TUFT POINT AND

ADJACENT COASTAL AREAS

FISHERIES PROJECT

Aquatic Environments Limited

1977

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FISHERIES PROJECT

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SUMMARY

A baseline fishery, aquatic invertebrate, and plankton study was conducted during the summer of 1977 in the vicinity of Imperial Oil dredging operations at Tuft Point, N.W.T.

The purposes of this study were to:

1) determine the species composition and relative abundance of fish within the study area;

2) identify important fish habitat zones;

3) determine species composition, standing crop, and diversity of benthic macroinvertebrate and plankton communities;

4) determine the food habits of the fish species present in the study area;

5) conduct basic life history analyses of the major fish species present;

6) use the baseline data thus obtained to:

a) assess the effects of present and future Imperial Oil borrow operations upon fish populations in the

area;

b) form the basis for recommendations to mitigate any effects and for guidelines to be used in planning future borrow sites.

The general conclusions of the study are:

1. Tuft Point coastal waters support a relatively abundant and diverse fish fauna (16 species). The region is of particular importance as a rearing area for the juveniles of anadromous species such as ciscoes, whitefish, and inconnu.

2. The most important fish habitat zones are the near-shore shallows including bays and lagoons and the entrance areas of bays and lagoons. Fish are not nearly as abundant in offshore areas such as the location of the IOL breakwater.

3. Invertebrates are relatively abundant and diverse wherever organic mud and debris can be found (39 species). Where the substrate is primarily sand such as in the vicinity of the IOL breakwater, lower densities of benthic macro-invertebrates are present.

4. Because of the proximity to the mouth of the east channel of the Mackenzie River which contributes to higher

water temperatures and nutrient levels, the phytoplankton communities in the Tuft Point area are relatively abundant and diverse (36 species phytoplankton). Zooplankton (33 species) appear to be less abundant in the Tuft Point than in other areas of the Beaufort Sea.

5. Present Imperial Oil dredging operations in the Tuft Point area are having little or no effect upon fish, invertebrate, or plankton populations.

6. The dredging site is far enough offshore to be outside of the most important fish habitat zones. The substrate being dredged is mostly clean sand where invertebrate densities are very low and the slight increases in turbidity levels in the immediate vicinity of the dredge site are unlikely to affect fish, invertebrates, or plankton significantly.

Based upon the results of this study, including a review of the literature cited, the following recommendations are made. It is recommended that:

1. Dredging operations within the study area be excluded from the nearshore shallows (closer than 1 mi--1.6 km--to shore) and from the vicinity of openings into bays and lagoons.

2. Removal of existing island, shore, sandspit, or beach areas be avoided.

3. Effects of breakwater construction be monitored along the coast to avoid significant changes in currents and erosion and deposition patterns.

4. Further studies be conducted to:

a) determine the extent seaward of the heavily utilized nearshore shallow zone;

b) determine the utilization of the offshore habitat zones by fish, particularly early life history stages of marine species;

c) monitor turbidity and suspended sediment levels whenever the site of dredging operations is changed.

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INTRODUCTION

In June, 1977, Aquatic Environments Limited of Calgary, Alberta, was contracted by Imperial Oil Limited to conduct baseline studies of the fish, aquatic invertebrate, and plankton populations in the vicinity of Tuft Point, N.W.T.

Briefly, the purposes of these studies were to:

1) determine the species composition and relative abundance of fish within the study area;

2) identify important fish habitat zones;

3) determine species composition, standing crop, and diversity of benthic macroinvertebrate and plankton communities;

4) determine the food habits of the fish species present in the study area;

5) conduct basic life history analyses of the major fish species present;

6) to use the baseline data thus obtained to:

a) assess the effects of present and future Imperial

Oil borrow operations upon fish populations in the area;

b) form the basis for recommendations to mitigate any effects and for guidelines to be used in planning future borrow sites.

THE STUDY AREA

Tuft Point is located approximately 40 km (25 miles) northeast of Tuktoyaktuk, N.W.T., on the Beaufort Sea coast. The East Channel of the Mackenzie River enters the Beaufort Sea 32 km (20 miles) further to the west and has a profound effect upon the aquatic flora and fauna of the area.

The topography around Tuft Point is generally characterized by rolling sand hills mostly 15 m (50 ft) or less in height. There are occasional pingos in the area and one or two hills slightly over 30 m (100 ft) in elevation. The coast itself is characterized by eroding sand cliffs and beaches and long low sand spits.

The large sand deposits common to the Tuft Point region extend for considerable distance under the sea and are the source of material for Imperial Oil Limited's borrow operations in the area.

Figure 1 shows the study area and sampling stations extending from Hutchison Bay west and south including a large unnamed inland bay approximately 9.6 km (6 miles) south of Tuft Point. Also indicated is the location of the breakwater created to shelter Imperial Oil dredging and barge loading facilities.

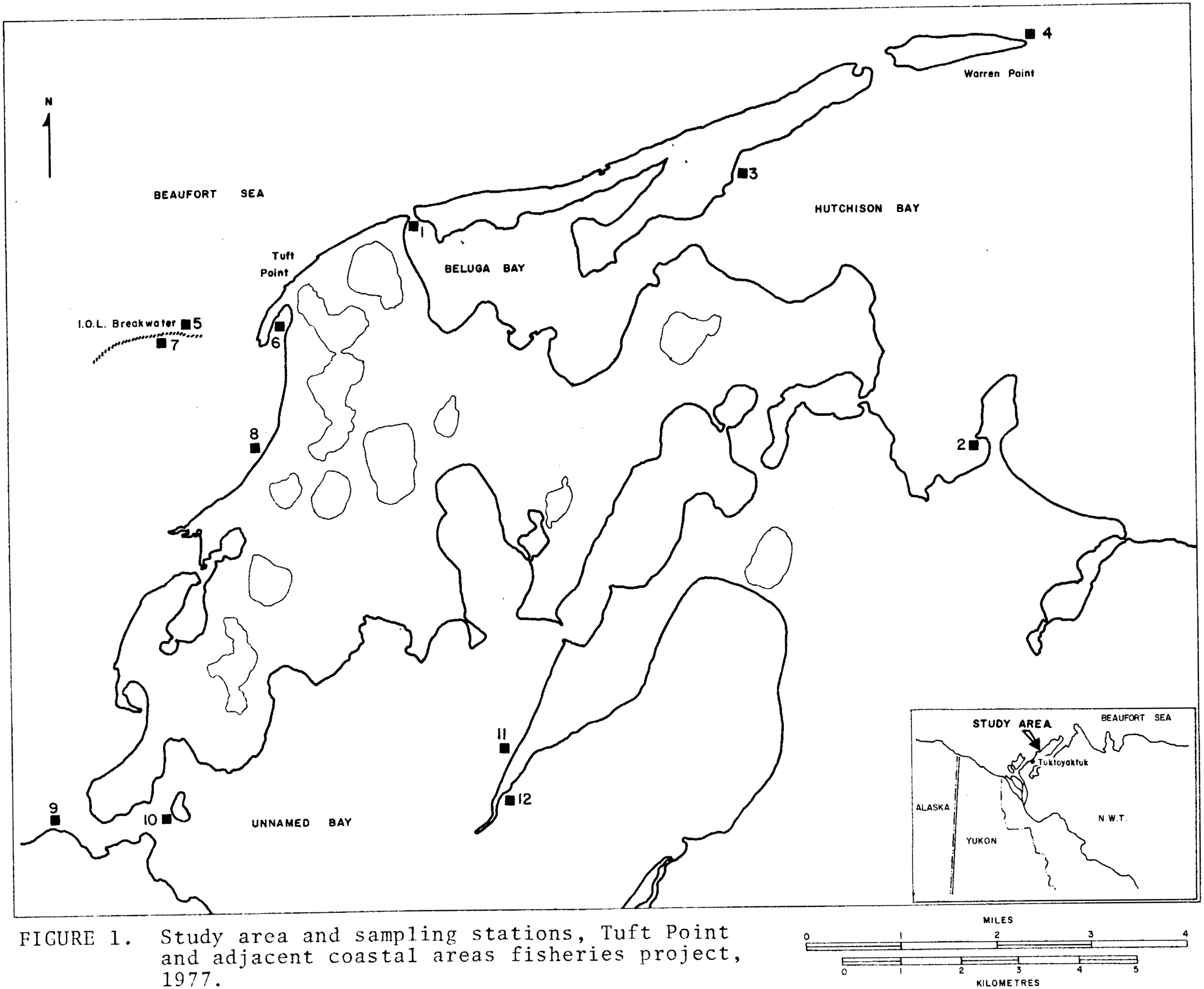


FIGURE 1. Study area and sampling stations, Tuft Point and adjacent coastal areas fisheries project, 1977.

Plate 1 is an aerial view west from Tuft Point showing the barge at Camp 208, the artificial breakwater, and the site of the borrow operations.

PLATE 1. View west from Tuft Point, Barge Camp 208 (right center); IOL breakwater and dredging operation (top center).

PLATE 2. Epibenthic trawl used for sampling bottom-dwelling macroinvertebrates and fish.

WATER QUALITY STUDIES

Methods

Selected water quality parameters were measured during the July and August-September sampling periods.

500 ml samples were collected from below the surface at each of 12 sampling stations. In addition, a transect was taken inside the Imperial Oil breakwater in the immediate vicinity of dredging operations.

Water samples were returned to the laboratory for analysis including determinations of specific conductivity (Beckman RB4-250 Solu Bridge), pH (Radiometer pH meter, Type 29, with GK 2311C electrode), turbidity (Hach Model 2100A turbidimeter), suspended solids (gravimetric method, dried at 180 C), and salinity (chloride titration method).

Temperature (pocket thermometer) and dissolved oxygen (Hach OX-10 oxygen kit) were measured in the field.

Results

Tables 1 and 2 summarize water quality data for each of the sampling periods. The Tuft Point region lies within a

TABLE 1. Water quality summary.

Station	Date	Temp. (C)	D.O. (mg/l)	Turbidity Shaken (FTU)	Turbidity Settled (FTU)	Suspended Solids (mg/l)	Conductivity µmhos/cm @ 25 C	Salinity mg/l NaCl	pH
	JULY								
1	23	11	9	4.0	0.4	11.4	31,815	21,430	7.2
2	22	11	9	6.1	0.5	13.4	16,800	10,400	7.2
3	21	11	9	1.9	0.5	8.3	17,850	10,400	7.4
4	21	8	10	1.6	0.3	5.1	33,705	23,900	7.4
5	17	7	10	3.7	0.4	8.3	31,500	20,600	7.4
6	16	4	11	6.2	0.7	14.6	34,650	23,500	7.4
7	17	7	10	2.3	0.3	8.0	32,130	21,000	7.1
8	16	5	11	3.7	0.7	11.1	32,550	21,430	7.3
9	18	6	10	4.5	0.5	11.4	13,755	8,700	7.5
10	18	7	10	2.3	0.6	5.4	12,180	8,080	7.5
11	19	11	9	3.1	0.5	9.1	13,440	8,575	7.4
12	19	12	8	3.9	0.7	17.4	9,502	5,625	7.1
Breakwater Transect									
A	17	7	10	9.8	0.7	18.3	31,500	21,000	7.4
B	17	7	10	7.1	0.5	14.6	31,605	20.600	7.4
C	17	7	10	5.0	0.4	10.3	32,550	20,600	7.4
D	17	7	10	2.4	0.4	6.6	32,025	22,250	7.4
E	17	7	10	3.0	0.3	7.1	31,710	21,400	7.3
F*	17	7	10	28.0	1.3	70.8	32,550	21,430	7.1
G	17	7	10	4.0	0.4	11.4	31,815	21,850	7.2

*Sample taken in immediate vicinity of dredge intake.

TABLE 2. Water quality summary.

Station	Date	Temp. (C)	D.O. (mg/l)	Turbidity Shaken (FTU)	Turbidity Settled (FTU)	Supended Solids (mg/l)	Conductivity μmhos/cm @ 25 C	Salinity mg/l NaCl	pH
	AUG.								
1	30	7.5	10	6.5	0.7	14.4	24,308	14,500	7.5
2	30	8	9.8	8.8	0.8	18.8	22,145	12,350	6.4
3	30	8	9.8	4.0	0.9	13.2	19,879	11,775	7.6
4	30	8	9.6	6.8	0.7	11.6	13,390	7,425	7.5
5	27	6	11	9.7	0.8	15.2	31,930	20,200	6.5
6	28	7	10	14.0	1.1	53.2	25,647	15,300	7.1
7	27	6	11	2.8	0.8	14.8	32,960	21,000	6.6
8	28	7	10	18.0	1.1	44.8	26,574	16,520	7.6
9	31	9.5	9.4	4.2	0.7	14.0	25,956	15,200	7.5
10	31	9	9.2	3.0	0.8	8.4	29,973	18,300	7.4
	SEPT								
11	2	11	9	5.7	0.8	19.6	28,634	17,200	7.6
12	2	7.5	10	3.7	1.5	5.2	28,634	17,800	7.9
Breakwater Transect									
A	2	6	10.6	11.0	0.5	18.4	12,051	6,200	7.8
B	2	6	10.6	9.4	0.4	15.2	11,021	6,000	7.5
C	2	6	10.6	10.0	0.7	18.4	11,021	5,920	7.4
D	2	6	10.6	7.4	1.1	18.8	11,330	6,000	7.3
E	2	6	10.6	11.0	0.7	19.2	14,729	7,650	7.4

broad mixing zone where the turbid fresh water of the Mackenzie River becomes mixed with the clear salt water of the Beaufort Sea. The broad range in values for conductivity, salinity, and to some degree turbidity and suspended sediments can be accounted for by this mixing action. Wind-induced currents are probably the single most important factor influencing the mixing of fresh and salt water in the Tuft Point region.

Salinities ranged from 5,625 to 23,900 mg/l NaCl in July and from 5,920 to 21,000 mg/l NaCl in August-September. As an example of the changes in salinity that can occur due to wind-induced currents, salinity values from Stations 5 and 7 can be compared to the salinity values for the breakwater transect in Table 2. Stations 5 and 7 are located in the vicinity of the Imperial Oil breakwater. On August 27 salinities in the vicinity of the breakwater ranged between 20,200 and 21,000 mg/l NaCl. On September 2, salinities from the same area ranged between 5,920 and 7,650 mg/l NaCl. During this six day period, wind direction had shifted abruptly from a prevailing easterly flow to a strong westerly flow. Specific conductivities show corresponding changes in values.

Turbidity and suspended sediment values ranged between 1.6 and 6.2 F.T.U. and 5.1 and 17.4 mg/l, respectively, for Stations 1-12 during the July sampling period. Samples taken on a transect behind the breakwater through the area affected by the Imperial Oil dredging operations generally showed turbidity and suspended sediment values comparable to those found elsewhere in the study area. The exception was one sample from Station F (Table 1) which was taken in the immediate vicinity of the dredge intake. Increases in turbidity and suspended sediment values due to Imperial Oil's dredging operations appear to be minimal and limited in extent, due mainly to the lack of silt and organic debris in the sand deposits being mined.

During the August-September sampling period, turbidity and suspended sediment values were generally higher than those which occurred in July (Table 2). Values ranged from 3.0 to 18.0 F.T.U. and 5.2 to 53.2 mg/l for turbidities and suspended sediments, respectively. These increases were most likely the result of the shift in wind direction from east to west and increased wave action due to stormy seas. Values from a transect taken behind the Imperial Oil breakwater once again indicate only slight increases in turbidities and suspended sediment concentrations due to the dredging operations.

High levels of dissolved oxygen were found consistently throughout the study area (range 8 to 11 mg/l). Water temperatures ranged from 4 to 12 C in July and 5 to 11 C in August-September. Values for pH ranged from 7.1 to 7.5 in July and from 6.4 to 7.9 in August-September.

INVERTEBRATE STUDIES

Methods

Macroinvertebrates were collected at each of the 12 sampling stations (Figure 1) during July (16-23) and August-September (27-2) field trips.

Two methods were used to obtain samples of the organisms present. A weighted Ekman grab sampler (surface area 232.3 cm^2, depth 7-10 cm, sample size)(Hudson, 1970) was used to collect epibenthic (those organisms which live on the substrate) and infaunal (those organisms which live in the substrate) organisms. At each sample site, a transect of 5 grab samples was taken. Samples were washed in a screen-bottomed bucket and placed in plastic containers.

In addition, a 1 m epibenthic trawl was used at each sample site (Plate 2). The trawl was towed across the substrate for a period of 3 to 4 minutes for an average distance of approximately 900 m. A Tsuruni-Seiki (Model 10-1971) flow meter was used to standardize tow distances so that catch-per-unit-effort calculations could be made.

All invertebrate samples were preserved in a 5% formalin solution. Rose bengal dye was added to the formalin to stain the organisms for easier sorting in the laboratory. In the laboratory, invertebrates were hand counted and identified using a Wild M4 binocular microscope. Organisms were identified to major taxa and the species and/or genera present were recorded. The principal taxonomic references used were: Canadian Arctic Expedition (1918), Fraser and Hansen (1939-1974), Grainger (1954), Borradaile *et al.* (1955), Davis (1955), Ellis (1955), Ellis (1960), Gosner (1971), Banse and Hobson (1974), Carey *et al.* (1974), Crane and Cooney (1975), Kendel *et al.* (1975), Wacasey (1975), Word and Charwat (1975), Slaney (1977a).

Shannon-Weaver species diversity indices (Shannon and Weaver, 1949) were computed for all invertebrate samples by the machine formula of Lloyd *et al.* (1968). This formula is:

$$\bar{d} = \frac{C}{N} (N \operatorname{Log}_{10} N - \Sigma n_i \operatorname{Log}_{10} n_i)$$

where: $C = 3.32193$

N = total number of individuals

n_i = total number of individuals in the i^{th} species

Species diversity is dependent on the number of species (richness) and the distribution of individuals among the species (evenness). Shannon and Weaver's information theoretical measure of mean species diversity per individual

($\bar{d}$) is sensitive to, and increases with, both species richness and evenness. The value of $\bar{d}$ is proportional to the uncertainty of identification of an individual selected at random from a multi-species population. In general, $\bar{d}$ values range from zero to any positive number, but are seldom greater than 10. The $\bar{d}$ value is at a minimum when all individuals belong to the same species, whereas $\bar{d}$ is at a maximum value when each species contains the same number of individuals.

Present studies were oriented toward examining species composition and distribution of invertebrates in the vicinity of Tuft Point to determine the effect of present development activity and to provide baseline data for future development. Benthic organisms have been found to be relatively sensitive indicators of environmental disturbance due to their long life histories and central position in the food chain, as well as their lack of mobility and their sensitivity to physico-chemical stress (MacKenthum, 1969; Cairns and Dickson, 1971).

Various sampling techniques utilized to examine invertebrate fauna place emphasis on different aspects of the community and tend to vary considerably in sampling efficiency (Flannagan, 1970). Ekman grabs tend to emphasize the infaunal organisms while bottom trawls capture epibenthic organisms most efficiently (Griffiths *et al.*, 1977).

Results

Available information on the invertebrate fauna of Beaufort Sea coastal areas is extremely limited and seldom in sufficient detail to provide a baseline adequate for monitoring the effects of development. The most comprehensive studies to date include Ellis (1960), Carey *et al.* (1974), Crane and Cooney (1975), Griffiths *et al.* (1975, 1977), Wacasey (1975), and Slaney (1977a).

In the Beaufort Sea, invertebrate communities in less than 2 m of water consist almost exclusively of epibenthic organisms (those living on or near the substrate) because freezing of the water column and substrate during winter months eliminates most organisms (Crane and Cooney, 1975; Griffiths *et al.*, 1977). Wacasey (1975) reports that both species composition and abundance are related to water depths with generally higher densities of invertebrates in areas greater than 10 m in depth. Since the present study was conducted in areas less than 10 m in depth, the densities of invertebrate fauna reported tend to be slightly lower than in areas further offshore (Slaney, 1977a).

Ekman Grabs

Standing Crop

In July, Ekman grabs at stations in the vicinity of Tuft

Point averaged 2863 organisms/m^2 (range 44-10,147 organisms/m^2) increasing to 3694 organisms/m^2 (range 245-18,106 organisms/m^2) in samples taken in late August-early September (Tables 3 and 4). Slaney (1977) reports densities from 0 to 3959 organisms/m^2 in Ekman grabs from the Tuft Point study area.

During both sampling periods, the highest standing crops were recorded at Stations 1 (at the mouth of Beluga Bay) and 12 (in the unnamed bay). Standing crops in the vicinity of dredging activity (Stations 5 and 7) were relatively low (range 132-1113 organisms/m^2). Similar coarse sand substrates at Stations 4, 9, and 10 also contained relatively low standing crops during both sampling efforts (range 44-1117 organisms/m^2). The unstable nature of the coarse sand at these stations probably eliminated most of the infaunal organisms thus reducing standing crop.

Infaunal polychaetes, pelecypods, and oligochaetes were abundant at most stations in the study area and comprised most of the total standing crop (Figure 2 and Tables 3 and 4). The relative abundance of crustaceans increased slightly from the July sampling to the August-September sampling (5.6% to 10.9%), while pelecypods dropped slightly (26.0% to 17.7%). All other major groups had approximately the same percentage of total standing crop during both sampling efforts. Other authors report that polychaetes, oligochaetes, molluscs, and

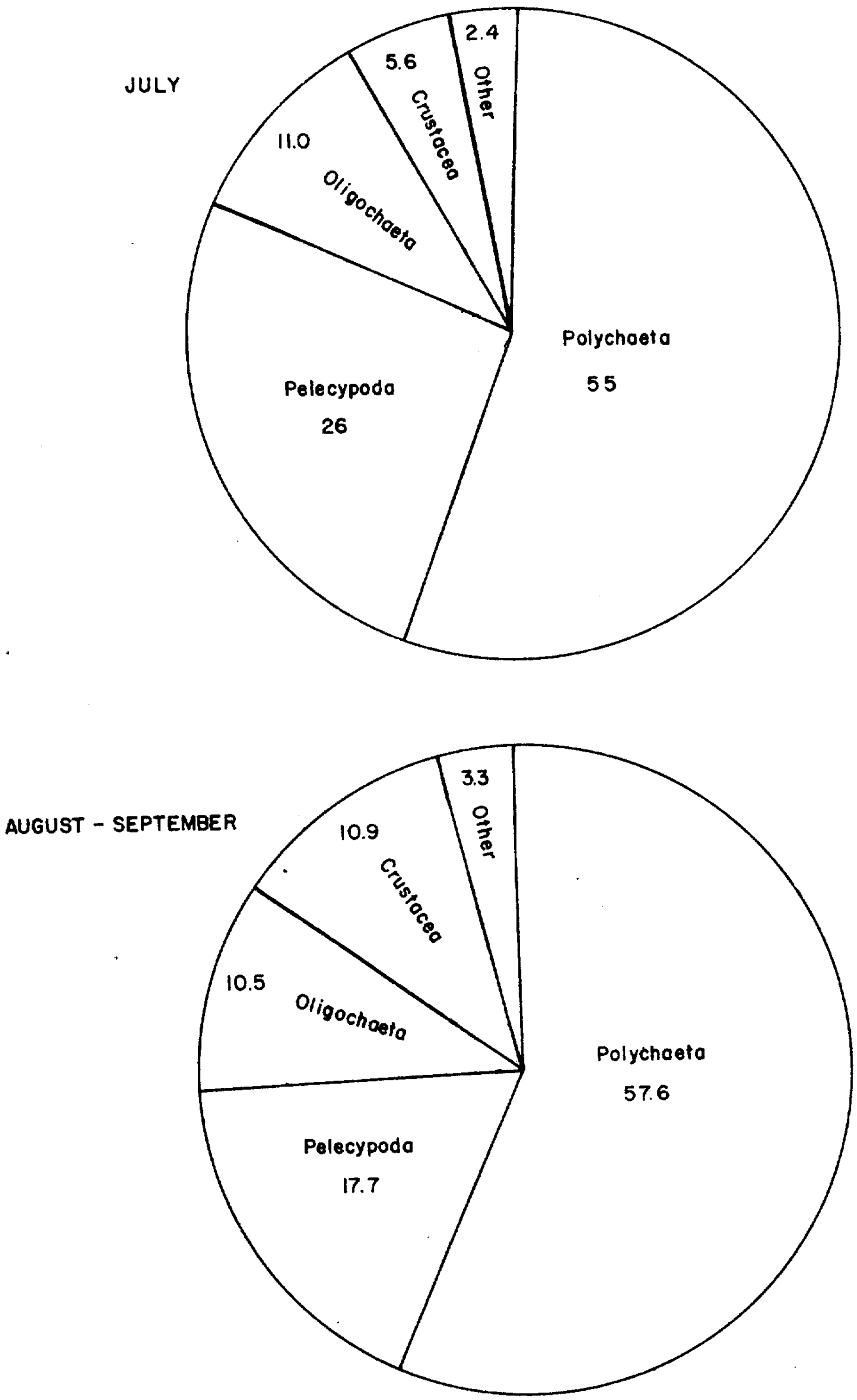


FIGURE 2. Per cent composition by major taxa for invertebrates from Ekman grab samples. Tuft Point fisheries project, 1977.

TABLE 3. Species composition and abundance of invertebrates in Ekman grab samples at 12 stations in the vicinity of Tuft Point, July, 1977. All values are number of organisms per m^2. Unidentifiable organisms are not included in calculation of diversity index. $\bar{x}$N=mean number of organisms; $\bar{x}$t=mean taxonomic diversity; $\bar{x}$d=mean diversity index.

Species	Station: 1	2	3	4	5	6	7
Annelida							
Polychaeta							
Ampharete vega	122		374			9	
Ampharete sp.							
Artacama proboscidea							
Cirratulus sp.	35						
Lumbrineris sp.	35	44	35	9		17	
Malacoceros fuliginosus	583						
Micronephthys minuta	7665		96		26		9
Prionospio cirrifera	731	87	1209		52	17	
Terebellides stroemi?			9		17	35	9
Polychaeta sp. A	9						
Polychaeta sp. B							
Polychaeta sp. C							
unidentified Polychaeta	131			17		9	9
Oligochaeta							
Peloscolex sp.	400	470	383	26		1235	
Oligochaeta sp. A						9	9
Chordata							
Ascidiacea							
Ascidia sp.?							
Crustacea							
Amphipoda							
Acanthostepheia behringiensis			9				
Apherusa glacialis						9	
Boeckosimus affinis							
Gammarus locustus	9		78			26	
Gammarus oceanicus	9		9			174	
Gammarus sp.							

(Continued)

TABLE 3. Continued.

Species Station:	1	2	3	4	5	6	7
Gammaracanthus loricatus							
Monoculodes latimanus		9					
Onisimus littoralis					9	9	
Parathemisto abyssorum						9	
Pontoporeia sp.							
Princillina armata	9	9	235	9	9		9
Weyprechtia sp.?							
unidentified Amphipoda			44			26	
Cumacea							
Diastylis rathkei	17	17	435		87	17	70
Isopoda							
Mesidotea entomon					9	35	
Mysidacea							
Mysis relicta		44	17		9		
Mollusca							
Pelecypoda							
Cyrtodaria kurriana	96		470		70	113	17
Macoma calcarea	78	26	1079			122	
Portlandia arctica	9					9	
Nematoda							
Chromadora sp.?	9	9	9				
Nemertina							
Nemertina sp. A							
Porifera							
Porifera sp. A			9			35	
Priapulida							
Halicryptus spinulosus	200		35			26	
Priapulus caudatus			9	9			

(Continued)

TABLE 3. Continued.

Station:	1	2	3	4	5	6	7
TOTAL ORGANISMS/m²	10,147	715	4,544	70	288	1,941	132
NUMBER OF SPECIES	17	9	18	5	9	18	6
DIVERSITY INDEX	1.30	1.80	2.96	2.17	2.64	2.10	1.96

(Continued)

TABLE 3. Continued.

Species	Station: 8	9	10	11	12	average number per m^2
Annelida						
Polychaeta						
Ampharete vega	444			704	3993	470.5
Ampharete sp.	9					0.8
Artacama proboscidea	9					0.8
Cirratulus sp.	9					3.7
Lumbrineris sp.			9	17	26	16.0
Malacoceros fuliginosus					70	54.4
Micronephthys minuta				1262	200	771.4
Prionospio cirrifera	78			209	339	226.8
Terebellides stroemi?				9		6.6
Polychaeta sp. A						0.8
Polychaeta sp. B	9					0.8
Polychaeta sp. C						-
unidentified Polychaeta	9			25	61	21.8
Oligochaeta						
Peloscolex sp.	183		252	304	470	310.2
Oligochaeta sp. A				52		5.8
Chordata						
Ascidiacea						
Ascidia sp.?				9		0.8
Crustacea						
Amphipoda						
Acanthostepheia behringiensis						0.8
Apherusa glacialis	9					1.5
Boeckosimus affinis	96					8.0
Gammarus locustus	26					11.6
Gammarus oceanicus		9		17	17	19.5
Gammarus sp.						-

(Continued)

TABLE 3. Continued.

Species	Station: 8	9	10	11	12	average number per m²
Gammaracanthus loricatus						-
Monoculodes latimanus					17	4.4
Onisimus littoralis	26			17		2.9
Parathemisto abyssorum						0.8
Pontoporeia sp.					9	0.8
Princillina armata				52	104	36.3
Weyprechtia sp.?						-
unidentified Amphipoda	9					6.6
Cumacea						
Diastylis rathkei	26					55.8
Isopoda						
Mesidotea entomon	9			9		5.2
Mysidacea						
Mysis relicta	9					6.6
Mollusca						
Pelecypoda						
Cyrtodaria kurriana	131	9		165	139	100.8
Macoma calcarea	357	26	9	1792	4037	627.0
Portlandia arctica	9					2.2
Nematoda						
Chromadora sp.?	9				9	3.8
Nemertina						
Nemertina sp. A						-
Porifera						
Porifera sp. A				17	87	12.3
Priapulida						
Halicryptus spinulosus	26			200	226	59.4
Priapulus caudatus					52	5.8

(Continued)

TABLE 3. Continued.

	Station: 8	9	10	11	12		average number per m^2
TOTAL ORGANISMS/m^2	1,492	44	270	4,860	9,856	$\bar{x}N=$	2,863.3
NUMBER OF SPECIES	19	3	3	16	16	$\bar{x}t=$	11.6
DIVERSITY INDEX	3.00	1.39	0.42	2.57	2.05	$\bar{x}d=$	2.03

TABLE 4. Species composition and abundance of invertebrates in Ekman grab samples at 12 stations in the vicinity of Tuft Point, August-September, 1977. All values are number of organisms per m^2. Unidentifiable organisms are not included in calculation of diversity index. $\bar{x}$N=mean number of organisms; $\bar{x}$t=mean taxonomic diversity; $\bar{x}$d=mean diversity index.

Species Station:	1	2	3	4	5	6	7
Annelida							
Polychaeta							
Ampharete vega		148	17		17	122	17
Ampharete sp.							
Artacama proboscidea						9	
Cirratulus sp.							
Lumbrineris sp.	792						
Malacoceros fuliginosus	2358						9
Micronephthys minuta	3384		418		9		296
Prionospio cirrifera	505	392	1801		26	87	17
Terebellides stroemi?						35	
Polychaeta sp. A	9						
Polychaeta sp. B	139	9					9
Polychaeta sp. C		9					
unidentified Polychaeta							
Oligochaeta							
Peloscolex sp.	418	331	1601	26	183	174	165
Oligochaeta sp. A	9	70	26				70
Chordata							
Ascidiacea							
Ascidia sp.?							
Crustacea							
Amphipoda							
Acanthostepheia behringiensis			9				
Apherusa glacialis	9						
Boeckosimus affinis						70	
Gammarus locustus	35	44	26	61	9	96	26
Gammarus oceanicus						52	
Gammarus sp.		26					

(Continued)

TABLE 4 . Continued.

Species	Station: 1	2	3	4	5	6	7
Gammaracanthus loricatus	17	9					
Monoculodes latimanus		9		9			
Onisimus littoralis	35			9			
Parathemisto abyssorum							
Pontoporeia sp.	17					113	
Princillina armata	70	17	287	61	104	139	122
Weyprechtia sp.?	9						
unidentified Amphipoda		9					
Cumacea							
Diastylis rathkei	200	78	392		235	26	218
Isopoda							
Mesidotea entomon	9					35	
Mysidacea							
Mysis relicta	9						
Mollusca							
Pelecypoda							
Cyrtodaria kurriana	17	218	513	44		104	104
Macoma calcarea	61	426	278	26	17	17	17
Portlandia arctica	61				9		26
Nematoda							
Chromadora sp.?			104		9		
Nemertina							
Nemertina sp. A					9	9	
Porifera							
Porifera sp. A	26	17	26	9		9	
Priapulida							
Halicryptus spinulosus	52	9	78			9	17
Priapulus caudatus	17		9		9		

(Continued)

TABLE 4. Continued.

Station:	1	2	3	4	5	6	7
TOTAL ORGANISMS/m^2	8,258	1,821	5,585	245	636	1,106	1,113
NUMBER OF SPECIES	24	16	15	8	12	17	14
DIVERSITY INDEX	2.50	2.99	2.70	2.66	2.46	3.62	3.03

(Continued)

TABLE 4. Continued.

Species	Station: 8	9	10	11	12	average number per m²
Annelida						
Polychaeta						
Ampharete vega	131	9		966	10640	1005.6
Ampharete sp.						-
Artacama proboscidea						0.8
Cirratulus sp.					26	2.2
Lumbrineris sp.	17			78	35	76.8
Malacoceros fuliginosus				1140	435	328.5
Micronephthys minuta	9	78	61	270	35	380.0
Prionospio cirrifera	9	44	70	61	722	311.2
Terebellides stroemi?	9					3.7
Polychaeta sp. A						0.8
Polychaeta sp. B				17		14.5
Polychaeta sp. C					9	1.5
unidentified Polychaeta					35	2.9
Oligochaeta						
Peloscolex sp.	131	26	566	513	148	356.8
Oligochaeta sp. A	9			174		29.8
Chordata						
Ascidiacea						
Ascidia sp.?						
Crustacea						
Amphipoda						
Acanthostepheia behringiensis			9			1.5
Apherusa glacialis	44					4.4
Boeckosimus affinis	113					15.2
Gammarus locustus	35	9	44		17	33.5
Gammarus oceanicus	35	252	9	26	44	34.8
Gammarus sp.						2.2

(Continued)

TABLE 4 . Continued.

Species	Station: 8	9	10	11	12	average number per m^2
Gammaracanthus loricatus		9				2.9
Monoculodes latimanus						1.5
Onisimus littoralis			9			4.4
Parathemisto abyssorum						-
Pontoporeia sp.	26	17	44			18.1
Princillina armata	305		113	52	26	108.0
Weyprechtia sp.?				9		1.5
unidentified Amphipoda						0.8
Cumacea						
Diastylis rathkei	679					152.3
Isopoda						
Mesidotea entomon	17	61	96			18.2
Mysidacea						
Mysis relicta					17	2.2
Mollusca						
Pelecypoda						
Cyrtodaria kurriana	35			35	87	96.4
Macoma calcarea	191	35	61	305	5116	545.8
Portlandia arctica					52	12.3
Nematoda						
Chromadora sp.?			9			10.2
Nemertina						
Nemertina sp. A						1.5
Porifera						
Porifera sp. A		35	26	17	44	17.4
Priapulida						
Halicryptus spinulosus	35			270	583	87.8
Priapulus caudatus					35	5.8

(Continued)

TABLE 4. Continued.

Station:	8	9	10	11	12		average number per m^2
TOTAL ORGANISMS/m^2	1,830	575	1,117	3,933	18,106	$\bar{x}N=$	3,693.8
NUMBER OF SPECIES	18	11	13	15	18	$\bar{x}t=$	15.1
DIVERSITY INDEX	3.02	2.67	2.56	2.90	1.70	$\bar{x}d=$	2.73

crustaceans were the most abundant organisms in nearshore Beaufort Sea habitats (Crane and Cooney, 1975; Kendel *et al.*, 1975; Wacasey, 1975; Slaney, 1976; Griffiths *et al.*, 1977).

The increase in total standing crop between the July and August-September sampling (from 2863 to 3694 organisms/m^2) was not significant ($t=0.453$, $P>0.05$). A similar paired t-test comparison of the most abundant group, polychaetes, indicates that the change in the numbers of these organisms (from 1574 to 2128 organisms/m^2) was also not significant ($t=0.106$, $P>0.05$). Polychaetes are particularly susceptible to the effects of sedimentation related to dredging activity due to the sedentary life style of many species. The high variation in total standing crop at adjacent stations suggests that there is a non-random distribution of invertebrates, particularly infaunal species, in nearshore habitats related to irregularities in substrate type. Other authors report similar high variation in total standing crop at other coastal locations (Griffiths *et al.*, 1975; 1977; Kendel *et al.*, 1975).

Species Composition

A total of 39 invertebrate species of 12 major groups was collected in Ekman grabs (Tables 3 and 4). Amphipods and polychaetes were highest in taxonomic diversity with 13 and 12 species, respectively. Wacasey (1975) and Slaney (1977a) also report relatively high taxonomic diversity among amphipods and polychaetes from stations in the vicinity of Tuft Point.

The average number of species increased from 11.6 in July samples to 15.1 in August-September samples with 8 of 12 stations higher in taxonomic diversity during the second sampling period. However, paired t-test comparisons of the two sampling periods indicate this change is not significant ($t=0.223$, $P>0.05$). Taxonomic diversity was highly variable in the study area and tended to follow the same general pattern as standing crop. Stations in sandy habitats (4, 5, 7, 9, and 10) were generally lower in taxonomic diversity (5-9 species in July; 8-14 species in August-September) during both sampling periods than the remaining stations (9-19 species in July; 15-24 species in August-September). Although taxonomic diversity is low at Station 5 in the vicinity of dredge operations, it is also low at Station 7 outside the breakwater in the same area. The unstable sand substrates probably limit taxonomic diversity more than disturbance due to dredging (i.e., siltation, habitat destruction, etc.).

The most abundant amphipods in the study area were *Gammarus* spp., *Princillina armata*, and *Boeckosimus affinis*. While *Gammarus* spp. and *Princillina armata* were widely distributed, *Boeckosimus affinis* was restricted to Stations 6 and 8 near the Imperial Oil Ltd. barge camp. Other amphipod species were rare and irregular in distribution.

Diastylis rathkei (a cumacean) was the most abundant crustacean in Ekman samples averaging 55.8 organisms/m^2 in July and 152.3 organisms/m^2 in August-September samples. Although relatively abundant in Hutchinson Bay and in the vicinity of dredge activity, this species was absent from stations in the unnamed bay. Wacasey (1974) reports that this species is abundant in deepwater stations of the southern Beaufort Sea.

The only other crustaceans encountered, *Mesidotea entomon* (an isopod) and *Mysis relicta* (a mysid), occurred in low densities at several stations (Tables 3&4). As relatively common components of the Beaufort Sea epibenthic fauna, these species have received considerable attention in the literature and are common food items for several fish species (Griffiths *et al.*, 1975; 1977).

The most common polychaetes in Ekman samples included *Ampharete vega*, *Malacoceros fuliginosus*, *Micronephthys minuta*, and *Prionopsis cirrifera* (Tables 3&4). Wacasey (1974) reports that all four of these species are common dominants in nearshore Beaufort Sea environments. Densities of these species commonly exceeded 100 organisms/m^2 during both sampling periods and at Station 12, densities of *Ampharete vega* reached 10,640 organisms/m^2 in August-September samples.

Of the two species of oligochaetes identified in the study area, *Peloscolex* sp. was the most abundant, averaging over 300 organisms/m^2 during both sampling periods. Kendel *et al.* (1975) and Wacasey (1974) report that this species is common in brackish water areas and Griffiths *et al.*, (1975) present data suggesting an abundance of oligochaetes in a lagoon with freshwater input (Nunaluk Lagoon, Yukon Territory).

Three species of pelecypod were identified from the study area (Tables 3&4), with *Macoma calcarea* the most abundant, averaging over 500 organisms/m^2 during both sampling efforts. The high average density of this species resulted largely from the occurrence of high concentrations at Station 12 (greater than 4000 organisms/m^2).

Other Taxa

Of the remaining species listed in Tables 3&4, only *Halicryptus spinulosus* (a priapulid) occurred in average densities greater than 50 organisms/m^2. The high average density of this species was the result of its abundance at stations in Beluga Bay (Station 1) and the unnamed bay (Stations 11 and 12). Priapulids were generally rare at stations with unstable sand substrates (Stations 4, 5, 7, 9, and 10).

Species Diversity

Shannon-Weaver species diversity indices averaged 2.05 (range 0.42 to 3.0) during the July sampling and increasing to a mean of 2.73 (range 1.70 to 3.62) in samples taken in August-September. Stations in the immediate vicinity of dredging activity (Stations 5 and 7) remained relatively unchanged in species diversity indicating that sediments released during the summer dredging program had little or no effect on invertebrates in the area.

Bottom Trawl (Epibenthic)

Standing Crop

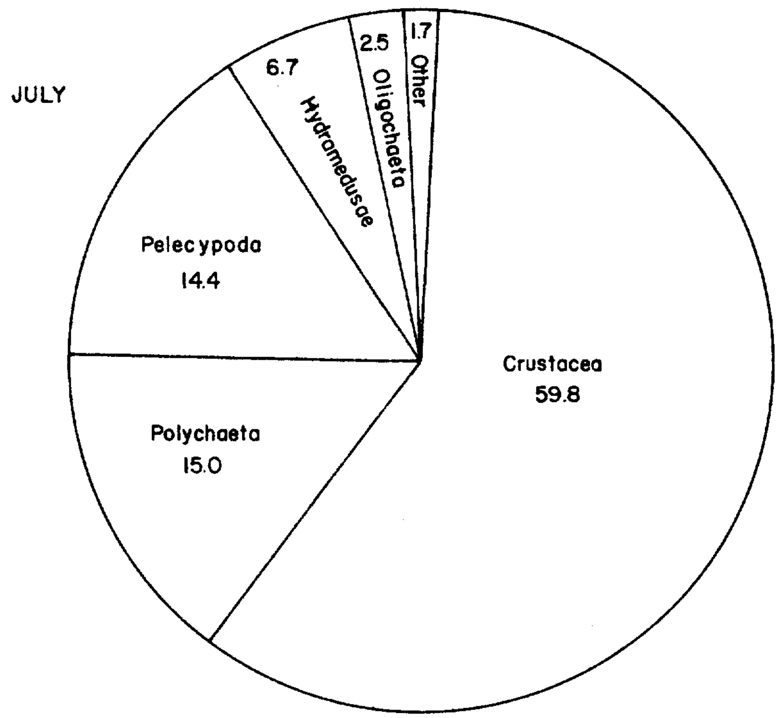
Densities of invertebrates sampled in bottom trawls averaged 194.3 organisms/1000 m (range 22-526 organisms/1000 m trawl) in July, and 834.8 organisms/1000 m (range 10-5834 organisms/1000 m) in August-September. Similar bottom trawls by Slaney (1977) indicated densities ranging from 30.5 to 499.6 organisms/1000 m in the vicinity of dredge activity.

The apparent seasonal increase in mean total standing crop observed during the present study was caused mainly by an abundance of infaunal organisms (e.g., polychaetes and pelecypods) in trawls at a single station (Station 12) during the second sampling period. Although 10 of the 12 stations showed some increase in total standing crop between the two sampling periods, paired t-test analysis indicates this difference was not significant ($t=0.113$, $P>0.05$). Data obtained from both Ekman grabs and bottom trawls indicate that the total standing crop of infaunal and epibenthic invertebrates remained relatively constant during the summer months.

While polychaetes were the dominant taxon in Ekman samples, crustaceans dominated bottom trawl samples during both sampling periods (Figure 3). Crustaceans comprised 59.8% of July trawl samples but declined to 45.3% in the second sampling period. Polychaetes averaged 15.0% of July trawl samples and increased to 24.3% of August-September trawls. Infaunal pelecypods were nearly as abundant in bottom trawl samples as in Ekman grabs, averaging 14.4% in July samples and 20.4% in August-September samples. Hydromedusae, not present in Ekman grabs, comprised 6.7% of July trawl samples and 3.9% of August-September samples.

Species Composition

A total of 37 invertebrate species was identified in bottom trawl samples from the Tuft Point study area, with amphipod species (N=9) and polychaete species (N=7) most abundant. Species composition of infaunal invertebrates captured by bottom trawl was generally similar to species composition in Ekman grabs (Tables 5&6). Several differences in species composition of epibenthic organisms were observed



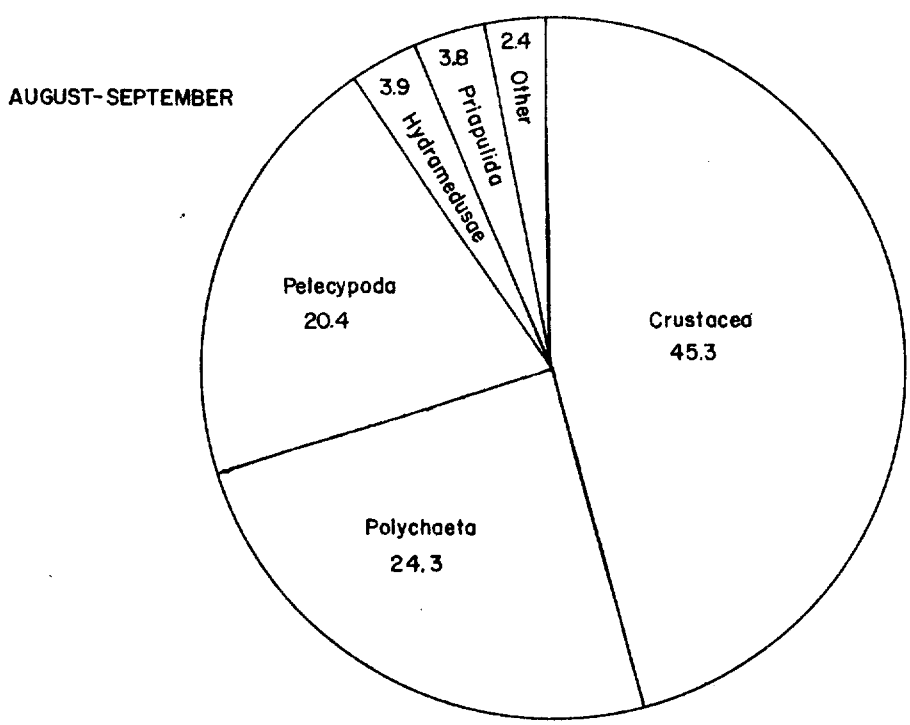


FIGURE 3. Per cent composition by major taxa for invertebrates from bottom trawl samples, Tuft Point fisheries project, 1977.

TABLE 5. Density of epibenthic and infaunal invertebrates in bottom trawl samples from 12 stations in the vicinity of Tuft Point, July, 1977. All densities are expressed as number of organisms per 1000 m² of bottom trawled. Shannon-Weaver species diversity index is also presented. x̄N=mean number of organisms; x̄t=mean number of taxa; x̄d=mean diversity index.

Species	Station: 1	2	3	4	5	6	7
Annelida							
Polychaeta							
Ampharete vega	1					3	
Malacoceros fuliginosus							
Micronephthys minuta	1						
Prionospio cirrifera			6			4	
Terebellides stroemi?							
Polychaeta sp. A	1						
Polychaeta sp. B	1						
Oligochaeta							
Peloscolex sp.		8	2			3	4
Oligochaeta sp. A							1
Chaetognatha							
Sagitta elegans					1		4
Cnidaria							
Hydrazoa (Hydramedusae)							
Halitholus cirratus				14	29		7
Sarsia sp.					5		
Hydrazoa sp. A					34		60
Crustacea							
Amphipoda							
Acanthostepheia behringiensis	16	48	11			1	1
Gammarus locustus	4		1			1	1
Gammarus oceanicus	47	3	1	3	3	19	
Gammaracanthus loricatus	57	3	5	1	5	18	7
Monoculodes latimanus	10		1		1	16	

(Continued)

TABLE 5. Continued.

Species	Station: 1	2	3	4	5	6	7
Onisimus littoralis	4				1		
Parathemisto abyssorum					1	1	1
Pontoporeia sp.	7						
Princillina armata	3						1
Cumacea							
Diastylis rathkei	20		7		5	6	
Euphasidacea							
Thysanoessa raschii	7						
Isopoda							
Mesidotea entomon	49	1	5	4	1	45	
Mesidotea sabini						2	
Mysidacea							
Mysis relicta	75	21	6		5	25	8
Mysis littoralis	3						
Ctenophora							
Mertensia ovum					1	2	1
Mollusca							
Pelecypoda							
Cyrtodaria kurriana	3	1	11			3	4
Macoma calcarea			36			7	1
Portlandia arctica							
Pteropoda							
Clione lamacina					10	1	14
Nematoda							
Chromadora sp.?		3					
Porifera							
Porifera sp. A						1	

(Continued)

TABLE 5. Continued.

Species	Station: 1	2	3	4	5	6	7
Priapulida							
Halicryptus spinulosus			3				
Priapulus caudatus							
TOTAL ORGANISMS/1000 m^2	309	88	95	22	102	158	115
TOTAL NUMBER OF SPECIES	18	8	13	4	14	18	15
DIVERSITY INDEX	3.13	1.93	2.96	1.45	2.77	3.23	2.54

(Continued)

TABLE 5. Continued.

Species	Station: 8	9	10	11	12	$\bar{x}N$
Annelida						
Polychaeta						
Ampharete vega	95			166	24	24.1
Malacoceros fuliginosus						-
Micronephthys minuta				7		0.7
Prionospio cirrifera		3	1	17	16	3.9
Terebellides stroemi?					3	0.3
Polychaeta sp. A						0.1
Polychaeta sp. B						0.1
Oligochaeta						
Peloscolex sp.		3		5	33	4.8
Oligochaeta sp. A						0.1
Chaetognatha						
Sagitta elegans		1				0.5
Cnidaria						
Hydrazoa (Hydramedusae)						
Halitholus cirratus						4.2
Sarsia sp.						0.4
Hydrazoa sp. A			8			8.5
Crustacea						
Amphipoda						
Acanthostepheia behringiensis		31	215	25	8	29.6
Gammarus locustus						0.6
Gammarus oceanicus	12	33	17	25	1	13.6
Gammaracanthus loricatus	55	7	3	1	3	13.7
Monoculodes latimanus			1			2.4

(Continued)

TABLE 5. Continued.

Species	Station: 8	9	10	11	12	x̄N
Onisimus littoralis				3		0.7
Parathemisto abyssorum						0.3
Pontoporeia sp.						0.6
Princillina armata	3	1	5	3	3	1.6
Cumacea						
Diastylis rathkei	11	12	5			5.5
Euphasidacea						
Thysanoessa raschii						0.6
Isopoda						
Mesidotea entomon	12	5	18	8	1	12.4
Mesidotea sabini						0.2
Mysidacea						
Mysis relicta	180	4	58		5	32.2
Mysis littoralis			17			1.7
Ctenophora						
Mertensia ovum						0.3
Mollusca						
Pelecypoda						
Cyrtodaria kurriana	32		3	10	12	6.5
Macoma calcarea	95	1	1	50	1	16.0
Portlandia arctica	29			7		3.0
Pteropoda						
Clione lamacina		5		1		2.6
Nematoda						
Chromadora sp.?					8	0.9
Porifera						
Porifera sp. A		3		4	4	1.0

(Continued)

TABLE 5. Continued.

Species	Station: 8	9	10	11	12	$\bar{x}N$
Priapulida						
Halicryptus spinulosus	2		1	1		0.6
Priapulus caudatus						-
TOTAL ORGANISMS/1000 m^2	526	109	353	333	122	$\bar{x}N$= 194.3
TOTAL NUMBER OF SPECIES	11	13	14	16	14	$\bar{x}t$= 13.2
DIVERSITY INDEX	2.68	2.84	2.01	2.57	3.11	$\bar{x}d$= 2.60

TABLE 6. Density of epibenthic and infaunal invertebrates in bottom trawl samples from 12 stations in the vicinity of Tuft Point, August-September, 1977. All densities are expressed as number of organisms per 1000 m^2 of bottom trawled. Shannon-Weaver species diversity index is also presented. $\bar{x}N$=mean number of organisms; $\bar{x}t$=mean number of taxa; $\bar{x}d$=mean diversity index.

Species Station:	1	2	3	4	5	6	7
Annelida							
Polychaeta							
Ampharete vega		1		11		5	
Malacoceros fuliginosus	10						
Micronephthys minuta							
Prionospio cirrifera			22	1		1	
Terebellides stroemi?							
Polychaeta sp. A							
Polychaeta sp. B	1						
Oligochaeta							
Peloscolex sp.	3	3					
Oligochaeta sp. A							
Chaetognatha							
Sagitta elegans	14				4		1
Cnidaria							
Hydrazoa (Hydramedusae)							
Halitholus cirratus				3			1
Sarsia sp.							
Hydrazoa sp. A	17			13	67		66
Crustacea							
Amphipoda							
Acanthostepheia behringiensis	10	90	37	4		1	
Gammarus locustus						1	1
Gammarus oceanicus	3	9	3				
Gammaracanthus loricatus	14	8	7				1
Monoculodes latimanus	37			2	25		35

(Continued)

TABLE 6. Continued.

Species	Station: 1	2	3	4	5	6	7
Onisimus littoralis							
Parathemisto abyssorum	1						
Pontoporeia sp.					1	1	14
Princillina armata	3	1	3		3	5	3
Cumacea							
Diastylis rathkei	93	1	10	1	3	4	5
Euphasidacea							
Thysanoessa raschii	3		5				
Isopoda							
Mesidotea entomon	10	5	9	5	8	23	5
Mesidotea sabini							
Mysidacea							
Mysis relicta	304	79	55	3	9	7	13
Mysis littoralis	38	4					
Ctenophora							
Mertensia ovum				1	1	3	1
Mollusca							
Pelecypoda							
Cyrtodaria kurriana	3	3	3	12	1		
Macoma calcarea	4		30			1	
Portlandia arctica	4		1		1	1	
Pteropoda							
Clione lamacina						4	
Nematoda							
Chromadora sp.?							
Porifera							
Porifera sp. A				2			

(Continued)

TABLE 6. Continued.

Species	Station: 1	2	3	4	5	6	7
Priapulida							
Halicryptus spinulosus	1		4	2			
Priapulus caudatus	3						
TOTAL ORGANISMS/1000 m^2	576	204	189	60	123	57	146
TOTAL NUMBER OF SPECIES	21	11	13	13	11	13	12
DIVERSITY INDEX	2.52	1.97	2.95	3.17	2.12	2.89	2.34

(Continued)

TABLE 6. Continued.

Species	Station: 8	9	10	11	12	$\bar{x}N$
Annelida						
Polychaeta						
Ampharete vega	62		50	752	3577	371.5
Malacoceros fuliginosus			21	35	16	6.8
Micronephthys minuta				9	20	2.4
Prionospio cirrifera			31	31	7	7.8
Terebellides stroemi?			3			0.2
Polychaeta sp. A			3			0.2
Polychaeta sp. B				9		0.8
Oligochaeta						
Peloscolex sp.						0.5
Oligochaeta sp. A						-
Chaetognatha						
Sagitta elegans				1		1.7
Cnidaria						
Hydrazoa (Hydramedusae)						
Halitholus cirratus						0.3
Sarsia sp.						-
Hydrazoa sp. A						13.6
Crustacea						
Amphipoda						
Acanthostepheia behringiensis	1	1	31		3	14.8
Gammarus locustus	1			4		0.6
Gammarus oceanicus	5		24	13	10	5.6
Gammaracanthus loricatus	1		8			3.2
Monoculodes latimanus	9		34			11.8

(Continued)

TABLE 6. Continued.

Species	Station: 8	9	10	11	12	$\bar{x}N$
Onisimus littoralis	1					-
Parathemisto abyssorum						0.1
Pontoporeia sp.	3		3		3	2.1
Princillina armata	37		8	4	3	5.8
Cumacea						
Diastylis rathkei	176		73			30.5
Euphasidacea						
Thysanoessa raschii						0.7
Isopoda						
Mesidotea entomon	216		42			26.9
Mesidotea sabini						-
Mysidacea						
Mysis relicta	33	8	81	61		54.4
Mysis littoralis	4		8			4.5
Ctenophora						
Mertensia ovum						0.5
Mollusca						
Pelecypoda						
Cyrtodaria kurriana	45		8	35	3	9.4
Macoma calcarea	13		55	612	2040	229.6
Portlandia arctica	37		8	13	29	7.8
Pteropoda						
Clione lamacina						0.3
Nematoda						
Chromadora sp.?				13	3	1.3
Porifera						
Porifera sp. A				39	26	5.6

(Continued)

TABLE 6. Continued.

Species	Station: 8	9	10	11	12	$\bar{x}N$
Priapulida						
Halicryptus spinulosus		1		31	3	3.5
Priapulus caudatus			5	17	95	10.0
TOTAL ORGANISMS/1000 m^2	644	10	496	1,679	5,834	$\bar{x}N$= 834.8
TOTAL NUMBER OF SPECIES	16	3	19	17	15	$\bar{x}t$= 13.6
DIVERSITY INDEX	2.72	0.92	3.67	2.15	1.24	$\bar{x}d$= 2.39

and will be discussed in the following section.

Although all species of amphipods captured in bottom trawls were found in Ekman samples, *Acanthostephia behringiensis*, *Gammaracanthus loricatus*, and *Monoculodes latimanus* were much more abundant in trawl samples. Of the amphipod species most abundant in Ekman grabs, only *Gammarus oceanicus* was abundant in bottom trawl samples. Amphipod species appeared to be distributed throughout the study area including stations near dredge activity (Stations 5 and 7).

Other common crustaceans in bottom trawl samples include *Diastylis rathkei* (a cumacean), *Mesidotea entomon* (an isopod), and *Mysis relicta* (a mysid). Three additional crustaceans, *Thysomoessa raschii* (an euphasid), *Mesidotea sabini*, and *Mysis littoralis* were present in some trawl samples, but were not captúred in Ekman grabs.

Three species of Hydramedusae, including *Halithalus cirratus*, *Sarsia* sp., and an unidentified species (Species A) were captured in bottom trawls. *Halithalus cirratus* and Species A were abundant in the vicinity of dredge activity (Stations 5 and 7), and generally absent from stations in Hutchinson Bay and the unnamed bay. The free-living, floating nature of Hydramedusae results in tide and wind conditions influencing the abundance and distribution of these organisms

(Davis, 1955).

Although absent from Ekman samples, a single species of ctenophore *(Mertensia ovum)* and a species of chaetognath *(Sagitta elegans)* were occasionally found in trawl samples. Both species were rare, but were present in the vicinity of the dredge operations (Stations 5 and 7) during both sampling periods.

Taxonomic diversity of bottom trawl samples from the Tuft Point study area was similar to that reported for Ekman grabs with July trawls averaging 13.2 species (range 4-18) and August-September trawls averaging 13.6 species (range 3-21). Although few polychaete species were present in most trawl samples, taxonomic diversity of epibenthic organisms (e.g., crustaceans) was sufficiently high to result in comparable total taxonomic diversity for Ekman grabs and bottom trawls.

Species Diversity

Shannon-Weaver species diversity indices for bottom trawls varied slightly between sampling dates averaging 2.60 (range 1.45-3.23) in July and 2.39 (0.92 to 3.67) in August-September. Diversity indices at stations in the vicinity of dredge activity were near or above the mean diversity indices during both sampling periods, indicating that sand removal operations had little effect on invertebrate populations. The low species diversity index at Station 9 (0.92) may have resulted from strong wind-generated currents in the narrow entrance to the unnamed bay interfering with the trawl operation thereby increasing sampling error.

In summary, the Tuft Point study area supports a diverse invertebrate fauna with a species composition similar to that reported at other coastal locations (Kendel *et al.*, 1975; Wacasey, 1975; Slaney, 1977a). Imperial Oil Limited's present dredging program appears to be having negligible impact on the invertebrate fauna within the study area. Since invertebrate communities along the Tuktoyaktuk Peninsula tolerate the high silt loads contributed to coastal waters by the Mackenzie River, it is not likely that siltation resulting from dredging will have a significant impact unless future dredging activity produced sediment loads considerably above present levels.

PLANKTON STUDIES

Phytoplankton

Methods

During each sampling period, a 125 ml phytoplankton sample was taken at each of the 12 stations. The sample was collected 0.5 m below the surface using a Kemmerer bottle. Samples were preserved using Lugol's solution (Schwoerbel, 1970) and returned to the laboratory for analysis.

Phytoplankton were counted following the method of Utermohl (1958). Whole water samples preserved with Lugol's solution were thoroughly agitated and a subsample allowed to settle in a phytoplankton settling chamber. The settled volumes ranged from 1 to 2.5 ml, depending upon the density of phytoplankton in each sample. Settling time was based on three hours per cm of chamber height. Counts and identifications were made using a Wild M40 Inverted Microscope with magnifications of 750x for enumeration and up to 1875x for identification. All counts are expressed as cells/ml. Identifications are to major taxa and based mainly upon the works of Bourrelly (1968), Desikachary (1958), Patrick and Reimer (1966), and Prescott (1962).

Species diversity indices were calculated as described for invertebrates.

Results

Species Composition

A total of 36 algal species representing the green algae (Chlorophyta), golden brown algae (Chrysophyceae), diatoms (Bacillariophyceae), euglenoids (Euglenophyta), and dinoflagellates (Cryptophyta) was recorded from the Tuft Point study area during the July and August-September sampling periods (Tables 7 and 8). Taxonomic diversity was slightly higher (30 species) in August-September samples than in July samples (27 species). Diatoms were the most abundant species, with 18 species present in July and 21 species in August-September. Other major groups were represented by only 1-4 species each. A similar species composition has been previously reported for nearshore Beaufort Sea habitats under the influence of the Mackenzie River (Foy and Hsiao, 1976; Hsiao *et al.*, 1977).

Standing Crop

The standing crop (cells/ml) of phytoplankton varied little during the two sampling periods, with total counts ranging from 337 to 8319 cells/ml in July and 773-8487 in August-September (Tables 7 and 8). Lowest July counts (337-1310 cells/ml) occurred at Stations 5-8 in the vicinity of dredge operations while higher counts (1570-8319 cells/ml) were recorded at stations in the unnamed bay (Stations 9-12) and Hutchison Bay (Stations 1-4). In contrast, August-

TABLE 7. Numbers of phytoplankton (cells/ml) in samples from Tuft Point and adjacent areas, July 15-25, 1977. Shannon-Weaver species diversity index is also indicated.

Station	1	2	3	4	5	6
Chlorophyta						
Chlamydomonas spp.		36				
Chrysophyta						
Class Chrysophyceae						
Chrysochromulina sp.						
Dinobryon balticum		178	36			
Pseudopedinella spp.						
Unidentified Chrysophyceae	36	249	106			
Class Bacillariophyceae						
Achnanthes spp.	36	178				53
Amphora sp.		36				
Chaetoceros spp.	6177	2556	2024	7489	195	71
Cyclotella caspia	107					
Cyclotella spp.		213		24		
Diatoma elongatum	36	462	36	308	18	
Gyrosigma wansbeckii						
Navicula salinarum	36	36				18
Navicula spp.	36	178		47		35
Nitzschia cf. acicularis						
Nitzschia sigma						
Nitzschia spp.	71			24	35	
Rhizosolenia spp.	355	604	249	119	53	53
Thallassiosira sp.				71		
Stephanodiscus nantzschia		71	36			
Surirella ovata						18
Synedra tabulata var. obtusa						
Synedra spp.					18	
Euglenophyta						
Euglena spp.		36	36			18
Trachelomonas sp.						

(Continued)

TABLE 7. Continued.

Station	1	2	3	4	5	6
Cryptophyta						
Rhodomonas sp.	284	462	249	95		18
Unidentified flagellates	249	320	320	142	106	
Total cells/ml	7423	5615	3092	8319	425	337
Per Cent Composition of Major Algal Groups:						
Chlorophyta	-	0.6 (36)	-	-	-	-
Chrysophyceae	0.5 (36)	7.6 (427)	4.6 (142)	-	-	-
Bacillariophyceae	92.3 (6854)	77.2 (4334)	75.8 (2345)	97.2 (8082)	75.1 (319)	89.4 (301)
Euglenophyta	-	0.6 (36)	1.2 (36)	-	-	5.3 (18)
Cryptophyta	3.8 (284)	8.2 (462)	8.1 (249)	1.1 (95)	-	5.3 (18)
Other flagellates	3.4 (249)	5.7 (320)	10.3 (320)	1.7 (142)	24.9 (106)	-
Species Diversity	1.11	2.80	1.79	0.72	2.07	2.98

(Continued)

TABLE 7. Continued.

Station	7	8	9	10	11	12
Chlorophyta						
Chlamydomonas spp.					71	
Chrysophyta						
Class Chrysophyceae						
Chrysochromulina sp.				14	53	532
Dinobryon balticum				7		
Pseudopedinella spp.				14		
Unidentified Chrysophyceae		35	389	56	796	591
Class Bacillariophyceae						
Achnanthes spp.						
Amphora sp.						
Chaetoceros spp.	407	832	2336	1164	2496	59
Cyclotella caspia			89			
Cyclotella spp.	35			36	124	
Diatoma elongatum					35	
Gyrosigma wansbeckii		18				
Navicula salinarum					18	
Navicula spp.		159	106			59
Nitzschia cf. acicularis				7		
Nitzschia sigma			18			
Nitzschia spp.		89	18			
Rhizosolenia spp.	18	53				
Thallassiosira sp.						
Stephanodiscus nantzschia		18				
Surirella ovata						
Synedra tabulata var. obtusa					18	
Synedra spp.	35		18			
Euglenophyta						
Euglena spp.			71	7		59
Trachelomonas sp.					18	

(Continued)

TABLE 7. Continued.

Station	7	8	9	10	11	12
Cryptophyta						
Rhodomonas sp.	18	53	761	263	1363	1655
Unidentified flagellates	18	53	389	2	212	59
Total cells/ml	531	1310	4195	1570	5204	3014
Per Cent Composition of Major Algal Groups:						
Chlorophyta	-	-	-	-	1.4 (71)	-
Chrysophyceae	-	2.7 (35)	9.3 (389)	5.8 (91)	16.3 (849)	37.3 (1123)
Bacillariophyceae	93.2 (495)	89.3 (1169)	61.6 (2585)	76.9 (1207)	51.7 (2691)	3.9 (118)
Euglenophyta	-	-	1.7 (71)	0.4 (7)	0.3 (18)	2.0 (59)
Cryptophyta	3.4 (18)	4.0 (53)	18.1 (761)	16.8 (263)	26.2 (1363)	54.9 (1655)
Other flagellates	3.4 (18)	4.0 (53)	9.3 (389)	0.1 (20)	4.1 (212)	2.0 (59)
Species Diversity	1.31	1.92	2.01	1.29	2.03	1.82

TABLE 8. Numbers of phytoplankton (cells/ml) in samples from Tuft Point and adjacent areas, August 26-September 3, 1977. Shannon-Weaver species diversity index is also indicated.

Station	1	2	3	4	5	6
Chlorophyta						
Carteria sp.		213	14	14		
Chlamydomonas sp.	106					
Scenedesmus quaricauda						
Chrysophyta						
Class Chrysophyceae						
Chrysochromulina spp.		36	7	28	142	
Kephyrion sp.			7			
Unidentified Chrysophyceae	566	533	99	99	817	320
Class Bacillariophyceae						
Achnanthes spp.						
Amphora sp.						
Amphipleura pellucida						
Chaetoceros spp.	3310	4544	2371	2371	533	3728
Cyclotella caspia			43	213	36	107
Cyclotella cf. atomus						
Cyclotella cf. striata				14		
Cyclotella sp.		107				
Cylindrotheca sp.			21			
Cocconeis sp.			7			
Diatoma elongatum			7			
Gyrosigma fasciola			7			36
Licmophora sp.						
Navicula salinarum			7			
Navicula spp.		36		28	71	213
Nitzschia spp.		107			36	
Rhizosolenia spp.	53	249	128	128	142	284
Thallassiosira sp.			14			
Stephanodiscus sp.					71	36
Synedra tabulata var. obtusa						36
Synedra sp.						

(Continued)

TABLE 8. Continued.

Station	1	2	3	4	5	6
Euglenophyta						
Euglena sp.	18		36			
Cryptophyta						
Rhodomonas spp.	71		78	270		71
Unidentified flagellates	425	320	114	213	675	107
Total cells/ml	4549	6145	2960	3378	2523	4938
Per Cent Composition of Major Algal Groups:						
Chlorophyta	2.3 (106)	3.5 (213)	0.5 (14)	0.4 (14)	-	-
Chrysophyceae	12.4 (566)	9.3 (569)	3.8 (113)	3.8 (127)	38.0 (959)	6.5 (320)
Bacillariophyceae	73.9 (3363)	82.0 (5043)	88.0 (2605)	81.5 (2754)	35.2 (889)	89.9 (4440)
Euglenophyta	0.4 (18)	-	1.2 (36)	-	-	-
Cryptophyta	1.6 (71)	-	2.6 (78)	8.0 (270)	-	1.4 (71)
Other flagellates	9.3 (425)	5.2 (320)	3.9 (114)	6.3 (213)	26.8 (675)	2.2 (107)
Species Diversity	1.35	1.49	1.34	1.66	2.44	1.48

(Continued)

TABLE 8. Continued.

Station	7	8	9	10	11	12
Chlorophyta						
Carteria sp.				53	14	
Chlamydomonas sp.	14	36				
Scenedesmus quaricauda			28			
Chrysophyta						
Class Chrysophyceae						
Chrysochromulina spp.						
Kephyrion sp.						
Unidentified Chrysophyceae	809	213	57	142	497	163
Class Bacillariophyceae						
Achnanthes spp.		36				21
Amphora sp.						7
Amphipleura pellucida			7			
Chaetoceros spp.	256	7029	831	124	469	440
Cyclotella caspia		36		53		
Cyclotella cf. atomus			7			
Cyclotella cf. striata						
Cyclotella sp.	43		28		14	43
Cylindrotheca sp.						
Cocconeis sp.						7
Diatoma elongatum		36				
Gyrosigma fasciola					14	
Licmophora sp.			7			
Navicula salinarum				18		
Navicula spp.	14	178	28	106	71	
Nitzschia spp.		142		53	28	14
Rhizosolenia spp.	114	426	85	35	71	57
Thalassiosira sp.						
Stephanodiscus sp.	14			18		
Synedra tabulata var. obtusa						7
Synedra sp.	14					

(Continued)

TABLE 8. Continued.

Station	7	8	9	10	11	12
Euglenophyta						
Euglena sp.			14	18		
Cryptophyta						
Rhodomonas spp.	85	213	57	301	14	
Unidentified flagellates		142	21	248		14
Total cells/ml	1363	8487	1170	1169	1192	773
Per Cent Composition of Major Algal Groups:						
Chlorophyta	1.0 (14)	0.4 (36)	2.4 (28)	4.5 (53)	1.2 (14)	-
Chrysophyceae	59.4 (809)	2.5 (213)	4.9 (57)	12.1 (142)	41.7 (497)	21.1 (163)
Bacillariophyceae	33.4 (455)	92.9 (7883)	84.8 (993)	34.8 (407)	55.9 (667)	77.1 (596)
Euglenophyta	-	-	1.2 (14)	1.5 (18)	-	-
Cryptophyta	6.2 (85)	2.5 (213)	4.9 (57)	25.7 (301)	1.2 (14)	-
Other flagellates	-	1.7 (142)	1.7 (21)	21.2 (248)	-	1.8 (14)
Species Diversity	1.88	1.16	1.75	3.04	1.97	1.98

September standing crops were lowest at Stations 9-12 in the unnamed bay (773-1192 cells/ml) with stations in the vicinity of dredging activity and in Hutchison Bay yielding higher counts (1363-8487 cells/ml). Fluctuation in standing crop generally resulted from changes in the abundance of diatoms. These shifts in the diatom community were probably caused by a complex of factors including changes in nutrient availability, water temperature, salinity, and turbidity levels related to mixing of Mackenzie River and Beaufort Sea waters (Hsiao *et al.*, 1977). Dredging activity appears to have had little effect on the phytoplankton standing crop within the study area.

The abundance of diatoms in the study area resulted largely from high numbers of *Chaetoceros* spp., *Rhizosolenia* spp., *Cyclotella* spp., and *Navicula* spp. Maximum density of *Chaetoceros* spp. was recorded at Station 4 during July, reaching 7489 cells/ml. Hsiao *et al.* (1977) report a maximum density for this species of 4700 cells/ml in similar habitat. The only other relatively abundant algal species present during both sampling periods was *Rhodomonas* spp. (a Cryptophyte) which occurred at maximum density at stations in the unnamed bay (Stations 9-12) during July.

Species Diversity

Shannon-Weaver species diversity of phytoplankton from stations in the vicinity of Tuft Point ranged from 0.72-2.98 during July and 1.16-3.04 in August-September (Tables 7 and 8). The relatively low diversities result from the relatively high number of a single species (generally *Chaetoceros* spp.) at most stations. Although slight seasonal variations in diversity occurred at some stations, these variations probably resulted from the effects of current mixing similar to the factors affecting standing crop.

Zooplankton

Methods

Initially, two methods of collecting zooplankton were used: vertical tows with a Wisconsin net (mouth opening 12 cm), and horizontal tows with a Faber net (mouth opening 60 cm, mesh size 0.392 mm)(Faber, 1968)(Plate 3). The Wisconsin net method was abandoned after the July sampling period when it was found that the samples contained too few organisms to be of use in describing the zooplankton present in the Tuft Point region.

The Faber net was found to collect a large sample, more than adequate to describe zooplankton populations. Tow distances were measured using a Tsurumi-Seiki (Model 10-1971) flow meter which allows calculations of the water volume sampled or catch-per-unit-effort.

PLATE 3. Modified Faber net pelagic trawl for sampling zooplankton and pelagic fish larvae.

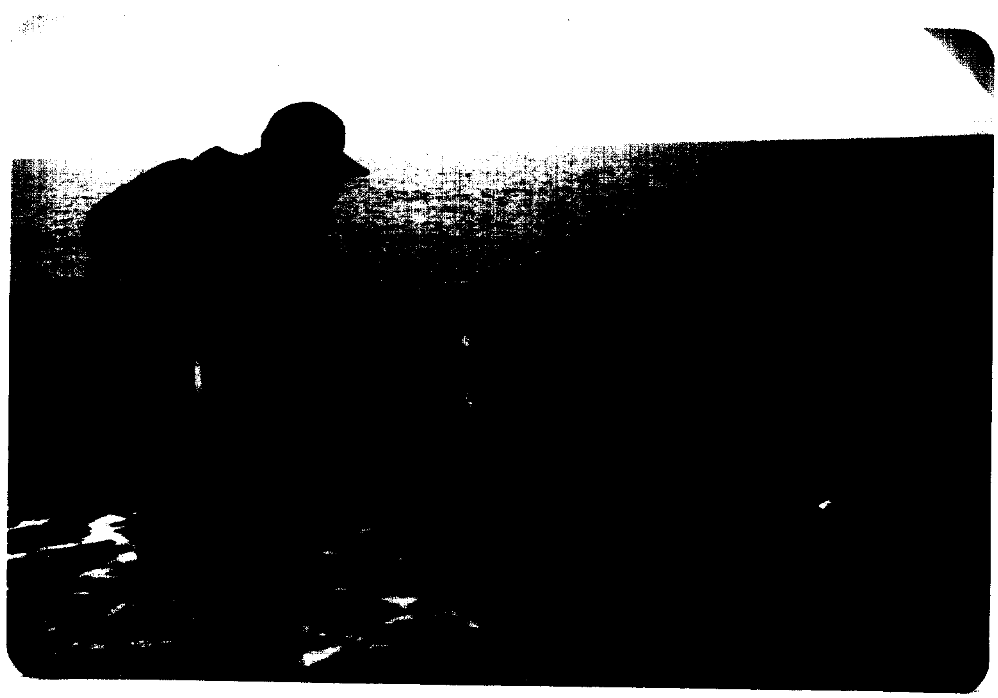


PLATE 4. Gillnet catch at Station 7, seaward side of IOL breakwater.

PLATE 3. Modified Faber net pelagic trawl for sampling zooplankton and pelagic fish larvae.

PLATE 4. Gillnet catch at Station 7, seaward side of IOL breakwater.

Zooplankton samples were preserved in the field using a 5% formalin solution. Zooplankton counts were made by dividing samples with a plankton splitter into appropriate subsamples, depending upon density, then counting the entire subsample. Counts were made using a Wild M5 binocular microscope at 25x and/or 50x magnification.

Organisms were identified to major taxa and the species/genera present recorded. Identifications were made by preparing temporary mounts of whole or dissected specimens for examination using a Wild M12 compound microscope at magnifications of 100, 400, or 1000x. Identifications were based primarily upon the taxonomic references of Fraser and Hansen (1939-1974), Davis (1955), Johnson (1956), Ellis (1960), Tattersall (1963), Grainger (1965), Fulton (1968), Deevey and Deevey (1971), Gosner (1971), Newell and Newell (1973).

Species diversity indices were calculated as described in the invertebrate section.

Results

Available information on zooplankton in the Beaufort Sea has been summarized by Slaney (1977a). To date, the most comprehensive examinations of Beaufort Sea zooplankton were carried out by Johnson (1956) in the western Beaufort Sea, and Grainger (1965) in the eastern Beaufort Sea. In the vicinity of Tuft Point, only one prior study of zooplankton has been made (Slaney, 1977b). They report that densities of zooplankters were relatively low prior to commencement of the 1976 dredging program, and no zooplankters were present in Wisconsin net samples after dredging was begun (July 18, 1976).

During the current study to determine the standing crop, species composition, and species diversity of the Tuft Point zooplankton community, the Wisconsin net method was abandoned in favour of data obtained by sampling large volumes of water (198-264 m^3/sample) with a Faber net.

Standing Crop

Relatively low densities of zooplankters were present in the vicinity of Tuft Point during both sampling periods. Total standing crop averaged 25.1 zooplankters/m^3 (range 0.78-45.4) during July and 32.8 zooplankters/m^3 in August-September samples. This difference is not significant when a paired Students t-test is applied ($t=0.290$, $P>0.05$). Slaney (1977a) report that zooplankton densities in Mackenzie Bay and along Tuktoyaktuk Peninsula were highly variable averaging 516.5 zooplankters/m^3 (range 9.8 to 4424.5). Densities of zooplankton in the vicinity of Tuft Point prior to dredging activity (early July, 1976) ranged from 20.7 to

141.2 zooplankters/m^3 (Slaney, 1977b).

Total zooplankton standing crop may have been slightly underestimated in the present study due to the coarse mesh Faber net utilized (0.392 mm). Coarse mesh samplers emphasize macroplankton (e.g., copepods), while allowing microplankton (e.g., small rotifers) to pass through the net (Newell and Newell, 1973). Although Slaney (1977a) report densities of rotifers from 2 to 4,620/m^3 in Mackenzie Bay, they do not report rotifers to be abundant in the vicinity of Tuft Point from samples utilizing a fine mesh (0.156 mm) sampler (Slaney, 1977b). During the present study, a few samples taken in July utilizing vertical hauls of Wisconsin net (mesh 0.0695 mm) indicated densities of rotifers to be less than 3/m^3. Thus, any source of error in calculation of total standing crop is considered minimal.

Total zooplankton standing crop at stations in the vicinity of dredge operations (Stations 5 and 7) fall midway within the ranges of total standing crop from the study area during both sampling periods (Tables 9&10). It appears unlikely that present dredging operations are having any significant effect upon the zooplankton communities. Standing crop was highly variable throughout the study area. Lowest standing crops generally occurred in the unnamed bay or in Hutchinson Bay. Copepods were the most abundant major group

TABLE 9. Species composition, standing crop, and Shannon-Weaver species diversity index of zooplankton collected by Faber net at 12 stations in the vicinity of Tuft Point, July 15-25, 1977. Standing crop is presented as number of organisms/100 m^3. $\bar{x}N$=mean number of organisms; $\bar{x}t$=mean number of taxa; $\bar{x}d$=mean diversity index.

Species Station:	1	2	3	4	5	6	7
Annelida							
unidentified Oligochaeta		1		1		1	
unidentified Polychaeta		1		1			
Chaetognatha							
Sagitta sp.				1	1		
Crustacea							
Amphipoda							
Acanthostephia sp.							
Apherusa glacialis							
Gammaricanthus loricatus	1						
Gammarus oceanicus		1				1	
Monoculodes latimanus	26	2	1	1		6	
Onisimus littoralis				1		2	
Parathemisto abyssorum			1			3	1
Pontoporeia affinis	27	3		2		16	
unidentified Amphipoda							
Cladocera							
Podon sp.	7	16			2		4
Copepoda							
Acartia sp.							
Calanus finmarchicus				3	2	6	40
Calanus hyperboreus			1	1	1	2	8
Calanus sp.			1		7		24
Eurytemora sp.					12		
Limnocalanus macrurus	372	53	1182	1681	946	355	1111
Metridia longa					2		4
Pseudocalanus minutus				65	89	103	206

(Continued)

TABLE 9. Continued.

Species	Station: 1	2	3	4	5	6	7
Cumacea							
Diastylis rathkei	3					1	
Isopoda							
Mesidotea entomon	1						
Mysidacea							
Mysis sp.	6	1		1	1	9	
Ctenophora							
Beroe cucumis					2		1
Hydromedusae							
Aglantha digitale				5	1	2	8
Halitholus cirratus				1	20	18	35
Sarsia princeps							1
unidentified Hydromedusae			1	2			1
Mollusca							
Clione limacina				1		2	27
unidentified Lamellibranch					2		
Tartigrada							
unidentified Tartigrada							
Tunicata							
unidentified Tunicata							
TOTAL ORGANISMS/100 m^3	443	78	1187	1767	1088	527	1471
TOTAL NO. OF SPECIES	8	8	6	15	14	15	14
DIVERSITY INDEX	0.96	1.49	0.27	0.36	0.82	1.63	1.33

(Continued)

TABLE 9. Continued.

Species	Station: 8	9	10	11	12	$\bar{x}$N
Annelida						
unidentified Oligochaeta					1	0.3
unidentified Polychaeta			2	37		3.4
Chaetognatha						
Sagitta sp.	1	8				0.9
Crustacea						
Amphipoda						
Acanthostephia sp.	1	1	1		1	0.2
Apherusa glacialis						-
Gammaricanthus loricatus						0.1
Gammarus oceanicus	6	2	5		1	1.3
Monoculodes latimanus	53	1	48	1	1	11.7
Onisimus littoralis						0.2
Parathemisto abyssorum	1	2	1			0.7
Pontoporeia affinis	29	3	4	1		7.1
unidentified Amphipoda						-
Cladocera						
Podon sp.		194	32	1164	242	138.4
Copepoda						
Acartia sp.						
Calanus finmarchicus	1	323				31.3
Calanus hyperboreus						1.1
Calanus sp.						2.7
Eurytemora sp.						1.0
Limnocalanus macrurus	1315	12994	889	3200	877	2081.3
Metridia longa						0.5
Pseudocalanus minutus	79	1681		129	8	196.7

(Continued)

TABLE 9. Continued.

Species	Station: 8	9	10	11	12		$\bar{x}N$
Cumacea							
Diastylis rathkei			1				0.4
Isopoda							
Mesidotea entomon	1	1					0.2
Mysidacea							
Mysis sp.	16	19	82	2	3		11.7
Ctenophora							
Beroe cucumis							0.2
Hydromedusae							
Aglantha digitale	8	2					2.2
Halitholus cirratus	13	26					9.4
Sarsia princeps	1						0.2
unidentified Hydromedusae	1						0.4
Mollusca							
Clione limacina	1	4					2.9
unidentified Lamellibranch							0.2
Tartigrada							
unidentified Tartigrada					8		0.7
Tunicata							
unidentified Tunicata				2			0.2
TOTAL ORGANISMS/100 m^3	1527	15261	1065	4536	1142	$\bar{x}N=$	2507.6
TOTAL NO. OF SPECIES	16	15	10	8	9	$\bar{x}t=$	11.5
DIVERSITY INDEX	0.94	0.79	0.97	1.08	0.93	$\bar{x}d=$	0.96

TABLE 10 Species composition, standing crop, and Shannon-Weaver species diversity index of zooplankton collected by Faber net at 12 stations in the vicinity of Tuft Point, August 26-September 3, 1977. Standing crop is presented as number of organisms/100 m^3. $\bar{x}N$=mean number of organisms, $\bar{x}t$=mean number of taxa; $\bar{x}d$=mean diversity index.

Species	Station: 1	2	3	4	5	6	7
Annelida							
unidentified Oligochaeta							
unidentified Polychaeta						2	
Chaetognatha							
Sagitta sp.					2	1	3
Crustacea							
Amphipoda							
Acanthostephia sp.							
Apherusa glacialis							
Gammaracanthus loricatus							
Gammarus oceanicus							
Monoculodes latimanus				2		2	
Onisimus littoralis							
Parathemisto abyssorum							8
Pontoporeia affinis				1		3	
unidentified Amphipoda				2		1	
Cladocera							
Podon sp.		117	2	12			
Copepoda							
Acartia sp.	7451	230	17	34		1455	32
Calanus finmarchicus		16	2	2	56	2	24
Calanus hyperboreus	16				48		8
Calanus sp.							
Eurytemora sp.	162	8		2			
Limnocalanus macrurus	2505	40	69	18	16	145	24
Metridia longa							
Pseudocalanus minutus	49	251	32	107	1026	4477	1285

(Continued)

TABLE 10. Continued.

Species	Station: 1	2	3	4	5	6	7
Cumacea							
Diastylis rathkei				1		1	
Isopoda							
Mesidotea entomon							
Mysidacea							
Mysis sp.						1	
Ctenophora							
Beroe cucumis					8		3
Hydromedusae							
Aglantha digitale					34		42
Halitholus cirratus			1		8	1	6
Sarsia princeps							
unidentified Hydromedusae					2	1	2
Mollusca							
Clione limacina				1	2	1	3
unidentified Lamellibranch							
Tartigrada							
unidentified Tartigrada							
Tunicata							
unidentified Tunicata							
TOTAL ORGANISMS/100 m^3	10183	662	123	182	1202	6093	1440
TOTAL NO. OF SPECIES	5	6	6	11	10	14	12
DIVERSITY INDEX	0.97	1.95	1.62	1.90	0.96	0.98	0.80

(Continued)

TABLE 10. Continued.

Species	Station: 8	9	10	11	12	$\bar{x}$N
Annelida						
unidentified Oligochaeta						-
unidentified Polychaeta	1					0.2
Chaetognatha						
Sagitta sp.	1	1	1	2	1	1.0
Crustacea						
Amphipoda						
Acanthostephia sp.			1			0.1
Apherusa glacialis	1					0.1
Gammaricanthus loricatus		1				0.1
Gammarus oceanicus						-
Monoculodes latimanus	128		2			11.2
Onisimus littoralis	1					0.1
Parathemisto abyssorum						0.7
Pontoporeia affinis	1					0.4
unidentified Amphipoda	1					0.3
Cladocera						
Podon sp.						10.9
Copepoda						
Acartia sp.	1325	453	162			929.9
Calanus finmarchicus	32	3	6	2	8	12.8
Calanus hyperboreus						6.0
Calanus sp.						-
Eurytemora sp.	32	65	16			23.8
Limnocalanus macrurus	129	6077	1455	145	73	891.3
Metridia longa						-
Pseudocalanus minutus	7046	1487	646	61	127	1382.8

(Continued)

TABLE 10. Continued.

Species Station:	8	9	10	11	12		$\bar{x}N$
Cumacea							
Diastylis rathkei		1					0.2
Isopoda							
Mesidotea entomon							-
Mysidacea							
Mysis sp.	1						0.2
Ctenophora							
Beroe cucumis							0.9
Hydromedusae							
Aglantha digitale	1				1		6.5
Halitholus cirratus	2	3	1		3		2.1
Sarsia princeps							-
unidentified Hydromedusae	1						0.5
Mollusca							
Clione limacina	1	1					0.7
unidentified Lamellibranch							-
Tartigrada							
unidentified Tartigrada							-
Tunicata							
unidentified Tunicata							-
TOTAL ORGANISMS/100 m^3	8704	8092	2290	210	213	$\bar{x}N=$	3282.8
TOTAL NO. OF SPECIES	17	10	9	4	6	$\bar{x}t=$	9.2
DIVERSITY INDEX	0.92	1.06	1.30	1.01	1.31	$\bar{x}d=$	1.23

comprising 92.3% of the July samples and 98.9% of August-September samples. The maximum standing crop of copepods occurred at Station 9 (entrance to unnamed bay) during July with 150.0 organisms/m^3 present. Slaney (1977a) report that copepods and rotifers are the most abundant organisms in the nearshore Beaufort Sea zooplankton community within the Mackenzie River freshwater influence.

Species Composition

A total of 33 zooplankton species was identified in samples from the study area with similar species composition during both sampling periods (Tables 9&10). An average of 11.5 species (range 6-16) were present in July samples and 9.2 species (range 4-17) in August-September samples. Due to the high variation in the number of species present at each station, this difference was not significant ($t=0.369$, $P>0.05$). Slaney (1977a) suggests that highest taxonomic diversity occurs in coastal waters during late August and early September. Data presented by Slaney (1975) and the present study, however, did not show a significant seasonal change.

The copepod *Limnocalanus macrurus* dominated all samples during the July sampling period with an average density of 20.8 organisms/m^3 (Table 9). This species has been previously reported to be most abundant in samples from the

Tuft Point study area (Slaney, 1977b). Only two other species were present in average densities greater than 1/m^3 in July samples: *Pseudocalanus minutus* (a copepod) and *Podon* sp. (a cladoceran).

Although *Limnocalanus macrurus* was also abundant in August-September samples (Table 10), two other copepods, *Pseudocalanus minutus* and *Acartia* sp., were slightly more abundant. *Acartia* sp. was absent from July samples, but was present at 9 of 12 stations in August-September samples. No other zooplankters were found in densities greater than 1/m^3 in August-September samples. In general, zooplankton species composition was similar to that reported by Grainger (1965) for the eastern Beaufort Sea.

Species composition at stations in the vicinity of the borrow site (Stations 5 and 7) was nearly identical to other stations outside the influence of possible turbidity caused by the dredge (Tables 9&10). Possible exceptions were the hydromedusae *Aglantha digitale* and *Halitholus cirratus* and the ctenophore *Beroe cucumis* which were more abundant at stations near the borrow site particularly during the second sampling period. Hydromedusae were also found to be most abundant in the vicinity of the borrow site in samples collected in bottom trawls (see Invertebrate Studies).

Species Diversity

Shannon-Weaver species diversity indices appear low for the Tuft Point zooplankton community averaging 0.96 (range 0.27 to 1.63) in July samples and 1.23 (range 0.80 to 1.95) in August-September (Tables 9 and 10). However, no diversity indices from comparable Beaufort Sea locations are available. Several factors may have resulted in the low diversities during the present study, including:

1) the use of horizontal tows, near the surface, in shallow water which may have prevented the capture of some portions of the zooplankton community, particularly those species inhabiting deeper water further offshore, and

2) the coarse mesh size of Faber net used in this study may have allowed some zooplankters, particularly rotifers, to be underestimated.

FISHERIES STUDIES

Methods

At each of the 12 sampling stations indicated in Figure 1, fish were collected using gillnets, seines, a Faber net, and a bottom trawl. Similar samples were taken during each of the two sampling periods. Gillnet sets varied in duration from 0.5 to 24 hours. Standard gangs of variable mesh monofilament gillnets, 2.4 m (8 ft) in depth and 45.0 m (150 ft) in length were used. Six panels, each 7.5 m (25 ft) long constituted a gang. Each gang was standardized by assembly in the following sequence: 2.5, 5.1, 11.4, 6.3, 3.8, and 8.9 cm (1, 2, 4.5, 2.5, 1.5, 3.5 in., respectively) stretch mesh (Plate 4). The seine used was a fine-mesh nylon minnow seine measuring 4 m (13 ft) x 1.2 m (4 ft). Seine hauls covered a standard distance of 50 m (164 ft) along the shoreline.

A modified Faber net (Faber, 1968) was used to capture small fish in surface waters in the study area (Plate 3). A Tsuruni-Seiki flow meter (Model 10-1971) was used to standardize tow distances. Tow distance was then multiplied by the area of the net opening to calculate the water volume sampled per tow (range: 198-264 m^3/tow).

The epibenthic bottom trawl (Plate 2) was used to capture small bottom-dwelling fish such as sculpins and flounder. The Tsurumi-Seiki flow meter was also used to measure tow distances and calculate the area of substrate sampled.

Specimens of each fish species were retained for life history analysis. An attempt was made to collect specimens from the entire size range of each species and excess numbers within any size range were released alive. Retained specimens were dissected and subjected to analysis as described by McCart *et al.* (1972).

In the field laboratory, each fish was measured to the nearest mm and weighed to the nearest 0.1 g. Egg diameters were determined to the nearest 0.1 mm by calculating the mean diameter of 10 unpreserved eggs of the largest size class lined up in a row. Otoliths were removed, placed in glycerin, and stored for later age determination.

Fish were classified in three broad reproductive categories using the criteria of McCart *et al.* (1972) and Craig and Mann (1974). Fish were classified as either "immature" (negligible gonadal development and no evidence of previous spawning), "spawners" (sufficient gonadal development to indicate that the fish would spawn during the year of capture), or "non-spawner" (some gonadal development, but would not spawn in the year of capture).

The stomach contents were analysed in the field using a modification of the Hynes's Point Method (Hynes, 1950) as outlined by Griffiths *et al.* (1975). In this manner, the per cent fullness of the whole stomach and the per cent composition for each food item were recorded. Individual food items were identified to the level of class or order. For each fish species, all contents from stomachs containing food were grouped to provide a representative or "average stomach". These results are presented in two ways. The first indicates the observed "average stomach" and the per cent content of each food item. The second indicates the percentage of stomachs examined which contained the food item.

Results

Species Composition and Relative Abundance

Of the 17 species collected in the Tuft Point study area (Table 11), 10 were primarily marine, 6 were anadromous, and 1 was an eurohaline freshwater species (Tables 12 and 13). A total of 2617 fish was captured in gillnets and seines and, of these, 75.9% were marine species. Large numbers of young-of-the-year and juvenile fourhorn sculpin caught in seines (N=1748) contributed to the high percentage of marine fish. Arctic cisco were the most abundant species in gillnet catches, comprising 42% of the July sample and 47% of the August-September sample. Fourhorn sculpin and least cisco were

TABLE 11. Fish caught in the Tuft Point study area, July-September, 1977. Fish appear in order of relative abundance.

Common Name	Scientific Name	Code
Fourhorn sculpin	*Myoxocephalus quadricornis*	FHSC
Arctic cisco	*Coregonus autumnalis*	ARCS
Least cisco	*Coregonus sardinella*	LSCS
Broad whitefish	*Coregonus nasus*	BDWT
Boreal smelt	*Osmerus eperlanus*	BORS
Inconnu	*Stenodus leucichthys nelma*	INCO
Arctic flounder	*Liopsetta glacialis*	ARFL
Saffron cod	*Eleginus navaga*	SNCD
Pacific herring	*Clupea harengus pallasi*	PCHR
Humpback whitefish	*Coregonus clupeaformis*	HBWT
Pacific sand lance	*Ammodytes hexapterus*	PCSL
Starry flounder	*Placichthys stellatus*	STFL
Ninespine stickleback	*Pungitius pungitius*	NNST
Arctic cod	*Boreogadus saida*	ARCD
Stout eelblenny	*Lumpenus medius*	STEB
Slender eelblenny	*Lumpenus fabricius*	SLEB
Arctic staghorn sculpin	*Gymnocanthus tricuspis*	ASSC

TABLE 12. Life history type, number captured, per cent composition, and CPUE (gillnet hour) for each species caught in gillnets in the Tuft Point study area, July 15-25 and August 26-September 3, 1977. A=anadromous, M=marine.

Species	Life History Type	July			August-September		
		Number Captured	Per Cent	CPUE	Number Captured	Per Cent	CPUE
Arctic cisco	A	148	42	3.40	185	47	13.70
Least cisco	A	50	14	1.15	49	13	3.63
Fourhorn sculpin	M	46	13	1.06	104	27	7.70
Broad whitefish	A	27	8	0.62	15	4	1.11
Humpback whitefish	A	14	4	0.32	0	0	0.00
Inconnu	A	25	7	0.57	2	0.5	0.15
Saffron cod	M	16	5	0.37	7	2	0.52
Pacific herring	M	4	1	0.09	12	3	0.89
Arctic flounder	M	15	4	0.35	5	1.3	0.37
Starry flounder	M	6	2	0.14	0	0	0.00
Boreal smelt	A	0	0	0.00	8	2	0.59
Arctic cod	M	0	0	0.00	1	0.2	0.08
Totals		351	100	8.07	388	100	28.74

TABLE 13. Per cent composition and life history type of species captured in seines in the Tuft Point study area, July 15-25 and August 26-September 3, 1977. A=anadromous, M=marine, FW=freshwater.

		July		August-September	
Species	Life History Type	Number Captured	Per Cent	Number Captured	Per Cent
Arctic cisco	A	13	0.8	40	13.1
Fourhorn sculpin	M	1536	97.7	212	69.3
Least cisco	A	9	0.6	2	0.7
Boreal smelt	A	9	0.6	22	7.2
Humpback whitefish	A	0	-	4	1.3
Broad whitefish	A	0	-	2	0.7
Ninespine stickleback	FW	1	0.1	5	1.6
Saffron cod	M	0	-	1	0.3
Pacific sand lance	M	0	-	9	2.9
Pacific herring	M	0	-	5	1.6
Arctic flounder	M	4	0.2	3	1.0
Stout eelblenny	M	0	-	1	0.3
Totals		1572	100 %	306	100 %

relatively abundant in gillnet catches, but least cisco represented less than 1% of seine catches. In contrast, least cisco comprised 75% of the total seine catch during an earlier survey in the Tuft Point study area (Slaney, 1977b). Reasons for this difference are obscure, but may have resulted from the use of longer (30.5 x 2.4 m) beach seines in the earlier survey. These longer nets capture a higher percentage of adult least cisco in comparison to the pole seines used in the present study. Adult least cisco can easily avoid capture in short (4 m) pole seines.

Gillnet catches ranged from 0.3 to 80 fish/hr, averaging 12.6 fish/hr (Tables 14 & 15). These values for average catch-per-unit-effort are intermediate between those reported by Griffiths *et al.* (1977)(3.0 fish/hr) and Kendel *et al.* (1975)(45.9 fish/hr). Most net sets were limited to one hour due to the relatively high catch-per-unit-effort at most stations. Lowest catch-per-unit-effort occurred at Stations 5 and 7 in the vicinity of dredge operations and Stations 10 and 11 in the unnamed bay during July. Late August sampling produced low catches at Station 5, but catches at Stations 7, 10, and 11 were higher than July values. Highest catch-per-unit-efforts were generally recorded at Stations 6 and 8 (southwest of Tuft Point) and at the entrances to Beluga Bay and the unnamed bay (Stations 1 and 9).

TABLE 14. Catch per unit effort and species composition in gillnet sets at 12 stations in the Tuft Point study area, July 15-25, 1977.

Station	Catch	Hours	Catch per Unit Effort (fish/gillnet hour)
1	2 BDWT 1 HBWT 8 LSCS 1 ARFL 2 STFL 31 ARCS	1	45.0
2	8 INCO 1 ARCS 1 PCHR 1 ARFL 4 LSCS 3 HBWT 2 BDWT 9 SNCD	1.5	19.3
3	3 INCO 2 BDWT 2 FHSC 9 LSCS 27 ARCS	2	21.5
4	1 SNCD 1 LSCS 20 ARCS	1	22.0
5	8 ARCS 1 FHSC	2	4.5
6	19 ARCS 1 BDWT 1 HBWT 2 LSCS 3 SNCD 18 FHSC	1	44.0
7	9 ARCS 1 FHSC 2 PCHR	2	6.0
8	17 ARCS 3 BDWT 1 INCO 4 LSCS 1 PCHR 2 ARFL 18 FHSC	1	46.0

(Continued)

TABLE 14. Continued.

Station	Catch	Hours	Catch per Unit Effort (fish/gillnet hour)
9	10 BDWT	3	18.0
	11 INCO		
	4 ARCS		
	19 LSCS		
	3 SNCD		
	2 STFL		
	2 ARFL		
	3 FHSC		
10	4 HBWT	24	0.6
	8 ARFL		
	1 STFL		
	2 FHSC		
11	2 BDWT	3	1.0
	1 ARFL		
12	2 INCO	2	14.5
	5 HBWT		
	5 BDWT		
	12 ARCS		
	3 LSCS		
	1 FHSC		
	1 STFL		

TABLE 15. Catch per unit effort and species composition in gillnet sets at 12 stations in the Tuft Point study area, August 26 - September 3, 1977.

Station	Catch	Hours	Catch per Unit Effort (fish/gillnet hour)
1	1 ARFL	1	34.0
	1 SNCD		
	3 LSCS		
	22 ARCS		
	7 FHSC		
2	15 LSCS	1	22.0
	4 ARCS		
	1 SNCD		
	1 BDWT		
	1 INCO		
3	19 LSCS	1	46.0
	24 ARCS		
	2 FHSC		
	1 ARFL		
4	34 ARCS	1	42.0
	6 LSCS		
	2 ARFL		
5	1 FHSC	3	0.3
6	6 PCHR	1	80.0
	1 LSCS		
	1 SNCD		
	4 BORS		
	18 ARCS		
	50 FHSC		
7	1 SNCD	1	17.0
	16 ARCS		
8	6 PCHR	1	69.0
	4 BORS		
	1 ARCD		
	44 FHSC		
	13 ARCS		
9	13 BDWT	0.5	66.0
	16 ARCS		
	3 LSCS		
	1 ARFL		

(Continued)

TABLE 15. Continued.

Station	Catch	Hours	Catch per Unit Effort (fish/gillnet hour)
10	3 SNCD 29 ARCS 2 LSCS 1 INCO	1	35.0
11	2 ARCS 1 BDWT	1	3.0
12	7 ARCS	1	7.0

Other studies suggest that the densities of most species are considerably higher in nearshore habitats than in offshore areas (Kendel *et al.*, 1975; Griffiths *et al.*, 1977). Craig and McCart (1975) have indicated that fish species diversity in nearshore Beaufort Sea habitats is highest at locations near the mouths of the Colville and Mackenzie rivers and declines with increasing distance from these rivers. The proximity of Tuft Point to the Mackenzie Delta (70 km) insures a high species diversity during open water months.

Seine catches were highly variable (Tables 16 and 17). The abundance of young-of-the-year (particularly fourhorn sculpin) and juvenile individuals suggest that nearshore habitats in the vicinity of Tuft Point are an important rearing area for a wide range of species. Other studies show similarly high densities of immature individuals in nearshore coastal waters of the Beaufort Sea during open water months, particularly in areas influenced by Mackenzie River water (Kendel *et al.*, 1975; Percy, 1975). Fourhorn sculpin were the most abundant species in seine hauls during both sampling periods, but represented a lower percentage of the total seine catch during the August-September sampling period (Table 17). A total of 12 species was caught in seines during the August-September sampling period, while only 6 species were caught in July.

TABLE 16. Species composition and catch per unit effort (as fish/m^2 seined) in seine hauls from 12 stations in the Tuft Point study area, July 15-25, 1977.

Station	Catch	Effort (m)	Catch per Unit Effort
1	2 FHSC 2 BORS	50	0.016
2	1 ARCS 9 FHSC	50	0.040
3	3 FHSC	50	0.012
4	3 FHSC 1 NNST	50	0.016
5	no fish	50	0.000
6	10 FHSC 3 ARCS	50	0.052
7	no fish	50	0.000
8	1 FHSC	50	0.004
9	500± FHSC 1 ARFL 1 ARCS	50	2.000
10	2 LSCS 1 ARCS 8 FHSC 1 ARFL	50	0.048
11	500± FHSC	50	2.000
12	500± FHSC 7 BORS 2 ARFL 7 ARCS 7 LSCS	50	2.090

TABLE 17. Species composition and catch per unit effort (as fish/m^2 seined) in seine hauls from 12 stations in the Tuft Point study area, August 26-September 3, 1977.

Station	Catch	Effort (m)	Catch per Unit Effort
1	11 FHSC 1 PCSL 1 SNCD 1 NNST 1 PCHR	50	0.060
2	6 FHSC 1 LSCS 2 PCHR 19 BORS	50	0.112
3	2 ARCS 1 LSCS 1 ARFL	50	0.016
4	15 FHSC 8 PCSL	50	0.092
5	no fish	50	0.000
6	152 FHSC 1 ARFL 1 PCHR 11 ARCS	50	0.660
7	1 STEB	50	0.004
8	1 BDWT 4 HBWT 27 ARCS 7 FHSC 1 ARFL	50	0.160
9	10 FHSC 1 BDWT 1 PCHR	50	0.048
10	3 BORS 9 FHSC	50	0.048
11	1 FHSC	50	0.004
12	4 NNST 1 FHSC	50	0.020

Faber tows in the vicinity of Tuft Point indicate relatively low densities of demersal fish species in the area (Table 18). Only boreal smelt (N=57) were taken in Faber tows totaling 2623 m^3 during the July sampling effort. Boreal smelt were present in densities of 25-182 fish/1000 m^2 at stations in the unnamed bay (Stations 9-12), but were absent from all other areas except the entrance to Beluga Bay (Station 1).

During the August-September sampling period, Pacific sand lance (N=6), boreal smelt (N=2), and Pacific herring (N=2) were taken in 2508 m^3 of sampling. Arctic cod, commonly the most abundant demersal species in coastal waters (Quast, 1974; Galbraith and Fraser, 1974; Griffiths *et al.*, 1977) were not captured in Faber tows in the Tuft Point area although a single specimen was taken in a gillnet.

A total of 32 young-of-the-year and juvenile fourhorn sculpins was caught in bottom trawls during a total of 19,685 m^2 of trawling. Fourhorn sculpins were taken at all stations except 5, 9, and 10. In addition, one Arctic staghorn sculpin (Station 5), one Arctic flounder (Station 8), and one ninespine stickleback (Station 12) were caught during July bottom trawling. Similar trawls in Kaktovik Lagoon, Alaska, produced catches of approximately 25 fourhorn sculpin per 1000 m^2 (Griffiths *et al.*, 1977).

TABLE 18. Species composition and abundance of young-of-the-year fish in Faber tows at 12 stations in the vicinity of Tuft Point, July 15-25 and August 26-September 3, 1977.

Station Number	JULY Volume Sampled (m^3)	Species	N	Catch/ 1000 m^3	AUGUST-SEPTEMBER Volume Sampled (m^3)	Species	N	Catch/ 1000 m^3
1	247	BORS	2	8	198	-	0	-
2	198	-	0	-	198	-	0	-
3	264	-	0	-	198	-	0	-
4	198	-	0	-	264	PCSL	4	15
5	198	-	0	-	198	-	0	-
6	264	-	0	-	198	PCHR	1	5
						PCSL	2	10
7	198	-	0	-	198	-	0	-
8	264	-	0	-	198	BORS	1	5
9	198	BORS	5	25	198	-	0	-
10	198	BORS	36	182	198	-	0	-
11	198	BORS	4	20	198	-	0	-
12	198	BORS	10	50	264	BORS	1	4
						PCHR	1	4
Totals	2623		57	22	2508		10	4

Seasonal Abundance

Due to the limited sampling period (i.e., two 10-day sampling periods), the data on seasonal abundance of species in the Tuft Point study area are limited. However, some general trends in seasonal abundance were evident.

Average catch-per-unit-effort for all species combined was 8.1 fish/gillnet hour during the July sampling, increasing to 28.8 fish/gillnet hour during the September sampling (Table 12). This increase resulted principally from higher catches per unit effort for Arctic cisco, least cisco, and fourhorn sculpin. Only humpback whitefish, inconnu, and starry flounder declined in relative abundance during the August-September sampling. Studies of the seasonal abundance of several species common to nearshore habitats in other coastal areas suggest that abundance is highly variable from area to area depending on distance from the Mackenzie River, feeding activity, influence of fresh water, water temperature, and other factors (Kendel *et al.*, 1975; Griffiths *et al.*, 1977).

Although the number of young-of-the-year captured during the July sampling period was slightly higher (N=142) than the number captured in the August-September sampling (N=85), the largest number of species (N=7) was present during the second sampling effort (Table 19). Only three species of young-of-

TABLE 19. Number and mean size of young-of-the-year captured in seines, Faber tows, and bottom trawl tows during the July 15-25 and August 26-September 3 sampling periods.

	July			August-September		
Species	N	Mean Length (mm)	Range (mm)	N	Mean Length (mm)	Range (mm)
Arctic cisco	4	36.5	32-42	0	-	-
Fourhorn sculpin	81	17.8	13-22	45	32.3	29-38
Humpback whitefish	0	-	-	4	66.5	63-79
Arctic flounder	0	-	-	1	14.0	-
Saffron cod	0	-	-	1	34.0	-
Boreal smelt	57	16.4	14-22	24	28.0	24-38
Pacific herring	0	-	-	5	32.4	27-38
Pacific sand lance	0	-	-	15	38.3	37-44
Totals	142			85		

the-year were caught during the July sampling period and only two species, fourhorn sculpin and boreal smelt, were abundant during both sampling periods.

Life History of Arctic Cisco *(Coregonus autumnalis)*

The life history of Arctic cisco in nearshore coastal environments of the Beaufort Sea has been recently studied by several authors (Roguski and Komarek, 1972; Craig and Mann, 1974; Craig and McCart, 1975; Furniss, 1975; Griffiths *et al.*, 1975; 1977; Kendel *et al.*, 1975; Percy, 1975). In addition, limited information suggests that only the Mackenzie and Colville rivers systems are utilized by this species for spawning and overwintering (Craig and McCart, 1975). Arctic cisco are an important species in the native domestic fisheries of both river systems and in coastal areas (Hatfield *et al.*, 1972; Kogl and Schell, 1974; Furniss, 1975; Delury *et al.*, 1975; Griffiths *et al.*, 1977).

Source and Distribution

Due to the proximity of Tuft Point to the Mackenzie River, the majority of Arctic cisco present in the area probably originated from the Mackenzie River population. Arctic cisco have been reported dispersed throughout nearshore coastal environments during the summer months, but no reports of overwintering in coastal waters are available. Adult and juvenile Arctic cisco appear in coastal waters during late

June and early July, although some may disperse earlier (Griffiths *et al.*, 1975; 1977).

Arctic cisco were present in all portions of the study area including stations in the vicinity of dredge activity during both sampling periods (Tables 14 and 15). Although Arctic cisco were not caught at some individual stations, this probably is the result of short net sets rather than of the distribution pattern in the area.

Size Distribution

The length-frequency of Arctic cisco from the Tuft Point area is more uniform than samples taken by Kendel *et al.* (1975) along the Yukon coast (Figure 4). A higher percentage of the Tuft Point sample consisted of fish in the 140-220 mm size range. This difference may be due to a difference in sampling methods rather than a difference in the abundance of juvenile Arctic cisco. Other studies along the Yukon coast and Alaska have captured few Arctic cisco under 200 mm indicating that most small Arctic cisco do not frequent waters beyond a 160 km radius of the Mackenzie Delta (Roguski and Komarek, 1972; Craig and Mann, 1974; Furniss, 1975; Griffiths *et al.*, 1975; 1977).

Age and Growth

Arctic cisco in the Tuft Point sample ranged in age from

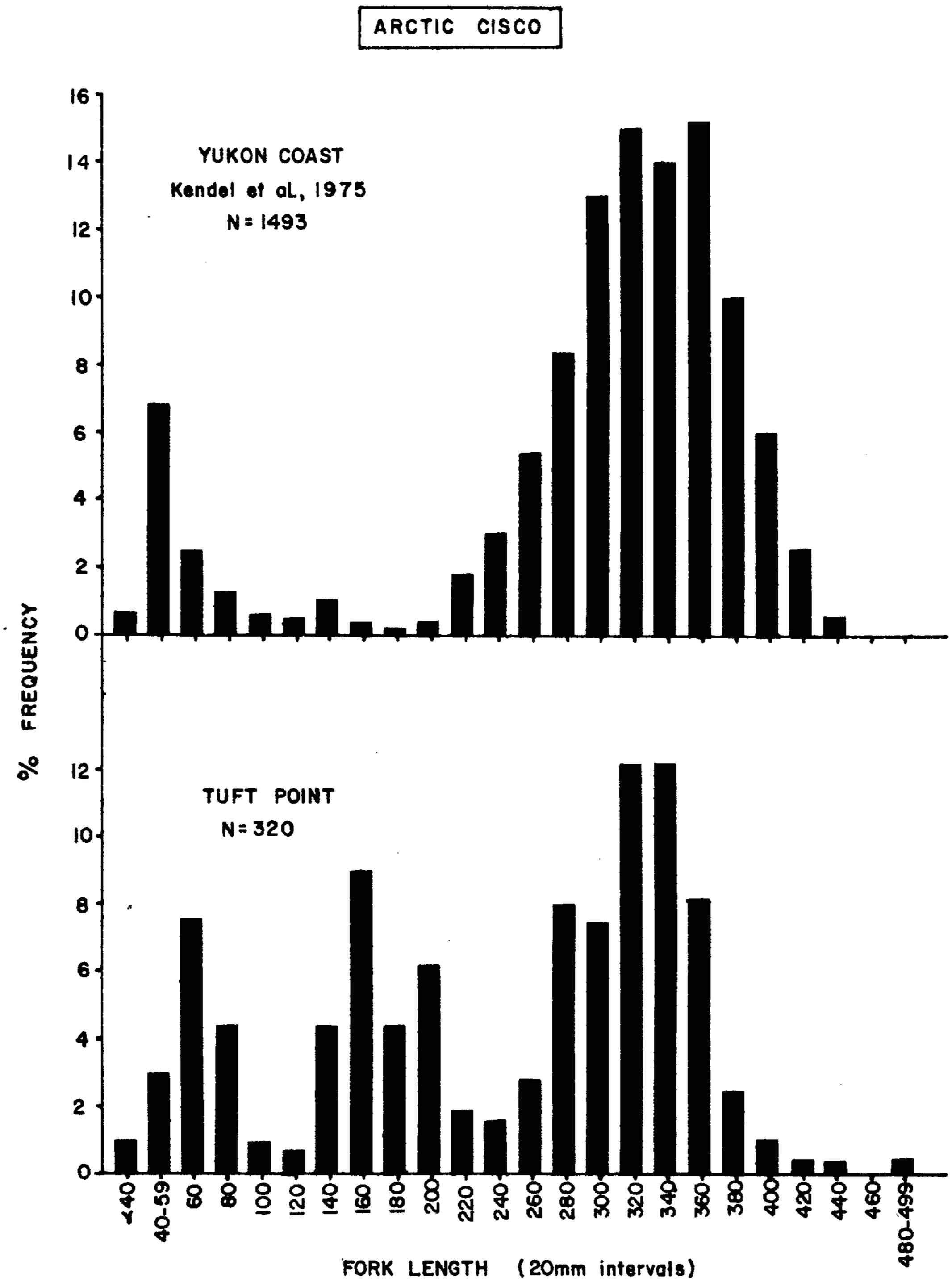


FIGURE 4. Length-frequencies of Arctic cisco from the Yukon coast, 1975, and Tuft Point and adjacent coastal areas, 1977.

0-13 years with most fish between the ages of 3 and 8 years (Table 20). Only four young-of-the-year were captured in seines during July and none during the second sampling effort. The largest individual, aged at 13 years, was 488 mm in length. Although only nine age 1 fish were dissected, juveniles of this size (50-100 mm) were relatively abundant (Figure 4). Other authors report a similar age-length relationship for Arctic cisco at other coastal locations (Figure 5).

Reproductive Development

Only 11.3% of aged Arctic cisco showed sufficient gonadal development to indicate spawning in the year of capture. A higher percentage of female spawners (20.5%) was present than male spawners (6.0%), with the first spawners appearing at age 7 (Table 20). All Arctic cisco caught during the August-September sampling period were considered non-spawners. The low percentage of spawning fish in older age classes suggests that many Arctic cisco are at least alternate year spawners. Since the spawning migration of this species in the Mackenzie River occurs from July to early September (Stein *et al.*, 1973; Craig and Mann, 1974), spawning individuals had probably undertaken migration by the August-September sampling period. Gonad development in individuals considered to be spawners was similar to that reported by Griffiths *et al.* (1975, 1977) for other coastal areas.

TABLE 20. Age-length relationship, sex ratio, and per cent spawners for Arctic cisco from Tuft Point and adjacent areas, 1977. Unsexed fish (4.1%) are not included in calculation of total sex ratio.

Age	N	% Male	% Spawners M	% Spawners F	Length (mm) Mean	Length (mm) Range	Length (mm) S.D.
1	9	-	-	0.0	84.1	54-102	16.0
2	2	50.0	0.0	0.0	126.0	121-131	7.1
3	33	63.6	0.0	0.0	166.0	144-191	10.6
4	34	61.7	0.0	0.0	202.1	174-239	14.4
5	13	84.6	0.0	0.0	253.4	211-285	22.6
6	25	72.0	0.0	0.0	287.6	262-317	12.1
7	58	67.2	8.3	21.0	325.7	255-371	19.5
8	30	53.8	31.2	57.0	357.1	336-377	11.0
9	8	37.5	0.0	60.0	386.0	330-445	37.7
10	6	33.3	0.0	33.3	396.8	390-415	9.3
11	1	0.0	-	0.0	396.0	-	-
12	1	0.0	-	100.0	402.0	-	-
13	1	100.0	0.0	-	488.0	-	-
Totals	221	62.7	6.0	20.5	272.3	57-488	85.8

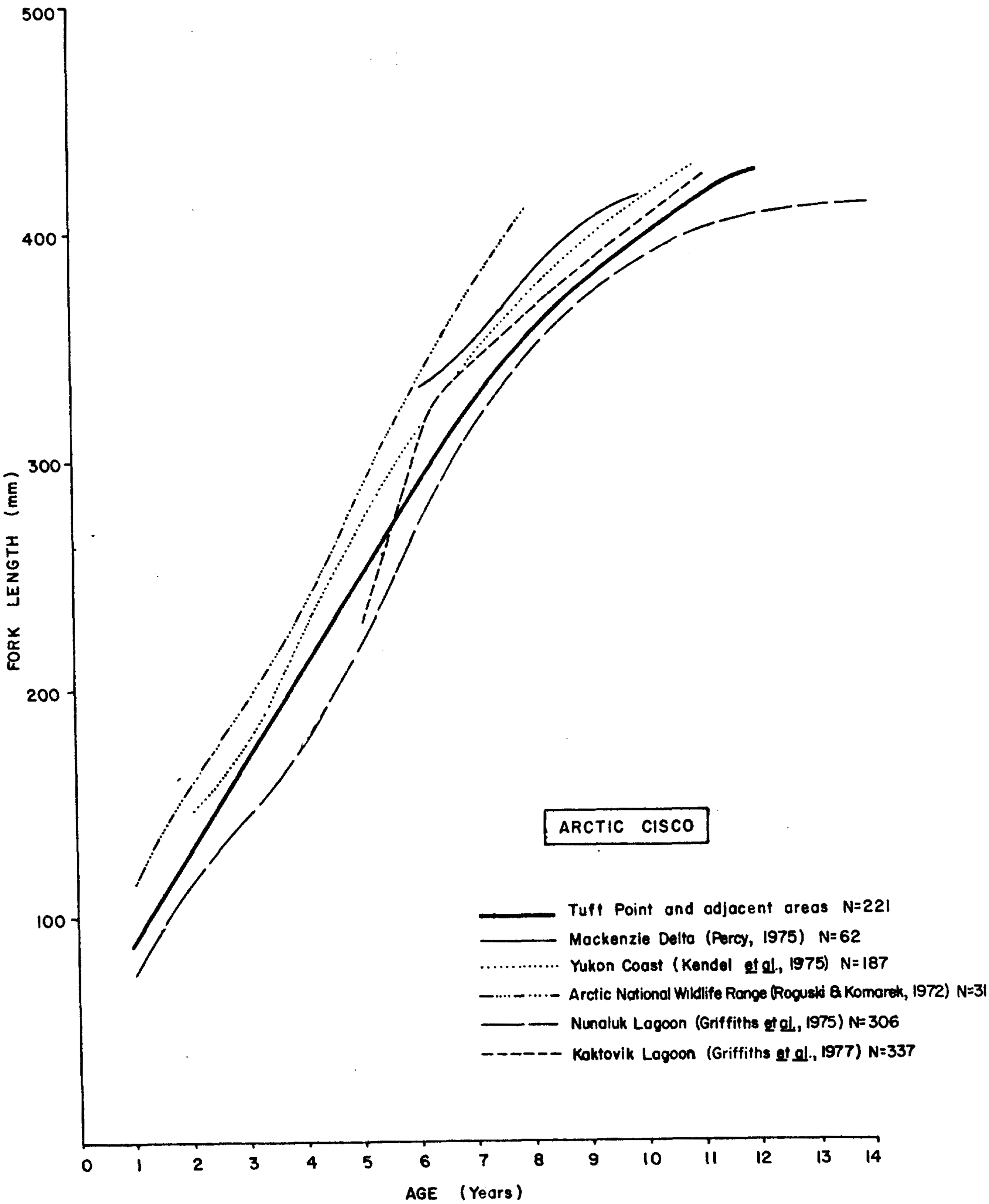


FIGURE 5. Comparison of growth curves for Arctic cisco from six locations along the Beaufort Sea coast in Canada and Alaska.

Sex Ratio

Male Arctic cisco (60.8%) were significantly more abundant than females (N=221, X^2=5.23, $P<0.05$) in the Tuft Point study area (Table 20). Similar results have been reported along the Yukon coast and in the Mackenzie River (Griffiths *et al.*, 1977). Griffiths *et al.* (1975) have suggested that the differences in sex ratios of Arctic cisco sampled at various locations may result from either sampling error or, more likely, from differences in the migratory movements of males and females.

Food Habits

Previous studies by Griffiths *et al.* (1975, 1977) suggest that Arctic cisco in coastal waters are opportunistic feeders. The same is true of samples of this species sampled during the present study. Amphipods and copepods were the most commonly utilized food item by both juveniles (<100 mm) and larger (>100 mm) Arctic cisco (Table 21). Of 216 stomachs from larger Arctic cisco, 138 (63.9%) contained no food. All stomachs from juvenile (<100 mm) fish contained food. In addition, the average stomach in small juvenile Arctic cisco contained more food proportionally (55.8%) than larger individuals (34.8%). Griffiths *et al.* (1975) have suggested that smaller Arctic cisco may be more active feeders than larger individuals. Other authors have also found high percentages of empty stomachs in Arctic cisco from coastal

TABLE 21. Food items eaten by Arctic cisco in the Tuft Point study area, 1977. Per cent composition of "average stomach" was determined by the Points Method. Only those fish with stomach contents are included in calculations of "average stomach" and "occurrence" values.

	Fish >100 mm N=216 (Empty=63.9%)		Fish <100 mm N=30 (Empty=0%)	
Food Item	per cent in average stomach	per cent occurrence	per cent in average stomach	per cent occurrence
Insecta				
Simuliidae adult	1.3	9.2	0.6	6.6
Odonata adult	0.02	1.3	-	-
Chironomidae larvae	-	-	0.2	3.3
Mollusca				
Pelecypoda	0.2	2.6	-	-
Gastropoda	6.5	11.8	-	-
Crustacea				
Amphipoda	8.2	50.0	25.8	53.3
Isopoda	0.4	5.3	-	-
Mysidacea	4.9	11.8	4.5	26.7
Euphasida	0.5	1.3	-	-
Cumacea	0.8	3.9	-	-
Cladocera	2.2	11.8	0.2	3.3
Decapoda	0.01	1.3	-	-
Copepoda	9.3	18.4	23.4	50.0
Conchostraca	-	-	0.3	3.3
Miscellaneous				
Digested material	0.3	7.9	-	-
Sand, gravel, etc.	0.2	3.9	0.8	3.3
Sticks, organic material	0.01	1.3	-	-
Totals	34.8		55.8	

areas (Kogl, 1972; Kendel *et al.*, 1975; Percy, 1975; Furniss, 1975). Kendel *et al.* (1975) suggest that feeding activity of Arctic cisco may decline prior to migration resulting in large numbers of empty stomachs.

Life History of Least Cisco *(Coregonus sardinella)*

During the summer months, least cisco are an abundant species in nearshore coastal environments along the Yukon coast and Mackenzie Delta (Craig and Mann, 1974; Kendel *et al.*, 1975; Percy, 1975). The presence of both juvenile and adult least cisco in the vicinity of Tuft Point suggests that areas east of the Mackenzie Delta are also important rearing and feeding habitats for this species. Spawning takes place in the Mackenzie drainage during fall months with an upstream migration of spawners preceeding the migration of immature and non-spawning individuals (Mann, 1974). The only available record of least cisco overwintering in coastal waters is a single individual caught in March, 1974, at Shingle Point (Steigenberger *et al.*, 1975).

Size Distribution

Least cisco in the vicinity of Tuft Point ranged from 66 to 336 mm fork length with fish between 240 and 280 mm most abundant (Figure 6 and Table 22). The presence of numerous individuals less than 200 mm fork length is similar to results obtained along the Yukon coast (Kendel *et al.*,

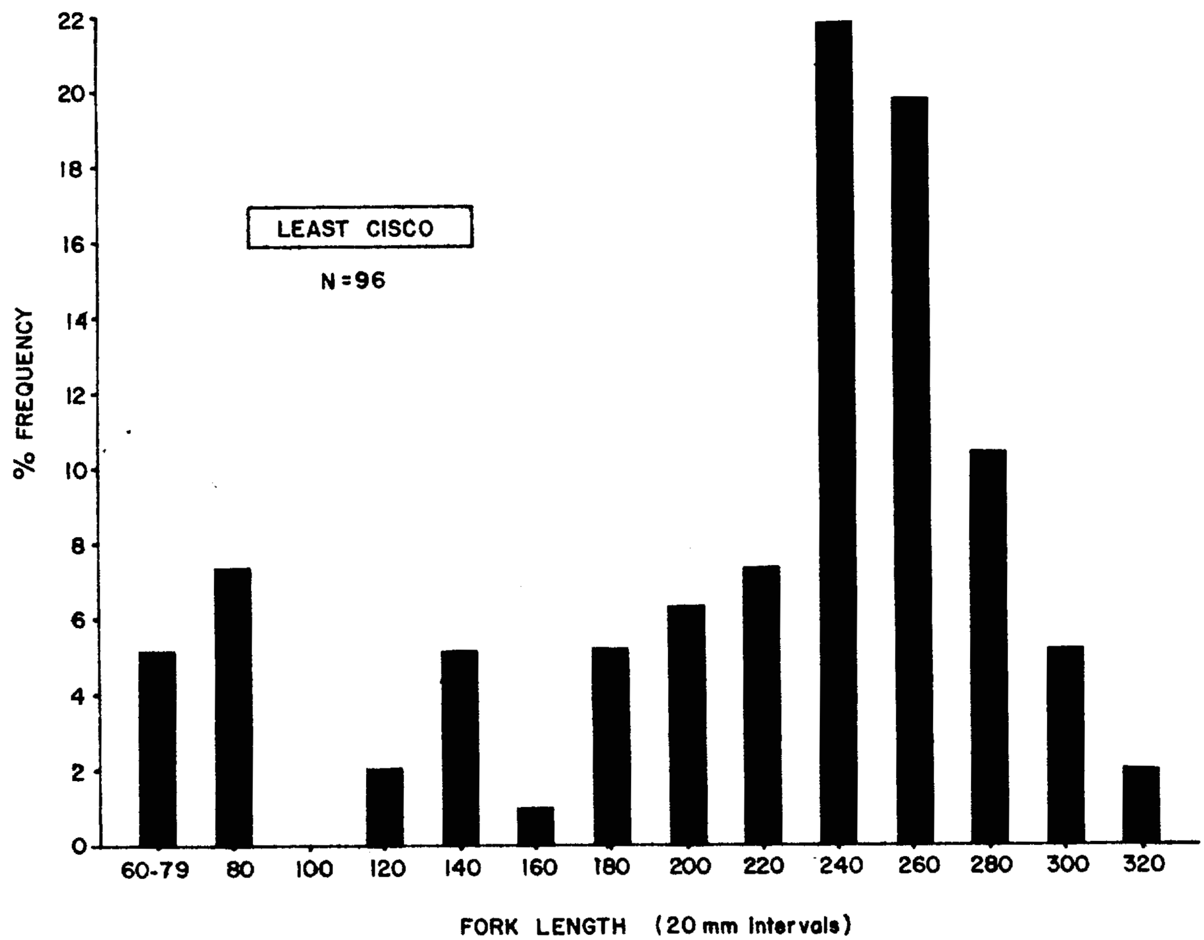


FIGURE 6. Length-frequency for least cisco from Tuft Point and adjacent coastal areas, 1977.

TABLE 22. Age-length relationship, sex ratio, and per cent spawners for least cisco from Tuft Point and adjacent areas, 1977. Unsexed fish (14.8%) are not included in calculation of total sex ratio.

Age	N	% Male	% Spawners M	F	Length (mm) Mean	Range	S.D.
1	9	-	-	0.0	78.2	66-87	7.1
2	4	-	-	0.0	106.0	94-137	20.7
3	8	87.5	0.0	0.0	152.6	136-167	9.9
4	8	62.5	0.0	0.0	195.4	186-203	6.1
5	8	75.0	0.0	0.0	230.2	221-289	25.2
6	21	52.4	36.3	0.0	255.8	234-300	16.6
7	14	28.6	0.0	70.0	263.3	253-278	8.4
8	8	50.0	50.0	25.0	281.6	255-296	16.5
9	6	0.0	-	50.0	298.7	290-308	6.7
10	0						
11	1	0.0	-	0.0	336.0	-	-
12	1	0.0	-	100.0	330.0	-	-
Totals	88	50.6*	16.2	13.8	223.1	66-336	69.8

*For sexed fish only

1975; Percy, 1975). Mann (1974) and Griffiths *et al.* (1975) report declining catches of both juvenile and adult least cisco with increasing distance from the Mackenzie Delta.

Age and Growth

The Tuft Point least cisco sample ranged in age from 1 to 12 years. No young-of-the-year fish were caught (Table 22). The observed age-length relationship is similar to that reported by other authors for anadromous Mackenzie River least cisco (Figure 7). Griffiths *et al.* (1975) reported one fish aged 17 years in Nunaluk Lagoon but caught a total of only four least cisco older than age 12.

Reproductive Development

Of 88 least cisco examined from the vicinity of Tuft Point, only 13 fish (14.7%) showed sufficient gonadal development to indicate spawning in the year of capture. Similarly low percentages of spawners have been reported at other coastal locations (Mann, 1974; Griffiths *et al.*, 1975; Kendel *et al.*, 1975; Percy, 1975). The youngest spawning males were age 6 and the youngest spawning females age 7. Other authors report that age at first reproduction in least cisco ranges from 4-9 years (Mann, 1974; Griffiths *et al.*, 1977). Mann (1974) also reports that male least cisco tend to mature before females. The presence of non-spawning individuals in the older age classes suggests that least

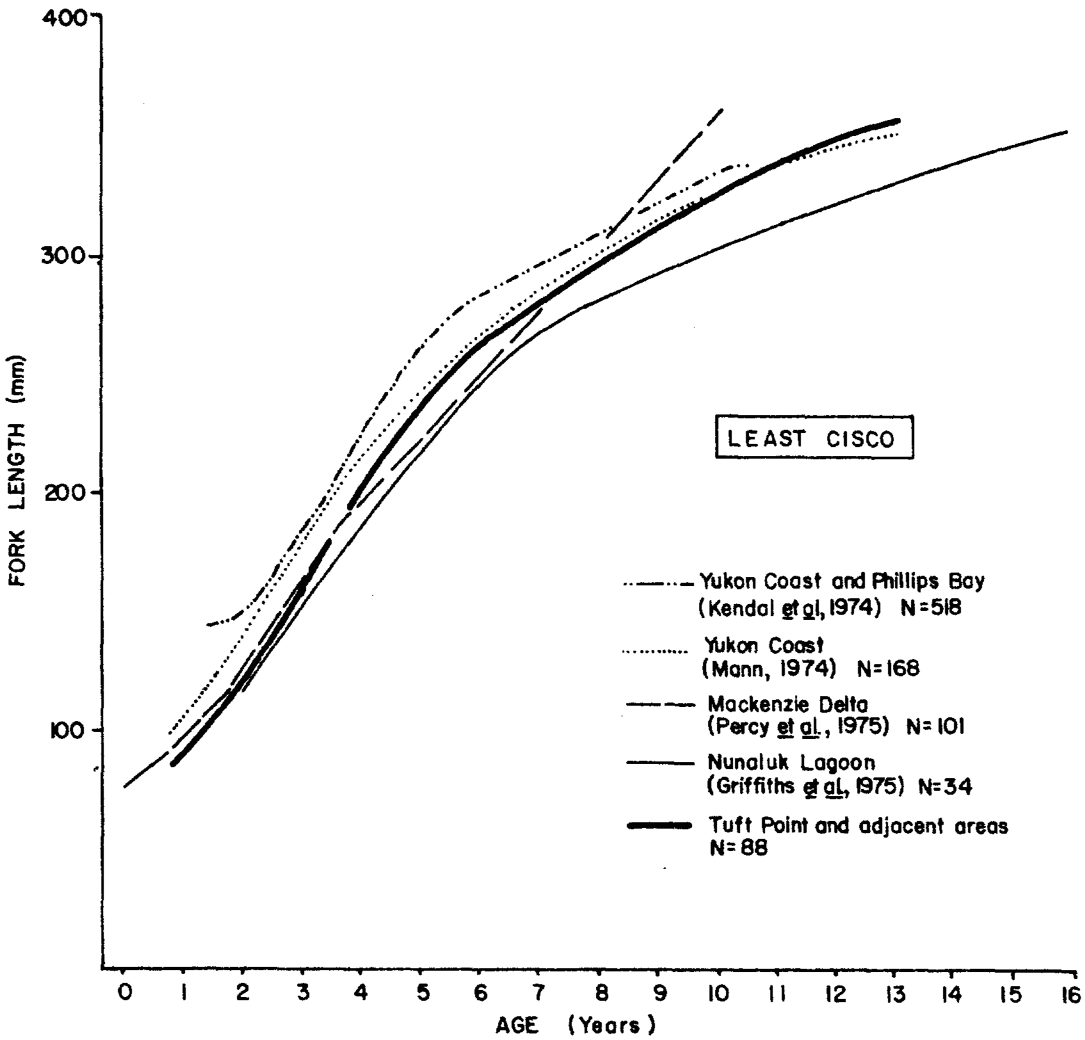


FIGURE 7. Comparison of growth curves for least cisco from five locations along the Beaufort Sea coast in Canada.

cisco are alternate year spawners (Mann, 1974).

Most least cisco spawners were caught during the July sampling period with only a single green female caught during the August-September sampling. This suggests that many spawners had already started migration before the second sampling effort began on August 26. Percy (1975) reports a significant increase in the number of least cisco migrating into the Mackenzie Delta after mid August.

Sex Ratio

No significant difference in the sex ratio of Tuft Point least cisco was observed (N=75, X^2=0.007, P>0.05). Samples from other coastal locations (Craig and Mann, 1974; Griffiths *et al.*, 1975; Percy, 1975) were variable in sex ratio (39-66% males), but may have been biased by small sample size. A large sample (N=2296) from the Yukon coast showed no significant difference in sex ratio (Kendel *et al.*, 1975).

Food Habits

Crustaceans, primarily amphipods (52.0%), copepods (28.0%), and cladocerans (16.0%) were the most common items in stomachs from the Tuft Point sample (Table 23). Of those stomachs containing food, the average stomach was 31.4% full consisting mainly of crustaceans (29.8%). Crustaceans were found to be the most abundant food items in least cisco

TABLE 23. Food items eaten by least cisco in the Tuft Point study area, 1977. Per cent composition in "average stomach" was determined by the Points Method. Only those fish with stomach contents are included in calculation of "average stomach" and "occurrence" values. (N=80, empty=37.5%).

Food Item	per cent in average stomach	per cent occurrence
Mollusca		
Pelecypoda	0.1	2.0
Gastropoda	0.06	2.0
Crustacea		
Amphipoda	14.8	52.0
Mysidacea	0.06	2.0
Cladocera	8.1	16.0
Copepoda	5.7	28.0
Cumacea	0.7	6.0
Decapoda	0.4	4.0
Miscellaneous		
Digested material	1.5	14.0
Total	31.4%	

stomachs at other coastal locations (Craig and Mann, 1974; Griffiths *et al.*, 1975; 1977; Kendel *et al.*, 1975; Percy, 1975). The percentage of empty stomachs in the Tuft Point sample was high (37.5%). However, other authors report similar high percentages for Beaufort Sea locations near the Mackenzie Delta (Kendel *et al.*, 1975; Percy, 1975).

Life History of Fourhorn Sculpin *(Myoxocephalus quadricornis)*

Fourhorn sculpin have been shown to be the most abundant marine species inhabiting nearshore habitats of the Beaufort Sea (Griffiths *et al.*, 1975; 1977). This species is of particular interest in the Tuft Point study area since it is the only common marine species utilizing nearshore habitats for spawning, rearing, feeding, and overwintering.

Distribution in the Study Area

Fourhorn sculpin were taken at every station in the study area in either seines or gillnets (Tables 14-16). Young-of-the-year were most abundant in shallow (<1 m) protected areas with few present in deeper areas as indicated by the relatively low bottom trawl catches. Since no fourhorn sculpin were caught in Faber tows, it appears this species is strictly bottom dwelling.

Size Distribution

The length frequency of fourhorn sculpin in the Tuft

Point sample (Figure 8) is similar to that reported for other coastal areas (Griffiths *et al.*, 1975; 1977). The bimodal distribution common in studies of this species results from the near absence of fish in the 60-140 mm size range. The most abundant size classes in the Tuft Point sample were young-of-the-year in the 0-39 mm size classes and adults (160-240 mm)(Figure 8). Few fish were larger than 260 mm (N=6).

Age and Growth

Fourhorn sculpin caught in the vicinity of Tuft Point ranged in age from 0-10 years with most adults aged between 5 and 8 years (Table 24). The growth rate is similar to that reported by Griffiths *et al.* (1977) at Barter Island, Alaska, and Kendel *et al.* (1975) along the Yukon coast, but slightly faster than a similar study by Griffiths *et al.* (1975) in Nunaluk Lagoon, Y.T. (Figure 9). An even faster rate of growth was reported by Percy (1975) in the Mackenzie Delta, with fish exceeding 200 mm by age 3. The differences in observed age-length relationships for this species may be caused in part by difficulties in reading the highly opaque otoliths. In the present study, fourhorn sculpin otoliths were ground flat on a jeweler's lapidary wheel and candled to stain the otolith, thus providing a relatively clear reading.

Young-of-the-year fourhorn sculpin in the Tuft Point

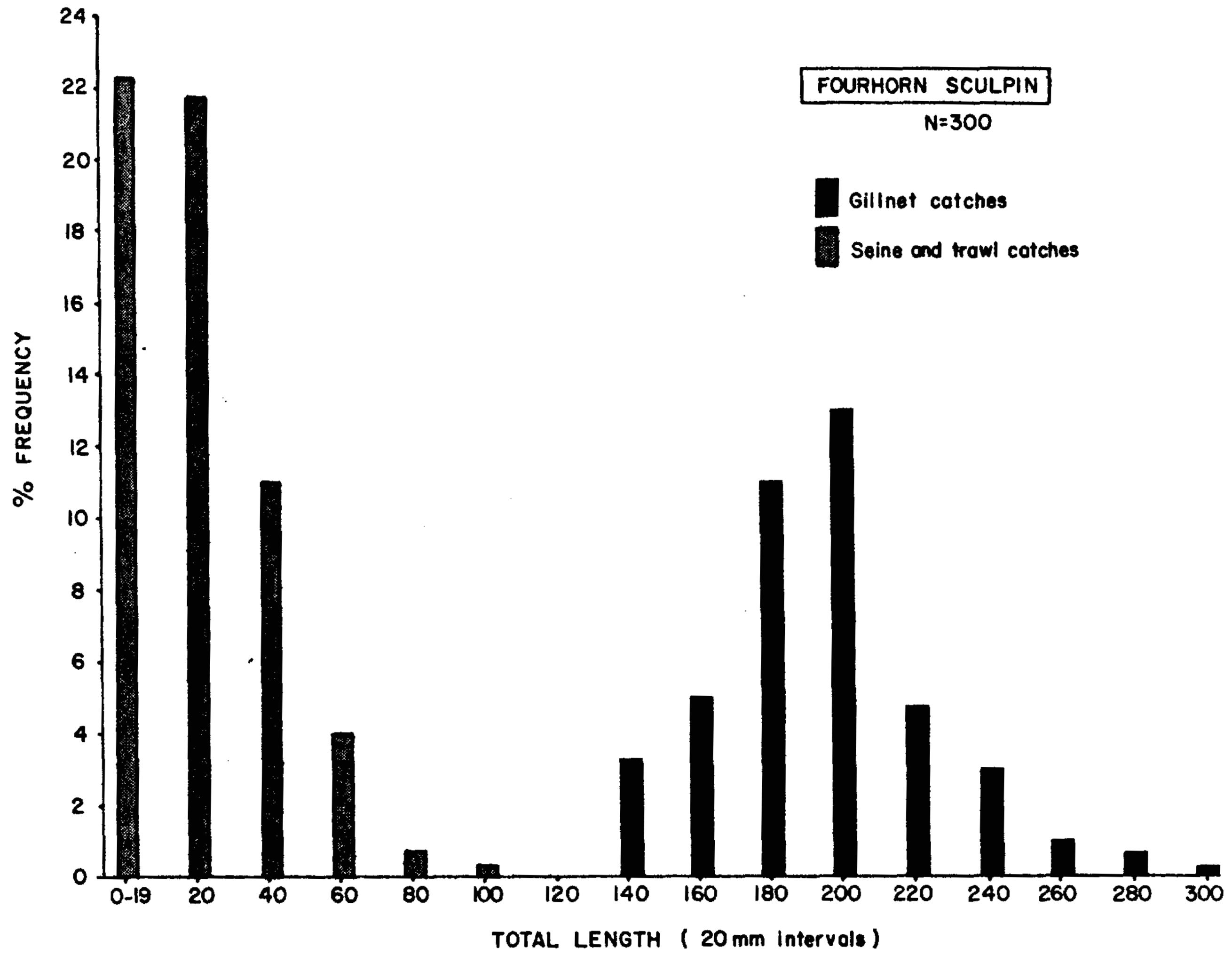


FIGURE 8. Length-frequency for fourhorn sculpin from Tuft Point and adjacent coastal areas, 1977.

TABLE 24. Age-length relationship, sex ratio, and per cent spawners for fourhorn sculpin from Tuft Point and adjacent areas, 1977. Unsexed fish (26.7%) are not included in calculation of total sex ratio.

Age	N	% Male	% Spawners M	% Spawners F	Length (mm) Mean	Length (mm) Range	Length (mm) S.D.
1	28	-	-	-	54.4	43-65	6.3
2	3	100.0	0.0	-	71.7	68-77	4.7
3	2	100.0	0.0	-	105.5	92-119	19.1
4	1	0.0	-	0.0	147.0	-	-
5	21	66.7	100.0	28.6	170.5	144-189	13.9
6	13	46.1	100.0	100.0	203.2	190-215	7.9
7	20	60.0	100.0	100.0	212.2	190-250	13.7
8	10	20.0	100.0	100.0	246.1	230-265	12.3
9	3	0.0	-	100.0	241.7	225-251	14.5
10	4	50.0	100.0	100.0	282.7	266-295	14.6
Totals	105	53.3	88.0	83.0	160.7	43-295	84.6

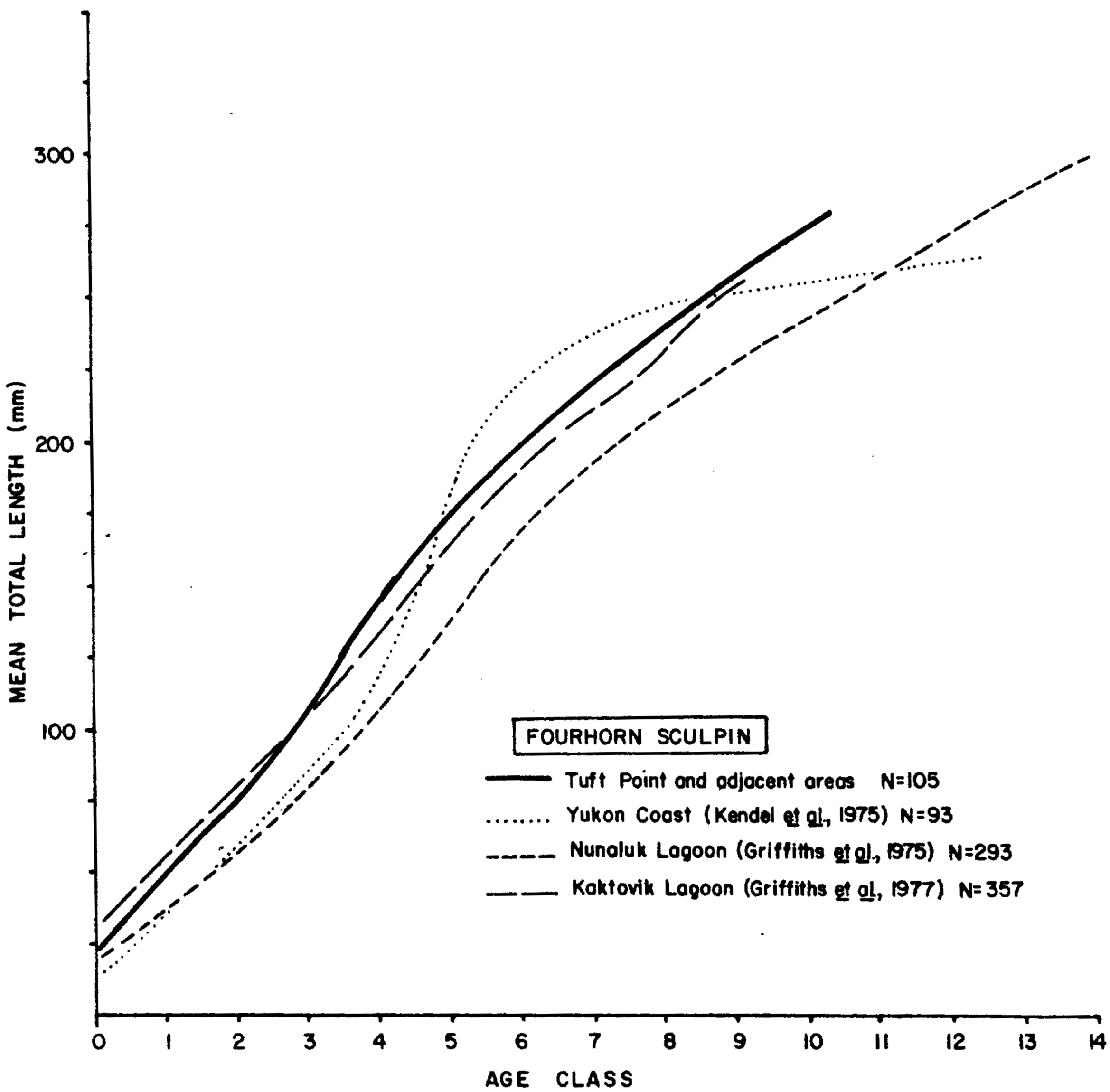


FIGURE 9. Comparison of growth curves for fourhorn sculpin from four locations along the Beaufort Sea coast in Alaska and Canada.

sample averaged 17.8 mm in length during the July sampling and 32.3 mm by the August-September sampling (Table 19). Although the data are too limited to provide a complete seasonal growth curve for young-of-the-year fourhorn sculpin, the mean sizes suggest a growth rate similar to that reported by Griffiths *et al.* (1977) at Barter Island, Alaska.

Reproductive Development

Of 105 fourhorn sculpin examined, 66 showed sufficient gonadal development to indicate spawning in the year of capture (Table 24). No fish were considered spawners until age 5, although the limited number of fish aged at 3 and 4 years (N=3) suggests that younger spawners may have been missed. All males were classified as spawners by age 5, but several females of the same age were still considered non-spawners. Other studies suggest spawning as early as age 3 in males and age 4 in females (Griffiths *et al.*, 1977; Kendel *et al.*, 1975; Percy, 1975).

Sex Ratio

In the study area, males made up 58% of the sexed (N=100) fourhorn sculpin catch, but this difference in sex ratio was not significant (X^2=1.28, P>0.05). All other studies, except Griffiths *et al.* (1977) report significantly larger catches of female fourhorn sculpin. Reasons for these deviations in sex ratio are unknown.

Food Habits

Fourhorn sculpin sampled in the vicinity of Tuft Point feed predominantly on benthic and epibenthic organisms (Table 25). Amphipods occurred in the highest percentage (45.1%) of stomachs examined. Isopods (39.0%) and mysids (31.7%) were the next most common stomach contents. The average stomach was 47% full with isopods (15.7%) present in largest quantities. Fish were consumed by 11.0% of feeding fish and 18.0% of the stomachs examined were empty. Fourhorn sculpin from other coastal locations are reported to feed largely on crustaceans with the percentage of empty stomachs ranging from 5-37% (Craig and Mann, 1974; Furniss, 1975; Griffiths *et al.*, 1975; 1977; Kendel *et al.*, 1975). The food habits of young-of-the-year fourhorn sculpin were not determined during this study. Considerable information on the seasonal food habits of young-of-the-year fourhorn sculpin is presented by Griffiths *et al.* (1977).

Broad Whitefish *(Coregonus nasus)*

The biology of broad whitefish is not well known (Scott and Crossman, 1973). The species inhabits both lakes and rivers and, in some areas, is anadromous. It is an important species in the domestic fishery of the outer Delta. The available information on the life history of broad whitefish in the region has been reviewed by Wynne-Edwards (1952), Muth (1969), McPhail and Lindsey (1970), Hatfield *et al.*

TABLE 25. Food items eaten by fourhorn sculpin in the Tuft Point study area, 1977. Per cent composition in "average stomach" was determined by the Points Method. Only those fish with stomach contents are included in calculation of "average stomach" and "occurrence" values. (N=100, empty=18.0%).

Food Item	per cent in average stomach	per cent occurrence
Mollusca		
Pelecypoda	0.2	3.6
Priapulida	0.2	3.6
Polychaeta	0.3	4.9
Diptera		
Simulidae adult	0.02	1.2
Chironomidae larvae	0.1	1.2
Crustacea		
Amphipoda	11.5	45.1
Isopoda	15.7	39.0
Mysidacea	10.5	31.7
Cumacea	0.1	1.2
Cladocera	0.4	2.4
Fish		
Coregonus spp.	4.1	7.3
FHSC	1.6	3.6
NSSB	0.1	1.2
Miscellaneous		
Sand, gravel, etc.	0.1	1.2
Digested material	1.8	9.8
Vegetative material	0.4	6.1
Total	47.1	

(1972), Stein *et al.* (1973), Kendel *et al.* (1975), Percy (1975), and de Graaf and Machniak (1977). Kendel *et al.* (1975) report that this species is widely distributed along the Yukon coast with numerous whitefish fry (not identified to species) present. Slaney (1977b) report this species was common in the vicinity of Tuft Point during 1976.

Broad whitefish in the Tuft Point study area ranged in size from 80 to 550 mm, with fish in the 300-550 mm size class most common (Figure 10). Similar length-frequencies were reported by Percy (1975) and de Graaf and Machniak (1977) in the Mackenzie Delta and Kendel *et al.* (1975) along the Yukon coast. Unidentified whitefish young-of-the-year were also present in the study area, but the species could not be determined.

The maximum otolith age recorded was 15 years, with fish evenly distributed in the younger age groups (Table 26). de Graaf and Machniak (1977) report a maximum age for this species (based on otoliths) of 19 years in the Mackenzie Delta. The growth rate of broad whitefish at Tuft Point is similar to growth rates reported by other authors utilizing otoliths for aging (Muth, 1969; de Graaf and Machniak, 1977), but slower than growth rates based on scale aging (Kogl, 1972; Stein *et al.*, 1973; Percy, 1975). Growth rates of broad whitefish have been shown to vary considerably between drainages (Berg, 1948-49), but reasons for this variation are not known.

Only seven broad whitefish caught in the study area showed sufficient gonadal development to indicate spawning in the year of capture (Table 26). The youngest male spawner was aged at 10 years and the youngest female spawner at 12. No evidence of alternate year spawning was observed in the Tuft Point sample. The sample size is too small to accurately determine age at first reproduction. de Graaf and Machniak (1977) report that the age at first reproduction for this species is 7-10 years. By contrast, Percy (1975) reports age at first reproduction to be 3-4 years. This difference may result from the different techniques used for aging (scales v. otoliths) in the two studies.

Of the 38 broad whitefish sexed, a significantly higher percentage (78.9%) were males ($X^2=6.37$, $P<0.05$). Other studies, in the Mackenzie Delta, involving larger numbers of fish yielded more even sex ratios (44-49% male, Stein *et al.*, 1973; Percy, 1975; de Graaf and Machniak, 1977).

Stomach analysis of 36 broad whitefish revealed 66.7% empty stomachs. The remaining stomachs contained only small amounts (<20% full) of pelecypods, priapulids, stones, and digested material. It does not appear that broad whitefish

TABLE 26. Age-length relationship, sex ratio, and per cent spawners for broad whitefish from Tuft Point and adjacent areas, 1977. Unsexed fish (5.3%) are not included in calculation of total sex ratio.

Age	N	% Male	% Spawners M	% Spawners F	Length (mm) Mean	Length (mm) Range	Length (mm) S.D.
1	2	-	-	-	91.0	89-93	2.8
2	0						
3	1	100.0	0.0	-	164.0	-	-
4	0						
5	5	100.0	0.0	-	297.0	283-313	13.2
6	6	100.0	0.0	-	343.0	322-362	15.0
7	4	100.0	0.0	-	361.0	340-380	16.7
8	9	88.9	0.0	0.0	388.8	370-407	12.4
9	2	100.0	0.0	-	408.0	400-416	11.3
10	2	50.0	100.0	0.0	447.5	428-467	27.6
11	3	100.0	66.6	-	499.3	470-514	25.4
12	2	50.0	100.0	100.0	525.5	522-529	4.9
13	1	0.0	-	100.0	468.0	-	-
14	0						
15	1	0.0	-	100.0	541.0	-	-
Totals	38	86.1*	13.9	60.0	371.1	89-541	102.8

*For sexed fish only.

were utilizing the Tuft Point area extensively for feeding. Similarly, other authors report a high incidence of empty stomachs (48-96%) in fish from the Mackenzie Delta and upstream areas (Stein *et al.*, 1973; Percy, 1975; Slaney, 1975). Stein *et al.* (1973) present data suggesting that lakes are the most important feeding area for this species. In Siberia, broad whitefish usually feed in lakes connected with river channels (Nikolsky, 1961).

Humpback Whitefish *(Coregonus clupeaformis)*

Humpback whitefish typically occur in lakes, but are also taken in larger rivers and brackish water. The species comprises a large portion of domestic fishery catches in the Mackenzie valley (Hatfield *et al.*, 1972). Several studies of the general biology and life history of humpback whitefish in the Mackenzie River drainage (McPhail and Lindsey, 1970; Hatfield *et al.*, 1972; Stein *et al.*, 1973; Jessop *et al.*, 1973; 1974; Slaney, 1974; Jessop and Lilley, 1975; Percy, 1975) and along the Beaufort Sea coast (Kendel *et al.*, 1974; Slaney, 1975) have been recently published.

Only 18 humpback whitefish (64-418 mm in length) were collected from the study area (Figure 10). In addition, several unidentified whitefish young-of-the-year caught in the study area may have been humpback whitefish. The small catches of this species probably result from the fact that

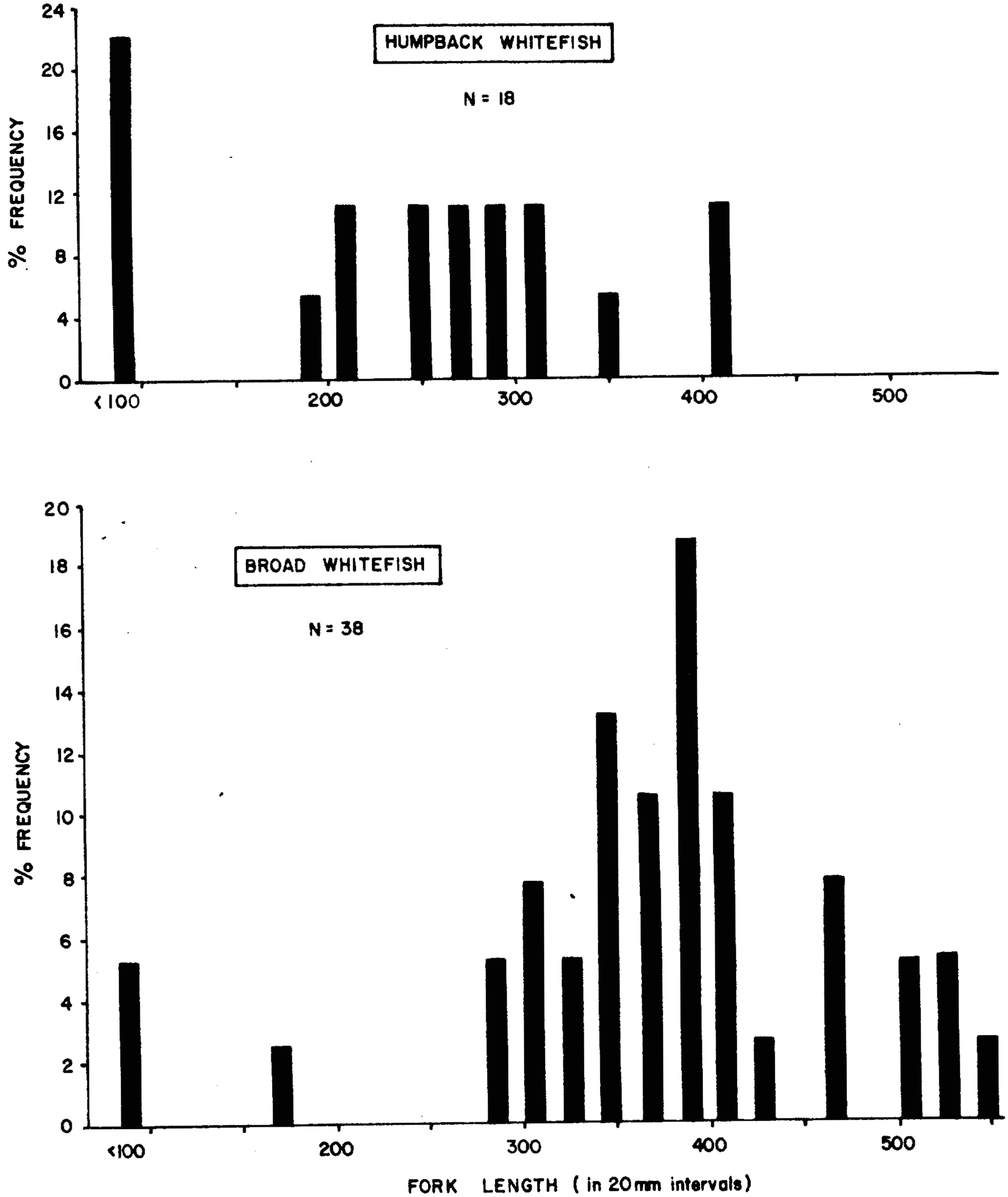


FIGURE 10. Length-frequency for humpback and broad whitefish from Tuft Point and adjacent coastal areas, 1977.

the spawning migration into the Mackenzie River begins as early as June (Stein *et al.*, 1973).

The Tuft Point humpback whitefish sample ranged in age from 0 to 12 years (Table 27). Although the data are minimal, the age-length relationship appears similar to those reported for the Mackenzie River (Hatfield *et al.*, 1972; Percy, 1975; de Graaf and Machniak, 1977).

Only two age 12 females showed sufficient gonadal development to indicate spawning in the year of capture (Table 27). These fish were caught July 23 in the unnamed bay and had egg diameters of 1.3 mm with gonad weights exceeding 10% of body weight. de Graaf and Machniak (1977) report that the age at sexual maturity for this species is 7 years for males and 9 years for females. Other authors report a wide variation (3 to 13 years) in age at sexual maturity (Kennedy, 1953; Alt, 1971; Alt and Kogl, 1973; Craig and Wells, 1975; Healey, 1975).

The Tuft Point sample was too small for sex ratio analysis. Results from other studies suggest a nearly even sex ratio for this species (Percy, 1975; de Graaf and Machniak, 1977).

Of 14 humpback whitefish stomachs examined, 5 were empty

TABLE 27. Age-length relationship, sex ratio, and per cent spawners for humpback whitefish from Tuft Point and adjacent areas, 1977.

Age	N	% Male	% Spawners		Length (mm)		
			M	F	Mean	Range	S.D.
4	1	0.0	-	0.0	182.0	-	-
5	1	100.0	0.0	-	213.0	-	-
6	1	0.0	-	0.0	245.0	-	-
7	2	100.0	0.0	-	271.0	267-275	5.7
8	6	66.7	0.0	0.0	298.5	286-308	7.4
9	0						
10	1	0.0	-	0.0	357.0	-	-
11	0						
12	2	0.0	-	100.0	411.5	405-418	9.2
Totals	14	50.0	0.0	28.6	296.6	182-418	64.8

and the remainder contained small amounts (<20% full) of pelecypods, stones, and digested material. Percy (1975) and de Graaf and Machniak (1977) report that the items most commonly utilized by this species include molluscs, isopods, insect larvae, and plant material.

Inconnu *(Stenodus leucichthys nelma)*

Although not extremely abundant in gillnet catches from the Tuft Point study area, inconnu are an important species in the Mackenzie River domestic fishery (McPhail and Lindsey, 1970). Recent studies of Canadian populations include Fuller (1955), Hatfield *et al.* (1972), Stein *et al.* (1973), Jessop *et al.* (1973, 1974), Percy (1975), Slaney (1975), and de Graaf and Machniak (1977).

Inconnu in the Tuft Point sample ranged in size from 140-710 mm (Table 28). No young-of-the-year were captured in the study area. Studies from the Mackenzie Delta indicate that the most abundant size classes are between 500 and 700 mm (Percy, 1975; de Graaf and Machniak, 1977). Kendel *et al.* (1975) caught only five immature inconnu (340-596 mm in length) during their extensive study along the Yukon coast.

Tuft Point inconnu ranged in age from 2-14 years with age classes 8-11 most abundant (Table 28). de Graaf and Machniak (1977) indicate that, in the Mackenzie Delta, the

TABLE 28. Age-length relationship, sex ratio, and per cent spawners for inconnu from Tuft Point and adjacent areas, 1977. Unsexed fish (7.7%) are not included in calculation of total sex ratio.

Age	N	% Male	% Spawners M	% Spawners F	Length (mm) Mean	Length (mm) Range	Length (mm) S.D.
2	2	-	-	-	146.0	140-152	8.5
3	0						
4	0						
5	0						
6	1	100.0	0.0	-	376.0	-	-
7	1	100.0	0.0	-	427.0	-	-
8	3	33.3	0.0	0.0	474.3	459-499	21.6
9	6	50.0	0.0	0.0	521.0	504-540	13.7
10	7	57.1	0.0	0.0	558.0	543-574	10.2
11	3	66.7	0.0	0.0	590.3	576-615	21.4
12	1	100.0	0.0	-	631.0	-	-
13	1	0.0	-	0.0	610.0	-	-
14	1	0.0	-	0.0	710.0	-	-
Totals	26	54.2	0.0	0.0	510.5	140-710	126.2

most common age classes were 8 to 13 years. Since all inconnu caught in the vicinity of Tuft Point were immature individuals (i.e., little or no gonadal development), it appears that few inconnu utilize coastal waters along the Tuktoyaktuk penninsula once age at first reproduction is reached. Percy (1975) and de Graaf and Machniak (1977) report that few spawning inconnu utilize the Mackenzie Delta during summer months. Age at first reproduction has been shown to be highly variable (6-10 years) in Canadian waters (Stein *et al.*, 1973; Percy, 1975; de Graaf and Machniak, 1977).

The sex ratio of 26 inconnu from the study area was nearly even (54% male). Similarly, both Percy (1975) and de Graaf and Machniak (1977) report nearly even sex ratios for large samples of this species (52 and 47% male, respectively).

Of 26 inconnu stomachs examined, 13 contained no food. The balance contained remains of *Coregonus* spp., with small amounts (<10% full) of amphipods and vegetable material. In the Mackenzie Delta, inconnu consumed *Coregonus* spp. as well as other types of fish (Percy, 1975; de Graaf and Machniak, 1977). This was the only species taken in the Tuft Point study area which utilized fish as the dominant food item.

Arctic Flounder *(Liopsetta glacialis)*

The Arctic flounder inhabits marine and brackish waters in coastal areas of the Beaufort Sea. It sometimes enters the lower portions of rivers (Andriyashev, 1954; McPhail and Lindsey, 1970). Little is known about the life history of this species although available information has been recently summarized (Andriyashev, 1954; Roguski *et al.*, 1971; Griffiths *et al.*, 1975; 1977; Kendel *et al.*, 1975; Percy, 1975).

Twenty-seven Arctic flounder caught in the vicinity of Tuft Point ranged in size from 14-323 mm, but were most abundant between 200 and 240 mm. The oldest specimen was aged at 11 years, although most fish were 7 to 9 years old (Table 29). A single young-of-the-year was caught in shallow water (<1 m) at Station 8. A comparison of age-length data for this sample with those from other studies suggests that growth rates are similar (Griffiths *et al.*, 1975; 1977; Kendel *et al.*, 1975; Percy, 1975).

Of 22 aged fish, 72% showed sufficient gonadal development to indicate spawning in the year of capture (Table 29). The youngest male spawner was age 5 and the youngest female age 8. Spawning may take place at younger ages, but sample size was too small to determine an accurate age at first reproduction. Andriyashev (1954) reports the age at first reproduction for this species at 4-5 years in the U.S.S.R.

TABLE 29. Age-length relationship, sex ratio, and per cent spawners for Arctic flounder from Tuft Point and adjacent areas, 1977. Unsexed fish (9.1%) are not included in calculations of total sex ratio.

Age	N	% Male	% Spawners M	F	Length (mm) Mean	Range	S.D.
1	2	-	-	0.0	59.5	59-60	0.7
2	1	100.0	0.0	-	96.0	-	-
3	1	100.0	0.0	-	137.0	-	-
4	1	0.0	-	0.0	121.0	-	-
5	2	100.0	50.0	-	192.0	182-202	14.1
6	2	100.0	100.0	-	187.0	185-189	2.8
7	3	100.0	100.0	-	213.0	200-235	19.2
8	6	66.7	100.0	100.0	227.3	213-240	10.8
9	3	33.3	100.0	100.0	223.0	212-235	11.5
10	0						
11	1	0.0	-	100.0	323.0	-	-
Totals	22	70.0	85.7	83.3	192.1	59-323	62.9

Timing and location of spawning are not known.

Pelecypods occurred in the highest percentage of Arctic flounder stomachs examined (69%), with some occurrence of isopods (23%), polychaetes (15%), amphipods (15%), and mysids (7.7%). Of 22 stomachs examined, 9 contained no food. Percy (1975) reports that 14 of 21 Arctic flounder stomachs examined from a Mackenzie Delta sample were empty. The remainder contained pelecypods, isopods, and amphipods.

Saffron Cod *(Eleginus navaga)*

The saffron cod inhabits marine and brackish waters and is relatively common in the Mackenzie estuary and nearby coastal areas (Percy, 1975). It is rare, however, in other coastal areas (Roguski and Komarek, 1972; Griffiths *et al.*, 1975; 1977; Kendel *et al.*, 1975). Andriyashev (1954) reviewed thé life history of this species.

With the exception of a single young-of-the-year caught August 30 (34 mm), saffron cod caught in the vicinity of Tuft Point ranged in size from 300 to 413 mm (Table 30). Ages ranged from 5 to 10 years among the larger group with most fish age 9 (Table 30). All saffron cod listed in Table 30 showed sufficient gonadal development to indicate spawning in the year of capture. Andriyashev (1954) suggests that, in the White Sea, this species probably spawns in December or

TABLE 30. Age-length relationship, sex ratio, and per cent spawners for saffron cod from Tuft Point and adjacent areas, 1977.

Age	N	% Male	% Spawners M	% Spawners F	Length (mm) Mean	Length (mm) Range	Length (mm) S.D.
5	1	100.0	100.0	-	300.0	-	-
6	0						
7	3	66.7	100.0	100.0	361.0	351-372	10.5
8	4	100.0	100.0	-	369.7	337-390	24.0
9	13	92.3	100.0	100.0	385.7	364-413	15.7
10	1	100.0	100.0	-	420.0	-	-
Totals	22	90.9	100.0	100.0	377.1	300-420	26.4

January. In the Beaufort Sea, spawning times and locations are not known. Percy (1975) reports that saffron cod from the Mackenzie Delta fell into two distinct age groups, 5-6 and 15-16. Reasons for the distinct size and age groups at different locations are obscure, but may be caused by 1) year class failures (Percy, 1975); 2) a tendency to school in size classes possibly in preparation for fall spawning activities (Andriyashev, 1954); or 3) sampling error.

Of the 22 sexed saffron cod, 90.9% were males (Table 30). Similarly, Percy (1975) reports that 76% of his sample consisted of males. Present samples are too limited to determine if this imbalanced ratio is characteristic for saffron cod in coastal waters.

Crustaceans and fish were the most common food items in the stomachs of 22 saffron cod examined (Table 31). Isopods were present in the stomachs of 50% of the fish, while *Coregonus* spp. were the most common fish (in 25% of stomachs). Only two stomachs were empty. Percy (1975) found isopods, amphipods, pelecypods, mysids, and plant material in saffron cod stomachs from Mackenzie Delta catches.

Other Species

In addition to the species described in some detail above, eight other species of fish were taken in small numbers. These

TABLE 31. Food items eaten by saffron cod in the Tuft Point study area, 1977. Per cent composition in "average stomach" was determined by the Points Method. Only those fish with stomach contents are included in calculations of "average stomach" and "occurrence" values. (N=22, empty=9.1%).

Food Item	per cent in average stomach	per cent occurrence
Polychaeta	0.3	5.0
Priapulida	0.1	5.0
Crustacea		
Amphipoda	6.7	15.0
Mysidacea	1.0	15.0
Isopoda	11.8	50.0
Fish		
Coregonus spp.	4.0	25.0
FHSC	5.7	15.0
ARCD	2.8	5.0
SLEB	0.4	5.0
Unidentified fish remains	5.8	10.0
Miscellaneous		
Digested material	1.0	10.0
Total	39.6	

are briefly described in the following section.

Boreal Smelt *(Osmerus eperlanus)*

Eight boreal smelt were captured in gillnets. They ranged in length from 190 to 283 mm and in age from 5 to 10 years (Table 32). In addition, 89 small juveniles and young-of-the-year boreal smelt were taken by seine. They ranged in length from 14 to 55 mm. Two of the larger fish captured had food items in their stomachs. One had eaten a coregonid fry, the other had been eating mysids and amphipods. Young-of-the-year averaged 16.4 mm in mid July and 28.0 mm by late August.

Percy (1975) and Kendel *et al.* (1975) report that boreal smelt are abundant in the Mackenzie Delta and along the Yukon coast as far west as Herschel Island.

Pacific Herring *(Clupea harengus pallasi)*

Fifteen Pacific herring were captured in gillnets in the study area. All were mature spawners and ranged in fork length from 240 to 310 mm and in age from 9 to 13 years (Table 33). Seven young-of-the-year Pacific herring were captured ranging in length from 27 to 38 mm. Five of the fry were captured by seine and two others in the Faber net. Kendel *et al.* (1975) reports catching small numbers of Pacific herring along the Yukon coast.

TABLE 32. Age-length relationship, sex ratio, and per cent spawners for boreal smelt from Tuft Point and adjacent areas, 1977.

Age	N	% Male	% Spawners M	% Spawners F	Length (mm) Mean	Length (mm) Range	Length (mm) S.D.
5	2	100.0	0.0	-	192.5	190-195	3.5
6	0						
7	3	100.0	0.0	-	219.3	211-226	7.6
8	2	50.0	0.0	0.0	238.5	230-247	12.0
9	0						
10	1	0.0	-	100.0	283.0	-	-
Totals	8	75.0	0.0	50.0	225.4	190-283	29.8

TABLE 33. Age-length relationship, sex ratio, and per cent spawners for Pacific herring from Tuft Point and adjacent areas, 1977.

Age	N	% Male	% Spawners M	% Spawners F	Length (mm) Mean	Length (mm) Range	Length (mm) S.D.
9	4	25.0	100.0	100.0	255.7	240-272	13.2
10	4	100.0	100.0	-	285.2	246-312	27.9
11	3	100.0	100.0	-	287.0	284-292	4.4
12	3	33.3	100.0	100.0	278.3	266-295	15.0
13	1	100.0	100.0	-	310.0	-	-
Totals	15	66.7	100.0	100.0	278.0	240-312	22.0

The Pacific herring is a marine species. The presence of young-of-the-year suggests that there is some spawning in the Beaufort Sea.

Only three of the herring captured in the study area had food items in their stomachs. The dominant items were mysids and amphipods.

Starry Flounder *(Platichthys stillatus)*

This marine fish is one of the most widely distributed flounders found in coastal waters of the Pacific and Arctic oceans. In the study area, however, it is considerably less abundant than the Arctic flounder, previously described. Only six individuals were captured, ranging in size from 218 to 355 mm fork length. Ages ranged from 8 to 15 years. Two of the starry flounders had food items in their stomachs. One had been feeding on amphipods, the other had the remains of a coregonid fry in its stomach.

Percy (1975) caught a similar number of starry flounders in approximately the same size ranges in Mallik Bay.

Arctic Cod *(Boreogadus saida)*

One juvenile Arctic cod was captured during the course of this study. It was 177 mm in length and 2 years of age. The remains of two other smaller Arctic cod were removed from the stomach of a saffron cod. They could not be accurately aged or measured. The Arctic cod is apparently rare in nearshore habitats in the southern Beaufort Sea. Kendel *et al.* (1975) report having caught only one individual in their studies along the Yukon coast.

Pacific Sand Lance *(Ammodytes hexapterus)*

Fifteen young-of-the-year of this species were captured in the study area. Nine were captured by seine and six in the Faber net. They have been previously reported in the Beaufort Sea by McAllister (1962).

Stout Eelblenny *(Lumpenus medius)*

One specimen of the stout eelblenny was captured by seine in the study area. This species has been previously reported from the Alaskan Beaufort Sea coast by Griffiths *et al.* (1977).

Slender Eelblenny *(Lumpenus fabricius)*

Two specimens of the slender eelblenny were identified from the stomach contents of a saffron cod. This species has been previously reported by McAllister (1962) and by Griffiths *et al.* (1977).

Ninespine Stickleback *(Pungitius pungitius)*

Seven ninespine sticklebacks were taken within the study area. Six were captured nearshore by seine and one was taken in the epibenthic trawl further offshore. Griffiths *et al.* (1977) report taking a number of ninespine sticklebacks in water as saline as 18,000 mg/1.

Arctic Staghorn Sculpin *(Gymnocathus tricuspis)*

One Arctic staghorn sculpin (72 mm) was taken in a bottom trawl at Station 5. This species is rare in the area but has been previously reported by McAllister (1962).

CONCLUSIONS

Tuft Point coastal waters support a relatively abundant and diverse fish fauna. The region is of particular importance as a rearing area for the juveniles of anadromous species such as ciscoes, whitefish, and inconnu.

The most important fish habitat zones are the nearshore shallows including bays and lagoons and the entrance areas of bays and lagoons. Fish are not nearly as abundant in offshore areas such as the location of the IOL breakwater.

Invertebrates are relatively abundant and diverse wherever organic mud and debris can be found. Where the substrate is primarily sand such as in the vicinity of the IOL breakwater, lower densities of benthic macroinvertebrates are present.

Because of the proximity to the mouth of the east channel of the Mackenzie River which contributes to higher water temperatures and nutrient levels, the phytoplankton communities in the Tuft Point area are relatively abundant and diverse. Zooplankton communities, however, are less dense than reported from other areas of the Beaufort Sea.

Present Imperial Oil dredging operations in the Tuft Point area are having little or no effect upon fish, invertebrate, or plankton populations.

The dredging site is far enough offshore to be outside of the most important fish habitat zones. The substrate being dredged is mostly clean sand where invertebrate densities are very low and the slight increases in turbidity levels in the immediate vicinity of the dredge site are unlikely to affect fish, invertebrates, or plankton significantly.

RECOMMENDATIONS

Based upon the results of this study, including a review of the literature cited, the following recommendations are made. It is recommended that:

1. Dredging operations within the study area be excluded from the nearshore shallows (closer than 1 mi (1.6 km) to shore) and from the vicinity of openings into bays and lagoons.

2. Removal of existing island, shore, sandspit, or beach areas be avoided.

3. Effects of breakwater construction be monitored along the coast to avoid significant changes in currents and erosion and deposition patterns.

4. Further studies be conducted to:
   a) determine the extent seaward of the heavily utilized nearshore shallow zone;
   b) determine the utilization of the offshore habitat zones by fish, particularly early life history stages of marine species;
   c) monitor turbidity and suspended sediment levels whenever the site of dredging operations is changed.

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