CHAPTER 3

Fish

by

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SUMMARY AND CONCLUSIONS

A fish study of limited duration (25 July-5 August) was undertaken in 1982 to determine if fish utilization of partially-closed, pulsing lagoons in the eastern Alaskan Beaufort Sea was similar to that in more open lagoons (e.g. Simpson Lagoon, a barrier-island lagoon system in the central Beaufort).

Results suggested that both types of lagoons are used by anadromous (arctic cisco and arctic char) and marine (arctic flounder and fourhorn sculpin) species for feeding on epibenthic invertebrates during the open-water season. The absence of least cisco, broad and humpback whitefishes in the eastern Beaufort is attributed more to the lack of spawning populations in nearby rivers thanto the absence of required habitat in the nearshore waters. Large individuals of arctic cisco, arctic char and fourhorn sculpin occur in similar abundances in all lagoons sampled from Pt. Barrow, Alaska to the Mackenzie 'River Delta, Northwest Territories. Smaller individuals of these species were less uniformly distributed among coastal habitat types.

INTRODUCTION

The rapid pace of oil and gas development activities in the Alaskan Beaufort Sea has increased the need to assess the potential impact of these activities at a variety of locations along the coast. In partial response to this need, detailed information on the fish use of Simpson Lagoon, a barrier-island lagoon system relatively open to the sea, was collected between 1977 and 1979 and this knowledge was used to determine the vulnerability of habitat types in this system to future development. The results of the study showed that Simpson Lagoon was used by anadromous and marine fishes to feed extensively on epibenthic invertebrates and to accumulate food reserves for spawning and/or overwintering. In addition, the results suggested that food was plentiful in the preferred habitats of the fish. The present study was initiated to compare the fish use of the relatively closed, pulsing lagoons located in the eastern portion of the Alaskan Beaufort Sea to that found in the more open lagoons typified by Simpson Lagoon.

Sufficient data had been gathered on the fish resources in the study area to reliably predict what species were likely to be present, their overall life history characteristics and to some degree their' temporal patterns of abundance. These predictions were based primarily on the results from Kaktovik Lagoon, just west of the proposed study area, and Nunaluk Lagoon some 100 km to the east. The approach used in this study was to utilize the available information in conjunction with new data collected from the closed or pulsing lagoons in the eastern Alaskan Beaufort Sea.

Objectives of the study were to:

1. Examine previously conducted studies (in or adjacent to the study area) in relation to fish use of different types of Beaufort Sea coastal habitats.
2. Examine fish use of a pulsing lagoon and adjacent waters and compare the composition and spatial patterns of fish use observed to those of other lagoon types.
3. Compare the trophic significance of epibenthic invertebrates in the diets of key fish species in closed and cpen lagoon systems.

Knowledge about fish resources in the Beaufort Sea has advanced steadily during the past decade, and in central coastal areas is sufficiently detailed to allow comparisons among aquatic habitats and their uses by fish. Craig (1983) presents an overview of available information.

A considerable effort has been expended in studies of the Simpson Lagoon-Prudhoe Bay area (e.g. Bendock 1979, Moulton et al. 1980; Craig and Haldorson 1981, Craig and Griffiths 1981, Griffiths and Gallaway 1982). In the last few years several site-specific fish studies have been undertaken in this area including the Waterflood causeway study in Prudhoe Bay (Griffiths and Gallaway 1982) and summer use by fish of the Sagavanirktok Delta region (Griffiths et al. 1982).

By comparison, the level of information available for other areas is much less, although several useful studies have been conducted in the geographic region of emphasis for this project, Barter Island to

Demarcation Point. Survey efforts here have been generally adequate to determine species composition in various coastal habitats (Roguski and Komarek 1972, Ward and Craig 1974, Griffiths et al. 1977). Two particularly pertinent studies are seasonal examinations of fishes in Kaktovik Lagoon near Barter Island (Griffiths et al. 1977) and Nunaluk Lagoon in Canada (Griffiths et al. 1975).

STUDY AREA

The "PREFACE" to this volume gives a general description of the study area. However, Figure 3-1 in this Chapter on "FISH" gives specific locations of fyke and gill net sampling stations.

METHODS

Field investigations for this study were conducted over the period 25 July-5 August 1982. The program included the collection of water quality data (temperature and salinity) and biological data (fish) from both Angun and Beaufort lagoons.

Water Quality

Water temperature and salinity were measured daily at each operating fyke net sampling station and at each of the 13 gill net stations (see Fig. 3-l). In all cases, water temperatures were measured with in-glass mercury thermometers (±0.5°C) and salinities were measured using a YSI-33 salinity/conductivity meter (±0.9 ppt above 4°C; ±1.0 ppt below 4°C).

Fyke Net

Fyke net sampling was conducted daily at two sampling sites (see Fig. 3-l). This sampling method was selected as the best overall technique as it had been demonstrated by previous studies to be an efficient method for collecting both large (>250 mm) and small (<250 mm) fishes in Prudhoe Bay and adjacent areas (Bendock 1979, Craig and Haldorson 1981, Craig and Griffiths 1981, Griffiths and Gallaway 1982).

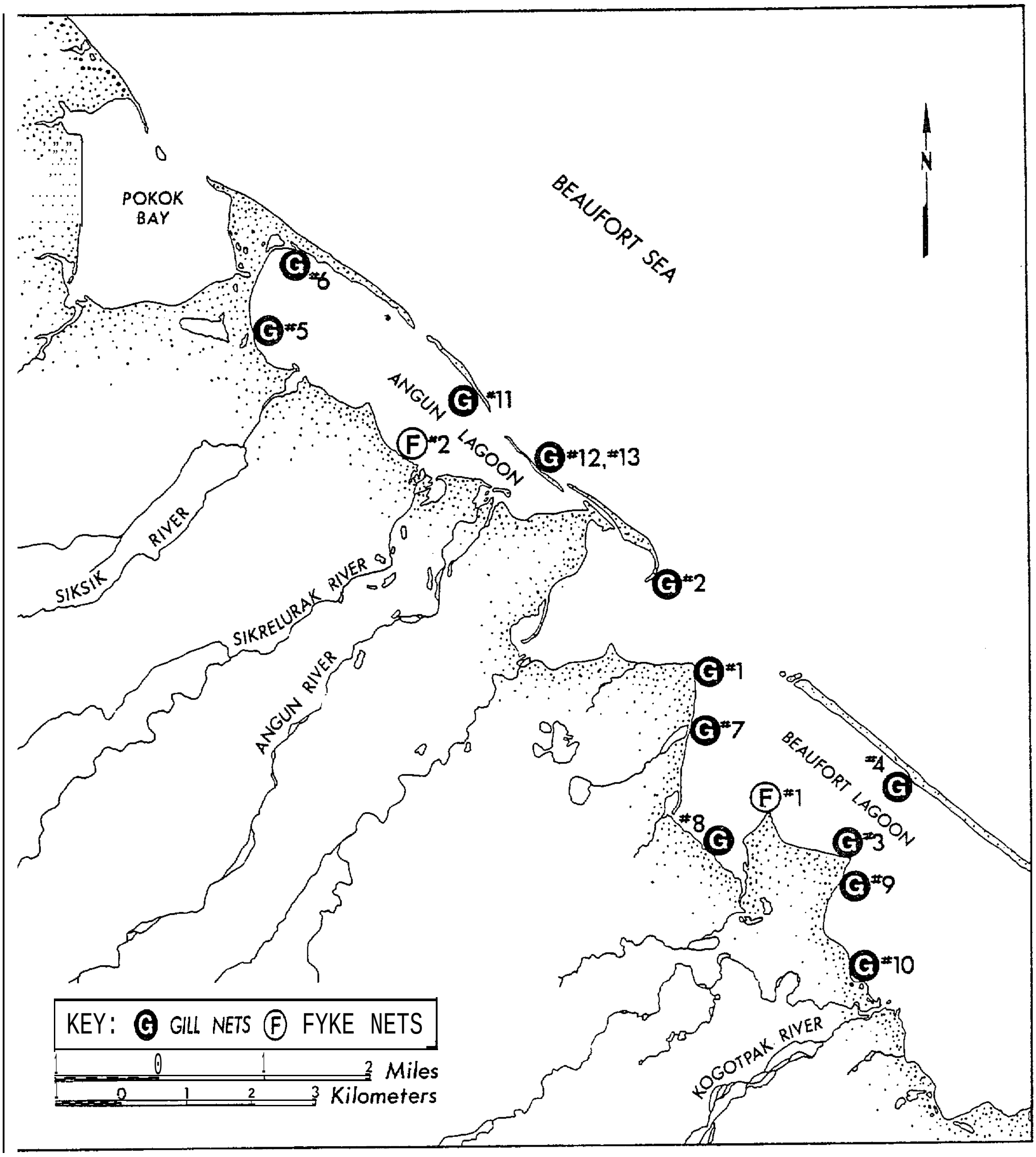

Figure 3-1. The eastern Beaufort Sea study area, showing Angun Lagoon and the western portion of Beaufort Lagoon (Nuvagapak Lagoon). Fyke net and gill net sampling stations are shown .

Fyke nets consisted of two cod-end traps with a single lead and two wings (Fig. 3-2). Traps consisted of a stainless steel frame mouth (1.8 x 1.2 m) attached to a knotless nylon net (3.7 x 0.9 x 0.9 m; 1.27 cm stretched mesh) and contained two throats (15 x 25 cm stretched mesh knotless nylon). The lead net (61 x 1.2 m; 2.5 cm stretched mesh knotless nylon) was connected to the center of the two frames. Fyke nets were set perpendicularly to shore so that the end traps were in approximately 1.0 m of water.

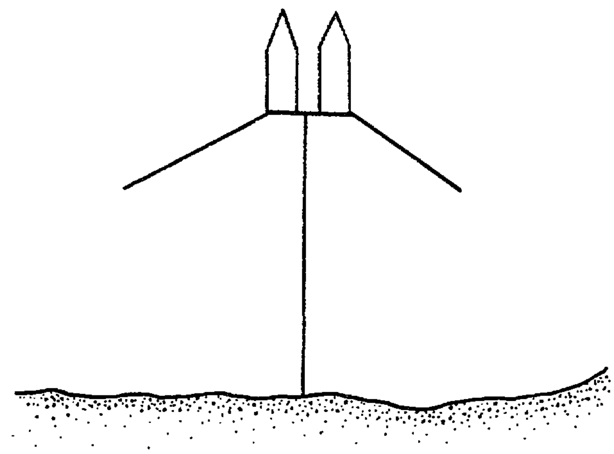

Fig. 3-2. Orientation of fyke nets used in Angun and Beaufort lagoons.

Weather permitting, the fyke nets were checked daily. Fish were emptied from the individual cod-ends into a holding pen attached to a boat. All specimens were identified, counted and measured (to the nearest 5 mm). In cases where large numbers of small fish (<250 mm) were collected, a subsample of 100 individuals of each species was dip-netted in a random fashion and measured.

Gill Net

In order to determine species composition and relative abundance of anadromous fish over a wide area, 13 sites were sampled by gill net (see Fig. 3-1). Each sample represents a 24-h gill net set. Each gill net used for this study was 45.7 x 1.8 m and was comprised of equal sized panels (1.54, 5.08 and 7.62 cm stretched mesh) of monofilament line. The following information was obtained for each specimen: species, total or fork length (to the nearest mm), wet weight (to the nearest g), sex and state of maturity, and stomach contents for dietary analyses.

Feeding Ecology

Stomach contents were identified in the field to the level of major taxa (e.g. amphipods, mysids, isopods, bivalves etc.) using the Hynes Point Method (Hynes 1950) which has been shown to be an adequate method for determining important organisms in the diets of birds and fish in Simpson Lagoon (Johnson and Richardson 1981, Craig and Haldorson 1981).

Beach Seine

Use of a large beach seine had been scheduled to aid in making density estimates of anadromous species; however, persistent high winds and poor ice conditions precluded the efficient use of this gear.

RESULTS AND DISCUSSION

This section compares results of the field sampling program with findings from other fisheries studies conducted along the Alaskan and Canadian Beaufort Sea coasts. Data describing daily collections and length-frequencies of fishes collected are presented in Appendices 3-I and 3-II.

Water Quality

Temperatures in both Angun and Beaufort Lagoons showed marked decreases during the Ii-day program (Fig. 3-3). This general cooling trend was due to the large amount of ice that piled up on the oceanside of the barrier islands and moved into both lagoons under the influence of the westerly winds that prevailed during most of the sampling period. Changes in salinity did not show a clear pattern. In Angun Lagoon the salinities tended to increase over the sampling period, but in Beaufort Lagoon salinities generally increased for most of the sampling period but decreased markedly during the last two sampling days (see Fig. 3-3).

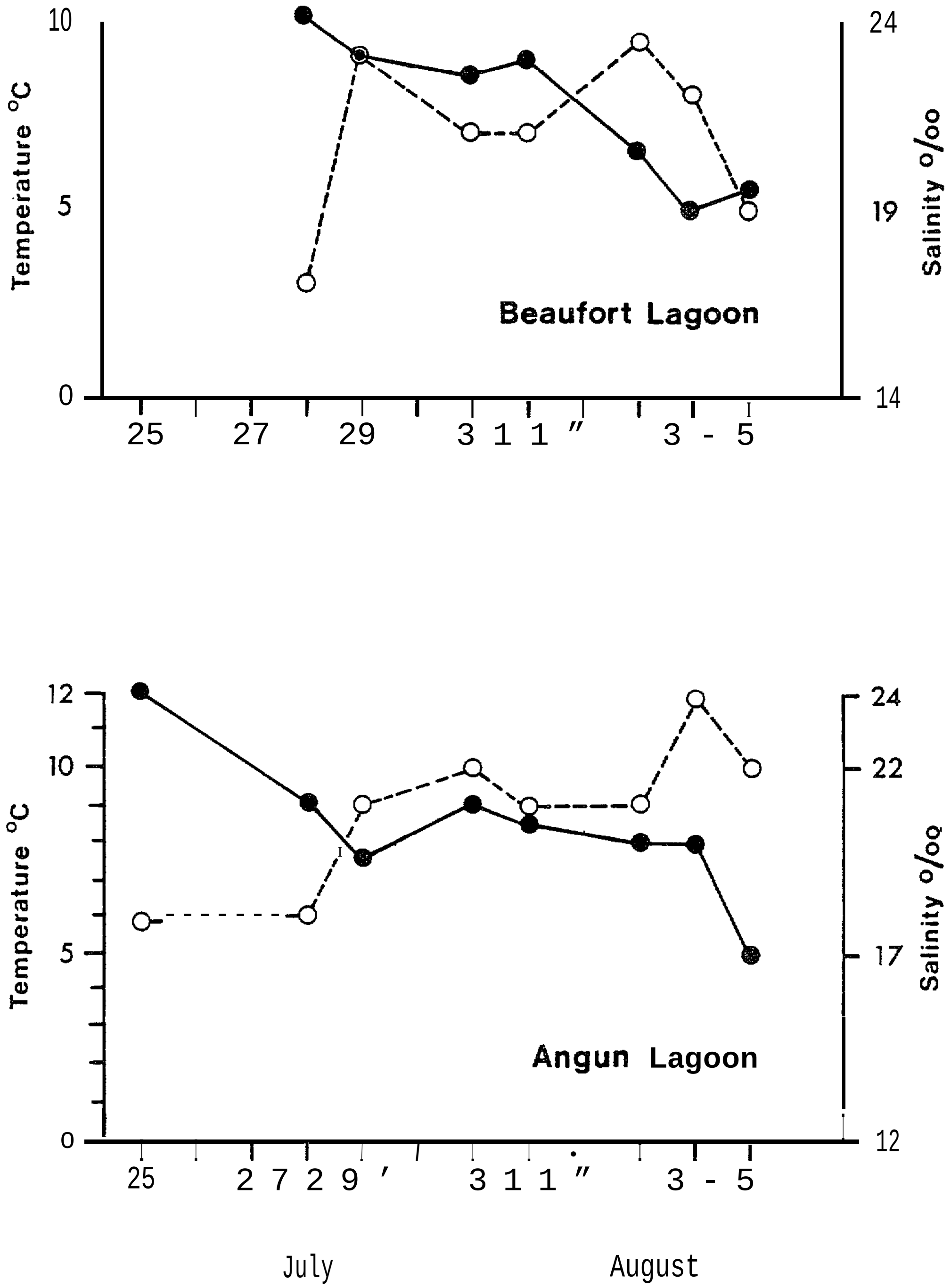

Figure 3-3. **Temperature and salinity** data collected at fyke net stations in Angun and Beaufort Lagoon 25 July-5 August 1982. Closed circles represent temperature measurements.

These salinity fluctuations are probably related to the uneven mixing of saline marine waters with brackish lagoon waters and fresh waters from streams.

Fish Populations

The fyke-netting and gillnetting efforts resulted in the capture of 2432 fish (nine species) and 276 fish (four species), respectively (Table 3-1). In fyke net samples, two marine species (fourhorn sculpin and arctic flounder) accounted for over 90% of the catch; the most abundant anadromous species were arctic cisco (4.2%) and arctic char (3.8%). In gill net samples, arctic char, arctic cisco and fourhorn sculpin collectively comprised over 99% of the catch. Somewhat similar results have been reported from Simpson Lagoon where marine species represented 70-79% of the total fyke-net catches during the two years of the study and anadromous species comprised 89% of the total gill net catch (Craig and Haldorson 1981). But the absence of such anadromous species as humpback and broad whitefishes and the low number of least cisco collected during the study contrasts with results from studies conducted from Prudhoe Bay to Pt. Barrow (Griffiths and Gallaway 1982, Craig and Haldorson 1981, Schmidt et al. 1983).

Distribution and Abundance

The catches per unit effort (CPUE) of fish caught by both fyke net and gill net were similar between Angun and Beaufort lagoons (Table 3-2) during the sampling period. In the following pages we compare the abundance (CPUE) of species caught during this study with those collected in other investigations along the Beaufort Sea coast (Fig. 3-4). Certain qualifying points about these comparisons should be realized.

1. The results used in the comparisons were collected over a period of years (1974-82) and are thus confounded by normal year-to-year variations.

Table 3-1. Summary of fish species and numbers caught in fyke nets and gill nets, 25 July-5 August 1982, Angun and Beaufort lagoons, Alaska.

Common Name	Code	Scientific Name	Total Number of Fish Caught	
			Fyke Net	Gill Net
Anadromous				
Arctic cisco	ARCS	*Coregonus autumnalis*	105	103
Arctic char	CHAR	*Salvelinus alpinus*	92	105
Least cisco	LSCS	*Coregonus sardinella*	2	
Arctic grayling	GRAY	*Thymallus arcticus*	1	
Boreal smelt	BORS	*Osmerus eperlanus*	2	
Ninespine sticklebacks	NN ST	*Pungitius pungitius*	1	
Marine				
Fourhorn sculpin	FHSC	*Myoxocephalus quadricornis*	1487	67
Arctic flounder	ARFL	*Liopsetta glacialis*	738	
Saffron cod	SFCD	*Eleginus gracilis*	4	
Capelin	CAPE	*Mallotus villosus*		1
Totals:			2432	276

Table 3-2. Catch per unit effort (number of fish/h) of the four major fish species collected in Angun and Beaufort lagoons and other Beaufort Sea locations.

Fyke Net (CPUE)[1]

Species	Angun Lagoon	Beaufort Lagoon	Simpson Lagoon		Prudhoe Bay		Sagavanirktok Delta
	1982	1982	1977[2]	1978[2]	1976[3]	1981[4]	1982[5]
ARCS	0.3	0.2	1.5	0.9	0.6	2.3	6.4
CHAR	0.1	0.3	0.2	1.3	2.0	0.4	1.2
FHSC	3.6	2.8	4.9	17.6	3.4	3.6	6.1
ARFL	1.2	2.1		<0.1			

Gill Net (CPUE)[1]

Species	Angun Lagoon	Beaufort Lagoon	Simpson Lagoon	Prudhoe Bay	Sagavanirktok Delta	Kaktovik	Nunaluk
	1982	1982	1977[2]	1981[4]	1982[5]	1975[6]	1974[7]
ARCS	0.5	0.2	0.7	0.3	1.3	0.8	1.4
CHAR	0.3	0.4	0.3	0.4	0.5	0.4	0.4
FHSC	0.1	0.3	0.1	0.1	0.4	2.5	0.6

[1] CPUE numbers are approximate as total number of days and/or hours fish could not be precisely determined for all studies.
[2] Craig and Haldorson 198′
[3] Bendock 1979
[4] Griffiths and Gallaway 1982
[5] Griffiths et al. 1982
[6] Griffiths et al. 1977
[7] Griffiths et al. 1975

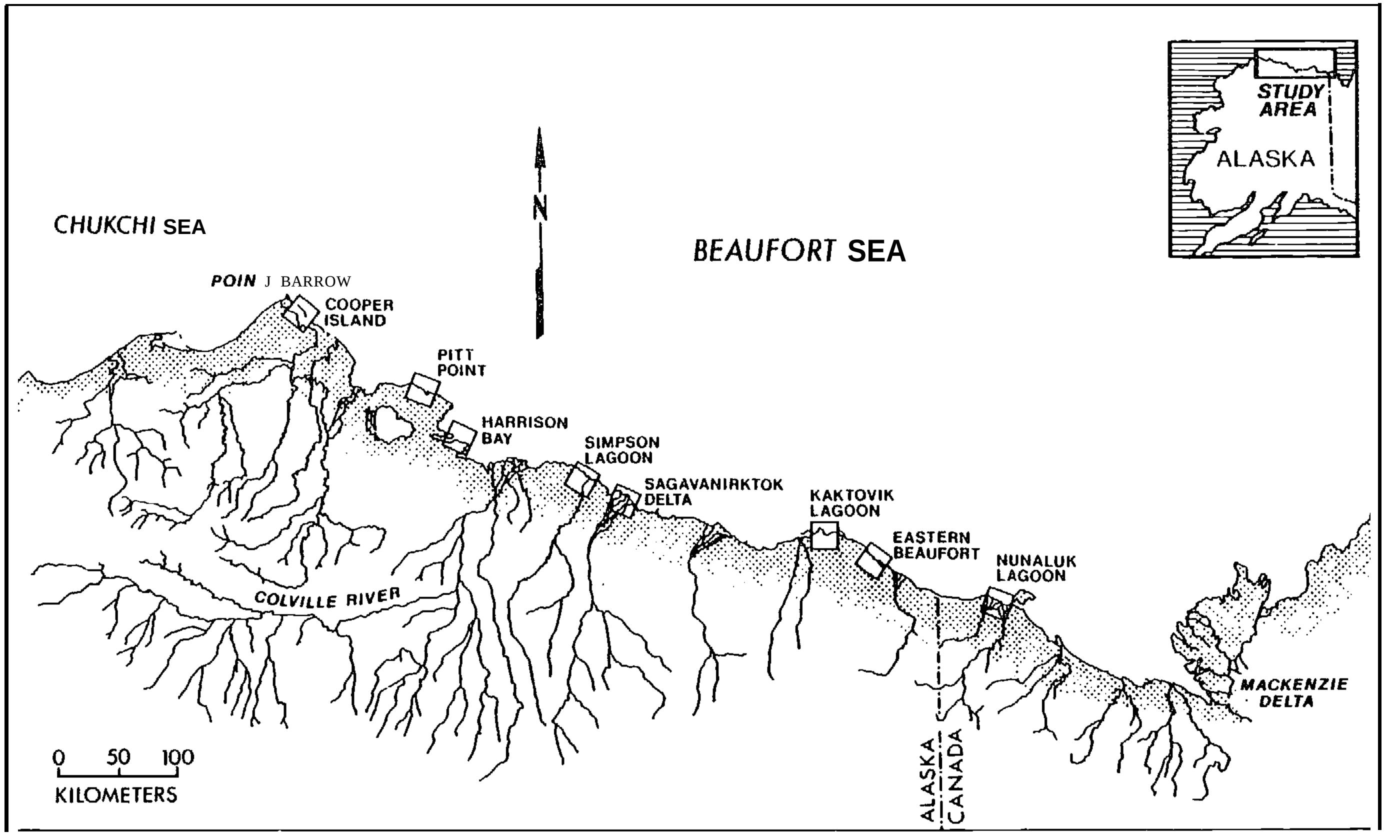

Figure 3-4. Locations of fisheries investigations conducted in Beaufort Sea coastal waters from 1974 to 1982.

2. Some of the studies were conducted over the whole of the open-water period while others were of much shorter duration.
3. Although comparisons are limited to similar sampling gear, there are some differences within each type of gear that may have affected the catch rates (e.g. different mesh sizes in gill nets; different wing and lead lengths in fyke nets).

Arctic Cisco

Results from both fyke and gill net studies show a wide variation between years both at specific sites and among sites (see Table 3-2). For fyke nets the highest CPUE was recorded in front of the Sagavanirktok Delta in 1982 (6.4 fish/h), and the lowest was from Beaufort Lagoon in 1982 (0.2 fish/h). However, as noted above, the year-to-year variations at a single site can also be substantial (1.5 vs 0.9 fish/h in Simpson Lagoon for 1977 and 1978, respectively). Some of the variation in CPUE is due to the presence of large numbers of a specific size class at a particular site (see length frequency comparisons below) rather than large numbers of all size classes. For example, the high CPUE for the Sagavanirktok River Delta study was due to the presence of 37,955 small individuals (<250 mm in length) as opposed to only 458 large fish (>250 mm in length). Consequently, small arctic cisco may be more abundant in the Simpson Lagoon-Prudhoe Bay.Sagavanirktok River Delta area in contrast to the eastern Beaufort Sea but larger arctic cisco appear to be more evenly distributed along the coast. This is more evident from the gill net data (see Table 3-2). Gill nets are more biased towards the capture of large fish than fyke nets and the relative abundance of arctic cisco collected in gill nets, although variable, was more nearly similar at the different locations. These data suggested that large arctic cisco (>250 mm in length) are distributed relatively evenly along the Alaskan and Canadian Beaufort Sea coasts during the open-water season.

Arctic Char

CPUE data for arctic char were less variable than for arctic cisco. The between-year variation (0.2 fish/h vs. 1.3 fish/h in Simpson Lagoon for 1977 and 1978, respectively) was in the same range as the maximum variation among sites (2.0 fish/h at Prudhoe Bay 1976 vs. 0.1 fish/h at Angun Lagoon 1982). In contrast, there was little variation in gill net CPUE for arctic char among the studies, suggesting that large Arctic char (>250 mm) are relatively evenly distributed along the Beaufort Sea coast.

Fourhorn Sculpin

The relative abundances of fourhorn sculpin collected in fyke nets were similar among studies with the exception of two studies (Simpson Lagoon 1978, 17.6 fish/h; Sagavanirktok River Delta 1982, 6.1 fish/h). Reasons for the high catch rates at these two locations are not known. Typically, fyke net results showed fourhorn sculpin to be more abundant in the nearshore waters of the Beaufort Sea than were Arctic cisco and Arctic char, but gill net results usually showed the reverse trend. This discrepancy is because small fourhorn sculpin are susceptible to capture in fyke nets but can swim through the individual meshes of gill nets. Large fourhorn sculpin (those vulnerable to capture in gill nets) appeared to be equally abundant among locations along the Alaskan and Canadian Beaufort Sea coasts.

In summary, there are large variations in CPUE for arctic cisco, Arctic char and fourhorn sculpin at different locations along the Beaufort Sea coast, but it appears that most of the differences are associated with the presence or absence of small individuals (<250 mm) of these. species. Gill net data indicate that larger individuals (>250 mm) of the three species are more evenly dispersed in the nearshore coastal waters than are the smaller ones (see length-frequency comparisons below).

Length-frequency

For comparative purposes, length-frequency data for arctic cisco, arctic char, fourhorn sculpin and, when available, arctic flounder have been compiled from various studies conducted from Pt. Barrow, Alaska to the Yukon coast. The results have been further analyzed by gear type (Table 3-3).

Table 3-3. Summary of gear type, location and year of sampling from which length-frequency data for fishes are available.

Gear Type	Location	Year of Sampling	Reference
Fyke net	Eastern Beaufort	1982	This study
	Simpson Lagoon	1978	Craig and Haldorson 1981
	Sagavanirktok River Delta	1982	Griffiths et al. 1982
Gill net	Cooper Island Area	1982	Schmidt et al. 1983
	Pitt Point Area	1982	Schmidt et al.. 1983
	Harrison Bay Area	1982	Schmidt et al. 1983
	Colville River	1972	Kogl and Schell 1974
	Simpson Lagoon	1977	Craig and Haldorson 1981
	Arctic Wildlife Range	1970	Roguski and Komarek 1972
	Kaktovik Lagoon	1975	Griffiths et al. 1977
	Eastern Beaufort	1982	This study
	Nunaluk Lagoon	1974	Griffiths et al. 1975
	Yukon Coast	1974	Kendel et al. 1975

Arctic Cisco

Fyke net length-frequency data for arctic cisco from the three available locations are shown in Figure 3-5. Results from Simpson Lagoon and the eastern Beaufort show similar length distribution patterns even though the sampling efforts are separated by four years in time and the eastern Beaufort study was only eight days in duration compared to 76 days for the Simpson Lagoon study. In both of these studies small fish (<250 mm) and large fish (>250 mm) occur in similar proportions. In contrast, in the Sagavanirktok River Delta study small Arctic cisco dominated the catch. Some of the differences among these locations may be related to

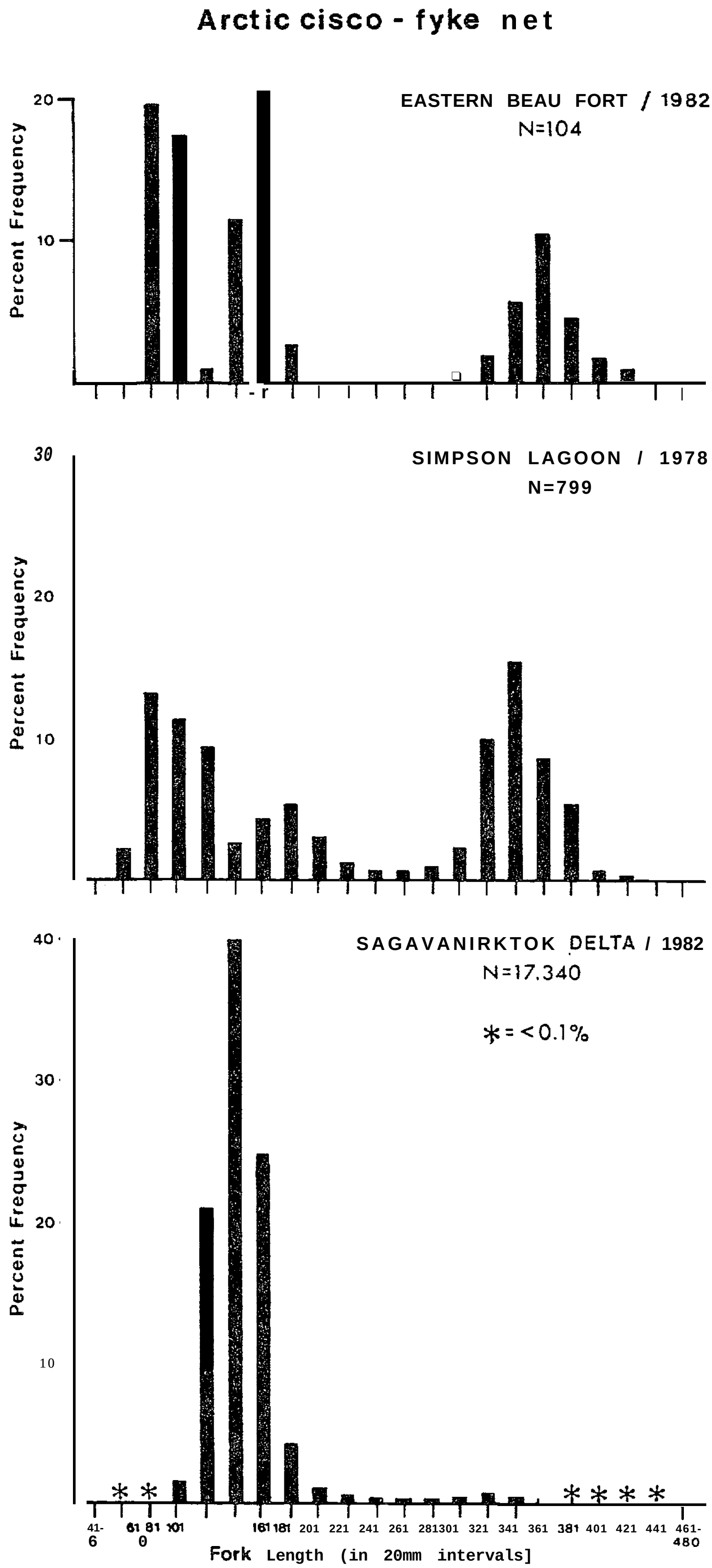

Figure 3-5. Length-frequency analyses of Arctic cisco caught in fyke nets at three sites on the Alaskan Beaufort Sea coast.

habitat type-- two were conducted in lagoons (i.e. Simpson and eastern Beaufort) but the third (Sagavanirktok study) was carried out in front of a large river.

Many more gill net studies have been conducted in the nearshore waters of the Alaskan and Canadian Beaufort seas, but as mentioned in the previous section, this sampling gear is biased towards larger individuals. Although the arctic cisco caught west of the Colville River (i.e. Cooper Island, Pitt Point and Harrison Bay) tend to be slightly smaller than those from the other studies, there is a remarkable similarity in the length-frequencies for this species even though the studies range over an eleven-year period (1972-82) and are coastwide in scope (Fig. 3-6). These data suggest that large arctic cisco in summer are distributed fairly uniformly along the entire Beaufort Sea coast, occupying a variety of habitats.

Arctic Char

As was the case with arctic cisco, the mean length-frequencies of arctic char from the two lagoon studies (Simpson and eastern Beaufort) were similar, but different from that of fish from the Sagavanirktok River Delta study (dominated by individuals between 250-275 mm) (Fig. 3-7). Reasons for the differences are not readily apparent. Arctic char representing most size groups were present at the three locations along the coast.

The gill net length-frequency data for arctic char also show a remarkable similarity among years and sites (Fig. 3-8). These data suggest that large arctic char (>250 mm) are rather uniformly distributed in the nearshore waters in the open-water season along the Alaskan and Canadian Beaufort Sea coasts.

Fourhorn Sculpin

Length-frequency data for fourhorn sculpin are available only from the Simpson Lagoon and eastern Beaufort studies. Fourhorn sculpin 60-150 mm in length dominated the catch in both places (Fig. 3-9). Length-frequency patterns were similar between the two areas, suggesting that all

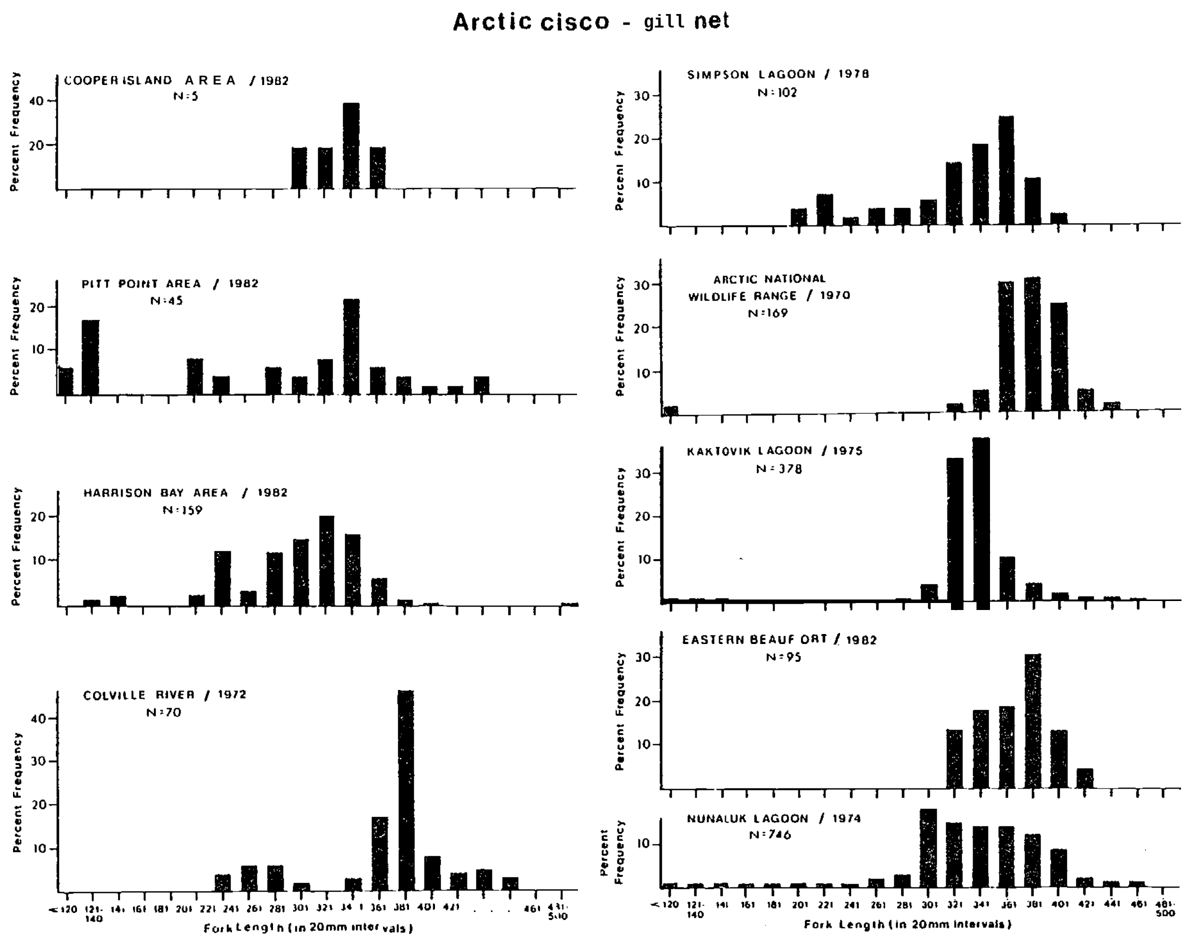

Figure 3-6. Length-frequency analyses of Arctic Cisco caught in gill nets at nine locations on the Beaufort Sea coast.

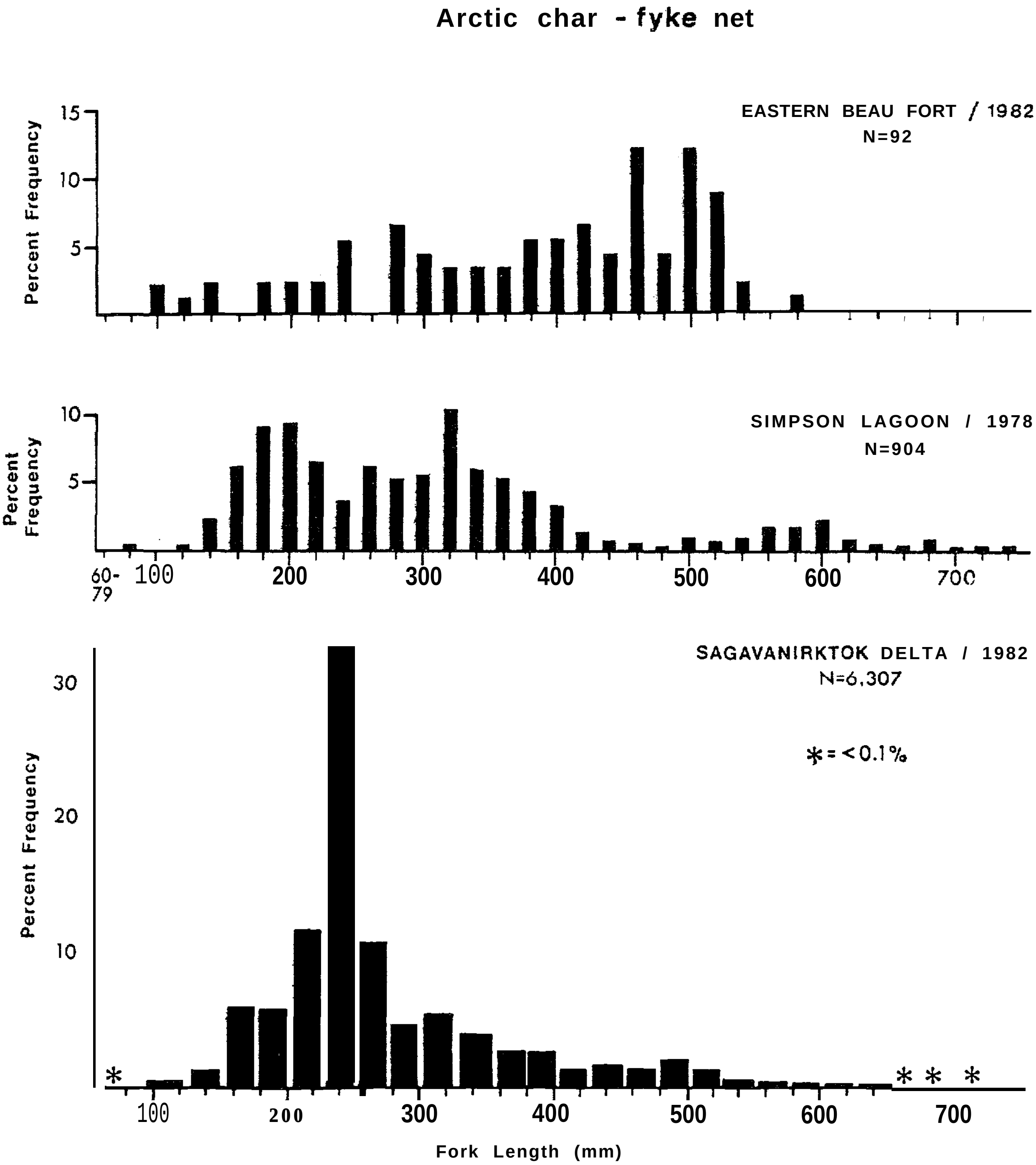

Figure 3-7. Length-frequency analyses of Arctic char caught in fyke nets at three locations on the Alaskan Beaufort Sea coast.

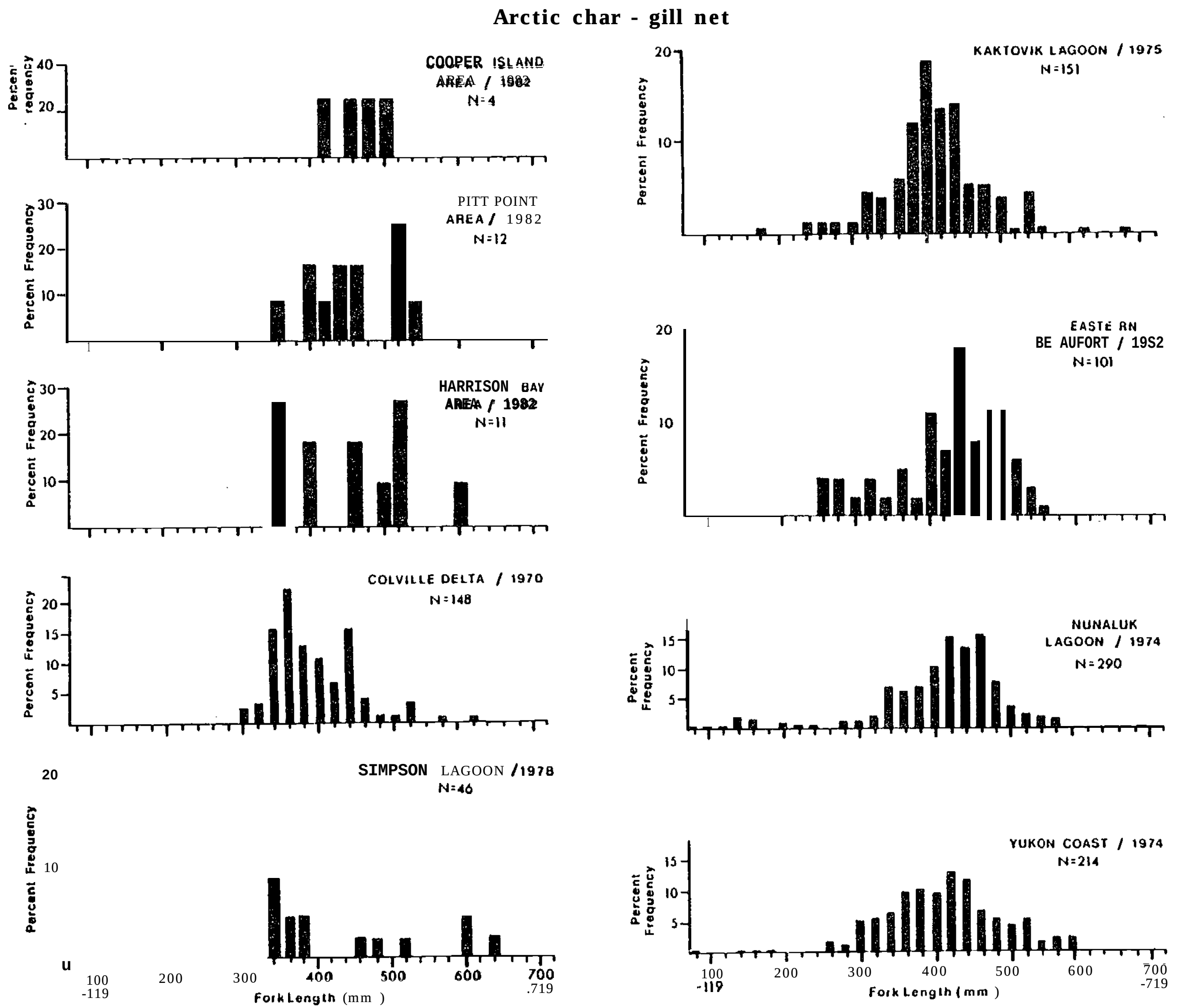

Figure 3-8. Length-frequency analyses of Arctic char caught in gill nets at nine locations on the Beaufort Sea coast.

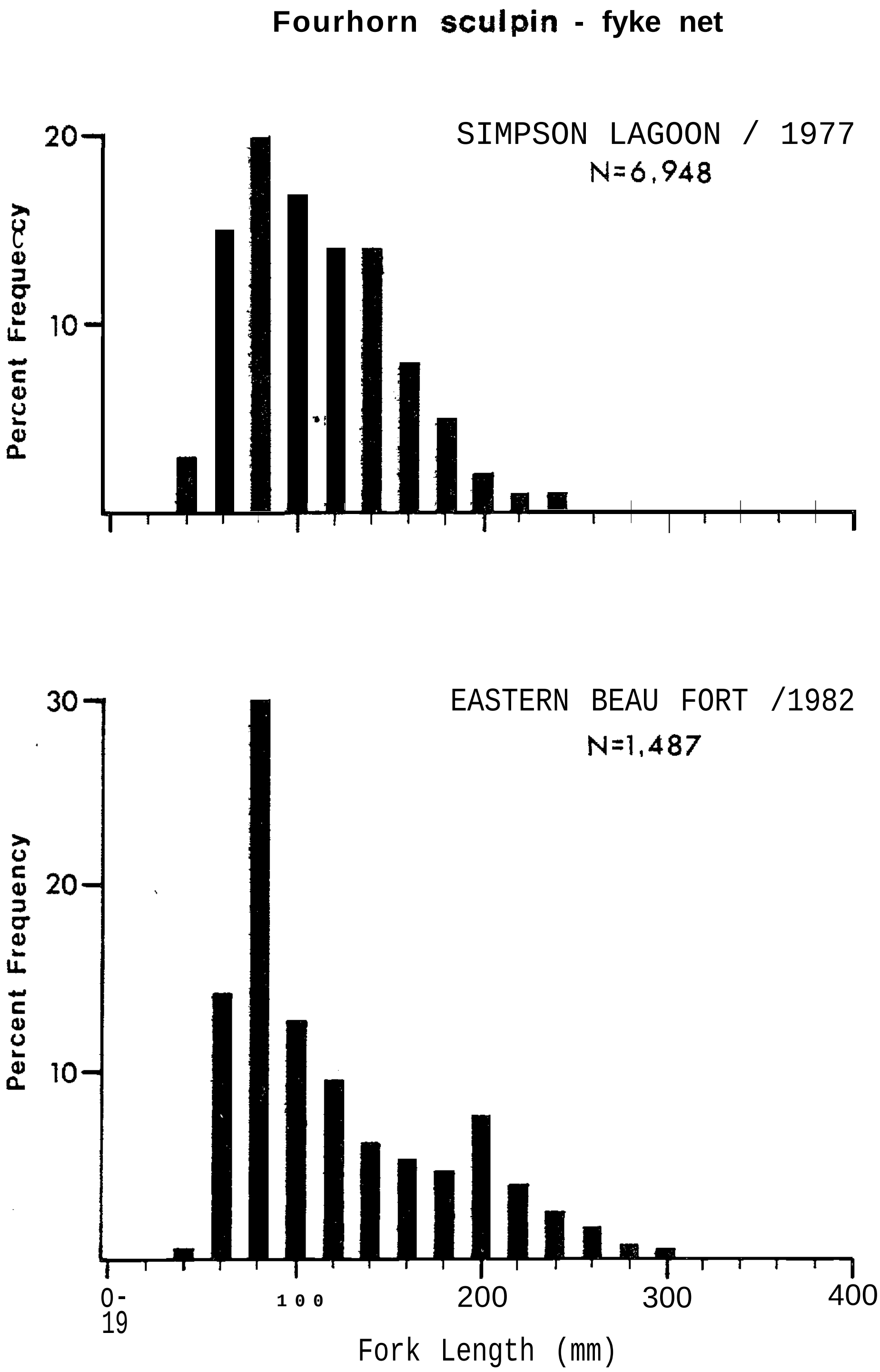

Figure 3-9. Length-frequency analyses of fourhorn sculpin caught in fyke nets at two locations on the Alaskan Beaufort Sea coast.

size classes of fourhorn sculpin utilized both nearshore lagoon habitats in summer.

The gill net length-frequency data from studies across the Alaskan and Canadian Beaufort Sea coasts showed that the same size groups of large fish occurred from Pt. Barrow, Alaska to Nunaluk Lagoon, Yukon Territory (Fig. 3-10).

Arctic Flounder

Only fyke net data are available for this species because it isnot readily captured in gill nets. In the two fyke net studies conducted where arctic flounder were measured, two different length-frequency patterns are evident (Fig. 3-11). The results from Simpson Lagoon showed large individuals (>150 mm) to be most abundant, while in the eastern Beaufort small arctic flounder (80-120 mm in length) dominated the catch. The reasons for this difference are not evident.

Feeding Ecology

The examination of fish feeding habits in Angun and Beaufort lagoons is based on analysis of contents of 175 stomachs of three species collected by gill net between 29 July and 5 August 1982. Epibenthic crustaceans (primarily amphipods and mysids) accounted for most of the food eaten by arctic cisco and arctic char, but amphipods and isopods were the dominant food items of fourhorn sculpin (Table 3-4). Fish were the only other important food item recorded, representing 10.8% of the diet of arctic char. Infaunal organisms and plants were not important food items for any of the three species. These findings suggest that the food chain for fish in Angun and Beaufort lagoons is very short. The fish feed primarily on epibenthic invertebrates (amphipods, mysids, isopods) and these organisms, in turn, feed directly or indirectly on marine primary production, peat and terrestrial production (Schell et al. 1983).

It is noteworthy that for all species, the average fullness of stomachs containing food was less than 50%, and that a substantial portion of the stomachs were empty (see Table 3-4). A large proportion of fish stomachs examined from several coastal lagoons [Simpson Lagoon (Craig and

Fourhorn sculpin - gill net

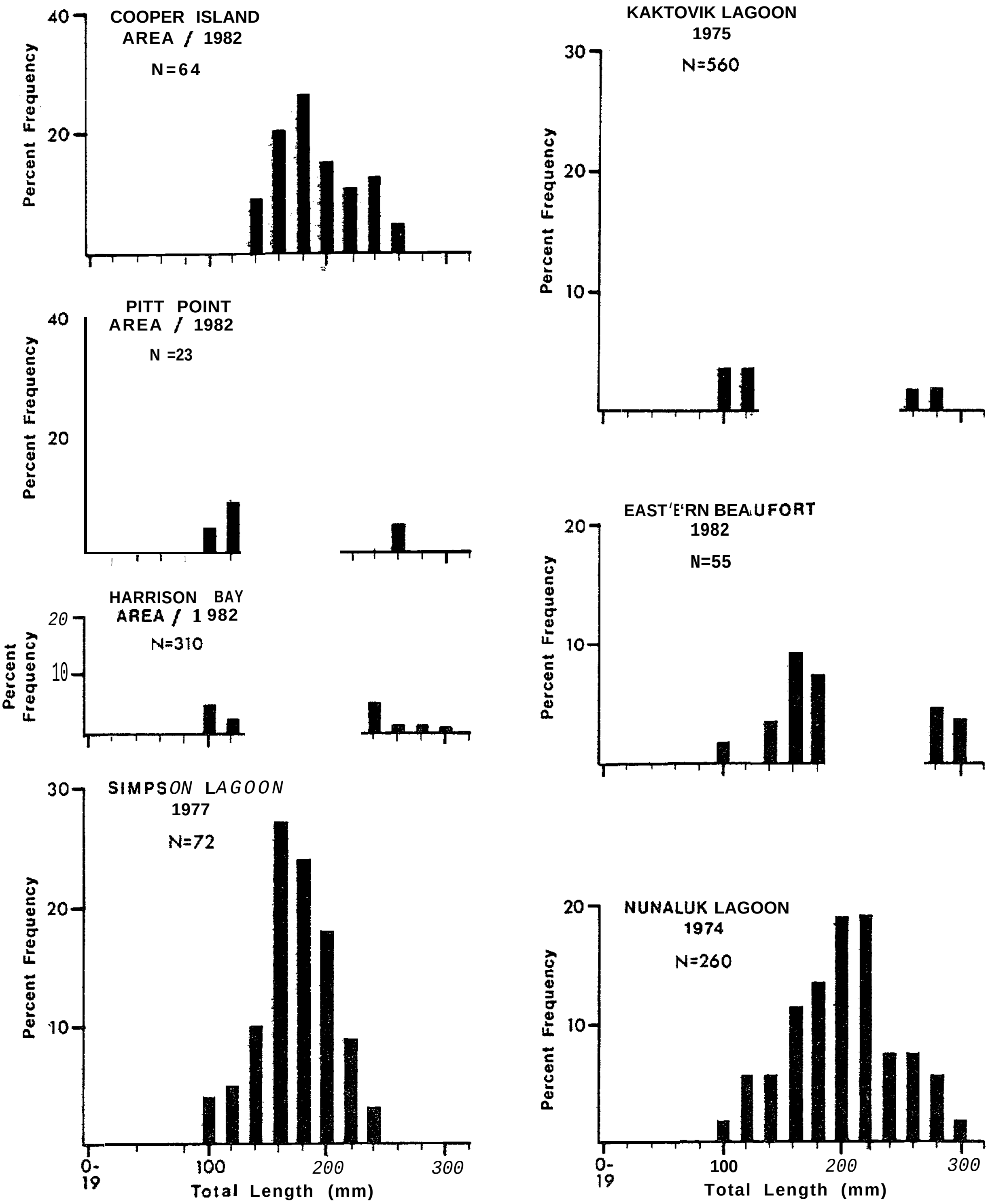

Figure 3-10. Length- frequency analyses of fourhorn sculpin caught in gill nets at seven locations on the Beaufort Sea coast.

Arctic flounder - fyke net

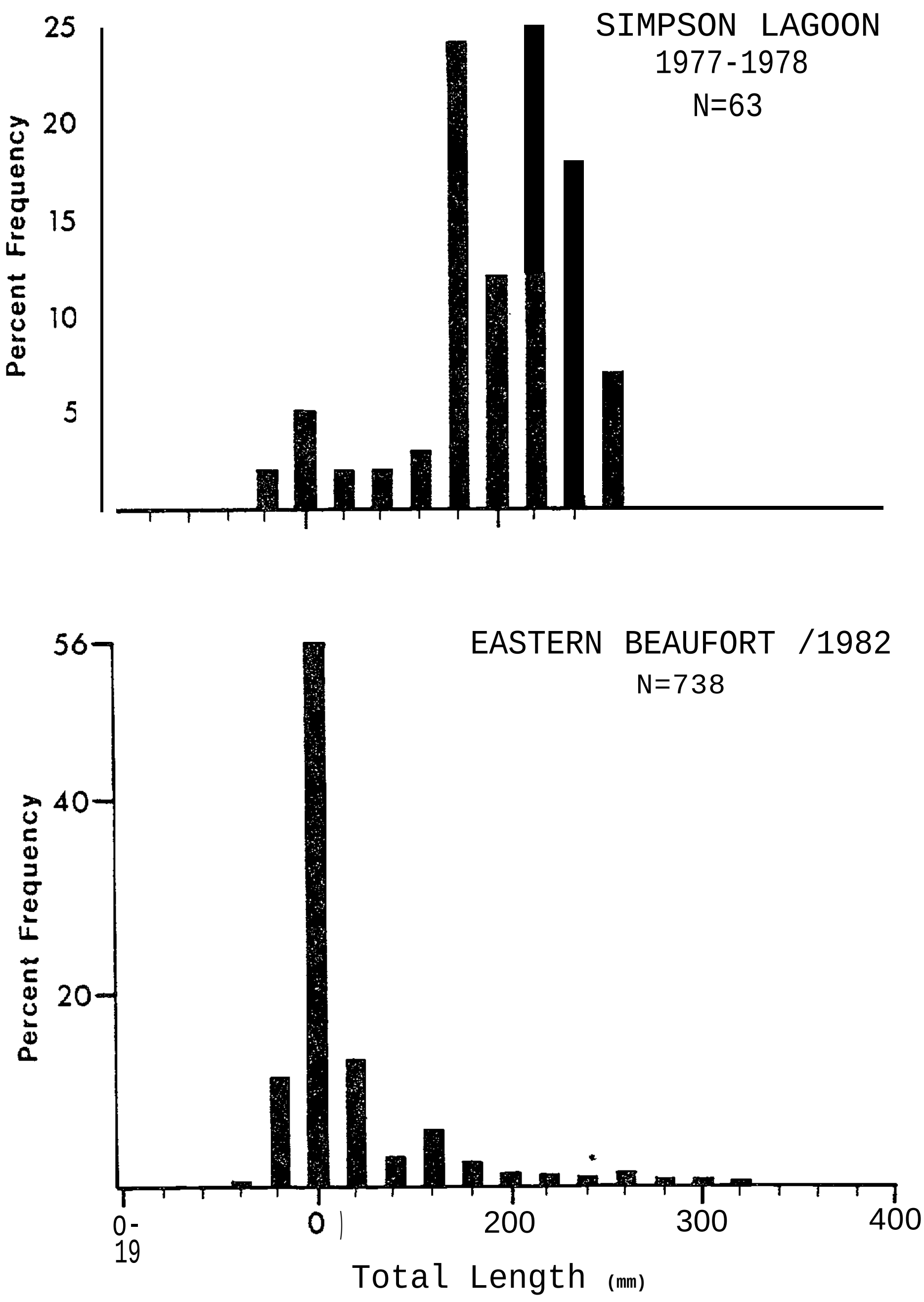

Figure 3-11. Length-frequency analyses of Arctic flounder caught in fyke nets at two locations on the Alaskan Beaufort Sea coast.

Table 3-4. Summary of the food items found in the stomachs of Arctic cisco, Arctic char and fourhorn sculpin collected in the eastern Beaufort Sea (Angun and Beaufort Lagoons) 1982.

Food Item	% Composition (Hynes Point Method)		
	Arctic Cisco [1]N = 75	Arctic Char [1]N = 50	Fourhorn Sculpin [1]N = 50
Amphipods	36.9	56.8	55.5
Mysids	51.9	15.5	0.7
Isopods			28.5
Copepods	3.6	1.8	
Chironomids	0.3		
Fish	0.7	10.8	3.8
Fish Eggs			0.1
Bivalves			0.1
Tunicates			0.4
Plants			1.8
Unidentified	6.3	15.1	8.7
% Fullness[2]	34	22	39
Number of empty stomachs (%)	11 (12.8%)	42 (45.7%)	3 (5*7%)

[1]N = the number of stomachs that contained food, empty stomachs not included.
[2]Percent fullness determined using only stomachs containing food.

Haldorson 1981), Kaktovik Lagoon (Griffiths et al. 1977) and Nunaluk Lagoon, Yukon Territory (Griffiths et al. 1975)] have been empty or only partly full, but there is no clear pattern of fullness levels among lagoon systems. It might simply be stated that feeding is not a continuous activity by fishes in any of the lagoons.

In order to compare the results of fish feeding habits from various Beaufort Sea locations, a trophic spectrum was constructed comprising the range of foods potentially available to fish (Darnell 1961) (Fig. 3-12). The five general sources of food used in the trophic spectrum were taken from the version used by Craig and Haldorson (1981) in Simpson Lagoon:

1. water column organisms (e.g. fish and zooplankton),
2. mobile epibenthic invertebrates (e.g. amphipods and mysids),
3. sedentary invertebrates (e.g. isopods and tunicates),
4. infaunal invertebrates (e.g. polychaetes and bivalves), and
5. flora (e.g. algae and vascular plants).

Arctic Cisco

In all cases, the vast majority of food items consumed by arctic cisco were water column and/or epibenthic organisms (see Fig. 3-12). In Simpson Lagoon, Katovik Lagoon and the eastern Beaufort study, amphipods and mysids were the dominant food organisms, while in the Nunaluk study copepods, epibenthic polychaetes and fish also contributed significantly to the diets. This difference may be due to the input of a large volume of fresh water into Nunaluk Lagoon from the Malcolm and Firth rivers, whereas the levels of freshwater influence in Simpson Lagoon, Kaktovik Lagoon and the eastern Beaufort study area were substantially less. The presence of this large freshwater mass in Nunaluk Lagoon could have caused a reduction in the abundance of brackish water epibenthic invertebrates, resulting in arctic cisco diets that were dominated by water column organisms (fish and copepods). Although most areas studied contained substantial infaunal communities which, at times, equaled or exceeded the biomass of water column and epibenthic organisms, this group was noticeably absent from the diets of arctic cisco.

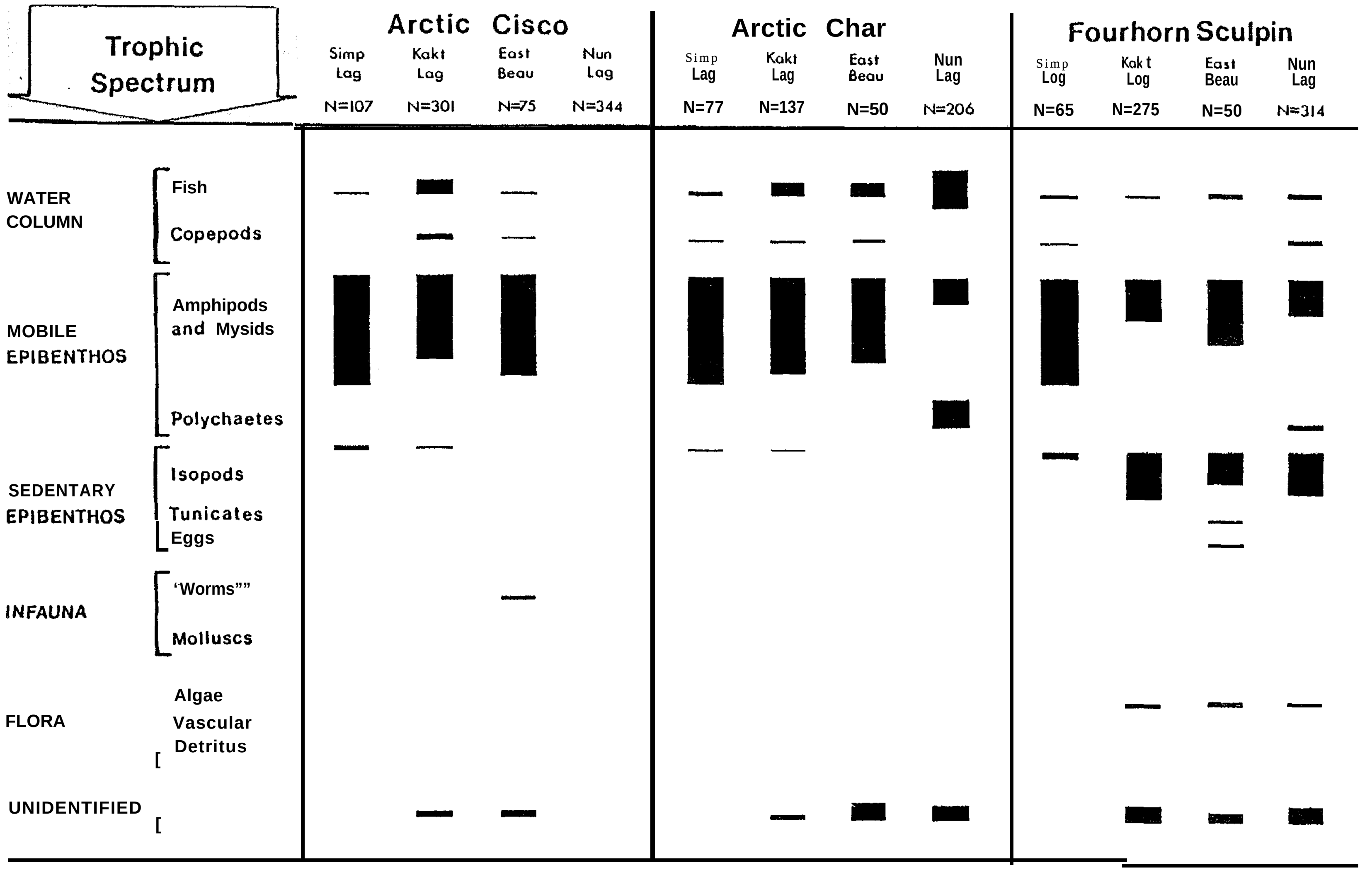

Figure 3-12. Food spectra of fishes from Simpson Lagoon (Craig and Haldorson 1981), Kaktovik Lagoon (Griffiths et al, 1977), Nanaluk Lagoon (Griffiths et al. 1975), and Angun and Beaufort lagoons in the eastern Beaufort Sea (this study).

Arctic Char

As was the ease with arctic cisco, the most important food items in the diet of arctic char from the four locations were water column and epibenthic organism (see Fig. 3-12). In Simpson Lagoon, Kaktovik Lagoon and the eastern Beaufort study, amphipods, mysids and to a lesser extent fish, were the dominant food items. Fish and epibenthic polychaetes were much more important contributors to the arctic char diet in Nunaluk Lagoon, presumably for the same reasons more were eaten by arctic cisco. There was a noticeable lack of infaunal organisms in the diets of arctic char at all locations.

Fourhorn Sculpin

The diet of this bottom-dwelling species was remarkably similar to those of arctic char and arctic cisco in the four areas studied (see Fig. 3-12). The one major difference was the importance of isopods (a sedentary crustacean) in the diet of fourhorn sculpin.

In summary, the diets of arctic cisco and arctic char were dominated by epibenthic invertebrates (amphipods and mysids) with significant contributions of copepods and fish in particular areas. There was a high degree of similarity in the diets of these species at all the locations studied along the Beaufort Sea coast. Fourhorn sculpin, a bottom--dweller, consumed both epibenthic invertebrates (amphipods, mysids) and sedentary invertebrates (isopods). Infaunal organisms were conspicuous by their absence in the diets of all the fishes examined.

GENERAL DISCUSSION

Anadromous fish typically enter nearshore waters of the Beaufort Sea during spring break-up (mid- to late June) and initially occupy the open-water leads that form nearshore, before dispersing along the coast to feed as the ice cover melts and recedes. This seaward movement of anadromous fish differs from that of subarctic anadromous species (e.g. salmon) in that it is generally restricted to a longshore band of warm, brackish water adjacent to the mainland shore. This band can be of variable width depending on climatic conditions and coastal morphology. Along exposed coastal shores the band can be very narrow, but in front of river deltas (e.g. Sagavanirktok and Colville rivers etc.) it can extend several kilometers out into the ocean, presumably due to the plume of fresh water flowing out from these rivers. The importance of this band in relation to the along-shore movements of anadromous and marine species has been dealt with in some detail by Craig (1983).

The coastal distribution patterns of anadromous and marine species vary to some degree among species. Craig (1983) suggests that these patterns are influenced by several factors, including 1) source of fish stocks, 2) migration timing, and 3) responses to water temperature and salinity. Of major significance in a geographic sense is that North Slope drainages can be classified (Craig and McCart 1976) as to stream type (i.e. coastal plain streams, mountain streams, and Mackenzie system streams) and that each stream type is associated with a dominant group of anadromous fishes (Fig. 3-13):

Coastal plain streams -	broad and humpback whitefishes, least cisco and salmon
Mountain streams	arctic char
Mackenzie system streams -	broad and humpback whitefishes, least and arctic ciscoes, salmon

This pattern of freshwater sources of anadromous stocks is, in turn, reflected in the coastwide distribution of anadromous fishes in nearshore waters. Overall distributions of important anadromous species are discussed below.

Broad and Humpback Whitefishes and Least Cisco

The coastwide summer distributions of these three species are shown in Fig. 3-13. Typically, their numbers appear to decline rapidly within 100 km to the east of the Colville River and to the west of the Mackenzie River when all available data are considered collectively (Roguski and Komarek 1972, Furniss 1975, Griffiths et al. 1975, Kendel et al. 1975,

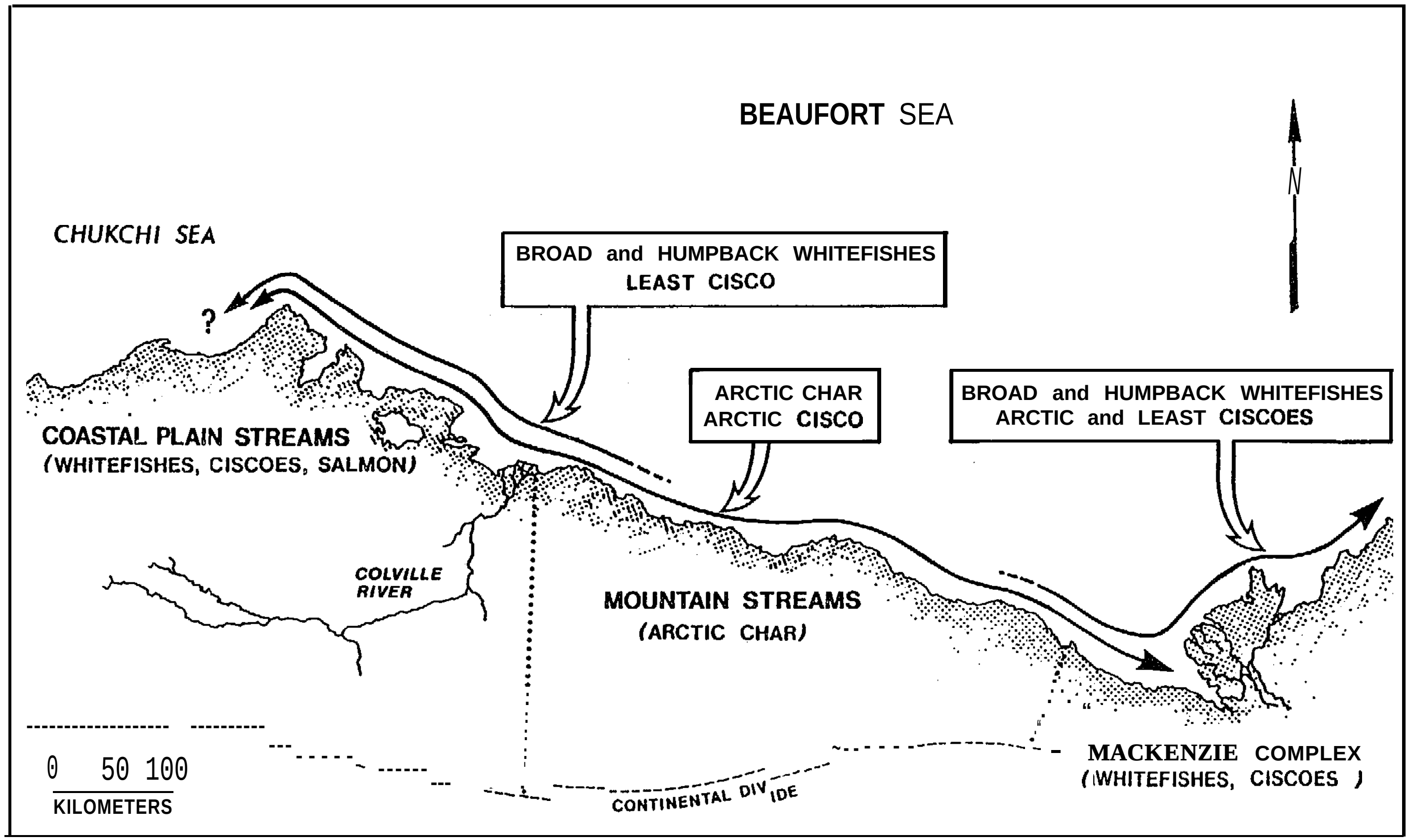

Figure **3-13.** **Coastal plain and Beaufort Sea coast showing stream classifications** and the anadromous fishes associated with each stream type. Distributions of Arctic char, ciscoes, and whitefishes in the nearshore waters in summer are shown. (Source: Craig 1983).

Craig and McCart 1976, Griffiths et al. 1977, Bendock 1979, Craig and Haldorson 1981, Griffiths and Gallaway 1982, Craig 1983, Schmidt et al. 1983). Very few least cisco or broad and humpback whitefishes have been caught east of Flaxman Island. For example, least cisco accounted for only 1% of the total catch and no broad or humpback whitefishes were taken in Kaktovik Lagoon (Griffiths et al. 1977) and similarly only two least cisco and no broad or humpback whitefishes were collected during the present study. A gill net survey conducted west of the Colville River showed that the abundances of broad and humpback whitefishes and least cisco do not decline to the west of the Colville River and this suggests that the tundra streams in this region contain spawning stocks of these species (Schmidt et al. 1983). The low numbers of these three species east of Flaxman Island are not caused by the lack of suitable summer habitat in the nearshore Beaufort Sea but rather by the absence of drainages in this region that support spawning populations of these species.

Arctic Char and Arctic Cisco

These two species are commonly caught all along the coastline from Pt. Barrow to the Mackenzie River. Arctic char is the dominant anadromous species associated with "mountain streams" from the Sagavanirktok River to the U.S./Canadian border. Tagging data indicate that at least some arctic char range widely in the nearshore waters of the Beaufort Sea.

Arctic cisco also range widely across the Alaskan and Canadian Beaufort Sea coasts. However, in contrast to char, this species probably does not spawn in Alaskan waters (Gallaway et al. 1983); the individuals in Alaskan waters are most likely from a Mackenzie River stock.

Marine Species

Numerous studies conducted in the nearshore waters of both the Alaskan and Canadian Beaufort seas have shown that arctic cod, fourhorn sculpin and arctic flounder are widespread and abundant (Griffiths et al. 1983). These species spend their entire lives in marine or brackish water habitats, typically overwintering and/or spawning in the deeper waters offshore of the barrier islands and shifting landward and sometimes moving through lagoons in summer to feed. Densities of arctic cod and arctic flounder in lagoons are generally low early in the season (just after break-up) and increase steadily as the season progresses, but fourhorn sculpin appear to be abundant throughout the open-water season. No arctic cod were caught in this study.

In summary, it appears that the fish use of nearshore waters along the Beaufort Sea coast is generally similar in some species but variable in others. Arctic char, arctic cisco and fourhorn sculpin, occur stall locations and they appear to be feeding on the same or similar organisms (epibenthic invertebrates). Differences among sites in coastal distributions of anadromous species occur in least cisco and broad and humpback whitefishes. These differences are caused by stretches of coast that have no nearby natal streams of fish stocks, and not by the lack of suitable coastal habitat for these species.

RELEVANCE TO PROBLEMS OF PETROLEUM DEVELOPMENT

The potential effects of petroleum development on fish could be direct or indirect:

1. direct because of the effects of contaminants (e.g. oil spills, the release of drilling muds etc.) or because fish migration pathways are blocked by solid-fill causeways.
2. indirect because of the alteration of the nearshore band of warm brackish water by solid-fill causeways projecting seaward from shore.

In most cases the direct mortality due to the effects of oil spills and release of toxic substances will likely be minimal since the species occurring in these waters range widely along the Alaskan Beaufort Sea coast and should be able to avoid contaminated areas nearshore. However, fish in certain habitat types like Angun and Beaufort lagoons (i.e. closed or pulsing lagoons) may be affected to a greater extent by such perturbations because their avenues of avoidance may be restricted.

Solid-fill causeways may project across fish migration routes, or alter current patterns so as to change nearshore temperature and salinity regimes (Griffiths and Gallaway 1982). Data collected over the last few years suggest that both large and small individuals of most anadromous species are able to swim around causeways such as the ARCO causeway in Prudhoe Bay with little apparent effect (Bendock 1979, Griffiths and Gallaway 1982). But this causeway also deflects warm, nearshore water offshore to be replaced nearshore by colder, offshore water (Griffiths and Gallaway 1982). Whether such changes in nearshore water quality affect habitat utilization by fish is not certain, but the effect would likely be minimal. However, the combined effect of several. such structures along the Alaskan Beaufort Sea coast is not known and would need to be assessed.

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APPENDICES

Appendices contain data on fish captured during the study. Types of data contained in these appendices are summarized below:

Appendix 3-I Directional, Fyke Net Data Listing

Appendix 3-II Gill Net Data Listing

APPENDIX 3-1. Directional Fyke Net Data Listing.

This section contains the catch data (number, length and day caught) of all fish species listed below captured in the directional fyke nets.

Arctic cisco	(ARCS)
Arctic char	(CHAR)
Fourhorn sculpin	(FHSC)
Arctic flounder	(ARFL)
Arctic cod	(ARCD)

Directional Fyke Net Species: ARCS

DATE(M/D)	7/26	7/27	7/28	7/29	7/30	7/31	8/1	8/2	8/3	8/4	8/5
LENGHT(MM)											
81-90				1				2			
91-100						2		15			
101-110			1					11	1		
111-120	1			1				2	1		
121-130								1			
131-140											
141-150									2		
151-160	1		2					2	5		
161-170	1		1					5	9	1	
171-130	2					1		1	1		
181-190	2										
191-200	1										
201-210											
211-220											
221-230											
231-240											
241-250											
251-260											
261-270											
271-280											
281-290											
291-300											
301-310											
311-320			1								
321-330											
331-340			1	1							
341-350			2								
357-360	1		2								
361-370	1		3	1		1					
371-380			4	1							
381-390			1								
391-400	2		1							1	
401-410									1		
411-420	1										
421-430	1										
431-440											
441-450											
451-460											
461-470											
471-480											
481-490											
491-500											
Total	14		19	6				40	20	2	

Directional Fyke Net   Species: CHAR

DATE(M/D) LENGHT(MM)	7/26	7/27	7/28	7/29	7/30	7/31	8/1	8/2	8/3	8/4	8/5
81-90											
91-100											
101-110			1	1							
111-120											
121-130						1					
131-140											
141-150											
151-160			1					1			
161-170											
171-180											
181-190								1			
191-200									1		
201-210											
211-220								1	1		
221-230				1							
231-240	1										
241-250	1								1		
251-260	1		1	1							
261-270											
271-280											
281-290			1	1		1					
291-300			1								
301-310			2								
311-320				2							
321-330				1		1					
331-340				1							
341-350											
351-360	1			1				1			
361-370	1					1					
371-380			1								
381-390	1		1	1						1	
391-400						1					
401-410						1					
411-420			2					2			
421-430				2							1
431-440			2					1			
441-450								2		1	
451-460				1							
461-470	1			1		3		1			
471-480			2	1				2			
481-490			1			1					
491-500						1				1	
501-510			5					2	2		
511-520				2							
521-530			2								
531-540			3			3					
541-550				2							
551-560											
561-570											
571-580											
581-590											
591--600											

Directional Fyke Net Species: FHSC

DATE(M/D) LENGHT(MM)	7/26	7/27	7/28	7/29	7/30	7/31	8/1	8/2	8/3	8/4	8/5
31-40						1			1	2	
41-50			4			2		2	1		
51-60			9	11		23		75	43	27	14
61-70			6	44		25		147	50	29	21
71-80			21	34		6		34	10	6	10
81-90			5	11		4		14	4	1	12
91-100	76		9	12		8		28	3	3	1
101-110			11	3		15		27	10	5	3
111-120			5	8		20		13	10	10	4
121-130			5	5		11		19	6	2	7
131-140			3	6		8		3	9	4	2
141-150			3	2		19		8	5	8	2
151-160			4	3		8		5	2	5	5
161-170			2	3		4		6	4	4	4
171-180			5	7		8		2	10	5	6
181-190			3	8		15		4	10	8	6
191-200			6	4		14		8	8	7	13
201-210			5	5		10		a	4	6	2
211-220				3		2		3	4	3	5
221-230				2		1		2	1	7	9
231-240				2		4		1	5	4	1
241-250						3		2	5	1	2
251-260			2	1				3	2	1	4
261-270			1			1			2	2	1
271-28o						2			2		
281-290			2								
291-300						2			1		
301-310											
311-320											
321-330											
331-340											
341-350											
Total	76		111	174		216		414	212	150	134

Directional Fyke Net   Species: ARFL

DATE(M/D) LENGHT(MM)	7/26	7/27	7/28	7/29	7/30	7/31	8/1	8/2	8/3	8/4	8/5
31-40											
41-50									1		
51-60								1			
61-70				5		1		2	1		
71-80	1		4	16		12		30	9	6	
81-90	1		17	26		22		97	21	13	5
91-100			19	24		31		106	20	9	5
101-110	1		10	5		11		38	7	4	
111-120	2		2			9		7		3	1
121-130						1		8	4	1	
131-140			2	2		1		5	1		
141-150						1		9	1	2	2
151-160			6	5		3		8	3	5	
161-170			1	1		1		2		2	3
171-180			1	1		1		2	3	1	
181-190				1				2		3	1
191-200	1			1		1		2			
201-210				2		1			2		
211-220			1					1		1	
221-230								1			1
231-240				1						1	1
241-250				1		1			2	2	1
251-260				1				1		1	
261-270								1		1	1
271-280											1
251-290											1
291-300				1							2
301-310								1			
311-320											
321-330											
331-340											
341-350											
351-360											
361-370											
371-380											
381-390											
391-400											
Total			63	93		97		324	75	55	25

Directional **Fyke** Net Species: ARCD

DATE(M/D) LENGHT(MM)	7/26	7/27	7/28	7/29	7/30	7/31	8/1	8/2	8/3	8/4	8/5
31-40											
41-50											
51-60										1	
61-70											
71-80											
81-90											
91-100											
101-110											
111-120											
121-130											
131-140											
141-150											
151-160											
161-170											
171-180											
181-190											
191-200											
201-210											
211-220											
221-230											
231-240											
241-250											
251-260											
261-270											
271-280											
281-290											
291-300											
301-310											
311-320											
321-330											
331-340											
341-350											
Total										1	1

APPENDIX 3-11. Gill Net Data Listing.

This section contains the catch data (number and length) of fish species listed below captured in gill nets.

Arctic cisco	(ARCS)
Arctic char	(CHAR)
Fourhorn sculpin	(FHSC)

Gillnet Species ARCS

Length (mm)	Number
321-340	13
341-360	17
361-380	18
381-400	30
401-420	13
425-440	4

Gill net Species CHAR

Length (mm)	Number
261-280	4
281-300	4
301-320	2
321-340	4
341-360	2
361-380	5
381-400	2
401-420	11
421-440	7
441-460	18
461-480	8
481-500	13
501-520	11
521-540	6
541-560	3
561-580	1

Gillnet Species FHSC

Length (mm)	Number
101-120	1
121-140	0
141-160	2
161-180	5
181-200	4
201-220	10
221-240	11
241-260	12
261-280	5
281-300	3
301-320	2