Waterbirds and oil-contaminated ponds at Point Storkersen, Alaska

by

Kenneth Floyd Abraham

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
MASTER OF SCIENCE

Department: Animal Ecology
Major: Wildlife Biology

Approved:

In Charge of Major Work

For the Major Department

For the Graduate College

Iowa State University
Ames, Iowa
1975

TABLE OF CONTENTS

INTRODUCTION

Alaska's Arctic Coastal Plain contains numerous wetlands important as breeding and molting areas for aquatic birds. Black and Barksdale (1949) estimated that 50 to 75 percent of the 65,000 km^2 area was covered by lakes and marshy ponds, of which King (1970) considered 59,000 km^2 to be suitable waterfowl habitat. A diversity of wetlands and their characteristic bird species was recognized and described by Kessel and Cade (1958) for the Colville River region, and by Bergman (1974) for the coastal plain near Prudhoe Bay.

A major factor determining the importance of wetlands to waterbirds is the invertebrate food resource available at critical stages of reproduction. Female ducks consume high protein animal foods during the pre-laying and laying periods (Moyle 1961, Krull 1968, Bengston 1971, and Krapu and Swanson 1975). Juvenile waterfowl also need high protein foods for rapid growth and development (Chura 1961, Collias and Collias 1963, Bartonek and Hickey 1969, and Bartonek 1972). Shorebirds utilize both adult and larval forms of insects most of their life (Hurd and Pitelka 1954, Pitelka 1959, Holmes 1966, and Holmes and Pitelka 1968).

Current development of oil resources near Prudhoe Bay poses a threat to the persistence of wetland communities. Construction of roads, drilling pads, and foundations for buildings may impede surface water flow, thus altering size, depth and vegetation of wetlands. These changes could alter traditional patterns of avian activity and habitat utilization, possibly lowering rates of production and survival in these areas.

Potential crude oil spills threaten both birds and wetland resources. The presence of surface oil would make ingestion likely during feeding, and direct oiling would result in loss of thermoregulation in downy young of most species. Because crude oil is toxic to many aquatic invertebrates (Katz 1973, Kontogiannis and Barnett 1973; Snow and Scott 1975), such spills would cause a loss of food resources important to birds. Bengtson and Berggren (1972) and Snow and Scott (1975) have shown that oil penetrates sediments where larval stages of many insects would be affected.

A study was initiated in 1971 by the United States Fish and Wildlife Service to appraise the potential impact of the trans-Alaska oil pipeline on migratory waterbirds and their habitats. Investigations by Bergman (1974) focused on bird populations and wetlands, and Howard (1974) studied aquatic macroinvertebrates in relation to waterbirds at Point Storkersen, Alaska. This phase of the long term project was designed to: (1) supplement data on bird populations and their selection of habitats, and (2) determine immediate effects of crude oil contamination on aquatic macroinvertebrates and bird activity in certain wetlands.

STUDY AREA

The study area is near Point Storkersen, Alaska (Lat. 70°25'N, Long. 148°15'W) (Figure 1). Current oil exploration and development on the Arctic Coastal Plain is centered at Prudhoe Bay, approximately 20 km southeast. This region is typical of the Arctic Coastal Plain Province (Payne et al. 1951), which extends approximately 900 km from Cape Beaufort east to the British Mountain, and reaches its maximum width of 175 km due south of Point Barrow (Black 1969). Unglaciated, and underlain by continuous permafrost to depths of 640 m (Brooks et al. 1971), this tundra landscape is characterized by low relief and abundant wetlands.

At Point Storkersen, relief is 10 m or less and consists of low pingos and stream banks. Geomorphology is similar to that described for Point Barrow by Hussey and Michelson (1966), and characteristic vegetation of the region was described by Wiggins and Thomas (1962). Mean annual precipitation is less than 15 cm, but aridity is prevented by low evaporation and transpiration rates, and by lack of subterranean drainage due to permafrost (Johnson and Hartman 1969).

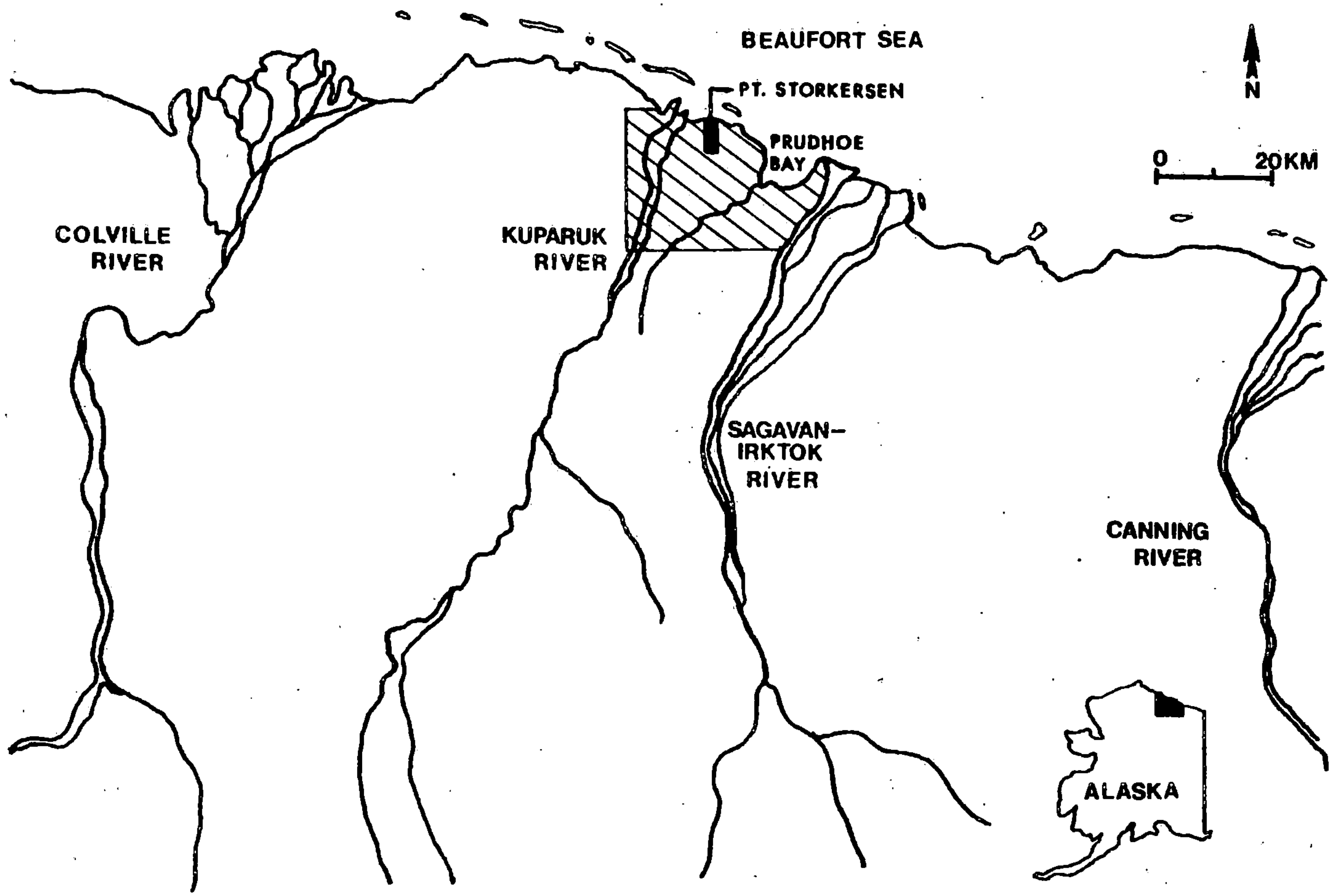

Figure 1. Location of Point Storkersen, the zone of intensive oil operations adjacent to Prudhoe Bay (shaded) and principal rivers on the Eastern Arctic Coastal Plain, northern Alaska (after Bergman, 1974)

METHODS

Waterbird Populations

Field seasons extended from 30 May to 14 August in 1974, and from 31 May to 21 July in 1975. Bird populations were estimated weekly or biweekly by two observers. Loons, waterfowl, plovers, and other large birds such as jaegers, gulls, and terns were censused on three 2.6-km^2 plots (R 13 E, T 12 N, Sections 13, 24, and 25). Passerines and small shorebirds were censused on nine 201 m (one-eighth mile) wide belt transects totaling 1.6-km^2 that were established in 1972 by Bergman (1974) (Figure 2).

Data collected during regular censuses included: species, number of individuals or pairs, flock size, broods, and when possible, age. All nests found were marked with garden wands, and rechecked to record clutch size and fate. No attempt was made to find all nests or broods, but most nests and broods of loons, geese and brant undoubtedly were found because they are conspicuous.

Experimental Oil Spills

To assess the impact of experimental oil spills, it was necessary to regulate where the oil went in the drainage, and to have adequate control ponds for comparison. Pond selection was based on observed drainage patterns to insure that oil would stay within a limited basin in each case. Because of permafrost depth and other logistic limitations, partitioning of ponds for controls as described by Snow and Scott (1975) was not used

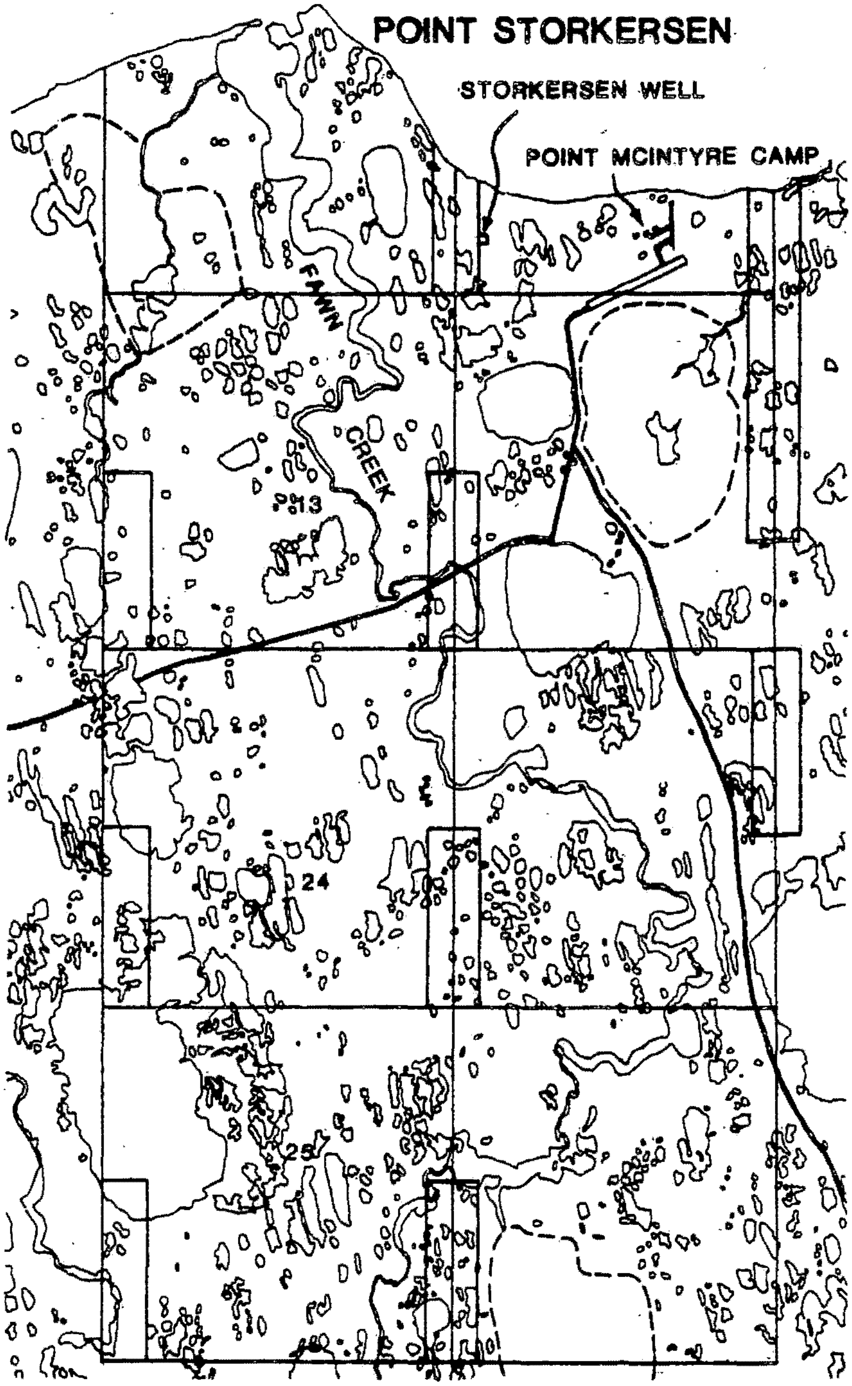

Figure 2. Map of Point Storkersen study area, showing three 1 sq mile sections (13, 24, 25) used for large bird census plots, nine small bird transects on section lines, Storkersen Well and Point McIntyre camp. Dashed lines indicate large second generation wetland basins.

in this study.

Six ponds selected from aerial photographs were located in the first week of June 1974 and three additional ponds were chosen during ground surveys in 1975. Preliminary sampling showed them to have very similar physical and biological characteristics. All are Class II ponds according to Bergman's (1974) classification of wetlands in the Point Storkersen area. These are shallow ponds with depths of 10 to 40 cm and a shoreward zone of emergent Carex aquatilis.

Aquatic macroinvertebrates were sampled according to procedures used by Howard (1974). Benthic organisms were collected with an Ekman dredge 15.2 x 15.2 cm (6 x 6 in). Free swimming invertebrates and those attached to emergent vegetation were collected with a sweep net 30.5 x 7.6 cm (12 x 3 in) having 7.9 meshes/cm (20 meshes/in) (Weller 1972). Weekly sampling at each pond was comprised of four Ekman grabs and six net sweeps randomly located in the central or shoreward zones. Macroinvertebrates were sorted from vegetation and sediment soon after collection, and preserved in formaldehyde for subsequent analysis.

Three sampling periods between 9 and 26 June preceded the 1974 spills. Ponds were sampled weekly for 7 weeks following the spills. Ponds used in 1974 also were sampled for 6 weeks from 14 June to 20 July, in 1975. Two ponds oiled in 1975 were sampled weekly for 3 weeks preceding and 2 weeks following the spill. A third pond was sampled one day before and three days after introduction of oil. A contaminated pond adjacent to the Storkersen Well was sampled on 1 and 30 July 1974, and 10 July 1975.

Physical and chemical parameters were measured during regular sampling periods. Hydrogen ion concentration (pH) was determined using Hach Chemical Company reagents, and specific conductivity (micromhos/cm) was measured with a Hach Model 2510 field conductivity meter. Because of seasonal progression of melt of permafrost in pond basins, thickness of bottom sediments as well as water depths were measured at all weekly sampling sites within the ponds. Water temperatures were measured at the time of sampling with a pocket thermometer. Marshalltown Model 1000 continuous recording thermographs were used to record water temperatures on the pond sediments in control pond 23 and oiled pond 7 in 1974, and in control pond 33 and oiled ponds 31 and 37 in 1975 (Figure 3).

Ponds 23, 30, and 33 served as controls in both 1974 and 1975. Ponds 7, 31, 32, 36, 37, and 39 received crude oil treatments, because no exchange of water was detected between these and surrounding wetlands. Prudhoe Bay crude oil, provided by Atlantic Richfield Company, was poured into ponds 32 and 36 on 27 June 1974 and into pond 7 on 28 June 1974. Oil was poured directly into the water along the windward shore at a rate of 19 liters/ha (2 gal/a). In 1975, oil was poured into ponds 31 and 37 on 2 July at a rate of 2000 liters/ha (200 gal/a). Pond 39 received oil on 15 July at a rate of 5500 liters/ha (550 gal/a). Characteristics of the spread and persistence of oil were observed in both years.

In 1974, random, 30 minute periods of observation of bird activity on the study ponds were made from a blind located between ponds 30, 32, 33, and 36. In 1975, because of the increased number of sites, observation periods were 15 minutes long and were made without a blind by lying motionless at strategic locations near the ponds. Major activities of each bird were recorded by species, pond treatment, and location within the pond.

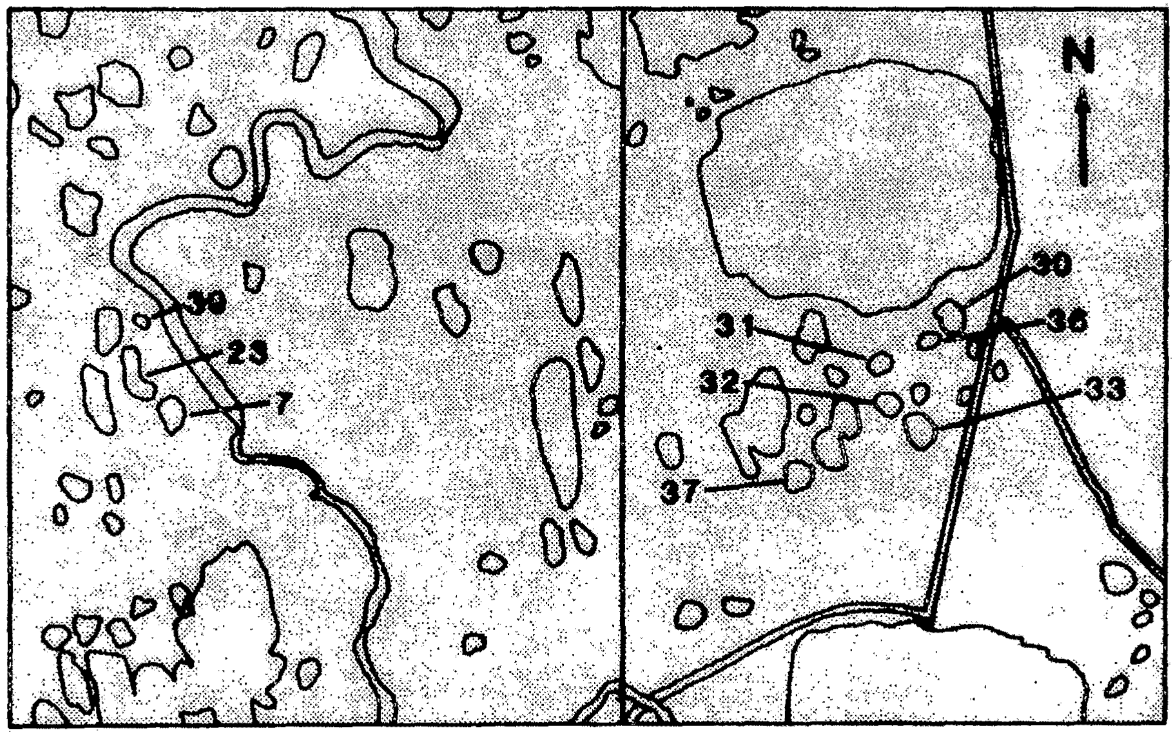

Figure 3. Location of control ponds 23, 30, and 33 and experimental ponds 7, 31, 32, 36, 37, 39.

RESULTS

Waterbird Populations

Nesting species

In 1974, 17 of 24 species shown by Bergman (1974) to nest on the study area had arrived by 1 June, at which time snow-melt was well advanced (Table 1). However, migration and breeding activities were interrupted by a period of subfreezing temperatures and new snow accumulations from 1 to 6 June. Most species left the area, retreating inland or to nearby deltas where open water was present. By 8 June, those species present on 1 June had returned and others began to arrive, including red and northern phalaropes.

In 1975, significant snow-melt was as late as in 1974 but proceeded rapidly after 5-6 June. Latest nesting species to arrive in both 1974 and 1975 were arctic loons, red-throated loons, spectacled eiders, and buff-breasted sandpipers.

Density estimates for nesting birds are presented in Table 2. Shorebirds (plovers, sandpipers and phalaropes) comprised 60 to 75 percent, waterfowl 8 to 10 percent, and passerines 14 to 22 percent of the total birds during June. Red phalaropes were the most abundant birds in both years, ranging from 15.6 to 33.1 birds/km^2 in June. In early July, females gather in large flocks prior to migration, while males are incubating, resulting in low estimates (8.3 birds/km^2). August estimates of red phalaropes (83.9 birds/km^2) as well as northern phalaropes (53.2 birds/km^2) increased markedly over June and July,

Table 1. First observations of 25 breeding birds in relation to spring thaw, 1974 and 1975.

Species	Date of first observation		Percent snow cover	
	1974	1975	1974	1975
Whistling Swan (*Olor columbianus*)	-[a]	16 June	50-75	5
White-fronted Goose (*Anser albifrons*)	-[a]	3 June	50-75	90-100
Black Brant (*Branta nigricans*)	-[a]	1 June	50-75	100
Pintail (*Anas acuta*)	-[a]	7 June	50-75	50-75
Oldsquaw (*Clangula hyemalis*)	-[a]	5 June	50-75	80-90
American Golden Plover (*Pluvialis dominica*)	-[a]	5 June	50-75	80-90
Black-bellied Plover (*Pluvialis squatarola*)	-[a]	7 June	50-75	50-75
Ruddy Turnstone (*Arenaria interpres*)	-[a]	4 June	50-75	90-100
Pectoral Sandpiper (*Calidris melanotos*)	-[a]	3 June	50-75	90-100
Dunlin (*Calidris alpina*)	-[a]	3 June	50-75	90-100
Baird's Sandpiper (*Calidris bairdii*)	-[a]	3 June	50-75	90-100
Semipalmated Sandpiper (*Calidris pusillus*)	-[a]	4 June	50-75	90-100
Parasitic Jaeger (*Stercorarius parasiticus*)	-[a]	3 June	50-75	90-100

Glaucous Gull (*Larus hyperboreus*)	-[a]	1 June	50-75	100
Lapland Longspur (*Calcarius lapponicus*)	-[a]	1 June	50-75	100
Snow Bunting (*Plectrophenax nivalis*)	-[a]	-[a]	50-75	100
King Eider (*Somateria spectabilis*)	1 June	5 June	50-75	80-90
Red Phalarope (*Phalaropus fulicarius*)	8 June	7 June	50-75	50-75
Northern Phalarope (*Lobipes lobatus*)	9 June	11 June	50	50
Arctic Loon (*Gavia arctica*)	9 June	10 June	50	50
Red-throated Loon (*Gavia stellata*)	11 June	7 June	25-50	50-75
Long-tailed Jaeger (*Stercorarius longicaudus*)	11 June	8 June	25-50	50-75
Spectacled Eider (*Somateria fischeri*)	12 June	16 June	25-50	5
Buff-breasted Sandpiper (*Tryngites subruficollis*)	15 June	16 June	25	5
Long-billed Dowitcher (*Limnodromus scolopaceus*)[b]	29 June	16 June	0	5

[a] Birds on study area when investigators arrived.
[b] No nest found but adult observed "feigning".

Table 2. Number of nesting birds per square km at Point Storkersen in 1974 and 1975.

Species	June 1974 15-16	June 1974 28-29	June 1975 9-10	June 1975 16-18
Arctic Loon	1.3	1.2	0.0	1.3
Red-throated Loon	0.5	1.0	0.0	0.8
Whistling Swan	0.0	0.0	0.0	0.0
Black Brant	1.0	0.0	0.0	0.3
White-fronted Goose	1.4	0.9	0.3	1.0
Pintail	0.9	4.0	0.3	0.3
King Eider	8.9	2.2	0.3	4.6
Spectacled Eider	1.8	0.6	0.0	1.0
Oldsquaw	5.0	4.1	0.3	3.8
American Golden Plover	3.1	2.1	0.1	0.8
Black-bellied Plover	0.4	0.0	0.1	0.6
Ruddy Turnstone	3.2	0.0	0.0	0.0
Buff-breasted Sandpiper	5.1	9.0	0.0	2.5
Pectoral Sandpiper	5.1	9.0	3.8	12.5
Dunlin	21.2	18.6	17.5	10.6
Long-billed Dowitcher	0.0	1.3	0.0	0.0
Baird's Sandpiper	0.4	1.3	0.0	0.0
Semipalmated Sandpiper	19.2	14.1	19.4	14.4
Red Phalarope	26.3	27.5	15.6	33.1
Northern Phalarope	0.0	0.0	0.0	0.6
Parasitic Jaeger	0.4	0.5	0.5	0.5
Long-tailed Jaeger	0.4	0.2	0.1	0.0
Glaucous Gull	0.1	0.0	0.0	0.0
Lapland Longspur	28.9	16.7	48.8	26.9
Snow Bunting	1.9	0.4	0.6	0.0

	July				August
	1974		1975		1974
23-24	12-13	27-28	7-8	19-20	9-10
1.2	1.0	2.9	1.8	1.0	2.2
0.8	0.4	0.5	0.4	0.1	0.1
0.0	0.2	0.0	0.5	0.0	0.0
0.5	0.0	0.0	0.0	0.0	0.0
1.4	0.0	0.0	0.3	0.0	0.4
2.7	0.2	0.0	0.0	0.0	19.0
2.7	1.7	0.1	0.5	5.1	0.9
0.6	0.0	0.6	0.5	0.0	0.6
1.8	7.0	1.2	3.5	2.2	0.1
1.7	0.4	2.1	1.0	0.0	0.0
0.4	0.1	2.2	0.9	1.4	1.3
0.0	0.0	0.0	0.0	1.3	0.0
3.8	0.4	0.0	2.5	0.0	3.2
16.9	3.2	2.5	29.4	8.1	40.4
10.6	23.1	26.3	25.0	12.5	16.0
0.0	1.3	0.0	0.6	0.0	0.4
0.6	1.9	0.0	5.0	0.0	0.4
14.4	18.0	47.0	18.1	12.5	17.3
23.1	8.3	3.2	23.1	15.0	83.9
5.0	0.0	0.4	1.3	2.5	53.2
0.5	0.2	0.1	0.9	0.5	0.0
0.0	0.0	0.1	0.0	0.1	0.0
0.0	0.0	0.0	0.0	0.0	0.0
23.1	8.3	19.2	20.6	10.6	5.1
1.3	2.5	0.0	0.6	0.0	0.0

primarily because of flying juveniles and perhaps some immigration. Two other shorebirds that were especially numerous were semipalmated sandpipers (14.1 to 19.4 birds/km^2 in June) and dunlins (10.6 to 21.2 birds/km^2 in June).

Oldsquaws and king eiders were the most abundant breeding waterfowl. Populations declined as male eiders left the study area in early July and male oldsquaws departed in mid-July to join others of their species in molt migrations. Pintails, mostly non-breeding, and white-fronted geese were conspicuous during June, and again in August following molt and preceding migration. A pair of whistling swans nested just east of the main study area in 1974, and frequented several lakes within the area throughout the summmer. Swans also were seen feeding on several lakes in 1975, but their breeding status was unknown. Some waterfowl undergo their annual wing-molt on the study area. Approximately 50 oldsquaws, primarily females, spent their flightless period on two large lakes in 1974, and a flightless white-fronted goose was observed on one of these lakes in 1975. Based on shed feathers, pintails also molted on the area.

Lapland longspurs were the most numerous of breeding passerines, reaching June densities of 16.7 to 48.8 birds/km^2. Snow buntings, the only other passerine nesting at Point Storkersen, were concentrated near the coast.

Quantitating bird production was difficult because young were very mobile after leaving the nest. Many young shorebirds and lapland longspurs were encountered on the tundra in early July during survey activities. In 1974, one spectacled eider brood and one whistling swan brood were observed. A brood of white-fronted geese and three king eider broods were observed on freshwater lakes in July 1975, and two black brant broods were observed along the Beaufort Sea coast.

Non-nesting species

Twenty-six species were observed during 1974 and 1975 at Point Storkersen but were not found nesting (Table 3). Thirteen species were represented only by early June migrants, such as common loons, yellow-billed loons, lesser snow geese, mallards, and American wigeons. Snowy owls, common ravens, arctic terns, and glaucous gulls all foraged on the study area; the latter two nested on offshore islands. Thirty adult Sabine's gulls fed intensively on Class II ponds from 9 to 11 August 1974.

Experimental Oil Spills

The shallow-Carex ponds used in this study freeze completely during winter. In spring, they thaw from top to bottom and from the edges toward the center. Thawing began about 7-8 June in both years with study ponds becoming icefree about 13-14 June. No difference was observed between oiled and control ponds in timing and pattern of thaw in either year.

Spills in 1974 and 1975 were similar. Prevailing winds spread the slick across the entire pond within five minutes. The oil spread in bands of increasing thickness identifiable by color: the thinnest band was a silver sheen, followed by multi-colored and bronze bands and finally

Table 3. Birds observed but not found nesting at Point Storkersen in 1974 and 1975.

Species	Date of first observation 1974	Date of first observation 1975	Status[a]	Total number seen 1974	Total number seen 1975
Common Loon (Gavia immer)	-[b]	6 June	A	0	6
Yellow-billed Loon (Gavia adamsii)	11 June	-[b]	A	4	0
Canada Goose (Branta canadensis)	12 June	16 June	D	14	28
Lesser Snow Goose (Anser caerulescens)	8 June	29 June	D	12	6
Mallard (Anas platyrhynchos)	13 June	-[b]	A	2	0
American Wigeon (Anas americana)	31 May	-[b]	A	6	0
Greater Scaup (Aythya marila)	-[b]	18 June	A	0	9
Common Eider (Somateria mollissima)	30 May	3 June	D	3	12
Surf Scoter (Melanitta perspicillata)	7 July	-[b]	B	2	0
Red-breasted Merganser (Mergus serrator)	7 July	-[b]	B	2	0
Stilt Sandpiper (Micropalma himantopus)	2 Aug.	-[b]	C	-[c]	0
Whimbrel (Numenius phaeopus)	-[b]	17 July	B	0	1
Pomarine Jaeger (Stercorarius pomarinus)	31 May	3 June	A,B	23	100

Sabine's Gull (Xema sabini)	9 Aug.	-[b]	C	30	0
Arctic Tern (Sterna paradisaea)	5 June	7 June	D	-[c]	83
Snowy Owl (Nyctea scandiaca)	31 May	6 June	D	-[c]	53
Short-eared Owl (Asio flammeus)	11 June	4 June	A	1	2
Cliff Swallow (Petrochelidon pyrrhonota)	-[b]	7 June	A	0	1
Bank Swallow (Riparia riparia)	-[b]	5 June	A	0	1
Common Raven (Corvus corax)	30 May	5 June	D	8	16
Wheatear (Oenanthe oenanthe)	-[b]	1 July	B	0	1
Water Pipit (Anthus spinoletta)	-[b]	7 June	A	0	1
Redpoll (Acanthis spp.)	8 June	8 June	A,B	7	4
Savannah Sparrow (Passerculus sandwichensis)	-[b]	9 June	A	0	1
Dark-eyed Junco (Junco hyemalis)	5 June	-[b]	A	1	0
Tree Sparrow (Spizella arborea)	2 June	-[b]	A	2	0

[a]Status: after Bergman 1974 (A = May or June visitor; B = July visitor; C = August visitor; D = Forages on area from nearby nesting or roosting areas).

[b]Species not observed.

[c]Reliable estimates not available.

a dark brown sludge. Evaporation of the volatile fractions of crude oil resulted in disappearance of most traces of the 1974 spills within four hours as reported also by Snow and Scott (1975). Oil accumulated around emergent Carex aquatilis and along the downwind shore. Shifting winds redistributed the oil so that all shorelines eventually were covered. Mosses and peat soils along shore absorbed oil and released films when disturbed. This phenomenon was especially evident in the heavier 1975 spills, but was seen throughout the 1975 periods on pond 36 that was oiled lightly in 1974. Thick black oil residues remained at the end of the season along the margins of all 1975 treated ponds.

Physical characteristics of all ponds are summarized in Table 4. Water level declines were similar in both treated and control ponds. In shallow ponds such as these, insolation of oil darkened sediments might be expected to increase temperatures and speed thawing. However, the difference in thaw depth was not significant in this study (Figure 4).

The distinct diel pattern in water temperatures of shallow arctic ponds reported by Danks (1971) also was recorded in this study, but lack of replication does not allow a statistical comparison of oiled and control ponds. Specific conductivity and pH exhibited slight seasonal variations also reported by Howard (1974), but no difference was detected between oiled and control ponds.

Table 4. Physical and chemical characteristics of control and experimental ponds.

Pond	size (ha)	Mean water depth (cm)	Mean thickness of bottom sediments (cm)	pH mean (range)	Specific conductivity micromhos/cm mean (range)[a]
Control					
23	0.2	19.8	21.4	8.5 (7.5-9.0)	480 (425-575)
30	0.1	18.2	33.4	8.9 (8.4-9.1)	535 (475-625)
33	0.15	18.3	34.0	8.8 (8.5-9.1)	500 (475-525)
Oiled 1974					
7	0.2	20.7	21.3	8.6 (7.5-9.0)	460 (425-550)
32	0.15	20.4	28.0	8.7 (8.0-9.0)	525 (500-550)
36	0.1	19.3	31.4	8.8 (8.0-9.1)	545 (510-560)
Oiled 1975					
31	0.1	22.5	25.2	8.5 (8.0-9.0)	455 (420-525)
37	0.1	17.3	20.9	8.5 (8.0-8.8)	515 (450-550)
39	0.04	9.8[b]	55.7[b]	8.3 (8.0-8.5)[b]	640 (525-750)[b]

[a]Measured in 1975 only.
[b]Measured third week of July 1975 only.

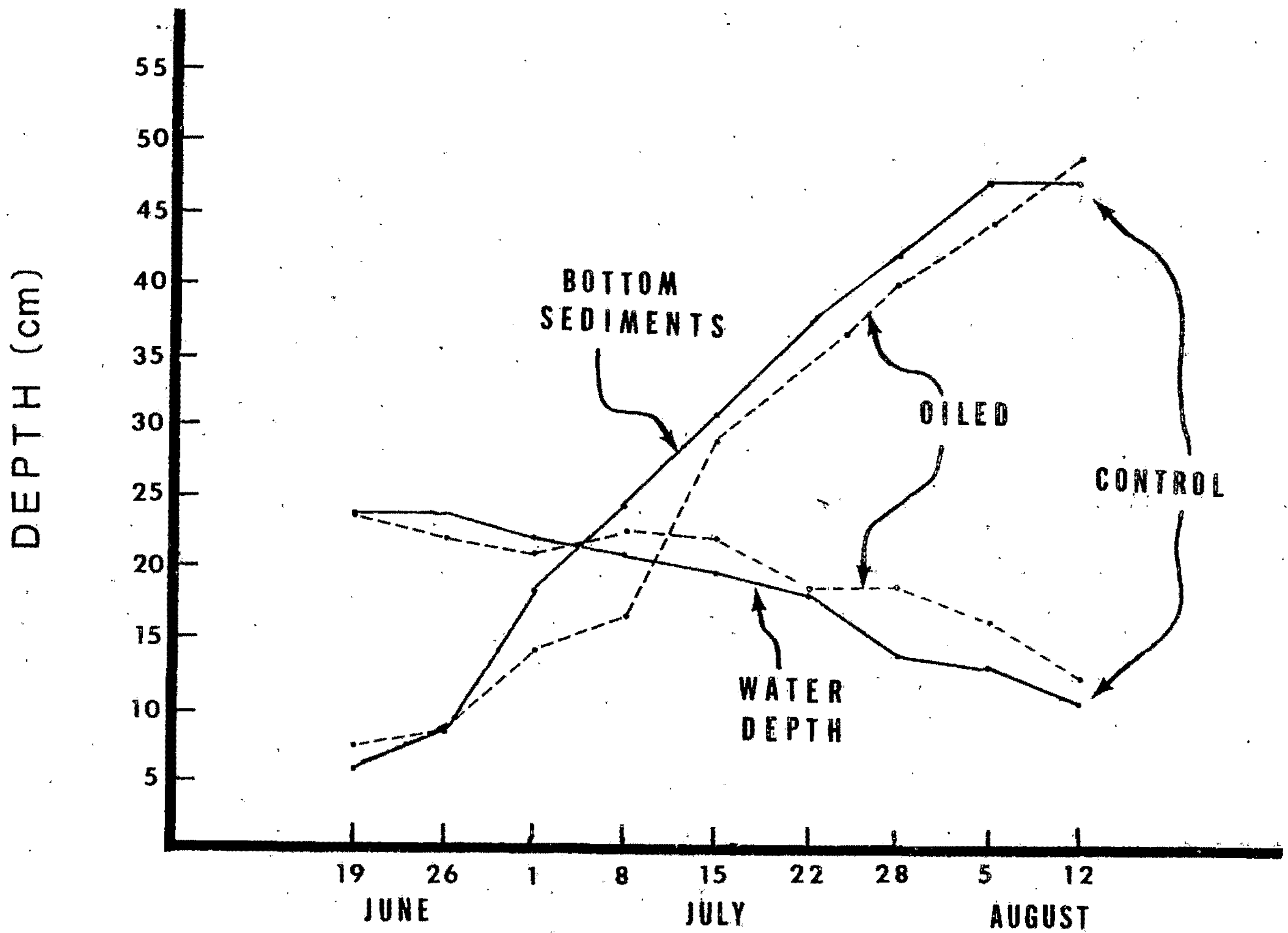

Figure 4. Seasonal variations in pond water depth and thickness of bottom sediments during summer 1974.

Invertebrate populations - 1974 spills

Total number of organisms per square meter showed a marked seasonal pattern (Figures 5 and 6). In Ekman samples, midge larvae (Chironomidae) were by far the most abundant invertebrates, and emergence of adults accounted for seasonal lows of total organisms, as also reported by Howard (1974) and Snow and Rosenberg (1975a). Some taxa were not collected in sweep samples during the pre-spill period, including water fleas (Chydoridae), seed shrimp (Ostracoda), and tadpole shrimp (Notostraca), but were present in post-spill samples as both number and size of individuals increased.

In 1974, species composition of invertebrates was nearly identical in control and experimental ponds prior to experimental oiling. Invertebrates living in the sediments were not significantly affected in 1974 by the application of crude oil at a rate of 19.0 liters/ha, whereas free-swimming species and those on emergent vegetation or the surface of sediments were significantly reduced. Fairy shrimp (Anostraca) were completely eliminated from oiled ponds by the second week following the spills, while populations in the control ponds increased (Figure 6). Copepod and diving beetle (Dytiscidae) populations were significantly lower in oiled ponds than in control ponds ($P<0.05$).

Invertebrate populations in ponds treated in 1974 had recovered by 1975 and were not significantly different from controls; populations in 1975 did not reach the levels of 1974 in either control or treated ponds (Figure 5). All taxa present in 1974 pre-spill period were represented in 1975, including fairy shrimp, which were abundant in all ponds.

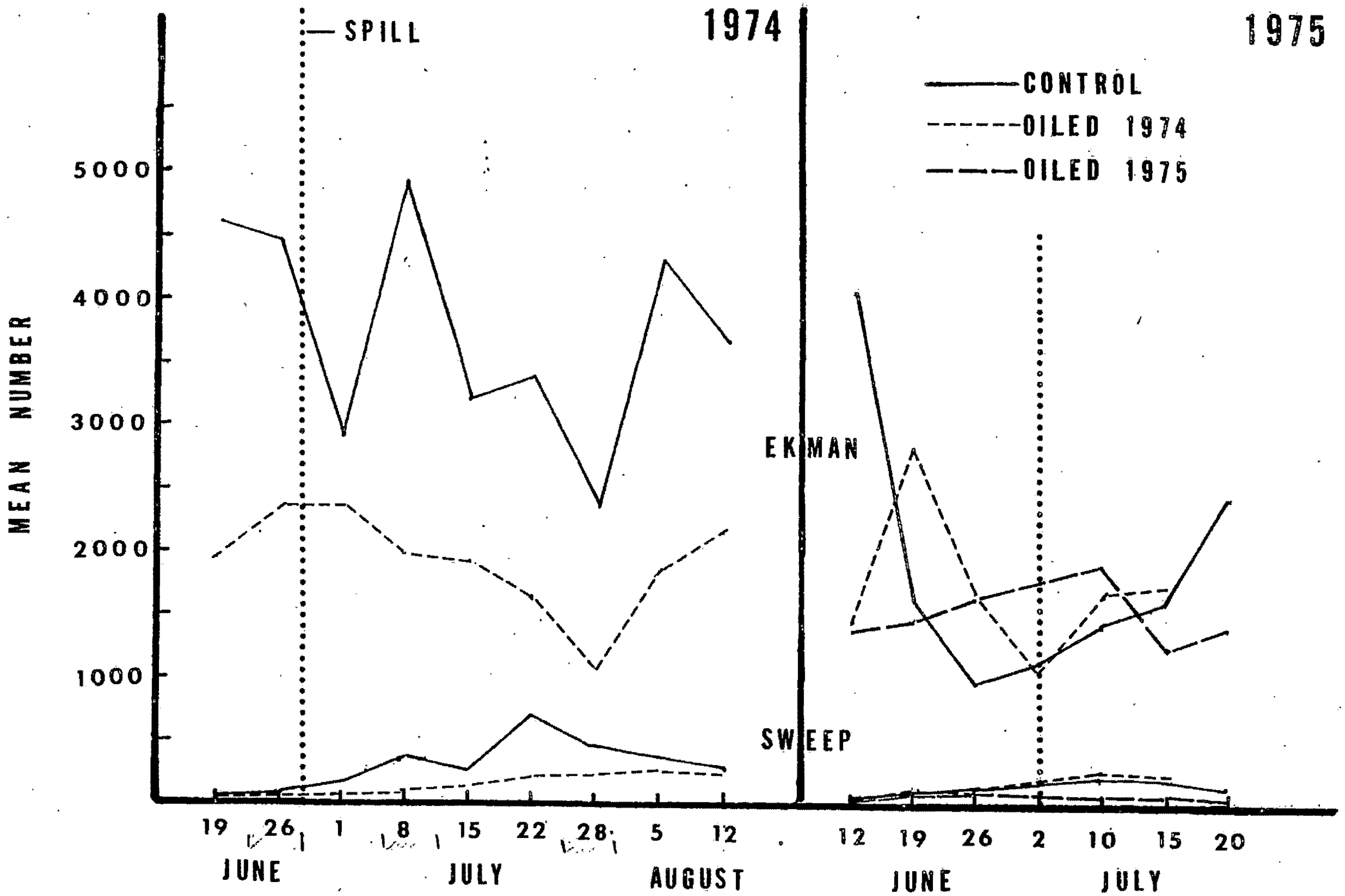

Figure 5. Seasonal variations in abundance of macroinvertebrates in control and experimental ponds during 1974 and 1975.

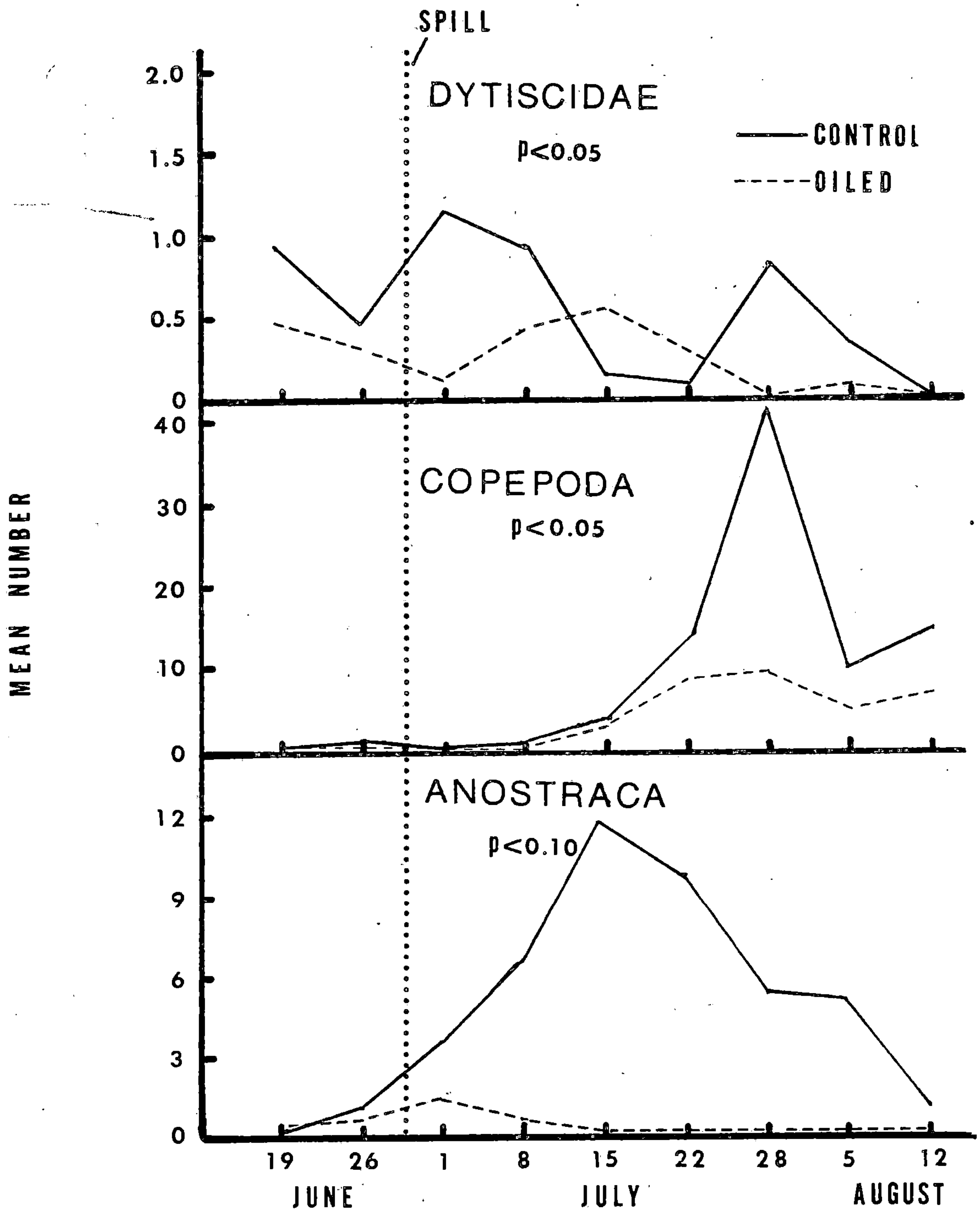

Figure 6. Abundance of some macroinvertebrates in relation to time of season and experimental oil spills.

Invertebrate populations - 1975 spills

As in 1974, samples taken in 1975 showed that control and treatment ponds had similar species composition and invertebrate populations in the pre-spill period. Benthos seemed unaffected by the addition of the crude oil (Figure 5), but sweepnet samples in oiled ponds following the spills contained few living organisms. All free-swimming invertebrates and those on vegetation or the surface of sediments suffered high mortality at the 2000 liter/ha rate of contamination. Many adult Diptera were also killed when they became immersed in oil.

Storkersen Well pond

The pond adjacent to the Storkersen Well was severely contaminated with oil, drilling muds and wastes, and other petroleum by-products, some time between drilling in 1969 and initiation of the study in 1971. All emergent vegetation is dead and pond shorelines are covered with thick oil residues. Bottom sediments are severely contaminated, and release oil slicks even when slightly disturbed. No living macroinvertebrates were found in samples from this pond in 1972 or 1973 by Howard (1974), or in the samples I took in 1974 and 1975.

Observations of birds at experimental ponds

Red phalaropes, oldsquaws, and northern phalaropes used the study ponds most frequently. Other species observed on study ponds included king eiders, dunlins, pectoral sandpipers, semipalmated sandpipers, golden plovers, and ruddy turnstones.

Phalaropes fed on the ponds throughout the season but reached their highest levels during late June to mid-July when females gathered in pre-migratory flocks (Figure 7). Oldsquaws and king eider pairs fed on ponds during the pre-laying and laying periods, and females continued to use them after males had departed. Females often fed constantly when they were on the ponds, while their mates swam quietly alongside or rested on the shore.

Oiled and control ponds were used equally prior to the spill in 1974; phalaropes comprised 35% of the birds on control ponds and 26% on oiled ponds, while oldsquaws were 5% and 7% respectively, during this period. Contaminated ponds had significantly fewer visits after the spill ($P<0.05$). Phalaropes and oldsquaws decreased to 18% and 9% on oiled ponds, compared to 37% and 18% on control ponds. However, in 1975, control ponds and ponds treated in 1974 were used equally. Ponds oiled in 1975 were used as much as control ponds prior to oil spills but oiled ponds had very little activity following the spill compared to control ponds ($P<0.01$). Red phalaropes landed on the ponds within an hour after oil was poured, but remained only a few seconds and did not feed. A male oldsquaw dived repeatedly for nearly an hour on 15 July 1975 on a treated pond two weeks after the spill. Invertebrate sweep samples taken at this time contained few organisms, suggesting the bird was feeding on benthos in sediments. A young dunlin was captured on 18 July as it flushed from the emergent vegetation of oiled pond 31. Its feathers were matted and bare skin was exposed in several places. The pond had been oiled on 2 July.

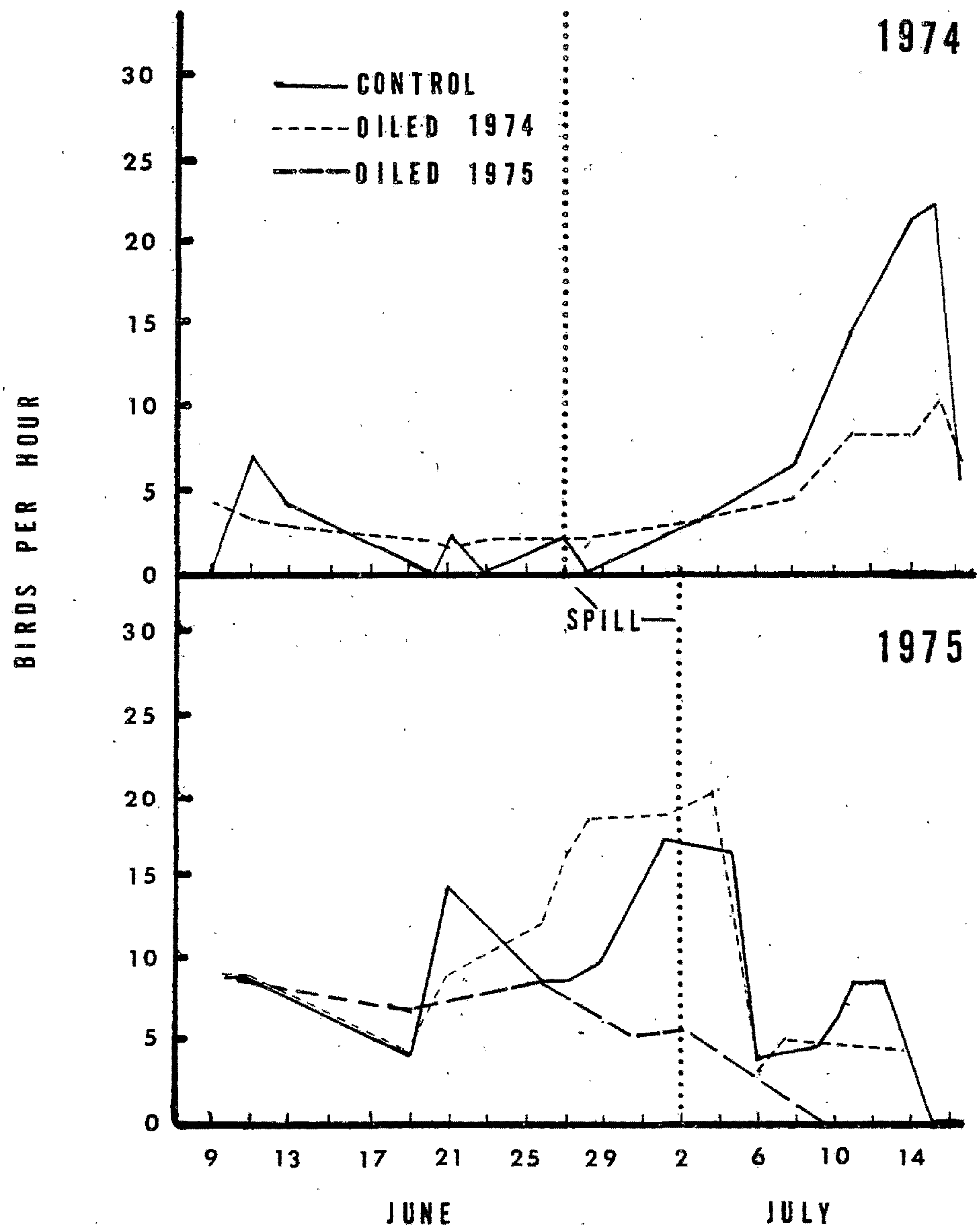

Figure 7. Occurrence of birds on control and oiled ponds in relation to time of season and experimental oil spills.

DISCUSSION AND RECOMMENDATIONS

The potential loss of wetland resources due to accidental oil spills is a serious threat to the welfare of waterbird populations on the Arctic Coastal Plain. In this study, important food organisms such as fairy shrimp and copepods were eliminated or reduced temporarily even at the lowest level of oil contamination. When levels were increased, nearly all organisms not living in bottom sediments were killed.

Sediments of ponds lightly oiled in 1974 were relatively unaffected and invertebrate and bird populations recovered by 1975. Long term effects of the heavier spill made in 1975 cannot yet be assessed, but Snow and Rosenberg (1975b) reported differential recovery of littoral zoobenthos. Evidence gathered from Storkersen Well pond, in which sediments were severely contaminated, indicates that the pond supports no organisms useful to feeding birds. Fewer birds used oiled ponds following spills in both years when compared to control ponds.

Transportation of oil from wells to gathering stations will be accomplished by a system of collection pipes transversing large areas of wetlands. Every effort must be made to minimize damage to wetlands resulting from accidental oil spills, and the following recommendations are made with this in mind: 1) Whenever possible, collection pipes should not be placed across or near flowing water systems which would spread oil to other wetlands during flood stages; 2) emergency plans must be made for immediate control of all spills; and 3) removal of residual oil is essential to reduce the incorporation of oil into sediments and the possibility of birds becoming oil-covered by contact with surface slicks and contaminated vegetation.

SUMMARY

Current development of oil resources near Prudhoe Bay poses a threat to the persistence of wetland communities. The possibility of crude oil spills threatens both waterbirds and their wetland resources. This study was designed to: (1) supplement data on bird populations and their selection of habitats, and (2) determine immediate effects of crude oil contamination on aquatic macroinvertebrates and bird activity in certain wetlands.

Between 30 May and 14 August 1974, and 31 May to 21 July 1975, field research was conducted at Point Storkersen, Alaska, near Prudhoe Bay. Bird populations were estimated weekly or biweekly on census plots and transects established by Bergman (1974). Nine ponds were selected for a study of oil contamination in wetlands. Weekly invertebrate sampling and observations of bird activity were designed to assess the impact of different rates of experimentally spilled oil.

Red phalaropes were the most abundant nesting birds in both 1974 and 1975. Semipalmated sandpipers and dunlins were also numerous. Oldsquaws and king eiders were the most numerous nesting waterfowl, although pintails (mostly males) were also common. Oldsquaws, white-fronted geese, and probably pintails molted their flight feathers on the study area.

Invertebrate species composition was similar in all ponds during pre-spill periods. Selective reduction of some taxa, including Anostraca and Copepoda, followed light spills in 1974 (19 liters/ha), although total numbers were not significantly different between oiled and control ponds.

A marked seasonal pattern was noted in all wetlands. In 1975, spills at higher rates (2000 liters/ha) significantly reduced all surface and swimming species to very low numbers. Benthos was relatively unaffected in both years. Although fairy shrimp (Anostraca) had been eliminated in oiled ponds in 1974, they had recovered in all ponds by 1975. Phalaropes and oldsquaws were the most frequent users of the ponds. Frequency of visits of all birds decreased significantly on oiled ponds following treatment in both 1974 and 1975. Ponds treated in 1974 were used as much in 1975 as were the controls.

Potential loss of wetland resources due to accidental oil spills is a serious threat to the bird populations on the Arctic Coastal Plain. Placement of collection pipes for transporting oil should avoid high use areas and streams which would carry spilled oil. Emergency plans for immediate control and removal of spilled oil are essential.

LITERATURE CITED

Bartonek, J. C. 1972. Summer foods of American widgeon, mallards, and a green-winged teal near Great Slave Lake, N.W.T. Can. Field-Nat. 82(2):140-144.

Bartonek, J. C., and J. J. Hickey. 1969. Selective feeding by juvenile diving ducks in summer. Auk 86(3):443-457.

Bengston, S. A. 1971. Food and feeding of diving ducks breeding at Lake Myvatn, Iceland. Ornis Fenn. 48:77-92.

Bengtsson, L., and H. Berggren. 1972. The bottom fauna of an oil-contamined lake. Ambio 1(4):141-144.

Bergman, R. D. 1974. Wetlands and waterbirds at Point Storkersen, Alaska. Ph.D. Thesis, Iowa State Univ., Ames. 58 pp.

Black, R. F. 1969. Geology, especially geomorphology of northern Alaska. Arctic 22(2):283-299.

Black, R. F. and W. L. Barksdale. 1949. Oriented lakes of northern Alaska. J. Geol. 57(2):105-118.

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. Resource Publ. 96. 24 pp.

Chura, N. J. 1961. Food availability and preferences of juvenile mallards. Trans. N. Am. Wildl. Nat. Resources Conf. 26:121-134.

Collias, N. E., and E. C. Collias. 1963. Selective feeding by wild ducklings of different species. Wilson Bull. 75(1):6-14.

Danks, H. V. 1971. Spring and early summer temperatures in a shallow arctic pond. Arctic 24(2):113-123.

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

Holmes, R. T., and F. A. Pitelka. 1968. Food overlap among coexisting sandpipers on northern Alaska tundra. Syst. Zool. 17:305-318.

Howard, R. L. 1974. Aquatic invertebrate-waterbird relationships on Alaska's Arctic Coastal Plain. M.S. Thesis, Iowa State Univ., Ames. 49 pp.

Hurd, P. D., Jr., and F. A. Pitelka. 1954. The role of insects in the economy of certain Arctic Alaskan birds. Proc. Alaskan Sci. Conf. 3:136-137.

Hussey, K. M., and R. W. Michelson. 1966. Tundra relief features near Point Barrow, Alaska. Arctic 19(2):162-184.

Johnson, P. R., and C. W. Hartman. 1969. Environmental atlas of Alaska. Univ. of Alaska, College. 111 pp.

Katz, L. M. 1973. The effects of water soluble fraction of crude oil on larvae of the decapod crustacean Neopanope texama (Sayi). Env. Poll. 5(3):199-204.

Kessel, B., and T. J. Cade. 1958. Birds of the Colville River, northern Alaska. Univ. Alaska Biol. Paper No. 2. 83 pp.

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

Kontogiannis, J. E., and C. J. Barnett. 1973. The effect of oil pollution on survival of the tidal pool copepod, Tigriopus californicus. Env. Poll. 4(1):69-79.

Krapu, G. L., and G. A. Swanson. 1975. Some nutritional aspects of reproduction in prairie nesting pintails. J. Wildl. Manage. 39(1): 156-162.

Krull, J. N. 1968. Are we neglecting the importance of animal foods in a duck's diet? Ducks Unlimited 31(3):12.

Moyle, J. B. 1961. Aquatic invertebrates as related to larger water plants and waterfowl. Minnesota Dept. Conserv. Rept. No. 233. 24 pp.

Payne, T. C., S. W. Dana, W. A. Fischer, and G. Grvc. 1951. Geology of the Arctic Slope of Alaska. U.S. Dept. Int. Geol. Surv. Map OM-126.

Pitelka, F. A. 1959. Numbers, breeding schedule, and territoriality in pectoral sandpipers of northern Alaska. Condor 61:233-264.

Snow, N. B., and D. M. Rosenberg. 1975a. Experimental oil spills on Mackenzie Delta lakes. I. Effects of Norman Wells crude oil on Lake 4. In G. J. Brunskill, ed. Ecological studies of aquatic systems in the Mackenzie-Porcupine drainages in relation to proposed pipeline and highway developments. Vol. III. Canada Task Force N. Oil Dev. Env. Soc. Comm., Winnipeg.

Snow, N. B., and D. M. Rosenberg. 1975b. Experimental oil spills on Mackenzie Delta lakes. II. Effect of two types of crude oil on Lakes 4C and 8. In G. J. Brunskill, ed. Ecological studies of aquatic systems in the Mackenzie-Porcupine drainages in relation to proposed pipeline and highway developments. Vol. III. Canada Task Force N. Oil Dev. Env. Soc. Comm., Winnipeg.

Snow, N. B., and B. F. Scott. 1975. The effect and fate of crude oil spilt on two arctic lakes. Proc. Conf. on Prevention and Control of Oil Pollution 1975:527-534.

Weller, M. W. 1972. Ecological studies of Falkland Islands' waterfowl. Wildfowl 23:25-44.

Wiggins, I. L., and J. H. Thomas. 1962. A flora of the Alaskan Arctic Slope. Arctic Inst. N. Am., Spec. Publ. No. 4. 425 pp.

ACKNOWLEDGMENTS

This study was funded by the U.S. Fish and Wildlife Service. I am grateful to personnel at the Alaska area office in Anchorage for their help in preparation for and while I was in the field. I also thank the people of Atlantic Richfield Company and British Petroleum Operations Center for their help while I was conducting the study.

I am especially grateful to Dr. Milton W. Weller for his guidance, inspiration and patience during all stages of the project and preparation of this thesis. I also thank the other members of my committee, Drs. Kenneth D. Carlander and David F. Cox, for their contribution to this thesis and my graduate education.

Robert Howard and the late Dr. Robert D. Bergman suggested the project and prepared me for the first season. Doug Janke and Dr. Dirk V. Derksen shared the work and discomforts as well as the excitement of the Arctic. The generous attitude of these friends made the effort worthwhile and the experience worth remembering.

Jolene Schnur typed this manuscript and skillfully handled the many problems which arose while I was away, for which I express my sincere appreciation.

APPENDIX A: WEATHER CONDITIONS AT POINT STORKERSEN
DURING 1974 AND 1975 FIELD SEASONS

Table 5. Weather conditions at Point Storkersen during 1974 and 1975 field seasons.

	1974	1975
Fifty percent snow cover	10 June	10 June
No snow except where drifted	14 June	15 June
Small ponds ice free	18 June	11 June
All lakes ice free	8 July	2 July
Mean minimum temperature	$-0.6^{o}C$	$-0.9^{o}C$
Mean maximum temperature	$5.5^{o}C$	$4.6^{o}C$
Extreme minimum temperature	$-8.3^{o}C$	$-6.6^{o}C$
Extreme maximum temperature	$26.1^{o}C$	$21.1^{o}C$
Prevailing wind direction	NE = 35%	NE = 47%
Secondary wind direction	E = 27%	E = 20%
Percent of days with clear or partly cloudy skies	47%	41%
Percent of days with overcast skies	37%	43%
Percent of days with fog	17%	16%

APPENDIX B: INVERTEBRATES COLLECTED AT POINT STORKERSEN IN 1974 AND 1975

- Class--Oligochaeta

- Class--Crustacea
  - Order--Anostraca
    - Family--Branchinectidae
      - *Branchinecta paludosa* (O. F. Muller) fairy shrimp
    - Family--Polyartemiidae
      - *Polyartemiella hazeni* (Murdock)
  - Order--Notostraca
      - *Lepidurus arcticus* (Pallas) tadpole shrimp
  - Order--Cladocera
    - Family--Daphnidae
      - *Daphnia pulex* (de Geer)
    - Family--Chydoridae
      - *Eurycerus lamellatus* (O. F. Muller)
  - Order--Copepoda
  - Order--Ostracoda

- Class--Arachnida
  - Order--Acari
  - Order--Araneae

- Class--Insecta
  - Order--Collembola
  - Order--Plecoptera Stoneflies
    - Family--Nemouridae
      - *Nemoura* sp.
  - Order--Tricoptera
    - Family--Limnephilidae
  - Order--Coleoptera
    - Family--Dytiscidae
  - Order--Diptera
    - Family--Tipulidae
    - Family--Chironomidae
    - Family--Muscidae

- Class--Gastropoda
  - Order--Pulmonata
    - Family--Physadae
      - *Physa* sp.