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Decapod Crustaceans of Newfoundland, Labrador and the Canadian Eastern Arctic

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H. J. SQUIRES

Establishment

Biological Station
St. John's, Newfoundland

Dated July, 1965

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N O T E

This is the reproduction of a thesis submitted in June, 1963, in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Pure Science at the University of Durham (King's College, Newcastle upon Tyne).

Decapod crustaceans of Newfoundland, Labrador
and the Canadian eastern Arctic

Abstract

About 24,000 specimens of decapod Crustacea comprising 50 species were examined from collections made by vessels of the Fisheries Research Board of Canada during 1946 to 1960. Most specimens of these decapods were taken incidentally in otter trawl surveys for groundfish chiefly of Newfoundland and Labrador. The remainder were taken in a shrimp trawl survey of the *Pandalus borealis* populations off Newfoundland, and during a survey of the benthos and plankton of Foxe Basin and Hudson Strait.

The distribution of these decapods is discussed with reference to (a) their occurrence in species complexes under prevailing physical conditions and (b) the biology of individual species. The latter includes details of their food, mandible structure, size, and breeding relationships.

For each species a field identification is given and a brief account of its taxonomy.

The principle of competitive exclusion is discussed for the *Pandalus borealis* and *P. montagui* communities in particular. The reproductive potential of these populations is thought to be a critical factor in deciding the dominance of a species or in maintaining its high numbers. The possibility of depletion of some of the *P. borealis* populations under future exploitation is suggested because of low breeding rates under the influence of low temperatures. Reproductive potential of other species is discussed in relation to their adaptation to temperature.

The section on *Homarus americanus* introduces a method for estimating the exploitation of its fished populations by noting the proportion of first year recruits in measurements of the commercial catch when the approximate growth per annual moult is known.

An attempt to analyze the decapod communities in this area reduces them to five major types.

CONTENTS

INTRODUCTION

The decapod Crustacea of the northwest Atlantic, seven species of which reach their most northern limit in the Newfoundland-Labrador area, comprise a few species only of the Reptantia (brachyuran and anomuran crabs and the American lobster and two deep-sea palinurans) but a considerable number of the Natantia (shrimps and prawns). These decapods are quite varied in form and they occupy various habitats from the shallow sublittoral to the deep continental slopes. Only the lobster, Homarus americanus, is exploited commercially to any extent, although the pink shrimp (sometimes called the northern prawn), Pandalus borealis, is found in considerable abundance over a large part of the area, has been fished in the Gulf of Maine (Wigley, 1960), and is a good prospect for a commercial fishery near Newfoundland (Squires, 1961). Many of the shrimps and spider crabs form a significant part of the food of commercial fishes in the area.

The purpose of this study is: (a) to give a brief note on taxonomy for field identification of each species; (b) to show the distribution of each species of decapod crustacean in the northwest Atlantic (but chiefly in the area of investigation); (c) to show that decapod species complexes occur regularly in this area according to temperature, depth, and submarine topography; (d) where numbers of specimens collected are adequate, to show the adaptation of each species to the prevailing conditions, particularly with respect to reproductive potential, and (e) to show type of feeding and its relation to mandible structure in each species.

AREA OF INVESTIGATION. The area investigated and to be reported on in this account extends from Fury and Hecla Strait (Foxe Basin) and Cape Dyer (just north of the Arctic Circle on the Baffin Island east coast) in the north, to the Grand Banks and the Gulf of St. Lawrence in the south (Fig. 1). The Nova Scotian Banks have been fished only occasionally by our research vessels and are not treated in detail. The deep water areas of the Gulf of St. Lawrence, the Southwest Newfoundland Channel and Newfoundland bays have been surveyed in detail for shrimps. During groundfish surveys the vessels have fished to depths of 800 m on the continental slopes off Newfoundland and Labrador but in Foxe Basin, Ungava Bay and Frobisher Bay, explorations were made usually near the shore and in comparatively shallow situations by the small research vessel "Calanus".

Since the decapod crustacean fauna of West Greenland is similar to that of the northern part of the area (Squires, 1957), records of distribution of each species as shown and reviewed by Hansen (1908) and Stephensen (1935) are included on the distribution maps. Also records within the area from various authors, chiefly Rathbun (1913 and 1919), Leim (1921), Frost and Thompson (1932), Van Winkle and Schmitt (1936), Squires (1957, 1961 and 1962) and Prefontaine and Brunel (1962) are included. Distribution south of the area is shown in a general way from Smith (1879) and Rathbun (1929). Distribution maps are made chiefly for those species which occur in relative abundance in the area of investigation.

NOTES ON LITERATURE. Sabine (1824) was the first to record species of decapod Crustacea from Davis Strait. These were from the collections of the 1st Parry Expedition in search of a northwest passage to the Pacific during 1819-20. Only 5 species were recorded and two of these, new to science, were named Crangon septemcarinatus (= Sabinea septemcarinata) and Alpheus polaris (= Lebbeus polaris). The 2nd and 3rd Parry Expeditions in 1822-24 collected 5 species near Igloolik in Foxe Basin (Ross, 1826 and 1835). Pfeffer (1886) identified 2 species collected by the German Arctic Expedition of 1882-83 from Cumberland Sound. These were Hippolyte groenlandicus (= Lebbeus groenlandicus and H. amazo (= L. polaris). Ohlin (1895) recorded Eualus fabricii from Cumberland Sound also. These and other collections of decapod crustaceans from Davis Strait and West Greenland were reviewed by Hansen (1908), Hofsten (1916) and Stephensen (1935). Hansen also recorded the decapods collected at stations of the "Ingolf" in 1900 and Stephensen those of the "Godthaab" Expedition in 1910[a].

Following Ross's collections of 1822-24, no decapod crustaceans were recorded from Foxe Basin until Captain Robert A. Bartlett's voyages of 1927 and 1933 when 12 species were collected (Van Winkle and Schmitt, 1936). The Canadian Arctic Expedition of 1910, however, had collected decapods near the mouth of Hudson Bay and at Port Burwell, Ungava Bay (Rathbun, 1919). Rathbun (1913 and 1919) also identified specimens from other collections from Hudson Strait and the coast of Labrador. Squires (1957) on the Calanus Expeditions of 1947-50 in Ungava Bay reviewed the collections previously made in Ungava Bay, Hudson Strait and the coast of Labrador. Also Squires (1962) recorded the species of decapods collected by the Calanus Expeditions in Frobisher Bay.

Among the various collections of invertebrates made in the Gulf of St. Lawrence, Newfoundland and Labrador, Whiteaves (1901) listed those which also had taken decapod Crustacea in the years 1882-85. Smith (1879) had previously drawn on the results of these collections and on others from the New England coast to discuss the relationships between the North American and north European decapod faunas. Rathbun (1929) on re-examining these collections, revised the taxonomy and gave the range in distribution of 34 species of decapod crustaceans found in the Canadian maritimes.

The deep-sea expeditions worked only a few stations at depths less than 1,000 m on the continental slopes. The "Challenger" dredged off the coast of Nova Scotia in 1873 and the "Hirondelle" and "Michael Sars" on the Grand Banks in 1877 and 1910, respectively. Bate (1888) listed 4 species, Milne-Edwards and Bouvier (1894) 4 species and Sivertsen and Holthuis (1956) 9 species, respectively, taken in these hauls.

Other collections include 7 species of hippolytids, some of which were taken in the Gulf of St. Lawrence (Leim, 1921), six species of decapods from the Gulf of St. Lawrence between Cabot Strait and Bay of Islands (Boone, 1930), twenty-one species collected in groundfish and plankton surveys off the Newfoundland coast including the Grand Banks (Frost and Thompson, 1932, and Frost, 1936) and 24 species taken in the St. Lawrence estuary (Prefontaine and Brunel, 1962).

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[a]These stations are recorded on maps of species distribution in the present paper

METHODS

EXPLORATORY FISHING GEAR. Standard otter trawls were used in exploratory fishing for groundfish by Canadian Government Ships "Investigator II" (1946-60), "Marinus" (1953-60) and "A.T. Cameron" (1958-60). The "Calanus" (1946-58) used different types of dredges, beam trawls, plankton nets, etc., and a chartered vessel the "Fortune Breeze" (1957 and 1958) used a shrimp net only. Collections of decapod crustaceans made by these vessels were used in the present study.

The "Investigator II" generally used a #36[b] otter trawl with a head-rope of 60 feet (18.5 m) and a foot-rope of 80 feet (24.5 m). The rubber rollers on the foot-rope were 6 inches (15 cm) in diameter on 40 feet (13.1 m) of the bosom and 4 inches (10 cm) in diameter on each of 20 feet (6.6 m) of the wings. The cod end was lined with nylon netting of 3/4 inch (19 mm) mesh or covered with shrimp netting of 1 3/4 inch (45 mm) mesh during exploratory fishing. Decapods were also obtained in ordinary fishing trials when a liner or cover was not used (Table L). Usually the area was completely surveyed with a lined or covered net at first, and later trials were made for quantities of groundfish at different seasons.

The "Calanus" used a variety of gear including (a) a bream trawl 10 feet (about 3 m) wide, 20 feet (5.6 m) long and about 2 feet (0.6 m) high at the mouth, with a cod end of about 1/2 inch (13 mm) mesh; (b) a dredge with a frame 3 feet (0.9 m) wide, 9 inches (23 cm) high and with a bag 3 feet long with 1/2 inch mesh but often a finer mesh cover of jute or #0 and #6 plankton netting; (c) Petersen and Ekman grabs, etc., and (d) plankton nets of stramin (1 mm mesh) with 1 and 2 m diameter openings.

The "Marinus" used a #35A otter trawl with a 50 feet (14.5 m) head-rope and a 70 feet (23.5 m) foot-rope. The rubber rollers on 18 feet (5.9 m) of the bosom were 6 inches (15 cm) in diameter and the same size on 9 feet (3 m) of each of the wings. In exploratory fishing this net had the cod end covered with 1/2 inch mesh nylon netting or was lined with 1¼ inch (32 mm) mesh shrimp netting.

The "A.T. Cameron" used a #41-5 otter trawl with a 70 feet (24 m) head-rope and 100 feet (30 m) foot-rope. The rollers on the foot-rope were six 21 inch (53 cm) steel bobbins on the bosom and five 14 inch (36 cm) steel bobbins on each wing. A lining of 1½ inch mesh nylon netting was used in the cod end.

The trawl doors in use on the "Investigator II", "Marinus" and "A.T. Cameron" were respectively about 800, 500 and 1600 pounds (350, 220 and 700 kilo) each.

The "Fortune Breeze" used a Kristiansands (Norway) deep-sea shrimp net in exploratory fishing for shrimp. This net had a foot-rope

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[b]Code number for fishing nets used at the Biological Station, St. John's.

of 33 m, a cod end with 38 mm mesh and small doors weighing about 40 kilos each. This net and its use are described by Squires (1961). Any discussion of relative abundance in the present paper refers to quantities from catches made with the shrimp net.

The sand shrimp, Crangon septemspinosus, was taken by hand-net, Homarus americanus and Cancer irroratus by lobster traps and by hand and Hyas araneus from cod-traps inshore in Labrador but from groundfish trawls elsewhere.

HYDROGRAPHY. Temperature and salinity were recorded for most trawling stations, including many of those made by the "Calanus". In addition, bathythermograph casts were made at each exploratory trawling station of the "Fortune Breeze", "A.T. Cameron", "Marinus" and "Investigator II" following 1957. Salinities and bathythermograms were processed by the Fisheries Research Board of Canada Biological Station at St. Andrews, New Brunswick, Canada.

METHODS USED IN THE STUDY OF THE BIOLOGY OF SPECIES

SAMPLING. Random sub-samples were taken when the catch comprised a large quantity of a single species; otherwise all specimens were preserved. They were preserved in about 7% formalin in sea water and examined later at the laboratory. Lobsters (Homarus americanus) and shore-crabs (Cancer irroratus) were examined fresh although some were preserved for further examination. About 20% of the lobsters examined in 1961 and 1962 were tested for Gaffkaemia.

MEASUREMENTS. Measurements were made with 12 cm and 25 cm vernier calipers, estimating to the nearest mm the carapace length (cl) from the posterior edge of the eye socket to the posterior mid-dorsal edge (between parallels). The total length when measured was taken from the tip of the rostrum to the end of the telson less hair fringe.

SEXING. In each specimen the carapace was cut away from its junction with the thorax and lifted for examination of the gonads. In addition, an external examination was made for the presence of a petasma on the 1st pleopod in penaeid shrimps and for an appendix masculina on the 2nd pleopod in caridean shrimps. Males were also distinguished in other species by examination for the modification of the 1st pleopod as a penial structure in lobsters, crabs and palinurans, and for the presence of the male openings on the 5th pereiopodal bases in anomurans.

MATURITY. Approximations of maturity was made by measuring the diameters of ova in the ovaries and of the vasa deferentia and classifying whether large or small. The presence of sperm was noted in shrimps and the presence of spermatophores in galatheids, palinurans, brachyurans, anomurans and lobsters. The greatest diameter of oval-shaped eggs was measured.

FOOD. Specimens were subsampled for examination of stomach contents. The stomachs were dissected out and food fragments scraped into a small amount of water in a dish. The stomach walls were also examined in stomachs found to be empty in the subsample. Examination was made by binocular microscope. Greenish material with some diatoms, filamentous algae or dinoflagellates was called phytobenthos. Animal fragments were classified in general terms relating to phyla, genera or species. The left mandible of each species was figured and described.

TAXONOMY. Each species is described briefly for quick field identification. In addition key characters used in more detailed taxonomy are reviewed briefly to identify the species.

LOCALITIES WHERE COLLECTIONS WERE MADE

The place names used in the text are included in Figure 1, and the summer and winter limits of ice cover in the years 1950-58 are shown in Figure 2. Winter surveys in the area were curtailed not only because of ice cover, but because the vessels usually underwent a re-fit in the period of late December - February. Also weather conditions in these months often make work at sea untenable. In all other months, but chiefly from June-September, samples were obtained throughout the area. None were taken monthly from the same place according to plan, although such regular sampling may have occurred incidentally during the fishing season.

The region was divided into unit areas sometimes for convenience but usually because these areas have fairly uniform features of depth and temperature and support uniform decapod species complexes. The geography of each unit area is referred to briefly with respect to depth, bottom configuration, temperature and current influences under a discussion of the decapod species complex to be found in each. However, a brief description of the whole region follows with notes on the extent to which each area was investigated by research vessels of the Fisheries Research Board of Canada in the years 1947-60.

Cape Dyer just north of the Arctic Circle on the east coast of Baffin Island was the most northerly point reached by the "A.T. Cameron" in August, 1959, approximating the summer limit of the ice field in west Davis Strait that year (Fig. 2). This is also near the northern slope of the deep submarine rise (Cape Walsingham-Holsteinsborg ridge) separating Baffin Bay from the Labrador Sea. The lines of stations fished by the "A.T. Cameron" extended from a depth of about 700 m offshore through depths of approximately 600, 500, 400, 300, 200 and 100 m toward the coast of Baffin Island and Labrador. The shallower areas above the 100 m contour were not explored. At the depths fished the continental slope was gradual or almost level to a considerable extent off Baffin Island, but further south off the coast of northern Labrador it was considerably steeper (Templeman, 1961, Figure 2; this paper Fig. 50). The shelf off Cumberland Sound was widest of all in the north, forming a continuation of the rise separating Baffin Bay and the Labrador Sea. Cumberland Sound was not included in these investigations because of ice cover in 1959. Frobisher Bay was investigated by the Calanus Expeditions of 1951 (Dunbar, 1960; Squires, 1962). It has a trough on the south side and a shelf (the Calanus Shelf) on the north side near the mouth of the bay. The Shelf was the area mainly investigated by the "Calanus". The extensive shallow areas of Ungava Bay were explored in 1946-50 by the Calanus Expeditions (Squires, 1957) but the deep (200-300 m) channel entering the bay on its east side and leaving on the west side of Akpatok Island was not trawled. The outer portion of this channel, the shelf near Akpatok Island and the deep channel of Hudson Strait (200-400 m) were trawled by the "A.T. Cameron" in 1959. During the years 1953-58, decapods were taken in explorations by the "Calanus" north of Hudson Bay and in Foxe Basin, a comparatively large but shallow depression forming the northern extension of Hudson Strait west of Baffin Island (40,000 square miles in area; Campbell and Collin, 1958). In these explorations stations were usually comparatively close to shore in Foxe Basin and among the islands at the mouth of Hudson Bay (Grainger and Dunbar, 1956; Grainger and Hunter, 1959).

Along the east coast of Labrador the Labrador Shelf to a depth of 200 m extends, in the north, to a distance of about 100 miles from the coast. Further south this depth is found at about 50 miles from the coast, except where the large Hamilton Inlet Bank extends for 100 miles from shore and forms an oval-shaped rise about 100 miles long in its north-south axis. The slopes to the Labrador Sea are relatively steep. These slopes were investigated for commercial quantities of redfish in the years 1947-54 (Templeman 1959). The shallower coastal areas of the shelf which are interspersed with many islands and shallow inlets were not included in these surveys although some coastal investigations were made by the "Calanus" at Nain in 1955, and by Mr. A. M. Fleming for shore cod at Nachvak, Nain and Domino in 1947. At my request a collection of Hyas araneus was made in several fishing stations between Nain and Battle Harbour by Mr. A. W. May in 1959. The "Investigator II" made one survey trip into Lake Melville (Hamilton Inlet) in 1952, but the deep areas of this large inlet were not explored because of unfavourable weather at the time.

Off the Newfoundland coast the Northeast Newfoundland Shelf extends to depths of 200 m at about 150 miles offshore. Here the 200 m contour outlines submarine extensions of the Northern, Burlington and Cape Freels peninsulas and admits deep channels into White and Notre Dame Bays. The shelf is further broken by the long Funk Island Deep where some exploratory fishing was done in 1947-54 by the "Investigator II". Exploratory fishing along the outer edge of the Shelf reached distances of 250 miles from shore and was made near shore in the deep channels of White and Notre Dame Bays.

The Northeast Newfoundland Shelf is separated from the shallow plateau of the Grand Banks by the wide channels entering Bonavista and Trinity Bays. These channels were explored by the "Investigator II" in 1947-51 including several hauls made in Trinity Bay. Bonavista Bay and Trinity Bay were surveyed by the "Fortune Breeze" in 1957 and 1958. A considerable extent of the bottom area of these bays appeared too rough for the shrimp trawl. Unlike the former two bays, Conception Bay has a small deep trough. This was fished by the "Investigator II" in 1951 and by the "Fortune Breeze" in 1957.

The Grand Bank forms an extensive submarine plateau roughly triangular in shape with its greatest dimension from St. John's eastward to the Flemish Cap. This dimension is 350 miles. The shallowest part of the Bank, the Southeast Shoal, lies just over 200 miles to the southeast of St. John's and forms an extensive area almost 100 miles long and 40 miles wide with a depth of less than 50 m. The southwest slopes of the Grand Bank form an area about 200 miles long which is generally the best fishing area of the Bank. Westward, two smaller banks, Green and St. Pierre Banks, are separated from each other and the Grand Bank by comparatively shallow channels but are separated by deep channels from the Newfoundland coast and the Nova Scotian Banks. The channels on either side of Green Bank are continuous with the Avalon Channel east of the Avalon Peninsula, and through these a considerable part of the volume of Arctic water flows southward (see also section on hydrography). The Grand Banks and its slopes have been surveyed for groundfish more intensively than any other part of the area of investigation (Fig. 49).

The deep Laurentian Channel (greatest depth about 500 m) between the Nova Scotian Banks and the Grand Banks extends long fingers into the Gulf of St. Lawrence. These form the Esquiman Channel to the north and near the Newfoundland coast, as well as the Mingan or Jacques Cartier and the St. Lawrence River Channels to the west. A further extension of the Laurentian Channel, the Southwest-Newfoundland Channel, is found along the south coast of Newfoundland as far as Hermitage Bay with possible extensions into Fortune Bay. These channels were explored extensively for commercial quantities of redfish (Sebastes marinus s.l.) by the "Investigator II" in 1947-54 (Templeman, 1959) and for commercial quantities of shrimp by the "Fortune Breeze" in 1957 and 1958 (Squires, 1961).

In Newfoundland, bays of the northeast coast and the fjordlike bays of the southwest coast (west of Fortune Bay) have deep channels communicating with the deep open sea. No bays in this area have sills such as are found at the mouths of many Norwegian fjords but some of them have a well-defined trough. This is a deep depression greater than 200 m which is cut off from Atlantic water by a relatively shallow area often of considerable extent. The most notable of these troughs is the one in Placentia Bay. Most of the bays mentioned were surveyed for redfish populations in 1947-54 and for shrimps in 1957 and 1958.

Port au Port Bay, which was chosen as a study area for lobster (Homarus americanus) in 1961, is a very shallow bay with its greatest depth of 50 m in one relatively small trough in the eastern portion. The rest of the bay is from 5-20 m in depth. It is about 100 square miles (260 km^2) in area and about twice as long as wide but becoming slightly narrowed at the mouth. There is little appreciable effect from the current system outside the bay although we have some evidence that the prevailing current sets inward on the east side of the bay and outward on the west side near its mouth. At least the surface circulation appears largely dependent upon prevailing winds. The lobster grounds are well-defined and occupy little more than half the surface area of the bay. This bay supports a lobster fishery of about 200,000 pounds of lobsters annually at present. A very shallow extension of the west portion of the bay has extensive sand and silt flats with Zostera present: specimens of Crangon septemspinosus and Cancer irroratus collected there in 1961 and 1962 are discussed in this paper.

HYDROGRAPHY

Hachey (1961) has written a comprehensive hydrography of the North Atlantic and reviewed the literature upon which it is based. The following is a brief account of the hydrography of the localities where decapods were collected in groundfish surveys of the St. John's Station of the Fisheries Research Board of Canada.

The coastal areas of the northwest Atlantic are greatly affected by the Labrador Current. The variability of its flow from year to year and the presence of compensating currents of Atlantic water, including incursions of the Gulf Stream drift, as well as various modifications through insolation of inshore waters or their winter cooling, makes for a very complex and variable picture of sea temperatures throughout the area. A map showing the general trend of the currents of the northwest Atlantic is given by Lucas and Lee (1963).

THE LABRADOR CURRENT. The great volume of Arctic water pouring outward from the Arctic Ocean through Smith, Jones and Lancaster Sounds and Hudson Strait is directed southward and against the east coasts of Baffin Island, Labrador and Newfoundland by Coriolis force. Because of its relatively low density this homogenous mass of cold water is largely a surface current, but the forces which push it against the coast cause it to occupy the bottom and the shallow inshore areas during its southward flow. Its temperatures are characteristically below 0°C and reach an extreme of -1.9°C (-1.4°C as recorded in our surveys).

The shape of this current varies as follows: Off Labrador it is deepest near the coast and becomes attenuate offshore (Fig. 5A). In the northerly bays of Newfoundland it tends to build up as a total mass of cold water except where it is overlain by an insolated layer in the bays. As it moves southward around capes such as Cape Bonavista it has a structure similar to that off Labrador (Fig. 5B). In effect, the seaward portion of this Arctic current may overlie but does not descend to the bottom on the continental shelf, except near the coast, and it in its turn is overlain, particularly in summer, by a layer of warm water usually due to insolation. (For additional figures and discussion see also Templeman's reports on Canadian Researches in Annual Proceedings of the International Commission for North Atlantic Fisheries, 1951-61). In the way described, two thermoclines often occur: the upper one usually the more shallow and stable and the lower showing considerable evidence of mixing or temperature transfer, so that comparatively low temperatures and/or salinities may be found on the shelf from off Baffin Island in the north to the Grand Bank in the south (Fig. 3 and 4).

The flow of Arctic water over the Grand Bank produces conditions that vary seasonally from year to year. The landward portion, after traversing Trinity Bay as an intermediate layer of cold water and filling the trough in Conception Bay, flows southward in the Avalon Channel. Usually the attenuate and seaward portion of the current divides on meeting the northern edge of the Bank. Some of the current volume is added to the flow in the Avalon Channel and the rest may spread over the Bank.

Sometimes it forms an intermediate but shallow cold water layer over the Bank and sometimes it forms a cold bottom layer, while a thicker leg may form along the edge of the eastern slope of the Bank, held against the bottom by Coriolis force. There is no evidence of Arctic water cascading over the edge of the Grand Bank into deep water. However, a process called "cabelling" is said to occur. This is described as the mixing of Arctic water with incursions of Gulf Stream water and because of the greater densities of the resulting water masses they sink (Hachey, 1961).

After flowing through the Avalon Channel, further division of the current is less clear. The trough in Placentia Bay is almost always full of water of very low temperature (about -1°C). However, the presence of Arctic water becomes less evident in its progress along the southwest coast and the last effects of its course are shown in the trough in Fortune Bay. Water movement is continued nevertheless as the current sweeps into the Gulf of St. Lawrence, north along the eastern shore of the Gulf and out through the Strait of Belle Isle. This surface current is not thought to contribute to the "intermediate (low temperature) water" of the Gulf which is said to be caused by periodic inflows of Arctic water through the Strait of Belle Isle near the Labrador coast and/or as a result of winter cooling (Hachey, 1961).

ATLANTIC WATER. The characteristic two thermoclines of the Gulf of St. Lawrence in summer are due to insolation forming a warm surface layer and intrusion of Atlantic water forming a warm layer along the bottom of the deep Laurentian Channel and its branches. Bottom water in this channel and its extensions is approximately 5°C throughout the year (Hachey, 1961). Atlantic water also enters the deep Southwest-Newfoundland Channel and penetrates as far eastward as Hermitage Bay and probably the inner portion of Fortune Bay. Temperatures in this channel are about 6°C throughout the year, somewhat higher than those in the bottom layer of the Gulf of St. Lawrence.

Although the Grand Banks may have a layer of Arctic water at some time during the year the presence of Atlantic water is often evident, particularly on the southwest slopes of the Bank where temperatures at least as high as 8°C may be reached. This Atlantic water influence is usually least in spring when the flow of Arctic water is greatest, but in late summer or autumn the Banks may be covered with water of moderate temperatures. The eastern slopes of the Grand Bank are most frequently found to have low temperatures to considerable depths but rarely below the 200 m contour. Eastward to the Flemish Cap, however, Arctic water is no longer in evidence and here the bottom temperatures are always moderate at 3 to 5°C.

Off the coast of Labrador and Baffin Island the bottom water isotherms are nearer the coast than might be imagined (Fig. 3). The 0°C bottom isotherm is usually a comparatively short distance from the coast and it is followed closely by the 1 to 4°C isotherms. In Hudson Strait temperatures taken in 1959 show that Atlantic water penetrates into the Strait at least as far as off Akpatok Island in Ungava Bay.

SUMMER INSOLATION AND WINTER COOLING IN COASTAL AREAS. In shallow water areas, particularly in sheltered bays or arms of the sea, the surface layers quickly warm up under the influence of the sun and onshore winds, and temperatures up to 19°C are common. Except in the shallowest bays, this results in a very stable thermocline and the deeper layers of water are relatively unaffected. Offshore winds tend to push the warm surface layers out of the bays and, even in summer, therefore, rapid cooling of inshore water may occur especially if the water is deep. On the other hand, winter cooling of surface water to sub-zero temperatures in the bays of Newfoundland and Labrador results in the elimination of summer thermoclines and a build-up of cold bottom layers which remain unchanged throughout the summer if depths are too great or the area enclosed and out of the influence of currents. Generally, the inshore shallow waters may be subject to considerable fluctuations of temperature in summer depending upon the wind and weather.

ICE. Usually ice begins to form in northern Newfoundland bays and along the coast of Labrador in early January. By February "pack" ice, largely originating in Baffin Bay and the coasts of Greenland and Baffin Island, has moved south off the coast of Labrador and is augmented by "fast" ice formed at the shore to reach a distance of about 30 miles seaward. The floes move rapidly southward expanding to distances of 60-100 miles from shore until the Grand Banks are reached in March. The maximum penetration southward is usually reached in April and shortly thereafter the pack begins to break up and recede. In almost any year the northern bays of Newfoundland, including White, Notre Dame and Bonavista Bays, are filled with ice, often frozen fast for a period which may vary from 1-4 months. Mobile pack ice may be present for a longer period depending upon the duration of onshore winds and may reach Trinity and Conception Bays in some years. Offshore winds in spring if continuous for at least a fortnight will carry the pack far enough eastward to reach Atlantic water where it disintegrates in a short time. Even the icebergs, sometimes part of the floes but occasionally alone, break up and are quickly melted on contact with Atlantic water over the southerly edges of the Grand Banks.

Ice reaches St. Mary's and Placentia Bays only for a short period in spring if there are persistent south-east winds when the pack ice reaches the central Grand Bank. The ice-field only rarely reaches the southwest coast from Fortune Bay to Ramea so that the Southwest Newfoundland Channel is almost always free of ice cover. Also very little ice forms at the shore along the southwest coast even in the most severe winter weather.

Ice from the Gulf of St. Lawrence may be present over part of the Laurentian Channel and in Cabot Strait in February-April but the prevailing surface currents carry it south over the Nova Scotian Banks where it rapidly disintegrates. In the Gulf the ice floes may reach a considerable extent in some years but they tend to be mobile even at maximum formation and may be carried out of sight of land with persistent offshore winds. The bays and inlets of the west coast of Newfoundland, however, are frozen over from February-April almost every year.

During the period 1950-58 the ice field was at its maximum in 1957 when it reached as far south as the southern Grand Bank in April, but its minimum was in 1958 when it only reached as far south as Bonavista Bay (Fig. 2).

REVIEW OF THE DECAPOD SPECIES COLLECTED

The synonymies listed for these species are not meant to be exhaustive but only to indicate the author or authors who provide an adequate description or a key to identify the particular species. Short descriptions are given here, however, and comprise a few outstanding features or key characters in the external morphology of each species.

The world distribution of each species is outlined, and its local distribution is related to observed optima and ranges of depth and temperature. Maps of distribution in the northwest Atlantic are included.

Data from subsamples are used as far as possible to estimate the averages and ranges of carapace length (here referred to as length or cl), and to estimate the age, maturity and frequency of breeding of individuals in populations of each species from different parts of the area. Associated decapod species, parasites, commensals or predators are given where possible. Food contents of stomachs examined are noted, and the left mandible of each species is described. In this section "ova" refers to the ova in the ovaries and "eggs" to eggs on the pleopods.

DECAPODA MACRURA

Tribe: PENAEIDEA

Family: PENAEIDAE

Sergestes arcticus Krøyer, 1885. Sund, 1920.

This shrimp might easily be mistaken for a euphausiid. When in fresh condition or recently preserved it has a few areas of intense red colour, the most conspicuous of which is in the gastric area and can be seen through the translucent carapace. The eyestalks are noticeably long. The first 3 pairs of legs are microscopically chelate and much longer than the others. The compact but dendrobranchiate gills are covered completely by the pleura. In euphausiids the gills are also dendrobranchiate but more diffusely branched and can be seen below the pleura.

Stephensen (1935) gave the North Atlantic distribution of this species to include many areas reaching as far north as the Faroe-Iceland ridge and reaching 69°N Latitude off northern Norway and 70°N off west Greenland. Elsewhere it is found south to the western half of the Mediterranean in Europe and south to 35°N in America. It is also reported from the South Atlantic and off Australia. It occurs in depths of 250-4500 m.

In the present collections, *Sergestes arcticus* occurred at depths from 220-290 m in Hermitage Bay and on the Northeast-Newfoundland Shelf, and from 560-770 m on the southwest slopes of the Grand Bank. It was found in temperatures ranging from 2.1 to 8.0°C and evidently is restricted to deep and warm Atlantic water (Fig. 7, 8 and 9).

Other pelagic species taken in the trawl with *S. arcticus* were *Pasiphaea tarda* and *P. multidentata* (Fig. 6). Large numbers of the euphausiid, *Meganyctiphanes norvegica*, were frequently present in the hauls (One exceptional sample of 700 *S. arcticus* had only 30 specimens of *M. norvegica*). *S. arcticus* probably competes with euphausiids for both food and space in this bay.

Food remains in the stomachs of both *S. arcticus* and *M. norvegica* consisted of calanoid copepods and chaetognaths.

The mandible of *S. arcticus* has a molar process with a flat grinding surface and one shearing cusp at the edge. The edge is joined to the sharp blade of the incisor process, which is curved and even, except for one low tooth near the centre. The long palp is in two parts, the distal of which is about one-quarter the length of the proximal (Fig. 10).

Average lengths were 15 mm in males and 18 mm in females from Hermitage Bay. The sizes of individuals from the Hermitage Bay population, which lives in moderately high temperatures and at optimum depths, were significantly larger than those taken further north. North of Newfoundland

and in Ungava Bay, males averaged 12 and 11 mm in cl and females 14 and 12 mm in cl, respectively. Where the species was trawled temperatures were lower than and depths were probably not within the optimal range (Table I). In Hermitage Bay males were mature at 11 mm in cl, but the size of females at first maturity could not be determined since all were taken in autumn and all had small ova.

Table I. Lengths of *Sergestes arcticus* collected from Newfoundland, Labrador and Ungava Bay during 1947-60.

Localities		Hermitage Bay	North of Newfoundland	Ungava Bay
Depth m		200-770	175-410	15-37[a]
Temperature °C		3.7 to 5.5	0.1 to 4.4	...
Average cl mm	M	15	12	11
	F	18	14	13
Range of cl mm	M	12 - 19	11 - 14	9 - 15
	F	13 - 20	10 - 17	9 - 16
Numbers examined	M	103	9	71
	F	104	40	81

[a]Some specimens from cod caught at these depths

Gennadas elegans (S. I. Smith, 1882).

This is a comparatively small red shrimp. It has a short pointed rostrum with a distinct dorsal crest at the carapace. The apex of this crest is formed by a forward directed spine. Each eye has an inner projection on the peduncle. As in all penaeids the 1st-3rd pairs of legs are chelate. The 4th and 5th legs are about as long as the others but they are very slender.

Sund (1920) states that this species is the commonest deep-sea shrimp in the Atlantic at depths over 400 m. It is not found north of the Faroe-Iceland ridge or the northern Labrador Sea but in many areas of the North Atlantic and in the Mediterranean as far as the Sea of Mamara. It is also found in the South Atlantic off South Africa.

Locally, specimens were collected off the Northeast-Newfoundland Shelf (50°25'N, 50°33'W) from 695 m, and south of Green Bank (44°57'N, 54°27'W) from 475-550 m (Fig. 9). The water temperature was 3.5°C.

Acanthephyra pelagica and *Pandalus borealis* (Fig. 6) were collected in the same hauls with *Gennadas elegans*.

Stomach contents were mostly amorphous, probably phytoplankton, but many partly digested fish scales were present and also crustacean fragments.

The mandible in this species has molar and incisor processes which are confluent. The incisor process has too teeth with cutting edges at the outer or anterior end. The molar is a long triangular ridge with 2 pointed cusps at the base or inner edge. The palp is in two sections which are large and flattened, with the inner edge double and fringed by plumose setae (Fig. 10).

Average carapace length of the males was 10 mm and the females 11 mm.

Plesiopenaeus edwardsianus (J. Y. Johnson, 1867); Milne-Edwards and Bouvier, 1909.

This is a very large shrimp, brilliant crimson in colour with a heavy fringe of gold coloured setae on the edges of the carapace, abdominal pleura , telson and exopods of the maxillipeds. The rostrum has an attenuate point and is about one-half the length of the carapace. Milne-Edwards and Bouvier (1909) state that there are invariably three spines above on the rostrum. In one of our specimens only two spines are present but this may have been caused by regeneration of part of the rostrum. The species is sexually dimorphic: the antennal scale has an elongate acuminate tip in the males. As in all penaeids the anterior 3 pairs of legs are chelate. The antennal and one of the antennular flagella are extremely long.

Burkenroad (1936) states that this species is "in considerable abundance in the North Atlantic and a form identified with it, although apparently not by direct comparison, in the Indian Ocean".

Specimens were collected on the southwest slope of the Grand Bank (43°42'N, 51°15'W and 43°17'N, 51°30'W) in depths ranging from 365-730 m and temperatures of 4 to 8°C (Fig. 9).

Species also in the trawl were Sergestes arcticus and Pasiphaea tarda.

Food in stomachs of P. edwardsianus was shrimp, euphausiid, amphipod, chaetognath and polychaete fragments.

As in the other penaeid mandibles examined, the molar and incisor processes are confluent. The incisor process had 3 teeth, the largest of which is in the centre. The smallest one is at the outer or anterior end of the incisor. The other is a low obtuse tooth between the large tooth and the molar process. All have sharp cutting edges and are joined to the molar process by a short blade. The molar process is triangular in shape and has 6 cusps of which two on the inner edge are sharp and pointed. The large palp is in two sections which are covered with long, robust and plumose setae (Fig. 10).

Two males, 54 and 55 mm in cl and 194 and 197 mm in total length were taken, and two females, 74 and 39 mm in cl, the former 195 mm in total length and the latter damaged.

Tribe: CARIDEA

Family: OPLOPHORIDAE

Acanthephyra pelagica (Risso, 1816).

" haeckeli Kemp, 1939; Chace, 1940.

" pelagica (Risso); Sivertsen and Holthuis, 1956.

This is a medium-sized shrimp, deep crimson in colour, with a moderately long pointed rostrum toothed above and below. There is a long mid-dorsal carina almost reaching the posterior edge of the carapace. A short carina extends from the branchiostegal spine on the carapace. All the abdominal segments except the first are dorsally carinate. There is a posterior dorsal spine on the 3rd, 4th, 5th and 6th abdominal segments and 8-11 pairs of lateral spines on the telson.

This species has been taken as far north as Davis Strait and Iceland in the North Atlantic and south to Latitude 13°N including the Mediterranean. It has also been taken over most of the deep Atlantic. It is found in the South Atlantic south of Latitude 24°S in the Indian Ocean south of Latitude 32°S and in the Pacific north of Latitude 57°S.

It occurred in catches from the eastern edge of the Grand Bank, off the Northeast-Newfoundland Shelf and northward to the east coast of Baffin Island. It occurred in depths ranging from 640-700 m and temperatures of approximately 4°C. The "Michael Sars" expedition took a few specimens southeast of Newfoundland at Stations 66, 67 and 70 in depths varying from 600-840 m (Sivertsen and Holthuis, 1956). Distribution in this area is shown in Figure 9.

Gennadas elegans and Pandalus borealis occurred in the same hauls with this species (Fig. 6).

Crustacean and chaetognath fragments were common in stomach contents; euphausiids, copepods, fragments of small fish were occasionally present, and sponge spicules more rarely (Table XLIX).

The mandible consists of both incisor and molar processes and a two-sectioned palp. The distal rounded section of the palp is about one-fifth as long as the proximal. Both sections are fringed with stout plumose setae. The incisor process has a short blade-like portion continuous with a recurved serrated edge bearing 10 teeth. A short gap separates the incisor from the molar process which has an inner recurved edge with small teeth along the outer half. Below this there is a hollow platform which bears short bristles and there appears to be no true grinding surface (Fig. 11).

The average length of the males taken was 21 mm (range 16-24 mm) and of the females 21 mm (range 15-31 mm). An ovigerous female with eyed embryos in the eggs was taken in May. It had small ova. Other mature females were non-ovigerous in May but had large maturing ova. This was also true of the mature non-ovigerous females taken during August-September. However, 67% were ovigerous in October suggesting that there is one spawning in late autumn in the populations sampled in this area. The high percentage (80%) potentially ovigerous in autumn also suggests annual spawning.

Family: NEMATOCARCINIDAE

Nematocarcinus ensifer (Smith, 1882). Sivertsen and Holtuis, 1956.

This shrimp has two groups of rostral spines. Four distal spines are well separated from each other while the eleven on the anterior carapace and the proximal part of the rostrum are close together. The pleura of the 4th and 5th abdominal segments are produced posteriorly and the ischio-meral joints of the pereiopods are distinctly enlarged.

It is found in the North Atlantic from the Mediterranean, Canary Islands, Bay of Biscay, southwest of Ireland, south of Iceland and from Newfoundland to 31°N Latitude off the American east coast. In the Indian Ocean it is reported from the Bay of Bengal and the Arabian Sea, and in the Pacific from Japan, New Guinea and the west coast of Central America. Depths frequented are 535-3650 m (Sivertsen and Holthuis, 1956).

A single specimen was taken in a haul near the southwest edge of the Grand Bank (43°27'N, 52°03'W) at a depth of 660-735 m. Distribution records in this area are shown in Figure 12.

Also present in the haul were *Polycheles granulatus* and *Stereomastis sculpta*.

The specimen was 24 mm in cl, an ovigerous female with small ova in May and eggs 0.8 mm in diameter.

Family: PASIPHAEIDAE

Pasiphaea tarda Krøyer, 1845. Sund, 1912; Sivertsen and Holthuis, 1956.

The glass shrimps are large, laterally compressed and translucent to bright red in colour. The rostrum is only a small thin and pointed projection. P. tarda has one to six, but mostly three, spines present on the basis of the 2nd pereiopod.

It is found in the North Atlantic as far north as Greenland and Jan Mayen and occurs along the European coast to Biscay Bay. On the American coast it occurs as far south as South Carolina. In the Pacific it is found from Unalaska to the State of Washington while Faxon (1895) reported it from Ecuador. Depths frequented are 250-2400 m (Sivertsen and Holthuis, 1956).

In the area of investigation it was found further east and north than P. multidentata (Fig. 12). It occurred in Hermitage Bay, southwest of the Grand Bank, off Cape Ray in Cabot Strait, on the Northeast-Newfoundland Shelf, off Labrador, in Hudson Strait and southeast of Baffin Island. Off Newfoundland it was caught in depths from 200-640 m and at temperatures from 1 to 6°C (Fig. 7 and 8); further north it appeared to be in deeper water (from 330-770 m) and temperatures were slightly lower (from 1 to 4°C) than off Newfoundland.

Off Labrador 14% of the specimens had the rostral area infested by Ellobiopsidae. On the Grand Bank 10% were infested. Other species of shrimp in the hauls were Sergestes arcticus and P. multidentata. Pandalus borealis and Spirontocaris lilljeborgi were also present in hauls from Hermitage Bay (Fig. 6).

Off Newfoundland the maximum length recorded for P. tarda was 59 mm compared with 30 mm for P. multidentata. The average length for males of P. tarda was 16 mm, which was considerably smaller than the average length of 29 mm for females. Off Labrador and in Ungava Bay the males were larger. They averaged 41 and 38 mm in cl, respectively, while the females were 30 and 31 mm in cl (Table II). Generally, average length appears to increase with increasing depth (Fig. 13).

Egg diameter in late autumn was 3.2 mm, 0.8 mm larger than the eggs of P. multidentata taken at the same time and in the same area. Although the majority of females from off Newfoundland were over 25 mm in cl and collected in October and December, only one was ovigerous. In those collected in May, however, 50% were ovigerous and one had eyed embryos in the eggs suggesting spring hatching by some individuals in this part of the area. In the north about 40% of the females caught in August and September and over 37 mm in cl had large ova in the ovaries. They would probably lay their eggs in late autumn. In these samples there were two females with advanced eyed embryos and they also had large ova (Table III). This would suggest that eggs are carried for the greater part of the year in the north and that a new batch is laid shortly after the larvae are released.

Table II. Lengths of Pasiphaea tarda and P. multidentata from different localities in the area of investigation, 1946-60.

Localities	Newfoundland	Newfoundland and Labrador	Ungava Bay	P. multidentata (Newfoundland)
Depth m	200-640	330-770	15-79[a]	200-380
Temp. °C	1.0 to 5.4	1.0 to 5.6	...	4.5 to 5.5
Average cl mm	M 16 F 29	41 31	38 33	23 23
Range of cl mm	M 14 - 17 F 14 - 59	31 - 45 16 - 43	30 - 44 18 - 42	16 - 30 13 - 30
Numbers examined	M 3 F 20	11 22	4 10	40 48

[a]Depths at which cod were taken with shrimp in stomachs

Table III. Maturity of *Pasiphaea tarda* collected from July to September off Labrador.

cl mm	Males		Females		
			Non-ovigerous		Ovigerous
	Small vd	Large vd	Small ova	Large ova	Large ova
14 - 16			2		
17 - 19			3		
20 - 22			4		
23 - 25			0		
26 - 28			1		
29 - 31		1	1		
32 - 34	3	0	1		
35 - 37	0	0	1		
38 - 40	0	1	3	2	1[a]
41 - 43	3	1	3	0	0
44 - 46	1	2	0	1	0
47 - 55			1		1[a]
Totals	7	5	20	3	2
Mature	7	5	7	3	2
% probably breeding in autumn		42		42	

[a]Eyed embryos

Euphausiids were the most frequent organisms in the stomachs. Chaetognath and shrimp fragments and a beak of a small squid each occurred once.

The mandible consists of an incisor process only. It has a sagittate edge, three of the largest teeth of which are anterior and the middle one of these has a short secondary tooth. The three are followed by 7 teeth in a series decreasing in size until a short even edge is reached which ends in a single tooth at the posterior end of the mandible (Fig. 11).

Pasiphaea multidentata Esmark, 1866. Sund, 1912; Sivertsen and Holthuis, 1956.

This species is very similar in appearance to Pasiphaea tarda but appears to be smaller on the average. Microscopic examination is necessary to reveal the 7-12 spines on the basis of the 2nd pereiopod. Immature specimens may have fewer spines than the specific number which is found in adults.

P. multidentata is found in the North Atlantic along the west coast of Europe and in the Mediterranean. It is present off Iceland, Greenland and the American coast from north of Hudson Strait to Massachusetts, occurring in depths of 10-2000 m (Sivertsen and Holthuis, 1956).

Hermitage Bay (200 m) and Cabot Strait (315 m) were the only places of capture in the present survey (Fig. 12). Temperatures were 4.8 to 5.5°C.

The pelagic shrimps P. tarda and S. arcticus were present also in catches from Hermitage Bay as well as semi-demersal species P. borealis and S. lilljeborgi.

Males and females taken were similar in size and are compared with P. tarda in Table II. In Hermitage Bay most females above 25 mm in cl were ovigerous in December and probably spawn annually. Egg diameters varied from 2.2 to 2.4 mm. The males had small or medium vasa deferentia with little or no sperm present in those from December catches. However, a male, 27 mm in cl, which was taken in November, had the vas deferens full of sperm.

Stomachs were mostly empty, but crstacean fragments, probably euphausiids, were found in one. The mandibles are similar to those of P. tarda (Fig. 11) but have 6 teeth following the 3rd or most posterior large tooth instead of 7 teeth as in P. tarda. In addition the 4th tooth is almost secondary to the 3rd and slightly separated from the decreasing series.

Family: HIPPOLYTIDAE

Bythocaris payeri (Heller, 1875); Sivertsen and Holtuis, 1956.

This is a small pale red shrimp with a short rostrum and long wide antennal scales. The eyes are large. The carpus of the 2nd pereiopod has 9 annulations. The endopodite of the 3rd maxilliped is expanded distally, flattened and provided with large rake-like teeth.

Sivertsen and Holthuis (1956) reported the capture of 2 specimens by the "Michael Sars" at Station 70 southeast of Newfoundland in 550 m. Its distribution further includes the North Atlantic and the Arctic Oceans, from the Kara Sea, the Faroes and Shetlands, Iceland, Greenland and Davis Strait to Newfoundland in 180-1000 m.

The present specimens were taken north of 66°N Latitude off the east coast of Baffin Island in depths from 265-715 m and temperatures varying from -1.1 to 1.2°C.

Other species present were Lebbeus polaris, Sclerocrangon ferox, Pandalus borealis and Sabinea septemcarinata (Fig. 6).

The average length of the males was 6 mm and the females 9 mm with ranges of 5-7 mm and 7-11 mm in cl, respectively.

All females were ovigerous in August and in one of these, large ova were present. The eggs were 2.2 mm in diameter. However, almost all had eyed embryos ready to hatch and the eggs would be slightly larger than usual at that time.

Crustacean remains and sponge spicules were found in the few stomachs examined.

The mandibles, unlike those of the other hippolytids examined, have no palps or incisor processes. The mandible is in effect a slender molar process with a sharp ridge across the centre of the crown. The ridge has a pointed cusp at each end. A slightly hollow platform outside the ridge is surrounded by a row of short close bristles similar to the edge of the slightly narrower platform inside the ridge (Fig. 38).

Eualus fabricii (Krøyer, 1841); Holthuis, 1947.

Spirontocaris fabricii (Krøyer); Rathbun, 1929.

This is a small pale-red shrimp. Its large rostrum is as long as the carapace which has 4 spines mid-dorsally at the base of the rostrum, but there are no spines above on the rostrum. No supraocular spines are present in this genus and there is an exopod on the 3rd maxilliped. Epipods are present on the 1st pereiopods only but are lacking in some specimens.

This species has been taken in the northwest Atlantic from Foxe Basin and West Greenland to Massachusetts Bay but not east of Greenland. In the Pacific it is found from the Japanese Sea and east Siberian coast to Alaska, and in the Arctic Ocean off Alaska. Depths recorded are 4-200 m (Holthuis, 1947).

It was trawled in small numbers throughout the present area in shallow water (Fig. 15). Off Newfoundland and Labrador the depths varied from 60-140 m with one exception at 255 m. In northern Foxe Basin it was taken at 0-35 m and in southern Foxe Basin at 14-75 m (Fig. 8). Temperatures at those stations were low, -0.9 to 0.7°C in Newfoundland and Labrador and as low as -1.5°C in Foxe Basin (Fig. 7). Rathbun (1913) had recorded it from Ungava Bay to Forteau in depths of 6-37 m; Leim (1921) at Grand Manan, etc.; Frost and Thompson (1932) from Labrador to the Grand Bank with fewer specimens to the south, Winkle and Schmitt (1936) from Foxe Basin, Squires (1957 and 1962) from many places in Ungava Bay and Frobisher Bay, and Prefontaine and Brunel (1962) from the St. Lawrence estuary. These records are included in Figure 15.

Cod would appear to be an important predator on this species. It was present in the stomachs of cod from Ungava Bay, Nachvak, Fogo, central Grand Bank, Ramea and Port-aux-Basques (Table XLVII). It was also present in stomachs of ringed, bearded and harbour seals from Ungava Bay.

E. fabricii was frequently trawled with specimens of Pandalus montagui, Spirontocaris spinus, S. phippsi, Lebbeus polaris and L. groenlandicus (Fig. 6).

The average length of males was similar throughout the area, but the males reached a larger size in Ungava Bay and Foxe Basin. The females had a greater average length and were larger to the north than in Newfoundland and Labrador (Table IV).

Almost all females examined from Newfoundland and Labrador were ovigerous in spring (May and June) and in autumn (October and November). In Foxe Basin, only 64% of the mature females were potentially ovigerous in autumn (Table V). This may indicate that individuals in the Foxe Basin populations spawn only in alternate years (Table XLIV).

In Foxe Basin, this species appeared to feed on detritus. The majority of stomachs contained phytobenthos. Only a few had crustaceans and polychaetes present (Table XLIX).

Table IV. Lengths of Eualus fabricii from different locations in the area of investigation, 1946-60.

Localities		Newfoundland and Labrador	Foxe Basin	Ungava Bay
Depth m		64-260	0-75	10-275
Temp. °C		-0.9 to 4.5	-1.5 to -1.0	-1.4 to 3.4
Average cl mm	M	7	7	7
	F	8	10	9
Range of cl mm	M	6, 7	3 - 10	4 - 12
	F	5 - 12	4 - 12	4 - 14
Numbers examined	M	2	40	119
	F	12	43	183

Table V. Maturity of Eualus fabricii collected in Foxe Basin in August and September.

cl mm	Males		Females		
			Non-ovigerous		Ovigerous
	Small vd	Large vd	Small ova	Large ova	Small ova
4		3			
5	1	0	2	1	
6	1	2	0	1	
7	0	7	3	1	
8	1	2	3	2	
9			3	2	9
10			4	1	8
11					1
12					1
Totals	3	14	15	7	19
% probably breeding in autumn		82		64	

The mandibles are typically hippolytid (Fig. 14). The outer division of the molar surface is larger than the inner and has 2 pointed cusps and a bristle fringe: the inner is small with a tuft of bristles. The incisor process has two small teeth following the larger terminal one. The palp, almost equal in length to the incisor process, has a distal section about 3 times as long as the proximal part.

Eualus gaimardi gaimardi (H. Milne-Edwards, 1837); Holthuis, 1947.

Spirontocaris gaimardi (Milne-Edwards); Heegard, 1941.

This sub-species resembles E. fabricii but its rostrum is toothed above as well as below and the blade of the rostrum is not as deep as in fabricii. Epipods are present on the 1st and 2nd pairs of pereiopods. In specimens from some localities there is a lobe on the 3rd abdominal segment but, even in the largest specimens, this lobe is never hooked to the same extent as it is in E. g. belcheri. Immature specimens from Ungava Bay showed progressive development of a lobe with increase in size. Generally, in the north, however, some of the larger and all the smallest specimens have no lobe (Cf. Appellof, 1908). Inspection of lengths and maturities as well as lobes of males and females of both forms from Foxe Basin suggests that intermediates occur and that all specimens from this locality at least should be assigned to the above sub-species (Cf. Holthuis, 1947). The belcheri forms are treated separately here to compare gaimardi with the more typical belcheri from Trinity Bay, Newfoundland.

Eualus gaimardi has been recorded in the North Atlantic from Spitzbergen to the North Sea (Yarmouth and Kiel) in Europe and from northern Greenland and Baffin Island to Cape Cod in America. In the Arctic Ocean it has been reported from Point Barrow and north of Siberia, and in the north Pacific as far south as Sitka. Depths range from 10-900 m (Holthuis, 1947).

Specimens of the above subspecies have been taken in our surveys from Foxe Basin, Ungava Bay, Frobisher Bay, Labrador, northern Newfoundland bays, the Grand Banks and St. Mary's Bay. It was present also in cod stomachs from the central Grand Bank (Table XLIX) and also from Ungava Bay where other predators were the bearded and ringed seals. In Conception Bay it was found in depths of 200-230 m but elsewhere in shallower water varying from 59-128 m (Fig. 8). Water temperatures were low ranging from -1.0 to 1.6°C (Fig. 7). Various authors have reported E. gaimardi from roughly the same areas as outlined for E. fabricii, and well-defined records are included in Figure 15.

The most frequently associated decapod species were Pandalus montagui and E. g. belcheri in Newfoundland and Labrador, and in Foxe Basin the following species: L. polaris, S. spinus, Sabinea septemcarinata, Argis dentata and Sclerocrangon boreas (Fig. 6).

Male and female specimens were similar in length averaging 8 mm (range 6-13 mm) off Newfoundland and Labrador. All females were non-ovigerous when collected in May, September and December. In Foxe Basin the males averaged 6 mm in cl (2-9 mm) and females 9 mm in cl (5-14 mm; Table VII). About 50% of the mature females were ovigerous or had large ova in August and September (Table VI).

Table VI. Eualus gaimardi gaimardi maturity when collected in Foxe Basin in August and September.

cl mm	Males	Females		
		Non-ovigerous		Ovigerous
	Small vd	Small ova	Large ova	Small ova
5		15		
6	9	21		
7	6	8		
8		12		
9	1[a]	11	1	
10		20	4	2
11		11	2	6
12		9	3	4
13		2	2	1
14			1	
Totals	16	109	13	13
Probably mature	1	53	13	13
% of the mature breeding in autumn		23		

[a]One with large vasa deferentia

Stomach contents consisted largely of phytobenthos, ostracods, foraminiferans, crustacean fragments and polychaetes. Hydroids, red seaweed, sponge spicules, gammarid amphipods, bivalves and small gastropods were occasionally present (Table XLIX).

The molar process of the mandible is massive. Its crushing surface is divided into two main parts, the outer with one large and one small pointed cusp at the outside edge, and the inner with an inside edge of bristles. The incisor process, a thin weak blade, has two teeth at the apex. The palp is as long as the incisor process and the distal and proximal parts are almost equal in length (Fig. 14).

Eualus gaimardi belcherei (Bell, 1855); Holthuis, 1947.

Spirontocaris gaimardi belcheri (Bell, 1855); Rathbun, 1929; Heegard, 1941.

This sub-species is very similar to *E. g. gaimardi* but it has a lobe with a very strong hook on the 3rd abdominal segment. In specimens from Trinity Bay in particular there are also bright red stripes around the abdomen (still visible after a considerable period in formalin). Epipods are present on the 1st and 2nd pereiopods except in some large ones which have them on the 1st pereiopod only.

Apparently *gaimardi* is the more northerly form which even as it increases in size does not develop as strong a hook as in *belcheri*. Both forms are considered to be the same species by Holthuis (1947).

The world distribution of *E. gaimardi* has not been clearly separated from *E. g. belcheri*.

The form *belcheri* was taken over a greater area near Newfoundland than *gaimardi* although neither was taken on the Grand Bank. The localities where taken included the Gulf of St. Lawrence and the south and east coast bays. It also occurred to the north as far as Ungava and Frobisher Bays. It was recorded at depths from 135-290 m and temperatures of -1.1 to 0.5°C, apparently preferring deeper and cooler water than the typical *gaimardi* (Fig. 7 and 8). Rathbun (1913) reviewed records of its occurrence from Nachvak to l'Anse au Loup, Labrador (Fig. 15). It was under predation by cod in the Gulf of St. Lawrence (Table XLIX).

E. g. belcheri was usually taken with other species that were numerically dominant - chiefly *Pandalus montagui*. In one haul where it was predominant (256 specimens) the next most plentiful species was *P. montagui* (110 specimens). Other species usually present were *E. macilentus*, *L. polaris*, *P. borealis*, *Sabinea septemcarinata* and *Argis dentata* (Fig. 6).

Table VII. Lengths of *Eualus gaimardi belcheri* collected from different localities in the area, and of *E. g. gaimardi* from Foxe Basin.

Localities	Newfoundland-	Foxe Basin	Ungava Bay	*E.g. gaimardi* from Foxe Basin
Depth m	135-320	180-185	15-275	2-162
Temp. °C	-1 to 0.5	-1.4 to 3.8	-0.5	-1.4 to 3.8
Average cl mm	M 14 F 16	9 12	9 11	7 9
Range of cl mm	M 11 - 17 F 7 - 21	6 - 12 9 - 14	6 - 14 6 - 14	2 - 9 3 - 14
Numbers examined	M 73 F 205	35 9	21 26	335 139

In the localities near Newfoundland, males averaged 14 mm in cl and females 16 mm in cl. These were larger than in other localities and all were larger than specimens of *E. g. gaimardi* from Foxe Basin (Table VII).

Females were first mature at 12 mm and males at 6 mm in cl. In Trinity Bay at a temperature of about 1°C, 70% of the mature females were ovigerous in autumn (Fig. 16). In Foxe Basin at lower temperatures only 50% were potentially ovigerous in autumn. This suggests that individuals in the colder situations spawn only every second year (Table VIII).

Stomach contents were similar to those found in *E. g. gaimardi*. The presence of phytobenthos and foraminiferans suggests bottom feeding.

Table VIII. Maturity of *Eualus gaimardi belcheri* collected in Foxe Basin and Labrador in August and September.

cl mm	Males: Small vd	Males: Large vd	Females, Non-ovigerous: Small ova	Females, Non-ovigerous: Large ova	Females, Ovigerous: Small ova
5, 6	2	1			
7, 8	7	4			
9, 10	8	12	5		
11, 12	1	4	0	2	
13, 14		0	0	2	1
15, 16		3	3		0
17, 18			0		1
19, 20			1		3
21, 22					1
Totals	18	24	9	4	6
% probably breeding in autumn		57		53	

Crustacean fragments, including ostracods, were common and also occasionally present were polychaetes, euphausiids and pelycopods.

The outer division of the crushing surface of the molar process of the mandible has one pointed cusp only but is otherwise similar to E. g. gaimardi. Also a small tooth is present between the two divisions of the surface. The incisor process has 4 teeth. The palp is a little shorter than the incisor process and its distal part is shorter than the proximal.

Eualus macilentus (Krøyer, 1841); Holthuis, 1947.

Spirontocaris macilenta (Krøyer, 1841); Rathbun, 1929.

This is a small slender shrimp. It has a short thin translucent rostrum with a high toothed crest and a deep rounded blade below. Epipods are present on the 1st, 2nd and 3rd pereiopods.

It is found in the west Atlantic from Greenland to Nova Scotia, in the northern Pacific from the Okhotsk and Behring Seas and in the Arctic Ocean from Siberia. Depths frequented are 55-540 m (Holthuis, 1947).

Rathbun (1913) reviewed the Labrador records of this species from Fish Island to Square Island in 28-137 m. In our surveys it was taken in small numbers in southern Foxe Channel and Ungava Bay. From Lake Melville to Fortune Bay, including all the deep cold water bays of the Newfoundland coast, conditions appear suitable for considerable numbers of this species. It was present also in the Bay of Islands and Bonne Bay on the west coast (Fig. 15), and was found in stomach contents of cod from the Grand Bank (134-141 m), Fortune Bay (183 m) and off Bonavista (285-322 m; Table XLVII). Generally it occurred in small numbers from shallow water in the north but in much greater numbers from 200-300 m in the south where temperatures were lower than 0°C (Fig. 7 and 8).

Although E. macilentus occurred in fairly large numbers, Pandalus montagui, which was invariably present, dominated the samples. P. borealis also occurred frequently in these associations as did Argis dentata and Sabinea septemcarinata (Fig. 6).

Males of this species averaged 9 mm and females 11 mm in cl, while the ranges of lengths were 5-14 and 6-15 mm, respectively.

In the southern part of the area females were first ovigerous at 8 mm in cl during October, and almost all those taken in November and December were ovigerous, suggesting annual spawning. Also a few specimens had advanced larvae in May indicating an ovigerous period of about 8 months (Fig. 16). Samples from further north, however, collected in July to September, suggest that only 62% were likely to lay eggs in the following months (Table IX).

Table IX. Maturity of female Eualus macilentus collected in July to September in Foxe Basin.

cl mm	Non-ovigerous Small ova	Non-ovigerous Large ova	Ovigerous Small ova
7	1		
8	8	1	
9	19	8	
10	44	50	
11	64	56	2
12	48	119	5
13	23	72	2
14	4	21	1
15, 16		1	
Totals	211	328	10
% probably breeding in autumn	62		

Phytobenthos was common in the stomach contents and crustacean fragments occasional.

The mandible is similar to that of E. gaimardi (Fig. 14). However, the incisor process has a terminal tooth followed by three small accessory teeth. The palp is shorter than the incisor process, the terminal part being almost equal to the proximal.

Eualus stoneyi (Rathbun, 1902). Holthuis, 1947.

Spirontocaris stoneyi Rathbun, 1902. Rathbun, 1929.

This species is like *E. macilentus* in appearance although considerably smaller and with a less deep and more pointed rostrum. Also segment 6 of the abdomen appears longer than in *E. macilentus*. In the juvenile stage the two species cannot be distinguished from each other. The rostral formula of *E. stoneyi* is $\frac{12}{2}$ while in *E. macilentus* it is $\frac{9\text{-}16}{1\text{-}4}$.

This species has been recorded only from eastern North America on the Labrador coast by Rathbun (1902) and south to the Burin Peninsula by Frost and Thompson (1932) (Fig. 17).

One specimen, an adult male, 7 mm in cl, was taken close to the shore in less than 1 m at Nutak, Labrador; and a second specimen was from the stomach of a cod caught in St. Mary's Bay at a depth of 49-52 m.

Eualus pusiolus (Krøyer, 1841). Holthuis, 1947.

Spirontocaris pusiola (Krøyer). Rathbun, 1929.

This is a small shrimp with a very short pointed rostrum which has few spines. It has some small reddish spots on a whitish translucent background over the body and a thin red edge around the uropods distally.

It is found in the North Atlantic from the Murman Sea to the Channel Islands and the Catalonian coast of Spain in Europe; in Iceland; and from the Gulf of St. Lawrence to Cape Cod in America. In the north Pacific it is found off the Alaska Peninsula, the Aleutian Islands and Behring Island. Depths frequented are from 0-500 m (Holthuis, 1947).

A specimen was taken off Presque, Placentia Bay, in a scallop dredge at a depth of 9-18 m. Two other specimens were obtained from stomachs of cod from the southwest edge of the Grand Bank (Fig. 17). Water temperatures were 1.3 to 6.7°C.

An ovigerous female 3 mm in cl and two non-ovigerous females 4 mm in cl comprise the total collection. Egg diameter was 0.6 mm.

Spirontocaris spinus (Sowerby, 1805). Rathbun, 1929; Allen, 1962.

All members of this genus have 2 superorbital spines and an exopod on the 3rd maxilliped.

This species is robust, has a high sagittate carina and a truncate rostrum with a deep blade. The 3rd abdominal tergum is usually produced mid-dorsally to form a hooked spine above the 4th segment. This species is a dull red with brown, bright red and green mottling and sometimes white markings on the legs. Epipods are present on the 1st to 3rd pereiopods.

Table X. Lengths of Spirontocaris spinus from different localities in the area of investigation, 1946-60.

Localities		Newfoundland	Newfoundland and Labrador	Foxe Basin	Ungava Bay
Depth m		45-304	60-230	14-162	9-275
Temp. °C		-1.0 to 4.5	-1.4 to 1.0	-1.4 to 0.7	-1.4 to 3.1
Average cl mm	M	8	10	7	8
	F	10	11	10	10
Range of cl mm	M	5 - 10	8 - 10	3 - 11	3 - 12
	F	6 - 12	6 - 17	5 - 17	3 - 17
Numbers examined	M	28	5	70	47
	F	59	40	101	87

Table XI. Maturity of Spirontocaris spinus collected from Foxe Basin in August and September.

cl mm	Males		Females		
			Non-ovigerous		Ovigerous
	Small vd	Large vd	Small ova	Large ova	Small ova
5	6[a]				
6	11[b]				
7	2	1	2		
8	4	10	9	5	1
9	6	11	7	3	1
10	1	11	14	12	5[c]
11		3	1	7	4
12			0	10	3
13			1	3	0
14				5	4[d]
15				3	
16				1	
Totals	30	36	34	49	18
% probably breeding in autumn		55		66	

[a] Two immature
[b] One immature
[c] One with eyed embryos
[d] One with large ova

It is found in the North Atlantic from Spitzbergen and Novaya Zemlya to the Irish Sea, the northern North Sea and the Kattegat in Europe, and from Iceland, northern Greenland and Foxe Basin to Massachusetts Bay in America. In the north Pacific it occurs from the Siberian east coast to the Alaska Peninsula and Vancouver, B.C. Depths frequented are 13-400 m (Holthuis, 1947).

In our surveys it was found from Fury and Hecla Straits, and Ungava and Frobisher Bays to the Grand Banks and the Gulf of St. Lawrence. The depths frequented were 10-305 m (Fig. 8) and temperatures -1.0 to 4.5°C (Fig. 7). Previous records from Labrador were reviewed by Rathbun (1913). Leim (1921) had specimens from Passamaquoddy Bay. Frost and Thompson's (1932) records were from the Strait of Belle Isle to the Grand Bank, Van Winkle and Schmitt's (1936) from Foxe Basin and Prefontaine and Brunel's (1962) from the St. Lawrence estuary (Fig. 17).

This species was accompanied most frequently in hauls by Sabinea septemcarinata and Lebbeus polaris. Also some other hippolytid species was almost always present (Fig. 6).

The isopod parasite, Hemiarthrus abdominalis, infested 18% of the females and 3% of the males from Foxe Basin, Hudson Strait and northern Labrador. It was not observed elsewhere.

A frequent predator on this species was cod from the northern, central and southern portions of the Grand Bank, from St. Pierre Bank, and off Ramea and Cow Head (Table XLVII).

Lengths of this species appeared to be greatest in specimens from northern Newfoundland and Labrador (Table X). However, there were fewer specimens from this part of the area and the range of lengths was not greatly different throughout the area.

In Newfoundland about 12% of the females were ovigerous in June and 25% ovigerous in October and November (Fig. 16). The low percentage ovigerous in late autumn might be accounted for by the few observed with eyed embryos in September whose larvae would probably hatch in autumn. In Foxe Basin about 15% had advanced larvae that would probably hatch in autumn. Also one ovigerous female had large ova in the ovaries and would most likely spawn when its larvae hatched. About 70% were potentially ovigerous in autumn (Table XI). It is suggested therefore that the population in Foxe Basin, unlike the populations sampled in Newfoundland, had individuals which, if they were spawning twice in a lifetime (Allen, 1962), would spawn annually (Table LII).

High percentages of stomachs with phytobenthos and foraminiferans indicate bottom feeding. Ostracods were taken frequently, but crustacean fragments, sponge spicules, small pelycopods and hydroids were infrequent. Polychaetes and gastropods were only rarely present (Table XLIX).

The mandible has a molar process which is massive and divided into two main parts. The inner part bears a row of bristles along the edge above the grinding surface and the outer has an arcuate edge and a brush of short bristles. The incisor process is a thin flexible blade with a single tooth. The palp is about equal in size to the incisor process and the distal part is about 4 times the length of the proximal (Fig. 14).

Spirontocaris phippsi (Krøyer, 1841). Rathbun, 1929;
Holthuis, 1947.

This shrimp is small but robust and has a large triangular rostrum with several large even teeth above and on the edge directed forward below. There is a carina of about 4 regular spines continued on the carapace from the base of the rostrum. The colour is brownish red with small light spots. Epipods are present on the 1st, 2nd and 3rd pereiopods.

It is found in the North Atlantic from Spitzbergen to southern Norway and from north of Greenland to Cape Cod. In the north Pacific it is found at Plover Bay on the Siberian east coast, in the Behring Sea, north of Siberia and north of Alaska (Holthuis, 1947).

It was present in samples from Foxe Basin in 12-110 m; and from Frobisher and Ungava Bays, Labrador, central Grand Bank, St. Mary's Bay and St. Pierre Bank in 60-300 m (Fig. 17). Temperatures frequented were -1.0 to 3.8°C (Fig. 7). Rathbun (1913) reviewed records from Labrador. Frost and Thompson (1932) thought that the centre of distribution of this species was on the central Grand Bank but this is not in agreement with our findings. Winkle and Schmitt (1936) reported it from Foxe Basin and Hudson Strait.

Cod was a predator on this species from the northern Grand Bank and St. Pierre Bank.

Associated species were Spirontocaris spinus, L. groenlandicus and Eualus fabricii (Fig. 6).

Lengths were similar throughout the area. Males averaged about 4 mm and females 7 mm in cl (Table XII).

In Foxe Basin about 70% were potentially ovigerous in autumn (Table XIII), indicating that this species probably spawned annually in Foxe Basin.

Stomach contents consisted largely of foraminiferans and phytobenthos. Ostracods and other crustacean fragments including mysids and copepods were also common. Hydroids, small pelycopods and rhodophytes were occasional (Table XLIX).

The mandibles are similar to those of S. spinus (Fig. 14), but the incisor process has one large and 3 small teeth terminally. The palp is shorter than the incisor process and has the distal part longer than the proximal.

Table XII. Lengths of Spirontocaris phippsi from different localities in the area of investigation, 1946-60.

Localities		Foxe Basin	Ungava Bay	Frobisher Bay
Depth m		20-200	14-110	27-118
Temp. °C		-1.5 to 3.8	-1.4 to 2.1	about 0
Average cl mm	M F	4 7	4 7	5 7
Range of cl mm	M F	2 - 7 3 - 10	2 - 7 3 - 10	4 - 6 5 - 8
Numbers examined	M F	28 59	6 68	16 15

Table XIII. Maturity of *Spirontocaris phippsi* collected from Foxe Basin in August and September.

cl mm	Males		Females		
			Non-ovigerous		Ovigerous
	Small vd	Large vd	Small ova	Large ova	Small ova
2	16[a]		1[a]		
3	4[b]	1	1		
4	3[b]	3	5[c]		
5	4	2	2		
6	2	2	4	3	
7		1	0	5	6
8			1	4	8
9			1	3	4[d]
10					1
Totals	29	9	15	15	19
% probably breeding in autumn		24		70	

[a] Immature [b] One immature [c] Two immature
[d] One with eyed embryos and large ova

Spirontocaris lilljeborgi (Danielssen, 1859); Rathbun, 1929.

This species resembles S. spinus. It is short and robust with a serrate carina two-thirds the length of the carapace. The rostrum has many small spines above and about 4 spines below and it ends in a long tapering point. The 3rd abdominal segment is not produced to form a spine posteriorly. Its colour is bright red with yellow and white spots. Epipods are present on the 1st-3rd pereiopods.

It occurs in the North Atlantic from the Murman Sea to the Kattegat, northern North Sea and the Irish Sea in Europe; and from Foxe Channel and Davis Strait to 37°N in America. It is also found in the Arctic Ocean off the north coast of Alaska (Rathbun, 1929).

It was collected in small numbers from Foxe Basin (14-15 m) and from Frobisher and Ungava Bays, on the Northeast Newfoundland Shelf, over the central and eastern portions of the Grand Bank, in Conception and Hermitage Bays and near Sable Island (Fig. 18) at depths varying from 75-300 m (Fig. 8). In all but one instance water temperatures were above 0°C (Fig. 7). Frost and Thompson (1932) found it common on the Grand Bank.

This species was one of a group of decapods in which Sergestes arcticus was occasionally predominant, and Pasiphaea multidentata present in fair numbers. It also occurred in the Pandalus borealis communities and with Pontophilus norvegicus.

Average length of males was 6 mm (range 5-7 mm) and females 12 mm (range 7-15 mm).

All females were non-ovigerous in May and June. One ovigerous specimen was taken in July, and in December 75% were ovigerous. This would suggest annual spawning. Allen (1962) found that a few females survive to lay a second batch of eggs in the following year. Water temperatures off Northumberland are considerably higher (6-14°C) than those where our specimens were taken, so that, although this species would probably take longer in our area to reach maturity, the possibility of survival to lay a second batch of eggs would be correspondingly great.

Lebbeus groenlandicus (Fabricius, 1775). Holthuis, 1947

Spirontocaris groenlandica (Fabricius), Rathbun, 1929.

All members of this genus have a single supraorbital spine and an exopod on the 3rd maxilliped.

This species is a comparatively large shrimp, brownish red to brosh brownish green in colour, with 4 high spines on the mid-dorsal carina on the carapace. The pleura of each abdominal segment is produced to form a large spine and one or two small spines. The rostrum is sharp-pointed and bears 2-3 spines above and 2-3 spines below. Epipods are present on the 1st-3rd pereiopods.

This species is found in the North Atlantic from east and west Greenland and Arctic Canada to Cape Cod. In the north Pacific it is found from the Behring Sea to Puget Sound and the Sea of Okhotsk (Holthuis, 1947).

Its distribution on the Labrador coast was reviewed by Rathbun (1913). Leim (1921) reported it from Grand Manan, the Bay of Fundy, etc. Frost and Thompson (1932) found it most plentiful near the Belle Isle Straits. It was collected in Foxe Basin by Captain Bob Bartlett (Van Winkle and Smith, 1936), in Ungava and Frobisher Bays by the Calanus expeditions (Squires, 1957 and 1962), and reported from the St. Lawrence estuary by Prefontaine and Brunel (1962).

Our collections were from Foxe Basin, Labrador, the central portion of the Grand Bank, east coast of the Avalon Peninsula, St. Mary's Bay, St. Pierre Bank and the northern part of the Gulf of St. Lawrence (Fig. 18). Temperatures varied from -1.3 to 4.5°C where this species was taken and depths were all less than 200 m (Fig. 7 and 8).

Cod is a predator on this species. Most of the specimens collected in the south were from stomachs of cod. In Ungava Bay the bearded seal was a common predator (Squires, 1957).

Usually a few specimens of this species was present in the catches and they were accompanied by larger numbers of Lebbeus polaris, Pandalus montagui and Spirontocaris spinus (Fig. 6).

Specimens from the north appeared to be larger than those from Newfoundland but were largest off northern Newfoundland and Labrador. In Frobisher Bay males averaged 12 mm in cl and females 16 mm (ranges 10-15 mm and 7-28 mm, respectively), representing in the females a larger size than those from Foxe Basin and Ungava Bay (Table XIV).

One female was ovigerous in May and about 57% were ovigerous in August and September. However, the embryos in some eggs taken in September and November were eyed and probably hatch in late autumn or early winter (Table XV). Therefore, the low percentage ovigerous in autumn may be accounted for by hatching in two seasons and the majority of females in the population may spawn annually. None of the 21 females

Table XIV. Lengths of *Lebbeus groenlandicus* from different locations in the area of investigation, 1946-60.

Localities		Newfoundland	Newfoundland and Labrador	Foxe Basin	Ungava Bay
Depth m		45-160	110-190	0-162	18-275
Temp. °C		-1.3 to 4.5	-0.6 to 0.6	-1.5 to 5.5	-1.4 to 2.2
Average cl mm	M	10	15	12	12
	F	11	18	13	14
Range of cl mm	M	6 - 14	11 - 27	2 - 18	6 - 18
	F	8 - 13	8 - 27	3 - 21	4 - 24
Numbers examined	M	3	5	33	99
	F	8	31	20	131

Table XV. Maturity of *Lebbeus groenlandicus* from Foxe Basin, Newfoundland and Labrador in August and September.

cl mm	Males		Females		
			Non-ovigerous		Ovigerous
	Small vd	Large vd	Small ova	Large ova	Small ova
7, 8	3		1		
9, 10	4		1		1[a]
11, 12	2	3	6		0
13, 14	1	7	3		0
15, 16	0	2	2	2	1
17, 18	1	2	3	1	4
19, 20			1	5	2
21 - 25			3	3	6
26, 27				1	
Totals	11	14	20	12	14
% probably breeding in autumn	56		57		

[a]With eyed embryos

(5-21 mm in length) taken in Foxe Basin in August and September were ovigerous.

Phytobenthos was predominant in occurrence in stomach contents but crustacean fragments, polychaetes and hydroids were present occasionally, and less frequently euphausiids, foraminiferans, ostracods, ophiurans, small pelycopods, gastropods and rhodophyte fragments (Table XLVII).

The mandibles are similar to those of other hippolytids (Fig. 14). The molar process has a shearing edge (an inner superior cusp which has a tuft of short setae), a primary grinding surface (its inner inferior platform) and a main grinding surface (a large low platform which forms the outer part of the molar). The incisor process is a thin flexible blade with 3 teeth at the apex. The palp has two parts equal in length, the distal one of which has long setae terminally and on the inner edge.

Lebbeus polaris (Sabine, 1821). Holthuis, 1947.

Spirontocaris polaris (Sabine), Rathbun, 1929.

Comparatively medium in size, this species is bright red in colour with concentrated spots formed by red and orange chromatophores on the dorsal side of the carapace and abdomen. The upper and lower margins of the large rostrum may be toothed or may be entire. The smooth rostrum occurred in 4 males out of 21 and in 2 females out of 61. This species can be identified by the single supraocular spine, the rounded abdominal pleura and the relatively long rostrum. Epipods are present on the first two pereiopods.

This species is found in the North Atlantic from the polar regions to the Skaggerak and the Hebrides in Europe, and to Cape Cod in America. In the north Pacific it was collected in the Aleutians and in the Behring and Okhotsk Seas. Depths recorded are 0-930 m (Holthuis, 1947).

Locally it was taken in Foxe Basin, Frobisher and Ungava Bays, Labrador and Newfoundland coasts, the Grand Banks, Gulf of St. Lawrence and the Nova Scotian Banks (Fig. 18). It was found at practically all depths fished from 42-720 m (Fig. 8) and at temperatures varying from -1.5 to 4.7°C but never in large numbers.

It was in stomachs of cod from the Grand Bank, off Nachvak and in Ungava Bay. It was also eaten by seals and murres (Tuck and Squires, 1955) in Ungava Bay.

Specimens from Newfoundland and Labrador, mostly taken in deeper water than elsewhere (78-720 m), were larger than those from Ungava Bay and Foxe Basin (from depths of 2-275 m). Males averaged 12 mm and females 13 mm in cl compared with 9 and 10 mm in cl, respectively (Table XVI).

Table XVI. Lengths of *Lebbeus polaris* from different localities in the area of investigation, 1946-60.

Localities		Newfoundland	Newfoundland and Labrador	Foxe Basin	Ungava Bay
Depth m		50-400	78-720	2-162	5-275
Temp. °C		-1.1 to 4.7	-1.4 to 5.4	-1.4 to 3.9	-1.4 to 3.4
Average cl mm	M	7	11	9	9
	F	12	12	10	10
Range of cl mm	M	4 - 11	6 - 18	2 - 13	2 - 13
	F	5 - 19	7 - 20	4 - 16	2 - 17
Numbers examined	M	19	99	476	122
	F	61	272	137	205

Table XVII. Maturity of *Lebbeus polaris* collected in Foxe Basin, Newfoundland and Labrador from July-September.

cl mm	Males: Small vd	Males: Large vd	Females, Non-ovigerous: Small ova	Females, Non-ovigerous: Large ova	Females, Ovigerous: Small ova	Suggested age years
5	1					
6	2	7	4			
7	3	0	5			I
8	4	4	6	3		
9	6	27	11	8		
10	2	23	2	14	4	
11	1	14	22	28	15	
12	1	10	12	33	17	II+
13		5	2	22	11	
14		6	4	10	6[a]	
15		4	2	8	5[b]	
16		1		3	7	III+
17		1		2	4	
18 - 20				6	7	
Totals	20	102	70	137	76	
% probably breeding in autumn		84		75		
First mature	6 mm cl			8 mm cl		

[a]One with eyed embryos [b]One with large ova

In this species some larvae hatched in autumn as well as in spring. In one sample taken in October and November 50% of the ovigerous females had eggs with advanced embryos. Also in May only 17% were ovigerous (Fig. 16). In other samples taken in early autumn (July-September) occasional specimens had advanced embryos, and 75% were potentially ovigerous (Table XVII). These data suggest that the majority of the females spawned annually, reached maturity at an early age and spawned more than once (Table LII). Three major year groups appeared to be present, approximately I, II and III plus years of age (Table XVII).

Phytobenthos, crustacean fragments, ostracods and gammarid amphipods occurred in most stomach contents. Polychaetes, foraminiferans, hydroids and rhodophytes occurred less frequently, while pteropods, small gastropods, pelycopods, mysids and sea urchins occurred only occasionally (Table XLIX). The mandibles are similar to those of L. groenlandicus but the incisor process has 4 teeth, and the palp has setae on both sides of its two sections.

Lebbeus microceros (Krøyer, 1841). Holthuis, 1947.

Spirontocaris microceros (Krøyer), Rathbun, 1929.

This small shrimp has a slender, pointed and very short rostrum, usually with 3 spines above plus 2 spines on the carapace. There is one supraocular spine. The colour is deep red with orange, white and blue markings. Epipods are present on the first 3 pereiopods.

It is reported from the northwest Atlantic only, from the southern part of west Greenland to Misaine Bank off Cape Breton Island. Depths were 8-80 m where it was collected.

Our collections were from Trepassey Bay, Newfoundland, in 35 m and at a temperature of 2.5°C. Also it was taken in Foxe Basin from 8-14 m (Fig. 18). Other species in these collections were Lebbeus polaris, L. groenlandicus, E. fabricii, E. gaimardi and S. phippsi.

The female from Trepassey Bay, 10 mm in cl, was non-ovigerous in November. Of the 2 females from Foxe Basin one was immature at 4 mm in cl and the other, 13 mm in cl, was ovigerous in September. The diameter of the eggs was 2.4 mm. The male, 9 mm in cl, was mature in September.

Phytobenthos was present in the stomachs.

The molar process, as in mandibles of other hippolytids (Fig. 16), has the surface divided into 2 parts. The outer division has 2 pointed cusps and a tuft of bristles at the inner edge. The incisor process has terminally 1 large and 3 small teeth. It is longer than the palp, the distal section of which is the shorter and is fringed with long setae. A few setae are present also on each side of the outer end of the proximal section.

Lebbeus zebra (Leim, 1921). Holthuis, 1947.

Spirontocaris zebra Leim, Rathbun, 1929.

This species resembles L. microceros closely and may be the same species (Rathbun, 1929) but it has considerably more dark blue colour. This forms vertical but irregular stripes over the brownish red carapace and whitish abdomen. There are conspicuous white markings on the legs. The rostral spine formula in our specimen was

$$\frac{2}{1} + 3$$

It is recorded from the northwest Atlantic, off New Brunswick and Nova Scotia. Makarov (1935) has described a species and given it the same name but Holthuis (1947) believes that both are the same species. Makarov's specimens were from the Behring Sea and off the east coast of Kamchatka at depths up to 32 m.

The specimen collected was from cod stomachs taken at Ramea, Newfoundland, from 35-70 m (Fig. 19).

Family: PANDALIDAE

Pandalus borealis (Krøyer, 1838). De Man, 1920. Rathbun, 1929.

Members of this genus have microscopic chelae on the first pereiopods and the second pereiopods are slender and unequal in length. The carpus of the second pereiopods has few to many annulations.

P. borealis is a large uniformly pale scarlet shrimp with a distinct, sharp, dorsal lobe in the middle of the 3rd abdominal segment. The rostrum is long, narrow and pointed with movable dorsal spines interspersed with many fine setae: it has only short fixed teeth on its lower edge. There are epipods on the 1st-4th pereiopods.

This species occurs in the North Atlantic from the Barents Sea to the North Sea in Europe and from 75°N Latitude in West Greenland to Georges Bank in America. It also occurs in the north Pacific from the Behring Sea to the coast of California (Allen, 1959). Several areas of great abundance of this species are to be found including the coast of Norway, west coast of Greenland and northern British Columbia to Alaska, where it supports large fisheries, and off the southwest coast of Newfoundland and in the Gulf of St. Lawrence where it is at present unfished.

It is abundant in this area at depths in excess of 200 m (Fig. 8) particularly in the areas mentioned and on the continental slope off the coast of Labrador and the Northeast-Newfoundland Shelf. It is also in considerable numbers in the deep coastal bays of Newfoundland and near the Flemish Cap. It also occurs on the slopes off the Nova Scotian and Grand Banks, in Lake Melville, as far north as our surveys reached in Davis Strait (just north of the Arctic Circle off the east coast of Baffin Island) and in Hudson Strait as far as Ungava Bay (Fig. 19).

This species was found in water temperatures varying from -1.4 to 7.6°C (Fig. 7). The areas in which it occurred in greatest abundance and at the largest sizes had depths of 200-375 m and temperatures varying from 4 to 6°C. It was almost entirely absent from the shallower parts of the area down to 100 m, as Frost and Thompson (1932) had found. In moderate depths of 100-175 m specimens were considerably smaller than in the optimal depths. The station farthest north where this species was taken was at about 365 m in depth off Baffin Island; off Labrador it was found at a similar depth. During the "Fortune Breeze" survey for shrimps (Squires, 1961), samples of this species from water of varying temperature demonstrated that the ratio of males to females was disproportionate at low temperatures but about equal at temperatures of 4 to 6°C (Table XVIII). In some low temperature areas (-1.1 to 3°C) only males were caught and in others there were 3 to 19 times as many males as females (Table XIX).

Table XVIII. Carapace length frequencies of Pandalus borealis in varying depths, temperatures and localities in the area investigated by the "Fortune Breeze" in 1957 and 1958.

Localities Depths m	SW Nfld. 210-270		Gulf S-L 250-370		N Gulf 170-220		Trinity 275-315		D'Espoir 165-210		Fortune 200-230		Placentia 190-260	
Temp. °C	6.0		5.1		3.4		1.0		0.7		-0.3		-1.1	
Sex	M	F	M	F	M	F	M	F	M	F	M	F	M	F
cl-mm														
10							3				2		4[d]	
11							4				7		4[d]	
12					1		8		1		10		10[d]	
13					0		30		7		23		5[e]	
14			1		1		65		5		12		20	
15			3		14		54		5		15		47	
16	1		4		35		39		22		15		30	
17	0		6		28		33		58		26		36	
18	5		7		22		16		42		14		12	
19	18		13		10		15		13		15		5	
20	12		13		9	1	17	1	11		4		8	
21	15		15		5	1	3	3	12		4		2	2
22	38	1	20	2		1	1	6	2	1	1	1	1	1[f]
23	22	3	10	[a]17		8		7	0	0	1	0		0
24		21		[b]47		6		8	1	0		0		0
25		29		[c]48		8		5		5		0		1
26		17		62		3		1		2		2		0
27		13		64		2		0		5		1		1
28		14		48		1		1		2				
29		3		33		0								
30		1		14		1								
31		2		1										
32		1												
Totals	111	105	92	336	125	32	288	32	179	15	149	4	184	5
% ovigerous		100		65		0		74		60		75		60

[a] 4 transitional, [b] 4 trans., [c] 1 trans., [d] immature, [e] 4 imm., [f] trans.

Table XIX. Ratio of males to females in random sub-samples from catches of *P. borealis* by the "Fortune Breeze" (1957-58) at different bottom water temperatures.

Temperatures °C	Number of hauls	M/F
-1.5 to -1.1	7	8.0
-1.0 " -0.5	7[a]	13.5
-0.4 " 0.0	4	6.7
0.1 to 0.5	2	(males only)
0.6 " 1.0	8[a]	18.5
1.1 " 1.5	2	17.6
1.6 " 2.0		
2.1 to 2.5	1	(males only)
2.6 " 3.0	1	8.1
3.1 " 3.5		
3.6 " 4.0	1	2.8
4.1 to 4.5	7	0.7
4.6 " 5.0	6	0.6
5.1 " 5.5	12	1.1
5.6 " 6.0	10	1.4
6.1 " 6.5	3	1.3

[a]3 hauls had males only

Where this species was abundant the bottom was invariably soft mud. "Hard" bottom, even where depths and temperatures were suitable did not support a population of this species (Squires, 1961). This is in agreement with Allen (1959) who says that this species occurs only over soft mud.

ECOLOGY. Where P. borealis occurred in large numbers and large sizes most catches had no other species of shrimp or only a few specimens of other shrimps (Table XX). This suggests that it is able to exclude other shrimp species where optimal conditions for itself pertain (Principle of competitive exclusion: Hardin, 1960). One of its chief competitors, P. montagui, failed to make any real encroachment, although depths and bottom conditions were suitable for it, except in places where temperatures were quite low, such as in the Placentia Bay trough and in Ungava Bay. Also under very cold water conditions another shrimp, Eualus macilentus, much smaller than either P. montagui or P. borealis, was present in considerable numbers (Fig. 6).

Occurring quite regularly in areas where optimal conditions for P. borealis prevailed was the large sea anemone Bolocera longicornis and the sedentary squid, Rossia leucopis. These areas are also frequented by the redfish, Sebastes mentella, which presumably school near the bottom yet rarely feed on adult P. borealis. Its chief predator here, however, is the Greenland halibut (Reinhardtius hippoglossoides) and occasionally cod (Gadus morrhua).

Stomach contents of specimens from the north (off Labrador and Baffin Island) largely consisted of phytobenthos, crustaceans (including gammarid amphipods), polychaetes and foraminiferans. The occasional pelycopod shell was present and more rarely ophiuroids, euphausiids and copepods. In southern areas pelycopod shells, euphausiids and small shrimps were more common (Table XLIX). The stomachs of those captured in plankton nets attached to the headrope of the trawls were full of undigested copepods. But no stomachs were empty. Since the usual percentage of stomachs found empty varies from 50 to 70% it is most likely that the copepods were eaten by P. borealis in the nets which were full of copepods when taken in.

The mandibles are similar to those of other pandalids found in the area (Fig. 26). There is a six-toothed incisor process forming a blade well-separated from and extending outside the molar process. A three-jointed setose palp is present. The molar process is stout, rounded and with a shearing cusp along the full width of the edge. It also has a larger, flattened but slightly irregular grinding surface.

SIZE AND AGE. The size of the sexes in P. borealis is conditioned by the fact that it is a protandrous hermaphrodite: each individual is a male for the first part of its life and after functioning as a male it changes sex. The testes atrophy, the ovarian tissues (always present) develop and the ova increase in size. The intersex moults result in the decrease in size and eventual loss of the

Table XX. Numbers of *Pandalus borealis* (Pb) in subsamples from hauls made by the "Fortune Breeze" during June-September, 1957 and 1958. Pm = *P. montagui*; code numbers for areas are as in Table XLV.

Area	Depth m	Temp. °C	Hauls with Pb only		Hauls with Pb and Pm only		Hauls with Pb and others		Totals	
			Hauls	Pb	Hauls	Pb	Hauls	Pb	Hauls	Shrimp
30	190-310	4 to 5	9	883	1	149	3	276	13	1322
30	170-180	3	...	...	1	64	...	...	1	106
33	238-394	4 to 5	9	429	...	...	6	353	15	802
28	247-448	4 to 6	1	6	1	54	4	130	6	220
27	209-271	5 to 6	5	299	...	...	2	148	7	495
31	245	2	...	...	...	...	1	23	1	98
26	192-211	0.6	...	...	...	...	1	101	1	106
26	83-165	0.5	1	93	...	...	...	...	1	93
27[a]	282	5	...	...	...	...	1	69	1	70
25	262-293	6	...	...	...	...	2	94	2	120
27[b]	137-242	5	1	59	...	...	...	...	1	59
24	198-330	-1 to 0	...	...	...	...	9	764	9	1077
23	183-256	-1 to 0	...	...	1	87	16	1601	17	3067
14	202-265	-1 to 0	...	...	...	...	3	224	3	378
13	253-316	0 to 1	1	386	...	...	7	1364	8	2009
10	289-317	0 to 1	...	...	...	...	3	500	3	1126
9	245-293	1	...	...	...	...	1	420	1	523
Totals									90	11671

27[a] = North Bay   27[b] = Great Bay de l'Eau

Table XXI. Subsamples of Pandalus borealis taken by the "Fortune Breeze" in 1957 and 1958 during June-September and shown as totals at each carapace length.

Carapace lengths	Males	Intersex	Females	Total
mm				
9	5			5
10	31			31
11	52			52
12	129			129
13	347			347
14	474			474
15	435			435
16	433			433
17	485			485
18	424			424
19	461			461
20	463		2	465
21	278	2	22	302
22	201	15	57	273
23	95	20	187	302
24	29	16	293	338
25	6	11	365	382
26		3	258	261
27		1	227	228
28			140	140
29			63	63
30			28	28
31			4	4
32			3	3
Totals	4,348	68	1,649	6,065

appendix masculina on the 2nd pleopod and the copulatory appendix on the endopod of the 1st pleopod (Berkeley, 1930; Hjort and Ruud, 1938; and Allen, 1959). Moulting into the female phase is followed by egg laying. In the abundant populations sampled, males were 9-25 mm, intersex 19-27 mm and females 19-32 mm in cl (Table XXI).

Following Peterson's method of determining the age of fish (Parrish, 1956), peaks in the length-frequency histograms were interpreted as possible age groups (Fig. 23). In addition, all the P. borealis in a sample were separated according to sex, and size groups were selected by inspection before measurement. These groups were measured separately. The resulting histograms suggest that the males comprised three major size groups which possibly correspond with 1, 2 and 3 years of age. Similar histograms for the females indicated that at least three age groups were present, possibly representing 4, 5 and 6 years of age (Fig. 24). Generally, the intersex phase, when present, was represented by one major size group which was about 4 years of age in this area.

Rasmussen (1953) by adequate sampling of the P. borealis populations in Norwegian fjords demonstrated that age and growth could be related to given temperatures. Temperatures in the Esquiman Channel of the Gulf of St. Lawrence at depths greater than 180 m are 4 to 5°C throughout the year (Hachey, 1961). These are slightly higher than the 3 to 4°C of the Mist Fjord but lower than the 6 to 7°C of the Ofoten Fjord. Rasmussen's age estimations for P. borealis from the Mist and Ofoten fjords are lower or higher, respectively, than those made for samples from the Esquiman Channel in 1957 (Fig. 25). Rasmussen's length measurements of P. borealis are given as average lengths at each age, and the actual range of length at each age was estimated from his tables.

Growth rates of P. borealis in British Columbia (Berkeley, 1930; Butler, 1964), southern Norway (Rasmussen, 1953) and off Northumberland (Allen, 1959), all from comparatively high water temperatures, are considerably greater than those from areas of comparatively low temperature such as occur in Newfoundland waters. For example, at temperatures of 6 to 11°C off Northumberland, transition to the female phase in P. borealis occurs at about $1\frac{1}{2}$ years. This compares with an approximate age at transition of 4 years in the populations off Newfoundland at temperatures of 4 to 6°C. Also, primary females were found in Northumberland waters (Allen, 1959). Both early transition to the female phase and primary females are adaptations to warm water stress when the life of this species appears to be shortened. At optimal conditions or under cold stress primary females are not found. In effect, under cold water stress growth and maturity is retarded to the extent that most individuals remain as males all their lives - natural mortality ensues before they become females (Squires, 1965).

Growth of P. borealis from the Esquiman Channel (Fig. 25), averaging 3 mm annually after the first year, does not occur in a single moult. Allen (1959) suggests that at least five moults are required to pass from the male to the female phase in this species. This change takes place over a five month period at an average temperature of 8.5°C off Northumberland, during which growth of 0.8 mm in cl per month occurs (p. 209). Also, at least three moults occur between ovigerous periods (Allen, 1959). Growth increments of the order indicated (viz. about 3 mm in cl per year) would, therefore, not be unreasonable in this species from the Gulf of St. Lawrence.

MATURITY AND BREEDING. Males appeared to come to full maturity for the first time at a length of 16 mm usually between July and September (Fig. 20). Copulation probably takes place during this period and mature males appeared to be functional for at least 2 years (Fig. 20 and 23). In the smaller females egg extrusion appeared to occur between July and September. The larger females had large ova in this period but most of them became ovigerous between September and December (Fig. 16 and 21). In at least one low temperature area (at 0.5°C in Bay d'Espoir in 1957) eggs were extruded earlier (in August) but a comparatively low ratio of females to males was present in this population. A high percentage of all females was ovigerous in late autumn in areas of moderate temperatures (Fig. 16), evidence that here they spawned annually. Specimens from low temperature areas appear to spawn less frequently. Such an area was the trough in Placentia Bay with average temperatures below 0°C (-1.1 to 0°C), where 40% were found to be non-ovigerous and with small ova in autumn. The females in this population would probably spawn biennially. In this species the eggs were carried from September-April approximately and the larvae all hatch at one time between April and June.

Egg diameters of P. borealis in this area average 1.3 mm when extruded. In a warm water area, such as off Northumberland, the eggs are 1.1 mm in diameter when extruded (Allen, 1959).

Pandalus montagui Leach, 1814. De Man, 1920; Rathbun, 1929.

This shrimp resembles P. borealis but the rostrum is more curved with a deeper blade and longer fixed teeth below than in P. borealis. The abdomen, which has no lobe on the 3rd abdominal segment, is conspicuously marked with dark pink oblique stripes on a light pink background. As in P. borealis the dorsal spines on the carapace are well in front of the midway point and there are epipods on the anterior 4 pereiopods.

It is found in the North Atlantic from the White Sea to the English Channel (including north of Norway, the North Sea and western part of the Baltic Sea) in Europe, and from West Greenland and Hudson Strait to Rhode Island in America. In the north Pacific (from Alaska to California) a close relative, P. montagui tridens, occurs. Mr. T. H. Butler (Personal communication) does not consider the subspecies to be greatly different from P. montagui. However, the colouration he describes (Butler, 1964) is so different from the colouration in P. montagui that a new species name is probably justified for this subspecies.

Except that it is usually found in shallower water, the local distribution of P. montagui closely parallels that of P. borealis. It was present in the shallow water on the Grand Banks and in the Gulf of St. Lawrence where it was frequently present in hauls from less than 100 fathoms deep. It is probably the dominant member of the mixed P. borealis-P. montagui community which is found on the fringe of the large homogenous P. borealis of the deep-water community. Rathbun (1913) reported it to be very common in the shallow coastal area of Labrador. Frost and Thompson (1932) believed it to be the one of the most abundant species in the Newfoundland area. They thought that its centre of distribution was in Trinity Bay. However, I am not in agreement with this premise, since larger numbers are found in cold water bays such as Placentia and Conception Bays, and the concept of distribution centres for decapod species in this area does not appear to be true in a restricted local sense at least. The largest numbers and sizes found were in samples from Conception, Bonavista and Ungava Bays where it was larger and more plentiful than P. borealis (Fig. 19). Most specimens were taken in this area at temperatures of -1.0 to 0.5°C and at depths of 90-320 m (Fig. 7 and 8). Wherever it occurred in the Newfoundland area the influence of Arctic water was unmistakable.

This species was very common in cod stomachs from many parts of the area, but particularly from the Grand Banks, the Gulf of St. Lawrence, Greenley Island (Labrador), and Ungava Bay (Table XLVII). It was also in the stomachs of ringed seals in Ungava Bay and from Beluga stomachs from near Term Point, Hudson Bay (D. E. Sergeant, personal communication).

P. montagui was occasionally taken alone, once in large numbers off Ungava Bay in Hudson Strait but usually in small numbers. Small P. borealis commonly occurred in the P. montagui communities in

Table XXII. Carapace length frequencies of Pandalus montagui from varying depths, temperatures and localities in the area of investigation during 1957-60.

Locality	Ungava Bay		Trinity Bay		Hudson Strait		Bonavista Bay		Hudson Strait		Off Makkovik Labrador		Placentia Bay	
Depth m	375		250-300		105-110		280-310		270-370		145-230		185-260	
Temp. °C	1.0		0.7		0.6		0.4		0.2		-0.7		-1.0	
Sex	M	F	M	F	M	F	M	F	M	F	M	F	M	F
11			2											
12	1		5				1						1	
13	2		6		4[d]		0		1				0	
14	2		5		13[e]		7		5		10		1	1
15	2		11		17		10		11		14			2
16	4		5		44		11	3	18		34			1
17	5		5	1	18		13	9[a]	6		27	3		4
18	7			3	13		3	20[b]	7		15	15		10
19	14			8	5		1	13[c]	15		1	41		12
20	10	1		8	7	2		15	11	2		57		9
21	6	0		4	1	3		17	11	7		30		6
22	1	15		1		10		11	2	28		14		4
23		19		1		12		10		30		5		
24		14				4		5		33		1		
25		22				5		22		32		1		
26		11				1		0		25				
27		9						1		13				
28								1		2				
Totals	54	91	39	26	122	37	46	107	87	172	101	167	2	49
% probably breeding in autumn		75		50		97		49		52		79		71

[a] 3 intersex [b] 5 intersex [c] 4 intersex [d] 1 juvenile [e] 4 juvenile

shallower water than the main P. borealis populations. Eualus macilentus was always present in hauls with P. montagui from deep cold-water bays, and several species of hippolytids were present in hauls from very shallow water (Fig. 6). The adaptation of P. montagui to cold water situations and its advantage in competition with other species in this area is evinced in the high ratio of females to males in most populations sampled (Table XXII).

Like P. borealis, P. montagui is a protandrous hermaphrodite. The sizes of males, intersex and females overlap to a greater extent than in P. borealis. Excluding megalops and juveniles the range in lengths of the males was 6-20 mm, intersex 10-20 mm and females 11-25 mm. No primary females were found in this area (Fig. 27). In this way and others the life history of P. montagui appears to be similar to P. borealis. The males appear to spend 1 year as immatures followed by 2 years as functional males. From inspection of length groups it is indicated that following the 3 years as males the 4-year-olds moult through the intersex phase to become females. The females probably lay eggs at least twice at 5 and 6 years of age (Fig. 30). The range of lengths of the male and intersex phases suggests that in this area a greater variation exists in the growth rate and in the onset of maturity in individuals of this species than in P. borealis.

Mature males with large vasa deferentia full of sperm were found between July and December (Fig. 28). A considerable number of the females were ovigerous in each month from April to December (Fig. 29). The proportion ovigerous in July to September was greater than in other months and it was lower in May and June. In October to December the proportion ovigerous gradually decreased to 50%, while of the non-ovigerous, 50% had large ova and 50% medium ova (Fig. 16). Advanced embryos were found in May only. It is possible that those with large ova extruded eggs in late December which would give a higher proportion of ovigerous females in the spring than in late autumn.

Average egg diameter in this area is 1.3 mm (1.2-1.5 mm) compared with 0.8 mm off Northumberland (Allen, 1963).

Although phytobenthos was present in many stomachs, crustacean fragments (gammarid amphipods and calanoid copepods) appeared very frequently and polychaetes occasionally. A few small pelycopod shells, ophiuroids and euphausiids were recorded (Table XLIX).

The mandibles are similar to P. borealis except that the incisor process has 5 teeth. The similarity of mandibles and food in both pandalids suggests that they would compete for the same niche (Weatherley, 1963).

Pandalus propinquus G. O. Sars, 1869. De Man, 1920; Rathbun, 1929.

This species is pale pink in colour and has a smooth surface, unlike the finely sculptured surface of Dichelopandalus leptocerus. It has a long and still more curved rostrum than P. montagui and has still larger teeth below. It does not have an exopod on the 3rd maxilliped, which is another feature distinguishing it from D. leptocerus. Both of these species have 5 annulations on the carpus of the right 2nd pereiopod.

P. propinquus is found in the North Atlantic only. Its distribution extends from west Norway at about 69°N Latitude to the Bay of Biscay on the coast of Europe. It is found off the Faroes, Iceland, east and west Greenland and as far south as Delaware Bay in America. Depths recorded are 72-2180 m (De Man, 1920).

It was collected on the Grand Bank and in the Gulf of St. Lawrence and farther north off the east coast of Baffin Island and off Labrador (Fig. 19). In the south of the area it was found in relatively shallow water, although one specimen was recorded from 550 m. Farther north it was collected from depths of 280-770 m (Fig. 8). Temperature limits of 2.6 to 7.2°C show that the species prefers moderately high temperatures (Fig. 7).

In the deep water haul was Acanthephyra pelagica, but P. propinquus was usually associated with Dichelopandalus leptocerus and P. borealis. It was rarely taken with P. montagui and occasionally no other decapod was taken with it.

This species is not hermaphroditic. Males were 10-17 mm in cl and females 9-20 mm in cl in our collections. One ovigerous female with advanced embryos was taken in April suggesting spring hatching. Examination of ovaries indicated that about 80% of the females would be ovigerous in autumn and the majority in these populations probably spawns annually (Table XXIII). Egg diameters average 1.2 mm in this area.

Food consisted of phytobenthos and crustacean fragments, including euphausiids, copepods, amphipods and isopods. Polychaetes were occasionally present and small gastropods very rarely (Table XLIX). The mandibles are similar to those of P. borealis (Fig. 26) but the incisor process has 5 teeth as in P. montagui.

Table XXIII. Maturity of <u>Pandalus propinquus</u> collected in Newfoundland and Labrador in August and September.

cl mm	Males		Females		
			Non-ovigerous		Ovigerous
	Small vd	Large vd	Small ova	Large ova	Small ova
9		1	1		
10	6	0	1		
11	10	4	3	2	
12	12	0	5	5	
13	6	7	1	5	
14	2	13	0	6	
15	3	8	1	7	
16	1	4		15	1
17	1	1		10	1
18		0		0	
19		1		1	
Totals	41	39	12	51	2
% probably breeding in autumn		49		82	

Dichelopandalus leptocerus S. I. Smith, 1881. De Man, 1920; Rathbun, 1929.

The genus is distinguished from Pandalus by the presence of an exopod on the 3rd maxilliped.

The species resembles P. propinquus but it is brick red in colour and has a finely sculptured or roughened surface. Microscopically it has 5 annulations on the carpus of the right 2nd pereiopod as in propinquus.

It is found in the northwest Atlantic from the Gulf of St. Lawrence and the Grand Banks to North Carolina. Whitely (1948) states that it is recorded from Greenland but this is doubtful. Like a few species of decapods which have their counterparts (different enough to be called another species) in the east Atlantic, it does not occur in Greenland. Its European counterpart is D. bonnieri Caullery and it also does not occur in Greenland (Hansen, 1908). D. leptocerus is recorded from the north Pacific off the Shumagin Islands, Alaska (Rathbun, 1929).

In our surveys it was found on the Grand Banks, in St. Mary's Bay and the southern Gulf of St. Lawrence (Fig. 31). Some specimens were obtained from the stomach of a harp seal (Phoca groenlandica) in the southern Gulf of St. Lawrence by D. E. Sergeant. Depths where it was taken in the nets were 105-205 m (Fig. 8) and the temperatures varied from 2.8 to 7.6°C with one exception at -0.1°C (Fig. 7).

In shallow hauls Argis dentata was present, and at greater depths P. borealis and P. propinquus (Fig. 6).

Some females were still ovigerous in late June, and in two of them the embryos were eyed and would soon hatch. Later in the year 61% of the mature females examined would be likely to lay eggs. It appears that the females first reach maturity (at 16 mm in length; Table XXIV) at least a year later than P. propinquus (at 11 mm; Table XXIII).

Crustacean remains, some whole euphausiids and mysids and a few copepods were in the stomachs examined.

The mandible is similar to other pandalid mandibles. The molar process has a hollow grinding surface which is less conspicuous than the well-capped and prominent three cusps along the inner edge. The incisor process has five teeth the central three of which are small and equidistant and the others long and pointed. The distal section of the palp is setose and about equal in length to the other two sections combined. The proximal section has an expanded lobe inside and a few setae only.

Table XXIV. Maturity of _Dichelopandalus leptocerus_ collected in Newfoundland during July to November.

cl mm	Males		Females		
			Non-ovigerous		Ovigerous
	Small vd	Large vd	Small ova	Large ova	Small ova
13	3				
14	2	2	1		
15	5	6	5		
16	2	5	3	5	
17	1	1	6	6	2
18			1	7	
19			3	3	
20			2		
Totals	13	14	21	21	2
% probably breeding in autumn		52		61	

Family: CRANGONIDAE

Sabinea sarsi S. I. Smith, 1879. De Man, 1920; Rathbun, 1929; Blacker, 1957.

This species resembles *S. septemcarinata* with its greyish brown colouration and seven spiny carinae longitudinally on the carapace, but it has a slightly longer and more pointed rostrum which is flattened vertically at the tip and reaches farther forward than the eyes. The abdomen is carinate on all segments, with double carinae on the first, fifth and sixth segments.

It is found only in the North Atlantic, off northern Europe, Iceland, and from Davis Strait to Cape Cod (Rathbun, 1929).

In our surveys it was taken mostly in the northern part of the area east of Baffin Island, off Labrador and northeast of Newfoundland and the Grand Banks. One specimen was taken off Hermitage Bay (Fig. 44). Temperatures varied between -0.6 and 4.1°C, and depths from 155-550 m (Fig. 7 and 8).

It was frequently associated with *Pandalus borealis*, but occasionally it was taken alone or with *S. septemcarinata* and *P. montagui*.

Crustacean remains including amphipods and copepods, and polychaetes were most frequently found in the stomachs. Phytobenthos also occurred commonly.

As in other crangonids examined no palp or incisor process is present on the mandibles. The molar surface is divided into two parts both essentially similar and consisting of a long pointed cusp or fang - longer and sharper than in *Crangon* - with a small subsidiary cusp beside it. The external cusp has a cutting edge (Fig. 32).

Although the number of specimens collected in each month was small, the breeding cycle appeared to follow the usual annual pattern of late summer or autumn laying of the eggs which hatch in spring. Eighty-eight percent of the females examined would most likely be ovigerous in autumn (Table XXV).

Table XXV. Maturity of *Sabinea sarsi* collected off Labrador in August and September.

cl mm	Males		Females		
			Non-ovigerous		Ovigerous
	Small vd	Large vd	Small ova	Large ova	Small ova
9	2				
10	0				
11	1	2			
12		1	2	3	3
13		0	1	1	6
14		1	0	2	4
15			0	0	2
16			1	1	2
17				1	4
18-20				1	
Totals	3	4	4	9	21
% probably breeding in autumn	57		88		

Sabinea septemcarinata (Sabine, 1824). De Man, 1920; Rathbun, 1929; Blacker, 1957.

This is a light brown crangonid (slightly darker or more reddish brown than sarsi) with seven spiny carinae longitudinally on the carapace and a short rostrum with a rounded tip.

It is found in the North Atlantic from Spitzbergen, the Kara Sea, White Sea and coast of Norway just south of the Lofotens, Iceland, east and west Greenland and from north of Canada to Cape Cod. It is also in the Arctic Ocean at Point Barrow and in the East Siberian Sea. It is not reported from the Pacific (Heegard, 1941).

This species occurred from Foxe Basin, Davis Strait, Frobisher and Ungava Bays to the Grand Banks, and also in St. Mary's Bay and the Gulf of St. Lawrence including the Bay of Islands (Fig. 31). Depths in these areas were from 45-345 m and temperatures usually below 0°C where this species was collected (Fig. 7 and 8).

It was taken in stomachs of cod from Labrador (inshore from 28-37 m and offshore from 220-340 m), the Grand Banks (75-165 m) and the northern part of the Gulf of St. Lawrence at 50 m (Table XLVII).

Associated species were mainly Lebbeus polaris, P. montagui and A. dentata (Fig. 6).

Phytobenthos and crustacean fragments (mostly gammarid amphipods and Diastylis sp.) were predominant in stomach contents of specimens from Newfoundland and Labrador, but occasionally polychaetes were present. In Foxe Basin phytobenthos and polychaetes were the most frequent food, while crustacean fragments, gammarids and ostracods were less common (Table XLIX).

The mandibles are similar to those of S. sarsi (Fig. 32) but the external subsidiary cusp is larger than in sarsi and has a cutting edge. The internal subsidiary cusp is small, and it too has a cutting edge.

In Newfoundland and Labrador males averaged 11 mm in cl and females 14 mm. The males were slightly smaller in Foxe Basin (Table XXVI).

The breeding cycle in this shrimp appears to vary among individuals of the same populations and between nearby populations. Some larvae hatched in May and June and others appeared to hatch in October. However, from the percentages ovigerous in spring and autumn (Fig. 16; Table XXVII), egg laying appeared to be annual. Autumn hatching occurs off St. Mary's Bay and in Trinity Bay, and spring hatching also in St. Mary's Bay and north of Green Bank and off Nachvak, Labrador. Eggs averaged 1.9 mm in diameter.

Table XXVI. Lengths of Sabinea septemcarinata collected in different localities in the area during 1946-60.

Localities		Newfoundland	Newfoundland and Labrador	Foxe Basin	Ungava Bay
Depth m		60-350	75-315	36-160	15-130
Temp. °C		-1.1 to 5.2	-1.4 to 0.9	-1.4 to 0.2	-1.2 to 3.1
Average cl mm	M	11	10	9	11
	F	14	13	14	13
Range of cl mm	M	5 - 18	7 - 16	5 - 12	10 - 13
	F	7 - 19	7 - 19	3 - 21	8 - 18
Numbers examined	M	22	43	19	4
	F	110	174	18	8

Table XXVII. Maturity of Sabinea septemcarinata collected in Foxe Basin, Labrador and Newfoundland in August and September.

cl mm	Males: Small vd	Males: Large vd	Females, Non-ovigerous: Small ova	Females, Non-ovigerous: Large ova	Females, Ovigerous: Small ova
6	1		1		
7	5		1		
8	9		2		
9	11	1	10		
10	4	14	7		1
11	2	12	12		0
12	0	5	22	2	1
13	0	1	19	9	5
14	0		5	13	3
15	0		7	12	6
16	1		3	11	5
17			2	7	1
18				6	0
19				1	1
20, 21				1	1
Totals	33	33	91	62	24
% probably breeding in autumn		50		49	

Sabinea hystrix (A. Milne-Edwards, 1881). De Man, 1920.

This species closely resembles the other Sabinea species. It is pale greyish brown with seven longitudinal spiny carinae on the carapace, the mid-dorsal one of which has high spines. Compared with the two other species of Sabinea, it has a longer and more spiny rostrum than either.

It is found only in the North Atlantic from southwest of Iceland and Davis Strait to the West Indies (Guadaloupe) in deep water. The "Michael Sars" took 3 specimens at Station 70 southeast of Newfoundland in a depth of 1100 m (Sivertsen and Holthuis, 1956).

In our surveys one specimen only was taken off Cape Mugford, Labrador where the temperature was 4.0°C and the depth 750-770 m. This record and others in the area are shown in Fig. 31.

Other species present were Acanthephyra pelagica and Pasiphaea tarda.

The specimen was a female 25 mm in cl. It was ovigerous and the egg diameters averaged 2.3 mm.

Argis dentata (Rathbun, 1902). Squires, 1964.

A robust shrimp, brown in colour, it has no rostrum and has both eyes in a single socket. The posterior ends of the carinae on the 6th abdominal segment are each pointed, with a tooth, and not rounded as in Argis lar (Squires, 1964).

This species is recorded from the western North Atlantic, from northern Canada and Greenland to Nova Scotia; in the Pacific it occurs from the Behring Sea to the southeast coast of Kamchatka, and from Plover Bay (Siberia), the Aleutian Islands and the Alaska Peninsula to Sitka. Depths are 11-320 m (De Man, 1920).

It was found in Frobisher and Ungava Bays, the Labrador coast, Newfoundland bays, the Grand Banks and the Gulf of St. Lawrence (Fig. 34). Temperatures frequented were usually below 0°C but ranged from -1.4 to 1.8°C (1 specimen was taken at a water temperature of 4.6°C), and depths varied from 12-320 m (Fig. 7 and 8).

This species was found in cod stomachs from Nachvak, Labrador (28-37 m); central Grand Bank (60-180 m); Fortune Bay (180 m), and the southwest Gulf of St. Lawrence (45-90 m; Table XLVII).

In deep areas the associated species were Sabinea septemcarinata and Pandalus montagui, while in shallow water Spirontocaris spinus and other hippolytids were present (Fig. 6).

Phytobenthos was most frequently present in stomachs of specimens from Foxe Basin, but occasionally crustacean fragments, foraminiferans and small bivalves were predominant. Gastropods, ostracods and polychaetes were infrequent (Table XLIX).

The mandibles are as in Crangon (Fig. 32), but the inner inferior cusp of the molar is rounded at the tip rather than sharp-pointed.

In Newfoundland the average length of the males was 15 mm (range 8-31 mm in cl) and of the females 20 mm (9-28 mm). Ungava Bay and Foxe Basin specimens were smaller: males averaged 14 mm in cl and females 16 mm in cl (Table XXVIII).

In this species, larvae were almost ready to hatch in autumn but may hatch in spring only. A considerable number of the ovigerous females had eyed embryos in the eggs in October, November and December (Fig. 16). None were taken with eyed embryos in spring. A higher percentage of ovigerous specimens was recorded in May than in June while none were ovigerous in July (Fig. 33). This indicates that hatching took place in spring. Since the number of females ovigerous in late autumn and in spring was approximately 35% of those taken, it is possible that the majority of females spawn every second year (Tables XXIX and LII).

Table XXVIII. Lengths of *Argis dentata* collected from different localities in the area of investigation from 1946-60.

Localities	Newfoundland	Newfoundland and Labrador	Foxe Basin	Ungava Bay
Depth m	55-320	180-300	0-160	18-130
Temp. °C	-1.4 to 1.8	-1.1 to 0.6	-1.5 to 0.2	-1.2 to 2.1
Average cl mm	M 15 F 20	12 19	12 17	14 16
Range of cl mm	M 8 - 31 F 9 - 28	12 - 14 14 - 23	11 - 16 12 - 27	9 - 24 7 - 24
Numbers examined	M 64 F 269	8 20	48 35	41 73

Table XXIX. Maturity of Argis dentata collected in Foxe Basin and Newfoundland in August and September.

cl mm	Males		Females		
			Non-ovigerous		Ovigerous
	Small vd	Large vd	Small ova	Large ova	Small ova
8, 9	3		1		
10, 11	1	7	1	1	
12, 13	1	24	6	0	
14, 15		9	12	0	
16, 17		1	3	1	
18, 19			4	3	
20, 21			2	3	3
22, 23			2	2	0
24, 25			1	0	2
26, 27				2	1
Totals	5	41	32	12	6
% probably breeding in autumn		89		36	

Crangon septemspinosus Say, 1818. Rathbun, 1904 and 1929.

This shrimp is medium in size. It is sandy grey in colour although occasionally darker and sometimes brownish. Three conspicuous dark spots occur on the abdomen just posterior to the flexure in the majority of specimens: one spot is found mid-dorsally on the 5th segment and the other two on each side of the mid-line of the 4th segment of the abdomen. The rostrum is short, forming an acuminate tip to the front of the carapace. There are 3 conspicuous spines on the carapace, one mid-dorsally and one on each side in the hepatic region.

Comparison of specimens of C. crangon from Northumberland with C. septemspinosus from Port au Port Bay, Newfoundland, reveals some minor morphological differences (Fig. 35). There is a somewhat variable difference in the shape of the antennal scales. The tip of the antennal scale is more frequently truncate than rounded in C. septemspinosus but I have not seen specimens as extreme as that figured by Rathbun (1904). Very few C. crangon were seen in which the antennal scale approached even the most rounded form achieved by C. septemspinosus. In any case, the apical spine of the scale in C. crangon is always shorter in comparison with that of C. septemspinosus which always exceeds the width of the distal end of the scale. Other constant but minor differences in the mouth parts give support to keeping the species separate. These are:

a. The 1st maxilliped in C. septemspinosus has 2 stout and long plumose setae laterally and just distal to the greatest width of the endopod. This is in addition to the many shorter and thinner ones. Below the joint of the endopod with the basis there are, laterally, about 5 plumose setae. In these positions C. crangon has but 1 stout and long plumose seta and about 9 setae, respectively.

b. The 2nd maxilliped has 4 stout spines along the outer edge of its distal part in C. septemspinosus while there are 5 such spines in C. crangon.

The east Atlantic populations of C. crangon extend from the White Sea to southern Europe (Wollebaek, 1908). There are none found in Greenland. They are, therefore, separated from the west Atlantic populations of C. septemspinosus which extend from east Florida to as far north as the northern part of the Gulf of St. Lawrence. Whitely (1948) gives Baffin Bay as the northern limit of this species without mentioning the source of his information: I consider this record to be doubtful. It is possible that this record is confused with the original record of specimens of Crangon septemcarinatus = Sabinea septemcarinatus (= Sabinea septemspinosa, Boone, 1930) collected in Baffin Bay by Sabine (1824). Rathbun (1904) reports C. septemspinosus from the northern Pacific.

Locally, C. septemspinosus is found in many sandy areas around the coast of Newfoundland particularly those with eel-grass (Zostera). Specimens were collected also from the Grand Banks and as far north as Notre Dame Bay on the east coast. Most specimens, however, were collected in the Gulf of St. Lawrence at Port au Port Bay (Fig. 34). Temperatures are widely variable in the shallow areas frequented by this species. They may reach at least 25°C in summer in Port au Port Bay (26°C was the highest temperature recorded at the sands in Port au Port Bay in 1962) but may fall in winter to below 0°C. This shrimp probably migrates away from shore in winter, but not necessarily out of Port au Port Bay. Meredith (1952) states that Crangon crangon which normally migrates offshore to escape low winter temperatures and low salinities, did not leave the Dee estuary even under severe winter conditions chiefly because salinities in this estuary remained high even in winter. In Port au Port Bay the salinities at the sands would be undoubtedly high in winter since only a small quantity of fresh water would be emptying into the bay in this area. C. septemspinosus was taken in Newfoundland at depths of 0-35 m.

No other shrimp species were present in the Zostera community investigated but the shore crab, Cancer irroratus, was occasionally present and the mysid, Mysis mixta, was schooling in considerable numbers and was taken in the hand-net hauls with C. septemspinosus. This mysid, M. mixta, was the chief food found in the stomachs of the shrimp and was often found whole. Amphipods, small gastropods (Littorina sp.) and small pelycopods also were common in the stomachs.

The mandibles of C. septemspinosus have no incisor process or palp. The molar process is divided into two major parts: the inner with 2 long and equal cusps and the outer also with 2 cusps but the superior one is much smaller than the other three. All are sharp pointed (Fig. 32).

The average size of the males in these samples was 4 mm (range 3-12 mm) and of females 5 mm (range 3-12 mm) in cl. Juveniles and megalops are not included in these length measurements (Fig. 36). Growth in a female specimen (9 mm in cl) kept at 10 to 19°C in an aquarium during October-April was 0.5 mm at each moult and it moulted about once a month. This growth increment was less than observed in a slightly larger specimen of C. crangon kept at the same room temperature and moulting also once a month; length of this specimen was 10 mm and the increment was 1.0 mm per moult. Summer temperatures were high at the sands in Port au Port Bay from June to September (approximately 8 to 25°C) and feeding was evidently adequate so that individuals must have moulted several times during the summer.

In Europe two and three annual spawning periods have been noted in C. crangon (Meredith, 1952). Spring and summer spawnings occurred in the Bristol Channel, in the Dee estuary and at Morecombe Bay. A resting period occurred from September to November in the latter areas and a few females were found to bear eggs in winter, but generally it was concluded that individual shrimp spawn twice in the year (Lloyd and Yonge, 1947; Meredith, 1952). Price (1962) working with C. septemspinosus in the west Atlantic, found winter temperatures of 0°C in Delaware Bay but up to 26°C in summer. None of his specimens were ovigerous in December or January but some were ovigerous in March to October. Eggs were, therefore, laid in early spring and at least one further batch was laid during the summer. Needler (1941) found that C. septemspinosus hatched its larvae from mid-June through July in the southern Gulf of St. Lawrence.

Samples of C. septemspinosus from Port au Port Bay taken from May to September indicate that some females produced at least two batches of eggs in this period (Fig. 36; Table XXX). The most important evidence for this supposition was that a few ovigerous females with embryos ready to hatch had large ova in the ovaries ready to be laid. Also large numbers of juveniles or megalops appeared in the samples in June and September but not in other months. It would appear, therefore, that the first batch of eggs was laid in late winter or early spring and the larvae hatched in May or early June. The second batch of eggs was probably laid in July and hatched in August. No females were ovigerous or had large ova in the autumn, suggesting that eggs are not carried in early winter. In May none were ovigerous but some were, by then, maturing to extrude eggs in June or July.

Table XXX. Maturity of female Crangon in samples from Port au Port Bay, Newfoundland, May-September, 1961, 1962.

	May	June	July	Aug.	Sept.
Megalops	0	0	0	0	176
Juveniles or immatures	14	65	23	0	186
Mature females	10	42	18	4	94
cl (mm) when first mature	4	4	5	6	5
% ovigerous	0	41	11	50	0
% of ovigerous with eyed embryos		41	50	0	
% of ovigerous with large ova		14	100	0	
% not ovigerous with large ova	21	19	10	0	0

Sclerocrangon boreas (Phipps, 1774). De Man, 1920; Squires, 1957.

This species is brown in colour and is chunky and rough-looking. Its antennal scales are wide and short. Its rostrum is short and flattened above with an acuminate tip and a rounded keel. The specimens show considerable variation: some fit the description given by Rathbun (1929), others are slightly more modified than those described from Ungava Bay (Squires, 1957) while still others have less modified structures and are intermediate between the two. The intermediates have a double central spine on the carapace but the posterior part is scarcely a protruberance. Similarly the branchiostegal spines are not as pronounced as those in the Ungava Bay specimens.

The distribution of this species is mainly in Arctic waters. It is found in the North Atlantic from Novaya Zemlya and Spitzbergen to the Norwegian coast north of the Arctic Circle, also in Iceland, east and west Greenland, Davis Strait, and from Baffin Island and Melville Island in the Canadian Arctic to Cape Cod. In the north Pacific it occurs from Behring Strait and Kilesnov to the Straits of Georgia, British Columbia. It is also in the Arctic Ocean from Siberia near Behring Strait to Point Barrow, Alaska. Depths recorded are 0-400 m (Heegaard, 1941).

In the northwest Atlantic S. boreas is distributed in Foxe Basin, Frobisher and Ungava Bays and from northern Labrador to the Grand Banks. It is also found off the southwest coast of Newfoundland and in the Gulf of St. Lawrence (Fig. 34). It was taken usually in shallow water from 12-140 m, and in low temperatures mostly from -1.4 to 0.6°C.

It was present in shallow water on the Grand Banks from catches which included Pandalus montagui, Sabinea septemcarinata, Argis dentata and Spirontocaris spinus. In comparatively deep water off Nachvak, Labrador, it occurred with Sabinea septemcarinata and several hippolytids of which Lebbeus polaris and Eualus fabricii were the most common. It was recorded from stomachs of cod (Gadus morhua) and the longhorn sculpin (Myoxocephalus octodecimspinosus).

Phytobenthos, polychaetes and crustacean fragments (gammarid amphipods, ostracods, isopods and copepods) were the most common in stomach contents of S. boreas. Small pelycopod shells, foraminiferans and ophiurans were occasionally present (Table XLIX).

The mandibles have no incisor process or palp. The molar process has two divisions with one large cusp each. The inner has a small pointed subsidiary cusp and the outer a subsidiary cusp which is modified as a long cutting edge (Fig. 32).

In comparatively deep water from Newfoundland and Labrador the lengths of the males and females were greater than those from the shallower waters of Foxe Basin, Ungava Bay and Newfoundland (Table XXXI).

Table XXXI. Lengths of Sclerocrangon boreas collected from different localities in the area from 1946-60.

Localities	Newfoundland	Newfoundland and Labrador	Foxe Basin	Ungava Bay
Depth m	75-105	105-140	12-110	18-91
Temp. °C	-0.3 to 1.2	-0.6 to 0.6	-1.5 to 3.8	1.9 to 2.1
Average cl mm	M F 21	18 27	13 19	16 22
Range of cl mm	M 19 F 15 - 26	8 - 24 11 - 35	3 - 15 5 - 28	8 - 24 7 - 28
Numbers examined	M 1 F 6	10 15	4 7	16 48

Table XXXII. Maturity of *Sclerocrangon boreas* collected in Foxe Basin and Labrador in August and September.

cl mm	Males	Females	
		Non-ovigerous	
	Large vd	Small ova	Large ova
5 - 10	1	1	
11 - 15	3	1	
16 - 20	2	3	
21 - 23	3	2	1
24 - 26	1	0	4
27 - 29		3	6
30 - 32		2	4
33 - 35			6[a]
Totals	10	12	21
% probably breeding in autumn	100	64	

[a]Two ovigerous and with small ova in ovaries.

In Foxe Basin and northern Labrador about 65% of the females would probably be ovigerous in late autumn. These appeared to mature late at a carapace length of 23 mm. The percentage potentially ovigerous indicates that they will spawn annually in these areas (Tables XXXII and LII).

Sclerocrangon ferox G. O. Sars, 1877. Blacker, 1957.

This large crangonid is similar in appearance to S. boreas except that its spines are longer and more numerous. It is brown in colour. Its rostrum is longer than in S. boreas and has a point directed forward and upward and a pointed blade below. The spines on the dorsal carina are high, there are long spines on the hepatic carinae and small spines occur below on the abdominal pleura.

S. ferox is found in deep water in the Arctic Ocean - in the East Siberian Sea - and in the eastern North Atlantic from the Kara Sea to the Shetland Islands. In the western North Atlantic it is taken from east Greenland and Baffin Bay to the eastern slope of the Grand Banks, including Ungava Bay to the north but at depths greater than 200 m. Its range of depth distribution is 90-1000 m.

In our surveys it was taken off the east coast of Baffin Island, in Hudson Strait, Ungava Bay and off Cape Mugford, Labrador (Fig. 34). Depths frequented were 275-735 m and temperatures -0.5 to 3.6°C (Fig. 7 and 8). The temperatures recorded are higher than those given for this species heretofore. Blacker (1957) records all temperatures below 1°C for this species in the Barents Sea.

Associated species were Pandalus borealis, Sabinea sarsi and Lebbeus polaris off Labrador (south of Cape Chidley) and P. montagui, Spirontocaris spinus and Lebbeus polaris in Ungava Bay (Fig. 6).

Phytobenthos, crustacean fragments (mostly of gammarid amphipods) and polychaetes were common in stomach contents. Ophiuroids, gastropods, pelycopods and sponge spicules were present only occasionally (Table XLIX).

The mandibles of this species are different from those of S. boreas, which has only two cusps forming the molar process. Four cusps almost equal in size make up the molar process. The outer inferior cusp which is slightly larger than the others, has a very small tooth at its base between it and the outer superior cusp (Fig. 37).

The average length of the males was 18 mm (range 15-24 m in cl) and the females 22 mm (range 12-31 mm in cl).

Table XXXIII. Maturity of *Sclerocrangon ferox* collected of northern Labrador and Baffin Island in August and September.

cl mm	Males	Females		
		Non-ovigerous		Ovigerous
	Large vd	Small ova	Large ova	Small ova
14		2		
15	3	2		
16	9	0		
17	19	2		
18	6[a]	9		
19	2	6		
20	2	1		
21	1	1	1	
22	0	3	1	
23	1	2	0	1
24	1	0	3	0
25		1	1	3
26			7	3
27			3	2
28 - 31			3	
Totals	44	29	19	9
% probably breeding in autumn	98	49		

[a]One with small vasa deferentia

Females did not mature until they reached a length of 21 mm. About 50% are probably ovigerous in autumn (Table XXXIII) and this is an indication of annual spawning if it takes this species three years to reach maturity (Table LII). In August almost half the ovigerous females had eggs with eyed embryos. If egg laying followed hatching of the larvae, it is possible that this species carried the eggs for an eleven month period. Egg diameter was 3.1 mm in this area.

Pontophilus norvegicus (M. Sars, 1861). De Man, 1920; Rathbun, 1929.

This smooth, brown shrimp is medium in size. In addition to the mid-dorsal carina (with 3 spines) there are two carinae (the upper with 2 spines and the lower with 1) on each side of the carapace. The rostrum is relatively long and narrow and has two small spines laterally near the base. The colour is brown with orange-red spots.

This species is found in the North Atlantic at Spitzbergen, northern and western Europe, Iceland, Greenland and from Labrador to Long Island.

It is locally distributed in deep water off the coast of Labrador, and in the southern part of the area, including Trinity Bay, the south-east edge of the Grand Bank, Hermitage Bay, the Southwest-Newfoundland Channel and in Cabot Strait (Fig. 38). Depths where this species was collected ranged from 225-660 m and the temperatures varied from 0.6 to 5.5°C (Fig. 7 and 8).

Other species present in catches with P. norvegicus were P. borealis, Sergestes arcticus, P. tarda and S. ferox.

Stomach contents included phytobenthos, crustaceans, polychaetes and foraminiferans. The large molar process of the mandible has two cusps only with no subsidiary teeth. A slight ridge or protruberance is present at the base of the outer cusp (Fig. 32).

The average length of the males was 11 mm (range 9-12 mm) and of the the females 14 mm (range 9-19 mm in cl).

The females first reached maturity at a length of 10 mm. From examination of the ovaries it appeared likely that about 90% of the females become ovigerous in the autumn (Table XXXIV). This high percentage suggests that the majority in these populations spawn annually. There were no ovigerous females in samples collected in June and July. The eggs were 1.3 mm in diameter, but one had eggs 1.8 mm in diameter in November.

Table XXXIV. Maturity of *Pontophilus norvegicus* collected in Newfoundland and Labrador from July-December.

cl mm	Males: Small vd	Males: Large vd	Females, Non-ovigerous: Small ova	Females, Non-ovigerous: Large ova	Females, Ovigerous: Small ova
9		2	1		
10	1	0	0	1	
11	3	1	0	1	
12	1	2	2	11	2
13			1	11	0
14			3	12	1
15				16	1
16				11	0
17				3	1
18				1	
Totals	5	5	7	67	5
% probably breeding in autumn		50		91	

DECAPODA PALINURA

Family: POLYCHELIDAE

Stereomastic sculpta (Smith, 1880). Selbie, 1914; Sivertsen and Holthuis, 1956.

This species is stocky, with a large flattened carapace, elliptical in shape, which is about as long as the dorso-ventrally flattened abdomen. The carapace is fringed with a spinous ridge, the spines forming three groups according to the divisions of the edge and number 6, 3 and 7 from the anterior to the posterior end. The mid-dorsal carina of the carapace has a pattern of spines usually in the order 2, 1, 2, 1, 2, 2, 2 from front to back. The eyes are not visible and are vestigial in this species.

S. sculpta is found from south of Iceland to the West Indies in the west Atlantic and from Iceland to the Cape Verde Islands and Angola in the east Atlantic. In the Indian Ocean it is known from the Arabian Sea and the Malay Archipelago. Depths recorded are 380-2865 m (Sivertsen and Holthuis, 1956).

It was collected on the south and southwestern slopes of the Grand Bank, in the Green Bank Gully and on the slope off Emerald Bank (Nova Scotian Shelf). Depths ranged from 420-810 m and temperatures from 4.1 to 4.5°C.

Associated species of decapods were Nematocarcinus ensifer and Polycheles granulatus.

Fish, euphausiids, polychaetes and foraminiferans were present in the stomachs.

The mandibles have no molar process. The incisor process is a large curved blade with saw-like teeth. There are 4 main teeth, the largest at the centre forming an apex with 4 smaller descending toward the outer edge where there is another large tooth. On the other side of the centre tooth there is a descending row of 3 teeth to a "V" notch followed by an ascending row of 3 more teeth to a 3rd large tooth. The 4th large tooth is separated from the 3rd by 2 small teeth and there are 2 other small teeth at the inner corner of the incisor (Fig. 37).

The average length of the males was 41 mm (range 33-47 mm) and of the females 54 mm (range 48-60 mm).

Most females were ovigerous in May and in October and November. About half those ovigerous had large ova in spring and autumn suggesting annual breeding in mature individuals. One female had eggs with advanced embryos in May. The egg diameter is 0.8 mm.

Polycheles granulatus Faxon, 1893. Selbie, 1914.

This species resembles Stereomastis sculpta very closely. The spinous lateral fringe of the large flattened carapace has a row of spines in the order 14, 3 and 7, but varied from 11, 3 and 6 to 15, 3 and 9 in our specimens, and are often different on both sides of the same carapace. The mid-dorsal carina has small spines which are scattered in no definite order.

P. granulatus is found in the Atlantic, at the Azores, Cape Verde Islands, coast of Spain, Ireland and Newfoundland. In the Pacific it is recorded from the Gulf of Panama and the Hawaiian Islands, and in the Indian Ocean off Colombo (Selbie, 1914).

The present specimens were collected near the southwest slope of the Grand Bank and off the Nova Scotian Shelf (Cape Roseway) (Fig. 38). The depths where taken were 350-440 m and the temperature 4.5°C.

The only decapod present in the catch with this species was Stereomastis sculpta.

Fish bones and sponge spicules were found in one stomach.

The mandibles are similar to those of S. sculpta (Fig. 37). There are 4 large teeth forming the incisor process. The tooth occupying the central position forms an apex. On one side 4 smaller teeth descend to a large tooth at the anterior corner of the incisor. On the other side of the central tooth there is an accessory tooth about half way from its tip to its base, and this is followed by 5 small teeth forming an arc to join the other 2 large teeth. There are no teeth between the latter as is found in S. sculpta and they are followed by a smaller pointed tooth at the posterior corner of the incisor process.

The two specimens obtained were both 46 mm in cl and 102 and 104 mm in total length. Both were ovigerous when collected in May and November. The eggs were 0.9 mm in diameter but had advanced embryos. The one taken in November had large ova (0.7 mm in diameter) so would possibly spawn in late autumn or early spring when the larvae had hatched.

DECAPODA ASTACURA

Family: HOMARIDAE

Homarus americanus H. Milne-Edwards, 1837. Rathbun, 1929.

The American lobster is the largest decapod crustacean in the area of investigation. In colour it is a glossy dark or bluish green with a reddish-orange background which shows in varying intensities at the edges of the abdominal pleurae, telson, uropods and ends of legs or claws. There is considerable mottling on abdomen and legs. The antennae and antennules are red. The colour of the European lobster (H. gammarus) makes it quite different in appearance from the American lobster. It has no green or orange-red in its colour but blue and pale orange and its surface texture is more finely granulated, giving it a somewhat duller finish than the American lobster. Also, the large chelae of H. gammarus are very light in colour underneath while in H. americanus they are only slightly lighter in colour than above. Generally H. gammarus is much darker in colour dorsally than H. americanus because of the predominant blue rather than green, and the lighter colour present below is largely a yellow-orange rather than a red-orange as in H. americanus.

The American lobster is found in the west Atlantic only, from North Carolina to the Strait of Belle Isle. It is common in all Newfoundland coastal areas. Depths frequented usually vary from a few metres to about 50 m in coastal areas. The deep sea populations on the outer slopes of Georges and the Nova Scotian Banks where sampled was at 135-230 m in the "A.T. Cameron" surveys and 90-480 m in the Woods Hole Oceanographic Institution investigations. Occasional lobsters have also been taken on St. Pierre and the Grand Banks at depths of 44-165 m (Schroeder, 1959) (Fig. 38). The "A.T. Cameron's" catches off Nova Scotia were of quite large lobsters averaging 6 lb (2.7 kg) for the 22 specimens captured. In the Georges Bank area the size range is much greater although the majority of specimens are large.

ECOLOGY. The lobster is primarily a sedentary animal (although mass swimming movements ("between two waters") have been observed occasionally according to reports by reliable fishermen. Schooling might be initiated in this species by the attainment of threshold numbers as it is in fish and probably in shrimps. (The threshold numbers in fish causing schooling was suggested as possibly applicable to shrimp by Dr. H. O. Bull in a personal communication). The lobster generally occupies a depression which it excavates in the bottom or one already available under stones (Wilder, 1959). That it occupies and defends "territory" was demonstrated by lobsters held in a small aquarium in a preliminary study of lobster behaviour in 1962. Also it became apparent that territory was yielded to individuals which were more dominant than the others. Only two were brought together at a time but a hierarchy could be worked out for the seven females of about the same size which were used (Squires, 1965). This has some consequence for tagged lobsters released on unfamiliar ground, since their occupation of new "homes" may in part be conditioned by the factor of dominance among individuals and that the newcomer will not always be at a disadvantage.

The following commensals were observed: Unicalteutha ovalis, a small harpacticoid copepod, was present on the claws or legs of almost all the lobsters examined. The bryozoan, Alcyonidium sp. soon settled on moulted lobsters and achieved considerable growth over claws, antennae, etc. Hydroids, Spirorbis sp., Balanus sp. and occasionally Anomia sp. were common on lobsters with shells of a year old (more or less) in Port au Port Bay (See also Dexter, 1955).

Larval lobsters are under predation by fish and probably by seabirds (but see Mills, 1956). As Stage I and II larvae they are positvely phototropic and spend some time near the sea surface during daylight (Templeman and Tibbo, 1945), where they may be taken with a plankton net towed at the surface. In August and September, 1962, the author towed a 50 cm diameter No. 000 mesh plankton net at the sea-surface daily, whenever possible, at stations distributed over Port au Port Bay in order to determine the distribution of early stage larvae in the surface currents of the bay. Although this work was of a preliminary nature, the results indicate that the larvae maintained a near-shore position (not exactly determined but between 100 and 200 m from the shore) in spite of surface currents, although subject to some drift. During severe onshore storms the breakers were repeatedly swept with a small-mesh hand net to determine whether the larvae or other zooplankton would drift ashore. Although minute inanimate flotsam and jetsam are continuously brought to shore and stranded by the onshore currents, zooplankton including lobster larvae did not drift ashore. As soon as the storms abated the waves receded quickly in this small bay and the near-shore zone was sampled with the plankton net as soon as possible. Considerable numbers of lobster larvae and zooplankton including the copepod Centropages were present invariably, after these onshore winds. Also, when winds were offshore, lobster larvae were found in the near-shore zone although in smaller numbers. Larvae were taken relatively infrequently over the deeper water of the bay. It is suggested that lobster larvae are not necessarily at the mercy of surface currents (Templeman and Tibbo, 1945) but can maintain position by moving up or down in the water column and taking advantage of counter-currents near the bottom.

The lobster would appear to be subject to few parasites or disease organisms. However, a blood disease, Gaffkaemia, has been demonstrated in the lobster populations of Nova Scotia by Stewart and Macdonald (1962). It is believed that unusual mortalities are not caused by Gaffkya homari in the population at large, but it has been shown (McLeese and Wilder, 1964) that it may be an important causative agent for deaths in lobsters when held in large numbers in storage tanks at comparatively high temperatures. Sampling the healthy population at large in Port au Port Bay during May to August in 1961 and 1962 has shown that the disease organism is most likely not present in this bay. /The ordinary methods of bacteriological technique were used but are not described here. Human blood agar plates were used to culture the lobster blood smears in 1961 and sodium-azide-dextrose broth in 1962. Slides of lobster blood smears stained in Gram's Stain were also made in 1962/. In general, a natural immunity may be present in populations which have this organism present. If these should be stored with non-immune lobsters the possibility of infection and mortality is enhanced. A knowledge of the natural incidence of Gaffkya in each area is therefore desirable in order that non-immune stock may be stored separately.

The stomachs of lobsters obtained in special fishing contained the following: Littorina sp., Cancer irroratus, fish bones, polychaete remains (including large polychaete jaws, etc.), opercula of whelks and whelk remains, small lobster or crab, hermit crab, small pelycopod shells Patella shell, Mytilus, brittle stars, small sea stars, sea cumber and occasional pieces of Chondrus crispus and kelp.

The mandibles are very massive. The molar process is sub-triangular in shape and about half as long as the width of the incisor process. The incisor is slightly curved and has a thick corneous biting or crushing edge which has undulations at the outer end of the left which fit those of the right incisor. The palp is in three sections. The distal section is an expanded blade about equal in length to the middle section while the proximal section is only about one-third the length of the others. The distal section has a wide fringe of bristles on the outer surface and long setae on the inner. There is also a fringe of setae on the outer edge of the middle section (Fig. 37).

SIZE, EXPLOITATION AND GROWTH. The average size of lobsters in commercially exploited populations may be considerably different from place to place around the Newfoundland coast (Templeman and Tibbo, 1945). Important factors governing these size differences are the varying rate of growth of the lobsters in different areas and the equally varying rate of exploitation of these populations. In Port au Port Bay the average carapace length of males and females was 90 mm and 87 mm in 1961, and 92 mm and 90 mm, respectively, in 1962. These were measured from samples caught in commercial traps which are designed to catch lobsters larger than 81 mm in cl. If exploitation rates and growth rates were unchanged from year to year, average sizes could be expected to remain approximately the same in a given area. However, as indicated by Templeman (1948) and Wilder (1953) growth rates vary according to the temperature of the environment. Perhaps, therefore, growth would vary slightly from year to year according to prevailing temperatures. In Port au Port Bay from 1961-1963 temperatures at the lobster grounds followed a regieme of approximately 0°C during January, 3°C in April, to 14°C in August, 6°C in October and 3°C in December.

About 1200 lobsters, male and female, were marked in Port au Port Bay in 1962 by punching holes in the tail fan (holes punched in two appendages at a time gave 10 combinations, each of which were coded to represent a length group of 3 mm in range). These were released at the end of the lobster fishing season in July just preceding ecdysis. One hundred and fourteen of those which had moulted were recognized and re-measured in 1963 during the fishery. The average gain in carapace length of males varied from 9.3 (at 77 mm) to 11.7 mm (at 102 mm), and of females 8.4 (at 77 mm) to 9.5 mm (at 100 mm). Age and growth have been observed in hatchery-grown lobsters (Hughes and Mathiessen, 1962) and have been estimated from lobsters marked and released in their natural environment (Wilder, 1953). From Wilder's estimates of growth of lobsters released in Northumberland Strait, lobsters of 81 mm in cl would be 6 years old and lobsters of 100 mm in cl would be 8 years old. In hatchery-grown lobsters these sizes would be 5 and 7 years of age respectively. Since both groups of lobsters were growing in relatively higher temperatures than usually found in Newfoundland, lobsters in this area would be somewhat older at the sizes mentioned. There are but two years of a lobster's life with which the fishery is mainly concerned when the legal minimum size is set at 81 mm in cl. Recruitment and exploitation may be estimated at these sizes and ages when we have a knowledge of the rate of growth in the population under study. A method of doing this is as follows.

A general recruitment curve may be drawn to show the large numbers of post-larval lobsters which rapidly decrease in number until a critical size of young settling lobsters is reached. After this size, decrease in numbers is more gradual until the lobsters become large enough to enter the fishery (curve B in Fig. 56 I). The decrease in the number under exploitation is represented by curve C, and curve A shows accumulation of lobsters at larger sizes in an unfished population since moulting at large sizes may not be annual.

The curves of Figure 56 I are superimposed on a histogram of lengths of lobsters taken in the Port au Port Bay fishery (Fig. 56 II) without relation to the actual percentages of the histogram. Superimposing also the above data on the annual average length increment, the actual recruitment to the fishable lobster population can be envisaged. When a sufficient number of lobsters in the annual catch is measured, the proportion of lobsters representing one year and two years of growth past the legal minimum size can be calculated. In our data from Port au Port Bay the proportion of 1st year recruits fished was 58% of the sample total in 1962 (Fig. 56 II). Tagging (a metal tag was fastened to the carapace with a rubber band as described by Wilder (1953) and the lobsters were released at the beginning of the fishery) and recapture results indicated an exploitation rate of about 50% during 1962. Expected error in small numbers used as well as tagging mortalities could account for the discrepancy. Determination of exploitation rates by this method will work if recruitment is relatively constant, or if the rates of growth will not vary greatly from year to year. Growth may be the greater factor in recruitment since initial larval year-success may be affected by the self-regulation of numbers imposed by the social orientation of this animal. Overfishing would show as an increased proportion of 1st year recruits appearing in the catch in the following year.

Maturity. It has been observed by various authors (Dawson, 1954) that the American lobster carries eggs for 11 months and that egg laying in individuals occurs only in alternate years. Measurements of ova indicate that females carrying eggs ready to hatch will not lay eggs until the following year. Non-ovigerous females with large ova ready to be laid comprised about 60% of the mature females, a much higher percentage than the ovigerous females found in catches the following spring (Table XXXV). The ovigerous lobsters may not trap so readily as the non-ovigerous ones (Templeman and Tibbo, 1945).

Table XXXV. Maturity of sexual products in female *Homarus americanus* during June-July, 1961 and 1962, from samples caught in lobster traps at Boswarlos, Port au Port Bay. All specimens are larger than the length at first maturity.

	1961		1962		1963	
	June	July	June	July	June	July
Numbers examined	79	57	39	35	46	85
% with small ova[a]	9	12	23	49	11	47
% with large ova[a]	84	74	49	40	61	29
% ovigerous	8	14	28	26	28	24

[a]Non-ovigerous

DECAPODA ANOMURA

Family: GALATHEIDAE

Munida tenuimana G. O. Sars, 1871. Hansen, 1908; Selbie, 1914.

This decapod is greyish pink in colour and has three long and sharp frontal spines. It is small but lobster-like in appearance since it is flattened dorso-ventrally. It has a sub-cylindrical carapace which is rough in appearance and has scale-like imbricate ridges. The abdomen is slightly longer than the carapace. The sternal plates are smooth and not ridged as in *M. bamffica*.

It is reported from the Adriatic and North Africa, southwest of Ireland, off Norway, Iceland and Greenland, and from Davis Strait to the Grand Banks.

It was collected from east of Baffin Island, in Davis Strait, off Labrador (Makkovik) and east of the Grand Bank in depths from 440-650 m and temperatures of 3.5 to 4.4°C (Fig. 40).

Lebbeus polaris, *Pasiphaea tarda*, *Pandalus propinquus* and *Pontophilus norvegicus* were present in catches with this species (Fig. 6).

Most stomachs were empty but sponge spicules and a pycnogonid were found in one stomach.

The molar process is comparatively small and lies behind the large curved blade of the incisor process. It is subtriangular in surface outline and has three rounded cusps along the outer edge and seven small pointed cusps along the inner edge. The incisor process is separated from the molar by a shallow notch. Its large blade has a rounded tooth near the centre and a small pointed tooth at the outer corner. The palp has three sections. The proximal section is longer than the middle section and together they are about equal in length to the distal section. On the outside and terminally the distal section is fringed with a double row of short setae (Fig. 41).

The size of the male was 21 mm in cl, and the average size of the females was 24 mm in cl (range 21-31 mm).

Munidopsis curvirostra Whiteaves, 1874. Selbie, 1914; Rathbun, 1929.

This species is rough in appearance, greyish white in colour and with a long, curved and slightly flattened spine-like rostrum. The carapace is flattened somewhat and measures about one-third the total length of the animal: it is usually shorter than the chelipeds. The arrangement of the mid-dorsal spines on the carapace varies. Most of those caught had spines grouped in the order 2, 1, 1, 1, 1 but occasionally a grouping of 2, 1, 1, 2, 2 was found.

This species has been found in the North Atlantic only, from northwest Africa, the British Isles, Iceland, Greenland and as far south as North Carolina in America. Depths 135-2360 m.

Its local distribution was east of Baffin Island, in Hermitage Bay, in the Gulf of St. Lawrence and off the Nova Scotian Shelf (Fig. 40). It was taken in depths from 245-770 m and at temperatures of 1.5 to 3.6°C (Fig. 7 and 8).

Decapod species also in the catches were Pandalus propinquus, Acanthephyra pelagica, Pandalus borealis, Sabinea sarsi and Lebbeus polaris (Fig. 6).

In the stomach contents, phytobenthos, foraminiferans and crustaceans were frequent in occurrence. Polychaetes and small pelycopod shells were occasionally present.

The mandibles are similar to those of Munida (Fig. 44), but the molar process is comparatively larger in Munidopsis. The centre tooth of the incisor process is smaller and the outer corner of the incisor is without a tooth.

Males and females both averaged 11 mm in cl and the ranges of carapace lengths were 8-12 mm and 5-15 mm, respectively.

Most females were ovigerous in March and one out of the two females caught in August. All the ovigerous and large non-ovigerous females had large ova in the ovaries. They were ovigerous for the first time at a length of 9 mm. Eggs were 1.5 mm in diameter. Males were first mature (carrying spermatophores) at 8 mm in cl.

Tribe: THALLASSINIDEA

Family: AXIIDAE

Calocaris templemani, H. J. Squires, 1965.

This small pink decapod has 2 carinae with 3 spines each forming the arm of a "V" on the front of the carapace and coming close at the front to form a short pointed rostrum with 4 or 5 spines on each side. A low mid-dorsal carina extends the full length of the carapace and continues well out on the rostrum (Fig. 41 A). The eyes have no dark pigment and the chelae are large as in C. macandreae which it resembles closely (Table XXXVI). There is a relatively large open notch posteriorly on the sternal plate of the 3rd pair of pereiopods; 2 dorsal carinae on the telson have only rudimentary or small spines; the outside edge of the outer uropods has only 4 spinules, and the outside edge of the inner uropod has 3 spinules (Fig. 41 D).

The maxillae and maxillipeds are quite similar in C. macandreae to those of C. templemani except that the second maxilla has no distal seta-like projection on the scaphognathite. Its mouth parts are shown in Figure 42 and are described as follows:

The mandibles are large and heavily calcified. The incisor process has an almost entire and regular edge, is slightly curved and has one small tooth at the inner end. It is separated at the inner end by a shallow notch from the large molar process which has a slightly hollowed elliptical surface for grinding. The palp is 3-sectioned. The distal section is about equal in length to the other two, half the outer edge is fringed with bristles and there is a tuft of long bristles proximally (Fig. 43, Mnd).

First maxilla. Precoxa and coxa are half as long as the basis and have a few setae. The basis has short stout bristles on the ventro-distal edge and a fringe of setae laterally. The endopod is in two parts: the proximal part has a few setae to the inside and the distal part which is recurved, has 2 plumose setae to the inside of the bend and distally 2 simple setae (Fig. 42, Mx_1).

Second maxilla. The precoxa is short and wide; the coxa, which is bilobed, has a triple fringe of setae on the large proximal lobe; the central fringe is on the pointed edge of the lobe and the other two originate at about one-third the length from its base and form an arc toward its apex on both the outside and inside of the lobe. The smaller lobe has a setal fringe which is longest at its tip. There is a setal fringe also on the edges of both lobes of the basis which is attached to the coxa. The endopod which is attached to the basis and coxa has a few long setae, most of them distal and to the inside. The exopod is attached to the basis and precoxa. It has a fringe of plumose setae the longest of which are distal. It has a triangular extension proximally, the scaphognathite, which also has a fringe of plumose setae (Fig. 42, Mx_2).

Table XXXVI. Comparison of *Calocaris macandreae* from off the coast of Northumberland, England, and *C. templemani* from Hermitage Bay, Newfoundland (Fig. 41 and 42)

Calocaris macandreae	*Calocaris templemani*
1. Rostrum with point turning upward and with one spine at each side proximally + 3 on each rostral-carapacial carina	1. Rostrum with point directed downward, 5 spines on the left and 4 on the right side of rostrum + 3 on each rostral-carapacial carina
2. Mid-dorsal carina begins on the carapace anteriorly and extends the full length of the carapace with one interruption at the cephalo-thoracic groove	2. Mid-dorsal carina begins well out on the rostrum anteriorly and extends the full length of the carapace with one interruption at the cephalo-thoracic groove
3. Rudimentary eye with a flat oblique surface facing sideways and foreward, with the anterior edge rounded	3. Rudimentary eye with a flat oblique surface facing sideways and forward but with the anterior edge not rounded and almost rectilinear
4. Antennal spine on carapace small and directed forward	4. Antennal spine on carapace large and directed forward and outward
5. Telson rounded posteriorly but with a shallow cleft in which there is a spine	5. Telson rounded posteriorly and with a very shallow depression but without a spine
6. Telson carinae have 7 strong spines each and directed posteriorly	6. Telson carinae have 3 very small low spinules each
7. Proximally the edge of the telson has a lateral expansion and 2 strong spines directed posteriorly on each side	7. Proximally the edge of the telson has a lateral expansion with 1 spine only directed posteriorly on each side

Table XXXVI (cont.)

Calocaris macandreae	Calocaris templemani
8. Following the lateral expansion at the edge of the telson there are 4 equidistant spines on each side and a continuous fringe of long plumose setae	8. Following the lateral expansion at the edge of the telson there are 6 equidistant spines on each side and a continuous fringe of long plumose setae
9. The outer uropods have 5 spines on the outside edge, and the inner uropods only 2 spines, the distal of which in each case is longer and heavier than the others	9. The outer uropods have but 3 small spines outside plus a short pointed distal spine, and the inner uropods have 3 small similar spines each on the outside edge
10. The 3rd sternite has a narrow groove posteriorly which extends to a little more half the length of the sternal plate	10. The 3rd sternite has a wide notch posteriorly and extending into the sternal plate about one-third of its length

First maxilliped. The precoxa is short and wide with the exopod and endopod attached distally, a double epipod attached laterally, outside, and the coxa attached laterally, inside. The coxa and basis both have an inner fringe of setae: the coxa is small and supports the basis. The endopod is slender and is divided into two parts which are equal in length and have a few setae. The exopod is longer than the endopod and has a finger-like projection at the tip with a long apical seta. It also has a short fringe of long plumose setae outside and distally while on the inside there is a fringe of simple setae. The epipod is bilobed, and the posterior extension which has skeletal support, acts as a scaphognathite. It has a shallow mid-fork distally while the anterior extension is rounded (Fig. 42, Mp_1).

Second maxilliped. The coxa is large and somewhat irregular in shape. The basis is short, wedge-shaped and crowded under the ischium which is about one-quarter the length of the merus. The carpus forms the permanent ventral flexure of the endopod, the propodus is flat and wide and the dactyl small, flat and triangular in shape. Also attached to the coxa are the exopod, a triangular shaped epipod and 2 podobranchs. The exopod for about one-quarter of its length is without a joint but this is followed by 16 short sections, or 15 annulations, with many lateral and terminal plumose setae (Fig. 42, Mp_2).

Third maxilliped. This is very much larger than the second maxilliped. It has profuse long setae along the inner side of the endopod and terminally, and has an exopod. The coxa and basis are closely coalesced and bear the large endopod and exopod as well as the epipod and 2 podobranchs. Both bear short stout spines on the inner side and short plumose setae. Outside, the large triangular-shaped epipod has skeletal stiffening and an arcuate base with long setae opposite to where the podobranch coalesces with it. The ischium of the endopod is triangular in cross-section and has twelve strong pointed teeth on the inner edge forming a gnathobase. The exopod has an annulated flagellum about one and one half times the length of its basal section (Fig. 42, Mp_3).

The distribution of this species appears to be confined to the West Atlantic from the Gulf of St. Lawrence and southern Newfoundland to the Gulf of Maine. [Specimens from the Gulf of Maine have been sent to me by Dr. R. L. Wigley of the Fish and Wildlife Service, Woods Hole, Mass.]

As in C. macandreae, this species is hermaphroditic. It had large ova, 1.3 mm in diameter. The spermatophores were ready to be released and some had already been extruded and were attached to spermatophore ribbons at the male openings.

The stomach contents consisted of phytobenthos, small pelycopod shell fragments, a polychaete jaw and foraminiferans.

The type locality is Hermitage Bay, Newfoundland.

The holotype, 14 mm in carapace length, 44 mm in total length, is sexually mature. It is deposited in the National Museum of Canada, Catalogue No. 5757.

The date of capture was 13 August, 1960.

The depth was 260 m and temperature 4.9°C. The bottom was of soft mud as shown by mud on the trawl and doors.

Family: PAGURIDAE

Pagurus acadianus Benedict, 1901. Rathbun, 1929.

This hermit crab has red to brownish markings on an off-white or pinkish background. Its chelae are similar in appearance although the left is smaller. The dorsal aspect of both chelae is rounded, spinulose and without the prominent grooves of *P. bernhardus* or any fixed pattern of spinules. *P. bernhardus* has a "V" of spinules on the right propodus dorsally. The inner ridge on the left propodus at the insertion of the dactyl, has three irregular rows of spinules not two regular rows as in *P. bernhardus*.

P. acadianus is found in the west Atlantic only. It has been identified as *P. bernhardus* occasionally (Boone, 1930), but the latter is confined to the east Atlantic and does not occur in Greenland. *P. acadianus* is found from the Strait of Belle Isle to Chesapeake Bay.

Locally it was found in coastal areas of Newfoundland from Notre Dame Bay to the Gulf of St. Lawrence, and on the Nova Scotian Banks (Fig. 40). The only temperature recorded where this species was taken was 0.7°C but may be as high as 20°C in coastal waters where this species is found near the shore. Depths varied from low water mark to 48 m. Most specimens seen had been collected near the shore by fishermen. They were usually in shells of *Buccinum* sp. and *Lunatia* sp.

The food observed in stomachs was mostly fish offal. Crustacean fragments and foraminiferans were occasionally present and a piece of purple shell, probably *Mytilus* shell, was found in one.

The mandibles are typically pagurid (Fig. 44). The teeth on the incisor process are low and rounded and the molar surface is almost as long as the width of the incisor process. The palp is two-sectioned, with a tuft of setae at the outer distal edge of the proximal section, and a brush of setae on the distal section.

Pagurus pubescens Krøyer, 1838. Squires, 1963b.

" krøyeri Stimpson, 1859. Rathbun, 1929; Squires, 1957.

This hermit crab is light red in colour when small but pale pink with red markings when large. Its left chela is smaller than the right and has a sharp spinous ridge dividing the upper surface into two facets. The larger outer facet is triangular in shape and flat or somewhat concave. The chelae are more or less pubescent. The anterior division of the 3rd sternite is a flattened and irregular semicircle in outline with a fringe of setae of medium length.

P. pubescens is found only in the North Atlantic and not in the North Pacific (Dr. J.F.L. Hart and Miss Patsy McLauglin, personal communication). It is recorded from the British Isles and northward to the Barents Sea, Iceland, East Greenland to 70°N Latitude, West Greenland to 73°N, the Queen Elizabeth Islands as far north as Cornwallis Island, east of Baffin Island in Frobisher Bay, in Foxe Basin, Hudson Bay and Strait, and from Labrador to Stellwagen's Bank off the New England coast in deep water. Depths recorded are 3-550 m.

It was collected throughout the area in moderate depths but in greater numbers to the north: over 1000 specimens were collected in Foxe Basin compared with 150 specimens from Labrador and southward. Trawling was carried out in relatively shallower water in Foxe Basin than elsewhere in this area (Fig. 45). Depths were 10-110 m in Foxe Basin and 42-460 m off Newfoundland and Labrador (Fig. 8). Temperatures varied from -1.6 to 4.6°C.

About twelve species of decapods occurred in catches with P. pubescens throughout the area. The five species in greatest number and frequency were Eualus gaimardi, Lebbeus polaris, Sabinea septemcarinata, Spirontocaris spinus and S. phippsi in Foxe Basin; and Pandalus borealis, S. septemcarinata, P. montagui, L. polaris and Hyas coarctatus off Baffin Island and Labrador (Fig. 6). On the Grand Banks P. pubescens frequently occurred with P. arcuatus. Infestation with Peltogaster paguri occurred in 15% of the specimens off Labrador but did not occur elsewhere in the area. Gastropod shells used by this species were usually Buccinum, but Neptunea, Colus, Lunatia and Thais were also used occasionally.

Food consisted mostly of phytobenthos, foraminiferans and crustacean fragments (amphipods and ostracods), and fragments of pelycopod shells, ophiurans, polychaetes and hydroids were also commonly present in stomachs. Small gastropods were found occasionally (Table XLIX).

The average whole length[e] of the carapace in males collected was 17 mm and in females 14 mm from Newfoundland and Labrador, but 14 and 11 mm, respectively, from Foxe Basin (Table XXXVII).

Females were first mature at a size of 7 mm in cl in Foxe Basin and 6 mm in cl from Labrador. Examination of the ovaries suggests that about 50% of the females would be ovigerous in the autumn in deep water off Labrador. But in Foxe Basin 75% would be ovigerous (Table XXXVIII). It appears, therefore, that the majority of the females of this species spawns annually in Foxe Basin and biennially off Labrador (Table XLIV). Eyed embryos were found in spring only: the eggs are probably laid in autumn. Egg diameters averaged 1.0 mm (0.8-1.2 mm). Spermatophores of the males were frequently seen adhering to the abdomen near the genital opening on the basis of the 5th pereiopod, and in mature males could be extruded artificially by applying pressure to the basis. Males were first mature at a carapace length of 7 mm in Foxe Basin and 10 mm off Newfoundland and Labrador.

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[e] The equation for conversion of whole carapace length to carapace length from the posterior rim of the eye socket to the cervical groove (the calcified portion of the carapace) is:

$$y = 1.6x + 0.2$$

where y = whole carapace length, and x = carapace length to cervical groove (Fig. 44 A).

Table XXXVII. Lengths of *Pagurus pubescens* collected from different localities in the area during 1946-60.

Localities	Newfoundland and Labrador	Foxe Basin	Ungava Bay
Depth m	40-460	10-110	15-275
Temp. °C	-1.6 to 4.6	-1.5 to 3.8	-1.2 to 3.1
Average cl[a] mm	M 17 F 14	14 11	13 11
Range of cl[a] mm	M 9 - 27 F 9 - 21	3 - 28 6 - 20	6 - 24 4 - 21
Numbers examined	M 109 F 45	73 46	27 32

[a]Whole carapace length, from posterior rim of eyesocket to depression at the posterior end of the soft part of the carapace

Table XXXVIII. Maturity of *Pagurus pubescens* collected in Foxe Basin, Newfoundland, and Labrador during August-September, 1947-60.

cl mm	Foxe Basin				Newfoundland, Labrador		
	Males	Females			Females		
		Non-ovigerous		Ovigerous	Non-ovigerous		Ovigerous
	Large vd	Small ova	Large ova	Small ova	Small ova	Large ova	Small ova
6		5					
7	1	1	1				
8	2[a]	0	4				
9	3[b]	1	1		1		
10	6	4	4	2	2		1
11	10	2	0	1	3		1
12	7	1	1	1	1		1
13	2	1	2	0	1	3	0
14	5		5	0	1	1	0
15	5		4	0	1	2	0
16	4		1	1	1		0
17	3		1	1			2
18 - 20	6		1	1			
21 - 25	9						
26 - 28	2						
Totals	65	15	25	7	11	6	5
% probably breeding in autumn		68			50		

[a] One with small vasa deferentia   [b] Two with small vd

Pagurus arcuatus H. J. Squires, March, 1964.

" bankensis K. N. Nesis, May, 1964.

" pubescens (not of Krøyer), Rathbun, 1929.

This hermit crab resembles P. pubescens (Krøyer) but its left chela is more narrow. The carina separating the facets of this chela is formed proximally by a double row of spines, and the larger facet is not flat but somewhat rounded or convex. The chelae are pubescent to a variable extent in individuals and are probably more pubescent than in P. pubescens. The anterior division of the 3rd sternite forms a full semicircle in outline (although slightly skewed to the right) and has a fringe of long setae.

P. arcuatus is found in the western Atlantic only and its distribution extends from the Grand Banks and the Gulf of St. Lawrence to Cape Hatteras on the New England coast. A specimen from Spotted Islands, Labrador, was sent to me in February, 1964, by Mr. John Webber who had caught it in a trap set for periwinkles in a depth of 12 feet in the harbour.

The majority of specimens were collected on the Grand Banks, mostly on the Southeast Shoal but also on St. Pierre Bank and Green Bank. A few were also taken on the Nova Scotian Banks (Fig. 45). Water temperatures where it was taken varied from 1.0 to 4.6°C except for 2 specimens from a station on the Grand Bank at -0.1°C. Depths ranged from 44-135 m.

P. pubescens (Krøyer) was only occasionally present in catches with this species. Other decapods commonly present were Spirontocaris spinus, Lebbeus polaris, L. groenlandicus and Pandalus montagui (Fig. 6). Only 1.4% were infested with Peltogaster paguri. Most specimens were in shells of Buccinum but a few in shells of Colus, Neptunea and Lunatia. Podoceropsis sp. males and females together were frequently found in the shells with this species.

The stomachs of this species frequently contained phytobenthos, foraminiferans, small pelycopod shells and crustacean fragments. Small gastropods, hydroids and ophiuroids were less common (Table XLIX).

The mandibles are similar to those of P. pubescens (Fig. 44) but the edge of the incisor process is entire (no teeth are present but this may have been the result of wear) and it appears to be thicker in cross section. The distal section of the palp has more and heavier setae than in P. pubescens.

The average length of the males was 16 mm (range 3-20 mm in total carapace length[f]) and the females 11 mm (range 3-17 mm)

The eggs were 0.8 mm in diameter, which is somewhat smaller than those of P. pubescens. From examination of the ovaries it is probable that only 20% of the females would be ovigerous in autumn but the numbers examined were too small to give definite conclusions about breeding. It appeared that females were first mature at a carapace length of 6 mm (Table XXXIX).

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[f]Total length of the carapace can be converted to the length of the calcified portion, or carapace length to the cervical groove, by the following equation:

$$y = 1.66x + 0.5$$

where y = the total carapace length, and x = carapace length to the cervical groove (Fig. 43).

Table XXXIX. Maturity of *Pagurus arcuatus* collected from the Grand Banks during April-November.

cl mm	April-June			July-November			
	Males	Females		Males		Females	
		Non-ovig.	Ovig.			Non-ovig.	Ovig.
	Large vd	Small ova	Small ova	Small vd	Large vd	Small ova	Small ova
6				2		3[a]	
7				2		1	
8				4		3	
9	1			7	1	3	
10	0	1	1	2	0	1	
11	1	0	0	1	0		
12	0	0	0		1		1
13	0	0	1[b]		0		2
14	0	0	0		0		
15	1	0	0		0		
16	0	0	0		0		
17	3	1	1		1		
18 - 20	2				1		
Totals	8	2	3	18	4	11	3
% probably breeding in autumn					18	21	

[a]One with large ova

[b]With eyed embryos

Family: LITHODIDAE

Lithodes maja (Linnaeus). Selbie, 1921; Rathbun, 1929.

This species has many spines, medium in length, particularly around the edge of the carapace and on the middle section (merus) of the pereiopods. The pereiopods are relatively long. The long rostrum has two spines forming a forked tip, two in the middle and three at the base, one of which is above. There is one spine below on the rostrum. The colour of the exoskeleton is purplish to red but occasionally brownish-purple.

This is an exclusively North Atlantic species occurring from the Barents Sea to the North Sea and Ireland in Europe, in Iceland, East Greenland to 66°N Latitude, West Greenland to 68°N, and from Davis Strait to New Jersey in America. Depths recorded are 65-530 m.

It was collected from Davis Strait (off southern Baffin Island), and southward to the Flemish Cap. It was also taken in Hermitage Bay, Bay d'Espoir and the Gulf of St. Lawrence (Fig. 45). Temperatures frequented were from 1.0 to 4.8°C, and depths from 185-790 m (Fig. 7 and 8).

This species was frequently a member of the Pandalus borealis community. Other species taken with it in catches were Lebbeus polaris, Sabinea sarsi, Chionocetes opilio and P. propinquus.

Phytobenthos, crustacean fragments, polychaetes, foraminiferans, sponge spicules, ophiuroids, small pelycopod and gastropod shells appeared frequently in the stomachs. Hydroids, a chiton, fish and a small scallop were found only once.

Mandibles are rather similar to those of the pagurids. There is a large grinding surface on the molar process separated only by a notch from a long slightly curved blade or incisor process. A projection or tooth is at the end of the blade nearest the molar and two teeth at the other end separated by a short even edge. The palp is in 3 sections. The distal section has a fringe of short setae plus a surface row of setae near the tip which reaches about half the length of the section. The distal section equals in length the other two sections together. A few setae are present on the inner side of the other sections.

The average carapace length of the males was 73 mm (range 33-92 mm) and of the females 53 mm (range 37-66 mm). This is probably not an accurate estimate of the average size in the populations since there was some selection of the catch: these decapods are difficult to fit into containers to be preserved so that there is a bias toward the smaller sizes in these samples.

Examination of the ovaries suggest that about 60% of the females would be ovigerous in autumn. They first mature at 37 mm in cl. Egg diameters averaged 2.1 mm. Males were first mature at 76 mm in carapace length, but a number of the specimens were badly preserved and could not be examined for maturity.

Neolithodes grimaldii A. Milne-Edwards and Bouvier, 1894.

This "spiny crab" has very long spines (30-40 mm long) standing erect or slightly oblique on the carapace. The rostrum or rostral area has three such long spines. The anterior and longest spine was 60 mm long in one specimen. The pereiopods are relatively long and have very long spines particularly on the ischia (40 mm long in one specimen) directed outwards. This species is an intense crimson in colour.

It is found only in the North Atlantic, near the Azores and Cape Verde Islands and from Iceland and Greenland (Davis Strait) to Cape Cod, in depths of 800-2,000 m.

Two specimens were taken in March on the southwest slope of the Grand Bank at a depth of 720 m (Fig. 45). The temperature at the bottom was 2.0°C.

The male was 124 mm in carapace length and the female 124 mm in cl and the overall lengths including spines were 230 and 170 mm, respectively. Both were mature but the female was non-ovigerous.

DECAPODA BRACHYURA

Family: CANCRIDAE

Cancer irroratus Say, 1818. Rathbun, 1929.

This "shore crab" is coloured reddish to pale purple on a light yellow background. The dorsal surface of the broad carapace is finely granulate. The marginal teeth of the carapace (nine on each side anteriorly and internal to the rostrum) are evenly rounded or pointed (crenate) but never finely scalloped or crenulate as in C. borealis.

C. irroratus is found only in the west Atlantic from the Strait of Belle Isle to South Carolina. In the north it is found in shallower water (5-20 m) but it is replaced in the intertidal area by C. borealis to the south, where it is found at greater depths (to 550 m).

In the area of investigation it is common wherever there are lobsters. It was not found north of the Strait of Belle Isle but occurs in White Bay. Small collections were made in Port au Port Bay for this study. It apparently comes into the intertidal area when the tide is in, as evinced by the occasional but continual strandings that occur. It is also taken quite frequently in lobster traps in 5-20 m along the coast and to depths of 40 m at least which is deeper than our coastal lobster grounds (Fig. 46). Temperatures varied greatly in the shore zone where these crabs were collected, reaching a high of slightly above 25°C at the sands and where some were partly stranded among Zostera near low tide in August. Temperatures were about 14°C on the lobster grounds at that time.

The average length of males taken was 71 mm (range 39-82 mm) and of females 44 mm (range 30-47 mm).

It appears to feed on small Littorina, amphipods, Crangon, polychaetes and small pelycopods.

Its mandibles are similar to those of Hyas, consisting of a large incisor blade and without a molar process. A stout three-sectioned palp is present.

Dominated by the lobster, it occupies fringe areas of the lobster grounds and makes forays into these grounds in search of food. Lobsters eat them and when stranded they are preyed upon by crows and gulls.

Family: MAJIDAE

Hyas araneus (Linnaeus). Rathbun, 1929.

This is a light red to brownish red spider crab with a subtriangular carapace. The carapace is covered with small tubercles. The rostrum is flat and long pointed and the basal article of the antenna is smooth and triangular in shape.

This species occurs only in the North Atlantic from the Kara Sea to Spitzbergen and the northern North Sea; also in Iceland, the east and west coasts of Greenland and from Davis Strait to Rhode Island. Depths recorded are shallow water to 510 m.

It was found in considerable numbers on the Labrador coast inshore and also on the continental slopes from Labrador to the Grand Banks. Inshore in White Bay at Spear Cove a Scuba dive showed that *H. araneus* was the dominant decapod occupying grounds ordinarily occupied by lobsters although apparently in the open (not hidden under rocks). It is suspected that *H. araneus* is dominant from White Bay to Cape Chidley. It was taken in deep water in the Gulf of St. Lawrence in the *P. borealis* communities (Fig. 46). The temperatures of Labrador inshore water (4-35 m) varied from -1.3 to 6.3°C, while offshore (35-730 m), temperatures varied from 0.8 to 3.6°C (Fig. 7 and 8).

Other species collected frequently with *H. araneus* were *Pandalus montagui*, *Spirontocaris spinus*, *Pagurus pubescens*, *Lebbeus polaris* and *Sabinea septemcarinata* (Fig. 6).

Phytobenthos and crustacean fragments (gammarid amphipods mostly and ostracods), polychaetes, foraminiferans, ophiuroids and pelycopod shells were commonly found in stomachs of specimens throughout the area. Occasionally gastropods, chitons, sea urchins, small crabs and hermit crabs were present. In the inshore area of Labrador, fish (probably discarded or killed in fishing operations) formed a large part of the food (Table XLIX).

No molar process is present on the mandible. The large incisor process is heavily calcified. The blade is arcuate in outline and is slightly irregular at the cutting edge. The palp is in three sections: the proximal section is very short and the other two long and sub-equal. The distal section has heavy bristles on the inner and outer edges, and the middle section has long setae on the inner edge (Fig. 44).

The average size of the males was 34 mm in cl (range 6-78 mm) and of the females 25 mm (range 7-55 mm).

The ovigerous females collected in spring had large ova present in the ovaries. These (representing about 60% of the mature females in the population) would hatch larvae in summer and lay eggs shortly afterwards. Also a few non-ovigerous females (15%) would lay eggs in

Table XL. Maturity of female *Hyas araneus* in Newfoundland and Labrador, April to November, 1947-1960.

cl mm	April-June			July-November			
	Non-ovigerous		Ovigerous	Non-ovigerous		Ovigerous	
	Small ova	Large ova	Large ova	Small ova	Large ova	Small ova	Large ova
7-18	4[a]			8[a]			
19-21	3	1	2	0	1		
22-24	3	3	6	4	3	4	2
25-27		2	10	0	1	1	1[b]
28-30			5	3	1	0	0
31-39			2[c]	0	0	4	0
40-55				3	2		1
Totals	10	6	25	18	8	9	4[d]
% probably breeding in autumn				54			

[a]Immature [b]With eyed embryos in July [c]One with small ova on June 19

[d]Three with large ova in July, one with large ova in September

summer or autumn. In the autumn samples there were still a few ovigerous females with large ova (10%), but most had hatched larvae and were ovigerous or would soon spawn (55%). The hatching and laying periods were but little separated in the population and there was ample evidence that individuals spawned annually. Eggs were carried for about 10 months (Table XL). Eggs were 0.7 mm in diameter.

Hyas coarctatus Leach, 1815. Rathbun, 1929.

H. coarctatus is about as large as H. araneus and somewhat similar in appearance. The carapace of H. coarctatus is less triangular in shape due to its lateral expansions anteriorly and just behind the orbit. The base of the antennule is quadrilateral in shape rather than triangular, and has tubercles along its lateral edge. Its colour is purplish red but lighter than in H. araneus. It is probable that the form alutaceus does not occur in the Atlantic (Squires, 1957) but in the Pacific only.

This species has an almost circumpolar distribution. It is found in the northern Atlantic from the White and Barents Seas to the English Channel and from Ireland to Iceland. It is in west Greenland as far north as 70°N Latitude but not in east Greenland except in the south. It is not in Foxe Basin but occurs from Hudson Bay and Strait to Cape Hatteras. The form alutaceus occurs in the northern Pacific along the west coast of Alaska and south to Korea on the east coast of Siberia. From Behring Strait it extends eastwards to the Beaufort Sea and westwards to north of Siberia. Depths recorded for the species are 5-1650 m.

Locally, H. coarctatus was caught on the Grand Banks (particularly on the eastern edge), the cod fishing grounds off St. John's, east coast bays of Newfoundland, the Gulf of St. Lawrence, off the Labrador coast, in Ungava Bay and in Hudson Strait (Fig. 46). Temperatures varied from -1.4 to 3.8°C and depths 5-550 m.

Decapods present in the catches with H. coarctatus were Lebbeus polaris, Spirontocaris spinus, Chionocetes opilio, Hyas araneus, and Pandalus montagui (Fig. 6).

Food was for the most part phytobenthos, crustacean fragments, foraminiferans, ophiuroids, pelycopod shells, crabs, sea urchins and gastropod shells (Table XLIX).

The mandibles are similar to those of H. araneus (Fig. 44). The incisor blade is very large and arcuate and there is no molar process.

In Newfoundland and Labrador the average length of the males was 28 mm and of the females 29 mm, but these were 40 and 37 mm, respectively, in Ungava Bay (Table XLI).

Table XLI. Lengths of *Hyas coarctatus* collected from different localities in the area of investigation during 1946-60.

Localities	Newfoundland and Labrador	Ungava Bay
Depth m	55-550	0-130
Temp. °C	-1.4 to 3.8	-1.4 to -1.2
Average cl mm	M 28 F 29	40 37
Range of cl mm	M 7 - 72 F 6 - 49	9 - 87 17 - 47
Numbers examined	M 89 F 107	17 18

Ovigerous females could be found throughout the year. Some ovigerous females caught both in spring and autumn had large ova in the ovaries. Eyed embryos were present in spring and autumn also. The percentage (62%) potentially ovigerous in autumn (Table XLII) indicates that, since this species most probably spawns at least 3 times in its lifetime, the majority of mature females in samples from these populations spawn annually (Table XLIV).

Table XLII. Maturity of female *Hyas coarctatus* in Newfoundland, Labrador and Hudson Strait, May to November, 1946-60.

cl mm	May-July		August-November			
	Non-ovigerous	Ovigerous	Non-ovigerous		Ovigerous	
	Large ova	Large ova	Small ova	Large ova	Small ova	Large ova
7-18			11			
19-21		1[a]	3	2		
22-24		0	6	2		
25-27		0	6	2		1
28-30	4[a]	1[a]	4	2	1	2[c]
31-33		3[b]	1	4	4	3
34-36			0	2	7	3
37-39			0	5	4	0
40-42			1		4	2
43-45			1		0	2
46-48					0	1
49-51					2	
Totals	4	5	33	19	22	14
% probably breeding in autumn			62			

[a] 1 with small ova [b] With eyed embryos [c] 1 with eyed embryos in September

Chionocetes opilio (O. Fabricius, 1788). Rathbun, 1929.

This spider crab is pale brown in colour and has a carapace which is almost circular in outline. The legs are very long and flattened in cross-section. The basal article of the antennule is long and narrow.

C. opilio is found in the west Atlantic from West Greenland to Maine, and in the north Pacific from the Behring Sea to Arctic Alaska and north of Siberia. Depths 0-640 m.

Locally, this species was found off the east and northeast coasts of Newfoundland, on the Grand Banks, in the Gulf of St. Lawrence and off the coast of Labrador (but not north of Cape Mugford in our catches; Fig. 46). Where taken the temperatures varied from -1.0 to 2.5°C and depths from 80-310 m (Fig. 7 and 8).

Decapod species taken in catches with C. opilio were P. borealis, Pagurus pubescens, Sabinea septemcarinata, P. montagui, H. araneus and H. coarctatus (Fig. 6). C. opilio occurred frequently in stomachs of cod from near St. John's.

Phytobenthos, foraminiferans, crustacean fragments, polychaetes, pelycopod shells and ophiuroids occurred frequently in the stomachs. Shrimps, crabs, gastropods, gammarid amphipods, copepods, isopods and chitons occurred occasionally, and Diastylis, hydroids and ostracods infrequently.

The mandibles are similar to those of H. araneus (Fig. 46), but the palp is in two sections the distal section of which is shorter than the proximal.

The average length of the males was 25 mm (range 5-61 mm) and of the females 23 mm (range 5-45 mm).

Females became mature at 22 mm in carapace length. Specimens in sample from Labrador, although at mature sizes did not have large ova nor were these ovigerous in August. In other areas 65% were potentially ovigerous in autumn (September-December), and during this period some of the ovigerous females had large ova in the ovaries (Table XLIII). This is evidence that the majority of the females will spawn annually in areas other than that represented by the sample from Labrador.

Table XLIII. Maturity of female *Chionocetes opilio* in Newfoundland and Labrador during April-December, 1947-60.

cl mm	April -June	July		August	September-December			
	Non-ovig.	Non-ovig.	Ovig.	Non-ovig.	Non-ovigerous		Ovigerous	
	Small ova	Small ova	Small ova	Small ova	Small ova	Large ova	Small ova	Large ova
9-11	1[a]				1[a]			
12-14	1[a]			4	8[a]			
15-17	0			2	0			
18-20	0			3	7			
21-23	1	1	1	26	2			
24-26		0	2	10	1			
27-29		0	1	1	3		2	
30-32		0	0	1	2		0	2
33-35		0	1		2	2	1	2
36-38		1	0		1	0	0	3
39-41		0	2			1	2	1
42-44		2[b]	2[c]				2	2
Totals	3	4	9	47[d]	27	3	7	10
Mature	1	4	9	33	111	3	7	10
% probably breeding in autumn			69				65	

[a]Immature [b]Two with large ova [c]One with large ova [d]From Labrador

Family: GRAPSIDAE

Planes minutus (Linnaeus). Rathbun, 1929; Sivertsen and Holthuis, 1956.

This is a small, light brown to brownish-olive crab with a convex carapace, square at the front (except for the orbits at each side) and rounded behind. The pereiopods are flattened for swimming. The antennae are very short and contained in the orbits.

P. minutus is found in the Atlantic from south of the British Isles and Newfoundland to the Azores, the Canary Islands and the West Indies (Sivertsen and Holthuis, 1956).

It was collected at the southwest edge of the Grand Bank where it was picked up at the surface among floating Sargassum weed in July. The water temperature at the surface was 15.8°C.

Food in the stomachs comprised fragments of crustaceans, probably shrimp.

The average length of the males was 13 mm (range 11-14 mm) and of the females 11 mm (range 9-15 mm).

Family: GONEPLACIDAE

Geryon quinquedens Smith, 1879. Rathbun, 1929, 1937; Chace, 1940; Schroeder, 1959.

This dark red crab is generally found only in very deep water. It is thick and squarish in appearance but broadest across the branchial region. The antero-lateral margins of the carapace each have 5 teeth varying in prominence. The chelipeds are comparatively slender and similar in size. The other pereiopods are longer than the first -- the 2nd and 3rd pairs longer than the others -- and they are slightly flattened in cross-section.

This species is confined in distribution to the western Atlantic from south of Sable Island (43°18'N, 60°50'W in our records) "to South Carolina and possibly to Brazil in depths of 40-2153 m" (Schroeder, 1959).

Twelve specimens were taken in 7 hauls between southeast of Browns Bank to south of Sable Island in depths of 420-740 m by the "A.T. Cameron" on November 9-27, 1959. At that time 18 lobsters were taken in 3 hauls at depths of 180-230 m, and in 25 hauls at depths of 90-700 m neither species was taken. In hauls where Geryon quinquedens was taken the bottom was of soft grey mud and temperatures were 4 to 8°C.

The one specimen examined was a male with carapace 98 mm long and 112 mm in greatest width. It was mature with large testes and large vasa deferentia. Stomach contents were detritus, foraminifera, a small Dentalium (?) shell and sand grains.

DISCUSSION

BIAS OF THE COLLECTIONS. Collections examined have been taken in hauls with fishing nets during surveys for groundfish or shrimp (except the "Calanus" Expeditions collections in Foxe Basin, etc., Crangon, Cancer and Homarus collections in Port au Port Bay and Hyas collections in Labrador by Mr. A. W. May). The collections from these surveys, therefore, have been biased mainly toward known groundfish or commercial shrimp habitats. These were usually trawlable fishing grounds, including deep water channel and slope areas and the more shallow offshore banks. The shallow inshore or bad ground areas have been largely neglected. The inshore area, however, has been shown to consist of a mosaic of communities, and hauls with a fishing trawl would be less likely to take representative samples of the fauna from these areas than from the more uniform communities of deep water (Morgans, 1959).

DECAPODS REPRESENTATIVE OF CERTAIN AREAS. Kendeigh (1960) states that ". . . in the ocean the important organisms that define biomes are usually the predominant animals ... characteristic combinations of animal species." While this refers to any animal phylum or phyla, the idea is here restricted to the decapod crustaceans. The diversity of decapod species (Russell, 1962) and their adaptability to various habitats make them particularly useful to characterize habitat types. It has been found in the area of investigation that, given a set of physical conditions -- temperature, depth and topography -- a particular complex of decapod species will be present. The following unit areas are reviewed to show what complexes of species may be found in each:

FOXE BASIN. In the northern part of the Basin, four species occurred in 50% or more of the catches, viz., Eualus gaimardi, Lebbeus polaris, Spirontocaris phippsi and Pagurus pubescens. These had been collected also by Captain Robert A. Bartlett in 1927 and 1933. Nine other species were present. In the southern part, including the western end of Hudson Strait, only three species occurred in 50% of the dredge hauls, L. groenlandicus, L. polaris and S. spinus. Thirteen other species were present including Hyas coarctatus which was taken at the shore by hand as well as in depths up to and including 90 m by dredge. Hyas was taken in small numbers in this area.

UNGAVA BAY. Distribution of decapod crustaceans in this bay has been discussed by Squires (1957). Characteristic species are A. dentata, L. polaris, L. groenlandicus, E. fabricii, S. spinus, P. pubescens and H. coarctatus. Ten other species were present. A species abundant in depths of 105-370 m at the mouth of the bay (taken by the "A.T. Cameron" in 1959) was Pandalus montagui. P. borealis was taken in the same place but in depths from 105-730 m and in small numbers only. The appearance of Pagurus pubescens larvae in many of the plankton hauls in Ungava Bay, while the adults occurred in only 30% of the dredge hauls, suggests that this species may be abundant there but perhaps not taken readily by the dredge. Hyas coarctatus larvae were also taken in considerable numbers in the plankton. This species was in many of the dredge hauls and sometimes picked up on the shore stranded by the falling tide. As stated below, in the geographical sequence of shore crabs from south to north, this species takes over from H. araneus which is common on the Labrador coast, and it occupies the littoral zone in Ungava Bay and Hudson Strait.

FROBISHER BAY. The decapod species characteristic of the Calanus Shelf in this bay are P. pubescens, L. polaris, L. groenlandicus, S. spinus and Argis dentata (Squires, 1961). Six other species of decapods were present.

EAST OF BAFFIN ISLAND (DAVIS STRAIT). The "Godthaab" Expedition (1928) collected decapods from south Greenland to Jones Sound crossing the Strait in three places (Cape Farvel to Hamilton Inlet, Fiskenasset to Resolution Island and just north of the Wolsingham-Holsteinsborg Ridge). Stephensen (1935) examined the specimens and reviewed all previous collections in West Greenland. The species most commonly found were L. polaris, L. groenlandicus, P. borealis, A. dentata, P. pubescens and H. coarctatus. Twenty-one other species were taken, seven of which were taken at depths greater than 1000 m. The P. borealis communities are large in West Greenland as shown by the fishery for this shrimp which takes about 3000 metric tons annually (Horsted, personal communication). The shallow water species in this area (0-200 m) correspond almost exactly with those of Ungava Bay (Squires, 1957) and the "A.T. Cameron" deep water catches took no species not already recorded for West Greenland. Six deep water species of decapods previously taken at depths greater than 1000 m were not taken by the "A.T. Cameron" which fished to 800 m only. Catches of the "A.T. Cameron" east of Baffin Island took most usually the species P. borealis, L. polaris, Sclerocrangon ferox and P. propinquus.

LABRADOR. Water movement into Hudson Strait at considerable depths (200-700 m) compensate for the outward surface flow and bring Atlantic water species of decapods such as Pasiphaea tarda and Sergestes arcticus as far as Ungava Bay at least (Squires, 1957). Arctic water exerts only a minor influence at these depths off the Labrador coast and temperatures of 3 to 4°C pertain. There is an abundance of P. borealis on these grounds at 200-400 m, and from 300-550 m P. propinquus is found. In water shallower than 200 m P. montagui and Pagurus pubescens are common and the temperatures reach -1.5°C where the Arctic water influence is greatest. L. polaris occurs at all depths and temperatures fished in this area.

Further south, from Cape Mugford to Hamilton Inlet Bank, Sabinea sarsi appeared consistently in the P. borealis communities at depths of 230-375 m and temperatures of -0.6 to 3.5°C. However, P. borealis was the dominant decapod crustacean in 70% of the hauls in this area and in 25% of the hauls it was the only decapod present. In deeper hauls, from 450-750 m, and temperatures of 3 to 4°C, P. propinquus, and occasionally Acanthephyra pelagica, appeared but no P. borealis. In shallower hauls, from 20-180 m and temperatures of -0.8 to 1.0°C, P. montagui was the dominant species, and in the deeper part of this range Sabinea septemcarinata was common.

The shallow sublittoral zone on the coast of Labrador was occupied by the spider crab, Hyas araneus. To the south in the Gulf of St. Lawrence and around the coast of Newfoundland as far as White Bay this zone is occupied by the lobster, Homarus americanus, and the shore crab, Cancer irroratus, both of which are not found farther north than the Strait of Belle Isle. In Ungava Bay and Hudson Strait, the niche occupied by these species is taken by Hyas coarctatus, and H. araneus does not occur. Both Hyas species are present off Labrador in depths extending to 320 m and were often taken in the same haul.

The five hauls made in Lake Melville, Labrador, in 1952, cannot be taken as representative, since no trawling was done at depths exceeding 140 m and there are considerable areas deeper than 200 m. Nevertheless, a few P. borealis were taken in depths of 90-130 m (1 specimen only at 26-29 m); they were all males, 13-21 mm in carapace length. Temperatures of bottom water were below 0°C in October except at the shallower haul. As shown in the species section on P. borealis, such low temperatures appear to suppress the sex change to females, so that this population may be self-propagating to a limited extent only. However, a report of large numbers of shrimp found dead at a beach near Goose Bay suggests that a population build-up may occur in this inlet, and cold-water kills such as occur sometimes in Greenland fjords (Horsted and Smidt, 1956) may occur here. Other species present in hauls made in 1952 were typical of a cold water bay and included P. montagui, P. borealis, Eualus macilentus, Argis dentata and Sabinea septemcarinata.

NORTH AND NORTHEAST COASTS OF NEWFOUNDLAND. The slope off this coast, including the Northeast-Newfoundland Shelf, at depths of 200-400 m varies in width from 30 to 100 miles and extends southeastward until the Grand Bank is reached. This area has predominant bottom temperatures of 1.2 to 3.6°C. P. borealis was present in a high percentage of the hauls, sometimes exclusive of other species. Sabinea sarsi, too, was present but in relatively fewer hauls than off Labrador.

In deeper hauls on the slope, from 500-700 m, Acanthephyra pelagica and Gennadas elegans appeared in the catches. In hauls shallower than 250 m, P. montagui was present frequently. When temperatures in the shallow part of this area were at 0°C or below, Eualus macilentus was found in addition to P. montagui. Hippolytid species were not usually present in these catches, but a few S. spinus, S. lilljeborgi and L. polaris were taken.

In contrast to the deep water of the offshore slope, the deep waters of White Bay and Notre Dame Bay usually had bottom temperatures below 0°C. Here the dominant species was P. montagui which reached a greater size as well as greater numbers than P. borealis which was also present in most catches. Also occurring frequently were relatively large numbers of E. macilentus and A. dentata. Small numbers of L. polaris, S. septemcarinata, E. gaimardi belcheri and Hyas coarctatus were common in these mixed catches. In the deep fjord-like arms of Notre Dame Bay (Badger Bay, New Bay and Hall's Bay) good catches of P. borealis were made with the groundfish trawl. Temperatures were moderate and the shrimps formed local and perhaps isolated communities.

The characteristic decapod fauna of the offshore slope would comprise P. borealis and Sabinea sarsi while the inshore bays support mixed P. montagui, P. borealis and E. macilentus communities.

At the shore, Homarus and Cancer are at the limit of their distribution northward between Notre Dame and White Bays as far as their usual large numbers are concerned. A sizable fishery for lobster exploits the sublittoral population in the summer insolated arms of Notre Dame Bay, but no lobsters are fished in White Bay. The persistence of low temperatures of the Arctic water filling this bay probably acts as a natural barrier to the movement of lobsters northward or to the settlement and success of larvae coming southward after egress from the Gulf of St. Lawrence. Lobsters are present but not in sufficient numbers to support a fishery. A rockfish, Tautogalabrus adspersus, also appears to be in reduced numbers in White Bay compared with other inshore areas of the coast of Newfoundland.

EAST COAST OF NEWFOUNDLAND. Bonavista and Trinity Bays are without sills or shallow areas where they open to the sea and consequently they have communication with deep slope water. This causes bottom water in these bays to have temperatures above 0°C (0.2 to 1.3°C). In Bonavista Bay there was evidence of mixing of Atlantic water with Arctic water. Salinities were lower (33.8‰) than Atlantic water and the temperatures were lower than the optima for P. borealis (Fig. 3 and 7). Therefore, although P. borealis was present, its numbers were exceeded by P. montagui which again was larger in size. In Trinity Bay, where water temperatures at the bottom were also above 0°C, some hauls in 260-420 m took P. borealis exclusively (in three hauls out of seven), but P. montagui and E. macilentus were present in others. In two hauls at depths of 210-250 m, P. montagui was more abundant than P. borealis but in one haul both species were greatly outnumbered by E. gaimardi belcheri. Since the greater part of this bay is deeper than 260 m, its decapod fauna is, in the main, a P. borealis-P. montagui type, although in the shallow parts of the bay a P. montagui-hippolytid complex could be expected.

The lobster landings in recent years have become large in Bonavista Bay. It is presumed that this fishery has developed only because of recent organization rather than a new availability. In both Trinity and Conception Bays, however, the lobster landings have remained comparatively small (Templeman and Tibbo, 1945).

Conception Bay is different from both Bonavista and Trinity Bays because it has a deep trough and, therefore, little connection with the deep slope water. Temperatures in the trough were below 0°C and salinities 33.3‰ indicating mixed water, but largely of Arctic origin. The decapod fauna was dominated by P. montagui and almost equalled in numbers by Eualus macilentus, the deep and cold water hippolytid. Three other species were common, P. borealis, A. dentata and E. gaimardi belcheri.

EAST COAST OF THE AVALON PENINSULA. In depths of 130-165 m, P. montagui was dominant in catches which also included L. groenlandicus, S. spinus, E. gaimardi belcheri, E. fabricii and A. dentata. Cod stomachs from the trap fishery off Torbay and St. John's had several species of shrimps including the above species and quite commonly H. coarctatus, H. araneus and Chionocetes opilio. Lobsters are too few on this coast to support a fishery.

NORTHWEST AND CENTRAL PORTIONS OF THE GRAND BANK. This area is continuous with the fishing grounds off Avalon and is 55-105 m deep. Its decapod fauna, similar to that off Avalon is dominated by P. montagui. This species did not occur in some catches, but its absence could not be related to season, depth or temperature. It is possible that this species lives in discrete or mobile communities over the Bank. Other species which appeared frequently were S. spinus, H. araneus, P. pubescens, S. septemcarinata and A. dentata. H. coarctatus, however, appeared to be much less common than it was near the coast of Avalon.

NORTHEAST, EAST AND SOUTHEAST SLOPES OF THE GRAND BANK. On the outer slopes of the Bank, in depths ranging from 220-330 m, the P. borealis, P. montagui and Sabinea sarsi combination was present as it was on the more northerly offshore slopes. Here, also, some catches were exclusively of P. borealis. C. opilio occurred occasionally, also as in the north, showing a preference for deeper water than H. araneus or H. coarctatus. At 550 m the depth range of P. borealis seemed to be exceeded and Acanthephyra pelagica and Pasiphaea tarda appeared. On the Southeast Shoal (at depths less than 55 m) Pagurus arcuatus was very common and this is its type locality. Lebbeus polaris and Hyas araneus were also present.

FLEMISH CAP. P. borealis was taken exclusive of other shrimp in eleven hauls in this area in depths of 200-550 m. The greatest numbers occurred at 290 m. Bottom temperatures were just over 3°C. In one haul at 720 m one specimen of Lithodes maja and one of P. borealis were taken. Generally both Lithodes maja and Hyas coarctatus occurred occasionally in this area at other depths.

SOUTHWEST SLOPE OF THE GRAND BANK. At depths less than 200 m the decapod fauna of this part of the Bank differed from other parts. An incursion of relatively warm water was evident from bottom water temperatures of 1.3 to 7.2°C. About half the hauls had P. montagui present, although in small numbers, and one-quarter of the hauls took P. propinquus and Dichelopandalus leptocerus. A few Pagurus arcuatus and Hyas araneus were also present in shallower hauls. Only a few hauls were deeper than 200 m. However, P. borealis was taken at 280-330 m, Pasiphaea tarda and Pontophilus norvegicus at 410-480 m and Sergestes arcticus and Plesiopenaeus edwardsianus at 710-770 m, although all were in small numbers only. Neolithodes grimaldii was also taken in this area where it had been taken for the first time by the "Hirondelle" in 1877.

ST. PIERRE BANK. At depths less than 200 m, P. montagui occurred in greater numbers than any other species, except in one haul where S. spinus was more plentiful. In addition to these two species S. phippsi, S. lilljeborgi, L. groenlandicus, L. polaris, S. septemcarinata and A. dentata occurred in small numbers. At depths of 200-284 m on the slopes of this bank P. borealis was present in greater numbers than P. montagui, the only other species taken at these depths.

Generally, the Grand Banks do not support an abundance of decapods. Many hauls have been made with the groundfish trawl during seasonal surveys over the banks in the years covered in this report, and the percentage of hauls in which decapods have been reported has been low (Fig. 48 and Table XLV). The outer slopes of the banks appear to be more heavily populated. This is consistent because higher and more constant temperatures appear to favour species such as P. borealis. The lower current speeds at these depths result in a build-up of finer sediments and possibly more suitable habitats for microphagus feeders. Wigley (1961) has shown that a considerable variation in sediments exists over Georges Bank. Undoubtedly a similar picture could be made of the Grand and Nova Scotian Banks, with a preponderance of sand and gravels on ridges or plateaus and finer sediments in the occasional depressions where deposits occur at slower current speeds. Here the epifauna, especially shrimps and crabs, depending partly upon sediments, but upon currents to a a considerable extent, would be composed of small, discontinuous and/or mobile populations. On the Grand Banks, these populations would be subjected periodically to flooding with Arctic water at temperatures below 0°C.

ST. MARY'S BAY. Varying depths over short distances and temperatures influenced by Arctic water result in a complicated picture of shrimp populations in this bay. At depths of 90-185 m and temperatures above 0°C, P. borealis appeared in most hauls (7 out of 11) but was dominated numerically in 4 hauls by Argis dentata, and in one by P. montagui. At similar depths but with temperatures below 0°C the usual combination for cold, deep bays appeared, viz., P. montagui was dominant in a complex of almost equal numbers of P. borealis, E. macilentus, S. septemcarinata and A. dentata.

PLACENTIA BAY. The low temperatures in the deep and very large trough in this bay appeared to favour P. montagui. Here this species is in competition with P. borealis, and it is larger on the average than P. borealis. The extent of the P. borealis community, however, was greater than that of P. montagui in depths over 200 m, as shown by the fact that it was taken in 95% of the hauls compared with 26% in which P. montagui was taken (Squires, 1961). E. macilentus was also present in 50% of the hauls. At depths less than 200 m P. montagui was dominant in a combination of species that included S. septemcarinata, A. dentata and L. polaris. In every haul the bottom temperatures were below 0°C.

Since this bay receives a continuous flow of Arctic water from the Avalon Channel, it is possible that its P. borealis population could be maintained by expatriate larvae, coming largely from the east coast bays (Trinity, Bonavista and Conception Bays). The population of P. borealis in Placentia Bay may also be partly self-propagating but in such a low temperature area the proportion of females to males is low, and the population, therefore, has a low reproductive potential. Although P. borealis maintains itself against competition with a cold water form (P. montagui) at the greater depths in this bay, fishing would most likely reduce its numbers drastically in a short time.

FORTUNE BAY. The influence of Arctic water was very strong in this bay in 1957 when 8 hauls with a shrimp trawl were made there. Temperatures of the bottom water were from -1.1 to 0°C, and salinities were 32.0 to 32.6‰. However, the cold, deep water complex of E. macilentus, P. montagui, P. borealis and A. dentata occurred only in the outer portion of the bay. From Garnish inward there was an apparently continuous P. borealis community. In the coldest water, specimens of P. borealis were small and most were males: at temperatures just below 0°C two hauls showed a proportion of males to females of 3:1 and 5:1. About 70 and 50%, respectively, of these females were ovigerous, so it is possible that this population is self-propagating at present, although its reproductive potential is low.

HERMITAGE BAY. This is a deep-water bay, not influenced by Arctic water and communicating with Atlantic water through the Southwest-Newfoundland Channel. Bottom temperatures were 5.9°C and salinities 34.5‰. The P. borealis community, however, appeared to be somewhat scattered in the bay itself where it was taken in only 20% of the hauls. These samples were taken where the temperatures were close to 2°C and at depths from 130-220 m. At depths of 200-370 m a complex of species occurred among which Sergestes arcticus and Pasiphaea multidentata (pelagic forms), and Spirontocaris lilljeborgi, P. borealis and Lithodes maja (benthic forms) were in considerable numbers. A specimen of a mud-burrowing axiid, Calocaris templemani, was also taken here in a fish trawl. This is a new species the holotype of which is described in this paper (see pages 189-196), and this bay is the type locality.

Bay d'Espoir is a deep, narrow and long inland extension of part of Hermitage Bay but separated from its deep water channel. Bottom water temperatures are low (0.5°C) with salinities of 32.3‰. These features are not due to Arctic water but must accrue from a very stable summer thermocline in fjordlike conditions, with severe winter cooling at the surface added to by a fresh water flow from rivers. Templeman and Tibbo (1945) recorded low salinities at the surface in this bay in summer. Hauls made with the shrimp trawl revealed a P. borealis community with a low proportion of females about 50% of which were ovigerous in August. A few E. macilentus also occurred in the catches. Such a population would sustain only a very limited fishery.

THE SOUTHWEST-NEWFOUNDLAND CHANNEL. This is an extensive deep water channel communicating with the Laurentian Channel on the west and lying close to the Newfoundland coast from Rose Blanche Bank to Hermitage Bay. It has a soft bottom area fully one hundred miles long and with an average width of about 10 miles. The bottom temperatures here are the highest in Newfoundland waters, reaching 6°C, and bottom salinities were high also at 34.6‰. The P. borealis community was large both in extent and in sizes of individuals. It offers the best prospect of commercial exploitation in the area (Squires, 1961). No other species of decapod was found in the P. borealis communities except a few Pontophilus norvegicus and Lithodes maja.

A number of fjord-like bays without sills communicate with this deep channel. Such are North Bay, Facheux Bay, Aviron Bay, La Hune Bay, Garia Bay, Bay de Vieux and La Poile Bay. In some of these bays the bottom was too deep or too rough for the warp and trawl used in the shrimp survey in 1957. However, North Bay maintains a "fringe" population of P. borealis at 280 m, at a temperature of 5.2°C and a salinity of 34.5‰. The ratio of males to females in this population was 4:1 compared with the almost 1:1 proportion in the main channel population nearby. One specimen of L. polaris was taken in a random sub-sample from the catch.

THE GULF OF ST. LAWRENCE. This large area, particularly in the Esquiman and Mingan Channels at depths greater than 200 m supports an apparently continuous one-species community of P. borealis. The bottom temperatures are 4 to 5°C and salinities of bottom water are 34.1 to 34.9‰. A "fringe" population seems to exist just above the 200 m contour where mixed catches were taken and in which P. montagui was dominant, although the specimens were slightly smaller in size than the P. borealis present. Temperatures were relatively low at these depths (2.8°C at 170 m) and the ratio of males to females in one sample was 8:1 (see also Table XIX). Since this population is close to the main P. borealis community, it is possible that it comprises many young shrimps which will later migrate to the deeper areas. P. montagui, which is adapted to cooler water, and/or because it is excluded by the adult P. borealis population, may possibly not take part in such a migration. Lithodes maja was commonly taken in these deep-water P. borealis communities but in very small numbers.

In Bay of Islands, a cold water bay with a deep trough which is separated from the deep Gulf channels by a wide shallow area, a species complex of P. montagui, P. borealis, E. macilentus and Argis dentata occurred. The temperatures were from 0.2 to 0.5°C at 240 m, and the salinity of the bottom water was 32.3‰. As in Bay d'Espoir, there is probably no Arctic water influence, these conditions being caused by severe winter cooling exacerbated by a considerable volume of cold water from the Humber River in winter and a stable but relatively shallow thermocline in summer.

The shallow waters of the Gulf of St. Lawrence are notable for their large sublittoral populations of lobster, Homarus americanus, and and the shore crab, Cancer irroratus. There are a few distinct, more or less enclosed populations such as in Port au Port Bay and the Bay of Islands, but most of the lobsters are present as "open coast" populations such as are extensively fished between Bonne Bay and Flowers Cove (Strait of Belle Isle), where shallow rocky shelves extend from the coast for several miles. On the shore sands, particularly where eel-grass (Zostera) grows, moderately large populations of Crangon septemspinosus are to be found.

DECAPOD COMMUNITIES IN THE AREA OF INVESTIGATION. The attempt to characterize each of these unit areas by combinations of decapod species leads to the conclusion that the types of decapod species communities are relatively few in this area. They include:

I. The major Pandalus borealis communities: (a) in the Gulf of St. Lawrence and the Southwest-Newfoundland Channel and (b) along the 200-400 m deep slope off the coast from Baffin Island to the Grand Banks. These are all soft bottom areas with a layer of Atlantic water which has high salinities and moderately high temperatures (Fig. 3 and 4). P. borealis here has high reproductivity, that is to say, has a high proportion of females, grows fairly fast, matures comparatively early and spawns annually.

II. The mixed P. borealis - P. montagui communities which are found (a) as "fringe" populations to the major P. borealis communities and (b) in deep cold bays containing mixed Atlantic and Arctic water just above 0°C and (c) in the troughs of the bays of the Newfoundland coast with deep cold water below 0°C where E. macilentus occurs as one of the three predominant species. In these areas the reproductivity of P. borealis is low (there is a low proportion of females in the population, growth is slow, maturity is late and spawning occurs most probably in alternate years). But reproductivity is high in P. montagui and E. macilentus in these areas. In (a) P. borealis may be expatriate because of larval drift, and a process of emigration by adults may make these fringe communities accessory recruitment sources for the major populations. In (b) and (c) low reproductivity may enable P. borealis to survive in small numbers only, but this state is critical in competition with P. montagui, and under commercial exploitation it would stand still less chance of survival.

"Competitive exclusion" can explain the domination of P. borealis over its close relative P. montagui over much of the whole area sampled. That they are possibly direct competitors is shown by their similar functional morphology and their similar feeding when they occur together. Normally, individuals of P. montagui do not grow as large as P. borealis: mature females of P. montagui in the Newfoundland area are 17-23 mm in carapace length while P. borealis females are 23-30 mm in cl. The eggs of both species are the same size in this area. There is, therefore, a significantly greater production of eggs in P. borealis than in P. montagui (Jensen, 1958, and Price, 1963). This gives a competitive advantage to P. borealis. P. montagui in the eastern Atlantic is moderately thermophilic (temperature range 3-20°C; Allen, personal communication). In the west Atlantic this species prefers Arctic water and is able to maintain high reproductivity even in water temperatures below 0°C (Table XXII). It is possible, therefore, that the thermophilic form of P. montagui has been eliminated in this area through competition with P. borealis which occupies the warm deep water areas. The race of P. montagui now surviving in this area has adapted well to Arctic water. Morphologically it has not greatly changed from the east Atlantic race, and this is understandable since it has not become discontinuous in geographical distribution. There has been no evolution of cold-water forms of P. borealis because of the ascendancy of the large warm water populations in this area or because of competition with the cold-adapted P. montagui. There are records of mass mortalities of this species when subjected to temperatures below 0°C over long periods (Horsted and Smidt, 1956).

III. Multi-species communities. A few of these are recognizable from trawl or dredge hauls. It is possible that they may be representative of a mosaic of communities (Morgans, 1959) rather than single communities. (a) The Ungava Bay group of L. polaris, L. groenlandicus, E. fabricii, S. spinus, P. pubescens and H. coarctatus which is typically found in cold and shallow water, occurs, with minor variations and additions, from Foxe Basin to the Grand Banks at depths of 20-95 m. (b) The Argis dentata, Sabinea septemcarinata, E. gaimardi belcheri and L. polaris group which occurs usually at medium depths (70-145 m) and moderately low temperatures in more restricted areas than the former, such as in St. Mary's Bay and the Bay of Islands. (c) The E. macilentus, P. montagui and P. borealis group found in deep (150-250 m) and very cold troughs in bays such as Conception and Placentia Bays. All these groups are likely to have P. montagui present and in some instances it will be the dominant species.

These multi-species communities are usually subject to either considerable seasonal variation in temperature which is largely influenced by variations in the flow of Arctic water, or they are subject to continuous low temperatures. Since these species have apparent flexibility or variability in food and/or shelter requirements, they may not be in direct competition. Some of them have only moderate reproductive potential and are small in size, e.g. E. fabricii. These features may indicate their lack of capacity to compete successfully with P. borealis or P. montagui or some closely allied species, and may account for their present distribution. On the other hand species with apparently high reproductive potential and large size, such as Sclerocrangon boreas, may have become adapted to specialized feeding or habitat and their small numbers may be due to dependence on density of their own kind in limited space or available food supplies.

IV. The lobster-shore crab (Homarus-Cancer) community. In comparatively shallow water, these decapods have to withstand seasonal changes which, at the most, can be moderated by short-distance migrations. Most parts of the Newfoundland coast provide a suitable environment for these two species, but the grounds are limited in extent and more or less discontinuous. Population size is conditioned by the area available for shelter and feeding.

Preliminary studies with lobsters in small aquaria in Port au Port Bay during 1962 suggest that individuals of the same size may show dominance over each other and may compete for shelter. Further studies are needed to determine the extent of density dependence, for it may be possible to increase the size of the population by increasing the amount of shelter available on otherwise suitable grounds. Scarrett (1962-63) reports that experiments with providing shelters for lobsters (drainage tiles) show possibilities for increasing the production of the lobster grounds.

The reproductive potential of individual lobsters may appear low in comparison with P. borealis, but this is offset by the longer life of and the greater number of broods produced by the lobster. Commercial exploitation has led to considerable reduction of numbers in the populations, particularly in areas where only a limited amount of suitable lobster ground is available, such as in Conception and Trinity Bays. Templeman and Tibbo (1945) state that, neglecting growth rates, the average length in a lobster population depended upon the intensity of fishing in any area and on the nearness of the area to a place where most larvae settle. They chose North Arm, Bay of Islands, to illustrate the latter point. Abundant larvae drifting into the Arm was demonstrated and the size of the lobsters found in the Arm was shown to be small. However, these two circumstances may be unrelated. Lobsters are known to be predominantly small in Middle Arm also although the numbers of larvae drifting into this Arm are not as great as in North Arm. While it is true that any lobster population must be recruited from a nearby settlement of larvae it is not known to what extent small lobsters can survive when settling among adults. As in other less well-developed larvae (Thorson, 1946), they will have some choice in where they settle and preliminary studies of larval drift in Port au Port Bay in 1962 suggest that settlement may be shoreward from the adult population. Overproduction of larvae in marine invertebrates is common, and the number produced in any year is not an assurance of year-class success. Settlement is critical and often density dependent (Moore, 1958). This would seem to apply to lobster larvae, and Wilder's (1953) figures from the capture by dredging of early settled stages of lobsters would seem to be more effective for year-class predictions than numbers taken in planktonic stages. Trancept counts of the early settled stages by diving would be probably still more effective. On the other hand several factors may contribute to small lobsters in North Arm, Bay of Islands: (a) There may be good annual survival of larvae and young; (b) Growth occurring in a moult may be arrested in a particular year especially at a size just below the legal minimum because (i) The small lobsters are caught and released after a considerable period of holding in sun and wind; (ii) Small lobsters in shallow water are subjected periodically to large volumes of fresh water from the Humber River and (iii) In some years temperatures may remain low in the Arm throughout the summer.

The role of *Cancer irroratus* is not well understood in the *Homarus-Cancer* community. *Cancer* is subject to depredations in the lobster fishery since it is frequently caught in the lobster traps and when caught is used to rebait the trap. This procedure may deter other specimens of *Cancer* from entering the trap (Hancock and Simpson, 1962). Generally it occupies a zone nearer the shore or deeper offshore than the lobster population, but there must be considerable overlap as well according to lobster trap captures. Stomach contents of lobsters show that *Cancer* forms one of the major items in the diet of lobsters. However, *Cancer* competes with *Homarus* for other constituents in its diet, particularly polychaete worms. Since *Cancer* appears to have a higher reproductive potential than *Homarus* its subordinate position in the community must be accounted for by the predator-prey relationship between them in which *Homarus* is much the larger at an earlier age.

V. *Sergestes-Pasiphaea* community. Populations of *Sergestes arcticus* and *Pasiphaea tarda* are present in the Southwest Newfoundland Channel and in the Laurentian Channel at depths of about 200-400 m. Since these species are pelagic, small numbers only would be expected in bottom hauls. The even ratios of males to females and the maturity of sexual products in the specimens collected indicate that these populations are self-propagating. Where they have been taken on the more distant slopes offshore from Baffin Island to the Grand Banks, the few specimens, like those of other deep-sea decapod species, are probably representative of a much more extensive deep sea community. *Acanthephyra pelagica* and *Gennadas elegans* are also trawled in the fringe areas of their large deep-sea populations.

BIOLOGY OF SPECIES

FEEDING. The stomachs of shrimps do not contain a gastric mill although there is a complicated pyloric filter (Cf. Price, 1963). In contrast, all palinurans, anomurans, astacurans and brachyurans have a gastric mill in the stomach.

Sand in varying amounts and coarseness was present in almost all decapod stomachs examined. It is possibly taken inadvertently with the food. Nevertheless it may be of importance in helping to triturate the food, particularly in shrimp stomachs. Even those shrimps which are thought to be pelagic had sand in the stomach so must reach the bottom occasionally.

RELATIONSHIP OF MANDIBLES TO FEEDING. The form of a generalized mandible of a decapod consists of a cutting or shearing edge -- the incisor process--, and a grinding surface -- the molar process. The right incisor shears past the left on the outside and the molars occlude. A palp of at least two parts is attached to guide the food to the shearing or grinding surfaces and to push the resultant particles into the mouth. The food is brought to the mandibles by the maxillae and maxillipeds. These are variously modified from an extreme of simple sifting baskets formed by many setae, to less setose spiny grasping appendages. The most extreme forms were not seen in decapods from the area investigated, all species having more or less setae for straining and recurved spines for holding food.

TYPES OF MANDIBLE. In each species the left mandible was described and figured; it differs only slightly from the right mandible in most instances. The closest to the generalized mandible in these species is that of the penaeid with a cutting incisor closely joined to the molar process (Fig. 10). There is little variation between the three pelagic or bathypelagic species examined. The palp is very large in each and would probably be used as an accessory appendage in capturing prey. The oplophorid mandible (in Acanthephyra) is similar to the penaeid but the palp is less elaborate and could be used only in adjusting food particles to the mandible or between the labia.

The pasiphaeid does not have this facility, because no palp or molar is present, and the saggitate incisor (Fig. 11) acts only to capture and hold prey which is forced into the mouth whole.

Among the other caridean shrimps examined the pandalid (Fig. 26) and the hippolytid (Fig. 14) mandibles show some similarity. The incisor process is widely separated from the molar and is formed from a thin flexible blade with a few teeth at its apex. This blade projects forward among the other mouth parts and would probably assist in the holding of prey and bringing it towards the molar. The molar process has shearing edges but most of its effectiveness is in crushing and grinding food with its large irregular surface. These shrimps are, therefore, equipped for feeding on phytobenthos and debris and small benthonic animals. Some selective feeding is still present in individual species as evinced by Spirontocaris spinus, which is microphagus on small hard-shelled animals (See also Allen, 1962). Similarly, P. montagui is partial to gammarid amphipods in this area and polychaetes in Great Britain (Mistakidis, 1957) although it takes other food (See also Allen, 1963). The similarity of the mandibles of P. montagui and P. borealis suggests that they would be capable of eating similar food.

One hippolytid examined departs from the usual form with a mandible which has no incisor process or palp (Bythocaris, Fig. 37). It is a bathypelagic species. The molar process has sharp cusps and a sharp ridge which may be used for holding rather than crushing. This may be a secondary adaptation to feeding pelagically on active prey.

The crangonid mandible has no incisor process or palp. The molar process is modified as a holding or shearing instrument with long pointed cusps, and no crushing surface is present. There is considerable variation in the form of the molar in different species: in Sclerocrangon ferox (Fig. 37) it has 4 long pointed cusps, while in S. boreas only 2 large with 2 small subsidiary cusps are present. In Crangon it has 4 cusps 3 of which are long, in Sabinea 2 large and 2 small, but in Pontophilus the number of cusps are reduced to 2 long only (Fig. 32). The more efficient for holding would probably be the latter, while forms like S. boreas and Crangon could probably be used for triturating as well. However, Crangon was found to have large prey whole in the stomachs.

The deep-sea palinurans, Polycheles and Stereomastis have mandibles with no molar process (Fig. 37); but the large saggitate incisor makes an effective holding and cutting tool.

The anomuran mandibles are similar to each other. Pagurus and Lithodes have heavy but sharp incisor blades for cutting and the large flat surfaces of the molars are effective crushers (Fig. 44). Munida (Fig. 44), Munidopsis and Calocaris (Fig. 11) show some variation from the pagurid mandible but they have basically the same crushing and cutting surfaces with bristled palps to clean them and bring food particles into the mouth. In Calocaris, however, feeding on mud, etc. is not in keeping with the type of mandible (Buchanan, 1963). The astacuran, Homarus (Fig. 37) has a type of mandible similar to the anomuran but the incisor edge is blunter and has a thick corneous cap. This is probably an adaptation to feeding on hard shelled molluscs. In the brachyurans, Hyas (Fig. 44) and Cancer there is no crushing molar process, the food being cut by the heavily calcified edge of the large incisor process. Homarus, Hyas, and Cancer are able to cope with large pieces of fish, for example, as well as small animals.

BLOOD DISEASE AND IMMUNITY IN HOMARUS. Gaffkaemia could not be demonstrated in the Port au Port Bay lobster population in two summers of monthly sampling. However, it has been shown to be present in a healthy Nova Scotian lobster population (Stewart and Macdonald, 1962). If lobster populations do in fact differ in incidence of this blood disease, difficulties may arise when lobsters from different areas are stored together. The presence of a disease in a healthy natural population implies the development of an immunity to a particular organism. Exposure of non-immune stock to the disease in infected storage tanks or to infected individuals would most likely result in increased moratlities. It is common commerical practice to store lobsters for long periods. A system of separate storage could be arranged if the incidence of the disease in the populations at large were known.

HATCHING PERIODS IN DECAPODS. Among decapod crustaceans, more than one hatching of larvae per season have been observed for Crangon crangon, Philoceras nanus, Leander adspersus and L. squilla in northern Europe (Thorson, 1946), C. allmani (Allen, 1960) off Northumberland and Crangon septemspinosus in Chesapeake Bay (Price, 1962). Evidence of monthly hatching of larvae from April to September, at least, has been observed in a more stable (subtropical and bathypelagic) environment (Dunbar, 1960) near Bermuda in the species Acanthephyra purpurea, Systellapsis debilis and Parapandalus richardi (Chace, 1940).

Autumn (August-December) hatching as well as spring hatching of larvae is probable in eight species of decapods from the present area of investigation. Eyed embryos were found in eggs of Spirontocaris phippsi in October, Lebbeus groenlandicus and L. polaris in Novemember, Sabinea septemcarinata in October and Argis dentata in October-December (Fig. 16). Of the latter, those taken in December were from St. Mary's Bay where bottom water temperatures are low throughout the summer but there is no ice cover in winter. November specimens were from the widely separated areas of St. Mary's Bay and Notre Dame Bay. Notre Dame Bay usually has ice cover in winter but not until January, so that the pelagic phase of larvae hatched in November could possibly be completed before severe winter cooling. October specimens were from the northern part of the Gulf of St. Lawrence (S. phippsi) and from St. Mary's and Trinity Bays (A. dentata and S. septemcarinata). S. septemcarinata had eggs with embryos ready to hatch in May and June also in specimens from St. Mary's Bay and Placentia Bay. A. dentata also appeared to hatch larvae in spring since the number of ovigerous females in early spring was greater than the number in late spring or summer (Fig. 16).

Spring and late summer hatching of larvae was apparent in Crangon septemspinosus from Port au Port Bay (Fig. 36).

In Foxe Basin hatching of larvae occurred in a few specimens during the collecting period from August-September. The species represented were S. spinus, S. phippsi, L. groenlandicus and L. polaris but it was evident that the greater number of individuals had hatched larvae in spring (Tables XI, XIII, XV and XVII).

A few specimens of Hyas coarctatus from Labrador and Hudson Strait had eyed embryos that would hatch in autumn. Most specimens, however, would have hatched their larvae in spring or early summer (Table XLII).

In all other species only one hatching period seemed to occur and this was from early spring to early summer. Eyed embryos in eggs were seen in spring captures only, and the numbers of ovigerous females decreased toward mid-summer and rose to a steady high level in late autumn (Fig. 16). This pattern was approximated closely by P. borealis and E. macilentus in particular.

Late autumn samples of lobsters from Port au Port Bay and Bay of Islands have eyed embryos, however, but it has not been possible to show that these larvae hatched in autumn. We suspect that in Homarus at least the eyed embryos are carried through the winter when their development is arrested by low temperatures and that these embryos are not hatched until July.

REPRODUCTIVE POTENTIAL. In decapod crustacean populations full reproductivity is defined as the ability of the females to spawn at least once annually. Generally, low temperatures mediate against the attainment of full reproductivity in this area and most species if found in low temperature areas spawn biennially, that is in alternate years. Some are sufficiently cold-adapted to over-ride the low temperature conditions and spawn annually after maturity is reached. Because temperatures are generally low most species live longer than in warm water areas and may spawn more than once in a lifetime after 1-4 years as immatures. The lobsters and crabs are the longest lived and may spawn many times before natural mortality ensues.

The percentage found to be potentially ovigerous in autumn in random samples of decapods from this area has been adopted as an indication of annual or biennial spawning. The percentages expected to be ovigerous in a hypothetical population, by definition a reproductivity index (R), may be calculated from the following equation:

$$R = \frac{y}{(a-1) + c} \times 100 \qquad (1)$$

where a = the number of years to reach maturity

c = the number of times individual females may spawn in a lifetime

and y = the number of year classes spawning in the present year

This equation, however, represents high reproductive potential of annual spawning in any species. For comparison a companion equation for biennial spawning or a low reproductive potential is also included since this appears to represent the condition occurring in some species which are apparently not fully adapted to low temperatures. This equation is:

$$R = \frac{y}{(a-1) + b + c} \times 100 \qquad \text{(II)}$$

where b = the number of year classes mature but not ovigerous in the present year.

The calculated percentages are shown in Table XLIV.

Table XLIV. Expected percentages of females potentially ovigerous in autumn if spawning takes place I. annually and II. biennially, calculated from the equations -

I. $\frac{y}{(a-1) + c} \times 100 = R$ and II. $\frac{y}{(a-1) + b + c} \times 100 = R$.[1]

Years to maturity	Frequency of spawning during lifetime				
	Once	Twice		Three times	
	I	I	II	I	II
	R	R	R	R	R
1	100	100	50	100	60
2	50	66	50	75	50
3	33	50	40	60	43
4	25	40	33	50	38

[1] O - group presumably not taken by the net in these samples and therefore ignored.

DECAPODS IN COD STOMACH CONTENTS. In frequency of occurrence decapods form a significant part of the diet of cod (*Gadus morrhua*) throughout the area.

Shrimps do not represent a large proportion of the total contents of cod stomachs as compared with fish, but they were found in about 40% of the stomachs of samples of cod from the following areas: the southwest Gulf of St. Lawrence, Port au Port Bay, Port aux Basques, Ramea, Fortune Bay, off Cape Pine, central Grand Bank, northern Grand Bank, off St. John's, Trinity Bay, northeast of Cape Bonavista, Greenley Island and Domino, Labrador (Table XLVI). The species most commonly occurring were *P. montagui*, *Spirontocaris spinus*, *Lebbeus polaris*, *L. groenlandicus*, *P. borealis*, *Sabinea septemcarinata* and *Eualus fabricii*.

Spider crabs, *Hyas* spp. and *Chionocetes opilio*, occurred frequently also in cod stomachs from samples taken at many places in the area. The highest frequency (about 40%) occurred in samples from St. Pierre Bank, the northern Gulf of St. Lawrence, and off the southwest coast (Table XLVII).

In all areas the lowest incidence of decapods in cod stomachs was during April-August and the highest in September-December. This difference may have been caused by cod feeding heavily on capelin (*Mallotus villosus*) in the spring and early summer (Fig. 47). In a few areas where capelin are not available at any time the cod foraged to a considerable extent on decapods as well as other benthonic fauna throughout the year.

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APPENDIX

Table XLV. Unit areas of investigation with depth and temperature ranges, total number of hauls and percent of hauls in which decapods were taken during survey cruises by the "Calanus" (1946-58), "Investigator II" (1947-54) and "A.T. Cameron" (1959: Cape Dyer to Cape Chidley only).

Unit area No.	Area	No. of hauls	% with d'pods	Depth range m	Temperature range °C
1	Foxe Basin, Hudson Strait	94	80	0-160	-1.5 to 5.5
2	Ungava Bay	68	95	0-275	-1.4 to 3.4
3	Frobisher Bay	17	65	15-190	-1.2 to 0.1
4	Cape Dyer to Cape Chidley	40	55	50-770	-1.1 to 4.0
5	Cape Chidley to Belle Isle	100	68	10-750	-1.0 to 4.5
6	Lake Melville	8	63	25-140	-0.5 to 1.0
7	NE-Newfoundland Shelf	40	85	105-710	-1.1 to 3.6
8	White Bay	8	88	250-270	-0.7 to 0.0
9	Notre Dame Bay	25	100	185-370	-1.1 to 1.0
10	Bonavista Bay	5	20	280-320	0.2 to 0.6
11	NE edge of the Grand Bank	149	20	70-650	-1.1 to 4.0
12	Flemish Cap	52	25	290-730	3.4 to 3.9
13	Trinity Bay	31	90	1-420	0.3 to 1.3
14	Conception Bay	3	67	195-265	-0.9
15	Off Avalon east coast	14	79	25-160	-0.9 to 1.3
16	Central Grand Bank	69	46	60-145	-1.6 to 2.6
17	SE slope of the Grand Bank	88	25	50-375	0.1 to 4.7
18	Southern Grand Bank	132	8	45-800	1.2 to 7.6
19	SW slope of the Grand Bank	223	12	65-770	1.3 to 7.2
20	Green Bank	10	30	75-690	-1.0 to 4.5
21	St. Pierre Bank	190	28	40-300	-0.2 to 4.9
22	St. Mary's Bay	22	68	50-210	-1.4 to 2.3
23	Placentia Bay	6	17	10-260	-1.1 to 0.0
24	Fortune Bay	33	100	185-320	-1.1 to 1.2
25	Hermitage Bay	16	50	130-290	1.5 to 5.9
26	Bay d'Espoir	3	100	130-210	0.5 to 2.0
27	SW Newfoundland Channel	81	32	210-335	4.5 to 6.4

(cont.)

(Table XLV concl.)

28	Nova Scotian Banks	26	23	25-730	0.7 to 4.9
29	S Gulf of St. Lawrence	6	50	55-530	0.0 to 5.9
30	Esquiman Channel	57	65	145-300	0.1 to 4.7
31	Bay of Islands, Bonne Bay	5	60	100-260	-1.0 to 0.4
32	Mingan Channel	31	65	210-280	3.2 to 5.2
33	Laurentian Channel	13	38	240-390	4.2 to 6.2
34	N. Gulf of St. Lawrence	4	100	35-110	-1.0 to 2.0

Table XLVI. Number of ovigerous females of different species of shrimps with eyed embryos in eggs when taken in Newfoundland and Labrador during 1946-60.

Species	Apr. May	June July	Aug. Sept.	Oct. Nov.	Dec.
Pasiphaea tarda	...	...	1	...	...
Eualus macilentus	8	...	...	...	...
Spirontocaris phippsi	...	...	...	1	...
Lebbeus groenlandicus	...	...	1	1	...
Lebbeus polaris	...	...	24	4	...
Pandalus borealis	6	...	...	...	...
Pandalus montagui	2	...	...	...	...
Pandalus propinquus	1	...	...	...	...
Dichelopandalus leptocerus	...	2	...	...	...
Sabinea septemcarinata	3	2	2	2	...
Argis dentata	...	...	...	8	4
Sclerocrangon ferox	...	1	3	...	...

Table XLVII. Percentage of cod stomachs in which shrimps occurred in collections from 1947-53 (some shrimps identified to family only).

Localities	No. of stom-achs	Depth m	Pandalidae Pb	Pm	P	Fr.	Hippolytidae Ef	E	Sp	L	Fr.	Crangonidae A	Sa	Fr.	All shrimps Fr.
						%					%			%	%
Nachvak	51	30-35	-	-	-	0	+	-	+	+	4	+	+	10	29
Domino	226	15-20				...					...			...	37
Greenley I	64	80-90	-	+	-	17	-	-	+	+	13	-	-	3	63
Labrador	224	200-340	+	-	-	5	-	-	+	-	0	-	+	2	12
Englee	256	90				...					...			...	16
NE Shelf	78	300	+	-	-	18	-	-	-	+	1	-	-	0	28
Fogo	198	15-45	-	+	+	2	+	-	-	+	3	-	-	0	8
Bonavista	246	210-330	+	+	+	20	-	+	+	+	5	-	-	3	36
Bonavista	332	20-35	-	-	-	0	-	-	-	-	0	-	-	1	1
Trinity	207	55-185	-	-	-	0	-	-	-	-	1	-	-	1	7-100
Bauline	29	40				...					...			...	4
St. John's	822	55-130	-	+	-	1-9	-	-	-	-	5	-	-	0	2-45
St. John's	154	25-30	-	-	-	...	-				...			...	7-9
N. Gd. Bank	469	75-165	-	+	-	6-17	-	+	+	+	2-7	-	+	1-2	11-35
N. Gd. Bank	264	140-430	+	+	-	3-10	-	-	+	-	3	-	-	1	8-28
NE Gd. Bank	120	130	-	-	-	0	-	-	-	-	1	-	-	2	3
Flemish Cap	136	130-190	-	-	+	1	-	-	-	-	0	-	-	0	1, 8
C Gd. Bank	328	60-80	-	+	-	7-11	+	+	+	+	25	+	+	1	22-54
SW Gd. Bank	347	80-200	-	-	+	2, 3	-	-	-	-	2	-	-	0	2-6
S Gd. Bank	218	45-85	-	-	-	0	-	-	-	-	2	-	-	0	3-10
Cape Pine	96	65	-	-	+	24	-	-	-	-	23	-	-	11	67
St. M's Bay	55	105-140	-	-	-	4	+	-	-	-	0	-	-	11	29
Burin	76	90				...					...			...	7
Green Bank	33	120-150	-	-	-	...	-	-	-	-	...	-	-	...	3
St. P. Bank	144	40-175	-	+	-	2-7	-	-	+	-	10	-	-	0	10-30
Fortune Bay	62	185	+	+	-	16	-	+	-	-	8	+	+	5	58
Ramea	110	35	-	-	+	4	+	-	+	+	36	-	+	3	44
Banquereau	111	45				...					...			...	2

(cont.)

(Table XLVII concl.)

Cape Breton	79	90-185	+	+	+	8	-	-	+	-	4	-	+	8	23
Port au Basq.	108	20-50	+	-	-	3	+	-	-	-	24	-	-	2	45
Port au Port	5	25-45				...					...			...	40
Lark Hr.	214	35-65				...					...			...	9
Cow Head	145	35-45	-	-	+	3	-	-	-	-	1	-	-	1	6
SW Gulf of SL	70	50-90	-	+	-	3	-	-	-	-	0	+	-	18	40
N Gulf of SL	88	85-230	+	-	+	8	-	-	-	-	8	-	+	8	22

Pb = *Pandalus borealis*

Pm = *Pandalus montagui*

P = *Pandalus* sp.

Ef = *Eualus fabricii*

E = *Eualus* sp.

Sp = *Spirontocaris* sp.

L = *Lebbeus* sp.

A = *Argis dentata*

Sa = *Sabinea septemcarinata*

Fr. = percentage of cod stomachs in which shrimp occurred

NE Shelf = Northeast-Newfoundland Shelf

N Gd. Bank = North Grand Bank

NE Gd. Bank = Northeast Grand Bank

C Gd. Bank = Central Grand Bank

St. M's Bay = St. Mary's Bay

St. P. Bank = St. Pierre Bank

Port au Basq. = Port aux Basques

Gulf of SL = Gulf of St. Lawrence

Table XLVIII. Occurrence of spider crabs in cod stomachs taken during 1947-53, expressed as a percentage of the total number of stomachs examined from each locality.

Locality	No. of stomachs examined	Depth m	C. opilio	Hyas spp.
			%	%
Southeast Grand Bank	388	62-183	0.3	18.8
North Grand Bank	849	75-430	8.5	9.3
South Grand Bank	244	66-205	0.4	20.1
Flemish Cap	48	130-190	...	10.4
St. Pierre Bank	91	40-175	1.1	36.3
Labrador	219	200-340	15.5	5.5
NE Nfld coast offshore	200	209-331	27.5	8.0
NE Nfld coast inshore	364	13-92	2.8	5.2
St. John's inshore	481	25-130	11.2	15.4
Cape Race to C. St. Mary's	142	64	11.3	7.8
C. St. Mary's to Pass I.	60	...	11.7	...
Pass Island to Cape Ray	209	10-20	...	35.4
S Gulf of St. Lawrence	99	55-90	1.0	1.0
N Gulf of St. Lawrence	94	7-92	...	39.4

Table XLIX. Occurrence of principal food elements in the stomachs of decapods expressed as a percentage of the total number of stomachs examined.

Species	E	Ph	C	OG	Eu	P	F	H	Ps	Ga	Ss	Op	Total stomachs
	%	%	%	%	%	%	%	%	%	%	%	%	
A. pelagica	37	5	76		7						2		41
E. fabricii	59	40	9	3[a]		6	4	1	3		1		68
E. gaimardi	31	69	23	16[a]		8	16				4		165
E. g. belcheri	33	65	17	20[a]	2	12	10		2		4		52
S. phippsi	17	77	31	14[a]			31	6	3		3		60
S. spinus	19	78	8	24[a]		2	64	5	8	6	3		160
L. groen.	22	65	17	3[a]	8	10	8	15	3	3	5	3	41
L. polaris	39	57	16	3[ab]		4	9	4		1	6		578
P. borealis (L)	74	25	9	5[b]			3		1			1	480
" " (Gulf)	52	59	40			6	9		4				80
P. montagui	68	33	13	6[b]	2	10	2						527
P. propinquus	69	14	14	8[b]	3	1	1						135
S. sarsi	67	23	10	10[b]		18	3						39
S. septemcar.	61	21	13	19[b]		7	2						188
A. dentata	80	22	7	1[a]		3	4		7	1			75
Sc. boreas	73	27	11	4[a]	18[b]	20	9		3			2	45

(cont.)

(Table XLIX concl.)

	E	Ph	C	OG	Eu	P	F	H	Ps	Ga	Ss	Op	No.
Sc. ferox	77	14	11	1[b]		9			1	1	2	1	102
P. pubescens	10	70	21	3[a]		1	27	18	1		5		122
P. arcuatus	7	94	30	1[b]		3	14	2	19			4	73
H. araneus	43	43	40	1[a]	3[b]	18	15	1	9	2		17	170
H. coarctatus	62	35	31			7	13	2	8	3		10	130
C. opilio	33	67	37	2[a]		29	15	1	16	3		14	195
L. maja	17	47	43			27	17	7	13	17	17	13	30

[a]Ostracod = O [b]Gammarid amphipod = G

Other abbreviations are as follows:

E = Empty
Ph = Phytobenthos
C = Crustacean
Eu = Euphausiid
P = Polychaete
F = Foraminiferan
H = Hydroid
Ps = Pelycopod
Ga = Gastropod
Ss = Sponge spicules
Op = Ophiuroid

Table L. The percentage occurrence of decapods (reported as shrimp, spider crabs or spiny crabs) in hauls during March-December, 1950-60[a].

Areas	Trawls with small-meshed liner or cover			Trawls without small-meshed liner or cover		
	No. of hauls	% with decapods	Month	No. of hauls	% with decapods	Month
Labrador	5	100	July			
	56	89	Aug.			
	38	46	Sept.			
Lake Melville	8	88	Oct.			
NE Newfoundland Shelf	7	71	Aug.			
	56	73	Sept.			
	21	72	Oct.			
	2	0	Dec.			
White Bay	14	86	Oct.			
Notre Dame Bay	12	75	Nov.			
Bonavista Bay	6	83	July	8	82	July
	8	63	Nov.			
Flemish Cap	14	86	March			
	16	44	June			
	15	33	July	22	32	July
	6	50	Aug.			
	10	80	Nov.			
Central Grand Bank	33	9	April			
	73	7	May			
	20	0	June			
Off Avalon east coast	11	54	April			
Eastern slope of the Grand Bank	10	0	June	43	14	June
	42	45	July			
	13	23	Aug.			
	55	46	Sept.			
	2	0	Nov.			

(cont.)

(Table L concl.)

Southeast Grand Bank	18	0	April			
	64	2	May			
	27	7	June			
	26	8	July			
	13	38	Sept.			
Southwest Grand Bank	7	0	March	6	0	March
	17	6	April	15	7	April
	94	17	May	8	0	May
	38	26	June			
	21	24	July			
	19	26	Oct.			
St. Pierre Bank	46	0	May			
	101	22	June			
	18	11	July			
	36	3	Oct.			
Placentia Bay	5	60	June			
	2	100	July			
Fortune Bay	7	57	Dec.			
	2					
Hermitage Bay	15	100	Nov.	18	50	Dec.
Southwest NF Channel	5	40	June	5	0	May
Nova Scotian Banks	37	33	Nov.	25	0	May
Gulf of St. Lawrence	60	5	Oct.			
	83	67	Nov.	4	75	Nov.
	13	54	Dec.			
Bonne Bay and Bay of Islands	6	83	Dec.			

Table LI. Summary of the average and total range of carapace lengths of the principal decapods from Newfoundland and Labrador (NL), Ungava Bay (UN), and Frobisher Bay (FR).

Species		Average cl			Range of cl			No. examined		
		NL	UN	FR	NL	UN	FR	NL	UN	FR
		mm	mm	mm	mm	mm	mm			
S. arcticus	M	15	11		12-19	9-15		103	71	
	F	18	12		13-20	9-16		104	81	
P. tarda	M	28	37		14-45	30-44		14	4	
	F	30	33		14-59	18-42		42	10	
E. fabricii	M	7[a]	7	6	3-10	4-12	5-9	42[a]	119	12
	F	10[a]	9	10	4-12	4-14	4-12	55[a]	183	31
E. gaimardi belcheri	M	14	9		11-17	6-14		63	21	
	F	16	11		7-21	6-14		195	26	
S. spinus	M	10	8	9	5-10	3-12	7-11	33	47	27
	F	11	10	11	6-17	3-17	8-15	99	87	40
S. phippsi	M	4[b]	4	5	2-7	2-7	4-6	28[b]	8	16
	F	7[b]	7	7	3-10	3-10	5-8	59[b]	68	15
L. groenlandicus	M	13	12	12	6-17	6-18	10-15	8	99	68
	F	17	14	16	8-27	4-24	7-28	39	131	124
L. polaris	M	10	9	9	4-18	2-13	6-14	118	122	23
	F	12	10	13	5-20	2-17	5-15	333	205	20
S. septemcarinata	M	10	11	9[b]	5-18	10-13	5-12	65	4	19[b]
	F	14	13	14[b]	7-19	8-18	3-21	284	8	18[b]
A. dentata	M	15	14	13	8-31	9-24	6-16	72	41	28
	F	20	16	17	9-28	7-24	6-26	289	73	26
Sc. boreas	M	18	16	17	8-24	9-25	11-16	11	16	5
	F	25	22	21	11-35	7-28	11-29	21	48	14
P. pubescens	M	17	14[c]	14	9-27	3-28	5-26	109	100[c]	29
	M	14	11	10	2-21	4-21	4-18	45	78[c]	22
H. coarctatus	M	28	40		7-72	9-87		89	17	
	F	29	37		6-49	17-47		107	18	

[a]Including Foxe Basin [b]Foxe Basin only

Table LII. Species and numbers of specimens collected by vessels of the Fisheries Research Board of Canada, Biological Station, St. John's, in 1946-60, and Arctic Unit, Montreal, in 1953-58 (the latter collected in Foxe Basin and Hudson Strait only). Homarus, Cancer and Crangon specimens are added from collections in Port au Port Bay in 1961 and 1962.

Species		No. of specimens	
		Male	Female
1.	Sergestes arcticus	117	142
2.	Gennadas elegans	2	4
3.	Plesiopenaeus edwardsianus	1	2
4.	Acanthephyra pelagica	39	39
5.	Nematocarcinus ensifer	0	1
6.	Pasiphaea tarda	17	49
7.	Pasiphaea multidentata	42	79
8.	Bythocaris payeri	2	5
9.	Eualus fabricii	42	55
10.	Eualus gaimardi gaimardi	336	144
11.	Eualus gaimardi belcheri	108	214
12.	Eualus macilentus	314	842
13.	Eualus stoneyi	1	1
14.	Eualus pusiolus	0	3
15.	Spirontocaris spinus	103	300
16.	Spirontocaris phippsi	90	33
17.	Spirontocaris lilljeborgi	3	66
18.	Lebbeus groenlandicus	41	59

(cont.)

(Table LII cont.)

19.	Lebbeus polaris	594	470
20.	Lebbeus microceros	1	3
21.	Lebbeus zebra	0	1
22.	Pandalus borealis	8,355	3,974
23.	Pandalus montagui	1,251	1,787
24.	Pandalus propinquus	90	89
25.	Dichelopandalus leptocerus	39	45
26.	Sabinea sarsi	17	128
27.	Sabinea septemcarinata	84	202
28.	Sabinea hystrix	0	1
29.	Argis dentata	120	324
30.	Crangon septemspinosus	599[a]	329
31.	Sclerocrangon boreas	15	29
32.	Sclerocrangon ferox	41	66
33.	Pontophilus norvegicus	19	83
34.	Stereomastis sculpta	6	9
35.	Polycheles granulatus	0	2
36.	Homarus americanus	302	361
37.	Munida tenuimana	1	3
38.	Munidopsis curvirostra	16	8
39.	Calocaris templemani	...	1[b]
40.	Pagurus acadianus	8	0
41.	Pagurus pubescens	109	45

(cont.)

(Table LII concl.)

42.	Pagurus arcuatus	46	25
43.	Lithodes maja	13	13
44.	Neolithodes grimaldii	1	1
45.	Cancer irroratus	9	1
46.	Hyas araneus	137	95
47.	Hyas coarctatus	89	107
48.	Chionocetes opilio	146	157
49.	Planes minutus	6	5
50.	Geryon quinquidens	1	0
	Totals	13,373	10,324

[a]Including megalops and juveniles [b]Hermaphroditic

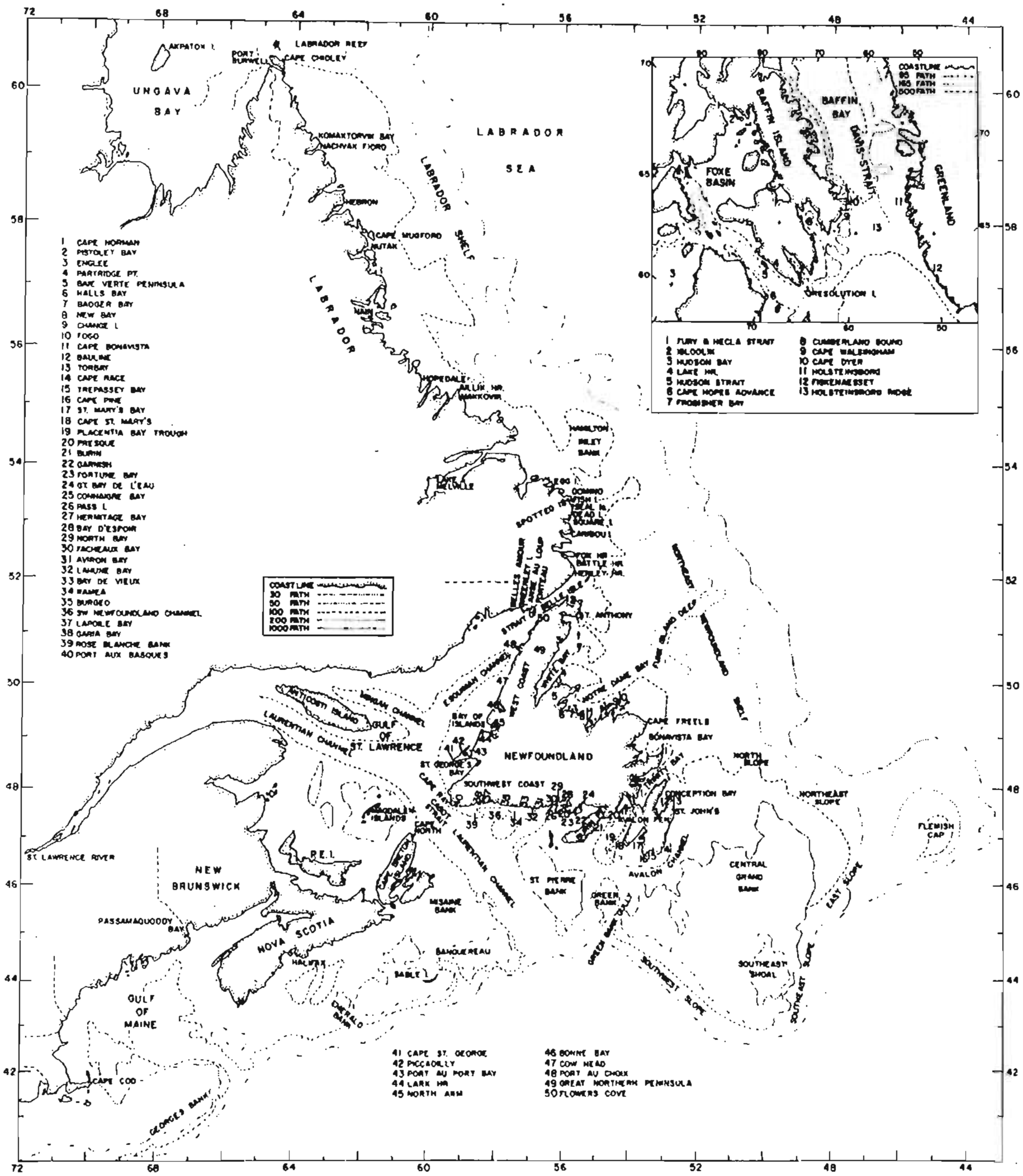

Figure 1. Map of place names mentioned in the text. (Inset of Foxe Basin and Davis Strait).

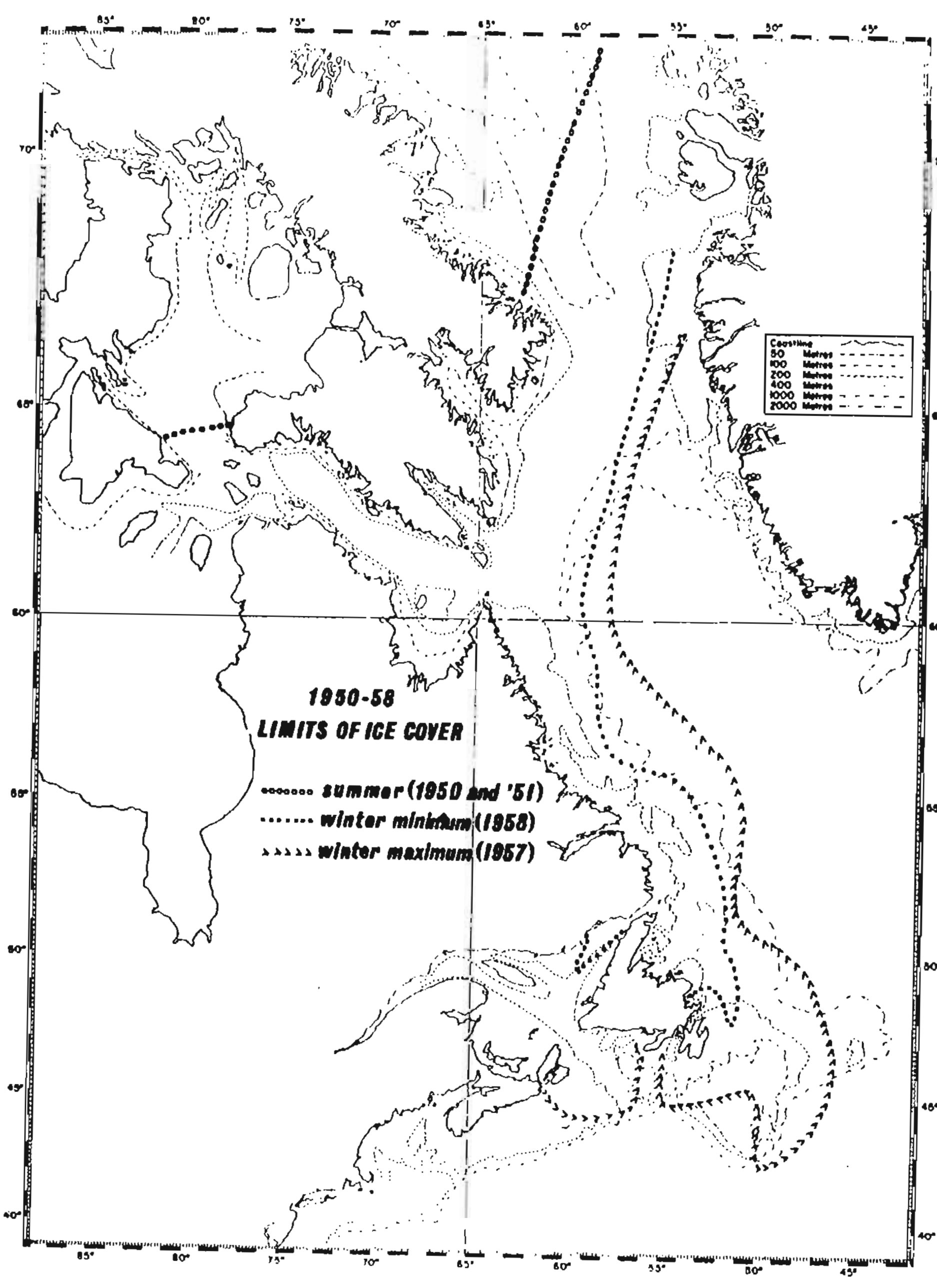

Figure 2. Summer and winter limits of ice cover in the northwest Atlantic during 1950-58 (Dansk Meteorologisk Institut, 1950-56, and Canada Department of Transport Ice forecasting Service, 1956-58).

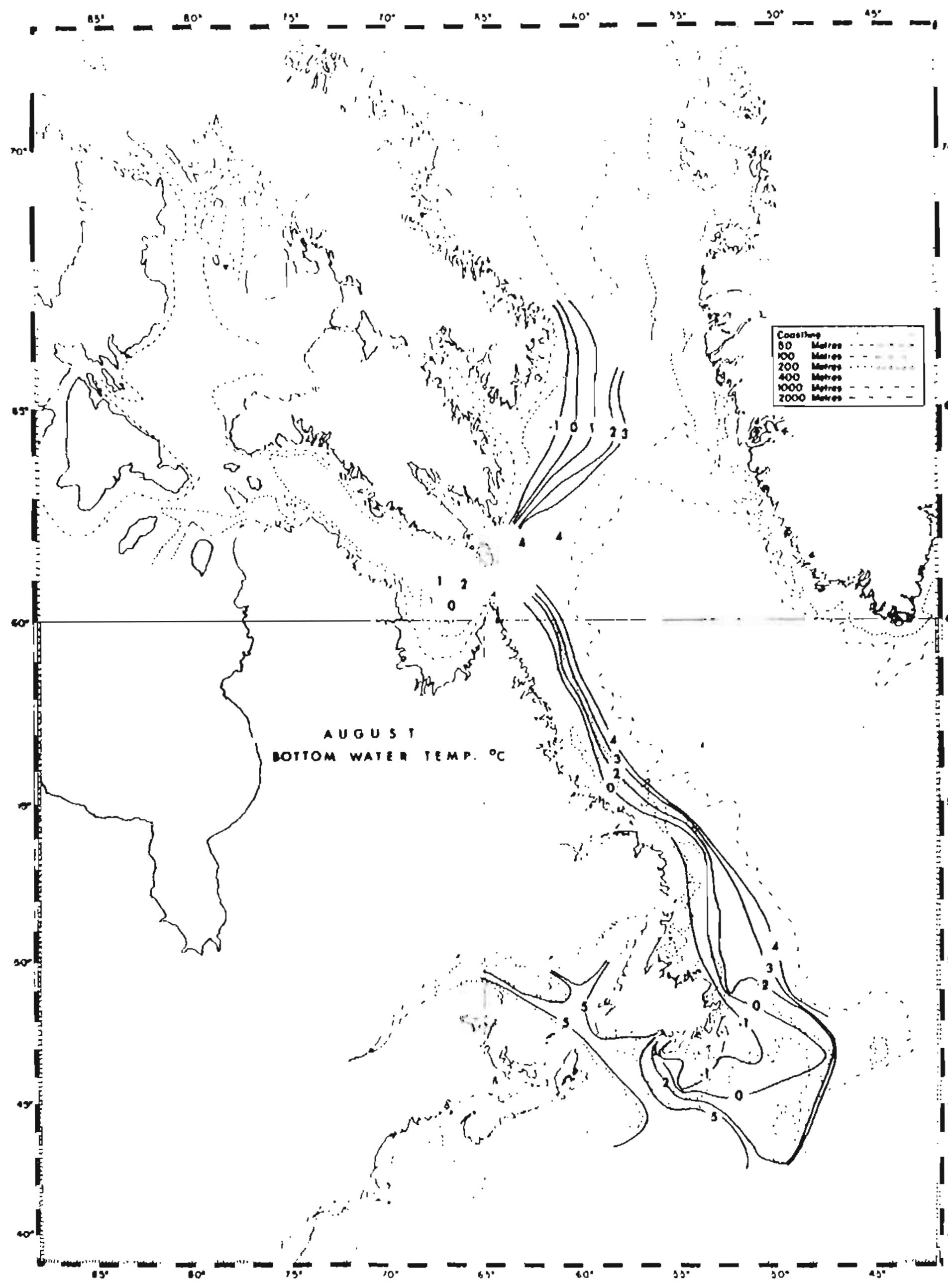

Figure 3. Map showing bottom water isotherms for August. Baffin Island results are from 1960, northern Labrador, 1950, southern Labrador to the Grand Banks, 1957, and southwest Newfoundland and the Gulf of St. Lawrence, 1957 and 1958.

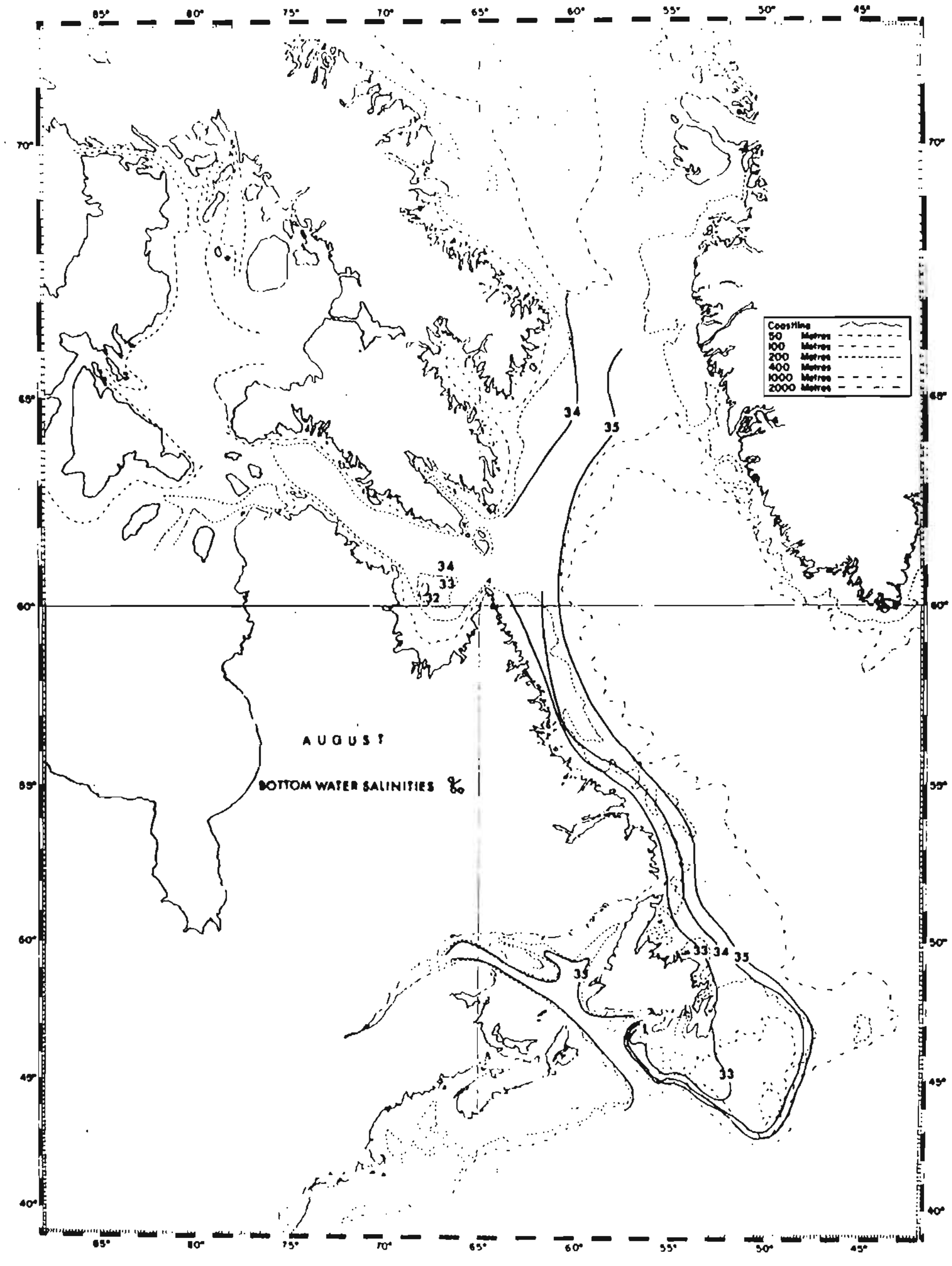

Figure 4. Map showing bottom water isohalines for August. Data obtained concurrently and as in Figure 3.

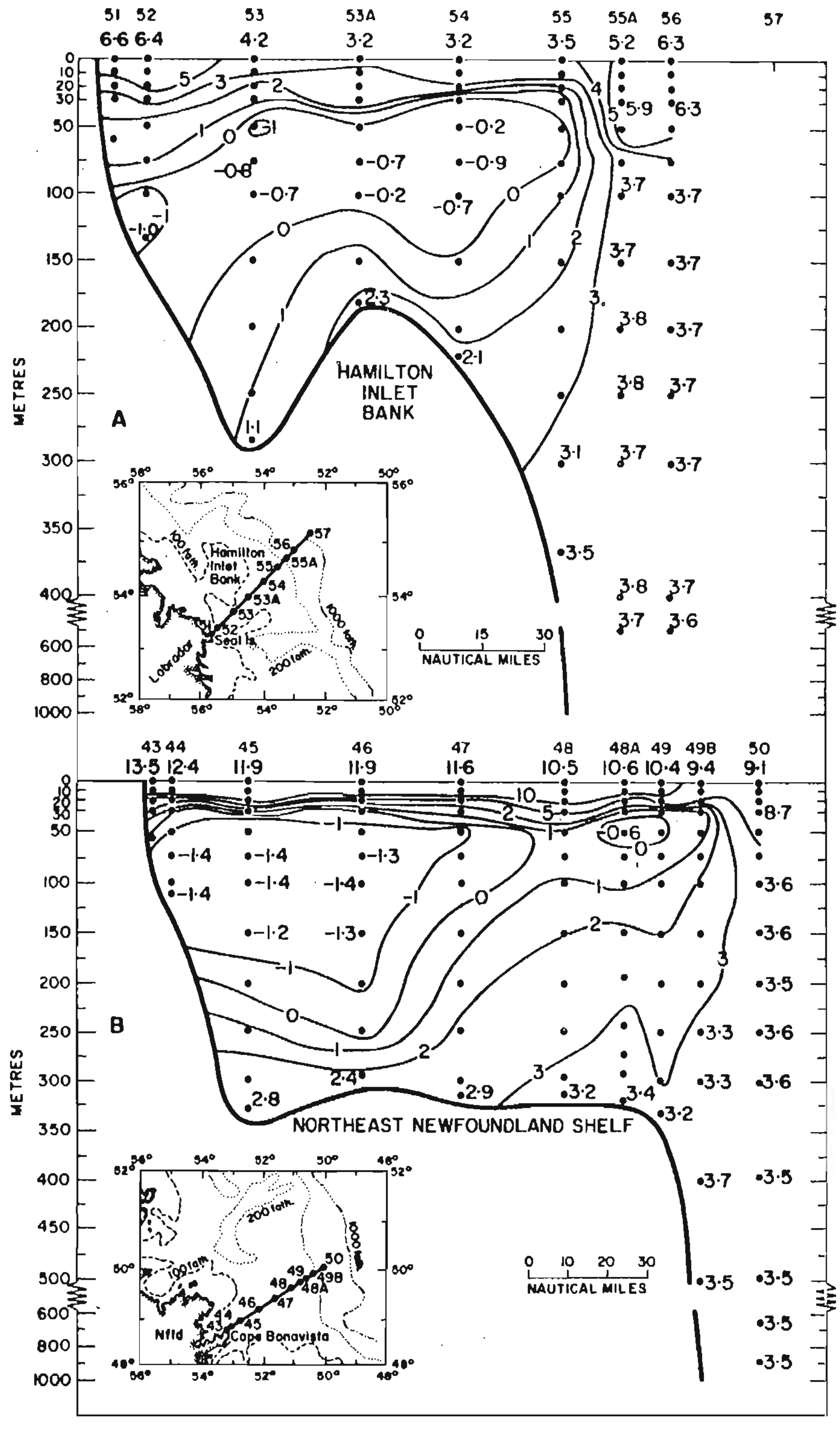

Figure 5. Cross-sections of water columns showing the extent of Arctic water A. Off the Seal Islands, Labrador, and B. Off Cape Bonavista, Newfoundland. July 27 to August 1, 1961 (Templeman, 1962).

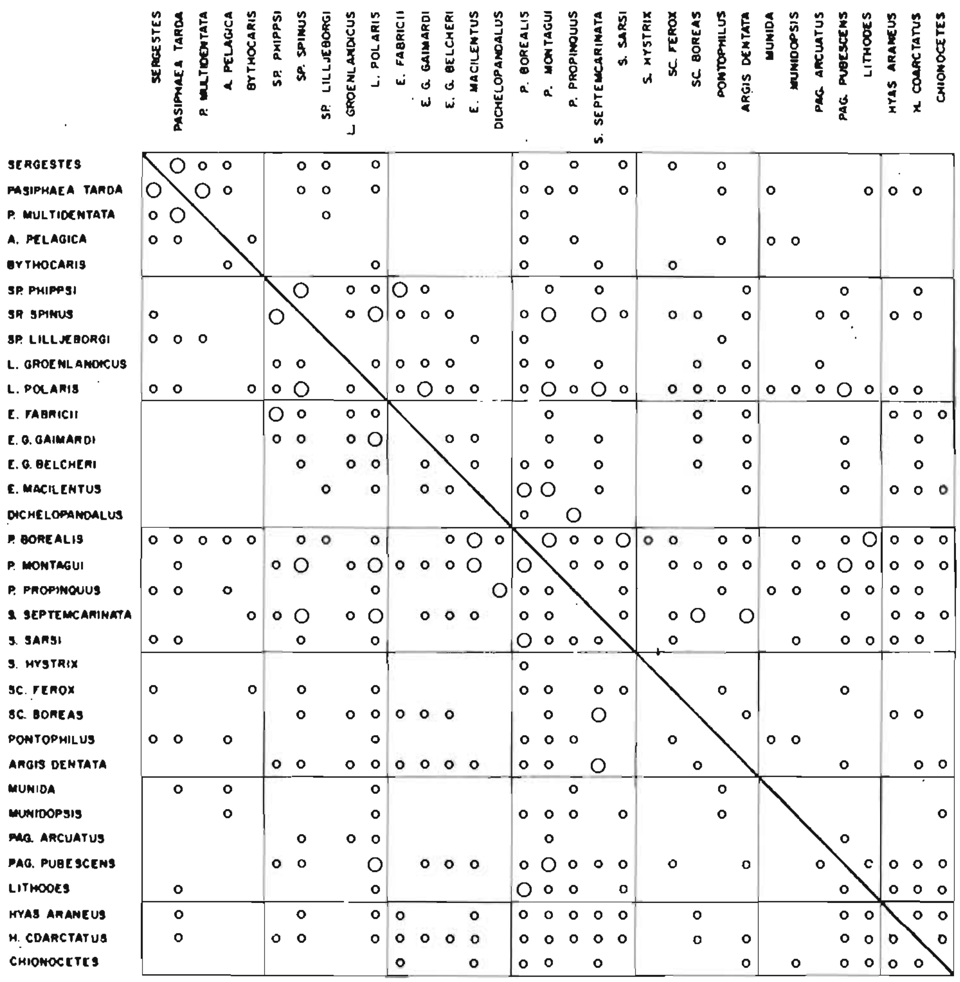

Figure 6. Diagram of the occurrence of decapod species in the same hauls (O = frequently and o = occasionally occurring together).

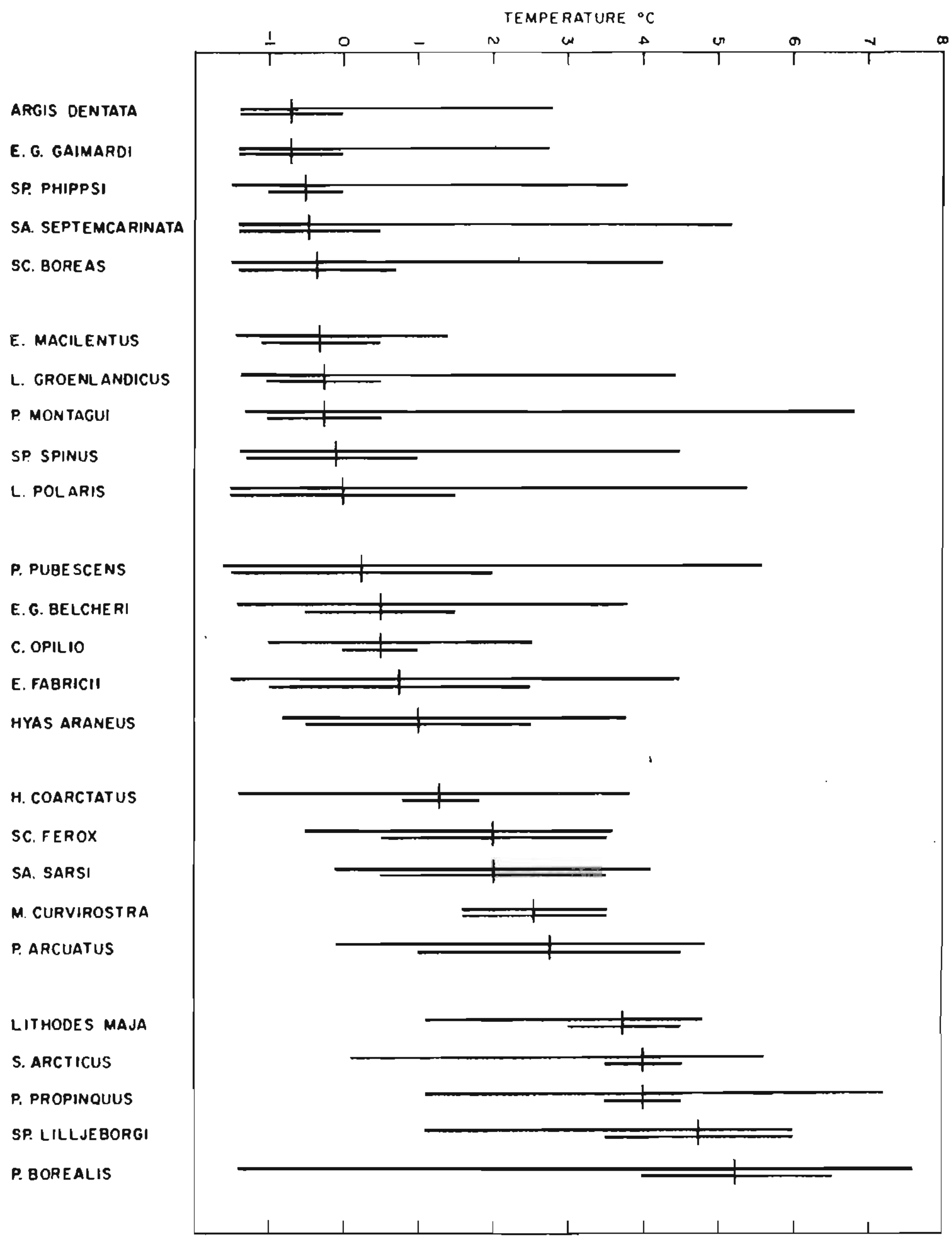

Figure 7. Temperature range of the more common decapod species in the area of investigation. The double line indicates where 80% or more of the specimens were taken.

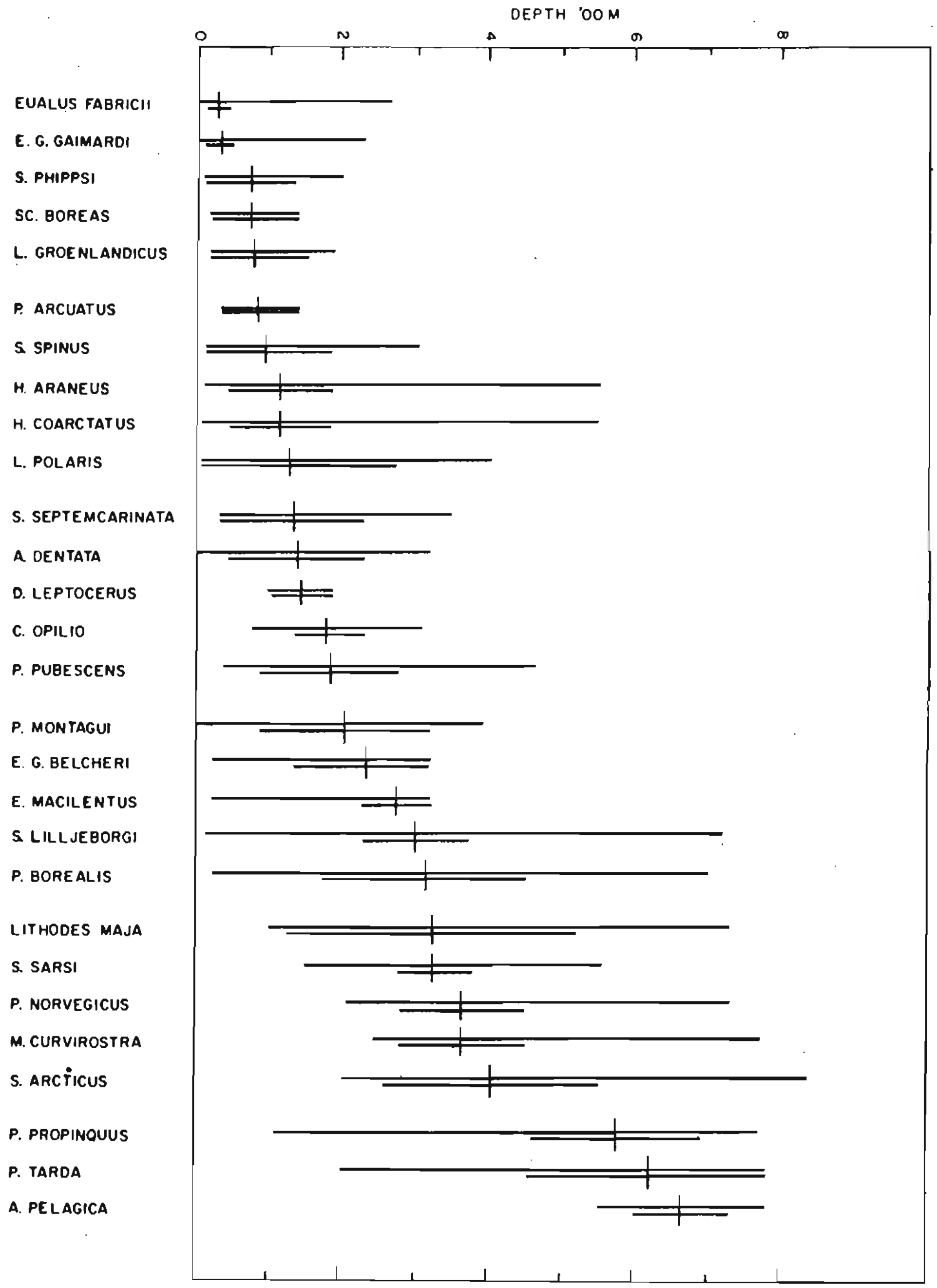

Figure 8. Depth range of the more common decapod species in the area of investigation. The double line indicates where 80% or more of the specimens were taken.

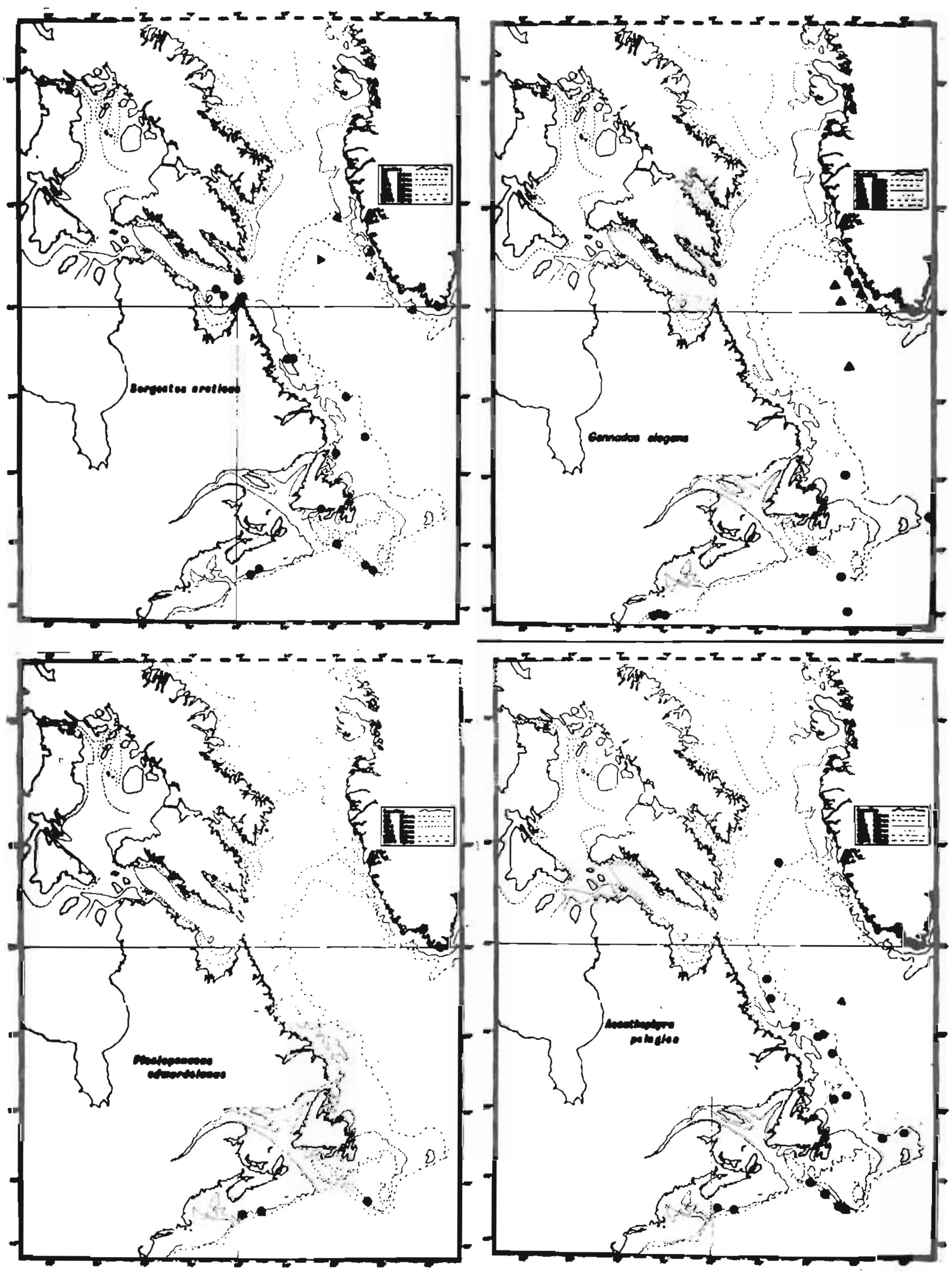

Figure 9. Distribution records of <u>Sergestes arcticus</u>, <u>Gennadas elegans</u>, <u>Plesiopenaeus edwardsianus</u>, and <u>Acanthephyra pelagica</u> in the northwest Atlantic.

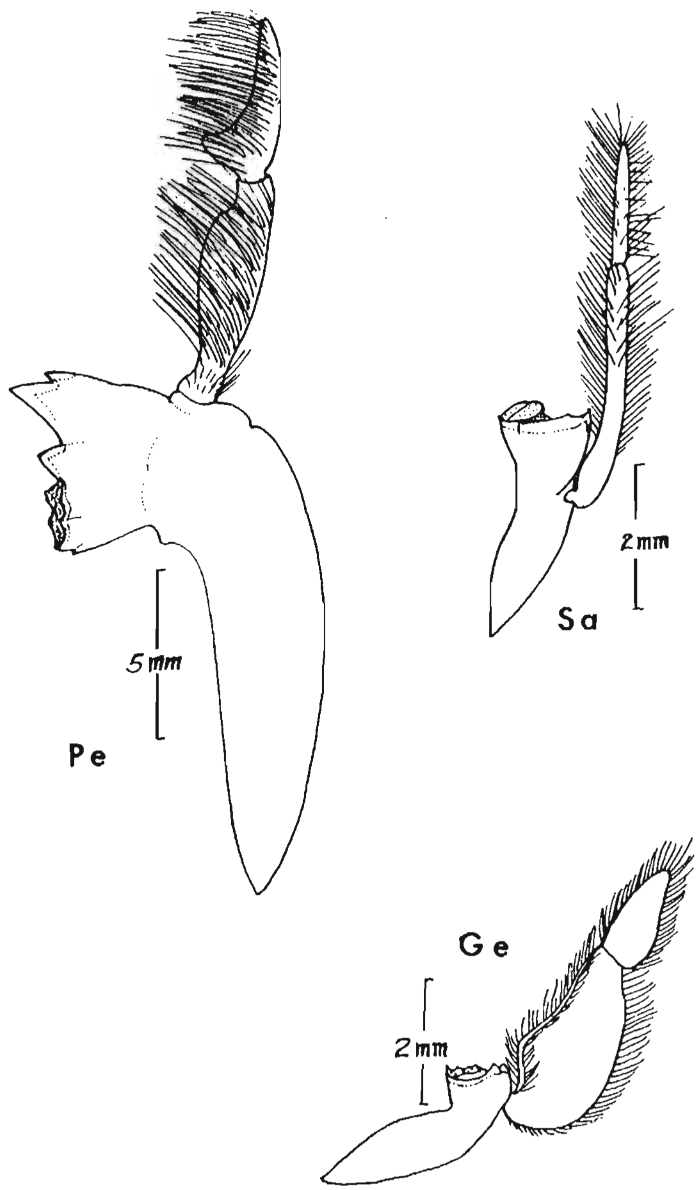

Figure 10. Mandibles of penaeid shrimps: Plesiopenaeus edwardsianus (Pe), Sergestes arcticus (Sa) and Gennadas elegans (Ge).

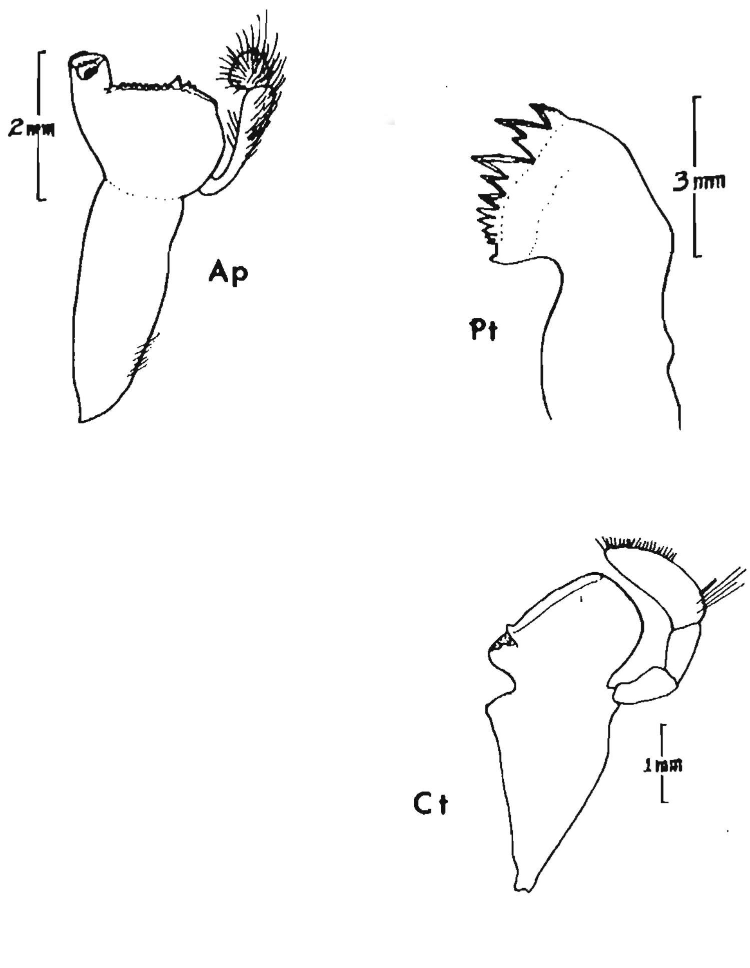

Figure 11. Mandibles of Acanthephyra pelagica (Ap), Pasiphaea tarda (Pt) and Calocaris templemani (Ct).

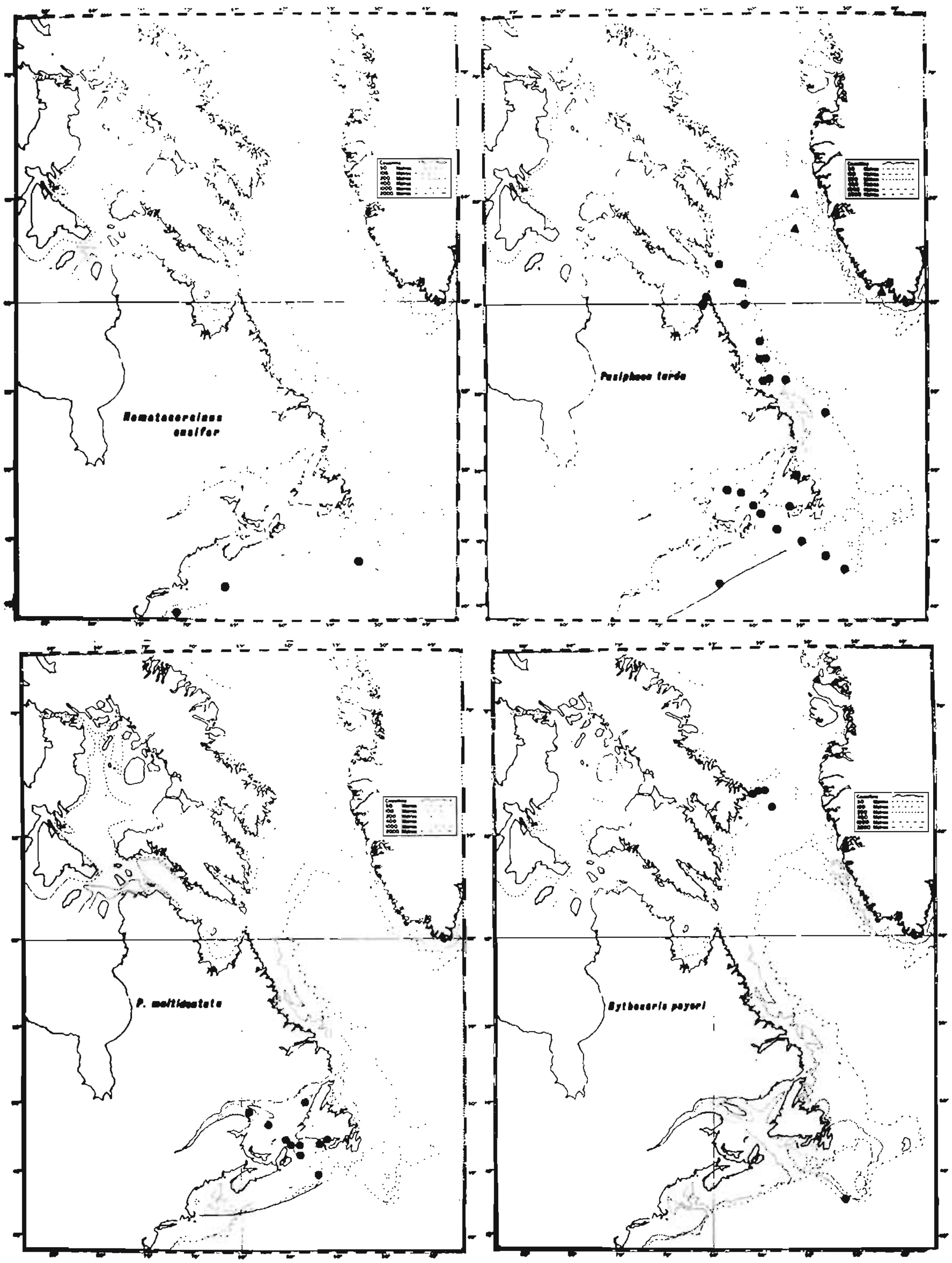

Figure 12. Distribution records of Nematocarcinus ensifer, Pasiphaea tarda, P. multidentata and Bythocaris payeri in the northwest Atlantic.

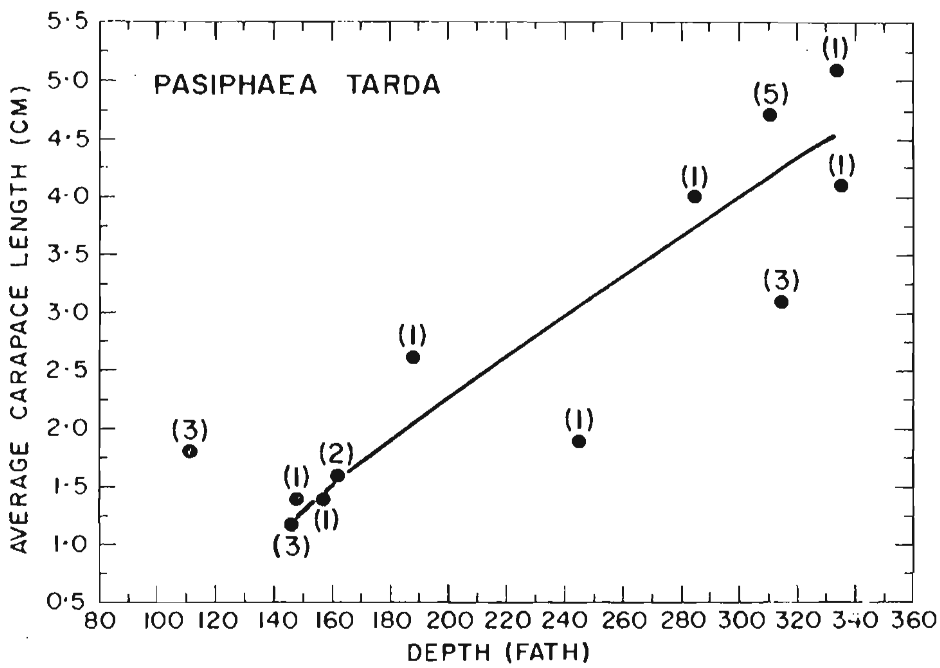

Figure 13. Carapace lengths of Pasiphaea tarda with relation to depth of captures in 1947-57.

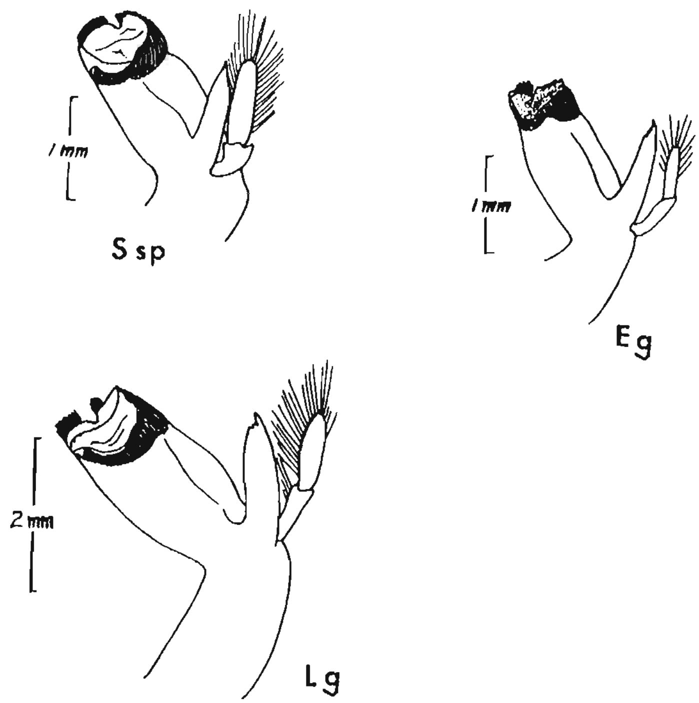

Figure 14. Mandibles of hippolytid shrimps, Spirontocaris spinus (S sp), Eualus gaimardi gaimardi (Eg) and Lebbeus groenlandicus (Lg).

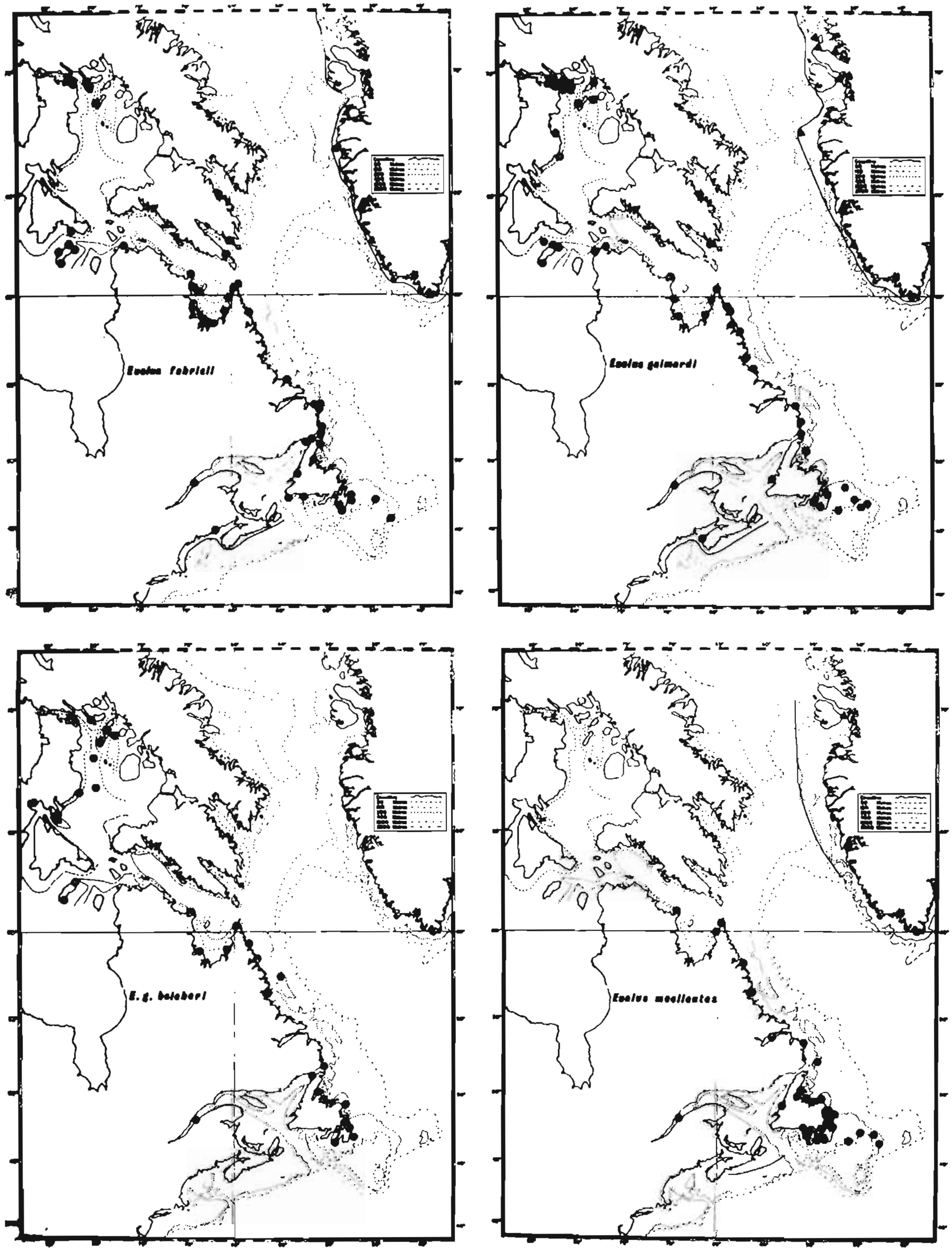

Figure 15. Distribution records of Eualus fabricii, E. gaimardi, E. g. belcheri and E. macilentus in the northwest Atlantic.

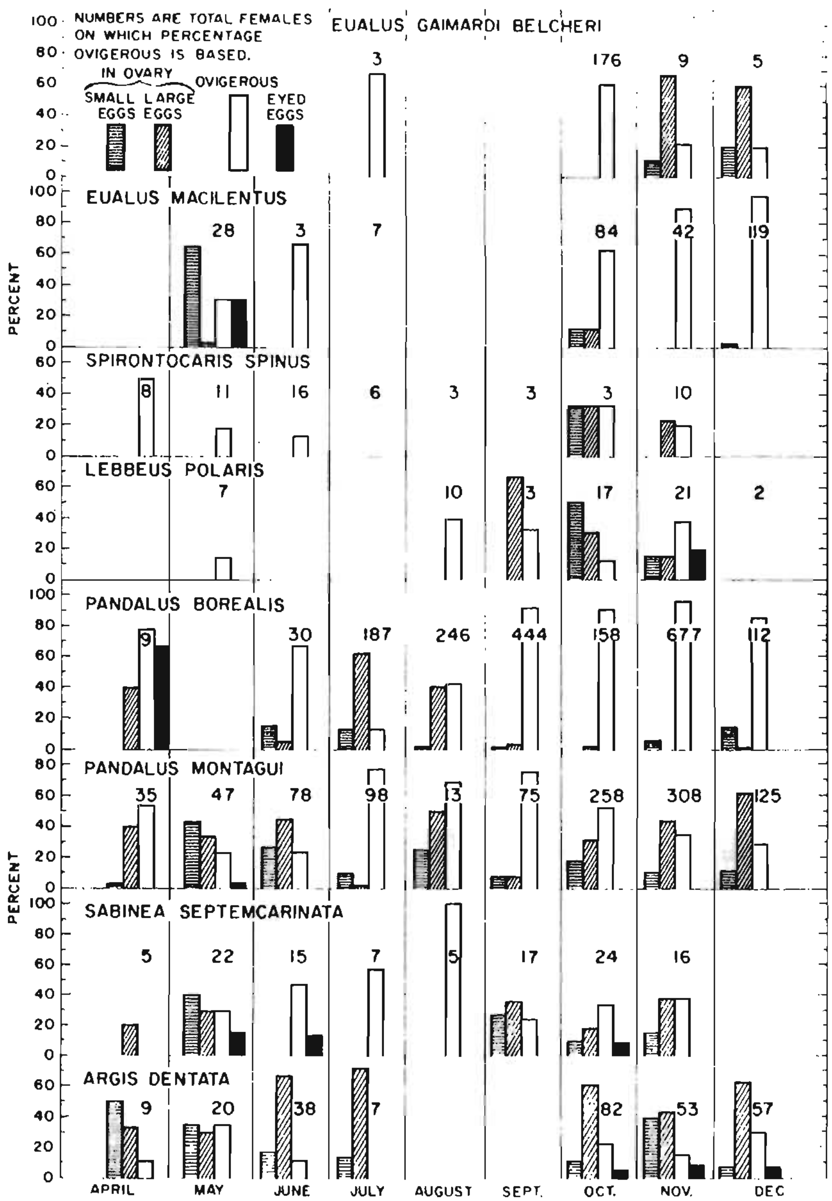

Figure 16. Percent of females with small or large ova but nonovigerous, of females ovigerous and with small ova and of females with advanced embryos. Specimens were collected from April to December, 1947-57, in Newfoundland.

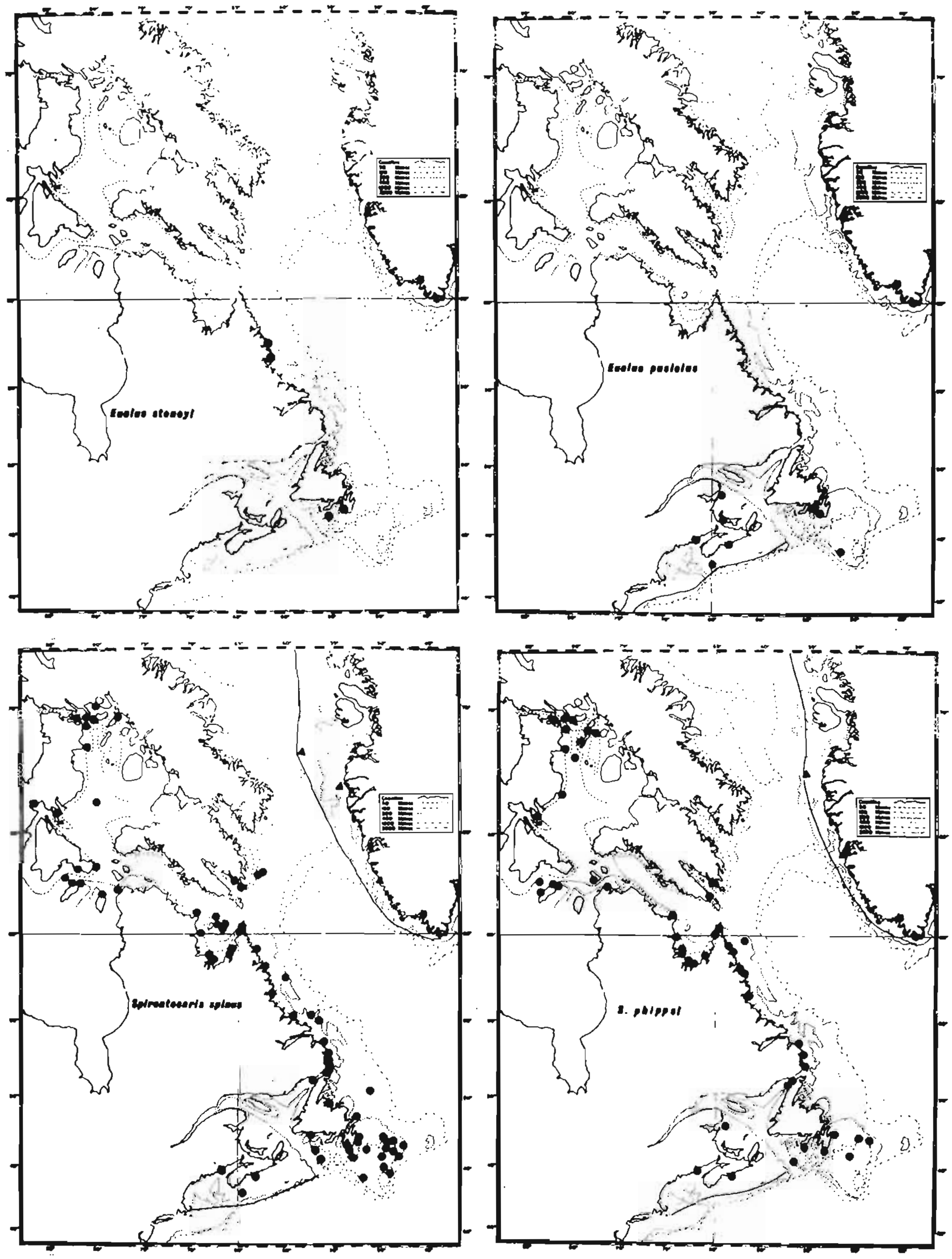

Figure 17. Distribution records of Eualus stoneyi, E. pusiolus, Spirontocaris spinus and S. phippsi in the northwest Atlantic.

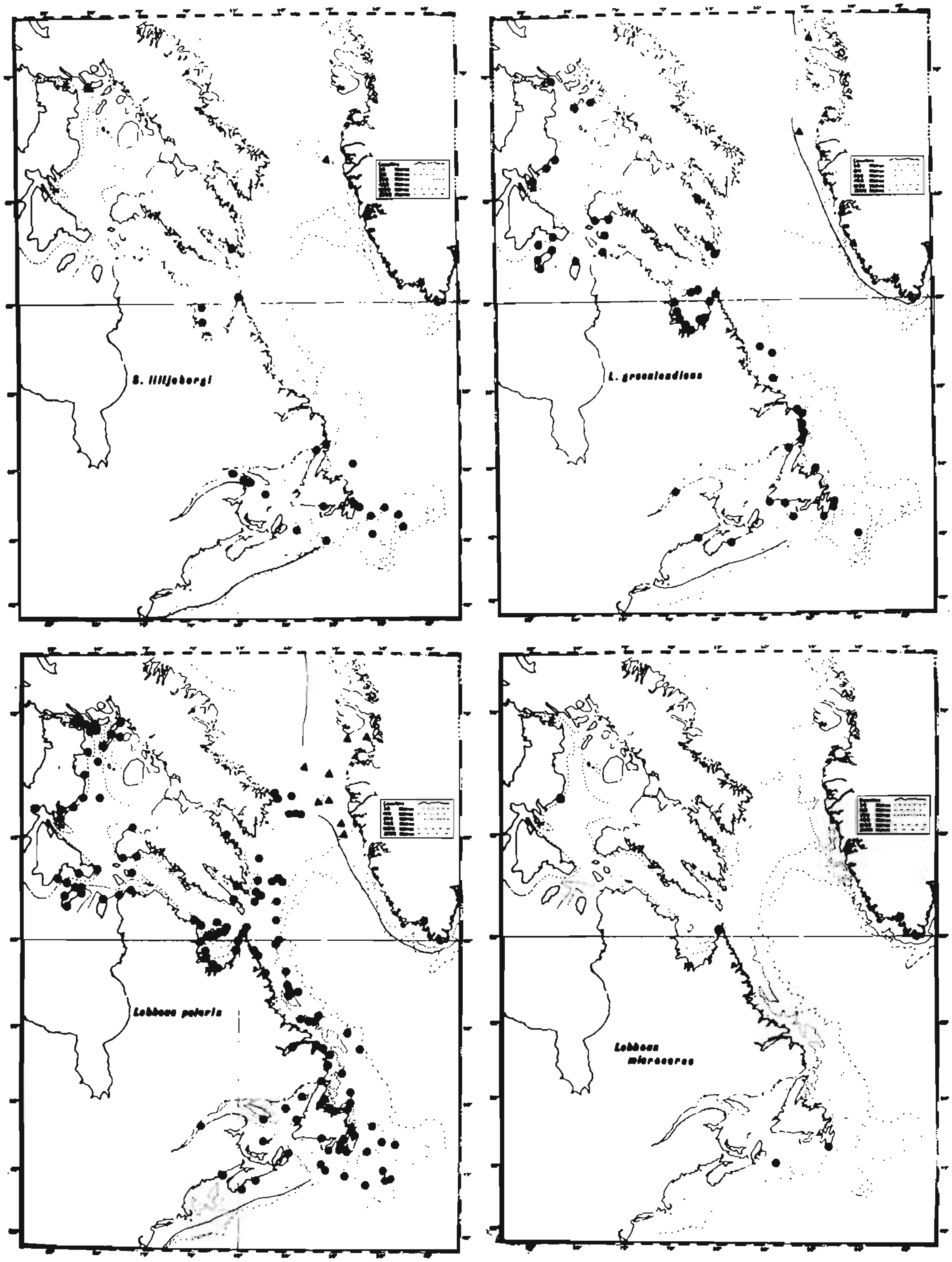

Figure 18. Distribution records of Spirontocaris lilljeborgi, Lebbeus groenlandicus, L. polaris and L. microceros in the northwest Atlantic.

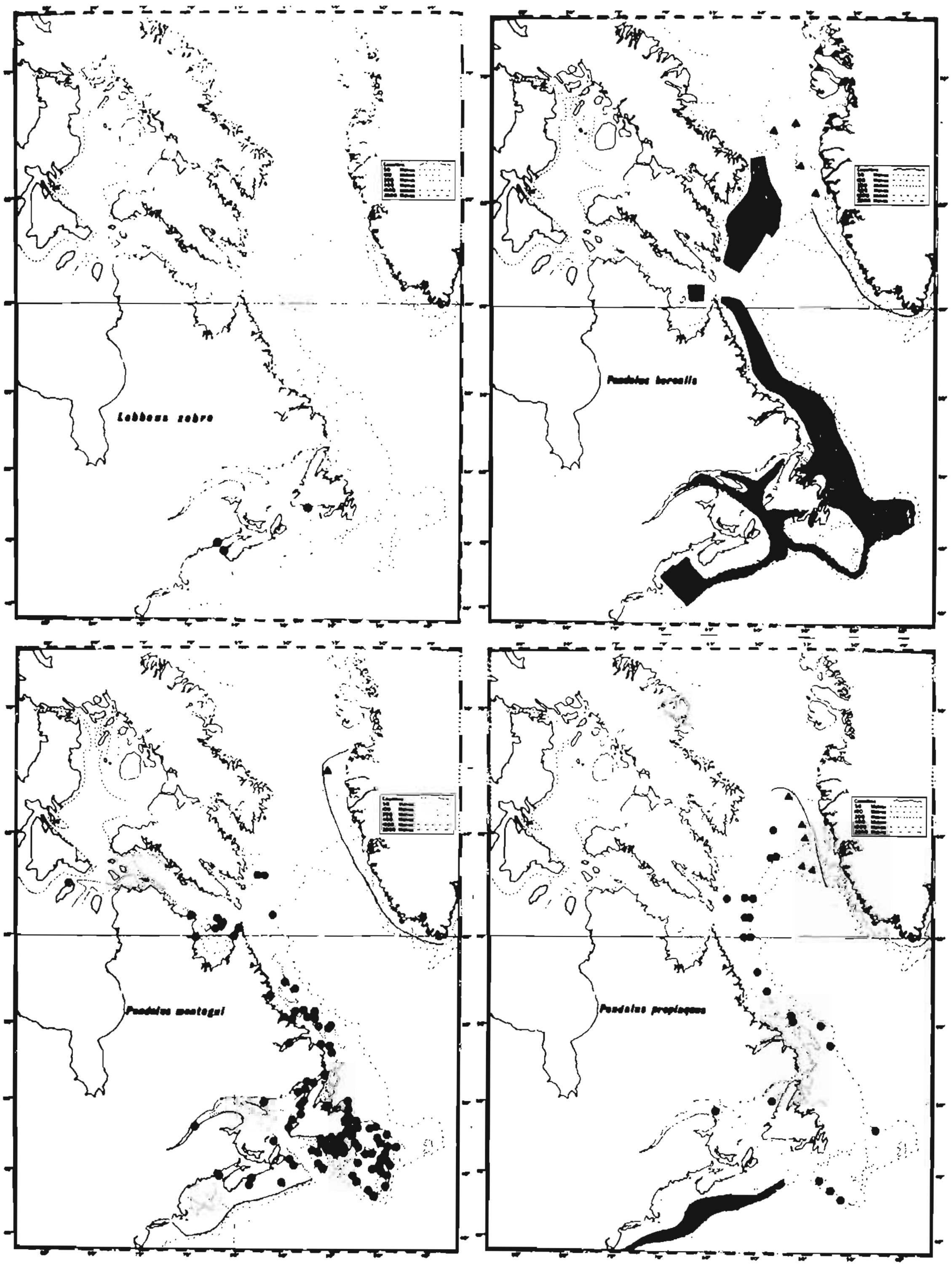

Figure 19. Distribution records of Lebbeus zebra, Pandalus borealis, P. montagui and P. propinquus in the northwest Atlantic.

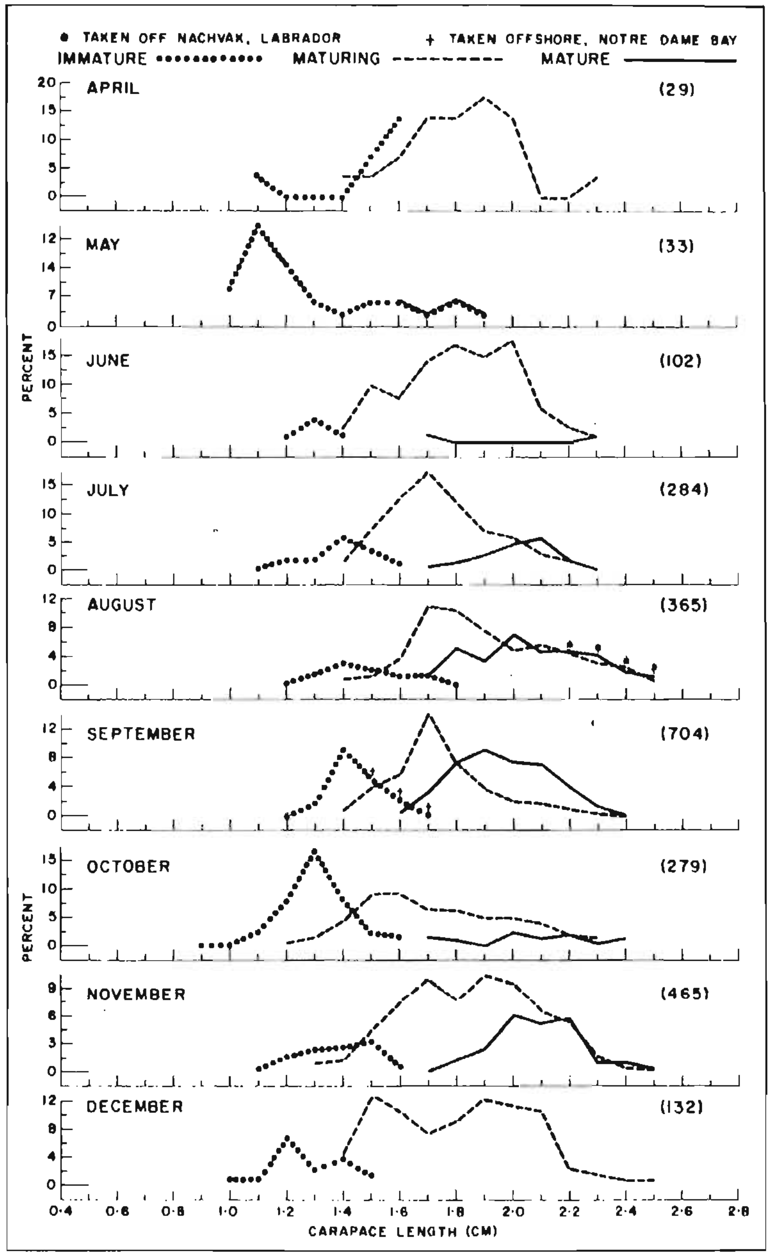

Figure 20. Maturity of male <u>Pandalus borealis</u> from Labrador and Newfoundland during April to December, 1947-57. Numbers examined are in parentheses.

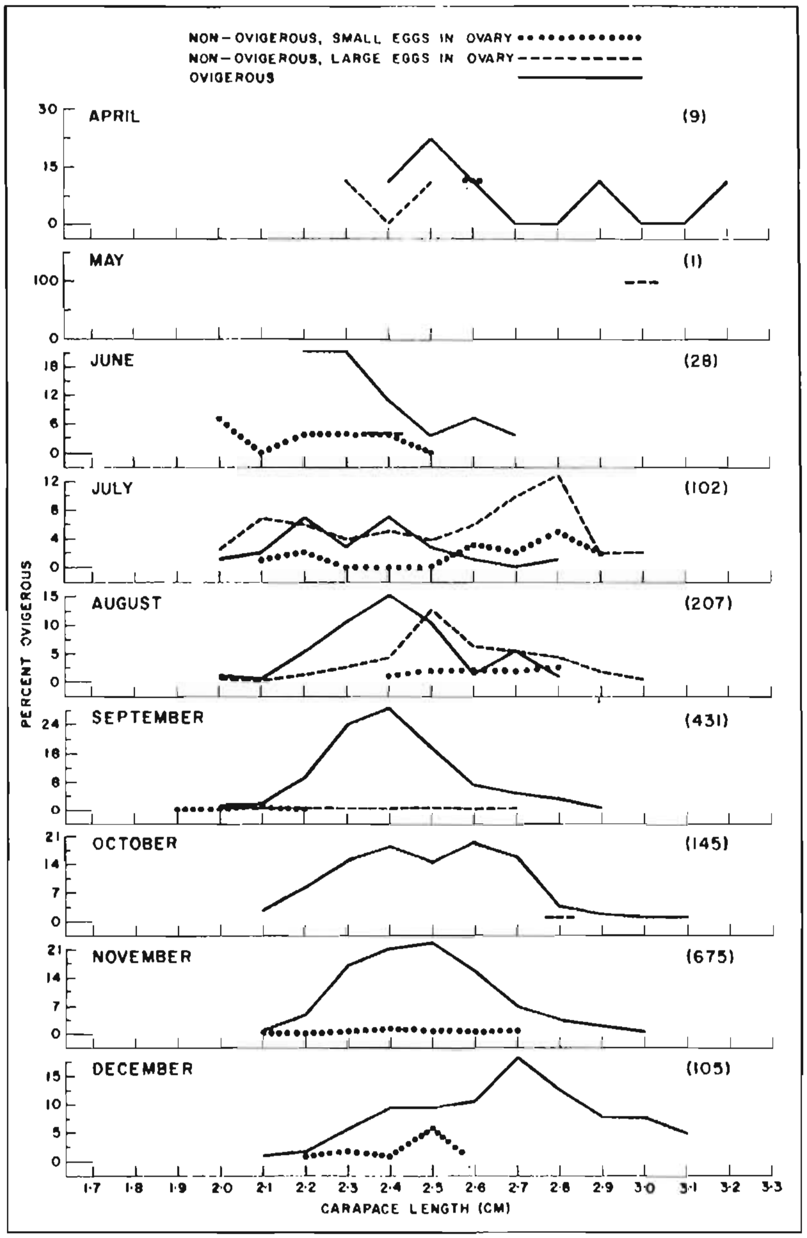

Figure 21. Maturity of female Pandalus borealis from Labrador and Newfoundland during April to December, 1947-57. Numbers examined are in parentheses.

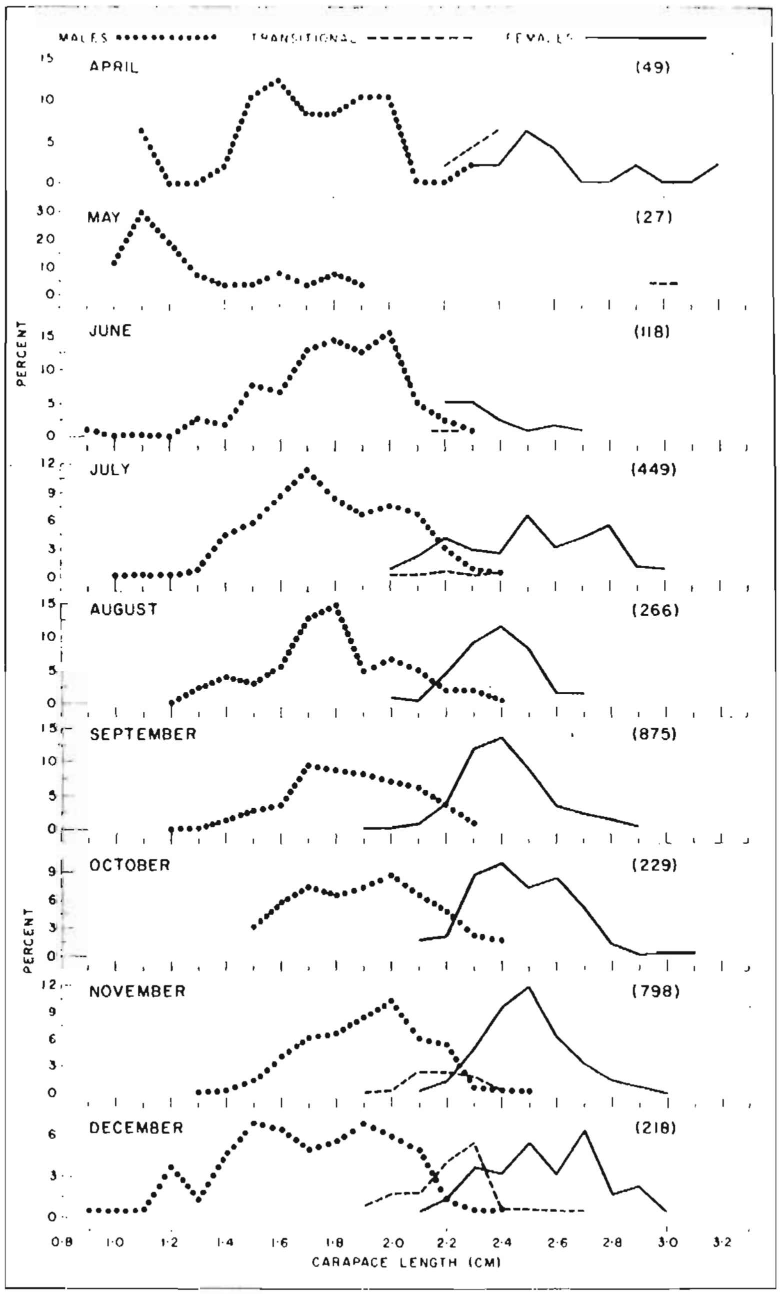

Figure 22. Male, intersex and female Pandalus borealis taken from April to December from several localities in the area in 1947-57. Numbers measured are in parentheses.

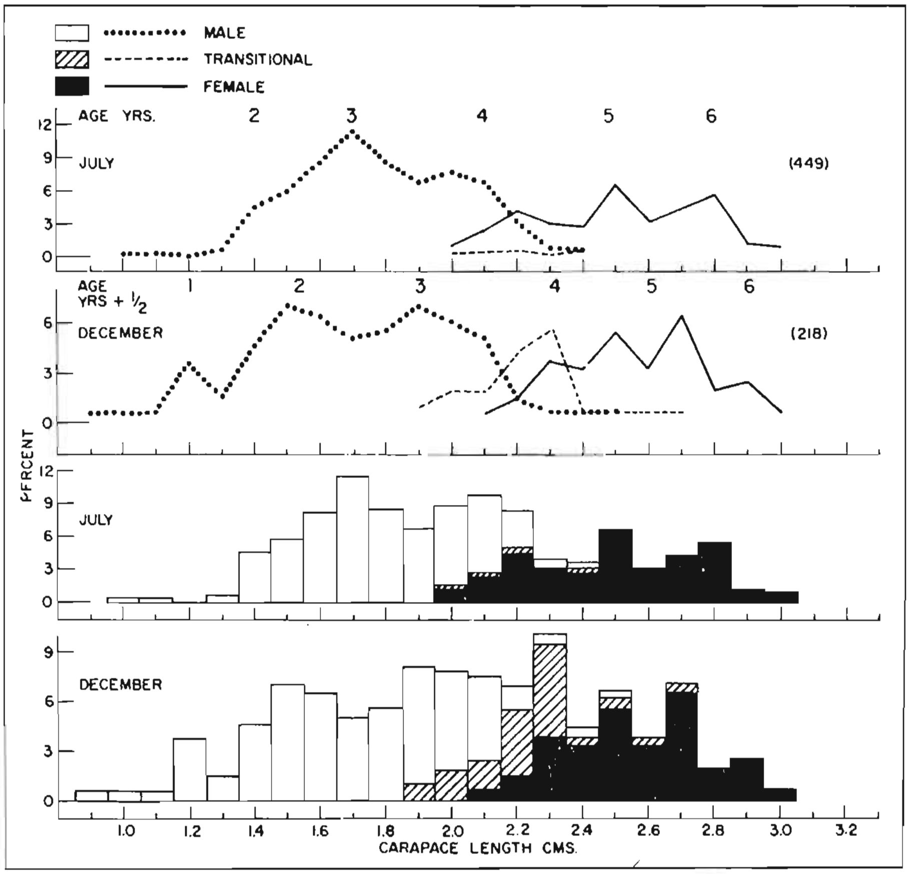

Figure 23. Estimation of age in <u>Pandalus</u> <u>borealis</u>. Lengths of specimens from several areas are combined in both months. The data are repeated from Figure 22.

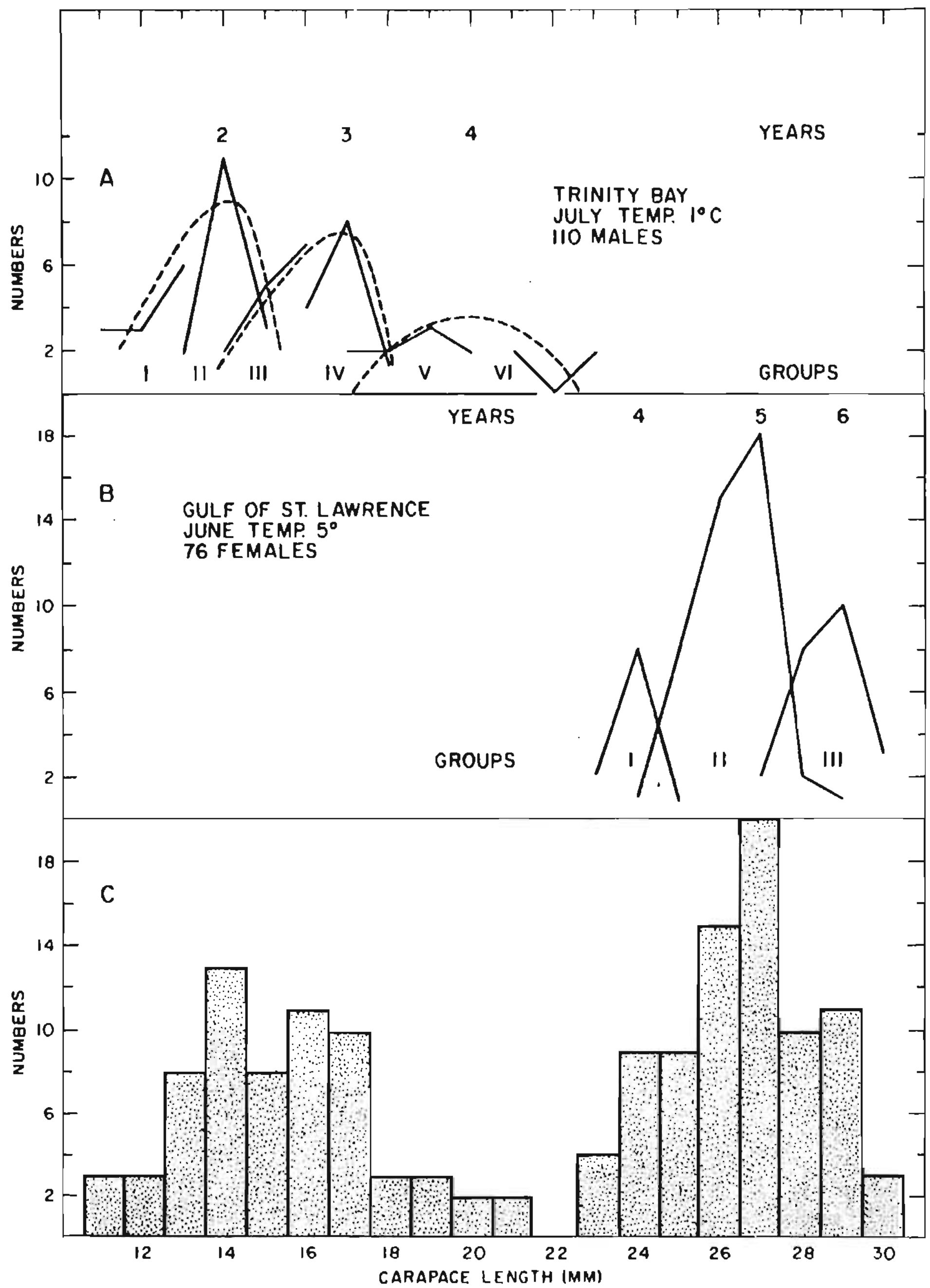

Figure 24. Pandalus borealis groups selected by eye before measuring, measured but kept separate and curves interpolated to show probable age groups. A. Males from Trinity Bay, B. females from the Gulf of St. Lawrence and C. combined frequencies of A and B. (The separation in size of males and females is normally less than shown but is caused here by different growth rates at the temperatures indicated.

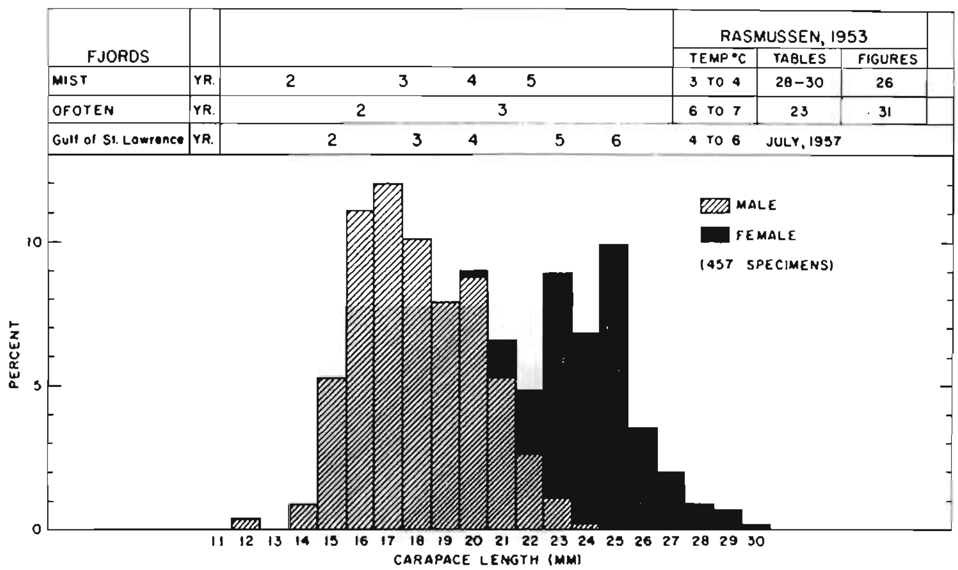

Figure 25. Estimated ages of Pandalus borealis from the Gulf of St. Lawrence (temperature 4 to 5°C) compared with ages of those from the Mist and Ofoten Fjords, Norway (temperatures 3 to 4 and 6 to 7°C, respectively (from Rassmussen, 1953)).

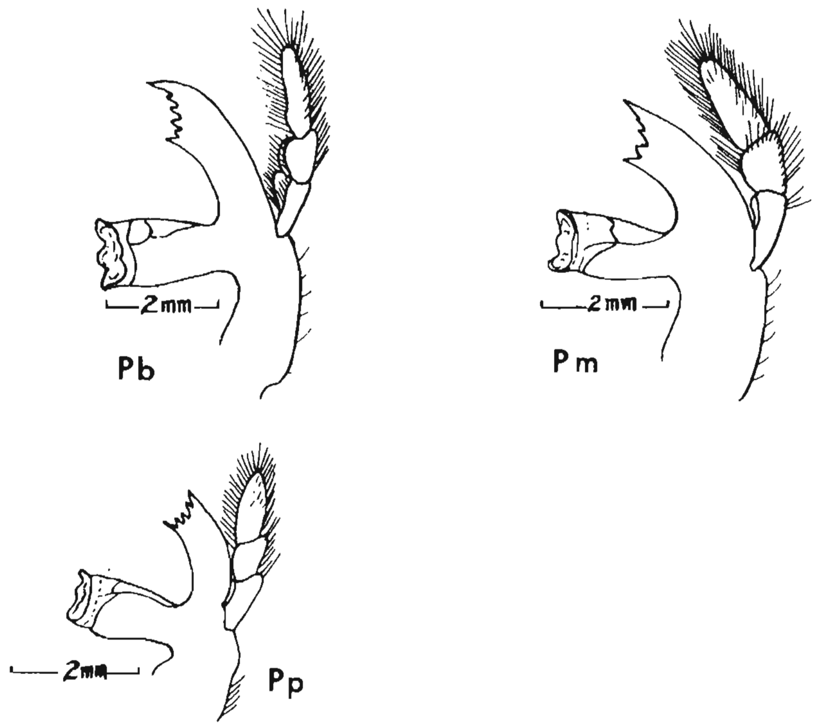

Figure 26. Mandibles of _Pandalus_ _borealis_ (Pb), _P_. _montagui_ (Pm) and _P_. _propinquus_ (Pp).

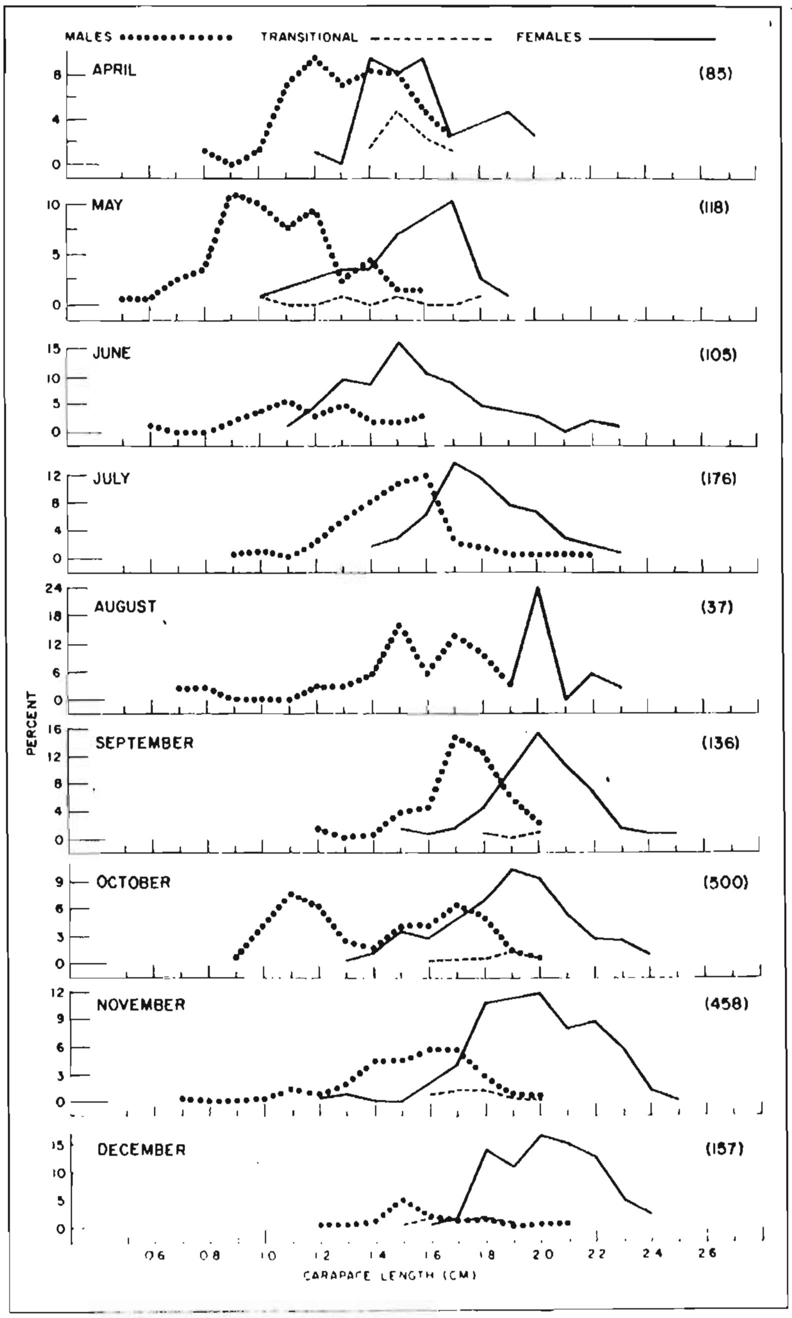

Figure 27. Male, intersex and female Pandalus montagui taken from April to December from several localities in 1947-57. Numbers measured are in parentheses.

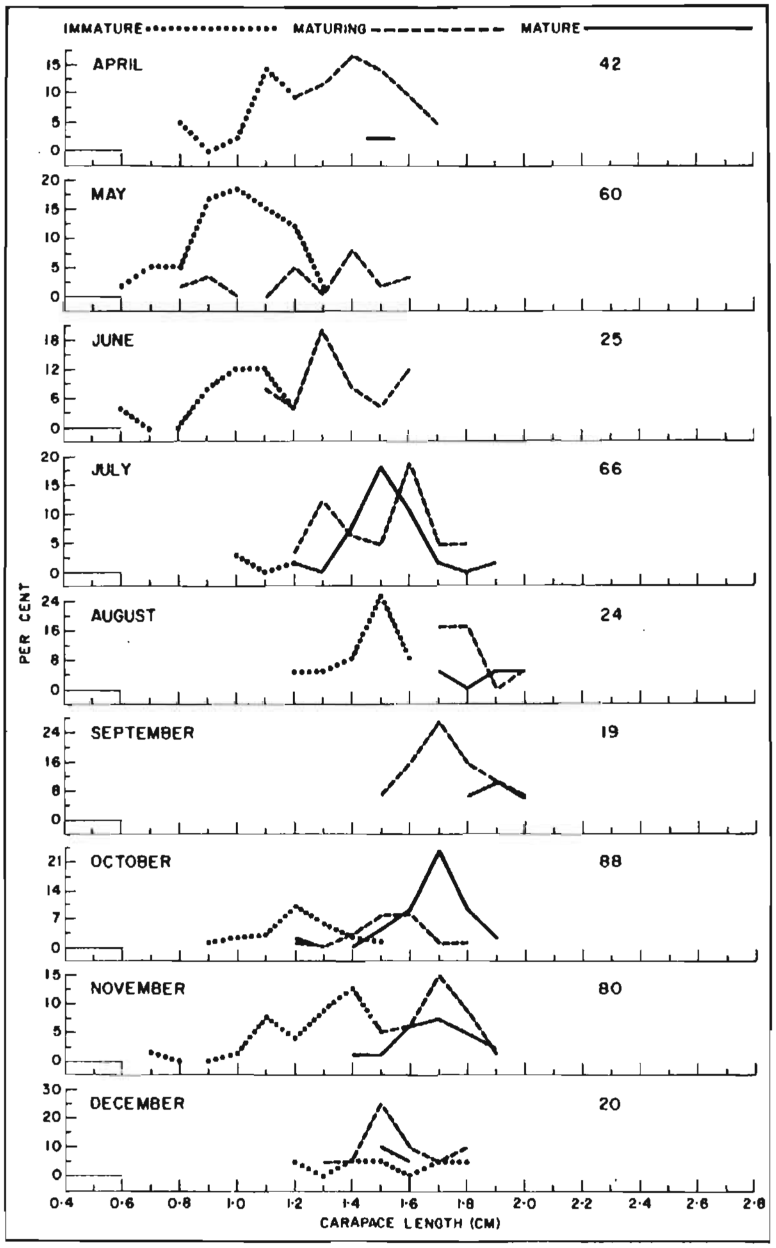

Figure 28. Maturity of male Pandalus montagui from Newfoundland during April to December, 1947-57. Numbers examined are shown.

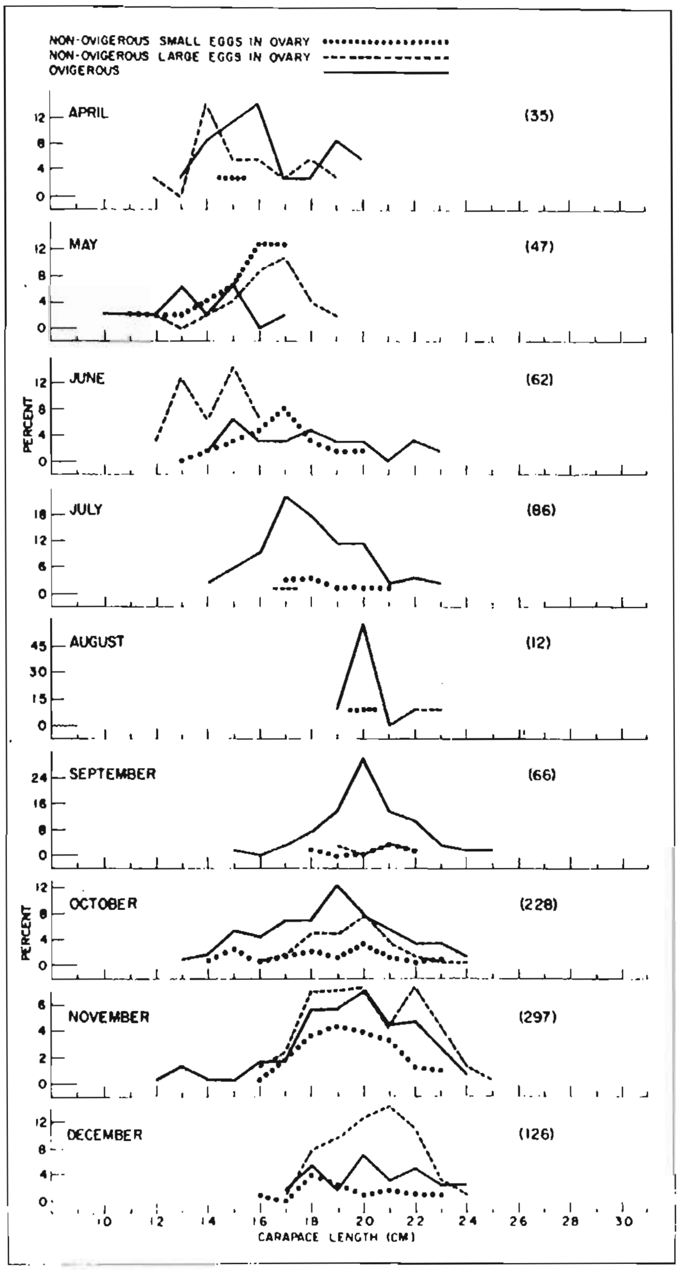

Figure 29. Maturity of female Pandalus montagui from Newfoundland during April to December, 1947-57. Numbers examined are in parentheses.

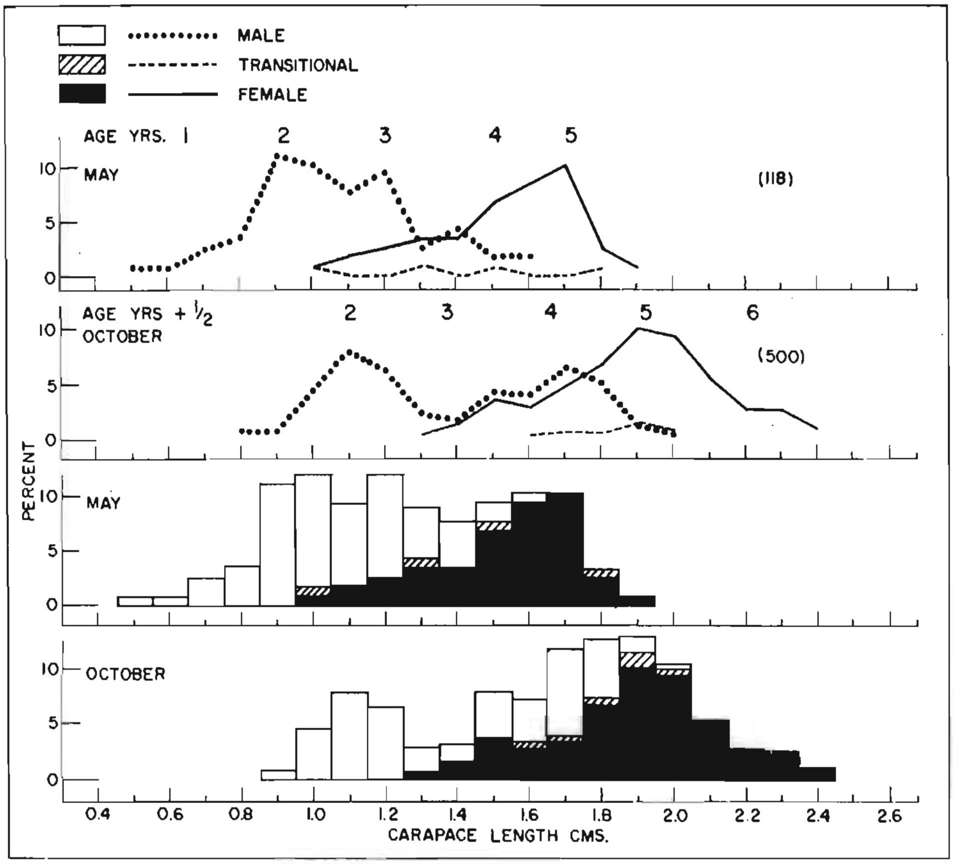

Figure 30. Estimation of age in Pandalus montagui. Lengths from several areas are combined in both months. The data are repeated from Figure 27.

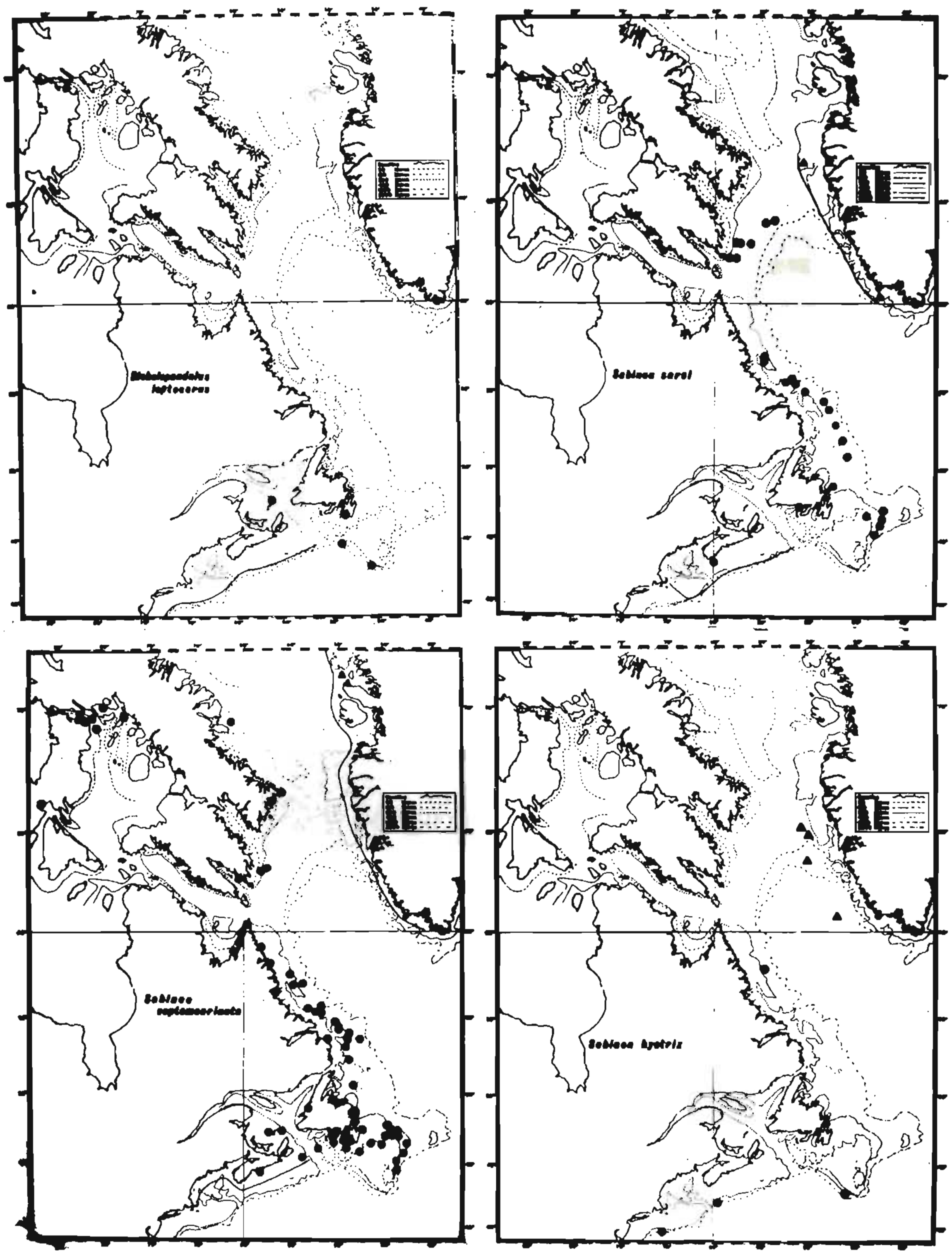

Figure 31. Distribution records of Dichelopandalus leptocerus, Sabinea sarsi, Sabinea septemcarinata and Sabinea hystrix in the northwest Atlantic.

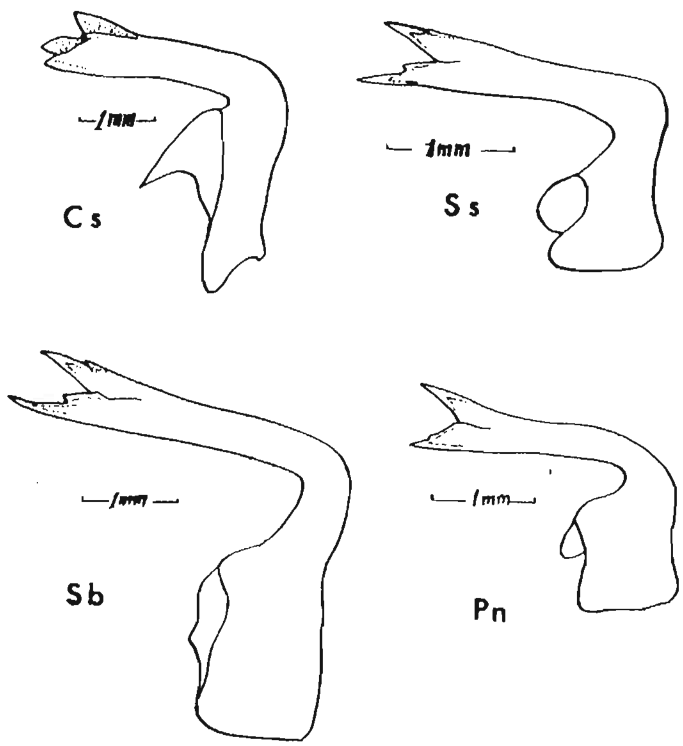

Figure 32. Mandibles of crangonid shrimps: Crangon septemspinosus (Cs), Sabinea sarsi (Ss), Sclerocrangon boreas (Sb) and Pontophilus norvegicus (Pn).

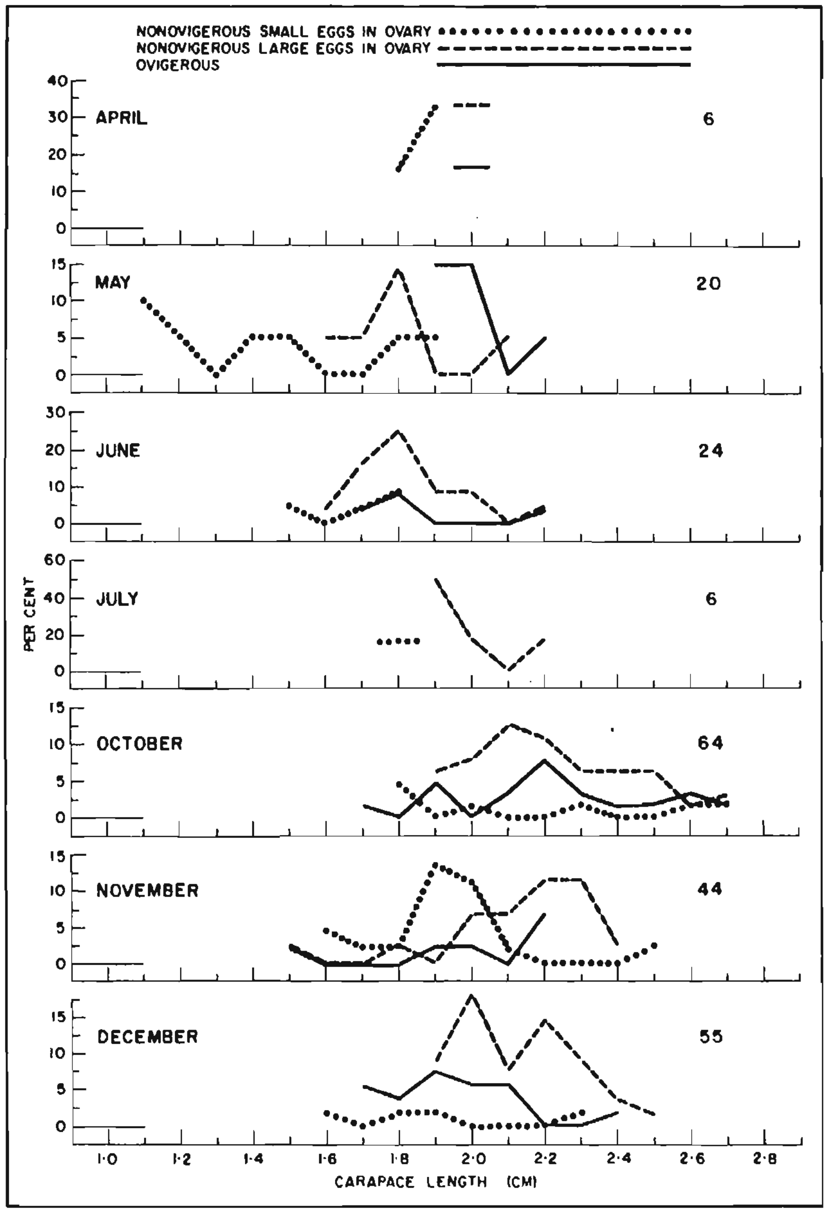

Figure 33. Maturity of female <u>Argis</u> <u>dentata</u> from Newfoundland and Labrador during May to December, 1947-57. Numbers examined are shown at the right.

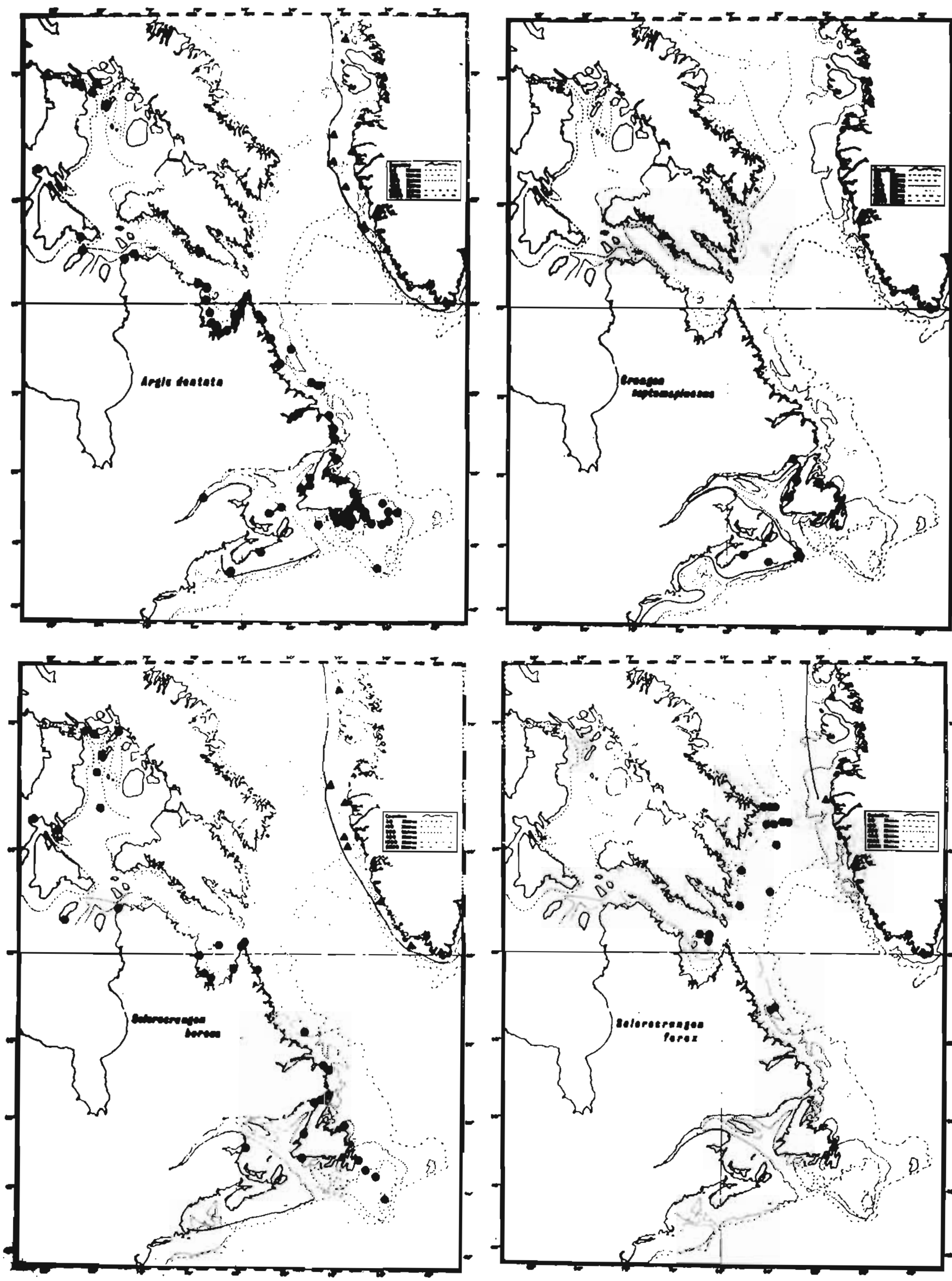

Figure 34. Distribution records of Argis dentata, Crangon septemspinosus, Sclerocrangon boreas and Sclerocrangon ferox in the northwest Atlantic.

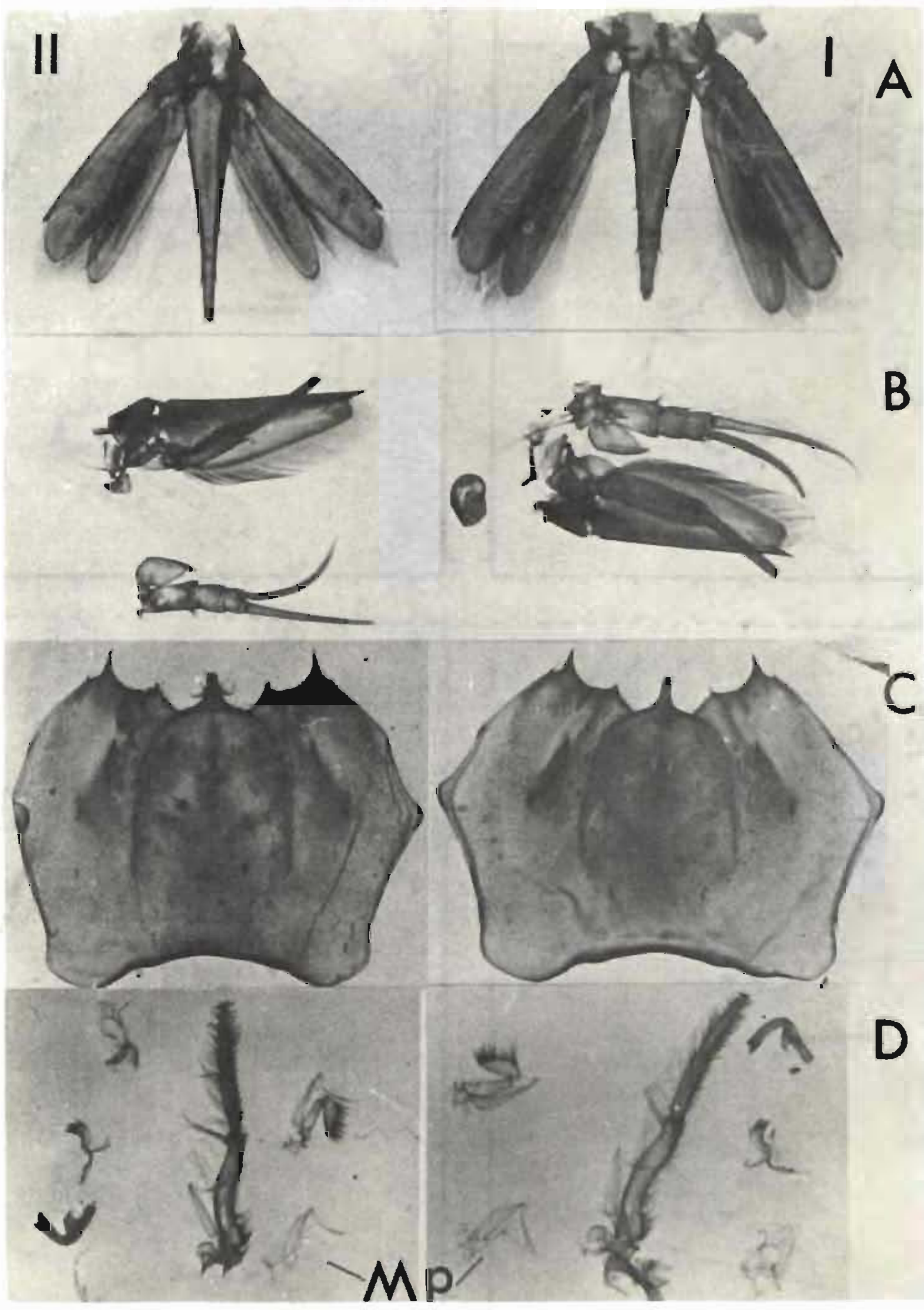

Figure 35. Photographs of whole mounts of (A) telson, (B) 1st and 2nd antennae, (C) carapace and (D) mouth parts of I. Crangon crangon and II. C. septemspinosus. (Mp = 2nd maxilliped).

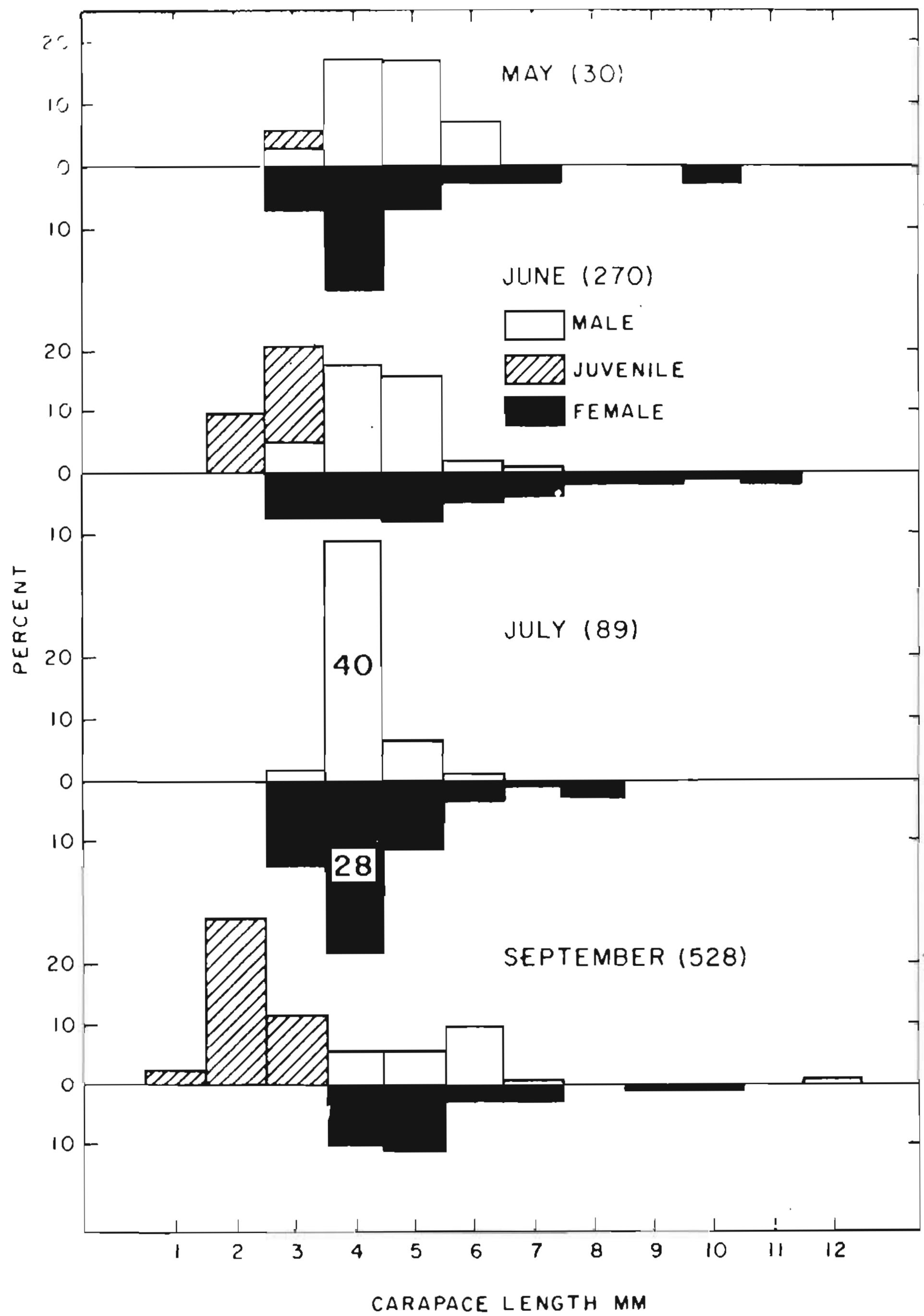

Figure 36. Histograms of lengths of <u>Crangon</u> <u>septemspinosus</u> taken from June to September, 1962, at Port au Port Bay, Newfoundland.

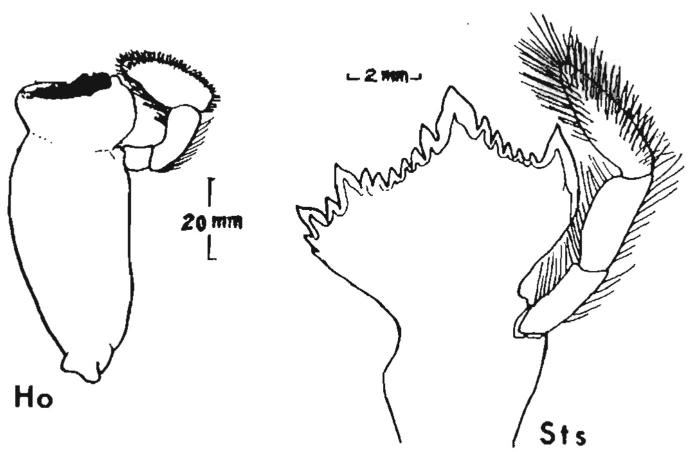

Figure 37. Mandibles of Bythocaris payeri (Bp), Sclerocrangon ferox (Sf), Homarus americanus (Ha) and Stereomastis sculpta (Sts).

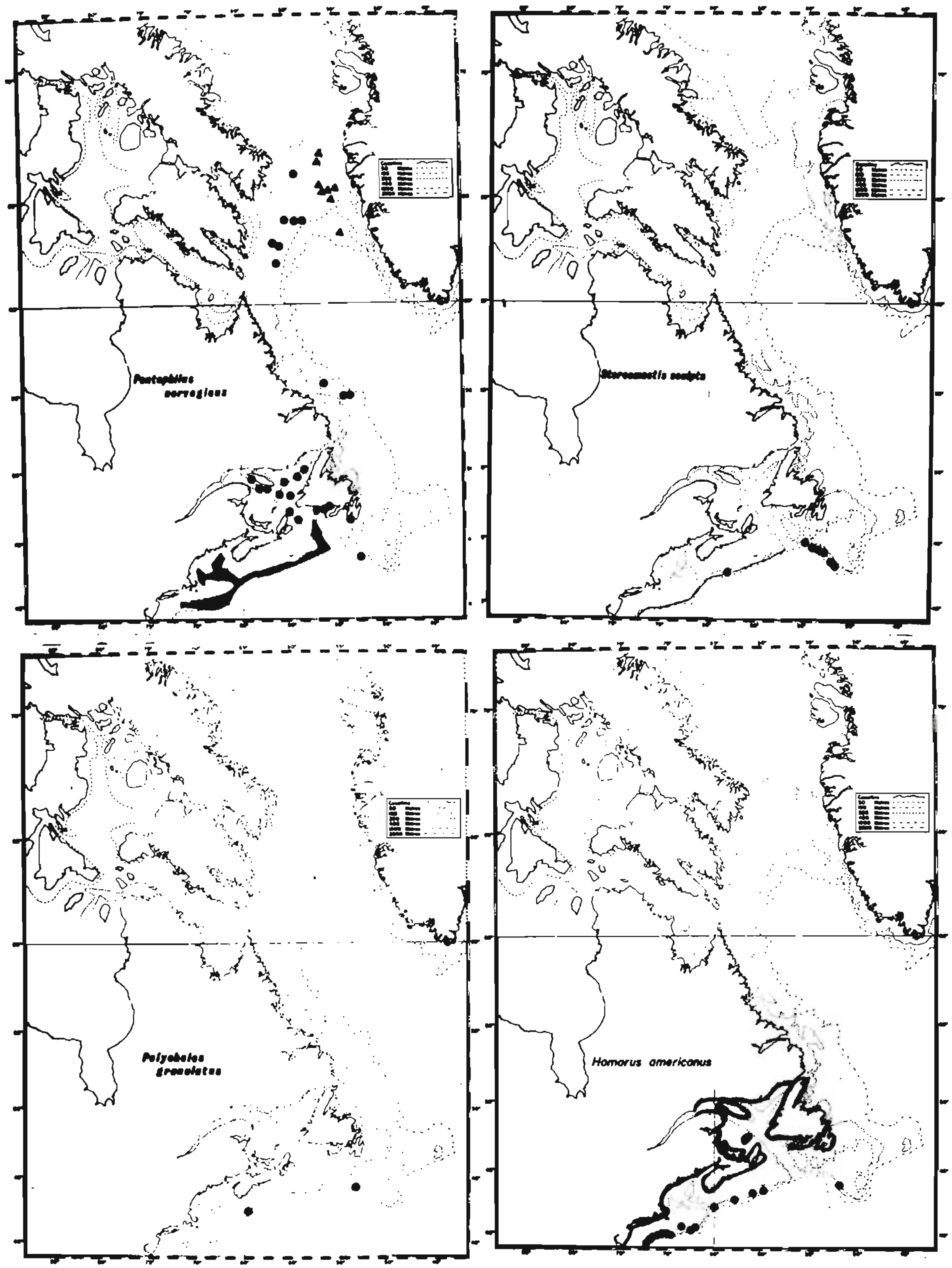

Figure 38. Distribution records of Pontophilus norvegicus, Stereomastis sculpta, Polycheles granulatus and Homarus americanus.

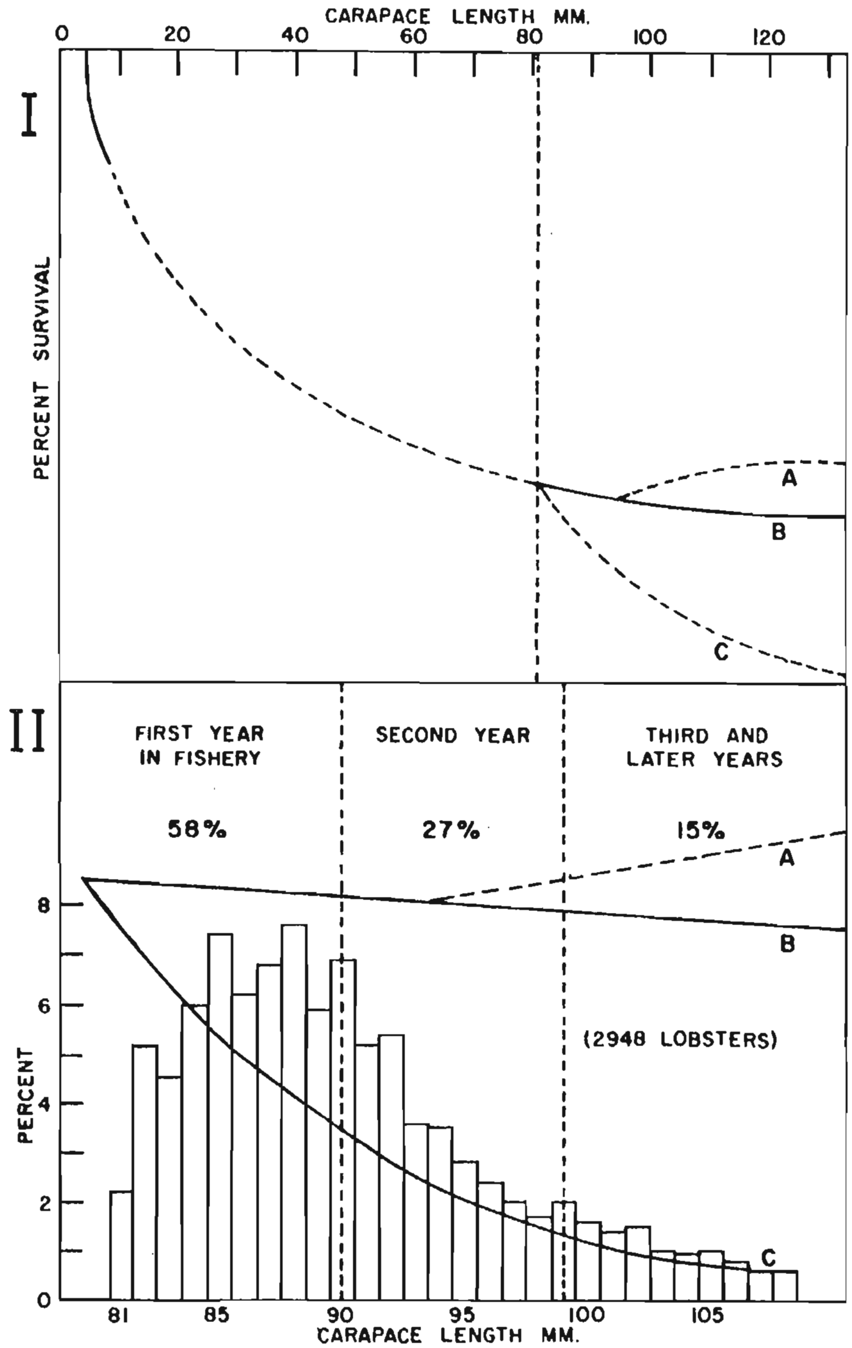

Figure 39 (I and II). Hypothetical curve of recruitment of lobsters showing (A) accumulation in a natural unfished population, (B) hypothetical rate of recruitment and (C) exploitation in a fishery. Part II of this Figure has these curves superimposed on a histogram of lengths from samples of the commercial catch of lobsters in Port au Port Bay in 1962.

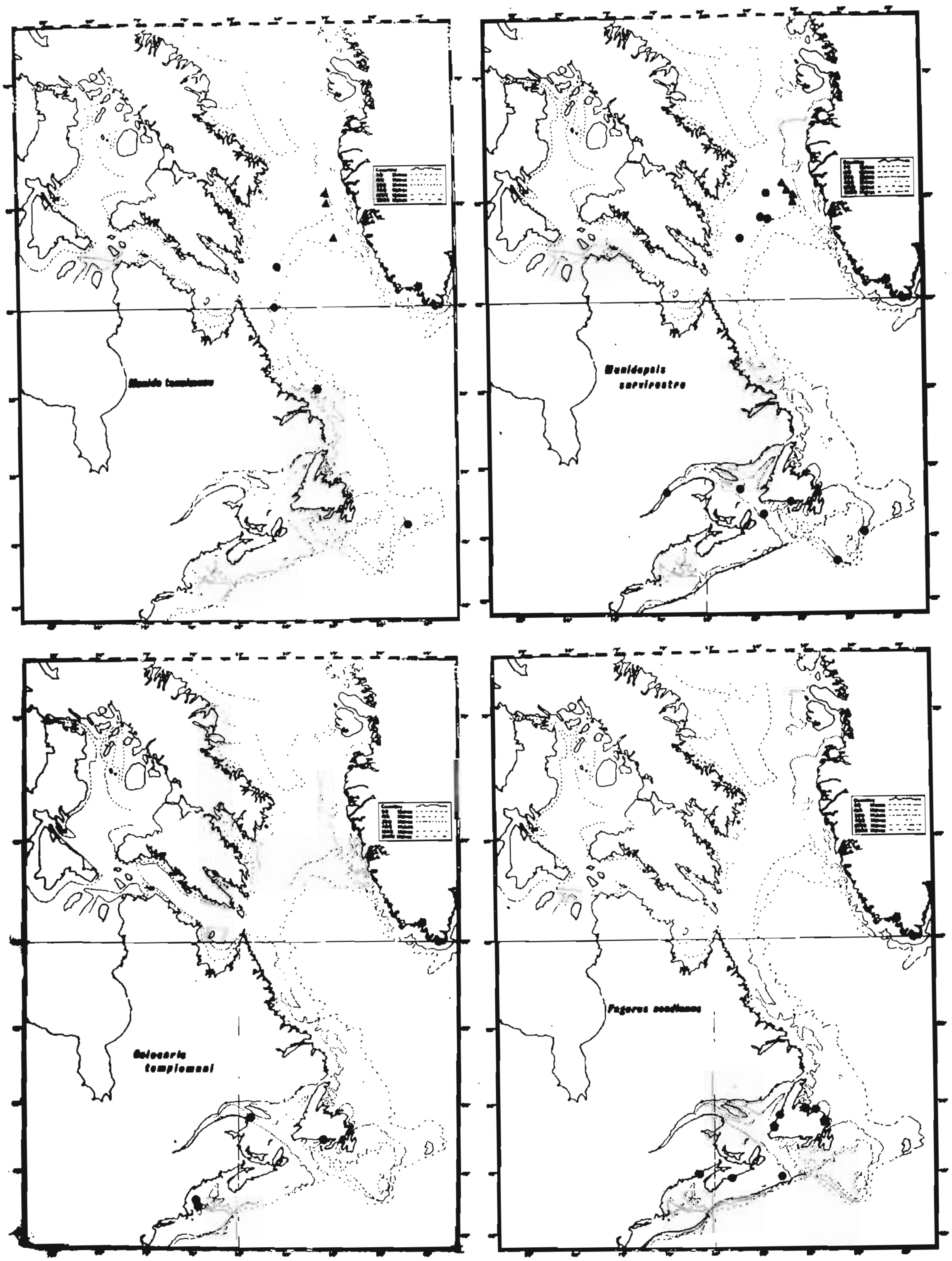

Figure 40. Distribution records of Munida tenuimana, Munidopsis curvirostra, Calocaris templemani and Pagurus acadianus in the northwest Atlantic.

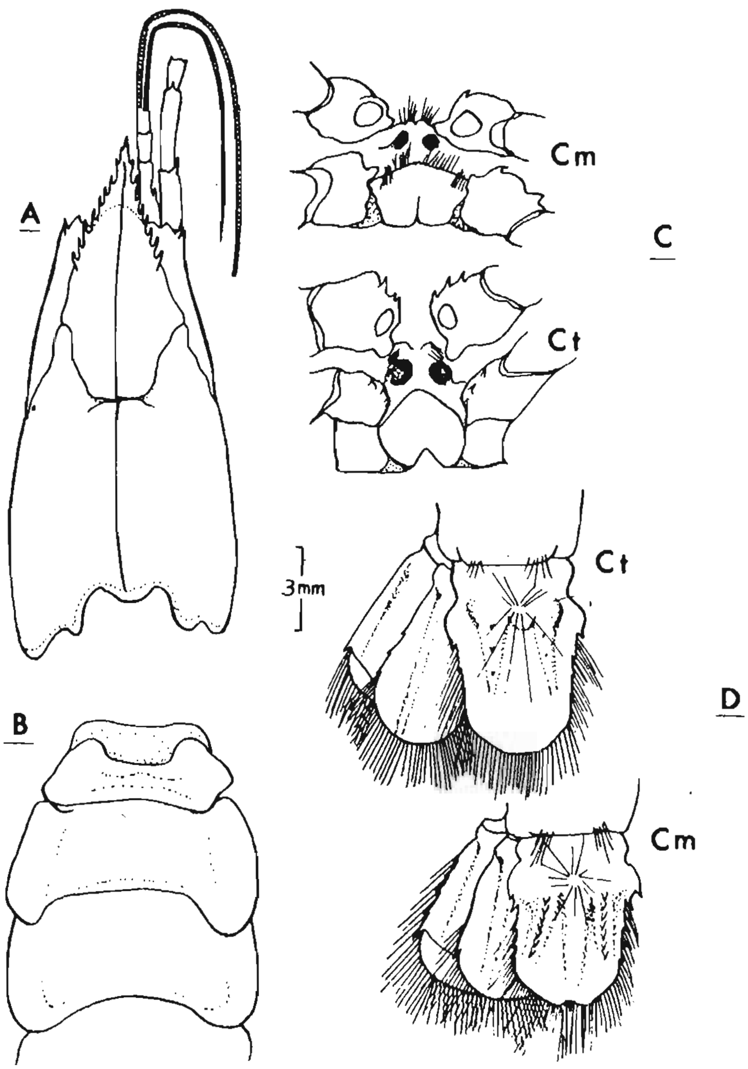

Figure 41. Calocaris templemani carapace (A) and anterior part of abdomen (B); sternal plates with ends of 3rd and 4th pereiopods attached (C), and telson and uropods (D) of C. macandreae (Cm) and C. templemani (Ct).

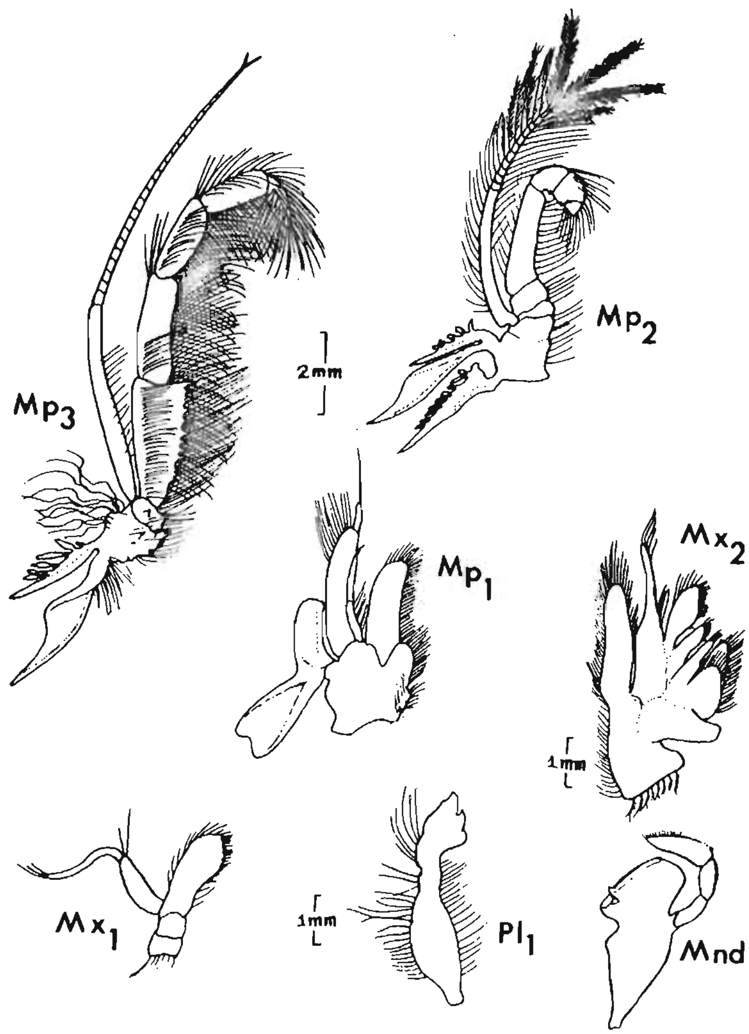

Figure 42. Calocaris templemani mouthparts: Mp_3 = third maxilliped, Mp_2 = second maxilliped, Mp_1 = first maxilliped, Mx_2 = second maxilla, Mx_1 = first maxilla and Mnd = mandible. Pl_1 = first pleopod.

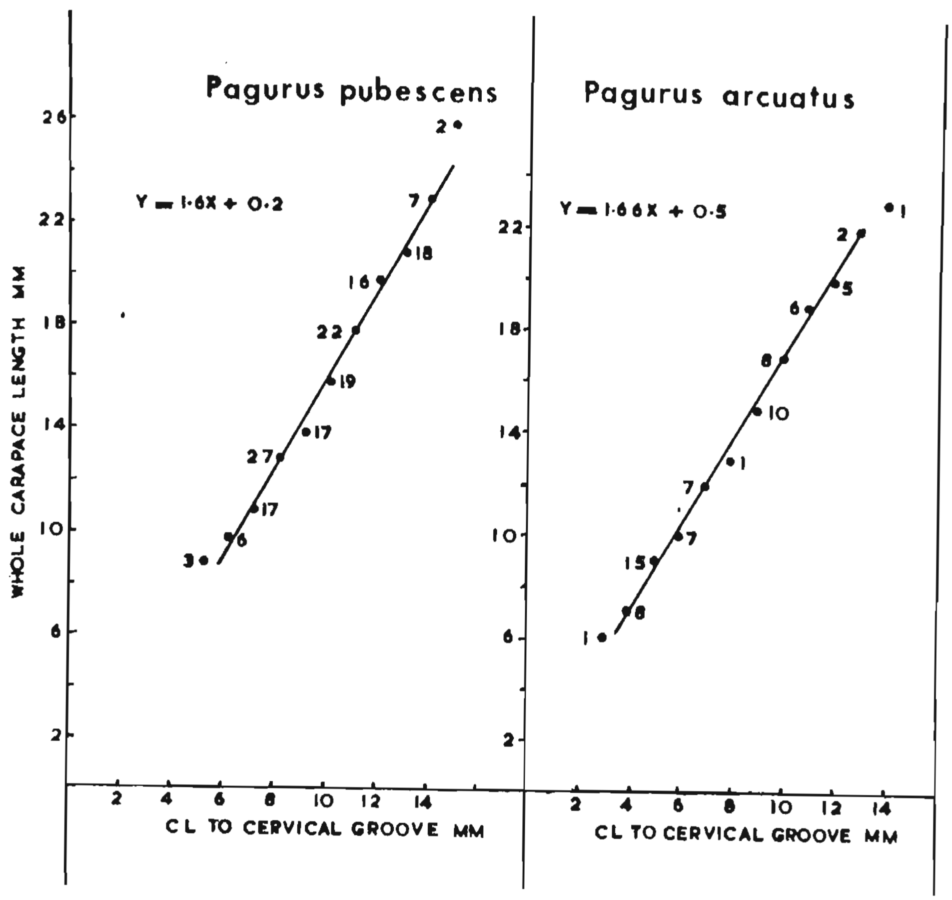

Figure 43. Regression equations for converting length of calcified portion of the carapace to whole carapace length in Pagurus pubescens (A) and Pagurus arcuatus (B).

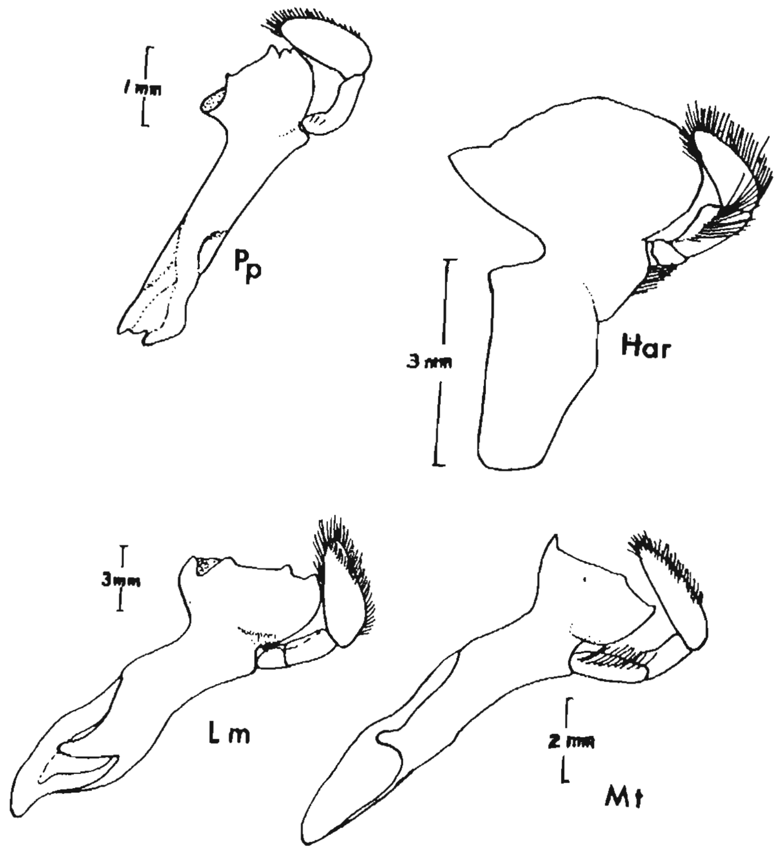

Figure 44. Mandibles of Pagurus pubescens (Pp), Hyas araneus (Har), Lithodes maja (Lm) and Munida tenuimana (Mt).

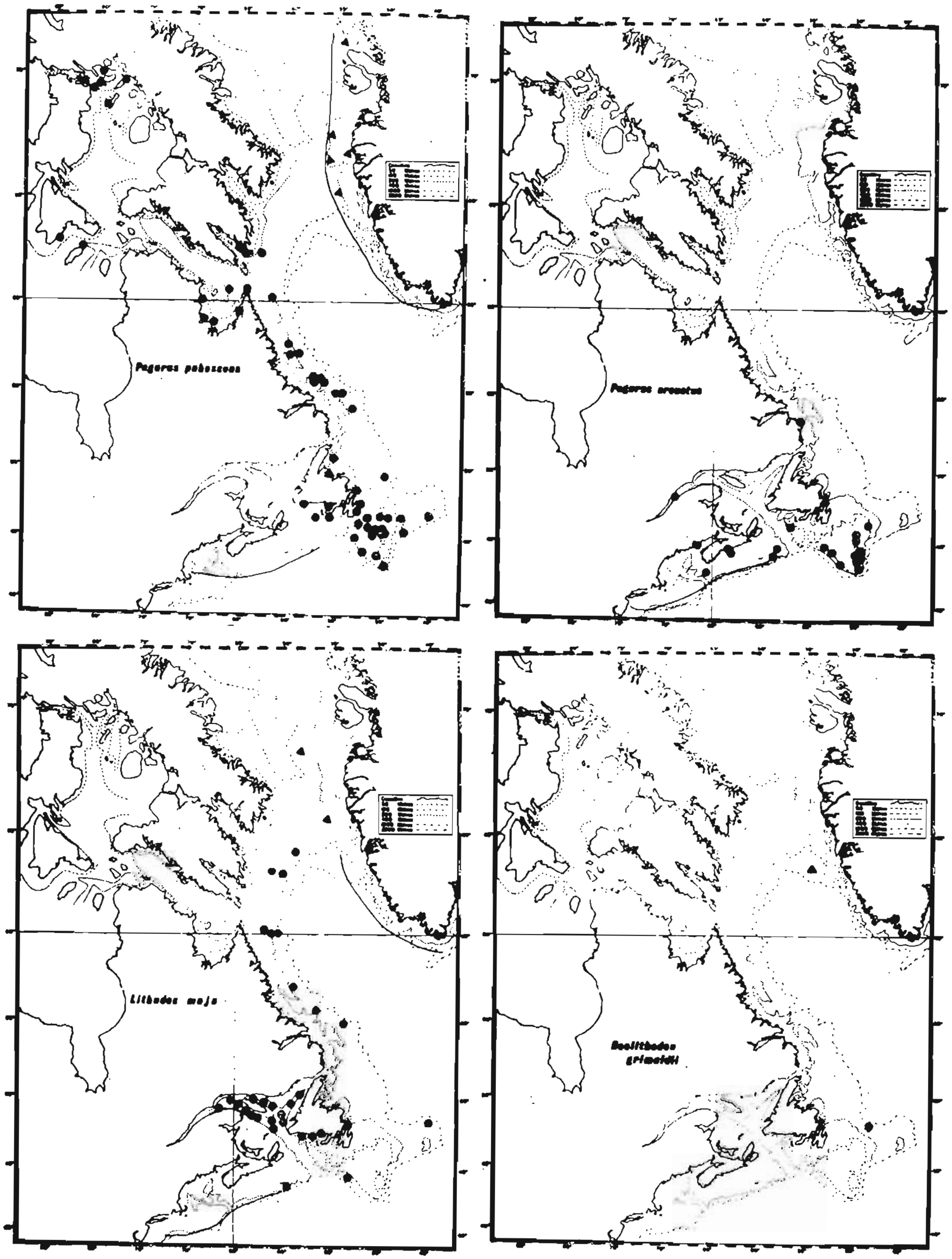

Figure 45. Distribution records of Pagurus pubescens, Pagurus arcuatus, Lithodes maja and Neolithodes grimaldii in the northwest Atlantic.

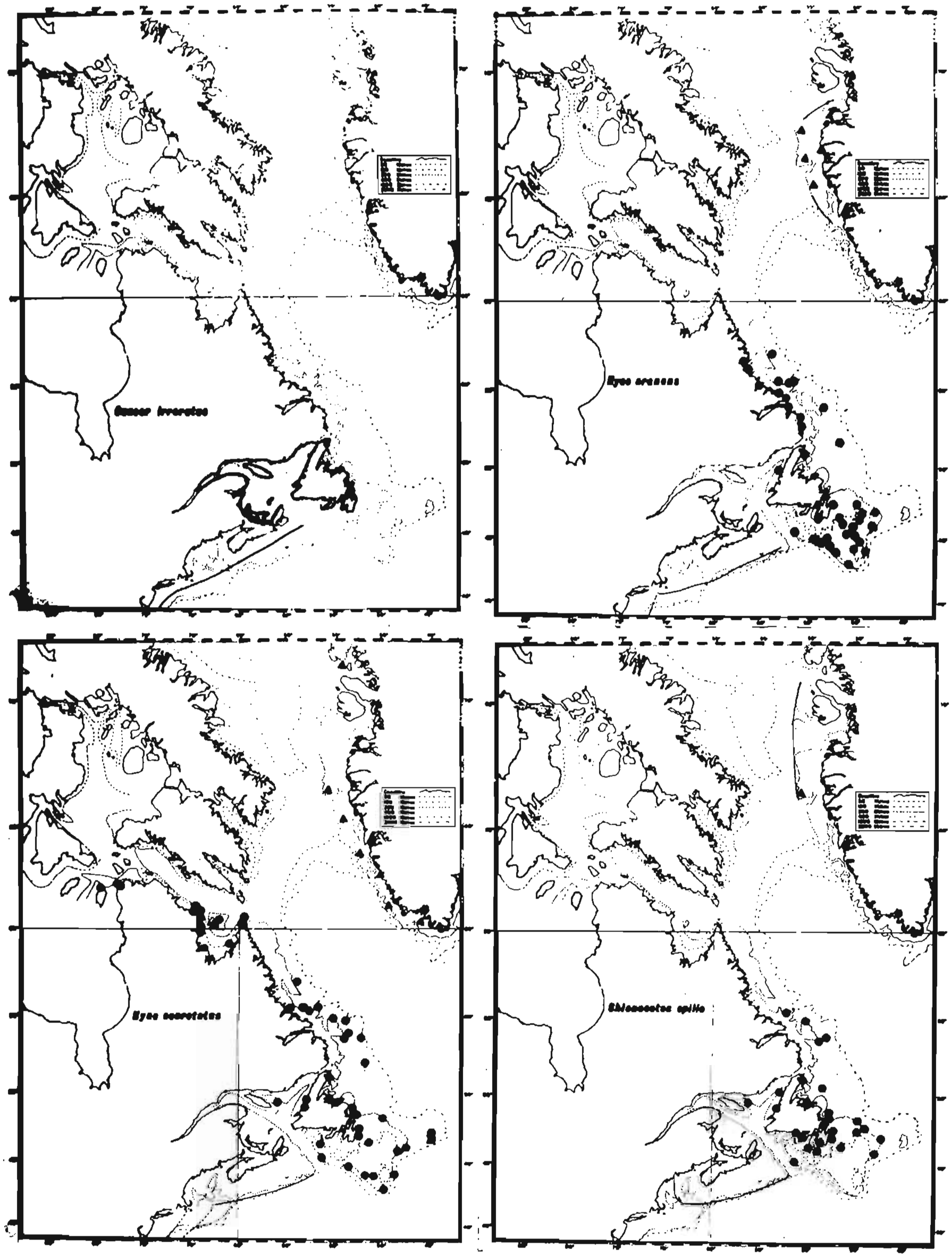

Figure 46. Distribution records of Cancer irroratus, Hyas araneus, Hyas coarctatus and Chionocetes opilio in the northwest Atlantic.

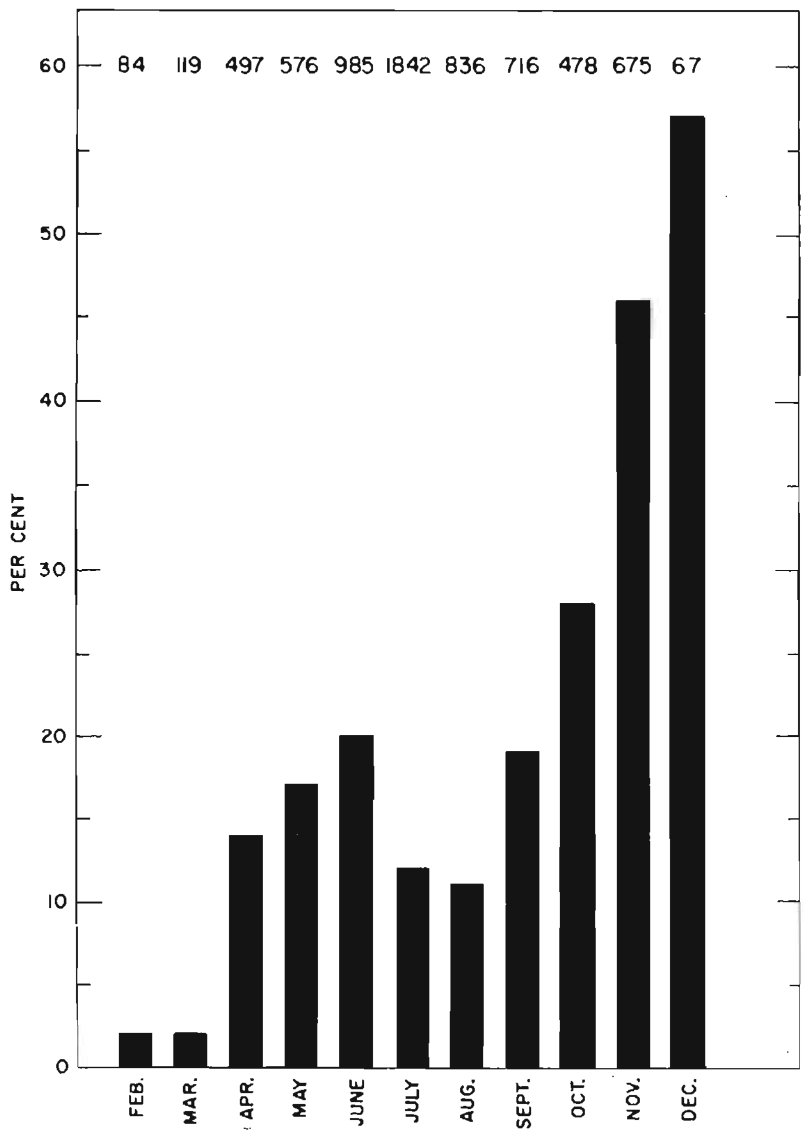

Figure 47. Percentage incidence of shrimp in stomachs of cod (Gadus morhua) from the east and south coasts of Newfoundland, etc. Numbers of stomachs examined are shown.

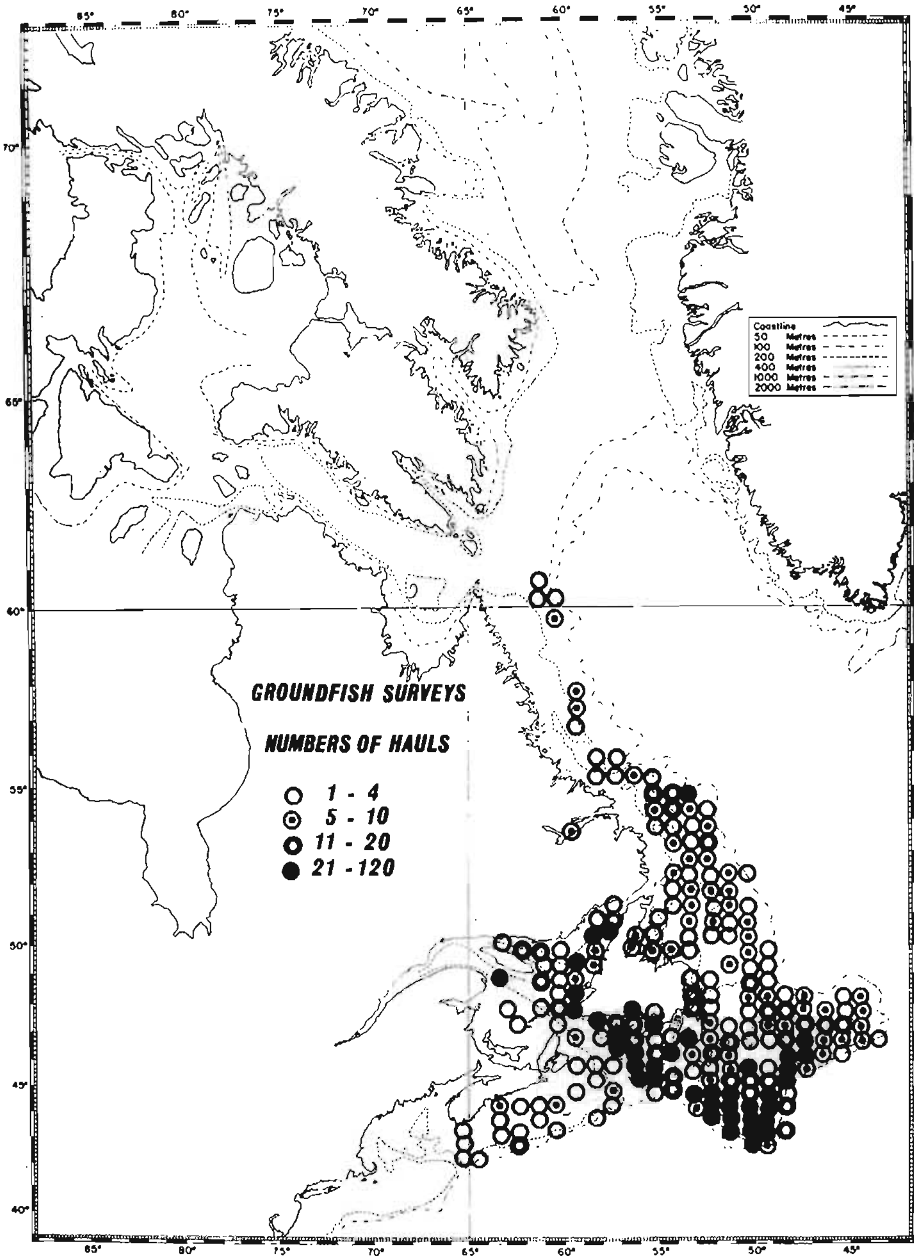

Figure 48. Groundfish surveys in the Newfoundland-Labrador fishing area, comprising the number of successful hauls made by the "Investigator II" during 1946-60 and by the "A. T. Cameron" during 1958-60 (except cruises 12 and 26 which are shown in Figure 49).

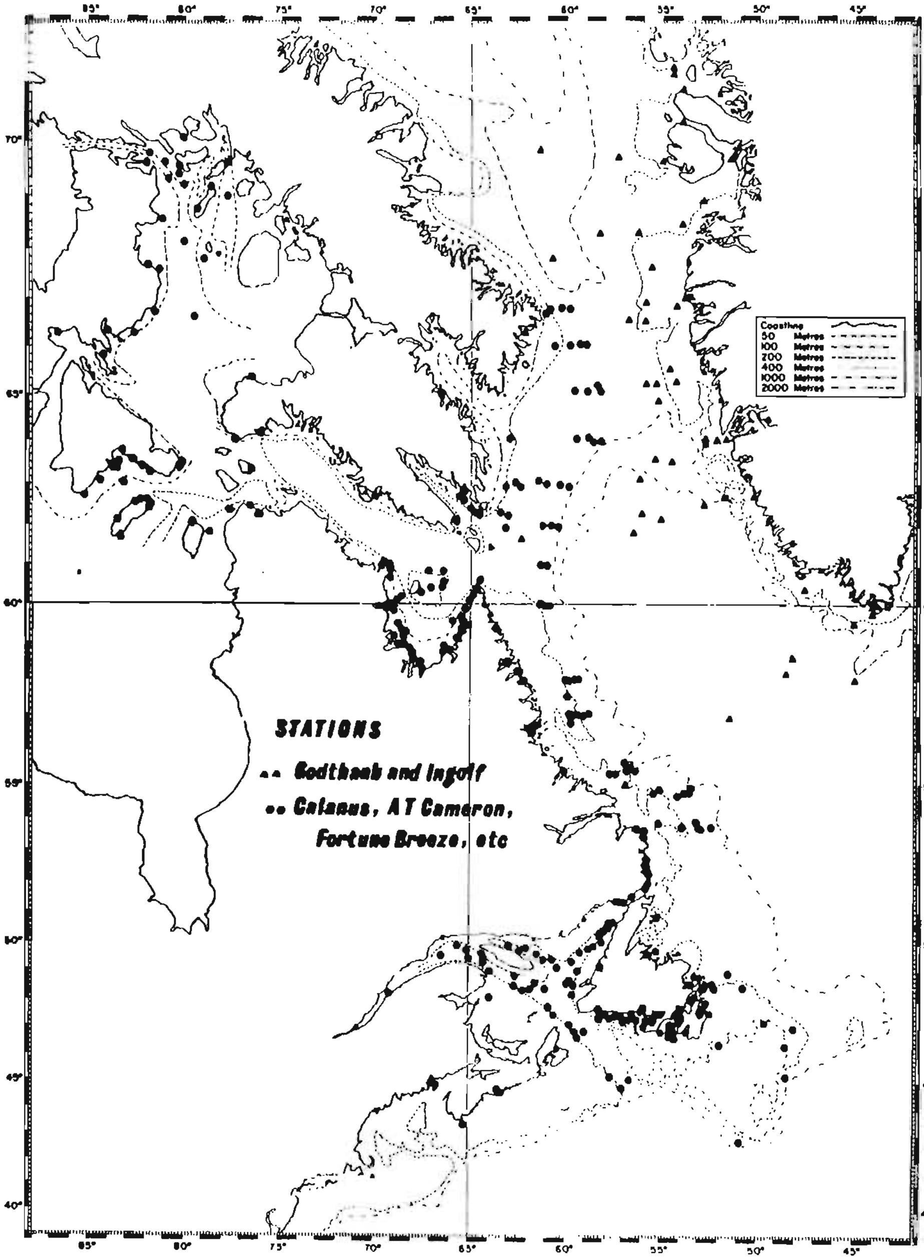

Figure 49. Stations of the "Calanus" (1946-58), "Fortune Breeze" (1957, '58), "A. T. Cameron" (1959, '60: cruises 12 and 26 only) and the "Ingolf" and "Godthaab" Expeditions (1896 and 1910).