The Fishes of St. Georges Bay, Nova Scotia

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FISHERIES AND AQUATIC SCIENCES 955

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THE FISHES OF ST. GEORGES BAY, NOVA SCOTIA

by

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A survey of the fishes in St. Georges Bay, based primarily on bottom trawling, found evidence for the presence of 47 species and allowed estimates of the biomasses of 22 of these. For each species, distribution and abundance are discussed and related both to reports from elsewhere and to the local oceanography, which is reviewed. The majority of the species appear to be resident within the Bay all year, although their location and availability to fishing varies seasonally. The commercial fisheries are described. Since species are not valid ecological units for fish, the data were examined for intraspecific variability in distribution. This was found in four species. Inexplicable differences in length frequency between trawl sets occurred in five species which may indicate a tendency for similarly sized fish to occur together. The biomass density of fish in St. Georges Bay (over 9 tons km^{-2}) is moderate, when compared to other areas of the northwest Atlantic.

Key Words: Trawl survey; fish biomass; St. Georges Bay, Nova Scotia; southern Gulf of St. Lawrence

Kenchington, T.J. 1980. The fishes of St. Georges Bay, Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 955: vi + 154 pp.

Un levé des poissons vivant dans la baie Saint-Georges, effectué essentiellement par chalutage de fond, a permis de dénombrer 47 espèces et d'évaluer la biomasse pour 22 d'entre elles. L'auteur examine la répartition et l'abondance de chaque espèce, les compare aux données relevées dans d'autres régions et les replace dans le contéxte de l'océanographie locale qui est examinée. La plus grande partie des espèces semble fréquenter la baie toute l'année, mais leur position et les possibilités de capture varient selon la saison. Par ailleurs, l'auteur décrit la pêche commerciale. Etant donné que les espèces ne sont pas des unités écologiques valables, les données ont été examinées du point de vue de la variation de la répartition propre à une espèce. Une telle variation a été constatée chez quatre espèces. Pour cinq espèces, on a observé des différences inexplicables dans la fréquence des longueurs, d'un trait de chalut à l'autre, ce qui pourrait indiquer que les poissons de taille similaire ont tendance à se regrouper. La densité de la diomasse de poisson dans la baie Saint-Georges (plus de 9 tonnes.km-2) est moyenne par comparaison à d'autres régions de l'Atlantique nord-ouest.

Mots clés: levés par chalutage; biomasse de poisson; baie Saint-Georges (Nouvelle-Ecosse); sud du golfe Saint-Laurent.

DEFINITIONS

Bay:	Unless qualified, refers to St. Georges Bay, N.S. (also called George Bay), from the Canso Causeway to a line joining Cape George (Antigonish Co.) and Cape Linzee (Inverness Co).
Bay stations:	Stations worked within the limits of St. Georges Bay, excluding Station 20.6 (see Section 3.2).
Dates:	Unless otherwise stated, all dates in this report refer to 1978.
Julian date:	A date expressed as the 'day of the year', where 1 January is 1 and 31 December is 365.
Southern Gulf:	That part of the Gulf of St. Lawrence which lies between the Gaspé Peninsula and Cape Breton Island, delimited in the north by the 200 metre bathymetric contour, and including all bays and other coastal inlets.
Magdalen Shallows:	Used interchangeably with Southern Gulf.
Trawl:	Unless qualified, this means a bag-like net towed by a fishing vessel, and not a fishing gear comprising hooks set along a line.
Trawlable biomass:	See discussion in Section 3.5.1.2.

In this report, all units have been converted to the metric (SI) system from those used in referenced publications. Most metric values have been rounded, so as not to imply more accuracy than was inherent in the original figures (e.g., a depth of 55 ft is here given as 17 m, rather than 16.72 ....). Likewise, length-weight equations from the literature have been converted to units of kilograms and millimetres. The term 'ton' is used for convenience to represent 10^3 kg.

1. INTRODUCTION

Over the last few years, various members of the Marine Ecology Laboratory (Fisheries and Oceans Canada) have been studying many aspects of the ecosystem of St. Georges Bay, Nova Scotia. The prime interest of the area is that it is a relatively self-contained, unpolluted, coastal embayment. Information on the fish is needed for a full understanding of other aspects of the ecosystem. It is unusual for a marine area to be this well studied, and it is hoped that a description of its fish in relation to its ecosystem will be of interest outside the immediate area. In 1978 an extensive bottom trawl survey of the Bay was carried out, as a part of a study of juvenile herring. The opportunity was taken to gather data on all the other fish species captured by the trawl. Assorted other observations made in 1978, and some unpublished data gathered in previous years, were also available.

This information is used to determine the distribution within the Bay of each species, its season of occurrence, and its abundance. So far as is possible, these are related to other factors of the ecosystem. The ichthyoplankton is not dealt with in this report, except insofar as it provdes vital information on adult fish. (A separate report on it is in preparation - Dr. D.M. Ware, pers. comm.). All marine fish, after the larval stages, are dealt with.

1.1 MARINE FISH SURVEYS IN THE SOUTHERN GULF

Lists of the ichthyofauna have been published for several places in the Southern Gulf, notably: Miramichi Estuary, N.B. (McKenzie 1959), Tignish, P.E.I. (Cornish 1912), Malpeque, P.E.I. (Stafford 1912; Needler 1940), Northumberland Strait (Caddy et al. 1977), Cheticamp, N.S. and the Magdalen Islands (Cox 1921)*. A similar list is available for the town of Canso, N.S. (Cornish 1907), which, at the time of its compilation, was linked to St. Georges Bay by the Strait of Canso; a connection now cut by a causeway.

With the partial exception of McKenzie's (1959) paper, these reports are little more than species lists resulting from highly selective sampling in a restricted area. The notes on abundance of each species are subjective and very brief. These papers contain very few comparisons with one another.

Statistics are available for the commercial fisheries of this region, but they are generally unsuitable for assessing the abundance of inshore fish populations. Data on effort are rarely recorded, and the statistics are gathered at the time and place of landing or first sale, not of capture (Caddy and Chandler 1976). The lack of information on origin is a problem in St. Georges Bay especially, because several boats work out of Mulgrave and Auld cove in Guysborough County. Their landings are therefore included with those from Chedabucto Bay and the Scotian Shelf.

For quantitative survey purposes, bottom trawls have the advantage of being less selective than other fishing gears (Ulltang 1977), although they are limited to demersal fish species and reasonably smooth seabed. While some of the above surveys included data from bottom trawling, only

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* Reference to these locations, in the context of fish surveys, unless otherwise stated, refers to the paper cited above.

that of Caddy et al. (1977) used it extensively. This fishing method has, however, been widely used elsewhere for such surveys (e.g. Richards 1963; Lux and Nichy 1971; Tyler 1971a; Oviatt and Nixon 1973; Jefferies and Johnson 1974; Grosslein 1974).

1.2 SPECIES AS ECOLOGICAL UNITS

Many ecologists tend to ignore the individuality of species, grouping them into larger units. However, even closely related species can have important differences in many aspects of their biology. These differences may cause them to react very differently to changes in an environmental variable. Thus, in section 4 of this report each species is treated separately, and its known biology related to its occurrence in St. Georges Bay.

However, even a species may be too large a unit, since the ecological relationships of fishes undergo major changes during their ontogenetic development (Helfman 1978). These changes include a movement through trophic 'levels' and changes in habitat. Therefore, during the analysis of this survey, attempts were made to identify heterogeneities between size-groups within species. Where these were found, the groups were analyzed separately.

2. THE OCEANOGRAPHY OF ST. GEORGES BAY

St. Georges Bay lies in the extreme southeast of the Gulf of St. Lawrence (Fig. 1 and 2). It is approximately rectangular, with a surface area of 1180 km^2. A bibliography of St. Georges Bay and the Strait of Canso has been prepared by Dadswell (1979b), while Loring and Nota (1973) include a review of most aspects of oceanography of the Gulf of

Figure 1 ; Southern Gulf of St.Lawrence, showing Places Mentioned in the Text.

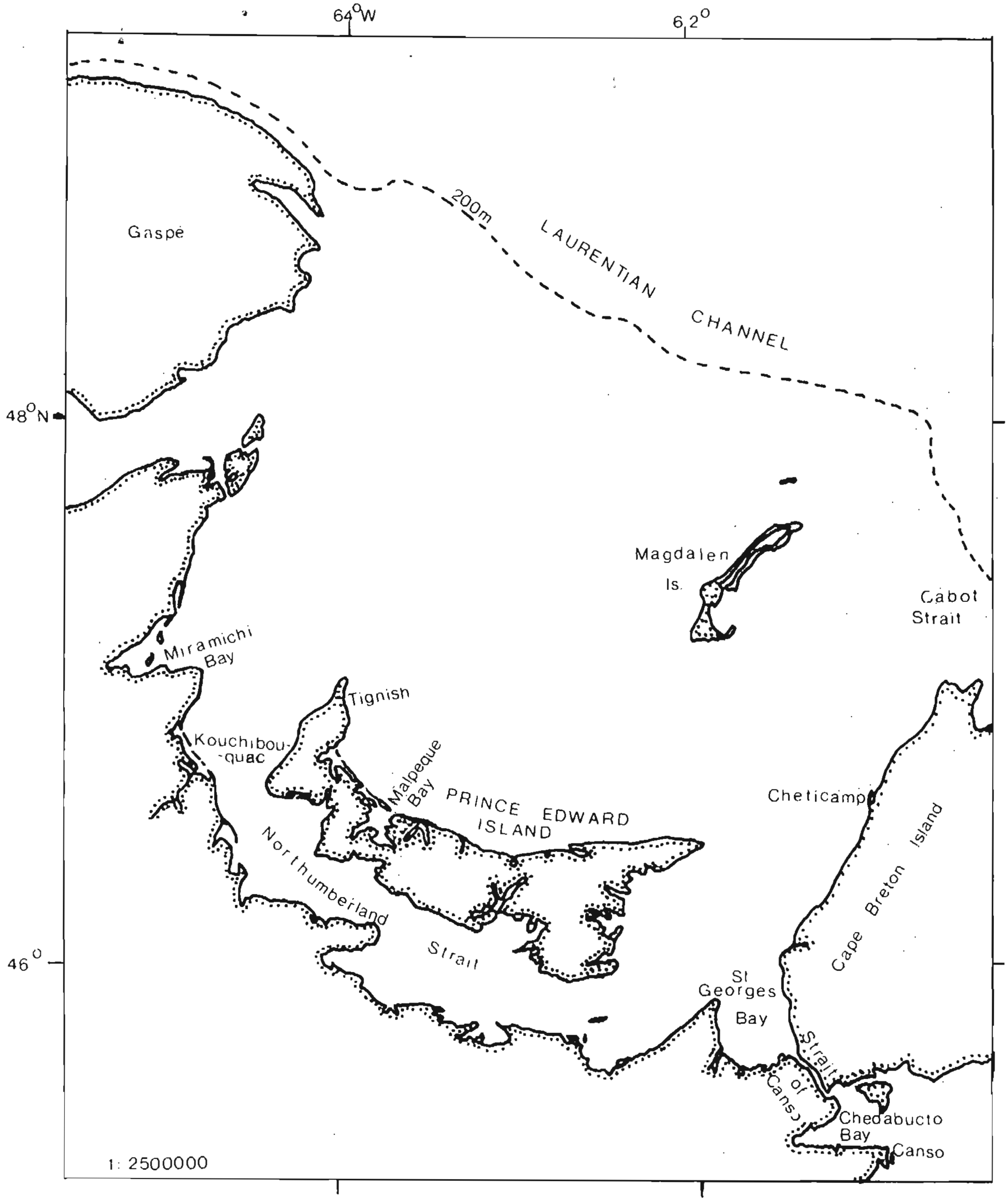
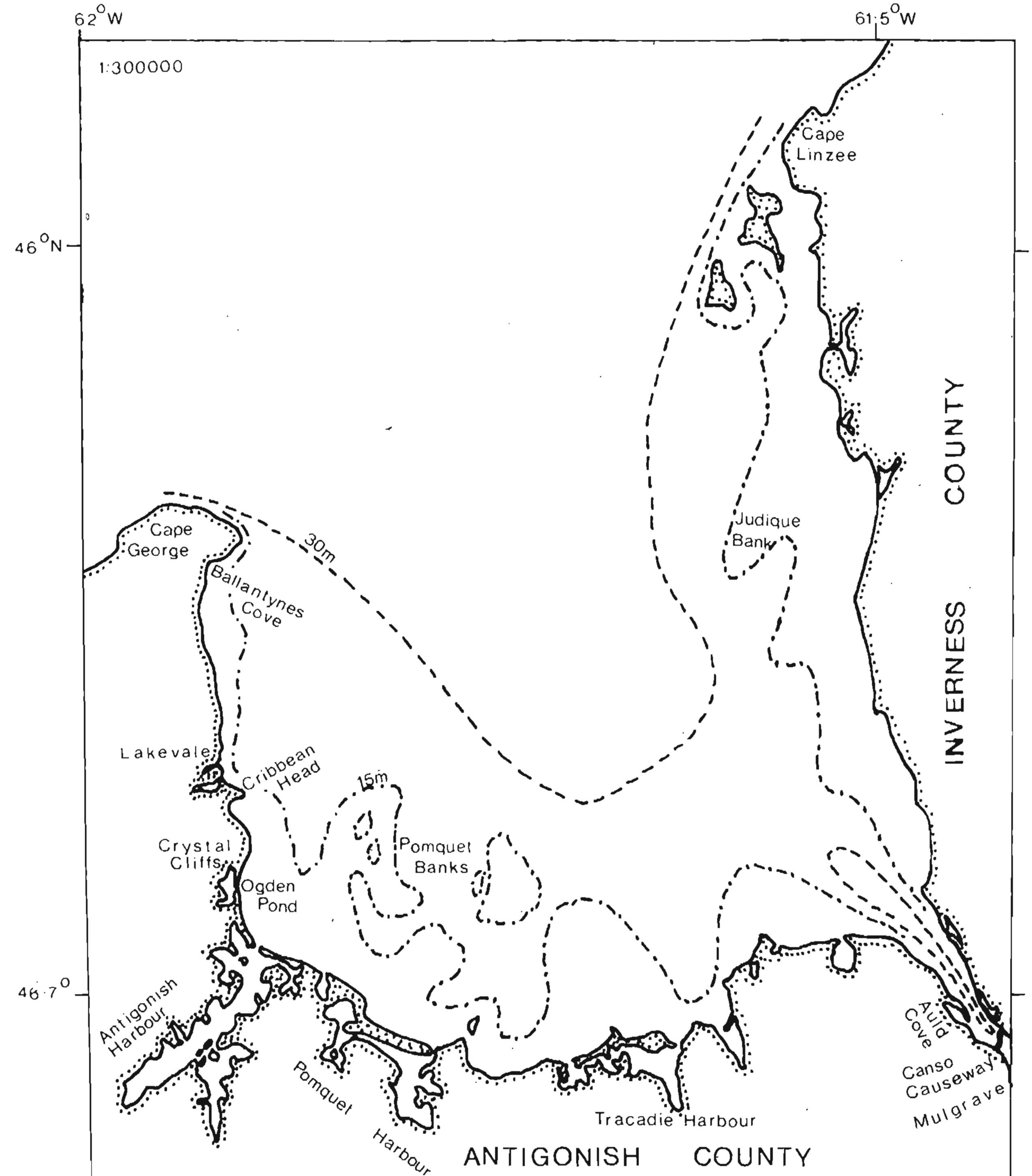


Figure 2; St. Georges Bay; Place Names and Bathymetry.



St. Lawrence in their study of its geology.

2.1 BATHYMETRY*

The Bay lies near the eastern end of the Northumberland Strait, but it is open to the northward and communicates with the deeper waters of the Magdalen Shallows. From its southeast corner, the Strait of Canso formerly connected it to Chedabucto Bay and the Atlantic Ocean. This connection was blocked in 1954, by the construction of a causeway (McCracken 1979).

The shallow (<15 m) zone of the Bay is generally narrow, but the Pomquet and Judique Banks extend this contour towards its centre. Elsewhere, the bottom slopes fairly steadily to maximum depths of about 40 m at the mouth. This slope continues into the Northumberland Strait, reaching 55 m within a few kilometres. In the Strait of Canso, and extending into the Bay, is a deep, narrow channel (maximum depth north of the causeway is 47.5 m). This channel is divided from the other deep parts of the Bay by a sill 26 m below chart datum.

2.2 GEOLOGY AND GEOMORPHOLOGY

The geology of the Northumberland Strait region has been described by Kranck (1971), with particular emphasis on the surficial layer, which is of most importance to demersal fish.

Four types of sediment are found in St. Georges Bay (Fig. 3):

I 'Buctouche Sand and Gravel': A sandy gravel with scattered pebbles (Kranck 1967).

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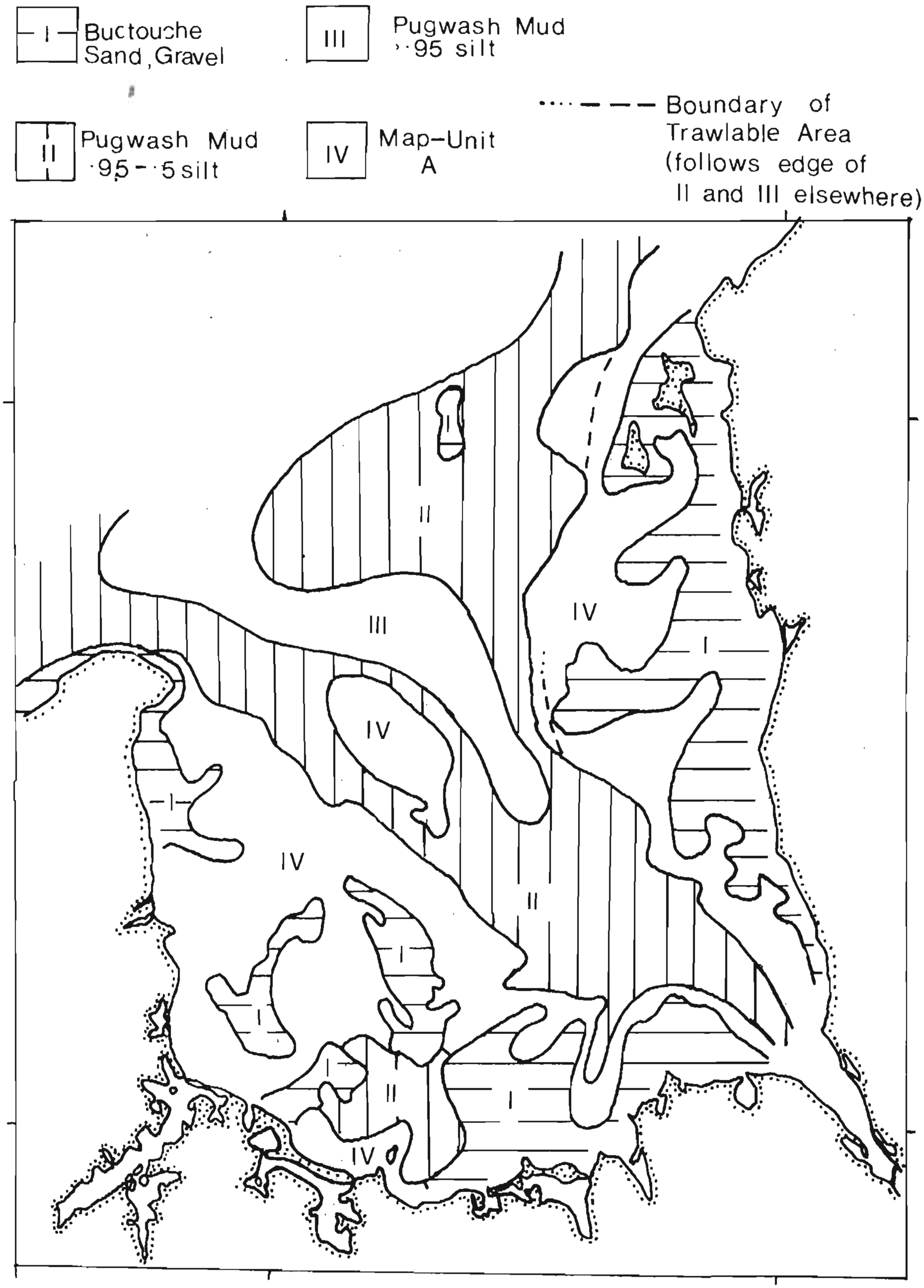
* St. Georges Bay is shown at a large scale on Canadian Hydrographic Service Chart 4462.

Figure 3 ; St. Georges Bay ; Sediments and Trawlable Area.



II 'Pugwash Mud': 50 to 90% silt and clay, the rest sand.

III 'Pugwash Mud': 95% silt and clay.

IV 'Map-Unit A': A complex sediment, with irregular lenses of 'Pugwash Mud' over 'Buctouche Sand and Gravel' or 'Pomquet Drift' (a glacial till: poorly-sorted and poorly-rounded coarse gravel, mixed with finer sediment). Its surface varies from fine mud to clean, well-sorted gravel.

Figure 3 also shows the boundary of the area in which a bottom trawl could safely be worked, based on experience in the present and former surveys. The trawl net could be safely worked on both kinds of 'Pugwash Mud', (where there was space to manoeveur) and on a few parts of 'Map-Unit A'. Sometimes, when fishing on the latter, stones, or such typically hard-bottom invertebrates as sea urchins, would be taken.

Kranck (1971) did not discuss the inshore and intertidal sediments, beyond stating that a sediment similar to 'Buctouche Sand and Gravel' is being formed in some areas. Casual observation suggests that, while this is true for much of the coast, elsewhere the shallow seabed is formed by pebble- or cobble-sized stones. Few areas of bedrock crop out below sea level.

The shore and intertidal zone of St. Georges Bay is mostly formed by narrow beaches against low cliffs. In several places barrier beaches occur, enclosing shallow lagoons. These are mostly small (about 0.3 km^2) and less than 2 m deep, but Pomquet, Tracadie and Antigonish Harbours are larger (up to about 10 km^2), and a few metres deep in their channels. The lagoons have wide intertidal areas of soft mud, though the channels have coarser sediments. The landward ends of the lagoons usually form salt marshes. Kranck (1967) has described similar lagoons in Kouchibouquac Bay, N.B.

2.3 CLIMATE

Mean daily maximum temperatures are -1.8°C in February, and 22.3°C in August (O'Neill 1979). The equivalent minimums are -9.9°C and 13.9°C. Mean annual precipitation is 1205 mm (165 mm as snow), falling on an average of 129 days. Evaporation from open water averages 550 mm per year. Westerly winds prevail for most of the year, but are less predominant in summer. The wind direction tends to be variable in the short term (Forward 1954). The limited local wind data for St. Georges Bay have been published by Petrie and Drinkwater (1977a,b).

2.4 PHYSICAL OCEANOGRAPHY

A west to east drift crosses the southern Gulf, supplied by the Gaspé Current (Leim 1957). This spreads across the Magdalen Shallows, and ultimately leaves the Gulf, by way of the Cabot Strait. The bottom circulation is broadly similar to that at the surface (Lauzier 1967). What is known of the winter circulation suggests a similar pattern (Ingram et al. 1969; Ingram 1973).

In winter, the water over the Shallows is well mixed, and very cold. In summer, it is strongly stratified, warm and of low salinity at the surface, and very cold below. Most of the dilution of the surface layer is due to the St. Lawrence River discharge (Lauzier 1957a). The peak discharge (spring runoff) forms an area of exceptionally low salinity, which moves east across the Southern Gulf, passing Gaspé in July and Cheticamp in August (Lauzier 1957b).

In St. Georges Bay salinity varies between 27 and 31°/₀₀, and maximum surface temperatures, in August, are about 20°C (Petrie and Drinkwater 1977a,b, 1978a,b). The surface layer is about 5 m thick in June, increasing to 25 m by September, and the water column is isothermal by November. Bottom temperatures are -1°C in mid-June, and increase to 15°C in September-October (Petrie and Drinkwater 1977a). A cold, fresh layer might form under winter ice, as observed in Malpeque Bay (Needler, 1941), which would have severe biological consequences in shallow areas.

The mean surface circulation is a clockwise gyre with velocities of about 0.1 m s^{-1}. The mean bottom flow is out of the Bay. Flushing time, for tides and the mean circulation, is about a month, while the Bay's water could be rapidly exchanged with that in the Northumberland Strait under the influence of a storm (Petrie and Drinkwater 1978a).

Runoff has only a minor effect on salinity in the Bay (Petrie and Drinkwater 1977a), but may have important effects in the lagoons, which can be expected to experience more extreme conditions and more rapid changes than deeper areas.

Tides in the Gulf of St. Lawrence are generally weak (Loring and Nota, 1973). In the Bay, tidal ranges are <2 m (Canadian Hydrographic Service, Tide and Current Tables, Vol. 2), and in practice are often overridden by meteorological effects.

No study has been made of the wave climate within the Bay.

2.5 SEA ICE

The occurrence of ice in St. Georges Bay is variable. It usually blocks the northern entrance to the Strait of Canso by 1 January (O'Neill 1979). By the end of that month, St. Georges Bay is filled with close pack ice (70 to 90% covered), and during February it is usually frozen over completely or filled with closely packed ice cemented into large sheets (Forward 1954; Loring and Nota 1973). The pattern of ice breakup is highly variable, but St. Georges Bay usually clears between early April and early May (Forward 1954).

2.6 BIOLOGICAL OCEANOGRPAHY

2.6.1 Plankton

Little published information is available on the plankton of St. Georges Bay, apart from the monographs on various taxa which include coverage of this area (see bibliographies by Shih et al. 1971, and Dadswell 1979b).

Prouse and Hargrave (1977, 1980) and Ware (1977) have presented some data on planktonic primary production. The spring bloom (in 1977) occurred before the end of April, and primary production was measured at rates of 5.3 to 16.4 g C m^{-2} mon^{-1}. These rates are considerably less than those found in St. Margaret's Bay (Platt 1971) or Bedford Basin (Taguchi and Platt 1977) on the Atlantic coast of Nova Scotia.

Zooplankton biomass is highest in April (166.5 mg dry wt. m^{-3}), decreasing to less than 60 mg m^{-3} in August and September (Harding et al. 1980). The wet weight of this plankton is about 400 to 1600 mg m^{-3}. Additional information on zooplankton in the Bay has been given by Ware (1977).

2.6.2 Benthos

The phytobenthos of the Bay has been briefly described by MacFarlane (1966) and by Pringle (1979). A general species list for the region was published by Bell and MacFarlane (1933). The invertebrate benthos has not been studied in St. Georges Bay, apart from some scallop surveys. However, a detailed survey of the macrobenthos of the Northumberland Strait has been published (Caddy _et al._ 1977; Stasko _et al._ 1977). This is likely to be closely similar to St. Georges Bay.

In summary, the intertidal is rather barren, because of ice scour (MacFarlane, 1966), but below this is a dense growth of algae, notably _Chondrus_, _Furcellaria_, and _Fucus serratus_. These reach to about 10 m depth. Zoobenthic biomass falls off with depth (Caddy _et al._ 1977), with bivalves and echinoderms predominant in the shallower parts, and 'worms' and bivalves at 30 m depth.

More information is available on 'shellfish' of commercial value. Caddy and Chandler (1976) note landings of lobsters and scallops from the Bay. The fishery for the former is spread over all areas of hard sea bed (i.e. those which were not trawlable) in the Bay (personal observation). However, it is widely claimed by local fishermen that the greatest catches of lobster can be taken close to the Canso Causeway.

The lagoons have extensive beds of _Zostera_ (personal observation).

2.6.3 Nekton and Other Predators

A complete bibliography on the fishes of the Gulf of St. Lawrence has been published by Srivastava (1971). Those of St. Georges Bay are discussed elsewhere in this report. The other members of the nekton, all predatory on fish, include marine mammals and squid. Sea birds and human fisheries complete the trophic structure exploiting the fishes in the Bay.

Grey seals breed in St. Georges Bay and the Northumberland Strait in winter (Mansfield and Beck 1977). Pup production in 1975 was estimated at 3700, while the adult population would be somewhat greater. However, these seals do not feed during the breeding season and are dispersed in summer. Few are seen in the Bay during that season (Capt. G. Reyno, pers. comm.), and their consumption of fish is unknown. There are a few harbour seals in the Bay (Boulva and McLaren 1979), and both pilot whales and harbour porpoise are known to occur (Anon. 1975).

There appears to be no reference in the scientific literature to squid in the Southern Gulf. However, their presence inshore in the late summer and early autumn is widely known amongst local fishermen. They are exceedingly abundant in some years.

The sea birds of this region have been surveyed by Brown et al. (1975). Great cormorants (47 pairs in 1971), black-back and herring gulls, and common and arctic terns are found in some abundance in St. Georges Bay. There are lesser numbers of gannets, Iceland gulls, black-legged kittiwakes, and black guillemots. Fish in the lagoons are also preyed upon by ospreys, bald eagles, eastern belted kingfishers, and blue herons (personal observation). Cormorants consume 0.425 to 0.700 kg of fish per day (Cramp 1977), which suggests an annual total for St. Georges Bay of the order of 10 tons. The total consumption of fish by avian predators may be several times this, but is unlikely to be a significant proportion of the population. Avian predation may be important to some fish species living in shallow water.

The fisheries are considered separately in the sections on the species taken.

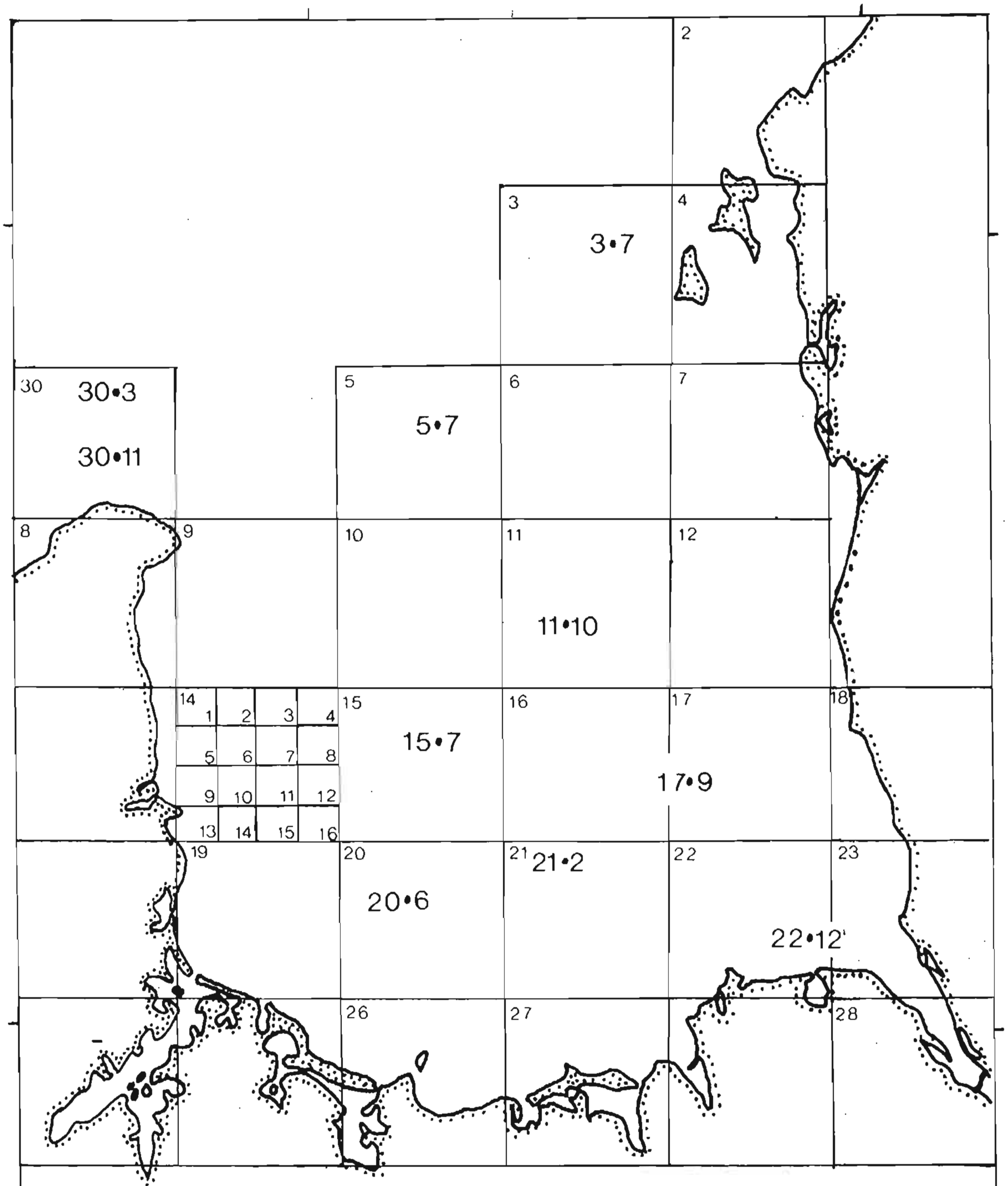
3. METHODS

3.1 SAMPLING SCHEME

The catch produced by any fishing gear is a biased sample of the population from which it is taken. However, a bottom trawl gives the least biased abundance estimates for demersal fishes (Ulltang 1977; Pennington and Grosslein 1978). For many purposes, a stratified random arrangement of stations is the best when using such a net (Grosslein 1968, 1974; Halliday and Kohler 1971; Mackett 1973; Ulltang 1977), but a systematic arrangement can give more precise estimates of abundance (Mackett 1973; Ulltang 1977). Such a systematic survey is especially suited to the study of temporal changes (e.g. Tyler 1971a; Jefferies and Johnson 1974).

In view of the lack of knowledge of the fishes in St. Georges Bay, and the small-scale variations in the environment of this inshore area, a useful arrangement of strata could not be devised. Thus a purely random sampling scheme was chosen. Such a scheme was used in the Bay for other purposes in previous years, and this was adopted with minor changes to facilitate bottom trawling (see Fig. 4). These changes will have biased the results in that too many of the stations were located near the edge of the trawlable area. The location of each station is described by the one nautical mile grid square in which it lies. In practice, the ship frequently strayed into neighbouring squares. The survey was repeated at intervals, using the same stations each time, thus making seasonal trends clearer.

Figure 4; St.Georges Bay; Grid Pattern and Trawl Stations.



The amount of ship time available determined the extent of the survey. It began as soon as possible after ice-breakup permitted fishing, and continued for as long as the ship was available.

3.2 FISHING METHODS

All trawling was carried out with RV Navicula, a stern trawler, 19.8 m long, of 365 hp. Position fixing was by Decca Navigator and radar ranges. The net was a '50 ft Flounder Trawl' (Gourock Industries Ltd., Halifax, N.S.), of 100 mm stretched-mesh polypropylene. This net has a head rope length of 16.8 m (7 m belly, 4.9 m wings). The codend, and part of the belly (totalling one-third to one-half of the length of the net) was lined with a fine mesh. Initially this was of 9 mm mesh, but the net was torn, and its replacement had a 24 mm knotlesss mesh liner. Subsequently, a mixed liner was used, with 24 mm mesh in the belly, and 9 mm mesh in the codend. The net was fitted with a 3/8 inch (9.5 mm) ground chain, but no rollers or other fittings to aid fishing on a rough bottom. All sets were made with 183 m of warp out, since it was thought that this would cause less variability than trying to adjust the length of warp to match the depth. Otter boards of 1.15 m by 0.8 m were used. At first, 183 m wire bridles were fitted between the boards and the net. These were damaged when the net was first torn, and thereafter short rope bridles were used. The net was towed at 3½ km for approximately one nautical mile.

Because of various technical problems, not all the stations were completed. Table 1 lists those which were. The fishing methods were not fully standardized in early May, but data from that time have been used because they are the only information from the early part of the open water

Table 1. Station completion and dates of survey repetitions

Date	Station 3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May (3,11 May)	x	+	+	x	+	x	+	+	x	x
mid-May (17,18 May)	+	x	+	+	+	x	+	+	+	+
late May (31 May, 1 June)	+	+	x	+	+	x	+	+	+	+
mid-June (22,23 June)	+	+	+	+	+	x	+	+	+	x
early July (5,6 July)	+	+	+	+	+	x	+	+	x	+
late July (19,20 July)	+	+	x	+	+	x	+	+	+	x
early August (2,3 August)	+	+	+	+	+	+	+	x	+	x
late August (16,17 August)	x	x	x	x	+	x	+	+	x	x
early September (5,6 September)	x	x	+	x	+	x	+	_	x	x

X: station nor worked +: station completed season. In calculating the abundance of fishes in the Bay, only data from stations 3.7 to 17.9 and 21.2 to 22.12 (the 'Bay stations') have been used.

The original net (with 9 mm mesh liner) was torn on 31 May. Stations 17.9, 21.2, and 22.12 in the late May survey used its replacement (with 24 mm liner). This net continued in use until 3 August, when it in turn was torn. Early August stations 17.9 and 21.2 used a replacement (with mixed liner), which did not seem to be fishing well (perhaps due to incorrect rigging of floats and gound chain). This net was torn when first shot on 16 August, and the few stations worked in late August (17.9, 21.2, 22.12) used a rather smaller net (40 ft Flounder Trawl - Gourock Industries Ltd., Halifax). For the early September survey, the trawl used in early August (stations 17.9 and 21.2), now repaired and correctly rigged, was used.

Inevitably, some fish were small enough to escape through the cod-end liner. Fifty percent retention lengths for large meshes are typically a few times the mesh size (Clay 1979). Snake blennies reach lengths of 25 times their greatest depth (Leim and Scott 1966). Thus the 9 mm liner probably retained most fish over 50 mm long, while some long-bodied fish up to 250 mm may have been underrepresented. The use of a coarser liner will have resulted in underrepresentation in the catches of fish smaller than 100 mm, while some species (such as the snake blenny) would not be caught at all. Inspection of the lengths of fish caught with the finer liner shows very few smaller than 100 mm, so the 9 mm mesh can be considered to have been adequate for this survey, while its 24 mm replacement was not.

At each station, including some not worked with the trawl, a bathythermograph cast was taken, and the time, position, and depth recorded.

Notes were also made on the weather, sea state, water colour, etc., and on the presence of animal life other than fish (FAO 1965). These notes are too incomplete to support useful analysis.

3.3 HANDLING THE CATCH

All fishes caught were identified, using Leim and Scott (1966). In general, all fishes were measured using an (undisplaced) measuring board. Total length, in millimetres, was recorded. Millimetre accuracy was chosen because of the flexibility it allows in subsequent grouping of lengths and because several statistical tests for comparing frequency distributions are sensitive to the 'ties' which would occur if centimetres had been used (Conover 1971). Some species, notably ocean pout, are 'uncooperative' when being measured alive and thus their lengths were only accurate to the nearest few centimetres.

Where a species was very numerous in a particular haul, a subsample of at least 50 fish was measured, and the rest counted and discarded. In such cases, the catch was divided as it lay on the deck, and the whole of one section was measured. This process is rather less complicated than that usually recommended (Paloheimo and Dickie 1963; Halliday and Kohler 1971), and thus its validity was tested. The American plaice at station 22.12 on each of 17 August and 5 September had three subsamples measured. A Kruskal-Wallis test (see section 3.5.1.1 for a full discussion of this test) of the similarity of length-frequency distributions in these subsamples showed them to be very similar (probability of being drawn at random from the same population = 0.7678). Thus, the subsampling procedure is considered to give adequately representative groups for measurement.

3.4 OTHER FIELD WORK

In previous years, a certain amount of trawling was done in St. Georges Bay, using methods similar to those described above, but not as part of a coordinated survey. The results of this fishing, kindly given to me by Dr. D.M. Ware, have only been included in this report when they conflict with those obtained in 1978.

Bait-traps are operated by the fishermen of Ballantynes Cove from mid-May until late in June. These catch fishes moving along the shore, especially 'gaspereau' (Alosa spp.). Their mesh is such that small fish (less than 150 to 200 mm length) escape. The catch of the northernmost of these traps was regularly inspected. Similar traps, designed to take salmon, are put out later in the year. At intervals, the catch of one of these (at Lakevale) was examined.

On a few occasions, a beach seine (30 m long, 5 m deep, of fine mesh) was used to sample fishes close to the beaches. A number of SCUBA dives were made, particularly near Crystal Cliffs. Captain G. Reyno (of RV Navicula) maintained a log of unusual observations in the Bay in 1978, as he had in previous years. These logs have provided much useful information.

This variety of methods served to provide qualitative data on those species of fish which were not vulnerable to the bottom trawl. Further details are included in the accounts of each species caught.

During the summer of 1978, the water temperature was measured close to the beach at Crystal Cliffs on most days, by Miss C. Bourbonnais, who kindly gave me her results. These have been used in some parts of the analysis.

3.5 METHODS OF ANALYSIS

Before the distribution of a species can logically be discussed it must first be shown to be a homogeneous (or, at least, not a significantly heterogeneous) ecological unit. The members of a species in St. Georges Bay differ in sex, age, condition, and many other factors. However, length can be used as a key to most of those of ecological importance. (The exceptions being mainly those related to the fish's sex, e.g. the distribution of lumpfish, where only the males remain inshore to guard the eggs.) Because of the nature of the available data, ecological differences are assumed to coincide with distributional ones.

To locate heterogeneities within species, it was necessary to draw the maximum amount of information from the length-frequency data, a source of knowledge which is generally underutilized in fish survey reports (e.g. Tyler 1971a; Oviatt and Nixon 1973). If a species (or a part of one) can be shown to be homogeneous between two stations, the catches can be combined for calculating mean weights, a simplification which would not otherwise be acceptable. For either purpose, the probability of heterogeneity which is considered significant is purely arbitrary. The conventional 5% has been chosen here.

Where heterogeneity was found, attempts were made to divide the species into homogeneous units, by length-groups, dates, or stations. In some cases, such groupings may have masked continuous clines in length frequency.

The only change of length within a homogeneous population which should occur is growth. In most cases, growth rates were slow enough that the homogeneity of length-frequencies was not significantly affected.

Where it was, lengths were regressed against the Julian date of capture (predictive regression; Ricker 1973). The 'growth' rate obtained was then used to increase the lengths of fish caught early in the survey to a common date, for valid testing of homogeneity. This 'growth' is a function of the catches, not of the population or of an individual fish. Many length-related variations (migrations, catchability, etc.) will cause it to be different from true growth.

3.5.1 Species Analysis

The data from trawling (species, length, station, date, trawl number) were written on a computer file. Most calculations used the Statistical Package for the Social Sciences, Version 7.0 (Nie et al. 1975), as implemented on the CDC 6400 at Dalhousie University Computer Centre. To this data file was added a calculated weight for every demersal fish (i.e. the shads, herring, smelt, capelin, and mackerel were excluded). The sources of equations for this calculation are given in the species sections below. Because the equations are not derived from St. Georges Bay, and often not from the Gulf of St. Lawrence, and because they take no account of sex, maturity state, or condition, the resulting weights are only approximate. Copies of this file are available from the author.

A Kolmogorov-Smirnov test (Conover 1971; SPSS, NPAR tests, Dalhousie University Computer Centre Publication PL.267) was used to test the Normality of the length-frequency data. They were found to be generally non-Normal. The skewness and kurtosis of various catches were highly variable. Thus, no simple transformation would make these data suitable for parametric statistical methods.

3.5.1.1 Kruskal-Wallis Test. Of the various non-parametric tests for two unrelated variables (Conover 1971), the Kruskal-Wallis test was chosen for comparing length-frequency distributions, because of its suitability, and its availability in SPSS (SPSS, NPAR tests, see above).*

This test is a non-parametric analysis of variance. It tests for a difference between distributions, especially of the means, but also of the variabilities, skewnesses, and other parameters (Kruskal and Wallis 1952; Conover 1971). Its final result is a probability of the distributions of the parent populations being the same. Probabilities of less than 5% are taken to indicate significant heterogeneity, but the validity of using this percentile for a second test (where the data have been selected after an earlier one) is unclear (Conover 1971). The accuracy of SPSS calculations is not known. Probabilities are given to four decimal places, and they are repeated here unchanged.

3.5.1.2 Calculation of Abundance. Catch per unit-effort has long been used as an index of fish abundance (Gulland 1964), and this forms the basis of abundance estimates in bottom trawl surveys (e.g. Pennington and Grosslein 1978). However, it is only a relative measure. To be useful, it must be converted into an estimate of biomass, three distinct types of which are recognized in this report. Firstly, 'trawlable biomass' is that weight of fish (of a species, or other group) which would be caught if a

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* Dahlberg (1978) has published a method of comparing the length-frequencies of fish, which is rather better than that used here. It was not available when this analysis was done.

series of standard-sets were made (as in this survey) covering all of the bottom area of the Bay suitable for trawling (including those parts which are too small for practical fishing), and assuming that the catchability of the fish was the same as that during this survey.

Secondly, 'assumed trawlable biomass' is as above, but with the assumption that the gear could be worked over the entire range of the species in St. Georges Bay.

Finally, 'absolute biomass' is the total weight of fish (in any given species or other group) present within St. Georges Bay. It is related to the assumed trawlable biomass by the catchability of the species concerned. For some species it is estimated, in this report, by methods which do not involve a trawlable biomass.

In the present survey, differences between locations and between dates invalidate simple averaging of catch per standard-set, as a means of obtaining an unbiased index of abundance. The arrangement of sets does not include any replication, and has gaps where stations were not worked. Because of this, no three-way statistical test (Analysis of Variance, Multiple Correlation, etc.) can be used. Tests between dates ignoring stations, or vice versa, are possible, but in the absence of complete coverage, the variation in the ignored variable would make the results meaningless.

Thus, a largely descriptive form of analysis has been adopted, which varies to suit the biology and catches of each species (see following sections). This has the advantage that maximal use can be made of existing biological knowledge.

The primary disadvantage of this situation is that it is not possible to calculate confidence limits for the estimates of abundance. Since imperfect knowledge of catchability, wing spread of the trawl, and other factors have a large effect on the final estimate, the absence of a statistically 'proven' variance for the catch is not too serious. The author's considered but subjective view is that, in general, the estimates have little better than order-of-magnitude accuracy, but that relative to one another they are much more accurate.

The number of fish caught by a bottom trawl is not normally distributed (Pennington and Grosslein 1978), and the arithmetic mean is an inadequate statistic for these data. They must undergo a logarithmic transform before the mean is calculated. Since a value of zero cannot be so transformed, all values must first be increased by one (Pennington and Grosslein 1978). These methods are used here.

Catch per standard-set is related to trawlable biomass by the ratio of some area of seabed to the area swept by the net. The one used had a headrope length of 16.8 m. The manufacturer's estimate of "wingspread" (the distance between the wings when the net is in use) was 6 m. For a similarly sized net (Yankee 35) Carrothers and Foulkes (1972) measured a wingspread of 8.8 m and a headline height of nearly 2.1 m (at a speed of $3\frac{1}{2}$ knots, using much larger otter boards than RV Navicula carries). Without measurements on the net used, an exact value of wingspread is not available. For the purpose of this report, a wingspread of 7.5 m and a headline height of 2 m will be assumed. Thus, on a one-nautical-mile tow, the net swept approximately 1/72 km2.

The area of St. Georges Bay, the lagoons around it, the various sediment zones (Kranck 1971), and the parts on which trawling is possible were calculated by counting the squares on a graph-paper tracing of Chart

4462 (Canadian Hydrographic Service) on which Kranck's zones had been plotted. The results are given in Table 2.

Trawlable biomass is related to absolute biomass by the availability and vulnerability of the species in question to the gear being used (Ricker 1975). That portion of availability that is due to some of the fish being on hard bottom is incorporated in calculating the assumed trawlable biomass in this report. The vulnerabiity of a demersal fish population to bottom trawling is a complex of behavioural, mesh selection, and other factors. Its value is almost impossible to estimate accurately, and is likely to vary between seasons, sizes of fish, time of day, etc. However, Edwards (1968) has provided a list of estimated vulnerabilities and availabilities, which has been added to by Scott (1971). Relevant values from these lists were combined as catchabilities, and used to calculate absolute biomass.

The catchability of skate is five times that given by Edwards (1968), because the net used in this survey lacked rollers and so is more similar to the Russian 27.1 herring trawl than to the Yankee 36 (for which Edwards and Scott intended their vulnerabilities). The Russian net is six times better at catching skate than the Yankee 36 (Edwards 1968), presumably because the latter rolls over them.

Catchabilities for snake blenny and alligatorfish were estimated, in comparison to those given by Edwards (1968) for other species. This is inaccurate, but no more so than the original choice of these factors. It should be noted that Edwards (1968), using these catchabilities, estimated the biomass on the continental shelf off New England to be higher than other authors have believed it to be (see section 4.44).

Table 2. Areas of parts of St. Georges Bay

Whole area below high water mark		1180 km^2
Bay		1140 km^2
Lagoons		40 km^2
Sediment types:	'Buctouche sand and gravel'	310 km^2
	'Pugwash mud' 50 to 90% silt and clay	330 km^2
	'Pugwash mud' 95% silt and clay	70 km^2
	'Map-Unit A'	420 km^2
Trawlable area*		570 km^2
Area deeper than 30 m, north and west of the sill		370 km^2

* Estimated from practical experience and from Kranck's (1971) sediment distributions.

3.5.1.3 Distribution. The distribution of each species (temporal, as well as spatial) and their movements were determined from the variations in catch per standard-set between dates or stations, with considerable reference to the scientific literature.

4. RESULTS AND DISCUSSION BY SPECIES

In this section, each species is considered separately, and estimates of its biomass, range within the Bay, and seasonal occurrence there are derived. It cannot be overemphasized that these are imprecise, especially for those species which are not vulnerable to trawling. All the estimates are conservative (minimum likely biomass, range, or season). However, even an imprecise and biased numerical estimate of biomass is more useful than such terms as 'numerous' or 'fairly common', provided that the reader is aware of the limitations of these estimates. The biomass values given are thought to have rather better than order-of-magnitude accuracy. All values are rounded to the number of figures shown.

The following sections are intended to supplement, and not replace, Leim and Scott's (1966) standard work on the fishes of Atlantic Canada. To assist the joint use of this report and their book, their order of species and nomenclature has been adopted unchanged.

Where possible, local names used in the Ballantynes Cove area have been noted. This is done in part for their intrinsic, anthropological interest. Of more immediate importance is that the wealth of knowledge that inshore fishermen have is denied to science, or (worse) applied to the wrong species, if biologists cannot understand these names.

The results of Kruskal-Wallis tests between the length-frequencies of various groups of fish are reported as probabilities. Section 3.5.1.1 explains the meaning of these. Unless otherwise stated, the results of a between-stations test are given first, followed by one between-dates.

Most of the biological information used in the following sections was derived from research in areas outside the Gulf of St. Lawrence. It must be recognized that what is true for a species elsewhere may not be so in St. Georges Bay.

A list of the species discussed, with estimates of their catchability and seasonal maximum biomass, is given in Table 3.

4.1 RAJA ERINACEA LITTLE SKATE; AND RAJA OCELLATA: WINTER SKATE

Locally, these species are both called 'skate' and are not distinguished. In this survey, they were separated by counting the tooth rows (Leim and Scott 1966), a character which may not be fully reliable (Templeman 1965).

R. ocellata are known from Canso, Cheticamp, Tignish (very common), and Malpeque. Apart from Cox's (1921) record from Cheticamp, these were all taken inshore. Cornish (1907) took no *R. erinacea* at Canso, but thought that they might be present. McKenzie (1959) found a skate, which he identified as *R. erinacea*, to be 'common' in the Miramichi. However, they were atypical of that species, and the teeth resembled those of *R. ocellata*.

Farther south, *R. erinacea* is the most abundant skate on the southern New England fishing grounds (Richards *et al.* 1963) and the most abundant 'winter periodic' in Passamaquoddy Bay (Tyler 1971a). In the latter survey *R. ocellata* was also taken in small numbers during the winter.

Table 3. Fish species found in St. Georges Bay, with estimates of their biomass.

	Assumed Trawlable Biomass	Catchability	Absolute Biomass
Little skate	74	0.50	148
Winter skate	-	-	148
Thorny skate	16	0.50	32*
Blueback herring	-	-	}
Alewife	-	-	} few
American shad	-	-	} 100s*
Atlantic herring	-	-	many*
Atlantic salmon	-	-	50+*
Brook trout	-	-	-
Capelin	-	-	<10
American smelt	-	-	100?
American eel	-	-	50+
Atlantic saury	-	-	-
Mummichog	-	-	40
Northern pipefish	-	-	-
Fourspine stickleback	-	-	-
Threespine stickleback	-	-	-
Black-spotted stickleback	-	-	-
Fourbeard rockling	-	-	-
Atlantic cod	63	0.28	225*
Silver hake	-	-	-
Pollack	-	-	few*
White hake	343	0.86	399*
Cunner	-	-	many
American sand lance	-	-	-
Atlantic mackerel	-	-	many*
Bluefin tuna	-	-	-
Rock gunnel	-	-	-
Wrymouth	-	-	-
Daubed shanny	-	-	-

Table 3 continued

	Assumed Trawlable Biomass	Catchability	Absolute Biomass
Snake blenny	2.9	0.36?	8
Radiated shanny	-	-	-
Ocean pout	176	0.63	279
Atlantic silverside	-	-	-
Atlantic sea raven	-	-	-
Grubby	-	-	-
Longhorn sculpin	38+	0.42	90+
Shorthorn sculpin	-	-	90?
Alligatorfish	0.1	0.42?	0.2
Lumpfish	-	-	-
Atlantic seasnail	-	-	-
Windowpane	0.8	0.23	3
Witch flounder	118	0.49	241*
American plaice	1562	0.28	5579*
Yellowtail flounder	20	0.56	36*?
Smooth flounder	-	-	few
Winter flounder	1264	0.42	3010

* These species are, to varying extents, migratory. The biomasses given for them are seasonal maxima.

In St. Georges Bay, skate were taken by bottom trawl (Table 4). The identificaiton of some of these is uncertain. Small numbers of skate were taken by the bait- and salmon-traps throughout the period that they were worked (May to July, inclusive), and a few were seen close inshore while diving. Of the inshore catches, the few specimens examined were all R. ocellata.

The length-frequencies of confirmed (trawl-caught) R. erinacea showed no difference between stations or dates (P = 0.3142, P = 0.7801). Including the doubtful specimens in this analysis did not greatly alter these probabilities. These little skate ranged in length from 292 to 606 mm. Thus, as observed by Richards et al. (1963) the juveniles are not abundant on the trawling grounds and probably inhabit rough bottom.

Catch per standard-set did not vary greatly between the stations, so the abundance index for each date should not be influenced by the stations worked. Catch per set for the various dates were:

early May	0.8	
mid-May	0.3	
late May	1.0	
mid-June	0	
early July	0.2	(including the doubtful specimens)
thereafter	0	

Previous studies (Richards et al. 1963; Tyler 1971a) suggest that little skate spawn in summer in Canadian waters, and migrate to hard bottom for this purpose. They would not need to leave St. Georges Bay to do so. A comparison to Tyler's (1971a) results suggests that the peak winter catch (were trawling possible) might be 10 times that in May.

Table 4. Trawl catches of little and winter skates (in numbers)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	1*	4**	x	0	x	0	1**	x	x
mid-May	0	x	1	1	1	x	0	0	0	0
late May	2	4	x	1	1	x	0	0	1	0
mid-June	0	0	0	0	0	x	0	0	0	x
early July	0	0	1	0	0	x	1	0	x	0
late July	0	0	x	0	0	x	0	1***	0	x
early August	0	0	0	0	0	0	0	x	0	x
late August	x	x	x	x	0	x	0	0	x	x
early September	x	x	0	x	0	x	0	0	x	x

* Tentatively identified as R. radiata.
** Tentatively identified as R. ocellata, probably R. erinacea.
*** Definitely R. ocellata.
Others definitely R. erinacea.

All the little skate are probably on soft bottom areas in midwinter, thus the trawlable area can be used in a biomass calculation. No length-weight relationship for *R. erinacea* has been published. Richards *et al.*'s (1963) data suggest weights about half those given by Kohler *et al.* (1970) for *R. radiata* of the same length. Thus the latter's equation has been used, and its results halved, giving a mean weight of *R. erinacea* taken by bottom trawl of 300 g.

These values give a minimum estimate of the trawlable biomass in St. Georges Bay of 74 tons.

The data on winter skate do not permit a similar calculation. They do, however, appear to be much more common than little skate in the inshore areas of the Bay, as has been found elsewhere in this region (Cornish 1907, 1912; Needler 1940). Their biomass in the Bay might be as great as that of *R. erinacea.*

4.2 *RAJA RADIATA*: THORNY SKATE

Although usually referred to locally as 'skate', the fishermen are aware that they differ from *R. erinacea* and *R. ocellata.*

This was the commonest skate taken by 'cod-trawls' (hooks) at Canso. It was 'fairly common' near Cheticamp, but Needler (1940) took only one in Malpeque Bay, and none were reported from Tignish or the Miramichi. This absence probably relates to the shallowness of the latter areas, since thorny skate are not caught in less than 18 m depth (Leim and Scott 1966).

In St. Georges Bay, they were taken only by bottom trawl (see Table 5), and were 251 to 720 mm in length. The length-frequencies of these catches were heterogeneous by station and date (P = 0.0004, P =

Table 5. Trawl catches of thorny skate (in numbers)

Date	Station 3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	1*	0	x	0	x	0	0	x	x
mid-May	0	x	0	0	0	x	0	0	0	0
late May	0	0	x	0	0	x	0	0	0	0
mid-June	7	2	2	1	0	x	0	0	1	x
early July	2	2	0	0	0	x	0	0	x	12
late July	2	1	x	0	0	x	0	0	0	x
early August	1	3	5	1	0	0	0	x	1	x
late August	x	x	x	x	0	x	0	0	x	x
early September	x	x	4	x	0	x	0	0	x	x

*Tentative identification.

0.0114) without any clear pattern; however, exluding stations 30.3 and 30.11 (outside the Bay) left fairly homgeneous length frequencies ($P = 0.0535$, $P = 0.2570$). This difference in distribution of variously sized fish may be related to a difference in diet (Tyler 1972).

Thorny skate were only caught at stations deeper than 30 m and were noticeably less abundant close to this limit (stations 15.7 and 21.2). They did not cross the 26 m deep sill to reach station 22.12.

They were rare (or absent, the only specimen was not identified with certainty) in the Bay before June, but thereafter maintained a fairly steady abundance. This is in contrast to Passamaquoddy Bay (Tyler 1971a) where they were taken in low, but constant, numbers all year. Bottom temperatures there did not fall below 1°C, which is within the preferred range of this species (0°-10°C; Pinhorn 1976). St. Georges Bay is colder in winter, and thorny skate were not found there until bottom temperatures at its mouth rose to -0.5°C. Thus it appears that this species leaves the Bay for the winter, returning in June.

The catch per set from June to September, at Bay stations deeper than 30 m, is 0.9. The weight of each fish can be calculated as:

$$W = 6.27426 \times 10^{-8} L^{3.038536}$$ (Kohler *et al.* 1970, Table 190A; converted to kg and mm)

This gives a mean weight for these fish of 0.688 kg. Using the area of the Bay deeper than 30 m (excluding the Strait of Canso) gives a trawlable biomass of 16 tons.

4.3 ALOSA AESTIVALIS: BLUEBACK HERRING; A. PSEUDOHARENGUS: ALEWIFE; A. SAPIDISSIMA: AMERICAN SHAD

These species are not distinguished locally, and are called 'gaspereau', except that A. sapidissima longer than about 300 mm are called 'shad'.

The bait-traps are directed toward 'gaspereau', and thus their catches presumably provide a reliable index of occurrence of these species. The nets were worked form early in May until late in June. This is the season of spawning runs elsewhere in the Southern Gulf (Leim 1924; McKenzie 1959; Leim and Scott 1966) and appeared to include those in the Bay. At first, most of these fish were A. pseudoharengus, but on 5 June some A. aestivalis were noticed in the catch. The proportion of these rose until, by 11 June, they formed the majority. Large 'shad' were taken intermittently throughout this period. Following the discovery of A. aestivalis, the 'gaspereau' were checked more closely and a small proportion of them were found to be A. sapidissima.

'Gaspereau' were also seen in Ogden Pond (18 June, 3 and 13 July); a 'shad' was taken by the salmon trap at Lakevale (23 July); and a school of juveniles was seen near Crystal Cliffs on 12 and 18 August (this is the season in which Needler (1940) observed them returning to the sea). Some of these juveniles were caught with a beach seine, but specific identification was not possible (Leim and Scott 1966). Finally, four adult A. aestivalis were taken by bottom trawl in September, at station 21.2 (270-292 mm length). A. aestivalis in the Connecticut River seemed to return to sea soon after spawning (Loesch and Lund 1977), and the same is thought to be true of A. sapidissima (Leim and Scott 1966). Kissil (1974), however, found that some *A. pseudoharengus* remained on the spawning grounds for 3 months. Thus, at any one time, a considerable proportion of the 'gaspereau' within the Bay area may be in fresh water.

Little is known of the marine life of the shads. Until recently, they were thought to remain close to their natal rivers (Leim and Scott 1966), but extensive migrations have been demonstrated for *A. sapidissima* (Talbot and Sykes 1958). *A. pseudoharengus* and *A. aestivalis* have been noted on Georges Bank after their spawning seasons (Netzel and Stanek 1966), so they may also undertake long migrations. Thus, each of these species is probably a seasonal visitor to St. Georges Bay.

A. aestivalis have not been reported from the Gulf of St. Lawrence since an (unsupported) record by Cox (1896). It is possible that they are present elsewhere in the Southern Gulf, but have been confused with the next species. *A. sapidissima* are abundant in the Miramichi, but uncommon east of there (Leim 1924; McKenzie 1959).

The 'gaspereau' fishery in St. Georges Bay is primarily for lobster bait. The annual catch is between 10 and 70 tons, of which almost all is taken on the Antigonish County side (Anon. 1975; Caddy and Chandler 1976).

There are insufficient data for calculating the biomass of shad in the Bay. In view of the fishery landings, the stock is perhaps a few hundred tons. They are present from mid-May (at the latest) until, at least, September, but their distribution is very uncertain other than during the spawning runs.

4.4 CLUPEA HARENGUS: ATLANTIC HERRING

4.4.1 Adults

Herring were taken by the Ballantynes Cove bait-traps throughout the period that they were worked (mid-May to late June), usually in small numbers. Further details of herring catches in the Bay are given by Ware and Hendricksen (1978) and Anon. (1975).

This species is widely distributed, and often abundant, in the Southern Gulf (Cornish 1912; Cox 1921; Needler 1940; McKenzie 1959; Leim and Scott 1966; Winters and Beckett 1978). They migrate into this region at the beginning of May (Winters 1976; Winters and Beckett 1978), to spawn on many grounds throughout the area (Messieh 1975a; Ware and Hendricksen 1978), and return eastwards from October onwards (Winters 1976; Winters and Beckett 1978).

The number of herring entering St. Georges Bay each summer is unknown. it is not sufficient for a significant fishery to occur (Ware and Hendricksen 1978; Dadswell 1979a), but this species may still be important to the pelagic ecosystem. Their biomass in the late 1970s may be unusually low, due to the combined effects of the *Ichthyosporidium* epizootic of 1954--55, the closure of Canso Strait, overexploitation by the offshore seine fishery, and competition from underexploited species such as mackerel (Winters and Hodder, 1975; Lett and Kohler 1976; Dadswell 1979a).

4.4.2 Juveniles

Unlike the herring stocks of the Scotian Shelf-Bay of Fundy (Messieh 1970), Europe (Parrish and Saville 1965), or British Columbia (*C. pallasii*; Taylor 1964), the location of the juveniles of the Southern Gulf stock-complex is almost unknown. They drift throughout the area as larvae (Messieh and Kohler 1972), but these fish are rarely found between metamorphosis and maturity (at about 250 mm length; Hodder and Parsons 1971).

Messieh (1975a) gave the location of some herring 'nursery grounds', including the northwest corner of St. Georges Bay. Cox (1921) took three specimens (140 mm long) at Cheticamp, in June. McKenzie (1959) reported 'sardine' herring in the Miramichi, occasionally in May and June, and regularly in the autumn. In some years, the latter season saw large numbers caught. Parsons (1973) took some juveniles at the Magdalen Islands. Dadswell (1979a) suggests that the Strait of Canso may have been a nursery ground for herring before the construction of the causeway.

Inshore autumn appearances of juvenile herring are known to many fishermen. Mr. D. Power (Manager, Pictou Division, National Sea Products) informed the author that large numbers entered Pictou Harbour in the autumn of 1977, accompanied by schools of squid. He also said that a few juveniles can be seen in the same place in spring. The autumn 1977 concentrations were also seen at Ballantynes Cove (Captain G. Reyno, pers. comm.), and may have been general along the coast.

In the present and earlier surveys, trawling in St. Georges Bay has taken herring juveniles (Table 6).

In summary, it appears that some, or all, of the juveniles from the Southern Gulf stock-complex move close inshore late in the autumn (October and November) in many areas from Cape Breton to the Gaspé. A few of them are similarly distributed in the spring. Their whereabouts at other seasons is unclear, but they may be below the thermocline in relatively shallow water (e.g. St. Georges Bay, the ends of the Northumberland Strait, or

Table 6. Records of juvenile herring from St. Georges Bay

Date	Number	Lengths*	Location
2 August 1973	48	119-155	
17 December 1973	'substantial'	about 150	southeast
19 November 1974	about 100	170-370**	
17 July 1977	3	157,170,176	southeast
17 July 1977	106	142-247	southeast
17 July 1977	1	180	southeast
21 July 1977	1	186	southeast
mid-May 1978	1	130	Station 30.3
mid-May 1978	4	81,133,138,141	Station 30.11
early August 1978	1	186	Station 17.9
early September 1978	2	227,280	Station 21.2

* in millimetres

** some of these fish were not juveniles

Chaleur Bay). If at times they ventured near the bottom, they would become vulnerable to fine-meshed research trawls, and so produce the sporadic observations mentioned above.

No estimate of biomass in St. Georges Bay is possible.

4.5 SALMO SALAR: ATLANTIC SALMON

Salmon were taken by commercial fishermen, the first at Ballantynes Cove on 13 June.

They are found around the coasts of the Southern Gulf (Cox 1921; Needler 1940; McKenzie 1959; Leim and Scott 1966) and ascending many rivers, notably the Miramichi and Margaree (Leim and Scott 1966). From St. Georges Bay, they enter the South, Pomquet, Black, Afton, and Tracadie Rivers (Anon. 1975). It is not known how long each fish spends in coastal waters on its way to and from spawning, nor the season in which this species occurs in the Bay. (The fishery is restricted by a closed season.)

No direct estimate of salmon biomass in St. Georges Bay is available. The fishery, primarily located on the western side of the Bay, takes 13 to 45 tons annually (Dadswell 1979a). Landings, and presumably the stock, have declined since the mid-1960s (Caddy and Chandler, 1976). Thus, the spawning stock which passes through the Bay is at least 50 tons. To this must be added the smolts (which are not fished) leaving local rivers.

4.6 SALVELINUS FONTINALIS: BROOK TROUT

No fish of this species were seen by the author, but sport anglers fishing in Ogden Pond, its tributary brooks, the Lakevale 'lakes', and similar places reported taking 'trout'. These were presumably S. fontinalis.

This species is widespread in the fresh waters draining to the Southern Gulf, and sea-runs occur in many places (Cornish 1912; Cox 1921; Needler 1940; McKenzie 1959; Scott and Crossman 1973). On the Atlantic coast of Nova Scotia, brook trout move downstream in April and May, returning in July (White 1941). They do not appear to move far from their rivers during this time (White 1940).

A similar pattern probably occurs in St. Georges Bay. No data are available for an estimate of biomass.

4.7 MALLOTUS VILLOSUS: CAPELIN

This species is not abundant in the Southern Gulf (Cox 1921; McKenzie 1959; Leim 1960; Leim and Scott 1966), and rarely spawns south of Miramichi Bay (Parent and Brunel 1977). The spawning range is said to be more extensive in years of below average temperatures (Jangaard 1974; Parent and Brunel 1977).

Capelin were unknown in St. Georges Bay before 1975, when a few were taken in the bait-traps. Their numbers increased in subsequent years, such that in 1977 they became a nuisance to the fishermen. In that year, beach spawning was extensive around Cape George (Dr. D.M. Ware, Mr. K. Falkenham, pers. comm.). Water temperatures during June were lower than in the previous few years (Drinkwater and Taylor 1980). In 1978, a few capelin were taken in the bottom trawl (Table 7; 125-180 mm length), and some were seen in the bait-trap late in May. Dr. P. Beamish searched the Bay, using a helicopter, early in June. He found only one school, off Cape George. Subsequently, there was limited spawning on a beach in that area (Mlle. M. Lanctôt, pers. comm.).

Table 7. Trawl catches of capelin (in numbers)

Date	Station 3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	0	2	x	0	x	0	1	x	x
mid-May	1	x	0	0	0	x	0	0	0	2
late May	0	0	x	0	0	x	0	0	0	1
mid-June	0	1	0	0	0	x	0	0	0	x
early July	0	0	0	0	0	x	0	0	x	0
late July	0	0	x	0	0	x	0	0	0	x
early August	0	0	0	0	0	0	0	x	0	x
late August	x	x	x	x	0	x	0	0	x	x
early September	x	x	0	x	0	x	0	0	x	x

Because of the pelagic habit of this species, bottom trawling cannot give an accurate estimate of abundance. The school that Dr. Beamish found was about 20 m by 10 m in size, in water 3 m deep. Some of these fish were caught, and later were subjected to observations of schooling behaviour (Miller and McInerney 1978). Those authors estimated a density of 2.1 kg m^{-3}. Thus, the school may have comprised 1.26 tons of capelin. These fish were predominantly males, the females typically forming schools at greater depth (Jangaard 1974). Some additional capelin were present in the Bay (and hence taken by the trawl). Thus, the biomass of capelin in the Bay may have been a few tons.

Elsewhere in the Gulf of St. Lawrence, this species begins to move towards the spawning grounds in November (Bailey et al. 1977), presumably continuing under the winter ice. They probably leave soon after spawning, as the water becomes too warm.

The abundance of capelin in the Bay is likely to be more variable, between years, than that of other species, on the basis of recent experience and the claimed relation between range and temperature. It is possible that major cycles of capelin abundance occur in the Southern Gulf. Perley (1859) reported a major fishery in the Chaleur Bay area, whereas Leim (1960) included capelin there amongst his "records of uncommon fishes". More recently, Parent and Brunel (1977) recorded them as "regular" in that place.

4.8 OSMERUS MORDAX: AMERICAN SMELT

Smelt are usually abundant around the shores of the southern Gulf (Cornish 1912; Cox 1921; Needler 1940; McKenzie 1959; Caddy et al. 1977).

Table 8. Trawl catches of smelt (in numbers)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	0	0	x	2	x	21	2	x	x
mid-May	0	x	0	0	1	x	0	0	0	0
late May	0	0	x	0	0	x	0	1	0	0
mid-June	0	0	0	0	0	x	0	0	0	x
early July	0	0	0	0	0	x	0	0	x	2
late July	0	0	x	0	10	x	2	8	0	x
early August	0	0	0	0	24	1	7	x	0	x
late August	x	x	x	x	3	x	12	14	x	x
early September	x	x	1	x	9	x	65	13	x	x

In St. Georges Bay they were taken in the bottom trawl (see Table 8). In addition, several small ones (less than 100 mm in length) were taken by beach seine near Cribbean Head (14 July) and at Crystal Cliffs (12 August). There is a spawning run in the brook at Ballantynes Cove, which started on 19 May 1976 and 3 May 1977. These fish probably return to the sea a few weeks later, followed by their young (McKenzie 1959). Elsewhere in the Southern Gulf, and in Passamaquoddy Bay, smelt are found in coastal waters all summer, moving inshore in the autumn (Needler 1940; McKenzie 1964; Tyler 1971a).

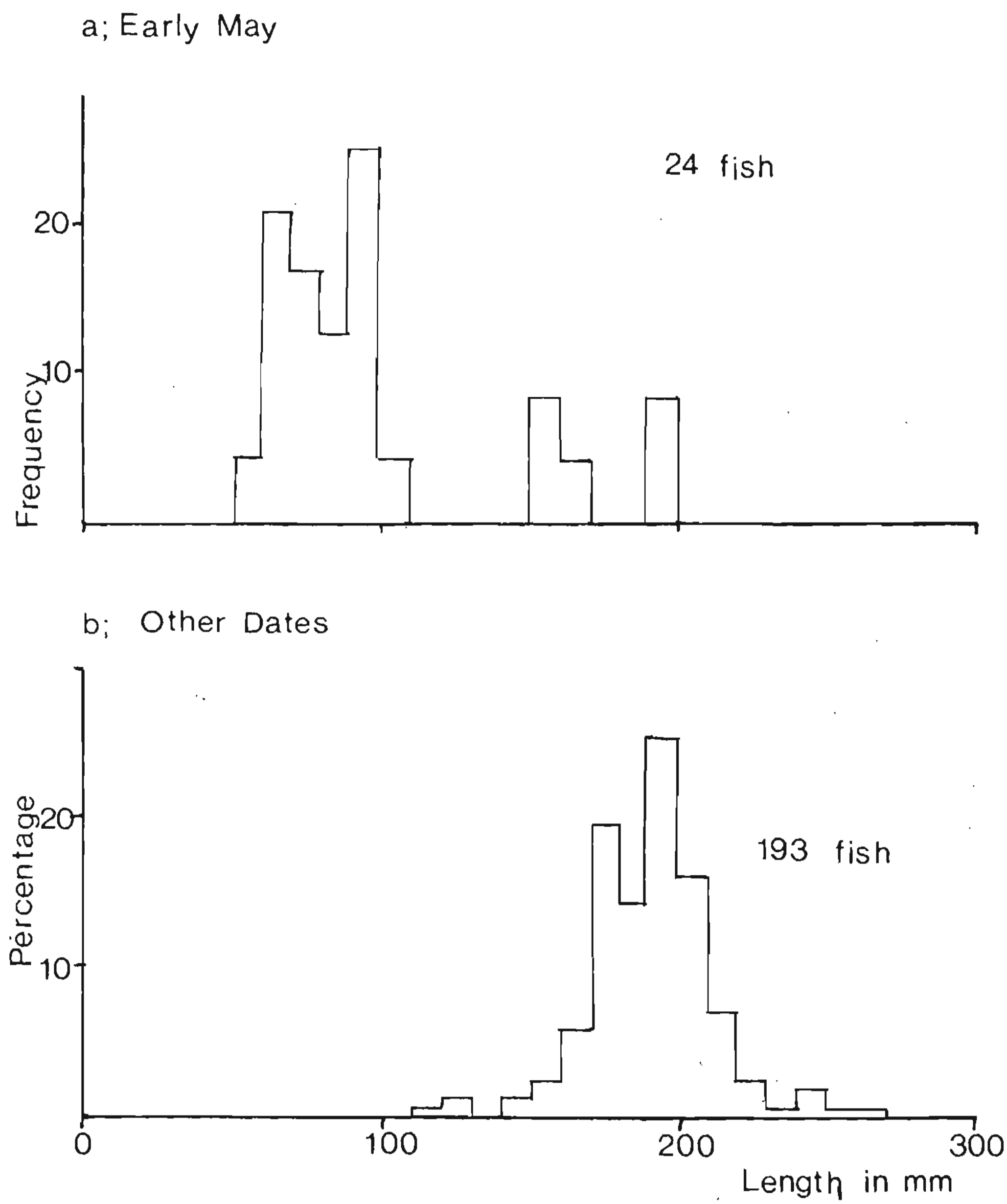
The trawl-caught smelt in St. Georges Bay have a strongly bimodal length-frequency (Fig. 5), which Cox (1921) similarly observed at Cheticamp. Although there are no significant differences beween the stations ($P = 0.2446$), there are between dates ($P < 0.0001$). This is due to the fish caught in early May being, almost exclusively, from the smaller mode. Separating these leaves the rest without significant differences by date ($P = 0.0632$) or station ($P = 0.8743$). The early May catches were homogeneous by station ($P = 0.0633$).

McKenzie's (1964) age-length data suggest that the smaller mode is of I-group fish (spawned in May 1977), while the slower growth of adult smelt has caused the older fish to appear as a single peak in the length-frequency histogram

I-group smelt were, therefore, taken at stations 17.9, 21.2, and 22.12 in early May. Thereafter, they moved off-bottom, and perhaps inshore (where some were taken in the seine).

A few adults were taken through May, but it is not known whether these were pre- or post-spawners. Smelt then disappeared from the catches,

Figure 5; Length-Frequencies of Trawl-Caught Smelt.



presumably because they were too far off-bottom to be taken, and re-appeared from July onwards in increasing numbers. This re-appearance may be in part due to the warming of the bottom water, and the steadily deepening thermocline. However, it is not perfectly correlated with temperature or depth. The restricted nubmer of stations at which smelt were found suggests that another factor limits their distribution, perhaps the availability of food.

Three I-group smelt were taken in late August at station 22.12.

There is no evidence that these catches are representative of the density of smelt at other depths, and so they cannot be used to estimate the biomass present. Smelt do not seem to migrate far from their spawning rivers (McKenzie 1964), and there is no evidence that they leave the Bay, except to spawn.

A small fishery takes place in the Bay (McKenzie 1964). Landings there and in the surrounding area have been about 20 to 30 tons in recent years (Anon. 1975; Caddy and Chandler 1976). These suggest that the biomass present may be about a hundred tons.

4.9 <u>ANGUILLA ROSTRATA:</u> AMERICAN EEL

Three eels were seen: in Ogden Pond (3 July), near the salmon-trap at Lakevale (23 July), and near Crystal Cliffs (12 August). The cryptic behaviour of the latter suggests that others may have been present, but unseen. None of these three was captured, but they all appeared to be large (over 600 mm).

Eels are found in fresh water systems draining to all parts of the Gulf of St. Lawrence (Leim and Scott 1966; Scott and Crossman 1973). In addition to the larvae ('glass eels') and mature adults ('bronze eels') which pass through the coastal zone on their way from or to the spawning areas, some immature 'adults' ('yellow eels') live in brackish waters permanently, particularly amongst Zostera (Eales, 1968). They are found thus around the coast of the southern Gulf (Cornish 1907; Cox 1921; Needler 1940; McKenzie 1959). Some overwinter in the estuaries, and are fished there with spears (Eales 1968). They are rarely taken in trawls, and are presumably absent from the trawling ground in St. Georges Bay.

There is a small commercial fishery for eels in the Judique River (St. Georges Bay, Inverness Co. shore), and they are taken for personal consumption at various places around the Bay (Eales 1968). Eales thought that the Antigonish area population was adequate to sustain a commercial fishery, and such an expansion subsequently occurred. The annual catch was 10 to 30 tons during the early 1970s, with the majority being taken on the Antigonish County shores of the Bay (Caddy and Chandler 1976).

Therefore, the biomass of eels in the Bay is presumably over 50 tons, but some of these may be in fresh water, and most of the others might be in the lagoons (amongst the Zostera; Eales 1968).

4.10 SCOMBERESOX SAURUS: ATLANTIC SAURY

There was no record of sauries in St. Georges Bay in 1978, but they have been common in previous years in the summer (Captain G. Reyno, pers. comm.). In some years they are abundant in Newfoundland waters (Pinhorn 1976), and Cornish (1907) saw large schools off Canso in July or August. Previous records of this species from the Southern Gulf are of solitary specimens.

4.11 FUNDULUS HETEROCLITUS: MUMMICHOG

Mummichog were very abundant in Ogden Pond throughout the spring and summer. Of two hauls with a beach seine, on 7 June, the first took only a few, while the second caught an estimated 30 kg of this species. (This haul swept a bottom area of about 1000 m^2, with depths from 0 to 1 m). These fish were mostly between 10 and 100 mm in length.

This species is abundant in the estuaries, tide pools, and other brackish areas of the Southern Gulf (Cornish 1912; Cox 1921; Needler 1940; McKenzie 1959). It was present throughout the open water season at Malpeque Bay (Needler 1940) and is thought to spend the winter in deep holes, or buried in the mud, in tidal inlets (Leim and Scott 1966).

An average biomass-density, calculated from the two hauls in Ogden Pond, is 0.015 kg m^{-2}. However, these were both taken in very shallow water close to shore, which appears to be the area of greatest abundance of this species. Thus, an average density of 1 g m^{-2} in the lagoons of St. Georges Bay may be a fair estimate of biomass. This would give a total of 40 tons present in the area; concentrated in the shallowest parts in summer, and rather deeper but still within the lagoons, in winter.

4.12 SYNGNATHUS FUSCUS: NORTHERN PIPEFISH

Two were seen underwater, near the beach at Crystal Cliffs (1 June, 13 August). The range of this species extends from Miramichi Bay southwards (Leim and Scott 1966). McKenzie (1959) believed it to be rare in the Miramichi, while Needler (1940) thought it generally distributed but not numerous in *Zostera* beds in Malpeque Bay. Pipefish are probably not uncommon in the lagoons around St. Georges Bay. The individuals seen may have been carried out into the Bay by spring ebb tides, which also transport large amounts of Zostera. This species is resident all year at Woods Hole (Bigelow and Schroeder 1953), and the same is probably true in St. Georges Bay.

4.13 APELTES QUADRACUS: FOURSPINE STICKLEBACK; GASTEROSTEUS ACULEATUS: THREESPINE STICKLEBACK; G. WHEATLANDI: BLACK-SPOTTED STICKLEBACK

Some A. quadracus were taken by beach seine in Ogden Pond (7 June). They are probably common in the lagoons, as Cornish (1907) at Canso, and Cox (1921) at Cheticamp, found them to be. They are presumably residents.

The taxonomy of Gasteroteus is the subject of some debate (Hagen and McPhail 1970; Miller and Hubbs 1969). Leim and Scott (1966) recognize two species, and their scheme will be followed here.

Some were seen in the bait-trap (28 May, 10 June), while others were caught by beach seine in Ogden Pond (7 June), at Cribbean Head (14 July), and at Crystal Cliffs (15 July). Large schools were seen in Ogden Pond, off Crystal Cliffs, and at Lakevale on many occasions in July and August. Most of these were probably G. aculeatus, and some in each seine were definitely that species. However, G. wheatlandi were taken in the haul at Crystal Cliffs on 15 July, and there may have been others amongst the schools.

Gasterosteiforms (of unknown species) were taken in neuston nets throughout the Bay. These were passed, with the icthyoplankton from these nets, to Dr. D.M. Ware for further consideration.

G. aculeatus has been found in large numbers all around the Southern Gulf coastline, in brackish waters and near the shore (Cornish 1907, 1912; Cox 1921; Needler 1940; McKenzie 1959). Dannevig (1919) took some in plankton nets in the western Northumberland Strait, and similar catches have been made offshore in the Gulf of Maine (Bigelow and Schroeder 1953).

G. wheatlandi has not often been distinguished in fish surveys in this area. Cox (1921) found it to be rare at Cheticamp and the Magdalen Islands, while McKenzie (1959) thought it common in the Miramichi estuary.

These two species combined are probably amongst the most abundant brackish and inshore fish in the Bay, and also comprise a significant part of the offshore pelagic community. It is not possible to state what the relative abundance of the two may be, but G. aculeatus was more abundant in the seine hauls. They are presumably resident all year, except that G. aculeatus moves to fresh (Leim and Scott 1966) or brackish (Garside and Kerekes 1969) water to breed.

4.14 ENCHELYOPUS CIMBRIUS: FOURBEARD ROCKLING

No rockling were taken during 1978, but a few have been caught in earlier research trawling, and their eggs taken in plankton nets, in the Bay (Dr. D.M. Ware, pers. comm.).

This species has been recorded from several places in the Southern Gulf (Bell 1859; Cox 1921; McKenzie 1959; Leim and Scott 1966; Caddy et al. 1977) but always in small numbers. Its planktonic stages are more frequently taken (Dannevig 1919; Faber 1976; Kohler et al. 1974a, 1957, 1977); indeed, Faber found rockling to be the second most abundant species in his catches in the Northumberland Strait. It would, therefore, appear that adult rockling are not vulnerable to the usual sampling methods.

They are more common below 50 m depth (Leim and Scott 1966) and thus could be expected to be scarce in the Bay.

4.15 GADUS MORHUA: ATLANTIC COD

Cod were taken in St. Georges Bay by otter trawl (Table 9) and in the bait-traps at Ballantynes Cove (starting in late May; maximum catch, 18 fish in a day).

They are abundant in the Southern Gulf (Cornish 1912; Cox 1921; Needler 1940; McKenzie 1959; all as G. callarias; Caddy et al. 1977), and support a major fishery (Paleoheimo and Kohler 1968; Halliday 1972). They are mostly found offshore and do not usually enter Malpeque or Miramichi Bays (Needler 1940; McKenzie 1959).

The length-frequencies of the cod in the trawl catches (Fig. 6) were heterogeneous between stations ($P = 0.0004$) and between dates ($P = 0.0048$). 'Large' cod (longer than 515 mm) had homogeneous length-frequencies ($P = 0.2024$, $P = 0.1232$); as did 'small' ones, when this group was defined by a length-limit which increased 5 mm per week (see Table 9; $P = 0.5476$, $P = 0.6002$).

The remaining 'medium' cod had heterogeneous length distributions, when compared between dates. A linear 'growth' rate of 0.84324 mm per day (calculated by regressing their lengths against the Julian dates of their capture) removed this heterogeneity ($P = 0.1983$, $P = 0.4772$). This 'growth' rate is rather faster than expected for cod in this area (Leim and Scott 1966), so a size-differential factor (such as migration or vulnerability) may be involved.

Cod were taken throughout the period of the survey, and at all the stations (except 20.6), but their numbers were highly variable. The catches indicate an increase in numbers in the spring, reaching a peak about midsummer, and then declining until the end of the survey. Catches

Table 9A. Trawl catches of 'small' cod (total length less than shown below) in numbers

Date	Maximum Length (mm)	Station 3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	145	x	0	1	x	0	x	0	0	x	x
mid-May	150	0	x	0	0	0	x	0	0	0	0
late May	160	0	0	x	0	0	x	0	0	0	0
mid-June	175	0	0	0	0	0	x	0	0	1	x
early July	185	0	0	0	0	0	x	0	0	x	0
late July	195	2	0	x	2	0	x	1	0	0	x
early August	205	1	4	17	6	0	0	0	x	0	x
late August	215	x	x	x	x	0	x	0	0	x	x
early September	230	x	x	5	x	0	x	1	0	x	x

Table 9B. Trawl catches of 'medium' cod (in numbers)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	1	2	x	0	x	0	0	x	x
mid-May	4	x	3	1	0	x	0	0	4	4
late May	1	0	x	0	0	x	0	0	0	0
mid-June	17	82	1	1	0	x	1	0	2	x
early July	21	3	0	0	0	x	1	0	x	3
late July	8	1	x	0	0	x	1	0	1	x
early August	11	5	9	2	0	0	3	x	0	x
late August	x	x	x	x	0	x	0	0	x	x
early September	x	x	6	x	0	x	0	0	x	x

Table 9C. Trawl catches of 'large' cod (longer than 515 mm) in numbers

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	0	0	x	1	x	0	0	x	x
mid-May	0	x	0	0	0	x	0	0	0	1
late May	0	0	x	0	0	x	0	0	0	0
mid-June	1	7	0	0	0	x	0	0	0	x
early July	1	2	2	0	0	x	0	2	x	0
late July	1	0	x	0	0	x	0	0	0	x
early August	0	0	5	0	0	0	0	x	1	x
late August	x	x	x	x	0	x	0	0	x	x
early September	x	x	0	x	0	x	0	0	x	x

were high at the deeper stations (3.7, 5.7, 11.10) and low at the shallowest (17.9). The low catch at station 22.12 may be due to the shallow sill which divides this area from the rest of the Bay.

'Small' cod were present throughout the survey in very small numbers, with a distinct maximum of abundance in August. They were not found in depths of <30 m. The average catch per standard-set for stations deeper than 30 m within the Bay (other than 22.12) from late July to September was 1.8. The most sutiable length-weight equation is for fork length, but the inaccuracy in using this with total length will not be excessive. It is:

$$W = 6.360862 \times 10^{-9} L^{3.046915}$$ (Kohler *et al.* 1970, Table 1; converted to kg and mm)

Using this, the average weight for a 'small' cod was 0.038 kg.

'Medium' cod had essentially the same distribution as the 'small' ones, except that the time of peak abundance was in June. A similar calculation of catch per standard-set, from mid-June to early August, gives 3.2. The average weight of these fish is 0.390 kg.

'Large' cod occurred in the catches at the same time as 'medium' ones, and were common at the same stations. They seem to tolerate shallower water; one being taken at station 17.9 and two at 22.12 after (presumably) crossing the sill. The catch per standard-set, with the same limits as those for 'medium' cod, was 0.5, and their mean weight was 1.707 kg.

The results for both 'small' and 'medium' cod were influenced by single productive sets. However, reducing these catches to levels typical of surrounding stations would have little effect on the final results.

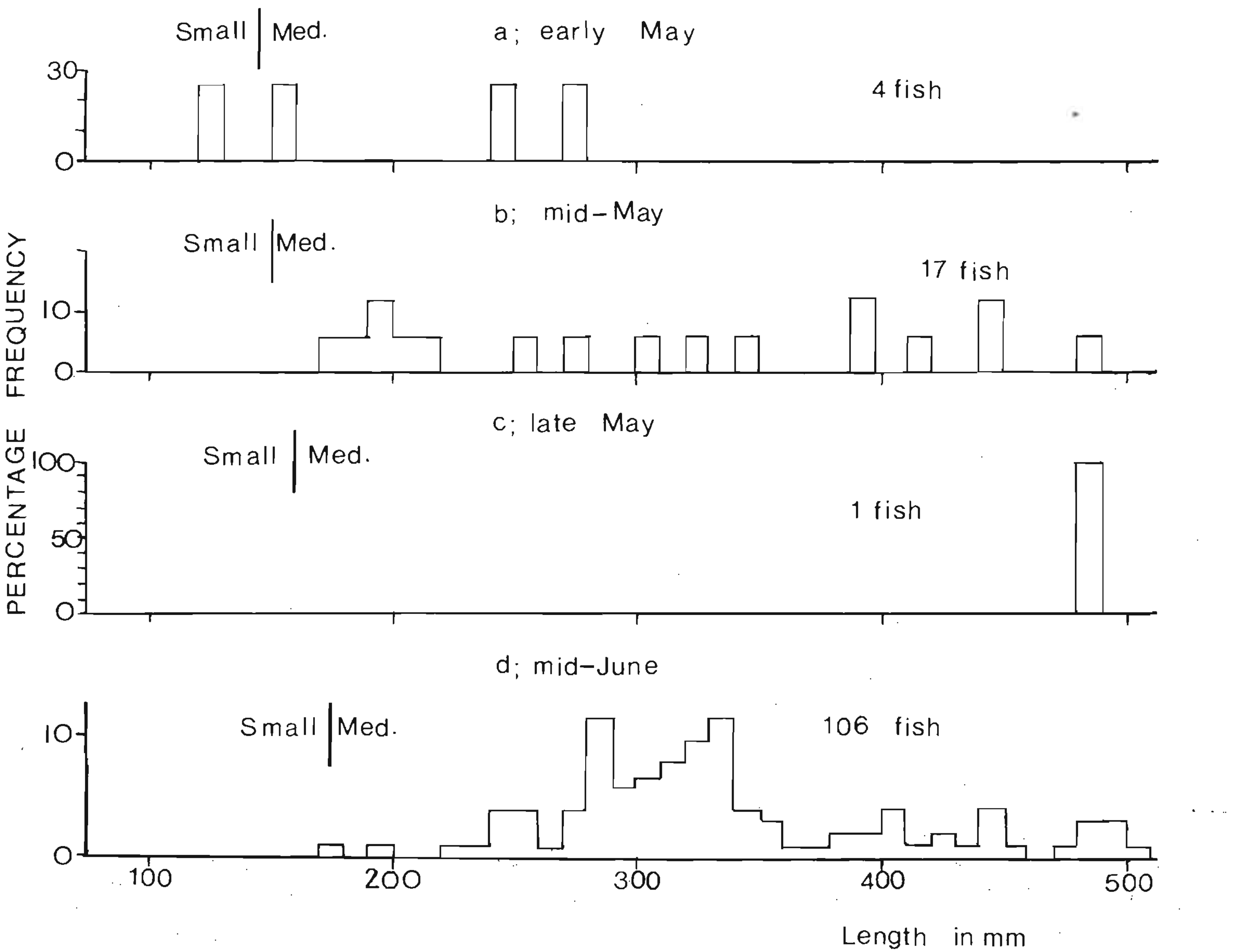


Figure 6; Length-Frequencies of Trawl-Caught Cod.
a-h Small and Medium Cod

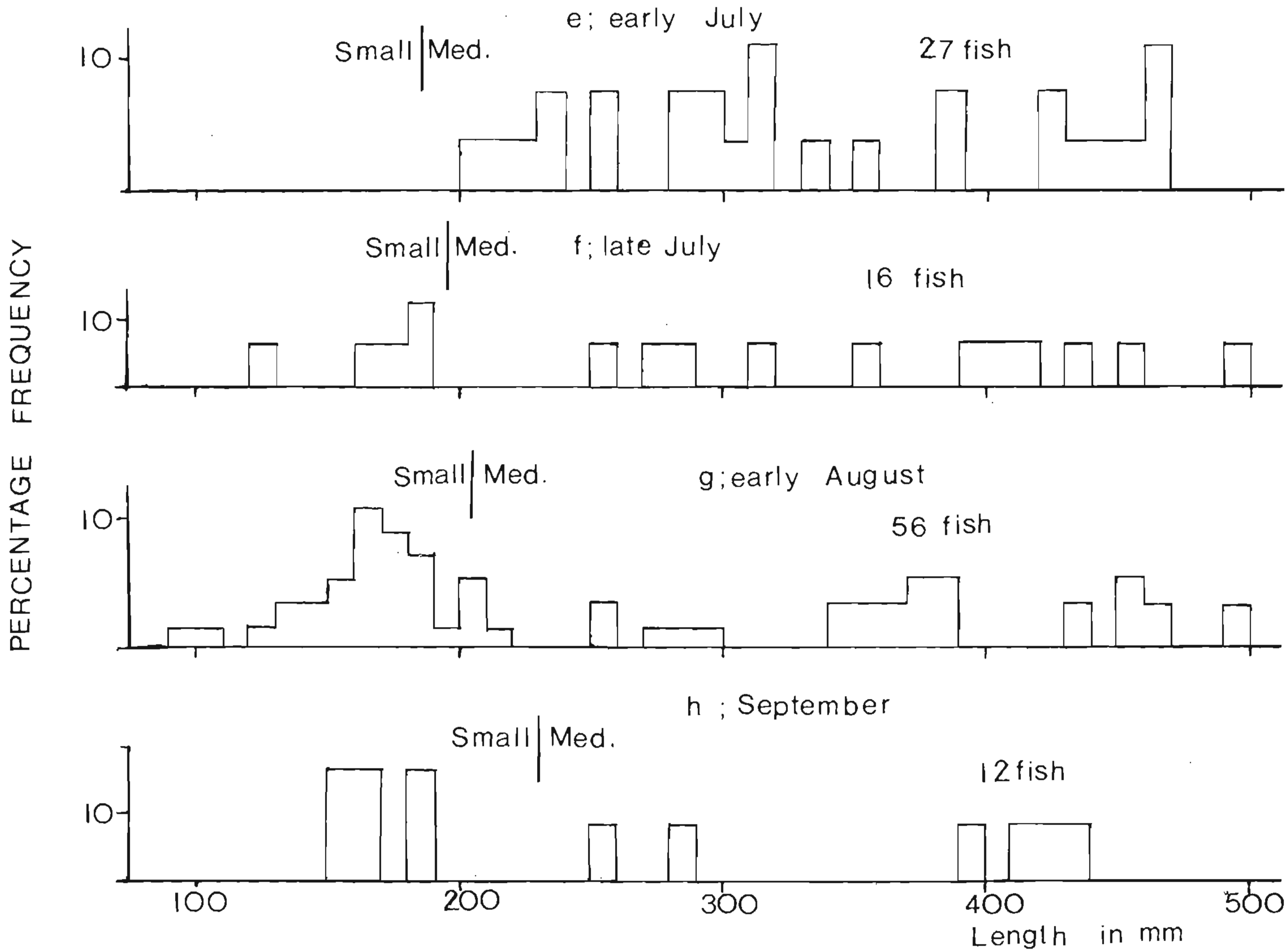


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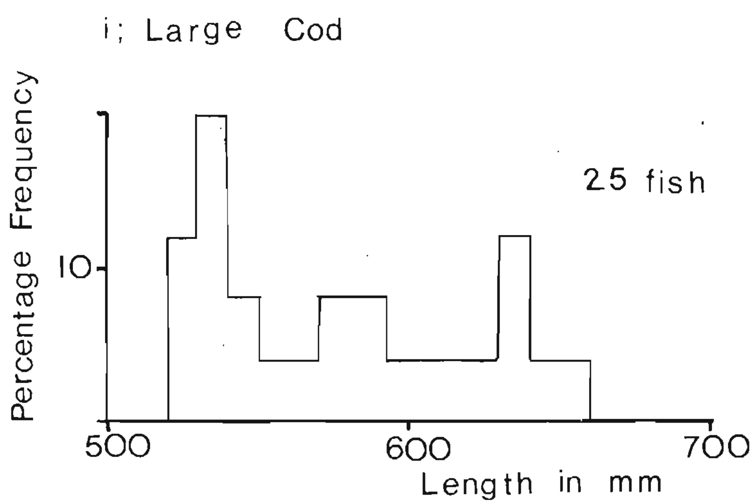
Figure 6 cont.



Adult cod are usually found between -0.05° and 10°C (Leim and Scott 1966), although they can tolerate temperatures up to 19°C. In the Gulf of St. Lawrence they are usually found, during the summer, between 0° and 6°C at depths of 35 to 145 m (Jean 1964). Thus, those caught in St. Georges Bay are at the edge of their normal range (being at -1.3° to +8.8°C, and 25 to 40 m depth).

The bait-trap catches were probably at temperatures below 10°C (from those measured at station 9.1, 1½ miles from the trap; and from beach temperatures measured at Crystal Cliffs, C. Bourbonnais, pers. comm.). These fish must have been above 10 m depth to be caught, and thus were probably taken at night, having ascended from greater depths.

In northern regions, cod migrate in winter so as to avoid the very cold water near the surface (McKenzie 1934). The extent of this migration varies in different stocks, and between ages of fish. The major commercial stocks in the southern Gulf (Gaspé and Western Cape Breton) move to deep water along the edge of the Laurentian Channel, and onto the eastern Scotian Shelf (Martin 1953; McKenzie 1956; Halliday 1972). The movements of the other stocks in this area - P.E.I., Chaleur, and Magdalen (McKenzie and Smith 1955; Templeman 1962; Jean 1964) - are not well known. Such tag returns as have been made in winter mainly indicate only limited migrations on the Magdalen Shallows (Martin 1953; McKenzie 1956). Some fish tagged on the Scotian Shelf have been caught in the eastern entrance of the Northumberland Strait (Martin and Jean 1964), and it is possible that both long- and short-migrating fish occur in St. Georges Bay. In many areas of Atlantic Canada, small local stocks of non-migratory cod are found (McKenzie 1934). One of these may be found in the Bay; indeed, the local fishermen distinguish 'rock cod' from other members of the species. They are notable mainly for dark colouring, and are said to be local and inshore, and to have large numbers of 'worms'.

The smaller cod (less than 390 m), even of the long-migratory stocks, remain in relatively shallow water (Templeman 1962; Jean 1964).

In summary, most of the cod are below 30 m depth, and so are vulnerable to trawling. The abundance indices derived above will, therefore, give a reasonable estimate of the maximum trawlable biomass in the Bay. This is 58 tons. The few large cod above 30 m depth, taken at stations 17.9 and 22.12 (catch per set 0.2 during the peak of abundance), account for about 5 tons of trawlable biomass. Some, or all, of these cod leave the Bay in winter.

There is no directed fishery for cod in St. Georges Bay, although some are taken as a bycatch in the hake and bait fisheries (Anon. 1975).

4.16 MERLUCCIUS BILINEARIS: SILVER HAKE

Apart from the statements of some Cheticamp fishermen (Cox 1921), this species was not reported from the Gulf of St. Lawrence until the 1950s. McKenzie and Scott (1956) give several records of individuals scattered across the Southern Gulf. They suggest that silver hake extended their range as temperatures increased. McKenzie (1959) reported one from Miramichi Bay.

It was thought that silver hake did not breed in the Gulf (McKenzie and Scott 1956; Leim and Scott 1966), but a few larvae have been reported from the Magdalen Shallows (Kohler *et al.* 1977), and their eggs have been taken in St. Georges Bay (Dr. D.M. Ware, pers. comm.). Thus it is possible that the range extension by this species is continuing.

Four silver hake were taken in the Bay, by bottom trawl, as below:

early July	Station 21.2	365 mm
late July	Station 22.12 (2 fish)	167,320 mm
early September	Station 21.2	407 mm

All these captures were in the southeast corner of the Bay, with no clear relationship to temperature or depth. It is possible that this distribution is related to that of plankton production.

In view of their partially pelagic existence, and their temperature preferences (Bigelow and Schroeder 1953), silver hake could have been present in the Bay during late May and June. They may have been much more abundant than these records indicate, and a biomass estimate is not possible.

4.17 POLLACHIUS VIRENS: POLLOCK

No pollock were seen during this survey, but Mr. K. Falkenham reported that two were taken in the bait-trap on 21 June.

This species is typically widespread but infrequent in the Southern Gulf (Stafford 1912; Cox 1921; McKenzie 1959). Such large catches as have been taken are from northern Cape Breton Island (Scott 1979). Pollock are much more abundant at the Atlantic end of the Strait of Canso (Cornish 1907; Dadswell 1979a), and there used to be a concentration of these fish within the Strait itself (Perley 1952; Dadswell 1979a). There is no sign of this concentration, presumably because of changes related to the causeway.

Pollock are believed to migrate to the Scotian Shelf and Gulf of St. Lawrence in the spring, returning to the Gulf of Maine to spawn in winter (Scott 1979). Thus, they are summer visitors to St. Georges Bay and comprise negligible biomass.

4.18 UROPHYSIS TENUIS: WHITE HAKE

This species is known locally simply as 'hake'.

Considerable confusion has arisen in the past between U. tenuis and U. chuss, leading both Vladykov and McKenzie (1935) and Leim and Scott (1966) to list them together. While most authors have called hake from the Gulf of St. Lawrence U. tenuis, some have identified them as U. chuss. Recently Musick (1973, 1974) has demonstrated that these are indeed separate species, and that U. tenuis is the usual one in the Gulf, U. chuss rarely, if ever, occurring there.

Following Leim and Scott (1966), no attempt was made to separate the two species during this study. In view of Musick's conclusions, it is assumed that all Urophycis sp. taken were U. tenuis.

Hake are plentiful throughout the southern Gulf (Cornish 1912; Cox 1921; Needler 1940; McKenzie 1959; Leim and Scott 1966; Caddy et al. 1977). They were taken in St. Georges Bay by bottom trawling in large numbers (Table 10). A few were caught in the bait-trap from 30 May onwards. Two were taken by beach seining in shallow water (14 July, 80 mm total length; 14 August, 10 mm).

The length-frequencies of trawl-caught hake (Fig. 7) were complex, and strongly bi-modal (which was true of few other species in this survey). The differences between stations and between dates were highly significant.

Table 10A. Trawl catches of 'small' white hake (total length less than shown below) in numbers

Date	Maximum Length (mm)	Station									
		3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May		x	0	0	x	0	x	0	0	x	x
mid-May		0	x	0	0	0	x	0	0	0	0
late May		0	0	x	0	0	x	0	0	0	0
mid-June	360	2	7	0	0	0	x	0	3	0	x
early July	370	6	14	0	3	0	x	1	0	x	0
late July	380	0	5	x	2	3	x	2	0	1	x
early August	390	0	0	5	0	2	0	0	x	0	x
late August	400	x	x	x	x	27	x	0	12	x	x
early September	415	x	x	5	x	20	x	19	0	x	x

Table 10B. Trawl catches of 'medium' white hake (in numbers)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	0	0	x	0	x	0	0	x	x
mid-May	0	x	0	0	0	x	0	0	0	0
late May	0	0	x	0	0	x	0	0	0	0
mid-June	5	0	2	2	1	x	2	1	1	x
early July	0	3	2	0	4	x	2	0	x	5
late July	1	0	x	1	9	x	5	14	0	x
early August	0	1	2	11	49	0	5	x	2	x
late August	x	x	x	x	70	x	1	5	x	x
early September	x	x	12	x	8	x	37	3	x	x

Table 10C. Trawl catches of 'large' white hake (longer than 630 mm) in numbers

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	0	0	x	0	x	0	0	x	x
mid-May	0	x	0	0	0	x	0	0	0	0
late May	0	0	x	0	0	x	0	0	0	1
mid-June	3	0	0	0	0	x	1	0	0	x
early July	0	0	0	1	0	x	0	0	x	3
late July	0	1	x	0	0	x	1	0	0	x
early August	0	0	0	1	0	0	0	x	0	x
late August	x	x	x	x	0	x	0	2	x	x
early September	x	x	0	x	0	x	1	0	x	x

The two size groups appear to be divided around a length of 375 mm, but closer inspection reveals that this division changes through time. It is best represented by dividing the fish caught in June at 360 mm, and subsequent ones by values 5 mm-per-week greater than this. The 'small' hake thus defined also show very significant differences between stations and dates. Regressing their lengths against the Julian date of each survey provided an estimate of 'growth' (confounded by size-differential factors such as availability and mortality) of 0.67154 mm per day from June to September. Adjusting the length-frequencies to allow for this 'growth' showed there to be no significant difference between stations (P = 0.0845), but there still was between dates (P = 0.0001). Non-linear 'growth' might have resolved this, but was not attempted.

The data suggested another size division, 'large' hake being those longer than 630 mm. These have similar length distributions in all hauls (P = 0.5222, P = 0.7866). Only 15 such fish were taken.

The remaining 'medium' sized fish show significant differences in length distribution by date and station, without any clear pattern. Neither 'growth', nor subgrouping of the hauls, gives meaningful homogeneous groups.

The lack of homogeneity between hauls may indicate that the hake are in schools of uniformly sized fish, but that the distribution of these schools is not closely determined by length.

The catches indicate an arrival of hake in the Bay at the start of June. The first record is for a 'large' fish at one of the deep stations just outside the Bay. The previous day (30 May) the first hake of the year had been taken at Ballantynes Cove.

Figure 7; Length-Frequencies of Trawl-Caught White Hake.

a-f; Small Hake

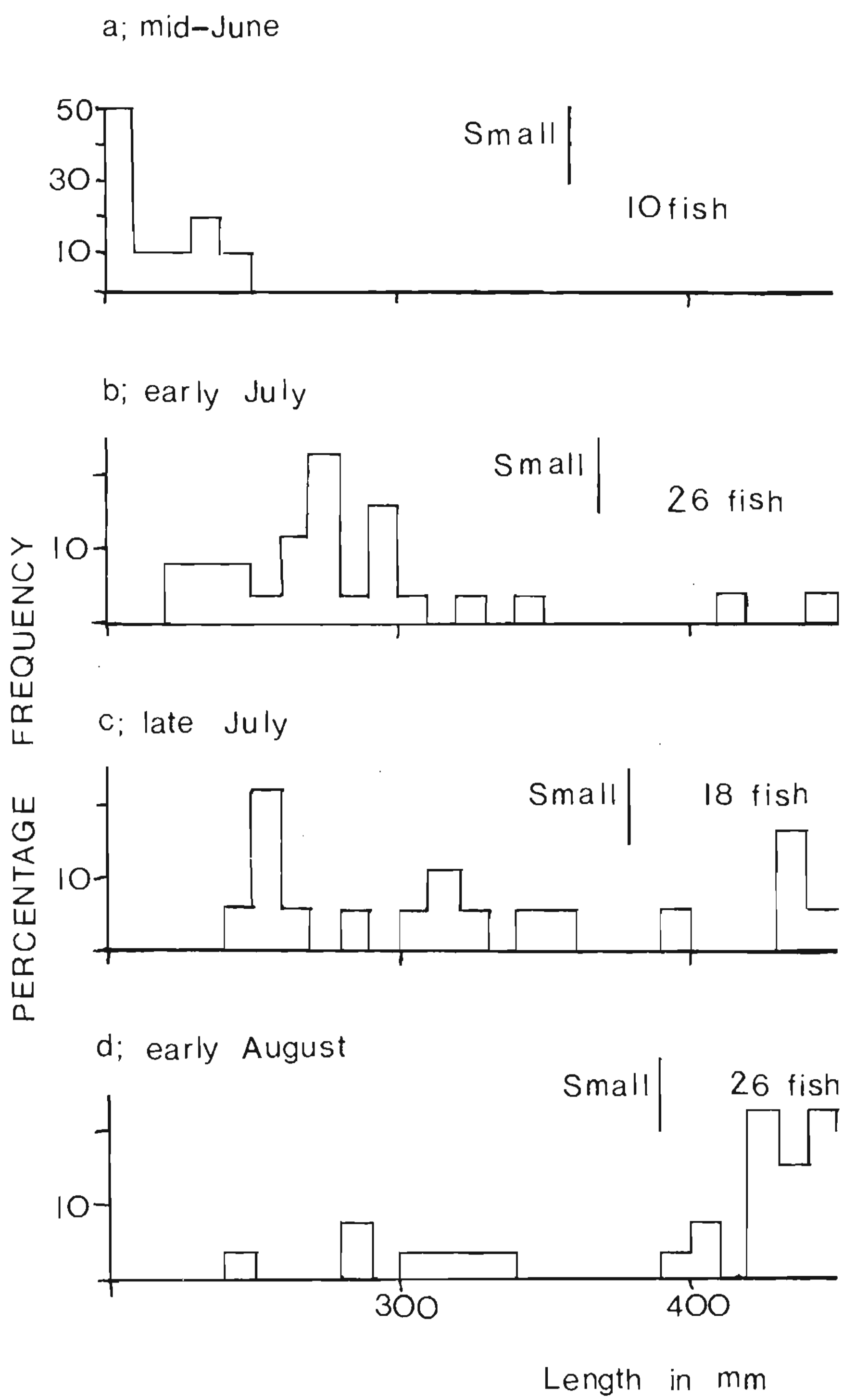


Figure 7 cont.

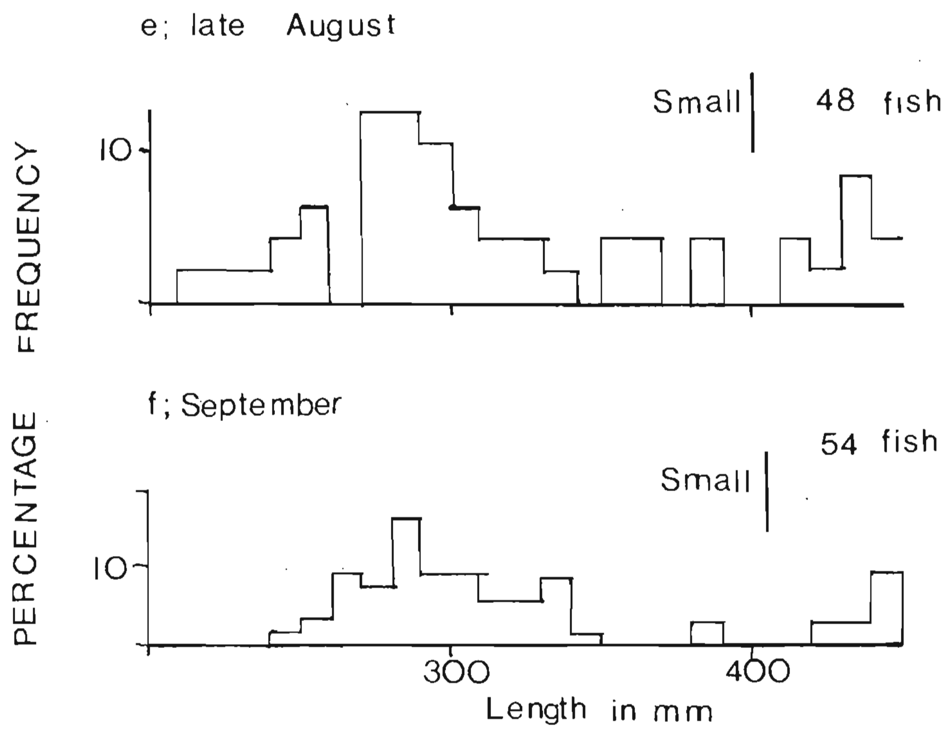
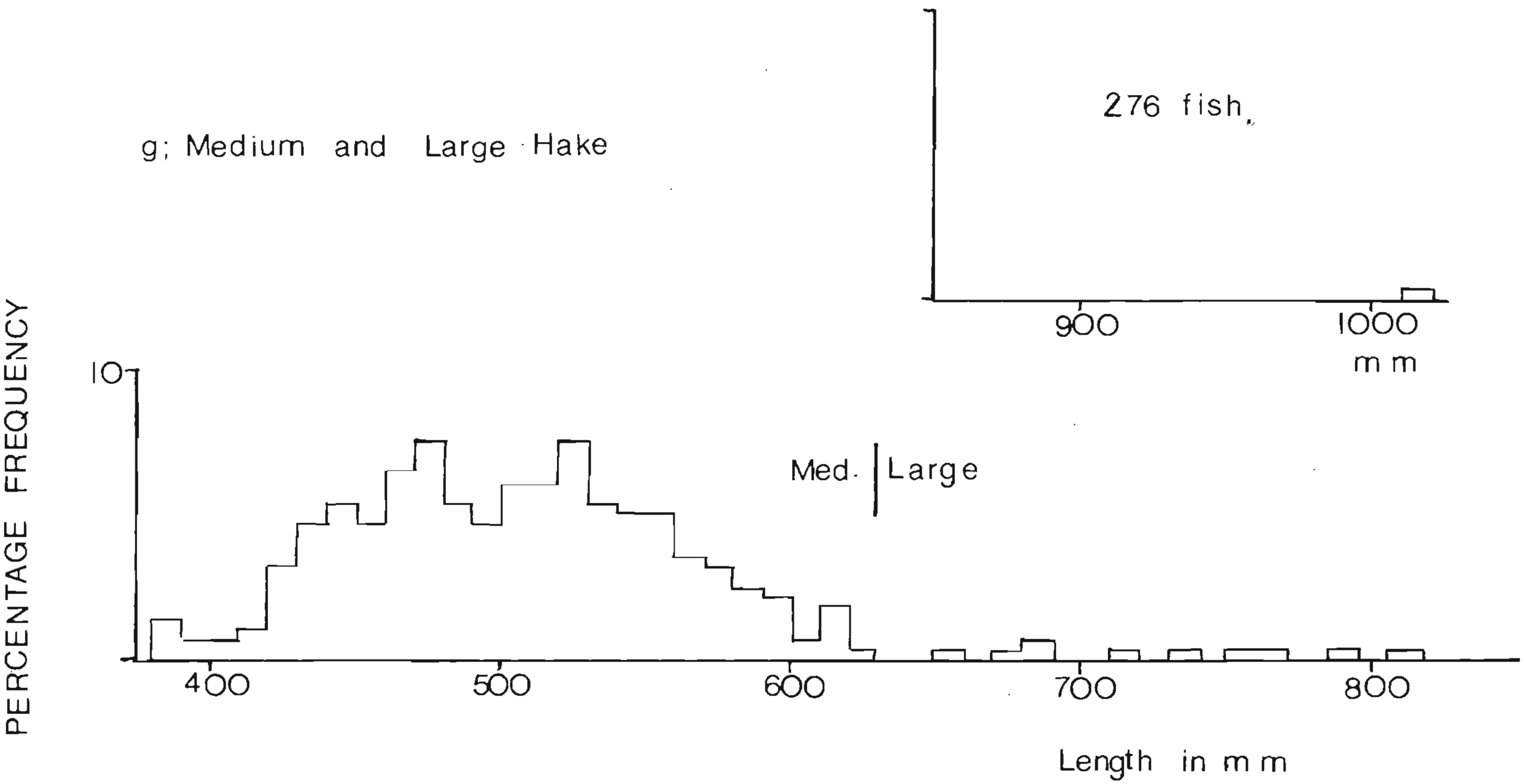


Figure7 cont.

g; Medium and Large Hake



By late in June, hake were widespread, being found at all the stations worked, but particularly at 3.7 and 5.7, near the mouth of the Bay (57% of catch). This tendency was especially marked for small hake (75% of catch at 3.7 and 5.7).

The first of these fish were taken at -1.0°C (trawl catch) and -0.5 to +10°C (bait-trap catch). [The latter figures are estimated from surface temperatures at stations 30.3 and 30.11 the following day, and the temperature close to the beach at Crystal Cliffs on the day of the catch, 10.3°C (C. Bourbonnais, pers. comm.).] At this time, most of the Bay had bottom temperatures above -1.0°C, so this factor was not confining hake to the mouth of the Bay.

In mid-June, when hake had spread to all the trawling stations, bottom temperatures were -0.5°C to +0.5°C. This conflicts with Leim and Scott's (1966) lower tolerated temperature for hake of +0.5°C.

Thus, it appears that hake arrive in the Bay when the temperatures in the Northumerland Strait rise enough to let them approach its mouth. The Bay is, at this time, already warm enough for them.

In July, the number of hake taken increased, and the maximum concentration moved to the southeastern part of the Bay (76% at stations 17.9, 21.2, and 22.12 in late July). The numbers of 'small' hake seemed to stabilize at this time, and they did not show a concentration in any particular part of the Bay.

In August, the catch of 'medium' hake rose still further, especially at station 17.9. The small fish showed similar trends, but with a less pronounced concentration. Station 17.9 had bottom temperatures of 7.1°C and 7.0°C on the day that it was worked in August, while the other trawled stations in the Bay lay in the ranges 0° to 3.5°C and 0.1° to 3.2°C on these days (17.9 is relatively shallow, and so lies higher in the thermocline at this season).

By September, the catch of 'medium' hake showed some decrease and they appeared to be spreading once again. At this time, the numbers of 'small' hake were increasing. The bottom temperature at station 17.9 was 12.9°C, which may be too high for adult hake (maximum tolerated temperatures 10°C for adults, 21°C for young; Leim and Scott 1966). The greatest catch (station 21.2, 8.8°C) was at a temperature close to that of station 17.9 the previous month. Thus the apparent movement of hake at this time may have been the avoidance of high temperatures rather than the beginning of a fall migration out of the Bay. Previous temperature studies (Petrie and Drinkwater 1977a) suggest that hake may be driven out of the Bay by high temperatures in October of some years.

The occasional trap catches of hake seem to be aberrant. These fish were too shallow and over the wrong bottom type. Also, if they live in the inshore, shallow zone, it seems strange that they didn't enter the Bay by this means earlier, when the deep water at its mouth was too cold for them to take that route. Instead of this, their arrival at depth and in the shallows seems to have been simultaneous. It is possible that hake move shallower at night, crossing the mile or so of seabed to be trapped. If they were dependent on deep water warmer than -1.0°C, by day, their arrival at the traps would coincide with that at depth. The author's notes show only four hake taken in the one trap which was regularly inspected (though doubtless others were caught), which is consistent with such a hypothesis.

These temporal changes in abundance are similar to those observed by Tyler (1971a). He took U. tenuis in Passamaquoddy Bay from June to December (and a few to February), with a strong peak of abundance in September. This was an arrival at 6°C, a maximum abundance at the peak temperature of about 10°C, and an emigration of most hake when temperatures dropped below 4°C. The correspondence of times, but not of temperatures, suggests that these may control, but not be the cause of, the migrations (at least at Passamaquoddy, where the temperatures are less extreme).

Hake were the only species for which Tyler (1971a) found a difference in the pattern of abundance with size. In Passamaquoddy Bay, hake between 150 and 230 mm length arrived about a month later, and stayed longer, than those of 260 to 430 mm length. These may have been 1 year olds and 2 and 3 year olds respectively (Leim and Scott 1966). The relation between these size groups and those in St. Georges Bay is not clear, since it is not known in which area hake grow faster.

In St. Georges Bay, the catches suggest a fairly even spread of hake, except for the increased abundance at Stations 17.9, 21.2, and 22.12, which may be due to warmer temperatures Thus a distribution throughout the trawlable area of St. Georges Bay, but not on the rough bottom areas, seems likely.

A tagging study of hake in the Southern Gulf (Kohler 1971) indicated that they were resident all year. However, a lack of returns in winter prevented any determination of where they might be at that season.

The distribution of very small hake (<200 mm length) is something of a mystery. The planktonic stages are known from this area (Fager 1976; Kohler et al. 1974a,b, 1975, 1977). They settle to the bottom at about

80 mm length (Musick 1974). Unlike U. chuss, U. tenuis does not live in the mantle cavity of live scallops (Musick 1967). They would be large enough to be vulnerable to the trawl, so their absence from the catches suggests that they are not on the trawlable area of the Bay.

Two were taken by beach seining, and such an inshore distribution is common (Leim and Scott 1966) for hake between 50 and 150 mm length (it is uncertain whether they refer to U. chuss, U. tenuis, or both). Small hake (150 to 200 and 250 to 320 mm length) were common in the tributary inlets of Malpeque Bay in the autumn (Needler 1940), and some (70 to 100 mm in length) were seined near Cheticamp (Cox 1921). Similarly, Lux and Nichy (1971) took juvenile hake in shallow water in Woods Hole Harbour.

Thus, there may be substantial numbers of small hake in St. Georges Bay in shallow or rough areas which cannot be worked with the bottom trawl.

The peak abundance of hake in the Bay can thus be estimated by the mean catch of all Bay stations in August and September. This index is:

9.9 fish

or 2.6 small

and 6.9 medium and large fish.

Because of the differences in length-frequencies, an average weight of these fish cannot be directly calculated. The catch per set in weight terms was therefore calculated using:

$$W = 2.347853 \times 10^{-8} L^{2.825097}$$ (Kohler et al. 1970, Table 154; converted to kg and mm)

Averaging these weights gives an index of abundance of 8.345 kg per standard-set, and an estimated trawlable biomass of 343 tons. To this must be added an unknown quantity of small hake living on non-trawlable seabed.

Hake are the principal groundfish taken in St. Georges Bay, being caught with gill nets, 'trawls' of hooks, and otter trawls (Kohler 1971; Anon. 1975; Scott 1979). The catches are not known, due to deficiencies in the statistics available (discussed above). Three or four small draggers (Cape Island-type boats, converted at the end of the lobster season) were working in the Bay in 1978 (one from Ballantynes Cove, and at least one from Mulgrave). They appeared to work mainly in the area near station 17.9. Hake catches were said by the fishermen of Ballantynes Cove to be rather poor in 1978.

4.19 TAUTOGOLABRUS ADSPERSUS: CUNNER

Cunner were very abundant around the shores of St. Georges Bay from late May onwards. They were taken by the bait-trap and by anglers and many were seen underwater. In less than 6 m depth, and away from nets, wharfs or other large objects, most were small (less than 100 mm length). None were taken in the beach seine in Ogden Pond.

A few were taken by bottom trawl (Table 11). Station 20.6 had a hard sand bottom, which badly damaged the net. Thus the catch there is not representative. Of the three stations at which cunner were taken in late August and September, 11.10 and 17.9 lie within 1 km of untrawlable bottom.

This species is widely distributed and abundant along the shores of the Southern Gulf (Cornish 1907, 1912; Cox 1921; Needler 1940; McKenzie 1959; Leim and Scott 1966; Caddy *et al.* 1977). It frequents hard substrates at all depths found in St. Georges Bay, but prefers areas with eel grass, pilings, or other 'cover' (Bigelow and Schroeder 1953).

Table 11. Trawl catches of cunner (in numbers)

Date	Station 3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	0	0	x	0	x	0	0	x	x
mid-May	0	x	0	0	0	x	0	0	0	0
late May	0	0	x	0	0	x	0	0	0	0
mid-June	0	0	0	0	0	x	0	0	0	x
early July	0	0	0	0	0	x	0	0	x	0
late July	0	0	x	0	0	x	0	0	0	x
early August	0	0	0	0	0	3	0	x	0	x
late August	x	x	x	x	1	x	0	19	x	x
early September	x	x	3	x	18	x	0	0	x	x

Johansen (1925) stated that these fish either shelter amongst vegetation for the winter, or move into deeper water. Recent observations have confirmed that some cunner do spend the winter sheltering in shallow water (Green and Farwell 1971; Olla et al. 1975). The present records from St. Georges Bay show a movement into deeper water late in the summer, which might have led to Johansen's (1925) statement. However, this movement appears to be related to increasing bottom temperatures and there is no reason to suppose that cunner remain at depth for the winter.

The length-frequency (Fig. 8) of the late August trawl catches differed from those of other dates ($P < 0.0001$), but this may be due to random placement of schools of uniform size. There was no significant difference between stations in late Aguust ($P = 0.0987$) or other dates ($P = 0.5277$).

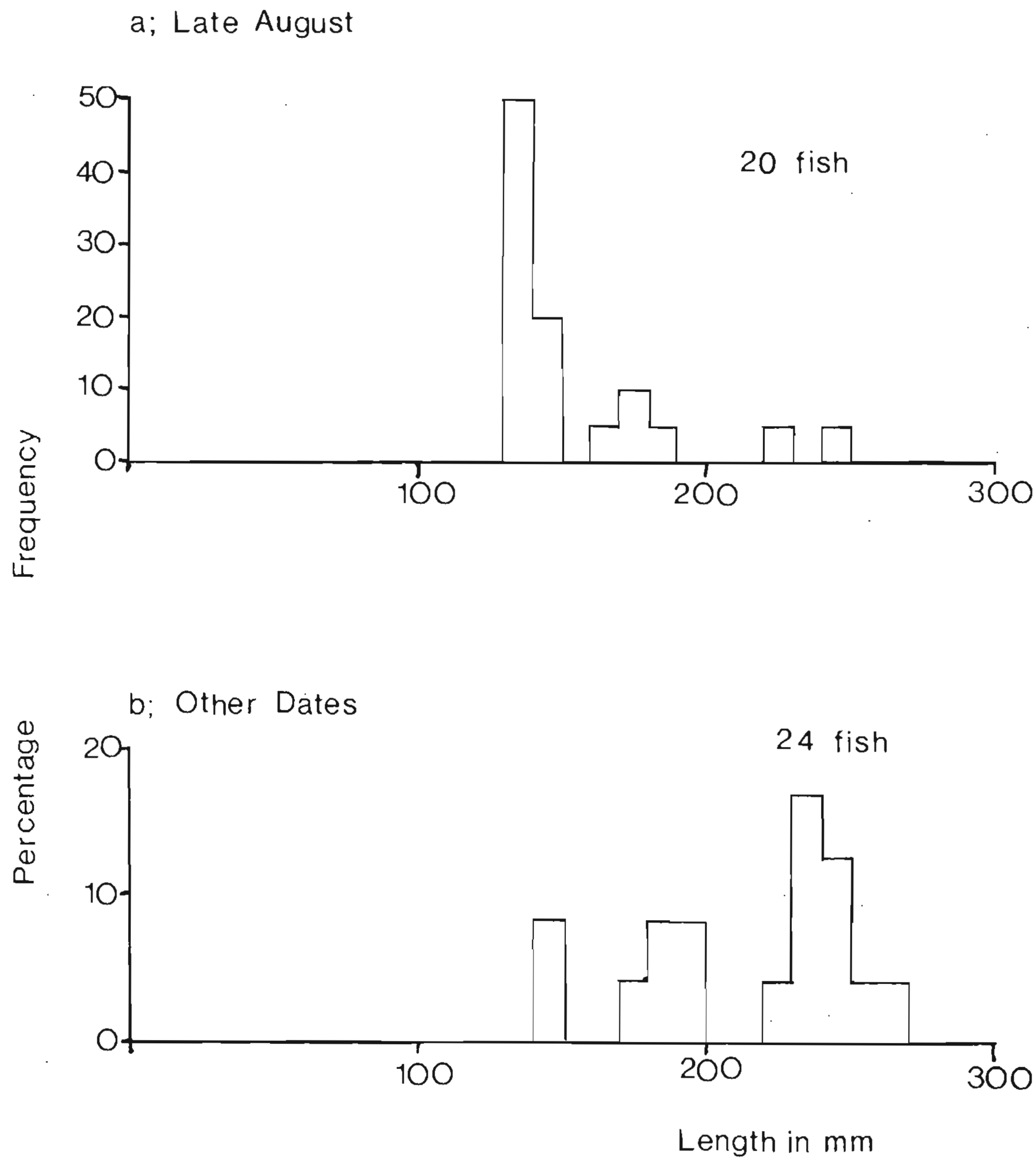
The length-frequencies show four distinct peaks which represent 3, 4, 5, and 6 year old fish, with two probably 7 years old (Johansen 1925). Younger fish presumably do not move onto soft bottom areas.

No length-weight key is available for cunner. Johansen (1925) published some typical weights for fish from the Southern Gulf, and these were used to derive an equation by the usual methods (Ricker 1975). The resulting key

$$W = 1.545693 \times 10^{-6} L^{3.07692} \text{ (kg and mm)}$$

is imprecise and biased. It has been used to calculate the weights entered on the data file.

Figure 8; Length-Frequencies of Trawl-Caught Cunner.



The trawl cataches are not suitable for a calculation of biomass of cunner in St. Georges Bay. This species is probably the most abundant one inshore, and appears to occur throughout the year on all rough-bottom areas. It strays onto the trawling grounds in late summer.

4.20 AMMODYTES AMERICANUS: AMERICAN SAND LANCE

No sand lance were seen in the Bay in 1978, but in previous years they have been taken by beach seine on the sand beach near Cribbean Head, and their larvae have been taken in the plankton (Dr. D.M. Ware, pers. comm.).

This species has been taken in large numbers in various parts of the southern Gulf (Cox 1921; Needler 1940; McKenzie 1959). Its larvae are abundant in the Northumberland Strait (Faber 1976) and known from elsewhere in this area (Kohler et al. 1974a, 1975, 1977).

The biology of this species is poorly documented. A recent study by Meyer et al. (1978) on Stellwagen Bank, Massachusetts Bay, indicates that they only burrow in clean sand or fine gravel. When not burrowed, they form schools in mid-water. Hence, they are not likely to be vulnerable to trawling on the silty grounds in St. Georges Bay.

No estimate of biomass of this species is possible. It might be considerable.

4.21 SCOMBER SCOMBRUS: ATLANTIC MACKEREL

Mackerel are fished commercially in the Bay (Anon. 1975). In 1978 the first at Ballantynes Cove was taken in a bait-trap on 7 June. Others were taken, at a rate of about one per day, until the last week of that month. Thereafter large numbers were taken by trap net, hard lines, and gill nets (the last set by RV Navicula). Gill net catches in late July-early August were very poor, but trap net catches, especially of 'small' mackerel, stayed high until late in October (Captain G. Reyno, pers. comm.).

One fish of this species was taken by bottom trawl at station 21.2 in early August. It is likely that this fish was caught above the thermocline as the net was being hauled.

The Southern Gulf is a major spawning area for mackerel (Sette 1943) from early June to early July (MacKay 1973). The fish enter the Gulf late in May and spread westwards, reaching the Gaspé before July. They start to return in September, and are all through Cabot Strait by December (Sette 1950). Between these movements, they are widespread and usually abundant (Cornish 1912; Cox 1921; Needler 1940; McKenzie 1959; Sette 1950).

I-group mackerel migrate rather behind the adults in spring, and do not always reach as far north as the Gulf of St. Lawrence (Sette 1950). This latitudinal limit appears to vary between years, and I-group fish are sometimes common there (MacKay 1967). Whether the 'small' mackerel taken in St. Georges Bay are I- or O-group is uncertain, since the latter may reach 180 mm length by October (Dr. D.M. Ware, pers. comm.).

Unlike the shad and spring-spawning herring, mackerel do not need to approach the shore to spawn, and so trap net catches cannot be considered representative. There is no adequate data from offshore fishing for a biomass estimate. However, it can safely be said that this species forms a very important part of the pelagic community from early June until November.

4.22 THUNNUS THYNNUS: BLUEFIN TUNA

No tuna were seen by the author, but a fishery for them along the Cape Breton shore, and especially within the Strait of Canso, has arisen in recent years.

Bluefin occur in variable numbers in Atlantic Canadian waters (Leim and Scott 1966), but they are usually considered to be rare in the Southern Gulf (Cox 1921; Needler 1940; McKenzie 1959; Leim and Scott 1966). Recreational and commercial angling began in this region in 1973 (Pinhorn 1976), and a few hundred tons are taken each year (Anon. 1975; McCracken and Macdonald 1976). They arrive in Canadian waters in mid- and late summer (Tibbo 1967), but do not seem to occur in St. Georges Bay until September.

No data are available for an estimate of biomass.

4.23 PHOLIS GUNNELLUS: ROCK GUNNEL

This is one of several species known locally as a 'rock eel'.

A few were seen underwater near Crystal Cliffs. This species is common in the Southern Gulf (Cox 1921; Needler 1940; McKenzie 1959; Caddy et al. 1977) often being found in the intertidal (Cornish 1907; Cox 1921). Sporadic searching in this zone in St. Georges Bay failed to locate any.

This species is probably more abundant than these records indicate, and may be present on all hard bottom areas in the Bay (since its recorded depth range is wide; Leim and Scott 1966). It avoids muddy areas (Bigelow and Schroeder 1953) and so was not vulnerable to the trawl.

4.24 CRYPTACANTHODES MACULATUS: WRYMOUTH

This species is also known locally as a 'rock eel'.

There are no records of adults of this species from St. Georges Bay, but planktonic stages have been taken (Dr. D.M. Ware, pers. comm.). Adults have been taken at a few places in this region (Cornish 1907; McKenzie 1959; Leim and Scott 1966), as have larvae and juveniles (Kohler et al. 1974a,b, 1975, 1976).

Very little is known of the biology of this species, but Willey and Huntsman (1921) gave an excellent account of its burrowing habit. Based on this, it can be assumed that any wrymouth present in the Bay are buried too deeply to be vulnerable to the trawl used. (They might be caught at dusk, when they seem to be more active.) They are probably present on the soft sediment in the central part of the Bay, but some might be elsewhere. They are known to occur in all deths to 110 m (Leim and Scott 1966).

There is no way to estimate the biomass present.

4.25 LUMPENUS MACULATUS: DAUBED SHANNY

Four daubed shanny, 132 to 157 mm in length, were taken by bottom trawl at the following stations:

22.12	mid-May
30.11	mid-May (2 fish)
5.7	early July

Adults of this species have previously been reported from the Magdalen Shallows only by Caddy et al. (1977) although they are known from elsewhere in the Gulf of St. Lawrence (Leim and Scott 1966). Larvae have been taken in the Southern Gulf (Kohler et al. 1977).

Very little information is available on the biology of this species. The biomass present is probably small.

4.26 LUMPENUS LUMPRETAEFORMIS: SNAKE BLENNY

This species is another in the group known locally as 'rock eels'.

Snake blennies were taken by bottom trawl (Table 12) in the Bay. They have only been reported from the southern Gulf by Caddy et al. (1977), although they are known from various points in Atlantic Canada (Leim and Scott 1966). The larvae of this species have been found widely over the Magdalen Shallows (Kohler et al. 1977) including St. Georges Bay (Dr. D.M. Ware, pers. comm.).

It appears that this lack of records results mainly from an absence of suitable fishing gear. Gordon and Duncan (1979) took large numbers off Scotland after changing the mesh of their codend from 25 mm to 16 mm. Similarly, Wheeler and Edwards (1971) noted large catches in an experimental sandeel trawl, from an area where they were previously thought to be rare. It should be noted that Gordon and Duncan's (1979) results, supported by the discussion in Section 3.2, suggest that many snake blennies could have escaped through the larger-meshed liner used in part of this survey.

The length-frequencies (Fig. 9) were heterogeneous by date ($P < 0.0001$) and station ($P = 0.0004$). Inspection of the data suggested different distributions of fish larger and smaller than 300 mm total length. These two size groups showed homogeneous length-frequencies between stations and dates ($P = 0.5060$, $P = 0.2509$; $P = 0.1080$, $P = 3103$). No biological explanation can be offered for this dichotomy of distribution.

Table 12A. Trawl catches of 'small' snake blennies (total length less than 300 mm) in numbers

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	37	8	x	1	x	0	0	x	x
mid-May	6	x	8	5	0	x	0	0	0	6
late May	*	8	x	0	0	x	0	0	0	4
mid-June	9	1	0	0	0	x	0	0	0	x
early July	9	3	0	0	0	x	0	0	x	0
late July	5	2	x	0	0	x	0	0	0	x
early August	9	3	0	0	0	0	0	x	0	x
late August	x	x	x	x	0	x	0	0	x	x
early September	x	x	0	x	0	x	0	0	x	x

* 118 snake blennies were taken in this haul, of which none were measured. Dividing them into size groups by the average proportions for this station gives 34.2 small ones.

Table 12B. Trawl catches of 'large' snake blennies (longer than 300 mm) in numbers

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	14	5	x	0	x	0	0	x	x
mid-May	19	x	7	1	1	x	0	1	2	7
late May	*	16	x	0	0	x	1	3	4	5
mid-June	21	6	0	0	0	x	2	0	0	x
eary July	13	18	0	0	0	x	0	0	x	1
late July	20	20	x	0	0	x	0	0	1	x
early August	20	12	7	1	0	0	0	x	0	x
late August	x	x	x	x	0	x	0	1	x	x
early September	x	x	0	x	0	x	0	0	x	x

* The catch in this haul, divided as in Table 12A, was 83.8 'large' snake blennies.

Sim (1887) took snake blennies, off Scotland, from an area of muddy sand and peat-like material. He suggested that they might be burrowers. This suggestion has recently been confirmed (R.D.M. Nash, pers. comm.). Wheeler and Edward's (1971) catches were from an area of clean sand, but they quote other Irish Sea records which suggest a preference for muddy substrates.

For a burrowing fish, sediment type is likely to be important. Thus, this species is probably confined to the area of muddy-sand in St. Georges Bay, which generally coincides with the trawlable area. Detailed differences in the sediments may account for variations in abundance of these fish at different stations.

Gordon and Duncan (1979) suggest that changes in catches of this species through the year are related to burrowing behaviour rather than to migrations (recent studies show that it is changes in burrow orientate behaviour, rather than in the actual process of burrowing; R.D.M. Nash, pers. comm.). If this is correct for St. Georges Bay, the biomass present will not change during the year.

The catch per set during May (when the finer mesh liner was used) was 1.9 for fish shorter than 300 mm, and 2.4 for larger ones. Gordon and Duncan (1979) give two length-weight equations for this species:

for Loch Linnhe: $W = 3.442085 \times 10^{-8} L^{2.2860}$

for Firth of Lorne: $W = 1.225465 \times 10^{-7} L^{2.02631}$ (both kg and mm)

Neither is likely to be accurate for the fish in St. Georges Bay, but an average of them is the best length-weight key available. Using

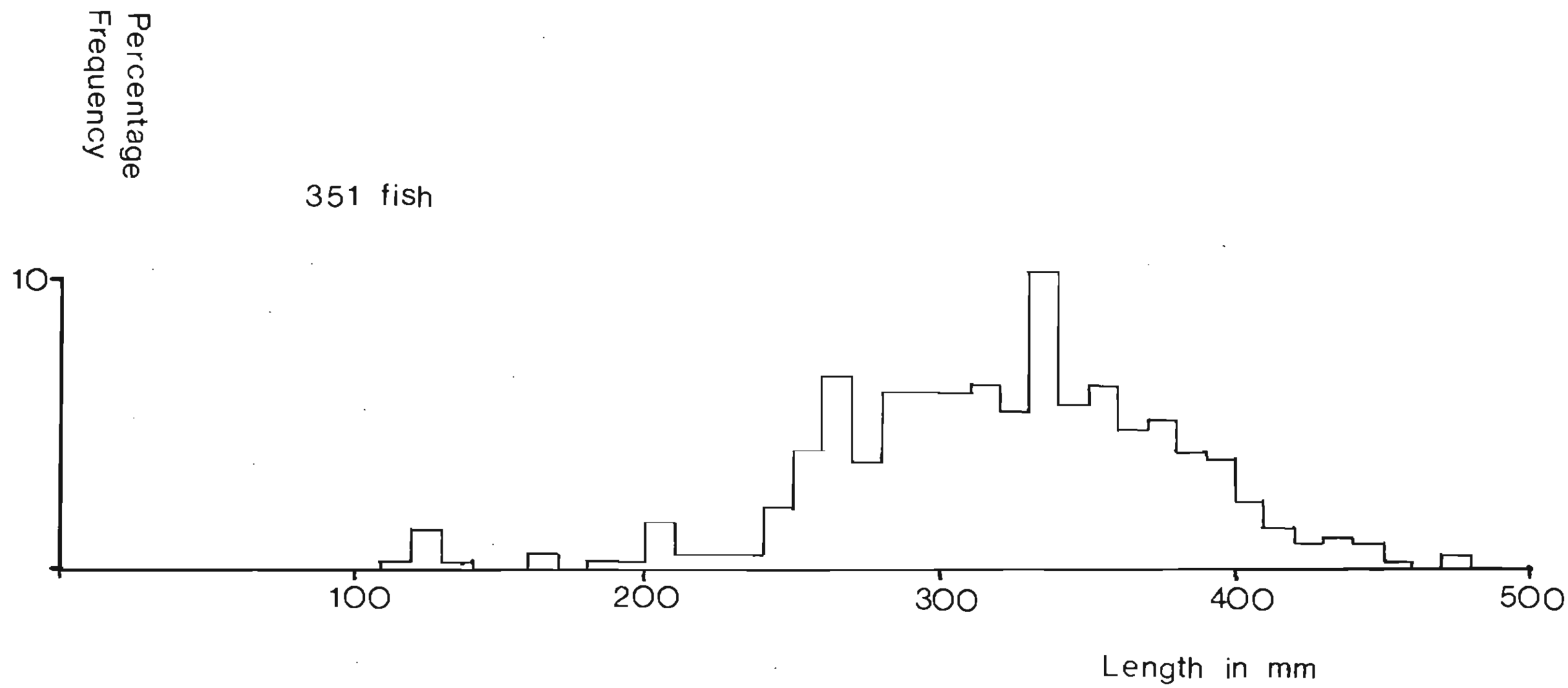


Figure 9: Length–Frequencies of Trawl–Caught Snake Blennies.

this, the weights of snake blennies caught during May average 10.4 g for the small fish, and 30.8 g for the large ones. Using the trawlable area of the Bay, the trawlable biomass of snake blennies is 2.9 tons.

4.27 ULVARIA SUBBIFURCATA: RADIATED SHANNY

There are no records of adults of this species from the Bay, but its planktonic stages have been taken (Dr. D.M. Ware, pers. comm.). Adults have been found at Canso, the Miramichi Estuary, western Northumberland Strait, and the Magdalen Islands (Leim and Scott 1966). Planktonic young have been taken in the Southern Gulf (Kohler et al. 1974a,b, 1975, 1977).

Radiated shannies live amongst seaweed on rocky shores, and on hard bottom at greater depths (Leim and Scott 1966). Thus, they are not available to the trawl. No estimate of biomass in the Bay is possible, but it is unlikely to be large in view of the scarcity of records of this species.

4.28 MACROZOARCES AMERICANUS: OCEAN POUT

This is another of the species known locally as 'rock eels'.

Pout are widespread in the Bay, being taken in fair numbers in inshore fish traps, as well as offshore by otter trawl (Table 13). Those taken inshore seemed to be of smaller average size than the ones in the trawl catch.

McKenzie (1959) found a similar distribution in the Miramichi area, and Tyler (1971b) photographed some in the intertidal zone of Passamaquoddy Bay. They have also been reported from Canso, Cheticamp, Tignish, and the Northumberland Strait.

Table 13. Trawl catches of ocean pout (in numbers)

Date	Station 3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	0	3	x	2	x	0	0	x	x
mid-May	0	x	2	1	0	x	0	1	0	0
late May	0	1	x	8	7	x	12	0	0	0
mid-June	35	1	1	1	1	x	20	5	2	x
early July	10	1	15	9	10	x	2	0	x	1
late July	1	0	x	1	19	x	18	0	1	x
early August	3	3	12	6	0	0	1	x	0	x
late August	x	x	x	x	0	x	0	1	x	x
early September	x	x	3	x	0	x	1	0	x	x

The 'migrations' of the ocean pout are rather unclear (Bigelow and Schroeder 1953). They may move offshore at some seasons (Clemens 1920; Olsen and Merriman 1946; Jefferies and Johnson 1974) because of temperature changes (Clemens and Clemens 1921) or competition for food (Jefferies and Johnson 1974). The latter is, however, unlikely since Tyler (1972) found little competition between this and other species. Alternatively, they may move onto and off rough bottom (Olsen and Merriman 1946) on which they spawn (White 1939). In the latter case, there would be little movement of ocean pout into or out of St. Georges Bay.

Pout were most abundant at stations 3.7, 11.10, 15.7, 17.9, and 21.2. This distribution coincides with that of "Pugwash Mud, 50 to 90% silt and clay" (see Section 2.2), and with Bigelow and Schroeder's (1953) statement that they are found on most bottom types but avoid "soft oozy mud with high organic content" (e.g., the mdudy sediment at Station 5.7). Catches rose during May, and the peak of availability of ocean pout to the bottom trawl was June and July.

The length-frequencies (Fig. 10) showed differences between stations, 5.7, 30.3, and 30.11 having larger pout. These three were homogeneous (P = 0.3638, P = 0.1734). The remaining stations were heterogeneous by date, because only small pout were taken in late August and September. However, before this they were homogeneous (P = 0.9537, P = 0.0664). Thus it appears that large ocean pout are more tolerant of "oozy mud" (or whatever other factor reduces abundance at Station 5.7).

The fish taken in September were 372 to 436 mm in length. From Olsen and Merriman's (1946) figures, these are probably immatures. It therefore appears that these fish migrate to hard bottom later than the adults,

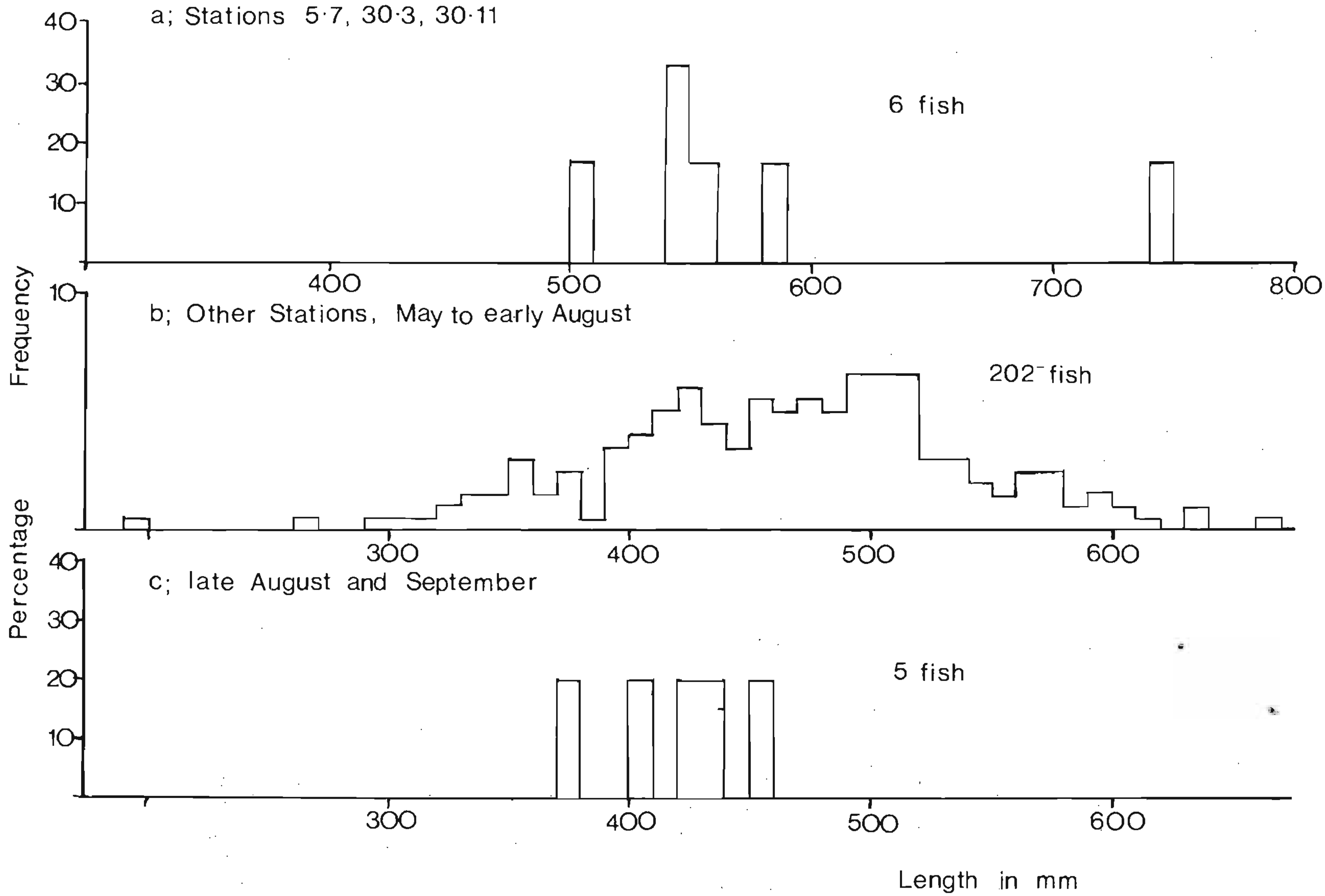


Figure 10; Length-Frequencies of Trawl-Caught Ocean Pout.

or perhaps remain on the trawling grounds all winter.

The two fish taken at station 5.7 in June and July are too few for the difference in length-frequencies to affect a biomass calculation. The catch per set for the Bay stations in June and July was 3.5. Using the equation from Kohler et al. (1970, Table 190B)

$$W = 8.814055 \times 10^{-10} L^{3.294168} \text{ (kg and mm)}$$

the mean weight of these fish was 0.612 kg. Apart from a reduced abundance on the softest sediment, there is no evidence to suggest any distribution other than an even one over hard and soft bottom areas in the Bay. Thus the assumed trawlable biomass of ocean pout was 176 tons.

4.29 MENIDIA MENIDIA: ATLANTIC SILVERSIDE

Silverside were taken by beach seine in Ogden Pond (7 June), off Crystal Clfifs (13 August), and at Cribbean Head (14 August), but all of these were small catches.

This species is widespread in the inshore and brackish waters of the Southern Gulf (Cox 1921; Needler 1940; McKenzie 1959; Leim and Scott 1966). It was abundant in Miramichi and Malpeque Bays, especially the latter (Needler 1940; McKenzie 1959). In winter, some remain near the shore, but others go deep enough to reach all parts of St. Georges Bay (Leim and Scott 1966).

No reliable estimate of their biomass is possible; it is probably small.

4.30 HEMITRIPTERUS AMERICANUS: ATLANTIC SEA RAVEN

Cornish (1907) found sea raven to be very common at Canso, and took them at all depths down to 50 to 60 fathoms. At Tignish, however, he (1912) remarked that they were "becoming scarce". Cox (1921) found them widely but sparingly distributed along the Cape Breton coast. Elsewhere this species is resident all year (Merriman and Warfel 1948; Tyler 1971a).

In St. Georges Bay they were taken in small numbers in the bait-traps at Ballantynes Cove, and by bottom trawl (Table 14; 200-435 mm length). The length-frequencies of trawl-caught fish were homogeneous (P = 0.6157, P = 0.0680).

Leim and Scott (1966) state that this species lives on rocky or hard bottom. Thus the trawl could only sample those fish which strayed onto the soft area. The numbers caught at each station (except 20.6) are directly related to its distance from hard bottom, which supports this hypothesis. Thus no estimate of their biomass in the Bay is possible.

4.31 MYOXOCEPHALUS AENEUS: GRUBBY

There are no confirmed records of grubby from St. Georges Bay, but some of the "shorthorn sculpins" seen close inshore, or taken in the bait-trap, may have been this species. The two are impossible to separate except by close examination (Leim and Scott 1966).

Grubby are known from various points in the Southern Gulf, and at some are the most abundant sculpin (Cox 1921; Needler 1940; McKenzie 1959; Caddy et al. 1977). They are present all year (Needler 1940; McKenzie 1959).

Table 14. Trawl catches of sea raven (in numbers)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	0	3	x	0	x	0	0	x	x
mid-May	0	x	6	1	0	x	0	0	0	1
late May	0	1	x	1	0	x	1	1	0	0
mid-June	2	0	2	0	2	x	0	0	0	x
early July	1	0	3	2	1	x	1	1	x	0
late July	0	0	x	0	0	x	0	0	0	x
early August	0	0	1	0	0	0	0	x	0	x
late August	x	x	x	x	1	x	0	0	x	x
early September	x	x	0	x	0	x	0	0	x	x

The proportion of "shorthorn sculpins" which were, in fact, grubby cannot be determined, so they will be included with that species in subsequent discussion.

4.32 MYOXOCEPHALUS OCTODECEMSPINOUS: LONGHORN SCULPIN

This species is generally referred to, locally, as 'sculpin' but is sometimes called a 'cobbler' or 'shoemaker'.

It is widespread in the Bay, being taken in the bait-traps (although less commonly than the shorthorn sculpin), and in the bottom trawl (Table 15). Longhorn sculpin have been noted from many points in the Southern Gulf (Cornish 1907, 1912; Cox 1921; Needler 1040; McKenzie 1959), but only in any abundance by Caddy et al. (1977). This may be related to unsuitable sampling gear in the earlier surveys.

In St. Georges Bay, longhorn sculpin were particularly abundant at stations 11.10, 15.7, and 21.2. This distribution is not clearly related to depth, temperature, or sediment type.

The catch per set was fairly steady through May and June, but then declined. Morrow (1951) found a similar movement off the fishing grounds in Block Island Sound (but rather earlier in the year). He thought that these sculpins went offshore, but accepted that they might move onto nearby rough patches. The latter explanation seems more likely for St. Georges Bay, since this species continued to be taken inshore and did not appear at the deeper stations.

The length-frequencies (Fig. 11) are heterogeneous. However, for each date, except mid-June, they are homogeneous between stations (P = 0.0515 to 0.8570; mid-June, P = 0.0057). The mid-June result may be

Table 15. Trawl catches of longhorn sculpin (in numbers)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	3	27	x	6	x	9	1	x	x
mid-May	5	x	7	19	3	x	10	5	2	1
late May	4	0	x	20	1	x	17	13	0	0
mid-June	12	3	10	7	2	x	28	0	0	x
early July	5	0	14	20	0	x	3	0	x	0
late July	2	0	x	4	0	x	3	1	0	x
early August	3	2	16	1	0	0	0	x	0	x
late August	x	x	x	x	0	x	0	1	x	x
early september	x	x	9	x	2	x	8	0	x	x

Figure 11; Length-Frequencies of Trawl-Caught Longhorn Sculpin.

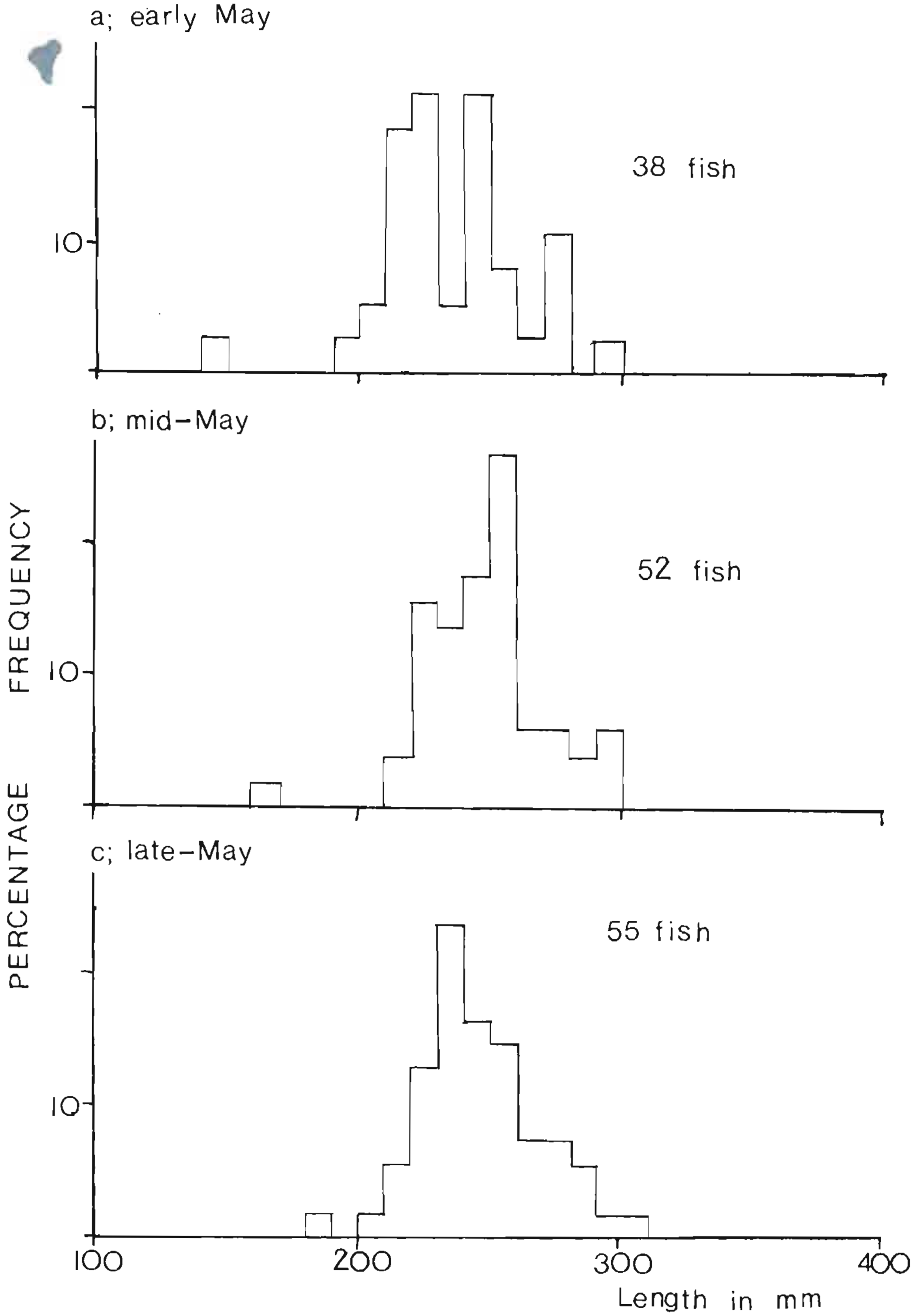
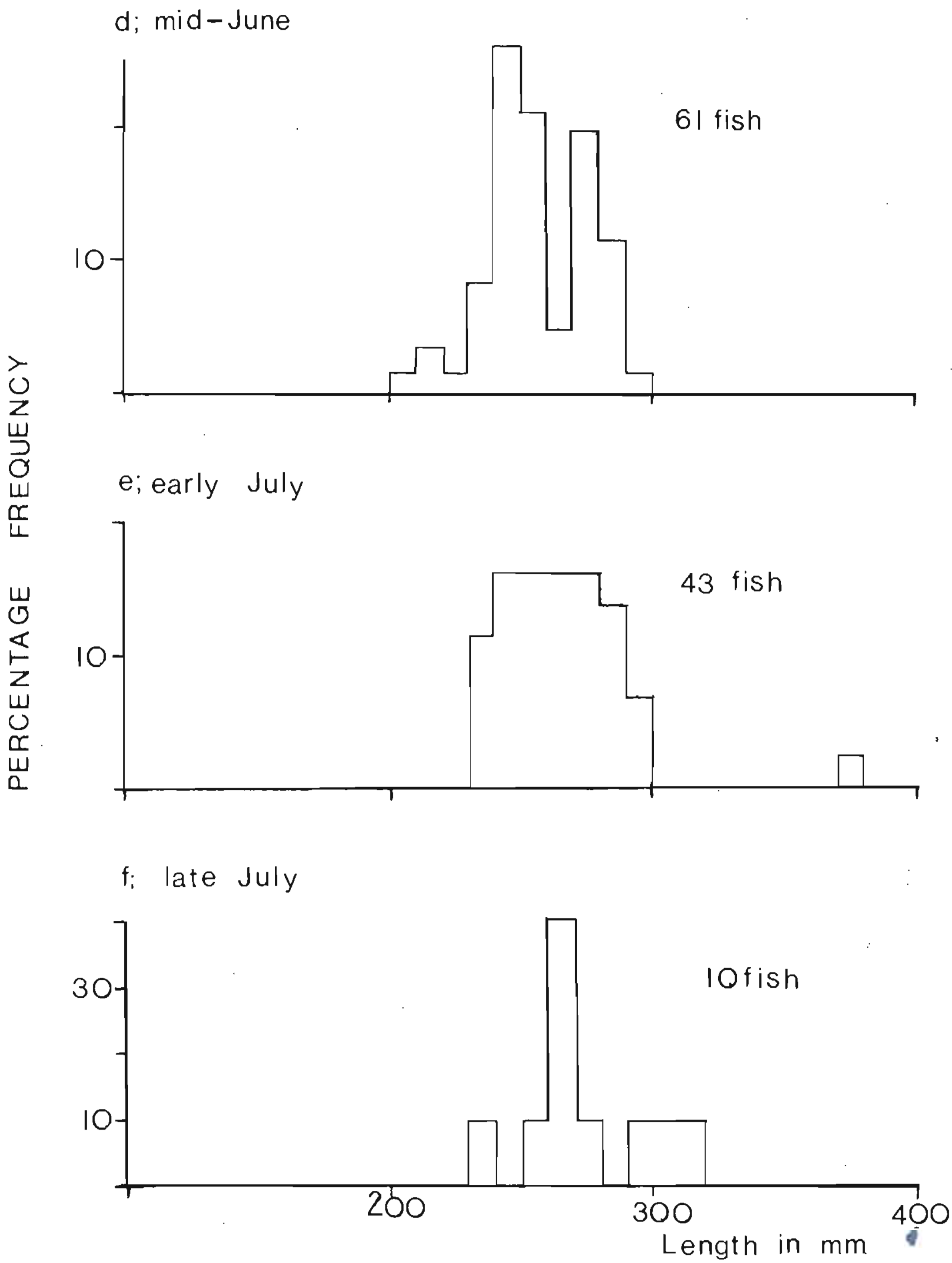


Figure II cont.



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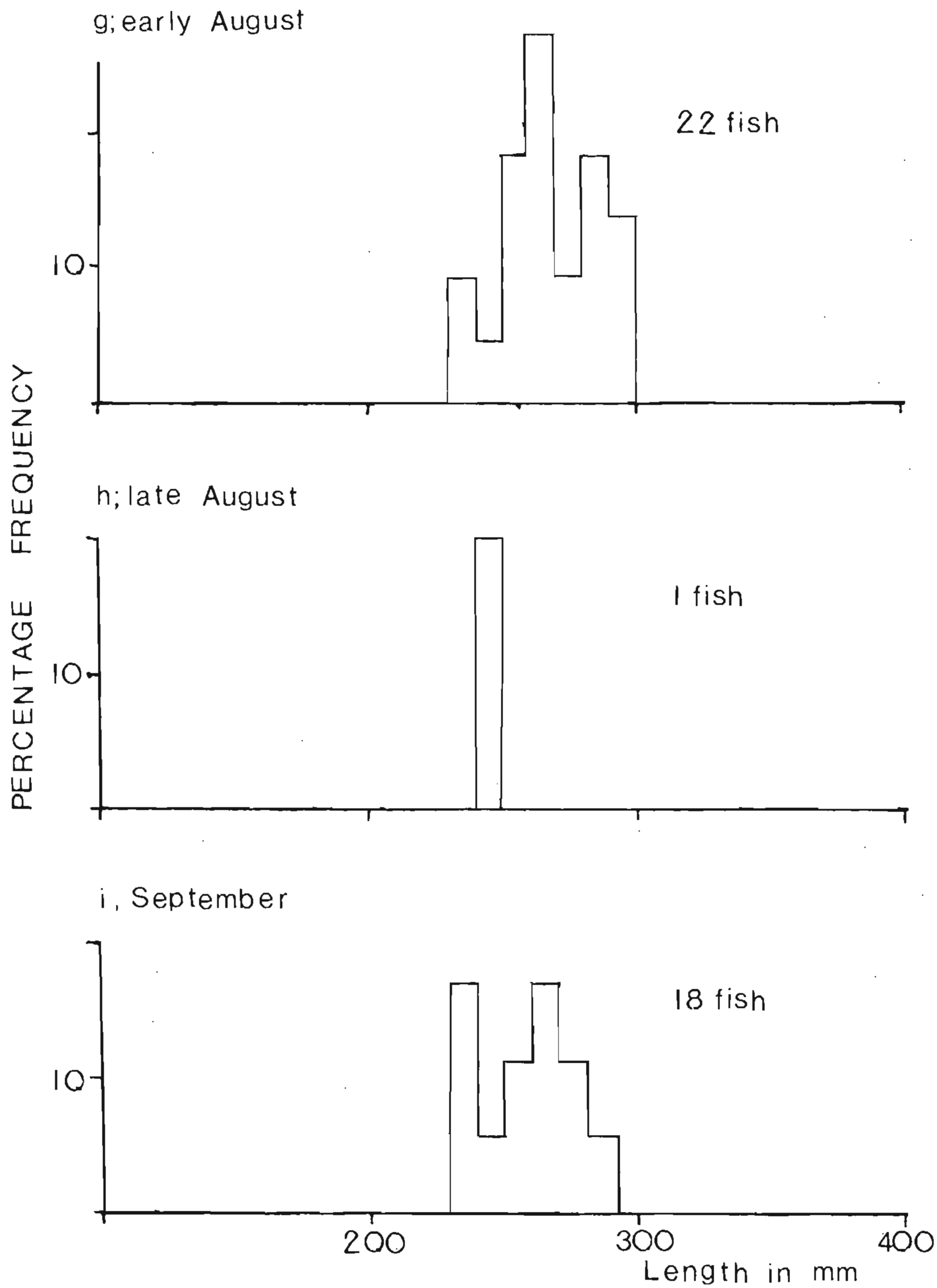


spurious (1/20 of these results should be falsely 'significant' by random chance). Late July to September catches were homogeneous between stations, as a unit ($P = 0.6692$).

Morrow (1951) observed rapid growth among longhorn sculpins only between May and August, and only for I- and II-group fish (less than 240 mm total length). Inspection of the data from St. Georges Bay suggested that the season of rapid growth ended late in July, and involved fish up to 285 mm in length. The lengths of these fish were regressed against the Julian date of their capture, to obtain a 'growth' rate of 0.24837 mm per day. Increasing the length of these fish by this rate, to late July, removed the variation between dates ($P = 0.0640$), but some remained between stations ($P = 0.0041$). An explanation for the latter cannot be offered.

Because of these length-frequency differences, the catch must be calculated in weight terms for each haul, using

$$W = 5.575155 \times 10^{-9} L^{3.108500}$$ (Kohler *et al.* 1970, Table 186; converted to kg and mm)

The average catch per set from May to early July was 0.914 kg. Thus the trawlable biomass was 38 tons. Since this species is also found on the hard-bottom parts of the Bay, it is not known what proportion this represents of the assumed trawlable biomass.

4.33 *MYOXOCEPHALUS SCORPIUS*: SHORTHORN SCULPIN

These were the commonest sculpins taken in the bait-trap, but only three were taken in the trawl (late May and mid-June, Station 17.9, 284, 272 mm; early August, Station 20.6, 349 mm). A few were seen while diving.

Cornish (1907) reported this species (as M. groenlandicus) as "exceedingly common" at Canso, and McKenzie (1959) found them to be "not uncommon" in the outer waters of the Miramichi. Some were taken in the Northumberland Strait. However, they were not noted at Tignish, Cheticamp, or Malpeque, although both M. octodecemspinosus and M. aeneus were found at the latter two sites.

Since few of these fish were taken in the trawl, no accurate estimate of biomass is possible. In shallow water, they seemed to be more abundant that M. octodecemspinosus, and thus may be as dense on hard bottom as the latter are on the trawling grounds.

4.34 ASPHIDOPHOROIDES MONOPTERYGIUS: ALLIGATORFISH

Six fish of this species were taken by bottom trawl in St. Georges Bay (Table 16, 102-126 mm). Cornish (1907) took several alligatorfish in Chedabucto Bay, as did Caddy et al. (1977) in the Northumberland Strait, while Cox (1921) and McKenzie (1959) took one each during their surveys.

Previous observations of this species suggest that it should be taken on all bottom types, at all temperatures (Bigelow and Schroeder 1953) and depths (Backus 1957) found in the Bay, and at all seasons (Tyler 1971a). That its occurrence in the catches was more restricted than this suggests a real change in its vulnerability to trawling, perhaps related to behaviour.

The average catch per set at all stations, from mid-June to early August, was 0.3. No length-weight key for this species is available, but four of those caught were preserved in formalin. One year later their mean weight was 0.0036 kg. This will be less than their fresh weight, because

Table 16. Trawl catches of alligatorfish (in numbers)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	0	0	x	0	x	0	0	x	x
mid-May	0	x	0	0	0	x	0	0	0	0
late May	0	0	x	0	0	x	0	0	0	0
mid-June	1	0	0	0	0	x	0	0	0	x
early July	0	0	0	0	0	x	0	0	x	0
late July	0	0	x	0	0	x	0	0	0	x
early August	1	1	1	2	0	0	0	x	0	x
late August	x	x	x	x	0	x	0	0	x	x
early September	x	x	0	x	0	x	0	0	x	x

of desiccation, but this species has heavy bony plates (the weight of which will not change), so it will be less affected than others. In the absence of a more suitable range, the area of the whole Bay will be used. This gives an assumed trawlable biomass of 0.1 tons.

4.35 CYCLOPTERUS LUMPUS: LUMPFISH

Lumpfish were taken occasionally in the bait-trap, one was taken by bottom trawl (at Station 3.7, in late July, 385 mm total length), and one was seen underwater off Crystal Cliffs (18 June). The latter was guarding its eggs. Some lumpfish eggs were taken by the trawl at Station 3.7 in mid-May.

Cox and Anderson (1922) show this species as widespread in Maritime Canada, but scarce from St. Georges Bay to the Miramichi, and around P.E.I. They are, however, common along the Cape Breton coast north of St. Georges Bay (Cox 1920, 1921), at Canso, and in the Miramichi.

Lumpfish are known to appear in shallow water in spring, and leave again during the summer or autumn, depending on locality (Cox 1920; Cox and Anderson 1922). These authors assume that they move offshore, but there is no direct evidence for this. This species prefers rocky bottoms (Cox and Anderson 1922; Leim and Scott 1966), and so the bottom trawl will not adequately sample them.

No estimate of biomass is possible from the available data.

4.36 LIPARIS ATLANTICUS: ATLANTIC SEASNAIL

There are no records of adult seasnails from the Bay, but their larvae have been taken there (Dr. D.M Ware, pers. comm.). Adults were taken by McKenzie (1959) in the Miramichi, and by Caddy et al. (1977) in Northumberland Strait (L. atlanticus and L. liparis).

Seasnails are probably present in St. Georges Bay, but are not vulnerable to the gears used in this survey. Their biomass cannot be estimated, but it is probably low.

4.37 SCOPHTHALMUS AQUOSUS: WINDOWPANE

Six windowpane were taken in the trawl (Table 17), while others were seen in bait- and salmon-trap catches. One escaped a beach seine at Cribbean Head in July, and several were seen close to the beach at Crystal Cliffs and Lakevale (June and July). The trawl-caught ones varied from 119 to 249 mm in length.

Windowpane are widespread but rarely abundant in the Southern Gulf (Cornish 1907; Cox 1921; Needler 1940; McKenzie 1959; Caddy et al. 1977). Most of these were taken inshore, and were small (30 to 130 mm in Malpeque Bay; Needler 1940). In southern New England, windowpane are distributed by length, such that the larger fish are deeper (Moore 1947). They are known from brackish waters (Scott and Crossman 1973), but are not usually found there (Moore 1947). Their preferred substrate is sand (Moore 1947), but they can be found on most sediments.

Moore (1947) found them to be present all year at depths of 31 to 50 m, and, while she noted random coastwise movements, concluded that there were no seasonal migrations. However, Jefferies and Johnson (1974), trawling at the mouth of Narragansett Bay, noted peaks of abundance of this species in March and July-August. They thought that these corresponded to fish moving into and out of the Bay. These two hypotheses are not, of course, mutually contradictory.

Table 17. Trawl catches of windowpane (in numbers)

Date	Station 3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	1	0	x	0	x	0	0	x	x
mid-May	0	x	1	0	0	x	0	0	1	0
late May	0	0	x	0	0	x	0	1	0	1
mid-June	0	0	0	0	0	x	0	0	0	x
early July	0	0	0	0	0	x	0	0	x	1
late July	0	0	x	0	0	x	0	0	0	x
early August	0	0	0	0	0	0	0	x	0	x
late August	x	x	x	x	0	x	0	0	x	x
early September	x	x	0	x	0	x	0	0	x	x

In St. Georges Bay, apart from Station 30.11, all the trawl-caught windowpane were taken in May. This suggests that part of the population overwintered on the trawling ground, or outside the Bay, but had moved inshore by June. Only relatively large fish were taken in the trawl, while many of those seen inshore were smaller. This suggests a similar distribution to that found by Moore (1947).

The density of windowpane inshore appeared to be higher than that on the trawling ground. However, using the mean catch per set in May (0.1), a weight of 0.1 kg per fish (estimated from Moore's 1947 data), and the whole area of the Bay the assumed trawlable biomass would be 0.8 tons.

4.38 GLYPTOCEPHALUS CYNOGLOSSUS: WITCH FLOUNDER

This species is known locally as 'gray sole'.

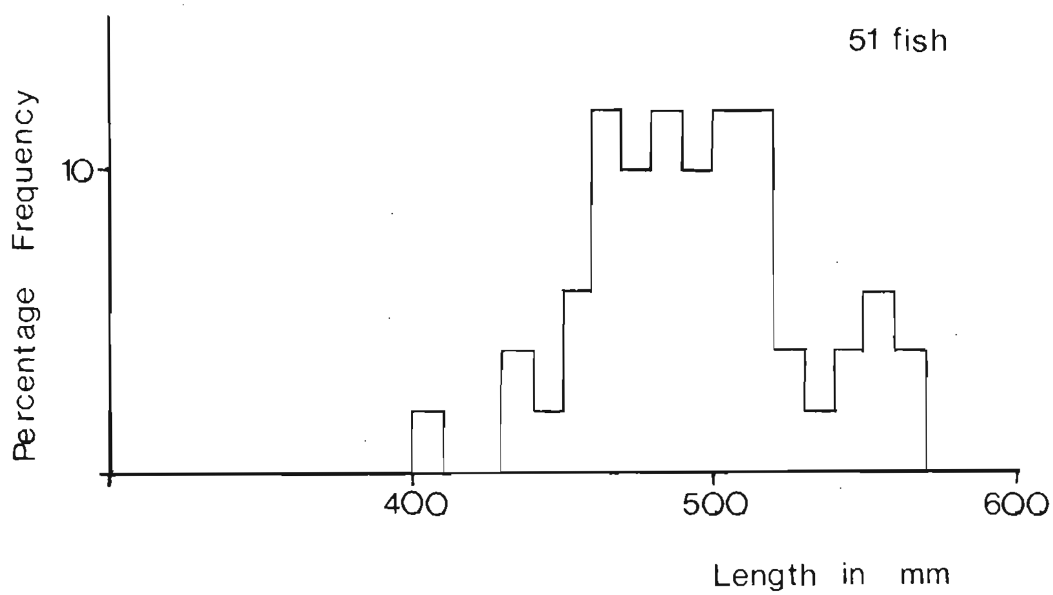
They are not normally thought to occur in the Northumberland Strait area (Leim and Scott 1966), but Powles and Kohler (1970) took a few there in summer. They have also been reported from Cheticamp and Miramichi Bay.

In St. Georges Bay 50 witch flounder were taken by bottom trawl (Table 18). Their length-frequencies (Fig. 12) were homogeneous ($P = 0.7664$, $P = 0.0979$). They were taken at every station deeper than 30 m, except 22.12 (divided from the rest by the shallow sill). Their preference for mud or muddy-sand substrates (Leim and Scott 1966) suggests that none would be present outside the trawlable area. They arrived in the Bay when bottom temperatures rose above -0.5°C, which compares with a minimum preferred temperature of -1°C (Leim and Scott 1966). They remained throughout the period of the survey.

Table 18. Trawl catches of witch flounder (in numbers)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	0	0	x	0	x	0	0	x	x
mid-May	0	x	0	0	0	x	0	0	0	0
late May	0	0	x	0	0	x	0	0	0	0
mid-June	1	1	2	1	0	x	0	0	0	x
early July	6	4	2	6	0	x	0	0	x	2
late July	3	1	x	2	0	x	0	0	0	x
early August	11	3	3	1	0	0	0	x	1	x
late August	x	x	x	x	0	x	0	0	x	x
early September	x	x	1	x	0	x	0	0	x	x

Figure 12 ; Length-Frequency of Trawl-Caught Witch Flounder.



The mean catch per set for Bay stations outside the 30 m contour from June onwards was 1.5. Using Bowering's (1976) formula

$$W = 1.548819 \times 10^{-4} L^{3.6142} \text{ (kg and mm)}$$

the average weight of these witch was 2.946 kg. Thus the trawlable biomass was 118 tons.

There is no fishery in the Bay for this valuable species. The maximum catch was about 30 kg from a standard set. In comparison, a standard set through the concentration of hake which is commercially exploited yielded about 70 kg. Many of the hake were below market size, and they are less valuable, per kilogram, than witch. Thus a viable trawl fishery for the latter might be possible in St. Georges Bay.

4.39 HIPPOGLOSSOIDES PLATESSOIDES: AMERICAN PLAICE

Plaice were taken in large numbers by the bottom trawl (Table 19), but not by other means. They are abundant in the deeper parts of the Southern Gulf (Cornish 1912; Cox 1921; Powles 1965; Leim and Scott 1966) and support a large fishery there (Powles 1965, 1969; Scott 1979). McKenzie (1959) thought them rare in Miramichi area, but this may be due to the lack of deep water there. This species has recently been reported from the Northumberland Strait, both as larvae (Faber 1976) and as adults (Caddy *et al.* 1977). Commercial concentrations are found down the coast of Cape Breton to Cape George, but not in St. Georges Bay or the central Northumberland Strait (Powles 1969).

Plaice are known from 9 to 710 m depth (Huntsman 1918), but in the Southern Gulf they are usually taken at 40 to 200 m in summer and 180 to

Table 19. Trawl catches of plaice (in numbers)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	120	96	x	5	x	0	9	x	x
mid-May	77	x	23	16	0	x	2	71	26	105
late May	238	156	x	37	3	x	8	34	83	80
mid-June	712	412	45	33	10	x	32	342	234	x
early July	692	616	126	89	39	x	54	147	x	430
late July	256	324	x	57	80	x	55	384	142	x
early August	390	484	238	157	16	2	3	x	87	x
late August	x	x	x	x	1	x	0	196	x	x
early September	x	x	20	x	3	x	4	153	x	x

460 m in winter (Powles 1965). St. Georges Bay is, therefore, on the shallow edge of their summer range. They are found mainly on fine sand and soft mud bottoms (Powles 1965; Leim and Scott 1966).

In the Southern Gulf, two stocks of plaice are found, of which the 'Cape Breton' group occurs in St. Georges Bay. The adults of this stock spend the winter near the Laurentian Channel, and move inshore during the spring and early summer (up to July). They stay until September. The immatures make less extensive movements (Powles 1965).

In St. Georges Bay, plaice were considerably more abundant at the deeper stations than at the shallower ones, as might be anticipated from their depth preferences. The catch at Station 22.12 was less than its depth might suggest, presumably because migration to it was limited by the shallow sill.

Catches increased through May and June, peaking in early July, as plaice migrated into the Bay. The size of fish taken at this time also increased (correlation of length against Julian date of capture, $r = 0.23217$, $P = 0.00001$), indicating the later arrival of adult fish.

Due to the lack of sets at the deeper stations in August and September, it is not possible to say when these fish leave the Bay.

The length-frequencies of these catches were strongly heterogeneous ($P < 0.0001$, $P < 0.0001$), and no pattern could be found to account for these differences.

The weights of these plaice can be calculated by:

$$L = 3.645355 \times 10^{-9} W^{3.377804}$$ (Kohler *et al.* 1970, Table 105; converted to kg and mm)

The biomass of plaice in St. Georges Bay is best estimated using an

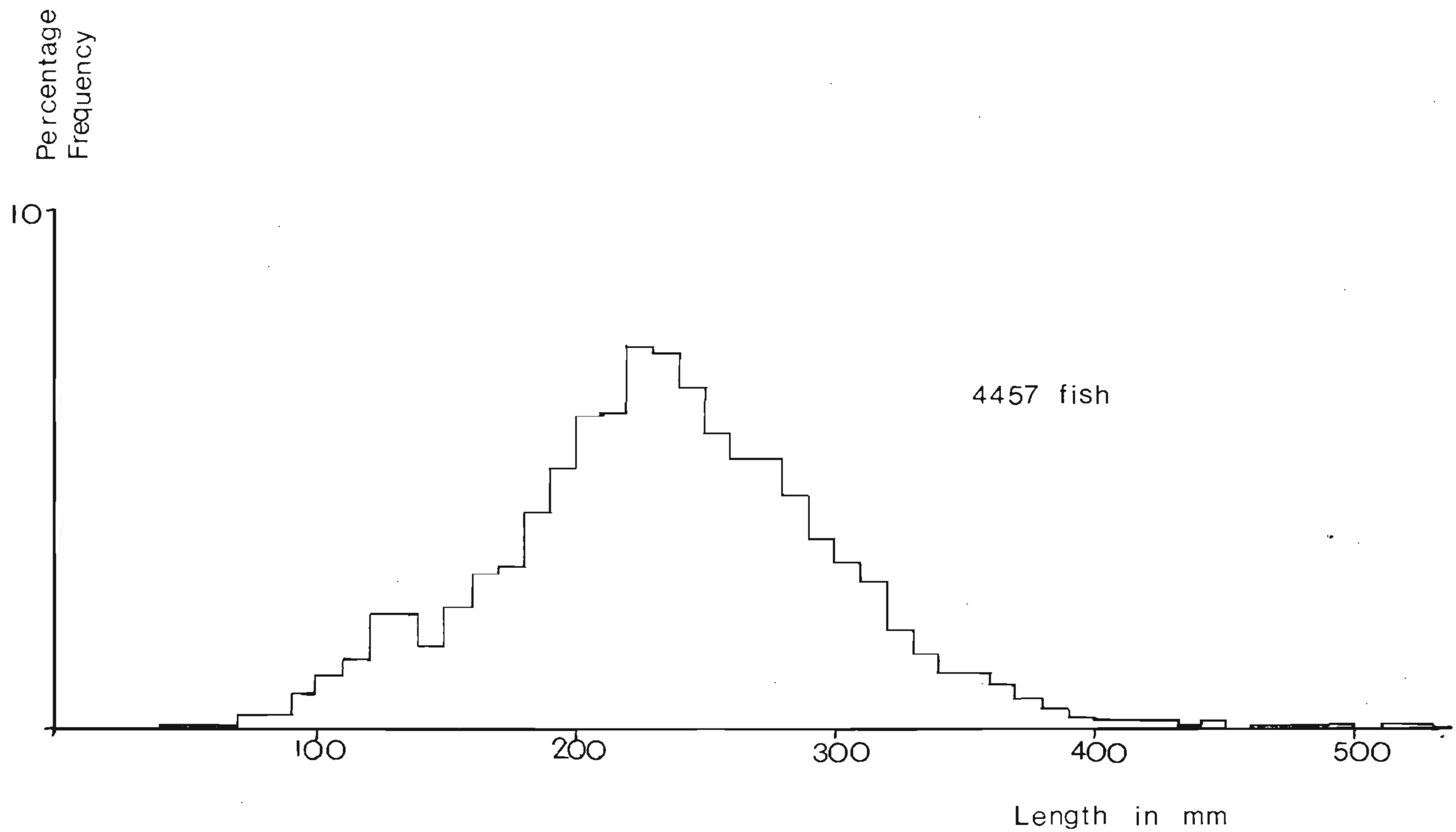


Figure 13; Length-Frequency of Trawl-Caught Plaice.

average of the mid-June to early August sets at all the Bay stations. Because of the heterogeneities of length-frequencies, this must be an average of the weights caught, and is 38.049 kg. Because of their preferred bottom type, plaice are not likely to occur other than on the trawlable grounds. Thus that area can be used to give an estimate of assumed trawlable biomass of 1562 tons.

4.40 LIMANDA FERRUGINEA: YELLOWTAIL FLOUNDER

Yellowtail were taken in St. Georges Bay by bottom trawl (Table 20). They are widely distributed in the southern Gulf (Cox 1921; Needler 1940; McKenzie 1959; Leim and Scott 1966; Caddy et al. 1977) but rarely found within the more enclosed, shallow bays (Needler 1940; McKenzie 1959).

This species was present in the trawl catches throughout the survey, with some decline in abundance during August and September. In May they were concentrated in the outer part of the Bay, while in July they were mostly in the southeastern corner. Such data as are available for August and September indicate a northward movement then.

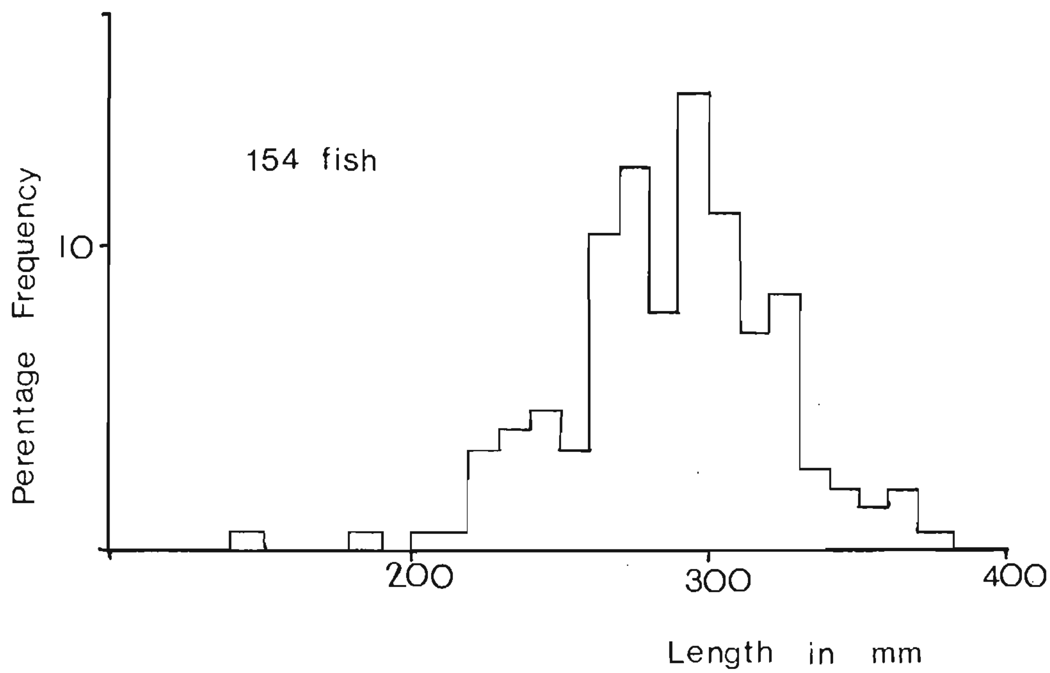
The length-frequencies for these sets (Fig. 14) are heterogeneous ($P = 0.0006$, $P < 0.0001$) without clear pattern.

The normal depth range of yellowtail is 9 to 110 m (Leim and Scott 1966), with the depth of greatest abundance being variously described as 37 to 73 m (Leim and Scott 1966) and 57 to 64 m (Pitt 1970). On the Newfoundland banks they are taken at temperatures of -1.0° to 7.7°C, and are most common at 3.1 to 4.8°C (Pitt 1970). They are found on sand and mixed sand and mud substrates (Leim and Scott 1966; Colton 1972). Thus St. Georges

Table 20. Trawl catches of yellowtail flounder (in numbers)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	2	20	x	6	x	0	0	x	x
mid-May	2	x	6	3	0	x	0	3	3	3
late May	1	3	x	1	1	x	3	3	1	3
mid-June	1	0	2	1	0	x	9	0	0	x
early July	0	0	0	3	16	x	17	0	x	3
late July	0	0	x	3	3	x	16	0	0	x
early August	0	0	6	2	0	0	0	x	0	x
late August	x	x	x	x	0	x	0	0	x	x
early September	x	x	2	x	5	x	2	0	x	x

Figure 14; Length-Frequency of Trawl-Caught Yellowtail Flounder.



Bay is a marginal environment for yellowtail, with depths of 25 to 40 m and temperatures of −1.3° to 12.9°C. It is therefore strange that they should have been most common at the shallowest and warmest stations.

No studies have been made of the movements of yellowtail in the Gulf of St. Lawrence. Off New England, this species moves seasonally within the fishing grounds, but rarely leaves them (Lux 1963). The catches in this survey indicate distinct movements within the Bay, which might carry the yellowtail into Northumberland Strait, or beyond, for the winter.

Trawlable biomass is best estimated using catches (in weight terms, because of the heterogeneity) from all the Bay stations, from May to July, and the area of trawlable bottom. Weights can be found from:

$$W = 2.341816 \times 19^{-8} L^{2.830419}$$ (Kohler et al. 1970, Table 134; converted to kg and mm)

The mean weight in these sets was 0.496 kg, coresponding to a trawlable biomass of 20 tons.

4.41 LIOPSETTA PUTNAMI: SMOOTH FLOUNDER

One specimen, about 150 mm in length, was taken in the bait-trap on 24 May, and passed to the author for identification. The local fishermen were not familiar with this species. Leim and Scott (1966) state that it is found throughout the Gulf, but has not been reported from the Atlantic coast of Nova Scotia. Cox (1921) found it to be the second most abundant flounder at Cheticamp. Needler (1940) noted it as abundant at Malpeque. It has also been reported from Tignish and the Miramichi estuary. Caddy et al. (1977) took some in the Northmberland Strait, but only in the western part.

The near absence of this species from St. Georges Bay is surprising. That this is not an artifact of sampling can be assumed from the lack of recognition of the specimen by local fishermen. It is possible that the sediments are too coarse in the shallow waters that it prefers (Leim and Scott 1966). Smooth flounder are known to enter fresh water (Scott and Crossman 1973), and it is possible that they are more abundant in the various lagoons than this solitary specimen indicates.

4.42 *PSEUDOPLEURONECTES AMERICANUS:* WINTER FLOUNDER

Winter flounder were taken in the trawl (Table 21) and in the bait-trap (from mid-May until at least mid-June). They were also seen, while diving, in less than 5 m depth, near Crystal Cliffs (mid-June to mid-August). Small flounders, which may have been this species, were seen at intervals in the mouth of Ogden Pond. They are subject to a commercial fishery (Anon. 1975).

In the Southern Gulf, this species is abundant, especially in shallow water, where they are usually the most common flounder (Cornish 1912; Cox 1921; Needler 1940; McKenzie 1959; McCracken 1963; Leim and Scott 1966; Caddy *et al.* 1977). Small winter flounder are especially common in the shallows (Cox 1921; McKenzie 1959), while the larger ones may tend to be outside the enclosed bays (McKenzie 1959).

The depth distribution of winter flounder is both complex and uncertain. While they are known from the intertidal zone (Warfel and Merriman 1944; Merriman 1947; McCracken 1963; Tyler 1971b; Wells *et al.* 1973),

Table 21. Trawl catches of winter flounder (in numbers)

Date	Station									
	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	14	7	x	1	x	3	3	x	x
mid-May	0	x	8	3	1	x	2	2	0	2
late May	0	0	x	4	2	x	7	380	2	0
mid-June	0	0	2	11	9	x	19	139	0	x
early July	0	0	6	27	73	x	122	69	x	5
late July	1	0	x	51	63	x	64	187	0	x
early August	0	0	13	32	3	1	16	x	0	x
late August	x	x	x	x	14	x	0	25	x	x
early September	x	x	27	x	32	x	7	1	x	x

brackish (Leim and Scott 1966), and occasionally fresh waters (Scott and Crossman 1973), and are common down to 37 m (Leim and Scott 1966), their depth of greatest abundance is less clear.

In southern New England, they overwinter in very shallow water (Perlmutter 1947; Saila 1961; Pearcy 1962a; McCracken 1963), moving offshore in the summer such that the greatest numbers of them remain between 12° and 15°C (McCracken 1963). In Passamaquoddy Bay, few mature flounder can be found in winter, while they move close inshore in the spring and away again during the summer (McCracken 1963). They are present all year at greater depths (38 to 55 m) with a peak abundance in April and May (Tyler 1971a). On the basis of this difference, and some data for other areas, McCracken (1963) suggested that north of Cape Cod winter flounder spent the summer in shallow water (unless its temperature rose above 15°C), and overwintered in offshore waters. However, recent studies in St. Margarets Bay, N.S. (Levings 1973), and Conception Bay, Nfld. (Kennedy and Steele 1971), have shown overwintering in shallow water (<2 m) by northern winter flounders.

Since no data are available for the Gulf of St. Lawrence in winter, all that can be said at present is that some winter flounder may spend the winter months inshore (perhaps buried in mud; Pearcy 1962b), but some may move offshore in winter to avoid the coldest water. In summer in the Northumberland Strait, McCracken (1963) found winter flounder mainly between 12° and 15°C. In August, off Pictou, this was at 13 to 27 m (the large fish tending to be below 22 m). In October and November, the stratification of the water column was destroyed, and this variation of depth with size of fish was lost. In spring, the flounder were concentrated in less than 9 m of water. The distribution in St. Georges Bay during the ice-free seasons is likely to be similar.

Other than the horizontal movements associated with seasonal depth changes, winter flounder seem to make only random movements. Tagging studies off New England (Perlmutter 1947; Saila 1961) and in St. Mary's Bay, N.S. (McCracken 1963), produced mainly local returns.

This species is found on all bottom types (Leim and Scott 1966).

The catches taken in St. Georges Bay probably missed the greatest concentrations of winter flounder. As discussed above, this species could be expected in large numbers above 12°C and 27 m depth. The shallowest trawl station (17.9) was at 25 m, and only one set there (early September, 12.9°C) was at over 8°C. The bait-traps were probably put out too late to take a spring, shallow-water, spawning concentration. Beach temperatures were above 15°C after early July. Thus the density of fish sampled could easily be an order of magnitude less than that at intermediate depths in the Bay.

Winter flounder were taken throughout the survey and at all stations. They were much less abundant at the deep stations (3.7, 5.7, 30.3, 30.11) than at the shallow ones (15.7, 17.9, 21.2). Catch per set for the Bay stations (except 20.6 and 22.12) was low through May and June, high in July, falling again for August, with an increase in September. The increase in July may correspond to an offshore movement at the end of the spawning season. An exception to this pattern was Station 22.12, which spanned a wide range of depth (30 to 38 m). It had the highest catches (and catch per set) of any station, and these were maintained from late May until the end of July. No explanation can be offered for this pattern.

The catches bear little or no relation to bottom temperatures in the Bay. This is, perhaps, not surprising if these fish were mostly strays below their preferred temperature range.

The length-frequency distributions (Fig. 15) of the trawl catches are strongly heterogeneous ($P < 0.0001$ by date and station), and are without clear pattern.

Weights of these fish can be calculated using

$$W = 2.518337 \times 10^{-9} L^{3.300010}$$ (Kohler *et al.* 1970, Table 144; converted to kg and mm)

The best estimate of trawlable biomass available is based on an average catch (in weight terms) for Bay stations, from late May to late July, and the whole trawlable area of the Bay. This is 189 tons. To estimate the density of fish at lesser depths, the catch per set at shallow stations (15.7, 17.9, 21.2) in July can be used. With the nontrawlable area, this gives an estimate of 1075 tons. These combine to give an assumed trawlable biomass, for winter flounder, of 1264 tons.

4.43 SPECIES EXPECTED, BUT NOT FOUND, IN ST. GEORGES BAY

There are unconfirmed records for three species from the Bay.

4.43.1 *Raja laevis*.

Barndoor skate. Mr. K. Falkenham, of Ballantynes Cove, informed the author that "barndoor skate" were once common in St. Georges Bay, but are rarely taken there now. This species was found to be frequent at

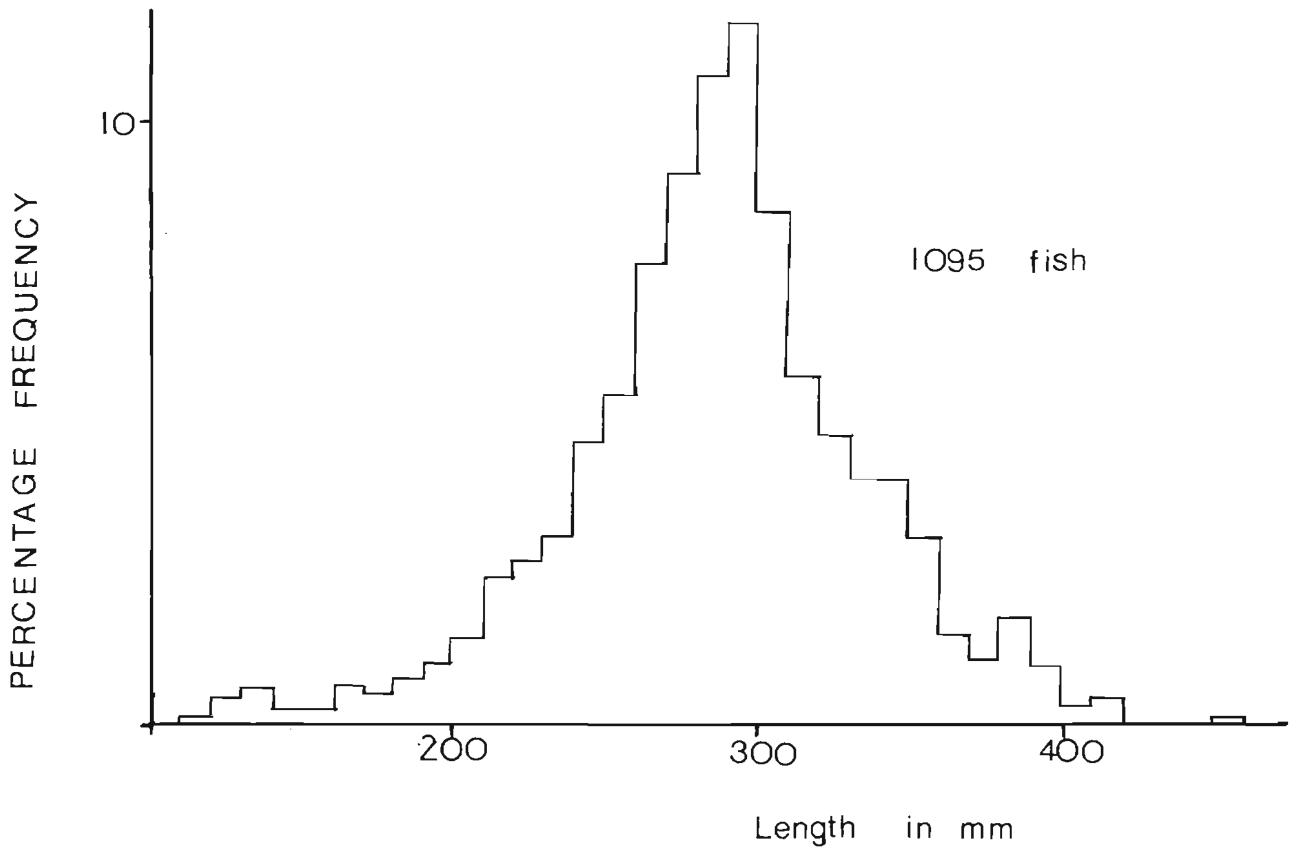


Figure 15; Length-Frequency of Trawl-Caught Winter Flounder.

Canso, Tignish, and Cheticamp (Cornish 1907, 1912; Cox 1921), but they were not seen at Malpeque or the Miramichi (Needler 1940; McKenzie 1959).

To what extent these differences are due to location, gear type, or a real temporal change is not known; however, the latter appears to be a distinct possibility.

4.43.2 Microgadus tomcod.

Atlantic tomcod. Some fish taken during research trawling in the Bay in previous years were identified as this species (Dr. D.M. Ware, pers. comm.). St. Georges Bay lies within the range of this species (Leim and Scott 1966). However, the lack of tomcod in 1978 catches casts doubt on the earlier identifications. The status of this species in the Bay is unknown at present.

4.43.3 Lophius americanus.

Monkfish, or Anarhichas lupus: Atlantic wolffish. A type of fish was reported by some fishermen as being occasionally taken by otter trawls worked very close to rough bottom off Cape George. They did not have a name for this fish, but remarked especially on its teeth.

It is most probable that these fish were Lophius americanus, which have been reported form various points in the Southern Gulf (Cornish 1912; Cox 1921; McKenzie 1959; Leim and Scott 1966). It is possible that they were Anarchichas lupus, but this species would probably have been termed a 'rock eel', due to the shape of its body. Wolffish are also known from the Southern Gulf (Cornish 1912; Cox 1921; Leim and Scott 1966).

A large number of fish species no doubt reach St. Georges Bay as strays at rare intervals. In addition to these, other fish surveys in this region (Cornish 1907, 1912; Cox 1921; Needler 1940; McKenzie 1959; Leim and Scott 1966; Caddy et al. 1977) suggest that some species which have not been found in the Bay may, nevertheless, occur there regularly. Of these, some are inconspicuous and not particularly vulnerable to the fishing gears used:

Myxine glutinosa:	hagfish
Petromyzon marinus:	sea lamprey
Pungitius pungitius:	ninespine stickleback
Stichaeus punctatus:	arctic shanny
Lycodes vahlii:	Vahl's eelpout
Poronotus triacanthus:	butterfish
Artediellus uncinatus:	arctic hookear sculpin
Triglops murrayi:	mailed sculpin
Eumicrotremus spinosus:	Atlantic spiny lumpsucker
Liparis liparis:	striped seasnail

Others, although large, would be expected to be uncommn and rarely seen:

Lamna nasus	porbeagle
Prionace glauca:	blue shark
Acipenser oxyrhyncus:	American Atlantic sturgeon
Sarda sarda:	Atlantic bonito
Xiphias gladius:	swordfish
Mola mola:	ocean sunfish

Any of these species might be expected in a more thorough fish survey of the Bay.

Finally, one absence from the species list is notable: Squalus acanthias, the spiny dogfish. This species has been recorded, in abundance, in the Southern Gulf (Cornish 1907, 1912; Cox 1921; McKenzie 1959; Leim and Scott 1966), from the end of July-beginning of August (Cornish 1912; Cox 1921) to late autumn (Leim and Scott 1966). It is known to occur on muddy bottoms (Muus and Dahlstrom 1964), and can be taken by bottom trawl (e.g. Jefferies and Johnson 1974). Thus, it might have been expected that dogfish would occur in the catches in St. Georges Bay.

Howver, their lower preferred temperature (5°C; Leim and Scott 1966) is high enough to keep them off bottom, and hence invulnerable to the net, on the trawling ground in the Bay, until August or September. Cox's (1921) report of their being "incredibly numerous", like Cornish's (1907) "extremely common" and other such comments, was based on fishing with hooked gear. It is possible that this species is less vulenerable to an otter trawl, so that an apparent reduction in abundance might have occurred.

The absence of any record of this species from the Bay, the lack of any mention of it by local fishermen (some of whom used hooked 'trawls'), and its absence from Caddy et al.'s (1977) trawl catches (most of which were within its preferred temperature range, although none were taken after 1 August) considered together do suggest that dogfish are uncommon in this part of the Gulf of St. Lawrence. No reason for this can be suggested.

4.44 BIOMASS OF FISHES .

The calculated biomass of demersal fish caught in each set is shown in Table 22. It can be seen to be relatively constant between areas for any given date. Until July, the trawlable biomass tended to have a bimodal distribution, with peak values at Station 22.12 and at the mouth of the Bay (Stations 3.7 or 30.11). Thereafter, the central part of the Bay had a slightly greater density. There is a clear increase in the weights of catches from the beginning of the survey until early July, afer which it declined.

The mean catch in June and July was 37.478 kg. This is equivalent to a trawlable biomass density of 2.7 tons km^{-2}. The greatest density of trawlable biomass encountered was at Station 22.12 in late July. It was 7.8 tons km^{-2}.

Using the estimates of absolute biomass in Table 3 (from which some major pelagic species are missing), the total weight of fish in St. Georges Bay may have exceeded 11,000 tons during the summer. This is equivalent to a biomass density of over 9.3 tons km^{-2}. The density in one very productive beach seine haul in Ogden Pond on 7 June may have been three times this.

These values are given, with others from the literature, in Table 23. The biomass density in St. Georges Bay is comparable with estimates of total abundance of demersal fish on the continental shelf of the northwest Atlantic. It should be noted that Edwards (1968) and Scott (1971) used essentially the same estimates of catchability as this survey, and they both achieved higher estimates of biomass density than earlier workers. Allowing for this difference in estimates of catchability, and comparing St. Georges Bay with coastal areas (e.g. Block Island Sound, Narragansett Bay) suggests that it has a moderate density of fish biomass.

Table 22. Calculated biomass of demersal fish in the trawl catches (in kg)

	Station									
Date	3.7	5.7	11.10	15.7	17.9	20.6	21.2	22.12	30.3	30.11
early May	x	7.991	19.808	x	8.044	x	3.009	1.561	x	x
mid-May	6.004	x	10.927	6.581	1.556	x	2.010	6.132	4.007	8.687
late May	15.450	10.805	x	10.766	5.448	x	10.091	60.33	7.096	7.855
mid-June	88.435	61.439	17.404	15.335	8.807	x	38.718	70.653	23.508	x
early July	57.980	43.407	35.865	46.251	42.581	x	68.628	40.228	x	78.618
late July	23.932	21.276	x	36.979	48.749	x	59.868	108.115	8.358	x
early August	33.336	31.013	59.355	51.152	46.807	1.583	16.028	x	14.901	x
late August	x	x	x	x	79.099	x	1.118	39.843	x	x
early September	x	x	44.064	x	26.974	x	52.459	15.350	x	x

Table 23. Estimates of fish biomass density (in tons km^{-2})

New England continental shelf (mean)[1]		18.935
New England continental slope		1.762-2.211
Nova Scotia continental shelf (mean)[2]		4.36 -16.26
Nova Scotia continental slope		5.129-10.83
Georges Bank		1.222-2.053
Georges Bank		1.571-7.407
Jefferies Ledge, Gulf of Maine (mean)		5.275
Highlands Ground, Gulf of Maine		7.632
Block Island Sound		1.122-19.641
Long Island Sound		0.606-1.100
Narragansett Bay		1.852-6.341
Sakonnet River, Rhode Island		3.816-13.917
Narragansett Bay salt marsh (maximum)		69.248
California kelp bed		33.221-37.598
Bermuda coral reef (summer mean)		59.372
St. Georges Bay:	Trawlable (summer mean)[3]	2.7
	Trawlable (maximum)[3]	7.8
	Absolute (mean)[3]	9.3
	Absolute (maximum)[3]	about 30

1 Edwards (1968)

2 Scott (1971)

3 this report

remainder from Oviatt and Nixon (1973)

The highest density, which was found in Ogden Pond, is less than those of extremely highly productive areas, such as kelp forest and salt marsh.

The available estimates of zooplankton biomass in St. Georges Bay (Ware 1977; Harding et al. 1980) are approximately 10 to 30 tons km^{-2}. Phytoplankton production has been measured at rates of the order of 10 tons C km^{-2} $month^{-1}$ (Prouse and Hargrave 1980). These figures are neither entirely comparable with the fish biomass estimates derived here, nor are they fully reliable as measures of standing stock and production for the whole Bay all summer. However, they do approximately agree with the relationships between plankton and fish suggested for the Gulf of Maine by Sheldon et al. (1977).

5. GENERAL DISCUSSION AND CONCLUSIONS

The fish population in St. Georges Bay is comprised of a very similar range of species to those found in other areas of the Gulf of St. Lawrence with similar bathymetry. Of the 47 species for which some evidence of presence in the Bay is available, 27 appear to be resident within the Bay and its surrounding rivers (8 are diadromous), 13 are summer migrants which spawn within this area, one (capelin) is a spawning winter migrant, 2 are non-spawning summer migrants, one (cod) seems to contain both residents and summer migrants, and finally for three species seasonal occurrence cannot be surmised. This proportion of resident species is higher than that found in many other surveys (e.g. Tyler 1971a), because the wide range of methods used allowed several species to be followed through their seasonal movements.

Only two of these species are thought not to spawn within the Bay, but there is no evidence from this survey that this is in any way a 'preferred' spawning area. Indeed, some of the migrant species are considerably more abundant outside the Bay in summer time (Kohler 1968).

Although most species are resident, a majority of the fish biomass (6600 tons, of the 11,000 tons estimated, plus some important pelagic species) is composed of summer migrants. The summer is the season both of spawning and active feeding, thus these migrations could be either a net supplement or a net loss to the St. Georges Bay ecosystem. It is not possible at present to say in which direction, nor how great this energy flow might be.

The construction of the Canso Causeway in 1954 (McCracken 1979) may have disrupted the migration routes of some fish species. Salmon (Marshall 1979), herring and mackerel (Goode 1884; Ware 1979) are known to have used the Strait of Canso, although its importance to them has been questioned (Messieh and Moore 1979; Dadswell 1979a). The occurrence of bluefin tuna and saury in St. Georges Bay in late summer, and their tendency to concentrate in the mouth of the Strait, suggests that they may still be attempting this route. Until more is known of the navigational methods of these fishes, this must remain a tentative hypothesis.

Analysis of the length-frequencies showed clear length- (or age-) related intraspecific variations in the distributions of 6 species. A difference in distribution is probably related to differences in many aspects of ecology, and these results show that ontogenetic changes in ecological relationships may be important in fishes even after maturity.

Four species had significant differences in length-frequencies between sets without noticeable pattern. At present, all that can be suggested is that these fishes form schools of similarly sized individuals, but that the schools are randomly distributed within St. Georges Bay. It should be noted that three of these species were the most abundant ones found. Other fishes might have displayed the same phenomenon if they were numerous enough for the statistical test to sense significance.

In conclusion, St. Georges Bay has a similar fish population to comparable areas in the Gulf of St. Lawrence. It appears to include at least 47 species and to comprise about 10 tons km^{-1} biomass, or about 11,000 tons in total (from which estimates some major species are missing). Although this biomass was fairly evenly distributed within the Bay, the southeast corner, and especially the Strait of Canso, was notably richer (this was the area in which smelt, silver hake and juvenile herring were taken, without known factors limiting their distribution). No explanation can be offered for this, beyond suggesting that this may be an area of greater plankton production.

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