitz *et al.* (1976). The diets were significantly different.

Table XV compares the feeding habits of the rex, dover, flathead, and rock soles, using the Spearman's rank correlation coefficient. Comparisons are made between comparable size categories plus all data combined. All interspecific comparisons were significantly different, even when controlled for predator size. Intraspecific diet comparisons by size are also summarized in this table.

De Groot (1971) discussed the interrelationships of alimentary morphology, behavior, and feeding of flatfishes. From the feeding habits of 59 species, he concluded that flatfishes can be classified according to three feeding strategies: (1) fish feeders, (2) crustacean feeders, and (3) polychaete-mollusc feeders. De Groot classified two congenerics of the rex sole, *Glyptocephalus cynoglossus* and *G. stelleri*, as feeding group (3) (polychaete-mollusc feeders). He described their principal prey as polychaetes, crustaceans, and molluscs. Compatible with De Groot's polychaete-mollusc strategy are the limited feeding data in these species by Rae (1969), Hayase and Hamai (1974) and Kravitz *et al.* (1976). These studies suggest that polychaetes and crusteceans were the dominant food items, with molluscs far less important.

Mineva (1968) states that feeding data on the rex sole are limited, and suggests that the intensity of feeding is less in the middle of September than at the beginning of the month. There is no information

TABLE XV

COMPARISONS OF FEEDING HABITS BY PREDATOR SIZE,
USING SPEARMAN'S RANK CORRELATION COEFFICIENTS
[$\alpha(2)$:0.005]

Significantly different diets are shown by minus (-)
and significantly similar diets are shown by plus (+) signs

	mm	REX SOLE 0-600	0-200	201-300	301-600	DOVER SOLE 0-600	0-200	201-300	301-600	FLATHEAD SOLE 0-600	0-200	201-300	301-600	ROCK SOLE 0-600	0-200	201-300	301-600
REX SOLE	0-600					-				-				-			
	0-200						-				-				-		
	201-300		+					-				-				-	
	301-600		+	+					-				-				-
DOVER SOLE	0-600									-				-			
	0-200										-				-		
	201-300						-					-				-	
	301-600						-	+					-				-
FLATHEAD SOLE	0-600													-			
	0-200														-		
	201-300										-					-	
	301-600										-	+					-
ROCK SOLE	0-600																
	0-200																
	201-300														-		
	301-600														-	-	

concerning prey composition. Figure 2 portrays the feeding habits of the rex sole. Clearly the rex sole feeds predominantly on polychaetes and crustaceans. Molluscs and other prey taxa contribute much less. Thus, the rex sole feeds much as the two congenerics already discussed, and can also be classified as De Groot's feeding group (3). This feeding strategy was used by 23 of the 49 species of Pleuronectidae investigated by De Groot. A detailed comparison with the rex sole data of Kravitz *et al.*, 1976 using SRCC, shows a significant difference in diets of Oregon and Alaskan populations. It should be noted that only 21 stomachs were examined in the Oregon study. A comparison of diets by predator size using SRCC failed to demonstrate any differences (Table XV).

The scope of this study is too limited to permit a detailed discussion of prey selectivity by the rex sole, but several points are worth mentioning. Molluscs consumed were predominantly in the Nuculanidae. Most individuals were only several millimeters long, suggesting that they had recently settled. Thus, postlarval molluscs and crabs (Fig. 2) seem to be important in the early summer diet of the rex sole. Table II shows that the Onuphidae contributed most of the polychaetes consumed. Probably most of the unidentified polychaetes that gave the large F, N, V, and IRI values for the Polychaeta were also Onuphidae. Yet the only species identified from this family was *Onuphis iridescens*, which is not a BIT in this area according to Feder *et al.* (1976). They reported *Onuphis geophiliformis* as the only BIT from this family. With this exception, taxa important in the diet of the rex sole tend to be important members of the local community.

Diet differences of flathead sole with depth in the Gulf of Alaska are pronounced, and therefore the importance of the euphausiids in Table X may be somewhat misleading. Five trawls at 66 to 88 m ($\bar{x}$ = 73 m) yielded 176 flathead sole. Empty stomachs occurred in 49% of these fishes. The index of relative importance for ophiuroids (IRI = 18,279) far exceeded the value for euphausiids (IRI = 274) for these five trawls. A single trawl south of Hinchinbrook Island at 26 m yielded 71 fishes, of which 30% had empty stomachs. Here the importance of euphausiids (IRI = 17,854) in the diet constrasts with that of the ophiuroids (IRI = 1). The theoretically maximum IRI value is 20,000 (given feeding predators have a particular prey species in every stomach, and this prey comprises 100% of the volume and count). Thus the respective dominance of eupahusiids in shallow water, and ophiuroids in the deep water feeding is nearly absolute. Comparisons of diet with predator size using SRCC demonstrated a significant difference between fishes under 201 mm and the larger size categories (Table XV).

The flathead sole diet in the Gulf of Alaska differs from that of a population in East Sound, Orcas Island, a shallow (28 m) embayment in Washington. Miller (1970) found that mysids comprised most of the diet (F = 77) followed by shrimps, fishes, clams, and polychaetes. Miller found 31% of the stomachs empty. Feeding intensity of Alaskan populations was greater in shallow areas (above the 50 m isobath), as evidenced by the frequency of empty stomachs and the mean fullness of stomachs. The flathead sole feeding in shallow water had a mean fullness of 57% while the deeper individuals had a mean fullness of 29%.

Miller (1970) discussed how predator size, season, and bottom temperature affected the frequency of empty stomachs in a Washington population of flathead sole. Season does not account for the apparent depth-related differences in the Gulf of Alaska population and temperature data are not available. Size may be partly responsible, as suggested by Table XII. Fishes below a length of 201 mm feed almost entirely on crustaceans. Fishes from 201-300 mm feed somewhat more intensively on ophiuroids than crustaceans. Larger fishes feed still more heavily on ophiuroids, but crustaceans remain an important part of the diet. While feeding by Washington and Alaskan flathead sole may always be more intense on nektonic organisms, one would expect from the Van't Hoff rule that the higher metabolic rate induced by warmer shallow waters would require a higher feeding rate than deeper populations.

Mineva (1968) found that, in the Bering Sea, flathead sole fed chiefly on ophiuroids, followed by shrimps, amphipods, fishes, and molluscs. The limited sampling of this study tends to support these conclusions. According to Mineva the flathead sole is caught together with yellowfin sole, Alaska plaice and rock sole in the southeast Bering. The present study suggests a similarity in geographic and depth-related feeding patterns of the flathead sole with Skalkin's (1963) study of the yellowfin sole. The flathead sole seems to feed primarily on pink shrimp and fishes from 200 to 100 m, on ophiuroids and pink shrimp just above the 100 m isobath, and crangonid shrimps, fishes and molluscs below the 50 m isobath, and upon nekton such as mysids in more shallow waters. Seasonal differences suggested by Table XI may simply result from migration-induced changes in prey availability with depth.

This study suggests that taxa important in the diet of the flathead sole tend to be important members of the local community. Both benthic and nektonic prey are consumed. This study plus the data of Mineva (1968) and Skalkin (1963) suggest a depth-related change from predominantly benthic to nektonic feeding somewhere around the 50 m isobath.

Very little is known about the feeding habits of the dover sole. Hart (1973) simply states that it is usually found on soft bottoms and feeds on burrowing organisms. A congeneric from the Atlantic, *Microstomus kitt*, feeds chiefly on polychaetes, followed by crustaceans, molluscs, echinoderms and fishes (De Groot, 1971). This study shows that *M. pacificus* also feeds predominantly on polychaetes, and to a lesser extent on ophiuroids, crustaceans and molluscs.

One sees a progressive decline in the importance of polychaetes as predator size increases (Table IX), molluscs and crustaceans become more important, and there is a dramatic increase in the importance of ophiuroids in larger predators. Using rank index (SRCC) comparisons, there is a significant difference between diets of the smallest and each of the larger size categories. No significant difference can be demonstrated between the two larger categories.

De Groot (1971) classified the rock sole as a crustacean feeder. Shubnikov and Lisovenko (1964) reported that, in the Bering Sea, polychaetes were the most important prey, followed by molluscs and crustaceans. Fishes and ophiuroids were sometimes taken. Forrester and Thomson (1969) found a British Columbia population feeding on clams, polychaetes, crustaceans, fishes and echinoderms. Kravitz *et al.* (1976) found rock sole in Oregon waters fed mainly on ophiuroids.

This study shows that rock sole in the Bering Sea feed mainly on polychaetes. Crustaceans (especially amphipods), fishes, and molluscs were also important. When the present study was compared using rank index (SRCC) with Skalkin (1963) and Kravitz *et al.* (1976), the diets were found to be significantly different.

The feeding habits of the rock sole change with size (Table XIV). All paired combinations were significantly different when compared by rank index (SRCC).

Rank index comparisons show that the feeding habits of all flatfish species in this study differ significantly from one another. This conclusion holds true when species are compared within a given size category. The diet of rex sole does not change with predator size. Small (0-200 mm) and large (201-600 mm) flathead sole have significantly different diets. Feeding by small and large dover sole also differ significantly. Small (0-200 mm), medium (201-300 mm), and large (301-600 mm) rock sole all have significantly different diets.

Arrowtooth flounder, *Atheresthes stomias*,
northeastern Gulf of Alaska

The stomach of 558 *Atheresthes stomias* were examined to determine the feeding habits of the species. Of these specimens, 236 contained prey items; the remaining 322 specimens had empty stomachs.

The specimens were taken from 28 trawl stations in the northeast Gulf of Alaska, from Yakutat Bay, on the east, to Cape Cleare, on the west (Table XVI). The majority of specimens were collected from May 3, 1975 to June 27, 1975. Additional specimens were collected from July 4, 1975 to August 8, 1975.

TABLE XVI

STATIONS WHERE SAMPLES OF *ATHERESTHES STOMIAS* WERE OBTAINED

Station #	Tow No.	Date	Time	Depth fished (m)
070C	2	5/3/75	1345	102.0 - 113.0
070D	3	5/3	1740	103.7 - 111.0
076A	16	5/10	1335	105.5 - 107.3
074H	20	5/12	1150	151.0 - 158.3
086C	43	5/30	1440	116.4 - 127.4
092D	50	6/2	0825	222.0 - 225.6
094D	51	6/2	1200	123.7 - 127.4
100B	55	6/4	0820	220.2 - 222.0
100C	56	6/5	0915	158.3 - 161.9
094G	63	6/27	1150	182.0 - 182.0
098C	74	7/4	1350	287.5 - 291.0
070B	111	7/20	0630	109.2 - 116.5
071B	112	7/20	0910	109.2 - 111.0
073A	115	7/25	0655	262.1 - 263.1
073C	117	7/25	1330	142.0 - 149.2
074G	121	7/26	1705	113.0 - 115.0
075G	122	7/27	0735	95.0 - 98.3
073H	123	7/27	1055	202.0 - 204.0
077I	125	7/28	0740	133.0 - 145.6
077E	128	7/28	1550	93.0 - 97.0
075A	132	8/1	0750	131.0 - 133.0
077B	133	8/1	1115	100.1 - 102.0
077A	134	8/1	1345	53.0 - 54.6
079C	137	8/2	1150	100.1 - 104.0
081F	140	8/3	0935	173.0 - 178.4
083F	141	8/3	1450	137.0 - 140.1
083E	142	8/4	0800	129.2 - 131.0
081G	144	8/4	1510	208.0 - 220.2

Fishes and crustaceans were the most frequently occurring prey items, with polychaetes, molluscs, and echinoderms occurring very rarely (Table XVII).

Crustaceans were the most frequently occurring prey items consumed (Table XVII). Of this group, decapods were most often taken, with euphausiids the second most commonly consumed. By number and volume, however, euphausiids were more important.

Fishes were the second most frequently occurring prey items (Table XVII). Members of the families Osmeridae, Gadidae, and Zoarcidae, in descending order of frequency of occurrence, where the most commonly occurring teleostean prey. Representatives of the families Clupeidae, Cottidae, Stichaeidae, and Pleuronectidae were also found among the stomach contents.

It should be noted that although fishes did not occur as frequently as prey as did crustaceans, their contribution to total prey volume was slightly greater than that contributed by the crustaceans (Table XVII).

Yazdani (1969) discussed adaptation in the jaws of flatfishes, and relates jaw structure to feeding habits. His "turbot-type" species, *Scophthalmus maximus*, *Lepidorhombus whiff-iagonis*, and *Arnoglossus laterna*, all possess large, relatively symmetrical jaws. These species feed primarily on free swimming prey such as small fishes and shrimp. The arrowtooth flounder is morphologically similar to these species, and its feeding habits are also quite similar.

Annual migratory cycles, with associated changes in diets have been observed in *Limanda aspera*, *Lepidopsetta bilineata*, *Hippoglossoides elassodon*, and *Pleuronectes quadrituberculatus* from the southeastern Bering Sea (Skalkin, 1963). Several of these species undergo periods of starvation during the winter months, and resume feeding from late April to September.

TABLE XVII

SUMMARY OF PREY ITEMS BY PHYLUM FOR *ATHERESTHES STOMIAS* FROM THE GULF OF ALASKA, MAY-AUGUST 1975

Prey Phylum	% Freq. of Occurrence	% by Number	% by Volume	Index of Relative Importance
Arthropoda: Crustacea	53.81	78.70	40.10	6393
Chordata: Teleostei	42.80	17.16	41.09	2493
Mollusca	0.85	0.24	0.33	0.48
Annelida	0.42	0.12	0.00	0.05
Echinodermata	0.42	0.12	0.00	0.05

Over the period of time that the specimens of *A. stomias* were collected, there was no evidence of changes in diet. The intensity of feeding was not as great as in the species mentioned above. For each month, the percentage of fish feeding remained relatively constant. Of the 265 fish taken in May, 46% had been feeding; 37% of 200 fish collected in June and 45% of 58 fish collected in July were feeding. Only 25 fish were collected in August, of which 52% had been feeding. Indices of stomach fullness varied widely within each month, with no observable trend.

Skalkin (1963) also gives data concerning changes in diet with regard to depth. Changes in diet of *H. elassodon* in the Gulf of Alaska and Bering Sea are discussed in this report. There was no clearcut difference in prey items consumed by *A. stomias* with regard to depth, however, a distinct difference in diet was seen between certain groups of stations. Specimens taken from stations 71B, 73H, 74H, 75G and 77I were feeding primarily on pandalid shrimp, including *Pandalus borealis* and *Pandalopsis dispar*. These stations are located on the fringe of an area recognized as untrawlable by the International Pacific Halibut Commission because of the rocky substrate.

Stations located in nearshore areas of Montague, Hinchinbrook, and Kayak islands (stations 70B, 75A, 76A, 77A and 83E) yielded specimens whose principal prey items were *Mallotus villosus*, other osmerids, and representatives of the family Clupeidae. Many of the *M. villosus* found in the stomachs of the flounders were ripe females.

Euphausiids were the single most important prey item in terms of percent by number and percent by volume. They were second only to unidentified teleosts in frequency of occurrence (Table XVIII). The majority of

TABLE XVIII

INDIVIDUAL PREY ITEMS OF *ATHERESTHES STOMIAS* FROM THE GULF OF ALASKA, MAY-AUGUST 1975

Listed in descending order of frequency of occurrence

Prey Taxon	% Freq. of Occurrence	% by Number	% by Volume	Index of Relative Importance
Teleostei (Unidentified)	30.08	10.18	23.45	1012
Euphausiacea	25.85	46.51	37.22	2164
Decapoda	13.56	24.85	0.88	349
Mallotus villosus	5.51	3.79	2.60	35
Pandalidae	4.66	1.66	0.26	8.9
Pandalus borealis	2.97	1.18	1.09	6.8
Crangonidae	2.54	0.71	0.04	1.91
Zoarcidae	2.12	0.71	0.43	2.43
Theragra chalcogramma	1.27	0.36	9.81	13
Pandalus spp.	0.85	0.36	0.07	0.36
Eualus sp.	0.85	0.24	0.03	0.23
Osmeridae	0.85	0.36	0.21	0.48
Polychaeta	0.42	0.12	0.00	-
Pelecypoda	0.42	0.12	0.00	-
Cephalopoda	0.42	0.12	0.33	0.19
Isopoda	0.42	2.25	0.06	0.98
Pandalus jordani	0.42	0.12	0.07	0.08
P. platyceros	0.42	0.12	0.01	0.05
Pandalopsis sp.	0.42	-	-	-
P. dispar	0.42	0.24	-	-
P. ampla	0.42	0.24	-	-
Crangon communis	0.42	0.12	0.01	0.06
Sclerocrangon sp.	0.42	0.12	0.01	0.05
Ophiuroidea	0.42	0.12	0.00	0.05
Clupeidae	0.42	0.36	0.22	0.24
Clupea pallasii	0.42	0.12	3.90	1.70

TABLE XVIII

CONTINUED

Prey Taxon	% Freq. of Occurrence	% by Number	% by Volume	Index of Relative Importance
Salmoniformes	0.42	0.12	0.07	0.08
Thaleichthys pacificus	0.42	0.12	-	-
Gadidae	0.42	0.12	-	-
Cottidae	0.42	0.12	0.06	0.07
Stichaeidae	0.42	0.12	0.06	0.08
Lumpenus sp.	0.42	0.36	0.07	0.18
Pleuronectidae	0.42	0.12	0.09	0.09
Atheresthes stomias	0.42	0.12	0.06	0.08
Glyptocephalus zachirus	0.42	0.12	0.06	0.07
Unidentified Animal Material	7.63	2.37	0.07	-

the euphausiids consumed were from 10 mm to 20 mm long, and were often the only prey items found in a particular stomach.

The more widespread and numerically abundant species of euphausiids found in the northeast Gulf of Alaska inhabit the 0.0 m to 100 m depth zone, but frequently descend to greater depths (Brinton, 1962). However, the larger members of many species live permanently below 200 m, and do not ascend and descend diurnally as do their smaller, younger conspecifics (Ponomareva, 1963). It has been found that the euphausiid species *Thysanoëssa inermis* and *T. raschii* from Russian waters do not descend to the benthopelagic layers, as they do elsewhere during their diurnal migrations (Ponomareva, 1963). This is apparently a predator avoidance adaptation, freeing them from predation by demersal fishes.

It may be possible that *A. stomias* leaves the bottom and moves up into the water column to feed upon euphausiids. This has been suggested by Gotschall (1969). *Reinhardtius hippoglossoides*, a closely related and morphologically very similar species, is suspected of similar behavior (De Groot, 1970). The importance of the capelin (*M. villosus*) in the diet of the arrowtooth flounder may also support the hypothesis that *A. stomias* leaves the bottom to feed.

Information on the feeding habits of the arrowtooth flounder with regard to predator length was obtained by arbitrarily dividing the sample into six length categories (Table XIX). Due to great differences in sample size, the length groups may not be strictly comparable, but a trend towards increased piscivory with increase in predator length is apparent (Table XX).

Very small specimens of *A. stomias* (10-19 mm) were found to be feeding on copepods (Barraclough, 1968). The smallest arrowtooths from this study

TABLE XIX

CATEGORIES USED FOR FOOD HABITS ANALYSIS BY PREDATOR LENGTH FOR *ATHERESTHES STOMIAS* CAUGHT IN NORTHEAST GULF OF ALASKA, MAY-AUGUST 1975

Length category (mm)	# of fish	Mean length of fish (mm)	# feeding	# empty
0-150	7	106	5	2
151-250	217	214	120	97
251-350	252	292	90	162
351-450	39	381	8	31
451-550	23	499	4	19
≥ 551	20	614	9	11

TABLE XX

SUMMARY OF PREY TAXA BY PHYLUM OR CLASS FOR LENGTH OF PREDATOR, *ATHERESTHES STOMIAS*

Length Category	Prey Taxon	% Freq. of Occurrence	% of Number	% of Volume	Index of Relative Importance
0-150 mm	Euphausiacea	40.00	97.78	71.43	6768
	Decapoda	20.00	2.22	1.59	76
	Unident. Animal Mat.	40.00	-	26.98	-
151-250 mm	Annelida	0.83	0.26	0.02	0.23
	Mollusca	0.83	0.26	-	-
	Crustacea	63.33	79.58	5.88	5413
	Echinodermata	0.83	0.26	0.02	0.23
	Teleostei	40.00	14.66	13.82	1139
	Unident. Animal Mat.	5.00	2.09	0.06	-
251-350 mm	Mollusca	1.11	0.26	0.78	1.15
	Crustacea	47.78	79.03	88.72	8014
	Teleostei	46.67	19.18	10.45	1383
	Unident. Animal Mat.	7.78	1.53	0.06	-
351-450 mm	Crustacea	62.50	38.89	18.57	3591
	Teleostei	37.50	33.33	81.36	4301
	Unident. Animal Mat.	12.50	27.78	0.07	-
451-550 mm	Teleostei	100.00	100.00	100.00	20000
≥ 551 mm	Teleostei	100.00	100.00	100.00	20000

ate euphausiids and small decapods. Specimens from 151-250 mm in standard length were found to ingest the greatest variety of prey items when compared to the other size classes. Crustaceans were the most frequently consumed prey of fish up to 450 mm in length. Specimens over 450 mm long preyed exclusively on other fishes, primarily on pollock (*Theragra chalcogramma*) and other gadoids.

Euphausiids were of increasing importance in the diet of the arrowtooth flounders up to 350 mm long; none were found among the stomach contents of specimens larger than 350 mm.

Arrowtooth flounders from northern California were examined by Gotschall (1969). Over a period of 13 months, they were found to feed upon many of the same genera of prey that the arrowtooths from the northeast Gulf of Alaska use for food. The proportions of the various groups of prey between the two areas were quite similar also.

The importance of euphausiids in the diet of the northern California arrowtooth flounders was greatest during the months of April through July; Spetember and October also yielded specimens feeding on euphausiids. Such seasonal data is not available from this study. However, considering the similarity of feeding habits between the two areas, there is the possibility that NEGOA arrowtooths utilize euphausiids primarily during the warm months.

In examining the feeding habits of *A. stomias* from the northeast Gulf of Alaska, and comparing these data with those of Gotschall, it appears that, within the range of its diet, the arrowtooth flounder is opportunistic and will feed upon those prey items that are most available at a given time. However, the similarities in diet between the two areas indicate that the arrowtooth flounder feeds primarily upon pandalid shrimp, osmerids, gadoids, and euphausiids. The greater importance of euphausiids in the diet of the NEGOA arrowtooth flounders may be due to their greater abundance in northern waters during the warmer months. Further seasonal feeding data would be required in order to determine whether NEGOA arrowtooth flounders feed on euphausiids throughout the year.

Greenland halibut, *Reinhardtius hippoglossoides*,
Bering Sea

The stomachs of 123 specimens of *Reinhardtius hippoglossoides* were examined, of which 54 contained prey items. The remaining 69 stomachs were empty. Specimens were collected from seven trawl stations in the Bering Sea from April 9, 1976 to May 27, 1976 (Table XXI).

Fishes were the most important component of the diet of *R. hippoglossoides*. Only one specimen was found to be preying on crustaceans; the particular specimen was 141 mm, standard length.

Of the identifiable fish found among the stomach contents, the walleye pollock, *T. chalcogramma*, was the most frequently occurring (Table XXII). Prey species unidentifiable beyond the family level were most often members of the family Gadidae. The possibility exists that many of these were also pollock.

Other prey items were *M. villosus*, found in one stomach; and a representative of the familly Cottidae, also found in only one stomach.

Although specimens were collected from only two months, a trend was evident in the number of fish found feeding. Of the 50 fish collected from April 9 to April 18, only 10 were feeding, and the average stomach fullness was 11.5%. The 73 fish collected from May 20 to May 27 yielded 44 feeding specimens with an average stomach fullness of 52.7%. It is apparent from

TABLE XXI

STATIONS AT WHICH SPECIMENS OF *REINHARDTIUS HIPPOGLOSSOIDES* WERE OBTAINED IN APRIL-MAY 1976, BERING SEA

Station	Tow No.	Date	Time	Depth fished (m)
C5	20	4/9	2200	112.0
AB56	50	4/16	2121	155.0
D8	56	4/18	1801	93.7
MB13	102	5/20	1603	48.0
MB16	110	5/25	1527	203.0
MB69	112	5/27	1602	116.5
MB86B	113	5/27	2312	117.0

TABLE XXII

SUMMARY OF INDIVIDUAL PREY TAXA OF *REINHARDTIUS HIPPOGLOSSOIDES*
APRIL-MAY 1976, BERING SEA

Listed in descending order of frequency of occurrence

Taxon	% Freq. of Occurrence	% by Number	% by Volume	Index of Relative Importance
Teleostei (Unidentified)	62.52	59.37	9.55	4723
Theragra chalcogramma	16.67	20.31	9.79	501
Gadidae (Unidentified)	12.96	12.50	79.43	1192
Gadiformes (Unidentified)	1.85	1.56	0.33	4
Mallotus villosus	1.85	1.56	0.41	4
Cottidae	1.85	1.56	0.43	4
Decapoda	1.85	3.12	0.05	6

these data that *R. hippoglossoides* may feed little during the winter months and resume feeding in mid to late May. Similar habits have been observed in other flatfishes from the Bering Sea (Skalkin, 1963).

The feeding data from the fishes collected in May also suggest that there may be differences in feeding habits in relation to the depth at which the fish are taken. Fifteen *R. hippoglossoides* were collected at station MB13 on May 20, 1976. The station depth was 48 m, and none of the specimens were found to be feeding. At station MB69, at a depth of 116 m, 19 specimens were collected, 16 of which had been feeding. This station was occupied on May 27, 1976.

In order to determine whether or not *R. hippoglossoides* undergoes a change in feeding habits as a function of length, the specimens were arbitrarily divided into three length groupings (Table XXIII). The results of the food habits versus predator length analyses can be seen in Table XXIV.

It can be seen that no substantial change is evident in the diet as the predator increases in length. However, the single incidence of prey other than fish being taken is from the smallest specimen (141 mm, standard length) examined. This suggests the possibility that crustaceans (or other invertebrates) may be more important in the diet of smaller size *Reinhardtius*. De Groot (1970) maintains that conspecifics in the Atlantic Ocean change their feeding habits as they grow. Fish up to 100 mm long feed largely upon decapod crustaceans, while larger individuals feed on polar cod, redfish, and capelin.

De Groot (1970) also suggests that in feeding, *R. hippoglossoides* may habitually leave the bottom and swim far up into the water column. When doing so, it is thought that the fish swims as roundfish do, with the dorsal side up.

TABLE XXIII

ARBITRARY LENGTH CATEGORIES OF *REINHARDTIUS HIPPOGLOSSOIDES* USED IN FEEDING HABITS ANALYSIS

Category (mm)	# of fish	Mean length (mm)	# feeding	# empty
101-275	40	229	23	17
276-450	80	300	30	50
$\geq$ 451	3	742	1	2

TABLE XXIV

INDIVIDUAL PREY TAXA OF *REINHARDTIUS HIPPOGLOSSOIDES* BY PREDATOR LENGTH CATEGORIES
APRIL-MAY 1976, BERING SEA

Length Category	Prey Taxon	% Freq. of Occurrence	% by Number	% by Volume	Index of Relative Importance
101-275 mm	Teleostei	52.17	44.44	34.96	4142
	Theragra chalcogramma	26.09	25.93	37.68	1659
	Gadidae	17.39	14.81	17.43	561
	Gadiformes	4.35	3.70	4.03	34
	Cottidae	4.35	3.70	5.25	39
	Decapoda	4.35	7.41	0.66	35
276-450 mm	Teleostei	83.33	72.22	42.38	9550
	Theragra chalcogramma	10.00	16.67	42.48	591
	Gadidae	6.67	8.33	12.54	139
	Mallotus villosus	3.33	2.78	2.60	18
≥ 451 mm	Gadidae	100.00	100.00	100.00	20000

More data on the feeding habits of *R. hippoglossoides* is needed to give a complete picture of the species' role in the Bering Sea ecosystem. Especially, more seasonal data are needed. Also, a greater number of specimens in the smaller size classes need to be examined in order to determine whether or not Bering Sea *Reinhardtius* undergo a change in feeding habits with increased length.

Capelin, *Mallotus villosus*,
southeastern Bering Sea

Little information is available on the biology of capelin from Alaskan waters. The species is distributed from Washington state to Korea and has been commercially fished by the Japanese. The economic importance of Pacific and Bering capelin has, to the present, been slight. Commercially important fish species such as salmon have been shown to feed on capelin (Jangaard, 1974) and recent studies on the food of other commercial and forage fishes in Alaska identify the capelin as a food organism of the arrowtooth flounder, pollock, and Greenland halibut, (this report). Additionally, Wehle (pers. comm.) has identified the capelin as an important food source for Alaskan seabirds of the family Alcidae. We here report on the food of capelin from the southeastern Bering Sea.

A summary of information on food of Bering Sea capelin is presented in Table XXV Only two phyla are represented among the food organisms, the Arthropoda (all crustaceans) and the Chaetognatha. The chaetognaths were so digested that no more specific identification could be made.

The most numerous prey organisms were calanoid copepods. The only identifiable genus was *Calanus*. Virtually all of the amphipods present were members of the pelagic Hyperiidae. Identifiable euphausiid speci-

TABLE XXV

A SUMMARY OF STOMACH CONTENTS FROM ALL SIZE CATEGORIES OF CAPELIN CAUGHT IN THE SOUTHEAST BERING SEA

Standard lengths ranged from ($\bar{x}$ = 141 ± 12 mm). Results are reported as frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and index of relative importance (IRI). Number of feeding individuals examined was 135.

Prey taxon	F	N	V	IRI
Crustacea	98	93	93	18258
Copepoda	19	63	8	1356
Mysidae	4	0.8	2	12
Amphipoda	6	10	6	92
Euphausiidae	73	19	74	6792
Chaetognatha	14	7	6	183
Unident. Animal Mat.	8	-	0.1	-

mens were all of the genus *Thysanoessa*. *T. longipes* and *T. raschii* were present in the stomachs of some capelin.

Table XXVI presents the food habits of the same population subdivided into three size categories. F, V and IRI values for each food category are presented for each size interval. In terms of relative importance (IRI), euphausiids rank first in all size categories, followed by copepods.

In this study, euphausiids constitute the most important food category in terms of IRI, volumetric contribution and frequency of occurrence. Copepods are most numerous in occurrence, contributing 63% of the individual food organisms counted. These findings differ somewhat from those reported for the Atlantic capelin by Prokhorov (1965) and Templeman (1948). In those studies, eupahusiids contributed the greatest proportion by weight but copepods were highest in frequency of occurrence. All studies to date agree, however, that capelin are plankton feeders and undoubtedly filter relatively small planktonic organisms with their mesh of elongated gill rakers.

One might speculate that filter mesh size increases in proportion to body size and, therefore, that smaller fishes might rely more heavily on smaller food organisms. This hypothesis could best be tested by examining the foods of widely divergent size categories of capelin. Unfortunately, such divergence was not available in our limited sample of Bering Sea capelin. However, the data on prey organisms versus size, in Table XXVI, does show some interesting trends.

The smallest food item, copepoda, has its greatest volumetric and relative importance in the smallest size category. The same is true of the next to smallest food items, the Mysidae. All of the mysids found in capelin stomachs were very small ($\leq$5 mm).

TABLE XXVI

FEEDING HABITS OF CAPELIN IN THREE SIZE CATEGORIES FROM THE SOUTHEAST BERING SEA

Results are reported as percent frequency of occurrence (F), the first number; percent volumetric contribution (V), the second number; and index of relative importance (IRI), the third number. Mean length ($\bar{x}$) and sample size (n) are reported for each interval.

Prey taxon	105-124 mm $\bar{x}$=116, n=9	125-144 mm $\bar{x}$=135, n=64	145-164 mm $\bar{x}$=151, n=61
Copepoda	22, 39, 2869	19, 6, 1239	20, 7, 1265
Amphipoda		3, 3, 30	10, 8, 215
Mysidae	11, 11, 140	3, 2, 6	5, 1, 11
Euphausiidae	78, 50, 4480	77, 80, 7903	69, 71, 6201
Chaetognatha	22, 0, 16	14, 7, 211	13, 7, 180

All specimens examined in this study were captured during the period from late spring to early fall. Therefore, no information is available on seasonality of feeding in Bering Sea capelin. Jangaard (1974), in summarizing studies on Atlantic capelin, indicates that feeding activity is highly seasonal. During midwinter feeding ceases, followed by early spring feeding activity. Feeding intensity declines with the beginning of spawning migrations and ceases during the spawning season. After spawning, feeding reaches high intensity and proceeds at high intensity until early winter. Condition, as indicated by percent fat content, changes seasonally in response to the seasonality of feeding. Winters (1969) reports fat content as low as 1% in postspawning fish and as high as 23% in fish in prime condition. Presumably, Bering Sea capelin experience similar fluctuations in feeding intensity and condition.

Shortfin eelpout, *Lycodes brevipes*

The shortfin eelpout is a widely distributed zoarcid, ranging from Oregon to Alaska, the Bering Sea and the Sea of Okhotsk (Hart, 1973). I could find no information specifically dealing with the feeding habits of this species.

The wattled eelpout, *Lycodes palearis*, feeds on small clams, and shrimps in the Puget Sound region (Slipp and DeLacy, 1952). *Lycodes raridens* from the Bering Sea consumes small bivalves (*Yoldia*) and crustaceans (Andriyashev, 1964). The blackbelly eelpout, *Lycodopsis pacifica*, feeds on bivalves, polychaetes, amphipods, small crabs and ophiuroids in British Columbia waters (Levings, 1969).

Table XXVII reports the stomach contents of a sample of 103 feeding individuals from the northeast Gulf of Alaska. In descending order of relative importance (IRI) are the following prey phyla: Arthropoda (Crustacea), Annelida (Polychaeta), Mollusca, Echinodermata and Chordata (Teleostei).

Important benthic food organisms were polychaetes, crabs (Majidae), clams, and ophiuroids, in descending order of IRI. Euphausiids, usually thought of as pelagic, were a major source of foods to shortfin eelpouts in the northern Gulf.

A sample of 24 feeding individuals was examined from the southeast Bering Sea (Table XXVIII). Food organisms were in an advanced state of digestion and/or degradation, allowing little identification. These limited data suggest that polychaetes and crustaceans were about equally important in shortfin diets, both in terms of volumetric contribution and the IRI parameter. However, the large contribution made by unidentifiable animal remains makes any further speculation futile.

Pacific cod, *Gadus macrocephalus*

Only a few authors have reported on food habits of the Pacific cod. Suyehiro (1942) lists the food organisms of cod captured in Bristol Bay. They include pollock, yellowfin sole, other flatfishes, crangonid and other shrimps, several crabs, several amphipods, hermit crabs, polychaetes and the clam *Yoldia*. Hart (1973) includes herring, sand lance, pollock, flatfishes, worms, crabs, molluscs and shrimps among Pacific cod foods.

Feeding may be somewhat tied to migrations in some populations of Pacific cod. Ketchen (1961) has shown that cod along the British Columbia coast move into deep water in autumn and back to shallow water in the

TABLE XXVII

A SUMMARY OF STOMACH CONTENTS FROM SHORTFIN EELPOUT CAUGHT IN THE NORTHERN GULF OF ALASKA

Standard lengths ranged from ($\bar{x}$ = 187 ± 32 mm). Results are reported as frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and index of relative importance (IRI). Sample size of feeding individuals was 103.

Prey taxon	F	N	V	IRI
Polychaeta	42	25	23	1984
Mollusca	12	8	11	220
Pelecypoda	11	8	10	187
Cephalopoda	1	0.4	1	1.3
Crustacea	56	59	51	6182
Isopoda	1	0.4	0.5	0.9
Gammaridae	1	0.4	0.5	0.9
Euphausiidae	15	25	24	718
Pandalidae	16	10	9	291
Hippolytidae	1	0.4	0.5	0.9
Majidae	17	16	11	437
Echinodermata	11	8	5	139
Asteroidea	1	0.4	1	1.3
Ophiuroidea	10	7	5	114
Teleostei	1	0.4	0.5	0.9

TABLE XXVIII

A SUMMARY OF STOMACH CONTENTS FROM
BERING SEA SHORTFIN EELPOUT

The sample of 24 feeding individuals ranged in standard length from ($\bar{x}$ = 224 ± 31 mm). Results are reported as frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and index of relative importance (IRI).

Prey taxon	F	N	V	IRI
Polychaeta	42	1.5	37	1599
Crustacea	33	1.2	37	1267
Amphipoda	13	1.1	26	342
Unident. Animal Material	46	97	26	-

springtime. Hart (1973) points out that B.C. cod congregate for spawning (winter) and disperse for feeding (presumably, spring).

Recently, Jewett (1978) has presented data on stomach contents from some 4200 Pacific cod from the vicinity of Kodiak, Alaska. Most of these fish were captured in crab pots; some 344 were taken in bottom trawls from the same area. Data are presented in percent frequency of occurrence and actual frequency of occurrence. Only summer sampling was conducted.

The most important food categories in both pot-caught and trawl caught cod were fishes, crabs, shrimps and amphipods, in decreasing order of occurrence. The fish most frequently eaten was the walleye pollock, *T. chalcogramma*, with Pacific sandlance, *Ammodytes hexapterus*, and flatfishes (Pleuronectidae) also contributing frequently to cod diets. Snow crab, *Chionoecetes bairdi*, was the most frequently occurring food species, appearing in almost 40% of the stomachs examined.

Jewett (1978) also presents data which indicate a year-to-year variation in the diet of Pacific cod in the Kodiak area. He also suggests that food organisms shift in frequency with increased size in cod. Fish and cephalopod frequencies seemed to be directly related to size, while amphipod and polychaete frequencies were inversely related to size of predator.

Yellowfin sole, *Limanda aspera*

Information on food habits of the yellowfin sole has been extracted from Russian workers. Andryiashev (1964) states that *Limanda aspera* feeds mainly on polychaetes, molluscs and ophiuroids.

Skalkin (1963) dealt with the diets of three flatfishes from the Bering Sea, and reported that about 50 different taxa contributed to the food of the yellowfin sole. He identified a group of taxa which contributed significantly in terms of frequency of occurrence and in numerical contribution.

This group includes amphipods, mysids, euphausiids, the bivalve *Gomphina fluctuosa* and *Cardium ciliatum* and the ascidian *Molgula*. A second group, the members of which occurred frequently but in smaller numbers, included *Echiurus echiurus*, *Crangon dalli*, *Pandalus borealis*, *Yoldia johanni* and *Y. hyperborea*. A third group, containing *Serripes groenlandicus* and *Ophiura sarsi*, consisted of forms which commonly occurred in yellowfin stomachs but always in fragmented condition.

Skalkin suggests that yellowfin feeding habits vary with geographic subregion within the southeastern Bering Sea and also vary with depth. For instance, he states that mysids and euphausiids predominate in the diet in the northeastern sector (southwest of Cape Newenham and Kuskokwim Bay), while other crustacean species begin to dominate further to the southwest and to the northwest. In terms of depth versus diet, he cites a predominance of polychaetes in guts from 50-60 m, molluscs from 65-80 m and *O. sarsi* from depths greater than 80 m.

Marked seasonality of feeding intensity is suggested by Skalkin. Yellowfin sole apparently do not feed until late April on the wintering grounds (north of Unimak Island). Feeding intensity is low as fish migrate toward shallow water in May. July is a period of high feeding intensity in the southeast Bering Sea. Intensity of feeding falls off during the fall as yellowfin populations begin moving back down to deeper water.

It is worth mentioning that these conclusions were reached based on an analysis of 263 fish captured from July-September 1958, and 285 fish captured from April-June 1960. This is a total of 548 individuals from two different years.

Pacific Halibut, *Hippoglossus stenolepis*

This species continues to be an important fish from a commercial standpoint. Impacts felt farther down in the food chain will certainly have an effect on this large carnivore.

Young halibut become established on the bottom after 6 to 7 months of pelagic larval existence. The earliest juveniles occur in water shallower than 100 m. During ontogeny individuals tend to move offshore to deeper water. Immature halibut are relatively nonmigratory while adults from the Gulf of Alaska are known to migrate rather long distances, up to 700 miles in some cases.

Some information on food of halibut from the northeastern Pacific has been gathered by the International Pacific Halibut Commission. Analysis of stomach contents has largely been confined to sub-commercial size individuals since the stomach contents of longline-caught halibut are not typical of halibut in general (Skud, pers. comm.). Based on a sample size of over 2000 individuals lumped from different years and from southern British Columbia to Kodiak, the following conclusions are offered.

Halibut less than 4 inches long, not yet one year old, feed primarily on small crustaceans. At larger sizes, halibut begin feeding on shrimps, crabs and fish. The latter food category, especially sand lances, becomes the predominant food item in individuals over 10 inches long (IPHC Rept. 29, 1960). An exception to this latter generalization may be found in Cook Inlet, Alaska, where halibut up to 16 inches in length feed largely upon shrimp (IPHC Rept. 27, 1959).

Unpublished information on food of juvenile halibut from the Bering Sea has kindly been provided by Dr. Skud of the International Pacific

Halibut Commission. Information on a sample of 132 individuals indicates that the major food organisms in terms of frequency of occurrence are shrimp (32%), digested fish (25%), sand lance (15%) and crab (6%). Other food items included sculpin (3%), cod (2%), poacher (1%), sandfish (1%), snow crab (1%), amphipods (1%) and smelt (1%).

Novikov (1968) has reported on the food habits from the southeastern Bering Sea. Small halibut (30 cm or less) fed primarily on crustaceans (89%F) while medium sized fishes (30 to 60 cm) shift to a largely fish diet (61%F). Flatfishes, smelt, capelin, pollock and sand lances are included while crustaceans appear in 33% of the stomachs. Fishes larger than 60 cm fed predominantly on fishes, especially the yellowfin sole. Feeding intensity was greater in summer than in winter. Marked seasonal movements of halibut in the southeast Bering Sea have been reported.

Information for this species was abstracted from Gray (1964), Hart (1973) and Novikov (1968).

III. STUDY AREA

The study area includes the Gulf of Alaska, primarily the area bounded by Yakutat on the east and Resurrection Bay on the west. The Bering Sea study area lies principally in the southeast. Almost all collections came from stations south of Nunivak Island. Collections include fishes from Bristol Bay, the vicinity of the Pribilof Islands and along the continental slope.

IV. RESULTS

The results of feeding analyses have been incorporated into the section on State of Current Knowledge.

V. DISCUSSION

Current information, including our own contributions, has been summarized for twelve species from the Gulf of Alaska and the Bering Sea. That information indicates that, in terms of frequency of occurrence, benthic organisms are very important in the diets of dover sole, halibut, rock sole and rex sole. The pollock rely heavily on pelagic organisms and must, therefore, feed up off the bottom to a great extent. Intermediate in feeding habits are the arrowtooth flounder and the flathead sole. These two species take large numbers of pelagic euphausiids and also feed intensively on benthic prey organisms. From our studies it appears that major predators on fishes are the Pacific halibut, arrowtooth flounder, and Greenland halibut. Euphausiids are a major food item of pollock and capelin. Polychaetes are consumed intensively by dover sole, rock sole, and rex sole.

Activities which impact the benthic environment and its invertebrate fauna will have an impact on the benthic feeders mentioned above. Activities which primarily affect the pelagic environment will have effects on the pelagic feeders quickly. However, since the benthic fauna is ultimately dependent on primary production in the pelagic environment, it too will be affected, as will the fishes feeding on the benthos.

From the little information at hand on seasonal variation in distribution and feeding, a number of critical areas can be suggested. In the

Bering Sea, winter concentrations of halibut, yellowfin sole, rock sole and perhaps flathead sole as well are all found just to the northwest of Unimak Island.

Much more data is needed on the feeding habits and seasonality of feeding within the fish fauna. This is especially true of the Gulf of Alaska, which has not come under as much scrutiny by the Russian workers. Much information will be supplied by this present study but seasonal information for the Gulf of Alaska will still be largely unavailable.

LITERATURE CITED

Alderdice, D. G., and C. R. Forrester. 1974. Early development and distribution of the flathead sole (*Hippoglossoides elassodon*). *J. Fish. Res. Bd. Can.* 31:1879-1918.

Andriyashev, A. P. 1964. Fishes of the northern seas of the USSR. Transl. Isr. Prog. Sci. Transl. 617 pp.

Armstrong, R. H. and P. C. Winslow. 1968. An incidence of walleye pollock feeding on salmon young. *Trans. Amer. Fish. Soc.* 97:202-203.

Barraclough, W. E. 1967. Data record. Number, size and food of larval and juvenile fish caught with a tow boat surface trawl in the Strait of Georgia, April 25-29, 1966. Fish. Res. Bd. Can. MS Rep. Ser. 922:54.

Barraclough, W. E. 1968. Food of larval and juvenile fish caught with a two boat surface trawl in Saanich Inlet during June and July 1966. Fish. Res. Bd. Can. MS Rep. Ser. 1003:78.

Best, E. 1964. Catch records of a trawl survey conducted by the International Pacific Halibut Commission between Unimak Pass and Cape Spencer, Alaska from May 1961 to April 1963. Rept. Int. Pac. Halibut Comm. 36:1-524.

Brinton, E. 1962. The distribution of Pacific Euphausiids. Bulletin of the Scripps Institution of Oceanography of the University of California. 8(2):51-270.

Cooney, R. T. 1967. Diet differences in trawl catches of some demersal fishes. M.S. Thesis, Univ. Wash. 97 p.

De Groot, S. J. 1970. Some notes on the ambivalent behavior of the Greenland halibut, *Reinhardtius hippoglossoides*. *J. Fish. Biol.* 2(2):275.

De Groot, S. J. 1971. On the interrelationships between morphology of the alimentary tract, food and feeding behaviour in flat fishes (Pisces: Pleuronectiformes). *Netherlands J. Sea Res.* 5(2):121-196.

Feder, H. M., G. Mueller, G. Matheke, and S. Jewett. 1976. The distribution, abundance, diversity, and productivity of benthic organisms in the Gulf of Alaska. Environmental Assessment of the Alaska Continental Shelf., Annual Report 1976, 7:263-454.

Forrester, C. R. 1964. Rate of development of eggs of rock sole (*Lepidopsetta bilineata* Ayers). *J. Fish. Res. Bd. Can.* 21(6):15-153.

Forrester, C. R. 1969. Life history information on some groundfish species. Fish. Res. Bd. Can. Tech. Rep. 105:17.

Forrester, C. R. and J. A. Thomson. 1969. Population studies on the rock sole *Lepidopsetta bilineata* of northern Hecate Strait, British Columbia. Fish. Res. Bd. Can. Tech. Rep. 108:104.

Gotschall, D. W. 1969. Stomach contents of Pacific Hake and Arrowtooth flounder from northern California. Calif. Fish and Game 55(1):75-82.

Gray, G. W. 1964. Halibut preying on large crustacea. *Copeia* 3:590.

Grinols, R. B. 1965. Check-list of offshore marine fishes occurring in the northeastern Pacific Ocean, principally off the coasts of British Columbia, Washington, and Oregon. M.S. Thesis, Univ. Washington. 217 p.

Hagerman, F. B. 1952. The biology of the dover sole, *Microstomus pacificus* (Lockington). Calif. Div. Fish Game Fish. Bull. 78. 64 p.

Hart, J. L. 1949. Food of fish of the cod family. Fish. Res. Can. Pac. Prog. Rep. 79:35-36.

Hart, J. L. 1973. Pacific fishes of Canada. *Fish. Res. Bd. Canada Bull.* 180. 740 p.

Hayase, S., and I. Hamai. 1974. Studies on feeding habits of three flatfishes, *Cleisthenes pinetorum herzensteini* (Schmidt), *Hippoglossoides dubius* (Schmidt), and *Glyptocephalus stelleri* (Schmidt). Bull. Fac. Fish. Hokkaido Univ. 25(2):82-99.

Hosie, M. J. and H. F. Horton. 1977. Biology of the rex sole, *Glyptocephalus zachirus*, in waters off Oregon. *Fish. Bull.* 75(1):51-60.

Hughs, S. E. 1974. Groundfish and crab resources in the Gulf of Alaska - based on International Pacific Halibut Commission trawl surveys, May 1961-March 1963. U.S. Dept. Commer., NOAA, NMFS, Seattle, WA Processed Rep. 87 p.

Jangaard, P. M. 1974. The capelin (*Mallotus villosus*), biology, distribution, exploitation, utilization, and composition. *Fish. Res. Bd. Can. Bull.* 186. 70 pp.

Jewett, S. C. 1978. Summer food of the Pacific cod *Gadus macrocephalus* near Kodiak, Alaska. *U.S.F.W.S. Fish. Bull.*, in press.

Ketchen, K. S. 1961. Observations on the ecology of the Pacific cod (*Gadus macrocephalus*) in Canadian waters. *J. Fish. Res. Bd. Can.* 18:513-558.

Kravitz, M. J., W. G. Pearcy and M. P. Guin. 1976. Food of five species of co-occurring flatfishes on Oregon's continental shelf. *Fish. Bull.* 74(4):984-990.

Levings, C. D. 1969. The zoarcid *Lycodopsis pacificus* in outer Burrard Inlet, British Columbia. *J. Fish. Res. Bd. Can.* 26(9):2403-2412.

Miller, B. S. 1970. Food of flathead sole (*Hippoglossoides elassodon*) in East Sound, Orcas Island, Washington. *J. Fish. Res. Bd. Can.* 27(9):1661-1665.

Mineva, T. A. 1968. On the biology of some flatfishes in the Bering Sea. *In: Sov. Fish. Inv. N. Pac. Pt. II*, 227-235. Ir. Prog. Sci. Trans. TT67-51204. 289 p.

Needler, M. 1954. Confidential report. Fish. Res. Bd. Canada Pac. Biol. Sta., Nanaimo 1953:1-128.

Nikolskii, G. V. 1961. Special ichthyology. Israel Program for Sci. Transl.

Novikov, N. P. 1968. Basic elements of the biology of the Pacific halibut (*Hippoglossus hippoglossus stenolepis* Schmidt) in the Bering Sea. *In: Sov. Fish. Inv. N. Pac. Pt II*, 175-219. Isr. Prog. Sci. Transl. TT67-51204.

Pereyra, W. T., J. E. Reeves, and R. G. Bakkala. 1976. Demersal fish and shellfish resources of the eastern Bering Sea in the baseline year 1975. U.S. Dept. Commer., NOAA, NMFS, Seattle, WA Processed Rep. 619 p.

Pinkas, L., M. S. Oliphant, and I. L. K. Iverson. 1971. Food habits of albacore, bluefin tuna, and bonito in California waters. Calif. Fish Game. *Fish. Bull.* 152:3-82.

Ponomareva, L. A. 1963. Euphausiids of the North Pacific Ocean: Their distribution and ecology. Israel Program for Sci. Transl., Jerusalem. 154 pp.

Prokhorov, 1965.

Rae, B. B. 1969. The food of the witch. *Scotland Dept. Agr. Fish. Mar. Res.* 2:1-21.

Shubnikov, D. A. and L. A. Lisovenko. 1964. Data on the biology of rock sole of the southeastern Bering Sea. *In: Sov. Fish. Inv. N. Pac. Pt. II*: 220-226. Isr. Prog. Sci. Transl. TT67-51204.

Skalkin, V. A. 1963. Diet of flatfishes in the southeastern Bering Sea. *In: Sov. Fish. Invest. N. Pac. Pt. I*: 235-250. Isr. Prog. Sci. Trans. TT67-51203. 333 p.

Slipp, J. W. and A. C. DeLacy. 1952. On the distribution and habits of the wattled eel-pout *Lycodes palearis*. *Copeia* 3:201-203.

Smith, R. T. 1936. Report on Puget Sound otter trawl investigations. Wash. Dept. Fish. Biol. Rep. 36B:1-61.

Suyehiro, Y. 1934. Studies on the digestive system and the feeding habits of the important fishes in the North Pacific. II. The plaice, *Lepidopsetta mochigarei* Snyder and the halibut, *Hippoglossoides elassodon* Jordan and Gilbert. *Bull. Jap. Soc. Sci. Fish.* 3:65-72.

Suyehiro, Y. 1942. A study on the digestive system and feeding habits of fish. *Jap. J. Zool.* 10:1-303.

Templeman, 1948.

Winters, 1969.

Yazdani, G. M. 1969. Adaptation in the jaws of flatfish (Pleuronectiformes). *J. Zool. London* 159:223-248.

Zar, J. H. 1974. *Biostatistical Analysis*. Prentice-Hall Inc., N.J. 620 pp.

FINAL REPORT

NOAA-OCSEAP Contract:	01-06-022-11437
Research Unit:	RU-339
Principal Investigators:	C. J. Lensink
	J. C. Bartonek

A REVIEW OF THE LITERATURE AND A SELECTED BIBLIOGRAPHY OF PUBLISHED AND UNPUBLISHED LITERATURE ON MARINE BIRDS OF ALASKA

By

James C. Bartonek and Calvin J. Lensink

U.S. Fish and Wildlife Service

Office of Biological Services - Coastal Ecosystems
800 A Street - Suite 110
Anchorage, Alaska 99501

April 1, 1978

CONTENTS

INTRODUCTION

Alaska's wildlife resources and pristine character have long attracted naturalists, sportsmen, and adventurers. Alaska's juxtaposition to Asia, its arctic, subarctic, and alpine habitats, and its relative remoteness and primitiveness when compared with the "lower 48" were and still remain factors attracting ornithologists hopeful of finding pleasure, satisfaction and perhaps even fame from their efforts. Both federal and state agencies, universities, and the private sector have conducted and sponsored many studies of birds in Alaska for often diverse reasons. These general and specific interests in Alaska's wildlife have generated considerable ornithological information of which much has been published and recorded in administrative and manuscript reports.

This report contains a bibliography of more than 900 references published before and during 1976 on birds of the coastal and marine environment, with emphasis being on those birds from Alaska and adjacent areas. We have also made a cursory review of some of that information. The purpose of this document is to facilitate the identification of literature that is of regional and topical importance in describing coastal and marine avifaunas and in assessing impacts upon those avifaunas from whatever causes.

The bibliography is divided into three parts:

Part I. Published references on birds of coastal Alaska

Part II. Unpublished references on birds of coastal Alaska

Part III. References on birds in marine waters adjacent to Alaskan coastal waters and general references on marine birds and hazards to them.

Parts I and II are annotated as to regional relevance by use of a numeric code. Figure I and Table 1 provide reference to the area annotations.

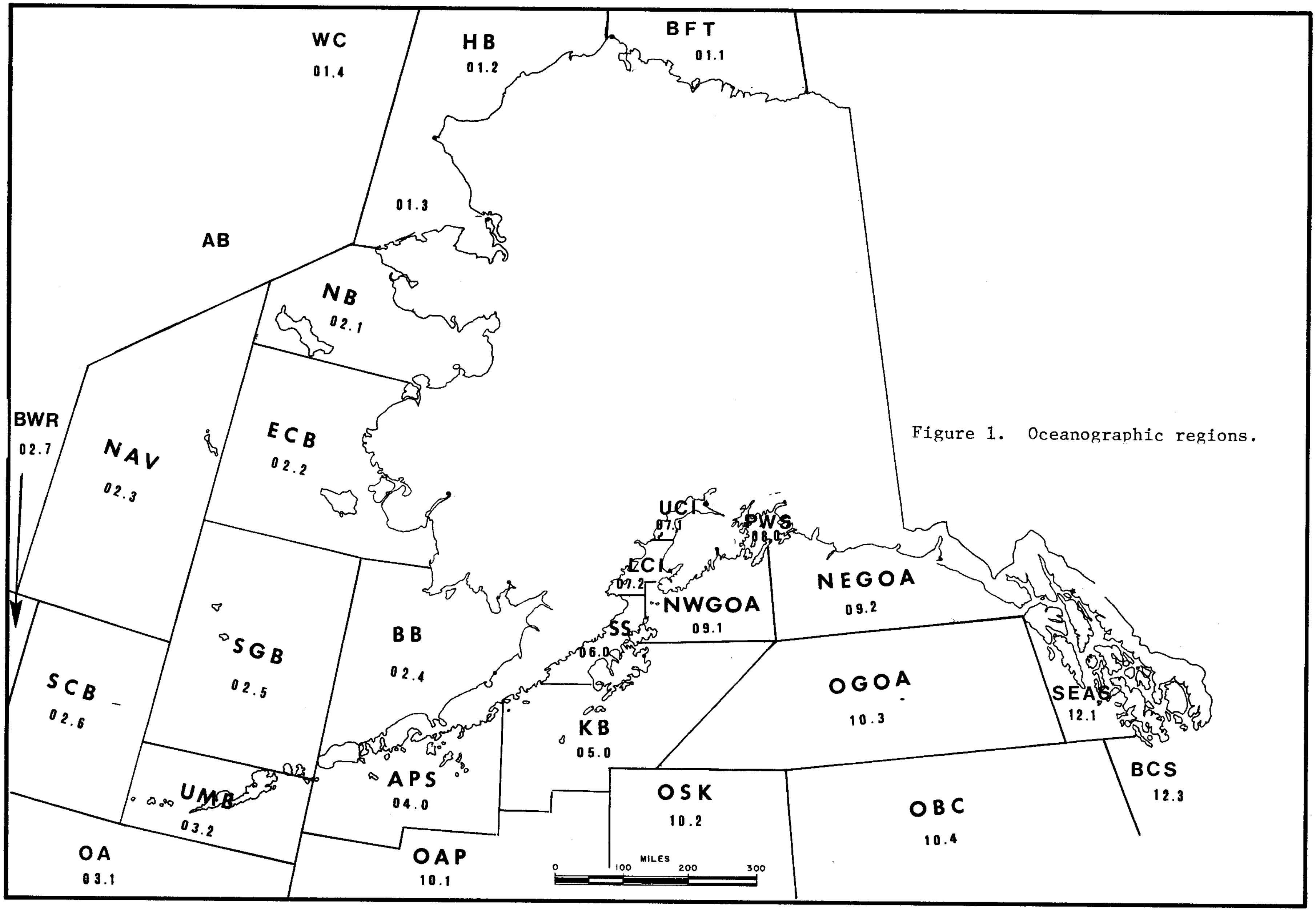


Figure 1. Oceanographic regions.

Table 1. Numeric codes for oceanographic regions used in annotations to bibliographic citations.

00.0		Statewide - General
01.0		Arctic Ocean
	01.1	Beaufort Basin (BFT)
	01.2	Northern Chukchi (NC)
	01.3	Hope Basin (HB)
	01.4	Western Chukchi (WC)
	01.5	Anadyrskly Basin (AB)
02.0		Bering Sea
	02.1	Norton Basin (NB)
	02.2	East Central Bering Sea (ECB)
	02.3	Navarin Basin (NAV)
	02.4	Bristol Bay Basin (BB)
	02.5	St. George Basin (SGB)
	02.6	South Central Bering Sea (SCB)
	02.7	Bower's Bank (BWR)
03.0		Aleutians
	03.1	Oceanic Aleutians (OA)
	03.2	Umnak Basin (UMB)
04.0		Alaska Peninsula South (APS)
05.0		Kodiak Basin (KB)
06.0		Shelikof Strait (SS)
07.0		Cook Inlet
	07.1	Upper Cook Inlet (UCI)
	07.2	Lower Cook Inlet (LCI)
08.0		Prince William Sound (PWS)
09.0		Gulf of Alaska
	09.1	Northwest Gulf of Alaska (NWGOA)
	09.2	Northeast Gulf of Alaska (NEGOA)
10.0		Sub-arctic North Pacific
	10.1	Oceanic Alaska Peninsula South (OAPS)
	10.2	Oceanic South Kodiak (OSK)
	10.3	Oceanic Gulf of Alaska (OGOA)
	10.4	Oceanic British Columbia
11.0		North Pacific
	11.1	North Pacific Transitional (NPT)
	11.2	Oceanic Washington (OW)
	11.3	Oceanic Oregon (OO)
	11.4	Oceanic Northern California (ONC)
	11.5	Oceanic Central California (OCC)
	11.6	Oceanic Southern California (OSC)
12.0		Shelf
	12.1	Southeast Alaskan Shelf (SEAS)
	12.2	Alaskan Inland Waterway (AIW)
	12.3	British Columbia Shelf (BCS)
	12.4	British Columbia Inland Waterway (BCIW)
	12.5	Washington Shelf (WS)
	12.6	Oregon Shelf (OS)
	12.7	Northern California Shelf (NCS)
	12.8	Central California Shelf (CCS)
	12.9	Southern California Shelf (SCS)
13.0		Kodiak (Inshore)

Although our delineation of the areas (Fig. 1) can correctly be regarded as being arbitrary, our intention is to facilitate information retrieval for both recognized oceanographic regions as well as those areas of the outer continental shelf that are being considered for petroleum exploration and possible production.

The bibliography is called "selected" because we recognize the likelihood of our omitting significant published literature. Although we used electronic date reference systems, including Fish and Wildlife Reference Service (Denver Public Library), BIOSIS, NTIS, Ocean Abstracts, and Dissertation Abstracts, to assist in our bibliographic search, we found visual searches of key references and such periodicals as Condor, Arctic, Canadian Field-Naturalist, Auk, Murrelet, and others, proved far more productive from the standpoint of both numbers of citations and thoroughness of the search.

Because of the nature of unpublished material (i.e., often irregularly appearing, nonserialized, limited distribution, not undergoing the rigors of editorial and peer group review), we have in this report barely scratched the surface of the body of unpublished information on birds of coastal Alaska. Much of the information cited herein comes from our personal familiarity with the material. The possible weaknesses in the bibliography from that standpoint are obvious. Since "unpublished references" can constitute about anything a person chooses to include, we have been arbitrary in that which we have included and excluded.

We believe that this document will assist persons interested in marine birds and their well-being and will provide a base for building what may someday approach being a "complete" rather than "selected" bibliography.

The nature of the "discovery" and later exploration of Alaska, provided more opportunities to describe the coastal and marine components of the avifauna than it did for the interior. Pearse (1968) and Stresemann (1948) provide modern-day interpretations to those sometimes not very illuminating glimpses of the avifauna as reported by naturalists, seamen, tradesmen, and explorers of the late 18th and early 19th centuries.

The thrust in ornithological investigations began in Alaska shortly after the territory was purchased from Russia in 1867 and continued through the 1920's. Museums, individuals, the Department of the Army, the Treasury Department, the Department of Agriculture, and others sponsored expeditions and maintained stations from which came much of the ornithological information that we use to measure changes in the status of some species. For obvious reasons of economy and war, the 1930's and early 1940's saw little significant work on Alaska's birds. Since then there has been a continuing increase in both the number and the quality of investigations. Systematic assessments of certain waterfowl populations have been conducted annually since 1947. Occasional spurts to general government and university support of studies has come from the National Science Foundation as in the case of the Tundra Biome studies, the Atomic Energy Commission for studies at Amchitka and Cape Thompson, the petroleum industry for studies related to routing of pipelines, and the Bureau of Land Management for studies of the outer continental shelf.

GENERAL INFORMATION ON ALASKAN BIRDS

Published Information

Gabrielson and Lincoln's (1959) "The Birds of Alaska" unquestionably is the single most significant literature on Alaska avifauna. This work has influenced the nature of ornithological investigations in the state for the past two decades and will likely continue to do so even after others improve on it. Their accounts of the 321 species then known to compromise Alaska's avifauna include theretofore unpublished information and summaries of published literature. Their bibliography is perhaps as important to students of ornithology as their species accounts. As Director of the U.S. Fish and Wildlife Service, Gabrielson had easy access to much of that agency's unpublished information and because of Lincoln's bibliophilic nature, most of the information in existence at that time was included within their bibliography. Persons who are unfamiliar with this work are cautioned that the species accounts often list only a portion of those relevant citations found in the bibliography.

Bent (1919-1926), Dement'ev, et al. (1951, 1952), Palmer (1962, 1972), Cottam (1939), Delacour (1954-1964), Bellrose (1976), Kozlova (1957), and Shuntov (1972) are general references which contain considerable information about marine and coastal birds in Alaska.

Unpublished Information

The unpublished information on birds of coastal and marine Alaska may exceed numerically that which has been published. For the most part, it contains more quantitative assessments of avian populations from which changes in status can be measured than that which has been published.

King and Lensink (1971) quantitatively describe waterfowl populations and habitats within various regions of the state and list marine bird colonies by location. Lensink (1969) analyzed band recoveries from white-fronted geese banded within the state and elsewhere. Timm (1972, 1974-76) and Timm and Haven (1973) reported on various investigations of waterfowl within the state and included population and harvest estimates of waterfowl in certain coastal areas. The U.S.D.I.'s (1973) proposal for Alaska Coastal National Wildlife Refuges contains theretofore unpresented information on marine bird colonies and populations at sea within proposal areas at or near Cape Lisburne to those proposal areas on the southeastern coast of the Kenai Peninsula.

BIRDS OF THE ARCTIC OCEAN AND COAST

Published Information

Much of Arctic Alaska's ornithological investigations has been done at or near Point Barrow. Being the "end of the line" for man and bird alike, Point Barrow has attracted ornithologists, in part, because of the tendency for birds that have wandered beyond their normal range to find their way there and, in part, because of the above average facilities, conveniences and transportation for this region that were associated with first the whaling stations, then the military, and now the Naval Arctic Research Laboratory. Petroleum development to the east has resulted in a recent, almost commensal, eastward shift in ornithological studies.

Two important reviews of Alaska's arctic avifauna are those of Bailey (1948) and Pitelka (1974), wherein most of the theretofore information is summarized and the qualitative status of birds is described. In an atlas of general information on Arctic Alaska, Selkregg ([1975]) maps various avian habitats, ascribes relative and absolute values for various populations, and includes a selected bibliography on birds which is not altogether duplicative of either Bailey (1948) or Pitelka (1974). Portenko (1973) describes the bird populations on the Asiatic side of the Chukchi Sea.

Intensive studies near Barrow by Pitelka, Holmes, Maher, Norton, Maclean, and others, individually and in collaboration (various dates for each author) has done much to characterize the behavior, productivity, and ecological requirements of certain sandpipers and, in part, explain cyclical relationships between certain birds and their mammalian prey. Quantitative assessments of bird populations at Cape Thompson (Williamson, et al. 1966, Swartz 1966), Little Diomede (Kenyon and Brooks 1960), and Point Storkersen (Bergman, et al. 1977) provide bases from which changes in the status of birds can be measured.

Information on abundance, distribution, and ecological requirements of birds in the seldom explored, ice-covered Arctic Ocean were reported by Swartz (1967), Watson and Divoky (1972, 1975), Frame (1973), Divoky (1975, 1976). Flock (1972, 1973, 1974, 1975) contributed to this small body of knowledge with his radar studies of bird migration along the coast from the Bering Strait to near the U.S.-Canadian border.

Unpublished Information

Reviews of ornithological studies on the Arctic Slope are given by Bartonek (1969) and A.I.N.A. (1974) and the former report contains some original data.

Avifauna of the Arctic National Wildlife Range has been treated in refuge narrative reports by Thayer (1971-1975) and Schmidt (1976), a reconnaissance report by Thayer (1966), a summer long study of coastal birds by Schmidt (1970), "wilderness" study reports (U.S.D.I. 1972, 1973), and extensions to the range through "d-2" legislation (U.S.D.I. 1973), and in reports describing Arctic Gas Pipeline's proposed routes across the Range (Gunn and Livingston 1974a,b,c, Gunn et al. 1974, Schweinsberg 1974, Tull, et al. 74).

BIRDS OF THE BERING SEA AND COAST

Published Information

Selkregg's ([1976]) all encompassing atlas cursorily treats birds of this region and includes a map delineating by density certain waterfowl populations and a selected bibliography of avian literature. The early works by Nelson (1883, 1887) and Turner (1886) give a broader, although understandably incomplete, description of the region's avifauna than does any single modern day writing with the exception of Gabrielson and Lincoln (1959).

Comparatively little has been published on the avifauna of southern Seward Peninsula and Norton Sound. Although Bailey (1943, 1948) reported on birds in the Bering Strait south to Fairway Rock, a majority of his efforts were northward along the Chukchi coast. Nelson (1883, 1887) traveled throughout the region studying the avifauna and the anthropology of Eskimos. Grinnell (1900) at Nome, McGregor (1902) along the Koyuk River, Hersey (1917) and Turner (1886) in the vicinity of St. Michael, Cade (1952) at Sledge Island, and Drury (1976) for the Nome to Golovin coast provide essential but nonetheless fragmentary examples of the regional avifauna.

The major contributions of Freidmann (1932), Fay and Cade (1959), Fay (1961), Bedard (1969a,b,c,), Sealy (1967-1971), Thompson (1967) and others are treated in the important review paper by Sealy, et al. (1971) on the avifauna of St. Lawrence

Island and various zoogeographical relationships. Papers published subsequently are largely those by Sealy (various dates), Sealy and Bedard (1974), Johnson (1974), and Johnson and West (1975).

Cursory accounts have been published on St. Matthew and Hall Island's avifauna by Elliot (1882), Bent (1919, 1922), Gabrielson and Lincoln (1959), Hanna (1917), Klein (1959) and McRoy, et al. (1971).

On that portion of the Arctic Coastal Lowlands being developed for petroleum, reports of the avifauna and their habitats have been reported by the U.S.D.I. (1970, 1972) for the field in general and the pipeline route specifically, Hall (1971) for Oliktok Point, Shepherd (1960) for black brant nesting in the Coleville River delta, Abraham (1975), Bartels (1973), Bergman (1974a,b), and Howard (1974) for the Point Storkersen area, and Schamel (1974, 1976) for the offshore Egg Island.

Some of the unpublished accounts of birds near Barrow are those by MacLean (1969) and Norton (1970, 1973) on shorebirds, which in part have been published, by Myres (1958, 1960) on the taxonomy and ecology of eiders, and by Johnson (1971) and Timson (1975) in assessment of the migration and economic use of eiders.

Various U.S.D.I. (1973) proposals for the Alaska Coastal and Selawik National Wildlife Refuges, Cape Kruzenstern National Monument, Chukchi-Imuruk National Wildlands, and Chamisso National Wildlife Refuge (U.S.D.I. 1970) wilderness designations contain important reviews of the avifauna and habitats and includes some original data.

Principally, the waterfowl along the north side of the Seward Peninsula have been the subject of various unpublished accounts by Hansen, et al. (1959), Nelson and Shepherd (1955), Scott (1949), and Thayer (1951). Kessel (1968) developed a checklist of birds for the Seward Peninsula.

Shipboard surveys of birds in the Arctic Ocean are reported by Burns (1973), Divoky (1972), Gould (1976d), Kirchhoff and Rauzon (1976), and Sowls (1975). Aerial surveys of birds in this region are reported by Bailey (1975), Barry (1974), Bartels (1971), Lensink, et al. (1976), Searing and Richardson (1975), and Searing, et al. (1976).

Rich in both numbers and diversity, the avifauna of the Yukon-Kuskokwin delta has been treated only part and parcel in the published literature. Nelson (1883, 1887), Turner (1886), Conover (1926), Brandt (1943), Gabrielson and Lincoln (1959), Williamson (1957), Hansen and Nelson (1957), Kessel, et al. (1964), Harris (1966), Springer (1966), Klein (1966), Holmes (1970, 1973), Lensink (1973), King (1973), and Mickelson (1975) have published about birds in this area. Only Swarth (1934) has published on the avifauna of nearby Nunivak Island.

Murie (1959) summarized the body of information on birds within the Bristol Bay area, including the Alaska Peninsula. The north shore of Bristol Bay, including Cape Newenham, Cape Peirce, and the Walrus Islands were given only cursory attention by early ornithologists (e.g., Turner 1886). More recently are published accounts of investigations in the lowlands near Lake Iliamna (Williamson and Peyton (1962, Gibson 1970) and Izembek Lagoon (Jones 1964, 1965, 1970, Jones and Jones 1966, Bailey 1973, 1974a,b, 1975, Bailey and Davenport 1972).

The avifauna of the Pribilof Islands has been described by Coues (1874), Elliot (1882), Palmer (1899), Hanna (1918), Preble and McAtee (1923), Kenyon and Phillips (1965), Thompson (1973) and others. Preble and McAttee (1923) provided the first substantive information on the food habits of some of those marine birds.

Murie (1959) also summarized the information on birds of the Aleutian Islands, including the important contributions by Dall (1873, 1874), Turner (1886), McGregor (1906), Cahn (1947), and others. Following Murie's review, greater descriptions of the avifauna are reported for Amchitka (e.g., Kenyon 1961, 1962, Emison, et al. 1971, White 1975), Adak (Byrd, et al. 1974), Bogoslof (Byrd and Divoky 1976), and efforts to re-establish the endangered Aleutian Canada goose on Buldir have been described (Byrd and Springer, 1976, King, et al. 1976).

Birds of the open ocean have not been overlooked by ornithologists. Anecdotal accounts of birds observed in the Bering Sea and in the North Pacific Ocean adjacent to the Aleutians have been reported by Reichenow (1909), Clark (1910), Laing (1924), Jaques (1930), Arnold (1948), Kenyon (1950), Kuroda (1955, 1960), Ryder (1957), and Irving, et al. (1970). The relative abundance and distribution of birds at sea was stressed by Shuntov (1961, 1962, 1963, 1966, 1972), Bartonek and Givson (1972), and King, et al. (1975). A meager beginning to understanding the trophic relationships among birds is discussed by Sanger (1972), Bartonek, et al. (1974), and Ogi and Tsujita (1975, 1976).

Unpublished Information

As with the published literature there has been little other than shipboard and aerial surveys of the Norton Sound region. U.S.D.I. (1973) discusses seabird colonies at Fairway Rock, King Island, Sledge Island, Bluff, and Egg Island and makes mention of other in the area.

Information on seabirds of St. Lawrence Island in theses by Bedard (1967) and Sealy (1968, 1972) have largely been published. Stephenson (1970) reports on the island's foxes using seabirds as food.

Annual narrative reports for the Clarence Rhode National Wildlife Range and Nunivak National Wildlife Refuge (e.g., King 1963, Lensink and Hout 1968, Hout 1966) provide substative new information on all aspects of birds of the Yukon-Kuskokwim region and adjacent Nunivak Island. Dau (1972), Gillham (1941), Jones and Kirchhoff (1976), and the U.S.D.I.'s (1973) proposal for a Yukon Delta National Wildlife Refuge contribute general ornithological information. Intensive studies of birds on the delta have been reported by Boise (1976) for sandhill cranes, Dau (1974) for spectacled eiders, Eisenhauer, et al. (1971), Eisenhauer and Kirkpatrick (1975), and Headley (1966, 1967) for emperor geese, Mickelson (1973) primarily for cackling Canada geese, Shepherd (1960) for brant, Olson (1950, 1954) for goose and brant production, and Peterson (1976) for red-throated loons. General waterfowl investigations including bandings are reported by Nelson (1951), Nelson and Scott (1956), and Nelson et al. (1951). Birds of Nunivak Island are reported in narrative accounts by Spencer (1952, 1967) and proposals for wilderness designation (U.S.D.I. 1972, 1973).

The birds of St. Matthews Island are described by Klein (1967) and within the U.S.D.I.'s (1967) review of the Bering Sea National Wildlife Refuge for wilderness status designation.

King (1966) described the avifauna of the Cape Newenham region in a report which was, in part, instrumental in that area being designated by Congress as the Cape Newenham National Wildlife Refuge. A larger area and its avifauna is described in the U.S.D.I. (1973) proposal for the Togiak National Wildlife Refuge. Lensink and Hout (1970), Hout (1971, 1972), Dick and Dick (1971), and Sigman (1976) describe the avifauna of the region, but primarily in the vicinity of Cape Peirce.

Miller (1972) describes the rich avifauna of Round Island in the Walrus Islands.

Avifauna of the lowlands along the southern shore of Bristol Bay are described by U.S.D.I. (1973) for the proposed Iliamna National Resource Range, Gill (1977) for the Port Moller-Herendeen Bay-Nelson Lagoon complex, and various narrative reports (e.g., Bailey 1973) of the Izembek National Wildlife Refuge for Izembek Lagoon, Cold Bay, and Unimak Island. Jones (in press) described various ecological relationships of birds to Izembek Lagoon. McRoy (1966) in his description of the world's largest eel-grass bed describes its importance to birds.

Sekora (1973) in his wilderness study report on the Aleutian Islands described the avifauna and cataloged many unreported seabird colonies. Birds on Bogoslof Island (U.S.D.I. 1967) and Unimak Island (U.S.D.I. 1971, 1972) are described in wilderness status reports. Byrd (1974) reports on activities, including bird studies, by staff of the Aleutian Islands National Wildlife Refuge. Wehle (1975) investigated the food habits of puffins on Buldir Island. Childs (1967), Kenyon (1966), Williamson and Emison (1969) and McCann (1963) contributed to the ornithological information on Amchitka Island. Harrison and Hatch (1975) and Phillips (1976) monitored bird migration through Unimak Pass from vantage points at Cape Sarichef and Scotch Cap.

Shipboard observations of birds within the Bering Sea and westward through the Aleutian Islands have been reported by Baird (1976a), Benson and Timson (1975a), Gould (1976a, b), Harrison and Hatch (1975), Hatch (1975), Hatch and Rauzon (1975), Henderson (1975a, b), Henderson, et al. (1975), King, et al. (1974), Kirchhoff and Rauzon (1975), Lensink and Bartonek (1976), Nysewander (1975, 1976), Phillips (1976), Rauzon (1975, 1976a, b, c), Rauzon and Ruehle (1975), Sowls (1975), Trapp (1975), Warner (1975), and Warner and Guzman (1975). Aerial surveys in this region include those reported by Bailey (1975), King and McKnight (1969), Lensink, et al. (1976), and Montgomery (1972).

BIRDS OF THE GULF OF ALASKA AND COAST

Published Information

There has been no published account that treats specifically the Gulf of Alaska, i.e., from Unimak Island eastward to Cape Fairweather. Selkregg ([1975, 1976]) in two regional profiles delineates waterbird habitats on maps and includes selected bibliographies of the major published and unpublished sources of information. LeResche and Hinman (1973), in an atlas which contained the first published state-wide catalog of marine bird colonies, provided limited information as to the location, size, and species composition of colonies in the region.

Bendire (1895), Bent (1919-21), Murie (1959), Gabrielson and Lincoln (1959), Kenyon (1964), Cahalane (1944, 1959), and Narver (1970) provide fragmentary information on birds of the coast and islands of the south side of the Alaska Peninsula.

The avifauna of Kodiak has fared better in published accounts than has the mainland across Shelikof Strait. Bretherton (1896), Friedmann (1935), Cahalane (1943), Dearborn (1957) reported on birds in general, while Hensel and Troyer (1964) and Troyer and Hensel (1965) reported on bald eagles and Mossman (1958) reported on glaucous-winged gulls preying on salmon.

The avifauna of the Cook Inlet-Kenai Peninsula area has been described in part by Osgood (1901), Figgins (1904), Williamson and

Peyton (1959, 1963), Williamson, Peyton and Isleib (1965), and Hemming (1966). Bailey (1976a, b) has described the birds of the Barren Islands which lie at the entrance to Cook Inlet.

Prince William Sound and the adjacent Copper River delta have been described for birds by Grinnell (1910), Hansen (1962), Yocum (1962) and Kessel, et al. (1967). Isleib and Kessel (1972) summarize the works of these and others studying birds in the region and make a significant contribution by estimating the numbers of birds seasonally using the region. Rausch (1968) and O'Farrell and Sheets (1962) describe the birds of Middleton Island prior to the earthquake of 1964 which altered both the physiography and bird populations of the island.

Observations of birds at sea within the Gulf of Alaska have been reported by Kurochkin (1963), Shuntov (1964, 1966, 1968, 1972), Sanger (1972a, b, 1973, 1974), Wahl (1976) and others.

Unpublished Information

The U.S.D.I. (1972), in its assessment of marine transportation of petroleum from Valdez to various ports, described the marine birds of the North Pacific Ocean from the Gulf of Alaska south to and including California and presented a catalog of bird colonies for the same area.

The avifauna of the coast and offshore islands along the south side of the Alaska Peninsula has fared better with unpublished information than with that which was published. Sowl (1973) and Vailey (1973) report on the location, size and composition of many previously unreported colonies. The U.S.D.I. (1973) proposal for Alaska Coastal National Wildlife Refuges described colonies within this area as well as around the Kodiak coast, the Barren Islands, and on the southeastern coast of the Kenai Peninsula. Moe (1976) for a portion of the Shumagin Islands, Power (1976a, b) and Wehle (1976) for Ugaiushak Island, and Hatch (1976) for Chowiet Island, reported on the local summer avifauna, stressing population estimates and species biology.

Dick (1976) and Dick, et al. (1976) describe colonies and ecological requirements and production of seabirds around Kodiak Island. Atwell (1975) in an annual narrative report of the Kodiak National Wildlife Refuge describes wintering bird populations in coastal waters.

The bird populations of the Barren Island have been reported by Roseneau (1965), U.S.D.I. (1973), and Manuwal and Boersma (1976).

The kittiwake colonies of Chisik Island in lower Cook Inlet was described by Snarski (1973, 1974). Quimby (1972) described birds summering on Chickaloon Flats. King (1968) estimated populations of trumpeter swans in coastal lowlands adjacent to Cook Inlet. Timm (1972, 1974-1976) and Timm and Haven (1973) provide population and harvest information of waterfowl in the Cook Inlet area.

Information on birds within Prince William Sound are provided by U.S.D.I. (1973), Haddock and Benson (1975), Lyon, et al. (1954), and McRoy and Stoker (1969). Wohl (1976) made winter observations of birds about Middleton Island.

Mickelson (1973) reviews information on birds in the Copper River delta, and he (Mickelson 1974) reports on a survey of birds on Egg Island. The dusky Canada geese specifically and waterfowl in general have been the subject of many investigations including those of Shepherd (1959, 1960), Trainer (1959), Olson (1954), King (1968), and Bromley (1976).

Shipboard observations of birds within the Gulf of Alaska include those of Baird (1976a), Benson and Timson (1975), DeGange (1977), Dick, et al. (1976), Forsell (1976a, b), Frazer and Hardy (1976), Gould (1976a, b, c, d, e, f), Gould and Rauzon (1976), Handel (1975), Handel and Benson (1975), Hardy and Nysewander

(1976), Harrison (1976a, b), Harrison and Hatch (1975), Hatch (1975, 1976), Hatch and Rauzon (1975), Hatch and Timson (1975), Henderson (1975a, b), Henderson, et al. (1975), Isleib and Eberhardt (1975), King, et al. (1974), Kirchhoff (1975), Kirchhoff and Rauzon (1975), Lensink and Bartonek (1976), Nysewander (1975, 1976), Phillips (1976), Phillips, et al. (1976), Rauzon (1975, 1976a, b, c), Rauzon and Ruehle (1975), Ruehle (1975), Sanger (1974), Sowls (1975), Trapp (1975), Warner (1975), and Warner and Guzmann (1975). Aerial surveys within this region are reported by Bailey (1975), Haddock and Benson (1975), and Lensink, et al. (1976).

BIRDS OF SOUTHEAST ALASKA

Published Information

It would appear that ornithologists for the most part bypassed Southeast Alaska enroute to arctic and subarctic portions of the state. Perhaps the spruce-hemlock forests and associated avifauna were to much akin to that extending southward along the coast to Oregon to capture the interest of those seeking the "unusual." Grinnell (1897a, b, 1898, 1909) provides the most comprehensive treatment of the region's avifauna. In a regional profile Selkregg ([1976]) cursorily treats the birds but lists in a selected bibliography most of the more significant published and unpublished references on the subject. Local and species specific accounts of birds were published by Hansen (1962), Heath (1915), Webster (1942, 1950), Willet (1912-32), Welch (1965), King, et al. (1972), White, et al. (1976) and Sealy (1973).

Pelagic observations of birds off the southeastern coast are lacking. Myres (1972) did, however, make radar observations of migration across this region into the Gulf of Alaska.

Unpublished Information

As with the published literature, there is comparatively less unpublished information on birds in this region than for other coastal regions. Gibson (1976), Gibson and MacDonald (1975), and Ritchie (1974) provide information on birds in general in this region. Imler (1941), Corr (1969, 1974) and Robards and King (1966) describe eagle populations and discuss certain timber management practices as related to nesting birds.

Birds of the Glacier Bay National Monument have been described by Jacot (1962), Wik (1967) and Patten and Patten (1975).

Nelson (1950) describes the food plants of waterfowl on the Stikine River delta.

Wilderness study reports (U.S.D.I. 1967) for the Forrester Island, Hazy Island, and St. Lazaria Island National Wildlife Refuges contain a review of most information on important seabird colonies and includes some original information.

Shipboard observations of birds in the waters of southeastern Alaska and offshore include those by Benson and Timson (1975), Forsell (1976a, b), Frazer and Hardy (1976), Handel and Benson (1975), Hardy and Nysewander (1976), Hatch and Rauzon (1975), Henderson (1975b), Isleib and Eberhart (1975), Kirchhoff and Rauzon (1975), Nysewander (1975), Phillips, et al. (1976), Rauzon (1976b), Sowls (1975), Warner (1975), and Warner and Guzmann (1975). There are no reported aerial surveys of birds at sea in this region.

CONSERVATION ISSUES

There have been a few published papers pertaining to the conservation of birds in the coastal and marine environment including those by Sowls and Bartonek (1974), Bartonek, et al. (1971), King (1973), and King, et al. (1976). Oil contamination of birds in the coastal environment is discussed by Evans (1969), Anonymous (1968, 1970), Vermeer (1976), and Vermeer and Anweiler (1975), and assessment of impacts on marine birds from OCS oil and gas development in Alaska is discussed in U.S.D.I. (1976a, b, 1977), as is organochlorines by Ohlendorf, et al. (1975). Gabrielson (1952), LeResche and Hinman (1973), and U.S.D.I. (1973) identify the desireability of protecting coastal bird habitat. The accidental gill netting of birds is discussed by Sanger (1976).

SELECTED BIBLIOGRAPHY

Part I. Published References on Birds of Coastal Alaska

Adams, E. 1878. Notes on the birds of Michalaski (Saint Michael), Norton Sound. Ibis :420-442. 02.1

Anderson, R. M. 1913. Report on the natural history collections of the expedition. Pages 436-527, in V. Stefansson, My life with the Eskimos. Macmillan Co., New York. 538 p. 01.1

Anderson, R. M. 1915. Canadian Arctic Expedition, 1913-14. Canad. Dept. Mines, Summ. Rept. Geol. Survey 1914, Sess. Paper 26 (1503): 163-166. 01.1, 02.1

Anderson, R. M. 1917. Canadian Arctic Expedition, 1916. --Zoology. Canad. Dept. Mines, Summ. Rept. Geol. Survey 1916, Sess. Paper 226(1684):374-384. 01.0

Anderson, R. M., and P. A. Taverner. 1919. Birds of western ArcticAmerica. Canadian Arctic Expedition, 1913-1918, Rept., Vol. 2, pt. B., Ottawa 01.0

Andersson, M. 1971. Breeding behavior of the long-tailed skua Stercorarius longicaudus (Vieillot). Ornis. Scand. 2(1):35-54. 01.1

Andersson, M. 1973. Birds of Nuvagapak Point, northeastern Alaska. Arctic 26(3):186-197. 01.1

Anonymous. 1968. Dead ducks again. Alaska Conserv. Rev. 9(3):6. 07.0

Anonymous. 1970. Bird deaths mount in Alaska. Marine Poll. Bull. 1(5):66. 05.0

Apollonio, S. 1958. Notes from the North Polar region. Auk 75(4):468

Arnold, L. W. 1948. Observations on populations of North Pacific pelagic birds. Auk 65(4):553-558. 01.0, 02.5, 02.6, 02.7, 10.0

Austin, O. L., Jr. 1952. Notes on some petrels of the North Pacific. Bull. Mus. Comp. Zool. 107:391-407. 00.0

Bailey, A. M. 1926. Winter notes for the Copper River, Alaska. Condor 28:174-175. 09.2

Bailey, A. M. 1925-1926. A report on the birds of northwestern Alaska and regions adjacent to Bering Strait. Parts I - X. 27(1):21-32; 27(2):62-67; 27(3):101-109; 27(4):164-171; 27(5):197-207; 27(6):232-238; 28(1):31-36; 28(2):84-127; 28(3):121-126; 28(4):165-170. 01.3, 02.1

Bailey, A. M. 1927. Notes on the birds of southeastern Alaska. Condor 44(1):1-23; 44:184-205; 44:351-367. 12.2

Bailey, A. M. 1943. The birds of Cape Prince of Wales, Alaska. Proc. Colorado Mus. Natur. Hist. 18. 113 p. 01.0, 02.1

Bailey, A. M. 1948. Birds of arctic Alaska. Colorado Mus. Natur. Hist. Popular Ser. 8. 317 p. 01.0, 02.1

Bailey, A. M. 1956. The bean goose and other specimens from St. Lawrence Island, Alaska. Auk 73:560. 02.1

Bailey, A. M., and L. B. Bishop. 1934. Additional records for the Barrow Region, Arctic Alaska. Condor 36(4):169 01.1, 01.2

Bailey, A. M., C. D. Bower, and L. B. Bishop. Birds of the region of Point Barrow, Alaska. Progr. Activities Chicago Acad. Sci. 4(2):15-40. 01.1, 01.2

Bailey, E. P. 1973. Discovery of a Kittlitz's murrelet nest. Condor 75(4):457. 02.4, 04.0

Bailey, E. P. 1974. Passerine diversity, relative abundance, and migration at Cold Bay, Alaska. Bird-Band. 45(2):145-151. 02.4, 04.0

Bailey, E. P. 1974. Winter banding of passerines on the Alaska Peninsula. Bird-Band. 45(4):307-314. 02.4, 4.0

Bailey, E. P. 1975. Discovery of a golden eagle nest on the Alaska Peninsula. Condor 77(2):207-208.

Bailey, E. P. 1975. Proposed Alaskan seabird refuges. Abstract. Pacific Seabird Group Bull. 2(1):40-41. 00.0

Bailey, E. P. 1976. Breeding avifauna of the Barren Islands, Alaska. Abstract. Pacific Seabird Group Bull. 3(1):33. 09.1

Bailey, E. P. 1976. Breeding bird distribution and abundance in the Barren Islands, Alaska. Murrelet 57(1):2-12. 09.1

Bailey, E. P., and G. H. Davenport. 1972. Die-off of common murres on the Alaska Peninsula and Unimak Island. Condor 74(2):215-219. 02.4

Banko, W. E. 1960. The trumpeter swan. U. S. Fish Wildl. Service, N. Am. Fauna 45. 214 pp.

Barry, T. W. 1968. Observations on natural mortality and native use of eider ducks along the Beaufort Sea coast. Canad. Field-Natur. 82(2):140-144. 01.1

Bartonek, J. C., D. D. Gibson. 1972. Summer distribution of pelagic birds in Bristol Bay, Alaska. Condor 74(4):416-422. 02.4, 02.5, 03.2

Bartonek, J. C., J. G. King, and H. K. Nelson. 1971. Problems confronting migratory birds in Alaska. Trans. N. Am. Wildl. Natur. Resources Conf. 36:345-361. 00.0

Bartonek, J. C., R. Elsner, and F. H. Fay. 1974. Mammals and birds. Pages 23-28, in E. J. Kelley and D. W. Hood, eds., PROBES: a prospectus on processes and resources of the Bering Sea shelf, 1975-1985. Univ. Alaska, Inst. Marine Sci. Publ. Inf. Bull. 75-1 (Alaska Sea Grant Rept. 73-10). 71 p. 02.0

Baysinger, E. B., and R. D. Bauer. 1971. A documented instance of reverse migration in the pintail. Auk 88(2):438. 12.1

Bean, T. H. 1882. Notes on birds collected during the summer of 1880 in Alaska and Siberia. Proc. U.S. Nat. Mus. 5:144-173. 01.0, 02.0

Bedard, J. 1966. New records of alcids from St. Lawrence Island, Alaska. Condor 68(5):503-506. 02.1

Bedard, J. 1969. Adaptive radiation in Alcidae. Ibis 111( ): 189-197. 02.1

Bedard, J. 1969. Feeding of the least, crested, and parakeet auklets around St. Lawrence Island, Alaska. Canad. J. Zool. 47(5):1025-1050. 02.1

Bedard, J. 1969. The nesting of the least, crested, and parakeet auklets around St. Lawrence Island, Alaska. Condor 71(4):386-398. 02.1

Bee, J. A. 1958. Birds found on the Arctic Slope of northern Alaska. Univ. Kansas Publ., Mus. Nat. Hist. 10(4):163-211. 01.0

Bellrose, F. C. 1976. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pennsylvania. 544 p. 00.0

Bendire, C. 1895. Notes on the ancient murrelet (Synthliboramphus antiquus by Chase Littlejohn. With annotations. Auk 12:270-278. 04.0

Bendire, C. E. 1895. Life histories of North American birds. U.S. Natl Mus. Spec. Bull. 3. 00.0

Bent, A. C. 1912. Notes on birds observed during a brief visit to the Aleutian Islands and Bering Sea in 1911. Smithsonian Misc. Coll. 56(2):1-29. 03.0

Bent, A. C. 1918. _Pterodroma_ _gularis_ in North America. Auk 35():221-222. 00.0

Bent, A. C. 1919. Life histories of North American diving birds, U. S. Natl. Mus. Bull. 107. viii + 245 p. 00.0

Bent, A. C. 1921. Life histories of North American gulls and terns. U. S. Natl. Mus. Bull. 113. ix + 345 p. 00.0

Bent, A. C. 1922. Life histories of North American petrels, pelicans, and their allies. U. S. Natl. Mus. Bull. 121. xii + 343 p. 00.0

Bent, A. C. 1923. Life histories of North American wild fowl (Part I), U. S. Natl. Mus. Bull. 126. ix + 250 p. 00.0

Bent, A. C. 1925. Life histories of North American wildfowl (Part II). U. S. Natl. Mus. Bull. 130. ix + 311 p. 00.0

Bent, A. C. 1926. Life histories of North American marsh birds. U. S. Natl. Mus. Bull. 135. xii + 490 p. 00.0

Bent, A. C. 1927. Life histories of North American shore birds (Part I). U. S. Natl. Mus. Bull. 142. ix + 359 p. 00.0

Bent, A. C. 1929. Life histories of North American shore birds (Part II). U. S. Natl. Mus. Bull. 146. ix + 340 p. 00.0

Bent, A. C. 1938. Life histories of North American Birds of Prey (Part II). U. S. Natl. Mus. Bull. 170. 00.0

Bergman, R. D., R. L. Howard, K. F. Abraham, and M. W. Weller. 1977. Water birds and their wetland resources in relation to oil development at Storkersen Point, Alaska. U. S. Dept. Int., Fish Wildl. Service Resqurce Publ. 129. 38 p. 01.1

Berlioz, J. 1951. Study of a collection of birds from the Pribilof Islands. Bull. Nat. Hist. Mus. Paris Ser. 2, 23:610-615. 02.5

Berry, A. L. 1946. Golden plover at sea. Condor 48(1):45. 10.0

Bishop, L. B. 1944. Ornithological notes from Point Barrow, Alaska. Field Mus. Nat. Hist., Zool. Ser. 29:181-190. 01.1, 01.2

Boggs, R. M., and E. M. Boggs. 1964. Sight record of short-tailed albatross. Murrelet 45(3):48. 03.1

Bourne, W. R. P. 1970. Observations of Seabirds. The Sea Swallow 20:47-54

Bousfield, E. L., and D. E. McAllister. 1962. Station list of the National Museum marine biological expedition to southeastern Alaska and Prince William Sound. Nat. Mus. Canada Bull. 183:76-103. 08.0, 12.1, 12.2

Brandt, H. 1943. Alaska bird trails. Bird Research Foundation, Cleveland, Ohio. 464 p. 02.2

Breckenridge, W. J. 1966. Dovekie on Little Diomede Island, Alaska. Auk 83(4):680. 01.3, 02.1

Breckenridge, W. J., and D. Cline. 1967. Sandhill cranes and other birds from Bering Strait, Alaska. Auk 84(2):277-278. 01.3, 02.1

Bretherton, B. J. 1896. Kodiak Island, a contribution to the avifauna of Alaska. Oregon Nat. 3:47-49, 61-64, 77-79, 100-102. 05.0

Brooks, J. W., J. C. Bartonek, D. R. Klein, D. L. Spencer, and A. S. Thayer. 1971. Environmental influences of oil and gas development in the Arctic Slope and Beaufort Sea. U. S. Dept. Int., Fish Wildl Serv. Resource Publ. 96. 24 p. 01.0

Brooks, W. S. 1915. Notes on birds from East Siberia and arctic Alaska. Harvard College, Bull. Mus. Compar. Zool. 54(5):361-413. 01.0

Byrd, G. V., D. D. Gibson, and D. L. Johnson. 1974. The birds of Adak Island, Alaska. Condor 76(3):288-300. 02.6, 03.1

Byrd, G. V., and G. J. Divoky. 1976. The birds of Bogoslof Island: a recently active volcano. Abstract. Pacific Seabird Group Bull. 3(1):33-34. 03.2

Byrd, G. V., and P. F. Springer. 1976. Restoration program for endangered Aleutian Canada geese. Abstract. Pacific Seabird Group Bull. 3(1):22. 03.1, 12.7

Cade, T. J. 1952. Note on the birds of Sledge Island, Bering Sea, Alaska. Condor 52(1):51-54. 02.1

Cade, T. J. 1955. Records of the black brant in the Yukon Basin and the question of a spring migration route. J. Wildl. Mgmt. 19 (2):321-324. 09.0

Cade, Tom J. and R. Fyfe. 1970. The North American Peregrine survey, 1970. Canad. Field-Nat., 84(3):231-245. 00.0

Cade, T. J., J. L. Lincer, C. M. White, D. G. Roseneau, and L. G. Swartz. 1971. DDE residues and eggshell changes in Alaskan falcons and hawks. Sci. 172:955-951 00.0

Cahalane, V. H. 1943. Notes on the birds of the Kodiak-Afognak island group. Auk 60:536-541. 05.0, 09.1

Cahalane, V. H. 1944. Birds of the Katmai region, Alaska. Auk 61( ): 351-375. 02.4, 04.0

Cahalane, V. H. 1959. A biological survey of Katmai National Monument. Smithsonian Misc. Coll. 138:83-155. 04.0

Cahn, A. R. 1947. Notes on the birds of the Dutch Harbor area of the Aleutian Islands. Condor 49(2):78-82. 03.2

Cantwell, G. C. 1897. From a collection in Alaska. Osprey 1:97-98. 12.1

? Cantwell, G. C. 1898. A June day on Egg Island. Outing 5:241-244. 12.2

Cantwell, G. C. 1898. Notes on the egg of the marbled murrelet. Auk 15( ):49 12.1

Cantwell, G. C. 1899. Nesting of the Alaska bald eagle. Osprey 3:66-67. 12.1, 02.5

Carver, W. H. 1928. Notes from St. George's Island, Alaska. Murrelet 9:63-65. 02.5

Chapman, F. M. 1902. List of birds collected in Alaska by the Andrew J. Stone expedition of 1901. Bull. Am. Mus. Nat. Hist., 16:231-247

Chapman, F. M. 1904. List of birds collected in Alaska by the Andrew J. Stone expedition of 1903. Bull. Am. Mus. Nat. Hist., 20:399-406.

Chapman, J. A., C. J. Henny, and H. M. Wight. 1969. The status, population dynamics, and harvest of the dusky Canada goose. Wildl. Monogr. 18 49 p. 09.2

Child, K. N. 1972. A new distributional record for the gadwall. Canad. Field-Natur 86(3):291-292. 01.1

Childs, H. E., Jr. 1969. Birds and mammals of the Pitmegea River region, Cape Sabine, northwestern Alaska. Biol. Papers Univ. Alaska 10. 01.2

Clark, A. H. 1907. Eighteen new species and one new genus of birds from eastern Asia and the Aleutian Islands. Proc. U.S. Natl. Mus. 32:467-475. 02.0, 03.0

Clark, A. H. 1910. The birds collected and observed during the cruise of the United States Fisheries Steamer "Albatross" in the North Pacific Ocean and in the Bering, Okhotsk, Japan, and Eastern Seas from April to December 1906. Proc. U. S. Natl. Mus. 38:25-74. 02.0, 03.0, 10.0

Conover, H. B. 1926. Game birds of the Hooper Bay Region, Alaska. Auk 43: 162-180, 303-318. 02.2

Cottam, C. 1939. Food Habits of North American diving ducks. U.S. Dept. Agr. Tech. Bull. 643. 139 p. 00.0

Cottam, C., and P. Knappen. 1939. Food of some uncommon North American birds. Auk 56(2):138-169. 03.0

Coues, E. 1874. Ornithology of the Prybilov Islands. Pages 168-212, in H. W. Elliott, Report on the Prybilov Group, or Seal Islands of Alaska. U.S. Treas. Dept., Washington, D.C. 02.5

Crow, J. H. 1971. Earthquake-initiated changes in the nesting habitat of the dusky Canada goose. Pages 130-136, in K. B. Krauskopf (Chmn.), The great Alaska earthquake of 1964: biology. Ntl. Research Council, Washington, D. C.

Dall, W. H. 1873. Notes on the avifauna of the Aleutian Islands, from Unalashka eastward. Proc. California Acad. Sci. 4(2):25-35. 03.2, 02.5

Dall, W. H. 1874. Notes on the avifauna of the Aleutian Islands, especially those west of Unalashka. Proc. California Acad. Sci. 5:270-281. 03.1

Dall, W. H., and H. M. Bannister. 1869. List of the birds of Alaska, with biographical notes. Trans. Chicago Acad. Sci. 1(2):267-310. 00.0, 02.2

Danielson, T. L. 1967. Bald Eagle swimming in the ocean with prey. Condor 69(3):313. 12.2

Dau, C. P. 1975. Occurrence and possible significance of an abnormal plumage in a spectacled eider. Murrelet 56(3):17. 02.2

Dawson, W. L. 1913. The tufted puffin. Bird-lore 15:268-271. 02.0, 03.0

Dearborn, J. N. 1957. Notes on the birds of Kitoi Bay, Afognak Island, Alaska. Proc. Alaskan Sci. Conf. 8:83-88. 09.1

Delacour, J. 1954-64. The waterfowl of the World. Country Life, London. 4 vols. 00.0

DeLong, R. L., and M. C. Thompson. 1968. Bar-tailed godwit from Alaska recovered in New Zealand. Wilson Bull. 80(4):490-491. 02.5

Dement'ev, G. P., and N. A. Gladkov. 1951. Birds of the Soviet Union. Vol. 1. (Transl. from Russian, Israel Progr. Sci. Transl., 1966. 705 p.). 00.0

Dement'ev, G. P., N. A. Gladkov, Yu. A. Isakov, N. N. Kartashev, S. V. Kirikov, A. V. Mikheev, and E. S. Ptushenko. 1952. Birds of the Soviet Union. Vol. 4. (Transl. from Russian, Israel Progr. Sci. Transl., 1967. 683 p.). 00.0

Dement'ev, G. P., N. A. Gladkov, and E. P. Spageburg. 1951. Birds of the Soviet Union. Vol. 2. (Transl. from Russian, Israel Progr. Sci. Transl., 1968. 553 p.) 00.0

Dick, M. 1975. Competition between the pelagic cormorant and black-legged kittiwake and its possible effects. Abstract. Pacific Seabird Group Bull. 2(1):33. 00.0, 02.4

Dick, M. 1975. Competition between the pelagic cormorant and black-legged kittiwake and its possible effects. Abstract. Pacific Seabird Group Bull. 2(1):33. 00.0, 02.4

Divoky, G. J. 1975. The association of seabirds with the Arctic pack ice off Alaska. Abstract. Pacific Seabird Group Bull. 2(1):36. 01.0, 02.0

Divoky, G. J. 1976. The pelagic feeding habits of ivory and Ross' gull. Condor 78(1):85-90. 01.0, 01.2, 02.0

Divoky, G. J., G. E. Watson, and J. C. Bartonek. 1974. Breeding of the black guillemot in northern Alaska. Condor 76(3):339-343. 01.0

Dixon, J. S. 1907. Some experiences of a collector in Alaska. Condor 9:128-135. 12.1, 12.2

Dixon, J. S. 1908. Field notes from Alaska. Condor 10:139-143. 08.0, 09.2

Dixon, J. S. 1908. A family of young duck hawks. Condor 10:198-200. 12.2

Dixon, J. S. 1916. Migration of the yellow-billed loon. Auk 33:370-376. 01.3

Dixon, J. S. 1917. Children of the midnight sun. Bird-lore 187-193. 01.0

Dixon, J. S. 1918. The nesting grounds and nesting habits of the spoon-billed sandpiper. Auk 33:387-404. 01.3

Dixon, J. S. 1943. Birds observed between Point Barrow and Herschel Island on the Arctic Coast of Alaska. Condor 45(2):49-57. 01.1

Drent, R. H. 1961. On the supposed nesting of the rhinoceros auklet near Metlakahtla, Alaska. Auk 78:257-258. 12.0

Drury, W. H. 1976. Seabirds of the Norton Sound area of Alaska. Abstract. Pacific Seabird Group Bull. 3(1):23. 02.1

Dufresne, F. 1942. Mammals and birds of Alaska. U.S. Dept. Int., Fish Wildl. Circ. 3. 37 p. 00.0

East, B. 1943. Seabird cities of the Aleutians. Nat. Hist. 51:64-71. 02.0, 03.0

East, B. 1948. Islands of mist. Fauna 10(3):69-73. 02.5

East, B. 1954. Seabird cities. An. Kingdom 57:36-42. 02.0, 03.0

Easterday, B. C., S. J. Hyland and J. A. Alexander. 1976. Influenza virus in Alaskan seabirds. Abstract. Pacific Seabird Group Bull. 3(1):24. 02.6

Edgar, A. T., H. R. McKenzie, and R. B. Sibson. 1969. Arctic waders in northern New Zealand, Summer 1968-69. Notornis, 16:285-287. 00.0

Einarson, A. S. 1965. Black brant, sea goose of the Pacific Coast. Univ. Washington Press, Seattle. 141 pp. 02.2, 02.4, 00.0

Eley, T. J., Jr. 1974. A sight record for Leach's petrel north of the Aleutian Islands, Alaska. Murrelet 55(3):44-45. 03.2

Eley, T. J., Jr. 1976. Extension of the breeding range of the black oyster-catcher in Alaska. Condor 78(1):115. 02.4

Elliott, H. W. 1882. Seal-islands of Alaska. U.S. Comm. Fish and Fisheries, Spec. Bull. 176, Sect. IX, Mongr. A. 176 p. 02.3, 02.5

Emerson, W. O. 1906. Oceanodroma leucorhoa and its relatives on the Pacific Coast. Condor 8:53-55.

Emison, W. B., F. S. L. Williamson, and C. M. White. 1971. Geographical affinities and migrations of the avifauna on Amchitka Island, Alaska. Bio Science 21(12):627-631. 00.0, 03.1

Evans, C. D. 1969. Environmental effects of petroleum development in the Cook Inlet area. Proc. Alaska Sci. Conf. 20:213-221. 07.0

Eyerdam, W. J. 1936. Notes on birds collected or observed during the summer of 1932 in the eastern Aleutian Islands, Alaska. Murrelet 17:48-52. 03.2

Fay, F. H. 1961. The distribution of waterfowl to St. Lawrence Island, Alaska. Ann. Rept. Wildfowl Trust 12:70-80. 02.1

Fay, F. H., and T. J. Cade. 1959. An ecological analysis of the avifauna of St. Lawrence Island, Alaska. Univ. California Publ. Zool. 63:73-150. 02.1

Figgins, J. D. 1904. Field notes on the birds and mammals of the Cook's Inlet region of Alaska. Proc. Linn. Soc. New York 15-16:15-39. 07.0

Fisher, H. I., and J. R. Fisher. 1972. The oceanic distribution of the Laysan albatrosses, Diomedea immutabilis. Wilson Bull. 84( ):7-27. 00.0

Fisher, J. 1952. The fulmar. N.M.N. Collins, London. 00.0

Flock, C. 1932. Note on the arctic tern in Bristol Bay region, Alaska. Murrelet 13:26. 02.4

Flock, W. L. 1972. Radar observations at Cape Prince of Wales. Arctic 25( ):83-89. 01.3, 02.1

Flock, W. L. 1973. Radar observations of bird movements along the Arctic Coast of Alaska. Wilson Bull. 85(3):259-275. 01.0

Flock, W. L. 1974. Radar studies of bird movements in Alaska and the Arctic. Pages 409-420, in S. A. Gauthreaux (ed.), A conference of the biological aspects of the bird/aircraft collision problem. Clemson Univ., Dept. Zoology. Clemson, S. Carolina. 01.0

Flock, W. L. 1975. Monitoring overwater bird movements by radar. Abstract. Pacific Seabird Group Bull. 2(1):40. 01.0

Flock, W. L. 1976. The spring migration at Pt. Barrow. Abstract. Pacific Seabird Group Bull. 3(1):22-23. 01.1, 01.2

Ford, E. R. 1934. Rufous-necked sandpiper nesting in Alaska. Auk 51:232. 01.3, 02.1

Ford, E. R. 1936. Kittlitz's murrelet breeding at Wales, Alaska. Auk 53:214-215 02.1

Frame, G. W. 1973. Occurrence of birds in the Beaufort Sea, summer Auk 90(3):552-563. 01.1

Francis, K., (ed.) 1976. Arctic Slope snow goose studies. Northeast by East, Rev. Alaskan Arctic Gas Res. 1(4): 1-4 . 01.1

Friedmann, H. 1932. The birds of St. Lawrence Island, Bering Sea. Proc. U.S. Natl. Mus. 80(12):1-31. 02.1

Friedmann, H. 1934. The ruff on St. Lawrence Island. Condor 36(1):42. 02.1

Friedmann, H. 1934. The Mongolian plover and other birds at Goodnews Bay, Alaska. Condor 36:89. 02.2

Friedmann, H. 1935. Avian bones from prehistoric ruins on Kodiak Island, Alaska. J. Washington Acad. Sci. 25:44-51. 05.0

Friedmann, H. 1936. Notes on Alaskan birds. Condor 38:173. 00.0, 05.0

Fritsch, L. E., and I. O. Buss. 1958. Food of the American merganser in Unakwik Inlet, Alaska. Condor 60( ):410-411.

Fyfe, R. W., S. A. Temple, and T. J. Cade. 1976. The 1975 North American peregrine falcon survey. Canad. Field-Natur. 90(3):228-273. 00.0

Gabrielson, I. N. 1940. America's greatest bird concentrations. Bird-lore 42:497-506. 00.0

Gabrielson, I. N. 1952. Alaskan waterfowl and their management. Pages 292-305, in H. B. Collins (ed.), Science in Alaska. Arctic Inst. N. Am., Washington, D. C. 00.0

Gabrielson, I. N., and F. C. Lincoln. 1959. The birds of Alaska. The Stackpole Co., Harrisburg, Pennsylvania, and the Wildl. Manage. Instit. Washington, D. C. 00.0

Gavin, A. 1970. Ecological survey of Alaska's North Slope, summer 1969 and 1970. Atlantic Richfield Co. Anchorage, Alaska 14 p. 01.1

Gavin, A. 1975. Wildlife of the North Slope, a five year study, 1969-1973. Atlantic Richfield Co., Anchorage, Alaska. 63 pp. 01.1

Geist, O. W. 1939. Seabirds found far inland in Alaska. Condor 41:68-70. 00.0

Gianini, C. A. 1917. Some Alaska Peninsula bird notes. Auk 34(4):394-402. 02.4

Gibson, D. D. 1970. Recent observations at the base of the Alaska Peninsula. Condor 72( ):242-243. 02.4, 06.0

Gill, R. E. 1977. Unusual foraging by a fork-tailed storm petrel. Auk 94:385-386.

Gordon, R. J. 1968. 1967 summer resident birds in the Juneau, Alaska, area. Bull. Alaska Ornithol. Soc., 6:3-5. 12.2

Gray, J. A., Jr. 1945. Land birds at sea. Condor 47:215-216. 05.0

Grinnell, J. 1897. Petrels of Sitka, Alaska. Nidologist 4:76-78. 12:1, 12.2

Grinnell, J. 1897. Notes on the marbled murrelet. Osprey 1:115-117. 12:1, 12.2

Grinnell, J. 1898. Summer birds of Sitka, Alaska. Auk 15(2):122-131. 12.1, 12.2

Grinnell, J. 1900. Birds of the Kotzebue Sound region, Alaska. Pacific Coast Avif. 1. 80 p. 01.3

Grinnell, J. 1900. Notes on some birds of Cape Nome, Alaska Condor 2( ) 112-115. 02.1

Grinnell, J. 1909. Birds and mammals of the 1907 Alexander Expedition to Southeastern Alaska. Univ. Calif. Publ. Zool. 5(2):171-264. 12.1, 12.2

Grinnell, J. 1910. Birds of the 1908 Alexander Alaska Expedition with a note on the avifauna relationships of the Prince William Sound district. Univ. Calif. Publ. Zool. 5:361-428. 08.0

Grinnell, J. 1911. Miscellaneous records for Alaska. Condor 12:41-53. 12.2

Grinnell, J., and F. H. Test. 1939. Geographic variation in the fork-tailed petrel. Condor 41:170-172. 00.0

Gromme, O. J. 1927. Some highlights on the faunal life of the Alaskan Peninsula. Milwaukee Publ. Mus. Year Book 7:30-45. 02.4

Grubb, T. G. 1976. Nesting bald eagles attacks researcher. Auk 93(4):842-843. 05.0

Gudkov, V. M. 1962. Relationship between the distribution of zooplankton, sea birds and baleen whales. Trudy Inst. Okeanol. 58:298-313. In Russian. (Transl. from Russian, U. S. Dept. Navy, Naval Oceanogr. Office, Washington, D. C., 1974). 02.0

Halkett, A. 1898. An Ottawa naturalist's journey westward. III. The Aleutian Islands and Bering Sea. Ottawa Natur. 12:81-85. 02.0, 03.0

Hanna, G. D. 1916. Records of birds new to the Pribilof Islands. Auk 33:400-403. 02.5

Hanna, G. D. 1917. The summer birds of the St. Matthew Island Bird Reserva-tion. Auk 34:403-410. 02.3

Hanna, G. D. 1918. Check list of birds of the Pribilof Islands, Alaska, with names of persons first recording the species from the islands. Pages 105-107, in W. T. Bower, Report of U.S. Comm. of Fisheries, Bur Fish. Doc. 872. 02.5

Hanna, G. D. 1919. Additions to the avifauna of the Pribilof Islands, Alaska, including species new to North America. J. Washington Acad. Sci. 9:176-177. 02.5

Hanna, G. D. 1922. Bird drives in the Yukon Delta. Condor 24:100. 02.2

Hanna, W. C. 1935. Long-billed dowitcher breeding in Alaska. Condor 42:166-167. 02.2

Hanna, W. C. 1961. Second specimen of the dovekie from Alaska. Condor 63(4):338. 02.0

Hansen, H. A., and U. C. Nelson. 1957. Brant of the Bering Sea--migration and mortality. Trans. N. Am. Wildl. Natur. Resources Conf. 22:237-256. 02.2

Hansen, H. A., P. E. K. Shepherd, J. G. King, and W. A. Troyer. 1971. The trumpeter swan in Alaska. Wildl. Mongr. 26. 83 p. 07.0, 09.2

Hansen, H. A. 1960 Changed status of several species of waterfowl in Alaska. Condor 62(2):136-137. 00.0

Hansen, H. A. 1961. Loss of waterfowl production to tide floods. J. Wildl. Mgmt. 25(3):242-248. 02.2, 09.2

Hansen, H. A. 1962. Canada geese of coastal Alaska. Trans. N. Am. Wildl. Natur. Resources Conf. 27:301-320. 09.2, 12.1 ?

Hansen, H. A. 1973. Trumpeter swan management. Wildfowl 24:27-32. 09.2

Harris, S. W., and P. E. K. Shepherd. 1965. Age determination and notes on the breeding age of black brant. J. Wildl. Mgmt. 29(3):643-645. 02.2

Harris, S. W. 1966. Summer birds of the lower Kashunuk River, Yukon-Kuskokwim Delta, Alaska. Murrelet 47(3):57-65. 02.2

Hasselborg, A. E. 1918. Bird notes from Admiralty Island, Southeastern Alaska. Condor 20:191. 12.1, 12.2

Heath, H. 1915. Birds observed on Forrester Island, Alaska during the summer of 1913. Condor 17:20-41 12.1

Hemming, James E. 1966. Notes on the status of some birds in south-central Alaska. Condor 68(2):163-166. 07.1

Henny, C. J. 1973. Drought displaced movement of North American pintails into Siberia. J. Wildl. Manage. 37( ):23-29. 00.0

Hensel, R. J. and W. A. Troyer. 1964. Nesting studies of the bald eagle in Alaska. Condor 66(4):282-286. 05.0

Hersey, F. S. 1916. A list of the birds observed in Alaska and northeastern Siberia during the summer of 1914. Smithsonian Misc. Coll. 66:1-33. 02.0

Hersey, F. S. 1917. The present abundance of birds in the vicinity of Fort St. Michael, Alaska. Auk 34:147-159. 02.2

Hibben, Mrs. F. C. 1942. Pacific eider nesting at Glacier Bay, Alaska Condor 44(4):181. 12.2

Hill, G. A. 1923. The migration of the king eider at Synuk, Alaska. Condor 25( ):103-104. 2.1

Hohn, E. O. 1965. Ornithological observations in the Askinuk Mountains and Scammon Bay area, Yukon Delta, Alaska. Arctic 18(4):260-261. 02.2

Hohn, E. O. 1965. The phalaropes. The New Brehm Library, A. Ziemsen, Wittenbergh

Hohn, E. O. 1968. Some observations on the breeding of northern phalaropes at Scammon Bay, Alaska. Auk 85(2):316-317. 02.2

Hohn, E. O. 1971. Observations on breeding behavior of grey and red-necked phalaropes. Ibis 113(3):335-347. 02.2

Holmes, R. T. 1964. Food overlap in breeding sandpipers in Northern Alaska. Proc. Alaskan Sci. Conf., 14:66. 01.0

Holmes, R. T. 1966. Breeding ecology and annual cycle adaptations of the red-backed sandpiper (Calidris alpina) in Arctic Alaska. Condor 68(1):3-46. 01.0

Holmes, R. T. 1966. Feeding ecology of the red-backed sandpiper (Calidris alpina) in Arctic Alaska. Ecology 47(1):32-45. 01.0

Holmes, R. T. 1968. Molt cycle of the red-backed sandpiper (Calidris alpina) in western North America. Auk 83(4):517-533. 01.0

Holmes, R. T. 1968. A dovekie on the Pribilof Islands, Alaska. Condor 70(1):86. 02.5

Holmes, R. T. 1970. Differences in population density, territoriality, and food supply of dunlin on arctic and subarctic tundra. Pages 303-319, in A. Watson (ed.), Animal populations in relation to their food resources. Brit. Ecol. Soc. Symposium, 10. 01.0, 02.2

Holmes, R. T. 1971. Latitudinal differences in the breeding and molt schedules of Alaskan red-backed sandpipers (Calidris alpina). Condor 73(1):93-99. 01.0, 02.0

Holmes, R. T. 1971. Density habitat and mating system of the western sandpiper (Calidris mauri). Oecologia 7(2):191-208. 02.2

Holmes, R. T. 1972. Ecological factors influencing the breeding season schedule of western sandpipers (Calidris mauri) in sub-arctic Alaska. Am. Midland Natur. 87(2):472-491. 02.2

Holmes, R. T. 1973. Social behavior of breeding western sandpipers (Calidris mauri). Ibis 115(1):107-123. 02.2

Holmes, R. T., and C. P. Black 1973. Ecological distribution of birds in the Kolomak River - Askinuk Mountain region, Yukon-Kuskokwim Delta, Alaska. Condor 75(2):150-163. 02.2

Holmes, R. T., and F. A. Pitelka. 1962. Behavior and taxonomic position of the white-rumped sandpiper. Proc. Alaska Sci. Conf. 12:19-20. 01.0

Holmes, R. T., and F. A. Pitelka. 1964. Breeding behavior and taxonomic relationships of the curlew sandpiper. Auk 81:362-379. 01.0

Holmes, R. T., and F. A. Pitelka. 1968. Food overlap among co-existing sandpipers on northern Alaskan tundra. System. Zool. 17(3):305-318. 01.0

Hout, J. L. 1967. Contribution toward a bibliography on brant. U.S. Dept. Int., Fish Wildl. Serv. Spec. Sci. Rept.--Wildl. 103. 15p. 00.0

Howell, J. C. 1948. Observations on certain birds the region of Kodiak, Alaska. Auk 65( ):352-358. 05.0

Hudson, G. E. 1957. Birds observed in the Kotzebue Sound area of Alaska during the summer of 1956. Murrelet 38(3):26-29. 01.3

Humphrey, P. S. 1957. Remarks on the courtship and voice of the black scoter. Condor 59(2):139-140. 02.2

Hurley, J. B. 1931. Birds observed in the Bristol Bay region, Alaska. (part 1). Murrelet 12(1):7-11. 02.4

Imler, R. H., and E. R. Kalmbach. 1955. The bald eagle and its economic status. U.S. Dept. Int., Fish Wildl. Service Circ. 50. 51 p. 00.0

Irving, L., C. P. McRoy, and J. J. Burns. 1970. Birds observed during a cruise in the ice-covered Bering Sea in March 1968. Condor 72(1):110-112. 02.0

Irving, L. 1972. Arctic life of birds and mammals. Springer-Verlag, New York. 192 pp. 00.0

Isleib, M. E. P., and B. Kessel. 1972. Birds of the North Gulf Coast -Prince William Sound region, Alaska. Biol. Papers Univ. Alaska 14. 149 p. 08.0

Jaques, F. L. 1929. Cranes crossing Bering Strait. Auk 46(): 250. 01.3, 02.1

Jaques, F. L. 1929. Birds of Little Diomede. Nat. Hist. pp. 521-529. 01.3, 02.1

Jaques, F. L. 1930. Water birds observed on the Arctic Ocean and the Bering Sea. Auk 47(3):353-366. 02.0, 01.3

Jarvis, R. L. 1966. Occurrence of European or Aleutian green-winged teal in Western North America with a recent record. Murrelet 47(1):15-18. 03.2

Johansen, H. C. 1960. The formation of the arctic avifauna. Proc. Ornith. Congr. 12:358-62. 00.0

Johansen, H. 1961. Revised list of the birds of the Commander Islands. Auk 78(1):44-56. 02.8

Johansen, H. 1963. Zoogeographic aspects of the birds of the subarctic. Proc. Intl. Ornithol. Congr. 13:1117-1123. 00.0

Johansen, H. 1969. Nordamerikanische zugvogel in der sudhalfte Sudamerikas. Bonner Zool. Beitr: 20(1/3):182-190. 00.0

Johnson, S. R. 1974. First specimen of a robin (Turdus migratorius) and three important sight records from St. Lawrence Island, Bering Sea, Alaska. Condor 76(1):108. 02.1

Johnson, S. R., and G. C. West. 1975. Growth and development of heat regulation in nestlings and metabolism of adult common and thick-billed murres. Ornis Scand. 6:107-115. 02.1

Johnston, D. W. 1961. Timing of annual molt in the glaucous gulls of northern Alaska. Condor 63:474-478. 00.0

Johnston, D. W. 1964. Ecologic aspects of lipid deposition in some post-breeding arctic birds. Ecology 45:848-852.

Jones, N. G. B. 1972. Molt migration of emperor geese. Wildfowl 23:92-93. 02.2

Jones, R. D., Jr. 1964. Age group counts of black brant in Izembek Bay, Alaska. Wildfowl Trust Ann. Rept. 15:147-148. 02.4

Jones, R. D., Jr. 1965. Returns from Steller's eiders banded in Izembek Bay, Alaska. Wildfowl Trust Ann. Rept. 16:83-85. 02.4

Jones, R. D., Jr. 1970. Reproductive success and age distribution of black brant. J. Wildl. Manage. 34(2):328-333. 02.4

Jones, R. D., Jr., and D. M. Jones, 1966. The process of family disintegration in black brant. Wildfowl Trust Ann. Rept. 17:75-78. 02.4

Kartashev, N. N. 1961. The birds of the Commander Islands and some proposals for their rational utilization. Zool. Zh. 40(9):1395-1410. 02.0, 10.0

Kenyon, K. W. 1949. Distribution of the Pacific kittiwake in November and December of 1948. Condor 51:188.

Kenyon, K. W. 1950. Distribution of albatrosses in the North Pacific and adjacent waters. Condor 52( ):97-103. 02.0, 10.0

Kenyon, K. W. 1961. Birds of Amchitka Island, Alaska Auk 78(3):305-326. 03.1

Kenyon, K. W. 1963. Further observations of whooper swans in the Aleutian Islands, Alaska. Auk 80(4):540-542. 03.0

Kenyon, K. W. 1964. Wildlife and historical notes on Simeonof Island, Alaska. Murrelet 45:1-8. 05.0

Kenyon, K. W., and J. W. Brooks. 1960. Birds of Little Diomede Island, Alaska. Condor 62(6):457-463. 01.3, 02.1

Kenyon, K. W., and R. E. Phillips. 1965. Birds from the Pribilof Islands and vicinity. Auk 82(4):624-635. 02.5

Kessel, B. 1963. West-east relationships of the birds of northern Alaska. Pages 79-84, in J. L. Gressit, ed., Pacific basin bio-geography. Bishop Museum Press, Honolulu. 00.0, 01.0, 02.0

Kessel, B., and T. J. Cade. 1958. Birds of the Colville River, northern Alaska. Biol. Papers Univ. Alaska 2. 83 p. 01.0

Kessel, B., H. K. Springer, and C. M. White. 1964. June birds of the Kolomak River, Yukon-Kuskokwim Deta, Alaska. Murrelet 45(3):37-47. 2.2

Kessel, B., R. B. Weeden, and G. C. West. 1967. Bird-finding in Interior and Southcentral Alaska. Alaska Ornithol. Soc. 42 p. Processed. 07.0, 08.0

King, J. G. 1970. The swans and geese of Alaska's Arctic Slope. Wildfowl 21:11-17. 01.0

King, J. G., 1973. A cosmopolitan duck molting resort, Takslesluk Lake, Alaska. Wildfowl 24:103-109. 02.2

King, J. G. 1973. The neglect of sea bird conservation. Alaska Conserv. Rev. 14(4):12-13. 00.0

King, J. G. 1973. The use of small airplanes to gather swan data in Alaska. Wildfowl 24:15-20. 01.0, 02.0

King, J. G., G. Marshal, J. H. Branson, F. H. Fay, and W. Allen. 1975. Alaskan pelagic bird observations and a data bank proposal. Abstract. Pacific Seabird Group Bull. 2(1):37-38. 02.0, 03.0

King, J. G., F. C. Robards, and C. J. Lensink. 1972. Census of the bald eagle breeding population in southeast Alaska. J. Wildl. Manage. 36(4):1292-1295. 12.2

King, W. B. Jr. (ed.), G. V. Byrd, J. J. Hickey, C. B. Kepler, W. Post, H. A. Raffaele, P. F. Springer, H. F. Snyder, C. M. White, and J. W. Wiley. 1976. Report of The American Ornithologists' Union Committee on Conservation 1975-76. Auk 93(4, Suppl.): 1DD-19DD. 02.5,02.7,03.1

Kistchinski, A. A. 1968. On the biology of Kittlitz and marbled murrelets. Ornitologiya 9:208-213. [In Russian.] 02.0

Kistchinski, A. A. 1971. Biological notes on the emperor goose in northeast Siberia. Wildfowl 22:29-34. 02.0, 01.3, 01.2

Kistchinski, A. A. 1972. Waterfowl on the northern coast of the Chukotski Peninsula. Part 2:82-84, in Waterfowl resources in the U.S.S.R., their reproduction and management. Publ. Moscow State Univ., Moscow. [In Russian.] 01.2, 01.3, 02.0

Kistchinski, A. A. 1973. Waterfowl in north-east Siberia. Wildfowl 24:88-102. 01.0, 02.0

Kistchinski, A. A., R. I. Zlotin, and V. E. Flint. 1975. The breeding of the whistling swan (Cygnus columbianus) in the U.S.S.R. Zool. Zh. 54(10):1525-1528. 01.2

Klein, D. R. 1959. Saint Matthew Island reindeer-range study. U.S. Dept. Int., Fish Wildl. Serv. Spec. Sci. Rept.-Wildl. 43. 02.3

Klein, D. R. 1966. Waterfowl in the economy of the Eskimos on the Yukon-Kuskokwim Delta, Alaska. Arctic 19(4):319-336. 02.2

Kortright, F. H. 1967. The ducks, geese and swans of North America. Stackpole Co. Harrisburg, Pa. 476 pp. 00.0

Kozlova, E. V. 1957. Charadriiformes, Suborder Alcae. in Fauna of U.S.S.R., Birds. Vol. 2, No. 3. Zool. Instit. Acad. Sci.

U.S.S.R. New Series 65. (Transl. from Russian by Israel Progr. Sci. Transl., Jerusalem, 1961). 140 p. 00.0

Kurochkin, E. N. 1963. Distribution of some marine birds in the North Pacific. [In Russian] Zool. Zh. 42(8):1223-1231. 10.0, 11.0

Kuroda, N. 1955. Observations on pelagic birds of northwest Pacific. Condor 57( ):290-300. 03.1

Kuroda, N. 1957. A brief note on the pelagic migration of the Tubinares. Misc. Rept. Yamashina's Inst. Ornith. Zool. 11:436-449. 00.0

Kuroda, N. 1960. Analysis of seabird distribution in the northwest Pacific Ocean. Pac. Sci. 14:55-67. 03.1

Kury, C. R. 1972. Ring-necked duck and ruddy turnstones wintering at Sitka. Murrelet 53(1):11.

Kuyt, E., B. E. Johnson, P. S. Taylor, and T. W. Barr 1976. Black guillemot's breeding range extended into western Canadian Arctic. Canad. Field-Natur. 90(1):75-76. 01.1

Kuzyakin, A. P. 1963. On the biology of the long-billed murrelet. Ornithologyia 6:315-320. [In Russian.] 02.0

Kuzyakin, A. P. 1965. On the waterfowl in northeast Siberia. Part 2:114-116, in Geography of the waterfowl resources in the U.S.S.R., Publ. Moscow Soc. Natur., Moscow. [In Russian.] 02.0

Laing, H. M. 1925. Birds collected and observed during the cruise of the Thiepval in the North Pacific, 1924. Canad. Dept. Mines Mus. Bull. 40. 46 p. 02.0, 03.0, 10.0

Lebedev, V. D., and V. R. Filin. 1959. Ornithological observations in the western Chukotsk. Ornithologia 2:122-129. [In Russian.] 01.4, 02.0

Leffingwell, E. 1919. The Canning River region, northern Alaska. U.S. Dept. Int., Geol. Survey Prof. Paper 109. 251 p. 01.1

Lensink, C. J. 1973. Population structure and productivity of whistling swans on the Yukon Delta, Alaska. Wildfowl 24:21-25. 2.2

LeResche, R. E., and R. A. Hinman, eds. 1973. Alaska's wildlife and habitat. Alaska Dept. Fish Game, Juneau. 144 p. + 564 maps. 00.0

Lloyd, H. 1963. Catharacta skua Brunnich sighted in North Pacific. Canad. Field-Natur. 77(2):127. 11.0

MacLean, S. F., Jr. 1974. Lemming bones as a source of calcium for Arctic sandpipers (Calidris) spp. Ibis 116(4):552-557. 01.1, 01.2

MacLean, S. F., Jr., and R. T. Holmes. 1971. Bill lengths, wintering areas, and taxonomy of North American dunlins, Calidris alpina. Auk 88(4):893-901. 00.0

MacLean, S. F., Jr., and F. A. Pitelka. 1971. Seasonal patterns of abundance of tundra arthopods near Barrow, Alaska. Arctic 24(1):19-40. 01.0

MacLean, S. F., Jr., and N. A. M. Verbeck. 1968. Nesting of the black guillemot at Point Barrow, Alaska. Auk 85(1):139-140. 01.0

Maher, W. J. 1960. Another record of the Baikal teal in northwestern Alaska. Condor 62(2):138-139. 01.2

Maher, W. J. 1970. The pomarine jaeger as a brown lemming predator in northern Alaska. Wilson Bull. 82(2):130-157. 01.1, 01.2

Maher, W. J. 1974. Ecology of pomarine, parasitic, and long-tailed jaegers in northern Alaska. Pacific Coast Avifauna 37. 148 p. 01.1, 01.2c

Manning, T. H. 1964. Geographical and sexual variation in the long-tailed jaeger, Stercorarius longicaudus Viellot. Biol. Papers Univ. Alaska 7. 16 p. 00.0

Markov, V. I. 1963. Waterfowl wintering in Kamchatka. Ornithologyia 6:376-383. [In Russian] 02.0

Martin, A. C., and F. M. Uhler. 1939. Food of game ducks in the United States and Canada. U.S. Dept. Agr. Tech. Bull. 634. 157 pp. + 153 plates. 00.0

Martinez, E. F. 1974. Recovery of a semipalmated sandpiper at Prudhoe Bay, Alaska. Bird-Banding 45(4):364-365. 01.1

McClure H. E. 1974. Migration and survival of the birds of Asia. U.S. Army Component, SEATO Medical Research Lab., Bangkok, Thailand Merrell, T. R., Jr. 1970. A swimming bald eagle. Wilson Bull. 82(2):220.

McGregor, R. C. 1902. A list of birds collected in Norton Sound, Alaska. Condor 4(6):135-144. 02.1

McGregor, R. C. 1906. Birds observed in the Krenitzin Islands, Alaska. Condor 8( ):114-122. 02.5, 03.0, 04.0

McKinney, F. 1965. The spring behavior of wild Steller eiders. Condor 67:273-290. 02.4

McRoy, C., S. W. Stoker, G. E. Hall, and E. Muktoyuk. 1971. Winter observations of mammals and birds, St. Matthew Island. Arctic 24(1):63-65.1. 02.3

Merrell, T. R., Jr. 1970. A swimming bald eagle. Wilson Bull. 82(2):220. 12.2

Mickelson, P. G. 1975. Breeding biology of cackling geese and associated species on the Yukon--Kuskokwim delta, Alaska. Wildl. Monogr. 45 35 pp. 02.2

Milne, H., and C. P. Dau. [no date]. A bibliography of eiders. Minister of Tourism, Hunting and Fishing, Quebec Wildl. Serv., Quebec, Can. 223 + 23 pp. Processed. 00.0

Monson, M. A. 1956. Nesting of trumpeter swan in the lower Copper River Basin, Alaska. Condor 58:444-445. 09.2

Mossman, A. S. 1957. Hooded mergansers at Afognak Island, Alaska. Condor 59:341. 05.0, 09.1

Mossman, A. S. 1958. Selective predation of glaucous-winged gulls upon adult red salmon. Ecology 39:482-485. 05.0, 0.1

Motoda, S., and T. Fujii. 1956. Report from the "Oshoro Maru" on oceanographic and biological investigations in the Bering Sea and northern North Pacific in summer of 1959. I. Programme of investigations and records of eye observations of seabirds and marine mammals. Bull. Fac. Fish. Hokkaido Univ., 6(4):280-297. 02.0, 03.0

Moyle, P. 1966. Feeding behavior of the glaucous-winged gull on an Alaskan salmon stream. Wilson Bull. 78(2):175-190. 08.0

Murdoch, J. 1885. Natural history. II.--birds. Pages 104-128, in Report of the International Polar Expedition to Point Barrow, Alaska. U.S. House Repr., 48th Congr., 2d Sess., Ex. Doc. 44. 01.0

Murie, O. J. 1936. The birds of St. Lawrence Island, Alaska. Pages 361-376, in O. W. Geist and F. G. Rainey, eds., Archaeological excavations at Kukulik, St. Lawrence Island, Alaska. Vol. 2. Univ.Alaska Misc. Publ. 02.1

Murie, O. J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. U. S. Dept. Int., Fish Wildl. Serv. N. Amer. Fauna 61:1-364. 02.4, 02.5, 02.6, 02.7, 03.0, 04.0, 05.0

Murie, O. J. 1950. Food habits of the northern bald eagle in the Aleutian Islands, Alaska. Condor 42(4):1989802. 03.0

Myres, M. T. 1972. Radar observations of three probable transoceanic migratory movements across the Gulf of Alaska in spring 1965. Syesis 5:107-116. 09.0, 10.0

Narver, D. W. 1970. Birds of the Chignik River drainage, Alaska. Condor 72:102-105. 04.0

Nelson, E. W. 1883. Birds of the Bering Sea and Arctic Ocean. Pages 44-120, in Cruise of the Revenue-steamer Corwin in Alaska and the N. W. Arctic Ocean. Treasury Dept. Doc. 429. 01.0, 02.0

Nelson, E. W. 1887. Report on natural history collections made in Alaska between the years 1877 and 1881. U. S. Army, Signal Service Arctic Series Publ. 3. 337 p. + xxi plates. 01.3, 02.0

Nelson, U. C., and H. A. Hansen. 1959. The cackling goose--its migration and management. Trans. N. Am. Wildl. Conf. 24:174-187. 02.2

Newby, T. C., and R. O. Larson. 1974. Aggression in the Pacific fulmar, Fulmarus glacialis. Murrelet 55(1):10. 02.5

Nichols, J. T. 1926. Standard and adaptive specialization in relation to migration and distribution in Bering Sea. Canad. Field-Natur. 40( ):169-171. 02.0

Norton, D. W. 1971. Growth rates and bioenergetics of Calidridine sandpiper chicks of northern Alaska. [Abstract] Proc. Alaska Sci. Conf. 22:16. 01.1, 01.2

Norton, D. W. 1971. Two Soviet recoveries of dunlins banded at Point Barrow, Alaska. Auk 88(4):924. 01.1, 01.2

Norton, D. W. 1972. Incubation schedules of four species of calidridine sandpipers at Barrow, Alaska. Condor 74(2):164-176. 01.1, 01.2

Norton, D. W. 1972. Metabolism of arctic sandpipers: modeling in relation to the overall shorebird model. Pages 156-159, in Proc. 1972 Tundra Biome Symp., Univ. Washington, Seattle. 01.1, 01.2

Norton, D. W., I. W. Ailes, and J. A. Curatolo. 1975. Ecological relationships of the inland tundra avifauna near Prudhoe Bay, Alaska. Pages - in J. Brown (ed.), Ecological investigations of the Tundra Biome in the Prudhoe Bay Region, Alaska. Biol. Papers Univ. Alaska Spec. Rept. 2. 163 pp. 01.1, 01.2

Norton, D. W., and U. N. Safriel. 1971. Homing by nesting semi-palmated sandpipers displaced from Barrow. Bird-banding 42(4):295-297. 01.1, 01.2

O'Farrell, T. P., and A. M. Sheets. 1962. Birds observed wintering at Middleton Island, Alaska. Condor 64(5):440-441. 09.2

Ofelt, C. H. 1975. Food habits of nesting bald eagles in southeast Alaska. Condor. 77(3):337-338. 12.1

Ogi, H., and T. Tsujita. 1973. Preliminary examination of stomach contents of murres (Uria sp.) from the eastern Bering Sea and Bristol Bay, June-August, 1970 and 1971. Jap. J. Ecol. 23(5):201-209. 02.0, 10.0

Ogi, H., and T. Tsujita. 1975. Food and feeding habits of the common murre and thick-billed murre in the Okhotsk Sea, northwestern Pacific Ocean and Bering Sea. Abstract. Pacific Seabird Group Bull. 2(1):29-30. 02.0, 10.0

Ogi, H., and T. Tsujita. 1976. Sexual and geographic variations in body weight, culmen length, wing length, and tarsus length for common murres in the Bering Sea. Abstract. Pacific Seabird Group Bull. 3(1):20. 02.0, 10.0

Ohlendorf, H. M., J. C. Bartonek, E. E. Klaas, and G. J. Divoky. 1975. Organochlorine residues in eggs of Alaskan seabirds. Abstract. Pacific Seabird Group Bull. 2(1):36:37. 02.4, 03.2, 05.0

Olson, S. T. 1954. Gull-waterfowl relationships on the waterfowl breeding grounds in Alaska. Abstract. Proc. Alaska Sci. Conf. 5:38-39. 02.2

Osgood, W. H. 1901. Natural history of the Cook Inlet region, Alaska. U. S. Dept. Agr., Div. Biol. Surv. N. Am. Fauna 21:72-81. 02.4

Palmer, R. S., ed. 1962. Handbook of North American birds. Vol. 1. Loons through flamingos. Yale Univ. Press, New Haven, Conn. 567 pp. 00.0

Palmer, R. S., ed. 1976. Handbook of North American birds. Vols. 2 & 3. Waterfowl. Yale Univ. Press, New Haven and London, Conn. 521 and 560 pp. 00.0

Palmer, W. 1899. The avifauna of the Pribilof Islands. Pages 355-431 + plates, in D. S. Jordan, ed., The fur seals and Fur Seal Islands of the North Pacific, Part III. U.S. Treas. Dept., Comm. Fur-seal Investig., Washington, D. C. 02.5

Patten, S., Jr., and A. R. Wisbrod. 1974. Sympatry and interbreeding of herring and glaucous-winged gulls in southeastern Alaska. Condor 76(3):343-344. 12.2

Patten, S. M., Jr. 1976. Sympatry and interbreeding of herring & glaucous-winged gulls in southern Alaska. Abstract. Pacific Seabird Group Bull. 3(1):25-26. 12.2

Pearse, T. 1968. Birds of the early explorers in the northern Pacific. Publ. by author, Comax, British Columbia. 275 pp. 00.0

Petersen, M. R. 1976. Nesting ecology of the arctic loon. Abstract. Pacific Seabird Group Bull. 3(1):22. 02.2

Phillips, J. C. 1922-26. A natural history of the ducks. Houghton Mifflin Co., Boston and New York. 4 vols. 00.0

Phillips, J. H. 1963. The pelagic distribution of the sooty shearwater, *Procellaria grisea*. Ibis 105:340-353. 00.0

Pitelka, F. A. 1955. Breeding behavior of jaegers and owls near Barrow, Alaska. Condor 57:3-18. 01.1, 01.2

Pitelka, F. A. 1956. Sex ratio in relation to predation near Barrow, Alaska. Bull, Ecol. Soc. Amer. 37:78-79. 01.1, 01.2

Pitelka, F. A. 1959. Numbers, breeding schedule, and territoriality in pectoral sandpipers of northern Alaska. Condor 61:233-264. 01.1, 01.2

Pitelka, F. A. 1974. An avifaunal review for the Barrow region and North Slope of Arctic Alaska. Arctic Alpine Res. 6(2):161-184. 01.0

Pitelka, F. A., R. T. Holmes, and S. F. MacLean, Jr. 1974. Ecology and evolution of social organization in arctic sandpipers. Amer. Zool. 14:185-204. 01.0

Pitelka, F. A., P. Q. Tomich, and G. W. Treichel. 1955. Breeding behavior of jaegers and owls near Barrow, Alaska. Condor 57(1):3-18. 01.1, 01.2

Pitelka, F. A., P. Q. Tomich, and G. W. Treichel. 1955. Ecological relations of jaegers and owls as lemming predators near Barrow, Alaska. Ecol. Monogr. 25:85-117. 01.1, 01.2

Ploegger, P. L. 1968. Geographic differentiation in arctic Anatidae as a result of isolation during the last glaciation. Ardea 56:1-159. 00.0

Portenko, L. A. 1960. Ornithological explorations in northeastern Asia. Proc. 12th Internat. Ornith. Cong., 1958, 2:615-620. 01.0, 02.0

Portenko, L. A. 1968. On the problem of the Beringia-bridge. Bonner Zool. Beitr. 19( ):176-180. [In German.] 00.0

Portenko, L. A. 1973. The birds of the Chukotsk Peninsula and Wrangel Island. Acad. Sci. SSSR, Zool. Instit., Sci. Publishers, Lenningrad. 2 vols. [In Russian.] 01.0, 02.0

Preble, E. A., and W. L. McAtee. 1923. A biological survey of the Pribilof Islands, Alaska. Part I. Birds and mammals. U. S. Dept. Agr., Bur. Biol. Surv., N. Am. Fauna 46:1-128. 02.5

Rausch, R. 1958. The occurrence and distribution of birds on Middleton Island, Alaska. Condor 60(4):227-242. 09.2

Reed, E. B. 1956. Notes on some birds and mammals of the Colville River, Alaska. Canad. Field-Natur. 70(3):130-136. 01.1

Reichenow, A. 1909. Birds. Pages 240-245, in P. Niedrach, Cruises in the Bering Sea. London. 02.0

Ridgway, R. 1893. Catalogue of a collection of birds made in Alaska by C. H. Townsend during the cruise of the U. S. Fish Commission steamer "Albatross" in the summer and autumn of 1888. Proc. U. S. Natl. Mus. 16:663-665.

Robards, F., and A. Taylor. No date. Bald eagles in Alaska. U. S. Dept. Int., Fish Wildl. Serv., Alaska Area, Anchorage, and U. S. Dept. Agr., Forest Serv., Alaska Reg., Juneau. 12 p. 00.0, 12.1

Roseneau, D. G., H. Reynolds III, and C. M. White. 1976. Northeastern Alaska. Pages 243-245, in R. W. Fyfe, S. A. Temple, and T. J. Cade, The 1975 North American peregrine falcon survey. Canad. FieldNatur. 90(3):228-273. 01.0, 02.0

Roseneau, D. G., A. M. Springer, and L. G. Swartz. 1976. The western coast of Alaska. Pages 257-259, in R. W. Fyfe, S. A. Temple, and T. J. Cade. The 1975 North American peregrine falcon survey. Canad. Field-Natur. 90(3):228-273. 02.0

Ryder, R. A. 1957. Avian-pinneped feeding associations. Condor 59(1):68-69 02.0

Rychetnik, J. 1966. There's always Diomede. Alaska Sportsman 32(1):811. 01.3, 02.1

Safriel, U. N. 1971. Population study of the semipalmated sandpiper (Calidris pusilla) in Barrow, Alaska. [Abstract.] Proc. Alaska Sci. Conf. 22:33. 01.1, 01.2

Safriel, U. N. 1975. On the significance of clutch size in nidifugous birds. Ecology 56(3):703-708. 01.1

Sage, B. 1975. Alaska and its wildlife. Viking Press, N. Y. 128 pp. 00.0

Sage, B. 1974. The Yukon Kuskokwim Delta in Alaska supports monumental numbers of birds, delta paradise. Wildlife 16(9):412-415. 2.2

Sanger, G. A. 1964. A possible sight record of a short-tailed albatross. Murrelet 45(3):47. 10.3

Sanger, G. A. 1972. Preliminary standing stock and biomass estimates of seabirds in the subarctic Pacific Region. Pages 581-611, in A. Y. Takenouti, et al., eds., Biological Oceanography of the northern North Pacific Ocean. Idemitsu Shoten, Tokyo. 02.0, 09.0, 10.0, 11.0, 1250

Sanger, G. A. 1972. Checklist of bird observations from the eastern North Pacific Ocean, 1955-1967. Murrelet 53(2):16-21. 00.0

Sanger, G. A. 1972. The recent pelagic status of the short-tailed albatross (Diomeda albatrus). Biol. Conserv. 4(3):189-193. 00.0

Sanger, G. A. 1973. Pelagic records of glaucous-winged and herring gulls in the North Pacific Ocean. Auk 90(2):384-393. 00.0

Sanger, G. A. 1974. Black-footed Albatross. Pages 96-128, in W. B. King, ed., Pelagic studies of seabirds in the central and eastern Pacific Ocean. Smithsonian Contrib. Zool., No. 158. 277 p.

Sanger, G. A. 1974. Laysan Albatross. Pages 129-153, in W. B. King, ed., Pelagic.

Sanger, G. A. 1975. Observations on the pelagic biology of the tufted puffin [Abstract]. Pacific Seabird Group Bull. 2(1):20-31.

Sauer, E. G. F. 1962. Ethology and ecology of golden plovers on St. Lawrence Island, Bering Sea. Psychol. Forschung. 26:399-470. 02.1

Schmidt. G. D., and K. A. Neiland. 1968. Hymenolepia deblocki sp. n., and records of other helminths from charadriform birds. Canad. J. Zool. 46(5):1037-1040. 02.4

Sealy, S. G. 1967. Sigh records of three new birds on St. Lawrence Island, Alaska. Murrelet 48(1):18. 02.1

Sealy, S. G. 1967. Spring bird phenology on St. Lawrence Island, Alaska. Blue Jay 25(1):23-24. 02.1

Sealy, S. G. 1968. Some alcid leg sizes and band sizes (Uria Aethia). Bird-Banding). 39(1):59. 02.1

Sealy, S. G. 1969. Color aberrations in some alcids on St. Lawrence Island, Alaska. Wilson Bull. 81(2):213-214. 02.1

Sealy, S. G. 1973. Interspecific feeding assemblages of marine birds off British Columbia. Auk. 90(4):796-802. 12.3

Sealy, S. G. 1975. Influence of snow on egg-laying in auklets. Auk 92(4):258-538. 02.1

Sealy, S. G., J. Bedard. 1974. Breeding biology of the parakeet auklet (Cyclorrhunchus psittacula) on St. Lawrence Island, Alaska. Astarte 2:59-68. 02.1

Sealy, S. G., J. Bedard, M. D. F. Udvardy, and F. H. Fay. 1971. New recrods and zoogeographical notes on the birds of St. Lawrence Island, Bering Sea. Condor 73(3):322-336. 02.1, 00.0

Selkregg, L. L. ed. [1975-77] Alaska regional profiles: Arctic region (218 p.), Southwest region (313 p.), Southcentral region (255 p.), Yukon region (346 p.), Southeast region (233 p.), Northwest region (265 p.). Univ. Alaska, Arctic Environ. Infor. Data Center, Anchorage. 00.0

Septsov, M. M. 1959. Tubinares in the whaling areas of the northwest Pacific. Ornithologyia 2:276-281. (In Russian). 00.0

Serventy, D. L. 1967. Aspects of the population ecology of the short-tailed shearwater, Puffinus tenuirostris. Proc. Int. Ornith. Congr. 14:165-190. 00.0

Shepherd, P. E. K. 1965. A preliminary evaluation of earthquake damage to waterfowl habitat in Southcentral Alaska. Proc. Ann. Conf. W. Assoc. State Game Fish Comm. 45:76-80. 09.2

Sherrod, S. K., J. A. Estes, and C. M. White. 1975. Depredation of sea otter pups by bald eagles at Amchitka Island, Alaska. J. Mammal. 56(3):701-703. 03.1

Shields, M. 1969. Activitiy of snowy owls at Barrow, Alaska. Murrelet 50(2):(1), 14-16. 01.1, 01.2

Shortt, T. M. 1939. The summer birds of Yakutat Bay, Alaska. Contr. Royal Ontario Mus. Zool. 17:1-30. 09.2

Shuntov, V. P. 1961. Migration and distribution of marine birds in southeastern Bering Sea during spring-summer season. Zool. Zh. 40(7):1058-1069. [In Russian, English summary]. 02.0, 03.0

Shuntov, V. P. 1962. Land birds and shorebirds in the Bering Sea. Ornithologiya 4: - . [In Russian]. 02.0, 03.0

Shuntov, V. P. 1963. Summer distribution of the kittiwakes in the Bering Sea. Ornithologiya 6:324-330. [In Russian]. 02.0, 03.0

Shuntov, V. P. 1964. Transequitorial migrations of the thin -billed stormy petrel (short-tailed shearwater) - Puffinus tenuirostris (Temm.) Zool. Zh. 43:590-598. [In Russian]. 00.0

Shuntov, V. P. 1966. On hibernations of marine birds in the far eastern seas and in the North Pacific. Zool. Zhur. 45(1):1698-1711. [In Russian, English summary]. 02.0, 03.0, 10.0

Shuntov, V. P. 1968. Some regularities in distribution of albatrosses Tubinares, Diomedeidae in the northern Pacific. Zool. Zh. 47(7):1054-1064. [In Russian, English summary]. 02.0, 03.0, 10.0

Shuntov, V. P. 1972. Marine birds and the biological structure of the ocean. Pac. Res. Instit. Fishery Manage. Oceanogr. (TINRO), Far-Eastern Publishers, Vladivostok. 378 p. (Transl. from Russian, Agence Tunisienee de Public-relations for U. S. Dept. Int., Bur. Sport Fish. Wild. and Natl. Sci. Found. 1974. 566 p.). 00.0

Shuntov, V. P. 1972. Ornithogeographic division of the world ocean. Zool. Zh. 51(10):1535-1546. [In Russian, English summary]. 00.0

Shuntov, V. P. 1972. Some peculiarities of spatial distribution of marine birds with respect to food competition. Zool. Zh. 51(3):393-405. [In Russian, English summary]. 00.0

Sladen, W. J. L. 1966. Additions to the avifauna of the Pribilof Islands, Alaska, including five species new to North America. Auk 83( ):130-135. 02.5

Sladen, W. J. L. 1973. A continental study of whistling swans using neck collars. Wildfowl 24:8-14. 01.0, 02.0

Smith, P. S., and J. B. Mertie, Jr. 1930. Geology and mineral resources of western Alaska. U. S. Dept. Int., Geol. Surv. Bull. 815. 351 p. 01.1

Smith, R. H., and R. P. Allen. 1948. An aerial waterfowl reconnaissance of the Far North. Pages 5-12, in Waterfowl populations and breeding conditions, Summer 1948, U. S. Dept. Int., Fish Wildl. Serv., Spec. Sci. Rept. 60. 01.1

Sowl, L. W., and J. C. Bartonek. 1974. Seabirds - Alaska's most neglected resource. Trans. N. Am. Wild. Natur. Resources Conf. 39:117-126. 00.0

Spring, L. 1971. A comparison of functional and morphological adaptations in the common murre (Uria aalge) and thick-billed murre (Uria lomvia). Condor. 73(1):1-27. 00.0

Springer, H. K. 1966. Unusual bird records from Hooper Bay, Alaska. Condor. 68(6):600-601. 02.0

Sprunt, A., IV, W. B. Robertson, Jr., S. Postupalsky, R. J. Hensel, C. E. Knoder, and F. J. Ligas. 1973. Comparative productivity of six bald eagle populations. Trans. N. Am. Wild. Natur. Res. Conf. 38:96-106.

Stegmann, B. 1963. The problem of the Beringian continental land connection in the light of ornithogeography. Pages 65-78, in J. L. Gressit, ed., Pacific Basin biogeography. Bishop Museum Press, Honolulu. 00.0

Stewart, P. A. 1964. Bird notes from Southeastern Alaska. Condor. 66(1): 78-79. 12.2

Stone, W. 1901. Report on the birds and mammals collected by the McIlhenny Expedition to Pt. Barrow, Alaska. Proc. Acad. Natur. Sci. Philadelphia.

Stone, W. 1901. Report on the birds and mammals collected by the McIlhenny Expedition to Pt. Barrow, Alaska. Proc. Acad. Natur. Sci. Philadelphia, 1900, pages 4-49. 01.0, 02.0, 02.1, 10.0

Stresemann, E. 1948. Birds collected in the North Pacific area during Capt. James Cook's last voyage (1778 and 1779). Ibis 91:244-245. 00.0

Stresemann, E. 1948. Dr. C. H. Merck's ornithologische Aufzeichnungen, wahrpend der Billingsschen Expedition von Ochotsk nach Alaska (1787-1791). Zoologische Jahrbucher; Abt. fur Systematik, Okologie and Geographie der Tiere 1948. Bd. 78:97-132. [In German]. 00.0

Swarth, H. S. 1934. Birds of Nunivak Island, Alaska. Pac. Coast Avifauna 22. 64 p. 02.2

Swartz, L. G. 1966. Sea-cliff birds. Pages 611-678, in N. J. Wilimovsky and J. N. Wolfe, eds., Environment of the Cape Thompson region, Alaska. U. S. Atomic Energy Comm., Div. Tech. Inf. 1250 p. 01.3

Swartz, L. G. 1967. Distribution and movements of birds in the Bering and Chukchi Seas. Pac. Sci. 21:332-347. 01.3

Thompson, C. F. 1967. Notes on the birds of the Northeast Cape off St. Lawrence Island and of the Punuk Islands, Alaska. Condor. 69( ):411-419. 02.1

Thompson, D. Q., and R. A. Person. 1963. The eider pass at Point Barrow, Alaska. J. Wildl. Manage. 27(3):348-356. 01.1, 01.2

Thompson, M. C. 1973. Migratory patterns of ruddy turnstones in the Central Pacific region. Living Bird. 12:5-23. 0.00

Thompson, M. C., and R. L. DeLong. 1969. Birds new to North America and the Pribilof Islands, Alaska. Auk 86(4):747-749. 02.5

Thompson, M. C., J. Q. Hines, and F. S. L. Williamson. 1966. Discovery of the downy young of Kittlitz's murrelet. Auk 83(3):349-351 + 1 plate. 01.3

Timm, D. E., S. O. Morgan, and R. E. Wood. 1975. Wolf as predator on mallards in a bait trap. Canad. Field Natur. 89(3):322. 12.2

Trautman, M. B. 1966. Birds. Part 6. In: R. P. Goldthwait, et al.; Soil development and ecological succession in a deglaciated area of Muir Inlet, southeast Alaska. Inst. of Polar Studies, Project 1988, Ohio State Univ. Res. Foundation. Report No. 20. 12.2

Troyer, W. A., and R. J. Hensel. 1965. Nesting and productivity of bald eagles on the Kodiak National Wildlife Refuges Alaska. Auk 28(4): 636-638. 05.0

Tuck, L. 1961. The murres. Canad. Wild. Serv. Series 1. 260 p. 00.0

Turner, L. M. 1886. Contributions to the natural history of Alaska. U. S. Army, Signal Service, Arctic Ser. Publ. 2. 226 p. + 10 plates. 02.0, 03.0

Udvardy, M. D. F. 1963. Zoogeographical study of the Pacific Alcidae. Pages 85-111, in J. L. Gressit, ed., Pacific Basin biogeography. Bishop Museum Press, Honolulu. 00.0

Udvardy, M. D. F. 1976. Did Santa Rosalia like seabirds? Proc. Int. Ornith. Congr. 16:739-746. 00.0

U.S. Dept. Agr., Forest Service, Alaska Region, and U. S. Dept. Int., Fish Wildl. Service, Alaska Area. [No date]. Bald eagles in Alaska. The agencies, Juneau and Anchorage, Alaska. 12 p. 12.2

U.S. Fish and Wildl. Serv. 1965. Birds of the Kodiak Natl. Wildl. Refuge. Revised edition. Refuge leaflet 151-R. 3 p. 05.0

U.S. Dept. Int., Fish Wildl. Service, Bur. Sport Fish. Wildl. 1973. To have and to hold: Alaska's migratory birds. The agency, Washington, D.C. i + 13 p. 00.0

U.S. Dept. Int., Bur. Land Mgmt. 1976a. Birds. Pages 163-185, in OCS proposed oil and gas leasing in the Northern Gulf of Alaska, sale No. 39. Final E.I.S. Vol. 2. Alaska OCS Office, Anchorage, Alaska. 09.2

U.S. Dept. Int., Bur. Land Mgmt. 1976b. Impact on Marine and Coastal Birds. Pages 179-209, in OCS proposed oil and gas lease sale No. CI, Lower Cook Inlet. Final E.I.S. Vol. 1. Alaska OCS Office, Anchorage, Alaska. 07.2

U.S. Dept. Int. Bur. Land Mgmt. 1977. Impact on Marine Birds. Pages 166-183, in OCS proposed oil and gas lease sale No. 46, Western Gulf-Kodiak. D.E.I.S. Vol. 2. Alaska OCS Office, Anchorage, Alaska. 05.0, 09.1

Unitt, P. 1976. Occurrence and migration of the long-tailed jaeger in North America. Abstract. Pacific Seabird Group Bull. 3(1):31.

Uspensky, S. M. 1959. Colonial sea breeding birds of the northern and far eastern seas of the U.S.S.R., their biotopic distribution, number and role as plankton and benthos consumers. Bull. Moscow Soc. Nature Res. Biol. Sect. 64(2):39-52. 01.2, 02.0

VanKammen, J. J. 1916. Whale Birds. Oologist. 33:171-172. 00.0

Vermeer, K. 1976. Colonial auks and eiders as potential indicators of oil pollution. Marine Poll. Bull. 17(1):165-167. 00.0, 12.0

Vermeer, K., and G. G. Anweiler. 1975. Oil threat to aquatic birds along the Yukon coast. Wilson Bull. 87:467-480. 01.1

Vincent, R. E. 1964. The origin and affinity of the biota of the Kodiak Island group, Alaska. Pac. Sci. 18:119-125. 05.0, 09.1

Wahl, T. R. 1976. Observations on seabird densities in the northwestern Pacific Ocean and the Bering Sea in June 1975. Abstract. Pacific Seabird Group Bull. 3(1):23. 05.0, 10.0

Walker, E. P. 1920. Southerly nesting records of the Arctic tern in southeastern Alaska. Condor. 22:72-73. 12.2

Walker, E. P. 1920. Probable breeding of the Aleutian tern in southeastern Alaska. Condor. 22:111-112. 12.2

Walker, E. P. 1923. Definite breeding record for the Aleutian tern in southern Alaska. Condor. 25:113-117. 12.2

Warter, S. L. 1975. Osteoarthritis in the short-tailed albatross: a crash-landing syndrome. Abstract. Pacific Seabird Group Bull. 2(1):41. 03.1

Watson, G. E., and G. J. Divoky. 1972. Pelagic bird and mammal observations in the eastern Chukchi Sea, early fall 1970. U. S. Coast Guard Oceanogr. Rept. 50:111-172. 01.2, 01.3

Watson, G. E., and G. J. Divoky. 1975. Marine birds in the Beaufort Sea. Pages 681-695, in J. C. Reed and J. E. Sater, eds., The coast and shelf of the Beaufort Sea. Arctic Instit. N. Am., Washington, D. C. 01.0

Webster, J. D. 1941. Notes on the birds of Sitka and vicinity, southeastern Alaska. Condor. 43(2):120-121. 12.2

Webster, J. D. 1941. The breeding of the black oyster-catcher. Wilson Bull. 53(3):141-156. 12.2

Webster, J. D. 1942. Notes on the growth and plumages of the black oyster-catcher. Condor. 44(5):205-211. 12.2

Webster, J. D. 1950. Notes on the birds of Wrangell and vicinity, southeastern Alaska. Condor. 52(1):32-38. 12.2

Webster, J. D. 1951. Corrections concerning data on Alaskan birds. Condor. 53(1):54. 12.2

Welch, R. A. 1965. Ecological observations in the Muir Inlet area, Glacier Bay National Monument, Alaska. Rep. Inst. Polar Stud. 15:1-19. 12.2

White, C. M. 1969. Breeding Alaskan and arctic migrant populations of the peregrine. Pages 2:45-51, in J. J. Hickey (ed.), peregrine 1.0 falcon populations, their biology and decline. Univ. Wisc. Press, Madison. 596 p.

White, C. M. 1975. The breeding seabird resource in the Rat Islands, Aleutians with emphasis on the Alcidae. Abstract. Pacific Seabird Group Bull. 2(1):39. 03.1

White, C. M. 1976. Aleutian Islands. Pages 262-264, in R. W. Fyfe, S. A. Temple, and T. J. Cade, The 1975 North American peregrine falcon survey. Canad. Field Natur. 90(3):228-273. 03.1

White, C. M., W. B. Emison, and F. S. L. Williamson. 1973. DDE in resident Aleutian Island peregrine population. Condor. 76(3)306:311. 03.1

White, C. M., D. G. Roseneau, M. Henhnke. 1976. Gulf of Alaska coast and southeastern Alaska. Pages 259-261, in R. W. Fyfe, S. A. Temple, and T. J. Cade. The 1975 North American peregrine falcon survey. Canad. Field Natur. 90(3):228-273. 09.0, 12.1

Willet, G. 1912. Report of G. Willet, Agent and warden stationed on St. Lazaria Bird Reservation, Alaska. Bird Lore. 14:419-426. 12.1

Willet, G. 1914. Birds of Sitka and Vicinity. Southeastern Alaska. Condor. 16 p. 12.1

Willet, G. 1915. Summer Birds of Forrester Island, Alaska. Auk. 32(3):295-305. 12.1

Willet, G. 1917. Further notes on the birds of Forrester Island, Alaska. Condor. 19:15-17. 12.1

Willet, G. 1918. Bird notes from Forrester Island, Alaska. Condor. 20:85. 12.1

Willet, G. 1920. Additional notes on the avifauna of Forrester Island, Alaska. Condor. 22:138-139. 12.1

Willet, G. 1920. Comments upon the safety of seabirds and upon the "probable" occurrence of the northern Bald Eagle in California. Condor. 22:204-205. 12.0

Willet, G. 1927. Destruction of eagles in Alaska. Auk 44:591-592. 12.2

Willet, G. 1928. Notes on some birds of Southeastern Alaska. Auk 45:445-559. 12.2

Willet, G. 1932. Summer birds of Forrester Island, Alaska. Auk 32(3):295-305. 12.1

Williamson, F. S. L. 1957. Ecological distribution of birds in the Napaskiak area of the Kuskokwim River Delta, Alaska. Condor. 59(5):317-338. 02.2

Williamson, F. S. L., and L. J. Peyton. 1959. Breeding record of the double-crested cormorant in South-central Alaska. Condor. 61(2):154-155.

Williamson, F. S. L., and L. J. Peyton. 1963. Interbreeding of glaucous-winged and herring gulls in the Cook Inlet region, Alaska. Condor. 65(1):24-28. 02.0

Williamson, F. S. L., and L. J. Peyton. 1962. Faunal relationships of birds in the Iliamna Lake area, Alaska. Biol. Papers Univ. Alaska 5. 73 p. 02.4

Williamson, F. S. L., L. J. Peyton, and M. E. Isleib. 1965. New distributtional and overwintering records of birds from South-central Alaska. Condor. 67(1):73-80.

Williamson, F. S. L., M. C. Thompson, and J. Q. Hines. 1966. Avifaunal investigations. Pages 437-480, in N. J. Wilimovsky and J. N. Wolfe, eds., Environment of the Cape Thompson region, Alaska. U. S. Atomic Energy Comm., Div. Tech. Inf. 1250 p. 01.2, 01.3

Wilson, R. S. 1948. The summer bird life of Attu. Condor. 59(3):124-129. 03.1

Wohl, K. D. 1975. Sightings of New Zealand shearwaters in the northern Gulf of Alaska. Canadian Field Naturalist. 89(3):320-321. 09.0

Yamashina, Y. 1931. Die vogel der Kurilen. J. Ornithol. 79(4):517-522. 02.8

Yesner, D. R. 1976. Aleutian Island albatrosses: a population theory. Auk. 93(2):263-280. 03.1

Yocum, C. 1963. July bird life in the Copper River delta country/Alaska - 1962. Murrelet. 44(3):28-34. 09.2

SELECTED BIBLIOGRAPHY

Part II. Unpublished References on Birds of Coastal Alaska

Abraham, K. F. 1975. Waterbirds and oil-contaminated ponds at Point Storkersen, Alaska. M. S. thesis, Iowa State Univ., Ames, Iowa. 01.1

Arctic Institute of North America. 1974. The Alaskan Arctic Coast: a background study of available knowledge. U.S. Dept. Defense, Army Corps of Engineers, Dist. Office, Anchorage, Alaska. 551 p. 01.0

Atwell, G. C. 1975. Kodiak National Wildlife Refuge narrative report, July 1, 1974 to June 30, 1975. U.S. Dept. of Int., U.S. Fish Wildl. Service, Kodiak, Alaska. Unpubl. admin. report. 40 p. 05.0

Bailey, E. P. 1973. Refuge narrative report, January 1, 1972-December 31, 1972, Izembek National Wildlife Range, Simeonof NWR, Semidi NWR. U.S. Dept. Int., Fish and Wildl. Service, Bureau Sport Fisheries and Wildl., Cold Bay, Alaska. Unpubl. admin. rept. 26 p. +[14] 02.2, 04.0

Bailey, E. P. 1975. Seabird surveys, Cape Lisburne to the Barren Islands. U.S. Dept. Int., Fish Wildl. Service, Anchorage, Alaska. Unpubl. admin. rept. 17 p. 01.2, 01.3, 02.0, 04.0, 06.0, 07.0, 09.1

Bailey, E. P. 1976. Breeding seabird distribution and abundance along the south side of the Kenai Peninsula, Alaska. U.S. Dept. Int., Fish Wildl. Service, Anchorage, Alaska. Unpubl. admin. rept. 68 p. + 18 fig. 09.1

Baird, P. A. 1976. Pelagic bird observations from the southern Bering Sea to Seattle, 7-23 June 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-071. Unpubl. admin. rept. 9 p, 8 tables, 5 maps. 02.4, 02.5, 03.2, 04.0, 05.0, 10.1, 10.2, 10.4

Baird, P. A. 1976. Seabird studies in the North Pacific Ocean, 4-23 November 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-095. Unpubl. admin. rept. 3 p, 3 tables, 4 maps. 05.0, 06.0, 09.1, 09.2, 10.3

Barry, T. W. 1967. Geese of the Anderson River Delta, N.W.T. Ph.D thesis Univ. Alberta, Edmonton. 212 p. 01.1

Barry, T. W. 1974. Waterfowl populations offshore in the Beaufort Sea. Canad. Dept. Environ., Beaufort Sea Proj. Interim Rept. A-3-Pt. I. 16 p. 01.1

Bartels, R. F. 1971. Waterfowl observations, Western Beaufort Sea Ecological Cruise, 1971. Iowa State Univ., Dept. Zool. Entom., Ames, Iowa. Unpubl. rept. 15 p. 01.1

Bartels, R. F. 1973. Bird survey techniques on Alaska's north coast. M.S. thesis, Iowa State Univ., Ames, Iowa. 47 p. 01.1

Bartonek, J. C. 1968. A survey of migratory bird problems in Alaska for the purpose of identifying research needs. Progress Report, Project A-53, Bureau of Sport Fisheries and Wildlife, Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Jamestown, N.D. 36 p. 00.0

Bartonek, J. C. 1969. Arctic Slope and Trans-Alaska Pipeline Task Force report: the bird resources of Alaska's Arctic Slope and petroleum development. U.S. Dept. Int., Fish Wildl. Serv., N. Prairie Wildl. Res. Center, Jamestown, N.D. Unpubl. admin. rept. 37 p. 01.0

Bedard, J. 1967. Ecological segregation among plankton-feeding Alcidae (*Aethia* and *Cyclorrhynchus*). Ph.D. thesis, Univ. British Columbia, Vancouver, B.C. 177 p. 02.1

Benson, J. and R. S. Timson. 1975. Marine bird shipboard survey in the Gulf of Alaska and southern Bering Sea, 11 to 31 July 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-011. Unpubl. admin. rept. 9 p, 30 tables, 3 maps. 02.4, 02.5, 03.2, 04.0, 05.0, 10.4, 12.2

Bergman, R. D. 1974. Wetlands and waterbirds at Point Storkerson, Alaska. Ph.D thesis. Iowa State Univ., Ames, Iowa. 58 p. 01.1

Bergman, R. D. 1974. Use of lakes by waterbirds in the Prudhoe Bay oilfields, 12-13 August 1974. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. admin. rept. 12 p. 01.1

Boise, C. 1976. Breeding biology of the lesser sandhill crane (*Grus canadensis canadensis*) on the Yukon Delta, Alaska. M.S. thesis, Univ. Alaska. 02.2

Bromley, R. G. 1976. Nesting and habitat studies of the dusky Canada goose (*Branta canadensis occidentalis*) on the Copper River Delta, Alaska. M.S. thesis, Univ. Alaska. 81 p. 09.2

Burns, J. J. (Compiler). 1973. Bird and mammal log of the RV *Alpha Helix*. Unpublished notes. 01.2, 01.3

Byrd, G. V. 1974. Refuge narrative report January 1, 1972 - December 31, 1973. Aleutian Islands Nat'l Wildl. Refuge and Bogoslof Nat'l. Wildl. Refuge. U.S. Dept. Int., Fish Wildl. Service, Adak, Alaska. Unpubl. admin. rept. 37 + 16 p. 03.0

Childs, H. E., Jr. 1967. Preliminary rept. on the avial ecology of Amchitka Island, June 1967. Battelle Mem. Inst., Columbus, Ohio. Unpubl. rept. 38 p. 03.1

Corr, P. O. 1969. Upland game. Bald eagle nest ecology. Alaska Dept. Fish Game, Alaska Game Manage. Invest. 10:5-14. 12.1

Corr, P. S. 1974. Bald eagle (Haliaeetus leucocephalus alaskanus) nesting related to forestry in Southeastern Alaska. M.S. thesis, Univ. Alaska, College. 144 p. Typewritten. 12.2

Cottam, C. 1936. Food habits of North American diving ducks. Ph.D. diss., George Washington Univ., Washington, D.C. Typewritten. 00.0

Dau, C. 1972. Observations on the spring migration of birds at Old Kashunuk Village, Alaska. Univ. Alaska, Dept. Wildl. Fish., Fairbanks. Unpubl. rept. 54 p. 02.2

Dau, C. 1974. Nesting biology of the spectacled eider Somateria fischeri (Brandt) on the Yukon-Kuskokwim Delta, Alaska. M.S. thesis, Univ. Alaska, Fairbanks. 72 p. 02.2

DeGange, A. R. 1977. Seabird studies in the Gulf of Alaska from Yakutat to the Shumagin Islands, 19 April to 21 May, 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-019. Unpubl. admin. rept. 13 p, 4 tables, 6 maps. 04.0, 05.0, 06.0, 07.2, 08.0, 09.1, 09.2

Dick, M. 1976. Beached bird surveys, Kodiak Island, Alaska, July 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-007.3. Unpubl. admin. rept. 1 p, 1 table, 1 map. 05.0

Dick, M. 1976. Notes on the breeding and other seabirds in Chiniak and southern Marmot Bays, Kodiak Island, Alaska, 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-007.4. Unpubl. admin. rept. 17 p. 05.0

Dick, M. H., and L. S. Dick. 1971. The natural history of Cape Peirce and Nanvak Bay, Cape Newenham Nat'l. Wildl. Refuge, Alaska. U.S. Dept. Int., Bur. Sport Fish. Wildl., Bethel, Alaska. iv 78 p. 02.4

Dick, M., I. M. Warner and R. MacIntosh. 1976. Distribution and abundance of breeding seabirds in Chiniak and southern Marmot Bays, Kodiak Island, Alaska, 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-007.2. Unpubl. admin. rept. 6 p, 13 tables, 1 map. 05.0

Dick, M., I. M. Warner and R. MacIntosh. 1976. Small boat census of seabirds: Marmot and Chiniak Bays, Kodiak Island, 28 June to 10 August 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-007.1. Unpubl. admin. rept. 7 p, 1 figure, 5 tables, 1 map. 05.0

Divoky, G. J. 1972. The pelagic birds and mammals of the Chukchi Sea in fall. M.S. thesis, Michigan State Univ., (East Lansing, Michigan). 97 p. 01.2, 01.3

Eisenhauer, D. I., and C. M. Kirkpatrick. 1975. Ecology of the Emperor goose in Alaska. Purdue Univ., Lafayette, Ind. Manuscript. 193 p. 00.0, 02.2, 02.4

Eisenhauer, D. I., C. A. Strang, and C. M. Kirkpatrick. 1971. Nesting ecology of the emperor goose (*Philacte canagica* Sewastianov) in the Kokechik Bay region, Alaska. First annual report, 1971. Dept. Forestry and Conservation, Purdue Univ., Lafayette, Ind. Unpubl. progress rept. 66 p. 02.2

Flock, W. L. 1975. Bird migration at Cape Prince of Wales: radar and visual observations. Pages 276-319. Environmental Assessment of the Alaskan Continental Shelf, V. 4. U.S. Dept. Comm., Nat. Oceanic Atmos. Admin., U.S. Dept. Int., Bur. Land Manage. 01.3, 02.1

Forsell, D. J. 1976. Marine bird observations in the western Gulf of Alaska, southern Bering Sea and eastern Aleutian Islands, 27 April to 4 June 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-021 and 76-057. Unpubl. admin. rept. 3 p, 2 tables. 02.3, 02.4, 02.5, 02.6, 03.1, 03.2, 04.0, 06.0, 09.1

Forsell, D. 1976. Pelagic bird observations in the southeastern Bering Sea and Kodiak Basin, 26 June to 16 July 1976. U.S. Fish Wildl. Serv. Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-075. Unpubl. admin. rept. 3 p. 02.2, 02.4, 02.5, 04.0, 05.0

Frazer, D. A., and D. M. Hardy. 1976. Marine bird observations in the North Pacific Ocean, 23 February to 11 March 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv. Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-005 and 76-007. Unpubl. admin. rept. 11 p, 54 tables, 3 maps. 05.0, 09.2, 10.3, 10.4, 12.3

Gibson, D. D. 1973. Check-list of the birds of Alaska. Univ. Alaska, Fairbanks. 2 p. 00.0

Gibson, D. D. 1976. Bird species and habitat inventory, Alexander Archipelago, Alaska. Univ. Alaska Mus. Unpubl. contract rept. to U.S. For. Serv. 66 p. 12.2

Gibson, D. D., and S. O. MacDonald. 1975. Bird species and habitat inventory, mainland Southeast Alaska, summer 1974. Univ. Alaska Mus. Unpubl. contract rept. to U.S. For. Serv. 73 p. 12.2

Gill, R. E. 1977. Avifaunal Assessment of Nelson Lagoon, Port Moller, and Herendeen Bay, Alaska. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage. Field Rept. 77-056.

Gillham, C. E. 1941. Report of Alaska waterfowl investigations, summer 1941; Lower Yukon River, Chevak, Hooper Bay. U.S. Fish and Wildlife Service. Unpubl. admin. rept. 02.2

Gould, P. 1976. Seabird studies in the Bering Sea, 20 Sept. to 1 Oct. 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv. Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-089. Unpubl. admin. rpt. 3 p, 11 tables, 4 maps. 02.2, 02.5, 04.0, 05.0

Gould, P. 1976. Seabird studies in the Gulf of Alaska, 25 May to 3 June 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-064. Unpubl. admin. rept. 2 p, 7 tables, 2 maps. 05.0, 09.1, 09.2

Gould, P. 1976. Seabird studies in the Kodiak Basin, Bering Sea and Chukchi Sea, 1-16 September 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-088. Unpubl. admin. rept. 4 p, 22 tables, 10 maps. 01.3, 01.4, 02.1, 02.2, 02.5, 04.0, 05.0

Gould, P. 1976. Seabird studies in the North Pacific Ocean from the Alaska Peninsula to the Hawaiian Islands, 23 October to 6 November 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-094. Unpubl. admin. rept. 3 p, 17 tables, 12 maps, 5 figures. 04.0, 05.0, 10.1, 11.1

Gould, P. 1976. Seabird survey of Kodiak Basin, Prince William Sound and the Gulf of Alaska, 12-20 May 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-052. Unpubl. admin. rept. 3 p, 5 tables, 2 maps. 04.0, 08.0, 09.1, 09.2

Gould, P., and M. Rauzon. 1976. Seabird survey of NEGOA and Kodiak Basin, 4-5 May 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-050. Unpubl. admin. rept. 3 p, 2 tables, 2 maps. 05.0, 09.2

Gould, P., and M. Rauzon. 1976. Seabird survey of Lower Cook Inlet and NWGOA, 6-8 May 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-051. Unpubl. admin. rept. 3 p, 4 tables, 2 maps. 07.2, 09.1

Gunn, W. W. H. and J. A. Livingston (eds.). Bird distribution and populations ascertained through ground survey techniques, 1972. Arctic Gas Biol. Rept. Ser. 12(2). 181 p. 01.1

Gunn, W. W. H., W. J. Richardson, R. E. Schweinsburg, and T. D. Wright (eds.). 1974. Ornithological studies conducted in the area of the proposed gas pipeline, 1973. Arctic Gas Biol. Rept. Ser. 26(2). 47 p. 01.1

Gunn, W. W. H., and J. A. Livingston (eds.). 1974. Bird distribution and populations ascertained through aerial survey techniques, 1972. Canadian Arctic Gas Studies, Biological Report Series, Vol. 11. L.G.L. Ltd., Calgary, Alberta. Unpubl. rept. 01.1

Gunn, W. W. H., and J. A. Livingston (eds.). 1974. Bird distribution and populations ascertained through ground survey techniques, 1972. Canadian Arctic Gas Studies, Biological Report Series, Vol. 12. L.G.L. Ltd., Calgary, Alberta. Unpubl. rept. 01.1

Gunn, W. W. H., and J. A. Livingston (eds.). 1974. Bird migrations on the North Slope and in the Mackenzie Valley regions, 1972. Canadian Arctic Gas Studies, Biological Report Series, Vol. 13. L.G.L. Ltd., Calgary, Alberta. Unpubl. rept. 01.1

Haddock, L., and J. Benson. 1975. Marine bird aerial survey in the Gulf of Alaska, 1 June 1972, 16 & 26 April 1973. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-001. Unpubl. admin. rept. 6 p, 8 tables, 2 maps. 05.0, 09.1, 09.2

Hall, G. E. 1971. A summary of observations of birds at Oliktok Point - summer 1971. Univ. Alaska, Inst. Marine Sci., College, Alaska. Unpubl. admin. rept. 31 p. 01.1

Handel, C. M. 1975. Fall pelagic bird observations in the Gulf of Alaska, 16 to 22 September 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-024. Unpubl. admin. rept. 18 p, 6 figures, 13 tables, 4 maps. 05.0, 09.1, 12.1

Handel, C. M. and J. E. Benson. 1975. Late fall pelagic bird observations in the Gulf of Alaska, 1 to 24 October 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-025. Unpubl. admin. rept. 20 p, 1 figure, 33 tables, 4 maps. 05.0, 08.0, 09.1, 09.2, 12.1

Hansen, H. A., S. T. Olson, P. E. K. Shepherd, and V. Berns. 1959. Selawik production studies and banding. [U.S. Dept. Int., Fish Wildl. Serv.], Alaska Game Commission, Fish and Game Restor., Job Completion Rept. 12(5): 1-5. 01.3

Hardy, D. M. and D. R. Nysewander. 1976. Pelagic bird observations in the Gulf of Alaska, 17 November to 2 December 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-034.1. Unpubl. admin. rept. 17 p, 15 tables, 5 maps. Appendix 9 p. 09.1, 09.2, 12.1

Harrison, C. S. 1976. Summer pelagic bird observations from the Gulf of Alaska to the Shumagin Islands, 22-31 July 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-083. Unpubl. admin. rept. 4 p, 16 tables, 6 maps. 04.0, 05.0, 09.1, 10.1

Harrison, C. S. 1976. Spring pelagic bird observations in Cook Inlet, Prince William Sound and the Gulf of Alaska, 6-13 April 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-016. Unpubl. admin. rept. 11 p, 13 tables, 2 maps. 05.0, 07.1, 07.2, -9.0, 09.1, 09.2

Harrison, C. S., and S. A. Hatch. 1975. Field observations on Unimak Island, Alaska, 11 to 25 August 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-017. Unpubl. admin. rept. 15 p, 5 tables, 1 map. 02.2, 03.2, 04.0

Hatch, S. A. 1975. Pelagic bird observations from the Alaska Peninsula to Washington, 8 to 17 November 1975. Unpubl. admin. rept. 8 p, 13 tables, 5 maps. 03.2, 04.0, 05.0, 10.2, 10.4

Hatch, Scott A. 1976. Population ecology and breeding biology of fulmars at Semidi Islands, Alaska. A progress report. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-024.1. Unpubl. admin rept. 3 p. 05.0

Hatch, S. A., and M. J. Rauzon. 1975. Pelagic bird observations in the North Pacific Ocean and Bering Sea, 16 to 29 July 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-013. Unpubl. admin. rept. 11 p, 35 tables, 7 maps. 02.1, 02.2, 02.5, 04.0, 05.0, 10.4, 11.2, 11.2, 11.4, 12.9

Hatch, S. A. and R. Timson. 1975. Spring pelagic bird observations in the Gulf of Alaska, 21 April to 14 June 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-004. Unpubl. admin. rept. 16 p, 16 figures, 75 tables. 04.0, 05.0, 07.2, 08.0, 09.1, 09.2, 11.0

Headley, P. C. 1966. Waterfowl. Ecology of the emperor goose. Alaska Dept. Fish Game Small Game Furbearer Invest. 7:1-3. 02.2

Headley, P. C. 1967. Waterfowl. Ecology of the emperor goose. Alaska Dept. Fish Game Small Furbearer Invest. 8:1-25. 02.2

Henderson, K. 1975. Pelagic bird observations in the Gulf of Alaska, 8 to 16 October 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-028. Unpubl. admin. rept. 9 p, 8 tables, 8 maps. 02.5, 04.0, 05.0, 06.0, 07.2, 09.1

Henderson, K., J. Benson and C. M. Handel. 1975. Pelagic bird observations in the Gulf of Alaska and the southern Bering Sea, 7 August to 12 September 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-016. Unpubl. admin. rept. 21 p, 22 tables, 27 maps. 02.2, 02.5, 04.0, 05.0, 07.2, 08.0, 09.1, 09.2

Henderson, K. 1975. Pelagic bird observations in the Gulf of Alaska, 28 October to 6 November 1975. U.S. Fish Wild. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-031. Unpubl. admin. rept. 8 p, 11 tables, 9 maps. 04.0, 06.0, 07.2, 08.0, 09.1, 09.2, 10.3, 12.1

Holmes, W. N., and J. Gronshaw. 1975. The effects of petroleum on marine birds, Univ. of California, Dpet. of Bio., Santa Barbara, California. Final Progr. Rept. to Am. Petroleum Instit. 77 p.

Hout, J. L. 1966. Fish and Wildlife resources of Nunivak Island. Part 1: fisheries. U.S. Dept. Int., Fish Wildl. Serv., Clarence Rhode Nat'l. Wildl. Refuge, Bethel, Alaska. Unpubl. progress report 23 + [20] p. 02.2

Hout, J. 1971. Cape Newenham Nat'l Wildl. Refuge narrative report, January 1 to December 31, 1970. U.S. Dept. Int., Fish Wildl. Serv., Bethel, Alaska. Unpubl. annual report. 17 p. 02.2

Hout, J. 1972. Cape Newenham Nat'l Wildl. Refuge annual report, January 1, to December 31, 1971. U.S. Dept. Int., Fish Wildl. Serv., Bethel, Alaska. Unpubl. rept 6 + 3 p. 02.2, 02.4

Howard, R. L. 1974. Aquatic invertebrate-waterbird relationships on Alaska's arctic coastal plain. M.S. thesis, Iowa State Univ. 49 p. 01.1

Humphrey, P. S. 1955. The relationships of the sea ducks (tribe Mergini). Ph.D diss., Univ. Michigan, Ann Arbor. 212 p. 00.0

Isleib, M. E. and T. Eberhardt. 1975. Marine bird shipboard survey in the Gulf of Alaska and along ocean route from Seattle, 27 January to 4 March 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-002. Unpubl. admin. rept. 21 p, 1 figure, 38 tables, 27 maps. 09.1, 09.2, 10.3, 10.4, 12.3, 12.5

Imler, R. H. 1941. Alaskan bald eagle studies. Bur. Sport Fish. Wildl. Files, Juneau, Alaska. 12.2

Jacot, F. H. 1962. A partial checklist and notes on birds of Glacier Bay National Monument, Alaska. U.S. Dept. Int., Natl. Park Serv. Glacier Bay Natl. Mon. Unpubl. booklet. 57 p. 12.2

Johnson, L. L. 1971. The migration, harvest, and importance of waterfowl at Barrow, Alaska. M.S. thesis, Univ. Alaska, College, Alaska. 87 p. 01.1, 01.2

Johnson, S. R., W. J. Adams, and M. R. Morrell. In press. Birds of the Beaufort Sea: I. A literature review. II. Spring Migration Observed during 1975. Can. Wildl. Serv., Prairie and Northern Region, Edmonton. Unpubl. report. 01.1

Jones, R. D., Jr. 1973. A method for appraisal of annual reproductive success in the black brant population. M.S. thesis, Univ. Alaska. Fairbanks, 117 p. 02.4

Jones, R. D., Jr. In press. The avian ecology of Izembek Lagoon. In W. S. Laughlin, (ed.), Aleut population and ecosystem analysis. IBP Synthesis Volume.

Jones, R. D., Jr. and M. Kirchhoff. 1976. Waterfowl habitat on the Yukon Delta. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-074. Unpubl. admin. rept. 17 p, 1 map, appendix 8 p.

Kenyon, K. W. 1966. Military use of island refuges, including Operation Long Shot; sea otter surveys and sea otter transportation experiment, October-December 1965. U.S. Dept. Int., Bureau of Sport Fisheries and Wildlife, Div. of Wildl. Research, Seattle, Washington. Unpubl. admin. rept. 50 p. 03.1

Kenyon, K. W., and J. G. King, 1965. Aerial survey of sea otter, other marine mammals and birds, Alaska Peninsula and Aleutian Islands, 19 April to 9 May, 1965. U.S. Dept. Int., U.S. Fish Wildl. Serv., Bureau of Sport Fisheries and Wildl., Sand Point Naval Air Station, Seattle, Washington. Unpubl. admin. rept. 61 p. 02.4, 03.1, 03.2, 04.0

Kessel, B. 1968. Checklist of the birds of the Seward Peninsula, Alaska. Univ. Alaska, Fairbanks. 1 p. 01.3, 02.1

King, J. G. 1963. Refuge narrative report, January 1 to April 30, 1963. U.S. Dept. Int., Fish Wildl. Service, Clarence Rhode Natl Wildlife Range, Bethel, Alaska. Unpubl. admin. rept. 23 + [6] p. 02.2

King, J. G. 1966. Cape Newenham, Alaska--a wildlife metropolis. U.S. Dept. Int., Fish Wildl. Serv., Bureau of Sport Fisheries and Wildlife, Juneau, Alaska. Unpubl. admin. rept. 32 p. 02.2, 02.4

King, J. G., 1968. Trumpeter swan survey Alaska - 1968. U.S. Dept. Int., Bur. Sport Fish. Wildl., Juneau, Alaska. Unpubl. admin. rept. 43 p. 00.0, 07.0, 09.0

King, J. G., and C. J. Lensink. 1971. An evaluation of Alaska habitat for migratory birds. U.S. Dept. Int., Bur. Sport Fish. Wildl., Washington, D.C., Nov. 1971. Unpubl. admin. rept. 46 p. + 26 p., appendix. 00.0

King. J. G., G. E. Marshall, J. H. Branson, F. H. Fay, and W. Allen. 1974. Alaskan pelagic bird observations and a data bank proposal. U.S. Fish & Wildl. Serv., Juneau. Unpubl. admin. rept. 16 p. + [6 p.]. 02.0, 10.0

King, J. G., and D. E. McKnight. 1969. A water bird survey in Bristol Bay and proposals for future studies. U.S. Bur. Sport Fish. Wildl. and Alaska Dept. Fish Game, Juneau, Oct. 1969. Unpubl. admin. rept. 14 p. 02.4

Kirchhoff, M. D. 1976. Pelagic bird observations in the Gulf of Alaska, 22 February to 4 March 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-004. Unpubl. admin. rept. 6 p, 40 tables, 9 maps. 08.0, 09.1, 09.2

Kirchhoff, M. 1976. Pelagic bird observations in the Gulf of Alaska, 16-29 March 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-011. Unpubl. admin. rept. 6 p, 32 tables, 6 maps. 05.0, 08.0, 09.1, 09.2

Kirchhoff, M., and M. Rauzon. 1975. Pelagic bird observations in the Bering Sea, 12 to 23 November 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-033. Unpbul. admin. rept. 15 p, 3 figures, 15 tables, 3 maps. Appendix 6 p. 02.2, 02.4, 02.5, 03.2, 04.0, 05.0, 09.1, 09.2, 12.1, 12.3

Klein, D. R. 1967. The introduction, increase and crash of reindeer on St. Matthew Island. Alaska Cooperative Wildlife Research Unit, Univ. of Alaska, College, Alaska. Unpubl. completion report. 34 p. 02.3

Lensink, C. J. 1972. Nunivak Natl Wildl. Refuge annual report 1970-71. U.S. Dept. Int., Fish Wildl. Serv., Bethel, Alaska. Unpubl. narrative report. 15 + [5] p. 02.2

Lensink, C. J. 1969. The distribution of recoveries from white-fronted geese (<u>Ansce albifrons frontalis</u>) banded in North America. U.S. Fish Wildl. Serv., Bethel, Alaska. Unpubl. admin. rept. 00.0

Lensink, C. J., and J. C. Bartonek. 1976. Preliminary catalog of seabird colonies and photographic mapping of seabird colonies. U.S. Fish & Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Unpubl. admin. rept. viii + 138 p. 00.0

Lensink, C. J., and J. C. Bartonek. 1976. Seasonal distribution and abundance of marine birds: Part I. Shipboard surveys.

U.S. Fish & Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Unpubl. admin. rept. xiv + 525 p. 00.0

Lensink, C. J., J. C. Bartonek, and C. S. Harrison. 1976. Seasonal distribution and abundance of marine birds: Part II. Aerial surveys. U.S. Fish & Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Unpubl. admin. rept. vi + 92 p. 00.0

Lensink, C. L. and J. L. Hout. 1968. Nunivak National Wildlife Refuge annual report, 1967. U.S. Dept. Int., Fish Wildl. Serv., Bethel, Alaska. Unpubl. annual report. 11 + [5] p. 02.2

Lensink, C. and J. Hout. 1970. Cape Newenham Natl Wildl. Refuge narrative report. January 1 to December 31, 1969. U.S. Dept. Int., Fish Wildl. Serv., Bethel, Alaska. Unpubl. annual report. 13 p. 02.2

Lewis, H. F. 1929. The natural history of the double-crested cormorant (Phalocorax auritus auritus (Lesson)). Ph.D diss., Cornell Univ., Ithaca, N.Y.

Lyon, L. J., A. C. Browne, and R. Krash. 1954. Annotated list of avifauna, Port of Whittier, Alaska, April - September 1954. Manuscript. [Original not seen; reported in Islieb and Kessel 1972.]

MacLean, S. F., Jr. 1969. Ecological determinants of species diversity of arctic sandpipers near Barrow, Alaska. Ph.D diss. Univ. California, Berkeley. 194 p. 01.1, 01.2

Maher, W. J. 1962. The ecology of the pomarine, parasitic, and long-tailed jaegers in northern Alaska. Ph.D diss., Univ. California, Berkeley. 01.1, 01.2

Manuwal, D. A. (Chairman), D. Anderson, G. Knoder, D. Nettleship, and S. G. Sealy. 2975. Seabird colony census techniques (preliminary draft). Pacific Seabird group, Comm. Colony Censusing, Univ. Washington, College Forest Sci., Wildl. Sci. Group, Seattle. 18 p. 00.0

Manuwal, D. A. and D. Boersma. 1976. The structure and dynamics of marine bird communities in the Barren Islands, Alaska. Quarterly progress report. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-054.1. Unpubl. admin. rept. 8 p, 1 table. 07.0, 09.2

McCann, J. A. 1963. A summary of biological field work done on Amchitka during the summer of 1962. U.S. Dept. Int., Fish Wildl. Serv. Unpubl. admin. rept. 22 p. 03.1

McKnight, D. E., and B. L. Hilliker. 1970. The impact of oil development on waterfowl populations in Alaska. Paper presented at 50th Conf. Western Assn. State Game and Fish Commissioners, Victoria, British Columbia, July 13-16, 1970. 12 p. 00.0

McRoy, C. P. 1966. The standing stock and ecology of eelgrass, Zostera marina L., in Izembek Lagoon, Alaska. Ph.D thesis, University of Washington. 02.4

McRoy, C. P., and S. Stoker. 1969. A survey of the littoral regions of Port Valdez. Pages 190-205, Univ. Alaska, Inst. Marine Sci. Baseline data survey for Valdez pipeline terminal and environmental data survey. College, Alaska. 08.0

Mickelson, P. G. 1973. Breeding biology of cackling geese (Branta canadensis minima), (Ridgeway) and associated species on the Yukon-Kuskokwim Delta, Alaska. Ph.D diss. Univ. Michigan, Ann Arbor. 246 p. 02.2

Mickelson, P. G. 1973. Status and abundance of birds and mammals of the Copper River Delta--1974. U.S. Dept. Agr., Forest Service, Chugach Natl Forest, Cordova, Alaska. Unpubl. admin. rept. 73 p. 09.1

Mickelson, P. G. 1974. Report on Egg Islands, Copper River Delta, Alaska . U.S. Dept. Agr., Forest Service, Chugach Natl Forest, Cordova, Alaska. Unpubl. admin. rept. 7 p. 09.1

Miller, E. H. 1972. Report on activities on Round Island (Walrus Islands), Bristol Bay, Alaska, 5 June - 12 July 1972. Alaska Coop. Wildl. Res. Unit, Univ. Alaska, Fairbanks. Unpubl. rept. 02.4

Moe, R. A. 1976. Field work undertaken during the 1976 field season on Big Koniuji Island, Alaska. A preliminary report. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-063.1. Unpubl. admin. rept. 12 p, 1 table, 6 figures. 04.0

Montgomery, D. T. 1972. Bristol Bay waterbird survey. U.S. Dept. Int., Fish Wildl. Serv., Bur. Sport Fish. Wildl., Alaska Area, River Basins Studies, Southeast Alaska, Operation Rept. - 1972. Unpubl. admin. rept. 8 p. + [unnumbered tables and figures]. 02.4

Morehouse, K. A. 1974. Development, energenitics and nutrition of captive Pacific brant (Branta bernicla orientalis, Tougarinov). Ph.D diss., Univ. Alaska, Fairbanks. 134 p. 00.0, 02.2, 02.4

Myres, M. T. 1958. Preliminary studies of the behavior, migration and distributional ecology of eider ducks in northern Alaska, 1958. Univ. British Columbia, Dept. Zool. Unpubl. rept. 01.0

Myres, M. T. 1960. The behavior of the sea-ducks and its value in the systematics of the tribes Mergini and Somaterini, of the family Anatidae. Ph.D diss., Univ. British Columbia, Vancouver. 00.0

Nelson, U. C. 1950. Preliminary survey of the species and distribution of food plants valuable for waterfowl on Stikine River Flats. U.S. Dept. Int., Fish Wildl. Serv., Alaska Quart. Prog. Rept. 4(3):2. 12.2

Nelson, U. C. 1951. Migratory waterfowl studies on breeding and wintering populations, nesting and banding. U.S. Dept. Int., Fish Wildl. Serv., Alaska Quart. Prog. Rept. 5(4):6-25. 02.2

Nelson, U. C., C. J. Lensink, and S. T. Olson. 1951. Migratory waterfowl studies, breeding and wintering populations, nesting and banding. U.S. Dept. Int., Fish Wildl. Serv., Alaska. Quart. Prog. Rept. 6(1):1-80. 02.2

Nelson, U. C., and R. E. Scott. 1950. Migratory waterfowl studies on breeding and wintering populations, nesting and banding. U.S. Dept. Int., Fish Wildl. Serv., Alaska Quart. Prog. Rept. 5(1):2-26. 2.2

Nelson, U. C., and P. E. K. Shepherd. 1955. Migratory waterfowl studies--nesting and banding--Selawik area. U.S. Dept. Int., Fish Wildl. Serv., Alaska Quart. Prog. Rept. 10(1):34-57. 01.3

Norton, D. W. 1970. Thermal regime of nests and bioenergetics of chick growth in the dunlin (Calidrialpina) at Barrow, Alaska. 77 M.S. thesis, Univ. of Alaska, Fairbanks. 78 p. 01.1, 01.2

Norton, D. W. 1973. Ecological energetics of Calidridine sandpipers breeding in northern Alaska. Ph.D diss., Univ. Alaska, Fairbanks. 193 p. 01.1, 01.2

Nysewander, D. 1975. Pelagic bird transects and studies in the southeastern Bering Sea and Gulf of Alaska, 13 September to 2 October 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-023. Unpubl. admin. rept. 15 p. 18 tables, 1 map. 02.2, 02.3, 02.4, 02.5, 02.6, 04.0, 05.0

Nysewander, D. 1975. Pelagic bird transects and studies on the North Pacific Ocean and southeastern Bering Sea, 12 August to 4 September 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-018. Unpubl. admin. rept. 19 p, 2 figures, 30 tables, 11 maps. 02.2, 02.3, 02.4, 02.5, 02.6, 03.2, 04.0, 05.0, 10.2, 10.4, 12.3

Nysewander, D. M. 1976. Pelagic bird transects in the northeastern North Pacific Ocean, 2 to 6 December 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-034.2. Unpubl. admin. rept. 7 p, 5 tables, 4 maps. 10.3, 10.4, 12.3

Olson, S. T. 1950. A study of goose and brant nesting on the Yukon-Kuskokwim Delta. U.S. Fish Wildl. Serv., Juneau, Alaska. Unpubl. admin. rept. 40 p. 02.2

Olson, S. T. 1954. Gull-waterfowl relationships in Alaska. Paper presented 5th Alaska Sci. Conf., Anchorage. 5 p. 02.2

Olson, S. T. 1954. Migratory waterfowl studies: Copper River Delta, banding and production studies. U.S. Dept. Int., Fish Wildl. Serv., Juneau, Alaska. Unpubl. admin. rept. 9 p, 09.1

Patten, S. and R. Patten, 1975. A marine bird survey of the Dixon Harbor area, Glacier Bay Natl Mon., Gustavus, Alaska, and a marine mammal survey, Dixon Harbor area, Glacier Bay Natl Mon. Dept. of Pathology, Johns Hopkins University, Baltimore, Maryland, 50 + [44] p. 12.2

Pedersen, S. 1971. Status and trends of subsistence resource use at Point Hope. Pages 37-89, in B. MacLean (director), Point Hope Project report. Univ. Alaska, Fairbanks. 01.2, 01.3

Petersen, M. R. 1976. Breeding biology of arctic and red-throated loons. Univ. California, Davis. M.S. thesis. 55 p. 02.2

Phillips, M. 1976. Field observations on Unimak Island, 21 April to 27 May 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-020. Unpubl. admin. rept. 12 p, 6 tables, 3 figures. 02.2, 03.2, 04.0

Phillips, M. 1976. Pelagic bird observations in the southern Bering Sea, south of the Alaska Peninsula and in Kodiak Basin, 8-25 March 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-009. Unpubl. admin. rept. 7 p, 24 tables, 9 maps.

Phillips, M. et al. 1976. Pelagic bird observations from Seattle, Washington to Seward, Alaska, 15-20 February 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-002. Unpubl. admin. rept. 12 p, 16 tables, 5 maps. 09.1, 0912, 12.1, 12.3

Powers, K. 1976. Field observations on Ugaiushak Island, Alaska, from 27 July to 2 September 1976. Preliminary report. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-061.2. Unpubl. admin. rept. 3 p, 1 tables, 2 maps. 04.0

Powers, K. 1976. Vegetation survey of Ugaiushak Island, Alaska, August 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-061.1. Unpubl. admin. rept. 5 p, 6 tables, 1 maps, appen. 5 p. 04.0

Quimby, R. 1972. Waterbird habitat and use of Chickaloon Flats. M.S. thesis. Univ. Alaska, Fairbanks. 85 p. 07.1

Rauzon, M. J. 1975. Pelagic bird observations in the southern Bering Sea and North Pacific Ocean, 2 to 26 October 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-026. Unpubl. admin. rept. 15 p, 1 figures, 24 tables, 5 maps. Appen. 28 p. 02.2, 02.4, 02.5, 02.6, 04.0, 05.0

Rauzon, M. 1976. Field observations on Unimak Island, 1-17 July 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-076 Unpubl. admin. rept. 9 p, 3 tables 02.4, 03.2, 04.0

Rauzon, M. 1976. Marine bird observations in Alaskan waters aboard the Linblad Explorer 27 May to 16 June 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-068. Unpubl. admin. rept. 7 p, 4 tables, 4 maps. 02.5, 04.0, 05.0, 06.0, 08.0, 09.1, 09.2, 10.3, 12.1, 12.3

Rauzon, M. 1976. Marine bird observations in the Gulf of Alaska and southern Bering Sea, 24 March to 21 April 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-012. Unpubl. admin. rept. 10 p, 3 tables, 1 map. 02.4, 02.5, 02.6, 04.0, 05.0, 09.1

Rauzon, M. J. and J. Ruehle. 1975. Pelagic bird observations in the North Pacific Ocean and Bering Sea, 6 August to 11 September 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-015. Unpubl. admin. rept. 17 p, 41 tables, 11 maps. 02.4, 02.5, 03.2, 04.0, 05.0, 09.1, 09.2, 10.3, 10.4

Richardson, W. J., M. R. Morrell and S. R. Johnson. 1975. Bird migration along the Beaufort Sea coast: radar and visual observations in 1975. Canad. Dept. of Environ., Beaufort Sea Proj. Tech. Rept. 3. 131 p. 01.1

Ritchie, R. J. 1974. Seabirds of southeastern waters. U.S. Dept. Agr., Forest Service, Juneau, Alaska. Unpubl. admin. rept. 12.2

Robards, F. C., and J. G. King. 1966. Bald eagle studies: Southeast Alaska. U.S. Dept. Int., Bur. Sport Fish. Wildl., Juneau, Alaska. Unpubl. admin. rept. 14 p. 12.2

Roseneau, D. C. 1965. Barren Islands field notes, 25 May through 1 July 1965. Manuscript 4 p. 05.0, 07.2, 09.2

Ruehle, J. O. 1975. Late fall pelagic observations in the Gulf of Alaska, 21 October to 10 November 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-030. Unpubl. admin. rept. 15 p, 11 tables, 2 maps. 08.0, 09.1, 09.2

Sanger, D. A. 1974. A review of the pelagic biology of the tufted puffin. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Unpubl. rept. 16 p, 6 figures.

Schamel, D. L. 1974. The breeding biology of the Pacific eider (<u>Somateria mollissima v-nigra</u> Bonaparte) on a barrier island in the Beaufort Sea, Alaska. M.S. thesis, Univ. Alaska, Fairbanks. 95 p. 01.1

Schamel, D. 1976. Avifaunal utilization of the offshore island area near Prudhoe Bay, Alaska. Univ. Alaska, Inst. Marine Sci., Marine Sorting Center, Fairbanks. Unpubl. rept. ii + 36 p. 01.1

Schmidt, W. T. 1970. A field survey of bird use at Beaufort Lagoon. U.S. Dept. Int, Bur. Sport Fish. Wildl., Arctic Natl Wildl. Range, Fairbanks, Alaska. Unpubl. admin. rept. 35 p. 01.1

Schmidt, W. T. 1976. Narrative report - FY 75. Arctic Natl Wildl. Range. U.S. Dept. Int., Fish Wildl. Serv., Fairbanks, Alaska. Unpubl. admin. report. 13 + 5 p. 01.1

Schweinsberg, R. E. 1974. An ornithological study of proposed gas pipeline routes in Alaska, Yukon Territory and the Northwest Territories, 1971. 2nd ed. Canadian Arctic Gas Study, Biological Report Series, Bol. 10. Prepared by L. G. L. Ltd. Unpubl. rept. 01.1

Scott, R. F. 1949. Waterfowl studies: nesting studies and banding: Kotzebue Sound. U.S. Dept. Int., Alaska Game Comm., Quart. Progr. Rept. Surv. Invest., Fed. Aid Wildl. Restor. Proj. 3-R-4 41):19-28. 01.3

Sealy, S. G. 1968. A comparative study of breeding ecology and timing in plankton-feeding alcids (<u>Cyclorrhynchus</u> and <u>Aethia</u> spp.) on St. Lawrence Island, Alaska. M.S. thesis, Univ. British Columbia, Vancouver. 02.1

Sealy, S. G. 1972. Adaptive differences in breeding biology in the marine bird family Alcidae. Ph.D thesis, Univ. Michigan, Ann Arbor. 295 p. 00.0, 02.1

Searing, G. F., and W. J. Richardson. 1975. A study of seabirds in the coastal Beaufort Sea area, 1972 and 1974. LGL Ltd., unpubl. rept. to Canad. Wildl. Service, Edmonton, Alberta. 460 p. 01.1

Searing, G. F., E. Kuyt, W. J. Richardson, and T. W. Barry. 1976. A study of seabirds in the coastal Beaufort Sea area, 1972 and 1974. Canad. Dept. Environ., Beaufort Sea Proj. Tech. Rept. 3. 256 p. 01.1

Sekora, P. 1973. Aleutian Islands Natl Wildl. Refuge wilderness study rept. U.S. Dept. Int., Bur. Sport Fish. Wildl., Anchorage, Alaska. Unpubl. admin. rept. 409 p. 02.4, 02.5, 02.6, 02.7, 03.0

Shepherd, P. E. K. 1960. Mortality studies of western Canada geese--Copper River Delta. Alaska Dept. Fish Game, Div. Game, Pittman-Robertson Proj. Rept. 2(8):50-57. 09.2

Shepherd, P. E. K. 1960. Distribution and abundance of the black brant in Alaska. Alaska Dept. Fish Game, Div. Game, Pittman-Robertson Proj. Rept. 2(8):58-60. 09.2

Shepherd, P. E. K. 1960. Production and abundance of the black brant in Alaska. Alaska Dept. Fish Game, Div. Game, Pittman-Robertson Proj. Rept. 2(8):58-57. 01.1, 01.2

Shepherd, P. E. K. 1960. Production, harvest, distribution and migration of waterfowl in Alaska. Alaska Dept. Fish Game, Game Div. Pittman-Robertson Proj. Rept. 2(8):61-77.

Shepherd, P. E. K. 1963. Game bird investigations. Distribution, abundance, and production of black brant in Alaska. Alaska Dept. Fish Game, Game Div. Pittman-Robertson Proj. Rept. 4:20-40. 02.2

Shepherd, P. E. K. 1959. Swans--Copper River Delta. M.S. thes is. Washington State Univ. 09.1

Sigman, M. 1976. SummerField studies at Cape Peirce and Shaiak Island, Alaska, 1976. Preliminary report. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 76-023.1. Unpubl. admin. rept. 20 p, 6 figures, 2 tables, appen. 5 p. 02.4

Snarski, D. 1973. Kittiwake ecology. Tuxedni Natl Wildl. Refuge. Alaska Coop. Wildl. Res. Unit Quart. Prog. Rept. 25(2):21-23. 07.2

Snarski, D. A. 1974. Some aspects of the ecology of the black-legged kittiwake during two years of nesting failure. Univ. Alaska, Coop. Wildl. Research Unit, Fairbanks thesis manuscript. 38 p. 07.2

Sowl, L. W. 1973. Marine bird survey, Alaska Peninsula--field notes 1973. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. admin. rept. 48 p. 04.0, 05.0, 06.0

Sowls, A. 1975. Pelagic bird observations from Long Beach, Clifornia to Point Barrow, Alaska, September 1975. U.S. Fish

Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-021. Unpubl. admin. rept. 14 p, 2 figures, 10 tables, 4 maps. 01.3, 02.0, 07.0, 10.0, 11.0

Spencer, D. L. 1952. Refuge narrative report, calendar year 1951, Nunivak Natl Wildlife Refuge. U.S. Dept. Int., Fish Wildl. Serv., Mekoryuk, Alaska. Unpubl. narrative rept. 18 + [6] p. 02.2

Spencer, D. L. 1967. Photographs, Amchitka Island. U.S. Dept. Int., Fish Wildl. Serv., Adak, Alaska. Unpubl. photographic assemblage. 18 p. 03.1

Spring, L. W. 1968. A comparison of functional and morphological adaptations in the common murre (Uria aalge) and the thick-billed murre (Uria lomvia). Ph.D diss., Univ. Washington, Seattle. 140 p. 02.1

Springer, A. M. 1974. Effects of seasonal geographic and dietary changes on pollutant levels in long-tailed jaegers (Stercorarius longicaudus). M.S. thesis, Univ. Alaska, Fairbanks. 00.0

Stephenson, R. O. 1970. A study of the summer food habits of the arctic fox on St. Lawrence Island, Alaska. M.S. thesis, Univ. Alaska, College. 75 p. 02.1

Thayer, A. 1971. Arctic Natl. Wildl. Range, Alaska. Narrative 1970. U.S. Dept. Int., Fish Wildl. Serv., Fairbanks, Alaska. Unpubl. narrative report 67 p. 01.1

Thayer, A. S. 1975. Narrative report - FY 74. Arctic Natl Wildl. Range. U.S. Dept. Int., Fish Wildl. Serv., Fairbanks, Alaska. Unpubl. admin. rept. 18 p. 01.1

Thayer, A. S. 1966. Surveillance in Arctic Natl Wildl. Range, July 1966. U.S. Dept. Int., Fish Wildl. Serv., Fairbanks, Alaska. Unpubl. prog. rept. 28 + 11 p. 01.1

Thayer, E. S. 1951. Shismaref waterfowl project. U.S. Dept. Int., Alaska Game Comm. Quart. Progr. Rept., Surv. Invest., Fed Aid Wildl. Restor. Proj. 3-R-6 6(1):3-16. 01.3

Timm, D. 1972. Report of survey and inventory activities - waterfowl. Alaska Dept. Fish Game Proj. Progr. Rept. Fed. Aid Wildl. Restor. Proj. W-17-4, Job 10, 3:i-iii, 1-46; Ammendment 3:i-v, i-27. 00.0

Timm, D. 1974. Report of survey and inventory activities - waterfowl. Alaska Dept. Fish Game Proj. Progr. Rept. Fed. Aid Wildl. Restor. Proj. W-17-16, Job 11 and 22, 5:i-iii, 1-54. 00.0, 02.4

Timm, D. 1975. Report of survey and inventory activities - waterfowl. Alaska Dept. Fish Game Proj. Prog. Rept. Fed. Aid Wildl. Restor. Proj. W-17-7, Jobs 11.0, 11.1, 11.2, 11.3, and 22 and Proj. Final Rept. Proj. W-17-7, Jobs 11.4 and 11.5, 6:i-ii, 1-53. 00.0, 02.4, 07.1, 09.2.

Timm, D. 1976. Report of survey and inventory activities - waterfowl. Alaska Dept. Fish Game Proj. Prog. Rept. Fed. Aid Wild. Restor. Proj. W-17-8, Jobs 11.0, 11.1, 11.2 and 11.3, 7:1 + 1-61. 00.0, 02.4, 07.1, 09.2.

Timm, D., and P. Havens. 1973. Report of survey and inventory activities - waterfowl. Alaska Dept. Fish Game Proj. Prog. Rept. Fed. Aid Wildl. Restor. Proj. W-17-5, Job 10 and 22, 4:i-iii, 1-64. 00.0, 12.1

Timson, R. S. 1975. Late summer migration at Barrow, Alaska. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-019. Unpubl. admin. rept. 16 p, 19 tables. 01.1, 01.2

Trainer, C. E. 1959. The 1959 western Canada goose (Branta canadensis occidentalis) study of the Copper River Delta, Alaska. 09.1

Trapp, J. L. 1975. Distribution and abundance of seabirds along the Aleutian Islands and Alaska Peninsula, Fall 1974. U.S. Dept. Int., Fish Wildl. Serv., Aleutian Is. Natl Wildl. Refuge, Adak, Alaska. Unpubl. Admin. rept. 39 p. 02.5, 02.6, 02.7, 03.0, 03.1, 04.0, 05.0

Tull, C. E., I. D. Thompson, and P. S. Taylor. 1974. Continuing surveys of terrestrial bird populations in the Northwest Territories, Yukon Territory and Alaska; June and July 1973. In: W. W. H. Gunn, W. J. Richardson, R. E. Schweinsburg, and T. D. Wright (eds.), Studies on terrestrial bird populations, moulting sea ducks and bird productivity in the western Arctic, 1973. Arctic Gas Biol. Rept. Ser. 29(1). 38 p. 01.1

U.S. Dept. Int., Bur. Sport Fish. and Wildl. 1967. Wilderness record - Bogoslof, Bering Sea, Tuxedni wilderness study areas. U.S. Fish Wildl. Service, Portland, Oregon. Unpubl. report approx. 230 p. 02.3, 03.2, 07.2

U.S. Dept. Int., Bur. Sport Fish. Wildl., Alaska Planning Group. 1973. Proposed Alaska Coastal Refuges, Alaska. Draft Envir. Stat. 73-94. 261 p. + appendixes. 00.0

U.S. Dept. Int., Bur. Sport Fish. Wildl., Alaska Planning Group. 1973. Proposed Arctic National Wildlife Refuge, Alaska. Draft Envir. Stat. 73-95. 247 p. + appendixes. 01.1

U.S. Dept. Int., Bur. Sport Fish. Wildl., Alaska Planning Group. 1973. Proposed Iliamna National Resource Range, Alaska. Draft Envir. Stat. 73-96. 195 p. + appendixes. 02.2

U.S. Dept. Int., Bur. Sport Fish. Wildl., Alaska Planning Group. 1973. Proposed Selawik National Wildlife Refuge, Alaska. Draft Envir. Stat. 73-99. 233 p. + appendixes. 01.3

U.S. Dept. Int., Bur. Sport Fish Wildl., Alaska Planning Group. 1973. Proposed Togiak National Wildlife Refuge, Alaska. Draft Envir. Stat. 73-100. 183 p. + appendixes. 02.4

U.S. Dept. Int., Bur. Sport Fish. Wildl. Alaska Planning Group. 1973. Proposed Yukon Delta National Wildlife Refuge, Alaska. Draft Envir. Stat. 73-101. 205 p. + appendixes. 02.2

U.S. Dept. Int., Federal Task Force on Alaska Oil Development. 1972. Evaluation of environmental impacts. Vol. 4., in Final environmental impact statement, proposed Trans-Alaska Pipeline. 6 vols. U.S. Dept. Comm., Natl Tech Inf. Serv. PB-206. 01.1, 08.0, 09.0, 10.0, 11.0, 12.0

U.S. Dept. Int., Fish Wildl. Serv. Various dates. Aleutian Islands National Wildlife Refuge and Izembek National Wildlife Range narrative report. The agency, Cold Bay, Alaska. Unpubl. admin. rept. 02.4, 03.0, 04.0

U.S. Dept. Int., Fish Wildl. Serv. 1967. Wilderness study area: Bering Sea, Alaska. The agency, Anchorage, Alaska 8 p. 02.3

U.S. Dept. Int., Fish Wildl. Serv. Various dates. Clarence Rhode National Wildlife Range narrative report. The agency, Bethel, Alaska. Unpubl. admin. rept. 02.2

U.S. Dept. Int., Fish Wildl. Serv. 1970. Cape Newenham National Wildlife Refuge narrative report. The agency, Bethel, Alaska. Unpubl. admin. rept. 14 p. 02.2, 02.4

U.S. Dept. Int., Fish Wildl. Serv. 1971. Unimak Island, Aleutian Islands National Wildlife Refuge, Alaska: wilderness proposal. The agency, Anchorage. 20 p. + 1 map. 02.2, 04.0

U.S. Dept. Int., Fish Wildl. Serv. 1973. Nunivak wilderness study summary. The agency, Anchorage, Alaska. 26 p. 02.2

U.S. Dept., Int., Fish Wildl. Serv. 1967. Wilderness study reports - St. Sazaria, Hazy Islands, Forrester Island National Refuges. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. rept. Approx. 200 p. 12.1

U.S. Dept. Int., Fish Wildl. Serv. 1970. A reconnaissance report on the impact on fish and wildlife resources of the North Slope oil development, trans-Alaska pipeline system, and marine terminal sites. The agency, Juneau, Alaska. Admin. rept. 57 p. 01.1, 08.0

U.S. Dept. Int., Fish Wildl. Serv. 1970. Chamisso wilderness record. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. rept. Approx. 150 p. 01.3

U.S. Dept. Int., Fish Wildl. Serv. 1970. Izembek wilderness record. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. admin. rept. 2 vol. 02.4, 04.0

U.S. Dept. Int., Fish Wildl. Serv. 1970. The wilderness record. Simeonof wilderness proposal. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. admin. rept. Approx. 300 p. 05.0

U.S. Dept. Int., Fish Wildl. Serv. 1972. Arctic NWR wilderness preliminary review package, 1972. U.S. Dept. Int., Bureau of Sport Fish. and Wildl., Anchorage, Alaska. Unpubl. rept. 200 p. 01.1

U.S. Dept. Int., Fish Wildl. Serv. 1972. Nunivak Natl Wildl. Refuge wilderness study rept. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. rept. 81 + 70 p. 02.2

U.S. Dept. Int., Fish Wildl. Serv. 1972. Unimak Island wilderness record. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. rept. Vol. I approx. 175 p. Vol. II approx 260 p. 02.2

U.S. Dept. Int., Fish Wildl. Serv. 1972. Unimak Island wilderness study. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. rept. 61 + 15 p. 02.4, 04.0

U.S. Dept. Int., Fish Wildl. Serv. 1972. Wilderness record, Semidi wilderness proposal. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. rept. 2 volumes. Vol. I approx 90 p. Vol. II approx 330 p. 04.0

U.S. Dept. Int., Fish Wildl. Serv. 1973. Arctic Natl Wildl. Range, Alaska - Wilderness study report. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. rept. 94 + 38 p. 01.1

U.S. Dept. Int., Fish Wildl. Serv. Arctic National Wildlife Range. U.S. Dept. Int., Fish Wildl. Serv., Fairbanks, Alaska. Unpubl. photographic assemblage. 20 p. 01.1

U.S. Dept. Int., Fish Wildl. Serv. 1973. Aleutian Islands National Wildlife Refuge wilderness study field report. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. field report. 409 + 100 p. 03.1, 03.2

U.S. Dept. of the Int., Fish Wildl. Serv. 1973. Nunivak wilderness hearing record. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. admin. rept. 2 volumes. Vol. I approx 450 p. Vol. II approx 800 p. 02.2

U.S. Dept. Int., Fish Wildl. Serv. 1974. Supporting actions, Nunivak wilderness record. U.S. Dept. Int., Fish Wildl. Serv., Anchorage, Alaska. Unpubl. rept. 31 p. 02.2

U.S. Dept. Int., Fish Wildl. Service. 1975. Computer codes for birds of North America. The agency, Off. Biol. Serv., Anchorage, Alaska. 54 p. 00.0

U.S. Dept. Int., Natl Park Serv., Alaska Planning Group. 1973. Proposed Aniakchak National Monument, Alaska. Draft Envir. Stat. 73-85. 186 p. 02.4, 04.0, 07.0

U.S. Dept. Int., Natl Park Serv., Alaska Planning Group. 1973. Proposed Cape Krusenstern National Monument, Alaska. Draft Envir. Stat. 73-87. 186 p. 01.3

U.S. Dept. Int., Natl Park Serv., Alaska Planning Group. 1973. Proposed Chukchi-Imuruk National Wildlands sic Chukchi-Imuruk National Reserve, Alaska. Draft Envir. Stat. 73-93. 503 p. 01.3

U.S. Dept. Int., Natl Park Serv., Alaska Planning Group. 1973. Proposed Katmai National Park, Alaska. Draft Envir. Stat. 73-84. 306 p. 07.0

U.S. Dept. Int., Special Interagency Task Force for Fed. Task Force Alaskan Oil Development. 1972. Birds. Page, 189-193, 222-238, in Final environmental impact statement, proposed trans-Alaska pipeline, V. 4, Evaluation of environmental impact. U.S. Dept. Comm., Natl Tech. Info. Serv., PB 206 921 4. 637 p. 00.0

Univ. Alaska, Arctic Envir. Inf. Data Center and Instit. Soc., Econ., Govt. Research. 1974. The Bristol Bay environment: a study of available knowledge. U.S. Dept. Army, Corps Eng., Alaska Dist., Anchorage, Alaska. 858 p. 02.4

Warner, I. M. 2975. Census of seabirds: Gulf of Alaska, September 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-020. Unpubl. admin. rept. 7 p, 49 tables, 4 figures. 03.2, 04.0, 05.0, 07.2, 09.1, 09.2, 10.1, 12.1

Warner, I. and J. Guzman. 1975. Shipboard census of pelagic birds: Bering Sea and Gulf of Alaska, 8 May to 21 June 1975. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alaska. Field Rept. 75-005. Unpubl. admin. rept. 11 p, 86 tables, 19 maps. 02.2, 02.4, 02.5, 02.6, 04.0, 05.0, 09.1, 09.2, 10.4, 12.3

Weeden, R. B. 1968. Small game and furbearer investigation. Waterfowl report. Alaska Dept. Fish Gam, Alaska Game Manage. Invest. 9. 42 p. 07.1, 09.2

Weeden, R. B. 1969. Small game and furbearer investigation. Waterfowl report. Alaska Dept. Fish Game, Alaska Game Manage. Invest. 10. 19 p. 07.1, 09.2

Wehle, D. H. S. 1975. Food and feeding ecology of horned and tufted puffins on Buildir Island -- summer 1975. U.S. Dept. Int., Fish Wildl. Serv., Aleutian Is. Natl Wildl. Refuge, Adak, Alaska. Unpubl. admin. rept. 23 p. 03.1

Wehle, D. H. S. 1976. Preliminary field report: chronology of activities, Ugaiushak Island, 1976. U.S. Fish Wildl. Serv., Off. Biol. Serv., Coastal Ecosystems, Anchorage, Alska. Field Rept. 76-060.1. Unpubl. admin. rept. 2 p. 05.0

White, C. M. 1968. Biosystematics of North American peregrine falcons. Ph.D diss., Univ. Utah, Salt Lake City. 211 p. 00.0

Wik, D. 1967. Birds of Glacier Bay National Monument. Revised by G. Streveler, 1968. U.S. Dept. Int., Natl Park Serv., Glacier Bay Natl Mon. 80 p. 12.2

Williamson, F. S. L., and W. B. Emison. 1969. Annual progress report, June 1968 - July 1969, studies of the avifauna on Amchitka Island, Alaska. Battelle Mem. Inst., Columbus, Ohio. Unpubl. rept. 36 p. + append. 03.1

Wohl, K. D. 1976. Middleton Island Field Trip, 18-20 February. Unpubl. field rept. Bur. Land Mgmt., Alaska OCS Off., Anchorage, Alaska (3 March 1976). 7 p.

SELECTED BIBLIOGRAPHY

Part III. References on Birds in Marine Waters Adjacent to Alaska Coastal Waters and General References on Marine Birds and Hazards to Them

Aldrich, J. W. 1970. Review of the problem of birds contaminated by oil and their rehabilitation. U.S. Dept. Int., Fish Wild. Serv. Resource Publ. 87. 23 p.

Alexander, W. B. 1963. Birds of the ocean. 2 ed. G. P. Putnam's Sons, New York. 306 p.

American Ornithologists' Union. 1957. Check-list of North American birds. 5th Ed. Baltimore, MD. 691 p.

American Ornithologists' Union. 1973. Thirty-second supplement to the American Ornithologists' Union check-list of North American birds. Auk 90(2):411-419.

American Ornithologists' Union. 1976. Third-third supplement to the American Ornithologists' Union check-list of North American bitds. Auk 93(4):875-879.

Anderlini, V. C., J. H. Martin, P. G. Connors, and R. W. Risebrough. 1972. Concentrations of heavy metals in some Antarctic and North American seabirds.

Ashmole, N. P. 1971. Sea bird ecology and the marine environment. Pages 223-286, in D. S. Farner and J. R. King, eds., Avian biology. Vol. I. Academic Press, New York, NY. 586 p.

Barnard, A. E. 1973. Occurrence of black brant moulting in Boundary Bay. British Columbia. Murrelet 54(1):12-13.

Barry, T. W., and M. E. Carpenter. 1968. Utilization of birds in the Mackenzie Delta region. Canad. Wildl. Service, Edmonton, Alberta. Unpubl. Ann. Prog. Rept. 97-4-5-100. 40 p.

Barry, T. W., and R. Spencer. 1976. Wildlife response to oil well drilling. Canad. Wildl. Service Prog. Notes 67. 15 p.

Bedard. J. 1976. Coexistence, coevolution and convergent evolution in sea bird communities: a comment. Ecology 57(1):177-184.

Belopol'skii, L. O. 1957. Ecology of sea colony birds of the Barents Sea. Izdatel'stvo Akad. Nauk SSSR, Moskva-Leningrad. (Transl. from Russian, Israel Progr. Sci. Transl., 1961).

Bianchi, V. V. 1967. Gulls, shorebirds, and alcids of Kandalakshskya Gulf. Works of Kandalakshskaya State. Vol. 6. Murmansk Book Publishers, Murmansk, USSR. 363 p. (Transl. from Russian, Israel Progr. Sci. Transl., 1977).

Binford, L. C., B. G. Elliot, and S. W. Singer. 1975. Discovery of a nest and the downy young of the marbled murrelet. Wilson Bull. 87(3):303-319.

Bourne, W. R. P. 1968. Oil pollution and bird populations. Pages 99-121, in J. D. Carthy and D. R. Arthur, eds., The biological effects of oil pollution on littoral communities. Field Studies, V. 2, Suppl. 198 p.

Brown, R. G. B. 1973. Sea birds and oil pollution, the investigation of an offshore oil slick. Canad. Wild. Service Prog. Notes 31:1-2.

Brown, R. G. B., D. I. Gillespie, A. R. Lock, P. A. Pearce, and G. H. Watson. 1973. Bird mortality from oil slicks off eastern Canada, February to April 1970. Canad. Field-Natur. 87(3):225-234.

Butler, R. W. 1974. The feeding ecology of the northwestern crow on Mitlenatch Island, British Columbia. Canad. Field Natur. 88(3):313-316.

Campbell, R. W. 1968. Alexandrian rat predation on ancient murrelet eggs. Murrelet 49(3):6.

Campbell, R. W. 1968. Long-tailed jaegars (sic.) sighted at Vancouver, B. C. Murrelet 49(1):6.

Campbell, R. W. 1971. First Canadian specimen of New Zealand shearwater. Canad. Field Natur. 85(4):329-330.

Campbell, R. W., and M. G. Shepard, 1973. Laysan albatross, scaled petrel, parakeet auklet: additions to the list of Canadian birds. Canad. Field Natur. 87(2):179-180.

Campbell, R. W., and M. G. Shepard. 1971. Summary of spring and fall pelagic birding trips from Tofino, B.C., Discovery 150:13-16.

Campbell, R. W., and M. G. Shepard. 1972. Summary of 1971 offshore birding trips. Discovery 154:7-8.

Campbell, R. W., J. G. Ward, and M. G. Shepard. 1975. A new common murre colony in British Columbia. Canad. Field Natur. 89(3):244-248.

Campbell, R. W., and D. Stirling. 1967. Notes on natural history of Cleland Island, British Columbia, with emphasis on the breeding bird fauna. British Columbia Prov. Mus. Rept.

Campbell, R. W., and D. Stirling. 1968. Notes on the vertebrate fauna associated with Brandt's cormorant colony in British Columbia. Murrelet 49(1):7-9.

Causey, S. D. 1976. Anti-predator defense in two species of cormorant. Abstract. Pacific Seabird Group Bull. 3(1):21.

Clark, R. B. 1969. Oil pollution and the conservation of seabirds. Pages 76-112, _in_ Proc. Intl. Conf. Oil Pollution Sea, Rome. 1968.

Cochfeld, M., and G. Tudor. 1975. Field identification and short-tailed albatross. _Diomedea albatrus_. Biol. Conserv. 8(2):153-160.

Cody, M. L. 1973. Coexistence, coevolution and convergent evolution in sea bird communities. Ecology. 54(1):31-44.

Coulson, J. C., and E. White. 1960. The effect of age and density of breeding birds on the time of breeding of the kittiwake (_Russa tridactyla_). Ibis. 102:71-86.

Crocker, A. D., J. Cranshaw, W. N. Holmes. 1975. The effect of several crude oils and some petroleum distillation fractions on intestinal absorption in ducklings. _Anas platyrhyncos_. Environ. Physiol. Biochem. 5(2):92-106.

Crocker, A. D., J. Cranshaw, W. N. Holmes. 1974. The effect of a crude oil on intestinal absorption in ducklings, _Anas platyrhynchos_. Environ. Pollut. 7(3):165-177.

Davis, R. A. 1972. A comparative study of the use of habitat by arctic loons and red-throated loons. Ph.D. diss., Univ. Western Ontario, Guelph.

DeVillers, P. 1972. The juvenile plumage of Kittlitz's murrelet. Calif. Birds 3(2):33-38.

Drent, R., G. F. Van Tets, F. Tompa, and K. Vermeer. 1964. The breeding birds of Mandarte Island, British Columbua. Canad. Field Natur. 78(4):208-263.

Drent, R. H., and C. J. Guiguet. 1961. A catalogue of British Columbia seabird colonies. Occ. Pap. British Columbia Prov. Mus. 12. 173 p.

Dunn, E. H. 1973. Energy allocation of nestling double-crested cormorants. Ph.D. diss., Univ. Michigan, Ann Arbor. 153 p.

Dunn, E. H. 1976. Growth, body components and energy content of nestling double-crested cormorants. Condor 77(4):431-438.

Footlit, R. G., R. Butler, and W. J. Merilees. 1973. Additional nesting sites of sea birds in northern Georgia Strait, B.C. Murrelet 54(3):39-40.

Frings, H., M. Frings, and C. Frings. 1966. An annotated bibliography on North Pacific albatrosses. Pacific Sci. 20(3):312-336.

Galkina, V. N. 1974. Chemical composition of soluable substances in the excreta of fish-eating seabirds. Ekologiya. 5(5):23-28. [In Russian].

Gillet, W. H., J. L. Hayward, Jr., and J. F. Stout. 1976. Effects of human activity on egg and chick mortality in a glacuous-winged gull colony. Condor 77(4):492-495.

Gjosaeter, J., and R. Saetre. 1974. Predation of eggs of capelin, Mallotus villosus by diving ducks. Astarte 7(2):92-99.

Godfrey, W. E. 1966. The birds of Canada. Natl. Mus. Canada Bull. 203. 428 p.

Golovkin, A. N. 1968. The effect of colonial seabirds on development of the phytoplankton. Okeanol. 7(4):521-529. [In Russian].

Golovkin, N., and E. A. Zelikman. 1965. Development of Calanus in the nesting areas of seabird bazarrs on the Murmansk coast. Okeanol. 5(1):117-127. [In Russian].

Gould, P. J. 1971. Interactions of seabirds over the open ocean. Ph.D. diss., Univ. Arizona, Tuscon. 120 p.

Grubb, T. C., Jr. 1971. Olfactory navigation in Leach's petrel and other procellariform birds. Ph.D. diss., Univ. Wisconsin, Madison. 156 p.

Grubb, T. C., Jr. 1972. Smell and foraging in shearwaters and petrels. Nature 237(5355):404-405.

Grubb, T. C., Jr. 1973. Colony location by Leach's petrel. Auk 90(1):78-82.

Gruchy, C. G., A. A. R. Dykes, and R. H. Bowen. 1972. The short-tailed albatross recorded at Ocean Station Papa, North Pacific Ocean, with notes on other birds. Canad. Field-Natur. 86(3):285-287.

Guiguet, C. J. 1971. A list of seabird nesting sites in Barkley Sound, B. C. Syesis 4(1-2):253-259.

Guiget, C. J. 1971. The birds of British Columbia. Part (9), Diving birds and tube-nosed swimmers. British Columbia Prov. Mus. Handbook 29.

Hancock, D. 1971. New common murre colonies for British Columbia. Canad. Field Natur. 85(1):70-71.

Hand, J. L. 1976. Comparison of vocal differences in the long call of selected populations of Eastern Pacific gulls (L. occidentalis, L. Cominicanus, L. glaucescens). Abstract. Pacific Seabird Group Bull. 3(1):30-31.

Harris, R. D. 1971. Further evidence of tree nesting in the marbled murrelet. Canad. Field-Natur. 85(1):68.

Harris, S. W. 1974. Status, chronology and ecology of nesting storm petrels in northwestern California. Condor 76(3):249-261.

Hartwick, E. B. 1973. Foraging stragtegy of the black oyster-catcher. Ph. D. diss., Univ. British Columbia, Vancouver.

Hartwick, E. B. 1974. Breeding ecology of the black oyster-catcher, Haematopus bachmaini. Syesis 7:83-92.

Hatler, D. F., R. W. Campbell, and A. Dorst. 1973. Birds of the Pacific Rim National Park, British Columbia. Canad. Wildl. Service, Edmonton, Alberta. Unpubl. Manuscript rept. 383 p.

Hawksley, O. 1950. A study of the behavior and ecology of the arctic tern, Sterna paradisaea, Brunnich. Ph. D. Diss., Cornell Univ. Ithica, N. Y. 376 p.

Hendersen, B. A. 1976. Role of the chick's begging behavior in the regulation of parental feeding behavior of Larus glaucescens. Condor 77(4):488-492.

Imber, M. J. 1975. Behavior of petrels in relation to the moon and artificial lights. Notornis 22(4):302-306.

Joensen, A. H. 1972. Studies on oil pollution and seabirds in Denmark 1968-1971. Danish Revue Game Biol. 6(90):1-32.

Johnson, R. A. 1936. A study of the life history of the Atlantic murre, Uria aalge aalge. Ph. D. thesis, Univ. Cornell, Ithica, N. Y.

Kazama, T. 1971. Mass destruction of Synthliboramphus antiquus by oil pollution of Japan Sea. Misc. Rept. Yamashina Inst. Ornithol. 6(4):389-398. (In Japanese).

King, W. B. 1970. The trade wind zone oceanography pilot study. Part VII: Observations of seabirds March 1964 to June 1965. U.S. Dept. Int., Fish Wildl. Serv. Spec. Sci. Rept.--Fish. 586. 141 p.

King, W. B., G. E. Watson, and P. J. Gould. 1967. An application of automatic data processing to the study of seabirds. I. Numerical coding. Proc. U.S. Natl. Mus. 123(3609):1-29.

King, W. B. 1974. Pelagic studies of seabirds in the central and eastern Pacific Ocean. Smithson. Contrib. Zool. 158. 277 p.

Kozlova, E. V. 1957. Charadriiformes, Suborder Alcae. In Fauna of U.S.S.R., birds, vol. 2, no. 3. Zool. Instit. Acad. Sci., U.S.S.R. New Ser. 65. (Transl. from Russian by Israel Progr. Sci. Transl., Jerusaleum, 1961. 140 p.)

Kurotchkin, E. N. 1966. The geographical distribution of the seabirds in the North Pacific. Abstract. Proc. 11th Pacific Sci. Congr. 5-7:7.

Kury, C. R. 1972. Ring-necked duck and ruddy turnstones wintering at Sitka. Murrelet 53(1):11.

LGL, Ltd., Environmental Research Associates. 1974. Review of current knowledge on reducing bird mortality associated with oil spill. Petroleum Assoc. Conserv. Canad. Envir. Rept. 75-4 vi + 96 p.

Leschner, L. L. 1976. The breeding biology of the rhinoceros auklet Destruction Island. M. S. thesis, Univ. Washington, Seattle. 77 p.

Lewis, R. W. 1966. Studies of the glyceryl ethers of the stomach oils of Leach's petrel Oceanodroma leucorhoa Viellot. Compar. Biochem. Phys. 19(2):363-377.

Manuwal, D. A. 1972. The population ecology of Cassin's auklet on southeast Farallon Island, California. Ph. D. diss., Univ. California, Los Angeles. 324 p.

Manuwal, D. A. 1974. The natural hisotry of Cassin's auklet (Ptychoramphus aleuticus). Condor 76(4):421-431.

Manuwal, D. A. 1974. The incubation patches of Cassin's auklet. Condor 76(4):481-484.

Manuwal, D. A. 1974. Effects of territorality on breeding in a population of Cassin's auklet. Ecology 55(6):1399-1406.

Manuwal, D. A., and L. L. Leschner. 1975. Comparative biology of the rhinoceros auklet in different nesting environments. Abstract. Pacific Seabird Group Bull. 2(1):28-29.

Martin, P. W., and M. T. Myres. 1969. Observations on the distribution and migration of some seabirds off the outer coasts of British Columbia and Washington State. Syesis. 2:241-256.

McEwan, E. H., and A. F. C. Koelink. 1973. The heat production of oiled mallards and scaup. Canad. J. Zool. 51(1):27-31.

Meseth, E. H. 1968. The behavior of the Laysan albatross, Diomedea immutabilis, on its breeding ground. Ph. D. diss., Southern Illinois Univ., Carbondale. 296 p.

Myres, M. T. 1970. Birds recorded at Ocean Station "Papa" (North Pacific Ocean) during a 12-year study. Abstract. XVth Intl. Ornith. Congr. 5:160.

Nelson, R. W., and M. T. Myres. 1973. Changes in the peregrine falcon and its seabird prey at Langara Island, British Columbia, 1973. Conference Raptor Conserv. Techniques. 27 p.

Nelson, T. 1939. The biology of the spotted sandpiper, Actitis macularia (Linn.). Ph. D. diss., Univ. Michigan, Ann Arbor.

Nelson-Smith, A. 1968. Biological consequences of oil pollution and shore cleansing. Pages 73-80, in J. D. Carthy and D. R. Arthur, eds, The biological effects of oil pollution on littoral communities.

Nelson-Smith, A. 1970. The problem of oil pollution in the sea. Adv. Marine Biol. 8:215-306.

Nettleship, D. N. 1976. Census techniques for seabirds of arctic and eastern Canada. Canadian Wild. Serv. Occ. Paper 25. 31 p.

Newby, T. C., and R. O. Larson. 1974. Aggression in the Pacific fulmar. Fulmar glacialis. Murrelet. 55(1):10.

Newton, I. 1976. Population limitation in diurnal raptors. Canad. Field Natur. 90(3):274-300.

Ozawa, K. 1966. Summer distribution of Laysan and black-footed albatrosses and Pacific fulmar in the eastern North Pacific. Abstract. Proc. 11th Pac. Sci. Congr. 5-7:214.

Preston, W. C. 1968. Breeding ecology and social behavior of the black guillemot. Cepphus grycle. Ph. D. diss., Univ. Michigan, Ann Arbor. 146 p.

Richardson, F. 1961. Breeding biology of the rhinoceros auklet on Protection Island, Washington. Condor. 63( ):456-473.

Richardson, F. 1971. Birds of Grant Bay and Browning Inlet, Northwest Vancouver Island, British Columbia; a year's phenology. Murrelet. 52(3):29-40.

Ricklefs, R. E., and S. C. White. 1975. A method for constructing nestling growth curves from brief visits to seabird colonies. Bird-Banding. 46(2):135-140.

Robert, H. C. and C. J. Ralph. 1976. Effects of human disturbance on the breeding success of gulls. Condòr. 77(4):495-499.

Robertson, I. 1974. An inventory of seabirds occurring along the west coast of Canada. Canad. Wildl. Service. Edmonton, Alberta. Unpubl. manuscript rept.

Robertson, I. 1974. The food of nesting double-crested and pelagic cormorants at Madarte Island, British Columbia, with notes on feeding ecology. Condor 76(3):346-348.

Robertson, I. 1975. Seasonal density and distributional patterns of Alcidae in the near offshore waters of British Columbia. Abstract. Pacific Seabird Group Bull. 2(1):31.

Rylander, M. K. 1965. A comparative study of the anatomy and physiology of Erolia, Vieillot, and Ereunetes, Illiger (Aves: Charadriiformes: Scolopacidae). Ph. D. diss., Tulane Univ. 132 p.

Sanger, G. A. 1973. New northern record for Xantus' murrelet. Condor. 75(2):253.

Saville, D. B. O. 1972. Evidence of tree nesting by the marbled murrelet in the Queen Charlotte Islands. Canad. Field Natur. 86(4):389-390.

Saville, D. B. O. 1972. Spring observations of Sabine's gull. Canad. Field Natur. 86(4):389.

Sealy, S. G. 1973. Interspecific feeding assemblages of marine birds off British Columbia. Auk 90(4):796-802.

Sealy, S. G. 1974. Breeding phenology and clutch size in the marbled murrelett. Auk 91(1):10-23.

Sealy, S. G. 1975. Aspects of the breeding biology of the marbled murrelet in British Columbia. Bird-Banding. 46(2):141-154.

Sealy, S. G. 1975. Feeding ecology of the ancient and marbled murrelets near Langara Island, British Columbia. Canad. J. Zool. 53( ):418-433.

Sealy, S. G. 1976. Egg size of murrelets. Condor. 77(1):500-501.

Shepard, M. G. 1976. Notes on the Laysan Albatross, New Zealand shearwater and skua in the North Pacific Ocean. Murrelet 57(2):48-49.

Speich, S. M., D. F. Udvardy, D. A. Manuwal, and S. M. Alden. 1975. Geographic variation in the timing of molt and breeding in the Cassin's auklet. Abstract. Pacific Seabird Group Bull. 2(1):29.

Spring, L. 1971. A comparison of functional and morphological adaptations in common murre (Uria aalge) and thick-billed murre (Uria lomvia). Condor. 73(1):1-27.

Stanton, P. B. (1972). Operation rescue: a bibliography (a selected bibliography on oiled waterfowl and their rehabilitation). American Petroleum Instit., Washington, D.C. (20) p.

Stettenheim, P. R. 1959. Adaptations for underwater swimming in the common murre, (Uria aalge). Ph. D. diss., Univ. Michigan, Ann Arbor. 307 p.

Storer, R. W. 1949. A comparison of variation, behavior, and evolution in the sea-bird genera of Uria and Cepphus. Ph. D. diss., Univ. California, Berkley. 256 p.

Summers, K. R. 1974. Seabirds breeding along the east coast of Moresby Island, Queen Charlotte Islands, British Columbia. Syesis. 7:1-12.

Summers, K. 1975. Breeding biology of the rhinoceros auklet on Cleland Island, British Columbia. Abstract. Pacific Seabird Group Bull. 2(1):28.

Taylor, E. W. 1973. Marine-associated birds of the British Columbia Coast. Canad. Wildl. Service, Edmonton, Alberta. Unpubl. manuscript rept. 82 p.

Thoresen, A. C. 1960. Breeding behavior and growth rates of Cassin's auklet Ptychoramphus aleutica (Pallas). Ph. D. diss., Oregon State Univ., Corvallis. 140 p.

Thoresen, A. C., and E. S. Booth. 1958. Breeding activities of the pigeon guillemot, Cepphus columba columba (Pallas). Walla Walla Coll. Publ. Dept. Biol. Sci. and Biol. Sta. 23:1-37.

Uspenski, S. M. 1956. The bird bazaars of Novaya Zemlya. Transl. from Russian, Canada Dept. N. Affairs Natl. Resources, Natl. Parks Br--Canad. Wildl. Service, 1958. 159 p.

Uspenski, S. M. 1965. The geese of Wrangel Island. Wildfowl Trust Ann. Rept. 16:126-129.

Van Tets, G. F. 1964. A comparative study of some of the social communication patterns of cormorants and related birds in the Pelecaniformes. Ph. D. diss., Univ. British Columbia, Vancouver. Typewritten.

Vermeer, K. 1963. The breeding biology of the glaucous-winged gull Clarus glaucescens on Mandarte Island, B. C. British Columbia Prov. Mus. Occ. Papers. 13:1-104.

Vermeer, K., and R. Vermeer. 1975. Oil threat to birds on the Canadian west coast. Canad. Field-Natur. 89(3):278-298.

Vermeer, R., and K. Vermeer, 1974. Oil pollution of birds: an abstracted bibliography. Canad. Wildl. Serv., Pesticide Sect. Manuscript Rept. 29. 68 pages.

Vermeer, K., D. A. Manuwal, and D. S. Bingham. 1976. Seabirds and pinnipeds of Sartine Island, Scott Island group, British Columbia. Murrelet. 57(1):14-16.

Ward, J. G. 1973. Reproductive success, food supply, and the evolution of clutch-size in the glaucous-winged gull. Ph. D. diss., Univ. British Columbia, Vancouver.

Wiens, J. A., and J. M. Scott. 1976. Model estimation of energy flow in Oregon coastal seabird populations. Condor. 77(4):439-452.

Yee, J. E. 1967. Oil pollution of marine waters. U.S. Dept. Int., Dept. Libr. Bibl. 5.

Zubakim, V. A. 1975. Index of nesting density for some larid species and a method of its calculation. Zool. Zh. 54():1386-1389. [In Russian].

RESEARCH UNIT 353

DETERMINATION AND DESCRIPTION OF KNOWLEDGE OF THE DISTRIBUTION, ABUNDANCE, AND TIMING OF SALMONIDS IN THE GULF OF ALASKA AND BERING SEA

A SUPPLEMENT TO THE FINAL REPORT

by

Donald E. Rogers

Fisheries Research Institute
College of Fisheries
University of Washington
Seattle, Washington 98195

November 22, 1977

This supplement concerns Salmonids in Bristol Bay (St. George Basin Region), December 31, 1976-September 30, 1977. It supplements the Final Report published in Environmental Assessment of Alaskan Continental Shelf Principal Investigators Quarterly Reports for October-December 1976, pp. 586-802.

CONTENTS

DETERMINATION AND DESCRIPTION OF KNOWLEDGE OF THE DISTRIBUTION, ABUNDANCE, AND TIMING OF SALMONIDS IN THE GULF OF ALASKA AND BERING SEA

SALMONIDS IN BRISTOL BAY (St. George Basin Region)

INTRODUCTION

In our previous three reports we described the general distribution and average abundance of salmon in the Kodiak, St. George Basin, and Prince William Sound to Yakutat regions of Alaska.[1] Bristol Bay in the St. George Basin contains the most valuable concentration of salmon in Alaska, and consequently there is more detailed information available on the Bristol Bay stocks than on any other stock of salmon in Alaska. Therefore, after completing our general survey of salmon in the three regions, we concentrated our effort on a more detailed description of the abundance of salmon in Bristol Bay.

This report is on salmon in the nearshore waters of Bristol Bay (Fig. 1). The objective was to describe the annual variation in abundance and seasonal timing of the migrations of adult and juvenile (smolt) salmon since 1951.

METHODS

Statistics on Bristol Bay salmon were collected by the National Marine Fisheries Service (NMFS) and Fisheries Research Institute (FRI) during the 1950's and since then by the Alaska Department of Fish and Game (ADF&G). The Informational Leaflets and Technical Data Reports by ADF&G were the major sources of data on sockeye salmon, whereas ADF&G Management Reports were used primarily for statistics on other species of adult salmon.

Statistics on the more abundant sockeye are fairly precise because daily estimates of catches and escapements were available; thus an estimate of the abundance of an annual run of sockeye is probably accurate to within $\pm$ 5-10%. However, only catch statistics were usually available for the other species of salmon and an estimate of the total run had to be made

[1]Stern, L. J., A. C. Hartt, and D. E. Rogers. 1977. Determination and description of knowledge of the distribution, abundance, and timing of salmonids in the Gulf of Alaska and Bering Sea. Pages 586-802 *in* Environmental assessment of the Alaskan Continental Shelf. Vol. 2, Rep. 1-3. Environmental Research Laboratories, Boulder, Colorado.

from these data. The abundance of a run of chum salmon was estimated from the catch and the rate of exploitation on age 0.3 male sockeye salmon (fish of comparable size); i.e., the ratio of run to catch of age 0.3 male sockeye salmon was multiplied by the catch of chum salmon. This provided a reasonable estimate of the abundance of chum salmon because the two species tended to occur together in the gill-net fishery. Aerial estimates of the number of pink salmon in the escapement to the Nushagak District were available for 5 years (1962, 1964, 1966, 1972, and 1974). In those years the run of pink salmon was estimated from the sum of the catch and estimated escapement and in other years the run was estimated from the catch and the average rate of exploitation for the 5 years when estimates of escapements were available. The annual runs of king salmon, which are must less abundant than the other species, were estimated by doubling the catch, i.e., a rate of exploitation of 0.5 was assumed.

The seasonal timings of the sockeye salmon runs in the fishing districts were taken from a report by P. R. Mundy and O. A. Mathisen.[2] They combined the daily estimates of escapements that are made at the outlets of the Bristol Bay lake systems with the daily catches in the fishing districts to estimate the number of fish that passed through the fishing districts on a given date. Catch statistics alone were available for the other species. These were sufficient to describe the average timing of the runs through the fishing districts but not the annual variation in the timing.

The abundance of juveniles (smolts) that annually migrated out of Bristol Bay was estimated from the abundance of returning adults and estimates of marine survival. The sockeye salmon smolts that migrated from four of the major river systems have been sampled by fyke nets since the early 1950's. In the Wood River and Kvichak systems the sampling provided estimates of the size, age composition, and relative abundance, whereas in the Naknek and Ugashik systems the sampling also provided absolute estimates of the abundance. However, some of the annual estimates of abundance were quite inaccurate; e.g., in some cases more adults returned

[2]Mundy, P. R., and O. A. Mathisen. 1977. Handbook of Bristol Bay sockeye salmon management. Univ. Washington, Fish. Res. Inst. Final Rep. FRI-UW-7720. 100 pp.

than the number of smolts that migrated from the lake system. Thus, the abundance of returning sockeye according to their freshwater age was divided by an average marine survival for smolts of a given age and average size to estimate the number that had migrated to sea. Sockeye usually spend 1 or 2 years in freshwater prior to their seaward migration and then 2 to 3 years at sea; however, pink and chum salmon migrate to sea in the spring or summer that follows their spawning. They are considerably smaller than sockeye (less than 1 g in weight compared to 4 to 15 g for sockeye) and thus they probably experience a higher mortality in their early marine life. Pink salmon return after 1 year at sea (age 0.1) and chum salmon in Bristol Bay return predominantly after 3 years at sea (age 0.3).

The annual timing of the sockeye smolt migrations was obtained from the daily catches in four of the major river systems. It was assumed that 2 days were required for the smolts to reach the center of the commercial fishing district from the outlets of all lakes except Iliamna Lake (Kvichak) and for that lake a 4-day travel time was assumed. No information was available on the timing of chum and pink salmon migrations; however, the abundance of these species is concentrated in the long Nushagak River system and this system is the latest to become ice-free in the spring. Ice breakup in Tikchik lakes, where many of the pink salmon spawn, usually occurs 1 to 2 weeks later than in the Wood River system and a month later than lake systems on the Peninsula. Therefore, it was assumed that pink and chum salmon began migrating into Bristol Bay primarily in July rather than in late May or June, as is the case with sockeye migrations.

RESULTS

Historical catch statistics on Bristol Bay salmon are summarized in Table 1. These catches provide estimates of the relative abundance and species composition of salmon in Bristol Bay; however, they may not accurately measure the total abundance (run) because fishing effort varied over the years and varied for individual species. The rates of exploitation on sockeye salmon have declined from the early 1900's to the present so the decline in the abundance of the runs has not been as great as the decline in catches (Mathisen 1971). Fishing effort on pink and king salmon is usually lower than on sockeye and chum salmon which occur together in the fishery, and fishing effort on coho salmon which run in August is less than the effort on all other species.

Sockeye salmon made up about 95% of the catch prior to 1951 and about 86% of the catch since then. The order of abundance of the other species is approximately the same since 1951 as it was in prior years. The average annual catches of chum, pink, and king salmon since 1951 are higher than they were during the period 1901-1950, whereas the catches of sockeye are less in recent years.

Bristol Bay sockeye salmon have also been extensively exploited on the high seas by Japanese fisheries since 1952. The annual rates of exploitation by this fishery on Bristol Bay sockeye have ranged from 3% to 39% (Fredin and Worland 1974). Other species of salmon from Bristol Bay are probably also caught by the high seas fishery; however, no accurate estimates of the exploitation are available. Statistics on Bristol Bay salmon that have been collected since 1951 are likely to provide the best estimates of abundance in future years with the possible exception that sockeye salmon may be more abundant in future years.

Annual Abundance of Adult Salmon

Sockeye salmon made up 89% of the salmon runs to Bristol Bay since 1951. Their annual abundance ranged from 2.4 to 53.1 million and in each year they were the most abundant species (Table 2). The relatively high annual variation in the sockeye runs is caused by the cyclical variability in the runs to Iliamna Lake in the Naknek-Kvichak District (Table 3). Even in years that were low points in the cycle, sockeye salmon were always more abundant in the Naknek-Kvichak District than in any of the other districts.

Chum salmon were the next most abundant species; however, they made up only 6% of the salmon runs since 1951. The annual variability in their runs was much less than for sockeye runs and their abundance tended to increase in recent years. About 52% of the chum salmon runs to Bristol Bay since 1951 were to the Nushagak District and they were not very abundant in the Egegik and Ugashik districts (Table 4).

Pink salmon are now abundant only in even-numbered years. There were runs in odd-numbered years but these practically disappeared after 1917. The pink salmon runs from 1922 to 1956 probably numbered less than one million annually; however, the runs (primarily to the Nushagak District) increased greatly in 1958 and since then there have been three runs that exceeded two million fish. In some years pink salmon may be a very valuable resource in Bristol Bay but the annual variability in their abundance is high and they are virtually absent in the Egegik, Ugashik, and Togiak districts.

King salmon occur primarily in the Nushagak District and, although they made up only 1% of the total salmon run to Bristol Bay, they are important in that district because of their large size and their presence in early June when other species are absent. Coho salmon occur mainly in the Nushagak and Togiak Districts. They are probably the least abundant of the salmon in Bristol Bay; however, their actual abundance is difficult to determine because their runs occur in August when most canneries have closed and there is relatively little fishing effort.

The Naknek-Kvichak District contains the largest runs of salmon in Bristol Bay because of the periodically large runs of sockeye salmon to Iliamna Lake; and the Nushagak District contains the next most abundant runs of salmon because it contains most of the pink and chum salmon runs. The total run of salmon was greater in the Nushagak District in 3 of the past 26 years (Fig. 2).

Timing of Adult Migrations

The seasonal occurrence of adult salmon in Bristol Bay follows a rather consistent pattern. King salmon arrive in early June and reach a peak abundance in late June. Sockeye and chum salmon arrive in late June but the sockeye reach a peak abundance in early July, whereas the chum salmon reach a peak abundance in mid-July. Pink salmon arrive in mid-July and reach a peak abundance in late July. Adult salmon are nearly absent in Bristol Bay after mid-August. The average daily abundance of salmon entering the Bristol Bay fishing districts is illustrated in

Fig. 3. The abundance of each species is based on the median run during 1951-1976, except the abundance of pink salmon is based on only even-numbered years.

Statistics on the timing of Bristol Bay salmon runs are most accurate for sockeye. In an average year they arrive at Port Moller (outer edge of the bay) from the North Pacific Ocean and Bering Sea on about June 15 and their travel time to the inner fishing districts is about 6 days. Annual variation in the timing of the runs in the fishing districts is illustrated in Fig. 4. Annual variation is partly associated with spring weather conditions. There was warm spring weather and early ice breakup in 1967, 1968, 1970, and 1974; average weather and ice breakup in 1969 and 1973; and colder than average weather in 1966, 1971, and 1975. The earliest that the sockeye arrived was in 1967 when 50% of the run had entered the fishing districts by June 29, and the latest run was in 1971 when 50% of the run had entered by July 10. The means and ranges in dates on which 10, 50, and 90% of the runs passed through the fishing districts in 1956-1975 are as follows:

	Mean	Range
10%	6/27	6/22-7/2
50%	7/4	6/29-7/10
90%	7/11	7/7-7/16

Annual Abundance of Juvenile Salmon

The annual abundances of sockeye smolts were calculated by first arranging the adult runs according to freshwater age and the year in which they migrated to sea (Tables 5 and 6). Estimates of the mean survival from smolts to returning adults (Table 7) were then used to calculate the number of sockeye smolts that migrated from each district in each year. In this method it was assumed that marine survival was a function of the mean size of smolts but relatively constant from year to year. Estimates of the number of pink and chum salmon smolts were made in the same way except that a constant marine survival of 2% was used and all chum salmon were assumed to mature at age 0.3, which is their primary age at maturity in Bristol Bay.

The Naknek-Kvichak District produced 53% and the Nushagak District 32% of the sockeye smolts that migrated during 1950-1974 (Table 8). The annual number that migrated from the Naknek-Kvichak ranged from 13-461 million and averaged 110 million; whereas, for the Nushagak District the numbers ranged from 14-168 million and averaged 66 million. Although more sockeye smolts migrated from the Naknek-Kvichak District over all years, the Nushagak District produced more sockeye smolts in 14 of the 25 years. The annual variation in the number of sockeye smolts migrating from Bristol Bay was relatively greater than the variation in the number of adult sockeye. The coefficient of variation was 129% for smolts, whereas it was 75% for adults.

Annual estimates of the number of pink and chum salmon smolts that migrated from Bristol Bay are given in Table 9. The average annual numbers of pink and chum salmon smolts were 57 and 37 million. Although their average numbers were smaller relative to the average number of sockeye smolts (209 million), they were together more numerous than sockeye in 6 of the past 25 years.

The average total number of smolts (sockeye, pink, and chum) in the annual migrations was 303 million and, of these, 260 million were about equally divided between the Naknek-Kvichak and Nushagak districts. Annual variation in abundance was greater in the Naknek-Kvichak and the abundance of pink and chum salmon was greater in the Nushagak (Fig. 5).

Timing of Juvenile Migrations

The dates on which 10, 50, and 90% of sockeye smolts migrated past the outlets of four of the Bristol Bay lake systems are given in Table 10. Smolts from Ugashik (and presumably Egegik) are the first to enter Bristol Bay. These are followed in order by those from Kvichak, Naknek, and Wood River (Nushagak). The Wood River smolts are still abundant in the outer region of Bristol Bay as late as September (Strady 1974). The daily abundance of smolts that entered Bristol Bay in an average year is illustrated in Fig. 6. The smolts that migrate from a lake system with only one or two lakes (e.g., Ugashik and Kvichak) tend to migrate over a short period, whereas those that migrate from a multi-lake system (e.g., Naknek and Wood River) tend to do so over a long period.

There is considerable annual variation in the abundance of smolts that are in Bristol Bay on a given date. This variation is caused by the annual variation in the number of smolts that are produced by each lake system, the time that smolt migrations begin which is strongly influenced by spring weather conditions, and the differences in timing of the migrations from each lake system. Figure 7 illustrates some of this annual variation that occurred in successive years. In 1963 there was an early migration that contained a very large number of sockeye smolts from Iliamna Lake; whereas in 1964 there was a late migration that contained relatively few smolts from Iliamna Lake.

SUMMARY

The number of juvenile or adult salmon that migrate through Bristol Bay in an average year is best measured by the median number because the annual numbers are not normally distributed. The medians and ranges in the annual numbers of salmon are given in Table 11. The annual estimates of the numbers of smolts and adults are shown in Fig. 8. In most years there is either a large abundance of smolts or a large abundance of adults. Years in which there are very large numbers of sockeye salmon occur at 4- or 5-year intervals. Juvenile pink salmon are usually present only in odd-numbered years and adult pink salmon are usually present only in even-numbered years. The Naknek-Kvichak District produced 36% of the smolts and 54% of the adult salmon in Bristol Bay in an average year; whereas, the Nushagak District produced 50% of the smolts but only 25% of the adults in Bristol Bay in an average year.

Salmon are present in Bristol Bay from May through September; however, they are most abundant in June and July. Figure 9 shows their locations in mid-June of a typical year. From then until the end of July there are usually millions of adults and hundreds of millions of smolts that are passing each other in their migrations to and from Bristol Bay.

LITERATURE CITED

Fredin, R. A., and D. D. Worlund. 1974. Catches of sockeye salmon of Bristol Bay origin by the Japanese mothership fishery, 1956-70. Int. N. Pac. Fish. Comm. Bull. 30:1-80.

Mathisen, O. A. 1971. Escapement levels and productivity of the Nushagak sockeye salmon runs from 1908-1966. NOAA Fish. Bull. 69(4):747-763.

Strady, R. R. 1974. Ecology and behavior of juvenile sockeye salmon (*Oncorhynchus nerka*) in Bristol Bay and the eastern Bering Sea. Oceanography of the Bering Sea - Occasional Publ. No. 2, Inst. Mar. Sci., Univ. Alaska. Pp. 285-320.

Table 1. Average annual catches of salmon in Bristol Bay by 10-year periods (number of fish in thousands)

Years	Sockeye	Chum	Pink	King	Coho	Total
1893-1900	3,443	-	15	28	87	3,573
1901-1910	13,043	201	506	112	112	13,974
1911-1920	16,526	538	628	115	128	17,935
1921-1930	14,216	334	98	88	42	14,778
1931-1940	15,971	454	99	37	9	16,570
1941-1950	10,454	338	35	35	24	10,886
1951-1960	6,736	414	165	72	40	7,427
1961-1970	9,314	517	736	105	39	10,711
1971-1976	2,454	666	350	68	29	3,567

Sources: 1893-1970: INPFC Secretariat. MS 1974. Historical catch statistics for salmon of the North Pacific Ocean.
1971-1976: ADF&G Bristol Bay Annual Management Reports.

Table 2. Bristol Bay runs of adult salmon in millions of fish, 1951-1976

Year	Sockeye	Chum	Pink	King	Total
1951	10.1	0.5		0.09	10.7
1952	19.3	0.6	0.1	0.10	20.1
1953	9.4	0.8		0.08	10.3
1954	7.6	1.0	0.2	0.10	8.8
1955	7.7	0.6		0.13	8.4
1956	23.9	0.7	0.2	0.13	24.9
1957	11.0	0.5		0.18	11.6
1958	5.7	0.8	1.8	0.19	8.6
1959	12.9	1.1		0.12	14.0
1960	36.4	2.3	0.6	0.17	39.5
1961	18.1	1.3		0.14	19.6
1962	10.4	1.3	1.5	0.14	13.3
1963	6.9	0.8		0.10	7.7
1964	10.9	1.2	2.5	0.24	14.8
1965	53.1	0.7		0.19	54.0
1966	17.5	0.7	4.1	0.14	22.4
1967	10.4	1.2		0.22	11.8
1968	8.0	0.7	3.2	0.18	12.1
1969	19.0	0.8		0.20	20.0
1970	39.4	1.6	1.0	0.23	42.2
1971	15.8	1.3		0.22	17.3
1972	5.4	1.3	0.2	0.13	7.1
1973	2.4	2.0		0.08	4.5
1974	10.9	1.6	2.0	0.09	14.7
1975	24.1	1.1		0.06	25.3
1976	11.5	2.7	1.7	0.18	16.1
Mean	15.68	1.12	0.73	0.15	17.68
S.D.	11.71	0.56	1.15	0.05	11.72
Cov. (%)	75	50	158	33	66

Table 3. Number (millions) of sockeye salmon by district and year of the run to Bristol Bay

Year	Naknek-Kvichak	Egegik	Ugashik	Nushagak	Togiak
1951	7.0	1.6	0.5	1.0	0.1
1952	15.5	1.6	0.9	1.1	0.1
1953	4.4	1.8	1.7	1.3	0.1
1954	3.0	2.0	1.5	1.0	0.1
1955	3.3	0.9	0.3	3.0	0.2
1956	18.0	2.3	0.8	2.5	0.4
1957	8.2	1.2	0.6	1.0	0.1
1958	1.8	0.8	0.7	2.4	0.1
1959	5.4	1.7	0.6	4.8	0.3
1960	26.5	3.3	3.1	3.2	0.3
1961	12.3	3.4	0.7	1.4	0.3
1962	5.7	1.7	0.5	2.4	0.2
1963	2.4	1.7	0.6	1.9	0.3
1964	4.8	2.0	1.1	2.8	0.4
1965	44.4	4.6	1.9	1.9	0.3
1966	10.4	2.9	1.2	2.8	0.3
1967	6.5	1.7	0.4	1.5	0.2
1968	5.0	1.0	0.2	1.7	0.1
1969	14.5	1.9	0.3	2.0	0.3
1970	32.6	2.3	0.9	3.2	0.4
1971	9.4	1.9	1.5	2.6	0.4
1972	2.9	1.3	0.1	0.9	0.2
1973	0.8	0.5	<0.1	0.8	0.2
1974	6.5	1.4	0.1	2.8	0.2
1975	18.3	2.1	0.4	2.9	0.4
1976	6.0	1.8	0.5	2.7	0.5

Table 4. Numbers (millions) of chum and pink salmon by district and year of the run to Bristol Bay

	Chum salmon					Pink salmon	
Year	Naknek-Kvichak	Egegik	Ugashik	Nushagak	Togiak	Naknek-Kvichak	Nushagak
1951	.1	*	*	.2	.2		
1952	.1	*	.1	.2	.2	*	*
1953	.3	*	.1	.3	.2		
1954	.2	.1	.1	.4	.2	*	.2
1955	.1	*	.1	.2	.2		
1956	.3	*	*	.3	.1	*	.2
1957	.1	*	*	.3	.1		
1958	.2	*	*	.4	.1	*	1.8
1959	.4	.1	*	.4	.1		
1960	.5	.1	.1	1.0	.6	*	.6
1961	.3	.1	.1	.7	.2		
1962	.5	.1	.1	.4	.3	.1	1.4
1963	.2	*	*	.4	.1		
1964	.3	*	*	.7	.2	.1	2.4
1965	.1	*	*	.4	.2		
1966	.1	.1	.1	.3	.2	.3	3.8
1967	.1	*	*	.9	.1		
1968	.1	*	*	.4	.2	.4	2.8
1969	.1	*	*	.6	.1		
1970	.2	.1	.1	1.0	.2	.1	.9
1971	.2	*	*	.7	.3		
1972	.3	.1	.1	.6	.3	.1	.1
1973	.5	.1	.1	1.0	.4		
1974	.3	*	.1	1.0	.2	1.0	1.0
1975	.3	*	.1	.6	.2		
1976	.7	.1	*	1.6	.3	.5	1.2

* Less than 50,000.

Table 5. Adult returns of sockeye salmon (in millions) arranged by year of smolt migration from the Naknek-Kvichak District

Year of migration	Kvichak and Branch rivers: Adult ages 1.2, 1.3	Kvichak and Branch rivers: Adult ages 2.2, 2.3, and 2.1*	Kvichak and Branch rivers: Total	Naknek River: Adult ages 1.2, 1.3	Naknek River: Adult ages 2.2, 2.3	Naknek River: Total
1950	.89	20.56	21.45	.34	1.11	1.45
1951	.23	1.88	2.11	.40	1.93	2.33
1952	.70	.22	.92	.91	.29	1.20
1953	1.24	1.10	2.34	1.94	1.60	3.54
1954	15.47	4.00	19.47	.80	1.54	2.34
1955	.15	.83	.98	.14	.23	.37
1956	.41	.45	.86	.36	.35	.71
1957	1.25	1.11	2.36	1.42	2.55	3.97
1958	29.13	.99	30.12	1.67	.25	1.92
1959	.43	6.01	6.44	.32	.27	.59
1960	.17	3.27	3.44	.28	1.02	1.30
1961	.80	.21	1.01	.63	.62	1.25
1962	1.91	.38	2.29	1.82	1.24	3.06
1963	.70	47.29	47.99	.86	1.73	2.59
1964	.43	2.65	3.18	.27	.85	1.12
1965	.39	4.57	4.96	.45	.65	1.10
1966	2.27	.79	3.06	.54	1.09	1.63
1967	9.61	2.88	12.49	.78	1.18	1.96
1968	1.80	30.70	32.50	2.54	1.06	3.60
1969	.78	4.20	4.98	.71	.59	1.30
1970	.39	.77	1.16	.27	.55	.82
1971	.46	.19	.65	.31	.29	.60
1972	.19	4.95	5.14	.42	1.93	2.35
1973	.39	14.36	14.75	.86	2.15	3.01
1974	.38	2.04	2.75**	.39	3.24	3.67**

* Significant returns of age 2.1 (i.e., greater than 50,000) occurred only from the migrations in 1963, 1967, 1968, and 1974 (years with warm spring weather).

** Includes returns of ages 3.2 and 3.3.

Table 6. Adult returns of sockeye salmon (in millions) arranged by year of smolt migration

Year of migration	Nushagak District: Adult ages 1.2, 1.3	Nushagak District: Adult ages 2.2, 2.3	Nushagak District: Total*	Egegik District: Adult ages 1.2, 1.3	Egegik District: Adult ages 2.2, 2.3	Egegik District: Adult ages 3.2, 3.3	Egegik District: Total	Ugashik District: Adult ages 1.2, 1.3	Ugashik District: Adult ages 2.2, 2.3	Ugashik District: Total
1950	1.29	.10	1.42	(.26)	(1.63)	(.05)	(1.94)	(.53)	(.66)	(1.19)
51	.33	.12	.48	(.29)	(1.50)	(.06)	(1.85)	(.66)	(1.02)	(1.68)
52	1.36	.01	1.47	(.20)	(1.26)	(.05)	(1.51)	(.38)	(.77)	(1.15)
53	3.21	.36	3.59	.37	.72	.03	1.12	.12	.19	.31
54	1.43	.41	1.86	.87	1.76	.08	2.71	.73	.24	.97
55	1.18	.12	1.31	.06	.42	.00	.48	.36	.20	.56
56	1.64	.24	1.91	.02	.72	.03	.77	.05	.59	.64
57	4.37	1.48	5.89	.16	1.70	.25	2.11	.05	.43	.48
58	2.02	.65	2.74	4.17	.90	.11	5.18	3.47	.11	3.58
59	.37	.06	.44	.07	1.28	.01	1.36	.12	.09	.21
60	2.68	.07	2.81	.10	1.77	.01	1.88	.15	.40	.55
61	1.58	.18	1.79	.21	1.00	.12	1.33	.05	.44	.49
62	2.96	.51	3.51	.68	1.34	.02	2.04	.87	.40	1.27
63	1.95	.31	2.27	.27	6.16	.03	6.46	.65	1.80	2.45
64	1.56	.07	1.66	.08	1.10	.09	1.27	.18	.33	.51
65	1.76	.16	1.94	.11	1.18	.04	1.33	.03	.19	.22
66	1.16	.14	1.32	.15	.77	.04	.96	.04	.09	.13
67	2.56	.49	3.10	.15	1.53	.08	1.76	.11	.24	.35
68	2.67	.60	3.30	.84	2.49	.07	3.40	1.86	.35	2.21
69	.93	.11	1.05	.23	1.16	.02	1.41	.09	.10	.19
70	1.06	.13	1.29	.07	.96	.02	1.05	.02	.06	.08
71	.65	.03	.68	.11	.28	.00	.39	.01	.01	.02
72	3.31	.71	4.05	.12	2.02	.01	2.15	.01	.07	.08
73	2.00	.53	2.59	.13	.89	.37	1.39	.36	.27	.63
74	1.99	.47	2.51	.10	2.24	.11	2.45	.08	[illegible]	[illegible]

Table 7. Estimates of marine survival of sockeye salmon (1955-73) that were used to estimate number of smolts in a migration from number of returning adults

Lake system	Smolt age	Mean weight (g)	Mean relative survival (%)	Mean survival (%)
Naknek	I	9.4		15
	II	12.5		24
Kvichak				
Peak years	I	5.0	5	(7)
	II	9.3	10	(14)
Other years	I	5.9	2.5	(4)
	II	11.3	6	(12)
Ugashik	I	6.6		5
	II	12.4		14
Egegik	I	9.4		(9.5)
	II	14.1		(16.5)
	III	16.5		(20.5)
Wood River (Nushagak)	I	4.8	6	(3)
	II	8.3	7	(7)

Table. 8. Estimates of the number (millions) of sockeye salmon smolts by district and year of migration from Bristol Bay

Year	Naknek-Kvichak	Egegik	Ugashik	Nushagak	Togiak	Total
1950	167	13	15	45	4	244
51	32	12	20	14	3	81
52	26	10	13	49	5	103
53	60	8	4	113	7	192
54	262	20	16	54	8	360
55	13	3	9	41	4	70
56	18	5	5	59	6	93
57	60	13	4	168	12	257
58	435	50	70	79	13	647
59	64	9	3	14	3	93
60	38	12	6	92	7	155
61	29	9	4	56	8	106
62	68	15	20	107	15	225
63	461	40	26	70	11	608
64	38	8	6	54	6	112
65	54	9	2	62	4	131
66	71	6	1	41	4	123
67	274	11	4	94	11	394
68	266	24	40	99	19	448
69	60	10	3	33	3	109
70	20	7	1	41	7	76
71	16	3	<1	22	6	47
72	57	14	1	121	9	202
73	120	9	9	76	16	230
74	42	12	3	47	10	114

Table 9. Estimates of the number (millions) of chum and pink salmon smolts by district and year of migration from Bristol Bay

Year	Chum salmon						Pink salmon		
	Naknek-Kvichak	Egegik	Ugashik	Nushagak	Togiak	Total	Naknek-Kvichak	Nushagak	Total
1950	12	2	2	16	5	37	0	0	0
51	11	4	2	22	5	44	1	2	3
52	2	1	3	12	5	23	0	0	0
53	12	1	0	15	4	32	0	11	11
54	4	1	1	13	4	23	0	0	0
55	12	1	1	19	3	36	0	10	10
56	22	3	1	22	6	54	0	0	0
57	27	4	4	52	28	115	2	90	92
58	12	4	3	33	14	66	0	0	0
59	26	3	2	20	13	64	1	31	32
60	12	1	1	18	6	38	0	0	0
61	13	2	2	34	8	59	3	71	74
62	4	1	1	22	8	36	0	0	0
63	6	2	4	13	8	33	5	120	125
64	6	1	2	44	6	59	0	0	0
65	6	1	1	18	10	36	14	189	203
66	5	1	0	29	5	40	0	0	0
67	10	3	2	52	12	79	22	137	159
68	12	2	1	35	13	63	0	0	0
69	13	4	4	28	16	65	3	44	47
70	26	3	3	48	21	101	0	0	0
71	17	2	3	49	8	79	6	6	12
72	15	1	3	29	9	57	0	0	0
73	34	3	2	82	13	134	51	51	102
74	-	-	-	-	-	-	0	0	0
75	-	-	-	-	-	-	26	60	86

Table 10. Timing of smolt migrations from Bristol Bay river systems. Dates on which 10, 50, and 90 percent of smolts migrated past the lake outlet

	Kvichak			Ugashik			Naknek			Wood River		
Year	10%	50%	90%	10%	50%	90%	10%	50%	90%	10%	50%	90%
1951										6/7	6/23	7/11
1952										6/12	6/25	7/18
1953										6/3	6/17	6/23
1954										6/2	6/10	6/15
1955	6/5	6/5	6/8	-	-	-	-	-	-	6/26	7/10	7/15
1956	6/1	6/5	6/15	-	-	-	-	-	-	6/16	7/6	7/12
1957	5/31	6/1	6/24	-	-	-	-	-	-	6/11	6/24	6/26
1958	5/22	5/27	6/13	5/23	5/29	6/5	5/28	6/21	7/7	6/9	6/15	7/1
1959	5/26	5/30	6/1	5/29	5/31	6/15	6/3	6/17	7/10	6/6	6/18	6/25
1960	-	-	-	6/2	6/5	6/12	6/4	6/13	6/25	6/2	6/18	7/10
1961	-	-	-	5/16	5/28	6/20	6/6	6/14	7/1	6/5	6/15	7/2
1962	6/2	6/9	6/15	5/16	5/30	6/9	6/2	6/8	6/18	6/13	6/21	7/5
1963	5/25	5/27	6/7	5/16	5/31	6/10	6/1	6/19	7/1	6/9	6/16	7/2
1964	6/4	6/7	6/13	5/25	6/5	6/9	6/9	6/16	7/2	6/21	6/30	7/5
1965	5/24	5/26	5/29	5/27	6/3	6/13	6/3	6/15	6/27	6/18	7/1	7/11
1966	6/5	6/7	6/11	-	-	-	6/6	6/14	6/22	6/17	6/26	7/8
1967	5/26	6/1	6/9	5/23	5/28	6/8	5/31	6/8	6/26	-	-	-
1968	5/21	5/23	5/27	5/23	5/27	6/5	6/3	6/8	6/26	-	-	-
1969	5/28	6/1	6/12	5/25	5/30	6/5	6/4	6/9	6/29	-	-	-
1970	5/22	5/27	6/3	5/19	5/29	6/6	6/5	6/6	6/26	-	-	-
1971	6/10	6/10	6/15	-	-	-	6/9	6/13	6/25	-	-	-
1972	6/8	6/12	6/17	5/28	6/12	6/18	6/9	6/11	6/20	-	-	-
1973	5/23	5/25	5/31	5/27	5/29	6/4	5/28	6/3	6/13	-	-	-
1974	5/23	5/27	6/1	5/27	5/29	6/7	5/31	6/3	6/21	-	-	-
1975	-	-	-	-	-	-	6/6	6/9	6/27	6/14	7/2	7/13
1976	6/9	6/11	6/13	-	-	-	-	-	-	6/20	7/14	7/29
Means	5/30	6/2	6/9	5/24	5/31	6/10	6/4	6/12	6/26	6/12	6/24	7/6

Table 11. Medians and ranges in the number of salmon smolts (1950-1974) and adults (1951-1976) in Bristol Bay (number of fish in millions)

	Naknek-Kvichak	Egegik	Ugashik	Nushagak	Togiak	Bay Total
Smolt						
Sockeye						
Median	68	10	5	62	7	123
Low	16	3	<1	14	3	47
High	461	50	70	168	19	647
Chum						
Median	12	2	2	26	8	55
Low	2	1	0	12	3	23
High	34	4	4	82	28	134
Pink (odd year)						
Median	3	0	0	51	0	74
Low	0			2		3
High	51			189		203
Adult						
Sockeye						
Median	6.5	1.7	.6	2.2	.25	10.9
Low	.8	.5	<.1	.8	.1	2.4
High	44.4	4.6	3.1	4.8	.5	53.1
Chum						
Median	.2	<.1	<.1	.4	.2	1.0
Low	.1	0	0	.2	.1	.5
High	.7	.1	.1	1.6	.6	2.7
Pink (even year)						
Median	.1	0	0	1.0	0	1.5
Low	<.1			<.1		.1
High	1.0			3.2		4.1

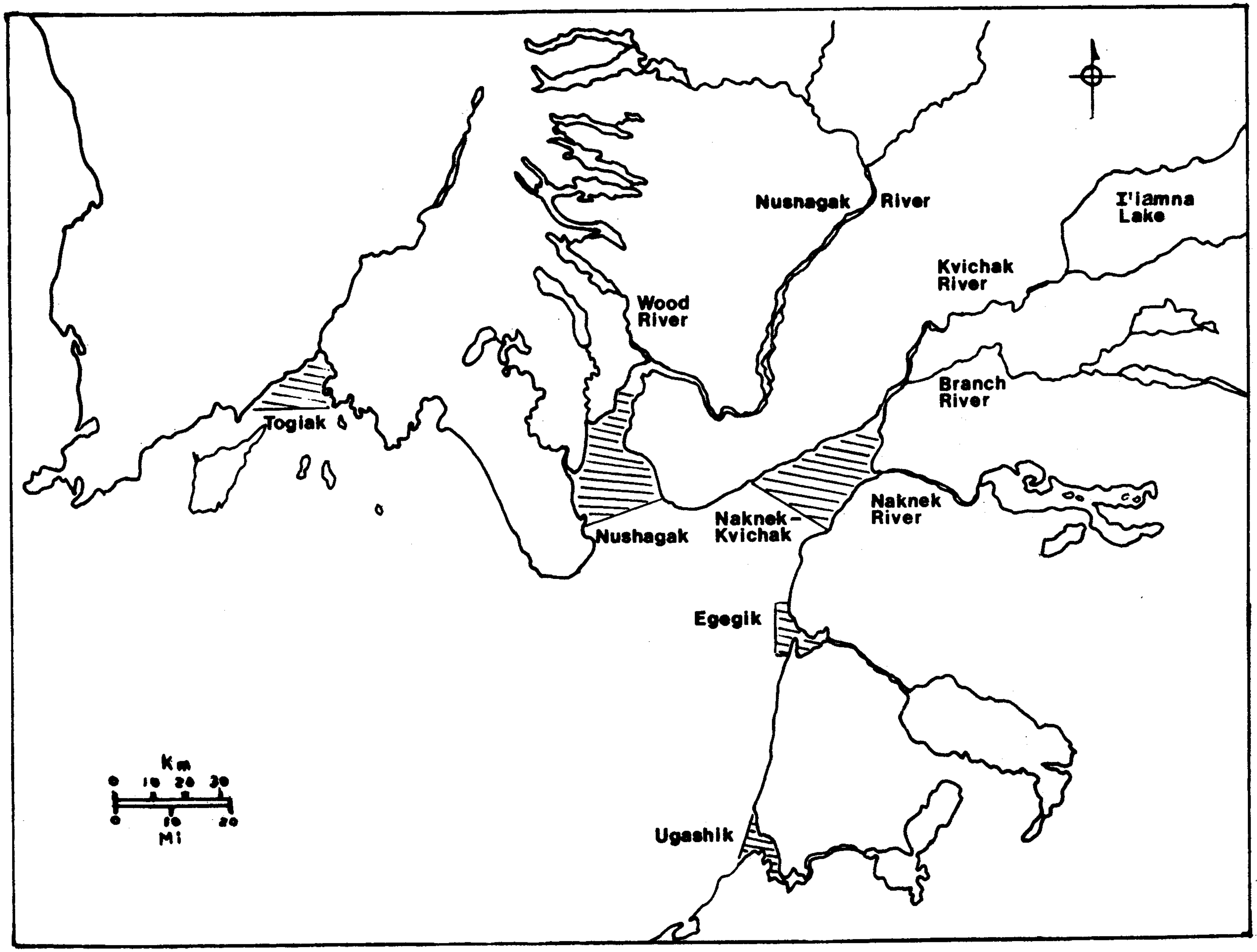


Fig. 1. The major river systems and fishing districts in Bristol Bay.

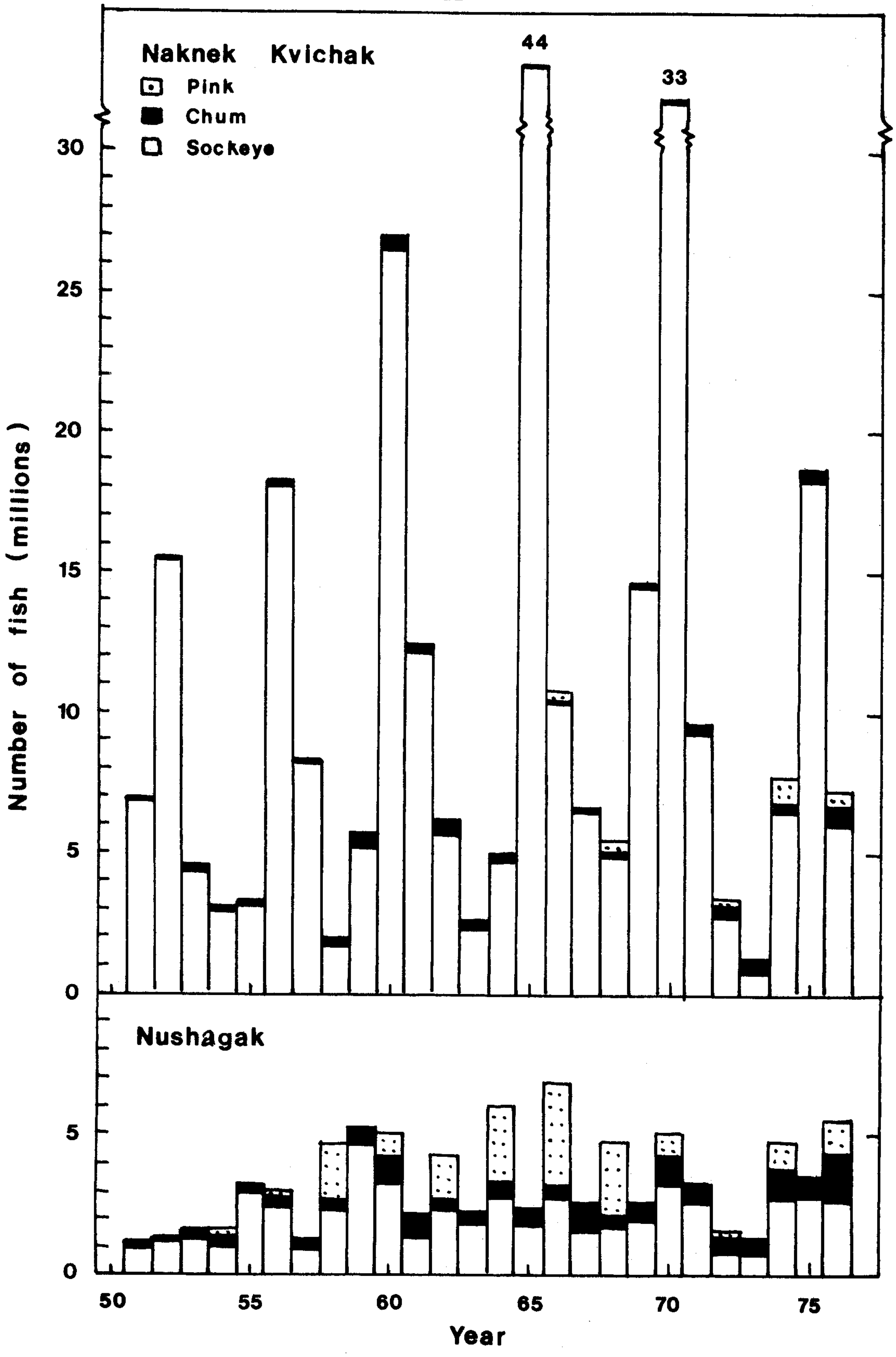


Fig. 2. Runs of salmon to the Naknek-Kvichak and Nushagak Districts of Bristol Bay, 1951-1976.

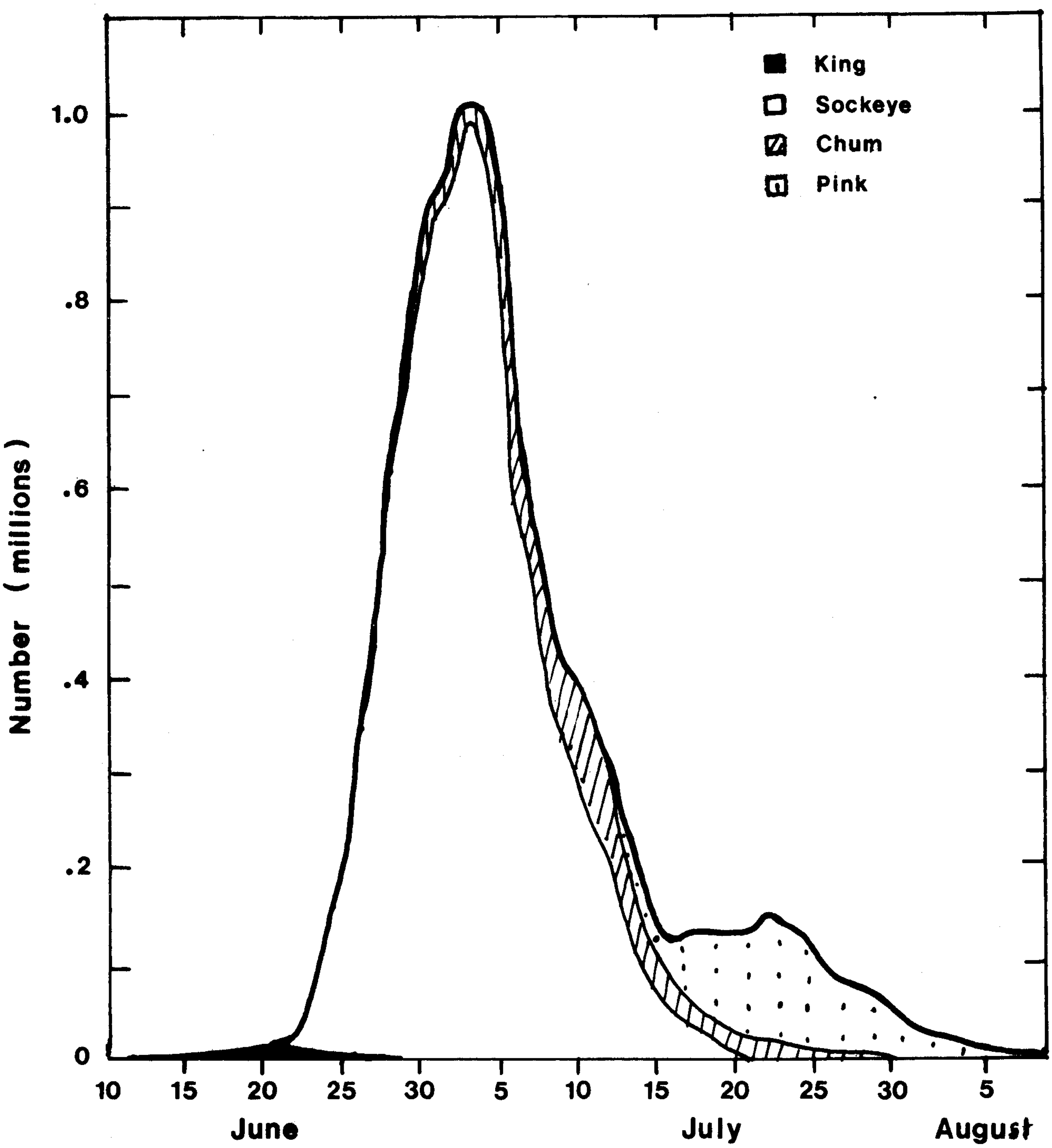


Fig. 3. Daily abundance of adult salmon entering the fishing districts of Bristol Bay in an average even-numbered year. Pink salmon would be nearly absent in an odd-numbered year.

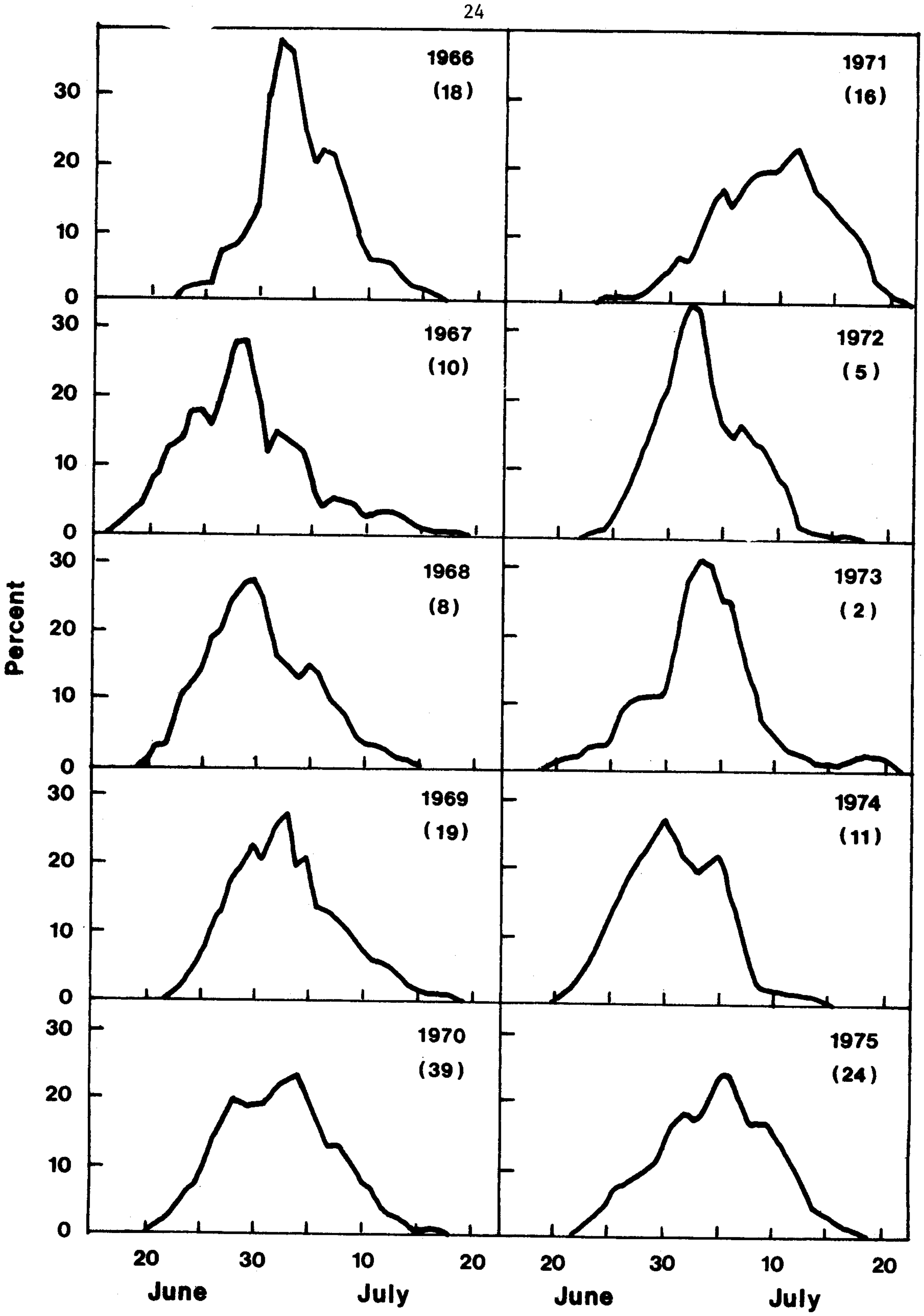


Fig. 4. Timing of the sockeye salmon runs in Bristol Bay, 1966-1975. Percent in the fishing districts on a given date plus the percent on the previous and following dates. Run in millions is given in parentheses.

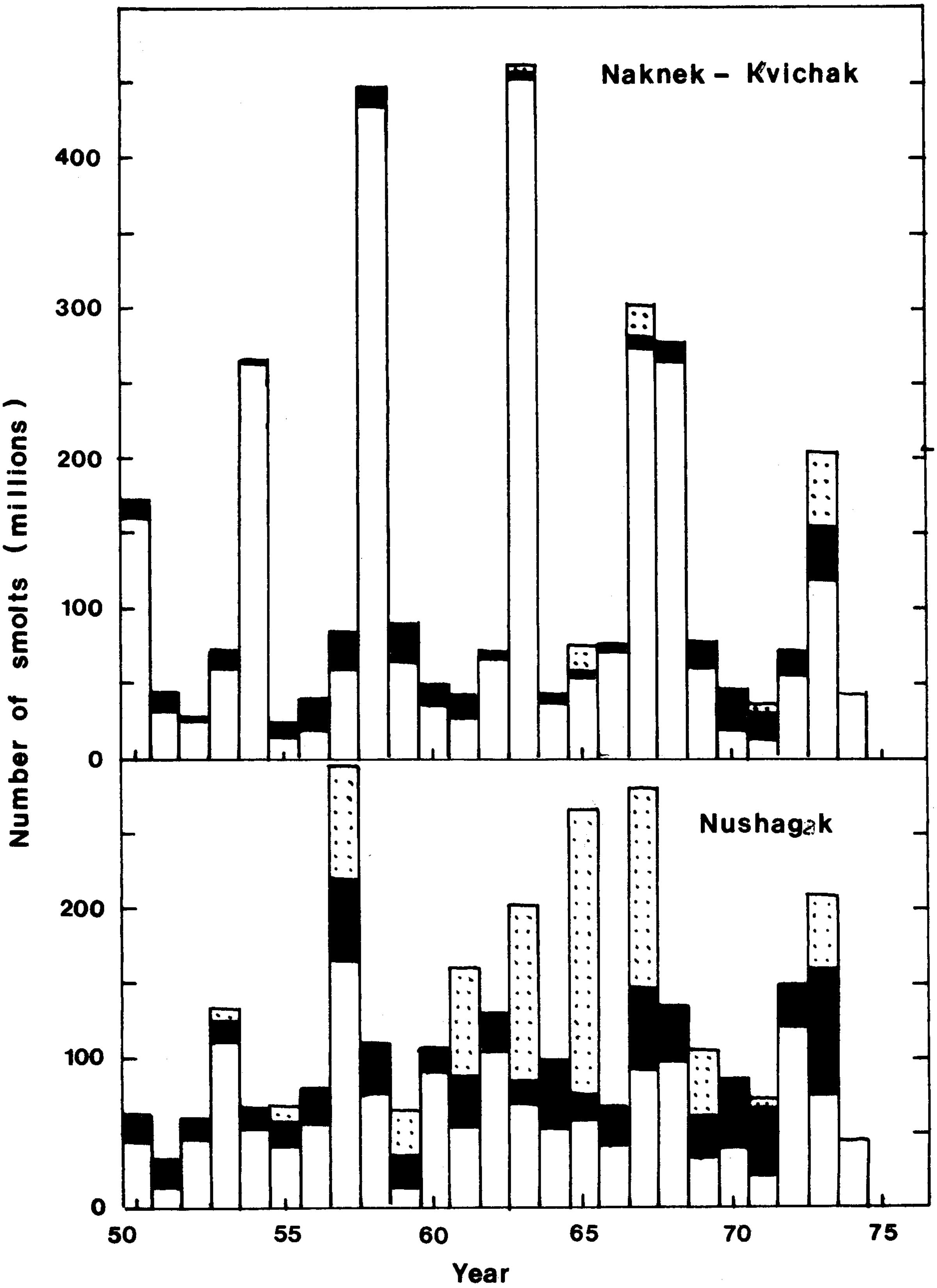


Fig. 5. Annual abundance of smolts that migrated from the Naknek-Kvichak and Nushagak Districts.

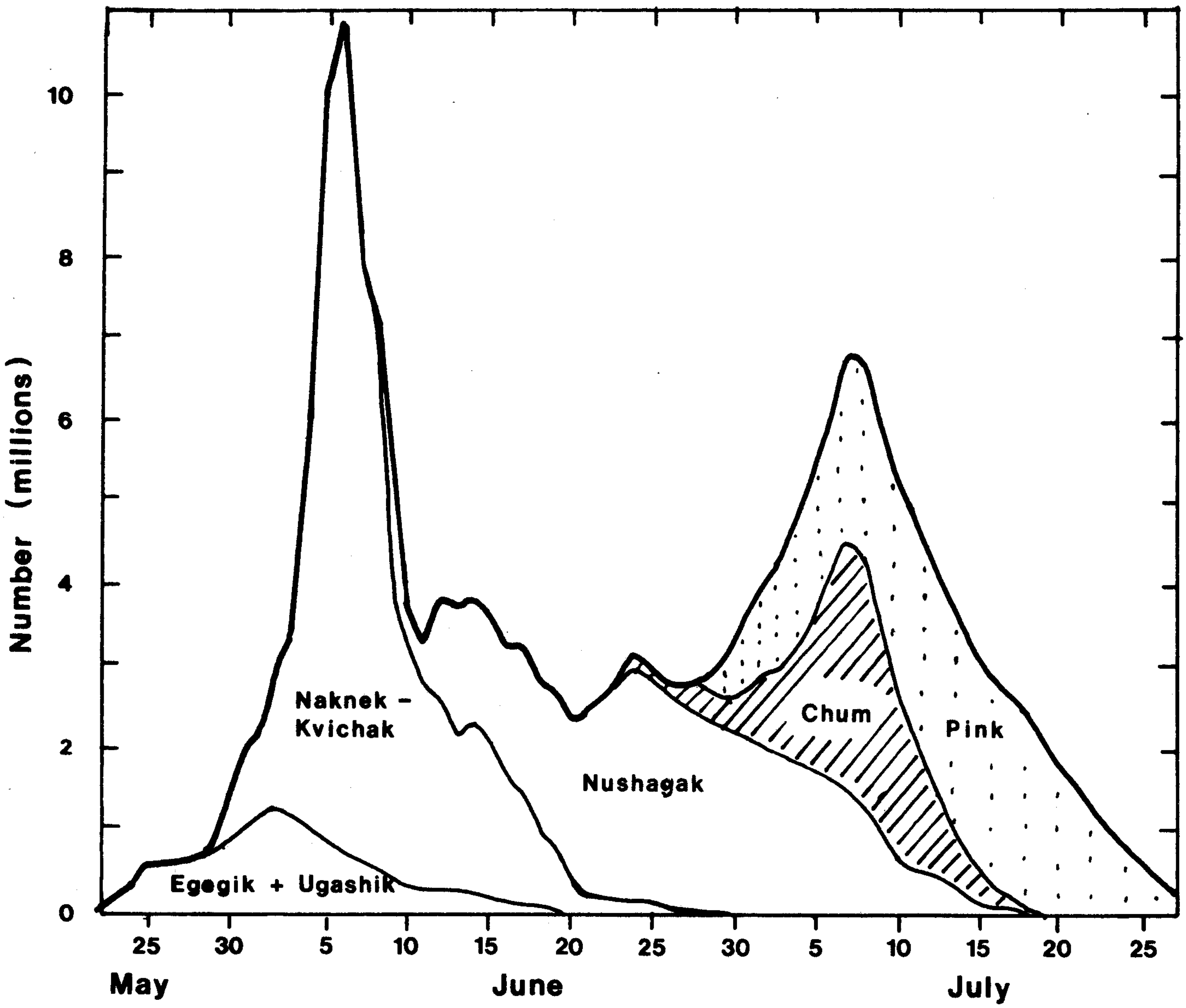


Fig. 6. Daily abundance of salmon smolt entering Bristol Bay in an average odd-numbered year, sockeye salmon for each district and pink and chum salmon from the Nushagak District only. Pink salmon would be nearly absent in an even-numbered year.

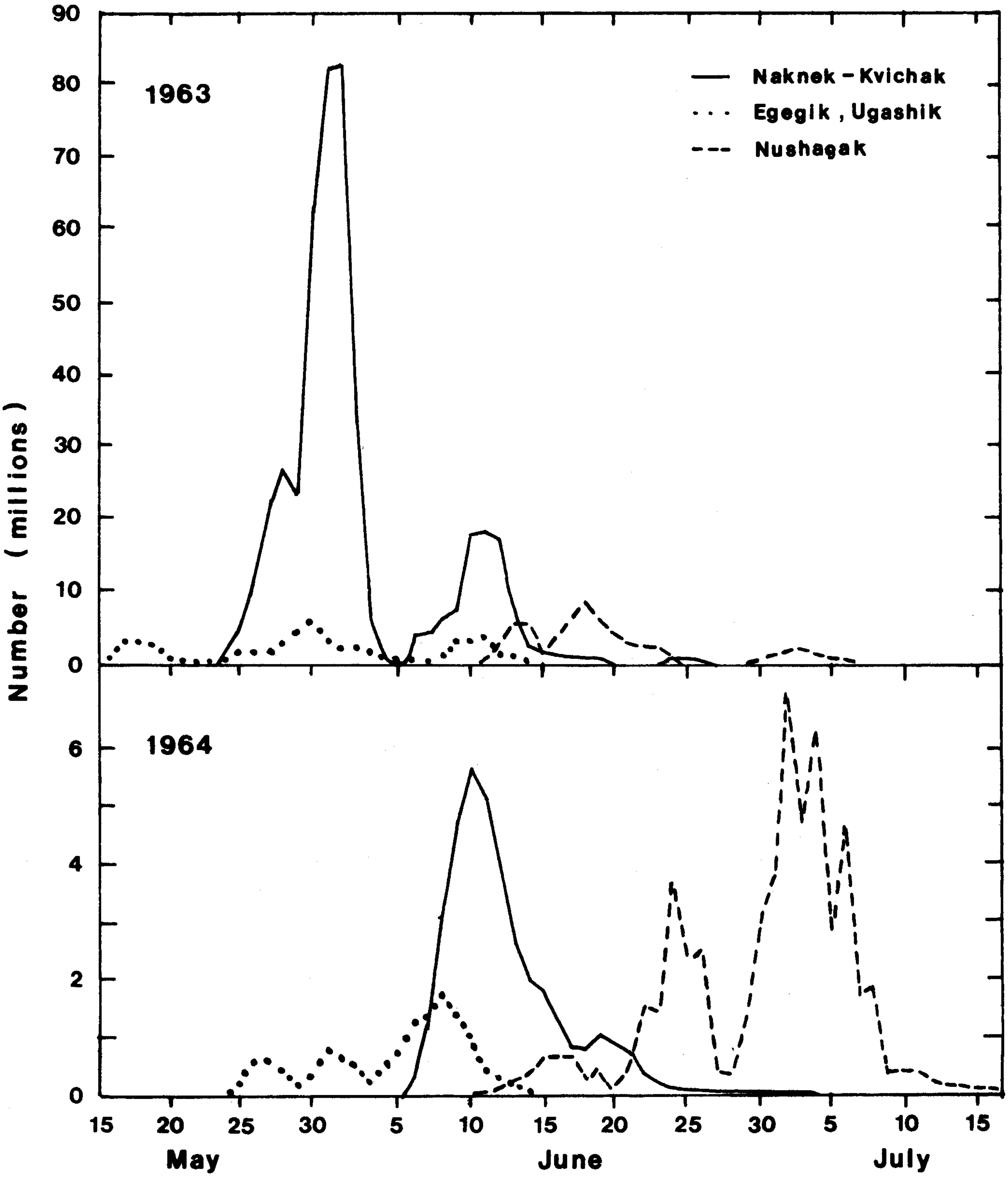


Fig. 7. Daily numbers of sockeye salmon smolts that entered Bristol Bay in 1963 and 1964.

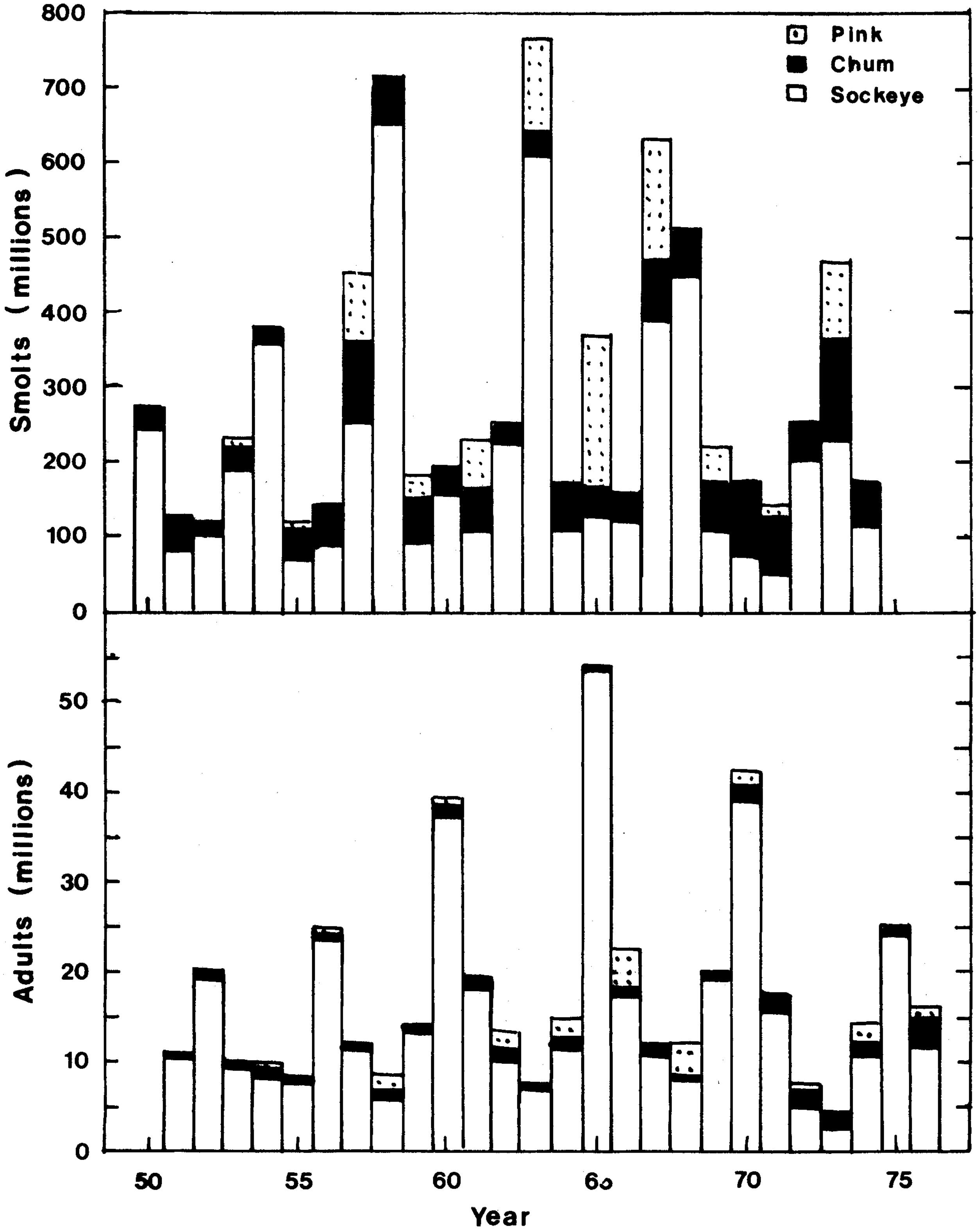


Fig. 8. Annual abundances of smolt and adult salmon in Bristol Bay.

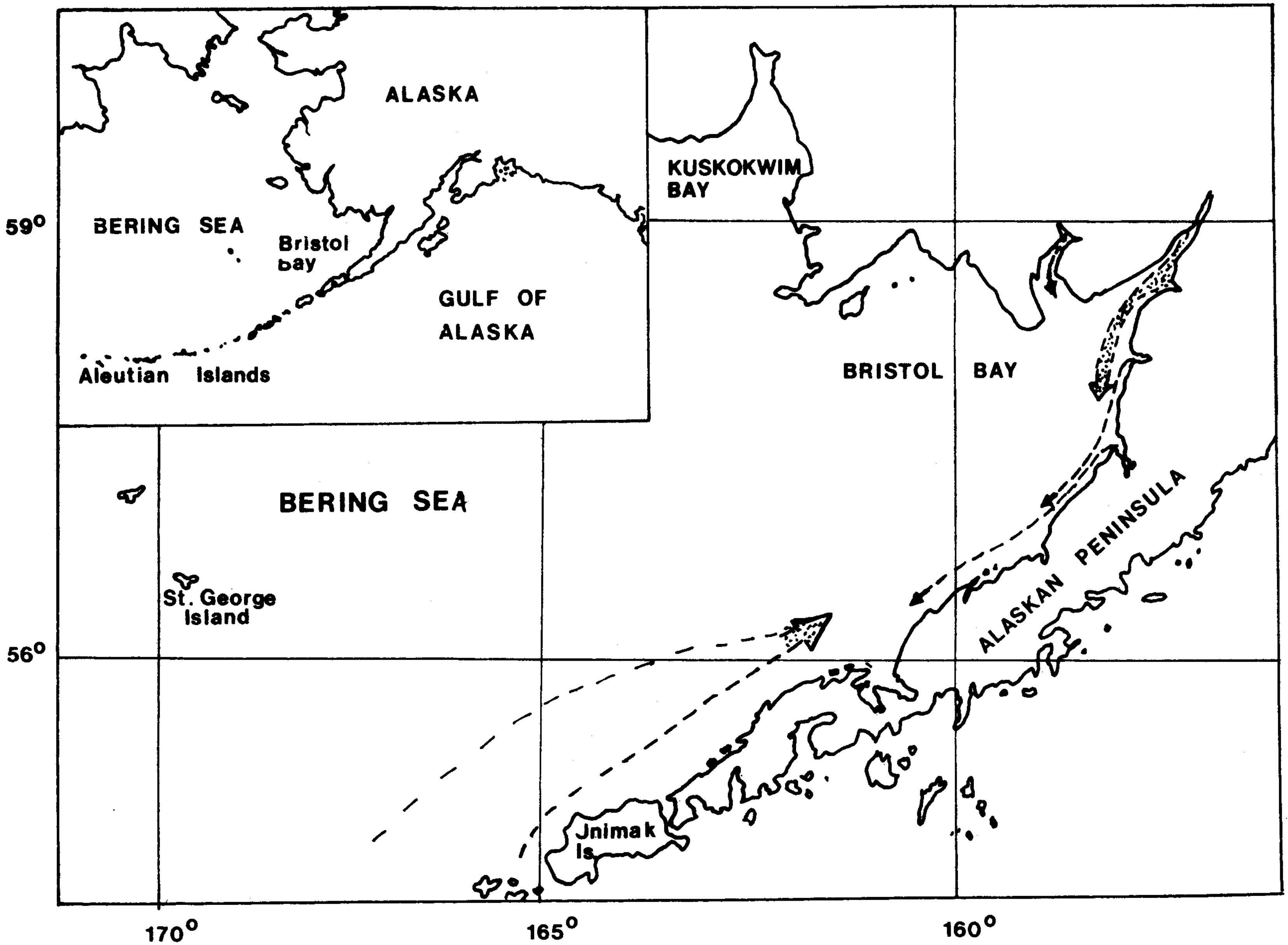


Fig. 9. Locations in mid-June of adult salmon entering and juvenile salmon leaving Bristol Bay.

ICHTHYOPLANKTON OF THE EASTERN BERING SEA

By

Kenneth D. Waldron and Beverly M. Vinter*

RESEARCH UNIT 380

Final Report

To

Outer Continental Shelf Environmental Assessment Program
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
(Major funding sponsor, Bureau of Land Management
U.S. Department of the Interior)

April 1978

*Resource Ecology and Fisheries Management Division, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Boulevard East, Seattle, WA 98112

ABSTRACT

Samples of ichthyoplankton collected with bongo and neuston nets at 64 locations in the eastern Bering Sea during 16 April - 15 May 1977 contained 24,611 fish eggs and 14,171 fish larvae. Pollock (Gadidae) accounted for 97% of the eggs and 59% of the larvae with the remainder divided among 18 families of which the 8 most numerous were, in order of decreasing abundance, Hexagrammidae, Cottidae, Pleuronectidae, Ammodytidae, Osmeridae, Scorpaenidae, Stichaeidae, and Bathylagidae.

There were no marked differences in distribution and abundance of pollock eggs and larvae between 1976 and 1977, though eggs appeared to have been more abundant in 1976 and larvae more abundant in 1977. Comparison of bongo and neuston net catches indicated that almost all pollock larvae and a majority or pollock eggs were more than 0.25 m below the sea surface. However, larval hexagrammids and cottids were caught almost entirely with neuston nets in the upper 0.25 m of water, and more of these two groups were caught in 1977 than in 1976.

Repetitive sampling at 24 locations showed that both pollock eggs and larvae were more abundant during late April and least abundant in mid-April. An estimated 7.829×10^{12} pollock eggs and 7.498×10^{12} pollock larvae were present in a survey area of 9.57×10^{10} m^2 during 19-27 April 1977.

FINAL REPORT

Contract: #03-5-022-56
Task Order: #13
Research Unit: #426
Reporting Period: 4/1/77-3/31/78
Number of Pages: 238

ENVIRONMENTAL ASSESSMENT OF THE SOUTHEASTERN BERING SEA: ZOOPLANKTON AND MICRONEKTON

R. Ted Cooney, Principal Investigator

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

March 1978

ACKNOWLEDGEMENTS

This study was funded as task order #13, contract #03-5-022-56 between the University of Alaska, Institute of Marine Science, and the National Oceanic and Atmospheric Administration's Environmental Research Laboratory, Boulder, Colorado.

Many individuals were responsible for the timely completion of this study. I wish to personally acknowledge the assistance of Mr. Ken Coyle who served on most cruises as my representative, as well as being responsible for the taxonomy of the microplankton in the laboratory. Ms. Patricia Wagner supervised the processing of zooplankton samples and identified the organisms. Mr. George Mueller, Director of Marine Sorting Center provided much of the part-time help required to process the field collections. Mr. Al Adams, Ms. Liz Clarke, and Mr. Lee Neimark are all completing masters theses on material gathered by this study. Their assistance at sea and with the preparation of reports is acknowledged. Dr. Charles Geist performed the statistical analyses. The Institute of Marine Science Publications section headed by Helen Stockholm prepared the manuscript and drafting for this report.

Lastly I wish to thank the many individuals aboard the NOAA vessels *Surveyor* and *Discoverer* without whose assistance the field work could not have been completed. Mr. Don Day, Juneau Project Office is also acknowledged for the assistance he provided both as chief scientist in the field and as admistrative advisor to the project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

I. SUMMARY

The unobtrusive pelagic fauna of the southeastern Bering Sea has been studied to determine species composition, distributions in time and space, and dependencies on "critical" habitat that may be impacted by the development of offshore oil in outer Bristol Bay and the St. George Basin areas. An abundant and diverse fauna was encountered which showed close affinities with pelagic assemblages described for the north Pacific Ocean south of the Aleutian chain and Alaska Peninsula.

The distributional data obtained in this study, coupled with an understanding of the biology of the dominant species, is used to assess the relationship between the adjacent oceanic watermass and that overlying the shelf and slope. Evidence is presented that suggests water shallower than about 80 m is isolated biologically from the rest of the shelf environment. Recent physical oceanographic information is discussed as it relates to this observation.

The results of this investigation complement the extensive work of Japanese and Soviet scientists by presenting data on the seasonality of the zooplankton and micronekton communities occurring in the slope and shelf regimes.

The influence of the seasonal ice pack is discussed and notions concerning the overall productivity of the region developed.

II. INTRODUCTION

This report is a synthesis of the many detailed observations obtained during the late spring, summer, and fall of 1975, and early spring of 1976 in the open water and near-ice zone of the southeastern Bering Sea. As previously noted (Appendices I, II), this study represents only a portion of a much larger attempt to characterize the biota associated with, or adjacent to, the waters of Alaska's continental shelves. Outer Bristol Bay and the St. George Basin area were both considered potential sites for offshore petroleum development and as such warranted careful examinations of community composition and descriptions of seasonality. Since most species found in these waters (excluding sea birds and marine mammals) pass through an early planktonic life history stage, an understanding of the ecology of this complex assemblage was thought to be of great importance in assessing the possible effect of offshore industrial development.

2.1 The Goal of Zooplankton and Micronekton Studies

The major objective of this study was to characterize the species composition and standing stock of the pelagic fauna of the southeastern Bering Sea in the approximate size range 0.3-50 mm using collections obtained by standard oceanographic means augmented occasionally by acoustic remote sensing. A field design was conceived which generated measures of variability associated with sampling a single location, with samples taken from relatively large spatial regimes, and with samples acquired at various times of the year. Within this framework the following specific tasks were addressed:

1. Determine seasonal density distributions and environmental requirements of principal species of zooplankton, micronekton, and ichthyoplankton;
2. Determine relationships of zooplankton and micronekton to the edge of the seasonal ice pack in the Bering Sea;

3. Identify and characterize critical factors in the planktonic stages of fish and shellfish species;
4. Describe the food dependencies of common species of dielly-migrating mesopelagic fishes;
5. Identify pathways of matter and energy transfer between primary producers and consumers;
6. Summarize the existing literature and unpublished data on the transfer of organic matter through the lower levels of the pelagic food web in the northern north Pacific Ocean and Bering Sea.

Tasks 1, 3 and 4, and to a limited extent 2, are described in this final report. Task 6 is submitted as the 1977 annual report, and the remainder of task 2, to include work accomplished in Norton Sound and in the southeastern Chukchi Sea, will appear in the final report of the project, September 1978. Task 5 was curtailed by budget restrictions to the FY78 proposal which eliminated any continuing field work for that period.

2.2 Status of Knowledge

Cooney (1976) reviewed the literature pertaining to zooplankton and micronekton in the Bering Sea (see Appendix I). The bulk of this information was available as reports and papers of the faculty of fisheries of Hokkaido University, and the Fisheries Agency of Japan from studies dating back to 1953. Most investigations were carried out during the late spring, and summer periods which cover the biologically productive times of the year but contain little or no information pertaining to levels of overwintering stocks or relationships to the seasonal ice pack. Work funded by NOAA specifically to study ichthyoplankton of the eastern Bering Sea (K. Waldron and F. Favorite;

RU 380) is adding valuable information, particularly during the early spring season when the reproductive processes of many fin-fish species occurs in this region. A large, multi-disciplinary ecosystem study, PROBES (Processes and Resources of the Bering Sea Shelf) is currently in its third field season examining the relationships between numerous oceanographic variables and the overall productivity of the outer shelf region south of the Pribilof Islands. The walleye pollock, *Theragra chalcogramma*, is serving as an ecosystem tracer for this project since in its life history the species integrates many processes occurring both in the pelagic realm and near the sea bed.

Notions presented by Motoda and Minoda (1974) concerning regional aspects of animal plankton communities as reflective of broad hydrographic regimes are probably quite representative of the large scale features of the Bering Sea and northern Pacific Ocean for the ice free periods of the year, but continuity with season is lacking. The literature is very sparse regarding the possible effects of seasonal ice on resident populations at lower trophic levels, particularly during the late fall and winter. The field work funded for this study and the subsequent synthesis of the information collected is expected to contribute significantly to the overall understanding of animal plankton ecology in this northern sea. Our observation in November and March will provide initial insight into the biological problems of overwintering and recruitment which are characteristic of seasonally fluctuating high latitude populations. Coupled with studies of other environmental factors incorporated in the breadth of the overall OCS investigation in the southeast Bering Sea, our results will also contribute some of the detail necessary to enable the Department of Interior to respond in a timely manner to the development schedule planned for this region.

III. RESEARCH OBJECTIVES

The achievement of a predictive understanding of the occurrence and seasonal abundance of natural populations of animal plankton and micronekton is only vaguely possible after the major components of the variance structure of a system have been described at some arbitrary level of precision. In high-latitude marine ecosystems, a very strong seasonal source of variation is always present and usually modified locally by hydrographic processes unique to a region. Overlying this strong seasonal signal are additional sources of variability which include both non-random diel displacements and ontogenetic migrations, and smaller-scale random patchiness associated with weather influences or internal advective processes. Since by definition plankters are weak swimmers, their overall distributions most often mirror the dynamics of physical fields of motion modified by temperature and salinity gradients which place biological constraints (i.e. upper and lower tolerance limits) on survival. It is within this complex association of variables that collections are obtained which in themselves are used to describe the framework of the system's structure. Because of the dynamic nature of the pelagic regime, both biologically and physically, a strict interpretation of time and space patterns is limited to a statistical evaluation of observations in which the precision of the methodology is most often "sample size" dependent. Quantitative plankton investigations have been notorious for the amount of work involved in the field, in sample processing, and in interpretation of results. This project was no exception.

My research objectives were these:

1. To inventory and quantitatively census the numerically dominant or otherwise obvious species;

2. To describe, within an appropriate statistical design, spatial and seasonal distributions;
3. To examine relationships that might exist between the various populations and existing hydrographic and/or biochemical parameters.

These objectives were viewed as realistic within the context of the extended study as planned by NOAA. Within this framework of collection, several smaller scale experiments were planned which would provide a basis for evaluating the function of some of the major species. Unfortunately, the field aspects of the program were terminated before any meaningful process studies could be initiated at the primary consumer level.

These research objectives were fulfilled in part and now form the basis for evaluating the project goals (tasks) as previously stated (see section 2.1).

IV. STUDY AREA AND CRUISES

This report describes results from four cruises which visited the southeast Bering Sea in May-June 1975, in August 1975, in November 1975, and in March-April 1976:

1. NOAA Ship *Discoverer*, cruise 808; 1975
2. NOAA Ship *Discoverer*, cruise 810; 1975
3. NOAA Ship *Miller Freeman*, cruise 815; 1975
4. NOAA Ship *Surveyor*, cruise SU 1 and 2; 1976

The area of study included the open ocean, outer shelf, central shelf, and northern coastal regimes of the southeastern Bering Sea as depicted in Figure 1. Although some samples were obtained north of Nunivak Island, most

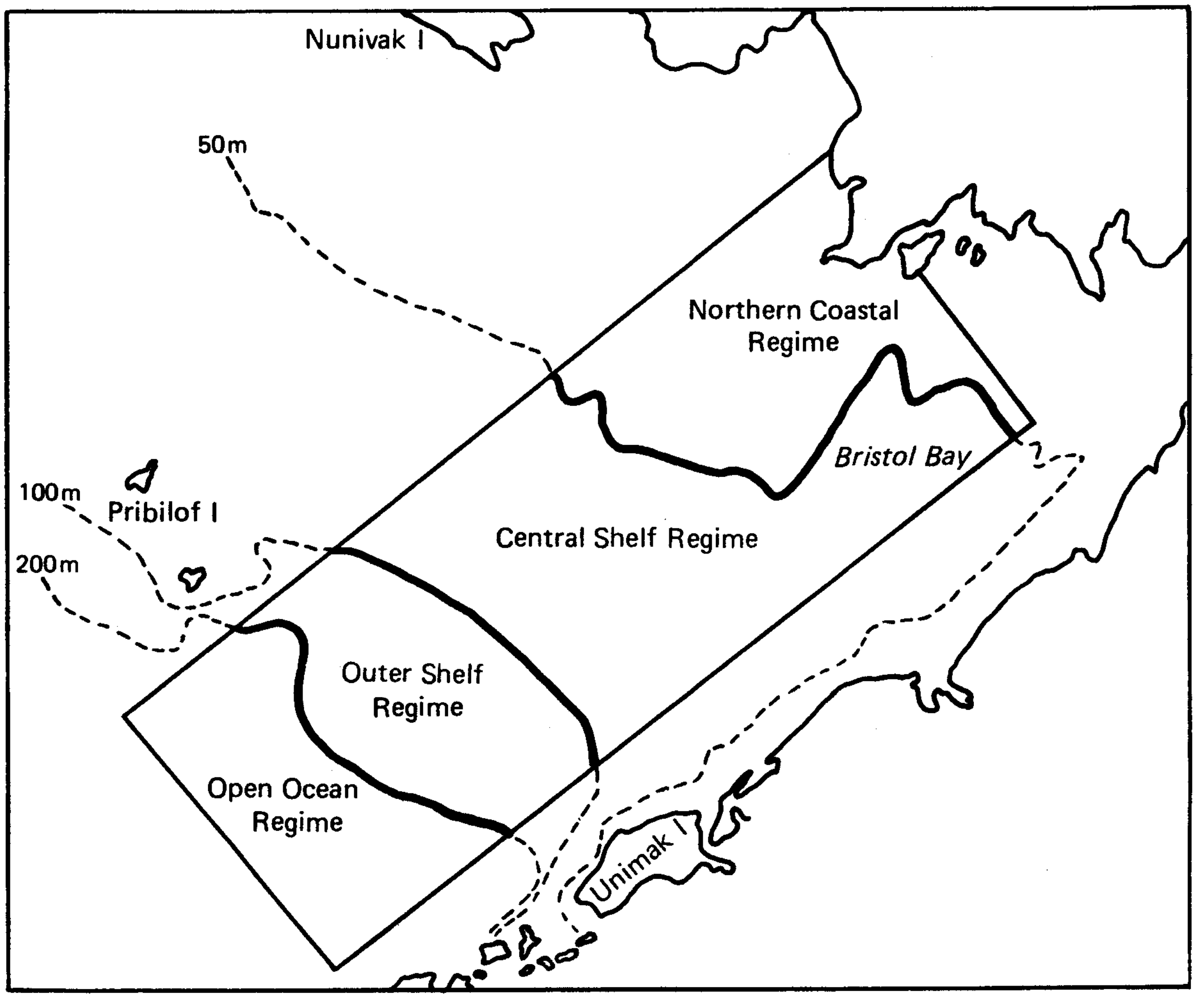


Figure 1. The area of study and its division into bathymetric regimes.

information reported here is for the open water and near-ice region of the shelf between Unimak Pass and the Pribilof Islands extending landward through Bristol Bay to Cape Newenham. Observations taken further to the north in association with the seasonal ice-pack will be reported in September 1978, as part of the project final report. Sampling frequency and location have been previously reported for this area (Appendices I, II).

V. METHODS AND SOURCES OF DATA

The field program was designed to test hypotheses and to estimate levels of variability using the statistical procedures of Analysis of Variance. This technique objectively evaluates the additive effects of major factors and their interactions relative to a background of variability associated with a combination of natural patchiness and error introduced by equipment and analytical technique. The procedure is widely used in plankton field research and affords a methodology whereby limited resources are most efficiently allocated within complex temporal and spatial sampling programs.

Using results from the analysis of data collected in the northern Gulf of Alaska (Cooney, 1975) I proposed to stratify the research area into several discrete regimes by depth, and to periodically visit these regimes (cruises) sampling each randomly with nets and trawls of appropriate dimension to representatively collect the numerically dominant zooplankton and micronekton species.

For purposes of analysis, the original plan of eight regimes and multiple cruises per year was revised by pooling to four subareas and four cruises within the period May 1975-April 1976 (Fig. 1). I attempted to obtain 10 observations per regime each cruise since previous analyses of within-area variance predicted that differences in population abundance of about one-half order of magnitude (i.e. factor of 5.0) or more could be discerned with this level of effort. The resulting matrix became unbalanced with missing observations due to ice conditions encountered during the early spring of 1976.

A fixed split plot model of Analysis of Variance was used to examine the main effect of cruise and regime, and their interaction on distributions of numerically dominant species or composites. As mentioned, four regimes were identified: 1) open ocean (depths greater than 200 m); 2) outer shelf (depth between 100 and 200 m); 3) central shelf (depths between 50 and 100 m); and 4) northern coastal (depths shallower than 50 m). Because the seasonal ice pack prevented sampling the northern coastal area during the spring of 1976, the analysis was performed on two configurations of the data: 1) four cruises and three spatial regimes (omitting the northern coastal in 1976); and 2) three cruises and four regimes (omitting the entire spring black 1976).

Counts of organisms per unit area of sea surface were transformed to base ten logarithms, an acceptable technique that tends to normalize the variance and adjust data sets in which the main effects are suspected of being proportional rather than additive. All analyses were conducted on transformed data.

Field collections were obtained using a 1-m net (0.333-mm Nitex) fished vertically from the seabed or from 200 m to the surface, if deeper, at each oceanographic station. The relative simplicity and reproducibility of this operation were factors considered in selecting the methodology. The major advantages of the vertically integrated collection include knowing the depth increment sampled from simple wire metering, avoiding difficulties in positioning a net to fish horizontally layered populations which may migrate dielly in the water column, and the small volume of catch to be processed and preserved. The disadvantages are with the small actual volumes filtered ($\sim 80^3$ in a 100 tow) and the relatively slow retrieval speed of the net ($\sim$1 m/sec). The amount of water filtered, 160 m^3 per tow from 200 m to the surface, was adequate for the common species but exceedingly marginal or completely inappropriate to sample the rarer members of the plankton community such as fish eggs and larvae. Since this study proposed to deal quantitatively with the numerically dominant or otherwise obvious organisms, the disadvantages were considered of second-order importance.

The 1-m vertical net towing was augmented with occasional samples obtained from a small mid-water trawl (2-m NIO version of the Tucker trawl; 1/8-inch knotless nylon). The trawl was lowered with the vessel underway (2-3 m/sec), fished to depth as determined by wire length monitored with a mechanical time-depth recorder, and then retrieved. Volumes filtered were measured with a flowmeter hung in the mouth of the trawl.

All samples were preserved in 10% buffered seawater and returned to the University of Alaska Marine Sorting Center for processing. Identification and enumeration of taxa was performed on sub-samples obtained using a Stempel pipet; between 100 and 300 animals were routinely counted per sub-sample. In addition, a fraction of the original sample was dried to constant weight and reported for each station using the method of Lovegrove (1966).

Collections of larger organisms taken with the NIO trawl were searched for the obvious taxa and then subsampled using a mechanical splitter described by Cooney (1971). Again, between 100 and 300 were enumerated.

It is realized that subsampling introduces a component of error into estimates of number per catch. However, the magnitude of the variability involved is minor compared with that encountered in repeatedly sampling a water column at sea (Cooney, 1971). In my view, the inability to consistantly census the rarer animals in these collections was vastly offset by the gain in precision afforded by rapidly processing large numbers of samples for the dominant members of the community.

A high-frequency recording echosounder was used at some stations at sea to profile the vertical distributions of larger organisms (pelagic fishes) and layers of micronekton (euphausiids, amphipods) that were acoustically visible at 105 kHz. Initially it was hoped that direct samples, particularly from the mid-water trawling, could be used to identify the scatterers and thus provide a means of interpreting sonic phenomena that could be measured continuously along transects within the regimes. An inability to accurately position the net at depth or to tow a transducer routinely while underway curtailed this approach. Several acoustic observations were obtained in the ice-related work and will be reported in support of that study, September 1978.

VI. RESULTS

The findings reported here represent a synthesis of data collected specifically to examine the time-space distribution patterns of zooplankton and micronekton occurring in the open water and edge-zone of the southeastern Bering Sea, May 1975-April 1976. Details of underice distributions will be available in the Final Report of Project, September 1978.

6.1 The Zooplankton and Micronekton Community

During the course of the investigation, 167 species and 6 composite taxa were sorted from 1-m net samples. Of these, only 21 species were designated as numerically common at most locations and seasons (Table I). Likewise, 161 species and 4 composite taxa are reported for 2-m NIO trawl samples taken at the same time and at many of the same locations (Table II). Only 18 of these species were consistantly numerically common. Although these two gear types sampled different size classes and consequently taxa due to mesh size selectivity, 9 species of the common groups were shared.

The 1-m net samples were dominated by copepods (41 species; 8 common) while the midwater trawl took more "jellyfishes", amphipods, and finfishes. Euphausiids, annelids, and molluscs appeared in roughly similar proportions by gear type. In cases where the life history stages varied greatly in size (i.e. euphausiids), the 1-m net most representatively sampled the juveniles while the trawl took the adults in greater number.

6.2 Distribution Patterns

Thirty-three categories including 23 species, 9 genera or larger composites, and total dry weight were examined statistically to determine if patterns of abundance related to season or regime were discernable within the variance structure of the collection. In the formal analysis of variance

TABLE I

ZOOPLANKTON AND MICRONEKTON SAMPLED WITH A 1-M NET IN THE SOUTHEASTERN BERING SEA; MAY 1975-APRIL 1976

Taxa	Common	Rare
Cnidaria		
Hydrozoa		
Aequorea forskalea		X
Perigonimus yoldia-arcticae		X
P. multicirratus		X
P. breviconis		X
Calycopsis nematophora		X
Bougainvillia superciliaris		X
Corymorpha flammea		X
Tubularia prolifer		X
Coryne tubulosa		X
C. principes	X	
Obelia longissima		X
Ptychogena lactea		X
Eirene indicans		X
Aglanthe digitale	X	
Aegina rosea		X
Dimophyes arctica		X
Scyphozoa		
Periphylla hyacinthina		X
Chrysaora helova		X
Ctenophora		
Beroe spp.		X
Annelida		
Polychaeta		
Hesperone complanata		X
Eteone longa		X
Lopadorrhynchus sp.		X
Pelagobia longicirrata		X
Typhloscolex muelleri	X	
Tomopteris septentrionalis		X
Laonice cirrata		X
Glycera capitata		X
Lumbrinereis sp.		X
Scoloplos armiger		X
Pelagobia longicirrata		X
Capitella capitata		X
Maldane sarsi		X
Terebellides stroemii		X

TABLE I

CONTINUED

Taxa	Common	Rare
Mollusca		
Gastropoda		
Euclio sp.		X
Limacina helicina	X	
Blione limacina	X	
Gonatus fabricii		X
Crustacea		
Cladocera		
Podon sp.		X
Evadne sp.		X
Ostracoda		
Conchoecia alata minor		X
Conchoecia borealis var. *antipoda*		X
C. borealis var. *maxima*		X
C. curta		X
C. pseudoalata		X
C. pseudodiscophora		X
C. skogsbergi		X
Copepoda		
Harpacticoida		
Microsetella rosea		X
Bradya sp.		X
Ectinosome sp.		X
Tisbe sp.		X
Calanoida		
Calanus cristatus	X	
C. glacialis		X
C. marshallae	X	
C. plumchrus	X	
Eucalanus bungii bungii	X	
Microcalanus spp.		X
Pseudocalanus spp.	X	
Aetideus pacificus		X
A. sp.		X
Bradyidius saanichi		X
Chiridius gracilis		X
Gaetanus intermedius		X
Gaidius variabilis		X
Euchaeta elongata		X
Haloptilus pseudooxycephalus		X
Xanthocalanus kurilensis		X
X. sp.		X

TABLE I

CONTINUED

Taxa	Common	Rare
Calanoid (cont'd)		
Racovitzanus antarcticus		X
Spinocalanus sp.		X
Scolecithricella minor		X
S. ovata		X
Eurytemora herdmani		X
E. pacifica		X
Metridia lucens	X	
M. okhotensis		X
Pleuromamma scutullata		X
Centropages abdominalis		X
Lucicutia sp.		X
Heterorhabdus compactus		X
H. sp.		X
Candacia columbiae		X
Acartia longiremis	X	
A. tumida		X
Lucicutia ovaliformis		X
Cyclopoida		
Oithona similis	X	
O. spinirostris		X
Onceae borealis		X
Nebaliacea		
Nebalia sp.		X
Mysidacea		
Eucopia sp.		X
Acanthomysis nephrophthalma		X
A. dybowskii		X
A. pseudomacropsis		X
A. stelleri		X
Boreomysis knicaidi		X
Holmesiella anomala		X
Neomysis rayii		X
Pseudomma truncatum		X
Cumacea		
Lamprops quadriplicata typica		X
Leucon nasica orientalis		X
L. fulvus		X
L. sp.		X
Eudorella pacifica		X
Eudorellopsis deformis		X
Diastylis bidentata		X
D. alaskensis		X

TABLE I

CONTINUED

Taxa	Common	Rare
Amphipoda		
Argissa hamatipes		X
Corophium sp.		X
Guernea sp.		X
Rhachotropis natator		X
Pontoporeia femorata		X
Photis sp.		X
Ischyrocerus commensalis		X
I. spp.		X
Protomedia sp.		X
Anonyx lilljeborgi		X
Eusirella multicalceola		X
Cyclocaris guilelmi		X
Cyphocaris challengeri		X
C. anonyx		X
Koroga megalops		X
Lepidepedcreum kasatka		X
L. comatum		X
Orchomene lepidula		X
O. nugax		X
Melphidippa sp.		X
Bathymedon obtusifrons		X
B. nanseni		X
Monoculodes diamesus		X
M. packardi		X
M. zernovi		X
Westwoodilla coecula		X
Paraphoxus sp.		X
Stenopleustes glaber		X
Dulichia sp.		X
Melphidippa sp.		X
Metopa alderi		X
Stenula sp.		X
Scina borealis		X
Hyperia medusarum		X
Hyperoche medusarum		X
Parathimisto libellula	X	
P. pacifica	X	
Primno macropa		X
Euphausiacea		
Euphausia pacifica		X
Thysanoessa inermis	X	
T. longipes	X	
T. raschii	X	
T. spinifera		X

TABLE I

CONTINUED

Taxa	Common	Rare
Decapoda		
Pandalus borealis		X
P. sp.		X
Eualus macilenta		X
Paracrangon echinata		X
Paralithodes camtschatica		X
Chionoecetes spp.		X
Hyas spp.		X
Telmessus cheiragonus		X
Erimacrus isenbeckii		X
Chaetognatha		
Eukrohnia hamata	X	
E. bathypelagica		X
Sagitta elegans	X	
Chordata		
Larvacea		
Fritillaria borealis		X
Oikopleura spp.	X	
Teleostei		
Clupea harengus pallasi		X
Mallotus villosus		X
Bathylagus pacificus		X
B. stilbius schmidti		X
Stenobrachius leucopsarus		X
Theragra chalcogramma		X
Sebastes spp.		X
Liparis spp.		X
Nectoliparis pelagicus		X
Atheresthes stomias		X
Hippoglossoides elassodon		X

TABLE II

ZOOPLANKTON AND MICRONEKTON SAMPLED WITH A 2-M NIO TRAWL IN THE SOUTHEASTERN BERING SEA; MAY 1975-APRIL 1976

Taxa	Common	Rare
Cnidaria		
Hydrozoa		
Aglantha digitale	X	
Perigonimus brevironis		X
Perigonimus c.f. P. yoldia arcticea		X
Perigonimus multicirratus		X
Calycopsis nematophora		X
Bougainvillia superciliaris		X
Rathkea jaschnowi		X
Corymorpha flammea		X
Coryne principes	X	
Ptychogena lactea		X
Eirene indicans		X
Aegina rosea		X
Aequores forskalea		X
Pantachogan haeckeli		X
Melicertum campanula		X
Botrynema burcei		X
Halicreas minimum		X
Crossota brunnea		X
Scyphozoa		
Periphylla hyacinthina		X
Atolla wyvillei		X
Chrysaora melanaster	X	
Chrysaora helvola		X
Cyanea capillata	X	
Phacellophora camtschatica		X
Aurelia limbata		X
Siphonophora		
Dimophyes arctica		X
Vogtia serrata		X
Ramosia vitiazi		X
Rosacea plicata		X
Chaetognatha		
Sagitta elegans		X
Eukrohnia spp.		X
Sagitta scrippsae		X
Mollusca		
Galiteuthis armata		X
Chiroteuthis veranyi		X
Gonatus fabricii		X
Gonatus magister		X
Gonatopsis sp.		X

TABLE II

CONTINUED

Taxa	Common	Rare
Clione limacina		X
Limacina heliciana		X
Annelida		
Polychaeta		
Tomopteris septentrionalis		X
Hesperone complanata		X
Chaetozone setosa		X
Krohnia excellata		X
Lopadorrhynchidae spp.		X
Antinoella sarsi		X
Nereis pelagica		X
Crustacea		
Copepoda		
Calanus cristatus	X	
Eucalanus bungii bungii	X	
Euchaeta elongata		X
Pachyptilus pacificus		X
Candacia columbiae		X
Euphausiacea		
Euphausia pacifica		X
Tessarabrachion oculatus		X
Thysanoessa raschii	X	
Thysanoessa inermis	X	
Thysanoessa spinifera		X
Thysanoessa longipes	X	
Isopoda		
Ilyarachna sp.		X
Synidotea bicuspida		X
Mysidacea		
Acanthomysis stelleri		X
Acanthomysis dybowskii		X
Pseudomma truncatum		X
Neomysis rayii		X
Neomysis czerniawskii		X
Holmesiella anomala		X
Eucopia sp.		X
Boreomysis kincaidi		X
Boreomysis californica		X

TABLE II

CONTINUED

Taxa	Common	Rare
Cumacea		
Diastylis bidentata	X	
D. alaskensis		X
Leucon quadriplicata typica		X
Amphipoda		
Hyperiidea		
Parathemisto pacifica	X	
Parathemisto libellula	X	
Hyperia medusarum		X
Hyperia springera		X
Hyperoche medusarum		X
Primno macropa		X
Phronima sedentaria		X
Hyperia galba		X
Paraphronima crassipes		X
Scina borealis		X
Scina rattrayi		X
Archoeoscina steenstrupi		X
Parathemisto japonica		X
Gammaridea		
Anonyx nugax		X
Cyphocaris challengeri		X
Byblis gaimardi		X
Protomedia sp.		X
Metopa alderi		X
Monoculodes zernovi		X
Ampelisca macrocephala		X
Westwoodilla coecula	X	
Dulichia unispina		X
Pontoporeia femorata		X
Bulichia arctica		X
Melitoides makarovi		X
Rhachotropis oculata		X
Pleustes panopla		X
Monoculoides diamesus		X
Rhachotropis natator		X
Priscillina armata		X
Eusirella multicalceola		X
Parandania boecki		X
Anonyx compactus		X
Stenopleustes glaber		X
Melita dentata		X
Paramphithoe polyacantha polyacantha		X
Monoculopsis longicornis		X
Anisogammarus macginitiei		X

TABLE II

CONTINUED

Taxa	Common	Rare
Gammaridea (cont'd)		
Hippomdeon kurilicus		X
Orchomene c.f. O. lipedula		X
Pontogenia ivanovi		X
Atylus bruggeni		X
Atylus collingi		X
Socarnes bidenticulatus		X
Ischerocerus anguipes		X
Melphidippa goesi		X
Cyclocaris guilelmi		X
Decapoda		
Pasiphaea pacifica		X
Cancer sp.		X
Crangon dalli		X
Argis lar		X
Hymenadora frontalis		X
Eualus macilenta		X
Eualus stonyei		X
Pandalus goniurus		X
Pandalus borealis		X
Sergestes similis		X
Chionoecetes spp.	X	
Erimacrus isenbecki		X
Erimacrus isenbecki		X
Telmessus cheirigonus		X
Telmessue cheirigonus		X
Paralithodes camtschatica		X
Paralithodes camtschatica		X
Hyas sp.		X
Pandalus montagui tridens		X
Pandalopsis spp.		X
Chordata		
Cyclostomata		
Lampetra tridentatus		X
Teleostei		
Mallotus villosus	X	
Lycodes palearis		X
Lumpenus maculatus		X
Reinharditius hippoglossoides	X	
Liparis herschelinus		X
Agonus acipenserinus		X
Theragra chalcogramma		X
Liparis dennyi		X

TABLE II

CONTINUED

Taxa	Common	Rare
Teleostei (cont'd)		
Clupea harengus pallasi		X
Lumpenus medius		X
Artediellus pacificus		X
Stenobrachius leucopsarus	X	
Bathylagus pacificus		X
Bathylagus alascanus		X
Ptilichthys goodei		X
Stenobrachius nannochir		X
Nectoliparis pelagicus		X
Bathylagus stilbius schmidti	X	
Hippoglossus stenolepis		X
Malacocottus zonurus		X
Hemilepidotus sp.		X
Chauliodus macouni		X
Bathymaster signatus		X
Triglops pingeli		X
Ammodytes hexapterus		X

considering three cruises and four regimes, a significant cruise effect ($P<0.05$) is evident for 22 categories, a regime effect is apparent for 25 categories, and the interaction of these factors is significant for 10 taxa (Table III). When four cruises and three regimes are examined using the same analysis, 24 categories exhibit a significant cruise effect, 28 show regime effects, and the interaction term is apparent for 14 (Table IV). The results of this statistical treatment demonstrate that seasonal and spatial fluctuations occur in the distribution of most common species or composites, and that for some the time-space distributions are very complex.

To examine the nature of these distributions, depictions of mean standing stock by cruise were drawn for each category (Figs. 2-33). When these distributions were further sorted by regime, several general distributions emerged (Table V).

Sixteen categories were usually found in greatest abundance in the open ocean regime seaward of the shelf break. This group includes the ecologically important interzonal copepods *Calanus cristatus*, *Calanus plumchrus*, and *Eucalanus b. bungii*, the pteropods *Clione limacina* and *Limacina helicina*, the chaetognath *Eukrohnia hamata*, the euphausiid *Thysanoessa longipes*, and the amphipod *Parathemisto pacifica*.

The copepod *Oithona spinirostris*, the euphausiid *Thysanoessa inermis*, and spider crab (Majiidae) larvae, mostly *Chionoecetes* spp., selected the outer shelf regime, while the central shelf water mass favored the copepods *Calanus glacialis*, *Calanus marshallae*, and *Pseudocalanus* spp., the amphipod *Parathemisto libellula*, the euphausiid *Thysanoessa raschii* and the arrow worm *Sagitta elegans*.

TABLE III

ANALYSIS OF VARIANCE FOR THREE CRUISES AND FOUR REGIMES
IN THE SOUTHEAST BERING SEA
MAY 1975 - NOVEMBER 1975

Taxonomic Category	Source of Variation					
	Cruise[1]		Regime[2]		Interaction	
	F[3]	df	F	df	F	df
Cnidaria						
Hydrozoa						
Aglantha digitale	**	2,87	*	3,87	NS	6,87
Dimophyes arctica	NS	2,39	**	3,39	NS	6,39
Mollusca						
Pteropoda						
Clione limacina	**	2,59	**	3,59	NS	6,59
Limacina helicina	**	2,81	**	3,81	**	6,81
Crustacea						
Ostracoda						
Conchoecia spp.	NS	2,47	**	3,47	NS	6,47
Copepoda						
Acartia longiremis	**	2,91	**	3,91	**	6,91
Calanus cristatus	*	2,24	**	3,24	NS	6,24
C. glacialis	**	2,29	NS	3,29	NS	6,29
C. marshallae	**	2,91	**	3,91	NS	6,91
C. plumchrus	NS	2,66	**	3,66	NS	6,66
C. spp. (juveniles)	**	2,83	NS	3,83	*	6,83
Eucalanus b. bungii	**	2,50	**	3,50	**	6,50
Metridia lucens	NS	2,81	**	3,81	NS	6,81
Oithona similis	**	2,91	**	3,91	**	6,91
O. spinirostrus	NS	2,42	**	3,48	NS	6,48
Pseudocalanus spp.	**	2,91	NS	3,91	NS	6,91
Nauplii (composite)	**	2,76	**	3,76	**	6,76
Amphipoda						
Parathemisto libellula	*	2,65	**	3,65	*	6,65
P. pacifica	**	2,66	**	3,66	NS	6,66
Euphausiacea						
Thysanoessa inermis	**	2,59	**	3,59	NS	6,59
T. longipes	NS	2,51	**	3,51	NS	6,51
T. raschii	**	2,63	**	3,63	**	6,63
T. spinifera	NS	2,43	NS	3,43	NS	6,43
T. spp. (juveniles)	NS	2,32	NS	3,32	NS	6,32
T. spp. (eggs and larvae)	**	2,91	NS	3,91	NS	6,91

TABLE III

CONTINUED

Taxonomic Category	Source of Variation: Cruise[1] F[3]	df	Regime[2] F	df	Interaction F	df
Crustacea (cont'd)						
Decapoda						
Majiidae (composite)	**	2,77	*	3,77	**	6,77
Chaetognatha						
Eukrohnia hamata	NS	2,58	**	3,58	NS	6,58
Sagitta elegans	**	2,91	**	3,91	NS	6,91
Composite (juveniles)	*	2,91	**	3,91	NS	6,91
Chordata						
Larvacea						
Oikopleura spp.	*	2,73	**	3,73	NS	6,73
Composite	NS	2,67	NS	3,67	NS	6,67
Teleostei						
Theragra chalcogramma	-	-	-	-	-	-
DRY WEIGHT (composite)	*	2,91	*	3,91	*	6,91

[1] May-June 1975; August 1975; October-November 1976.

[2] Open ocean; Outer shelf; Central shelf; Northern coastal.

[3] * = $P \leq 0.05$; ** = $P \leq 0.01$; NS = $P > 0.05$

TABLE IV

ANALYSIS OF VARIANCE FOR FOUR CRUISES AND THREE REGIMES
IN THE SOUTHEAST BERING SEA
MAY 1975 - APRIL 1976

Taxonomic Category	Source of Variation					
	Cruise[1]		Regime[2]		Interaction	
	F[3]	df	F	df	F	df
Cnidaria						
Hydrozoa						
Aglantha digitale	**	3,89	NS	2,89	*	6,89
Dimophyes arctica	NS	3,66	**	2,66	*	6,66
Mollusca						
Pteropoda						
Clione limacina	**	3,86	*	2,86	NS	6,86
Limacina helicina	**	3,93	**	2,93	**	6,93
Crustacea						
Ostracoda						
Conchoecia spp.	NS	3,57	**	2,57	NS	6,57
Copepoda						
Acartia longiremis	**	3,93	**	2,93	**	6,93
Calanus cristatus	**	3,51	**	2,51	*	6,51
C. glacialis	**	3,32	NS	2,32	NS	6,32
C. marshallae	**	3,93	**	2,93	NS	6,93
C. plumchrus	NS	3,93	**	2,93	NS	6,93
C. spp. (juveniles)	**	3,93	**	2,93	**	6,93
Eucalanus b. bungii	**	3,77	**	2,77	**	6,77
Metridia lucens	NS	3,93	**	2,93	NS	6,93
Oithona similis	**	3,93	NS	2,93	**	6,93
O. spinirostrus	NS	3,65	**	2,65	NS	6,65
Pseudocalanus spp.	**	3,93	**	2,93	NS	6,93
Nauplii (composite)	**	3,78	**	2,78	**	6,78
Amphipoda						
Parathemisto libellula	*	3,60	**	2,60	NS	6,60
P. pacifica	**	3,93	**	2,93	NS	6,93
Euphausiacea						
Thysanoessa inermis	**	3,86	**	2,86	NS	6,86
T. longipes	NS	3,75	**	2,75	NS	6,75
T. raschii	**	3,67	**	2,67	**	6,67
T. spinifera	NS	3,60	NS	2,60	NS	6,60
T. spp. (juveniles)	**	3,43	NS	2,43	NS	6,43
T. spp. (eggs and larvae)	**	3,93	**	2,93	NS	6,93

TABLE IV

CONTINUED

Taxonomic Category	Source of Variation					
	Cruise[1]		Regime[2]		Interaction	
	F[3]	df	F	df	F	df
Crustacea (cont'd)						
Decapoda						
Majiidae (composite)	**	3,87	*	2,87	**	6,87
Chaetognatha						
Eukrohnia hamata	NS	3,86	**	2,86	NS	6,86
Sagitta elegans	**	3,93	**	2,93	NS	6,93
Composite (juveniles)	*	3,93	**	2,93	NS	6,93
Chordata						
Larvacea						
Oikopleura spp.	*	3,93	**	2,93	NS	6,93
Composite	NS	3,76	**	2,76	*	6,76
Teleostei						
Theragra chalcogramma	**	3,17	*	2,17	**	6,17
DRY WEIGHT (composite)	*	3,93	*	2,93	*	6,93

[1] May-June 1975; August 1975; October-November 1975; March-April 1976.

[2] Open ocean; Outer shelf; Central shelf

[3] * = $P \leq 0.05$; ** = $P \leq 0.01$; NS = $P > 0.05$

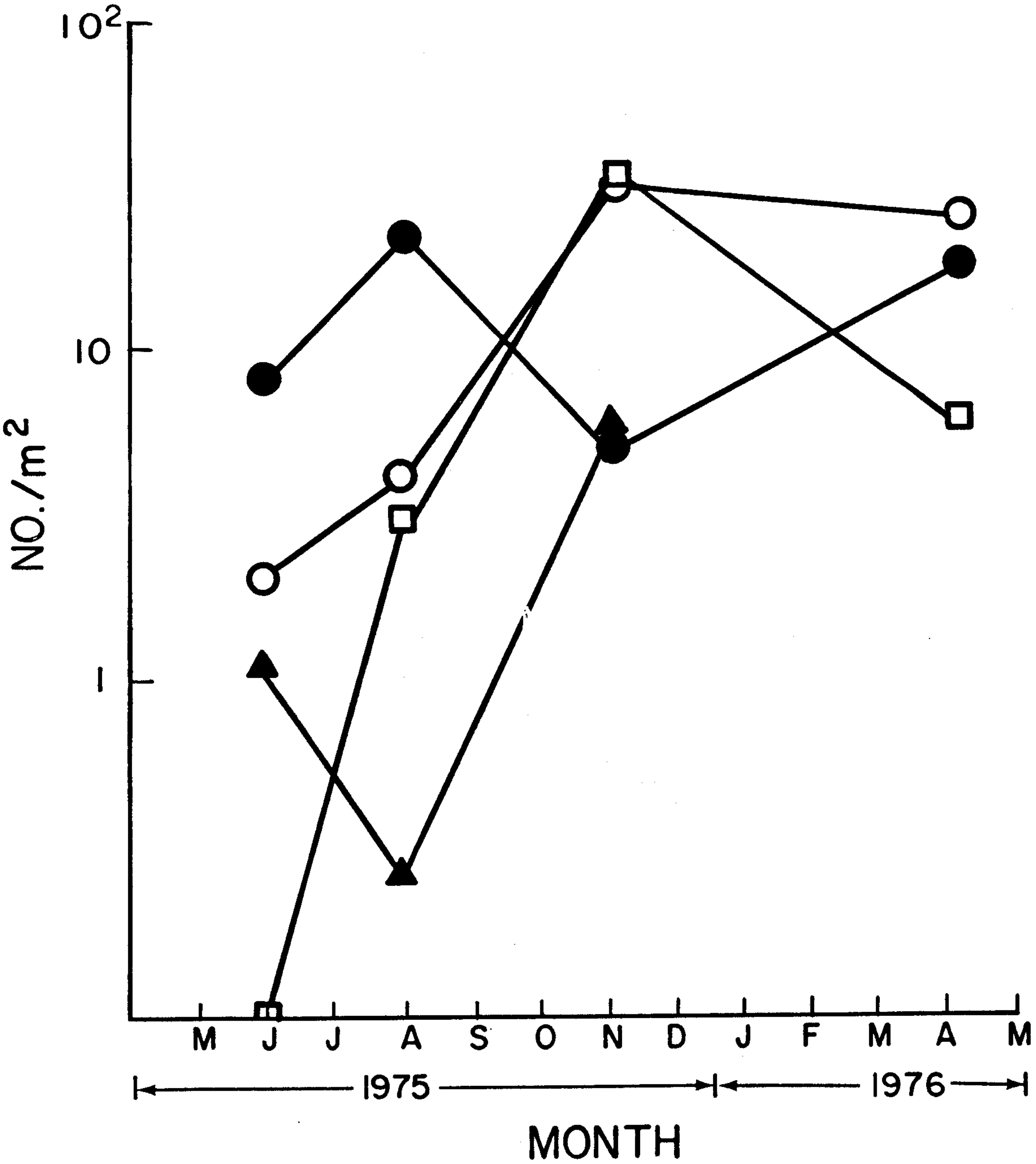


Figure 2. The average abundance of the hydrozoan, *Aglantha digitale*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regimes; squares the outer shelf; open circles the central shelf; and triangles the northern coastal regime.

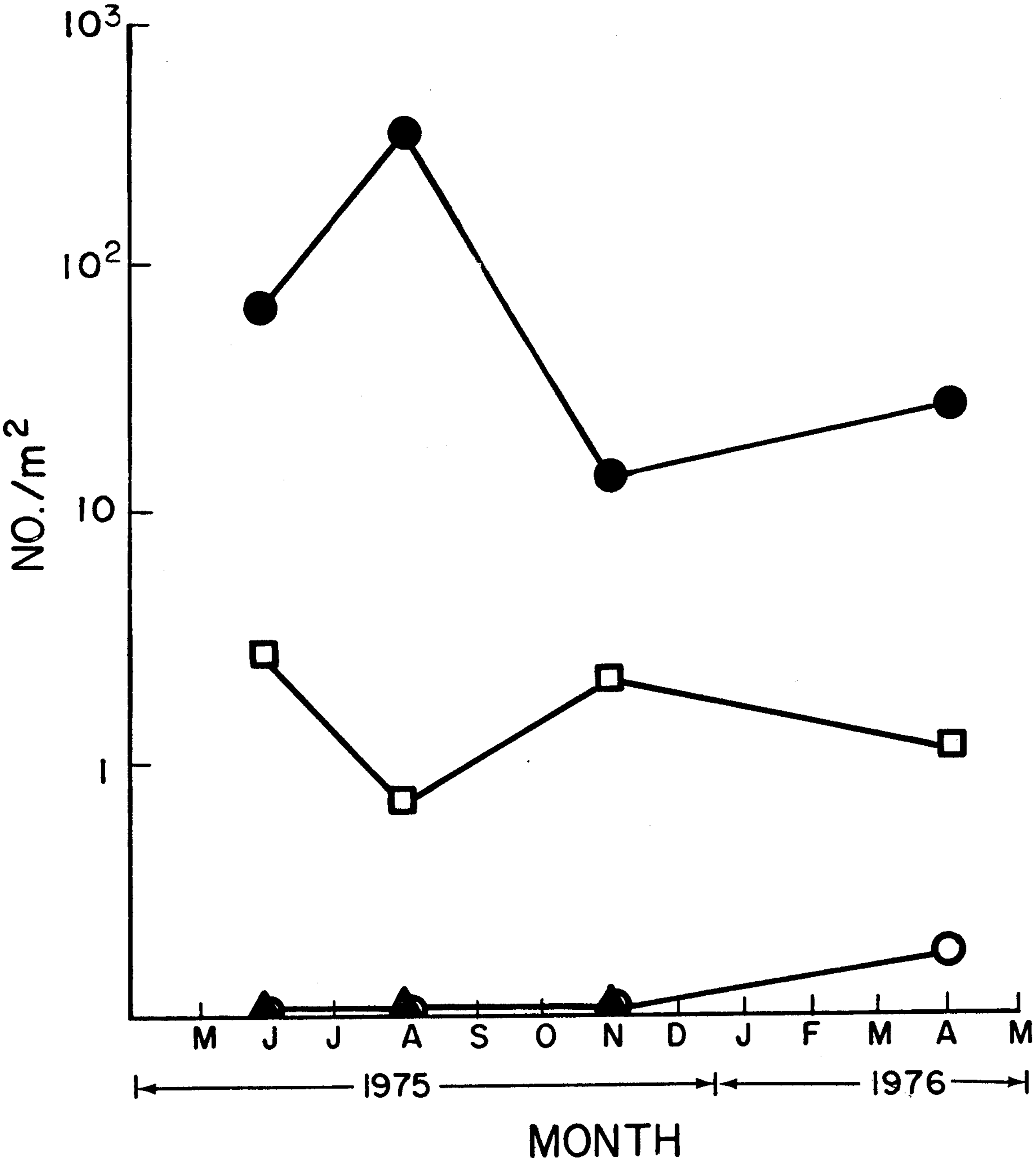


Figure 3. The average abundance of the hydrozoan, *Dimophyes arctica*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles the central shelf; and triangles, the northern coastal regime.

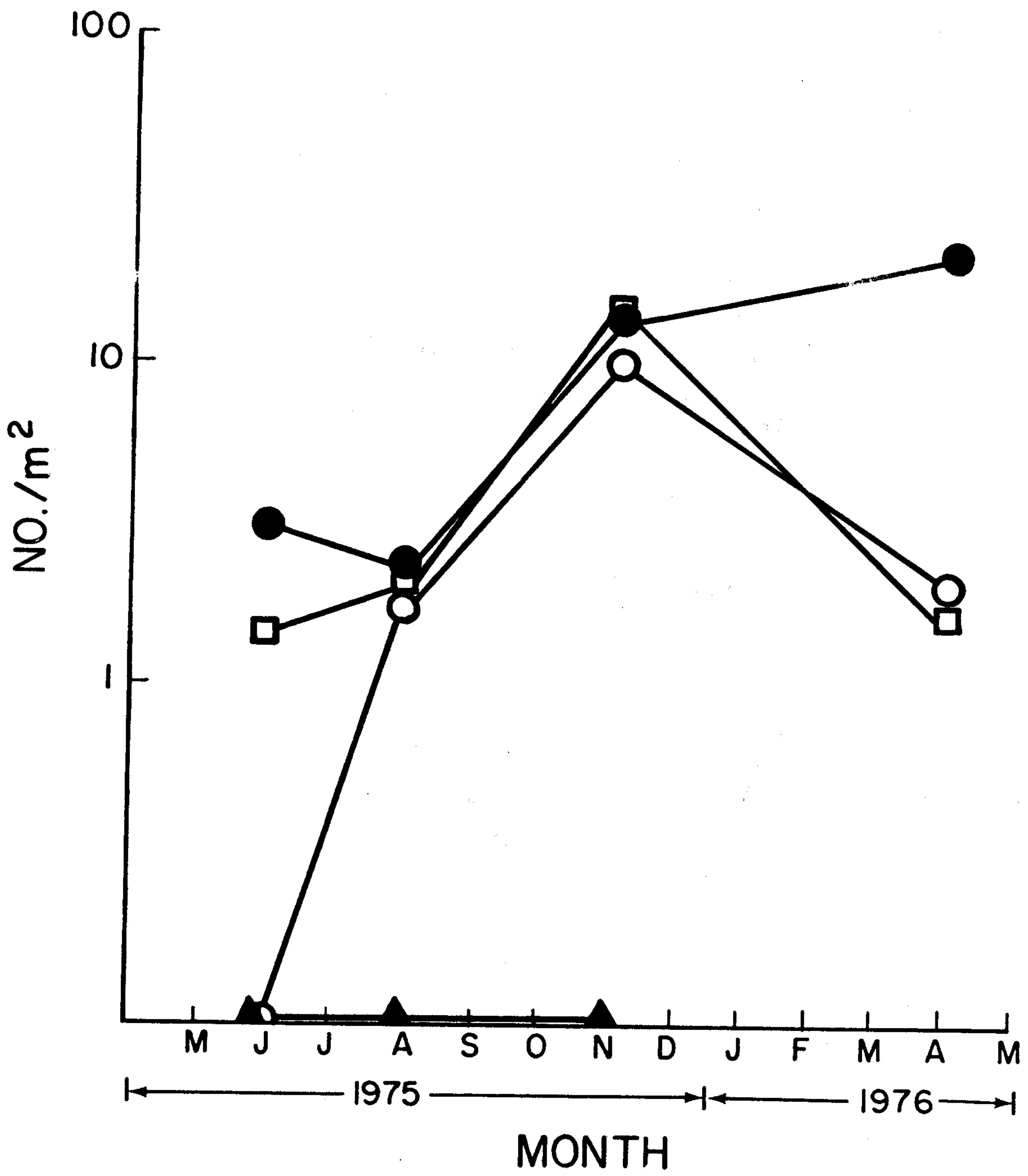


Figure 4. The average abundance of the pteropod, *Clione limacina*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

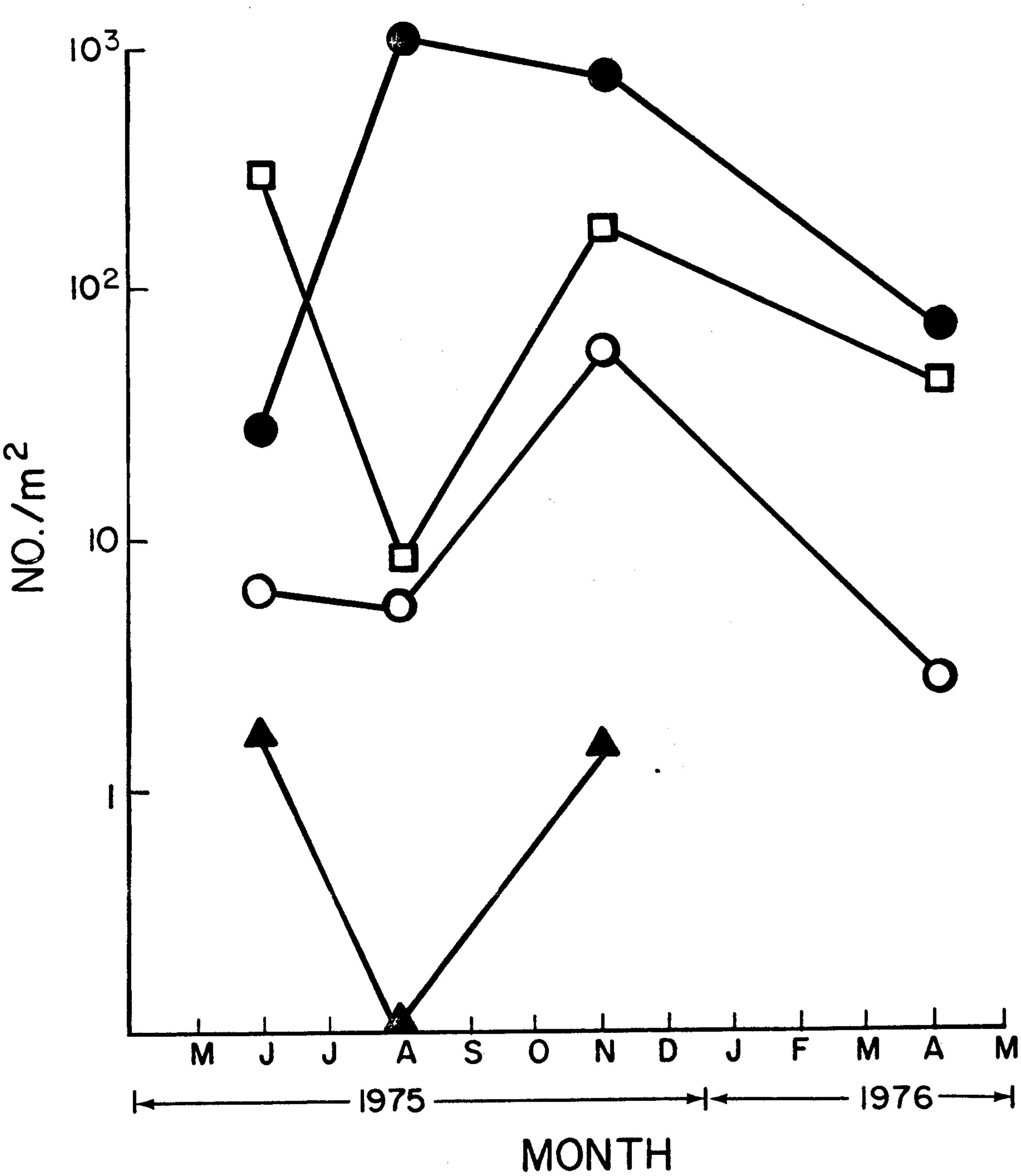


Figure 5. The average abundance of the pteropod, *Limacina helicina*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

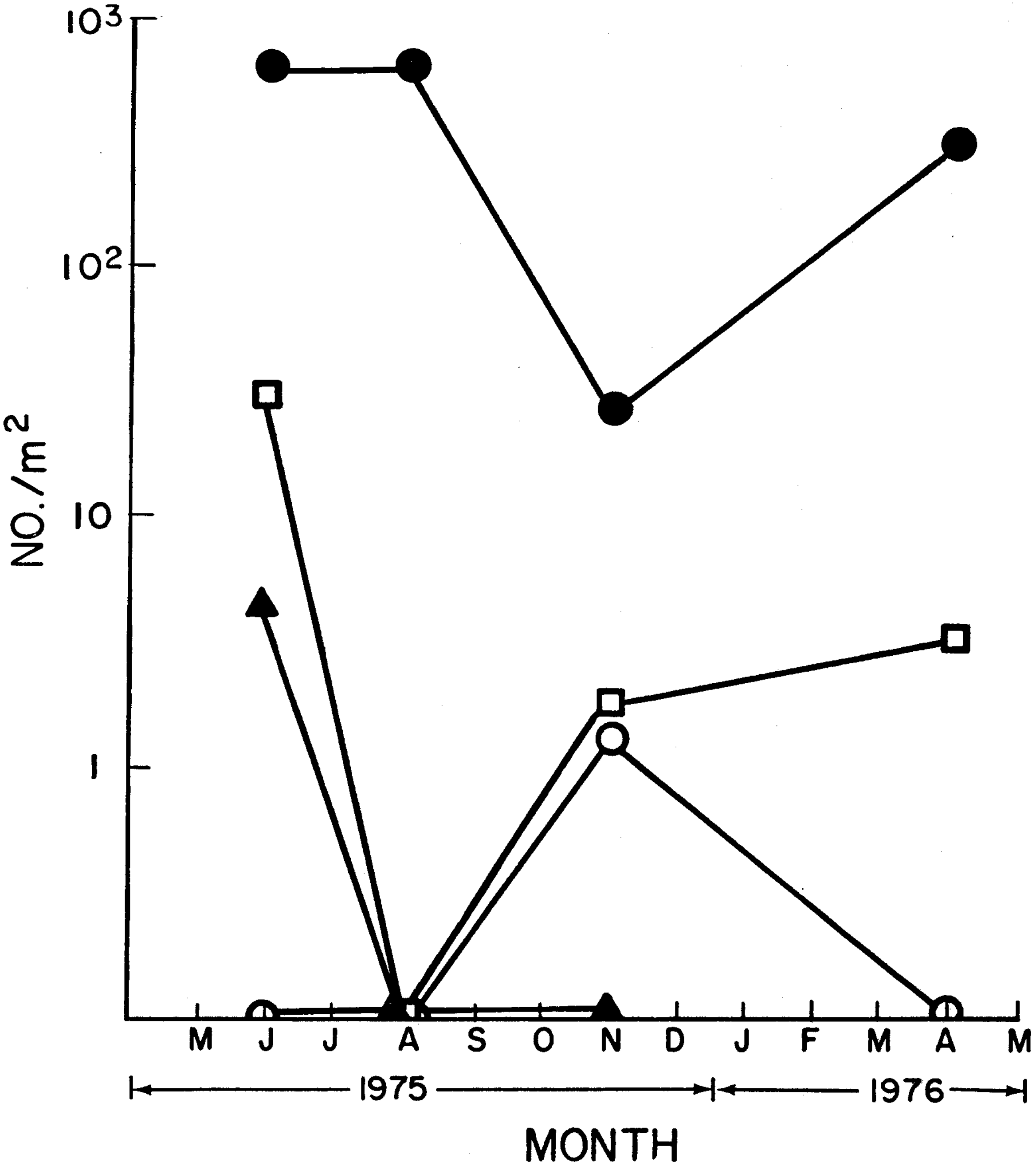


Figure 6. The average abundance of ostracods, *Conchoecia* spp., in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

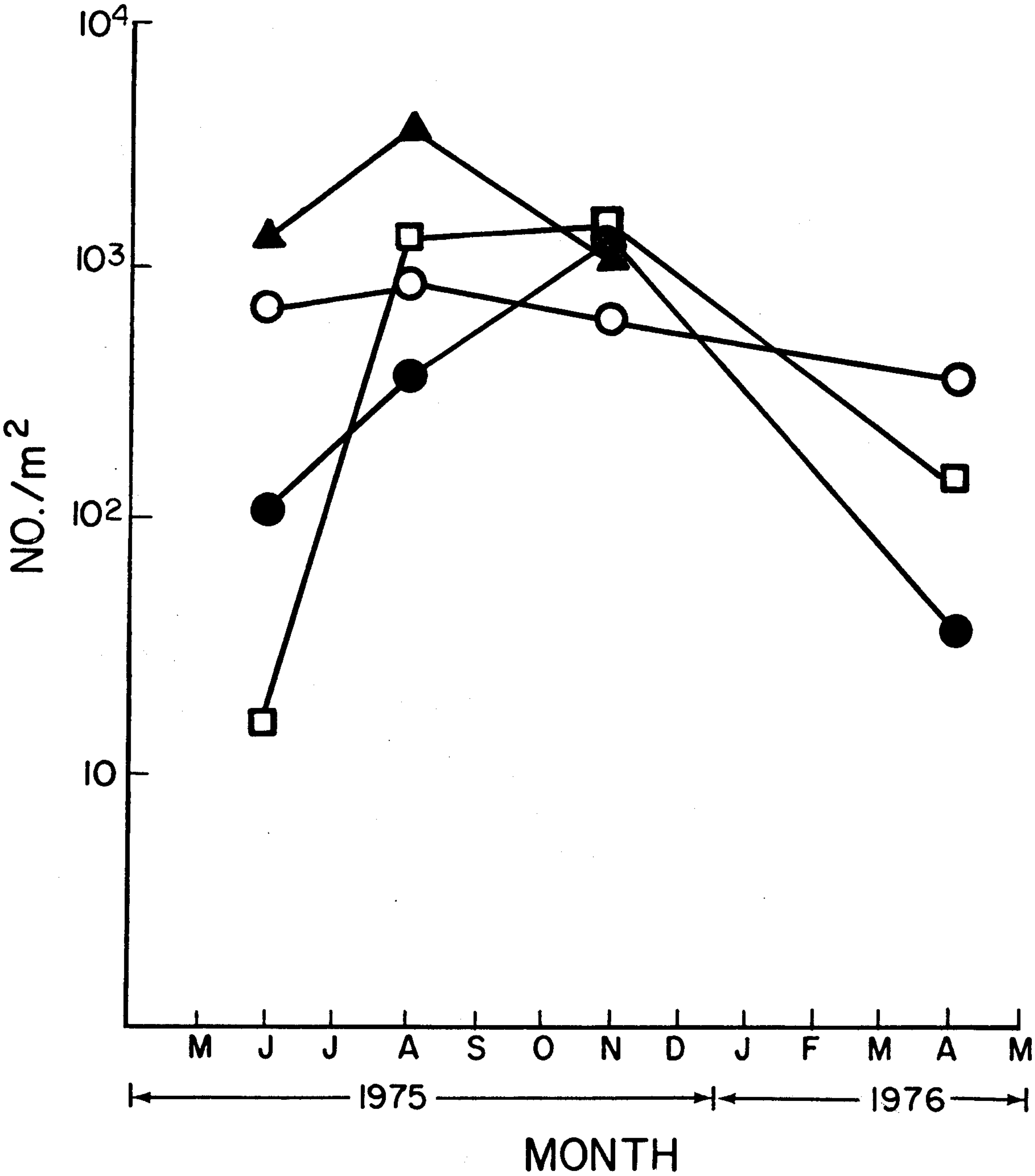


Figure 7. The average abundance of the copepod, *Acartia longiremis*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

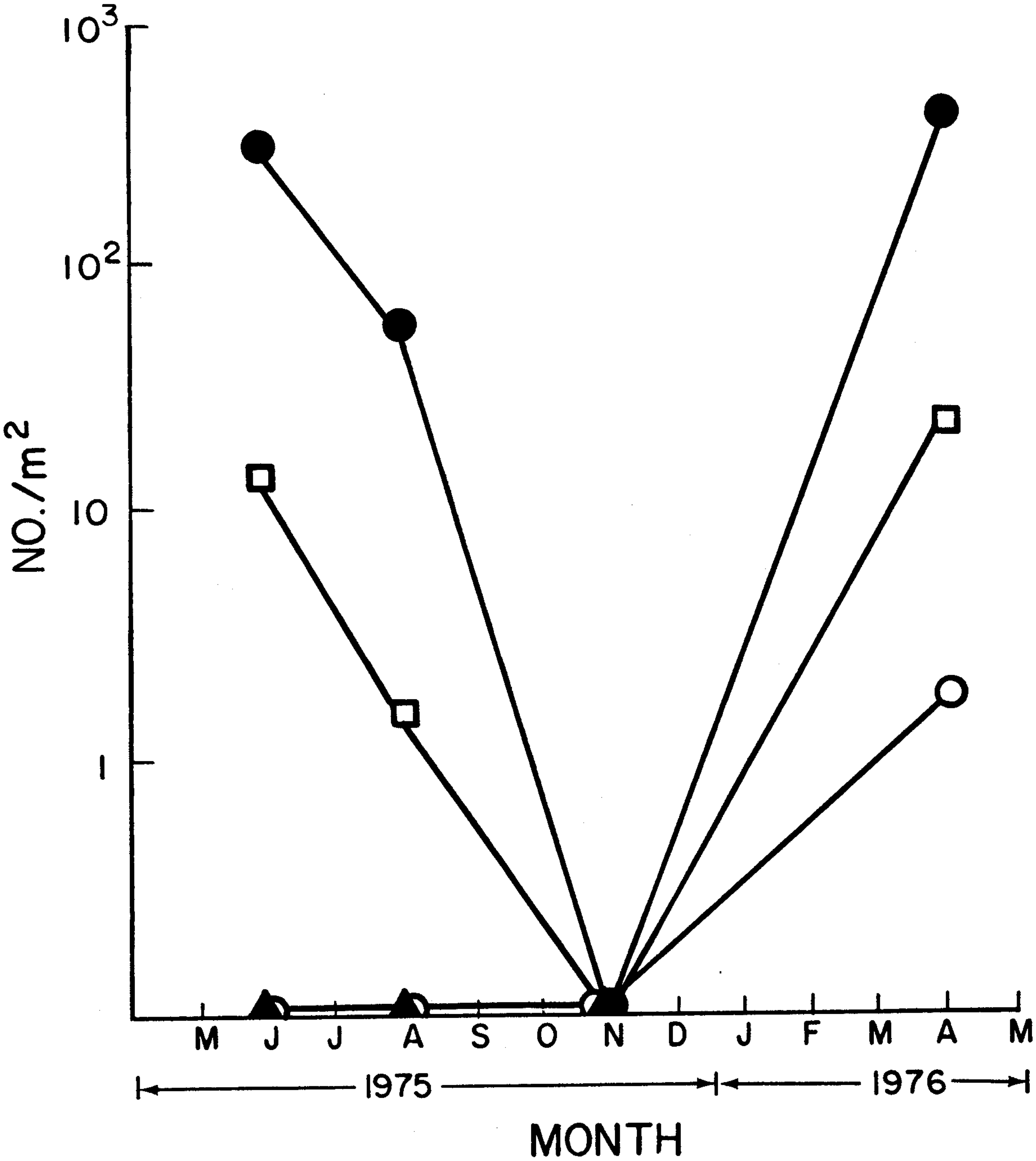


Figure 8. The average abundance of the copepod, *Calanus cristatus*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

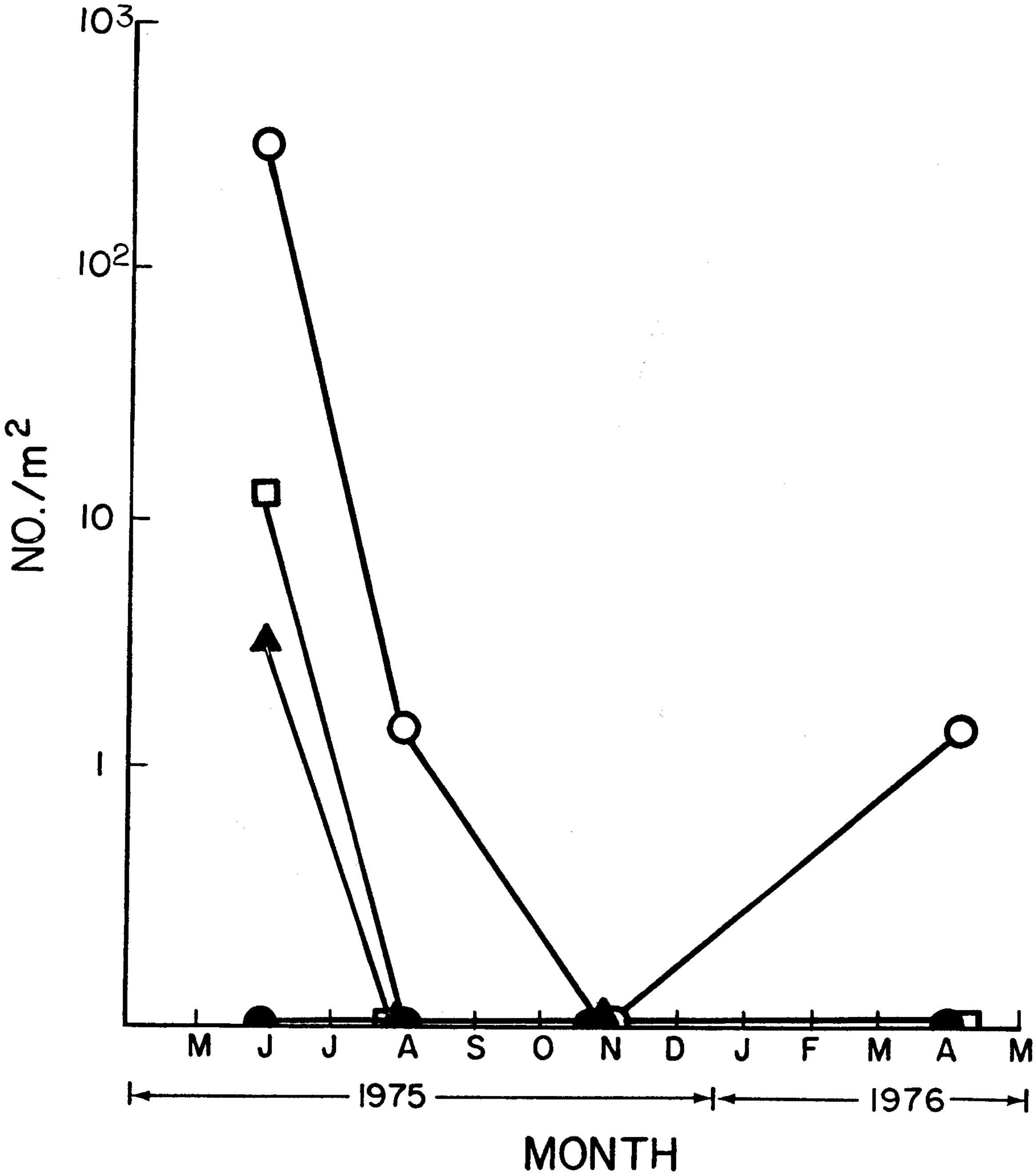


Figure 9. The average abundance of the copepod, *Calanus glacialis*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

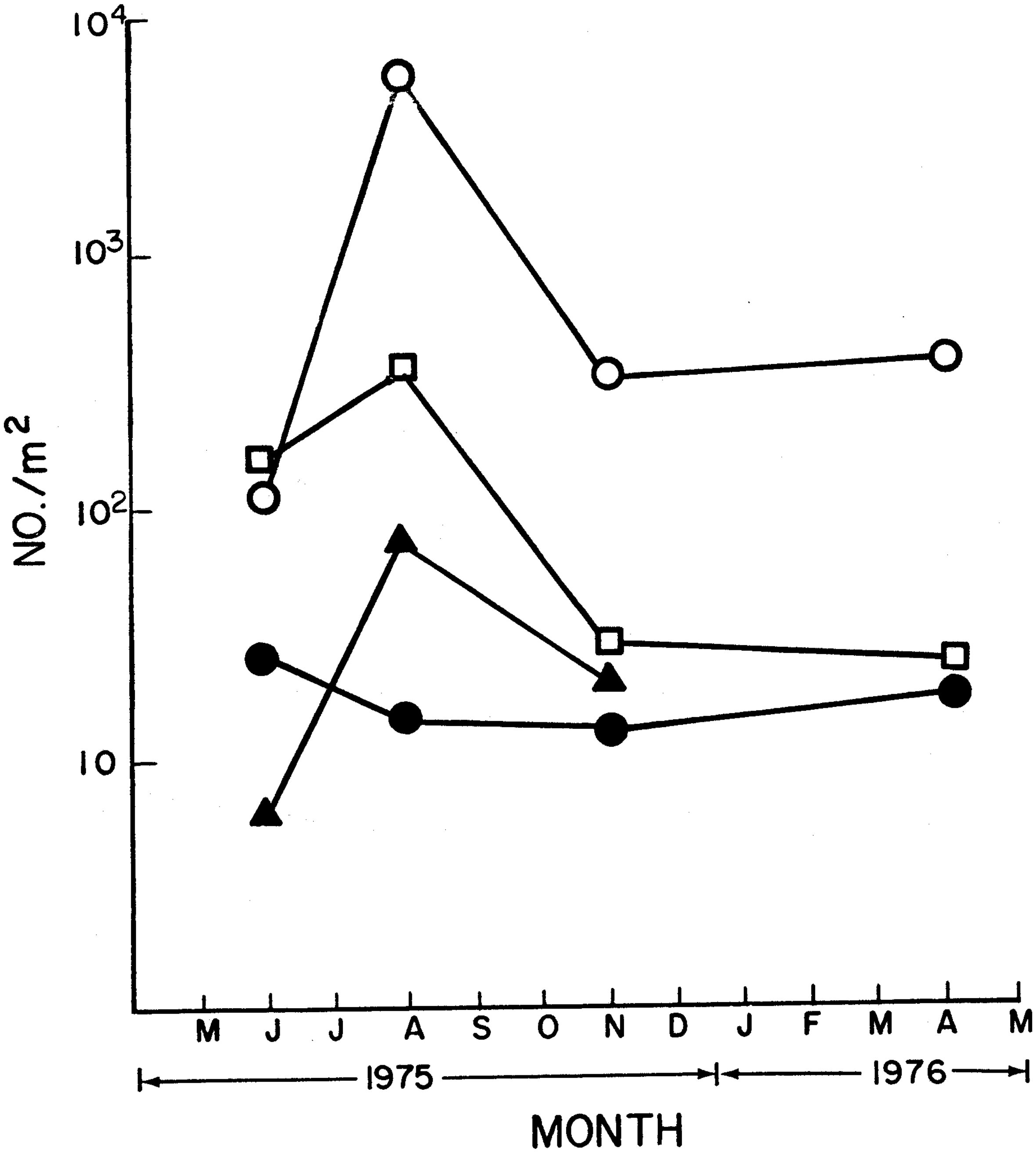


Figure 10. The average abundance of the copepod, *Calanus marshallae*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

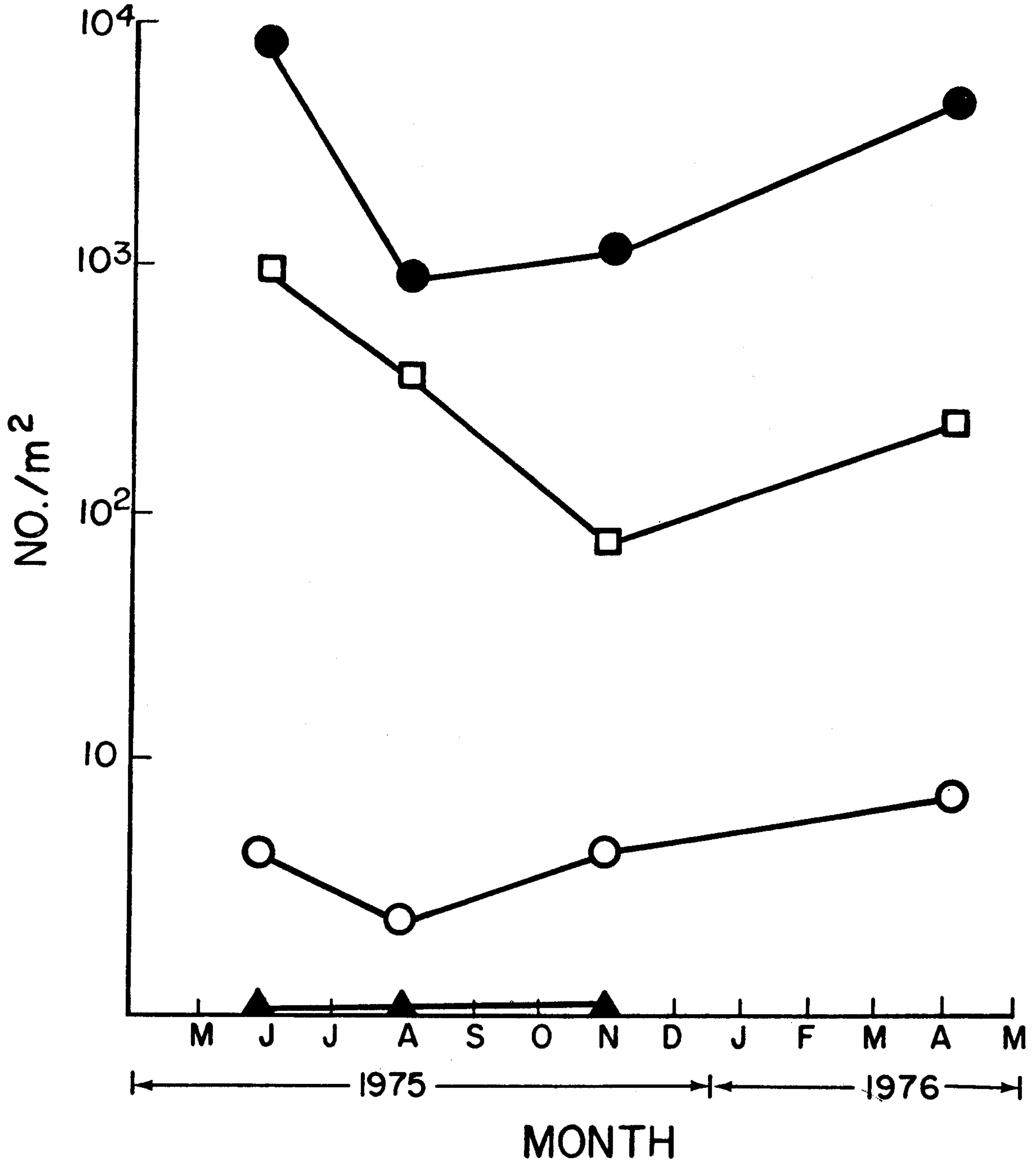


Figure 11. The average abundance of the copepod, *Calanus plumchrus*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

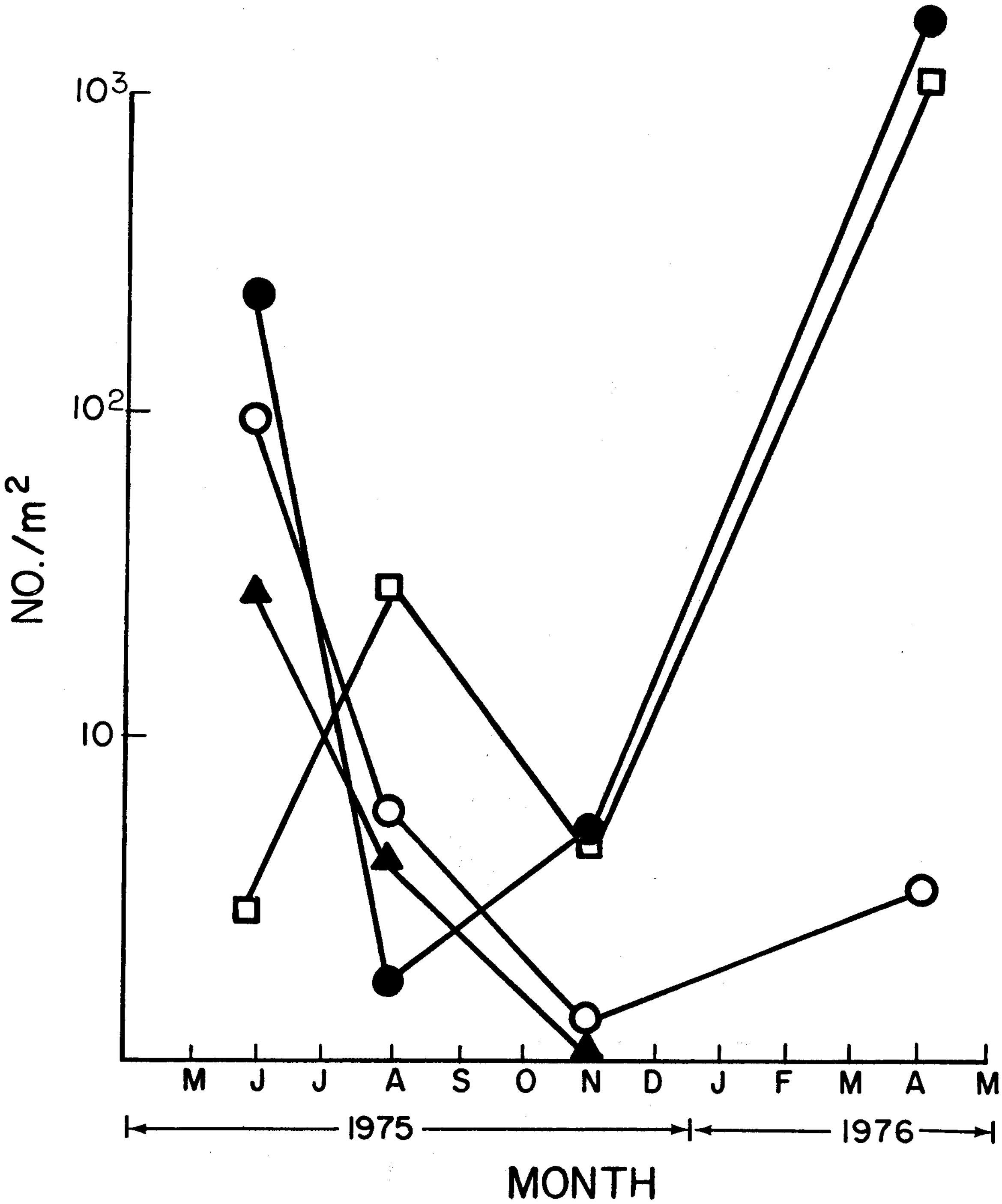


Figure 12. The average abundance of the *Calanus* spp. copepodites in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

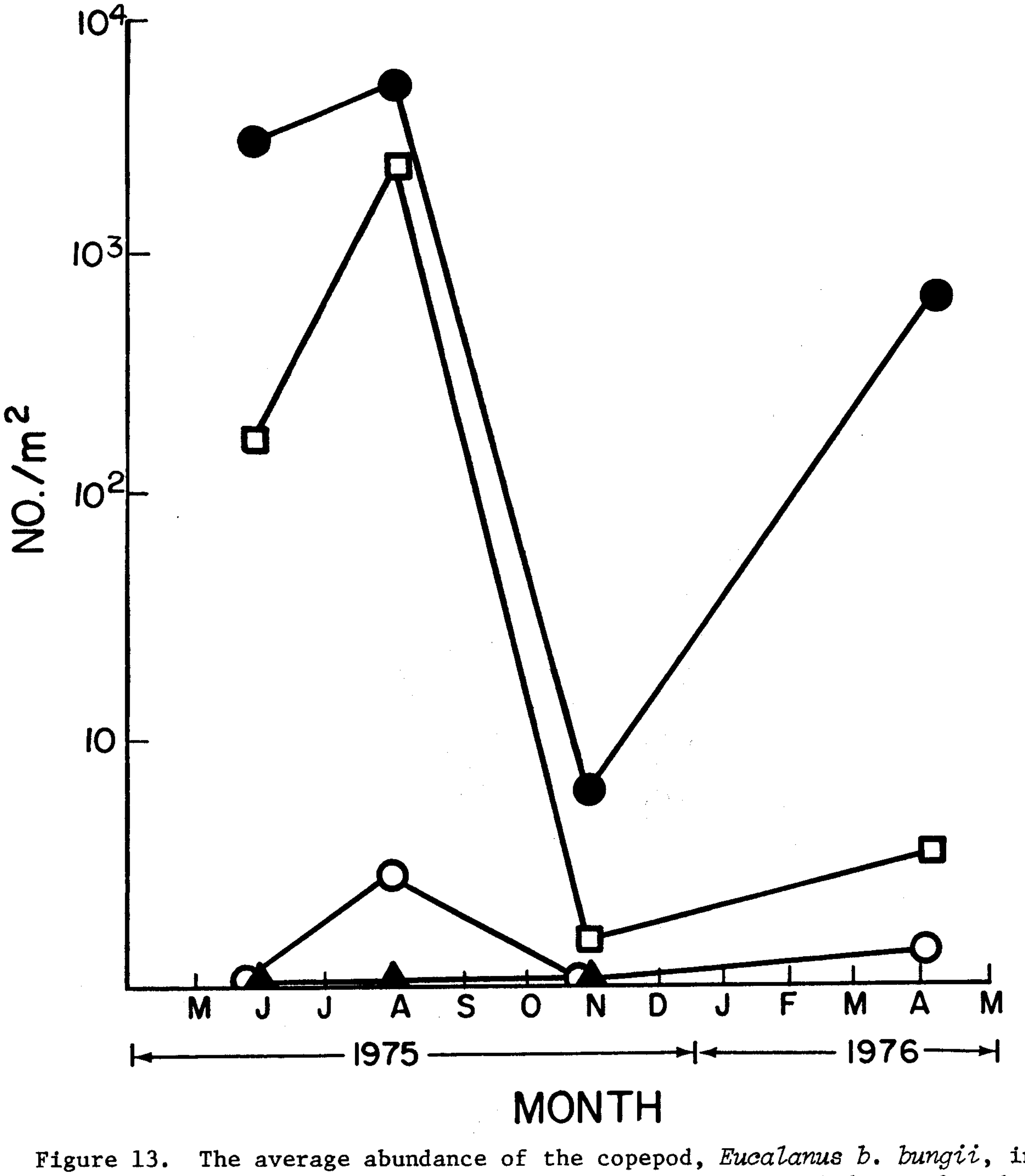


Figure 13. The average abundance of the copepod, *Eucalanus b. bungii*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

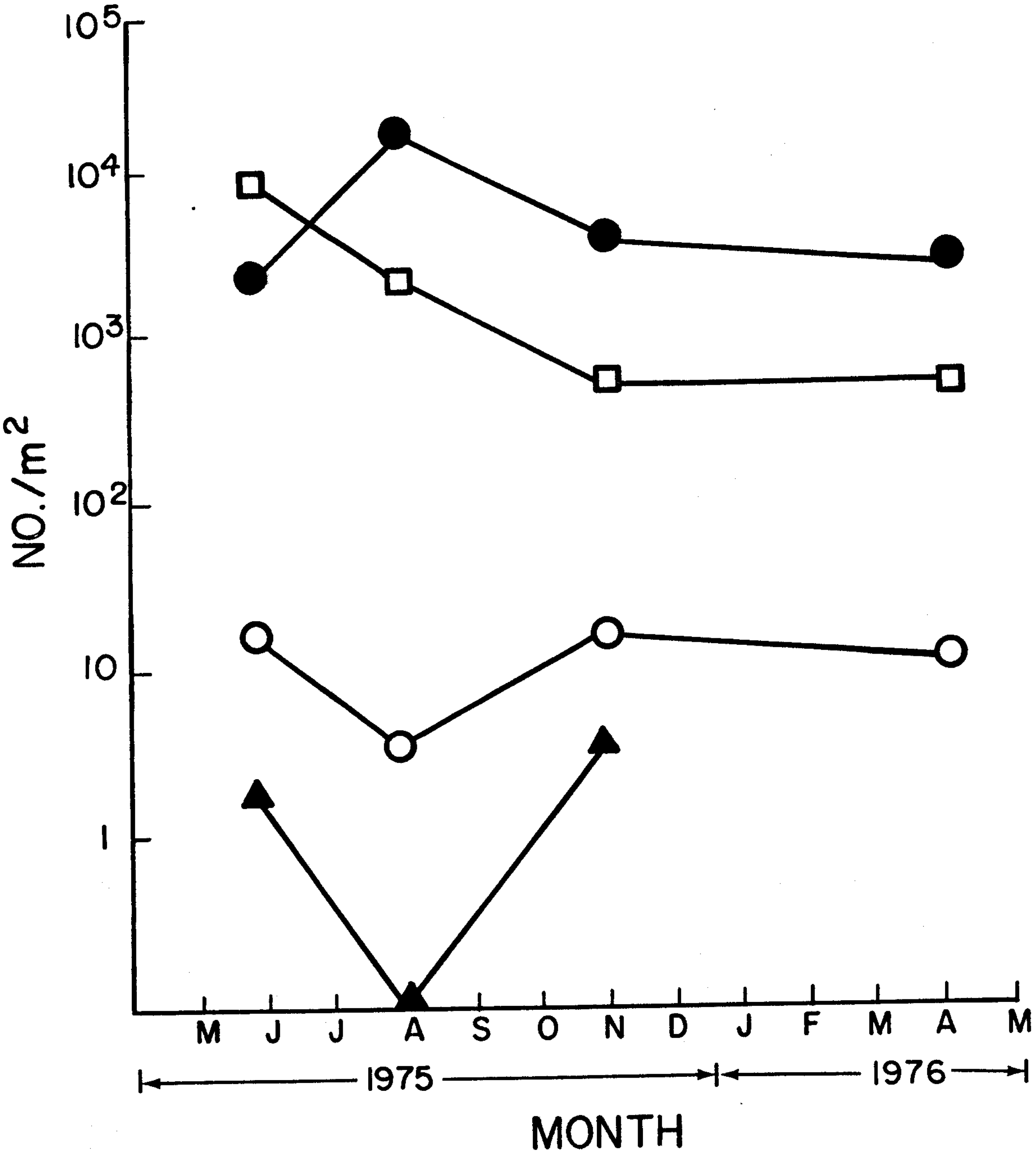


Figure 14. The average abundance of the copepod, *Metridia lucens*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

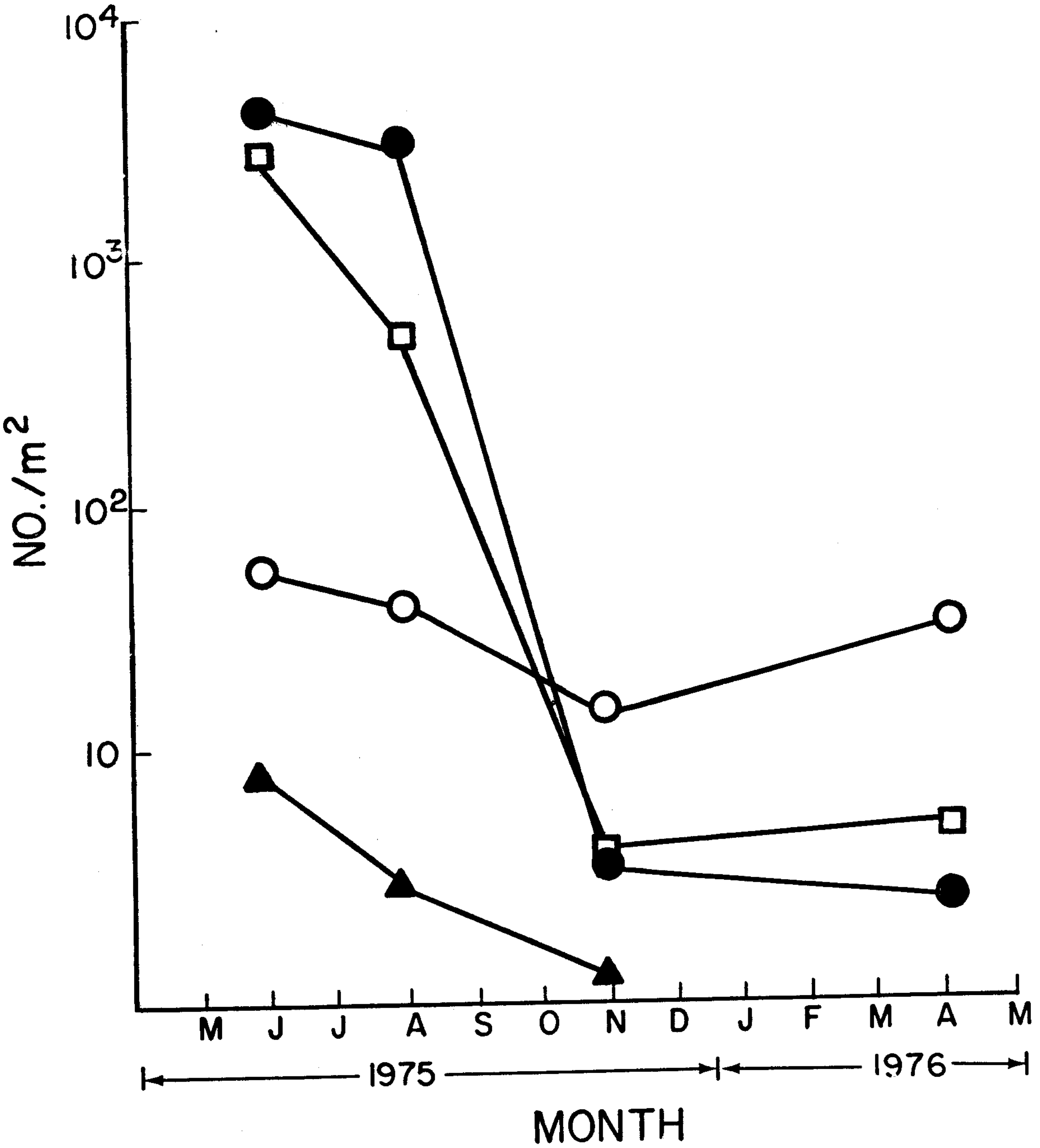


Figure 15. The average abundance of the copepod, *Oithona similis*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

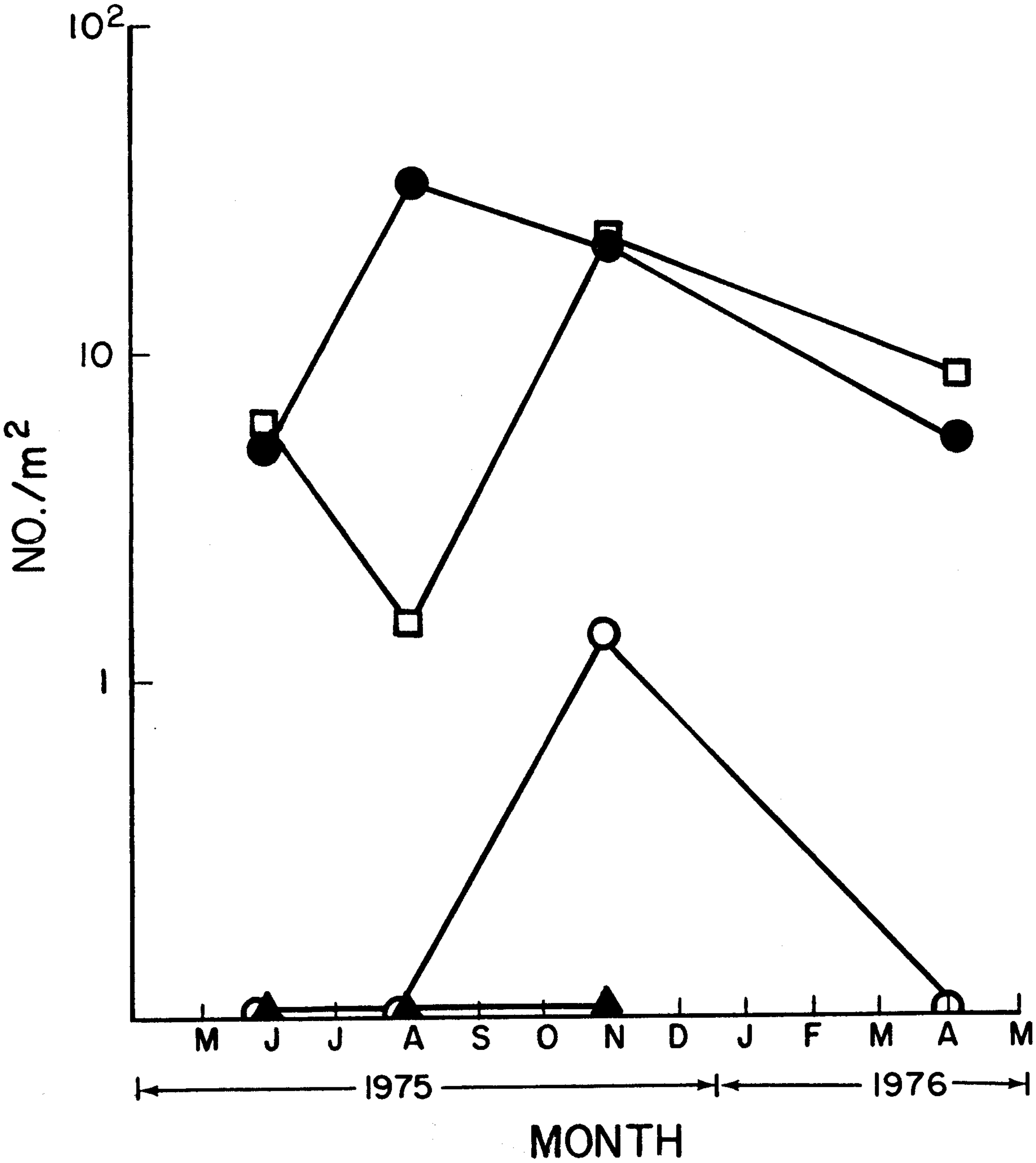


Figure 16. The average abundance of the copepod, *Oithona spinirostris*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

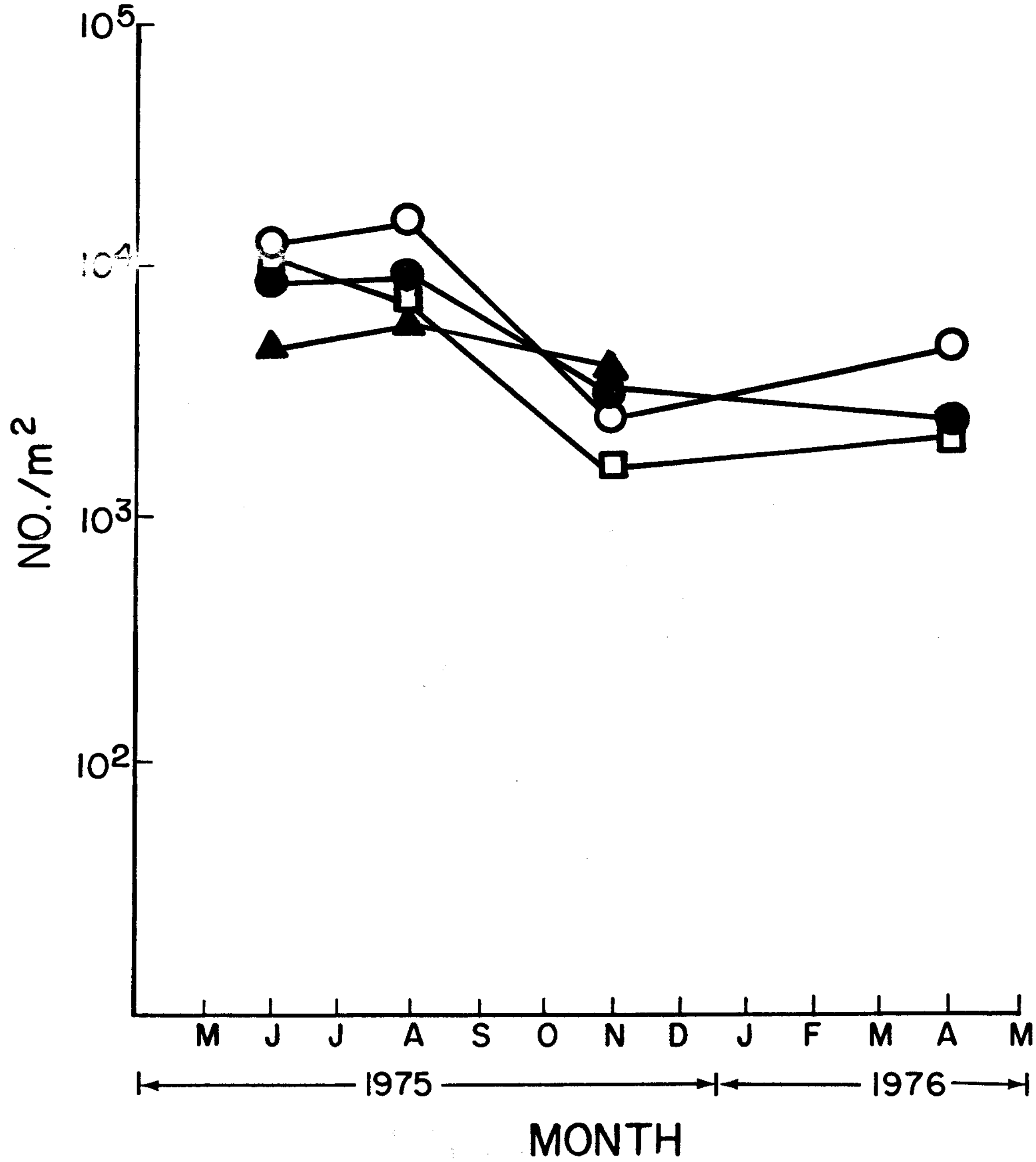


Figure 17. The average abundance of the copepod, *Pseudocalanus* spp., in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

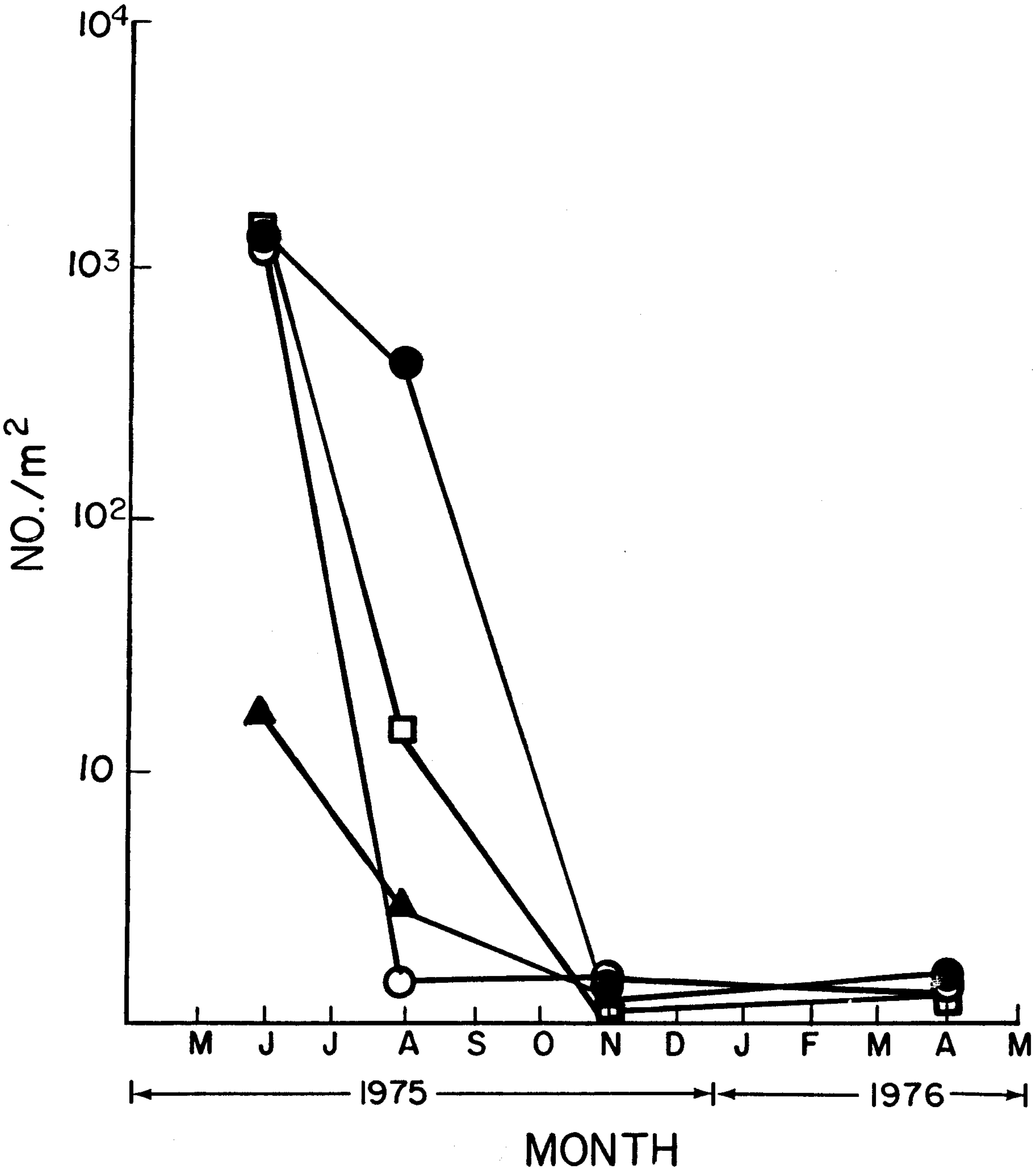


Figure 18. The average abundance of a composite of unidentified copepod nauplii in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

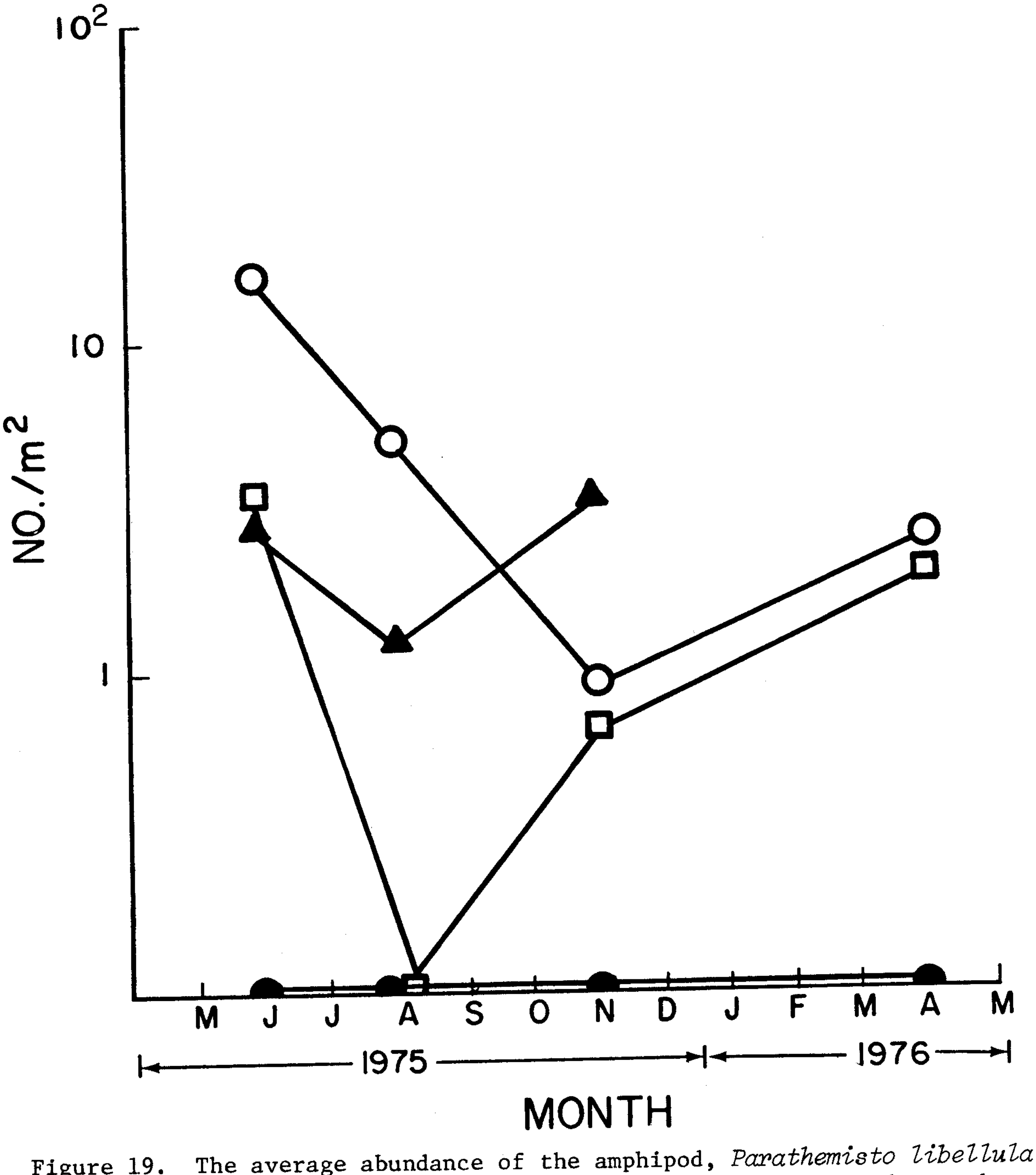


Figure 19. The average abundance of the amphipod, *Parathemisto libellula*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

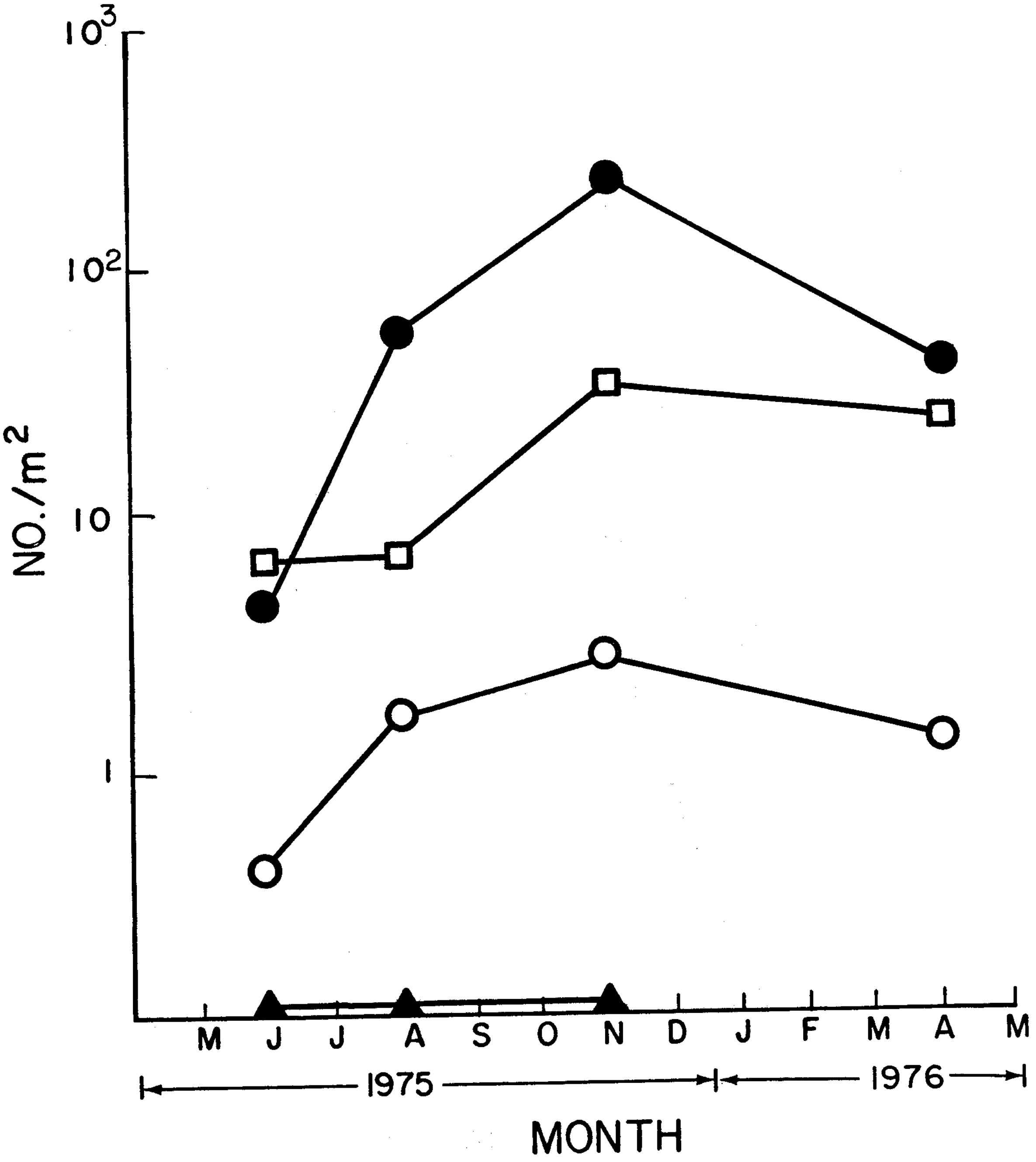


Figure 20. The average abundance of the amphipod, *Parathemisto pacifica*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

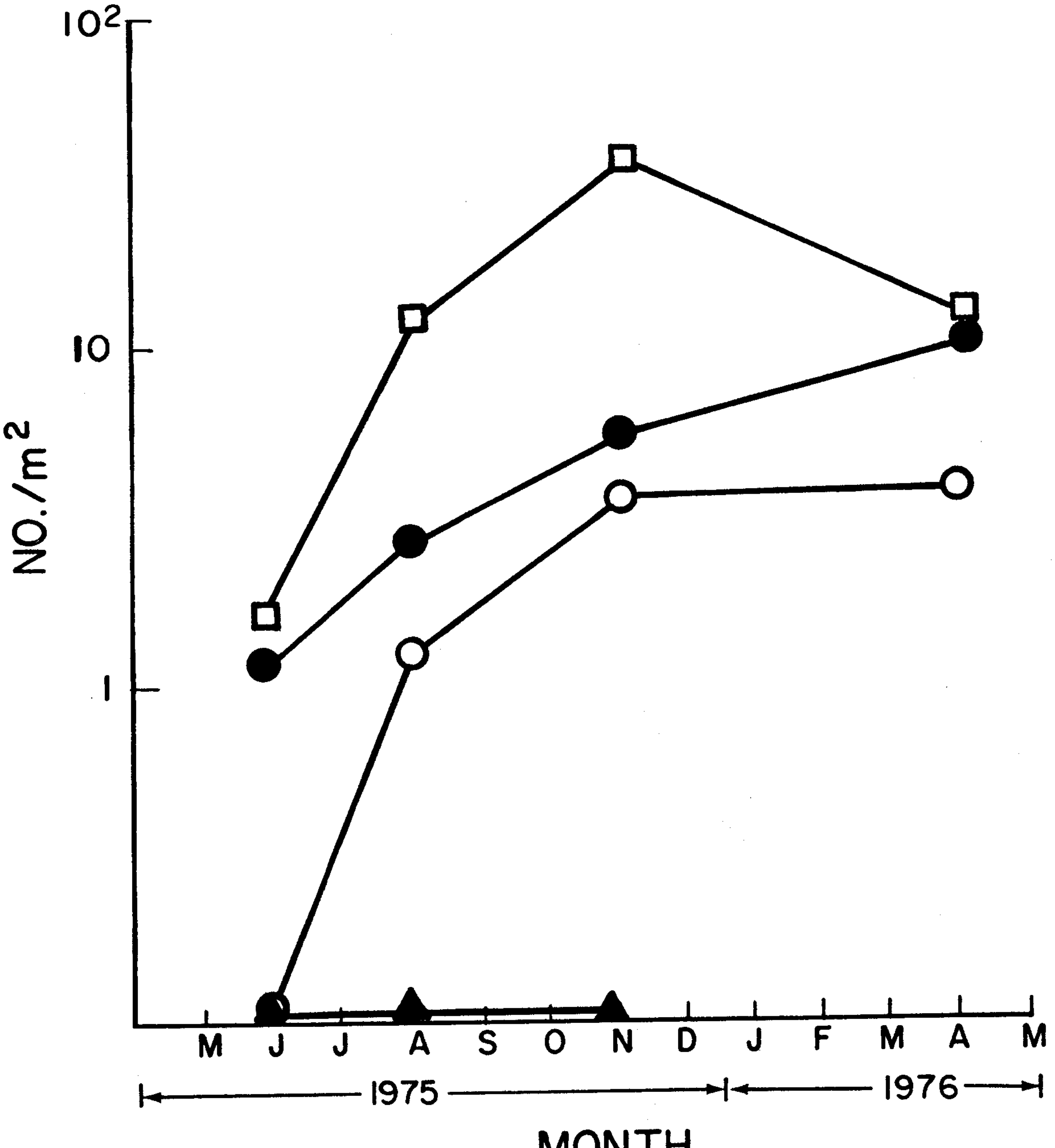


Figure 21. The average abundance of the euphausiid, *Thysanoessa inermis*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

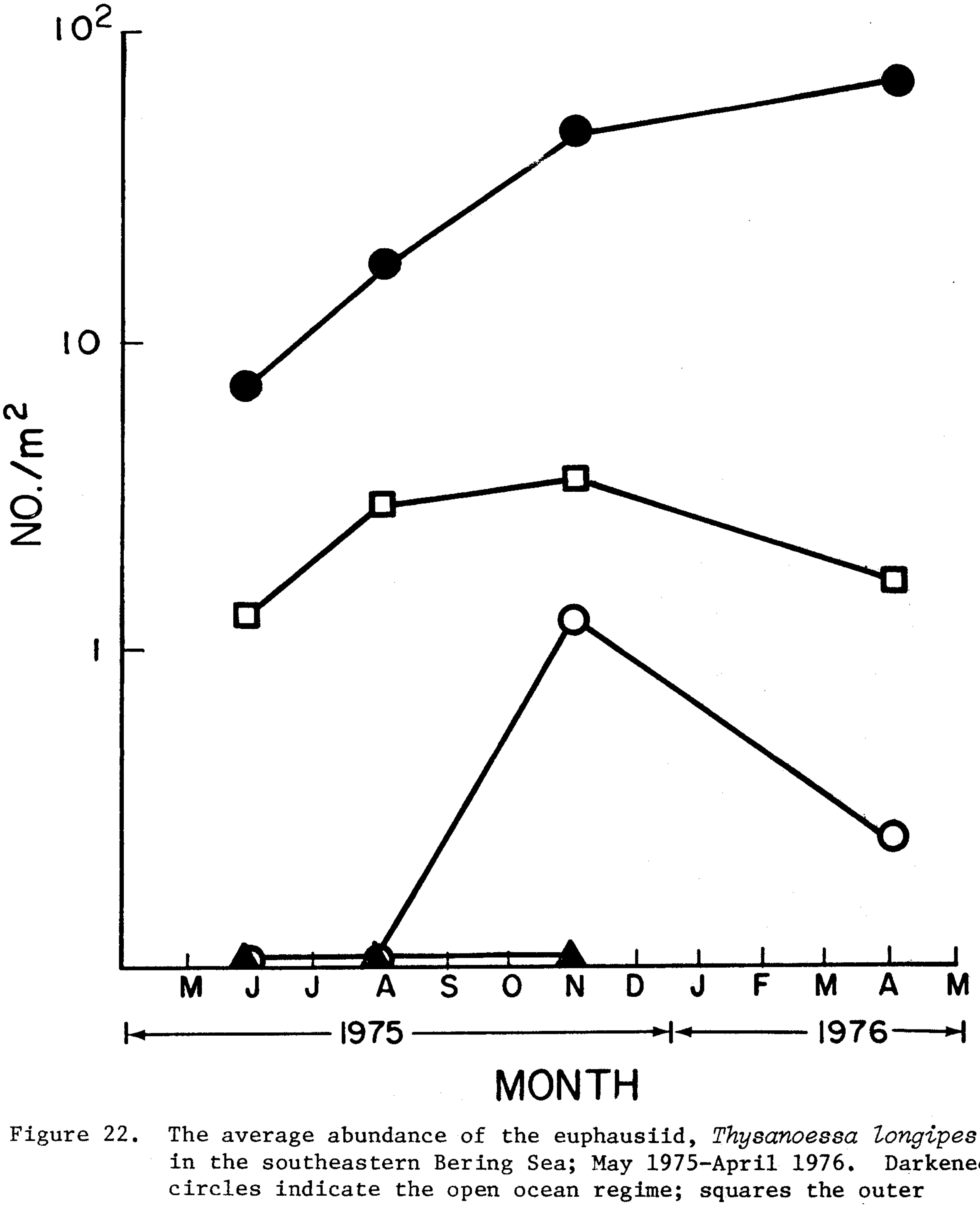


Figure 22. The average abundance of the euphausiid, *Thysanoessa longipes*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

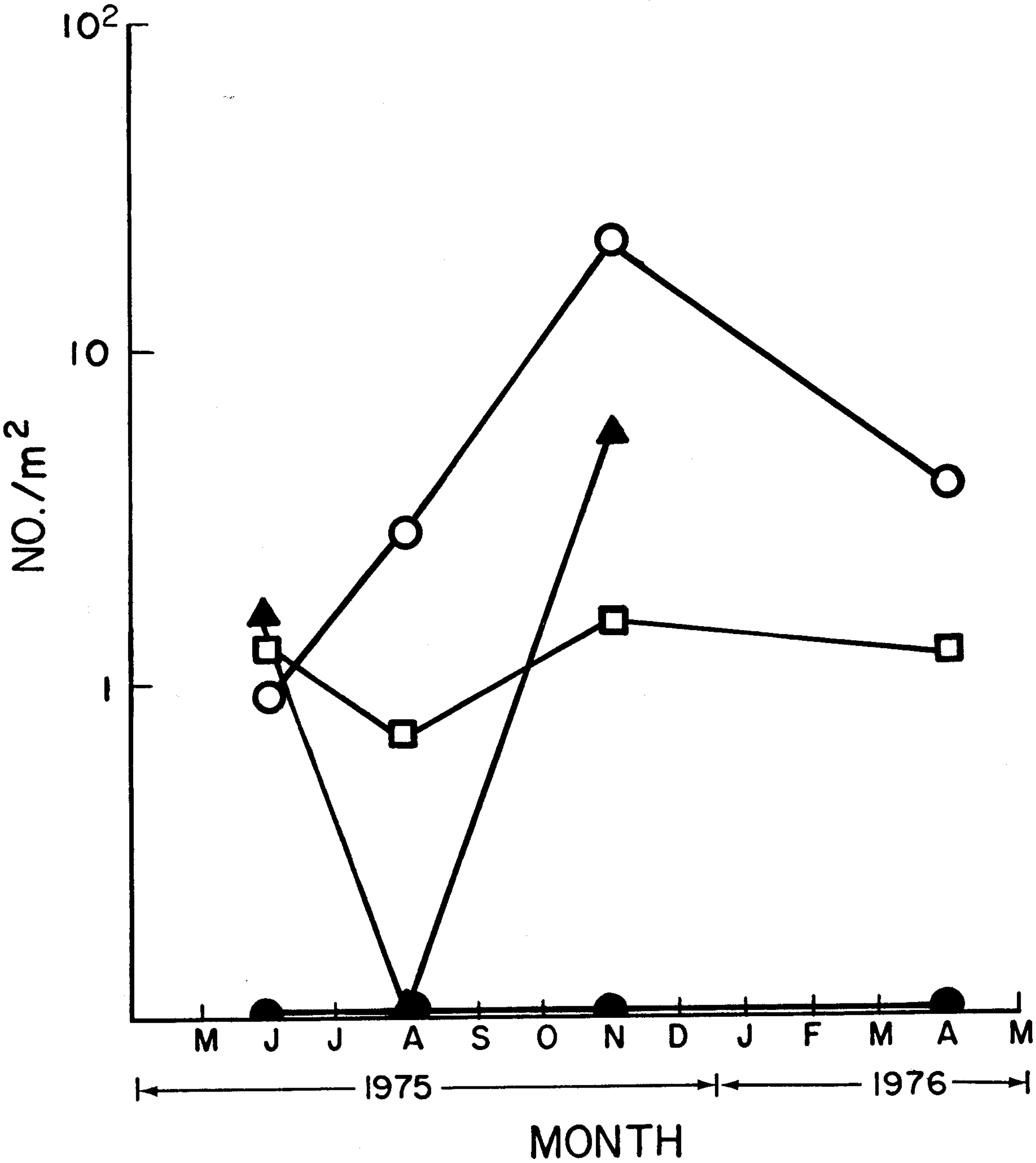


Figure 23. The average abundance of the euphausiid, *Thysanoessa raschii*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

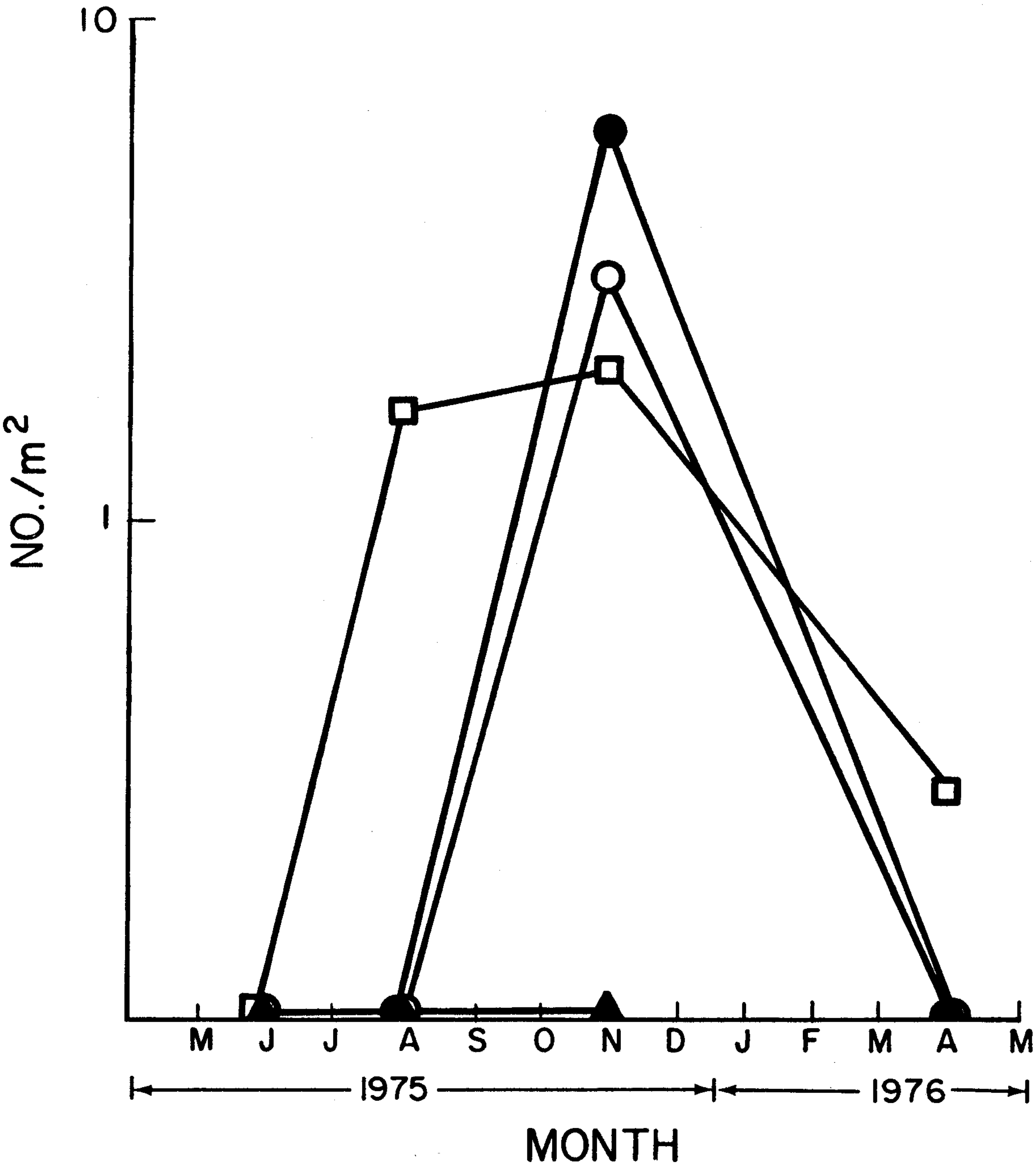


Figure 24. The average abundance of juvenile *Thysanoessa* spp., in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

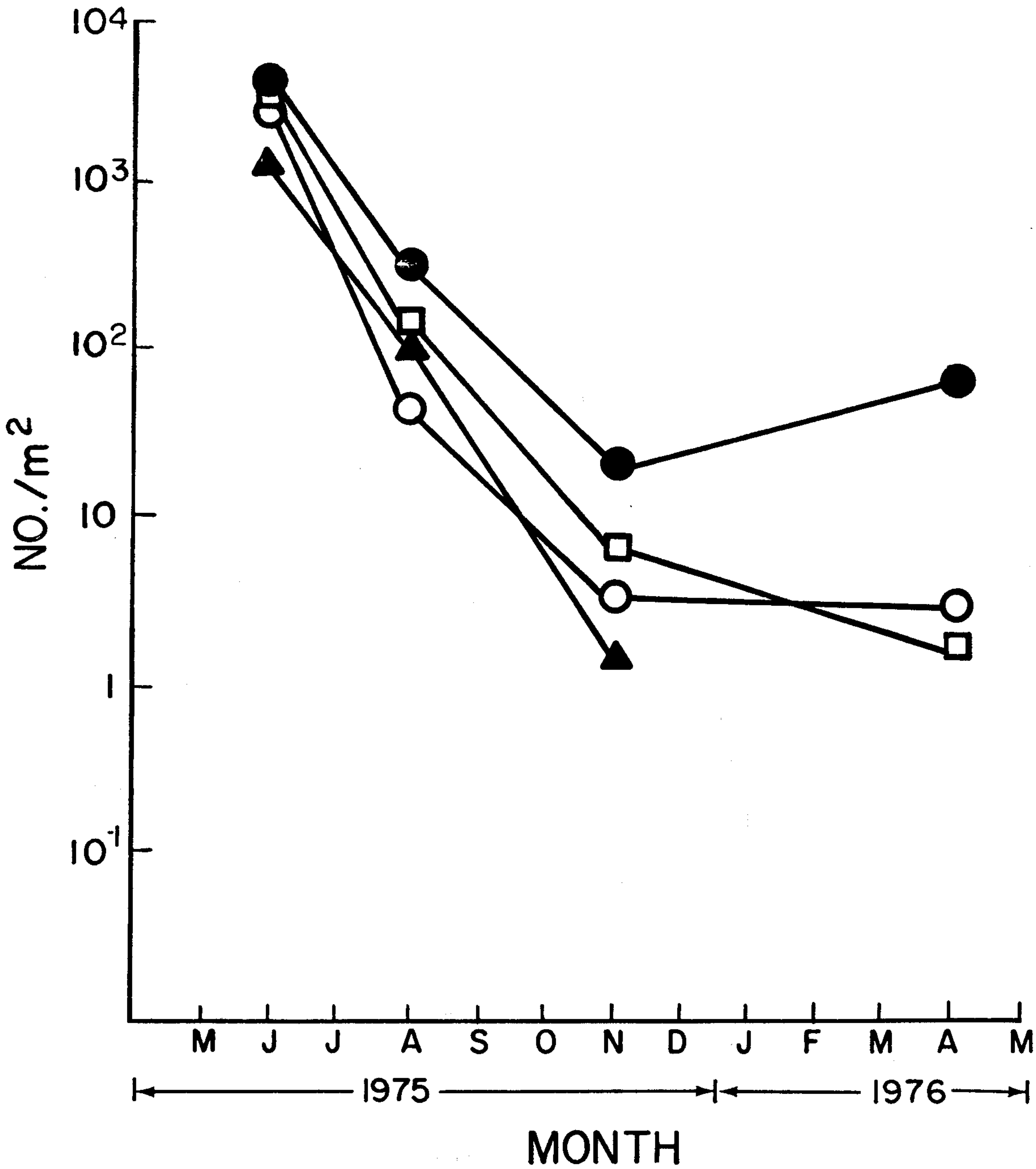


Figure 25. The average abundance of a composite of euphausiid eggs and larvae in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

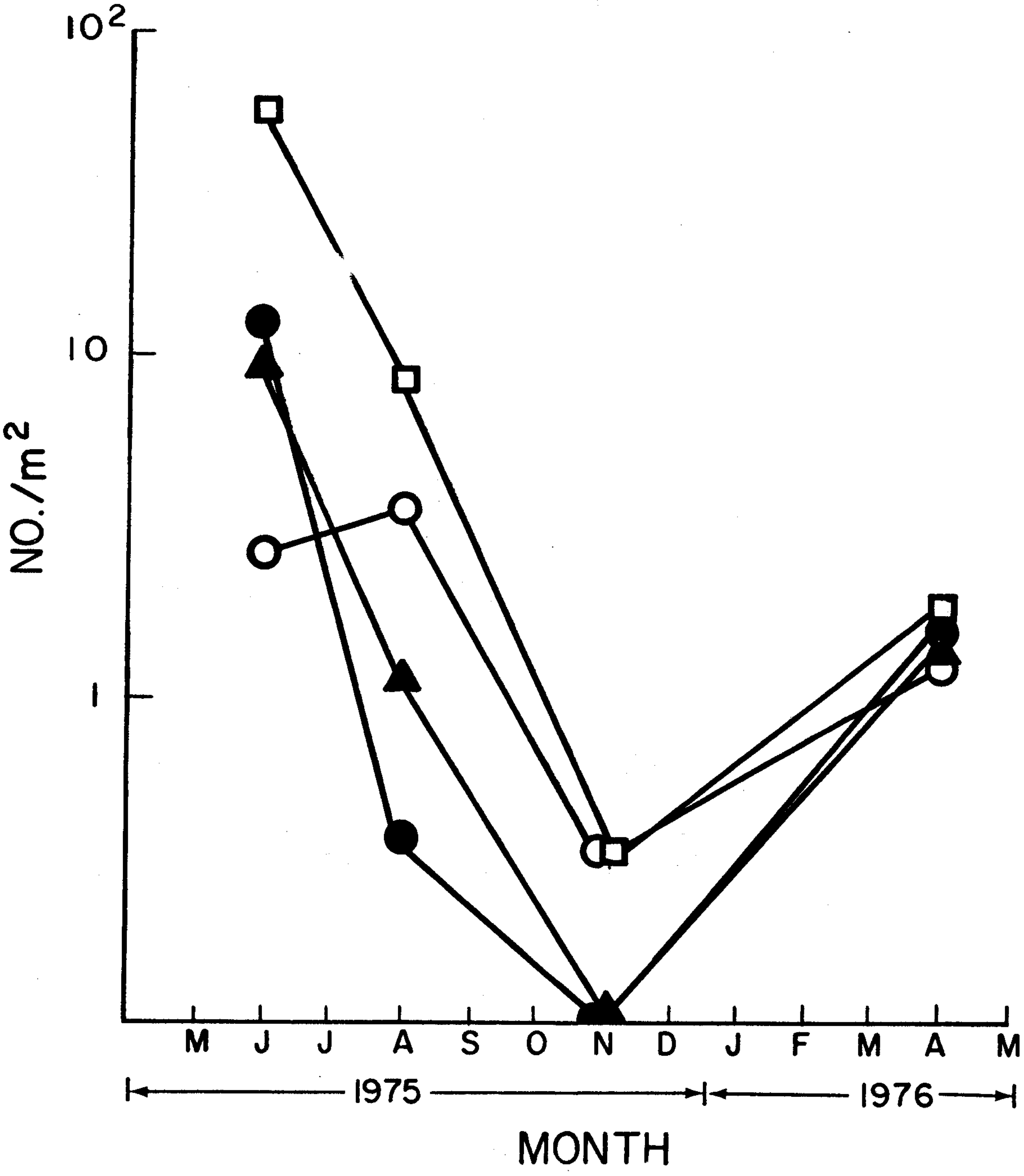


Figure 26. The average abundance of larval spider crabs, Majiidae, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

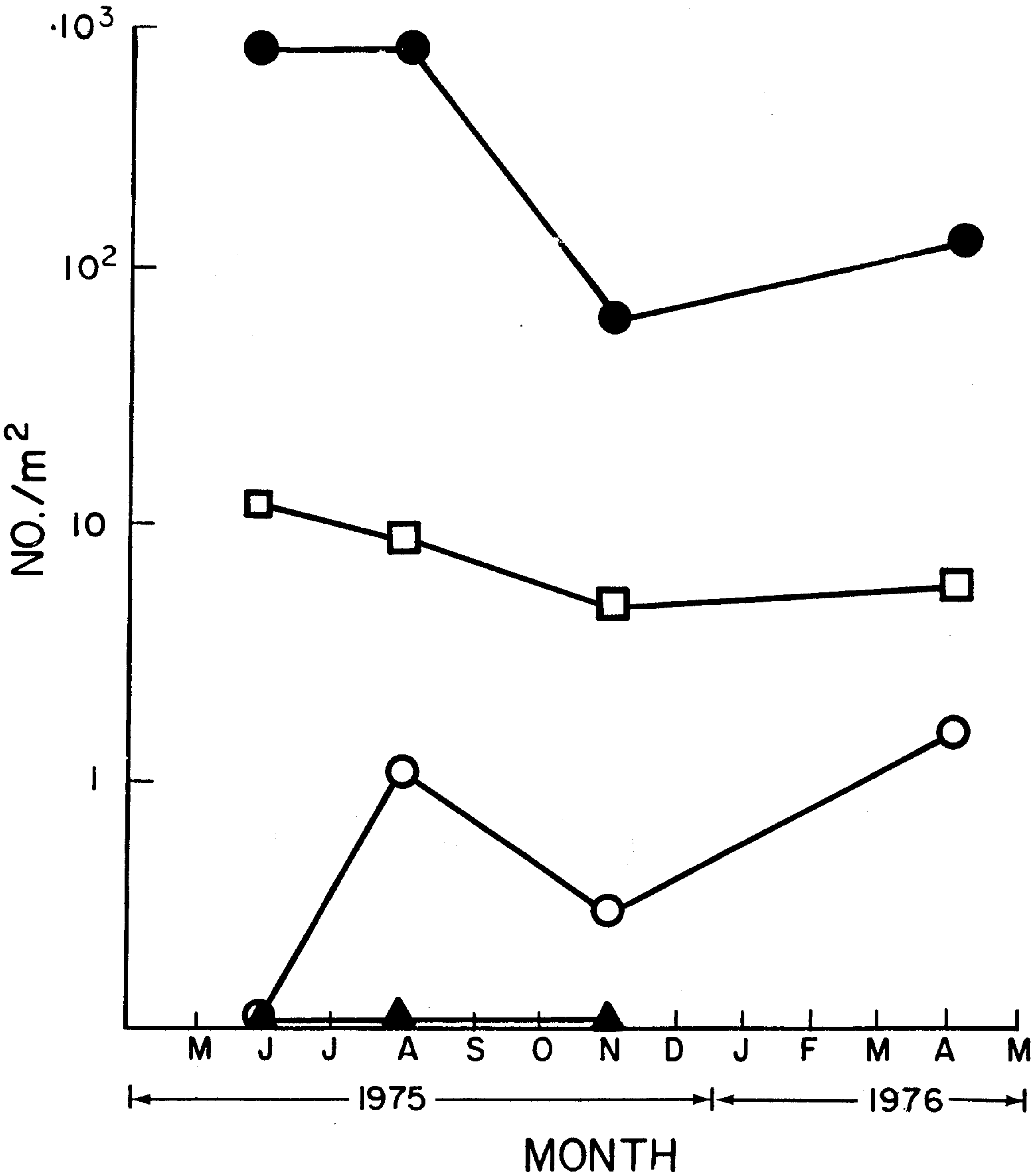


Figure 27. The average abundance of the chaetognath, *Eukrohnia hamata*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

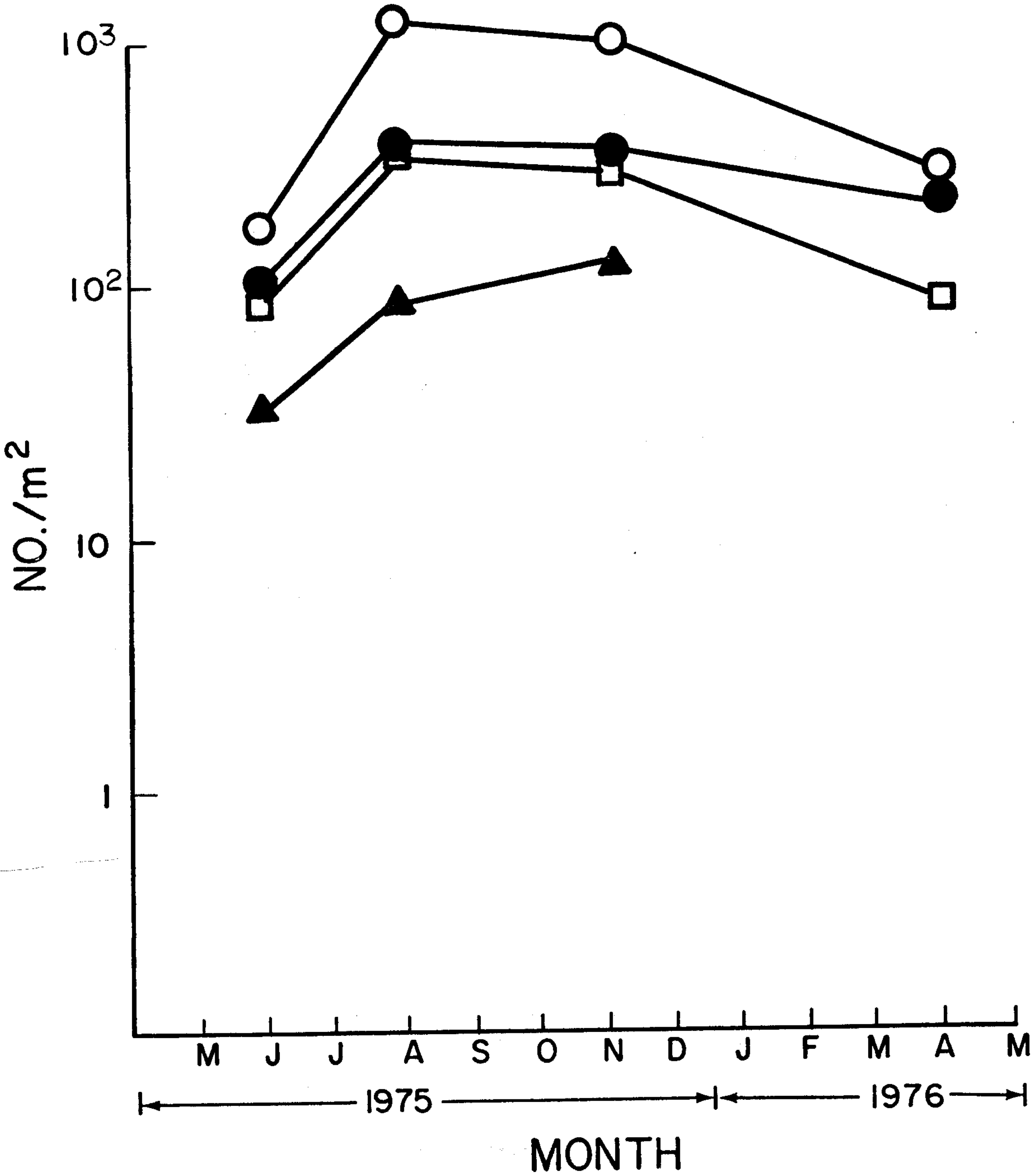


Figure 28. The average abundance of the chaetognath, *Sagitta elegans*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

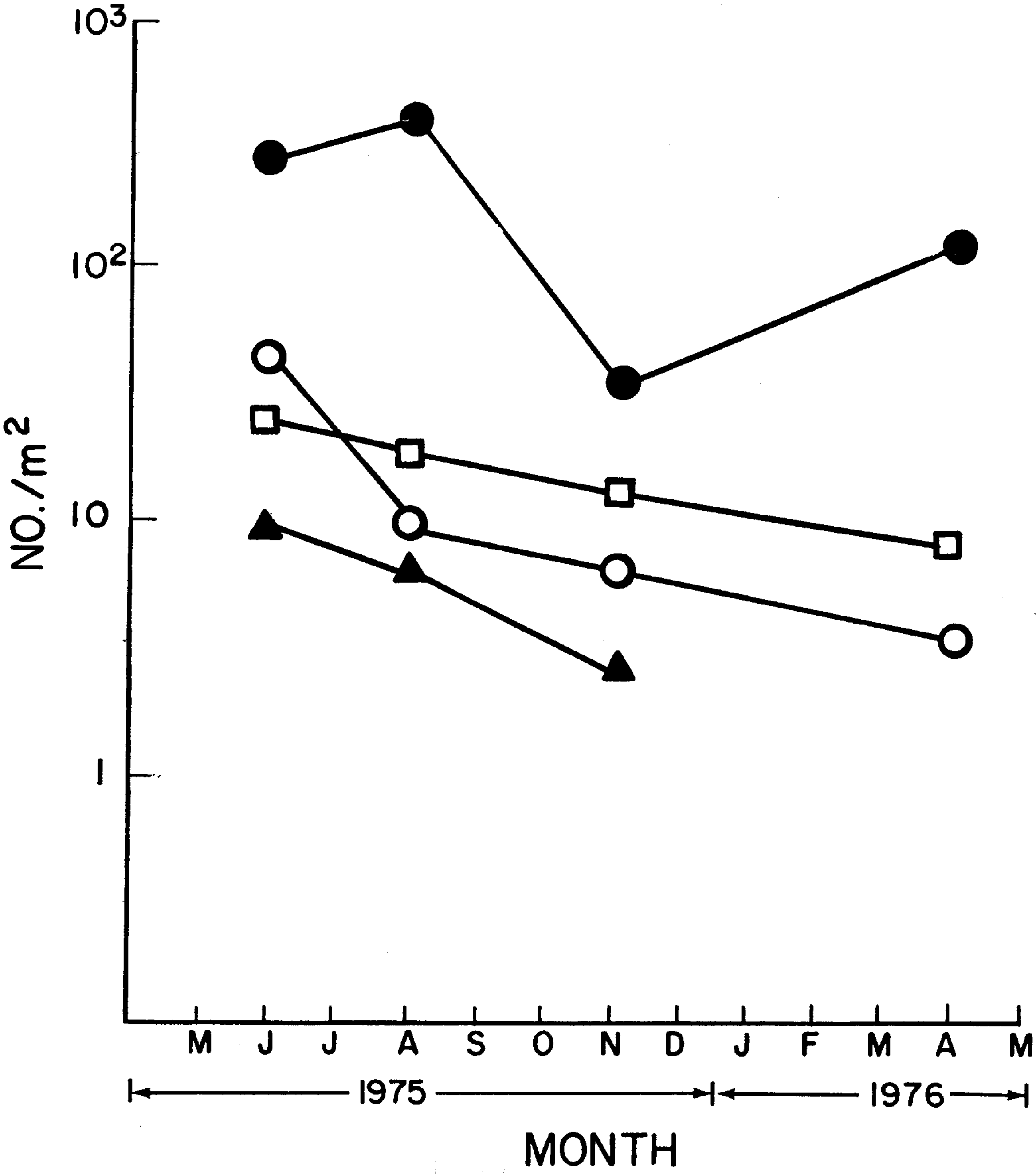


Figure 29. The average abundance of juvenile chaetognaths in the south-eastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

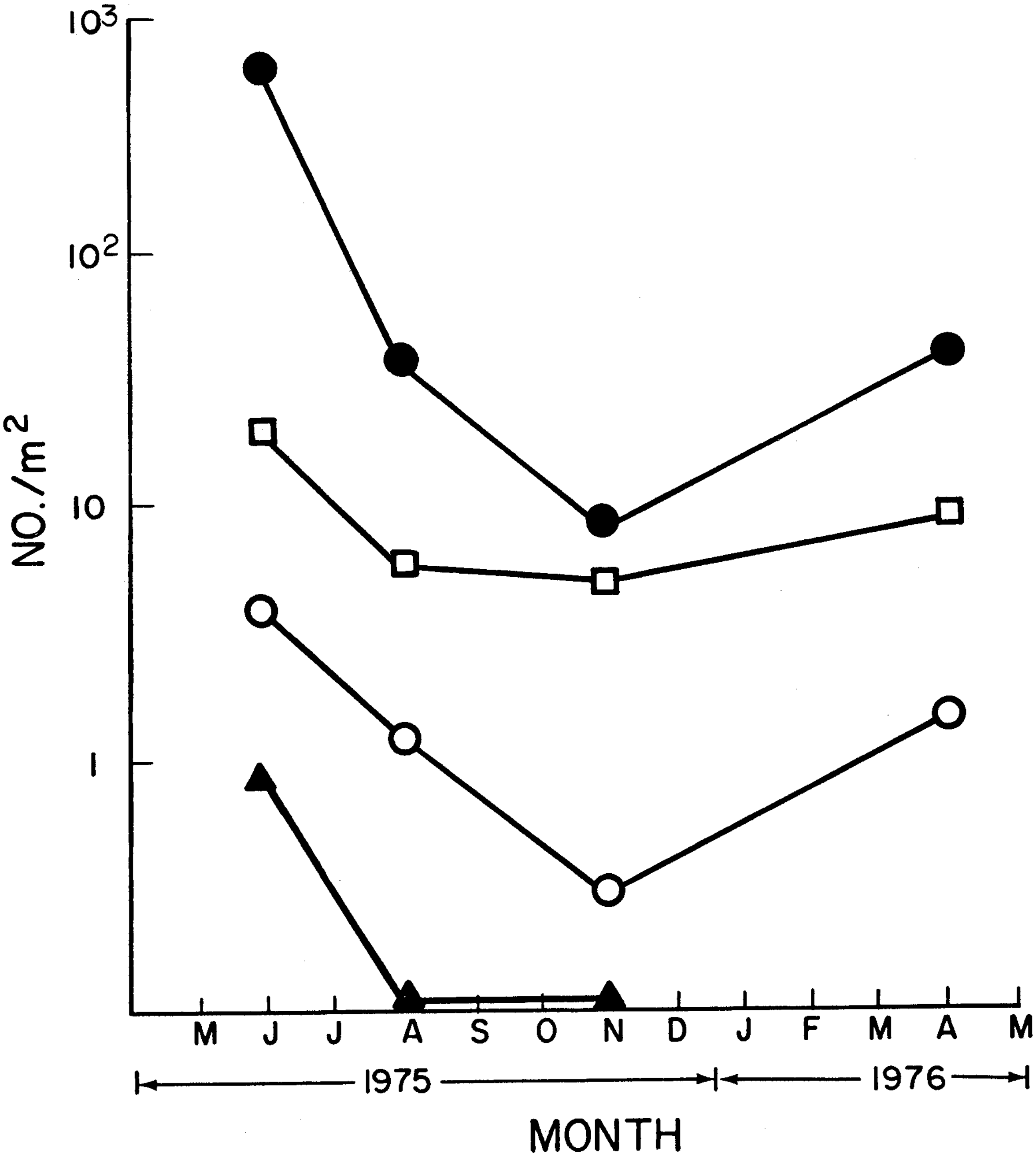


Figure 30. The average abundance of larvaceans, *Oikopleura* spp., in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

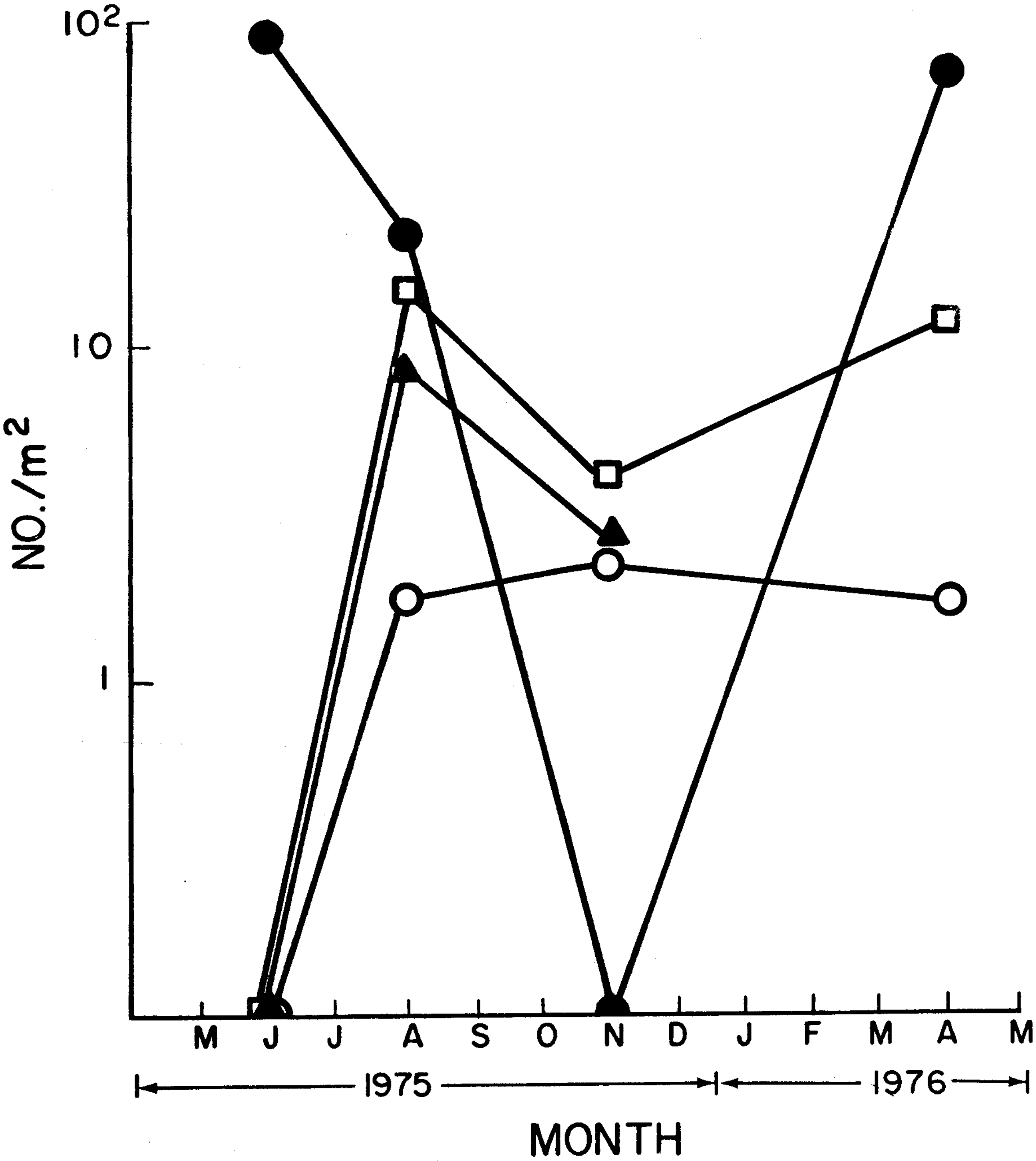


Figure 31. The average abundance of a composite of unidentified larvaceous in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

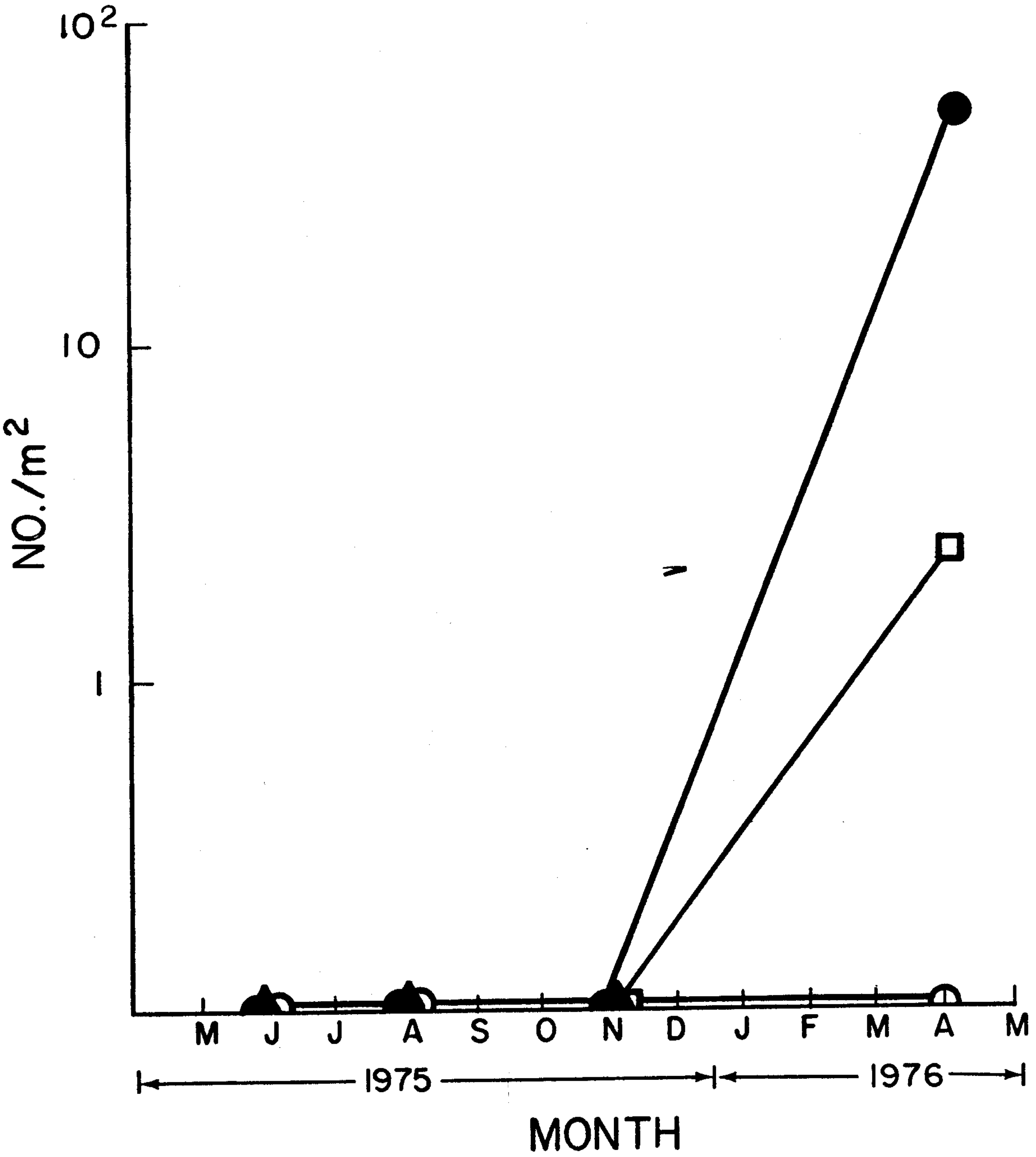


Figure 32. The average abundance of larval pollock, *Theragra chalcogramma*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

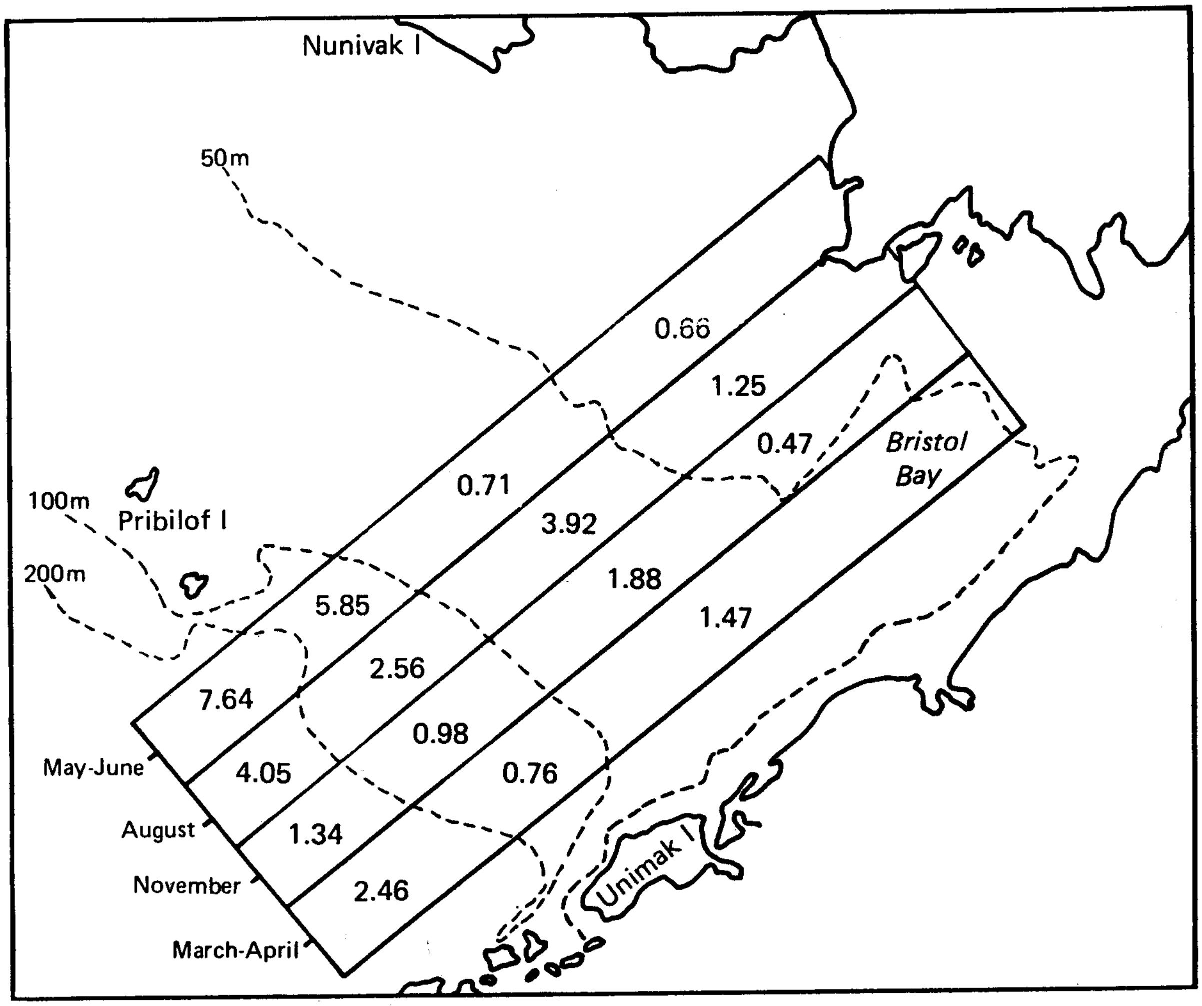


Figure 33. The average dry weight in grams per square meter of sea surface for net plankton retained by a 0.333-mesh 1-m net.

TABLE V

DISTRIBUTION PATTERNS BY REGIME FOR NUMERICALLY DOMINANT ZOOPLANKTON AND MICRONEKTON GROUPS IN THE SOUTHEAST BERING SEA

A. Usually Most Abundant in the Open Ocean

Dimophyes arctica
Clione limacina
Limacina helicina
Conchoecia spp.
Calanus cristatus
C. plumchrus
Eucalanus b. bungii
Larvacea (juveniles)
Metridia lucens
Parathemisto pacifica
Euphausiid (eggs and larvae)
Thysanoessa longipes
Eukrohnia hamata
Chaetognath (juveniles)
Oikopleura spp.
Theragra chalcogramma

B. Usually Most Abundant in the Outer Shelf

Oithona spinirostris
Thysanoessa inermis
Majiidae (larvae)

C. Usually Most Abundant in the Central Shelf

Calanus glacialis
C. marshallae
Pleudocalanus spp.
Parathemisto libellula
Thysanoessa raschii
Sagitta elegans

D. Usually Most Abundant in the Northern Coastal Area

Acartia longiremis

E. No Consistant Regime Affinity

Aglantha digitale
Calanus spp. (juveniles)
Copepod nauplii
Thysanoessa spp. (juveniles)
T. spinifera
Oithona similis

F. Absent in the Northern Coastal Regime

Dimophyes arctica
Clione limacina
Calanus cristatus
C. plumchrus
Eucalanus b. bungii
Oithona spinirostris
Parathemisto pacifica
Thysanoessa inermis
T. longipes
T. spp. (juveniles)
Eukrohnia hamata
Theragra chalcogramma

Of the entire dominant group, only the copepod *Acartia longiremis* seemed to prefer the northern coastal regime. In fact, twelve categories were completely absent from this shallow water at all times of the year. This result is not interpreted to suggest that the coastal zone is a biological desert, but rather that forms originating in deeper water are not successful in populating this regime.

Average dry weight as g/m^2 pooling all cruises, ranges from 3.87 in the open ocean to 2.54 in the outer shelf, down to 2.00 in the central shelf, and finally to 0.79 in the coastal zone shallower than 50 m. However, when this data is normalized to estimates per unit volume (mg/m^3) by accounting for an average depth fished in each regime (200 m, 150 m, 75 m, 25 m), the pattern is somewhat reversed such that the coastal area exhibits about 32, the central shelf 27, the outer shelf 17, and the open ocean 19. Expressed in this manner the various regimes differ in biomass per unit volume by less than a factor of 2.0. There is reason to suspect that suspended sediment in the nearshore collections may have biased these weights slightly high.

Within and among the spatial regimes most populations exhibited a strong seasonal component associated with annual reproduction or migration into and/or away from the area. Those categories which were obvious composites of early life history stages [i.e. juvenile *Calanus* spp., copepod nauplii, euphausiid eggs, larvae, and juveniles, spider crab larvae (Majiidae), immature chaetognaths, and larval fish *(Theragra chalcogramma)*] are examples of this phenomena. Pooling dry weight valves (g/m^2) for all regimes within each cruise, the average seasonal variation over the year ranges from a high of 3.72 in May-June, to 1.17 in November.

The copepods *Calanus cristatus*, *Calanus plumchrus*, and *Eucalanus b. bungii* which overwinter in the north Pacific as stage V copepodites well below the surface, were expected to reflect this ontogenetic behavior in their seasonal patterns of abundance in the upper 200 m. *Calanus cristatus* was absent from catches in November, and *Eucalanus* was much reduced in number in accord with the seasonal displacement (Figs. 8, 13). Surprisingly, *Calanus plumchrus* did not leave the upper 200 m as had been expected but held through the season with only minor variations in number (Fig. 11).

6.3 Statistical Studies

Estimates of within-regime variability by cruise were used to compute confidence intervals for single samples and for the average number of samples obtained per regime (n=9). As stated previously, it had been the intention of the field program to generate no fewer than 10 observation per stratum so that real differences exceeding about a factor of 5.0 could be discerned. In fact, confidence intervals (P=0.05) calculated using individual mean-square error values for each category ranged from 6.26 to 1.55 for geometric means with nine observations (Table VI). This indicates that in general all differences between means which exceed about a factor of 6 are real although the level of precision is much better than that for some categories. Differences associated with mean-square-error values calculated from the two configurations (3 cruises by 4 regimes; 4 cruises by 3 regimes) are considered negligible.

TABLE VI

CONFIDENCE INTERVALS FOR SINGLE SAMPLES AND GEOMETRIC MEANS
(P = 0.05)

Taxonomic Category	Confidence Interval: 3 cruises x 4 regimes, n = 1	3 cruises x 4 regimes, n = 9	4 cruises x 3 regimes, n = 1	4 cruises x 3 regimes, n = 9
Cnidaria				
Hydrozoa				
Aglantha digitale	43.60	3.52	51.56	3.72
Dimophyes arctica	29.86	3.10	16.65	2.55
Mollusca				
Pteropoda				
Clione limacina	20.71	2.74	15.10	2.47
Limacina helicina	31.98	3.16	29.88	3.10
Crustacea				
Ostracoda				
Conchoecia spp.	168.69	5.53	141.24	5.21
Copepoda				
Acartia longiremis	24.90	2.92	48.29	3.64
Calanus cristatus	159.40	5.42	124.38	4.99
C. glacialis	216.37	6.00	142.27	5.22
C. marshallae	235.73	6.18	176.73	5.61
C. plumchrus	66.54	4.05	70.30	4.13
C. spp. (juveniles)	196.83	5.83	123.69	4.98
Eucalanus b. bungii	41.02	3.45	57.21	3.85
Metridia lucens	66.47	4.05	74.61	4.21
Oithona similis	130.64	5.07	141.42	5.21
O. spinirostris	68.18	4.05	71.94	4.16
Pseudocalanus spp.	4.68	1.67	3.72	1.55
Nauplii (composite)	89.99	4.48	50.48	3.70
Amphipoda				
Parathemisto libellula	12.57	2.32	16.67	2.55
P. pacifica	20.57	2.74	16.55	2.54
Euphausiacea				
Thysanoessa inermis	19.19	2.68	22.80	2.84
T. Longipes	17.99	2.62	15.91	2.52
T. raschii	10.72	2.21	6.93	1.91
T. spinifera	5.32	1.75	6.63	1.88
T. spp. (juveniles)	31.57	3.16	32.47	3.19
T. spp. (eggs and larvae)	24.80	2.92	16.24	2.53

TABLE VI

CONTINUED

Taxonomic Category	Confidence Interval: 3 cruises x 4 regimes		4 cruises x 3 regimes	
	n = 1	n = 9	n = 1	n = 9
Crustacea (cont'd)				
Decapoda				
Majiidae (composite)	13.62	2.39	12.99	2.35
Chaetognatha				
Eukrohnia hamata	20.96	2.76	20.02	2.72
Sagitta elegans	11.93	2.28	4.87	1.69
Composite (juveniles)	98.09	4.61	59.79	3.91
Chordata				
Larvacea				
Oikopleura spp.	133.44	5.11	97.87	4.60
Composite	254.90	6.26	133.35	5.11
Teleostei				
Theragra chalcogramma	-	-	19.27	2.68
DRY WEIGHT (composite)	4.22	1.62	3.86	1.57

VII. DISCUSSION AND SYNTHESIS

Implicit in the effort to survey and "characterize" the shelf environments of Alaska was the worry about possible detrimental effects associated with the development and eventual exploitation of non-renewable resource fields in these areas. Studies were initiated to gather and synthesize data that could be used to modify lease-area nominations and sale schedules so that so-called "critical habitat" might be protected. Surveys of the unobtrusive pelagic flora and fauna (phyto- and zooplankton) were prompted by the need to understand in greater detail specific aspects of organic matter transfer processes in the water column overlying the shelf in the southeastern Bering Sea, acknowledged internationally as the location of one of the most productive commercial fisheries in the world. It was argued that since the majority of populations at all trophic levels are dependent upon the plankton communities for their survival, either directly or indirectly, specific regions or times of the year that are "biologically active" should be documented and described. This study was undertaken to provide some of that information.

It is not surprising that many of the numerically dominant species sampled in the upper 200 meters of the southeastern Bering Sea are also reported as dominant and ecologically important in the northwestern Pacific, the northern Gulf of Alaska and the western Bering Sea (Minoda, 1971; Cooney, 1975; LeBrasseur, 1965). The general counter-clockwise surface circulation provides a near shelf and coastal "river in the sea" which carries plankton populations to the north from the subarctic current around the periphery of the northern Gulf where the Alaska Stream then moves them westward along the Aleutian Chain and eventually into the Bering Sea. This biological continuity was observed over the shelf south of Hinchinbrook Entrance to Prince

William Sound in the northern Gulf of Alaska where the species composition was found to be nearly identical to that reported at the Canadian offshore weather station P some 800 nautical miles upstream (Cooney, 1975). The numerically common copepods *Calanus cristatus*, *Calanus plumchrus*, *Eucalonus b. bungi*, *Metridia lucens*, and *Pseudocalanus* spp., the amphipod *Parathemisto pacifica*, the chaetognath *Eukrohnia hamata* and *Sagitta elegans*, and the pteropods *Clione limacina* and *Limacina helicina* are all major constituents of the holoplankton in the shelf waters between station P and the Pribilof Islands.

The major significance of this continuity is in the process of recruitment at any location along the path of this generalized current system. Of potentially greater importance is the question of how the shelf plankton community composition and the relative abundance of species compares with that found in deeper adjacent ocean waters. Many of the numerically dominant species undergo extensive ontogenetic migrations associated with overwintering and reproduction. These populations move to deep water, 500-1000 m, in late summer and early fall where some (the interzonal copepods *Calanus cristatus*, *Calanus plumchrus*, and *Eucalanus b. bungii*) reproduce. This being the case, those shelf environments influenced most directly by adjacent oceanic water exhibit strong seasonal fluctuation in the composition of the dominant animal plankters. This phenomenon was clearly observed in the northern Gulf of Alaska (Cooney, 1975).

In the southeastern Bering Sea, the seasonal distributions of these same copepods are similar with the striking exception that *Calanus plumchrus* was present at all times in the upper 200 m over both deep water and the shelf. This behavior is not consistent with the general description of the reproductive cycle in this specie sampled elsewhere.

The more widespread distribution patterns of the oceanic species provides a biological clue to the influence of oceanic waters on the shelf of the southeastern Bering Sea. As was noted (Table V), a large percentage of dominant plankters were absent at all times from water shallower than 50 m in the northern coastal regime. This was not the case in the northern Gulf of Alaska, where oceanic species occured regularly in the coastal water particularly during the spring and summer months. It is quite probable that freshwater entering Bristol Bay directly and from the Kuskokwim River somwhat to the north freshens the nearshore regime beyond the tolerances of the oceanic species. The euryhaline copepods *Acartia longiremis* and *Pseudocalmus* spp. occur there without apparent difficulty.

Takenouti and Ohtani (1974) describe three major water masses for this area: (1) a relatively saline (32 to 33°/₀₀) source from the Alaska Stream via Unimak Pass and the deep Bering Sea Basin. At its coldest this water is always relatively warm (3° to 4°C); (2) relatively stable resident shelf water of slightly lower salinity (32.0 ± 0.5°/₀₀) which is strongly stratified in summer. The deeper water below the seasonal thermocline is consistently the coldest found over the shelf (-1° to +2°C); and (3) a coastal water of lowest salinity (<31.6°/₀₀) indicating the direct influence of freshwater runnoff. The circulation within and the interaction between these water masses is extremely complex (Coachman and Charnell, 1977).

In an effort to determine how this physical partitioning of the shelf environment could effect the distribution and abundance of animal plankton and micronekton, a series of stations was occupied in August 1975 from deepwater landward up the axis of Briston Bay (see Appendix I, Fig. 9-11;

Table II, Appendix III). Sixty-six taxonomic categories were reported for open ocean collections, with 43, 41, and 40 occurring in the outer shelf, central shelf and coastal regimes. However, only 10 species in the coastal area were also found in the deeper water indicating a somewhat unique near-shore community. When the abundance of several common taxa were examined along this transect, it was apparent that for most, the distributions either terminated or exhibited some marked decrease in abundance in the area of stations 72 and 82. Only *Sagitta elegans* seemed unaffected.

An examination of CTD data taken at this time indicates that a remarkable decrease in temperature at depth was encountered somewhere between station 62 and 72 (see Appendix III). Water below 38 m at the deeper station (62) averaged about 4°C while at location 72, the temperature at this depth and below fell to 1.3°C. I suggest this strong "thermal barrier" was responsible for excluding many of the oceanic species from waters landward of this feature.

Cooney (1977; Appendix II) reported that while the seasonal ice-edge seemed to have little effect on the distribution of plankton and micronekton, inverse thermal stratification associated with ice-cooled water did in fact influence the community. A relatively low diversity and sparse assemblage was found in regions where the cold underice water mass extended to the bottom (depths <80 m). At locations somewhat deeper, the community abundance and diversity increased markedly presumably due to the inclusion of organisms living in the warmer near-bottom oceanic water. This stratification of the population was examined more closely during the spring of 1977 and will be reported in September, 1978. The fact that remnants of this cold underice water mass persist as a thermal band along the shelf during late spring, summer, and early fall, means that many oceanic species which would normally invade this region are probably excluded by extremely low temperatures. During the warmer season, a landward community of more neritic species develops in the absence of the typical oceanic assemblages.

The notion of "critical" periods or habitats relative to plankton assemblages probably applies most appropriately to the temporary or meroplanktonic forms, such as the eggs and larvae of fishes and shellfishes. This entire region is one of great commercial importance particularly for the harvest of walleye pollock, king and snow crabs, and other demersal fin-fishes (Low, 1975).

The zoea and megalops of spider crabs of which *Chionoecetes* spp. the snow crab is probably dominant, and larval pollock were censused in this study (Figs. 26, 32). While crab larvae were collected in all areas and seasons, the pollock was restricted to the early spring, and open ocean and outer shelf regions. This "window" seemingly has the characteristics of both critical timing and location with regard to the survival of this species. I suspect that had sufficient volumes of water been sampled, a larger number of fishes with similar critical periods would have been reported.

The much more complex question of the overall productivity of this region of the Bering Sea is being examined critically by the National Science Foundation, Office of Polar Programs ecosystem study, PROBES. Now in its third funding season, this multidisciplinary effort has focussed its attention on walleye pollock, an abundant commercial species which utilizes both the pelagic and near-bottom realms of the outer shelf and open ocean. Although the annual production of organic matter in this region is not unusually high (range 85-589 g C/m^2), the system seemingly favors an above average production at higher trophic levels both in the water column and on the seabed. The mechanics of this process are now understudy. It may be that a combination of physical factors related to water stability and cold temperature formed by seasonal sea ice, together with a low diversity at higher levels provides the means to distribute the annual primary production very efficiently to consumers. Nishiyama (1975) describes two relatively simple food chains for the southeastern Bering Sea based on work conducted by Mito (1974): (1) a pelagic chain beginning with the euphausiid genus *Thysanoessa* → walleye pollock pacific cod, turbot, halibut, and blackcod; and (2) a benthic chain with the pink shrimp *Pandalus borealis* → flathead and rock sole. I suspect these notions are over simplifications to some degree although both euphausiids and pollock occur in the diets of most species of large fishes, seabirds and marine mammals, suggesting this system is relatively more simple than some.

Cooney (1976; see Appendix I) speculated that much (perhaps more than 50%) of the organic matter produced over the shelf is not harvested by grazers in the watercolumn but rather sinks to the seabed. Exceptional standing stocks of benthic deposit and suspension feeders in the outer shelf regime testify to the availability of ample food. In fact, the very noticable "blooms" observed in this region during late spring probably result more from an uncoupling of grazing pressure related to the size of the algal chains forming at this time than to light or nutrient availability. This hypothesis was to have been examined during the FY 78 field season. However, budget restrictions eliminated further field work. The PROBES scientific effort this year will address this notion in the framework of a systems study.

VIII. CONCLUSIONS

1. The animal plankton and micronekton communities of the southeastern Bering Sea are similar in their composition and relative dominance structure to assemblages reported for the north Pacific, the northern Gulf of Alaska, and the northwestern Pacific Ocean.

2. The distribution of taxa within and between specific bathymetric regimes is related to the physical structure of the shelf water masses and the biology of the major species. A very cold-water remnant associated with winter cooling and the presence of seasonal sea ice seemingly blocks the penetration of many oceanic species into the central shelf and coastal waters during the spring and summer. The coastal regime freshened by runoff, annually develops a neretic fauna that can be identified in coastal areas further to the north.

3. Seasonality in the plankton community is associated with ontogenetic migration and responses to the annual production of organic matter. Interzonal copepods, with the exception of *Calamus plumchrus*, leave the shelf in the fall and reappear in late winter and early spring.

4. The notion of "critical habitat" or "critical season" seems to apply most clearly to members of the temporary plankton community i.e., commercial species. Walleye pollock (*Theragra chalcogramma*) survives its planktonic early life history during a narrow time window in the spring in waters of the open ocean and outer shelf In respect to this species the area and timing are critical.

IX. IMPLICATIONS OF CONCLUSIONS

Since the major motivation for this study was in relation to offshore oil development, I feel obliged to comment on the ramifications of the conclusions in this regard. It must be noted that although the results suggest some specific continuity of populations with time and location, they in fact only represent discrete observations at four times during one year. However, given this qualification, I feel the major time and space patterns as well as seasonal changes in species composition are portrayed representatively in this study. Further details of ecological interaction will require a more careful examination of specific hypotheses.

9.1 Scientific Merit

In my view this study is scientifically sound and reports some new facts concerning the distribution and abundance patterns of zooplankton and micronekton in the southeastern Bering Sea. Because observations were obtained as early as March and as late as November, some information is now available to evaluate the effect of the seasonal ice pack on the unobtrusive fauna of the region. The ice itself seems to be of little consequence, but the process of freezing, and the effect of the pack on the underice water mass does appear to define some apparently real biological boundaries for most of the oceanic species. A more thorough examination of this hypothesis will be reported in September, 1978.

While in itself, a simple reconnaissance of the animal plankton and micronekton communities is not particularly noteworthy, the information obtained by this project will now allow other more sophisticated studies to be undertaken. The PROBES investigation was able to move quickly into specific hypothesis testing because much of the basic information was available on standing stocks, levels of seasonal variability, and relationships to oceanic factors. Many aspects of this study will be submitted to scholarly journals for publication in the marine sciences.

9.2 Relations to OCS Petroleum Development

The specific implications of this study will not be understood until the petroleum chemists and laboratory biologists are able to more fully describe the effects of fossil fuels on representatives of wild plankton populations. This horrendous, perhaps impossible task, will presumably rank the relative sensitivities of the most "ecologically important" species, and their life history stages, so that a new category of "susceptible" organisms may be identified. Coupled with information concerning food dependencies at higher trophic levels, and the specifics of seasonal distributions, a model of probable affects could then be developed which would address in some way, the problem of impact. It is my understanding that the Environmental Assessment of the Alaskan Continental Shelf and associated research studies are moving in this direction.

This study reveals that there is nothing particularly unusual about the animal plankton and micronekton communities in the southeastern Bering Sea. As mentioned previously, the species composition and seasonal variations are similar to those described for other areas in the north Pacific Ocean. What is not clearly known, is how these populations exploit their environment in this region and are in turn utilized by other members of the community. I surmise that the major food items occurring in the diets of plankton feeding birds, marine mammals and fishes will be the same dominant species as reported here. This means that although nearly 200 species can be found, only 20 or 30 are trophically important at the lowest consumer levels in maintaining the large populations which feed upon them. From an ecological vantage point, this result indicates that most of the organic carbon utilized by pelagic grazers passes through relatively few but abundant subpopulations which sustain the rest of the system. While this may be biologically efficient, it could become critical if these sustaining populations were adversely affected in any longterm way. This statement is not meant as a "red flag" but rather an interpretation of a biological mechanism which appears efficient but relatively simple in terms of redundance. However, since the coastal shelf areas tend to be influenced by relatively steady current flow, any localized effects would soon be absorbed by mixing and advection.

X. FUTURE STUDIES

Research planned but not implimented for FY 78 included experimental measures of the process of organic matter transfer. There is increasing evidence that much of the organic carbon produced in any coastal bloom is not directly utilized, but rather sinks to the seabed or is advected away from a region. This partitioning of the water column productivity must be understood if the balance and production associated with both the pelagic and benthic systems is to be described in predictive terms. Also, if petroleum from accidental spills or catastrophes enters the system and mixes with a bloom, there would seem to be a probability that incorporation might occur which would then feed into both the pelagic and benthic trophic structure. This eventually should be examined experimentally in the laboratory or with controlled releases at sea.

At the very least, future studies in the southeastern Bering Sea should develop models of the trophic relationships between the obvious higher trophic levels (fishes, birds, and mammals) and the dominant zooplankton and micronekton reported here.

REFERENCES

Coachman, L. K. and R. L. Charnell. 1977. Fine structure in outer Bristol Bay, Alaska. *Deep-sea Research* 24:869-889.

Cooney, R. T. 1971. Zooplankton and micronekton associated with a diffuse sound-scattering layer in Puget Sound, Washington. Ph.D Thesis, Univ. Washington, Seattle. 209 p.

Cooney, R. T. 1975. Environmental Assessment of the northeastern Gulf of Alaska: zooplankton and micronekton. First year Final Report; Institute of Marine Science, Fairbanks. 159 p.

Cooney, R. T. 1976. Environmental Assessment of the Alaskan Continental Shelf: zooplankton and micronekton studies in the Bering-Chukchi/Beaufort Seas. Annual Report; Institute of Marine Science, Fairbanks. 53 p.

Cooney, R. T. 1977. Environmental Assessment of the Alaskan Continental Shelf: zooplankton and micronekton studies in the Bering-Chukchi/Beaufort Seas. Annual Report; Institute of Marine Science, Fairbanks. 84 p.

LaBrasseur, R. J. 1965. Seasonal and annual variations of net zooplankton at ocean station P 1956-1964. Fish. Res. Bd. Can., M. S. Rep. Ser. Ocean. Limnol. No. 202. 153 p.

Lovegrove, T. 1966. The determination of the dry weight of plankton and the effect of the various factors on the values obtained *In* H. Barnes, *Some Contemporary Studies in Marine Science*. Hafner Publishing Company, New York. 216 p.

Low, L. L. 1975. Available fisheries statistics for the Bering Sea. *In* Bering Sea Oceanography: an update; D. W. Hood and Y. Takenouti (ed.) Inst. Mar. Sci. Rept. R75-2, Univ. of Alaska, Fairbanks. 291 p.

Minoda, T. 1971. Pelagic copepoda in the Bering Sea and northwestern north Pacific with special reference to their vertical migrations. Mem. Fac. Fish., Hokkaido Univ. Hokodate, Japan. 18:1-74.

Mito, K. 1974. Food relation in demersal fishing community in the Bering Sea - walleye pollock fishing ground in October and November 1972. M. S. Thesis, Hokkaido Univ., Hokodate, Japan. 86 p.

Nishiyama, T. 1974. Ecological approach to fisheries. *In* Bering Sea Oceanography: an update; D. W. Hood and Y. Takenouti (ed.) Inst. Mar. Sci. Rept. R75-2, Univ. of Alaska, Fairbanks. 291 p.

Takenouti, A. Y. and K. Ohtani. 1974. Currents and water masses in the Bering Sea: A review of Japanese work. *In: Oceanography of the Bering Sea*, D. W. Hood and E. J. Kelley (ed.) Inst. Mar. Sci. Occas. Pub. No. 2, Univ. of Alaska, Fairbanks. pp. 39-57.

APPENDIX I

ZOOPLANKTON AND MICRONEKTON STUDIES IN THE
BERING - CHUKCHI/BEAUFORT SEAS
1976

(Published in Environmental Assessment of Alaskan Continental Shelf, Principal Investigators Annual Reports for the year ending March 1976, Vol. 7, pp. 95-158)

APPENDIX II

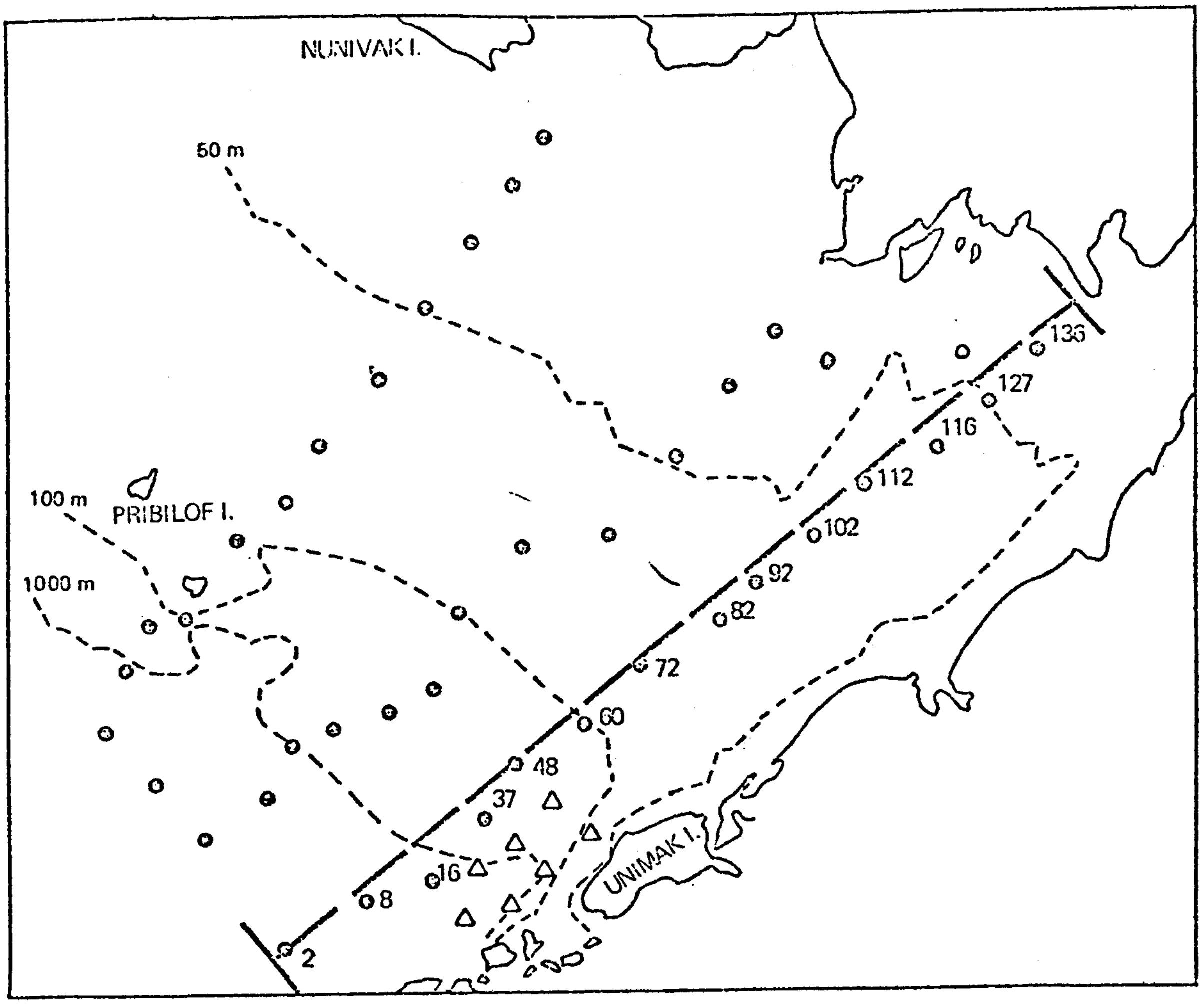
ZOOPLANKTON AND MICRONEKTON STUDIES IN THE BERING - CHUKCHI/BEAUFORT SEAS 1977

(Published in Environmental Assessment of Alaskan Continental Shelf, Principal Investigators Annual Reports for the year ending March 1977, Vol. X, pp. 275-363)

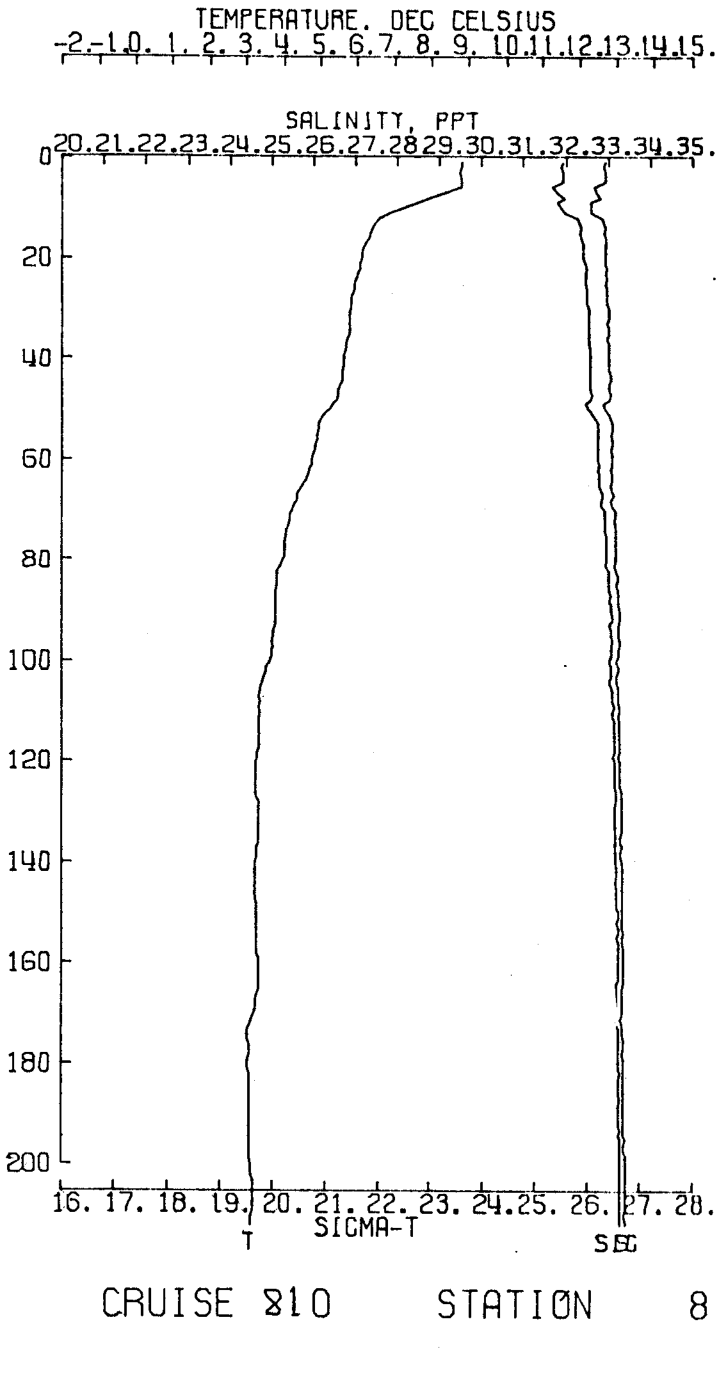
APPENDIX III

FOURTEEN STD PROFILES TAKEN ABOARD THE NOAA VESSEL *DISCOVERER*
AUGUST 1975

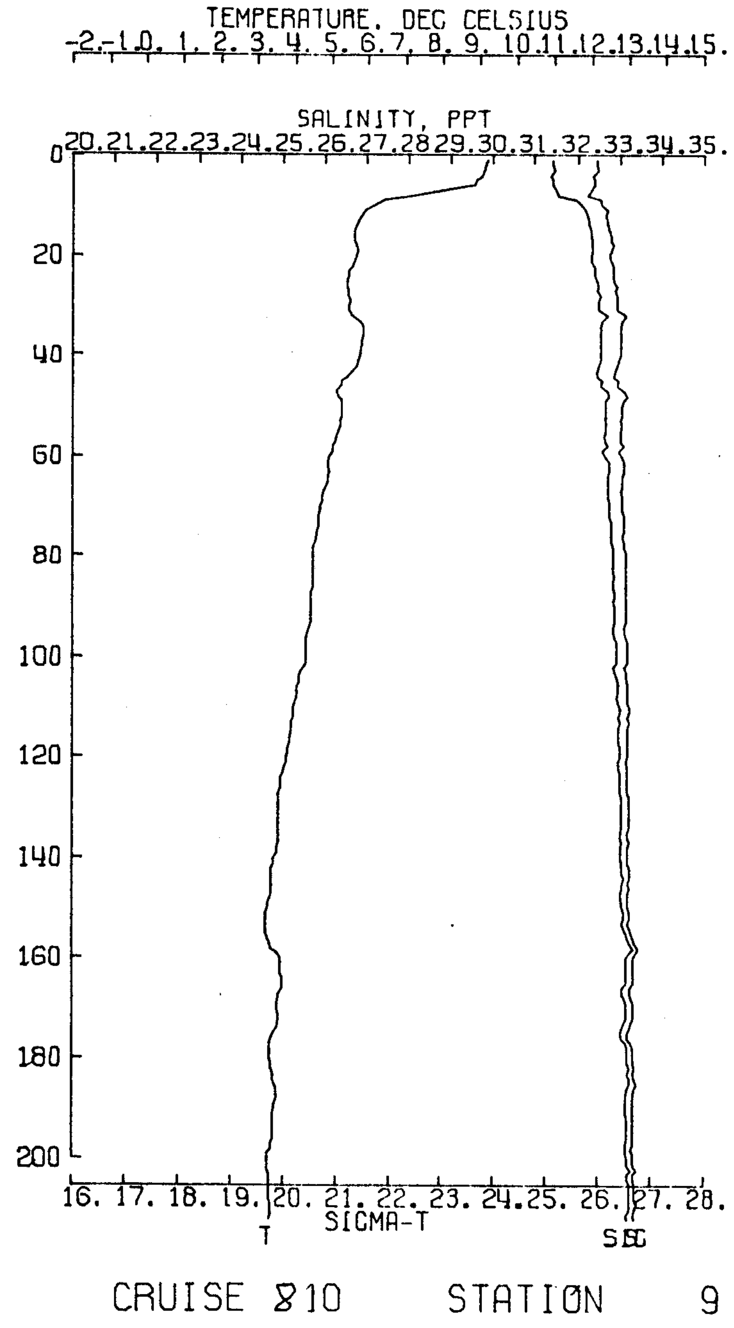
(from Appendix I, Figure 9, transect details)



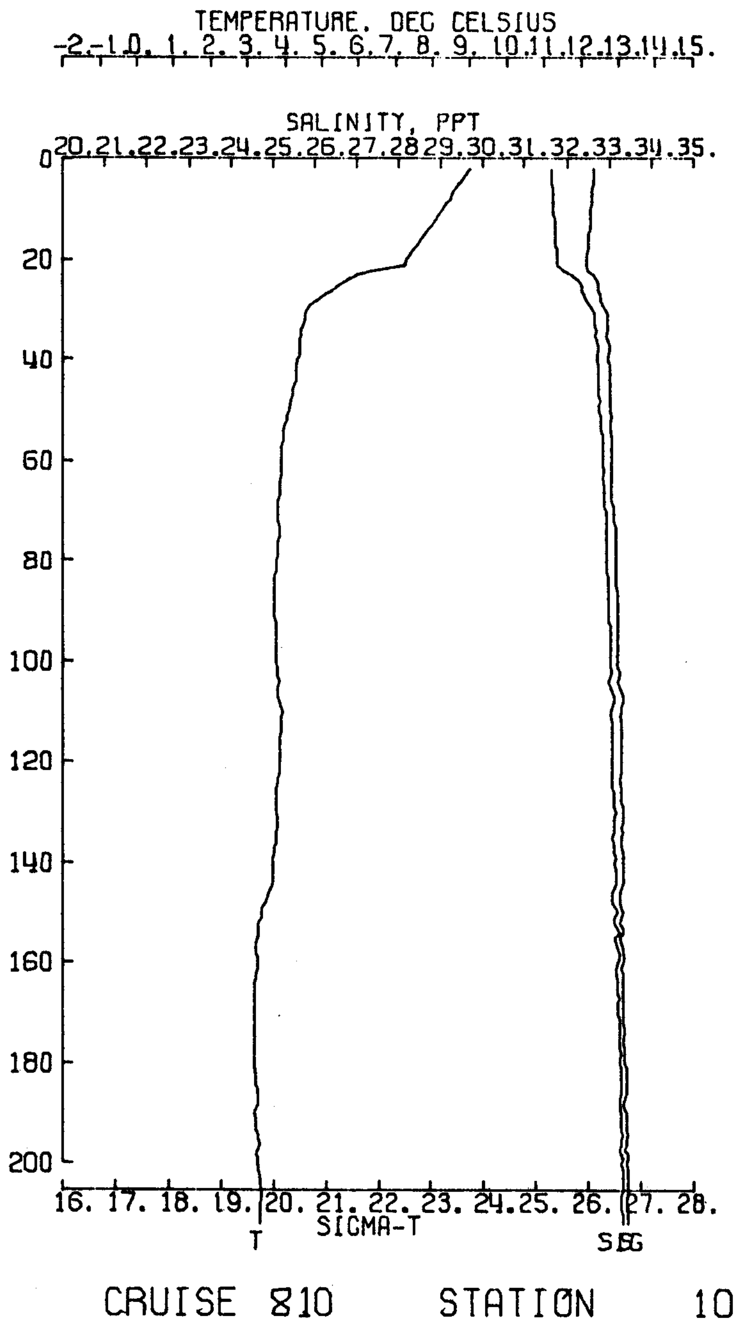
August 1975, cross-shelf transect. Numbers refer to oceanographic station name.



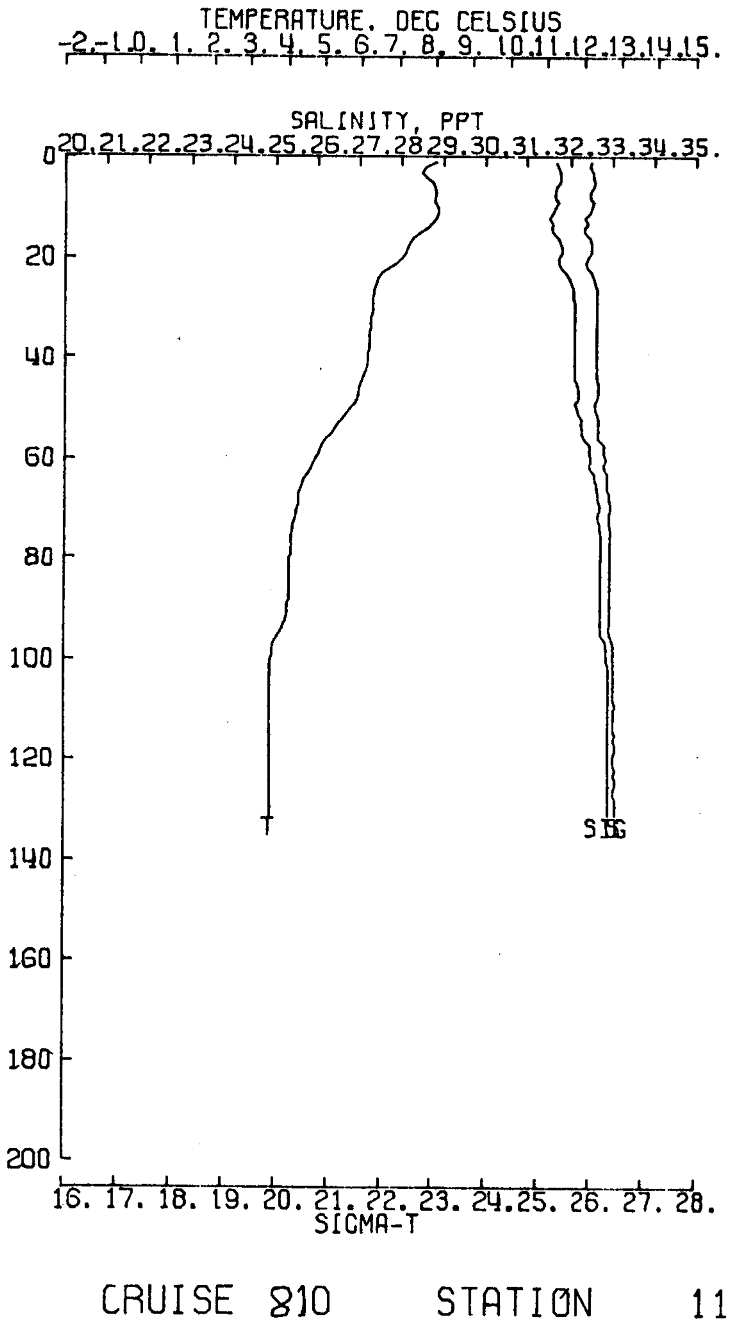
Appendix III - Figure 1. Plankton station 2 (*Discoverer* 810, station 8), STD profile.



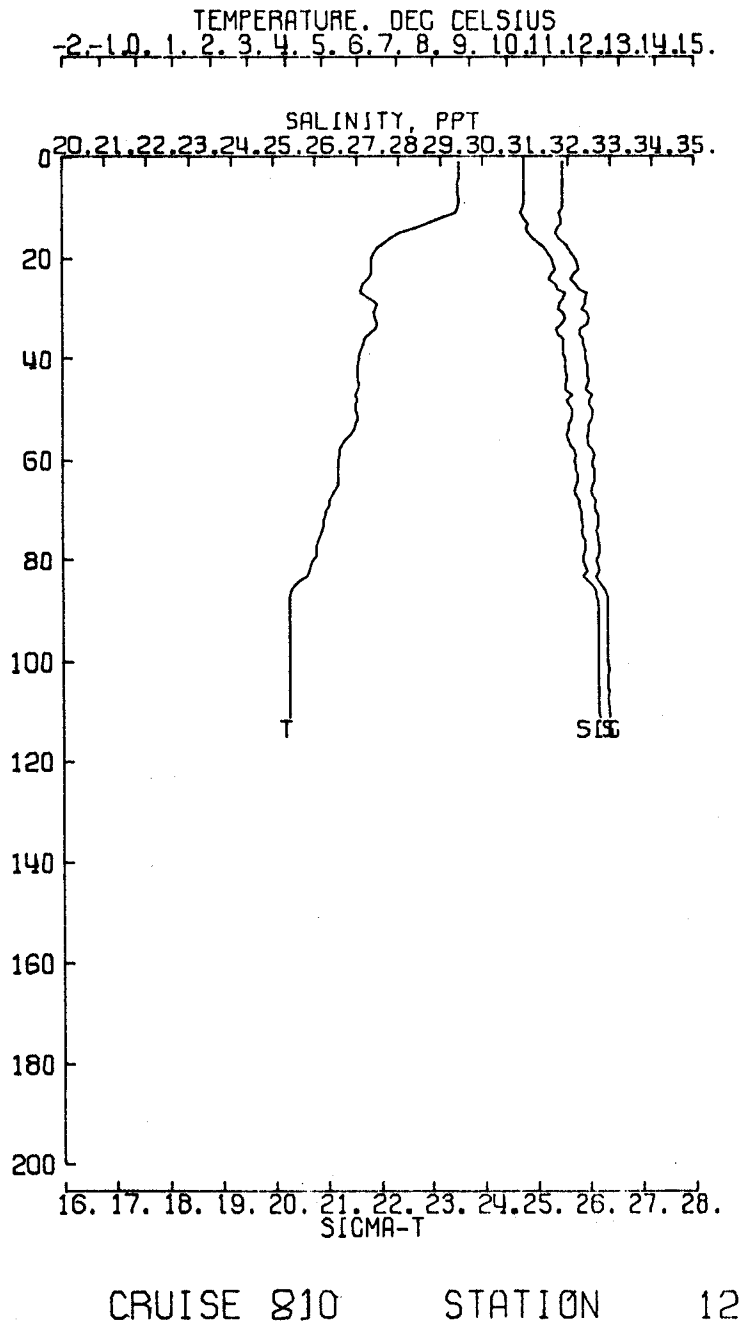
Appendix III - Figure 2. Plankton station 8 (*Discoverer* 810, station 9), STD profile.



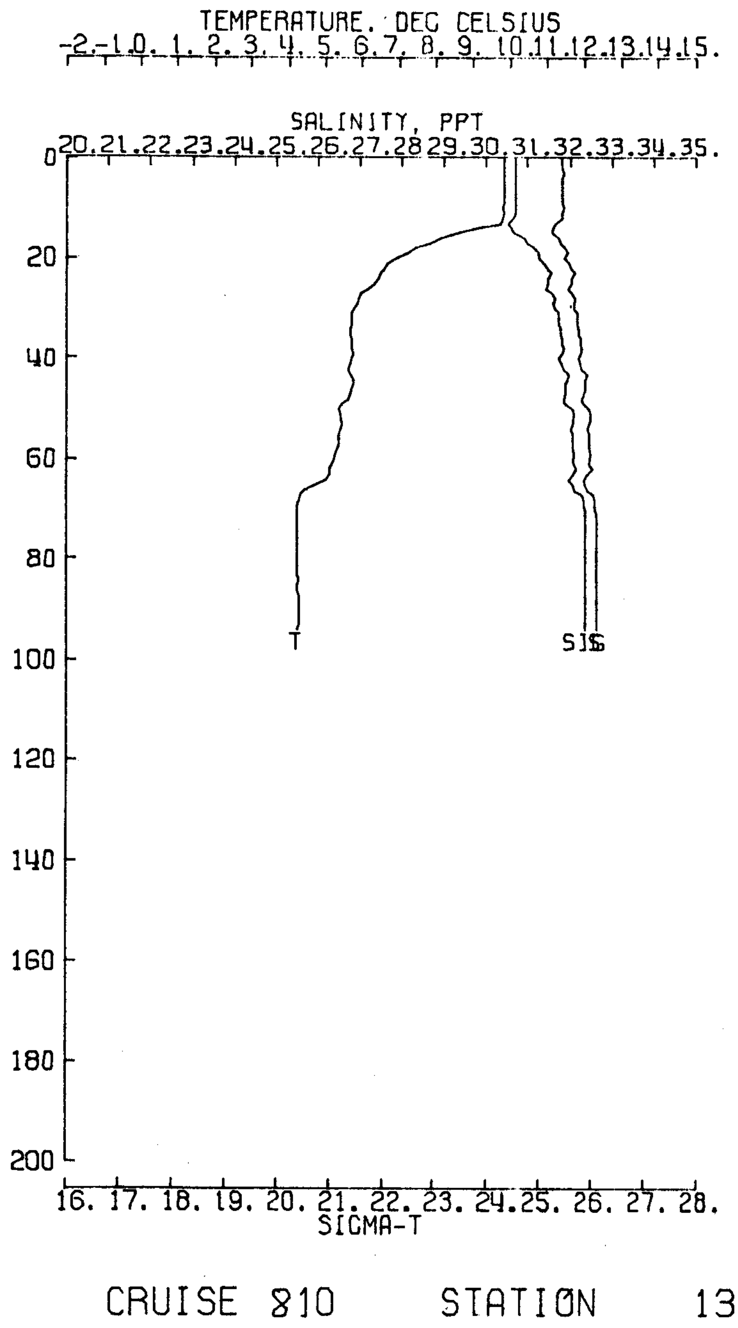
Appendix III - Figure 3. Plankton station 16 (*Discoverer* 810, station 10), STD profile.



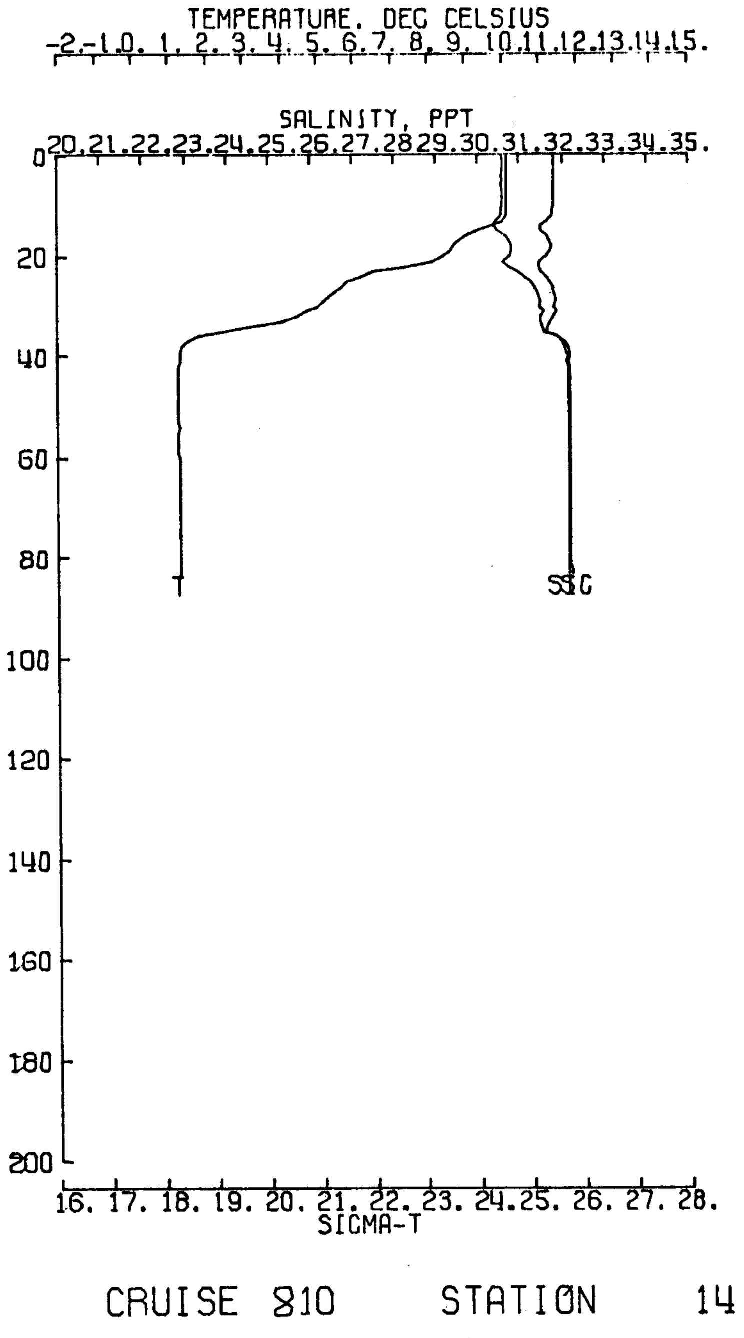
Appendix III - Figure 4. Plankton station 37 (*Discoverer* 810, station 11), STD profile.



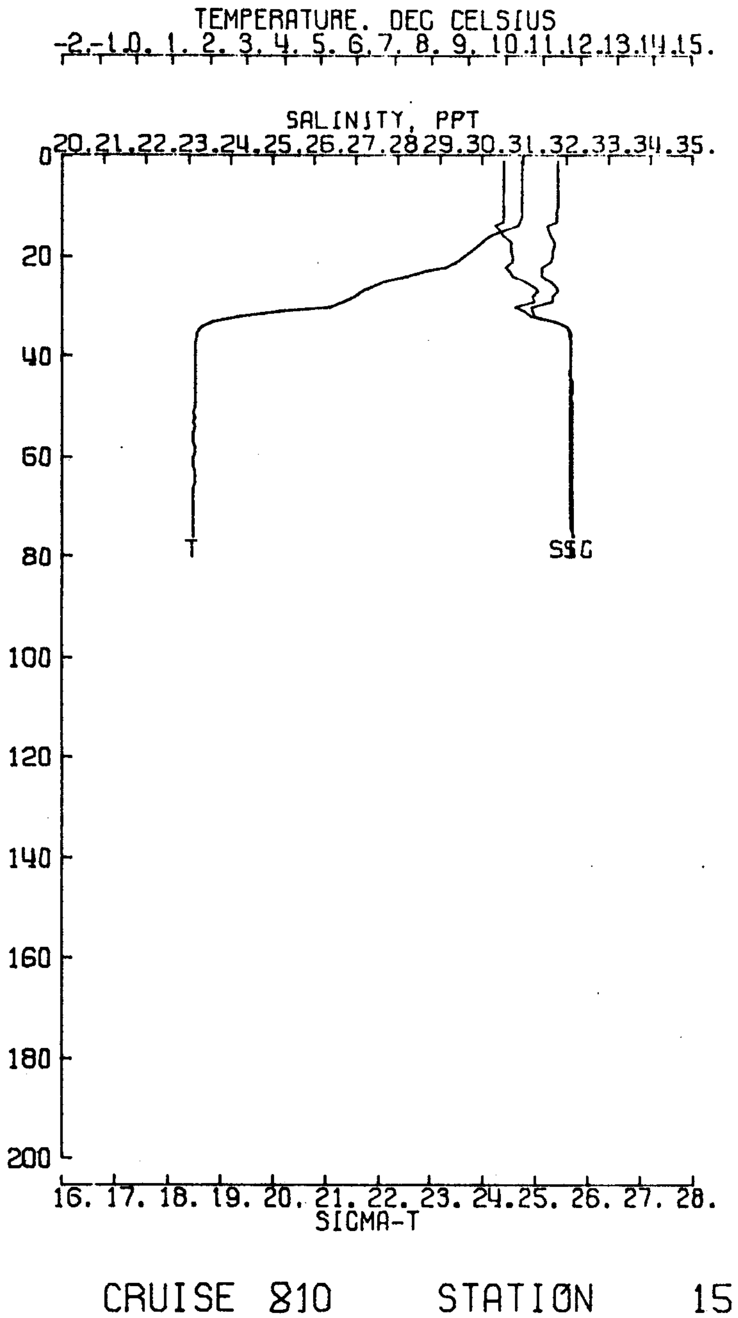
Appendix III - Figure 5. Plankton station 48 (*Discoverer* 810, station 12), STD profile.



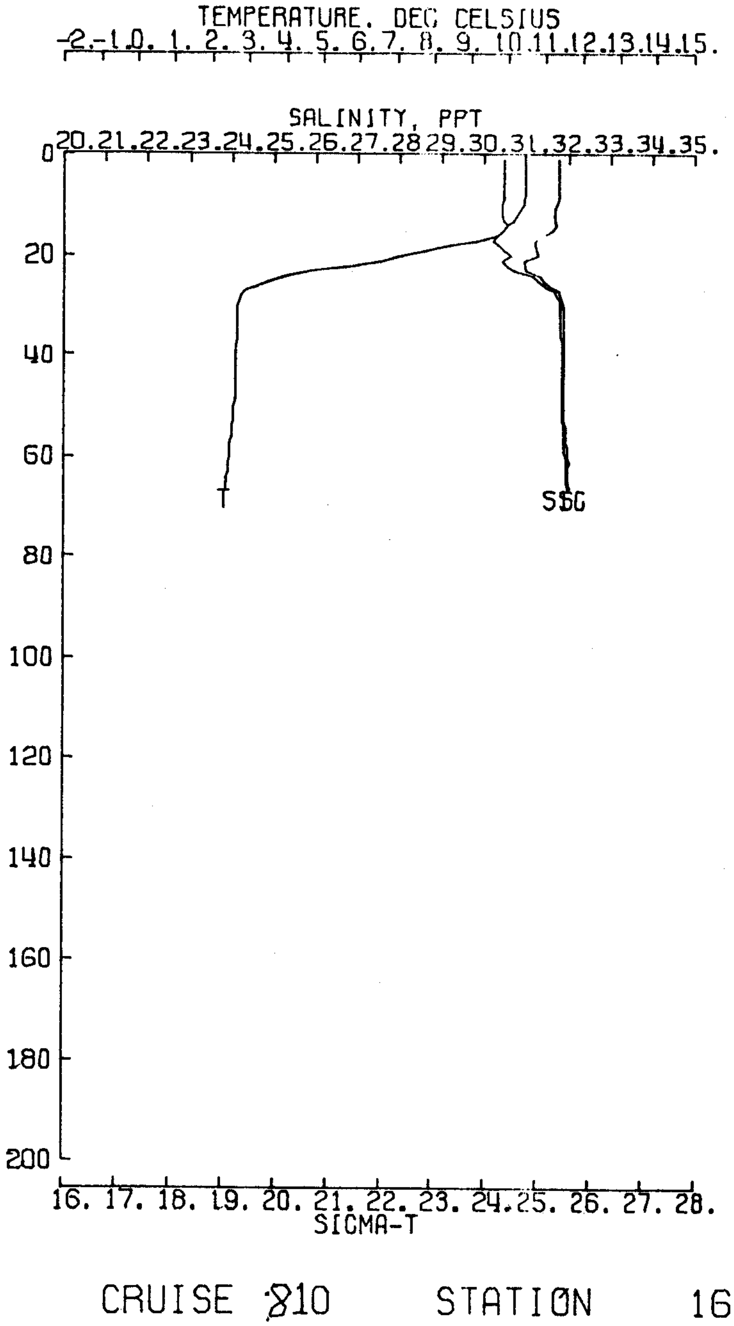
Appendix III - Figure 6. Plankton station 60 (*Discoverer* 810, station 13), STD profile.



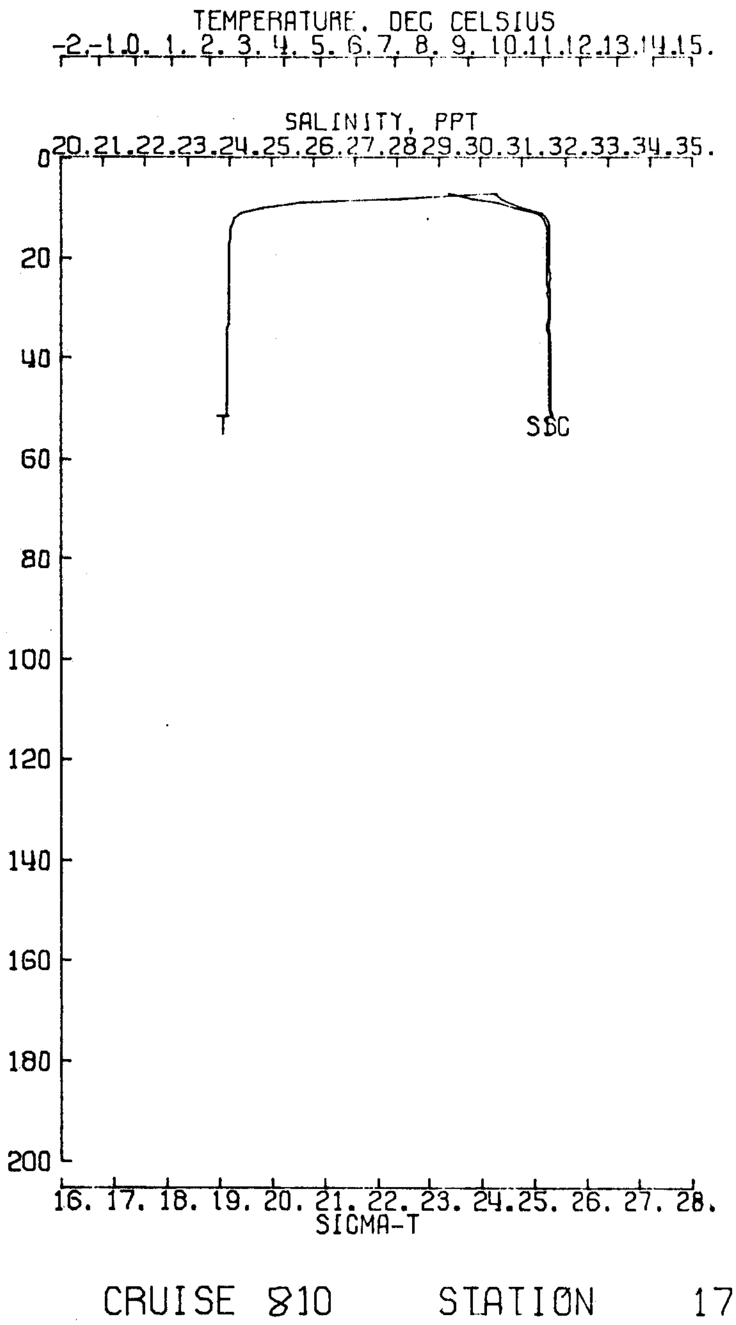
Appendix III - Figure 7. Plankton station 72 (*Discoverer* 810, station 14), STD profile.



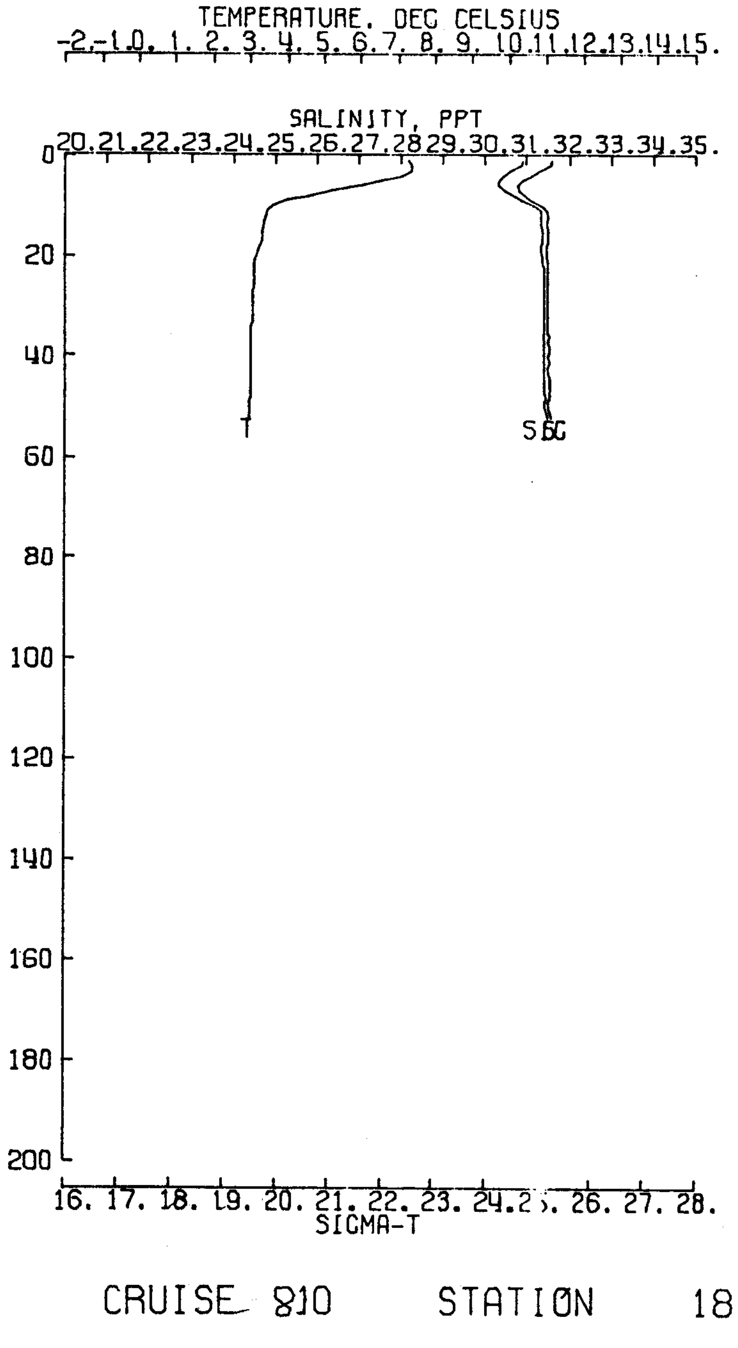
Appendix III - Figure 8. Plankton station 82 (*Discoverer* 810, station 15), STD profile.



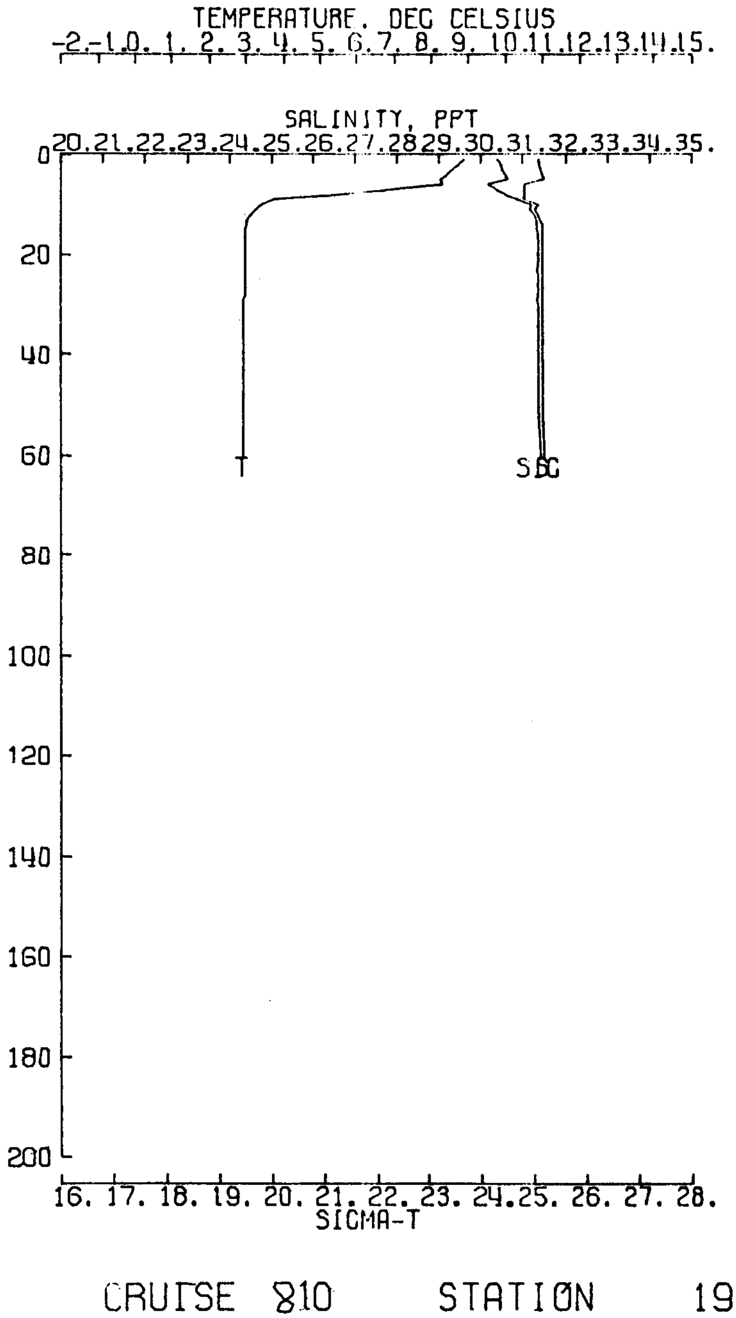
Appendix III - Figure 9. Plankton station 92 (*Discoverer* 810, station 16), STD profile.



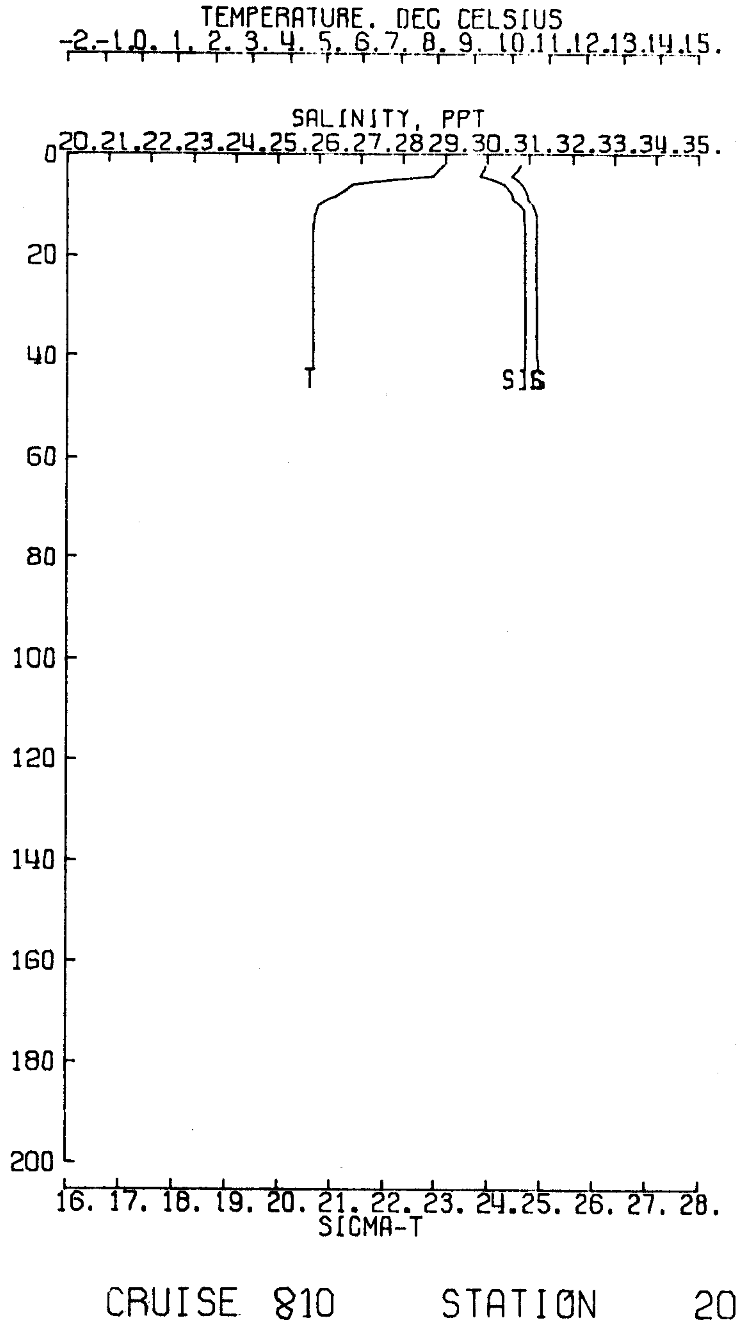
Appendix III - Figure 10. Plankton station 102 (*Discoverer* 810, station 17), STD profile.



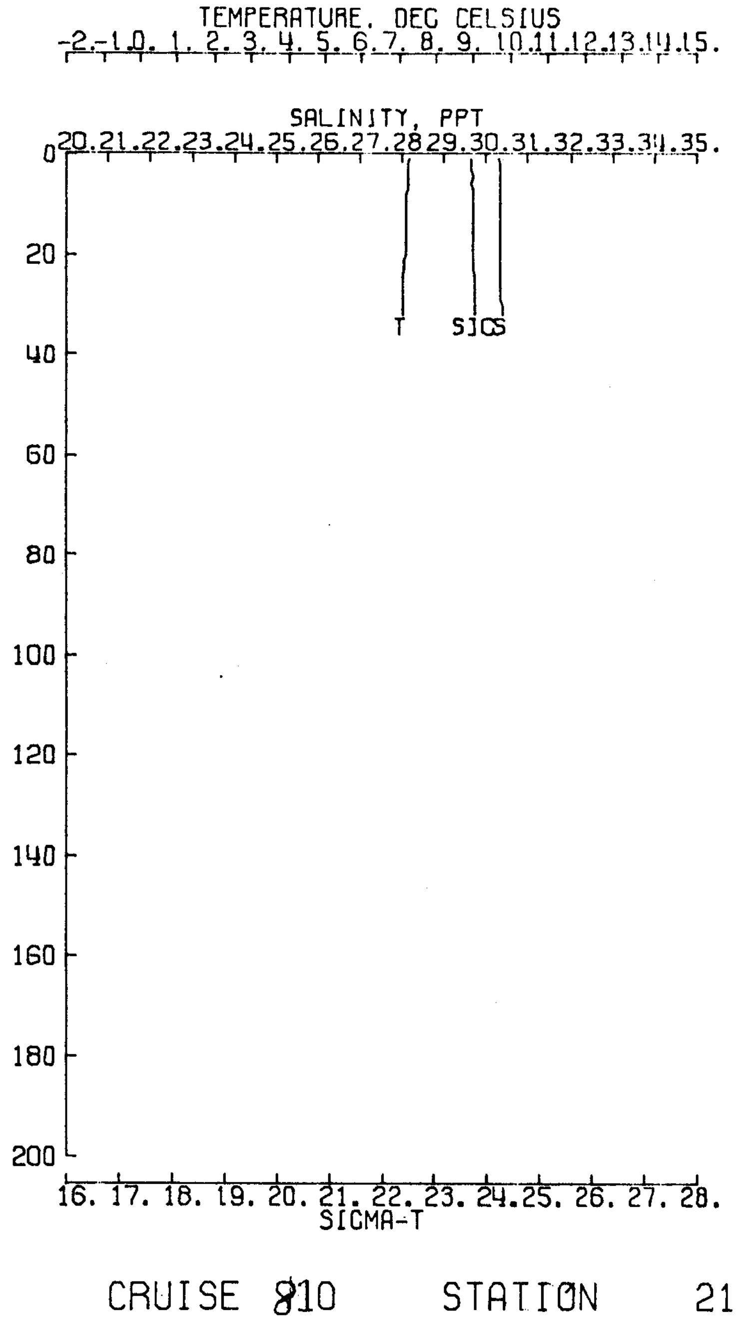
Appendix III - Figure 11. Plankton station 112 (*Discoverer* 810, station 18), STD profile.



Appendix III - Figure 12. Plankton station 116 (*Discoverer* 810, station 19), STD profile.



Appendix III - Figure 13. Plankton station 127 (*Discoverer* 810, station 20), STD profile.



Appendix III - Figure 14. Plankton station 136 (*Discoverer* 810, station 21), STD profile.

FINAL REPORT

Contract 03-5-022-56
Research Unit #502
Reporting Period: 7/1/76-12/31/77
Task Order No. 30
Number of Pages: 148

TRAWL SURVEY OF THE EPIFAUNAL INVERTEBRATES OF NORTON SOUND, SOUTHEASTERN CHUKCHI SEA, AND KOTZEBUE SOUND

Dr. H. M. Feder, Principal Investigator

with

Stephen C. Jewett

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

December 1977

ERRATA

Feder, H. M. and S. C. Jewett. 1977. Trawl survey of the epifaunal invertebrates of Norton Sound, Southeastern Chukchi Sea, and Kotzebue Sound. Final Report to NOAA. R.U. No. 502. 148 p.

To meet the due date for this report, it was necessary to assemble, type and edit the report within a short time interval. This led to a number of errors. Corrections are listed below.

<u>Page</u>

72 Figure 22, correct caption is - Percent composition in number, volume, and frequency of occurrence of major food items from 16 Norton Sound starry flounders.

73 Figure 23, correct caption is - Food web for starry flounders, *Platichthys stellatus*, from Norton Sound, Port Clarence and Southeastern Chukchi Sea. The thickness of lines in the food web indicates the relative importance of prey items.

74 Figure 24, correct caption is - The relative importance of major food items of starry flounders from Norton Sound, Port Clarence, and the Southeastern Chukchi Sea. See Sect. V of the text for discussion of the Index of Relative Importance (IRI).

ACKNOWLEDGEMENTS

We would like to thank the following for assistance during this study: the crew of the NOAA Ship *Miller Freeman* for logistic support; University of Alaska, Institute of Marine Science personnel-Max Hoberg and John Hilsinger for shipboard and taxonomic assistance; John Rose, George Mueller and Nora Foster for taxonomic assistance; Dr. Ronald Smith, Alan Paulson, and Shirley Liss for assistance with the starry flounder food data; Rosemary Hobson for assistance in data processing; and Ana Lea Vincent for drafting assistance. Robert Wolotira, National Marine Fisheries Service (NMFS), Seattle, Wa., assisted with logistic support, and Richard MacIntosh, NMFS, Kodiak, Alaska, identified the gastropod specimens.

This study was supported under contract 03-5-022-56 between the University of Alaska and NOAA, Department of Commerce through the Outer Continental Shelf Environmental Assessment Program to which funds were provided by the Bureau of Land Management, Department of Interior.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

APPENDIX TABLES

APPENDIX TABLES (Continued)

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

Very few studies have had the assessment of the sublittoral epifaunal invertebrates of the northern Bering Sea and/or the Chukchi as their goal (Ellson *et al.*, 1950 Sparks and Pereyra, 1966 Mueller and Feder, 1974). Further data on composition and basic biology of speices in these northern waters are essential before industrial activities take place there. It was the primary intent of this investigation to collect information on the composition, distribution, and biology of the epifaunal invertebrate components of Norton Sound, southeastern Chukchi Sea, and Kotzebue Sound.

The specific objectives of this study were:

1. A qualitative inventory of dominant benthic invertebrate epifaunal species within the study sites.
2. A description of spatial distribution patterns of selected benthic invertebrate epifaunal species in the designated study sites.
3. Preliminary observations of biological interrelationships between selected segments of the benthic biota in the designated study areas.

The trawl survey for the investigation of epifaunal invertebrates was effective, and excellent spatial coverage of the shelf of the northeastern Bering Sea and southeastern Chukchi Sea was obtained. One hundred seventy-six stations were established; 106 stations in the Norton Sound area and 70 stations in the Chukchi Sea-Kotzebue area. Each station was occupied for 30 minutes with a 400-mesh Eastern otter trawl during September and October, 1976. Taxonomic analysis of the invertebrates collected in the Norton Sound area delineated 13 phyla and 187 species; Chukchi Sea - Kotzebue Sound invertebrates consisted of 11 phyla and 171 species. Echinoderms made up the bulk of the invertebrate biomass with 80.3% in the Norton Sound region and 59.9% in the Chukchi Sea-Kotzebue Sound region. Other important phyla were Arthropoda and Mollusca.

Feeding data were obtained on four species of sea stars (*Asterias amurensis, Leptasterias polaris acervata, Evasterias echinosoma, Lethasterias nanimensis*) and one species of flatfish (*Platichthys stellatus*). The sea stars were feeding on a variety of epifaunal and infaunal species with *E. echinosoma* and *L. nanimensis* primarily taking clams, specifically the Greenland cockle, *Serripes groenlandicus*. Differences in the food habits of the starry flounder, *P. stellatus*, between the study areas were apparent. Starry flounders from Norton Sound fed mainly on the clam, *Yoldia hyperborea* and the brittle star, *Diamphiodia craterodmeta*; starry flounders from the southeast Chukchi Sea mainly utilized the proboscis worm, *Echiurus echiurus alaskensis* and the prickleback fish, *Lumpenus fabricii*. Food data collected for *P. stellatus* have made it possible to develop a preliminary food web for the study areas.

The possible importance of sea stars, the invertebrate group dominating in biomass in the areas, is considered in this report. It is suggested that these organisms may contribute pulses of high energy organic material by way of gametes at spawning time, into overlying waters, and that they represent important components of secondary production in the study areas.

A large number of the species collected in the study area were either sessile or slow-moving forms. Furthermore, many important food organisms were deposit feeders or were species capable of using this feeding method part of the time. Many of these species would be affected by oil spills either because of their inability to leave the area or as a result of their dependence on sediments in the feeding process.

The importance of deposit-feeding clams in the diet of starry flounders and sea stars is demonstrated. A high probability exists that oil hydrocarbons will enter starry flounders, sea stars and other bivalve predators *via* deposit-feeding molluscs, suggesting that studies interrelating sediment, oil, deposit-feeding clams, and appropriate predator species should be initiated soon.

Initial assessment of the data suggests that a few unique, abundant, and/or large benthic species (snow crabs, king crabs, crangonid shrimps, sea stars, starry flounders) are characteristic of the areas investigated and that these species may represent organisms that could be useful for monitoring purposes. Two biological parameters that should be addressed in conjunction with petroleum-related activities are feeding and reproductive biology of important species. It is suggested that an intensive program designed to examine these parameters be initiated well in advance of industrial activity in the oil lease areas.

II. INTRODUCTION

General Nature and Scope of Study

The operations connected with oil exploration, production, and transportation in Norton Sound and the Chukchi Sea present a wide spectrum of potential dangers to the marine environment (see Olson and Burgess, 1967, for general discussion of marine pollution problems). Adverse effects on a marine environment cannot be assessed, or even predicted, unless background data pertaining to the area are recorded prior to industrial development.

Insufficient long-term information about an environment, and the basic biology and recruitment of species in that environment can lead to erroneous

Figure 1. Benthic trawl stations occupied by NOAA Ship *Miller Freeman*, 2 September - 13 October, 1976.

interpretation of changes in species composition and abundance that might occur if the area becomes altered (see Nelson-Smith, 1973; Pearson, 1971, 1972; Rosenberg, 1973, for general discussions on benthic biological investigations in industrialized marine areas, and Lewis, 1970 for comments on the populations of marine species fluctuaion or populations of marine species over a time span of a few to 30 or more years).

Benthic organisms (primarily the infauna, and sessile and slow-moving epifauna) are useful as indicator species for a disturbed area because they tend to remain in place, typically react to long-range environmental changes, and by their presence, generally reflect the nature of the substratum. Consequently, the organisms of the infaunal benthos have frequently been chosen to monitor long-term pollution effects, and are believed to reflect the biological health of a marine area (see Pearson, 1971, 1972, 1975; and Rosenberg, 1973, for discussions on usage of benthic organisms for monitoring pollution).

Experience in pollution-prone areas of England (Smith, 1968), Scotland (Pearson, 1972), and California (Straughan, 1971) suggests that at the completion of an initial exploratory study, selected stations should be examined regularly on a long-term basis to determine any changes in species composition, diversity, abundance, and biomass. Such long-term data acquisition should make it possible to differentiate between normal ecosystem variation and pollutant-induced biological alteration. An intensive investigation of the benthos of Norton Sound and the Chukchi Sea is essential to an understanding of the trophic interactions involved there and the potential changes that may take place once oil-related activities are initiated.

The study reported here is a preliminary assessment of the benthic biology of selected invertebrate epifauna and the feeding biology of the starry flounder, *Platichthys stellatus*, of Norton Sound and the southeastern Chukchi Sea. This study is intended to extend northward the investigation of the Alaska continental shelf as part of the Outer Continental Shelf Environmental Program (OCSEAP). A quantitative assessment of the infauna of the study areas is still lacking. Specifically, this report considers the following: (1) the distribution and biomass of epifauna; (2) feeding observations on three species of sea stars and the starry flounder, *Platichthys stellatus*; (3) reproductive observations on five species of shrimps, eight species of crabs, and two species of sea stars; and (4) parasitological observations on two species of sea stars, and one species of hermit crab.

Relevance to Problems of Petroleum Development

The effects of oil pollution on subtidal benthic organisms have generally been neglected, although the results of a few studies, conducted after serious oil spills, have been published (see Boesch *et al.*, 1974 for review of these papers). Thus, lack of a broad data base elsewhere makes it difficult to predict the effects of oil-related activity on the subtidal benthos of the Norton Sound - Chukchi Sea - Kotzebue Sound. However, the expansion of research activities into these waters should ultimately enable us to identify certain species or areas that might bear closer scrutiny once industrial activity is initiated. It must be emphasized that a considerable time span is needed to comprehend fluctuations in density of marine benthic species, and it cannot be expected that a short-term research program will result in predictive capabilities. Assessment of the environment must be conducted on a continuing basis.

Data indicating the effects of oil on most subtidal benthic invertebrates are fragmentary (Nelson-Smith, 1973), but echinoderms are "notoriously sensitive to any reduction in water quality" (Nelson-Smith, 1973). Echinoderms (ophiuroids and asteroids) are conspicuous members of the study areas (Feder *et al.*, 1977b), and could be affected by oil activities there. The sea star, *Asterias amurensis*, is the dominant epibenthic species of the shallow shelf of the Norton Sound - Chukchi Sea - Kotzebue Sound areas examined (Feder *et al.*, 1977b). Laboratory experiments have demonstrated the sensitivity of *Asterias rubens*, a species from the North Sea, to hydrocarbons when it is fed tissues contaminated with crude oil. The latter sea star, when fed *Mytilus edulis* containing low concentrations of crude oil, eventually died (Crapp, 1970). The sensitivity of *A. amurensis* to oil should also be examined experimentally. The snow crab, *Chionoecetes opilio*, is also commonly found in the study areas. Laboratory experiments with the closely related *Chionoecetes bairdi* have shown that postmolt individuals lose most of their legs after exposure to Prudhoe Bay crude oil (Karinen and Rice, 1974); obviously this aspect of the biology of *C. opilio* must be considered in future OCSEAP investigations in the Norton Sound - Chukchi Sea - Kotzebue Sound areas. Little other direct data based on laboratory experiments are available for subtidal benthic species (see Nelson-Smith, 1973). Thus, experimentation on toxic effects of oil on other common members of the subtidal benthos should be strongly encouraged for the near future in northern Alaska waters as well as for all OCSEAP areas of investigation. In addition, potential effects of the loss of sensitive species to the trophic structure of the shelf must be examined. The latter problems can best be addressed once benthic food studies resulting from the Outer Continental Shelf program are available (e.g., see the following annual reports: Feder *et al.*, 1977a; Feder and Jewett, 1977; and Smith *et al.*, 1976).

A direct relationship between trophic structure (feeding type) and bottom stability has been demonstrated by Rhoads (see Rhoads, 1974 for review). He describes a diesel-fuel oil spill that resulted in oil becoming adsorbed on sediment particles which in turn caused the death of deposit feeders living on sublittoral muds. Bottom stability was altered with the death of these organisms, and a new complex of species became established in the altered substratum. Many common members of the infauna of the Norton Sound - Chukchi Sea are deposit feeders (Feder and Mueller, 1974; Feder *et al.*, 1977b; Feder and Jewett, unpub. observations); thus, oil-related mortality of these species could likewise result in a changed near-bottom sedimentary regime with alteration of species composition there. Furthermore, king and snow crabs and some bottom fishes use deposit feeders as food (Feder *et al.*, 1977a; Feder and Jewett, 1977).

III. CURRENT STATE OF KNOWLEDGE

Few studies of benthic invertebrates have been made in the Norton Sound - Chukchi Sea - Kotzebue Sound areas. Sparks and Pereyra (1966) include a partial species list and general discussion of the benthos of the southeast Chukchi Sea. Feder and Mueller (1974) present data including species lists, population density, biomass, and feeding methods for invertebrates collected by otter trawl, van Veen grab, and dredge in Norton Sound near Nome. Ellson *et al.* (1950) present results of an exploratory fishing survey in the Nome area in 1949.

Most of the species collected in the current investigation were known; also similar species have been reported for other regions of the northeastern Bering Sea shelf by Soviet investigations (Neiman, 1960; Stoker, in prep.).

The starry flounder, *Platichthys stellatus*, occurs from southern California northward to the Gulf of Alaska, Bering Sea, extending into the Chukchi Sea and also off central Japan and Korea extending north to the Okhotsk Sea. Feeding information for the starry flounder is available for this species from Monterey Bay, California (Orcutt, 1950) and from the San Juan Archipelago (Miller, 1967). Moiseev (1953) examined the food of coastal, small-mouthed, benthophagic flounders (a group to which *Platichthys stellatus* belongs) from the eastern coast of Russia.

IV. STUDY AREAS

The two regions examined included: (1) Norton Sound and the area north of St. Lawrence Island, and (2) the eastern Chukchi Sea south of Point Hope including Kotzebue Sound (Fig. 1). The Bering Strait arbitrarily divides the two areas. All stations were east of the U.S.-Russia Convention Line of 1867. The sampling area for the starry flounder food study reported here was divided into three general regions: the Norton Sound area, Port Clarence, and southeastern Chukchi Sea (Fig. 2).

V. SOURCES, METHODS, AND RATIONALE OF DATA COLLECTION

Data were collected in conjunction with trawling activities of the National Marine Fisheries Service on the NOAA Ship *Miller Freeman* from September 2-October 13, 1976. All collections were made with a 400-mesh

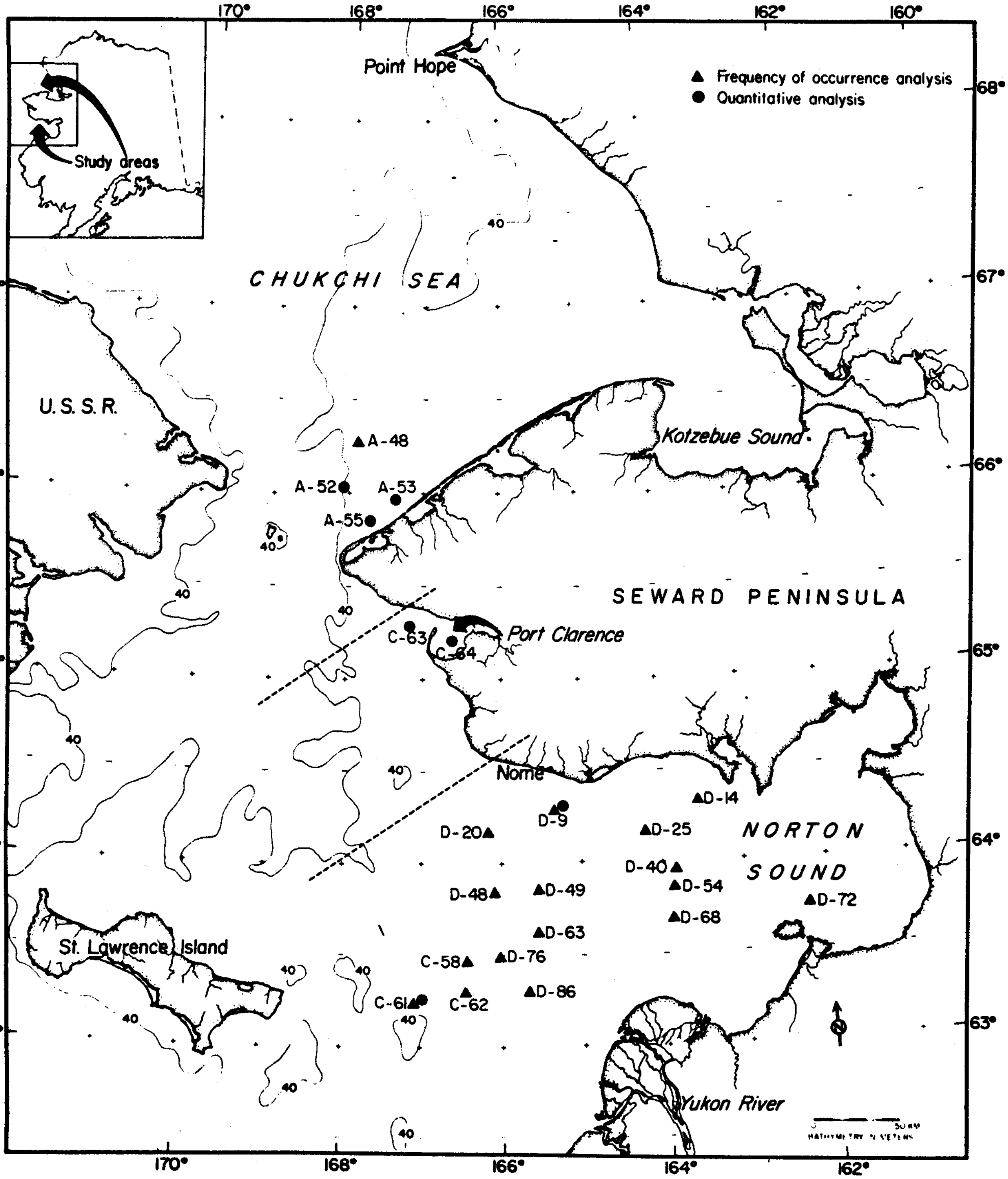


Figure 2. Sampling locations where starry flounder, *Platichthys stellatus*, digestive tracts were examined by frequency of occurrence and/or quantitative analysis. Dashed lines are arbitrarily placed to delineate the three sampling areas. See Sect. V of the text for methodology used in the starry flounder food studies.

eastern otter trawl with a 12.2 m horizontal opening; standard tows were 30 minutes.

Invertebrates, except for gastropods, were enumerated, weighed in the field, and given tentative identifications onboard ship by Institute of Marine Science personnel. The bulk of the gastropod data was collected by National Marine Fisheries Service personnel in accordance with contractual agreements. Aliquot samples and voucher specimens of all invertebrates (excluding gastropods) were preserved, and taken to the University of Alaska for positive identification. Taxonomic, distribution, abundance and biomass data were compiled in the laboratory at the University of Alaska at Fairbanks. Biomass per unit area (g/m^2) is calculated as follows: $\frac{W}{Tw\ (Dx1000)}$; where W = weight (grams), Tw = width of trawl opening (meters), and (Dx1000) is distance fished (kilometers x 1000). The data bases for all calculations of biomass per m^2 are included with the station data submitted to the National Oceanographic Data Center (NODC).

When laboratory examination revealed more than a single species in a field identification, the counts and weights of the species in question were arbitrarily expanded from the laboratory species ratio to encompass the entire catch of the trawl.

Information on feeding, reproduction, parasites and general ecology of the invertebrates collected was recorded whenever time permitted. At a station where parasitism was evident, a sample of the host organism was examined to determine the degree of infection. In addition, feeding data on the starry flounder, *Platichthys stellatus*, was obtained.

Stations selected for starry flounder food studies were determined in the field, and were dependent upon the time available for proper preservation of fish stomachs. Fish were immediately sorted, and either examined aboard ship or the digestive tracts removed and preserved in 10% buffered formalin for later examination in the laboratory in Fairbanks. The entire digestive tract, including the stomach and intestine, was examined. Each prey item was identified to the lowest taxon permitted by their state of preservation. The frequency of occurrence method of analysis, a semi-quantitative technique, was used for fish examined in the field (see Konstantinov, 1972; and Jewett, 1977, for application of this method). In the present report, since most fish were feeding, prey items are expressed as the number and percent of fish containing various food items relative to the total number of fish analyzed. Fish examined in the laboratory were analyzed using a quantitative method, i.e., frequency of occurrence in conjunction with a numerical and volumetric analysis of gut contents. Counts of all items and volumes of each taxon, measured by water displacement to the nearest 0.1 ml, were made. Fish examined in the field were sexed and measured (total length to the nearest 0.1 mm), and those examined in the laboratory were sexed, measured (total length), and weighed (total wet weight of fish to the nearest 0.1 g). The percent frequency of occurrence (F), the percent contribution by number (N), the percent by volume (V), and the index of relative importance (IRI) were calculated for each of the prey items for each station and each area. The latter index, IRI=F(N+V), was developed by Pinkas *et al.* (1971). A one way analysis of variance was used for all tests of significance on the index of relative importance (IRI).

VI. RESULTS

Distribution, Abundance and Biomass - Norton Sound Area

The preliminary Norton Sound - Chukchi Sea - Kotzebue Sound benthic study permitted successful occupation of 106 stations in the Norton Sound area. A total of 347.98 km were fished, and the total epifaunal invertebrate biomass was 18,231.06 kg or 3.73 g/m^2. The occurrence of each species from the Norton Sound area is found in Appendix Table I.

Taxonomic analysis delineated 13 phyla, 26 classes, 89 families, 124 genera, and 187 species (Table 1). Mollusca, Arthropoda, and Echinodermata dominated in species representation with 74, 45, and 27 species respectively (Table II). These three phyla also dominated the invertebrate biomass, but in reverse order, i.e., Echinodermata (80.3% of the total biomass), Arthropoda (9.6%), and Mollusca (4.4%) (Table III).

The echinoderm families Asteridae, Gorgonocephalidae, and Strongylocentrotidae were the most abundant and important in biomass (Table IV; See App. Table II for percentage composition of all phyla by family). Four sea stars of the family Asteridae, *Asterias amurensis, Lethasterias nanimensis, Evasterias echinosoma* and *Leptasterias polaris acervata* made up 67.4% of the total invertebrate biomass (Table V; See App. Table III for percentage composition of all phyla by species). The basket star, *Gorgonocephalus caryi*, and the sea urchin, *Strongylocentrotus droebachiensis*, were also dominant by weight.

The sea star, *Asterias amurensis*, was distributed throughout most of Norton Sound. Stations north and northeast of St. Lawrence Island had few occurrences of this species (Fig. 3). High biomass stations were generally restricted to the inner-sound region. However, station D-20, located off

TABLE I

Species taken by trawl from the Norton Sound area onboard the NOAA Ship *Miller Freeman*, 2 September-13 October, 1976

Phylum Porifera
  Class Demospongia
    Family Axinellidae
      Phakellia sp.
      Phakellia cribrosa (Miklucho-Maclay)

Phylum Cnidaria
  Class Hydrozoa
    Family Sertulariidae
      Unidentified species

  Class Scyphozoa
      Unidentified species

  Class Anthozoa
    Family Nephtheidae
      Eunephthya rubiformis (Pallas)

    Family Actinostolidae
      Stomphia coccinea (O. F. Müeller)

    Family Actinidae
      Unidentified species

Phylum Rhynchocoela
      Unidentified species

Phylum Annelida
  Class Polychaeta
    Family Polynoidae
      Arctonoe vittata (Grube)
      Eunoe depressa (Moore)
      Eunoe senta (Moore)

    Family Nereidae
      Nereis sp.

    Family Flabelligeridae
      Brada villosa (Rathke)

    Family Sternaspidae
      Sternaspis scutata (Ranzani)

    Family Pectinariidae
      Cistenides hyperborea (Malmgren)

    Family Terebellidae
      Terebella sp.

    Family Sabellidae
      Potamilla sp.
      Jasminiera sp.

TABLE I (Cont'd)

Class Hirudinea
  Family Piscicolidae
    Carcinobdella sp.

Phylum Mollusca
  Class Polyplacophora
    Family Acanthochitonidae
      Cryptochiton stelleri (Middendorff)

    Family Mopaliidae
      Amicula pallasii (Middendorff)
      Amicula vestita (Broderip and Sowerby)

  Class Pelecypoda
    Family Nuculanidae
      Yoldia sp.
      Yoldia hyperborea (Loven)
      Yoldia myalis (Couthouy)

    Family Glycymeridae
      Glycymeris subobsoleta (Carpenter)

    Family Mytilidae
      Mytilus edulis Linnaeus
      Musculus niger Gray
      Musculus discors (Linné)

    Family Pectinidae
      Chlamys rubida (Hinds)

    Family Astartidae
      Astarte borealis (Schumacher)
      Astarte montagui (Dillwyn)

    Family Carditidae
      Cyclocardia crebricostata (Krause)
      Cyclocardia crassidens (Broderip and Sowerby)

    Family Kelliidae
      Pseudopythina sp.

    Family Cardiidae
      Clinocardium sp.
      Clinocardium ciliatum (Fabricius)
      Clinocardium nuttallii (Conrad)
      Clinocardium californiense Deshayes
      Serripes groenlandicus (Bruquière)

    Family Veneridae
      Liocyma fluctuosa (Gould)

    Family Mactridae
      Spisula polynyma (Stimpson)

TABLE I (Cont'd)

Family Tellinidae
Macoma sp.
Macoma calcarea (Gmelin)
Macoma brota Dall
Tellina lutea Wood

Family Myidae
Mya pseudoarenaria Schlesch

Family Hiatellidae
Hiatella arctica (Linné)
Panomya arctica (Lamarck)

Class Gastropoda
Family Trochidae
Margarites giganteus (Leche)
Solariella sp.
Solariella obscura (Couthouy)
Solariella varicosa (Mighels and Adams)

Family Turritellidae
Tachyrhynchus erosus (Couthouy)

Family Epitoniidae
Opalia sp.

Family Trichotropididae
Trichotropis bicarinata (Sowerby)
Trichotropis insignis Middendorff
Trichotropis kroyeri Philippi

Family Naticidae
Natica clausa Broderip and Sowerby
Polinices pallida (Broderip and Sowerby)

Family Velutinidae
Velutina sp.
Velutina plicatilis (Müller)

Family Muricidae
Boreotrophon clathratus (Linnaeus)

Family Buccinidae
Buccinum sp.
Buccinum angulosum Gray
Buccinum scalariforme Möller
Buccinum glaciale Linnaeus
Buccinum solenum Dall
Buccinum polare Gray
Buccinum fringillum Dall
Buccinum tenellum Dall

TABLE I (Cont'd)

Family Neptuneidae
- *Ancistrolepsis* sp.
- *Beringius crebricostatus* Dall
- *Beringius beringii* (Middendorff)
- *Beringius stimpsoni* (Gould)
- *Colus spitzbergensis* (Reeve)
- *Colus ombronius* (Dall)
- *Colus hypolispus* (Dall)
- *Liomesus ooides* (Middendorff)
- *Neptunea ventricosa* (Gmelin)
- *Neptunea borealis* (Philippi)
- *Neptunea heros* (Gray)
- *Plicifusus kroyeri* (Möller)
- *Plicifusus verkruzeni* Kobelt
- *Pyrulofusus deformis* (Reeve)
- *Volutopsius* sp.
- *Volutopsius filosus* Dall
- *Volutopsius fragilis* Dall

Family Turridae
- *Oenopota harpa* (Dall)
- *Obesitoma simplex* (Middendorff)

Family Dorididae
- *Doris* sp.

Family Dendronotidae
- *Dendronotus* sp.

Class Cephalopoda

Family Octopodidae
- *Octopus* sp.

Phylum Arthropoda

Class Pycnogonida
- Unidentified species

Class Crustacea

Order Thoracica

Family Balanidae
- *Balanus* sp.
- *Balanus balanus* (Linné)
- *Balanus rostratus* Pilsbry

Order Cumacea
- Unidentified species

Order Isopoda

Family Idoteidae
- *Saduria entomon* (Linnaeus)
- *Synidotea bicuspida* (Owen)

Family Sphaeromatidae
- *Tecticeps* sp.

TABLE I (Cont'd)

Order Amphipoda
Family Ampeliscidae
Unidentified species

Family Eusiridae
Eusirus sp.
Rhachotropis sp.

Family Gammaridae
Melita sp.
Melita dentata Kröyer

Family Ischyroceridae
Jassa sp.

Family Lysianassidae
Anonyx sp.
Anonyx nugax pacifica Kröyer
Anonyx ampulloides Bate
Socarnes sp.

Family Podoceridae
Dulichia spinosissima

Family Stegocephalidae
Stegocephalus inflatus Kröyer

Family Hyperiidae
Parathemisto japonica Bovallius

Family Caprellidae
Unidentified species

Order Decapoda
Family Pandalidae
Pandalus borealis Kröyer
Pandalus goniurus Stimpson
Pandalus hypsinotus Brandt

Family Hyppolytidae
Lebbeus groenlandica (Fabricius)
Eualus sp.
Eualus fabricii (Kröyer)
Eualus gaimardii belcheri (Bell)
Eualus macilenta (Kröyer)

Family Crangonidae
Crangon dalli Rathbun
Sclerocrangon boreas (Phipps)
Argis lar (Owen)

TABLE I (Cont'd)

Family Paguridae
Pagurus ochotensis (Benedict)
Pagurus capillatus (Benedict)
Pagurus trigonocheirus (Stimpson)
Pagurus dalli (Benedict)
Labidochirus splendescens (Owen)

Family Lithodidae
Hapalogaster grebnitzkii Schalfeew
Paralithodes camtschatica (Tilesius)
Paralithodes platypus Brandt
Sculptolithodes derjugini Makarov

Family Majidae
Hyas coarctatus alutaceus Brandt
Chionoecetes opilio (Fabricius)

Family Atelecyclidae
Telmessus cheiragonus (Tilesius)

Phylum Sipunculida
Family Golfingiidae
Golfingia margaritacea (M. Sars)

Phylum Echiurida
Class Echiuridea
Family Echiuridae
Echiurus echiurus alaskensis Pallas

Phylum Priapulida
Family Priapulidae
Priapulus caudatus Lamarck

Phylum Ectoprocta
Class Cheilostomata
Family Flustridae
Flustra sp.

Family Bicellariellidae
Dendrobeania sp.

Class Cyclostomata
Family Diastoporidae
Diaperoecia sp.

Family Heteroporidae
Heteropora sp.

Class Ctenostomata
Family Alcyonidiidae
Alcyonidium sp.
Alcyonidium disciforme Smitt
Alcyonidium vermiculare Okada

TABLE I (Cont'd)

Family Flustrellidae
Flustrella gigantea Silen

Phylum Brachiopoda
Class Articulata
Family Dallinidae
Laqueus californianus Koch

Phylum Echinodermata
Class Asteroidea
Family Echinasteridae
Henricia sp.

Family Pterasteridae
Pteraster obscura (Perrier)

Family Solasteridae
Crossaster papposus (Linné)
Solaster sp.
Solaster damsoni (Verrill)

Family Asteriidae
Asterias amurensis Lükten
Asterias rathbuni (Verrill)
Evasterias echinosoma Fisher
Evasterias troschellii (Stimpson)
Leptasterias sp.
Leptasterias alaskensis Fisher
Leptasterias polaris acervata Stimpson
Lethasterias sp.
Lethasterias nanimensis (Verrill)

Class Echinoidea
Family Echinarachniidae
Echinarachnius parma Lamarck

Family Strongylocentrotidae
Strongylocentrotus droebachiensis (O. F. Müller)

Class Ophiuroidea
Family Amphiuridae
Amphiodia sp.
Diamphiodia craterodmeta (Clark)

Family Gorgonocephalidae
Gorgonocephalus caryi (Lyman)

Family Ophiactidae
Ophiopholis aculeata (Linné)

Family Ophiuridae
Ophiura sarsi Lükten
Stegophiura sp.
Stegophiura nodosa Lükten

TABLE I (Cont'd)

Class Holothuroidea
  Family Cucumariidae
    Cucumaria sp.
    Cucumaria calcigera (Stimpson)

  Family Psolidae
    Psolus japonicus Öestergren

Phylum Chordata
 Subphylum Urochordata
  Class Ascidiacea
   Family Rhodosomatidae
    Chelyosoma sp.
    Chelyosoma columbianum Huntsman
    Chelyosoma orientale Redikorzev

   Family Styelidae
    Styela macrenteron Ritter
    Pelonaia corrugata Forbes and Goods

   Family Pyuridae
    Boltenia ovifera (Linné)
    Boltenia echinata Linné
    Halocynthia sp.
    Halocynthia aurantium (Pallas)

  Class Thaliacea
   Family Salpidae
    Unidentified species

TABLE II

Number and percent of epifaunal invertebrate species by phylum and class from the Norton Sound area

Phylum	Class	No. of Species	% of Species
Porifera	Demospongia	2	1.08
Cnidaria	Hydrozoa	1	0.54
	Scyphozoa	1	0.54
	Anthozoa	3	1.61
	Totals	5	2.69
Rhynchocoela	Unidentified	1	0.54
Annelida	Polychaeta	10	5.38
	Hirudinea	1	0.54
	Totals	11	5.92
Mollusca	Polyplacophora	3	1.61
	Pelecypoda	27	14.52
	Gastropoda	43	23.12
	Cephalopoda	1	0.54
	Totals	74	39.79
Arthropoda	Pycnogonida	1	0.54
	Crustacea	44	23.12
	Totals	45	23.66
Sipunculida	-	1	0.54
Echiurida	Echiuridea	1	0.54
Priapulida	-	1	0.54
Ectoprocta	Cheilostomata	2	1.08
	Cyclostomata	2	1.08
	Ctenostomata	5	2.69
	Totals	9	4.85
Brachiopoda	Articulata	1	0.54
Echinodermata	Asteroidea	14	7.53
	Echinoidea	2	1.08
	Ophiuroidea	8	4.30
	Holothuroidea	3	1.61
	Totals	27	14.52
Chordata	Ascidiacea	9	4.84
	Thaliacea	1	0.54
	Totals	10	5.38
	Grand Totals	186	100.00

TABLE III

Number, weight, and biomass (g/m^2) of the invertebrate phyla of the Norton Sound area (N.S.) and Chukchi Sea - Kotzebue Sound area (C.S.)

Phylum	Number of organisms N.S.	Number of organisms C.S.	Weight (kg) N.S.	Weight (kg) C.S.	% Total wt. N.S.	% Total wt. C.S.	g/m^2 N.S.	g/m^2 C.S.
Porifera	764	777	74.01	73.49	0.41	0.76	0.015	0.025
Cnidaria	24485	9488	782.56	426.55	4.29	4.44	0.160	0.146
Rhynchocoela	7	5	0.01	0.06	<.01	<.01	<.001	<.001
Annelida	1090	7282	4.72	14.53	0.03	0.15	0.001	0.005
Mollusca	8788	16489	794.86	1230.00	4.36	12.79	0.162	0.411
Arthropoda (Crustacea)	68510	66530	1756.44	1204.27	9.63	12.52	0.359	0.411
Sipunculida	3	10	0.04	0.24	<.01	<.01	<.001	<.001
Echiuroidea	9	31	0.19	0.82	<.01	<.01	<.001	<.001
Ectoprocta	65	65	6.03	11.25	0.03	0.12	0.001	0.004
Priapulida	1	-	<.01	-	<.01	-	<.001	-
Brachiopoda	2	-	<.01	-	<.01	-	<.001	-
Echinodermata	93206	60720	14632.83	5763.55	80.26	59.93	2.994	1.967
Chordata (Ascidiacea)	7366	41814	179.35	892.45	0.98	9.28	0.036	0.304
TOTALS	204296	203211	8231.06	9617.21	100%	100%	3.73	3.28

TABLE IV

Number, weight, and biomass (g/m^2) of major invertebrate families of the Norton Sound area (N.S.) and Chukchi Sea - Kotzebue Sound area (C.S.)

Phylum	Number of organisms		Weight (kg)		% Total wt.		g/m^2	
	N.S.	C.S.	N.S.	C.S.	N.S.	C.S.	N.S.	C.S.
Actiniidae	21498	7663	540.05	238.81	2.94	2.47	0.110	0.082
Neptuneidae	6495	12563	735.19	1176.40	4.00	12.18	0.150	0.405
Crangonidae	22568	15772	159.74	100.30	0.87	1.03	0.032	0.034
Paguridae	24420	21106	336.88	317.57	1.83	3.28	0.068	0.109
Lithodidae	1046	20	773.81	6.87	4.21	0.07	0.158	0.002
Majidae	6264	25553	245.54	682.13	1.33	7.06	0.050	0.234
Atelecyclidae	1116	674	150.62	89.50	0.82	0.92	0.030	0.030
Asteridae	70866	28682	12669.50	4640.09	69.04	48.04	2.592	1.597
Strongylo-centrotidae	9572	8794	610.58	616.15	3.327	6.37	0.124	0.212
Gorgono-cephalidae	5218	1285	1281.55	331.81	6.98	4.43	0.262	0.114
Rhodosomatidae	146	15481	3.72	466.46	0.02	4.83	0.001	0.160
Styelidae	5541	5822	139.62	198.73	0.76	2.05	0.028	0.068
Pyuridae	1469	19018	33.01	219.69	0.18	2.27	0.006	0.075
TOTALS	176219	162433	17679.81	9084.51	96.31	94.00	3.61	3.12

TABLE V

Percentage composition by weight and the feeding methods[1] of the leading invertebrate species collected in the Norton Sound area

Phylum	% wt. of all phyla	Leading Species	Feeding[2] Method	Avg. wt. per Individual	% wt. of phylum	% wt. of all phyla
Echinodermata	80.30	*Asterias amurensis*	P	178 g	68.29	54.46
		Gorgonocephalus caryi	Sus-P	246 g	8.76	6.98
		Lethasterias nanimensis	P	311 g	7.06	5.63
		Evasterias echinosoma	P	692 g	4.93	3.93
		Leptasterias polaris acervata	P	106 g	4.23	3.37
		Strongylocentrotus droebachiensis	H-S-P	64 g	4.17	3.33
		Totals			97.44	77.70
Arthropoda (Crustacea)	9.59	*Paralithodes camtschatica*	P-S	801 g	41.90	3.99
		Hyas coarctatus alutaceus	P-S ?	49 g	10.53	1.00
		Pagurus trigonocheirus	P-S ?	15 g	10.02	0.95
		Telmessus cheiragonus	P-S ?	135 g	8.62	0.82
		Pagurus capillatus	P-S ?	12 g	6.14	0.58
		Argis lar	S ?	7 g	5.66	0.54
		Totals			82.87	7.88
Mollusca	4.36	*Neptunea heros*	P-S	130 g	69.57	3.01
		Neptunea ventricosa	P-S	80 g	11.17	0.48
		Beringius beringi	P-S	90 g	6.00	0.26
		Serripes groenlandicus	Sus	38 g	5.43	0.24
Total	94.25	Totals			92.17	3.99

[1]Based on Hatanaka and Kosaka, 1958; Reese, 1966; Pearce and Thorson, 1967; Feder *et al.*, 1977b; and pers. observation. Feeding methods for related species are included when no direct data are available for species included above.

[2]Feeding methods: P = predator; P-S = predator-scavenger; S = scavenger; Sus = suspension feeder; Sus-P = suspension feeder-predator; H-S-P = herbivore-scavenger-predator.

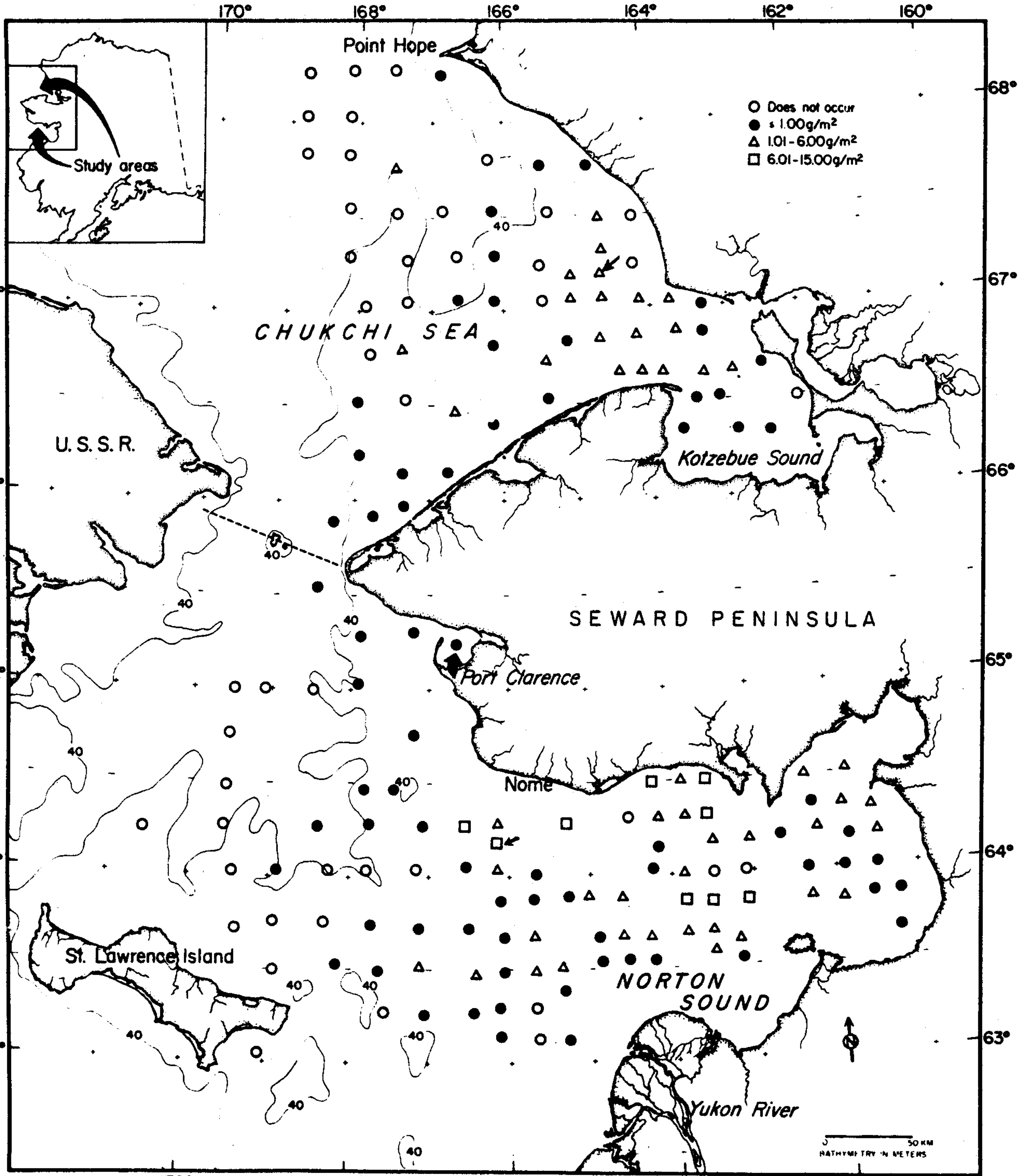


Figure 3. Distribution and biomass of the sea star, *Asterias amurensis*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 14.95 g/m^2 for Norton Sound area station D-20, and 5.98 g/m^2 for Chukchi Sea - Kotzebue Sound area station B-4.

Nome, had the highest biomass with 539.80 kg per standard tow or 14.95 g/m^2 (Fig. 3). Slightly less than 2500 specimens were taken at this station.

Lethasterias nanimensis occurred mainly in the northern half of Norton Sound (Fig. 4). This species was absent from stations north of St. Lawrence Island. Station D-7, also located off Nome, had the highest biomass with 85.58 kg per standard tow or 2.52 g/m^2 (Fig. 4).

Evasterias echinosoma, the largest sea star found on the survey (average wet weight of 692 g), and *L. nanimensis* were found at similar stations and attained similar biomasses at these stations (Fig. 5). Likewise, station D-7 also had the highest biomass of *E. echinosoma* with 136.20 kg per standard tow or 4.02 g/m^2 (Fig. 5).

Leptasterias polaris acervata had a different distributional pattern from the other sea stars. This species occurred mainly at those stations north and northeast of St. Lawrence Island (Fig. 6). However, station C-32, another station located off Nome, had the highest biomass with 322.03 kg per standard tow or 6.79 g/m^2 (Fig. 6).

The basket star, *Gorgonocephalus caryi*, was more restricted in its distribution, i.e., most stations of occurrence were in outer Norton Sound (Fig. 7). Station C-1, off Cape Prince of Wales near Bering Strait, had the highest biomass: 671.65 kg per standard tow or 14.88 g/m^2 (Fig. 7). Over 2000 basket stars were obtained at this station.

Another echinoderm, *Strongylocentrotus droebachiensis*, also contributed significantly to the overall biomass. High biomass stations were mainly in inner Norton Sound; however, station C-32 had the highest biomass: 224.42 kg per standard tow or 4.73 g/m^2 (Fig. 8).

Crabs dominated the arthopod biomass with 86.3% of the weight of the phylum, but they only comprised 8.25% of the total invertebrate biomass

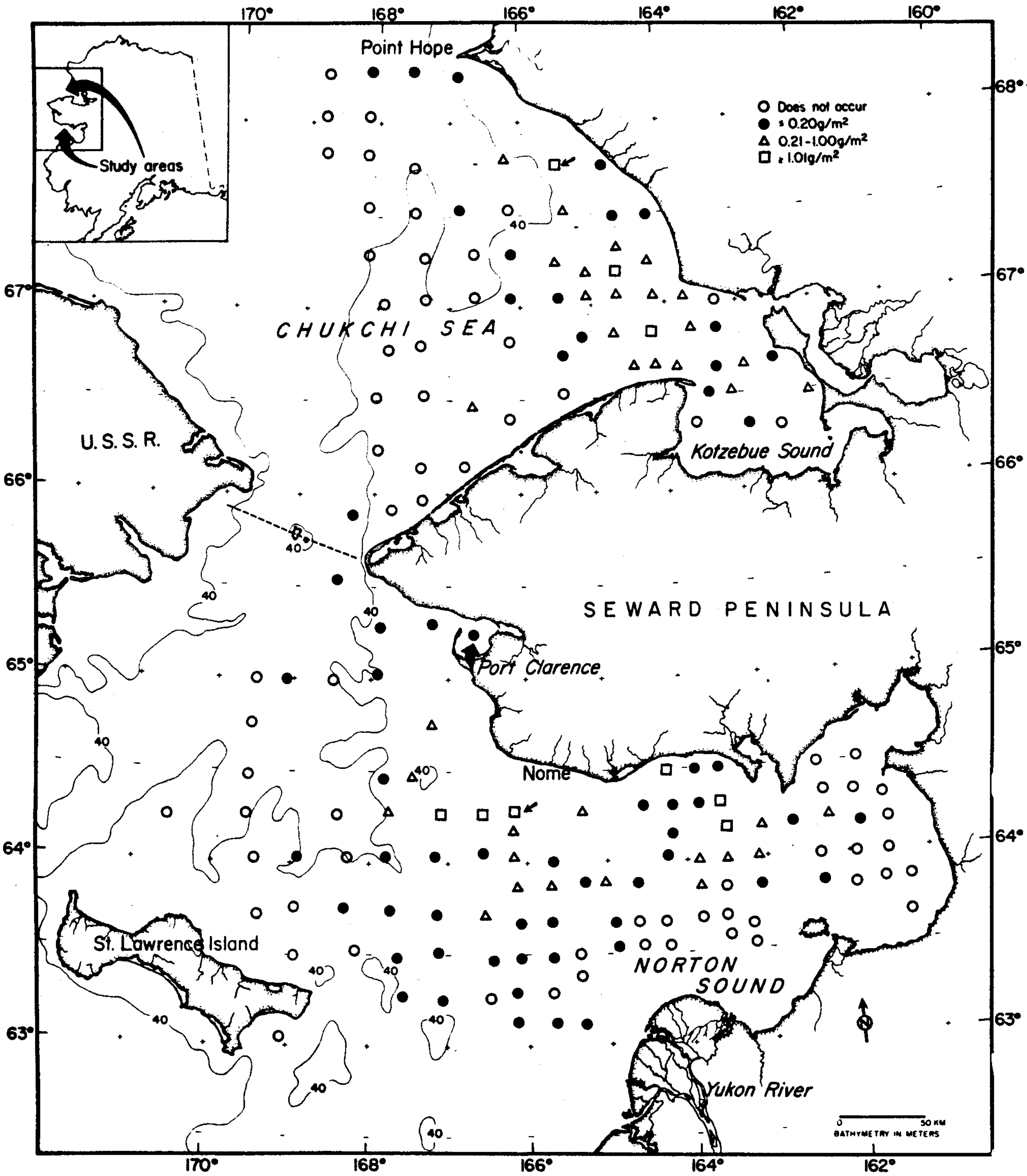


Figure 4. Distribution and biomass of the sea star, *Lethasterias nanimensis* from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 2.52 g/m^2 for Norton Sound area station D-7 and 2.45 g/m^2 for Chukchi Sea - Kotzebue Sound area station A-14.

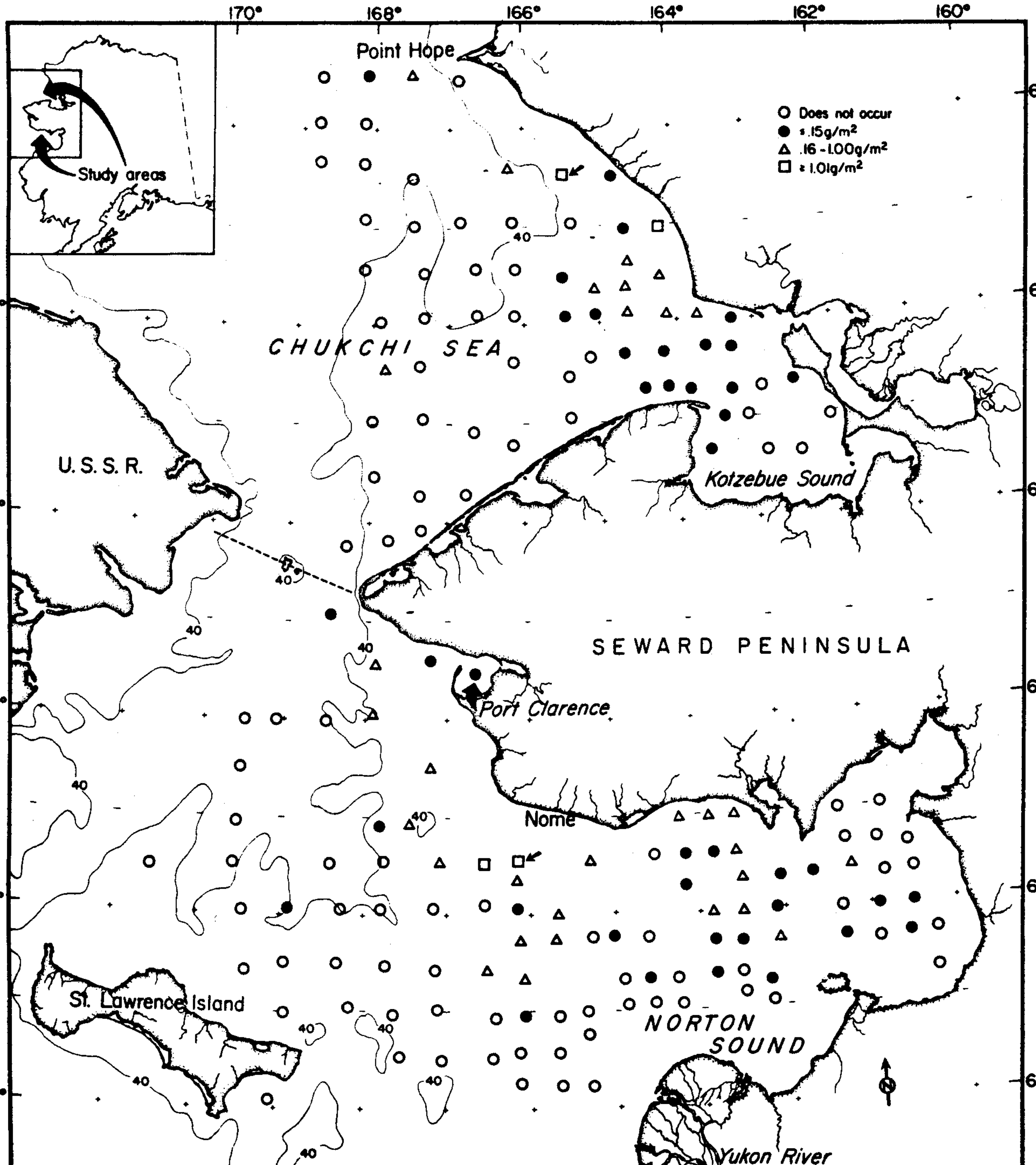


Figure 5. Distribution and biomass of the sea star, *Evasterias echinosoma* from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 4.02 g/m^2 for Norton Sound area station 0-7 and 3.03 g/m^2 for Chukchi Sea - Kotzebue Sound area station A-14.

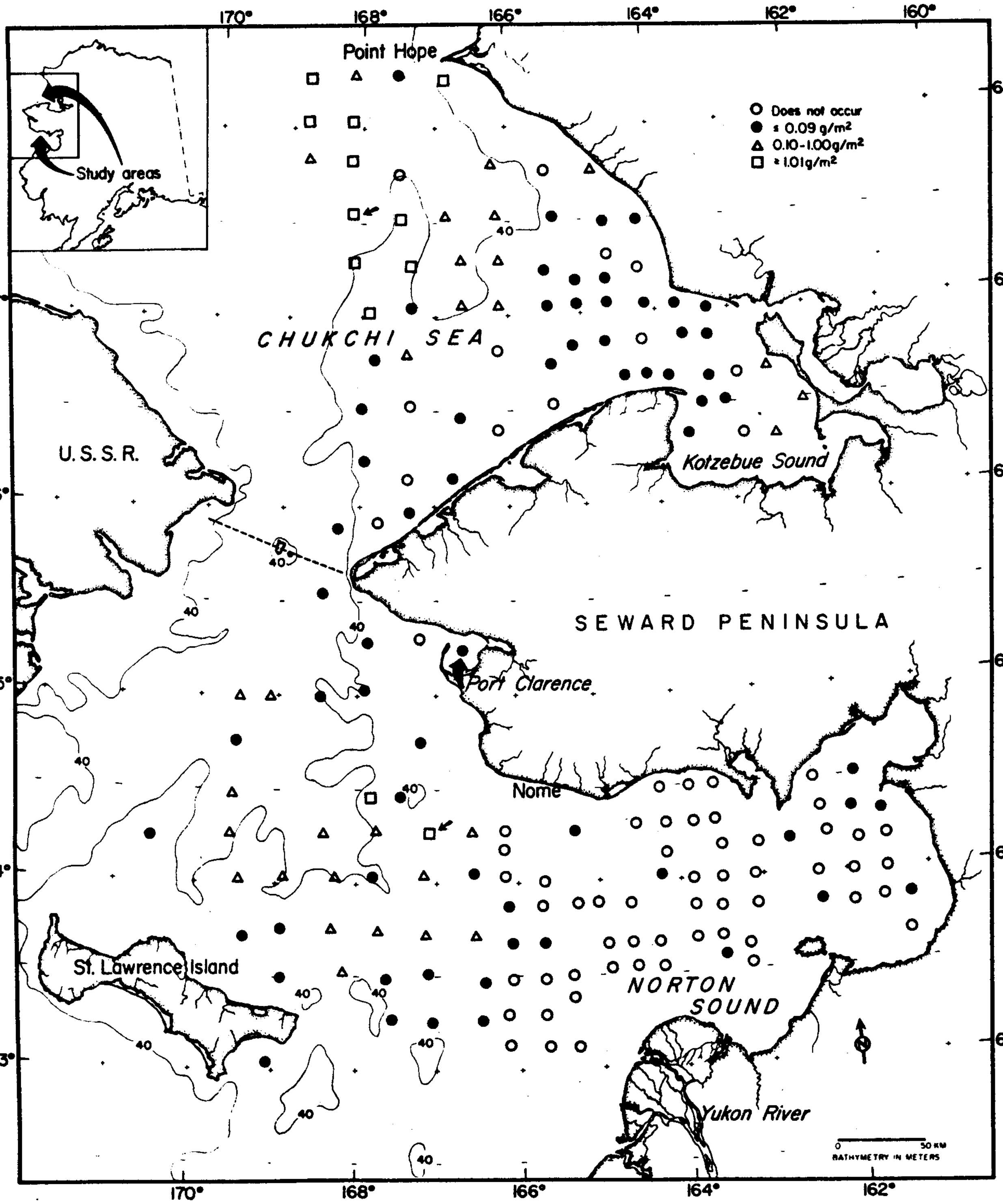


Figure 6. Distribution and biomass of the sea star, *Leptasterias polaris acervata*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 6.48 g/m^2 for Norton Sound station area C-32 and 7.48 g/m^2 for Chukchi Sea - Kotzebue Sound area station B-4.

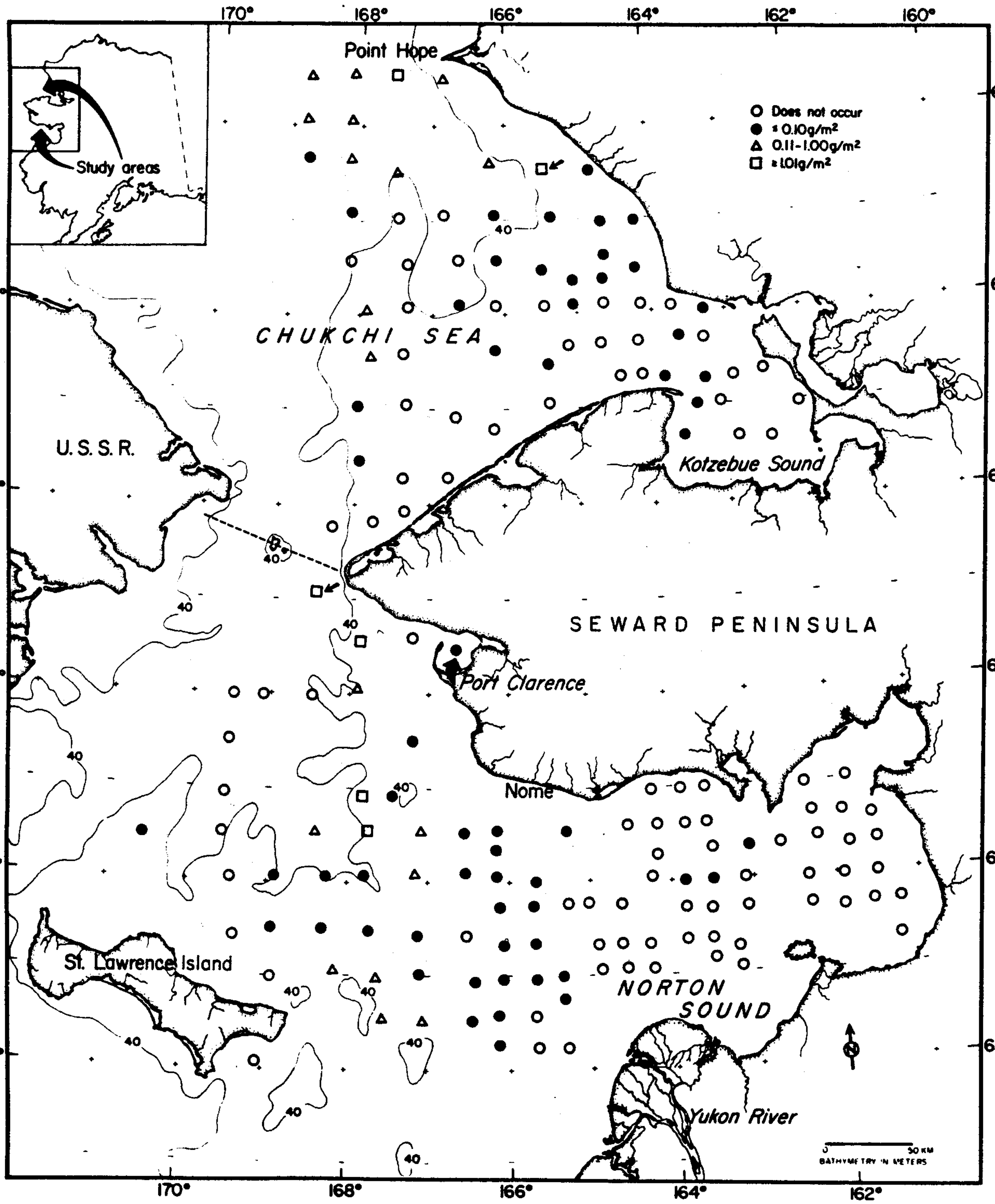


Figure 7. Distribution and biomass of the basket star, *Gorgonocephalus caryi*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 14.88 g/m^2 for Norton Sound area station C-1 and 2.59 g/m^2 for Chukchi Sea - Kotzebue Sound area station A-14.

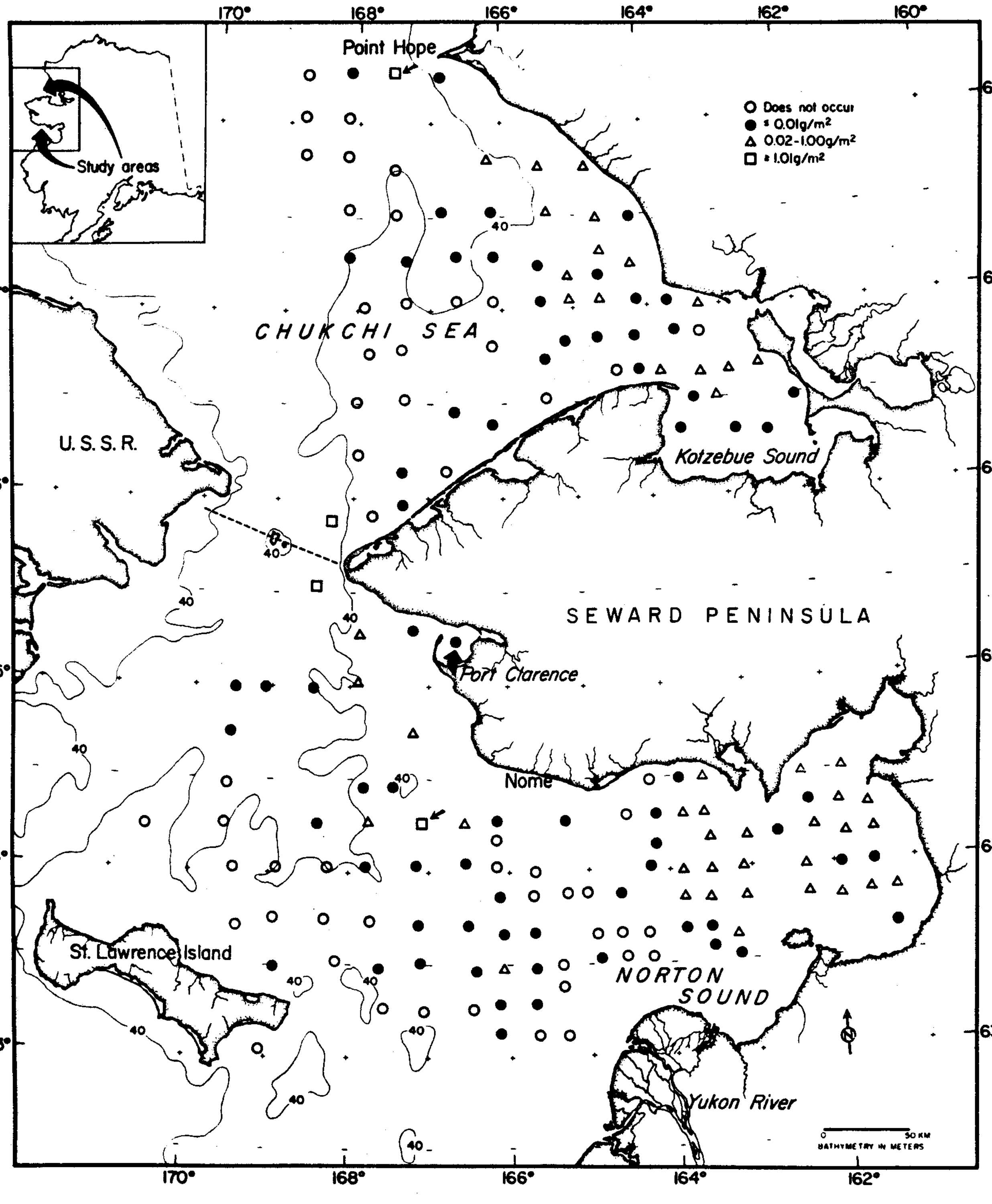


Figure 8. Distribution and biomass of the sea urchin, *Strongylocentrotus droebachiensis*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 4.73 g/m^2 for Norton Sound area station C-32 and 6.45 g/m^2 for Chukchi Sea - Kotzebue Sound area station A-2.

(see App. Table III for data base). The red king crab, *Paralithodes camtschatica*, occurred in less than half of the Norton Sound area stations. The distribution of this large crab (average weight of 801 g) was confined to the inner and mid portions of the Sound. The station with the highest biomass was D-9: 89.66 kg per standard tow or 2.14 g/m^2 (Fig. 9). However, only 34 king crabs were caught here.

Other crabs which also contributed considerably to the crustacean biomass were the spider crab, *Hyas coarctatus alutaceus*, the hermit crabs, *Pagurus trigonocheirus* and *P. capillatus*, and the crab of the family Atelecyclidae, *Telmessus cheiragonus*. The distribution and biomass of these species are shown in Figures 10-13 respectively.

The snow crab, *Chionoecetes opilio*, contributed little to the overall crustacean biomass (Fig. 14).

Shrimps contributed less than 10% of the arthropod biomass and less than 1% of the total invertebrate biomass (See App. Table III for data base). The crangonid, *Argis lar*, was the dominent shrimp and was widely distributed (Fig. 15).

The most common mollusc was the gastropod, *Neptunea heros*. This gastropod was widely dispersed throughout the Norton Sound area, and the station with the highest biomass was D-14 with 142.13 kg per standard tow or 1.10 g/m^2 (Fig. 16). Distribution and biomass maps for other common gastropods, *Beringius beringi* and *Neptunea ventricosa*, and the pelecypod, *Serripes groenlandicus*, are shown in Figures 17-19 respectively.

Distribution, Abundance and Biomass - Chukchi Sea - Kotzebue Sound area

The preliminary trawl survey of the Chukchi Sea - Kotzebue Sound area permitted the successful occupation of 70 stations. The total epifaunal

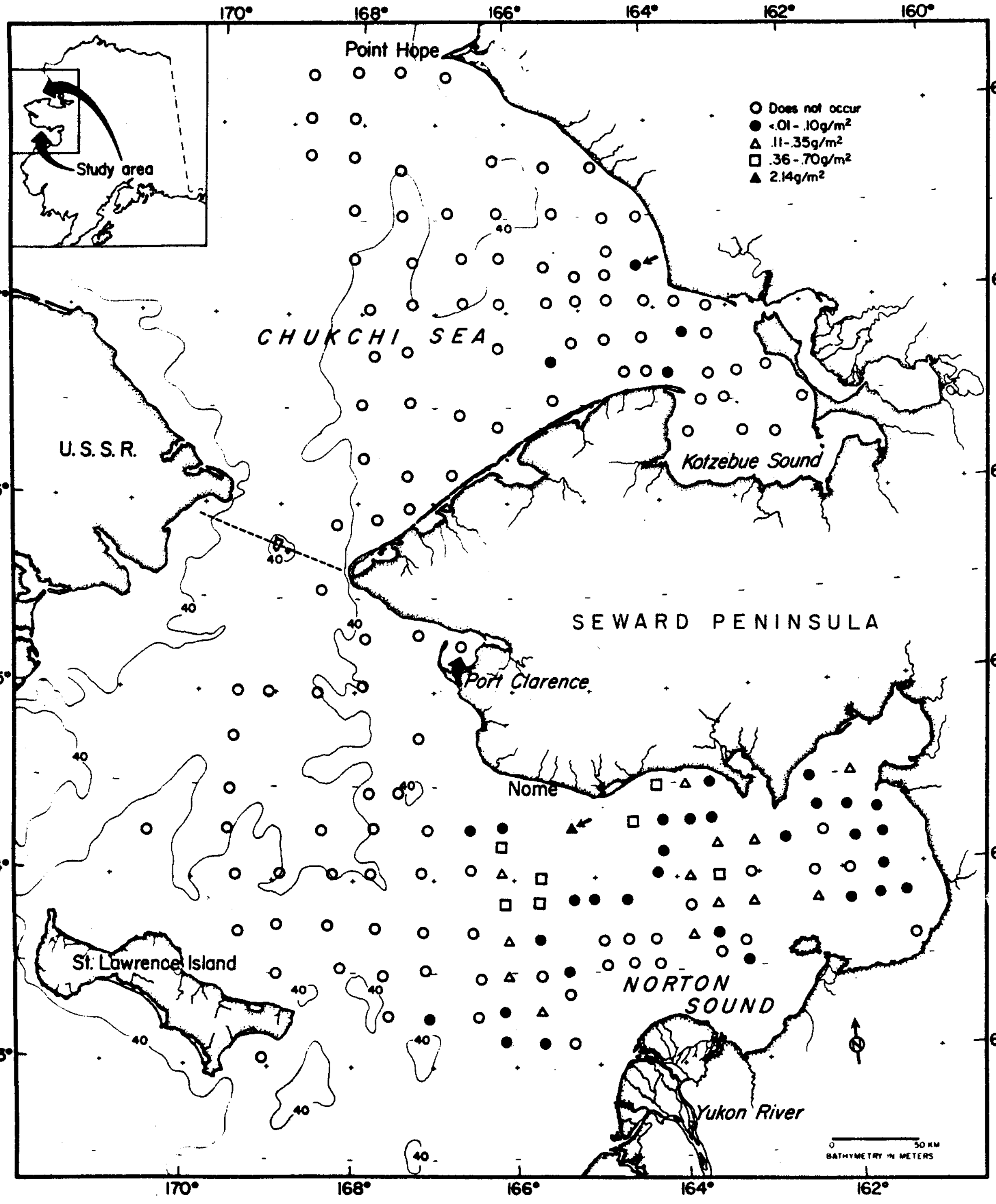


Figure 9. Distribution and biomass of the red king crab, *Paralithodes camtschatica*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 2.14 g/m^2 for Norton Sound area station D-9 and 0.03 g/m^2 for Chukchi Sea - Kotzebue Sound area station B-5.

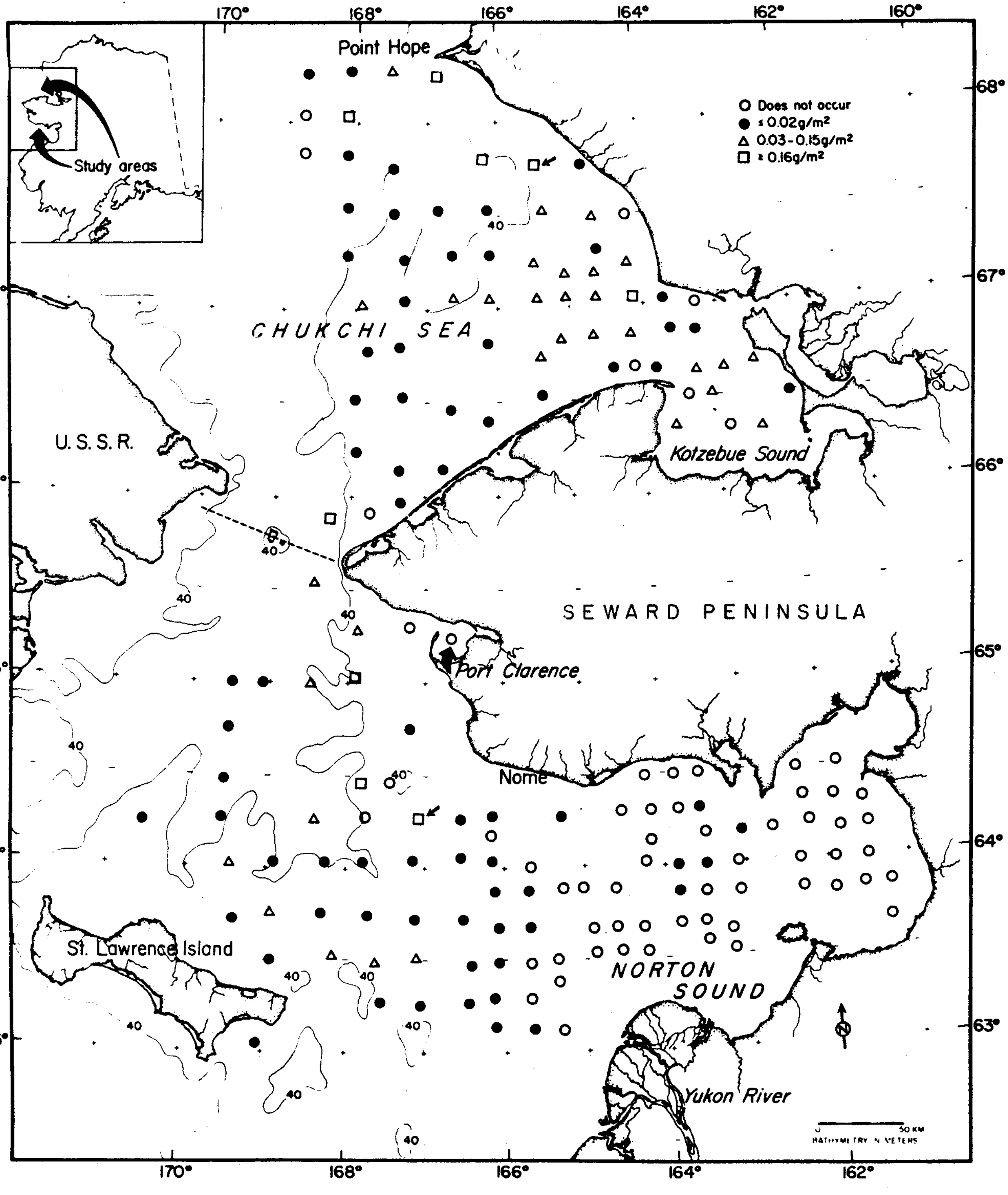


Figure 10. Distribution and biomass of the crab, *Hyas coarctatus alutaceus*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 2.57 g/m^2 for Norton Sound area station C-32 and 0.95 g/m^2 for Chukchi Sea - Kotzebue Sound area station A-14.

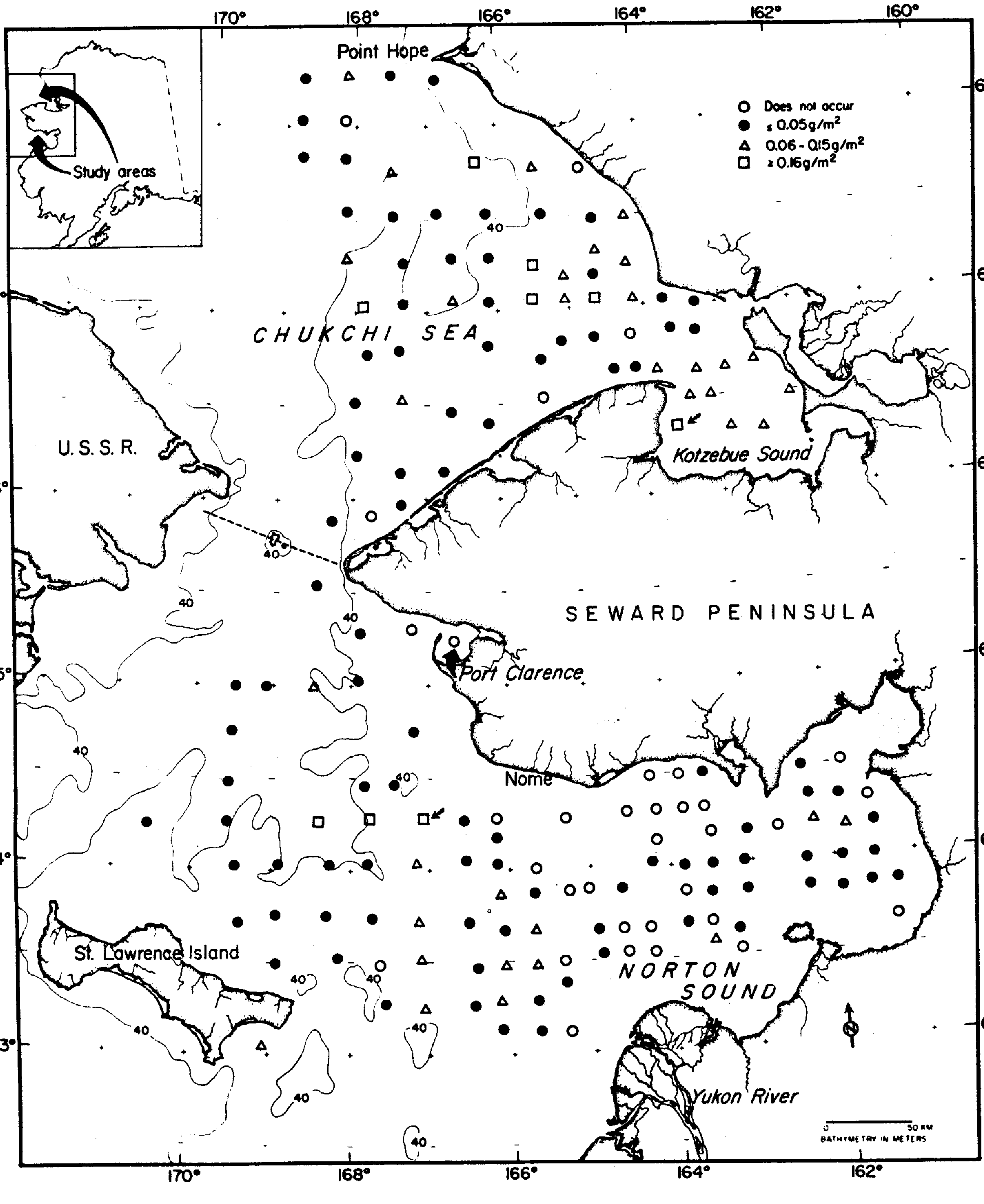


Figure 11. Distribution and biomass of the hermit crab, *Pagurus trigonocheirus*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 1.38 g/m^2 for Norton Sound area station C-32 and 0.64 g/m^2 for Chukchi Sea - Kotzebue Sound area station B-27.

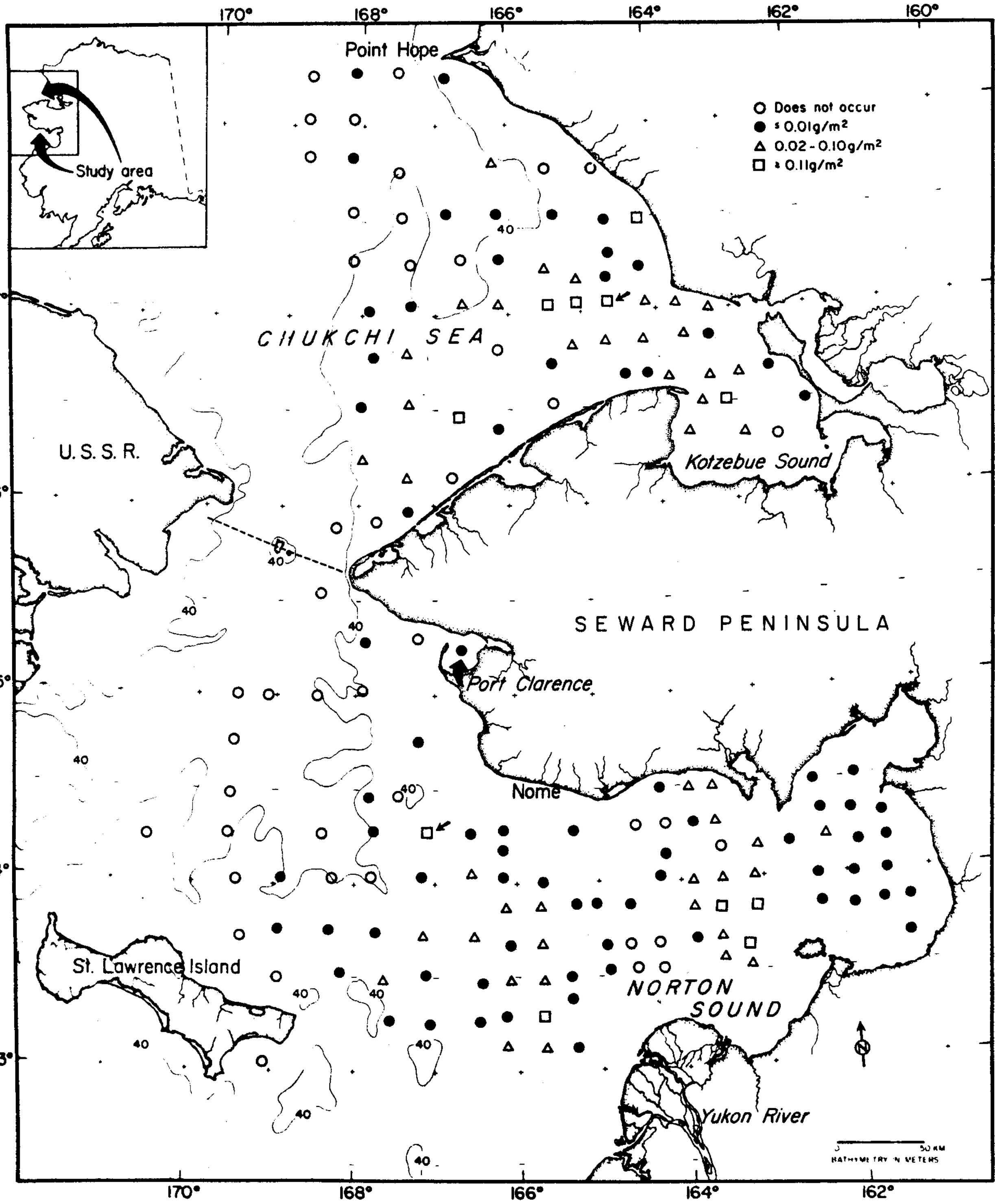


Figure 12. Distribution and biomass of the hermit crab, *Pagurus capillatus* from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 0.41 g/m² for Norton Sound area station C-32 and 0.28 g/m² for Chukchi Sea - Kotzebue Sound area station B-7.

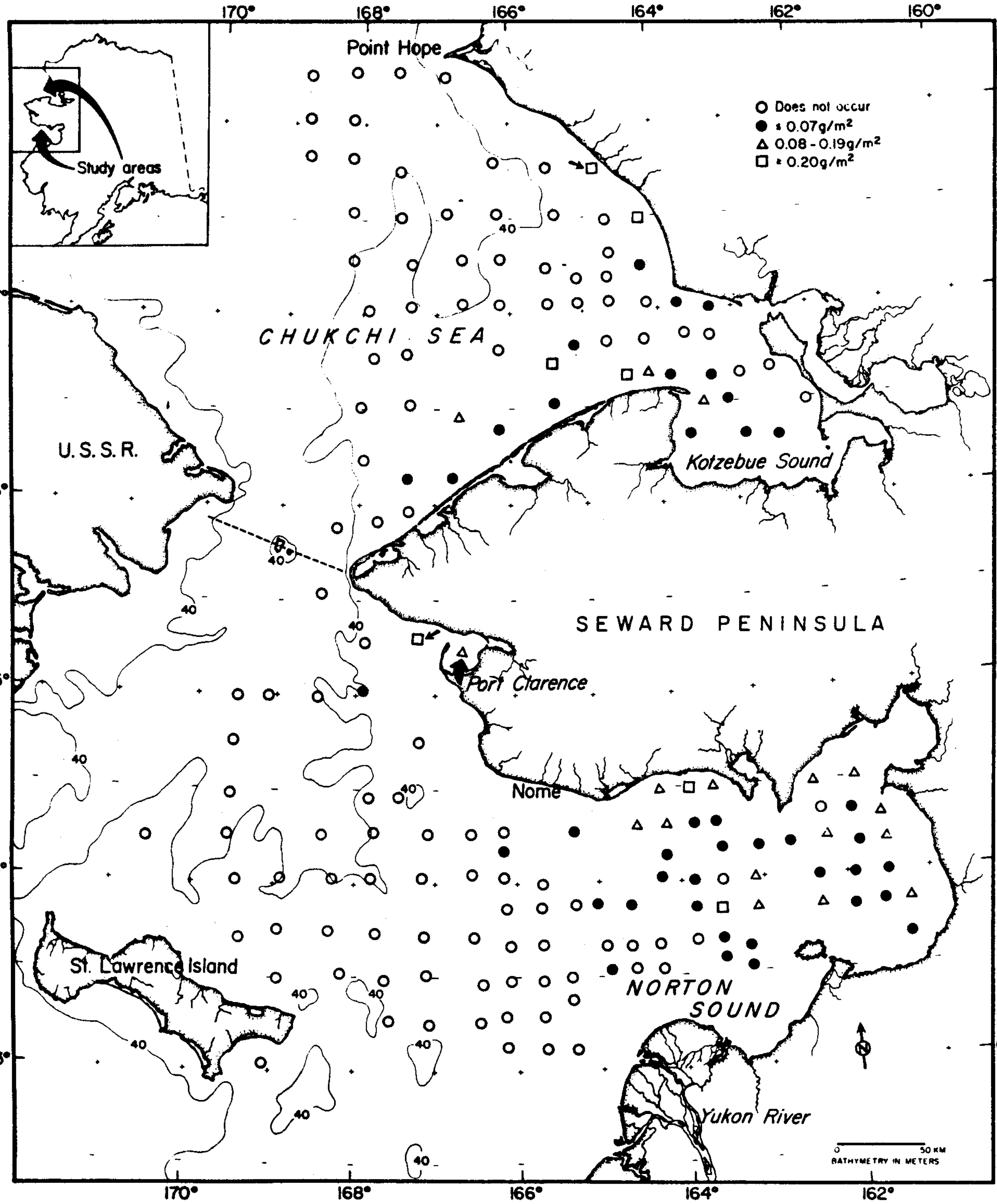


Figure 13. Distribution and biomass of the crab, *Telmessus cheiragonus*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 0.39 g/m^2 for Norton Sound area station C-63 and 1.00 g/m^2 Chukchi Sea - Kotzebue Sound area station A-15.

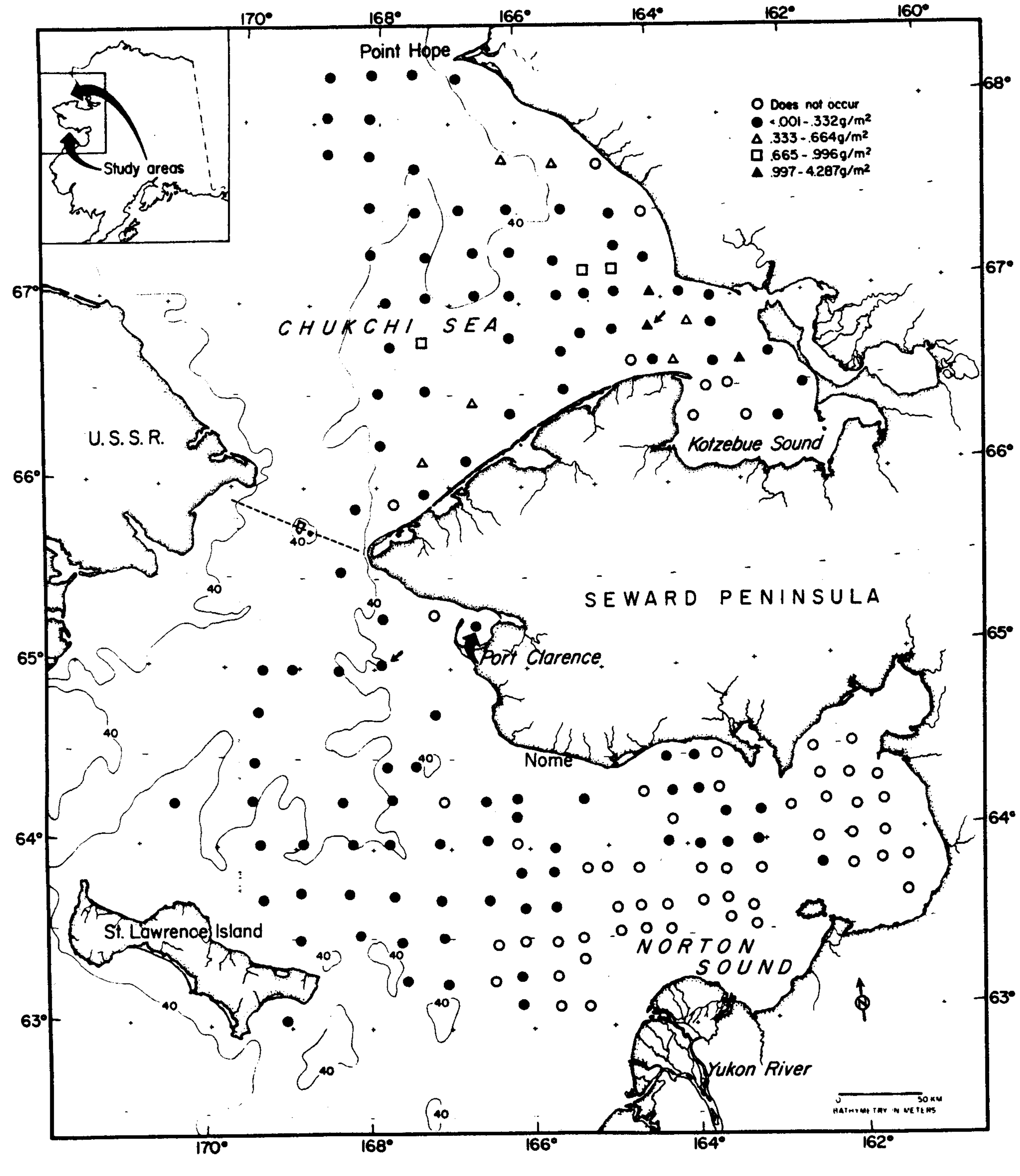


Figure 14. Distribution and biomass of the snow crab, *Chionoecetes opilio*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 0.23 g/m^2 for Norton Sound area station C-9 and 4.29 g/m^2 for Chukchi Sea - Kotzebue Sound area station B-13.

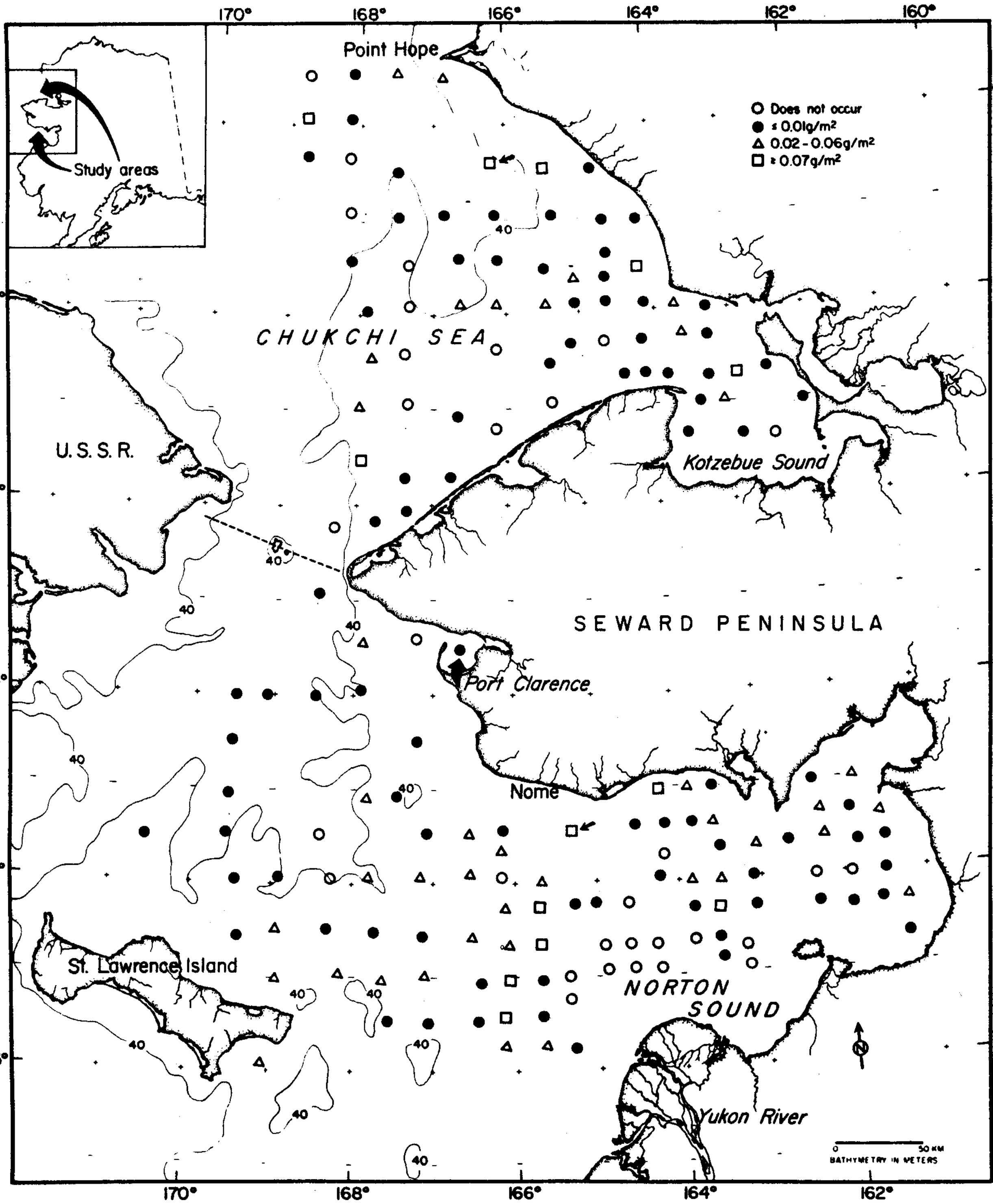


Figure 15. Distribution and biomass of the shrimp, *Argis lar*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 0.22 g/m^2 for Norton Sound area station D-9 and 0.29 g/m^2 for Chukchi Sea - Kotzebue Sound area station A-13.

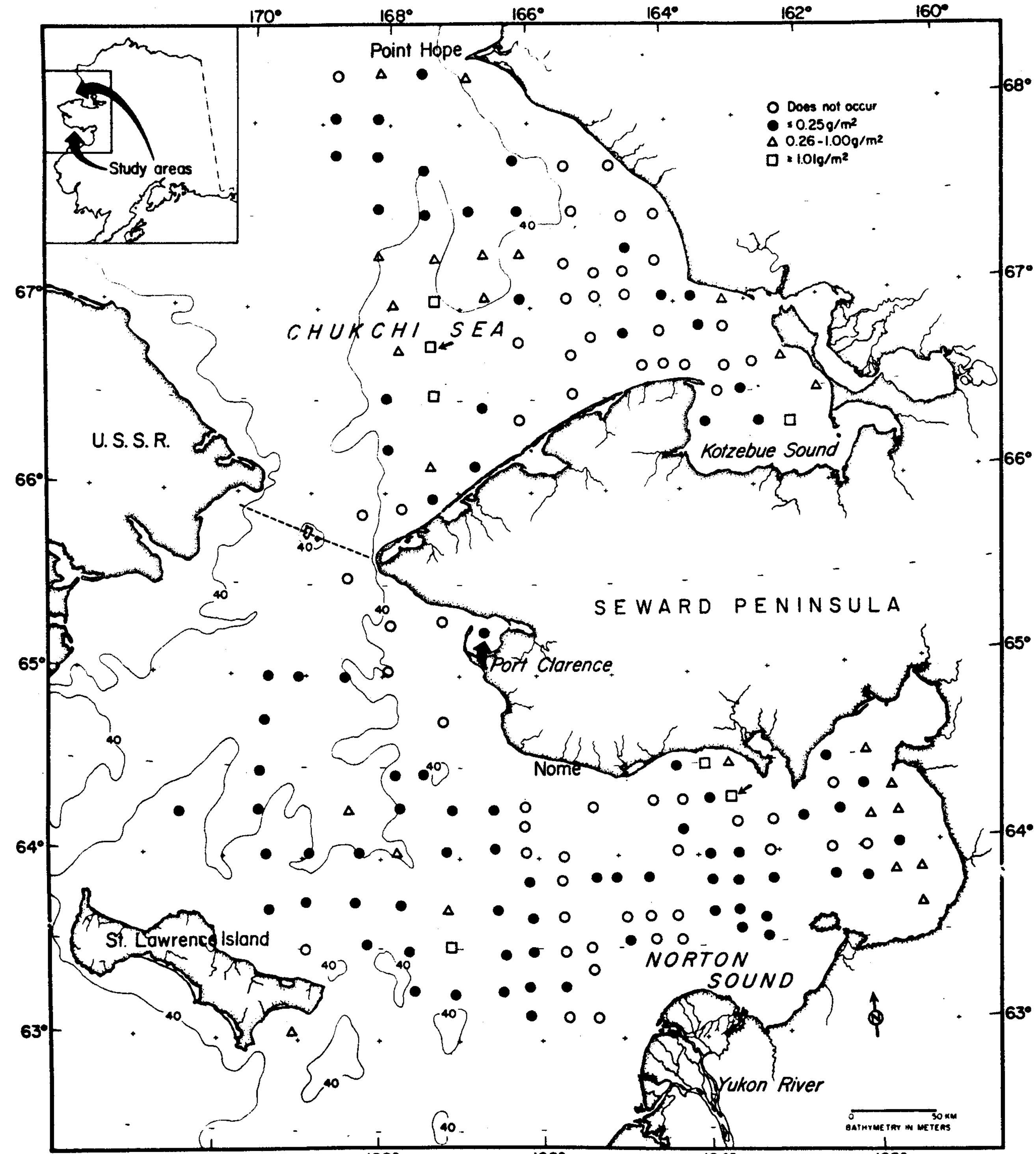


Figure 16. Distribution and biomass of the gastropod, *Neptunea heros*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 1.10 g/m^2 for Norton Sound area station D-14, and 11.40 g/m^2 for Chukchi Sea - Kotzebue Sound area station A-37.

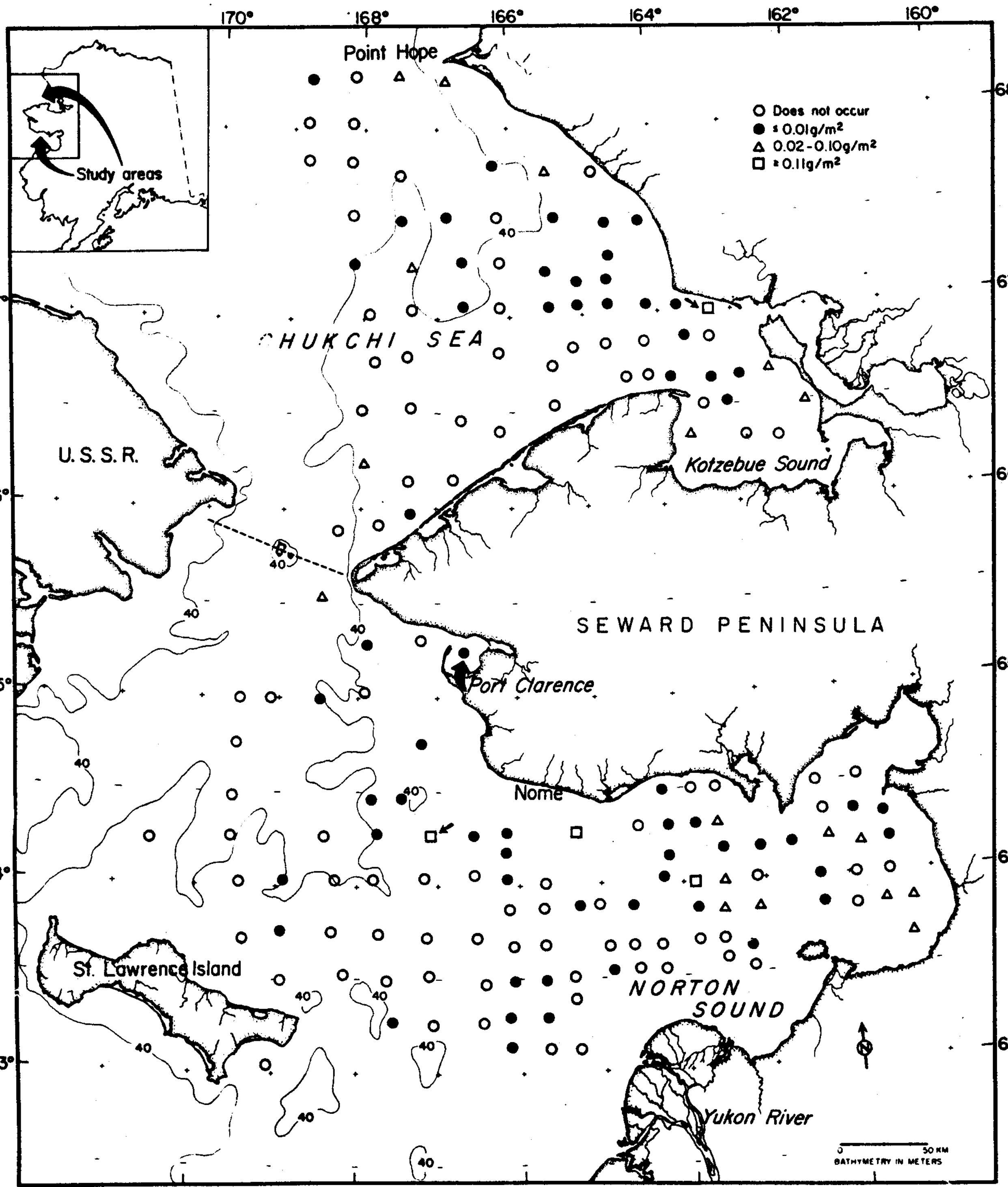


Figure 17. Distribution and biomass of the gastropod, *Beringius beringi*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas., i.e., 0.30 g/m^2 for Norton Sound area station C-32 and 0.17 g/m^2 for Chukchi Sea - Kotzebue Sound area station B-10.

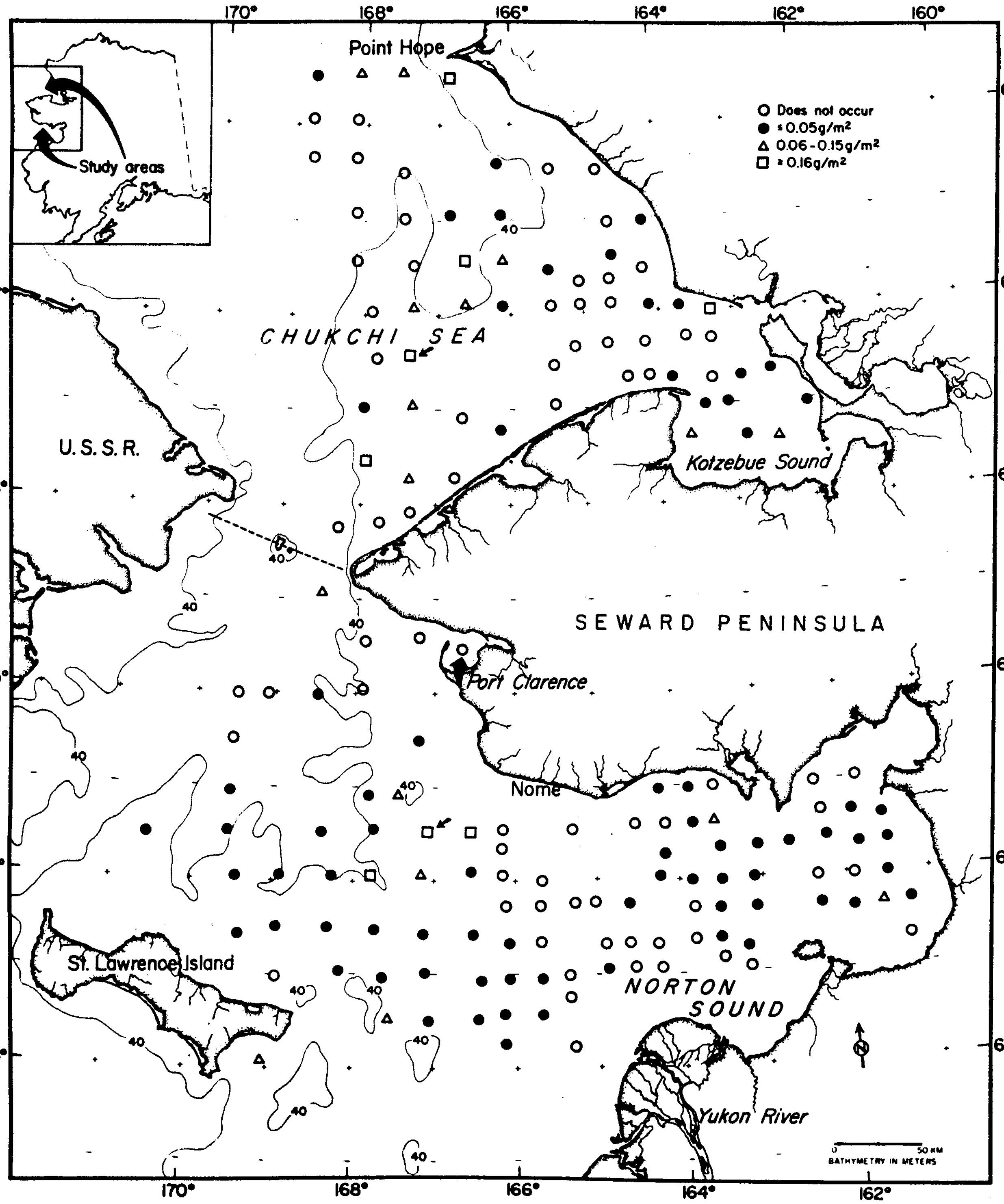


Figure 18. Distribution and biomass of the gastropod, *Neptunea ventricosa*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 0.28 g/m^2 for Norton Sound area station C-32 and 1.25 g/m^2 for Chukchi Sea - Kotzebue Sound area station A-37.

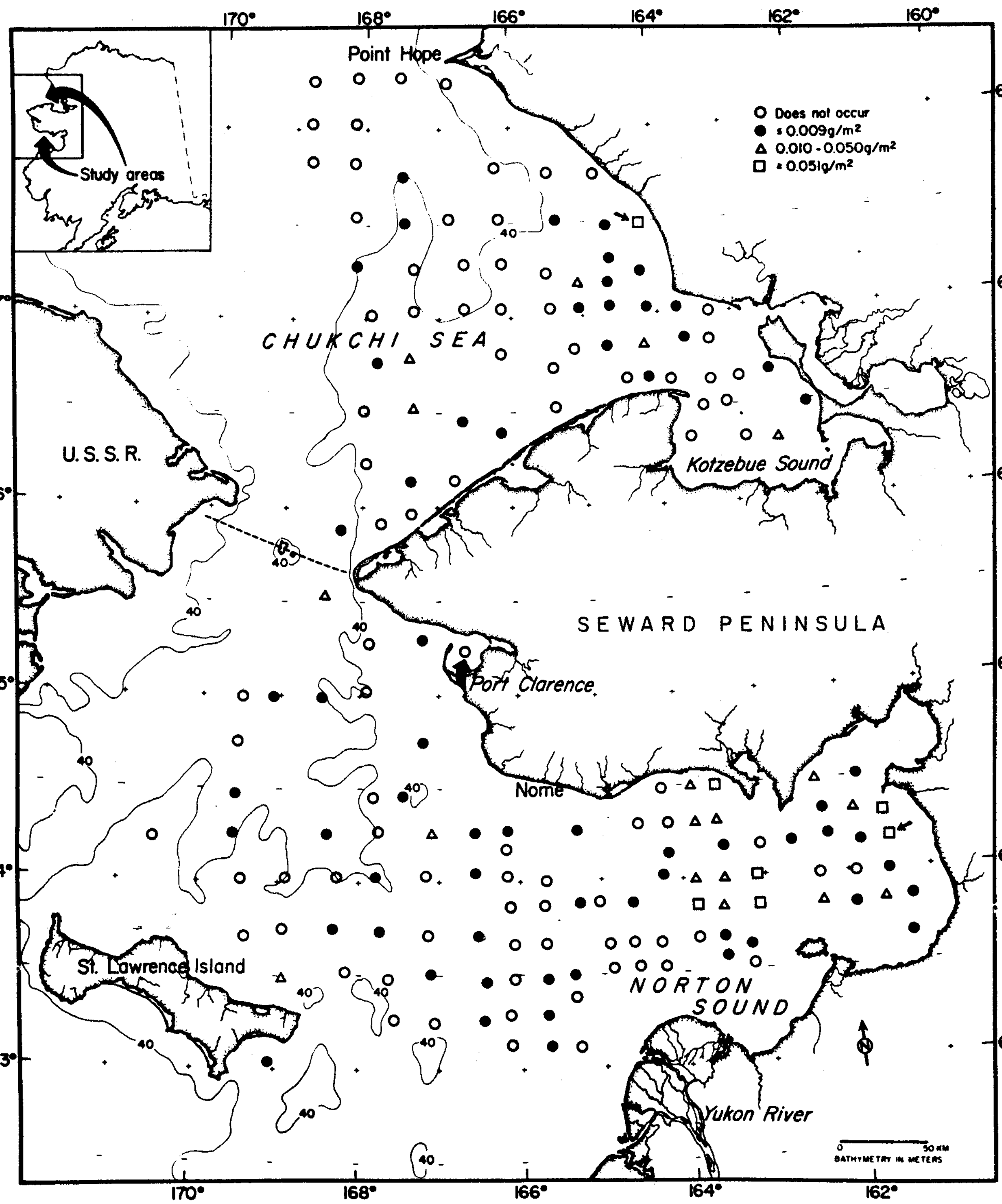


Figure 19. Distribution and biomass of the Greenland cockle, *Serripes groenlandicus*, from the Norton Sound, Chukchi Sea - Kotzebue Sound study areas. Small arrows indicate highest biomass stations from the respective areas, i.e., 0.20 g/m^2 for Norton Sound area station D-32 and 0.05 g/m^2 for Chukchi Sea - Kotzebue Sound area station A-22.

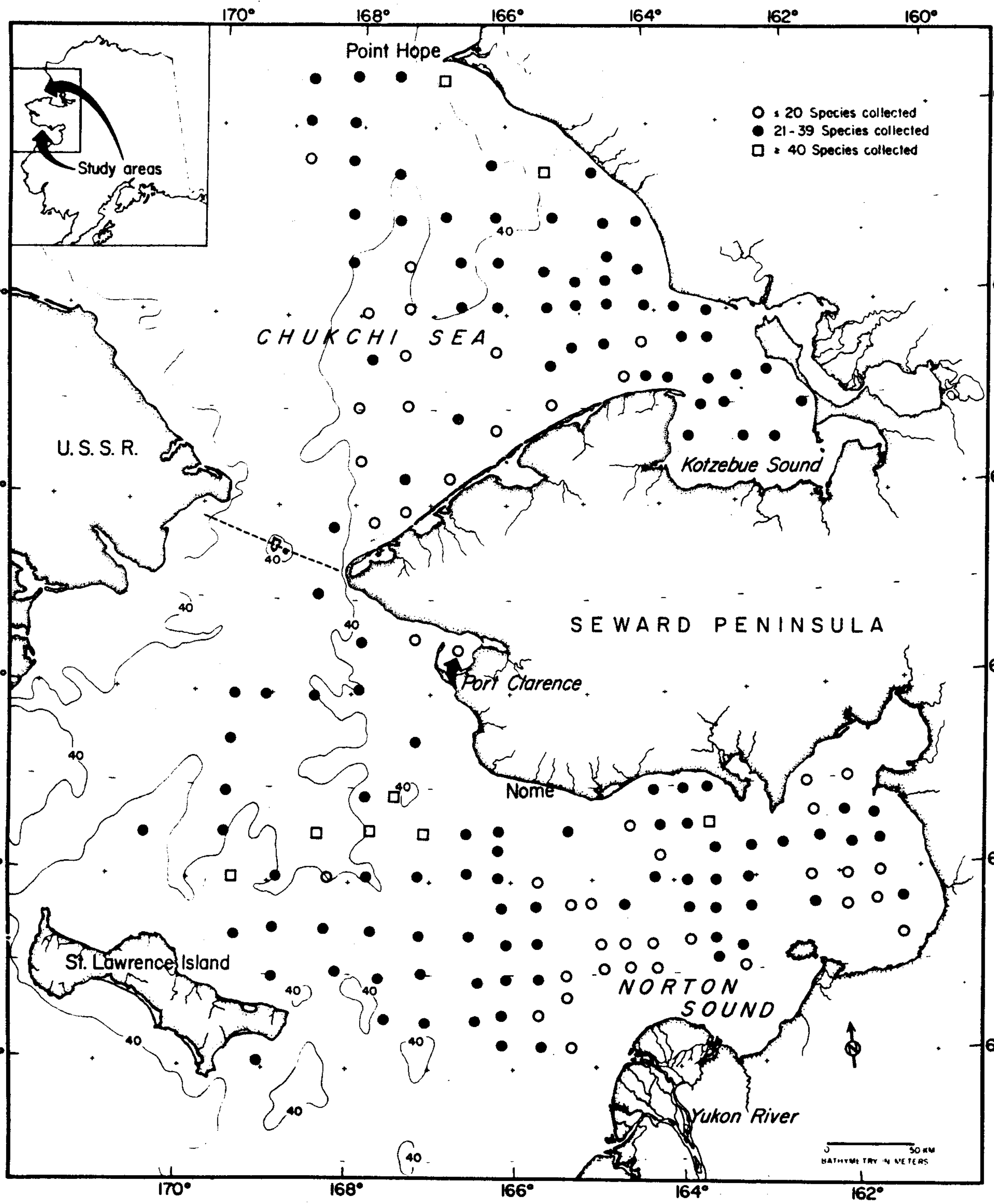


Figure 20. Species diversity by station location.

invertebrate biomass was 9617.24 kg or 3.31 g/m^2 in a total fishing distance of 224.07 km. Invertebrates from this area included 11 phyla and 171 species (Table VI). The occurrence of each species from the Chukchi Sea - Kotzebue Sound area is found in Appendix Table IV. Two phyla present in the Norton Sound area, Priapulida and Brachiopoda, were absent from the Chukchi Sea - Kotzebue Sound samples. Molluscs dominated in species representation with 70, and arthropod crustaceans and echinoderms followed with 36 and 24 species respectively (Table VII). Echinoderms made up the bulk of the invertebrate biomass with 59.9%; molluscs and arthropod crustaceans contributed 12.8% and 12.5% of the biomass, respectively (Table III).

The most common group present was the sea star family Asteridae (Phylum Echinodermata) (Table IV; See App. Table V for percentage composition of all phyla by family). The main species represented, in order of decreasing biomass, were *Asterias amurensis*, *Leptasterias polaris acervata*, *Lethasterias nanimensis* and *Evasterias echinosoma* (Table VIII; See App. Table VI for percentage composition of all phyla species). Other echinoderms of considerable importance were *Strongylocentrotus droebachiensis* and *Gorgonocephalus caryi*.

The most common species, *Asterias amurensis*, occurred mainly in Kotzebue Sound with station B-4 the station of highest biomass: 270.13 kg or 5.98 g/m^2 in a standard tow (Fig. 3)

Leptasterias polaris acervata occurred in most of the Chukchi Sea - Kotzebue Sound sampling area. High biomasses occurred in the western end of the station grid, especially at station A-16 where 202.48 kg or 7.47 g/m^2 were obtained in a standard tow (Fig. 6)

Lethasterias nanimensis and *Evasterias echinosoma* had similar distribution and biomass patterns. Most occurrences were in Kotzebue Sound and station A-14 had the highest biomass of both species, i.e., 99.66 kg or

TABLE VI

Species taken by trawl from the Chukchi Sea - Kotzebue Sound area onboard the NOAA Ship *Miller Freeman*, 2 September-13 October, 1976

Phylum Porifera
- Class Demospongia
  - Family Microcionidae
    - *Microciona* sp.
    - *Microciona lambei* Burton
  - Family Axinellidae
    - *Phakellia* sp.
  - Family Halichondriidae
    - *Halichondria* sp.

Phylum Cnidaria
- Class Hydrozoa
  - Family Sertulariidae
    - *Abietinaria* sp.
- Class Scyphozoa
    - Unidentified species
- Class Anthozoa
  - Family Nephtheidae
    - *Eunephthya rubiformis* (Pallas)
  - Family Actinostolidae
    - *Stomphia* sp.
    - *Stomphia coccinea* (O. F. Müller)
  - Family Actiniidae
    - *Tealia crassicornis* (O. F. Müller)

Phylum Rhynchocoela
- Unidentified species

Phylum Annelida
- Class Polychaeta
  - Family Polynoidae
    - *Eunoe depressa* (Moore)
    - *Gattyana ciliata* Moore
  - Family Nereidae
    - *Nereis* sp.
  - Family Nephtyidae
    - *Nephtys* sp.
  - Family Flabelligeridae
    - *Brada inhabilis* (Rathke)
    - *Brada ochotensis* Annenkova

TABLE VI (Cont'd)

Family Sternaspidae
Sternaspis scutata (Ranzani)

Family Sabellariidae
Idanthyrsus armatus Kinberg

Family Pectinariidae
Cistenides hyperborea (Malmgren)

Family Ampharetidae
Amphitrite cirrata O. F. Müller

Family Sabellidae
Chone cincta Zachs
Potamilla sp.

Family Serpulidae
Unidentified species

Phylum Mollusca
Class Polyplacophora
Family Ischnochitionidae
Ischnochition albus (Linné)

Class Pelecypoda
Family Nuculidae
Nucula tenuis Montagu

Family Nuculanidae
Nuculana fossa Baird
Yoldia hyperborea (Loven)

Family Mytilidae
Mytilus edulis Linnaeus
Musculus niger (Gray)
Musculus discors (Linné)
Modiolus modiolus (Linnaeus)

Family Pectinidae
Chlamys rubida (Hinds)
Chlamys islandica (Müller)
Chlamys beringiana (Middendorff)

Family Astartidae
Astarte borealis (Schumacher)
Astarte montagui (Dillwyn)

Family Carditidae
Cyclocardia sp.
Cyclocardia ventricosa (Gould)
Cyclocardia crebricostata (Krause)
Cyclocardia crassidens (Broderip and Sowerby)

TABLE VI (Cont'd)

Family Cardiidae
- *Clinocardium ciliatum* (Fabricius)
- *Clinocardium nuttallii* (Conrad)
- *Clinocardium californiense* Deshayes
- *Serripes groenlandicus* (Bruguière)

Family Veneridae
- *Liocyma fluctosa* (Gould)

Family Mactridae
- *Spisula polynyma* (Stimpson)

Family Tellinidae
- *Macoma* sp.
- *Macoma calcarea* (Gmelin)
- *Macoma brota* Dall

Family Myidae
- *Mya japonica* Jay

Family Hiatellidae
- *Hiatella arctica* (Linné)
- *Panomya arctica* (Lamarck)

Class Gastropoda

Family Trochidae
- *Margarites giganteus* (Leche)
- *Solariella obscura* (Couthouy)
- *Solariella varicosa* (Mighels and Adams)

Family Turritellidae
- *Tachyrhynchus reticulatis* (Mighels and Adams)

Family Calytraeidae
- *Crepidula grandis* (Middendorff)

Family Trichotropididae
- *Trichotropis bicarinata* (Sowerby)

Family Naticidae
- *Natica clausa* Broderip and Sowerby
- *Natica russa* Gould
- *Polinices pallida* Broderip and Sowerby

Family Velutinidae
- *Piliscus commondum* (Middendorff)
- *Velutina* sp.
- *Velutina plicatilis* (Müller)
- *Velutina undata* (Brown)

Family Muricidae
- *Boreotrophon clathrus* (Linné)

TABLE VI (Cont'd)

Family Buccinidae
- *Buccinum angulosum* Gray
- *Buccinum scalariforme* Möller
- *Buccinum glaciale* Linnaeus
- *Buccinum solenum* Dall
- *Buccinum polare* Gray
- *Buccinum tenellum* Dall

Family Neptunidae
- *Ancistrolepis* sp.
- *Ancistrolepis magna* Dall
- *Beringius crebricostatus* (Dall)
- *Beringius beringi* Middendorff
- *Colus* sp.
- *Colus spitzbergensis* (Reeve)
- *Colus hypolispus* (Dall)
- *Mohnia corbis* (Dall)
- *Neptunea lyrata* (Gmelin)
- *Neptunea ventricosa* (Gmelin)
- *Neptunea borealis* (Philippi)
- *Neptunea heros* (Gray)
- *Plicifusus brunneus* (Dall)
- *Pyrulofusus deformis* (Reeve)
- *Volutopsius* sp.
- *Volutopsius fragilis* (Dall)

Family Cancellariidae
- *Admete couthouyi* (Jay)

Family Dorididae
- Unidentified species

Family Dendronotidae
- *Dendronotus* sp.

Family Tritonidae
- *Tochina tetraquetra* (Pallas)

Class Cephalopoda
- Family Octopodidae
  - Unidentified species

Phylum Arthropoda
- Class Crustacea
  - Order Thoracica
    - Family Balanidae
      - *Balanus* sp.
      - *Balanus balanus* (Linné)
      - *Balanus rostratus* Pilsbry
  - Order Mysidacea
    - Unidentified species

TABLE VI (Cont'd)

Order Cumacea
        Unidentified species

Order Isopoda
    Family Idoteidae
        Saduria entomon (Linnaeus)

Order Amphipoda
    Family Eusiridae
        Rhachotropis sp.

    Family Gammaridae
        Melita sp.
        Melita dentata Kröyer

    Family Lysianassidae
        Anonyx sp.

    Family Stegocephalidae
        Stegocephalopsis ampulla (Phipps)
        Stegocephalus inflatus Kröyer

Order Decapoda
    Family Pandalidae
        Pandalus sp.
        Pandalus goniurus Stimpson

    Family Hippolytidae
        Spirontocaris sp.
        Spirontocaris murdochi Rathbun
        Spirontocaris arcuata Rathbun
        Lebbeus groenlandica (Fabricius)
        Eualus gaimardii belcheri (Bell)
        Heptacarpus sp.

    Family Crangonidae
        Crangon dalli Rathbun
        Sclerocrangon boreas (Phipps)
        Argis lar (Owen)
        Argis crassa (Rathbun)

    Family Paguridae
        Pagurus capillatus (Benedict)
        Pagurus trigonocheirus (Stimpson)
        Pagurus rathbuni (Benedict)
        Labidochirus splendescens (Owen)

    Family Lithodidae
        Hapalogaster grebnitzkii Schalfeew
        Paralithodes camtschatica (Tilesius)
        Paralithodes platypus Brandt
        Paralithodes brevipes (Milne-Edwards and Lucas)

    Family Majidae
        Hyas sp.
        Hyas coarctatus alutaceus Brandt
        Chionoecetes opilio (Fabricius)

TABLE VI (Cont'd)

Family Atelecyclidae
Telmessus cheiragonus (Tilesius)

Phylum Sipunculida
Family Golfingiidae
Golfingia margaritacea (M. Sars)

Phylum Echiurida
Class Echiuroidea
Family Echiurdae
Echiurus echiurus alaskensis Pallas

Phylum Ectoprocta
Class Cheilostomata
Family Flustridae
Flustra sp.

Family Bicellariellidae
Dendrobeania sp.

Class Cyclostomata
Family Diastoporidae
Diaperoecia sp.

Family Heteroporidae
Heteropora sp.

Class Ctenostomata
Family Alcyonidiidae
Alcyonidium sp.
Alcyonidium disciforme Smitt
Alcyonidium vermiculare Okada

Phylum Echinodermata
Class Asteroidea
Family Echinasteridae
Henricia sp.
Henricia derjugini (Djakonov)

Family Pterasteridae
Pteraster obscura (Perrier)

Family Solasteridae
Crossaster papposus (Linné)
Solaster sp.
Solaster endeca (Linné)

Family Asteridae
Asterias sp.
Asterias amurensis Lütken
Asterias rathbuni (Verrill)
Evasterias echinosoma Fisher
Leptasterias sp.
Leptasterias polaris acervata Stimpson
Lethasterias sp.
Lethasterias nanimensis (Verrill)

TABLE VI (Cont'd)

Class Echinoidea
  Family Echinarachniidae
    Echinarachnius parma Lamarck

  Family Strongylocentrotidae
    Strongylocentrotus droebachiensis (O. F. Müller)

Class Ophiuroidea
  Family Amphiuridae
    Diamphiodia craterodmeta

  Family Gorgonocephalidae
    Gorgonocephalus caryi (Lyman)

  Family Ophiactidae
    Ophiopholis aculeata (Linné)

  Family Ophiuridae
    Ophiura sarsi Lütken
    Stegophiura nodosa Lütken

Class Holothuroidea
  Family Cucumariidae
    Cucumaria sp.
    Cucumaria calcigera (Stimpson)

  Family Psolidae
    Psolus japonicus Öestergren

Phylum Chordata
 Subphylum Urochordata
  Class Ascidiacea
   Family Rhodosomatidae
    Chelyosoma sp.
    Chelyosoma orientale Redikorzev

   Family Styelidae
    Styela macrenteron Ritter
    Pelonaia corrugata Forbes and Goods

   Family Pyuridae
    Boltenia ovifera (Linné)
    Boltenia echinata Linné
    Halocynthia aurantium (Pallas)

  Class Thaliacea
   Family Salpidea
    Unidentified species

TABLE VII

Number and percent of epifaunal invertebrate species by phylum and class from the Chukchi Sea

Phylum	Class	No. of Species	% of Species
Porifera	Demospongia	4	2.34
Cnidaria	Hydrozoa	1	0.58
	Scyphozoa	1	0.58
	Anthozoa	4	2.34
	Totals	6	3.50
Rhynchocoela	Unidentified	1	0.58
Annelida	Polychaeta	13	7.60
Mollusca	Polyplacophora	1	0.58
	Pelecypoda	28	16.37
	Gastropoda	40	23.39
	Cephalopoda	1	0.58
	Totals	70	40.92
Arthropoda	Crustacea	36	21.05
Sipunculida	-	1	0.58
Echiurida	Echiuroidea	1	0.58
Ectoprocta	Cheilostomata	2	1.17
	Cyclostomata	2	1.17
	Ctenostomata	3	1.75
	Totals	7	4.09
Echinodermata	Asteroidea	14	8.19
	Echinoidea	2	1.17
	Ophiuroidea	5	2.92
	Holothuroidea	3	1.75
	Totals	24	14.03
Chordata	Ascidiacea	7	4.09
	Thaliacea	1	0.58
	Totals	8	4.67
	Grand Totals	171	100.00

TABLE VIII

Percentage composition by weight and the feeding methods[1] of the leading invertebrate species collected in the Chukchi Sea - Kotzebue Sound area

Phylum	% wt. of all phyla	Leading Species	Feeding[2] Method	Avg. wt. per Individual	% wt. of phylum	% wt. of all phyla
Echinodermata	59.93	*Asterias amurensis*	P	202 g	35.54	21.21
		Leptasterias polaris acervata	P	96 g	20.90	12.47
		Strongylocentrotus droebachiensis	H-S-P	70 g	10.69	6.38
		Lethasterias nanimensis	P	299 g	9.67	5.77
		Evasterias echinosoma	P	656 g	6.39	3.81
		Gorgonocephalus caryi	Sus-P	258 g	5.76	3.44
		Totals			88.95	53.08
Mollusca	12.79	*Neptunea heros*	P-S	101 g	79.98	10.19
		Neptunea ventricosa	P-S	71 g	10.80	1.38
		Beringius beringi	P-S	85 g	2.35	0.30
		Totals			93.13	11.87
Arthropoda (Crustacea)	12.52	*Chionoecetes opilio*	P-S	27 g	43.76	5.46
		Pagurus trigonocheirus	P-S ?	17 g	15.77	1.97
		Hyas coarctatus alutaceus	P-S ?	25 g	12.87	1.61
		Telmessus cheiragonus	P-S ?	133 g	7.43	0.93
		Pagurus capillatus	P-S ?	12 g	7.24	0.90
		Argis lar	S ?	7 g	4.34	0.54
Total	85.24	Totals			91.41	11.41

[1] Based on Hatanaka and Kosaka, 1958; Reese, 1966; Pearce and Thorson, 1967; Feder *et al.*, 1977b; and pers. observation. Feeding methods for related species are included when no direct data are available for species included above.

[2] Feeding methods: P = predator; P-S = predator-scavenger; S = scavenger;
Sus = suspension feeder; Sus-P = suspension feeder-predator;
H-S-P = herbivore-scavenger-predator.

2.45 g/m^2 for *L. nanimensis* and 122.91 kg or 3.03 g/m^2 for *E. echinosoma* (Figs. 4 and 5).

The sea urchin, *Strongylocentrotus droebachiensis*, was also found primarily in Kotzebue Sound. However, the highest biomass was recorded in one of the northern-most stations, A-2. In a standard tow, 261.96 kg or 6.45 g/m^2 was obtained at this location (Fig. 8).

The only other echinoderm that contributed significantly to the overall invertebrate biomass was the basket star, *Gorgonocephalus caryi*. The stations of high biomass of this species occurred in the northern region, specifically, station A-14 where 105.20 kg or 2.59 g/m^2 were obtained in a single tow (Fig. 7).

Of the 70 species of molluscs collected, the gastropod *Neptunea heros* dominated. This species represented 80.0% of the mollusc biomass, but only 10.2% of the total invertebrate biomass (Table VIII). *Neptunea heros* occurred at the eastern and western stations of the Chukchi Sea - Kotzebue Sound grid. The highest biomass occurred at station A-37 with 360.08 kg or 11.40 g/m^2 in a standard tow (Fig. 16).

The distribution and biomass of *Beringius beringi* and *Neptunea ventricosa*, two other leading gastropods, are shown in Figures 17 and 18, respectively.

The King crab, *Paralithodes camtschatica*, the most important arthropod in the Norton Sound area, was only found at four stations in the Chukchi Sea - Kotzebue Sound area (Fig. 9). The snow crab, *Chionoecetes opilio*, replaced *P. camtschatica* in the latter area, occurring in 96% of the stations (App. Table IV) and contributing 43.8% of the crustacean weight or 5.5% of the invertebrate weight (Table VIII). Station B-13 had the highest biomass of this crab with 106.69 kg or 4.29 g/m^2 in a standard tow (Fig. 14). The crabs *Pagurus trigonocheirus*, *Pagurus capillatus*, *Hyas coarctatus alutaceus*, and *Telmessus cheiragonus*, and the shrimp *Argis lar* were also important crustaceans in this area as well as in the Norton Sound area. The distribution and biomass of these crustacean species are found in Figures 10-13 and 15.

Diversity

The number of species for each station was tabulated, and three general categories of species diversity were arbitrarily established: High (≥40 species), intermediate (21-39 species), and low (≤20 species) (Table IX: Fig. 20). Most of the low diversity stations in the Norton Sound area were located in the eastern portion of Norton Sound and the stations off the Yukon River. Most of the high diversity stations were located between Nome and St. Lawrence Island. Intermediate diversities were recorded at all of the other stations (Fig. 20).

Only two high diversity stations, stations A-3 and A-14, were noted in the Chukchi Sea - Kotzebue Sound area (Fig. 20). Low diversity stations were located mainly northeast of the Bering Strait.

Feeding Observations

Sea stars

A preponderance of invertebrates collected were predators and/or scavengers, and the leading species (listed in Tables V and VIII) that were in these categories made up nearly 90% of the total invertebrate biomass. Only two feeding *Asterias amurensis* were taken; one was eating the sea urchin, *Strongylocentrotus droebachiensis*, and the other was eating the sand dollar,

TABLE IX

Trawl stations from the Norton Sound, Chukchi Sea - Kotzebue Sound areas, and number of species obtained at each station

Norton Sound area stations

Station	No. of Species	Station	No. of Species	Station	No. of Species
C-1	35	C-61	33	D-46	16
C-5	26	C-62	30	D-48	23
C-6	17	C-63	11	D-49	23
C-7	20	C-64	16	D-50	16
C-8	35	C-65	42	D-51	15
C-9	31	D-2	24	D-52	25
C-12	21	D-3	26	D-54	22
C-16	33	D-4	22	D-55	27
C-19	22	D-5	16	D-56	36
C-22	37	D-6	16	D-58	26
C-23	50	D-7	23	D-59	20
C-26	36	D-9	35	D-60	19
C-28	24	D-11	16	D-61	24
C-30	41	D-12	22	D-62	24
C-31	40	D-13	29	D-63	25
C-32	43	D-14	43	D-65	11
C-33	32	D-17	16	D-66	6
C-38	41	D-18	21	D-67	7
C-39	33	D-19	21	D-68	19
C-40	19	D-20	23	D-69	25
C-41	28	D-25	18	D-70	28
C-42	34	D-27	29	D-75	14
C-43	29	D-28	34	D-76	26
C-47	25	D-29	32	D-77	22
C-48	25	D-30	30	D-78	9
C-49	24	D-31	26	D-79	17
C-50	37	D-32	30	D-80	5
C-51	27	D-34	28	D-81	7
C-52	30	D-35	17	D-83	21
C-54	22	D-39	26	D-84	16
C-55	23	D-40	32	D-85	8
C-56	26	D-41	34	D-86	19
C-57	27	D-42	35	D-87	24
C-58	30	D-44	7	D-88	10
C-60	30	D-45	15	D-89	21
				D-90	22

TABLE IX (Cont'd)

Chukchi Sea - Kotzebue Sound area station

Station	No. of Species	Station	No. of Species	Station	No. of Species
A-1	32	A-32	27	B-4	24
A-2	39	A-33	35	B-5	30
A-3	54	A-34	29	B-6	33
A-5	21	A-36	24	B-7	29
A-10	35	A-37	17	B-8	26
A-11	21	A-39	12	B-9	31
A-13	31	A-40	28	B-10	33
A-14	41	A-42	18	B-11	22
A-15	28	A-43	15	B-12	23
A-16	29	A-44	33	B-13	20
A-17	23	A-45	15	B-14	25
A-18	34	A-46	9	B-15	23
A-19	26	A-48	18	B-17	18
A-20	37	A-49	25	B-18	25
A-21	35	A-50	16	B-19	29
A-22	29	A-53	22	B-20	31
A-24	27	A-54	33	B-21	34
A-25	16	A-55	6	B-22	33
A-26	26	A-56	24	B-23	25
A-27	24	A-57	21	B-24	38
A-28	28	A-58	17	B-26	27
A-30	17	B-1	29	B-27	29
A-31	12	B-3	22	B-28	24
				B-29	23

Echinarachnius parma. More extensive feeding observations were made on the other common sea-star species: *Leptasterias polaris acervata, Evasterias echinosoma*, and *Lethasterias nanimensis* (Table X). In the Norton Sound area, 30 *L. polaris acervata* were observed feeding at 18 stations. The species most frequently consumed were *Echinarachnius parma* and *Balanus* spp. At least 30 *L. polaris acervata* in the Chukchi Sea - Kotzebue Sound area were found feeding at 17 stations. Main prey items were two ascidians, (*Chelyosoma orientale* and *Boltenia echinata*), a gastropod (*Natica clausa*), a polychaete (*Cistenides* sp.), and a clam (*Macoma calcarea*). In both study areas, *Evasterias echinosoma* and *Lethasterias nanimensis* were feeding primarily on clams, specifically, the Greenland cockle, *Serripes groenlandicus*.

Starry flounder (*Platichthys stellatus*)

Combined study areas - During the sampling period, 307 starry flounder digestive tracts were examined from 22 stations (Fig. 2; Table XI). Stomach contents included representatives of 10 phyla, 12 classes, 39 families, 42 genera, and 48 species (Table XII). The number of fish examined in Norton Sound, Port Clarence, and southeastern Chukchi Sea was 142, 134, and 31 individuals, respectively (Table XI). One hundred thirty-one (131) fish were examined using the frequency of occurrence of prey method. Most fish in the Chukchi Sea and all fish in Port Clarence were examined using a quantitative method of analysis (See Methods; Table XI). The mean length and weight of the 176 fish examined quantitatively were 341 ± 54 mm and 614 ± 405 g respectively. The frequency of occurrence method delineated 21 different food organisms (Table XIII); an additional 28 food organisms were

TABLE X

Food of the sea stars *Leptasterias polaris acervata*, *Evasterias echinosoma* and *Lethasterias nanimensis* as determined in the present study

Prey	*Leptasterias polaris acervata*		*Evasterias echinosoma*		*Lethasterias nanimensis*	
	Chukchi Sea	Norton Sound	Chukchi Sea	Norton Sound	Chukchi Sea	Norton Sound
Polychaeta	–	2:2	–	–	–	–
Cistenides sp.	4:7[1]	–	–	–	–	–
Nuculana fossa	1:1	–	–	–	–	–
Musculus niger	–	–	1:1	–	–	–
Astarte borealis	1:1	–	3:3	–	–	–
Cyclocardia ventricosa	1:1	–	–	–	–	–
Cyclocardia crebricostata	1:1	2:2	–	–	–	–
Clinocardium ciliatum	–	–	1:1	–	–	1:1
Clinocardium californiense	–	–	–	–	1:1	–
Serripes groenlandicus	–	2:2	3:12	3:3	3:5	2:6
Macoma sp.	–	1:1	–	–	–	–
Macoma calcarea	2:4	–	–	–	–	–
Mya truncata	–	–	1:1	–	–	–
Margarites sp.	–	–	–	1:1	–	–
Natica sp.	1:1	–	–	–	–	–
Natica clausa	2:9	–	–	–	–	1:1
Boreotrophon clathratus	1:2	–	–	–	–	–
Buccinium sp.	1:1	–	–	–	–	–
Gastropod fragments	–	2:2	–	–	–	–
Balanus spp.	–	3:6	–	–	–	–
Amphipoda	–	1:1	–	–	–	–
Eualus sp.	–	1:1	–	–	–	–
Hyas coarctatus alutaceus	–	1:1	–	–	–	–
Ectoprocta	–	1:1	–	–	–	–
Echinarachnius parma	–	2:11	–	1:1	–	1:2
Chelyosoma orientale	1:many[2]	–	–	–	–	–
Boltenia echinata	1:many[2]	–	–	–	–	–
TOTALS	17:30+	18:30	9:18	5:5	4:6	5:10

[1] Number of stations where predators were feeding on prey:Number of predators feeding on prey

[2] Many observations noted; no tally available.

TABLE XI

A summarization of station data for the three sampling areas. The number of starry flounders examined, the number and percent of fish feeding, and the method of analysis used for examining these fish in the study areas

					Method of Analysis				
					Freq. of Occur.		Quantitative		
Sampling area	Station	Depth m	Latitude	Longitide	Number Examined	Number Feeding	Number Examined	Number Feeding	% Feeding
Norton Sound	D-09	23.0	64°18'	165°21'	17	15	10	9	89
	D-20	24.0	64°11'	166°09'	12	12	-	-	100
	D-49	22.7	63°51'	166°04'	10	9	-	-	90
	D-48	29.0	63°51'	165°40'	6	6	-	-	100
	D-63	26.3	63°40'	165°46'	10	9	-	-	90
	D-76	27.3	63°29'	166°01'	4	0	-	-	0
	D-86	25.4	63°19'	165°45'	4	4	-	-	100
	D-54	20.0	63°51'	163°52'	8	7	-	-	88
	D-68	16.3	63°40'	163°53'	9	9	-	-	100
	D-72	19.0	63°46'	162°15'	4	4	-	-	100
	D-25	22.0	64°10'	164°14'	4	4	-	-	100
	C-58	27.0	63°28'	166°28'	3	2	-	-	67
	C-62	26.0	63°15'	166°29'	2	1	-	-	50
	D-14	22.0	64°20'	163°33'	9	8	-	-	89
	D-40	20.0	63°58'	163°50'	18	16	-	-	89
	C-61	26.0	63°14'	167°05'	6	6	6	6	100
TOTALS	16				126	112	16	15	89
Port Clarence	C-63	14.5	65°18'	167°11'	-	-	6	6	100
	C-64	15.0	65°16'	166°36'	-	-	128	121	95
TOTALS	2				-	-	134	127	95
Chukchi Sea	A-48	35.0	66°15'	167°59'	5	4	-	-	80
	A-52	38.2	66°02'	168°02'	-	-	10	10	100
	A-55	16.3	65°50'	167°46'	-	-	12	9	75
	A-53	20.0	65°59'	167°22'	-	-	4	3	75
TOTALS	4				5	4	26	22	84
GRAND TOTALS	22				131	116	176	164	91

TABLE XII

A list of food items from the stomachs of 280 feeding *Platichthys stellatus* collected in Norton Sound, Port Clarence, and southeastern Chukchi Sea, 2 September - 13 October, 1976

Phylum Cnidaria
  Class Hydrozoa
      Unidentified species

Phylum Rhynchocoela
      Unidentified species

Phylum Annelida
  Class Polychaete
    Family Nephtyidae
      Nephtys sp.
      Nephtys rickettsi
    Family Goniadidae
      Glycinde armigera
    Family Lumbrineridae
      Lumbrineris sp.
    Family Sternaspidae
      Sternaspis scutata
    Family Arenicolidae
      Arenicola glacialis
    Family Pectinaridae
      Cistenides hyperborea
    Family Ampharetidae
      Lysippe labiata
    Family Polynoidae
      Unidentified species

Phylum Mollusca
  Class Pelecypoda
    Family Nuculanidae
      Yoldia sp.
      Yoldia hyperborea
      Yoldia seminuda
    Family Mytilidae
      Musculus niger
      Musculus corrugatus
    Family Carditidae
      Cyclocardia ventricosa
    Family Cardiidae
      Clinocardium ciliatum
      Serripes groenlandicus
    Family Myidae
      Mya sp.
    Family Lyonsiidae
      Lyonsia norvegica

TABLE XII (Cont'd)

Class Gastropoda
Family Naticidae
Polinices pallida
Family Cancellaridae
Admete sp.
Family Scaphandridae
Cylichna occulta
Family Turridae
Oenopota sp.

Phylum Arthropoda
Class Crustacea
Order Thoracia
Family Balanidae
Order Cumacea
Family Leuconidae
Leucon sp.
Family Diastylidae
Diastylis sp.
Diastylis sulcata
Order Isopoda
Family Idoteidae
Saduria entomon
Synidotea nodulosa
Order Amphipoda
Family Gammaridae
Family Haustoriidae
Pontoporeia femorata
Order Decapoda
Family Hippolytidae
Unidentified species
Family Crangonidae
Crangon sp.
Crangon dalli
Argis lar
Family Paguridae
Labidochirus splendescens
Family Majidae
Chionoecetes opilio

Phylum Priapulida
Priapulus caudatus

Phylum Echiuroidea
Class Echiurida
Family Echiuridae
Echiurus echiurus alaskensis

TABLE XII (Cont'd)

Phylum Echinodermata
  Class Echinoidea
    Family Echinarachniidae
      Echinarachnius parma
  Class Ophiuroidea
    Family Ophiuridae
      Stegophiura nodosa
    Family Amphiuridae
      Diamphiodia craterodmeta

Phylum Urochordata
  Class Ascidiacea
    Family Styelidae
      Pelonaia corrugata

Phylum Chordata - Superclass Pisces
  Class Osteichthyes
   Order Gadiformes
    Family Gadidae
      Eleginus gracilis
   Order Scorpaeniformes
    Family Cottidae
      Myoxocephalus sp.
   Order Perciformes
    Family Stichaeidae
      Lumpenus fabricii

TABLE XIII

Frequency and percent frequency of occurrence of food items in stomachs of 126 *Platichthys stellatus* collected in 16 Norton Sound Stations 2 September - 13 October, 1976

Food Items	Number	Percent
Coelenterata		
Hydrozoa	1	0.7
Annelida		
Polychaeta	3	2.3
Polynoidae	1	0.7
Pectinariidae		
Cistenides hyperborea	1	0.7
Mollusca		
Pelecypoda		
Nuculanidae		
Yoldia hyperborea	46	35.9
Mytilidae		
Musculus niger	18	14.0
Cardiidae		
Serripes groenlandicus	29	22.6
Myidae		
Mya sp.	1	0.7
Gastropoda		
Turridae		
Oenopota sp.	1	0.7
Arthropoda		
Crustacea		
Balanidae	1	0.7
Idoteidae		
Saduria entomon	1	0.7
Synidotea nebulosa	1	0.7
Crangonidae		
Argis lar	1	0.7
Paguridae		
Labidochirus splendescens	1	0.7
Echiurida		
Echiurdea		
Echiuridae		
Echiurus echiurus alaskensis	6	4.6
Priapulida		
Priapulus caudatus	6	4.6

TABLE XIII (Cont'd)

Food Items	Number	Percent
Echinodermata		
Echinoidea		
Echinarchniidae		
Echinarachnius parma	6	4.6
Ophiuroidea		
Ophiuridae		
Stegophiura nodosa	7	5.4
Amphiuridae		
Diamphiodia craterodmeta	33	25.7
Chordata		
Osteichthyes		
Stichaeidae		
Lumpenus fabricii	3	2.3
Unidentified fish	7	5.4
Empty Stomachs	14	10.9

determined in the laboratory from quantitative samples (Table XIV). Leading species identified by the frequency of occurrence method were a protobranch clam (*Yoldia hyperborea*), a brittle star (*Diamphiodia craterodmeta*) and the Greenland cockle (*Serripes groenlandicus*). In order of decreasing relative importance, the major prey items from the quantitative samples were *Diamphiodia craterodmeta*, *Yoldia hyperborea*, a tube-dwelling polychaete (*Cistenides hyperborea*), a sand dollar (*Echinarachnius parma*), a proboscis worm (*Echiurus echiurus alaskensis*), and a priapulid worm (*Priapulus caudatus*) (see Table XIV; Fig. 21; App. Table VII). A food web for Norton Sound - Port Clarence - Chukchi Sea starry flounders is presented in Figure 22, and is based on unpublished notes and data contained in Appendix Table VII.

Feeding differences (based on the index of relative importance: IRI) between sexes were examined in fish analyzed by the quantitative method. The number of males and females examined was 106 and 70, respectively; the number of empty stomachs was 7 and 5, respectively. No significant differences (α=0.05) in feeding between sexes was apparent (see App. Tables VIII and IX).

Feeding differences (based on IRI) between each of the three sampling areas were found to be significantly different (α=0.05) (Fig. 23). The heterogeneity of major food organisms between sampling areas is shown in Figures 23-26.

Among the 106 males and 70 females examined, 58.5% and 74.3% respectively were found to be sinistrial (eyes on the left side). For the total 176 fish, 64.7% were sinistral.

Norton Sound - The most frequently consumed organisms in 126 Norton Sound starry flounders, in order of decreasing percent frequency of oc-

TABLE XIV

Frequency of occurrence, number, volume and index of relative importance of food items from starry flounders of Norton Sound, Port Clarence, and the southeastern Chukchi Sea, 2 September-13 October, 1976. Food items with corresponding percentage represent the level at which identifications were made. SE = number of stomach examined.

	NORTON SOUND SE=16				PORT CLARENCE SE=134				CHUKCHI SEA SE=26			
		Percent		Index of relative importance		Percent		Index of relative importance		Percent		Index of relative importance
Food Items	Frequency F	Number N	Volume V	F(N+V)	Frequency F	Number N	Volume V	F(N+V)	Frequency F	Number N	Volume V	F(N+V)
Rhynchocoela	6.25	0.10	1.58	10.50	--	--	--	--	--	--	--	--
Annelida												
Polychaeta	6.25	0.10	0.06	1.00	11.19	0.66	0.71	15.33	--	--	--	--
Nephtys sp.	--	--	--	--	0.75	0.01	0.08	0.06	--	--	--	--
Nephtys rickettsi	--	--	--	--	0.75	0.01	0.02	0.02	--	--	--	--
Glycinde armigera	--	--	--	--	0.75	0.01	0.02	0.02	--	--	--	--
Lumbrineris sp.	--	--	--	--	0.75	0.01	0.03	0.03	--	--	--	--
Sternaspis scutata	--	--	--	--	26.87	1.19	1.00	58.84	--	--	--	--
Arenicola glacialis	--	--	--	--	--	--	--	--	3.85	0.94	4.47	20.82
Cistenides hyperborea	6.25	0.10	0.03	0.81	20.90	4.50	2.96	155.91	--	--	--	--
Lysippe labiata	--	--	--	--	0.75	0.08	0.01	0.06	--	--	--	--
Mollusca												
Pelecypoda	--	--	--	--	2.99	0.05	0.06	0.32	--	--	--	--
Yoldia sp.	--	--	--	--	0.75	0.04	0.25	0.21	--	--	--	--
Yoldia hyperborea	37.50	1.86	4.52	239.25	81.34	10.92	41.54	4267.09	--	--	--	--
Yoldia seminuda	--	--	--	--	0.75	0.05	0.58	0.47	--	--	--	--
Musculus niger	--	--	--	--	7.46	0.14	0.57	5.29	--	--	--	--
Musculus corrugatus	--	--	--	--	0.75	0.01	0.01	0.01	--	--	--	--
Cyclocardia ventricosa	6.25	0.10	0.03	0.81	--	--	--	--	--	--	--	--
Clinocardium ciliatum	--	--	--	--	2.99	0.07	0.08	0.44	--	--	--	--
Serripes groenlandicus	12.50	0.20	0.19	4.87	8.96	0.14	0.58	6.45	--	--	--	--
Mya sp.	--	--	--	--	8.96	0.14	0.40	4.83	--	--	--	--
Lyonsia norvegica	--	--	--	--	2.24	0.04	0.05	0.20	--	--	--	--
Gastropoda												
Naticidae	--	--	--	--	0.75	0.01	0.04	0.03	--	--	--	--
Polinices pallida	--	--	--	--	0.75	0.01	0.01	0.01	--	--	--	--
Admete sp.	--	--	--	--	1.49	0.02	0.02	0.05	--	--	--	--
Cylichna occulta	--	--	--	--	0.75	0.01	0.01	0.01	--	--	--	--
Arthropoda												
Crustacea	--	--	--	--	0.75	0.01	0.01	0.01	--	--	--	--
Cumacea												
Leucon sp.	--	--	--	--	0.75	0.02	0.01	0.02	--	--	--	--
Diastylis sp.	--	--	--	--	6.72	0.32	0.09	2.75	--	--	--	--
Diastylis sulcata	--	--	--	--	0.75	0.06	0.01	0.05	--	--	--	--
Isopoda												
Synidotea nodulosa	12.50	0.88	0.35	15.37	26.87	0.73	0.41	30.63	--	--	--	--
Amphipoda	12.50	0.20	0.06	3.25	5.97	0.24	0.12	2.14	--	--	--	--
Gammaridae	--	--	--	--	0.75	0.01	0.01	0.01	--	--	--	--
Pontoporeia femorata	--	--	--	--	1.49	0.04	0.02	0.08	--	--	--	--

TABLE XIV (Continued)

Food Items	NORTON SOUND SE=16 Percent Frequency F	NORTON SOUND SE=16 Percent Number N	NORTON SOUND SE=16 Percent Volume V	NORTON SOUND SE=16 Index of relative importance F(N+V)	PORT CLARENCE SE=134 Percent Frequency F	PORT CLARENCE SE=134 Percent Number N	PORT CLARENCE SE=134 Percent Volume V	PORT CLARENCE SE=134 Index of relative importance F(N+V)	CHUKCHI SEA SE=26 Percent Frequency F	CHUKCHI SEA SE=26 Percent Number N	CHUKCHI SEA SE=26 Percent Volume V	CHUKCHI SEA SE=26 Index of relative importance F(N+V)
Decapoda												
Hippolytidae	--	--	--	--	--	--	--	--	19.23	5.66	3.73	180.56
Crangon sp.	--	--	--	--	1.49	0.02	0.02	0.05	--	--	--	--
Crangon dalli	6.25	0.10	0.32	2.62	--	--	--	--	--	--	--	--
Argis lar	--	--	--	--	0.75	0.01	0.04	0.03	--	--	--	--
Chionoecetes opilio	6.25	14.30	1.58	99.25	0.75	0.35	2.24	1.94	--	--	--	--
Echiuroidea												
Echiurida												
Echiurus echiurus alaskensis	--	--	--	--	--	--	--	--	46.15	28.30	50.88	3654.15
Priapulida												
Priapulus caudatus	6.25	0.29	0.44	4.56	20.90	0.35	2.81	66.04	--	--	--	--
Echinodermata												
Echinoidea												
Echinarachnius parma	31.25	24.19	75.47	3114.37	0.75	0.06	0.04	0.07	--	--	--	--
Ophiuroidea												
Diamphiodia craterodmeta	43.75	57.49	15.35	3186.75	52.24	79.54	38.16	6148.64	--	--	--	--
Stegophiura nodosa	--	--	--	--	0.75	0.02	0.02	0.03	3.85	27.36	7.83	135.48
Unidentified Ophiuroids	6.25	0.10	0.03	0.81	--	--	--	--	--	--	--	--
Urochordata												
Ascidiacea	--	--	--	--	--	--	--	--	11.54	7.55	0.11	88.39
Pelonaia corrugata	--	--	--	--	0.75	0.05	0.05	0.07	--	--	--	--
Chordata-Pisces	--	--	--	--	--	--	--	--	3.85	9.43	9.32	72.18
Osteichthyes												
Eleginus gracilis	--	--	--	--	0.75	0.01	6.23	4.68	3.85	0.94	0.37	5.04
Myoxocephalus sp.	--	--	--	--	0.75	0.01	0.71	0.54	--	--	--	--
Lumpenus fabricii	--	--	--	--	--	--	--	--	38.46	19.81	23.29	1657.62

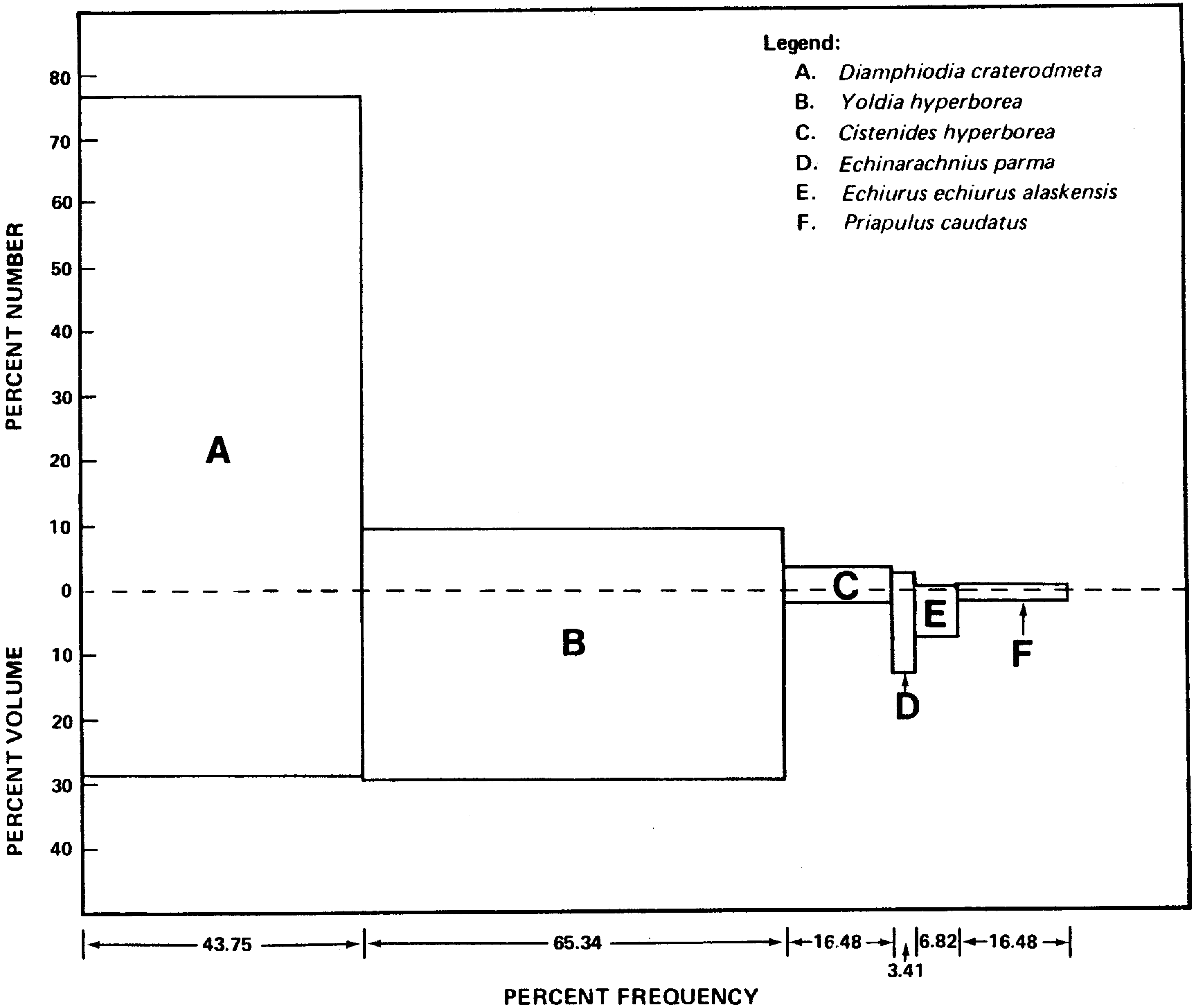


Figure 21. Percent composition by number, volume, and frequency of occurrence of major food items from 176 starry flounders, *Platichthys stellatus*, from Norton Sound, Port Clarence and the Southeastern Chukchi Sea.

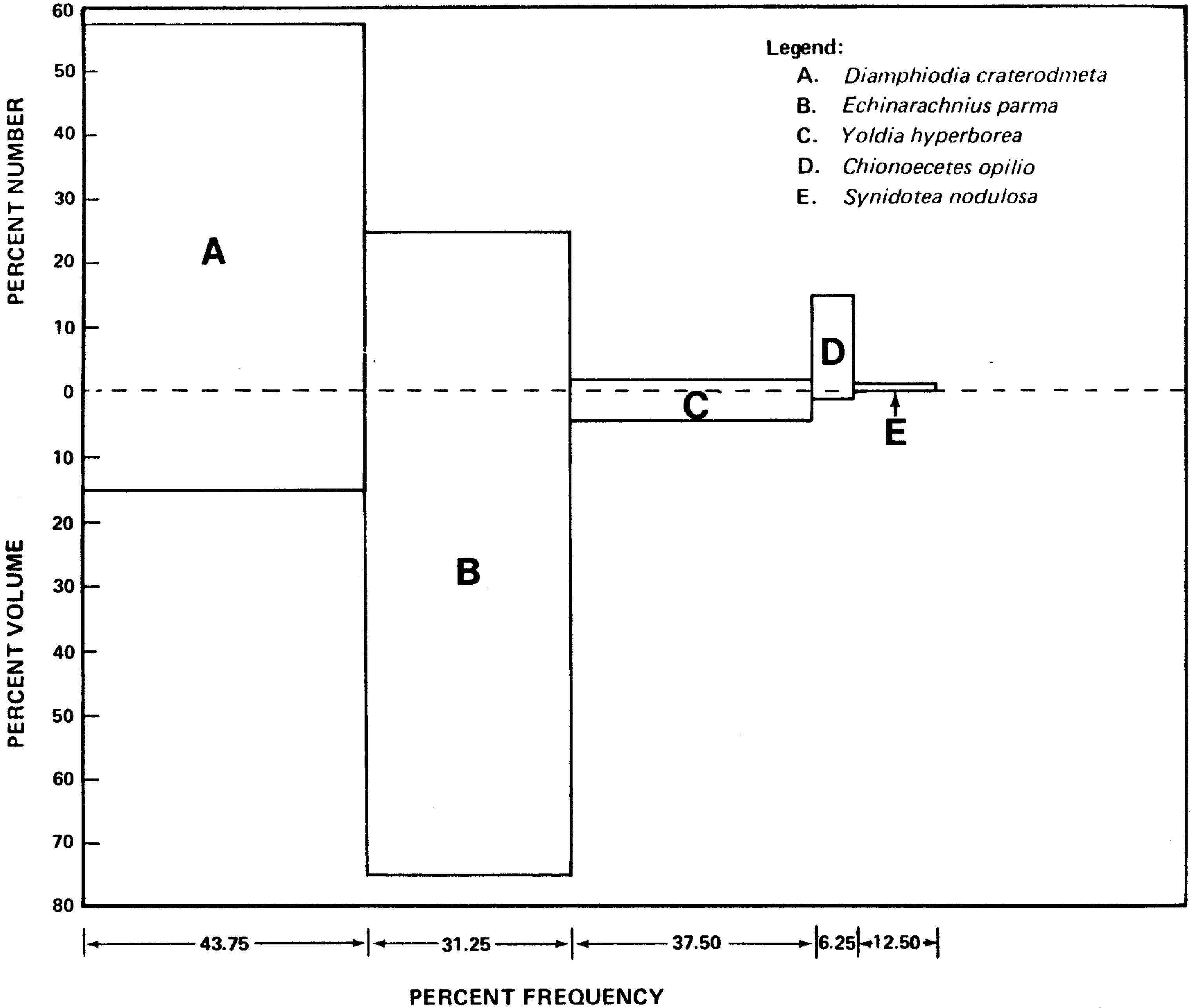


Figure 22. Food web for starry flounders, *Platichthys stellatus*, from Norton Sound, Port Clarence and Southeastern Chukchi Sea. The thickness of lines in the food web indicates the relative importance of prey items.

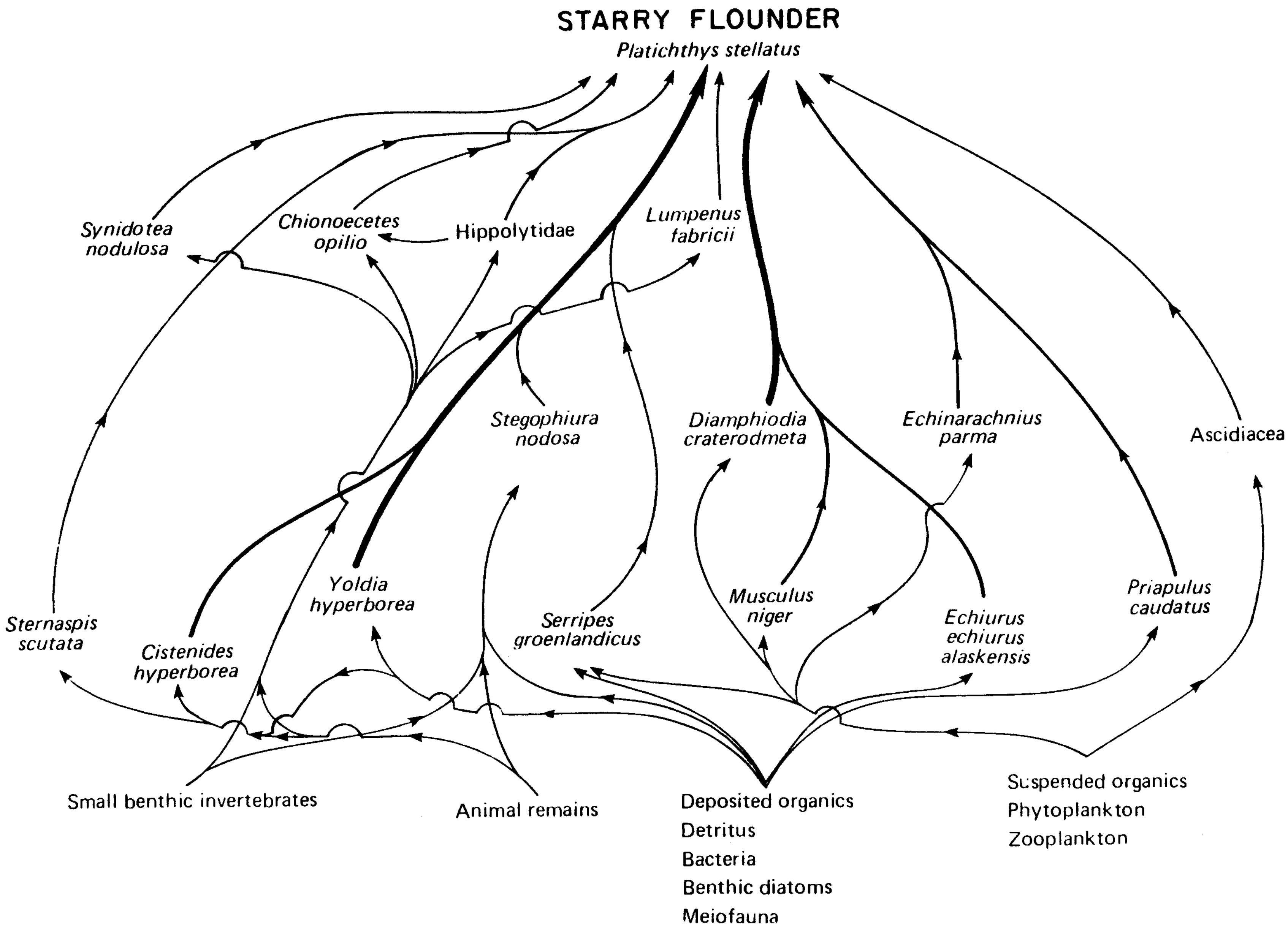


Figure 23. The relative importance of major food items of starry flounders from Norton Sound, Port Clarence, and the Southeastern Chukchi Sea. See Sect. V of the text for discussion of the Index of Relative Importance (IRS).

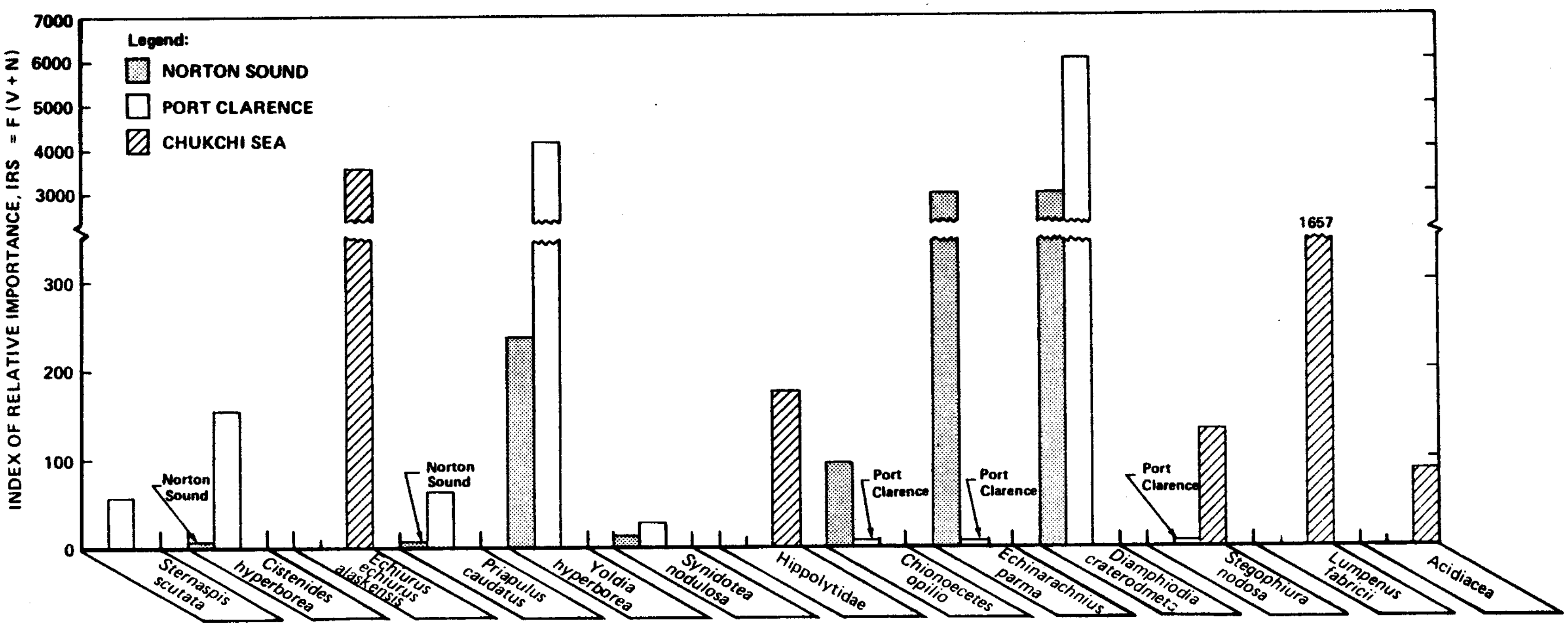


Figure 24. Percent composition by number, volume, and frequency of occurrence of major food organisms from 16 Norton Sound starry flounders.

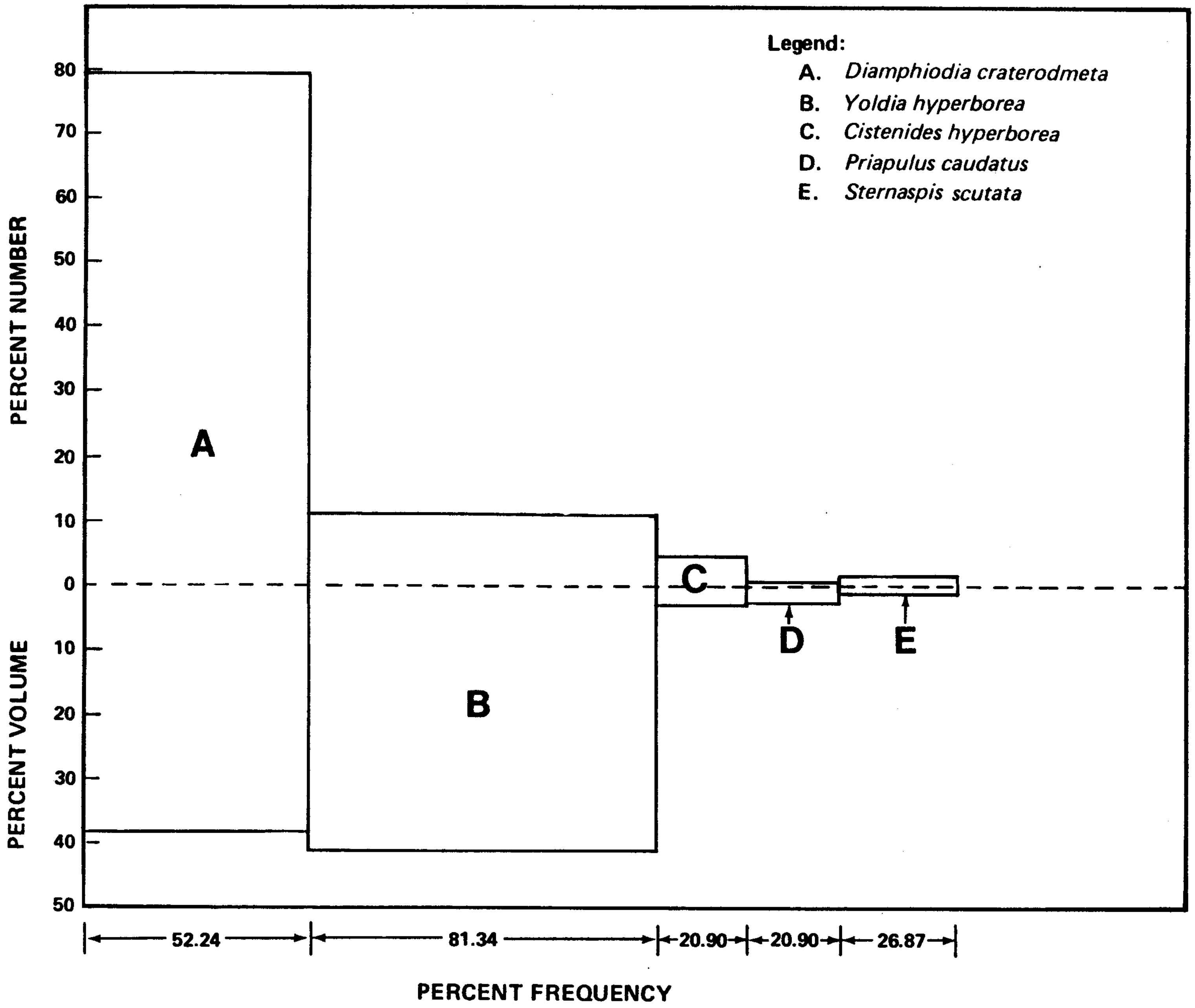


Figure 25. Percent composition by number, volume, and frequency of occurrence of major food items from 134 Port Clarence starry flounders.

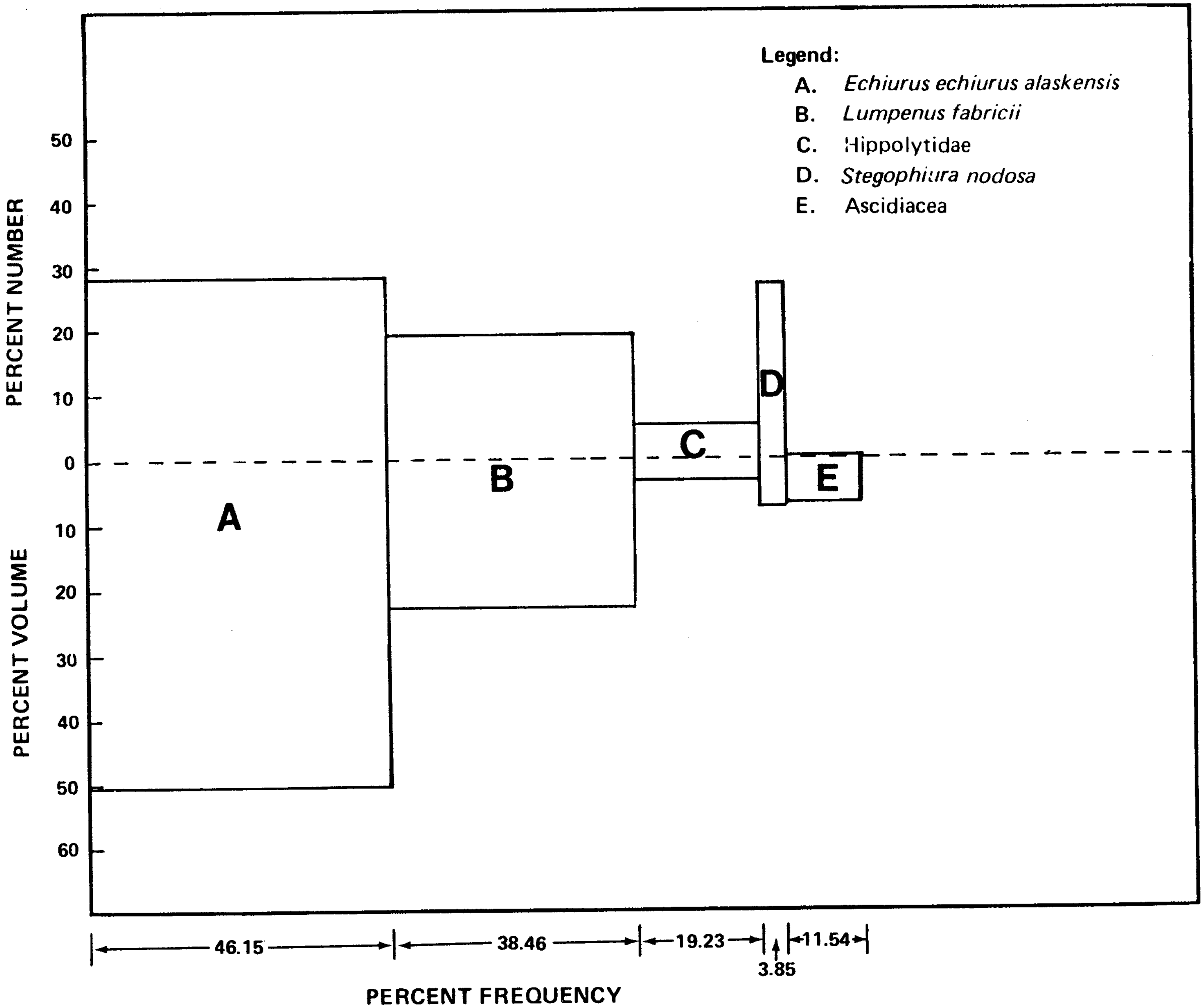


Figure 26. Percent composition by number, volume, and frequency of occurrence of major food items from 26 southeastern Chukchi Sea starry flounders.

currence, were the protobranch clam, *Yoldia hyperborea* (35.9%), the brittle star, *Diamphiodia craterodmeta* (25.7%), the Greenland cockle, *Serripes groenlandicus* (22.6%), and the mussel, *Musculus niger* (14.0%) (Table XIII).

Fourteen different organisms were identified from 16 starry flounders examined by the quantitative method of analysis (Table XIV; App. Table X). In decreasing order of relative importance, the major prey items were *Diamphiodia craterodmeta, Echinarachnius parma, Yoldia hyperborea,* the snow crab, (*Chionoecetes opilio*), and an isopod (*Synidotea nodulosa*) (Table XIV; Fig. 24).

Port Clarence - Stomach contents of 134 starry flounders were examined from this area by the quantitative method. Forty (40) food items were identified, with annelids and molluscs leading in species representation (Table XIV: App. Table XI). The major food items, in decreasing order of relative importance, were *Diamphiodia craterodmeta, Yoldia hyperborea, Cistenides hyperborea, Priapulus caudatus*, and an errant polychaete (*Sternaspis scutata*) (Table XIV; Fig. 25).

Whole organisms were typically consumed, but the caudal appendage of the burrowing worm, *Priapulus caudatus*, was occasionally the only portion of this animal taken.

Southeastern Chukchi Sea - A small sample of 26 starry flounder was examined by the quantitative method from the southeastern portion of the Chukchi Sea. Major food organisms, in terms of decreasing relative importance, were *Echiurus echiurus alaskensis*, the prickleback fish (*Lumpenus fabricii*), shrimps of the family Hippolytidae, a brittle star (*Stegophiura nodosa*), and unidentified tunicates of the class Ascidiacea (Table XIV; App. Table XII; Fig. 26).

Typically, only the anterior portion of the worm-like *Echiurus* was consumed. *Echiurus* burrows in the sediment with its proboscis at the surface, and the entire worm is rarely fully exposed (Meglitsch, 1972).

The prickleback fish, *Lumpenus fabricii*, ranged from 85-160 mm in length, and was always swallowed whole. As many as 18 of these fish were found in a single stomach.

The five starry flounders examined by the frequency of occurrence method showed the same organisms to be important.

Reproductive Observations

Reproductive observations were made on five species of shrimps, eight species of crabs, and two species of sea stars (Table XV). Most reproductive data were obtained from the Norton Sound area.

Most of the shrimp data are for the shrimp, *Argis lar*. More than 12,000 individuals of this species were examined from 62 stations of the Norton Sound area, and nearly 5,000 were examined from 24 Chukchi Sea - Kotzebue Sound stations. In Norton Sound, 17% had blue and green ovaries visible through the cephalothorax and 24% were carrying aqua or green eggs attached to their pleopods. In the Chukchi Sea - Kotzebue Sound area, 23% were carrying aqua eggs.

A summarization of the reproductive observations of *Pandalus goniurus*, *Argis lar*, *Crangon dalli*, *Sclerocrangon boreas*, *Eualus gaimardii belcheri*, *Pagurus trigonocheirus*, *P. capillatus*, *P. ochotensis*, *Labidochirus splendescens*,

TABLE XV

Reproductive observations on selected epifaunal invertebrates by area

Norton Sound Area		Chukchi Sea - Kotzebue Sound Area	
Argis lar			
No. stations examined -	62	No. stations examined -	24
No. shrimps examined -	12,136	No. shrimps examined -	4,786
% with blue ovary -	3%	% with aqua eggs -	23%
% with green ovary -	14%		
% with green eggs -	5%		
% with aqua eggs -	19%		
% with internal eggs -	17%		
% with external eggs -	24%		
Crangon dalli			
No. stations examined -	13	No observations	
No. shrimps examined -	4,630		
% with pale green eggs -	<.01%		
% with white eggs -	9%		
% with eggs -	9%		
Pandalus goniurus			
No. stations examined -	12	No observations	
No. shrimps examined -	2,490		
% with green eggs -	1%		
% with aqua eggs -	17%		
% with eggs -	18%		
Sclerocrangon boreas			
No. stations examined -	12	No. stations examined -	2
No. shrimps examined -	539	No. shrimps examined -	2,845
% with tan and green eggs -	6%	Many with green eggs - no % available	
% with aqua eggs -	31%		
% with eyed-aqua eggs -	8%		
% with eggs -	45%		
Eualus gaimardii belcheri			
No. stations examined -	4	No observations	
No. shrimps examined -	156		
% with green eggs -	22%		

TABLE XV (Cont'd)

Norton Sound Area		Chukchi Sea - Kotzebue Sound Area	
Pagurus trigonocheirus			
No. stations examined -	35	No. stations examined -	3
No. crabs examined -	3,853	No. crabs examined -	429
% with dark purple eggs -	8%	% with dark purple eggs -	6%
Labidochirus splendescens			
No. stations examined -	26	No. stations examined -	3
No. crabs examined -	2,426	No. crabs examined -	112
% with dark purple eggs -	18%	% with purple-black eggs -	33%
% with purple-gray eggs -	1%	% with eggs -	33%
% with eggs -	19%		
Pagurus capillatus			
No. stations examined -	9	No. stations examined -	2
No. crabs examined -	1,416	No. crabs examined -	303
% with purple-black eggs -	8%	% with purple eggs -	3%
% with eggs -	8%		
Pagurus ochotensis			
No. stations examined -	9	No observations	
No. crabs examined -	412		
% with purple-black eggs -	33%		
% with brown eggs -	1%		
% with eggs -	34%		
Paralithodes camtschatica			
No. stations examined -	9	No observations	
No. female crabs examined-	412		
% with purple eggs -	15%		
% with brown eggs -	6%		
% with eggs -	21%		
Hyas coarctatus alutaceus			
No. stations examined -	20	No. stations examined -	14
No. female crabs examined-	739	No. female crabs examined-	707
% with orange eggs -	17%	% with orange eggs -	24%
% with eyed eggs -	1%	% with purple eggs -	1%
% with eggs -	18%	% with dark brown eggs -	1%
		% with eggs -	26%

TABLE XV (Cont'd)

Norton Sound Area		Chukchi Sea - Kotzebue Sound Area	
Chionoecetes opilio			
No. stations examined -	6	No. stations examined -	6
No. female crabs examined -	432	No. female crabs examined -	1,908
% with orange eggs -	4%	% with orange eggs -	5%
Telmessus cheiragonus			
No. stations examined -	9	No. stations examined -	21
No. female crabs examined -	403	No. female crabs examined -	not determined
% with orange ovaries -	29%	None with eggs; all large females with orange ovaries.	
% with orange eggs -	2%		
Leptasterias polaris acervata			
No. stations examined -	2	No. stations examined -	6
No. sea stars examined -	87	No. sea stars examined -	6,318
% brooding young -	2%	% brooding young -	<.1%
***Leptasterias* sp.**			
No. stations examined -	16	No. stations examined -	5
No. sea stars examined -	1,784	No. sea stars examined -	322
% with orange eggs in oral region -	2%	% with orange eggs in oral region -	1%
% with brooding young -	3%	% with brooding young -	1%

Paralithodes camtschatica, *Hyas coarctatus alutaceus*, *Chionoecetes opilio*, *Telmessus cheiragonus*, *Leptasterias polaris acervata*, and *Leptasterias* sp. is found in Table XV.

Twenty-nine percent of the female horse crab, *Telmessus cheiragonus*, examined in Norton Sound stations contained orange ovaries; 2% were bearing eggs. None of the *T. cheiragonus* in the Chukchi Sea - Kotzebue Sound stations were bearing eggs, but all of the large females examined contained orange ovaries.

Parasitological Observations

Microscopic examination of nodules on the aboral surface of two sea stars, *Leptasterias polaris acervata* and *Leptasterias* sp. from randomly selected stations revealed the presence of unidentified parasitic gastropods.[1] As many as 25 nodules up to 2.5 cm in diameter were observed on some specimens. Parasitized *L. polaris acervata* was observed in seven scattered stations in the Norton Sound area and 11 localized stations in the Chukchi Sea - Kotzebue Sound area; the percentage of parasitized individuals in the respective stations was 15% and 10% (Table XVI, Fig. 1).

Stations with parasitized *Leptasterias* sp. were localized in the Norton Sound area. The percentage of infection at these stations was 13% (Table XVI). Samples from only four stations in the Chukchi Sea area contained parasitized *Leptasterias* sp.

Other parasitic observations included: rhizocephalids (parasitic barnacles) attached to the abdomen of hermit crabs, specifically *Pagurus capillatus*; parasitic isopods found under the cephalothorax of shrimps, primarily *Argis lar*.

---

[1]Taxonomic work and further aspects of the biology of this parasitic gastropod will be included in B. McCain, R. U. 332.

TABLE XVI

Occurrence of parasitic gastropods on two sea stars in the Norton Sound and Chukchi Sea - Kotzebue Sound sampling areas, 2 September-13 October, 1976

P indicates parasitism observed but not enumerated.

Leptasterias polaris acervata

Norton Sound

Station	No. Examined	Parasitized No.	Parasitized %
C-61	8	3	38
C-55	52	11	21
C-48	30	1	3
C-51	31	3	10
C-64	4	1	25
C-39	13	1	8
D-62	4	1	25
Totals	142	21	15

Chukchi Sea

Station	No. Examined	Parasitized No.	Parasitized %
A-19	153	23	15
A-17	287	13	5
A-27	132	36	27
A-56	416	7	2
A-26	112	24	21
A-32	110	21	19
A-31	P	P	P
A-25	P	P	P
B-6	P	P	P
A-16	P	P	P
A-30	P	P	P
Totals	1,210	124	10

Leptasterias sp.

Norton Sound

Station	No. Examined	Parasitized No.	Parasitized %
C-60	26	8	31
C-56	47	1	2
C-51	48	11	23
C-50	30	6	20
C-52	43	17	40
C-33	1,348	202	15
C-32	601	30	5
C-61	8	1	13
D-87	12	1	8
D-39	24	6	25
Totals	2,187	283	13

Chukchi Sea

Station	No. Examined	Parasitized No.	Parasitized %
A-2	11	3	27
A-1	5	3	60
B-20	22	5	23
B-7	P	P	P
Totals	38	11	29

VII. DISCUSSION

General Observations

Most invertebrate species collected in this investigation were reported in other benthic studies of the northeastern Bering Sea shelf and southeastern Chukchi Sea (Ellson *et al.*, 1950; Neiman, 1963; Sparks and Pereyra, 1966; Feder and Mueller, 1974; and Stoker, in prep.). The majority of the species identified are of boreal Pacific origin. The near absence of higher arctic species is not surprising in view of the strong northerly currents that prevail during the summer months on the eastern side of the Bering Sea, Bering Strait, and the Chukchi Sea (Stoker, in prep.). Likewise, Pruter and Alverson (1962) found few high arctic species of flatfishes in the southeastern Chukchi Sea.

Benthic trawl studies in the northeast Gulf of Alaska and the southeast Bering Sea showed that arthropod crustaceans dominated the invertebrate biomass, with 71.4% and 61.7% in the respective regions (Jewett and Feder, 1976; Feder *et al.*, 1977a). The total echinoderm biomass from each of these areas was 19.0% and 17.5%, respectively. Trawl surveys in the coastal waters of Norton Sound, near Nome, and the southeastern Chukchi Sea showed that echinoderms (especially asteroids) dominated the invertebrate biomass (Feder and Mueller, 1974; Sparks and Pereyra, 1966). The echinoderm biomass in the present study was 80.3% in the Norton Sound area and 59.9% in the Chukchi Sea - Kotzebue Sound area. This change in dominance from crustaceans to echinoderms in the northern waters examined may be attributable to an increased availability of food for the echinoderms. This availability of food may, in turn, reflect the absence of large populations of competing crabs and demersal fishes in these northern regions (Neiman, 1963), many of which use similar food items elsewhere (Feder and Jewett, 1977; Feder *et al.*, 1977a).

Since sea stars made up 69 and 48% of the total epifaunal invertebrate biomass in the Norton Sound and the Chukchi Sea - Kotzebue Sound areas, respectively, their importance cannot be overlooked. Sea stars are not typically utilized at higher trophic levels (Feder *et al.*, 1974; Feder, unpubl. data from the Gulf of Alaska and Bering Sea), and are known to be long lived (Hyman, 1955). Thus, it would appear that these animals represent relatively immobile carbon reservoirs. However, a considerable portion of sea-star carbon is, in fact, returned to the sea annually as gamete production (Feder and Paul, unpubl.). For example, Hatanaka and Kosaka (1958) calculated that 20-30% of the weight of *Asteria amurensis* in Tokyo Bay is gonadal material which is ultimately extruded during spawning (also see Feder, 1956 and 1970 for comments on the reproductive biology of the sea star *Pisaster ochraceus*). Sea stars generally exhibit distinct annual reproductive cycles, and those species that shed their gametes into the surrounding water tend to liberate their sex products over short periods of time (Feder, 1956, Boolootian, 1966). Such pulses of high energy reproductive material during the spawning of large populations of sea stars probably represent important components of secondary production in the study areas.

The epifaunal standing stock reported in the present study is similar to standing stock estimates presented in OCSEAP benthic trawl studies elsewhere, i.e., see Jewett and Feder, 1976; Feder *et al.*, 1977a; and Feder and Jewett, 1977. The total biomass of epifaunal invertebrates in the northeast Gulf of Alaska and two bays around Kodiak Island was 2.6 g/m^2 (Jewett and Feder, 1976) and 4.7 g/m^2 (Feder and Jewett, 1977) respectively. The epifaunal biomass in the present study deviated little from past studies, i.e., 3.7 g/m^2 in the Norton Sound area and 3.3 g/m^2 in the Chukchi Sea - Kotzebue Sound area.

Russian benthic investigations (Neiman, 1963), provide biomass estimates based on grab samples for infauna and small epifauna from the southeast Bering Sea with the lowest value reported as 55 g/m^2. Use of a commercial trawl results in the loss of infaunal and small epifaunal organisms that are an important part of the benthic biomass. Therefore, the total benthic biomass value is probably best expressed by combining both grab and trawl values. Combined infaunal and epifaunal surveys should be part of all future investigations designed by OCSEAP.

Highest biomass stations for nine of the 17 dominant species (Tables V, VIII; Figs. 3-5, 9-12, 17, 19) are located in northern Norton Sound, primarily off Nome, extending northwest to the Bering Strait. The highest biomass stations for the remaining eight dominant species were scattered throughout the Chukchi Sea - Kotzebue Sound area (Tables V, VIII; Figs. 6-8, 13-16, 18). Most of these organisms rely on detritus either directly or indirectly. The main current flow in the St. Lawrence Island into Norton Sound before flowing toward the Bering Strait (Ellson *et al.*, 1950). Due to the shallow depth, these currents likely extend from the surface to the bottom. Substantial sediment input from the Yukon and Kuskokwim Rivers are carried by these currents and the finer fractions settle out as the velocity decreases (McRoy and Goering, 1976). Near its source, this sediment input (consisting largely of coarser and heavier fractions), may smother many species, and may markedly deter settlement of benthic larvae (Stoker, in prep.). This effect, as well as the low chlorinity and salinity from these rivers (Ellson, *et al.*, 1950), probably account for the many low diversity stations off the Yukon River.

Feeding Observations

Sea Stars

The sea stars, *Leptasterias polaris acervata, Evasterias echinosoma,* and *Lethasterias nanimensis* are food generalists, and their diet is probably determined largely by the relative abundance of prey species available to them. These three sea-star species exhibit extraoral feeding and typically remain arched over their prey when taken from the bottom. Although certain species have been identified as more frequently consumed prey items than other species, spatial and seasonal variations as well as preference and availability of prey have not been examined. Therefore, caution must be exercised in interpreting the present feeding data.

Starry Flounders

Major food groups consumed by *Platichthys stellatus* from the northern limits of its range do not differ from those taken by the fish in other geographic localities (Orcutt, 1950; Miller, 1967). The main organisms preyed upon by starry flounders in the present study were the brittle star, *Diamphiodia craterodmeta*, and the protobranch clam, *Yoldia hyperborea*. Although brittle stars are reported from *P. stellatus* stomach contents in other areas, they were never consistently important food items there (Orcutt, 1950; Moiseev, 1953; and Miller, 1967). Orcutt (1950) occasionally found the entire digestive tract of starry flounders filled with the brittle star *Ophiura lütkeni* (disc diameter 12-25 mm), and Miller (1967) observed the brittle star, *Amphiodia* sp. among gut contents. The gut contents of starry flounders from Port Clarence and Norton Sound, the two areas where the largest samples were obtained, were dominated by *Diamphiodia craterodmeta*. Nearly 600 of these tiny brittle stars (disc diameter 1.5-7 mm) were found in a single gut in Port Clarence; typically 20-200 brittle stars were observed per digestive tract.

Small clams, particularly thin-shelled species, are reported to be a main food group of adult starry flounders elsewhere (Villadolid, 1927; Orcutt, 1950; Moiseev, 1953; Miller, 1967; Jewett and Feder, 1976). The digestive tracts of starry flounders in the present study were often completely filled with the thin-shelled clam *Yoldia hyperborea*. Other bivalves, such as *Serripes groenlandicus* and *Musculus niger*, were also important food items for starry flounders in Norton Sound (Table XIV). These molluscs were usually swallowed whole. The selectivity for *Diamphiodia craterodmeta* and *Y. hyperborea* is probably due to their high abundance in the sampling areas and their vulnerability at the sediment surface (Feder, unpub. data).

The proboscis of *Echiurus echiurus alaskensis* and the caudal appendages of *Priapulus caudatus* lie close to the surface during feeding and defecating activities, and, therefore, are readily accessible to active bottom feeding fishes, such as *P. stellatus*. *Priapulus* has previously been reported as food for starry flounders (Miller, 1967; Land, 1970).

The prickleback, *Lumpenus fabricii*, was an important food of starry flounders in the Chukchi Sea. However, fishes are not commonly consumed by *P. stellatus*. Starry flounders from the San Juan Archipelago did not contain fishes (Miller, 1967) although, small fishes such as *Sardinops*, *Citharichthys, Cymatogaster* and *Lycodopsis* have been listed as uncommon food for this species (Villadolid, 1927; Orcutt, 1950; Clemens and Wilby, 1961).

The shortcomings of the Index of Relative Importance (IRI) are noted by Pinkas *et al.* (1971). They point out that frequency of occurrence tabulations are sensitive to sampling error, numerous small organisms overshadow the importance of a few large ones, and differential digestion rates distort volumetric measurements. In our data, *Chionoecetes opilio* appears as one of the major food organisms for Norton Sound starry flounders. However, only one stomach contained this crab which amounted to less than 5 ml in volume. The reason for the high index is explained by the large number of small individuals present, 146 megalopa larvae. A similar situation is noted for *Stegophiura nodosa* in the Chukchi Sea. In the latter case, only one stomach contained the prey, but the percent by number and volume was high enough to yield a high index. Both of the previous illustrations came from small samples; Norton Sound - 16 stomachs and the Chukchi Sea - 26 stomachs, respectively. For the best interpretation of the importance of food organisms, larger samples should be available e.g., Norton Sound - 134 stomachs available for analysis. Although the IRI may fall short of the theoretical ideal, it does allow one to handle the importance of various foods when frequency of occurrence, numerical, and volumetric data is available.

Food items of major importance in the diet of starry flounders tend to differ in each of the study areas. These food differences probably reflect differential prey selectivity and/or differences in prey density and/or availability of the prey in each area. Although *Diamphiodia craterodmeta* and *Yoldia hyperborea*, were food organisms of major importance to starry flounders of Norton Sound and Port Clarence, they were completely absent from the diet of the Chukchi Sea starry flounders. The availability of prey organisms to starry flounders and the comprehension of their biological interactions with *P. stellatus* can only be fully understood when accomplished in conjunction with quantitative sampling via grabs and/or dredges as well as further trawl sampling. Grab and dredge activities were not part of the present study.

Platichthys stellatus belongs to a group of flatfishes normally having eyes on the right side (dextral), but, reversed individuals having eyes on the left side (sinistral) are very common in this species. There is a regional trend in the degree of sinistral starry flounders (see Orcutt, 1950, for a review of the geographic variations in the starry flounder). In general, the proportion of sinistral specimens increases northward along the east Pacific and dextral specimens are nearly absent from Japan waters. The percent of sinistral fish in the present study (64.7%) coincide with the findings of Townsend (1937) i.e., 67.1% of starry flounder from Alaska were sinistral.

Starry flounders may not be perennial inhabitants of the Chukchi Sea. Pruter and Alverson (1962) found only one starry flounder while conducting a demersal trawl investigation in the southeastern Chukchi Sea during August, 1959. In discussing variations in the biomass of food benthos in the Bering Sea, Neiman (1963) suggests that yearly fluctuations in water temperature, rather than availability of food, may be the determining factor responsible for the northern distribution of flatfishes. In the study of Pruter and Alverson (1962) the average bottom water temperature was 4.9°C. However, in the present study where the average bottom water temperature was 6.3°C, nearly 100 starry flounders were

NOTICE

Some required modifications to the Final Report of RU 339 will be available at a later date. These volumes had already gone to press when the Editor was informed of the requirements.

caught in the southeastern Chukchi Sea. It seems unlikely that small temperature differences alone are sufficient to cause movement of *P. stellatus* into the Chukchi Sea during fall months. Perhaps other physical factors such as water currents and O_2 content act synergistically in northward movement of starry flounders.

Reproductive Observations

Little is known about the reproductive biology of invertebrate species for the Norton Sound - Chukchi Sea - Kotzebue Sound areas. Knowledge of the reproductive condition of species may be useful in view of probable increased petroleum mineral and fishing exploration in northern waters. It may be useful in the sense that reproductive data might suggest that probing certain areas during critical reproductive periods should be avoided, i.e. mating, spawning, and/or egg bearing and egg-hatching periods. Examination of the percentage of different egg colors in invertebrates should give some initial insights to the developmental sequence.

The color of king crab (*Paralithodes camtschatica*) eggs elsewhere progresses from dark purple when deposited, to light purple, to light tan in the eyed-egg condition (personal observation). The egg color of the snow crab (*Chionoecetes bairdi*) elsewhere transform from bright orange when deposited, to eyed-light-tan eggs just prior to hatching (personal observation). Presumably, similar color changes of eggs from *P. camtschatica* and *C. opilio* occur in the study area.

The sequence of egg maturation for most of the other species listed in Table XV is not known.

VIII. CONCLUSIONS

Trawling operations in the Norton Sound resulted in the collection of 13 phyla and 187 species; 11 phyla and 171 species were collected in the Chukchi Sea - Kotzebue Sound area. Mollusca, Crustacea, and Echinodermata are the most heavily represented phyla with 74, 45, and 27 species respectively in the Norton Sound Area and 70, 36, and 24 species respectively in the Chukchi Sea - Kotzebue Sound area. Echinoderms, primarily sea stars, made up the major portion of the invertebrate biomass with 80.3% from the Norton Sound area and 59.9% from the Chukchi Sea - Kotzebue Sound area. Arthropod crustaceans and molluscs also contributed considerably to the overall biomass from both areas.

Since sea stars make up the bulk of the epifaunal invertebrate biomass in the study areas, their biological importance cannot be overlooked. It is suggested that these sea stars do not represent relatively immobile carbon reservoirs as has been often suggested, but, instead, that they contribute pulses of high energy organic material, as gametes, into adjacent waters, during their spawning periods. It is possible that the gametes shed by large populations of sea stars in the study areas represent important components generally overlooked in calculations of secondary productivity.

There is now a satisfactory knowledge, on a station basis (for the months sampled), of the distribution, abundance and biomass of the major epifaunal invertebrates in the study areas. Additional seasonal data are essential. It is only when such continuing information is available that a reasonable biological assessment of the effect of an oil spill on these areas can be made.

The sea stars, *Leptasterias polaris acervata, Evasterias echinosoma,* and *Lethasterias nanimensis* are food generalists, and their diet is probably determined largely by the relative abundance of prey species available to them. The latter two species fed mainly upon clams, specifically the Greenland cockle *Serripes groenlandicus.* Due to lack of dredge or grab data on the abundance of infauna in the area, it is not known whether this variability in consumption of food items are due to preference or availability of these items.

Analysis of stomach contents of the starry flounder *Platichthys stellatus* show many differences in the feeding habits between Norton Sound, Port Clarence and the southeastern Chukchi Sea. Starry flounders from Norton Sound mainly use the deposit-feeding clam, *Yoldia hyperborea,* and the small brittle star, *Diamphiodia craterodmeta,* as food, while starry flounders from southeastern Chukchi Sea mainly consume the proboscis worm, *Echiurus echiurus alaskensis*, and the prickleback fish, *Lumpenus fabricii.*

Availability of many readily identifiable, biologically well understood organisms is a preliminary to the development of monitoring programs. Sizeable biomasses of taxonomically well-known echinoderms, crustaceans, and molluscs were typical of most of our stations, and many species of these phyla were sufficiently abundant to represent organisms potentially useful as monitoring tools. The present investigation has clarified several aspects of the biology of some of these organisms, and should aid in the development of future monitoring programs for the Norton Sound - Chukchi Sea - Kotzebue Sound areas.

IX. NEEDS FOR FURTHER STUDY

1. Although the trawling activities were satisfactory for determination of the distribution, abundance, and biomass of epifauna, a substantial component of both areas, the infauna, was not sampled. Since infaunal species represent important food items, it is essential that dredging and grab sampling be accomplished in the near future.

2. Additional studies are needed during other seasons and years to describe seasonal and year-to-year variations in the distribution, relative abundance and biomass, and reproductive biology of the epifauna.

3. Seasonal predator-prey relationships should be examined in conjunction with simultaneous infaunal sampling.

4. It is essential that large samples of the dominant clam prey species be obtained to initiate recruitment, age, growth, and mortality studies. These data will then be comparable to similar data being collected for clams of Cook Inlet and the Bering Sea (Feder *et al.*, 1977a). Any future modeling efforts concerned with carbon or energy flow in the Norton Sound - Chukchi Sea area will need this type of information.

5. No systematically collected physical, chemical, and geological data are currently available. These, data should be obtained in the future in conjunction with all biological sampling efforts.

REFERENCES

Boesch, D. F., C. H. Hershner and J. H. Milgram. 1974. *Oil Spills and the Marine Environment.* Ballinger Publ., Co., Cambridge, Mass. 114 p.

Boolootian, R. A., ed. 1966. *Physiology of Echinodermata.* Interscience Publishers. 822 p.

Clemens, W. A. and G. V. Wilby. 1961. Fishes of the Pacific Coast of Canada, 2nd ed. *Bull. Fish. Res. Bd. Canada*, No. 68, 443 p.

Crapp, G. B. 1970. The biological effects of marine oil pollution and shore cleansing. Ph. D. dissertation, University of Wales, 274 p.

Ellson, J. G., D. E. Powell, and H. H. Hildebrand. 1950. Exploratory fishing expedition to the northern Bering Sea in June and July 1949. *U.S. Fish Wildl. Serv. Fish. Leafl.* 369, 56 p.

Feder, H. M. 1956. Natural History of the Starfish *Pisaster ochraceus* (Brandt, 1835) in the Monterey Bay Area. Doctoral Dissertation. Stanford University, 294 p.

Feder, H. M. 1970. Growth and predation by the ochre sea star, *Pisaster ochraceus* (Brandt), in Monterey Bay, California. *Ophelia* 8:161-185.

Feder, H. M. and S. C. Jewett, 1977. The distribution, abundance and diversity of the epifaunal benthic organisms in two bays (Alitak and Ugak) of Kodiak Island, Alaska. Final report to NOAA. R. U. No. P29. 79 p.

Feder, H. M. and G. J. Mueller. 1974. Biological studies. *In* D. W. Hood, V. Fisher, D. Nebert, H. Feder, G. J. Mueller, D. Burrell, D. Boisseau, J. J. Goering, G. D. Sharma, D. T. Kresge, and S. R. Fison (eds.), *Environmental Study of the Marine Environment Near Nome, Alaska.* Inst. Mar. Sci. Report, R74-3, Sea Grant Report, R73-14, University of Alaska, Fairbansk. 265 p.

Feder, H. M., C. Turner, and C. Limbaugh. 1974. Observations on fishes associated with kelp beds in southern California. *Calif. Dept. Fish and Game Bull.* 160:144.

Feder, H. M., D. Haflinger, J. Hilsinger, M. Hoberg, S. Jewett, G. Matheke, and G. Mueller. 1977a. The distribution, abundance, diversity, and biology of benthic organisms in the Gulf of Alaska and the Bering Sea. Annual report to NOAA, R. U. No. 281/5/303. 340 p.

Feder, H. M., J. Hilsinger, M. Hoberg, and S. C. Jewett. 1977b. Trawl survey of the benthic epifauna of the Chukchi Sea and Norton Sound. Annual report to NOAA, R. U. No. 502. 27 p.

Hatanaka, M. and M. Kosaka. 1958. Biological studies of the population of the starfish, *Asterias amurensis* in Sendai Bay. Tohoku *J. Agric. Res.* 4:159-178.

Jewett, S. C. 1977. Food of the Pacific cod, *Gadus macrocephalus* Tilesins near Kodiak Island, Alaska. M. S. Thesis, University of Alaska. 23 p.

Jewett, S. C. and H. M. Feder. 1976. Distribution and abundance of some epibenthic invertebrates of the northeast Gulf of Alaska, with notes on the feeding biology of selected species. Inst. Mar. Sci. Report R76-8, University of Alaska, Fairbanks. 61 p.

Karinen, J. F. and S. D. Rice. 1974. Effects of Prudhoe Bay crude oil on molting tanner crabs, *Chionoecetes bairdi*. *Mar. Fish. Rev.* 36(7):31-37.

Konstantinov, K. G. 1972. The assessment of the frequency of occurrence of food components. Proceedings of the Polar Research Institute of Marine Fisheries and Oceanography. 28:219-222. (transl. from Russian *In: Fish. Res. Bd. Can. Transl. Ser.* No. 2375).

Land, J. van der. 1970. Systematics, zoogeography, and ecology of the priapulids. *Zoologische Venhandelingen* No. 112, 118 p.

Lewis, J. R. 1970. Problems and approaches to baseline studies in coastal communities. FAO Technical Conference on Marine Pollution and its Affect on Living Resources and Fishing. FIR:MP 70/E-22, 7 p.

McRoy, C. P. and J. J. Goering. 1976. Annual budget of primary production in the Bering Sea. *Mar. Sci. Communications* 2(5):255-267.

Meglitsch, P. A. 1972. Invertebrate Zoology. 2nd ed. Oxford University Press, 834 p.

Miller, B. S. 1967. Stomach contents of Adult Starry Flounder and Sand Sole in East Sound, Orcas Island, Washington. *J. Fish. Res. Bd. Canada* 24(12):2515-2526.

Moiseev, P. A. 1953. Cod and flounders of the far eastern seas. Vladivostok, Izv. Tikhookeans, *Nauchn. Issled. Rybn. Khoz. Ser.*, No. 119 (1956). p. 463-490.

Neiman A. A. 1960. Quantitative distribution of benthos in the eastern Bering Sea (in Russian). *Zool. Zhur.* 39:1281-1292, (Transl. 402, U. S. Naval Oceanogr. Office, 1968.)

Neiman, A. A. 1963. Quantitative distribution of benthos and food supply of demersal fish in the eastern part of the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Mersk. Rybn. Khoz. Okeanogr. 48. (Transl. from Russian by Israel Prog. Sci. Transl., Jerusalem, as Soviet Fish. Inv. Northeast Pacific. Part I. p. 143-217. Avail. Nat'l. Tech. Inf. Serv., Springfield, Va., as TT67-51203.)

Nelson-Smith, A. 1973. *Oil Pollution and Marine Ecology*. Paul Elek (Scientific Books) Lts., London. 260 p.

Olson, T. A. and F. J. Burgess, eds. 1967. *Pollution and Marine Ecology*. Interscience, New York. 364 p.

Orcutt, H. G. 1950. The life history of the starry flounder, *Platichthys stellatus* (Pallas). *Calif. Fish and Game Fish. Bull.* 78:64.

Pearce, J. B. and C. Thorson. 1967. The feeding and reproductive biology of the red whelk, *Neptunea antiqua* (L.) (Gastropoda, Prosobranchia). *Ophelia* 4:277-314.

Pearson, T. H. 1971. The benthic ecology of Loch Linnhe and Loch Eil, a sea loch system on the west coast of Scotland, III. The effect on the benthic fauna of the introduction of pulp mill effluent, *J. Exp. Mar. Biol. Ecol.* 6:211-233.

Pearson, T. H. 1972. The effect of industrial effluent from pulp and paper mills on the marine benthic environment. *Proc. Roy. Soc. Land. B.* 130:469-485.

Pearson, T. H. 1975. The benthic ecology of Loch Linnhe and Loch Eil, a sea loch system on the west coast of Scotland. IV. Changes in benthic fauna attributable to organic enrichment. *J. Exp. Mar. Biol. Ecol.* 20:1-41.

Pinkas, L., M. S. Oliphant, and I. L. K. Iverson. 1971. Food habits of Albacore, Bluefin Tuna, and Bonito in California waters. Calif. Fish & Game Fish. Bull. No. 152. 105 p.

Pruter, A. T. and D. L. Alverson, 1962. Abundance, distribution, and growth of flounders in the southeastern Chukchi Sea. *J. Conseil, Conseil Perm, Intern. Exploration Mer.* 27(1):81-99.

Reese, E. S. 1966. The complex behavior of Echinoderms. p. 167-218 *In: Physiology of Echinodermata*. R. A. Boolootion (Ed.). John Wiley & Sons, Inc. 822 p.

Rhoads, D. C. 1974. Organism-sediment relations on the muddy sea floor. *Oceanogr. Mar. Biol. Ann. Rev.* 12:263-300.

Rosenberg, R. 1973. Succession in benthic macrofauna in a Swedish fjord subsequent to the closure of a sulphite pulp mill. *Oikos* 24:244-258.

Smith, J. E., ed. 1968. *Torrey Canyon Pollution and Marine Life.* Cambridge University Press, Cambridge. 196 p.

Smith, R., A. Paulson and J. Rose. 1976. Food and feeding relationships in the benthic and demersal fishes of the Gulf of Alaska and Bering Sea. Annual Rept. to NOAA, R. U. No. 284, Inst. Mar. Sci., Univ. Alaska, Fairbanks, 38 p.

Sparks, A. K. and W. T. Pereyra. 1966. Benthic invertebrates of the southeastern Chukchi Sea. *In* N. J. Wilimovsky and J. N. Wolfe (eds.), *Environment of the Cape Thompson Region, Alaska.* U. S. Atomic Energy Commission. 1250 p.

Stoker, S. W. In prep. The Benthos of the Northeast Bering and Chukchi Seas. Doctoral Dissertation. Inst. Mar. Sci., Univ. Alaska, Fairbanks.

Straughan, D. 1971. Biological and oceanographical survey of the Santa Barbara Channel oil spill 1969-1970. Allan Hancock Foundation, University of Southern California, Los Angeles. 425 p.

Thorson, G. 1960. Paralled level-bottom communities, their temperature adaptation, and their "balance" between predators and food animals p. 67-83. *In: Perspectives in Marine Biology.* A. A. Buzzati-Traverso (ed.), University of California Press, Berkeley and Los Angeles. 621 p.

Townsend, L. D. 1937. Geographical variation and correlation in Pacific flounders. *Copeia.* p. 92-103.

Villadolid, D. V. 1927. The flatfishes (Heterosomata) of the Pacific coast of the United States. Ph. D. Dissertation. Stanford University. 332 p.

APPENDIX TABLE I

Occurrence of each species in the Norton Sound area
September-October 1976

A total of 106 stations were occupied. Taxonomic names represent the lowest level of identification

Taxonomic Name	Cumulative Occurrence	% of all Occurrences[1]	% of all Sta.[2]
Porifera	17	0.583	16.038
Phakellia sp.	7	0.240	6.604
Phakellia cribrosa	1	0.034	0.943
Cnidaria	5	0.172	4.717
Hydrozoa	22	0.755	20.755
Sertulariidae	3	0.103	2.830
Scyphozoa	31	1.064	29.245
Anthozoa	20	0.686	18.869
Eunephthya rubiformis	69	2.368	65.094
Stomphia sp.	10	0.343	9.994
Stomphia coccinea	18	0.618	16.981
Actiniidae	51	1.750	48.113
Rhynchocoela	3	0.103	2.830
Polychaeta	8	0.275	7.547
Polynoidae	48	1.647	45.283
Arctonoe vittata	1	0.034	0.943
Eunoe depressa	4	0.137	3.774
Eunoe senta	2	0.069	1.887
Nereidae	2	0.069	1.887
Nereis sp.	2	0.069	1.887
Brada villosa	1	0.034	0.943
Sternaspis scutata	1	0.034	0.943
Cistenides hyperborea	2	0.069	1.887
Terebella sp.	2	0.069	1.887
Sabellidae	8	0.275	7.547
Potamilla sp.	1	0.034	0.943
Jasminiera sp.	2	0.069	1.887
Carcinobdella sp.	4	0.137	3.774
Cryptochiton stelleri	1	0.034	0.943
Amicula pallasii	1	0.034	0.943
Amicula vestita	6	0.206	5.660
Yoldia sp.	1	0.034	0.943
Yoldia hyperborea	4	0.137	3.774
Yoldia myalis	5	0.172	4.717
Glycymeris subobsoleta	2	0.069	1.887
Mytilus edulis	10	0.343	9.434
Musculus niger	1	0.034	0.943
Musculus discors	22	0.755	20.755
Chlamys rubida	1	0.034	0.943
Astarte borealis	9	0.309	8.491
Astarte montagui	2	0.069	1.887

APPENDIX TABLE I (Cont'd)

Taxonomic Name	Cumulative Occurrence	% of all Occurrences	% of all Sta.
Cyclocardia crebricostata	4	0.137	3.774
Cyclocardia crassidens	1	0.034	0.943
Pseudopythina sp.	1	0.034	0.943
Clinocardium sp.	1	0.034	0.943
Clinocardium ciliatum	13	0.446	12.264
Clinocardium nuttallii	1	0.034	0.943
Clinocardium californiense	10	0.343	9.434
Serripes groenlandicus	68	2.334	64.151
Liocyma fluctuosa	2	0.069	1.887
Spisula polynyma	2	0.069	1.887
Macoma sp.	2	0.069	1.887
Macoma calcarea	6	0.206	5.660
Macoma brota	10	0.343	9.434
Tellina lutea alternidentata	1	0.034	0.943
Mya pseudoarenaria	2	0.069	1.887
Hiatella arctica	28	0.961	26.415
Panomya arctica	1	0.034	0.943
Gastropoda	11	0.377	10.377
Margarites giganteus	1	0.034	0.943
Solariella sp.	1	0.034	0.943
Solariella obscura	1	0.034	0.943
Solariella varicosa	2	0.069	1.887
Tachyrhynchus erosus	1	0.034	0.943
Opalia sp.	1	0.034	0.943
Trichotropis bicarinata	6	0.206	5.660
Trichotropis insignis	2	0.069	1.887
Trichotropis kroyeri	1	0.034	0.943
Natica clausa	3	0.103	2.830
Polinices pallida	2	0.069	1.887
Velutina sp.	3	0.103	2.830
Velutina plicatilis	5	0.172	4.717
Boreotrophon clathratus	3	0.103	2.830
Buccinum sp.	1	0.034	0.943
Buccinum angulosum	12	0.412	11.321
Buccinum scalariforme	3	0.013	2.830
Buccinum glaciale	4	0.137	3.774
Buccinum solenum	1	0.034	0.943
Buccinum polare	5	0.172	4.717
Buccinum fringillum	1	0.034	0.943
Buccinum tenellum	2	0.069	1.887
Ancistrolepis sp.	1	0.034	0.943
Beringius crebricostatus	1	0.034	0.943
Beringius beringi	52	1.784	49.057
Beringius stimpsoni	6	0.206	5.660
Colus spitzbergensis	7	0.240	6.604

APPENDIX TABLE I (Cont'd)

Taxonomic Name	Cumulative Occurrence	% of all Occurrences	% of all Sta.
Colus ambronius	1	0.034	0.943
Colus hypolispus	4	0.137	3.774
Liomesus ooides	1	0.034	0.943
Neptunea ventricosa	66	2.265	62.264
Neptunea communis borealis	13	0.755	12.264
Neptunea heros	77	2.642	72.642
Plicifusus kroyeri	3	0.103	2.830
Plicifusus verkruzeni	1	0.034	0.943
Pyrulofusus deformis	23	0.789	21.698
Volutopsius sp.	1	0.034	0.943
Volutopsius filosus	1	0.034	0.943
Volutopsius fragilis	10	0.343	9.434
Oenopota harpa	1	0.034	0.943
Obesitoma simplex	1	0.034	0.943
Dorididae	2	0.069	1.887
Doris sp.	1	0.032	0.943
Dendronotus sp.	3	0.103	2.830
Octopus sp.	2	0.069	1.887
Pycnogonida	2	0.069	1.887
Balanus sp.	8	0.275	7.547
Balanus balanus	44	1.510	41.509
Balanus rostratus	1	0.034	0.943
Cumacea	2	0.069	1.887
Isopoda	2	0.069	1.887
Idoteidae	2	0.069	1.887
Saduria entomon	17	0.583	16.038
Synidotea bicuspida	13	0.446	12.264
Tecticeps sp.	3	0.103	2.830
Amphipoda	4	0.137	3.774
Ampeliscidae	2	0.069	1.887
Eusirus sp.	10	0.343	9.434
Rhachotropis sp.	3	0.103	2.830
Gammaridae	2	0.069	1.887
Melita sp.	10	0.343	9.434
Melita dentata	2	0.069	1.887
Jassa sp.	1	0.034	0.943
Lysianassidae	1	0.034	0.943
Anonyx sp.	11	0.377	10.337
Anonyx nugax pacifica	3	0.103	2.830
Anonyx ampulloides	1	0.034	0.943
Socarnes sp.	1	0.034	0.943
Podoceridae	1	0.034	0.943
Dulichia spinosissima	1	0.034	0.943
Stegocephalus inflatus	3	0.103	2.830
Parathemisto japonica	4	0.137	3.774
Caprellidae	1	0.034	0.943
Pandalus borealis	1	0.034	0.943

APPENDIX TABLE I (Cont'd)

Taxonomic Name	Cumulative Occurrence	% of all Occurrences	% of all Sta.
Pandalus goniurus	49	1.682	46.226
Pandalus hypsinotus	14	0.480	13.208
Lebbeus groenlandica	20	0.686	18.868
Eualus sp.	1	0.034	0.943
Eualus fabricii	3	0.103	2.830
Eualus gaimardii belcheri	18	0.618	16.981
Eualus macilenta	1	0.034	0.943
Crangon dalli	50	1.716	47.170
Sclerocrangon boreas	36	1.235	33.962
Argis lar	104	3.569	98.113
Pagurus ochotensis	36	1.235	33.962
Pagurus capillatus	94	3.226	88.679
Pagurus trigonocheirus	87	2.986	82.075
Labidochirus splendescens	79	2.711	74.528
Lithodidae	1	0.034	0.943
Hapalogaster grebnitzkii	12	0.412	11.321
Paralithodes camtschatica	58	1.990	54.717
Paralithodes platypus	15	0.515	14.151
Sculptolithodes derjugini	1	0.034	0.943
Hyas lyratus	2	0.069	1.887
Hyas coarctatus alutaceus	59	2.025	55.660
Chionoecetes opilio	61	2.093	57.547
Telmessus cheiragonus	55	1.887	51.887
Golfingia margaritacea	3	0.103	2.830
Echiurus echiurus alaskensis	7	0.240	6.604
Priapulus caudatus	1	0.034	0.943
Ectoprocta	41	1.407	38.679
Flustridae	1	0.034	0.943
Flustra sp.	13	0.446	12.264
Dendrobeania sp.	1	0.034	0.943
Diaperoecia sp.	11	0.377	10.377
Heteropora sp.	2	0.069	1.887
Alcyonidium sp.	6	0.206	5.660
Alcyonidium disciforme	5	0.172	4.717
Alcyonidium vermiculare	6	0.206	5.660
Flustrella gigantea	3	0.103	2.830
Dallinidae	1	0.034	0.943
Laqueus califorianus	1	0.034	0.943
Henricia sp.	29	0.995	27.358
Pteraster obscurus	10	0.343	9.434
Crossaster papposus	25	0.858	23.585
Solaster sp.	2	0.069	1.887
Solaster dawsoni	1	0.034	0.943
Asterias amurensis	103	3.535	97.170
Evasterias echinosoma	58	1.990	54.717
Evasterias troschelii	1	0.034	0.943

APPENDIX TABLE I (Cont'd)

Taxonomic Name	Cumulative Occurrence	% of all Occurrences	% of all Sta.
Leptasterias sp.	72	2.471	67.925
Leptasterias polaris acervata	54	1.853	50.943
Lethasterias sp.	2	0.069	1.887
Lethasterias nanimensis	77	2.642	72.642
Echinoidea	1	0.034	0.943
Echinarachnius parma	19	0.652	17.925
Strongylocentrotus droebachiensis	83	2.848	78.302
Amphiodia sp.	1	0.034	0.943
Amphipholis sp.	18	0.618	16.981
Diamphiodia craterodmeta	4	0.137	3.774
Gorgonocephalus caryi	51	1.750	48.113
Ophiopholis aculeata	2	0.069	1.887
Ophiura sarsi	8	0.275	7.547
Stegophiura sp.	2	0.069	1.887
Stegophiura nodosa	30	1.030	28.302
Cucumaria sp.	4	0.137	3.774
Cucumaria calcigera	1	0.034	0.943
Psolus japonicus	5	0.172	4.717
Chordata:ascidiacea	73	2.505	68.868
Chelyosoma sp.	8	0.275	7.547
Chelyosoma columbianum	2	0.069	1.887
Chelyosoma orientale	2	0.069	1.887
Styelidae	9	0.309	8.491
Styela macrenteron	66	2.265	62.264
Pelonaia corrugata	8	0.275	7.547
Boltenia ovifera	26	0.892	24.528
Boltenia echinata	8	0.275	7.547
Halocynthia sp.	1	0.034	0.943
Halocynthia aurantium	11	0.377	10.377
Salpidae	1	0.034	0.943
	2914	100%	-

1 $\frac{\text{Cumulative occurrence}}{\text{Total cumulative occurrence}}$

2 $\frac{\text{Cumulative occurrence}}{\text{Total No. of stations occupied}}$

APPENDIX TABLE II

Percentage composition of all phyla by family from all stations
in the Norton Sound area
September-October 1976

Taxonomic Name	Count	% Count	Wt.(gm)	% Wt.	gm/m^2 all Sta.
Porifera (Unident. family)	754	0.3688	72577.00	0.3995	0.01485
Axinellidae	10	0.0049	1429.00	0.0079	0.00029
Cnidaria (Unident. family)	51	0.0249	6592.00	0.0363	0.00135
Hydrozoa (Unident. family)	64	0.0313	3624.00	0.0199	0.00074
Sertulariidae	3	0.0015	80.00	0.0004	0.00002
Scyphozoa (Unident. family)	287	0.1404	139532.00	0.7680	0.02856
Anthozoa (Unident. family)	268	0.1311	39452.00	0.2172	0.00807
Nephtheidae	1520	0.7434	27641.00	0.1521	0.00566
Actinostolidae	793	0.3879	25594.00	0.1409	0.00524
Actiniidae	21499	10.5151	540052.27	2.9726	0.11053
Rhynchocoela (Unident. family)	7	0.0034	12.00	0.0001	0.00000
Polychaeta (Unident. family)	10	0.0049	13.00	0.0001	0.00000
Polynoidae	921	0.4505	4181.00	0.0230	0.00086
Nereidae	4	0.0020	4.00	0.0000	0.00000
Flabelligeridae	1	0.0005	5.00	0.0000	0.00000
Sternaspidae	1	0.0005	1.00	0.0000	0.00000
Pectinariidae	4	0.0020	5.00	0.0000	0.00000
Terebellidae	3	0.0015	11.00	0.0001	0.00000
Sabellidae	142	0.0695	502.00	0.0028	0.00010
Piscicolidae	4	0.0020	4.00	0.0000	0.00000
Acanthochitonidae	2	0.0010	120.00	0.0007	0.00002
Mopaliidae	25	0.0120	425.73	0.0023	0.00009
Nuculanidae	22	0.0108	32.00	0.0002	0.00001
Glycymerididae	3	0.015	2.00	0.0000	0.00000
Mytilidae	474	0.2318	4064.00	0.0224	0.00083
Pectinidae	5	0.0024	524.00	0.0029	0.00011
Astartidae	86	0.0418	1287.73	0.0071	0.00026
Carditidae	20	0.0097	76.09	0.0004	0.00002
Kelliidae	1	0.0005	2.00	0.0000	0.00000
Cardiidae	1210	0.5919	45607.45	0.2510	0.00933
Veneridae	30	0.0147	41.00	0.0002	0.00001
Mactridae	3	0.0015	355.00	0.0020	0.00007
Tellinidae	28	0.0137	514.00	0.0028	0.00011
Myidae	2	0.0010	130.00	0.0007	0.00003
Hiatellidae	125	0.0611	181.00	0.0010	0.00004
Gastropoda (Unident. family)	27	0.0130	783.45	0.0043	0.00016

APPENDIX TABLE II (Cont'd)

Taxonomic Name	Count	% Count	Wt. (gm)	% Wt.	gm/m^2 all Sta.
Trochidae	6	0.0029	225.00	0.0012	0.00005
Turritellidae	8	0.0039	45.00	0.0002	0.00001
Epitoniidae	1	0.0005	20.00	0.0001	0.00000
Trichotropididae	34	0.0165	562.27	0.0031	0.00012
Naticidae	10	0.0049	181.00	0.0010	0.00004
Velutinidae	9	0.0044	67.00	0.0004	0.00001
Muricidae	12	0.0059	192.27	0.0011	0.00004
Buccinidae	113	0.0553	2530.00	0.0139	0.00052
Neptuneidae	6495	3.1766	735193.18	4.0467	0.15047
Turridae	2	0.0010	90.00	0.0005	0.00002
Dorididae	3	0.0015	13.00	0.0001	0.00000
Dendronotidae	26	0.0128	1053.64	0.0058	0.00022
Octopodidae	8	0.0037	545.45	0.0030	0.00011
Arthropoda: Pycnogonida					
(Unident. family)	2	0.0010	2.00	0.0000	0.00000
Balanidae	1171	0.5727	36474.00	0.2008	0.00746
Cumacea					
(Unident. family)	2	0.0010	2.00	0.0000	0.00000
Isopoda					
(Unident. family)	3	0.0015	2.00	0.0000	0.00000
Idoteidae	3538	1.7304	31325.00	0.1724	0.00641
Sphaeromatidae	121	0.0592	22.00	0.0001	0.00000
Amphipoda					
(Unident. family)	20	0.0098	5.00	0.0000	0.00000
Ampeliscidae	8	0.0039	4.00	0.0000	0.00000
Eusiridae	53	0.0259	62.00	0.0003	0.00001
Gammaridae	54	0.0264	48.00	0.0003	0.00001
Ischyroceridae	1	0.0005	1.00	0.0000	0.00000
Lysianassidae	183	0.0895	120.00	0.0007	0.00002
Podoceridae	3	0.0015	2.00	0.0000	0.00000
Stegocephalidae	10	0.0049	58.00	0.0003	0.00001
Hyperiidae	27	0.0132	27.00	0.0001	0.00001
Caprellidae	1	0.0005	1.00	0.0000	0.00000
Pandalidae	7102	3.4736	9883.00	0.0544	0.00202
Hippolytidae	728	0.3559	1893.45	0.0104	0.00039
Crangonidae	22568	11.0382	159742.27	0.8793	0.03269
Paguridae	24420	11.9439	336885.36	1.8543	0.06895
Lithodidae	1046	0.5116	773817.00	4.2593	0.15837
Majidae	6265	3.0641	245544.55	1.3515	0.05025
Atelecyclidae	1184	0.5791	159802.00	0.8796	0.03271
Sipunculida	3	0.0015	37.00	0.0002	0.00001
Echiuridae	9	0.0044	192.00	0.0011	0.00004
Priapulida	1	0.0005	1.00	0.0000	0.00000
Flustridae	15	0.0073	545.00	0.0030	0.00011
Alcyonidiidae	18	0.0088	885.00	0.0049	0.00018

APPENDIX TABLE II (Cont'd)

Taxonomic Name	Count	% Count	Wt.(gm)	% Wt.	gm/m^2 all Sta.
Dallinidae	1	0.0005	1.00	0.0000	0.00000
Echinasteridae	106	0.0516	1293.73	0.0071	0.00026
Pterasteridae	34	0.0166	3062.00	0.0169	0.00063
Solasteridae	241	0.1177	6804.82	0.0375	0.00139
Asteridae	70866	34.6608	12669499.91	69.7366	2.59297
Echinarachniidae	2040	0.9978	2188.00	0.0120	0.00045
Strongylocentrotidae	9572	4.6818	610588.46	3.3609	0.12496
Amphiuridae	2745	1.3426	1117.00	0.0061	0.00023
Gorgonocephalidae	5218	2.5522	1281550.00	7.0540	0.26229
Ophiactidae	74	0.0360	172.73	0.0010	0.00004
Ophiuridae	982	0.4803	1409.00	0.0078	0.00029
Cucumariidae	18	0.0088	51.00	0.0003	0.00001
Rhodosomatidae	146	0.0714	3723.00	0.0205	0.00076
Styelidae	5541	2.7101	139622.00	0.7685	0.02858
Pyuridae	1469	0.7185	33013.00	0.1817	0.00676

APPENDIX TABLE III

Percentage Composition of all Phyla by Species from all Stations in the Norton Sound area, September-October 1976
Taxonomic names represent the lowest level of identification.

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m^2 for* occurrence stations	g/m^2 for all stations	% Phylum Count	% Phylum Weight
Porifera	754	0.4	72577.00	0.40	0.1086	0.01485	98.69	98.07
Phakellia sp.	9	0.0	1427.00	0.01	0.0051	0.00029	1.18	1.93
Phakellia cribrosa	1	0.0	2.00	0.00	0.0001	0.00000	0.13	0.00
Cnidaria	51	0.0	6592.00	0.04	0.0328	0.00135	0.21	0.84
Hydrozoa	64	0.0	3624.00	0.02	0.0041	0.00074	0.26	0.46
Sertulariidae	3	0.0	80.00	0.00	0.0007	0.00002	0.01	0.01
Scyphozoa	287	0.1	139532.00	0.77	0.1162	0.02856	1.17	17.83
Anthozoa	268	0.1	39452.00	0.22	0.0488	0.00807	1.09	5.04
Eunephthya rubiformis	1520	0.7	27641.00	0.15	0.0099	0.00566	6.21	3.53
Stomphia sp.	43	0.0	1514.00	0.01	0.0040	0.00031	0.18	0.19
Stomphia coccinea	750	0.4	24080.00	0.13	0.0310	0.00493	3.06	3.08
Actiniidae	21499	10.5	540052.27	2.97	0.2614	0.11053	87.80	69.01
Rhynchocoela	7	0.0	12.00	0.00	0.0001	0.00000	100.00	100.00
Polychaeta	10	0.0	13.00	0.00	0.0000	0.00000	0.92	0.28
Polynoidae	907	0.4	4152.00	0.02	0.0022	0.00085	83.21	87.85
Arctonoe vittata	1	0.0	1.00	0.00	0.0000	0.00000	0.09	0.02
Eunoe depressa	10	0.0	17.00	0.00	0.0001	0.00000	0.92	0.36
Eunoe senta	3	0.0	11.00	0.00	0.0001	0.00000	0.28	0.23
Nereidae	2	0.0	2.00	0.00	0.0000	0.00000	0.18	0.04
Nereis sp.	2	0.0	2.00	0.00	0.0000	0.00000	0.18	0.04
Brada villosa	1	0.0	5.00	0.00	0.0001	0.00000	0.09	0.11
Sternaspis scutata	1	0.0	1.00	0.00	0.0000	0.00000	0.09	0.02
Cistenides hyperborea	4	0.0	5.00	0.00	0.0001	0.00000	0.37	0.11
Terebella sp.	3	0.0	11.00	0.00	0.0001	0.00000	0.28	0.23
Sabellidae	48	0.0	319.00	0.00	0.0010	0.00007	4.40	6.75
Potamilla sp.	91	0.0	181.00	0.00	0.0040	0.00004	8.35	3.83
Jasminiera sp.	3	0.0	2.00	0.00	0.0000	0.00000	0.28	0.04
Carcinobdella sp.	4	0.0	4.00	0.00	0.0000	0.00000	0.37	0.08
Cryptochiton stelleri	2	0.0	120.00	0.00	0.0031	0.00002	0.02	0.02
Amicula pallasii	4	0.0	59.09	0.00	0.0012	0.00001	0.05	0.01
Amicula vestita	20	0.0	366.64	0.00	0.0014	0.00008	0.23	0.05

APPENDIX TABLE III (Continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m^2 for* occurrence stations	g/m^2 for all stations	% Phylum Count	% Phylum Weight
Yoldia sp.	1	0.0	2.00	0.00	0.0001	0.00000	0.01	0.00
Yoldia hyperborea	13	0.0	13.00	0.00	0.0001	0.00000	0.15	0.00
Yoldia myalis	8	0.0	17.00	0.00	0.0001	0.00000	0.09	0.00
Glycymeris subobsoleta	3	0.0	2.00	0.00	0.0000	0.00000	0.03	0.00
Mytilus edulis	56	0.0	1757.00	0.01	0.0043	0.00036	0.64	0.22
Musculus niger	1	0.0	25.00	0.00	0.0007	0.00001	0.01	0.00
Musculus discors	417	0.2	2282.00	0.01	0.0026	0.00047	4.75	0.29
Chlamys rubida	5	0.0	524.00	0.00	0.0116	0.00011	0.06	0.07
Astarte borealis	79	0.0	1120.00	0.01	0.0030	0.00023	0.90	0.14
Astarte montagui	6	0.0	167.73	0.00	0.0020	0.00003	0.07	0.02
Cyclocardia crebricostata	15	0.0	53.36	0.00	0.0003	0.00001	0.17	0.01
Cyclocardia crassidens	4	0.0	22.73	0.00	0.0005	0.00000	0.05	0.00
Pseudopythina sp.	1	0.0	2.00	0.00	0.0000	0.00000	0.01	0.00
Clinocardium sp.	3	0.0	70.00	0.00	0.0016	0.00001	0.03	0.01
Clinocardium ciliatum	48	0.0	979.00	0.01	0.0018	0.00020	0.55	0.12
Clinocardium nuttallii	1	0.0	15.00	0.00	0.0004	0.00000	0.01	0.00
Clinocardium californiense	38	0.0	1397.00	0.01	0.0034	0.00029	0.43	0.18
Serripes groenlandicus	1120	0.5	43146.45	0.24	0.0156	0.00883	12.75	5.43
Liocyma fluctuosa	30	0.0	41.00	0.00	0.0005	0.00001	0.34	0.01
Spisula polynyma	3	0.0	355.00	0.00	0.0046	0.00007	0.03	0.04
Macoma sp.	2	0.0	26.00	0.00	0.0003	0.00001	0.02	0.00
Macoma calcarea	9	0.0	134.00	0.00	0.0006	0.00003	0.10	0.02
Macoma brota	15	0.0	352.00	0.00	0.0009	0.00007	0.17	0.04
Tellina lutea alternidentata	2	0.0	2.00	0.00	0.0000	0.00000	0.02	0.00
Mya pseudoarenaria	2	0.0	130.00	0.00	0.0017	0.00003	0.02	0.02
Hiatella arctica	123	0.1	180.00	0.00	0.0002	0.00004	1.40	0.02
Panomya arctica	2	0.0	1.00	0.00	0.0000	0.00000	0.02	0.00
Gastropoda	26	0.0	783.45	0.00	0.0017	0.00016	0.30	0.10
Margarites giganteus	1	0.0	45.00	0.00	0.0012	0.00001	0.01	0.01
Solariella sp.	1	0.0	45.00	0.00	0.0012	0.00001	0.01	0.01
Solariella obscura	2	0.0	45.00	0.00	0.0012	0.00001	0.02	0.01
Solariella varicosa	2	0.0	90.00	0.00	0.0012	0.00002	0.02	0.01
Tachyrhynchus erosus	8	0.0	[illegible].00	0.00	0.0012	0.00001	0.09	0.01
Opalia sp.	1	0.0	20.00	0.00	0.0006	0.00000	0.01	0.00

APPENDIX TABLE III (Continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m^2 for* occurrence stations	g/m^2 for all stations	% Phylum Count	% Phylum Weight
Trichotropis bicarinata	31	0.0	427.27	0.00	0.0018	0.00009	0.35	0.05
Trichotropis insignis	2	0.0	90.00	0.00	0.0015	0.00002	0.02	0.01
Trichotropis kroyeri	1	0.0	45.00	0.00	0.0010	0.00001	0.01	0.01
Natica clausa	3	0.0	91.00	0.00	0.0008	0.00002	0.03	0.01
Polinices pallida	7	0.0	90.00	0.00	0.0011	0.00002	0.08	0.01
Velutina sp.	3	0.0	12.00	0.00	0.0001	0.00000	0.03	0.00
Velutina plicatilis	6	0.0	55.00	0.00	0.0003	0.00001	0.07	0.01
Boreotrophon clathrus	12	0.0	192.27	0.00	0.0015	0.00004	0.14	0.02
Buccinum sp.	7	0.0	499.00	0.00	0.0111	0.00010	0.08	0.06
Buccinum angulosum	38	0.0	812.00	0.00	0.0017	0.00017	0.43	0.10
Buccinum scalariforme	16	0.0	271.00	0.00	0.0022	0.00006	0.18	0.03
Buccinum glaciale	5	0.0	180.00	0.00	0.0012	0.00004	0.06	0.02
Buccinum solenum	2	0.0	45.00	0.00	0.0010	0.00001	0.02	0.01
Buccinum polare	15	0.0	452.00	0.00	0.0025	0.00009	0.17	0.06
Buccinum fringillum	1	0.0	45.00	0.00	0.0010	0.00001	0.01	0.01
Buccinum tenellum	29	0.0	226.00	0.00	0.0029	0.00005	0.33	0.03
Ancistrolepis sp.	123	0.1	6395.45	0.04	0.1348	0.00131	1.40	0.80
Beringius crebricostatus	16	0.0	1407.00	0.01	0.0415	0.00029	0.18	0.18
Beringius beringi	527	0.3	47687.91	0.26	0.0222	0.00976	6.00	6.00
Beringius stimpsoni	26	0.0	1740.27	0.01	0.0071	0.00036	0.29	0.22
Colus spitzbergensis	16	0.0	417.27	0.00	0.0014	0.00009	0.19	0.05
Colus ombronius	2	0.0	102.27	0.00	0.0022	0.00002	0.03	0.01
Colus hypolispus	8	0.0	237.27	0.00	0.0013	0.00005	0.09	0.03
Liomesus ooides	1	0.0	45.00	0.00	0.0015	0.00001	0.01	0.01
Neptunea ventricosa	1099	0.5	88768.09	0.49	0.0337	0.01817	12.51	11.17
Neptunea communis borealis	87	0.0	1625.00	0.01	0.0019	0.00033	0.99	0.20
Neptunea heros	4264	2.1	553003.27	3.04	0.1790	0.11318	48.53	69.57
Plicifusus kroyeri	47	0.0	1017.27	0.01	0.0076	0.00021	0.54	0.13
Plicifusus verkruzeni	2	0.0	102.27	0.00	0.0022	0.00002	0.03	0.01
Pyrulofusus deformis	204	0.1	28882.82	0.16	0.0297	0.00591	2.32	3.63
Volutopsius sp.	2	0.0	136.00	0.00	0.0035	0.00003	0.02	0.02
Volutopsius filosus	1	0.0	45.00	0.00	0.0010	0.00001	0.01	0.01
Volutopsius fragilis	68	0.0	3581.00	0.02	0.0090	0.00073	0.77	0.45

APPENDIX TABLE III (Continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m^2 for* occurrence stations	g/m^2 for all stations	% Phylum Count	% Phylum Weight
Oenopota harpa	1	0.0	45.00	0.00	0.0012	0.00001	0.01	0.01
Obesitoma simplex	1	0.0	45.00	0.00	0.0010	0.00001	0.01	0.01
Dorididae	2	0.0	3.00	0.00	0.0000	0.00000	0.02	0.00
Doris sp.	1	0.0	10.00	0.00	0.0003	0.00000	0.01	0.00
Dendronotus sp.	26	0.0	1053.64	0.01	0.0078	0.00022	0.30	0.13
Octopus sp.	7	0.0	545.45	0.00	0.0059	0.00011	0.09	0.07
Arthropoda: Pycnogonida	2	0.0	2.00	0.00	0.0000	0.00000	100.00	100.00
Balanus sp.	172	0.1	3057.00	0.02	0.0097	0.00063	0.25	0.17
Balanus balanus	979	0.5	33397.00	0.18	0.0185	0.00684	1.43	1.90
Balanus rostratus	20	0.0	20.00	0.00	0.0006	0.00000	0.03	0.00
Cumacea	2	0.0	2.00	0.00	0.0000	0.00000	0.00	0.00
Isopoda	3	0.0	2.00	0.00	0.0000	0.00000	0.00	0.00
Idoteidae	21	0.0	3.00	0.00	0.0000	0.00000	0.03	0.00
Saduria entomon	3480	1.7	31300.00	0.17	0.0495	0.00641	5.08	1.78
Synidotea bicuspida	37	0.0	22.00	0.00	0.0000	0.00000	0.05	0.00
Tecticeps sp.	121	0.1	22.00	0.00	0.0002	0.00000	0.18	0.00
Amphipoda	20	0.0	5.00	0.00	0.0000	0.00000	0.03	0.00
Ampeliscidae	8	0.0	4.00	0.00	0.0001	0.00000	0.01	0.00
Eucirus sp.	50	0.0	58.00	0.00	0.0001	0.00001	0.07	0.00
Rhachotropis sp.	3	0.0	4.00	0.00	0.0000	0.00000	0.00	0.00
Gammaridae	6	0.0	13.00	0.00	0.0002	0.00000	0.01	0.00
Melita sp.	45	0.0	33.00	0.00	0.0001	0.00001	0.07	0.00
Melita dentata	3	0.0	2.00	0.00	0.0000	0.00000	0.00	0.00
Jassa sp.	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Lysianassidae	3	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Anonyx sp.	83	0.0	50.00	0.00	0.0001	0.00001	0.12	0.00
Anonyx nugax pacifica	46	0.0	37.00	0.00	0.0003	0.00001	0.07	0.00
Anonyx ampulloides	50	0.0	30.00	0.00	0.0006	0.00001	0.07	0.00
Socarnes sp.	1	0.0	2.00	0.00	0.0001	0.00000	0.00	0.00
Podoceridae	2	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Dulichia spinosissima	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Stegocephalus inflatus	10	0.0	58.00	0.00	0.0005	0.00001	0.01	0.00
Parathemisto japonica	27	0.0	27.00	0.00	0.0002	0.00001	0.04	0.00
Caprellidae	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Pandalus borealis	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00

APPENDIX TABLE III (Continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m^2 for* occurrence stations	g/m^2 for all stations	% Phylum Count	% Phylum Weight
Pandalus goniurus	6888	3.4	7918.00	0.04	0.0040	0.00162	10.05	0.45
Pandalus hypisonotus	213	0.1	1964.00	0.01	0.0035	0.00040	0.31	0.11
Lebbeus groenlandica	277	0.1	1416.45	0.01	0.0018	0.00029	0.40	0.08
Eualus sp.	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Eualus fabricii	7	0.0	9.00	0.00	0.0001	0.00000	0.01	0.00
Eualus gaimardii belcheri	442	0.2	466.00	0.00	0.0007	0.00010	0.65	0.03
Eualus macilenta	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Crangon dalli	5927	2.9	16082.00	0.09	0.0083	0.00329	8.65	0.92
Sclerocrangon boreas	3361	1.6	44695.82	0.25	0.0303	0.00915	4.91	2.54
Argis lar	13280	6.5	98964.45	0.54	0.0236	0.02025	19.38	5.63
Pagurus ochotensis	641	0.3	20331.00	0.11	0.0150	0.00416	0.94	1.16
Pagurus capillatus	8800	4.3	107270.45	0.59	0.0284	0.02195	12.84	6.11
Pagurus trigonocheirus	11629	5.7	175122.91	0.96	0.0507	0.03584	16.97	9.97
Labidochirus splendescens	3350	1.6	34161.00	0.19	0.0109	0.00699	4.89	1.94
Lithodidae	2	0.0	726.00	0.00	0.0248	0.00015	0.00	0.04
Hapalogaster grebnitzkii	28	0.0	209.00	0.00	0.0004	0.00004	0.04	0.01
Paralithodes camtschatica	914	0.4	732070.00	4.03	0.3129	0.14983	1.33	41.68
Paralithodes platypus	103	0.1	41537.00	0.23	0.0646	0.00850	0.15	2.36
Sculptolithodes derjugini	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Hyas lyratus	14	0.0	3904.00	0.02	0.0455	0.00080	0.02	0.22
Hyas coarctatus alutaceus	3791	1.9	184060.55	1.01	0.0793	0.03767	5.53	10.48
Chionoecetes opilio	2460	1.2	57580.00	0.32	0.0240	0.01178	3.59	3.28
Telmessus cheiragonus	1184	0.6	159802.00	0.88	0.0702	0.03271	1.73	9.10
Golfingia margaritacea	3	0.0	37.00	0.00	0.0003	0.00001	100.00	100.00
Echiurus echiurus alaskensis	9	0.0	192.00	0.00	0.0007	0.00004	100.00	100.00
Priapulus caudatus	1	0.0	1.00	0.00	0.0000	0.00000	100.00	100.00
Ectoprocta	43	0.0	5334.00	0.03	0.0033	0.00109	39.71	46.93
Flustridae	1	0.0	20.00	0.00	0.0007	0.00000	0.92	0.18
Flustra sp.	15	0.0	545.00	0.00	0.0010	0.00011	13.85	4.79
Dendrobeania sp.	1	0.0	20.00	0.00	0.0005	0.00000	0.92	0.18
Diaperoecia sp.	25	0.0	3588.36	0.02	0.0081	0.00073	23.34	31.57
Heteropora sp.	2	0.0	292.00	0.00	0.0039	0.00006	1.85	2.57
Alcyonidium sp.	6	0.0	819.00	0.00	0.0035	0.00017	5.54	7.21
Alcyonidium disciforme	5	0.0	47.00	0.00	0.0002	0.00001	4.62	0.41

APPENDIX TABLE III (Continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m^2 for* occurrence stations	g/m^2 for all stations	% Phylum Count	% Phylum Weight
Alcyonidium vermiculare	7	0.0	19.00	0.00	0.0001	0.00000	6.47	0.17
Flustrella gigantea	3	0.0	682.00	0.00	0.0054	0.00014	2.77	6.00
Dallinidae	1	0.0	1.00	0.00	0.0000	0.00000	50.00	50.00
Laqueus californianus	1	0.0	1.00	0.00	0.0000	0.00000	50.00	50.00
Henricia sp.	105	0.1	1293.73	0.01	0.0011	0.00026	0.11	0.01
Pteraster obscurus	34	0.0	3062.00	0.02	0.0074	0.00063	0.04	0.02
Crossaster papposus	238	0.1	6149.82	0.03	0.0058	0.00126	0.25	0.04
Solaster sp.	2	0.0	390.00	0.00	0.0044	0.00008	0.00	0.00
Solaster dawsoni	1	0.0	265.00	0.00	0.0059	0.00005	0.00	0.00
Asterias amurensis	56898	27.8	10216723.27	56.24	2.4628	2.09098	61.04	69.82
Evasterias echinosoma	1043	0.5	721412.91	3.97	0.3069	0.14765	1.12	4.93
Evasterias troschelii	2	0.0	205.00	0.00	0.0050	0.00004	0.00	0.00
Leptasterias sp.	3645	1.8	57899.45	0.32	0.0200	0.01185	3.91	0.40
Leptasterias polaris acervata	5862	2.9	618418.55	3.40	0.2784	0.12657	6.29	4.23
Lepthasterias sp.	94	0.0	22246.00	0.12	0.2734	0.00455	0.10	0.15
Lethasterias nanimensis	3323	1.6	1032594.73	5.68	0.3292	0.21133	3.56	7.06
Echinoidea	3	0.0	50.00	0.00	0.0012	0.00001	0.00	0.00
Echinarachnius parma	2040	1.0	2188.00	0.01	0.0029	0.00045	2.19	0.01
Strongylocentrotus droebachiensis	9572	4.7	610588.46	3.36	0.1823	0.12496	10.27	4.17
Amphiodia sp.	20	0.0	1.00	0.00	0.0000	0.00000	0.02	0.00
Amphipholis sp.	2472	1.2	864.00	0.00	0.0011	0.00018	2.65	0.01
Diamphiodia craterodmeta	253	0.1	252.00	0.00	0.0015	0.00005	0.27	0.00
Gorgonocephalus caryi	5218	2.6	1281550.82	7.05	0.6182	0.26229	5.60	8.76
Ophiopholis aculeata	74	0.0	172.73	0.00	0.0023	0.00004	0.08	0.00
Ophiura sarsi	788	0.4	1285.00	0.01	0.0041	0.00026	0.85	0.01
Stegophiura sp.	2	0.0	2.00	0.00	0.0000	0.00000	0.00	0.00
Stegophiura nodosa	192	0.1	122.00	0.00	0.0001	0.00002	0.21	0.00
Cucumaria sp.	11	0.0	41.00	0.00	0.0002	0.00001	0.01	0.00
Cucumaria calcigera	7	0.0	10.00	0.00	0.0002	0.00000	0.01	0.00
Psolus japonicus	1308	0.6	55042.82	0.30	0.2463	0.01127	1.40	0.38

APPENDIX TABLE III (Continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m^2 for* occurrence stations	g/m^2 for all stations	% Phylum Count	% Phylum Weight
Chordata: Ascidiacea	115	0.1	122814.00	0.68	0.0428	0.02514	1.54	40.64
Chelyosoma sp.	20	0.0	2938.00	0.02	0.0096	0.00060	0.27	0.97
Chelyosoma columbianum	4	0.0	265.00	0.00	0.0036	0.00005	0.05	0.09
Chelyosoma orientale	122	0.1	520.00	0.00	0.0072	0.00011	1.63	0.17
Styelidae	208	0.1	2990.00	0.02	0.0076	0.00061	2.78	0.99
Styela macrenteron	5525	2.7	139564.00	0.77	0.0534	0.02856	73.85	46.19
Pelonaia corrugata	16	0.0	58.00	0.00	0.0002	0.00001	0.21	0.02
Boltenia ovifera	237	0.1	19986.00	0.11	0.0188	0.00409	3.17	6.61
Boltenia echinata	1168	0.6	2391.00	0.01	0.0074	0.00049	15.61	0.79
Halocynthia sp.	1	0.0	350.00	0.00	0.0078	0.00007	0.01	0.12
Halocynthia aurantium	63	0.0	10286.00	0.06	0.0234	0.00211	0.84	3.40
Salpidae	2	0.0	2.00	0.00	0.0001	0.00000	0.03	0.00

*Biomass listed here is only for those stations where the respective taxa occurs; not all stations.

APPENDIX TABLE IV

Occurrence of Each Species in the Chukchi Sea - Kotzebue Sound area, September-October, 1976

A total of 70 stations were occupied. Taxonomic names represent the lowest level of identification.

Taxonomic Name	Cumulative Occurrence	% of all Occurrences[1]	% of all Sta.[2]
Porifera	3	0.157	4.286
Microciona sp.	1	0.052	1.429
Microciona lambei	1	0.052	1.429
Phakellia sp.	3	0.157	4.286
Halichondria sp.	2	0.105	2.857
Hydrozoa	2	0.105	2.857
Abietinaria sp.	1	0.052	1.429
Scyphozoa	26	1.363	37.143
Eunephthya rubiformis	24	1.258	34.286
Stomphia sp.	7	0.367	10.000
Stomphia coccinea	14	0.734	20.000
Actiniidae	32	1.677	45.714
Tealia crassicornis	1	0.052	1.429
Rhynchocoela	3	0.157	4.286
Polychaeta	1	0.052	1.429
Polynoidae	48	2.516	68.571
Eunoe depressa	3	0.157	4.286
Gattyana ciliata	1	0.052	1.429
Nereis sp.	1	0.052	1.429
Nephtys sp.	3	0.157	4.286
Brada inhabilis	1	0.052	1.429
Brada ochotensis	1	0.052	1.429
Sternaspis scutata	2	0.105	2.857
Idanthyrsus armatus	1	0.052	1.429
Cistenides hyperborea	1	0.052	1.429
Ampharetidae	1	0.052	1.429
Amphitrite cirrata	1	0.052	1.429
Chone cincta	1	0.052	1.429
Potamilla sp.	2	0.105	2.857
Serpulidae	1	0.052	1.429
Ischnochiton albus	1	0.052	1.429
Nucula tenuis	4	0.210	5.714
Nuculana fossa	6	0.314	11.429
Yoldia hyperborea	1	0.052	1.429
Mytilus edulis	1	0.052	1.429
Musculus niger	3	0.157	4.286
Musculus discors	8	0.419	11.429
Modiolus modiolus	1	0.052	1.429
Chlamys rubida	1	0.052	1.429
Chlamys islandica	2	0.105	2.857
Chlamys beringiana	1	0.052	1.429
Astarte borealis	12	0.629	17.143
Astarte montagui	2	0.105	2.857
Cyclocardia sp.	1	0.052	1.429

APPENDIX TABLE IV (continued)

Taxonomic Name	Cumulative Occurrence	% of all Occurrences	% of all Sta.
Cyclocardia ventricosa	2	0.105	2.857
Cyclodardia crebricostata	1	0.052	1.429
Cyclocardia crassidens	3	0.157	4.286
Clinocardium ciliatum	23	1.205	32.857
Clinocardium nuttallii	1	0.052	1.429
Clinocardium californiense	5	0.262	7.143
Serripes groenlandicus	29	1.520	41.429
Liocyma fluctuosa	2	0.105	2.857
Spisula polynyma	2	0.105	2.857
Macoma sp.	3	0.157	4.286
Macoma calcarea	5	0.262	7.143
Macoma brota	4	0.210	5.714
Mya japonica	1	0.052	1.429
Hiatella arctica	20	1.048	28.571
Panomya arctica	1	0.052	1.429
Gastropoda	10	0.524	14.286
Margarites giganteus	1	0.052	1.429
Solariella obscura	1	0.052	1.429
Solariella varicosa	1	0.052	1.429
Tachyrynchus reticulatus	1	0.052	1.429
Crepidula grandis	3	0.157	4.286
Trichotropis bicarinata	2	0.105	2.857
Natica clausa	11	0.577	15.714
Natica russa	1	0.052	1.429
Polinices pallida	8	0.419	11.429
Piliscus commodum	1	0.052	1.429
Velutina sp.	1	0.052	1.429
Velutina plicatilis	7	0.367	10.000
Velutina undata	1	0.052	1.429
Boreotrophon clathratus	2	0.105	2.857
Buccinum angulosum	10	0.524	14.286
Buccinum scalariforme	16	0.839	22.857
Buccinum glaciale	1	0.052	1.429
Buccinum solenum	4	0.210	5.714
Buccinum polare	11	0.577	15.714
Buccinum tenellum	6	0.314	8.571
Ancistrolepis sp.	3	0.157	4.286
Ancistrolepis magna	1	0.052	1.429
Beringius crebricostatus	1	0.052	1.429
Beringius beringi	36	1.887	51.429
Colus sp.	1	0.052	1.429
Colus spitzbergensis	4	0.210	5.714
Colus hypolispus	7	0.367	10.000
Mohnia corbis	1	0.052	1.429
Neptunea lyrata	2	0.105	2.857
Neptunea ventricosa	36	1.887	51.429
Neptunea communis borealis	19	0.996	27.143

APPENDIX TABLE IV (continued)

Taxonomic Name	Cumulative Occurrence	% of all Occurrence	% of all Sta.
Neptunea heros	44	2.306	62.857
Plicifusus brunneus	1	0.052	1.429
Pyrulofusus deformis	7	0.367	10.000
Volutopsius sp.	3	0.157	4.286
Volutopsius fragilis	14	0.734	20.000
Admete couthouyi	1	0.052	1.429
Dorididae	2	0.105	2.857
Dendronotus sp.	8	0.419	11.429
Tochuina tetraquetra	4	0.210	5.714
Octopus sp.	5	0.262	7.143
Balanus sp.	6	0.314	8.571
Balanus balanus	7	0.367	10.000
Balanus rostratus	3	0.157	4.286
Mysidae	1	0.052	1.429
Cumacea	1	0.052	1.429
Isopoda	2	0.105	2.857
Saduria entomon	1	0.052	1.429
Amphipoda	3	0.157	4.286
Eusiridae	1	0.052	1.429
Rhachotropis sp.	2	0.105	2.857
Melita sp.	1	0.052	1.429
Melita dentata	3	0.157	4.286
Anonyx sp.	10	0.524	14.286
Stegocephalopsis ampulla	1	0.052	1.429
Stegocephalus inflatus	8	0.419	11.429
Pandalus sp.	1	0.052	1.429
Pandalus goniurus	17	0.891	24.286
Spirontocaris sp.	1	0.052	1.429
Spirontocaris murdochi	1	0.052	1.429
Spirontocaris arcuata	7	0.367	10.000
Lebbeus groenlandica	11	0.577	15.714
Eualus gaimardii belcheri	11	0.577	15.714
Heptacarpus sp.	1	0.052	1.429
Crangon dalli	8	0.419	11.429
Sclerocrangon boreas	22	1.153	31.429
Argis lar	64	3.354	91.429
Argis crassa	2	0.105	2.857
Pagurus capillatus	55	2.883	78.571
Pagurus trigonocheirus	69	3.616	98.571
Pagurus rathbuni	12	0.629	17.143
Labidochirus splendescens	56	2.935	80.000
Hapalogaster grebnitzkii	1	0.052	1.429
Paralithodes camtschatica	5	0.262	7.143
Paralithodes platypus	2	0.105	2.857
Paralithodes brevipes	1	0.052	1.429
Hyas sp.	1	0.052	1.429
Hyas coarctatus alutaceus	66	3.459	94.286

APPENDIX TABLE IV (continued)

Taxonomic Name	Cumulative Occurrence	% of all Occurrence	% of all Sta.
Chionoecetes opilio	67	3.512	95.714
Telmessus cheiragonus	21	1.101	30.000
Golfingia margaritacea	6	0.314	8.571
Echiurus echiurus alaskensis	11	0.577	15.714
Ectoprocta	8	0.419	11.429
Flustridae	3	0.157	4.286
Flustra sp.	17	0.891	24.286
Dendrobeania sp.	2	0.105	2.857
Diaperoecia sp.	10	0.524	14.286
Heteropora sp.	1	0.052	1.429
Alcyonidium sp.	4	0.210	5.714
Alcyonidium disciforme	1	0.052	1.429
Alcyonidium vermiculare	13	0.681	18.571
Henricia sp.	16	0.839	22.857
Henricia derjugini	1	0.052	1.429
Pteraster obscurus	33	1.730	47.143
Crossaster papposus	37	1.939	52.857
Solaster sp.	1	0.052	1.429
Solaster endeca	1	0.052	1.429
Asterias sp.	2	0.105	2.857
Asterias amurensis	51	2.673	72.857
Asterias rathbuni	4	0.210	5.714
Evasterias echinosoma	34	1.782	47.571
Leptasterias sp.	44	2.306	62.857
Leptasterias polaris acervata	60	3.145	85.714
Lethasterias sp.	1	0.052	1.429
Lethasterias nanimensis	44	2.306	62.857
Echinoidea	1	0.052	1.429
Echinarachnius parma	2	0.105	2.857
Strongylocentrotus droebachiensis	50	2.621	71.429
Amphipholis sp.	1	0.052	1.429
Gorgonocephalus caryi	38	1.992	54.286
Ophiopholis aculeata	2	0.105	2.857
Ophiura sarsi	39	2.044	55.714
Stegophiura nodosa	8	0.419	11.429
Cucumaria sp.	6	0.314	8.571
Cucumaria calcigera	1	0.052	1.429
Psolus japonica	7	0.367	10.000
Chordata: Ascidiacea	36	1.887	51.429
Chelyosoma sp.	15	0.786	21.429
Chelyosoma orientale	4	0.210	5.714
Styelidae	9	0.472	12.857

APPENDIX TABLE IV (continued)

Taxonomic Name	Cumulative Occurrence	% of all Occurrence	% of all Sta.
Styela macrenteron	36	1.887	51.429
Pelonaia corrugata	2	0.105	2.857
Boltenia ovifera	31	1.625	44.286
Boltenia echinata	20	1.048	28.571
Halocynthia aurantium	6	0.314	8.571
Salpidae	3	0.157	4.286
	1908	100%	--

[1] $\frac{\text{Cumulative occurrence}}{\text{Total cumulative occurrence}}$

[2] $\frac{\text{Cumulative occurrence}}{\text{Total No. of stations occupied}}$

APPENDIX TABLE V

Percentage Composition of all Phyla by Family from all Stations in the Chukchi Sea - Kotzebue Sound area, September-October 1976

Taxonomic Name	Total No. of individuals (Count)	% Count	Wt. (gm)	% Wt.	gm/m^2 all Sta.
Porifera (Unident. family)	758	0.3731	71894.56	0.7523	0.02455
Microcionidae	3	0.0017	248.90	0.0026	0.00008
Axinellidae	9	0.0044	933.00	0.0098	0.00032
Halichondriidae	6	0.0030	415.00	0.0043	0.00014
Hydrozoa (Unident. family)	3	0.0015	93.00	0.0010	0.00003
Sertulariidae	1	0.0005	200.00	0.0021	0.00007
Scyphozoa (Unident. family)	167	0.0821	138996.00	1.4544	0.04746
Nephtheidae	926	0.4555	14479.27	0.1515	0.00494
Actinostolidae	727	0.3578	33971.95	0.3555	0.01160
Actiniidae	7664	3.7698	238819.00	2.4989	0.08154
Rhychocoela (Unident. family)	5	0.0025	61.00	0.0006	0.00002
Polychaeta (Unident. family)	1	0.0005	5.00	0.0001	0.00000
Polynoidae	501	0.2464	1258.89	0.0132	0.00043
Nereidae	3	0.0015	12.00	0.0001	0.00000
Nephtyidae	39	0.0192	241.25	0.0025	0.00008
Flabelligeridae	2	0.0010	20.00	0.0002	0.00001
Sternaspidae	206	0.1015	156.25	0.0016	0.00005
Sabellariidae	12	0.0059	10.00	0.0001	0.00000
Pectinariidae	1	0.0005	1.00	0.0000	0.00000
Ampharetidae	10	0.0049	18.00	0.0002	0.00001
Terebellidae	1	0.0005	2.00	0.0000	0.00000
Sabellidae	6406	3.1512	12811.00	0.1340	0.00437
Serpulidae	100	0.0492	1.00	0.0000	0.00000
Ischnochitonidae	4	0.0020	2.00	0.0000	0.00000
Nuculidae	1414	0.6956	1607.00	0.0168	0.00055
Nuculanidae	23	0.0111	25.50	0.0003	0.00001
Mytilidae	24	0.0118	191.94	0.0020	0.00007
Pectinidae	88	0.0433	6058.00	0.0634	0.00207
Astartidae	415	0.2041	6151.67	0.0644	0.00210
Carditidae	12	0.0061	85.44	0.0009	0.00003
Cardiidae	286	0.1404	8831.25	0.0924	0.00302
Veneridae	2	0.0010	2.00	0.0000	0.00000
Mactridae	2	0.0010	100.00	0.0010	0.00003
Tellinidae	58	0.0285	1763.25	0.0184	0.00060
Myidae	1	0.0005	45.00	0.0005	0.00002
Hiatellidae	115	0.0566	185.00	0.0019	0.00006
Gastropoda (Unident. family)	95	0.0468	6595.59	0.0690	0.00225

APPENDIX TABLE V (continued)

Taxonomic Name	Total No. of individuals (Count)	% Count	Wt.(gm)	% Wt.	gm/m^2 all Sta.
Trochidae	3	0.0015	91.00	0.0010	0.00003
Turritellidae	1	0.0005	45.00	0.0005	0.00002
Calyptraeidae	6	0.0030	57.00	0.0006	0.00002
Trichotropididae	92	0.0455	276.88	0.0029	0.00009
Naticidae	365	0.1795	3966.25	0.0415	0.00135
Velutinidae	18	0.0088	41.94	0.0004	0.00001
Muricidae	2	0.0010	90.00	0.0009	0.00003
Buccinidae	858	0.4222	14842.50	0.1553	0.00507
Neptuneidae	12564	6.1802	1176408.32	12.3094	0.40164
Cancellariidae	2	0.0010	1.00	0.0000	0.00000
Dorididae	2	0.0010	11.00	0.0001	0.00000
Dendronotidae	17	0.0084	445.00	0.0047	0.00015
Tritoniidae	5	0.0025	1170.00	0.0122	0.00040
Octopodidae	16	0.0078	913.20	0.0096	0.00031
Balanidae	1084	0.5332	2058.00	0.0215	0.00070
Mysidae	1	0.0005	1.00	0.0000	0.00000
Cumacea	1	0.0005	1.00	0.0000	0.00000
Isopoda (Unident. family)	2	0.0010	2.00	0.0000	0.00000
Idoteidae	2	0.0010	5.00	0.0001	0.00000
Amphipoda	229	0.1126	456.00	0.0048	0.00016
Eusiridae	12	0.0059	7.00	0.0001	0.00000
Gammaridae	5	0.0025	4.00	0.0000	0.00000
Lysianassidae	146	0.0718	372.44	0.0036	0.00012
Stegocephalidae	499	0.2455	2202.00	0.0230	0.00075
Pandalidae	1089	0.5357	1095.00	0.0115	0.00037
Hippolytidae	334	0.1643	1691.51	0.0177	0.00058
Crangonidae	15772	7.7585	100308.16	1.0496	0.03425
Paguridae	21107	10.3826	317578.95	3.3230	0.10843
Lithodidade	20	0.0098	6873.00	0.0719	0.00235
Majidae	25554	12.5701	682138.71	7.1376	0.23289
Atelecyclidae	674	0.3317	89507.00	0.9366	0.03056
Sipunculida (Unident. family)	10	0.0049	240.00	0.0025	0.00008
Echiuridae	31	0.0154	818.50	0.0086	0.00028
Flustridae	17	0.0084	763.00	0.0080	0.00026
Alcyonidiidae	28	0.0140	9169.44	0.0959	0.00313
Echinasteridae	911	0.4480	8106.95	0.0848	0.00277
Pterasteridae	230	0.1131	13964.00	0.1461	0.00477
Solasteridae	480	0.2362	20807.61	0.2177	0.00710
Asteridae	28683	14.1094	4640093.92	48.5517	1.58420
Echinarachniidae	3	0.0015	30.00	0.0003	0.00001
Strongylocentrotidae	8795	4.3263	616152.68	6.4471	0.21036
Amphiuridae	5	0.0025	1.00	0.0000	0.00000
Gorgonocephalidae	1285	0.6323	331809.12	3.4719	0.11329

APPENDIX TABLE V (continued)

Taxonomic Name	Total No. of individuals (Count)	% Count	Wt. (gm)	% Wt.	gm/m^2 all Sta.
Ophiactidae	45	0.0221	70.00	0.0007	0.00002
Ophiuridae	20047	9.8613	80374.75	0.8410	0.02744
Cucumariidae	63	0.0310	808.63	0.0085	0.00028
Rhodosomatidae	15481	7.6154	466460.46	4.8808	0.15926
Styelidae	5822	2.8641	198733.12	2.0794	0.06785
Pyuridae	19018	9.3552	219690.51	2.2987	0.07501

APPENDIX TABLE VI

Percentage Composition of all Phyla by Species from all Stations in the Chukchi Sea - Kotzebue Sound area, September-October, 1976.

Taxonomic names represent the lowest level of identification.

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m^2 for* occurrence stations	g/m^2 for all stations	% Phylum Count	% Phylum Weight
Porifera	758	0.4	71894.56	0.75	0.6119	0.02455	97.63	97.83
Microciona sp.	2	0.0	243.90	0.00	0.0060	0.00008	0.31	0.33
Microciona lambei	1	0.0	5.00	0.00	0.0001	0.00000	0.13	0.01
Phakellia sp.	9	0.0	933.00	0.01	0.0086	0.00032	1.16	1.27
Halichondria sp.	6	0.0	415.00	0.00	0.0051	0.00014	0.77	0.56
Hydrozoa	3	0.0	93.00	0.00	0.0011	0.00003	0.03	0.02
Abietinaria sp.	1	0.0	200.00	0.00	0.0047	0.00007	0.01	0.05
Scyphozoa	167	0.1	138996.00	1.45	0.1329	0.04746	1.76	32.59
Eunephthya rubiformis	926	0.5	14479.27	0.15	0.0166	0.00494	9.76	3.39
Stomphia sp.	501	0.2	23253.00	0.24	0.0757	0.00794	5.28	5.45
Stomphia coccinea	226	0.1	10718.95	0.11	0.0206	0.00366	2.39	2.51
Actiniidae	7662	3.8	238729.00	2.50	0.1864	0.08151	80.76	55.97
Tealia crassicornis	1	0.0	90.00	0.00	0.0028	0.00003	0.01	0.02
Rhynchocoela	5	0.0	61.00	0.00	0.0007	0.00002	100.00	100.00
Polychaeta	1	0.0	5.00	0.00	0.0002	0.00000	0.01	0.03
Polynoidae	354	0.2	797.89	0.01	0.0004	0.00027	4.86	5.49
Eunoe depressa	142	0.1	396.00	0.00	0.0039	0.00014	1.95	2.72
Gattyana ciliata	5	0.0	65.00	0.00	0.0016	0.00002	0.07	0.45
Nereis sp.	3	0.0	12.00	0.00	0.0003	0.00000	0.04	0.08
Nephtys sp.	39	0.0	241.25	0.00	0.0019	0.00008	0.54	1.66
Brada inhabilis	1	0.0	8.00	0.00	0.0002	0.00000	0.01	0.06
Brada ochotensis	1	0.0	12.00	0.00	0.0004	0.00000	0.01	0.08
Sternaspis scutata	206	0.1	156.25	0.00	0.0020	0.00005	2.83	1.07
Idanthyrsus armatus	12	0.0	10.00	0.00	0.0002	0.00000	0.16	0.07
Cistenides hyperborea	1	0.0	1.00	0.00	0.0000	0.00000	0.01	0.01
Ampharetidae	10	0.0	18.00	0.00	0.0004	0.00001	0.14	0.12
Amphitrite cirrata	1	0.0	2.00	0.00	0.0001	0.00000	0.01	0.01
Chone cincta	1	0.0	1.00	0.00	0.0000	0.00000	0.01	0.01
Potamilla sp.	6405	3.2	12810.00	0.13	0.1669	0.00437	87.96	88.12
Serpulidae	100	0.0	1.00	0.00	0.0000	0.00000	1.37	0.01
Ischnochiton albus	4	0.0	2.00	0.00	0.0000	0.00000	0.02	0.00
Nucula tenuis	1414	0.7	1607.00	0.02	0.0113	0.00055	8.58	0.13

APPENDIX TABLE VI (continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m^2 for* occurrence stations	g/m^2 for all stations	% Phylum Count	% Phylum Weight
Nuculana fossa	21	0.0	23.50	0.00	0.0001	0.00001	0.13	0.00
Yoldia hyperborea	1	0.0	2.00	0.00	0.0001	0.00000	0.01	0.00
Mytilus edulis	1	0.0	15.00	0.00	0.0003	0.00001	0.01	0.00
Musculus niger	3	0.0	95.00	0.00	0.0008	0.00003	0.02	0.01
Musculus discors	19	0.0	76.94	0.00	0.0002	0.00003	0.11	0.01
Modiolus modiolus	1	0.0	5.00	0.00	0.0002	0.00000	0.01	0.00
Chlamys rubida	20	0.0	400.00	0.00	0.0098	0.00014	0.12	0.03
Chlamys islandica	65	0.0	5498.00	0.06	0.0658	0.00188	0.39	0.45
Chlamys beringiana	3	0.0	160.00	0.00	0.0039	0.00005	0.02	0.01
Astarte borealis	412	0.2	6148.67	0.06	0.0128	0.00210	2.50	0.50
Astarte montagui	3	0.0	3.00	0.00	0.0000	0.00000	0.02	0.00
Cyclocardia sp.	2	0.0	10.00	0.00	0.0002	0.00000	0.01	0.00
Cyclocardia ventricosa	3	0.0	14.00	0.00	0.0002	0.00000	0.02	0.00
Cyclocardia crebricostata	2	0.0	4.00	0.00	0.0001	0.00000	0.01	0.00
Cyclocardia crassidens	5	0.0	57.44	0.00	0.0005	0.00002	0.03	0.00
Clinocardium ciliatum	78	0.0	1590.00	0.02	0.0017	0.00054	0.47	0.13
Clinocardium nuttallii	1	0.0	25.00	0.00	0.0005	0.00001	0.01	0.00
Clinocardium californiense	27	0.0	613.00	0.01	0.0035	0.00021	0.16	0.05
Serripes groenlandicus	179	0.1	6603.25	0.07	0.0059	0.00225	1.09	0.54
Liocyma fluctuosa	2	0.0	2.00	0.00	0.0000	0.00000	0.01	0.00
Spisula polynyma	2	0.0	100.00	0.00	0.0011	0.00003	0.01	0.01
Macoma sp.	22	0.0	913.00	0.01	0.0084	0.00031	0.13	0.07
Macoma calcarea	17	0.0	346.25	0.00	0.0019	0.00012	0.10	0.03
Macoma brota	19	0.0	504.00	0.01	0.0033	0.00017	0.12	0.04
Mya japonica	1	0.0	45.00	0.00	0.0011	0.00002	0.01	0.00
Hiatella arctica	114	0.1	160.00	0.00	0.0002	0.00005	0.69	0.01
Panomya arctica	1	0.0	25.00	0.00	0.0007	0.00001	0.01	0.00
Gastropoda	95	0.0	6595.59	0.07	0.0159	0.00225	0.58	0.54
Margarites giganteus	1	0.0	45.00	0.00	0.0017	0.00002	0.01	0.00
Solariella obscura	1	0.0	1.00	0.00	0.0000	0.00000	0.01	0.00
Solariella varicosa	1	0.0	45.00	0.00	0.0017	0.00002	0.01	0.00
Tachyrhynchus reticulatis	1	0.0	45.00	0.00	0.0011	0.00002	0.01	0.00
Crepidula grandis	6	0.0	57.00	0.00	0.0004	0.00002	0.04	0.00
Trichotropis bicarinata	92	0.0	276.88	0.00	0.0034	0.00009	0.56	0.02
Natica clausa	223	0.1	2313.00	0.02	0.0058	0.00079	1.35	0.19

APPENDIX TABLE VI (continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m^2 for* occurrence stations	g/m^2 for all stations	% Phylum Count	% Phylum Weight
Natica russa	12	0.0	93.75	0.00	0.0026	0.00003	0.08	0.01
Polinices pallida	129	0.1	1559.50	0.02	0.0055	0.00053	0.79	0.13
Piliscus commodum	2	0.0	2.00	0.00	0.0001	0.00000	0.01	0.00
Velutina sp.	2	0.0	2.50	0.00	0.0001	0.00000	0.02	0.00
Velutina plicatilis	11	0.0	35.44	0.00	0.0001	0.00001	0.07	0.00
Velutina undata	2	0.0	2.00	0.00	0.0000	0.00000	0.01	0.00
Boreotrophon clathratus	2	0.0	90.00	0.00	0.0011	0.00003	0.01	0.01
Buccinum angulosum	219	0.1	4717.00	0.05	0.0121	0.00161	1.33	0.38
Buccinum scalariforme	241	0.1	3944.00	0.04	0.0063	0.00135	1.46	0.32
Buccinum glaciale	90	0.0	1180.00	0.01	0.0290	0.00040	0.55	0.10
Buccinum solenum	30	0.0	1088.00	0.01	0.0080	0.00037	0.18	0.09
Buccinum polare	197	0.1	2900.00	0.03	0.0077	0.00099	1.19	0.24
Buccinum tenellum	81	0.0	1013.50	0.01	0.0043	0.00035	0.49	0.08
Ancistrolepis sp.	6	0.0	453.00	0.00	0.0040	0.00015	0.04	0.04
Ancistrolepis magna	3	0.0	90.00	0.00	0.0028	0.0003	0.02	0.01
Beringius crebricostatus	2	0.0	45.00	0.00	0.0012	0.00002	0.01	0.00
Beringius beringi	340	0.2	28897.07	0.30	0.0200	0.00987	2.06	2.35
Colus sp.	1	0.0	45.00	0.00	0.0012	0.00002	0.01	0.00
Colus spitzbergensis	10	0.0	271.00	0.00	0.0016	0.00009	0.06	0.02
Colus hypolispus	42	0.0	551.25	0.01	0.0021	0.00019	0.26	0.04
Mohnia corbis	11	0.0	953.00	0.01	0.0192	0.00033	0.07	0.08
Neptunea lyrata	4	0.0	317.00	0.00	0.0038	0.00011	0.02	0.03
Neptunea ventricosa	1857	0.9	132807.25	1.39	0.0938	0.04534	11.26	10.80
Neptunea communis borealis	197	0.1	3352.00	0.04	0.0045	0.00114	1.19	0.27
Neptunea heros	9671	4.2	983728.50	10.29	0.5815	0.33586	58.65	79.98
Plicifusus brunneus	1	0.0	45.00	0.00	0.0011	0.00002	0.01	0.00
Pyrulofusus deformis	157	0.1	9334.00	0.10	0.0351	0.00319	0.95	0.76
Volutopsius sp.	75	0.0	5035.00	0.05	0.0391	0.00172	0.45	0.41
Volutopsius fragilis	185	0.1	10484.25	0.11	0.0187	0.00358	1.12	0.85
Admete couthouyi	2	0.0	1.00	0.00	0.0000	0.00000	0.01	0.00
Dorididae	2	0.0	11.00	0.00	0.0001	0.00000	0.01	0.00
Dendronotus sp.	17	0.0	445.00	0.00	0.0014	0.00015	0.10	0.04
Tochuina tetraquetra	5	0.0	1170.00	0.01	0.0076	0.00040	0.03	0.10
Octopus sp.	16	0.0	913.20	0.02	0.0051	0.00031	0.10	0.07

APPENDIX TABLE VI (continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m² for* occurrence stations	g/m² for all stations	% Phylum Count	% Phylum Weight
Balanus sp.	932	0.5	296.00	0.00	0.0012	0.00009	1.40	0.02
Balanus balanus	116	0.1	716.00	0.01	0.0023	0.00024	0.17	0.06
Balanus rostratus	36	0.0	1073.00	0.01	0.0086	0.00037	0.05	0.09
Mysidae	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Cumacea	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Isopoda	2	0.0	2.00	0.00	0.0000	0.00000	0.00	0.00
Saduria entomon	2	0.0	5.00	0.00	0.0001	0.00000	0.00	0.00
Amphipoda	229	0.1	456.00	0.00	0.0040	0.00016	0.34	0.04
Eusiridae	9	0.0	5.00	0.00	0.0001	0.00000	0.01	0.00
Rhachotropis sp.	3	0.0	2.00	0.00	0.0000	0.00000	0.00	0.00
Melita sp.	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Melita dentata	4	0.0	3.00	0.00	0.0000	0.00000	0.01	0.00
Anonyx sp.	146	0.1	342.44	0.00	0.0009	0.00012	0.22	0.03
Stegocephalopsis ampulla	2	0.0	10.00	0.00	0.0003	0.00000	0.00	0.00
Stegocephalus inflatus	497	0.2	2192.00	0.02	0.0080	0.00075	0.75	0.18
Pandalus sp.	5	0.0	1.00	0.00	0.0000	0.00000	0.01	0.00
Pandalus goniurus	1084	0.5	1094.00	0.01	0.0017	0.00037	1.63	0.09
Spirontocaris sp.	1	0.0	1.00	0.00	0.0000	0.00000	0.00	0.00
Spirontocaris murdochi	1	0.0	15.00	0.00	0.0006	0.00001	0.00	0.00
Spirontocaris arcuata	26	0.0	53.00	0.00	0.0002	0.00002	0.04	0.00
Lebbeus groenlandica	226	0.1	1535.51	0.02	0.0037	0.00052	0.34	0.13
Eualus gaimardii belcheri	69	0.0	80.00	0.00	0.0002	0.00003	0.10	0.01
Heptacarpus sp.	11	0.0	7.00	0.00	0.0002	0.00000	0.02	0.00
Crangon dalli	25	0.0	74.00	0.00	0.0002	0.00003	0.04	0.01
Sclerocrangon boreas	7438	3.7	47779.21	0.50	0.0553	0.01631	11.18	3.97
Argis lar	8286	4.1	52314.95	0.55	0.0211	0.01786	12.45	4.34
Argis crassa	23	0.0	140.00	0.00	0.0019	0.00005	0.03	0.01
Pagurus capillatus	7124	3.5	87235.75	0.91	0.0407	0.02978	10.71	7.24
Pagurus trigonocheirus	10851	5.3	189951.85	1.99	0.0702	0.06485	16.31	15.77
Pagurus rathbuni	691	0.3	8313.00	0.09	0.0187	0.00284	1.04	0.69
Labidochirus splendescens	2440	1.2	32073.35	0.34	0.0146	0.01095	3.67	2.66
Hapalogaster grebnitzkii	3	0.0	20.00	0.00	0.0004	0.00001	0.00	0.00
Paralithodes camtschatica	5	0.0	2497.00	0.03	0.0137	0.00085	0.01	0.21

APPENDIX TABLE VI (continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m² for* occurrence stations	g/m² for all stations	% Phylum Count	% Phylum Weight
Paralithodes platypus	11	0.0	4313.00	0.05	0.0477	0.00147	0.02	0.36
Paralithodes brevipes	1	0.0	43.00	0.00	0.0009	0.00001	0.00	0.00
Hyas sp.	15	0.0	180.00	0.00	0.0042	0.00006	0.02	0.01
Hyas coarctatus alutaceus	6105	3.0	155029.85	1.62	0.0600	0.05293	9.18	12.87
Chionoecetes opilio	19433	9.6	526928.86	5.51	0.2020	0.17990	29.21	43.76
Telmessus cheiragonius	674	0.3	89507.00	0.94	0.1071	0.03056	1.01	7.43
Golfingia margaritacea	10	0.0	240.00	0.00	0.0010	0.00008	100.00	100.00
Echiurus echiurus alaskensis	31	0.0	818.50	0.01	0.0020	0.00028	100.00	100.00
Ectoprocta	9	0.0	259.88	0.00	0.0008	0.00009	12.61	2.26
Flustridae	3	0.0	207.00	0.00	0.0019	0.00007	4.01	1.80
Flustra sp.	17	0.0	763.00	0.01	0.0012	0.00026	22.70	6.63
Dendrobeania sp.	2	0.0	14.00	0.00	0.0002	0.00000	2.67	0.12
Diaperoecia sp.	11	0.0	1020.00	0.01	0.0026	0.00035	14.69	8.86
Heteropora sp.	4	0.0	80.00	0.00	0.0020	0.00003	5.34	0.69
Alcyonidium sp.	5	0.0	9127.00	0.10	0.0570	0.00312	6.68	79.27
Alcyonidium disciforme	1	0.0	2.00	0.00	0.0001	0.00000	1.34	0.02
Alcyonidium vermiculare	22	0.0	40.44	0.00	0.0001	0.00001	29.97	0.35
Henricia sp.	898	0.4	7289.88	0.08	0.0128	0.00249	1.48	0.13
Henricia derjugini	12	0.0	817.07	0.01	0.0201	0.00028	0.02	0.01
Pteraster obscurus	230	0.1	13964.00	0.15	0.0108	0.00477	0.38	0.24
Crossaster papposus	467	0.2	13625.76	0.14	0.0090	0.00465	0.77	0.24
Solaster sp.	7	0.0	5365.85	0.06	0.1321	0.00183	0.01	0.09
Solaster endeca	6	0.0	1816.00	0.02	0.0383	0.00062	0.01	0.03
Asterias sp.	941	0.5	207024.00	2.17	2.6187	0.07068	1.55	3.59
Asterias amurensis	10150	5.0	2048652.40	21.44	0.9980	0.69944	16.72	35.54
Asterias rathbuni	1789	0.9	234037.00	2.45	1.5470	0.07990	2.95	4.06
Evasterias echinosoma	561	0.3	368018.20	3.85	0.2743	0.12565	0.92	6.39
Leptasterias sp.	725	0.4	8763.79	0.09	0.0050	0.00299	1.19	0.15
Leptasterias polaris acervata	12613	6.2	1204691.00	12.61	0.5163	0.41130	20.77	20.90
Lethasterias sp.	37	0.0	11350.00	0.12	0.3143	0.00388	0.06	0.20
Lethasterias nanimensis	1866	0.9	557557.54	5.83	0.3189	0.19036	3.07	9.67
Echinoidea	2	010	150.00	0.00	0.0037	0.00005	0.00	0.00

APPENDIX TABLE VI (continued)

Taxonomic Name	Count	% Count	Weight (g)	% Total Wt.	g/m² for* occurrence stations	g/m² for all stations	% Phylum Count	% Phylum Weight
Echinarachnius parma	3	0.0	3.00	0.00	0.0006	0.00001	0.00	0.00
Strongylocentrotus droebachiensis	8795	4.3	616152.68	6.45	0.3114	0.21036	14.48	10.69
Amphipholis sp.	5	0.0	1.00	0.00	0.0000	0.00000	0.01	0.00
Gorgonocephalus caryi	1285	0.6	331809.12	3.47	0.2343	0.11329	2.12	5.76
Ophiopholis aculeata	45	0.0	70.00	0.00	0.0008	0.00002	0.07	0.00
Ophiura sarsi	19956	9.8	80328.75	0.84	0.0526	0.02743	32.87	1.39
Stegophiura nodosa	91	0.0	46.00	0.00	0.0001	0.00002	0.15	0.00
Cucumaria sp.	61	0.0	778.63	0.01	0.0034	0.00027	0.10	0.01
Cucumaria calcigera	2	0.0	30.00	0.00	0.0008	0.00001	0.00	0.00
Psolus japonica	171	0.1	51185.12	0.54	0.1785	0.01748	0.28	0.89
Chordata: Ascidiacea	67	0.0	40694.00	0.43	0.0282	0.01389	0.16	4.36
Chelyosoma sp.	7509	3.7	439444.12	4.60	0.7178	0.15003	17.93	47.09
Chelyosoma orientale	7972	3.9	27016.34	0.28	0.1760	0.00922	19.04	2.90
Styelidae	107	0.1	4803.00	0.05	0.0125	0.00164	0.26	0.51
Styela macrenteron	5820	2.9	198727.12	2.08	0.1384	0.06785	13.90	21.30
Pelonaia corrugata	2	0.0	6.00	0.00	0.0001	0.00000	0.00	0.00
Boltenia ovifera	481	0.2	28429.17	0.30	0.0237	0.00971	1.15	3.05
Boltenia echinata	17391	8.6	35412.34	0.37	0.0465	0.01209	41.53	3.79
Halocynthia aurantium	1146	0.6	155849.00	1.63	0.6835	0.05321	2.74	16.70
Salpidae	1385	0.7	2770.00	0.03	0.0273	0.00095	3.31	0.30

*Biomass listed here is only for those stations where the respective taxa occurred; not all stations.

APPENDIX TABLE VII

Summary of Prey Items of *Platichthys stellatus*[1] by Frequency of Occurrence, Number, Volume, and Relative Importance from Norton Sound, Port Clarence, and Southeastern Chukchi Sea

Samples taken from September 4 through October 4, 1976 at stations C-61, D-9, C-63, C-64, A-52, and A-53.

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Rhynchocoela	410.0	1222.0	75.0	0.57	1	0.01	1	0.28	5.0	0.16
Polychaeta	333.8	562.0	54.7	9.09	16	0.59	57	0.49	8.7	9.82
Nephtys sp.	390.0	806.0	100.0	0.57	1	0.01	1	0.06	1.0	0.04
Nephtys rickettsi	290.0	339.0	0.0	0.57	1	0.01	1	0.01	0.2	0.01
Glycinde armigera	360.0	750.0	25.0	0.57	1	0.01	1	0.01	0.2	0.01
Lumbrineris sp.	360.0	750.0	25.0	0.57	1	0.01	1	0.02	0.4	0.02
Sternaspis scutata	323.1	483.6	53.5	20.45	36	1.05	101	0.67	12.0	35.25
Arenicola glacialis	440.0	1320.0	25.0	0.57	1	0.01	1	0.67	12.0	0.39
Pectinariidae	320.0	415.0	50.0	1.14	2	0.95	91	0.39	7.0	1.52
Cistenides hyperborea	324.3	483.7	50.9	15.34	27	3.03	291	1.61	28.8	71.23
Lysippe labiata	280.0	252.0	0.0	0.57	1	0.07	7	0.01	0.1	0.04
Pelecypoda	322.5	533.0	43.8	2.27	4	0.04	4	0.04	0.7	0.18
Yoldia sp.	340.0	550.0	25.0	0.57	1	0.03	3	0.17	3.0	0.11
Yoldia hyperborea	324.6	490.9	51.7	65.34	115	9.83	943	28.76	514.7	2521.62
Yoldia seminuda	290.0	324.0	50.0	0.57	1	0.04	4	0.39	7.0	0.25
Musculus niger	355.0	680.0	57.5	5.68	10	0.13	12	0.39	6.9	2.90
Musculus corrugatus	310.0	354.0	25.0	0.57	1	0.01	1	0.01	0.1	0.01
Cyclocardia ventricosa	530.0	2500.0	100.0	0.57	1	0.01	1	0.01	0.1	0.01
Clinocardium ciliatum	317.5	461.3	68.8	2.27	4	0.06	6	0.06	1.0	0.27
Serripes groenlandicus	324.9	503.1	50.0	7.95	14	0.15	14	0.42	7.6	4.54
Mya sp.	322.1	448.5	50.0	6.82	12	0.13	12	0.27	4.8	2.68

APPENDIX TABLE VII

Continued

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Lyonsia norvegica	316.7	455.3	58.3	1.70	3	0.03	3	0.03	0.6	0.11
Naticidae	360.0	750.0	50.0	0.57	1	0.01	1	0.03	0.5	0.02
Polinices pallida	310.0	379.0	25.0	0.57	1	0.01	1	0.01	0.1	0.01
Admete sp.	325.0	472.5	62.5	1.14	2	0.02	2	0.01	0.2	0.04
Cylichna occulta	290.0	237.0	75.0	0.57	1	0.01	1	0.01	0.1	0.01
Crustacea	310.0	377.0	25.0	0.57	1	0.01	1	0.01	0.1	0.01
Leucon sp.	310.0	375.0	25.0	0.57	1	0.02	2	0.01	0.1	0.02
Diastylis sp.	296.1	338.8	41.7	5.11	9	0.28	27	0.06	1.1	1.75
Diastylis sulcata	350.0	565.0	50.0	0.57	1	0.05	5	0.01	0.1	0.03
Synidotea nodulosa	330.5	554.4	61.8	21.59	38	0.74	71	0.34	6.0	23.22
Amphipoda	352.9	653.5	52.5	5.68	10	0.23	22	0.09	1.6	1.81
Gammaridae	310.0	375.0	25.0	0.57	1	0.01	1	0.01	0.1	0.01
Pontoporeia femorata	310.0	386.5	75.0	1.14	2	0.03	3	0.01	0.2	0.05
Hippolytidae	436.0	1299.0	75.0	2.84	5	0.06	6	0.56	10.0	1.77
Crangon sp.	265.0	308.5	25.0	1.14	2	0.02	2	0.01	0.2	0.04
Crangon dalli	360.0	666.0	0.0	0.57	1	0.01	1	0.06	1.0	0.04
Argis lar	400.0	1022.0	25.0	0.57	1	0.01	1	0.03	0.5	0.02
Chionoecetes opilio	389.5	797.0	50.0	1.14	2	1.83	176	1.79	32.0	4.12
Echiurus echiurus alaskensis	420.0	1245.8	60.4	6.82	12	0.31	30	7.63	136.5	54.14
Priapulus caudatus	317.5	437.8	49.1	16.48	29	0.34	33	1.97	35.2	38.08
Echinarachnius parma	432.2	1501.0	75.0	3.41	6	2.63	252	13.38	239.5	54.58
Ophiuroidea	530.0	2500.0	100.0	0.57	1	0.01	1	0.01	0.1	0.01

APPENDIX TABLE VII

Continued

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Diamphiodia craterodmeta	329.1	526.5	52.3	43.75	77	76.31	7320	28.40	508.3	4581.35
Stegophiura nodosa	400.0	1035.0	50.0	1.14	2	0.32	31	1.18	21.2	1.71
Urochordata	440.0	1345.7	41.7	1.70	3	0.08	8	0.02	0.3	0.17
Pelonaia corrugata	360.0	750.0	25.0	0.57	1	0.04	4	0.03	0.6	0.04
Teleostei	400.0	1000.0	125.0	0.57	1	0.10	10	1.40	25.0	0.84
Eleginus gracilis	430.0	1098.5	62.5	1.14	2	0.02	2	4.25	76.0	4.85
Myoxocephalus sp.	400.0	1022.0	25.0	0.57	1	0.01	1	0.48	8.6	0.28
Lumpenus fabricii	369.0	802.5	60.0	5.68	10	0.22	21	3.49	62.5	21.09
TOTAL							9592		1789.6	

[1] Predator Data: Mean length - 340.7 mm; Std. deviation - 54.2 mm; Median length - 330.0 mm

Mean weight - 613.8 g; Std. deviation - 405.0 g; Median weight - 460.0 g

Mean fullness - 47.0%; Std. deviation - 31.8%; Number examined - 176 (includes 12 empty)

Sinistral individuals - 64.77%; Dextral individuals - 35.23%

APPENDIX TABLE VIII

Summary of Prey Items of Male *Platichthys stellatus*[1] by Frequency of Occurrence, Number, Volume and Relative Importance from Norton Sound, Port Clarence, and Southeastern Chukchi Sea

Samples taken from September 4 through October 4, 1976 at stations C-61, D-9, C-63, C-64, A-52, A-55, and A-53.

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Polychaeta	315.0	430.5	54.2	11.32	12	1.17	53	0.85	6.3	22.84
Nephtys rickettsi	290.0	339.0	0.0	0.94	1	0.02	1	0.03	0.2	0.05
Sternaspis scutata	311.8	410.6	52.1	22.64	24	1.63	74	1.28	9.5	65.92
Pectinariidae	320.0	415.0	50.0	1.89	2	2.01	91	0.94	7.0	5.57
Cistenides hyperborea	308.8	389.4	51.6	15.09	16	4.57	207	3.42	25.4	120.55
Lysippe labiata	280.0	252.0	0.0	0.94	1	0.15	7	0.01	0.1	0.16
Pelecypoda	300.0	351.3	25.0	2.83	3	0.07	3	0.04	0.3	0.30
Yoldia sp.	340.0	550.0	25.0	0.94	1	0.07	3	0.40	3.0	0.44
Yoldia hyperborea	315.4	427.2	47.9	80.19	85	9.71	440	51.69	384.2	4923.70
Yoldia seminuda	290.0	324.0	50.0	0.94	1	0.09	4	0.94	7.0	0.97
Musculus niger	345.0	632.5	54.2	5.66	6	0.13	6	0.30	2.2	2.43
Clinocardium ciliatum	296.7	346.7	58.3	2.83	3	0.11	5	0.12	0.9	0.66
Serripes groenlandicus	311.3	394.6	45.0	9.43	10	0.22	10	0.90	6.7	10.59
Mya sp.	322.9	466.3	53.6	6.60	7	0.15	7	0.28	2.1	2.89
Lyonsia norvegica	285.0	326.0	75.0	1.89	2	0.04	2	0.03	0.2	0.13
Admete sp.	325.0	472.5	62.5	1.89	2	0.04	2	0.03	0.2	0.13
Cylichna occulta	290.0	237.0	75.0	0.94	1	0.02	1	0.01	0.1	0.03
Crustacea	310.0	377.0	25.0	0.94	1	0.02	1	0.01	0.1	0.03
Leucon sp.	310.0	375.0	25.0	0.94	1	0.04	2	0.01	0.1	0.05
Diastylis sp.	290.0	311.1	40.6	7.55	8	0.55	25	0.13	1.0	5.18
Diastylis sulcata	350.0	565.0	50.0	0.94	1	0.11	5	0.01	0.1	0.12

APPENDIX TABLE VIII

Continued

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Synidotea nodulosa	310.8	404.4	54.0	23.58	25	0.91	41	0.47	3.5	32.45
Amphipoda	343.3	584.3	62.5	5.66	6	0.31	14	0.15	1.1	2.59
Gammaridae	310.0	375.0	25.0	0.94	1	0.02	1	0.01	0.1	0.03
Pontoporeia femorata	310.0	386.5	75.0	1.89	2	0.07	3	0.03	0.2	0.18
Crangon sp.	265.0	308.5	25.0	1.89	2	0.04	2	0.03	0.2	0.13
Echiurus echiurus alaskensis	250.0	200.0	75.0	0.94	1	0.02	1	1.10	8.2	1.06
Priapulus caudatus	315.6	420.6	48.6	16.98	18	0.42	19	3.18	23.6	61.04
Diamphiodia craterodmeta	314.7	432.9	47.6	50.00	53	77.17	3496	31.31	232.7	5424.04
Lumpenus fabricii	303.3	375.0	41.7	2.83	3	0.09	4	2.29	17.0	6.72
TOTAL							4530		743.3	

[1]Predator Data:

Mean length - 313.7 mm	Mean weight - 419.1 g	Mean fullness - 42.7%	Sinistral individuals - 58.49%
Std. deviation - 31.8 mm	Std. deviation - 149.0 g	Std. deviation - 27.0%	Dextral - 41.51%
Median length - 310.0 mm	Median weight - 390.0 g	Number examined - 106 (includes 7 empty)	

APPENDIX TABLE IX

Summary of Prey Items of Female *Platichthys stellatus*[1] by Frequency of Occurrence, Number, Volume and Relative Importance from Norton Sound, Port Clarence, and Southeastern Chukchi Sea

Samples taken from September 4 through October 4, 1976 at stations C-61, D-9, C-63, C-64, A-52, A-55, and A-53.

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Rhynchocoela	410.0	1222.0	75.0	1.43	1	0.02	1	0.48	5.0	0.71
Polychaeta	390.0	956.5	56.3	5.71	4	0.08	4	0.23	2.4	1.76
Nephtys sp.	390.0	806.0	100.0	1.43	1	0.02	1	0.10	1.0	0.16
Glycinde armigera	360.0	750.0	25.0	1.43	1	0.02	1	0.02	0.2	0.06
Lumbrineris sp.	360.0	750.0	25.0	1.43	1	0.02	1	0.04	0.4	0.08
Sternaspis scutata	345.8	629.4	56.3	17.14	12	0.53	27	0.24	2.5	13.24
Arenicola glacialis	440.0	1320.0	25.0	1.43	1	0.02	1	1.15	12.0	1.67
Cistenides hyperborea	346.8	620.7	50.0	15.71	11	1.66	84	0.32	3.4	31.18
Pelecypoda	390.0	1078.0	100.0	1.43	1	0.02	1	0.04	0.4	0.08
Yoldia hyperborea	350.7	671.5	62.5	42.86	30	9.94	503	12.47	130.5	960.40
Musculus niger	370.0	751.3	62.5	5.71	4	0.12	6	0.45	4.7	3.24
Musculus corrugatus	310.0	354.0	25.0	1.43	1	0.02	1	0.01	0.1	0.04
Cyclocardia ventricosa	530.0	2500.0	100.0	1.43	1	0.02	1	0.01	0.1	0.04
Clinocardium ciliatum	380.0	805.0	100.0	1.43	1	0.02	1	0.01	0.1	0.04
Serripes groenlandicus	358.8	774.3	62.5	5.71	4	0.08	4	0.09	0.9	0.94
Mya sp.	321.0	423.6	45.0	7.14	5	0.10	5	0.26	2.7	2.55
Lyonsia norvegica	380.0	714.0	25.0	1.43	1	0.02	1	0.04	0.4	0.08
Naticidae	360.0	750.0	50.0	1.43	1	0.02	1	0.05	0.5	0.10
Polinices pallida	310.0	379.0	25.0	1.43	1	0.02	1	0.01	0.1	0.04
Diastylis sp.	345.0	560.0	50.0	1.43	1	0.04	2	0.01	0.1	0.07
Synidotea nodulosa	368.5	842.8	76.9	18.57	13	0.59	30	0.24	2.5	15.44

APPENDIX TABLE IX

Continued

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Amphipoda	367.3	757.3	37.5	5.71	4	0.16	8	0.05	0.5	1.18
Hippolytidae	436.0	1299.0	75.0	7.14	5	0.12	6	0.96	10.0	7.67
Crangon dalli	360.0	666.0	0.0	1.43	1	0.02	1	0.10	1.0	0.16
Argis lar	400.0	1022.0	25.0	1.43	1	0.02	1	0.05	0.5	0.10
Chionoecetes opilio	389.5	797.0	50.0	2.86	2	3.48	176	3.06	32.0	18.67
Echiurus echiurus alaskensis	435.5	1340.9	59.1	15.71	11	0.57	29	12.26	128.3	201.70
Priapulus caudatus	320.6	466.0	50.0	15.71	11	0.28	14	1.11	11.6	21.77
Echinarachnius parma	432.2	1501.0	75.0	8.57	6	4.98	252	22.89	239.5	238.87
Ophiuroidea	530.0	2500.0	100.0	1.43	1	0.02	1	0.01	0.1	0.04
Diamphiodia craterodmeta	360.9	733.2	62.5	34.29	24	75.54	3824	26.34	275.6	3493.16
Stegophiura nodosa	400.0	1035.0	50.0	2.86	2	0.61	31	2.03	21.2	7.54
Urochordata	440.0	1345.7	41.7	4.29	3	0.16	8	0.03	0.3	0.80
Pelonaia corrugata	360.0	750.0	25.0	1.43	1	0.08	4	0.06	0.6	0.19
Teleostei	400.0	1000.0	125.0	1.43	1	0.20	10	2.39	25.0	3.70
Eleginus gracilis	430.0	1098.5	62.5	2.86	2	0.04	2	7.26	76.0	20.87
Myoxocephalus sp.	400.0	1022.0	25.0	1.43	1	0.02	1	0.82	8.6	1.20
Lumpenus fabricii	397.1	985.7	67.9	10.00	7	0.34	17	4.35	45.5	46.84
TOTAL							5062		1046.3	

[1]Predator Data: Mean length - 381.7 mm; Std. deviation - 55.4 mm; Median length - 380.0 mm

Mean weight - 908.7 g; Std. deviation - 484.2 g; Median weight - 805.0 g

Mean fullness - 53.6%; Std. deviation - 36.9%; Number examined - 70 (includes 5 empty)

Sinistral individuals - 74.29%; Dextral individuals - 25.71%

APPENDIX TABLE X

Summary of Prey Items of *Platichthys stellatus*[1] by Frequency of Occurrence, Number, Volume and Relative Importance from Norton Sound

Samples taken from September 30 through October 4, 1976 at stations C-61 and D-9.

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Rhynchocoela	410.0	1222.0	75.0	6.25	1	0.10	1	1.58	5.0	10.48
Polychaeta	410.0	1222.0	75.0	6.25	1	0.10	1	0.06	0.2	1.01
Cistenides hyperborea	410.0	1222.0	75.0	6.25	1	0.10	1	0.03	0.1	0.81
Yoldia hyperborea	340.8	622.7	45.8	37.50	6	1.86	19	4.52	14.3	239.11
Cyclocardia ventricosa	530.0	2500.0	100.0	6.25	1	0.10	1	0.03	0.1	0.81
Serripes groenlandicus	371.5	876.5	50.0	12.50	2	0.20	2	0.19	0.6	4.82
Synidotea nodulosa	470.0	1861.0	87.5	12.50	2	0.88	9	0.35	1.1	15.36
Amphipoda	394.5	864.5	25.0	12.50	2	0.20	2	0.06	0.2	3.24
Crangon dalli	360.0	666.0	0.0	6.25	1	0.10	1	0.32	1.0	2.59
Chionoecetes opilio	409.0	1059.0	0.0	6.25	1	14.30	146	1.58	5.0	99.24
Priapulus caudatus	257.0	228.0	25.0	6.25	1	0.29	3	0.44	1.4	4.60
Echinarachnius parma	446.6	1651.2	85.0	31.25	5	24.19	247	75.47	239.0	3114.30
Ophiuroidea	530.0	2500.0	100.0	6.25	1	0.10	1	0.03	0.1	0.81
Diarckiodia craterodmeta	350.0	661.7	39.3	43.75	7	57.49	587	15.35	48.6	3186.68
TOTAL							1021		316.7	

[1]Predator Data:

Mean length - 380.6 mm	Mean weight - 967.4 g	Mean fullness - 45.3%	Sinistral individuals - 93.75%
Std. deviation - 68.5 mm	Std. deviation - 693.6 g	Std. deviation - 34.5%	Dextral individuals - 6.25%
Median length - 360.0 mm	Median weight - 649.0 g	Number examined - 16 (includes 1 empty)	

APPENDIX TABLE XI

Summary of Prey Items of *Platichthys stellatus*[1] by Frequency of Occurrence, Number, Volume and Relative Importance from Port Clarence

Samples taken from September 4 through September 17, 1976 at stations C-63 and C-64.

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Polychaeta	328.7	518.0	53.3	11.19	15	0.66	56	0.71	8.5	15.30
Nephtys sp.	390.0	806.0	100.0	0.75	1	0.01	1	0.08	1.0	0.07
Nephtys rickettsi	290.0	339.0	0.0	0.75	1	0.01	1	0.02	0.2	0.02
Glycinde armigera	360.0	750.0	25.0	0.75	1	0.01	1	0.02	0.2	0.02
Lumbrinereis sp.	360.0	750.0	25.0	0.75	1	0.01	1	0.03	0.4	0.03
Sternaspis scutata	323.1	483.6	53.5	26.87	36	1.19	101	1.00	12.0	58.82
Cistenides hyperborea	321.0	455.3	50.0	20.90	28	4.50	381	2.96	35.7	155.99
Lysippe labiata	280.0	252.0	0.0	0.75	1	0.08	7	0.01	0.1	0.07
Pelecypoda	322.5	533.0	43.8	2.99	4	0.05	4	0.06	0.7	0.31
Yoldia sp.	340.0	550.0	25.0	0.75	1	0.04	3	0.25	3.0	0.21
Yoldia hyperborea	323.7	483.7	52.1	81.34	109	10.92	924	41.54	500.4	4266.97
Yoldia seminuda	290.0	324.0	50.0	0.75	1	0.05	4	0.58	7.0	0.47
Musculus niger	355.0	680.0	57.5	7.46	10	0.14	12	0.57	6.9	5.33
Musculus corrugatus	310.0	354.0	25.0	0.75	1	0.01	1	0.01	0.1	0.02
Clinocardium ciliatum	317.5	461.3	68.8	2.99	4	0.07	6	0.08	1.0	0.46
Serripes groenlandicus	317.1	440.8	50.0	8.96	12	0.14	12	0.58	7.0	6.47
Mya sp.	322.1	448.5	50.0	8.96	12	0.14	12	0.40	4.8	4.84
Lyonsia norvegica	316.7	445.3	58.3	2.24	3	0.04	3	0.05	0.6	0.19
Naticidae	360.0	750.0	50.0	0.75	1	0.01	1	0.04	0.5	0.04
Polinices pallida	310.0	379.0	25.0	0.75	1	0.01	1	0.01	0.1	0.02

APPENDIX TABLE XI

Continued

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Admete sp.	325.0	472.5	62.5	1.49	2	0.02	2	0.02	0.2	0.06
Cylichna occulta	290.0	237.0	75.0	0.75	1	0.01	1	0.01	0.1	0.02
Crustacea	310.0	377.0	25.0	0.75	1	0.01	1	0.01	0.1	0.02
Leucon sp.	310.0	375.0	25.0	0.75	1	0.02	2	0.01	0.1	0.02
Diastylis sp.	296.1	338.8	41.7	6.72	9	0.32	27	0.09	1.1	2.76
Diastylis sulcata	350.0	565.0	50.0	0.75	1	0.06	5	0.01	0.1	0.05
Synidotea nodulosa	322.8	481.8	60.4	26.87	36	0.73	62	0.41	4.9	30.61
Amphipoda	342.5	600.8	59.4	5.97	8	0.24	20	0.12	1.4	2.10
Gammaridae	310.0	375.0	25.0	0.75	1	0.01	1	0.01	0.1	0.02
Pontoporeia femorata	310.0	386.5	75.0	1.49	2	0.04	3	0.02	0.2	0.08
Crangon sp.	265.0	308.5	25.0	1.49	2	0.02	2	0.02	0.2	0.06
Argis lar	400.0	1022.0	25.0	0.75	1	0.01	1	0.04	0.5	0.04
Chionoecetes opilio	370.0	535.0	100.0	0.75	1	0.35	30	2.24	27.0	1.94
Priapulus caudatus	319.6	445.3	50.0	20.90	28	0.35	30	2.81	33.8	66.04
Echinarachnius parma	360.0	750.0	25.0	0.75	1	0.06	5	0.04	0.5	0.08
Diamphiodia craterodmeta	327.0	513.0	53.6	52.24	70	79.54	6733	38.16	459.7	6148.58
Stegophiura nodosa	360.0	750.0	25.0	0.75	1	0.02	2	0.02	0.2	0.03
Pelonaia corrugata	360.0	750.0	25.0	0.75	1	0.05	4	0.05	0.6	0.07
Eleginus gracilis	460.0	1172.0	125.0	0.75	1	0.01	1	6.23	75.0	4.66
Myoxocephalus sp.	400.0	1022.0	25.0	0.75	1	0.01	1	0.71	8.6	0.54
TOTAL							8465		1204.6	

[1]Predator Data:

Mean length - 325.1 mm
Std. deviation - 39.1 mm
Median length - 320.0 mm

Mean weight - 490.5 g
Std. deviation - 220.2 g
Median weight - 415.0 g

Mean fullness - 47.2%
STD deviation - 29.4%
Number examined - 134
(includes 7 empty)

Sinistral individuals - 58.21%
Dextral individuals - 41.79%

APPENDIX TABLE XII

Summary of Prey Items of *Platichthys stellatus*[1] by Frequency of Occurrence, Number, Volume and Relative Importance from Southeastern Chukchi Sea

Samples taken from September 5, 1976 at stations A-52, A-55, and A-53.

Taxon-Prey Items	Avg Length of Pred., mm	Avg Weight of Pred., g	Avg Full of Pred %	% Freq. of Taxon	Freq. of Taxon	% by No. of Taxon	No. of Taxon	% by Vol. of Taxon	Vol. of Taxon (ml)	Importance of Taxon
Arenicola glacialis	440.0	1320.0	25.0	3.85	1	0.94	1	4.47	12.0	20.83
Hippolytidae	436.0	1299.0	75.0	19.23	5	5.66	6	3.73	10.0	180.53
Echiurus echiurus alaskensis	420.0	1245.8	60.4	46.15	12	28.30	30	50.88	136.5	3654.36
Stegophiura nodosa	440.0	1320.0	75.0	3.85	1	27.36	29	7.83	21.0	135.33
Urochordata	440.0	1345.7	41.7	11.54	3	7.55	8	0.11	0.3	88.37
Teleostei	400.0	1000.0	125.0	3.85	1	9.43	10	9.32	25.0	72.12
Eleginus gracilis	400.0	1025.0	0.0	3.85	1	0.94	1	0.37	1.0	5.06
Lumpenus fabricii	369.0	802.5	60.0	38.46	10	19.81	21	23.29	62.5	1657.93
TOTAL							106		268.3	

[1] Predator Data:
Mean length - 396.9 mm
Std. deviation - 60.9 mm
Median length - 400.0 mm

Mean weight - 1031.8 g
Std. deviation - 484.2 g
Median weight - 1025.0 g

Mean fullness - 47.1%
Std. deviation - 40.6%
Number examined - 26
(includes 4 empty)

Sinistral individuals - 80.77%
Dextral individuals - 19.23%