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Distribution and movements of herring in the Bay of Fundy
from juvenile surveys

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Introduction

The origin of the Bay of Fundy "sardines" remains one of the most pressing and difficult problems in the identification and management of northwestern Atlantic herring stocks. Juvenile tagging results (Stobo et al. 1975) and the analysis of meristic characters (Iles 1970) and length frequency data (Messieh 1970) have suggested some relationships. However, these studies are restricted in that they focused on the recruited (i.e. mainly 2 year old) part of the population when considerable mixing of "pure" stocks may have already occurred. Larval surveys (e.g. Stobo and Iles 1973) are useful in delineating spawning grounds and outlining the initial pattern of movement from them, but they leave off when fish begin to metamorphose, develop stronger swimming abilities and begin to school. In 1978-79 we conducted a number of midwater trawling surveys to determine the distribution of post-metamorphosis, pre-recruit herring with a view toward understanding their movements and stock relationships.

Methods and Materials

Four surveys were conducted between February 1978 and February 1979. They focused on the New Brunswick side of the Bay of Fundy between Grand Manan and Chignecto Bay (Figure 1). A zig-zag search pattern was

followed with the ship's sounder operating continuously (Figure 2). Standard 1/2-hr sets were made with a midwater trawl through fish traces when acoustic information indicated the presence of fish. The trawl used was a "Boris" single boat midwater trawl with a headrope length of 75 feet, mouth opening of approximately 2 fathoms and a codend mesh size of 0.5 inches. Depth was determined with a sonic transducer mounted on the headrope. In February and August 1978 additional fixed fishing stations were allocated along the cruise track prior to the cruise. At these stations a standard step-oblique haul (near bottom, midwater, near surface) was done if fish traces were not present. Trawling was generally restricted to daylight hours.

Total numbers of herring caught (by subsampling if necessary) and length frequencies were obtained for each catch. Measurements were made to the half centimeter below. Frozen samples were returned to the laboratory for aging.

Results

The fishery and biology of juvenile herring in the Bay of Fundy

The juvenile fishery is conducted during the spring, summer and fall, concentrating at the entrance of the Bay of Fundy on the New Brunswick (Passamaquoddy area) and Nova Scotia (Digby and St. Mary's Bay area) side. The New Brunswick fishery is almost exclusively a weir fishery while both weirs and purse seines are used in Nova Scotia at this time. The fishery exploits largely 2-year-olds but a new year class of approximately 1-year-old herring is recruited toward the end of the season.

During winter a purse seine fishery concentrates in the Saint John area which exploits fish approximately 10-14 cm long and 1 1/2-years-old. This suggests movement of at least part of the newly recruited year-class toward the northeast along the New Brunswick coast during fall and winter.

Growth of juveniles in the Passamaquoddy area (1976 year-class) during 1977 and 1978 is shown in Figure 3. The size range of any year-class is rather wide, particularly for 2-year-olds. Messieh (1970) has demonstrated the presence of three reoccurring size groups of 2-year-olds in the Passamaquoddy juvenile fishery. In 1977 and 1978 two groups of spawning fish were evident from maturity data collected during the adult purse seine fishery (Figure 4). One group spawns during the later part of July in the Scots Bay area. The southwest Nova Scotia spawning begins somewhat later during August and continues into early October. This extended spawning season could produce the polymodal length frequency distribution of 2-year-olds described by Messieh. He hypothesized that two groups originate from summer and fall spawnings, with a third group from spring spawning. Spring spawning was common at the head of the Bay of Fundy in the 1930's (McNairn 1933; Das 1968) but has not been demonstrated recently.

Juvenile surveys

February 1978

Catches were low but consistent. Ninety-two percent of the preselected stations caught herring with an average catch size of 99 fish. Catches were highest near shore at the head of the Bay of Fundy (Figure 5).

A very dense school (1976 year-class) was encountered off Quaco Head (Figure 6A). Three groups of herring were present in the Chignecto Bay area (Figure 6B) with two well represented in most catches. These exhibited modes at 5.5 and 7 cm and belonged to the 1977 and 1976 year-class, respectively. The third group consisted of larger fish, present only within Chignecto Bay. These fish belonged to the 1975 year-class and were relatively small (ave. 12.9 cm) for three-year-olds. The 1976 and 1977 year-classes were also present between Chignecto Bay and Saint John and on the Nova Scotia side of the Bay of Fundy (Figure 6C & D), but in very low numbers. Mainly 1977 year-class larvae were caught between Saint John and Passamaquoddy Bay, also in low numbers (Figure 6E). It is apparent that this year-class was slightly larger in the Chignecto Bay area, where it consisted of completely metamorphosed herring. The slightly smaller herring caught to the southwest were premetamorphoses or metamorphosing larvae. No herring concentrations were encountered to the southwest of Quaco head or offshore.

April 1978

The same area was covered but only a limited number of trawling stations were done in areas where acoustic information indicated the presence of fish. Two areas of herring concentrations were encountered. A group found off Saint John had a length frequency distribution virtually identical to fish previously sampled in Chignecto Bay (Figure 7A; compare with Figure 6B). It was apparent that this group was moving toward the southwest. Herring were also present in Maces Bay. Trawling in this area revealed the presence of two groups with principle modes at 12.5 and 13.5 cm (Figure 7B & C). These fish may represent the 1976 year-class previously seen off Quaco Head (compare Figure 6A with Figures 7B & C).

August 1978

The fixed stations first done in February were repeated. The average catch size (3903 fish) was considerably higher than in February but only 44% of these stations caught herring. Herring were widely distributed on the New Brunswick side of the Bay of Fundy from Passamaquoddy Bay to Chignecto Bay (Figure 8). Relatively dense schools were encountered up to 10 miles offshore. Weighted length frequencies for groups of stations show progressively smaller fish occurring along the coast from the entrance of the Bay of Fundy to its head (Figure 9).

Almost all fish caught belonged to the 1977 year-class except in Chignecto Bay where some 1976 year-class fish (average length 12.1 cm) were also taken. This area contained both the smallest and the largest (modal size) 1977 year-class fish found during the survey (Figure 9D). At least three groups of relatively small fish were present at the Head of the Bay (Figure 10).

February 1979

The same area was covered again but fishing was restricted to inshore areas. Results generally confirm and accentuate patterns found during the previous February and April. No offshore herring concentrations were encountered. Inshore concentrations were found in Chignecto Bay, at Saint John, and in Maces Bay (Figure 11). Three groups of herring were again present in Chignecto Bay (1976, 77 and 78 year-class) with the smallest size group (1978 year class) consisting of completely metamorphosed fish (Figure 12A). Concentrations of herring at Saint John consisted mainly of the two smaller size groups (1977 & 1978 year-class) also found to the northeast but with the smallest group again comprising

premetamorphosis and metamorphosing larvae (Figure 12C). As in April 1978, two main groups of herring (1977 year-class) were again found in the Maces Bay area (Figure 12, D & E).

Discussion

In view of the spatial and temporal distribution of spawning in the area, it is probable that the newly metamorphosed fish found in the Chignecto Bay area during winter originate from the July spawning in the Scots Bay area. The premetamorphosis and metamorphosing larvae found to the southwest may originate from later spawning in the Trinity-Lurcher area. Iles (1971) found evidence of larval drift from southwest Nova Scotia deep into the Bay of Fundy. The two principle modes of 2-year-olds found in the Maces Bay area may represent the previous year-class of these two groups of fish. In addition to the Scots Bay group evidence was found of another group of fish originating from the head of the Bay of Fundy and that it migrates towards the southwest. These fish were small for their age (assuming fall spawning) and may represent the small size group of 2-year-olds which recruits to the Passamaquoddy weir fishery in the spring and was hypothesized by Messieh (1970) to originate from spring spawnings. The increasing size of fish with increasing distance from the head of the Bay of Fundy in summer also indicate earlier spawning near the upper reaches of the Bay.

During summer, 1-year-olds were found at a considerable distance from shore. The sudden appearance of 1-year-old fish in the Passamaquoddy weirs in August indicates an inshore movement at this time. Herring in the area appear to remain inshore during their second winter.

Although three groups of fish and their possible origin were identified, it is not possible at this time to evaluate their relative importance to the juvenile fishery. Quantitative acoustic surveys planned for the future may help solve this problem. The present data suggests that summer may be an optimum time and the one-year-old fish is a good object for quantitative acoustic surveys because:

1. They are relatively widespread in geographical distribution.
2. They are up in the water column and accessible to acoustic equipment (Figure 13).
3. The strength of the year-class has probably been established.
4. They have not recruited to the adult fishery and have only partially recruited to the juvenile fishery.

The possibility of immigration from the Gulf of Maine, and the relationship between the New Brunswick and Nova Scotia juveniles was not investigated and must be included in future studies. The existence of spring spawning at the head of the Bay of Fundy should be confirmed.

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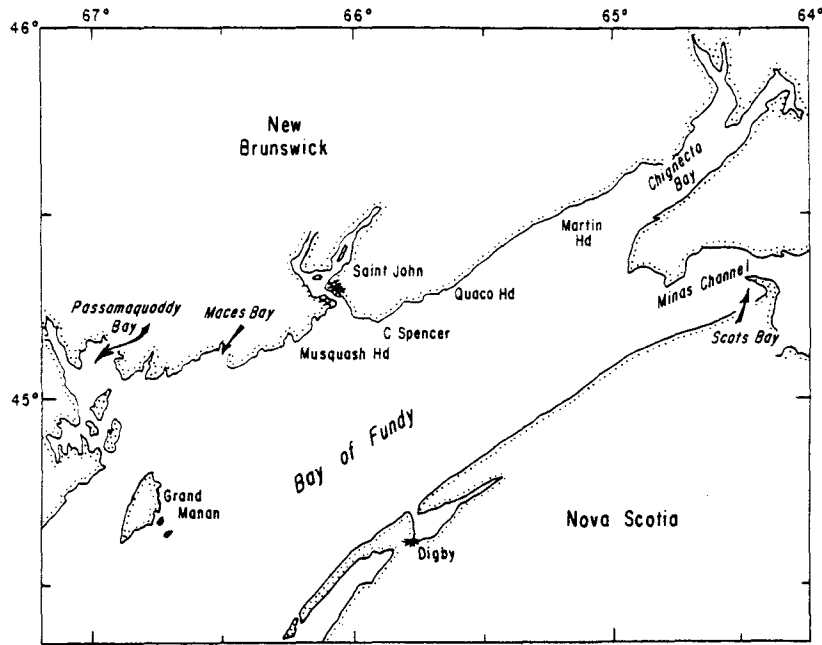


Figure 1. Area investigated with place names used in the text.

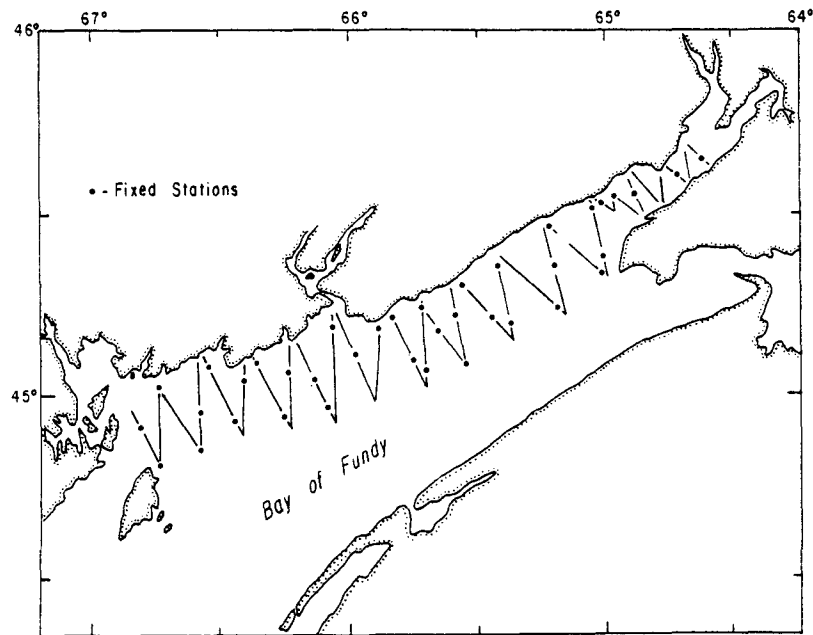


Figure 2. Zig-zag search pattern with fixed fishing stations used during the February and August 1978 cruises.

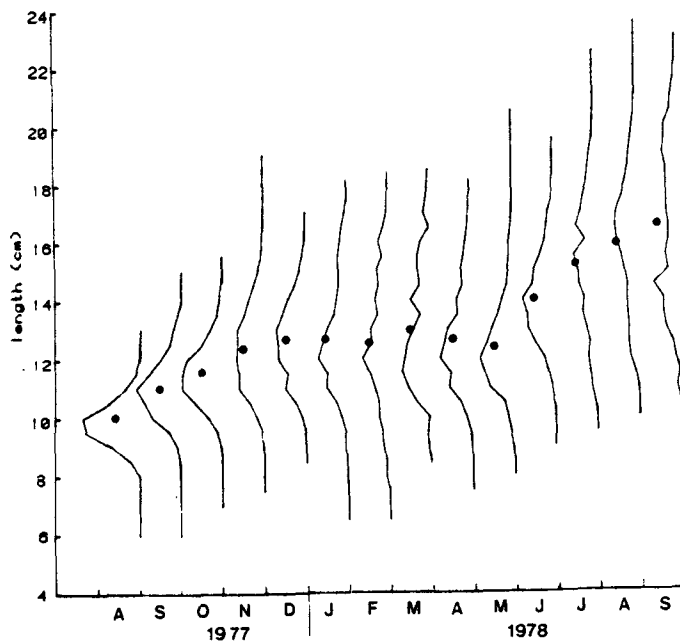


Figure 3. Monthly length frequencies (%) of the 1976 year class caught in the New Brunswick sardine fishery. Black dots indicate average length.

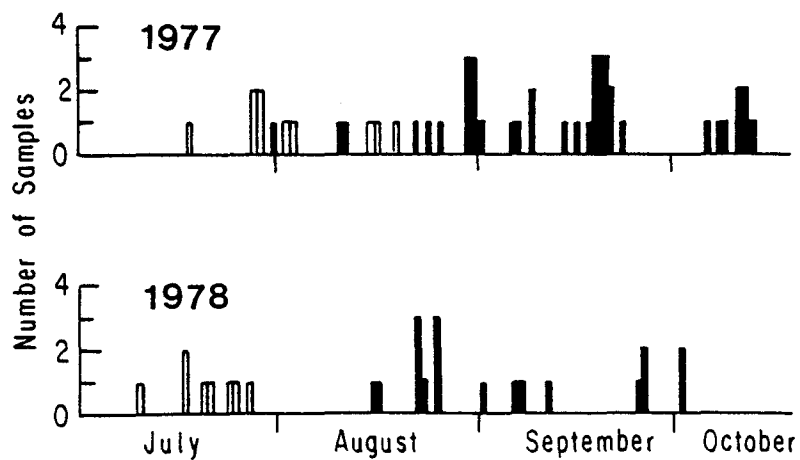


Figure 4. Frequency of samples in which more than 50% of fish were ripe and running. White bar- Scots Bay area; Black bar- south-west Nova Scotia.

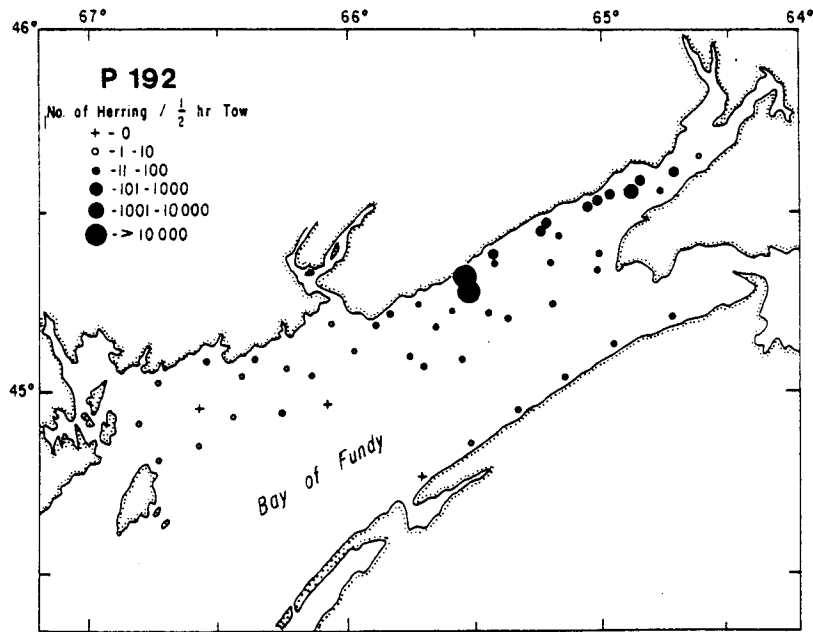


Figure 5. Number of herring caught per standard tow in February 1978.

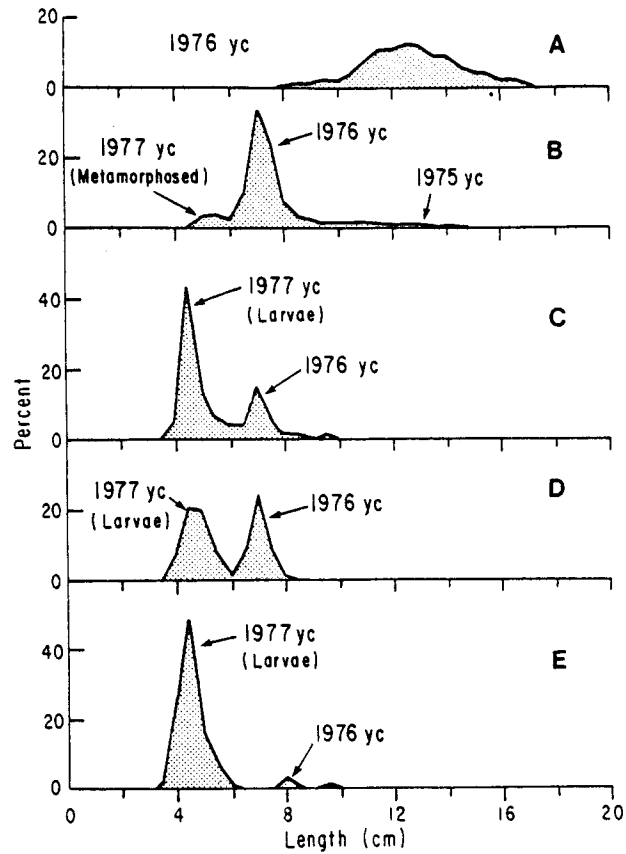


Figure 6. Length frequencies from the February 1978 cruise.
 A. Quaco Head (n=438)
 B. Chignecto Bay (n=2709)
 C. Nova Scotia (n=86)
 D. Chignecto Bay to St. John (excluding Quaco Hd., n=438)
 E. St. John to Passamaquoddy Bay (n=90)

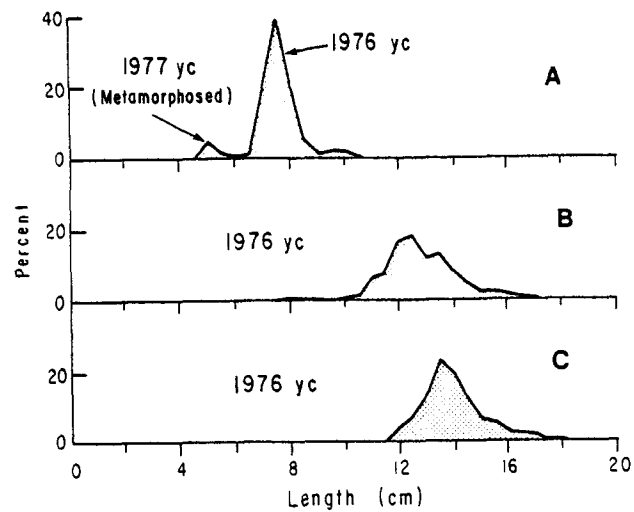


Figure 7. Length frequencies of herring caught during the April 1978 cruise.

- A. St. John (n=263)
- B. Maces Bay (n=191)
- C. Maces Bay (n=274)

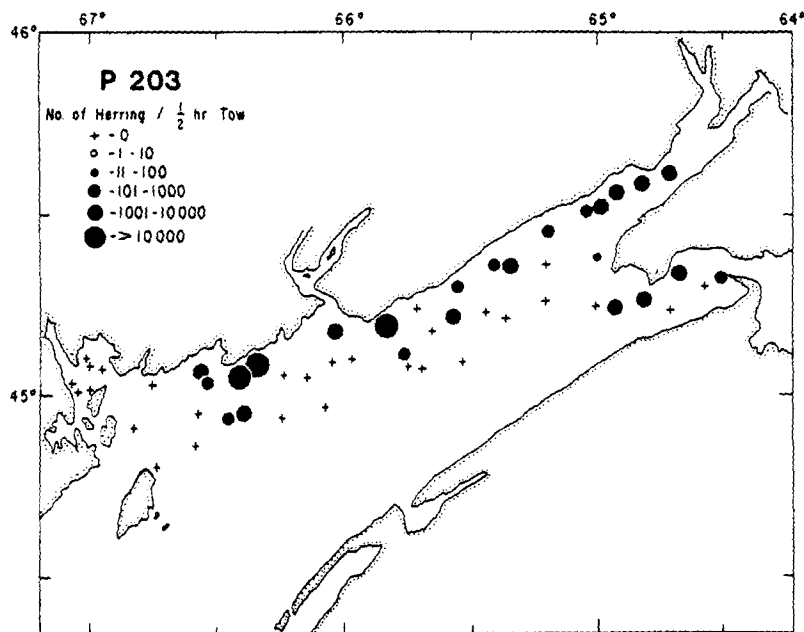


Figure 8. Number of herring caught per standard tow in August 1978.

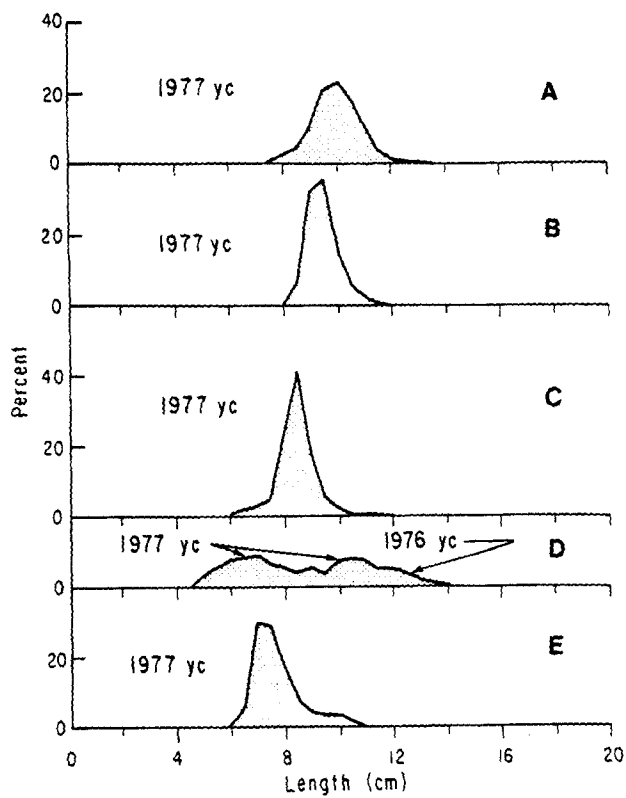


Figure 9. Length frequencies from the August 1978 cruise.

- A. Passamaquoddy Bay to Musquash Head (n=1774)
- B. Musquash Head to Cape Spencer (n=802)
- C. Cape Spencer to Martin Head (n=839)
- D. Chignecto Bay (n=1782)
- E. Minas Channel (n=954)

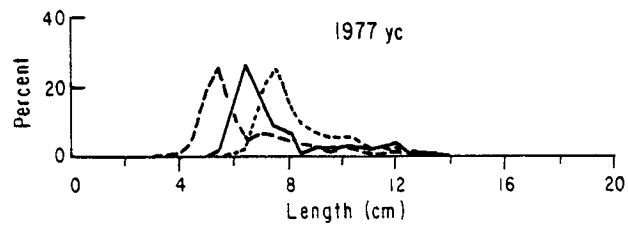


Figure 10. Length frequencies from three individual midwater trawl sets (Stations 30, n=168; 33, n=403; and 40, n=290) made at the head of the Bay of Fundy in August 1978

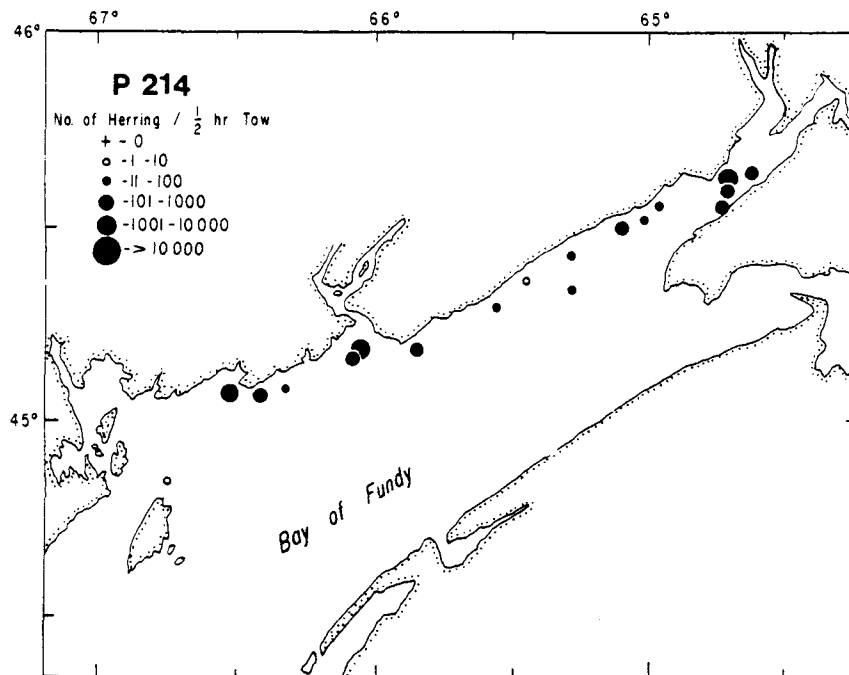


Figure 11. Number of herring caught per standard tow in February 1979

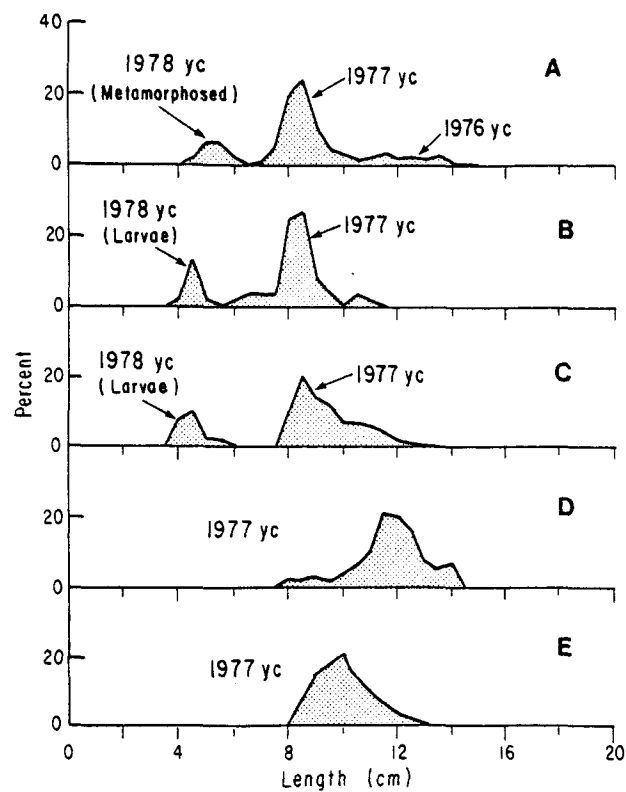


Figure 12. Length frequencies of herring caught during the February 1979 cruise.
 A. Chignecto Bay (n=1459)
 B. Chignecto Bay to Quaco Head (n=52)
 C. Quaco Head to Maces Bay (n=677)
 D. Maces Bay (n=214)
 E. Maces Bay (n=238)

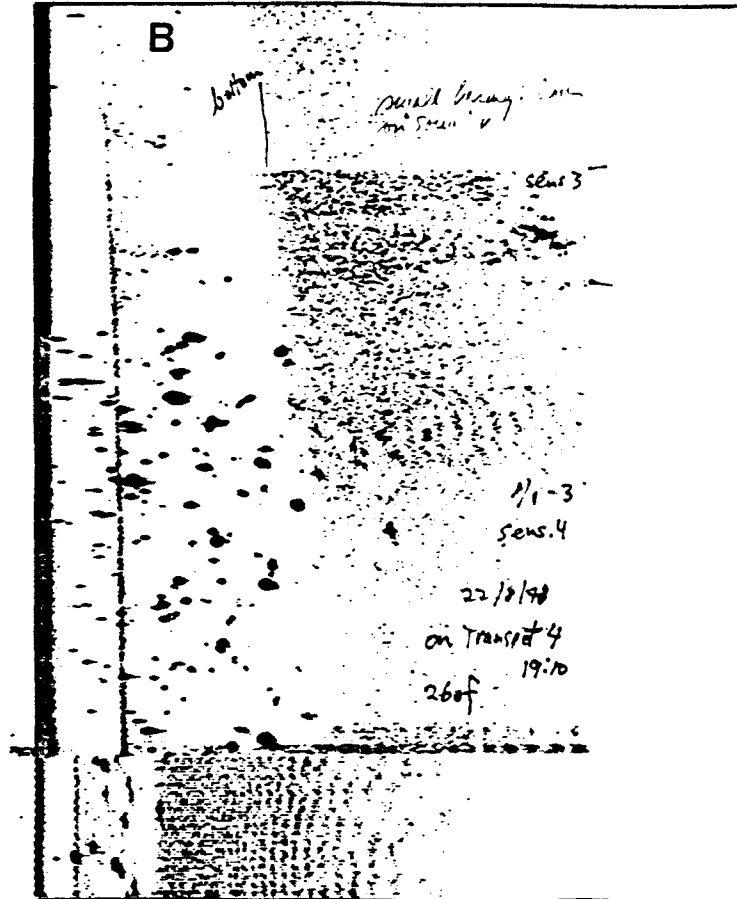
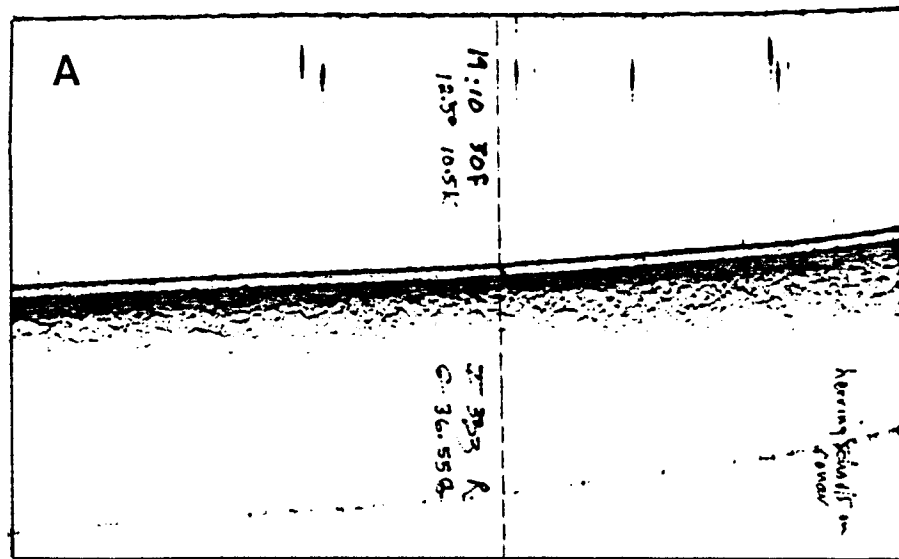


Figure 13. A. Sounder traces of brit schools during daylight hours.
 B. Side-scanning sonar traces of brit schools taken at the same time as A. Bay of Fundy, August, 1978.