

INVESTIGATION INTO THE
FEASIBILITY OF ESTABLISHING
FISHERIES FOR MARINE SHELLFISH AND
FINFISH IN THE VICINITY OF
SACHS HARBOUR

Submitted to:

The Fisheries Joint Management Council

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DISCLAIMER

This report was prepared for the Fisheries Joint Management Committee, as part of the implementation terms of the Inuvialuit Final Agreement. The opinions, findings, conclusions and recommendations expressed in this report are those of the Authors and do not necessarily reflect the views of the Fisheries Joint Management Committee.

EXECUTIVE SUMMARY

This report is submitted in response to the terms of reference defined in the contract between Archipelago Marine Research and the Joint Secretariat, acting on behalf of the Fisheries Joint Management Council. The information presented in this report was collected as part of a literature review and interview process.

The focus of this report is on the identification of those marine shellfish and finfish species which may have an economic potential to support a commercial fishery in the vicinity of Sachs Harbour. The study area includes portions of the southeastern Beaufort Sea and the Amundsen Gulf. The study has focused on marine species only. Anadromous and semi-anadromous species were not included in this investigation.

Information regarding ice conditions and water circulation within the study area is presented. The eastern Arctic northern shrimp and scallop fisheries are also reviewed.

Based on available information regarding known distribution, abundance and market potential, the following six shellfish species and eight finfish species are reviewed as to their commercial potential:

Shellfish

Clinocardium cililatum (cockle shell)

Serripes groenlandicus

Mytilus edulis (Bay mussel)

Delectopecten greenlandicus (Greenland scallops)

Pandalus montagui tridens (striped shrimp)

Pandalus borealis (pink shrimp)

Marine fish

Arctic cod
Fourhorn sculpin
Arctic cod
starry flounder
Greenland cod
saffron cod
Pacific herring
capelin

Based on an overall assessment of available information, the following recommendations are made:

1. A small scale exploratory fishery in the region of Sachs Harbour is warranted
2. Due to the high market value and circumstantial evidence regarding possible stocks in the area, priority should be given to locating commercial concentrations of northern shrimp (P. montagui and P. borealis) and Greenland scallops (Delectopecten greenlandicus)
3. Due to a lower market value, secondary emphaiss of an exploratory fishing program should be placed on clams, starry flounder, saffron cod and Greenland cod if local N.W.T. markets for these species can be developed.
4. An exploratory fishery for northern shrimp and scallops should be conducted methodically and gradually.
5. Commercial viability is based on more than the value and availability of fish or shellfish stocks. Other factors which must be addressed include:
 - community interest in development of the fishery
 - trained labour force
 - use of proper technology
 - adequate processing and storage facilities
 - familiarity and development of markets

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INTRODUCTION

During the Fisheries Joint Management Committee (FJMC) community tour in February 1987, the Sachs Harbour Hunters and Trappers Committee (HTC) requested an investigation into the feasibility of establishing fisheries for marine shellfish and finfish in the vicinity of Sachs Harbour. At their October 22, 1987 meeting, the FJMC decided to proceed with investigations into an exploratory fishing program in a step by step fashion.

This report is the first step towards evaluating the potential for marine fisheries in the southeast Beaufort and Amundsen Gulf region. The report reviews and summarizes published and unpublished information required to accomplish this goal. The main components of the study include area specific information pertaining to ice conditions, water currents, and potential commercially valuable invertebrate and marine fish. Information regarding shrimp, scallop and other marine fisheries in the eastern Arctic is also presented. Finally recommendations regarding an exploratory fishery in the area are made. Upon reviewing the contents of this report, the FJMC and Sachs Harbour HTC will jointly decide on the next step towards developing an exploratory fishing program.

The area covered by this study includes portions of the southeastern Beaufort Sea, Amundsen Gulf and adjacent marine areas south of $74^{\circ}20'N$, west of $118^{\circ}W$, and east of $130^{\circ}W$ (Figure 1). The southern boundary of the study area excludes the outer portion of Liverpool Bay and includes Franklin Bay, Darnley Bay and the coastal regions adjacent to the Amundsen Gulf. Figure 2

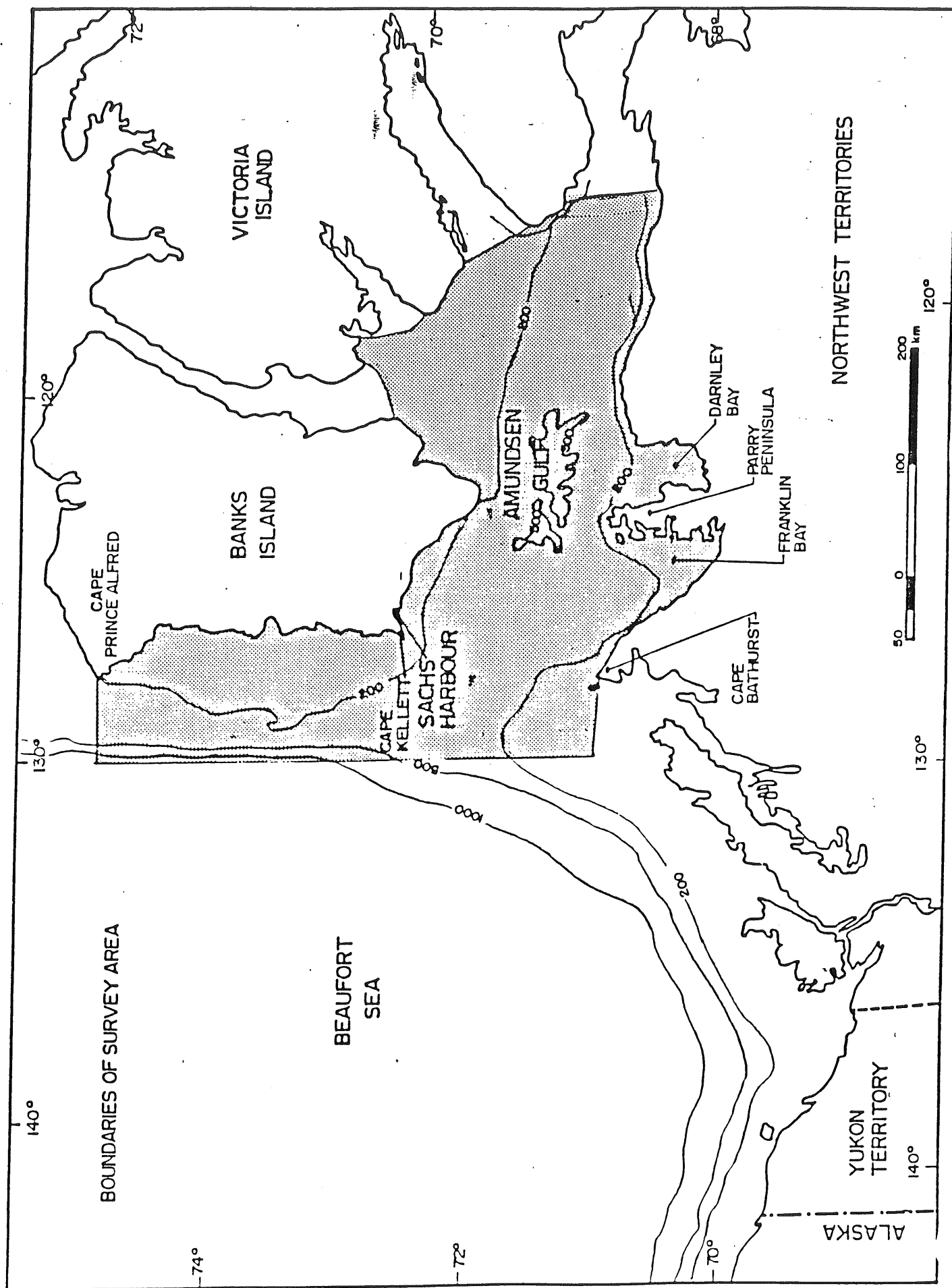


Figure 1. The study area.

Information presented in this report is based mainly on the review of available literature. Excellent inventories of published and unpublished literature on marine fish and shellfish in the study area are provided by the Arctic Data Cataloguing and Appraisal Program (ADCAP), produced by the Data Assessment Division of the Institute of Ocean Sciences (DFO) in Sidney, B.C. (see Wainwright et al, 1987 and Ratynski et al, in press). Information was also obtained through conversations with various individuals involved in marine fisheries research in the western Arctic region. Information pertaining to marine fisheries in the eastern Arctic is based on conversations with Department of Fisheries and Oceans personnel and personnel of the NWT Department of Economic Development and Tourism.

ICE IN THE SOUTHERN BEAUFORT SEA

The ice climate of the southern Beaufort Sea has been studied in considerable detail in order to facilitate offshore petrochemical activity. The Atmospheric Environment Service of the Department of the Environment has flown ice reconnaissance surveys in support of shipping in the Beaufort Sea since 1958 (Markham, 1975). Satellite imagery is also used to forecast the movement of ice flows. Little information was found in the literature regarding ice conditions in the Amundsen Gulf region.

The southern Beaufort Sea (below 75°N) can be generally subdivided into three ice zones: (1) fast ice zone, (2) seasonal pack ice zone, and (3) polar pack ice zone.

The fast ice zone consists of seasonal ice which is an extension of the land since it remains generally immobile during the winter. Depending upon coastal geometry, this zone typically extends to the 20 m depth contour by the end of winter. Depending upon snow cover, this ice may reach a thickness of 2.0 to 2.4 m (Kovacs and Mellor, 1974).

The seasonal pack ice begins with a narrow shear zone of brecciated ice at the edge of the fast ice and continues out 100 to 200 km to the edge of the continental shelf. The ice in this zone is mobile and reaches an average thickness of 2.0 to 2.1 m. (Kovacs and Miller, 1974).

The polar ice zone consists, predominantly, of thick multi-year floes which are surrounded in summer by open water or thin ice, and in winter by first-year ice. These floes vary in thickness from 2.1 to 4.5 m (Bushuev, 1964; Kovaks and Mellor,

1974). The polar pack ice can be driven towards the coast at any time by a strong onshore wind.

Since 1959 Canadian ice reconnaissance flights over the southeast Beaufort Sea have been flown in support of shipping. Weekly charts indicating the location, concentration and age classification of sea ice have been produced for the period from mid May until late October of each year from their observations and meteorological data such as wind and air temperature. In later years observations from aircraft have been augmented by the use of satellite imagery. Markham (1975) describes a system whereby a week-by-week analysis of ice conditions at a series of data points in the southeastern Beaufort Sea in a 15 x 20 nautical mile grid have been recorded (Figure 2). From this data computer drawn weekly maps of median ice conditions, of occurrences of open water, and concentrations of two tenths ice or less were drawn. The following description of ice conditions in the study area has been drawn from this information (Markham, 1975).

Median Ice Conditions

The ice begins to clear north of Cape Bathurst in the second half of May. The land fast ice has usually disappeared by July 9 and by the end of the month the ice concentration is less than one tenth in the Arctic area from Herschel Island to Cape Kellett on Banks Island. Minimum ice cover exists on September 17, then concentrations rise to four tenths over the main area by October 15 and to seven tenths by October 22.

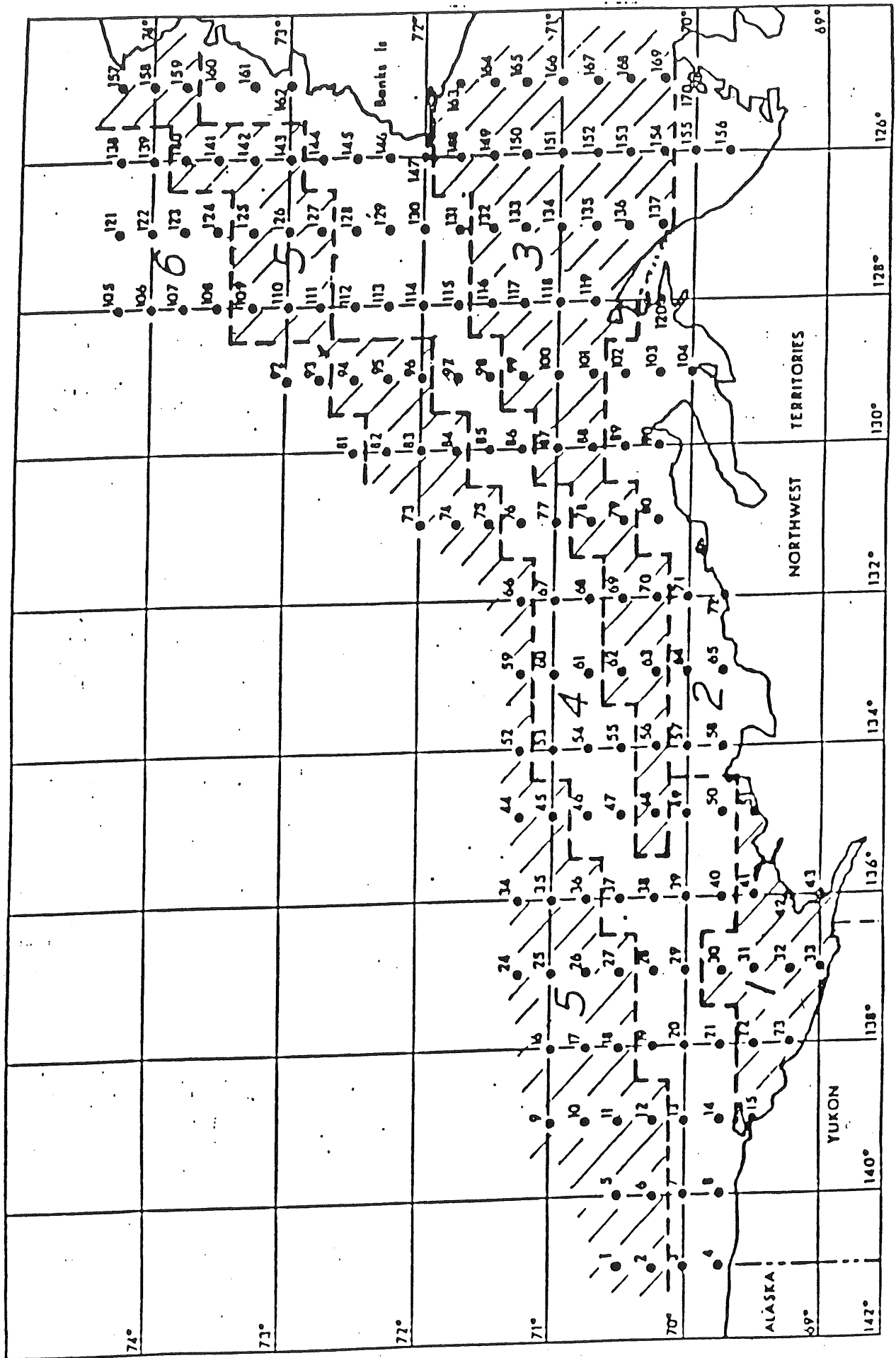


Figure 2 Locations of the data points used in the analysis of historical weekly ice charts (from Markham, 1975).

In "good" ice years extensive water is present in Amundsen Gulf by May 21 and, although the fast ice is still in position at that time, clearing is rapid. In Mackenzie Bay this concentration falls to less than one tenth by June 18. This condition spreads over the entire area by July and open water remains until mid October. Freeze up is then fairly rapid during late October.

In "bad" years the ice concentration remains at seven tenths or more until mid August except in shallow water areas within thirty nautical miles of shore from Herschel Island to Cape Parry. Minimum ice conditions by mid September extend the clearing to sixty miles offshore but refreezing begins by October 1 and extensive ice is present by mid month.

Breakup at Sachs Harbour may occur anytime between late June and late July while freezeup may occur anytime between late September and late November (Kovacs and Mellor, 1974). Good ice thickness measurements are available for Sachs Harbour. From an analysis of these data the median freeze-over date is October 12 while the mean date for the growth 30 cm ice is October 27.

Total ice concentrations for four zones within the study area are illustrate in Figures 3-6. The boundaries of these zones are shown in Figure 2.

Ice conditions in zone 3, the near offshore area from Richards Island to Cape Bathurst and Cape Kellett including the approaches to Amundsen Gulf (Figure 3), generally include the formation of offshore polynyas resulting in an early decrease in ice cover. Clearing progresses slowly from early June until

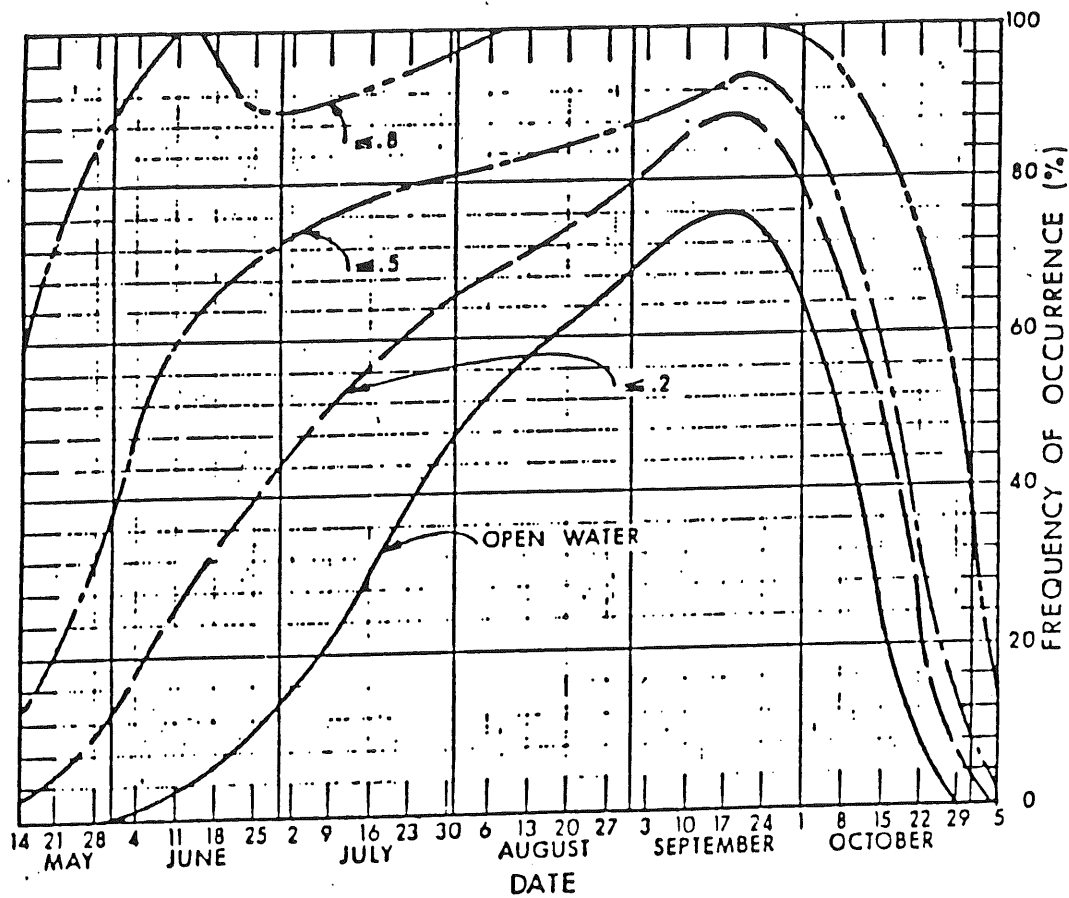


Figure 3. Total ice concentrations for zone 3 within the study area (from Markham, 1975).

early September. In zone 4, the offshore area from Herschel Island to the west coast of Banks Island (Figure 4), clearing is less common than in inshore areas. There is a lengthy period when the ice is well dispersed. In the deep water area (Zone 5), where the fringes of the Arctic pack are usually present, clearing or even dispersed ice is uncommon (Figure 5). There is a trend for slowly improving ice conditions from May to mid September. There are brief ice dispersals in the northern offshore area west of Banks Island (Zone 6, Figure 6). Ice dispersals can occur in this area at anytime during the summer, but congested conditions are usually present.

Bi-weekly charts of median ice conditions in the southeastern Beaufort and Amundsen Gulf region are illustrated in Appendix I. These charts were taken from Markham (1975). When considering the navigable period a fishing vessel would have to operate in these various regions of the study area, one should keep in mind the highly irregular sea and ice conditions which exist. The spatial extent, variation in thickness, and movement of sea ice is extremely variable from year to year. With this in mind, the following conclusions regarding fishing time in the study area are made.

A fishing vessel should be able to safely operate at various locations within the study area between late June and early October. Early in the season fishing activity would most likely occur along the southwest corner of Banks Island. By early July, fishing activity could be extended further east into the Amundsen Gulf region, further west into the Beaufort Sea and further north

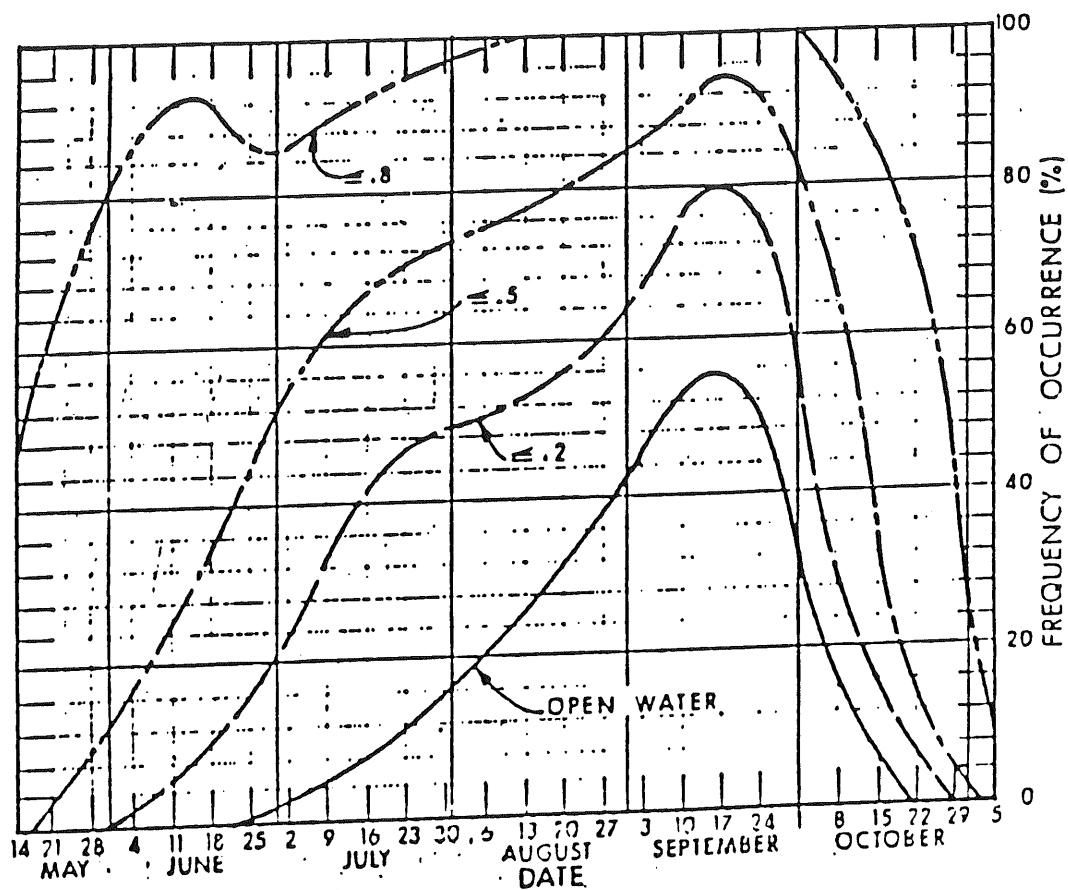


Figure 4 Total ice concentrations for Zone 4 within the study area (from Markham 1975).

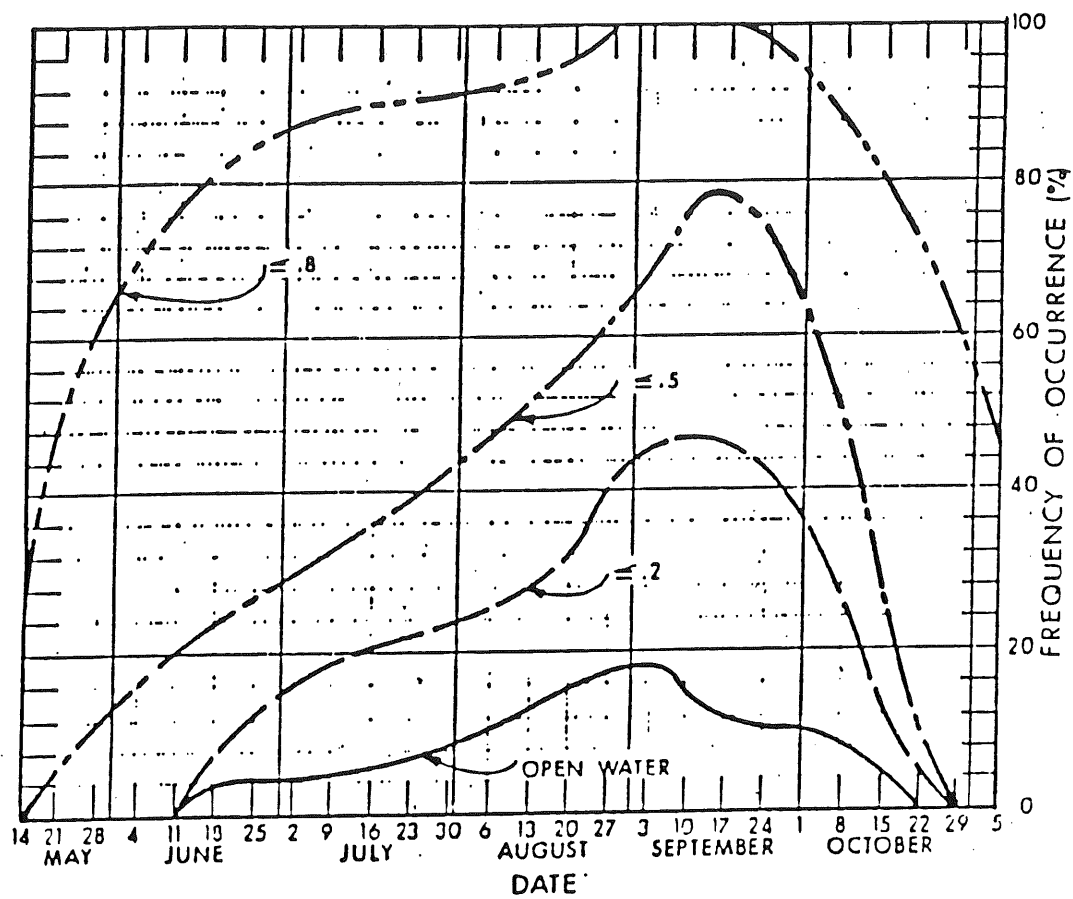


Figure 5 Total ice concentrations, for Zone 5 within the study area (from Markham 1975).

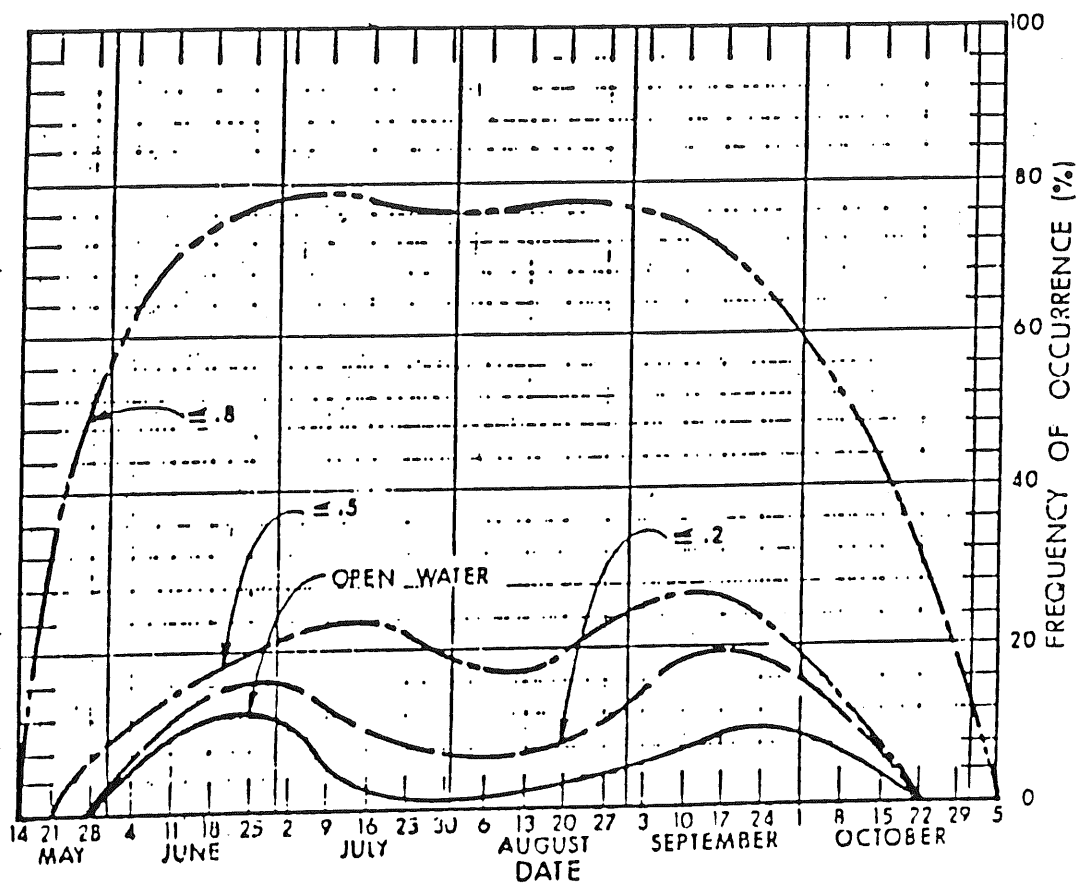


Figure 6 Total ice concentrations for Zone 6 within the study area (from Markham 1975)

along the west coast of Banks Island. By early October fishing activity would most likely be restricted to the southwest area of Banks Island. Fishing vessels would most likely have to be hauled out by mid October.

WATER CIRCULATION WITHIN THE SOUTHEASTERN BEAUFORT SEA AND AMUNDSEN GULF

The water masses of the Arctic Ocean have been described by Coachman (1963). There are three main water masses which are identified by the following general characteristics (O'Rourke, 1974).

- (1) Arctic water: 0 to 200 m, low salinity, cold (-1.5°C)
- (2) Atlantic water: 200 to 900 m, high salinity, warm ($>0^{\circ}\text{C}$)
- (3) Bottom water: 900 to bottom, high salinity, cool (-0.3°C)

The Arctic water originates in the Arctic, and can be subdivided into a surface layer (0 to 50 m) and a subsurface layer (50 to 200 m). The surface layer varies in thickness depending on the amount of melt water, river runoff and wind mixing. The open water temperature at the surface becomes relatively warm in the summer (2° to 6°C) due to solar radiation and, at the nearshore, river runoff. This warm water is confined to a thin layer, usually less than 5 m deep.

The Atlantic water flows into the Arctic from the Greenland-Spitsbergen gap. The bottom water derives from the Norwegian and Greenland seas where it was originally Atlantic water which has been cooled in winter, becoming more dense than the warmer Atlantic water. It sinks below the Atlantic water and enters the Arctic Ocean between Greenland and Spitsbergen.

In the deeper water off the Beaufort shelf, there are two layers of circulation (O'Rourke, 1974). The Arctic water (0-200 m) circulation is dominated by the clockwise rotation of the Beaufort Gyre. The Atlantic and bottom water masses appear to

move as a unit and in a pattern somewhat different from the Beaufort Gyre. There is Atlantic intrusion into the Eastern Beaufort, but it is not well delineated (Markham, 1975).

The Mackenzie River has a dominant effect on the surface waters of the southeastern Beaufort Sea and eastern Amundsen Gulf. Because of this dominant influence, the Beaufort Sea comprises a two-layer estuarine system throughout the year with salinities that vary from 0 ‰ to 34 ‰, and temperature that ranged from -1°C to 18°C (Grainger, 1975).

A significant feature of water circulation pattern in the area is the eastward flow of the Mackenzie River runoff. The river water travels along the coast until diverted by the outflow from Amundsen Gulf or by wind. In July, a strong westerly wind which usually prevail, blowing the Mackenzie River water to the east. When the wind turns north the river water is forced to flow northward thus mixing with the Beaufort Gyre before reaching the Amundsen Gulf.

In August, southwest winds usually prevail, thus allowing the river water to flow into Amundsen Gulf, move out again on the north side of the Gulf, and then move along the west coast of Banks Island. An offshore wind along Banks Island blows the water out to sea where it mixes with the Beaufort Gyre. In September, the circulation pattern is usually similar to that of August. The general distribution of horizontal surface and subsurface water movements within the study area is illustrated in Figure 7.

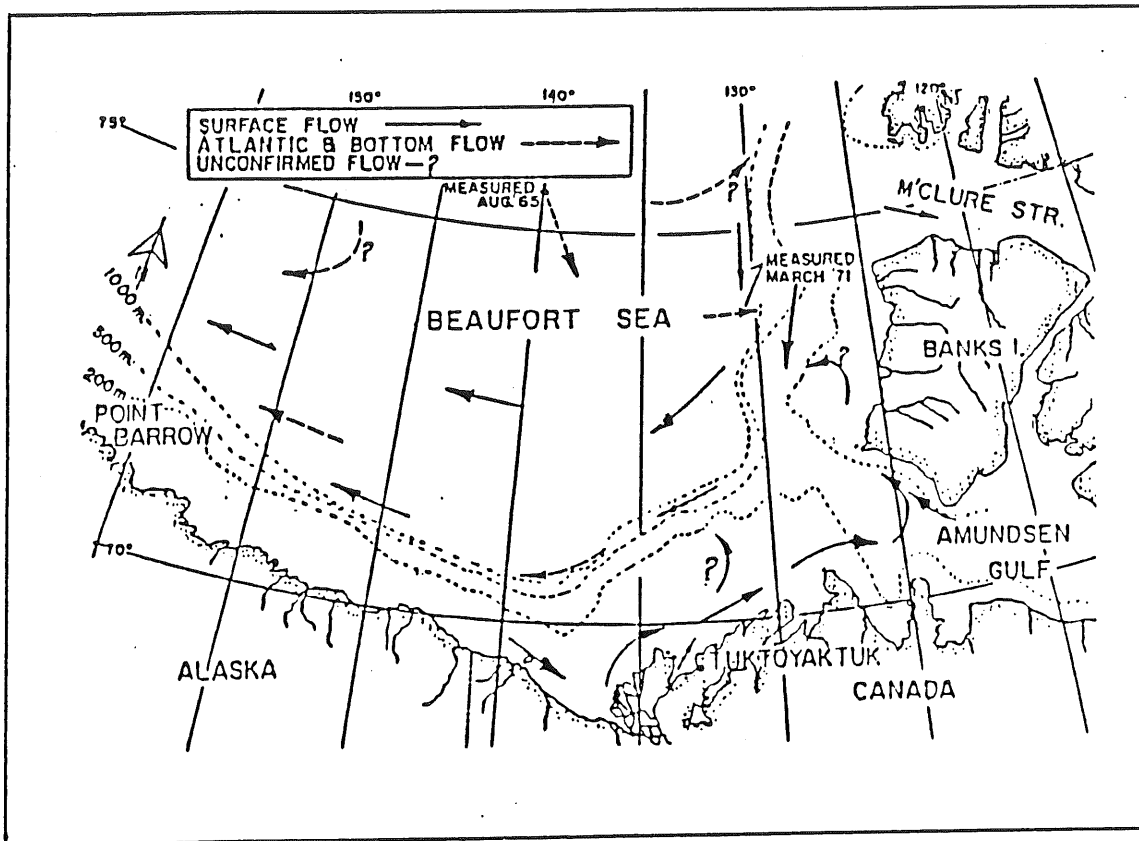


Figure 7 Beaufort Sea surface currents.

MARINE SHELLFISH

The potential for invertebrate fisheries in the southeast Beaufort is largely unknown, as little information is available on the abundance of potentially commercial species.

Most of the data available on invertebrates for this region comes from faunistic surveys conducted by the federal government Department of Fisheries and Oceans, the Beaufort Sea Project, research vessel cruises, (see Wagner 1977), or by private consultants examining various aspects of the effect of the petrochemical industry upon the Arctic environment (North and Thomas 1984, Cross et al. 1984, Thomas et al. 1981). Most of the data has been collected by the use of benthic grabs, thus restricting description of species composition to sessile infaunal species and excluding potentially fishable mobile decapod species. Abundance is rarely estimated, and in general, only species lists are generated. Otter trawls (or traps) can be used to capture species of decapod crustaceans. Otter trawls have been used primarily in fish surveys, yet little mention is made of invertebrate by-catch.

Based on existing invertebrate fisheries in the northeast Pacific, north Atlantic and eastern Arctic Oceans, the following species are reviewed:

- Molluscs: Clinocardium ciliatum (incidental fishery)
Serripes groenlandicus (fishery potential)
Mya spp.
Mytilus edulis.
Delectopecten greenlandicus (Greenland scallop)
- Decapoda: Pandalus montagui tridens (striped shrimp)
Pandalus borealis (pink shrimp)

Summaries of the distribution abundance and fisheries potential of these species are outlined below; existing fisheries, when applicable, are summarized.

Mollusca - Clams, Mussels and Scallops

Clinocardium ciliatum (cockles)

Clinocardium ciliatum is found from 10-200 m in muddy sediment. A short-siphoned species, it is found within a few centimeters of the substrate surface (Lubinsky 1980). It is reported as a 'rare' species in the Western Arctic (Figure 8) and tends to be small rarely exceeding 40 mm.

In British Columbia the fishery for cockles (Clinocardium nuttalli) is only incidental as a bycatch associated with other clam fisheries (Quayle and Bourne 1972).

There is insufficient information available to determine if Clinocardium ciliatum is abundant enough or the market suitably attractive to support a commercial fishery. Benthic dredging would allow estimates of abundance and local availability.

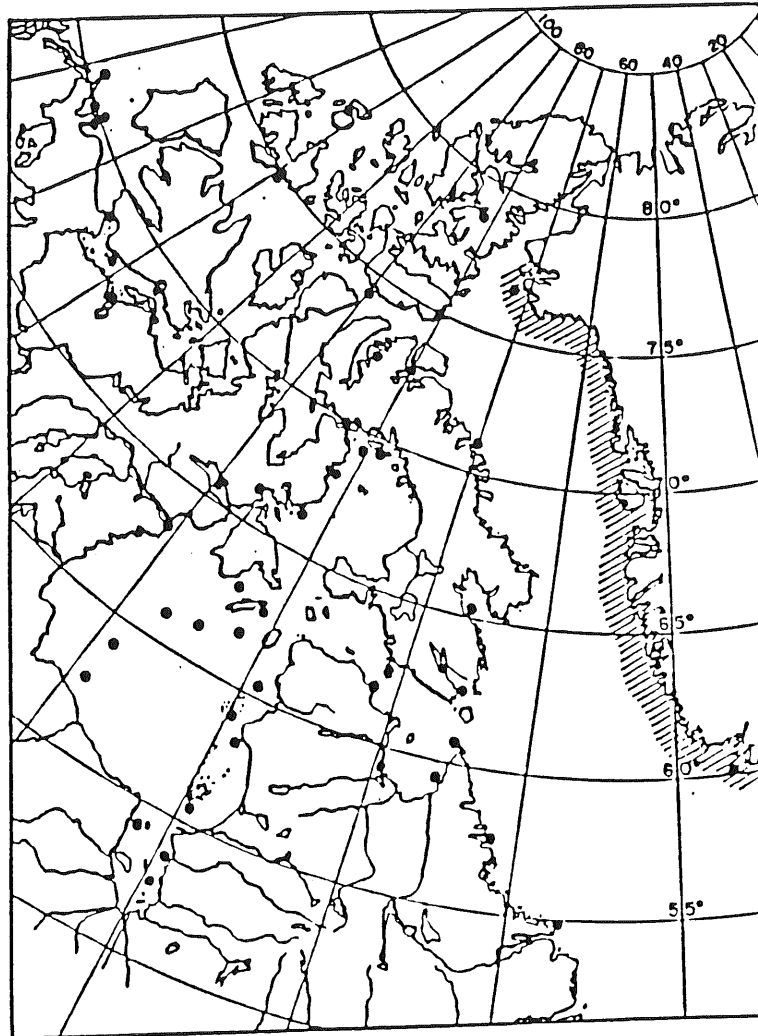


Figure 8 Known occurrences of *Clinocardium ciliatum* in the Canadian Arctic (from Lubinsky, 1980).

Serripes groenlandicus

Serripes is a pan Arctic, circumpolar species (Figure 9) (Lubinsky 1980). While this clam is extremely abundant in the eastern Arctic at depths of 7-10 m (20-80 Serripes/m², Cross et al. 1984) it appears to be rare in the western Arctic (Lubinsky 1980). It rarely exceeds a length of 52 mm in this region (Lubinsky 1980). No reported commercial fisheries for this species were encountered in the literature. There is insufficient information on the abundance and distribution of this species, however it is found in the top 8 cm of the sediment (Jane Watson, pers. comm.) in the eastern Arctic, and so would be easily dredged. Stock assessments could be made using a benthic dredge.

Mya spp - The soft shelled clams

Three species of the genus Mya are reported from the Arctic. Of these only Mya truncata and Mya pseudoarenaria have been confirmed (Figure 10). Large fisheries for the 10 cm shelled clam, Mya arenaria exist on the Atlantic coast of North America (Quayle and Bourne 1972). This species was accidentally introduced to the Pacific coast, and is found in isolated concentrations. The Pacific species lacks the flavour of its Atlantic counterpart (Quayle and Bourne 1972). Only fossil shells of this species have been found in the Western Arctic (Lubinsky 1980).

Records of Mya species (Mya truncata and Mya pseudoarenaria) found in the Arctic indicate that these clams are generally dwarfed and rarely exceed 80 mm in length. Modest abundances of

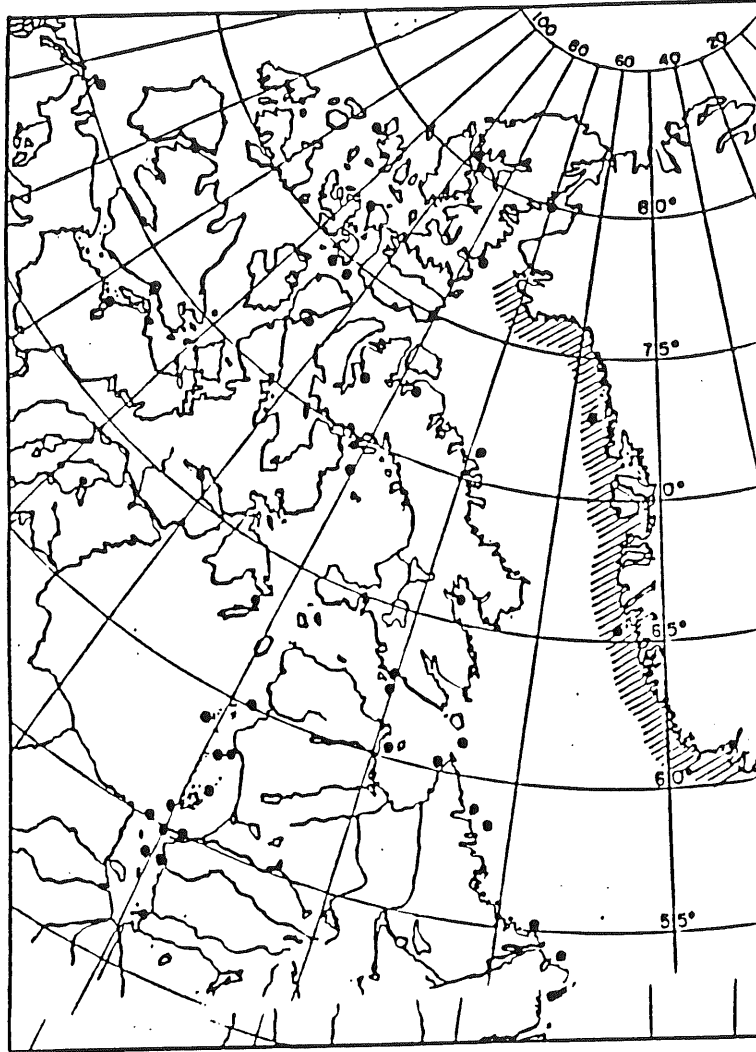


Figure 9 Known occurrences of *Serripes groenlandicus* in the Canadian Arctic (from Lubinsky, 1980).

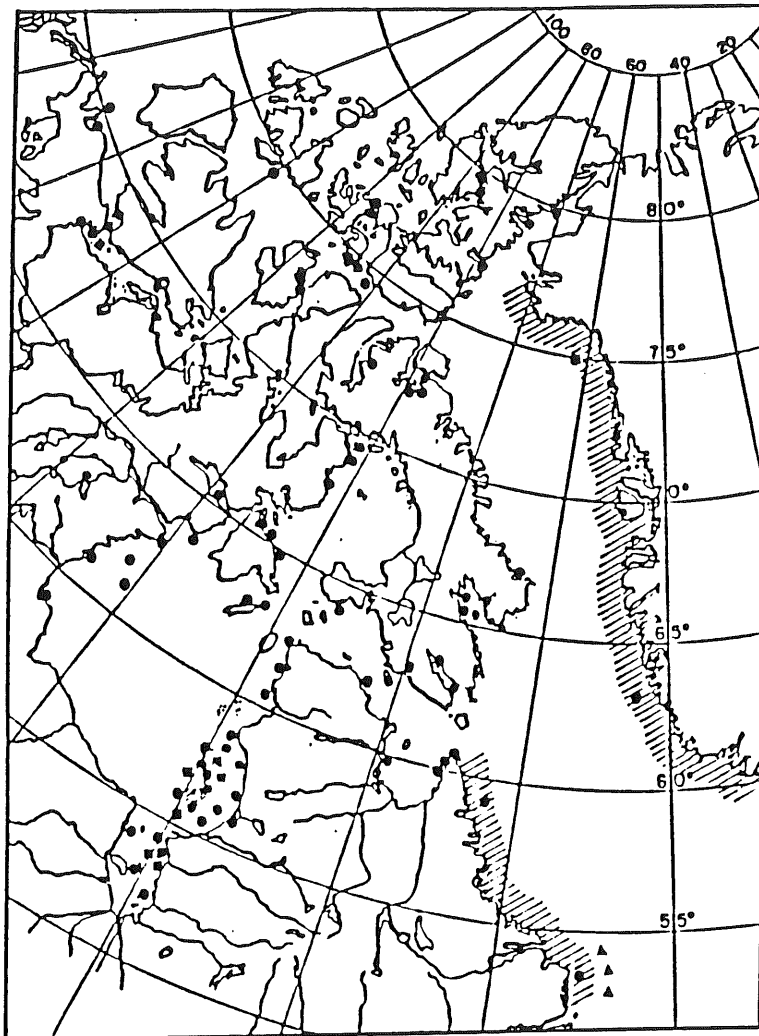


Figure 10 Known occurrences of *M. truncata* (o) and *M. pseudoarenaria* (■) in the Canadian Arctic (from Lubinsky, 1980).

these clams are suggested by faunal surveys (Lubinsky 1980, Wacasey 1975). Distribution and abundance information on these species are lacking in detail, and while it is unlikely they exist in fishable abundance, they may merit further investigation.

Mytilus edulis (Bay Mussel)

Mytilus edulis is a boreal subarctic species (Figure 11). It penetrates Arctic waters with the offshore currents of the Atlantic and Pacific subarctic waters. M. edulis also occurs in shallow regions of polar waters, which are warmed during the summer.

Mussels (M. edulis) are cultured and wild harvested extensively along European and North American Atlantic shores.

In Bathurst Inlet M. edulis are common, and occur from depth of 3 to 30 m (B. Emmett, pers. comm.). In Arctic waters mussels (M. edulis) may grow to be 80 mm in length. The abundance of mussels in more accessible southern locations, and their relatively low market value makes M. edulis an unlikely species for a commercial fishery.

Delectopecten greenlandicus - Greenland Scallops

"Numerous records" (Lubinsky 1980) show that Delectopecten greenlandicus is widely distributed and abundant in the Canadian Arctic (Figure 12). It is found in the Western Arctic at depths of 5-30 m, but usually below 50 m. The maximum size reported for this species is 30 mm (Lubinsky 1980).

A commercial fishery for a different species of scallop is developing in the eastern Arctic. Chlamys islandica is presently

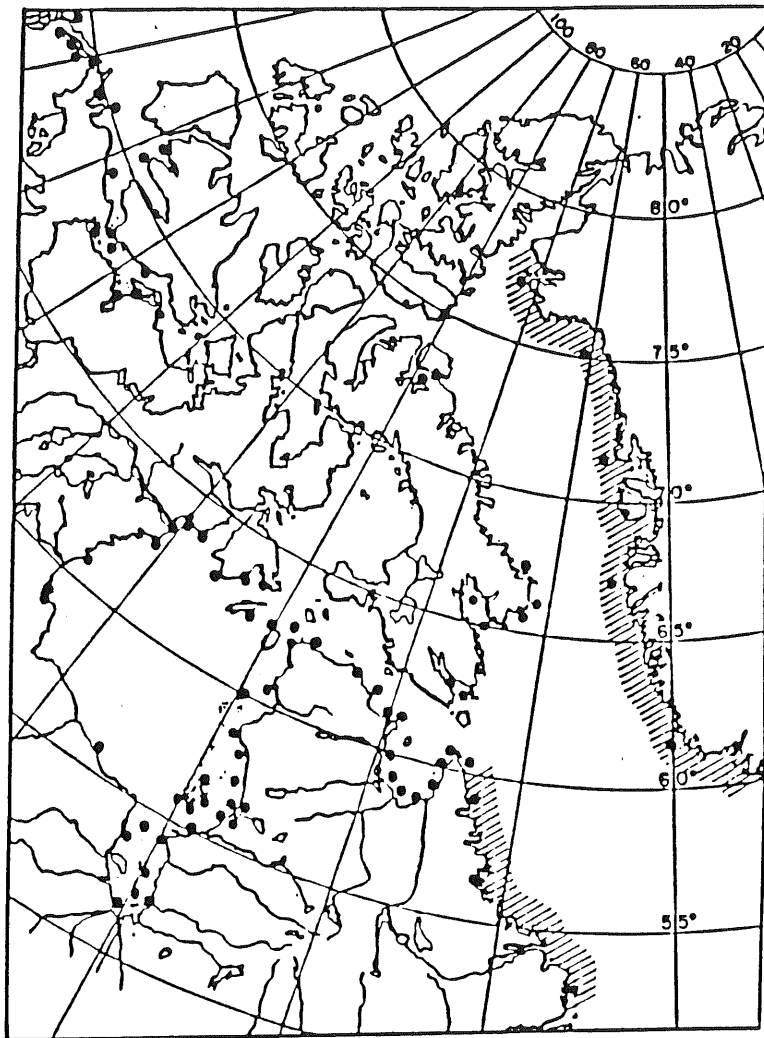


Figure 11. Known distribution of *Mytilus edulis* in the Canadian Arctic (from Lubinsky, 1980).

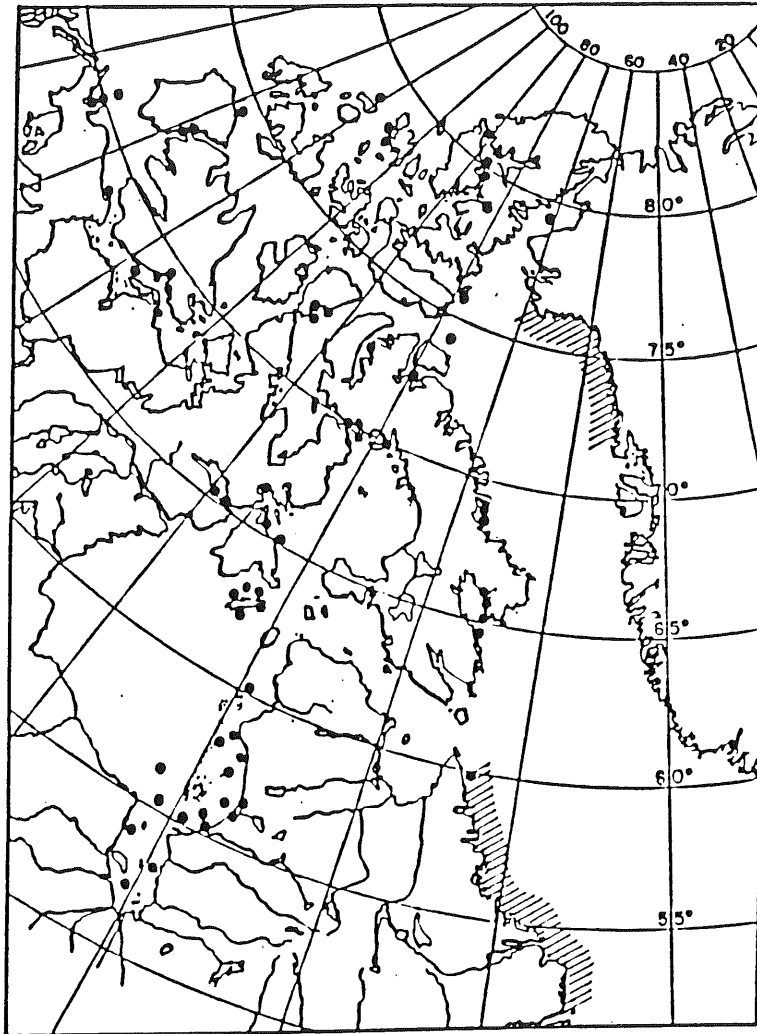


Figure 12 Known distribution of Delectopecten greenlandicus in the Canadian Arctic (from Lubinsky, 1980).

fished in the inland waters of Cumberland Sound, Hudson Strait and Ungava Bay (Allen, pers. comm.; Simpson, pers. comm.) at relatively shallow depths (100-300 ft.).

In Canadian waters, Lubinsky (1980) reports that C. islandica occurs only in the eastern Arctic southward from Foxe Channel and Cumberland Peninsula.

Because D. greenlandilus is reported in the literature as abundant in the western Arctic, an effort should be directed towards locating commercial densities of this scallop species.

Pecapoda - Shrimps

Pandalus montagui tridens

Pandalus montagui (the yellow legged or striped shrimp) is reported from both the Bering Sea and eastern Arctic. While there are no records of its occurrence in the Western Arctic, this species might be found in this region (Butler 1980, J. Boutillier, pers. comm.). Commercially viable populations of this shrimp occur in Alaska where it is fished commercially by trawling and trapping.

A commercial fishery for this species occurs in Ungava Bay, and Hudson Strait. Literature reports that P. montagui is generally found on rocky or firm substrate in depths of 60-200 meters (Butler, 1980), although P. montagui is fished in the eastern Arctic at depths exceeding 250 m (Parsons, pers. comm.). The commercial fishery in the eastern Arctic is described later.

Pandalus borealis

P. borealis is a circumboreal species and is known to be present in the eastern Arctic, Bering Sea and Chukchi Sea.

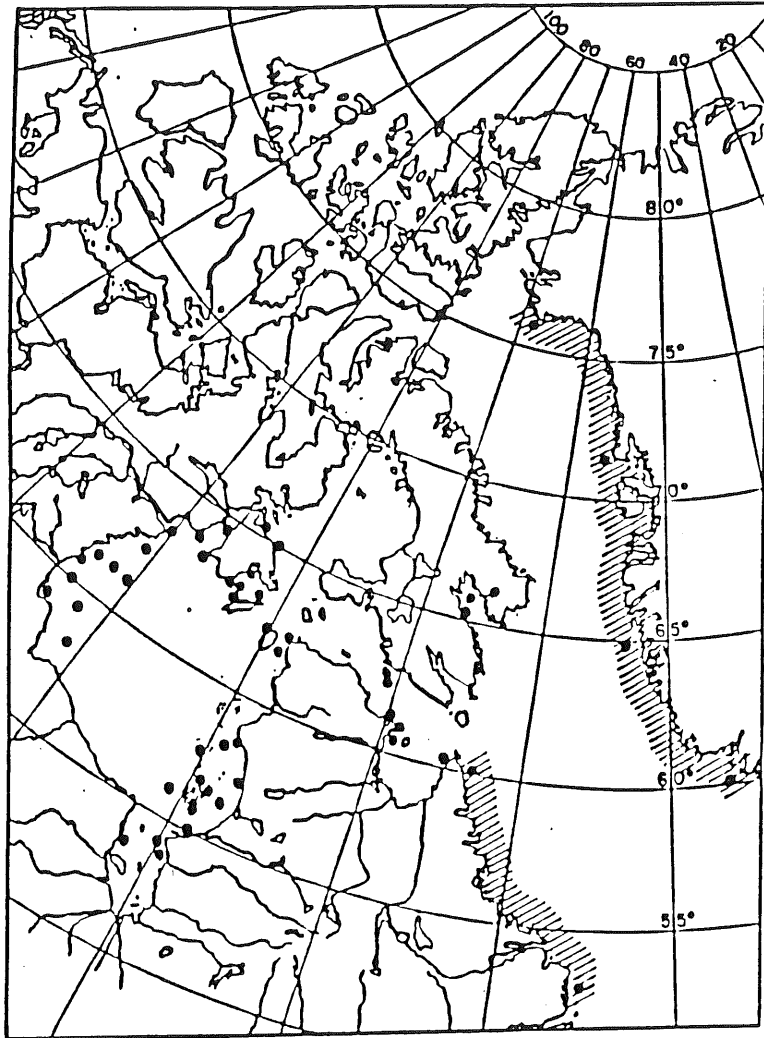


Figure 13 Known distribution of Chlamys islandica in the Canadian Arctic (from Lubinsky, 1980).

P. borealis is being commercially fished in the offshore waters of Davis Strait and the Labrador Sea at depths exceeding 350 m (Parsons, pers. comm.).

Although neither northern shrimp species (P. borealis or P. montagu) have been reported in the southeastern Beaufort Sea/Amundsen Gulf region, considerable potential exists for a commercial fishery for these species in this region, and should be further investigated. In 1987, Lawrence (pers. comm.), using mid-water and bottom trawls, found two species of shrimp in 27-36 m of water off the Tuktoyaktuk Peninsula. These shrimp are presently being identified.

MARINE FINFISH

Information about the fish resources of the southern Beaufort Sea has accumulated since the voyages of the early explorers and whalers. It is only within the recent years that these fish have received considerable attention, due mostly to petroleum exploration and development activities.

The distribution and biology of marine fish in Arctic waters is not well known. Distribution of marine species in the Beaufort Sea are discussed in a general way by McAllister (1962) and Hunter et al (1984). Most of the literature regarding the distribution of marine fish in the southeastern Beaufort Sea is restricted to coastal region of the Mackenzie River estuary during the open water season (see Percy 1975 for a review). Hunter (1981), Fraker et al (1979) and LGL (1982) provide summaries of information available regarding marine fish in the outer southeastern Beaufort Sea, Amundsen Gulf and adjacent coastal areas. Most sampling of marine species has been conducted in waters shallower than 30 m and abundance estimates are available only for those species which have been sampled for larvae or young fish (Hunter, 1981). The deeper waters (below 30 m) have been sampled so lightly that more species than presently known are likely to be found (Hunter, 1981).

The most prominent marine fish that have been identified in the study area include the following species:

Arctic flounder	<u>Liopsetta glacialis</u>
Starry flounder	<u>Platichthys stellatus</u>
Fourhorn sculpin	<u>Myoxocephalus quadricornis</u>
Pacific herring	<u>Clupea harengus pallasi</u>
Saffron cod	<u>Eleginus navaga</u>
Arctic cod	<u>Boreogadus saida</u>

Greenland cod
Capelin

Gadus ogac
Mallotus villosus

Marine species form an integral part of Arctic marine food webs. A number of studies have demonstrated that marine species are important food for Arctic marine mammals, birds and other fish (Anadriyashev 1964; Griffiths et al. 1975; Bradstreet 1977; Fraker et al. 1978; Bain and Sekerak 1978).

It appears that marine fish are more abundant in nearshore areas than previous studies have indicated (Fraker et al. 1979). In most studies of nearshore coastal waters, anadromous fish have represented 70-90 percent (numerically) of the catch while the remainder was composed of marine species (Kendel et al. 1975; Griffiths et al. 1975, 1977; Jones and DenBeste 1977). This larger proportion of anadromous species is most likely an artifact of sampling methodology, as gillnets tend to selectively trap large fish. Craig and Griffiths (1970) and Craig and Haldorson (1979) have shown that when a variety of sampling techniques are used (ie. gillnets, fyke nets, and seines), the percentage of marine fish increased dramatically (ie. from 10-30 percent to 75-80 percent of the catch). However, in terms of biomass the amount of marine and anadromous fish collected are about equal (Craig and Haldorson 1979).

Several species of marine fish have been reported in the Parry Peninsula - Amundsen Gulf area (see list above). Hunter (in RRCS 1972) reported that Greenland cod has been observed to be numerous approximately one year in seven along the west coast of Parry Peninsula in Franklin Bay. Hunter (1979) states that the most abundant marine fish collected in Franklin and Darnley

Bays were Arctic cod and herring. Hunter also commented that the large volume of deep Atlantic water that occurs in the Amundsen Gulf has not been adequately examined for fish resources. Tom Cod Bay on the west side of Parry Peninsula has been noted for the large numbers of saffron cod, jigged from under the ice (Abrahamson 1963). Heavy runs of herring have been reported at the head of Darnley Bay from early September until freeze-up (Abrahamson 1963). Large numbers of herring have been reported north of Tuktoyaktuk Peninsula by Gilbraith and Fraser (1974). Gillman and Kristofferson (1984) speculate that they move inshore to spawn in areas within Liverpool Bay and the Eskimo Lakes.

In the Amundsen Gulf region, large but unpredictable numbers of capelin have been reported (RRCS 1972). Usher (1965) reported that large concentrations of capelin spawned in Sachs Harbour on Banks Island for two or three consecutive years.

Movement and distributions of marine fish can vary dramatically from year to year. Maturation of some pelagic marine species suggests that some species do not spawn annually (Hunter 1981). This may partially explain the yearly variations in movements of marine fish (ie. capelin and herring). Similar variations in marine fish movement patterns have been documented in other areas of the western Arctic. Craig and Griffiths (1978) and Craig and Haldorson (1979) collected 767 Arctic cod in 1977 and 139,792 in 1977 using Fyke nets during a two year study of a lagoon-barrier island system in Alaska.

Cod (Gadidae), snailfish (Liparidae) and sculpin (cottidae) have been the most abundant groups of marine fish collected in studies in the western Beaufort Sea and the Canadian High Arctic

(Griffiths et al 1975, 1977; Kendel et al. 1975; Sekerak and Graves 1975; Sekerak et al. 1976; Buchanan et al. 1977; Jones and DenBeste 1977; Thomson et al. 1978; Bain and Sekerak 1978; Craig and Griffiths 1978; Craig and Haldorson 1979). In terms of trophic pathways the Arctic cod, the key forage fish in the Arctic Ocean, is the most important species studied to date (Quast 1974). In the Parry Peninsula - Amundsen Gulf region, Greenland cod and capelin appear to be more abundant, although Arctic cod are present (Fraker et al. 1979).

Marine fish tend to utilize shallow nearshore waters in summer to feed mainly on epibenthic and pelagic invertebrates (Griffiths et al. 1975, 1977; Kendel et al. 1975; Craig and McCant 1976; Jones and Denbeste 1977; Craig and Griffiths 1978; Craig and Haldorson 1979).

Given the current state of knowledge of marine fish resources in the southeast Beaufort Sea and Amundsen Gulf, a meaningful assessment of the potential of a commercial fishery is difficult to make from the literature. A brief description of what is known about specific marine species found in the area is presented in the following pages.

Arctic cod

Arctic cod frequently occur where water temperatures are relatively low and where salinities are over 25‰ (Hunter, 1981). Trawl catches indicate that Arctic cod are migratory (Hunter, 1981). Based on the size distribution of catches from different trawls made in 1977 Hunter (1981) suggests that Arctic cod tend to occur in small schools. Arctic cod reach 140 mm in

length, while the average size is 120-130 mm (Griffiths, pers. comm.).

Arctic cod are numerically an important marine fish species found throughout much of the Arctic. They have been captured with mid-water trawls in the southern Beaufort Sea beyond the major influence of the Mackenzie discharge (Galbraith and Hunter, 1976).

Midwater trawling studies were carried out in the Amundsen Gulf at depths greater than 40 m in 1973 and 1977 (Hunter, 1979) in order to obtain density distribution estimates of pelagic larval fish. Estimates of the mean density of Arctic cod in each 20 m depth zone, based on the combined 1973 Amundsen Gulf and 1975 Mackenzie Bay trawl catches, indicate a total mean density of 18.1 young of the year Arctic cod per $\text{m}^3 \times 10^{-4}$. Quast (1974) indicates a depth weighted average of 280 per $\text{m}^3 \times 10^{-4}$ for the eastern Chukchi Sea and Sekerak et al. (1972) estimated 677 and 376 per $\text{m}^3 \times 10^{-4}$ for Lancaster Sound. Therefore estimates for the southeastern Beaufort Sea and Amundsen Gulf region are 15 to 25 times lower than most of the other Arctic areas studied.

It appears that young of the year Arctic cod generally prefer shallower depths (ie. less than 50 m), but occupy a wider depth range (Hunter, 1979). The depth density distribution of Arctic cod in Amundsen Gulf in 1973 suggests a greater abundance in the southern sector (Hunter 1979). Only sub-adult Arctic cod were caught in numerous trawls taken in Cape Parry, Cape Bathurst and inshore Mackenzie Bay waters.

Fourhorn Sculpin, Arctic Sole and Starry Flounder

These three marine species occur in similar areas and under similar conditions (Hunter, 1979). Along the southeastern Beaufort coast, these three species constitute the principal benthic fish (Hunter, 1979). Erratic catches of Arctic sole suggests that it forages or migrates in itinerant schools (Hunter, 1979).

The starry flounder is one of the most widely distributed flounder in coastal waters of the Pacific and Arctic Oceans. This euryhalic species prefer a soft sand or mud substrate and has a wide depth tolerance, from the shallower inshore zone to 150 fathoms or more (Percy, 1975).

Miller (1962) suggests a seasonal trend in the feeding intensity of the starry flounder. Percy (1975) suggests that observed cessation of feeding by this species during the months of low water temperature may also be related to pre-spawning behaviour. Within the Mackenzie Delta, spawning takes place once a year between November and February, in shallows at river mouths (Percy 1975).

Greenland Cod

Greenland (Ogac) cod seldom occurs west of Cape Bathurst and no specimens have been recorded in the southeastern Beaufort Sea west of Cape Dalhousie, yet this species is common and abundant around Cape Parry and the adjacent islands (Hunter 1981). Hunter (1981) suggests that based on the age compositions of collected Greenland cod most of the stock is dependent upon one or two year classes.

Saffron Cod

Tom Cod Bay on the west side of Parry Peninsula has been noted for the large numbers of saffron cod that have been traditionally jigged from under the ice (Abrahamson 1963; Usher 1965). Saffron cod are often found in beluga whale stomachs and therefore may indicate a substantial offshore population of the species (Percy, 1975).

Saffron cod breed at sea (McPhail and Lindsey, 1970) thus explaining why fry are seldom seen in coastal areas. Saffron cod were sampled in the outer Mackenzie delta region in 1974 and 1975 by Percy (1975). Lengths ranged from 310 mm to 450 mm and two distinct age groups were apparent. Fish were either 5 to 6 or 15 to 16 years old.

Pacific Herring

Pacific herring have been reported in the nearshore waters of the Beaufort Sea (Riske 1960; Gilbraith and Hunter 1975; Hunter 1981) and in numerous large inlets and bays of Tuktoyaktuk Peninsula (Lawrence et al 1984) and Liverpool Bay (Riske 1960; Hunter and Leach 1981). Herring have been captured as far east as the Coppermine River (Gillman and Kristofferson 1984). The Department of Fisheries and Oceans undertook to determine the feasibility of developing a herring roe fishery in the Liverpool Bay/Eskimo Lakes region during May and June of 1982 and 1983. A total of 2466 herring were gillnetted through the ice in 1982 and 37,000 herring were collected in 1983 (Gillman and Kristofferson, 1983). A diver survey of herring spawns in the Fingers area of Liverpool Bay (where the herring were caught in 1983) during the

summer of 1985 estimated that only 8.2 tonnes of herring had spawned (Shields, 1985). Pacific herring have been domestically fished in the past in the Cape Bathurst area (Hunter, 1975).

In the southeastern Beaufort Sea herring congregate nearshore during winter and spawn in shallow brackish water of coastal bays and river mouths (Riske, 1960). Herring in the North Pacific mature at age 3 and spawn annually while herring from the Tuktoyaktuk and Eskimo Lakes area do not mature until their sixth year (Riske, 1960). Shields (1985) suggests that herring in the region may be alternate year spawners, thus partially explaining the erratic nature of their observed distribution.

Capelin

Capelin is another species for which records of abundance vary dramatically from year to year. Reports of large numbers of capelin at Sachs Harbour and along the mainland shore during the open water season of 1960 are reported by Hunter (1981). Small numbers of capelin were also observed at Shingle Point (July 1961), Baillie Island (1962) and Liverpool Bay (1972 and 1977).

Fishery Potential - Marine Fish

There are few estimates of the standing stocks of marine pelagic fish in Amundsen Gulf and southeastern Beaufort Sea. Arctic cod is the most abundant species due to the size of its habitat, yet densities are generally low throughout the water column (Hunter, 1981). Russian trawlers have fished Arctic cod in the Chukchi Sea and it was determined that the fish were too

small in size to warrant a larger scale fishery (Griffiths, pers. comm.). It is therefore unlikely that a commercial fishery for Arctic cod in the southeastern Beaufort Sea and Amundsen Gulf would be economically viable.

Capelin have been observed in massive numbers at various locations throughout the study area. Yet these sightings have been so sporadic and rare that a commercial fishery seems unwarranted.

Pacific herring appear in itinerant schools and are occasionally plentiful (Hunter 1981). Due to insufficient sampling in the wide area of their summer habitat the abundance of herring is unknown. Although a lucrative fishery for female herring roe exists in California, British Columbia and Alaska, more information about biomass, migration patterns and reproductive biology of herring stocks in the southeastern Beaufort Sea and Amundsen Gulf is required before a commercial sac-roe fishery can be considered in the region.

In his analysis of subsistence fisheries in the Alaskan Arctic, Craig (1987) states that relatively few marine fishes are harvested for several reasons: (1) marine species are generally small, yielding relatively little meat for the effort expended, (2) some of the common marine species (Fourhorn sculpin, Arctic flounder) are not desired table fare and (3) the marine species that are eaten (Arctic cod, saffron cod) are too small to be caught by the principal fishing gear uses (gillnets).

Costs of transportation, equipment and labour, combined with overhead costs associated with processing, cold storage and market development will put major constraints on the development

of any marine fishing in the Sachs Harbour. There must be an abundant stock of marketable fish available during the open water season for any commercial value to succeed. Additional information regarding seasonal distribution about the abundance of such species as Greenland cod, saffron cod, starry flounder, and Pacific herring is required before a commercial fishery can be considered.

COMMERCIAL MARINE FISHERIES IN THE EASTERN ARCTIC

In the eastern Arctic there are fisheries for northern shrimp and Icelandic scallops. There also has been interest in developing fisheries for Greenland halibut (turbot). Sea urchins, sea cucumbers and mussels have also been explored as potential commercial species. In terms of landed tonnage, dollar value and labour requirements, the northern shrimp fishery is by far the main fishery.

Northern Shrimp

Prior to the mid 1970's there was virtually no offshore shrimp fishery in the Canadian Arctic. There was a shrimp trawl fishery in Davis Strait along the Greenland coast, but no Canadians were involved that far north. During the later 1970's, concentrations of shrimp were located off the Labrador shelf as a result of an exploratory fishing program. A shrimp fishery developed and expanded through the late 1970's. During this period DFO issued licences and the industry built a number of large trawlers capable of working in northern waters. In the early 1980's the economic recession caused difficult times for the industry. For a time the costs associated with fishing shrimp exceeded the landed value of the shrimp. At present the industry is doing well. There is a strong demand for northern shrimp, catch rates are good and prices are excellent (Parsons, pers. comm.).

Since the late 1970's, northern shrimp have been fished in Davis Strait and off the Labrador shelf (termed the Davis Strait fishery). The pink shrimp (Pandalus borealis) is the target

species for this off-shore fishery. In 1982 a survey of shrimp stocks was conducted by DFO in Hudson Strait and Ungava Bay (Parsons, pers. comm.). Large stocks of striped shrimp (Pandalus montagui) were located in Hudson Strait, east of Resolution Island, and into Ungava Bay.

P. borealis can be found in water temperatures that range from 0°C to 10°C (or even warmer in northern Norway) (Parsons pers. comm.). In Hudson Bay and Ungava Bay, where temperatures are generally colder (ie. 0-4°C) only P. montagui are found.

Most of the shrimp fishery is conducted in daylight hours due to the diurnal migration behaviour of northern shrimp. Parsons (pers. comm.) has observed northern shrimp go through extensive diurnal vertical migration (at least 200 m). The vertical migration of P. borealis seems to be restricted only by colder waters, whereas P. montagui exhibits no such reaction to temperature gradients (Parsons, pers. comm.). Salinities of the ocean water at the depths where northern shrimp are found (200 to 400 m) is in the range of 35 ‰. At these depths salinity is fairly stable and constant.

Concentrations of both northern shrimp species are variable from year to year. Locations which produce higher yields (ie. 30-40 tons/day) one year may produce nothing the following year. Parsons (pers. comm.) attributes this to movement by the shrimp rather than to overfishing.

Both P. borealis and P. montagui are fished in waters greater than 250 m in depth. P. borealis tends to inhabit deeper water; the best catches at depths exceeding 350 m (Parsons, pers.

comm.) In Ungava Bay P. montagui are fished at depths between 200 m and 400 m (Parsons, pers. comm.).

Commercial densities of both species are located mostly on firm mud substrates. One of the fishermen's main concerns is to prevent the trawl doors from digging into the mud.

The northern shrimp fishing season is restricted by ice. Although no literature regarding the open water season in the eastern Arctic was examined, it can be generally stated that the Baffin Island side of Davis Strait is ice covered from late November/early December until May/early June (Parsons, pers. comm.). Because northern shrimp fishing is for the most part an offshore fishery, the fishing vessels are 150 ft. (45.5 m) in length or longer. All vessels are rigged with standard bottom trawl gear, and most vessels are stern trawlers (Parsons, pers. comm.). The fishery is usually conducted in daylight hours as the shrimp migrate toward the surface at night. Some vessels are experimenting with larger nets (ie. 30 m vertical lift) in order to fish at night (Parsons, pers. comm.).

At the present time 16 vessels are licenced to fish northern shrimp, and can fish anywhere in the Canadian waters of Davis Strait, Hudson Strait, Ungava Bay or off the Labrador coast.

In 1987 an estimated 11,000 tonnes of P. montagui had been fished in the relatively small area of Hudson Strait and Ungava Bay (Parsons, pers. comm.). This is the greatest yield from this region since the fishery began three years ago. Although distribution of the shrimp can be patchy, concentrations are dense when they are found. Daily landings per vessel were up to

50 tonnes per day. The quota for northern shrimp in the Davis Strait fishery was 14,000 tonnes in 1987 (Parsons, pers. comm.).

Most vessels have onboard processing facilities. Most of the product is cooked in the shell and frozen in 5 kg blocks or frozen raw, also in 5 kg blocks. Some processing includes glazing of the product prior to freezing. Shrimp can be stored in this form for six months or more.

During the past two years the market for small shrimps has improved. As a result there has been some secondary processing of small shrimp on shore. The main market for northern shrimp is in Europe (Denmark), Japan and the United States.

Shrimp are delivered to various ports in Atlantic Canada. There is some transshipment of the product on the fishing grounds. Some of the product is delivered directly to Danish and Norwegian ports. These deliveries are associated with "Royalty Charters". Some of the licenses are leased fully or in part to foreign fishing companies.

A number of different Inuit regional groups (corporations) have formed a variety of affiliations (ie. joint ventures) with Canadian and foreign interest in order to partake in this capital intensive fishery.

Because the northern shrimp fishing season is only five or six months long, the Canadian-owned stern trawlers have to fish other species in other Canadian waters during the winter months. Other groups option to enter into "Royalty Charter" agreements with foreign fishing companies (ie. Norwegian), thereby leasing a fishing vessel only for the duration of the shrimp season. Some

of the vessels that are partially owned by fishing companies in the Maritimes fish off eastern Canada during the off-season. Some trawlers fish for haddock off Nova Scotia, and others fish for cod and ocean perch off Newfoundland's north coast and south coast (respectively).

Icelandic Scallop

During the 1986 season a group from Pangnirtung started looking for exploitable beds of scallops (Chlamys islandica) in Cumberland Sound using the local Hunter and Trapper's Association's boat. Approximately 135 kg of Icelandic scallops meat was caught and processed (Allen, pers. comm.). This effort was repeated in 1987. Although the boat was not properly rigged for scallop dragging, some dense beds of scallops were located "within site of Pangnirtung in 100 to 200 feet of water (Simpson, pers. comm.). The sizes of the scallop beds and density of scallops were not determined. This year a private group plans on building a boat capable of working proper scallop dragging gear (Simpson, pers. comm.).

In 1987, the Baffin Island Inuit Association and Faro-Can cooperatively explored the off-shore and near-shore waters of southern Baffin Island in search of Icelandic scallop beds. A 125 ft. Nova Scotian scallop dragger was used to conduct the exploratory fishery. Dense beds of Icelandic scallops were located in the nearshore waters in Hudson Strait and Ungava Bay. No offshore stocks were located. Approximately 1,000 kg. of shucked scallops meat was processed in 1987 (Allen, pers. comm.).

Based on this preliminary information, it is likely that the scallop fishery in this area will continue to expand slowly.

Other Marine Fisheries

A variety of other marine species are presently being examined as possible commercial fisheries.

Greenland halibut (Reinhardtius hippoglossoides) are being fished through the ice and along the ice floes up to 50 miles offshore from Pangnirtung (Simpson, pers. comm.). The experimental fishery is being conducted by the local Hunters and Trappers Association with financial assistance provided by the Northwest Territories government. A fisherman was brought from Greenland to help with the development of a winter Greenland halibut fishery. Skidoos and sleds are used to get out to the fishing grounds. Presently efforts are directed towards using hydraulic automatic longline haulers which are powered by a gas engine. In 1987, 10,000 to 12,000 pounds of Greenland halibut were caught (Simpson, pers. comm.). The fish, ranging in size from 8-12 lbs. were caught in up to 450 m of water (Simpson, pers. comm.). The economic viability of such a fishery has not yet been determined. Based on the results of the experimental fishery, a 100 ton commercial Greenland halibut quota was established for 1988 by DFO.

Some small scale exploratory work was conducted in the Belcher Island in Hudson Bay to determine the abundance of sea urchins, mussels and sea cucumbers in 1985. Animals were collected by SCUBA divers working in shallow water during the fall. The NWT Department of Economic Development and Tourism

plans on test marketing these species in the Northwest Territories and northern Quebec sometime in the near future.

RECOMMENDATIONS

Based on available literature it is impossible to accurately assess the commercial potential of a marine fishery in the southeastern Beaufort Sea/Amundsen Gulf region. Lack of information however does not preclude the potential for a fishery.

Given the high market value per/unit weight, and circumstantial evidence regarding possible stocks in the region, a small scale exploratory fishery for northern shrimps and scallops is warranted. P. montagui is reported from both the Bering Sea and North Atlantic and this species is commercially fished by trawling and trapping gear in the Bering Sea. P. borealis has been reported in the Bering Sea, Chukchi Sea and Point Barrow. A commercial fishery exists in eastern Arctic waters. There is a good chance that commercial densities of these northern shrimp species are present in the western Arctic.

Commercial potential also exists for the scallop Delectopecten greenlandicus. Lubinsky (1980) reports that the species is widely distributed and abundant in the Canadian Arctic and that it is found at depths of 5-30 m but usually below 50 m. Dense beds of scallops similar in size to the Iceland scallops (80-90 mm) that are being fished off Baffin Island would have to be located in order to warrant a commercial fishery. Due to the paucity of information regarding the distribution of molluscs in the Arctic, it is likely that specimens larger than those reported in the literature (30 mm; Lubinsky 1980) are present.

Due to lower market values, secondary emphasis should be placed on other marine species that may be present in local waters. If local markets in the NWT can be developed for less valued seafood times, then they too may warrant the development of commercial fishery. Included in this group are clams, starry flounder, saffron cod and Greenland cod.

An exploratory fishery operating from Sachs Harbour is recommended with primary emphasis placed on northern shrimp and scallops. Secondary efforts should be placed on locating commercial densities of clams, starry flounder, saffron cod and Greenland cod.

Commercial viability is based on much more than the value and availability of fish or shellfish stocks. Other factors which must be developed and maintained along with harvesting operations include:

- community interest in development of the fishery
- trained labour force
- use of proper technology
- adequate processing and storage facilities
- familiarity and development of markets

The recent development of marine fisheries in the eastern Arctic should be used as a model from which to base the development of a commercial fishery in Sachs Harbour.

Initial efforts should be kept at the community level, an exploratory fishery should be done slowly and methodically. Skills within the community should be used wherever possible. If these skills do not exist, training programmes should be initiated. There most likely are a number of Sachs Harbour residents who have experience in operating and maintaining boats. If a commercial fishery seems feasible, use of the proper

technology (ie. fishing gear) will be a critical factor in order to efficiently operate the fishery.

Proper processing and storage facilities are an important element to a successful fishing venture. The facilities should be designed to accommodate the efficient handling of the product and they must also meet territorial and federal health requirements. Cold or freezer storage facilities must be capable of holding the seafood between shipments to market. Familiarity with the species to be processed is critical to effective processing. In the eastern Arctic it was determined that the shell characteristics of C. islandica made this species more difficult to shuck than other commercial species (Allen, pers. comm.). It was more labour intensive and therefore more costly to process than originally anticipated. It was found that shucking can be a bottleneck in such a commercial venture.

An understanding of the marketing (ie. sales and distribution) of the species to be fished is essential to a commercially viable fishery. Prior to capitalization a thorough study of the marketability of the species of interest should be undertaken. An understanding of the anticipated destinations, volume and frequency of shipments of the product should be understood prior to going ahead with a full scale fishery.

In summary, based on developments in the eastern Arctic, a small scale exploratory fishery in the Sachs Harbour area is recommended. Emphasis should be placed on northern shrimp and scallops. A seaworthy vessel, capable of working during open water season from late June to early October should be used.

Initially, standard bottom trawl gear should be used to explore the waters of Amundsen Gulf and southwestern Beaufort Sea for shrimp and scallops within a 50-70 mile radius of Sachs Harbour. The trawl gear should be capable of fishing between 200 m and 500 m depths. Longline gear can also be set with hooks (both to locate fish species) and traps (to test a secondary method of catching shrimp).

The exploration program should be conducted in a methodical manner, perhaps using a grid system and initially working close to Sachs Harbour.

Depending on the outcome of an exploratory shrimp and scallop fishery, additional efforts toward locating other marine species may be warranted.

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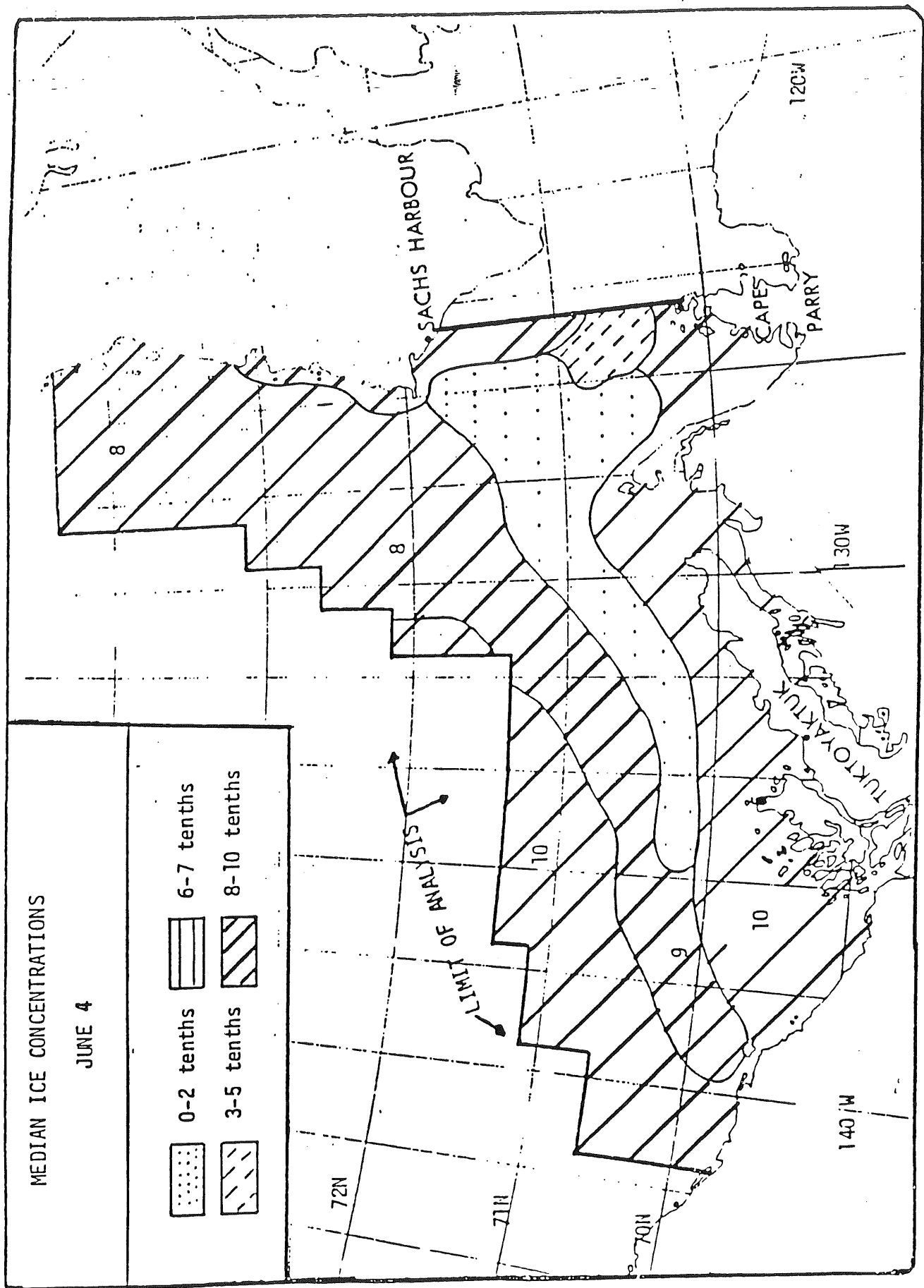
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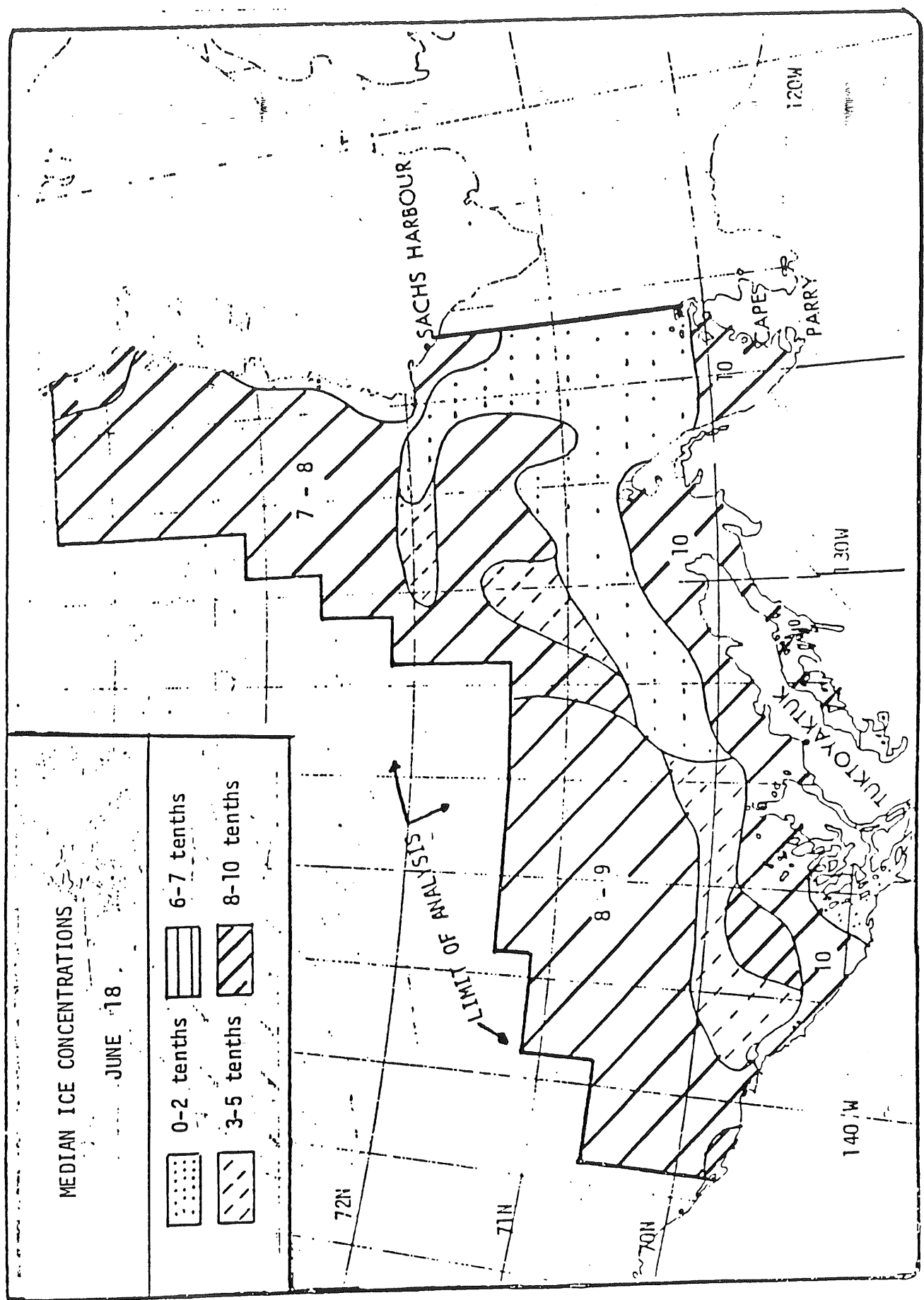
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Appendix I

Bi-weekly charts of median ice conditions
in the southeastern Beaufort Sea and Amundsen Gulf Region
(from Markham, 1975)





MEDIAN ICE CONCENTRATIONS

JULY 2

