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1999 Evaluation of 4VWX Herring

by

R.L. Stephenson, M.J. Power, K.J. Clark, G.D. Melvin,
F.J. Fife, S.D. Paul, L.E. Harris, and S. Boates

Marine Fish Division
Maritimes Region, Science Branch
Biological Station
531 Brandy Cove Road
St. Andrews, New Brunswick, E5B 2L9

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Abstract

Fishery, sampling and research results are compiled and used to evaluate the status of herring in the 4VWX area. Spawning stock biomass (SSB) of the southwest (SW) Nova Scotia herring spawning component was estimated from industry based acoustic surveys of spawning grounds to be at least 520,000t. Age composition continues to improve, but the population contains few fish older than the 1992 year-class. Large amounts of spawning fish were documented on German Bank and in Scots Bay, but spawning was again absent from the Seal Island grounds, and the Trinity Ledge spawning group remains below the level of the early 1980's.

The 1998 fishery for herring on the Scotian Shelf Banks landed 5,580t, substantially less than in the previous two years. The second year of a larval herring survey indicated spawning on the Western/Sable Island Bank area, and greater herring abundance in 1998 than in 1997. The July bottom trawl survey indicated a general increase in abundance and distribution. Age composition from both the fishery and research surveys showed a dominant 1992 year-class.

The fisheries and stock status of spawning groups along the coast of Nova Scotia remain undocumented except for Little Hope and Eastern Passage. A questionnaire survey improved documentation of these coastal spawning areas and fisheries, but further information is required to evaluate stock status. There is continued concern for the status of the Bras d'Or Lakes spawning herring.

Résumé

Les résultats de la pêche, de l'échantillonnage et de la recherche ont été compilés et utilisés pour l'évaluation de l'état du hareng en 4VWX. La biomasse du stock de géniteurs (SSB) de la composante de frai du hareng du sud-ouest (SW) de la Nouvelle-Écosse a été estimée à au moins 520 000 t à partir des résultats des relevés acoustiques des frayères réalisés par l'industrie. La composition par âge continue de s'améliorer, mais la population comprend peu de poissons antérieurs à la classe d'âge de 1992. D'importantes densités de géniteurs ont été décelées sur le banc German et dans la baie Scots, mais le frai était toujours absent des fonds de l'île Seal et le groupe de géniteurs de la chaussée Trinity demeurait bien en deçà de son effectif du début des années 1980.

La pêche du hareng de 1998 sur les bancs du plateau néo-écossais a permis de débarquer 5 580 t de poisson, soit beaucoup moins qu'au cours des deux années précédentes. Un relevé des larves de hareng réalisé pour la deuxième année a montré l'existence de frai dans la région du banc Western et de l'Île de Sable et une plus grande abondance en 1998 par rapport à 1997. Le relevé au chalut de fond réalisé en juillet indiquait une augmentation générale d'abondance et de la répartition. La composition selon l'âge déterminée à partir des relevés de pêche et de relevé de recherche montre la dominance de la classe d'âge de 1992.

À l'exception de Little Hope et du passage Eastern, la pêche et l'état des groupes de géniteurs le long de la côte de la Nouvelle-Écosse demeurent à vérifier. Une enquête par questionnaire a permis d'améliorer les connaissances de ces zones de frai et de pêche côtières, mais d'autres renseignements devront être obtenus pour évaluer l'état des stocks. On continue de s'inquiéter de l'état de la composante de géniteurs du hareng des lacs Bras d'Or.

Evaluation of 4VWX Herring

1) Background and Context

1.1 Management Plan and Objectives

The 1998 Scotia-Fundy herring integrated fisheries management plan (Anon (DFO) 1998a) set out principles, conditions, and management measures for the 4VWX fisheries.

The 4VWX management unit is known to contain a number of spawning areas separated to various degrees in space and time. For the purposes of evaluation and management, the 4VWX fisheries are divided into four components (Fig. 1):

1. Southwest Nova Scotia/Bay of Fundy spawning component
2. Offshore Scotian Shelf banks spawning component
3. Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia spawning component; and
4. Southwest New Brunswick migrant juveniles.

Recognizing that each component has several spawning areas, and that there is mixing of fish outside the spawning season, industry and management have developed approaches to distribute fishing effort among spawning components according to their relative size and to take appropriate account of interaction among components (such as restrictions on fishing in some areas of mixing).

The main principle stated in the plan was “the conservation of the…stock and the preservation of all of its spawning components”.

Specific objectives were reviewed and developed further during 1997 (Sinclair 1997). Three objectives and a number of targets within these objectives have been defined:

1. To maintain the reproductive capacity of herring in each management unit;

    - persistence of all spawning components in each management unit;
    - maintenance of biomass of each spawning component above a minimum threshold;
    - maintenance of a broad age composition for each spawning component; and
    - maintenance of a long spawning period for each spawning component.

2. To prevent growth overfishing;

    - maintain fishing mortality at or below F0.1

3. To maintain ecosystem integrity/ecological relationships (“ecosystem balance”).

An “in-season” management process, first implemented in the southwest Nova Scotia fishery during 1995 (Anon 1997, 1998b; Stephenson et al. 1996, 1997, 1998, 1999) continued to be used widely, and was extended to other areas and fisheries within the 4VWX management area. The approach encouraged surveying using the commercial fishing fleet under scientific direction prior to fishing to ensure that fishing effort was distributed appropriately among various components of the stock (particularly among spawning components) according to the relative

size and current state of each component. It improved data collection and enabled modifications to management decisions to be made with the involvement of participants and on the basis of up-to-date information. The 1998 management plan extended the Dockside Monitoring Program (DMP) further to improve documentation of landings by the fixed gear sector.

1.2 Pelagics Research Council

The Pelagics Research Council (PRC) is an organization created by the herring and mackerel fishing industry in 1996 to sponsor and promote research projects which will increase the state of knowledge of these species thereby improving fisheries management. In 1998 the PRC undertook a set of research projects in collaboration with DFO and the Nova Scotia Dept. of Fisheries and Aquaculture including:

Technical training of vessel crew members and captains so that they have an appreciation of biological methods and rationale and are competent in sampling and tagging.

Enhanced biological sampling in mackerel and herring fisheries throughout Scotia-Fundy area.

An acoustic survey of the Scotian Shelf at expected spawning time using industry vessels.

An ichthyoplankton survey of the Scotian Shelf to document spawning

Initiation of a new tagging program to resolve issues of stock structure and movement of herring and mackerel (Paul 1999).

A questionnaire survey of coastal herring and mackerel fishers from Cape Breton to Yarmouth to document spawning areas, and to improve knowledge of trends and activity in this relatively undocumented part of the fishery.

Improved acoustic survey methods, including improved editing and advancement in the area of quantitative sonar (in collaboration with Univ. of New Brunswick Ocean Mapping Dept.).

Organization and conduct of acoustic surveys of spawning areas and major aggregations of herring

Initiation of a genetic study of herring population structure using advanced methods (through collaboration with Dalhousie University).

Documentation of incidental catches in the purse seine fishery.

Analysis of information on several aspects of herring and mackerel ecology, including fluctuations in fat content, relationship between distribution and hydrographic conditions, turnover rate on the spawning grounds, and a literature review regarding the management of herring in an ecosystem context.

2) SW Nova Scotia/Bay of Fundy Spawning Component

2.1 The 1998 Fishery

The TAC in 1998 for this component was set at 90,000t (an increase from 57,000t allocated the previous two years), with 71,280t (80%) allocated to the mobile gear sector 17,820t (20%) to the fixed gear sector (Anon (DFO) 1998a). In order to facilitate involvement in surveying, 2000t (50t/license) of the mobile gear quota was retained by the Department, to be reallocated as compensation for surveying. Continuation of the in-season management approach resulted in continued improvement in sampling and in ongoing discussion and review of the fishery. Again, fishing on spawning aggregations operated under a "survey, assess then fish" protocol, in which spawning aggregations were surveyed and predefined conditions had to be met before that part of the fishery was allowed to take place.

Total landings from this component were 78,139t for the 1998 calendar year and 77,027 for the 1997/8 quota year (Table 1,2,3; Fig. 2). Landings for the 1997/98 quota year by the purse seine sector (70,332t, which included some quota reallocated from the fixed gear sector) were higher than in 1997, reflecting the higher quota. Landings by Nova Scotia weirs (4,464t) were similar to 1997, but gillnet landings (2,231t) were lower, reflecting primarily poor market conditions.

The distribution of herring as reflected by the fishery was similar to time periods when the biomass was at moderate to high levels. Herring occurred in the usual summer feeding and pre-spawning areas, and with the exception of an absence of fishing on Seal Island and limited spawning at Spectacle Buoy, at all major spawning locations at the expected times. As has been the case for several years, there was only a limited abundance of herring during the winter months in Chedabucto Bay, where during the 1970's and 1980's a fishery took place on large overwintering aggregations (Appendix I - fleet activity).

2.2 Resource Status

<u>Acoustic surveys</u>

Building on developments since 1995, acoustic surveys of major spawning areas and some of the major fishing areas were undertaken using the acoustic equipment on commercial vessels (Melvin et al. 1999). Sonars and sounders of the purse seine fleet, and sounders of the gillnet fleet were used to document the number, location and approximate size of herring schools. Five acoustic recording devices (four permanently aboard purse seiners, and one mobile unit used on purse seiners and gillnet vessels) allowed the logging of quantitative records for later analysis from 'structured surveys' and during many fishing trips in 1998. Surveys with automated recorders were edited as described by Melvin et al. (1999) using standard quantitative acoustics methods. Biomass estimates were made using standard target strength relationships.

Due to the increased number of quantitative acoustic recording systems, mapping records collected from vessels without quantitative recording gear made up a smaller fraction of available information in 1998. Mapping information was used to define school size in acoustic

surveys, and was quantified using the area and a relative density category (light, medium and heavy) as in recent years (Melvin et al. 1988, 1999; Paul 1998).

There was a deterioration in 1998 (compared to 1996 (Stephenson et al. 1997) and 1997 (Melvin et al 1998, Stephenson et al 1998)), in the number of 'structured survey' estimates made by the purse seine and gillnet fleets, but there was better surveying of school size in association with fishing operations.

The 1998 estimates from spawning grounds (Table 4) documented over 500,000t of spawning herring. As these surveys were separated by at least 10 day periods, double counting was thought to have been avoided. The observed spawning stock biomass was higher on German Bank than in the previous year, but lower in other areas primarily due to reduced survey coverage (Melvin et al. 1999).

Catch at age

Biological sampling continued to improve with additional processing plant, vessel crew and PRC sampling. Table 5 shows the distribution of length frequency and detail samples, including numbers aged, from the 1998 fishery.

The 1992 (age 6), followed by 1994 (age 4) and 1993 (age 5) year-classes dominated the 1998 landings from this fishery in weight, but the 1996 year-class (age 2) was most prevalent in number (Table 6). The contribution of the strong 1992 year-class improved the fraction of fish age 6+ in the population (Fig. 3), however, the expected distribution at age under F0.1 fishing and average recruitment would include a greater fraction of herring ages 7+ (Fig. 4), and the very low numbers older than the 1992 year-class remains a negative aspect of the age composition of this stock at the present time.

Larval Abundance

The Bay of Fundy larval herring survey was undertaken between October 28 and November 9, 1998 (Fife 1998 MS). The larval abundance index of 33.6 larvae m^2 was higher (Fig. 5,6; Table 7) than it has been the previous four years, and above the average of the 27 year time series. The larval abundance series indicates a progressive recovery from a low in 1994, although the sudden, large drop in larval abundance index in 1994 remains difficult to explain.

Sources of uncertainty

The acoustic estimation process used in this evaluation is still in the developmental stage. There has been continued positive evolution of acoustic biomass estimates using recording devices on industry vessels, but there is need for improved survey coverage (spatial and temporal), as well as further investigation of the duration of the spawning stages, and investigation of target strength. There is a need to provide a means of comparing acoustic survey observations and forming an index of abundance that is comparable between years. The use of standardized survey areas and an acoustic design based on historical fishing patterns has been proposed (Melvin and Power 1999).

2.3 Ecosystem considerations

Herring is a prominent species in the diets of many other fish, birds and marine mammals, and should be managed with these interactions in mind. At present, a natural mortality rate of 0.2 is assumed to account for these interactions. Recent management initiatives to protect spawning components are intended to maintain biodiversity of herring stock structure.

Since 1994 when low fat content and poor condition of herring were observed, there has been increased interest in the condition and behaviour of herring as it relates to environmental conditions. Fat content information from 1987 to 1998 gathered from records of three processing plants (Appendix II) indicated that the fat content of herring in 1998 was below average, but not as low as in 1994.

Preliminary analysis of the distribution of humpback and finback whales (predators of herring) in the month of August (Appendix III) indicated that since 1995 there have been fewer animals near the Long Island shore of Nova Scotia than in the early 1990's. Some of these animals are known to have been in the vicinity of dense herring aggregations on German Bank in 1998.

Examination of the catch composition of 1,404 sets spanning 9 years of the 4WX herring purse seine fishery (Appendix IV) shows that there is little by-catch. Further, the nature of the purse seine fishery allows release of sets in which by-catch is detected early in the setting process.

2.4 Outlook

Acoustic surveys documented 520,000t of herring on spawning grounds. As there was incomplete coverage, especially of Scots Bay, this is considered to be a minimum estimate of SSB.

Surveys and fishing confirmed the presence of large amounts of herring on German Bank. Scots Bay spawning was documented to have taken place over a long time period, but the lack of surveys for about a month during the peak period of spawning resulted in a lower observed spawning biomass than in 1997. Observed spawning stock biomass at Trinity Ledge was lower than in 1997, and although this was considered to be an underestimate because of insufficient survey coverage, it is concluded that the Trinity Ledge spawning area has not fully recovered, and remains below historical levels. There remains concern that there was no spawning observed in the traditional Seal Island area and limited spawning at Spectacle Buoy.

Substantial aggregations of herring were documented outside the spawning areas. The geographical distribution of herring during the summer feeding period was as expected from observations in previous years when the stock was at moderate to high abundance.

The 1998 TAC was not caught, but this is attributed primarily to allocations and market conditions, rather than resource status.

The age composition has improved, with age 6+ making a greater than average contribution to the catch (18% by number, 36% by weight), but there were very few fish older than the 1992 year-class. The prevalence of the 1996 year-class in the catch and in a very large aggregation of young over-wintering herring documented off Chebucto Head, may indicate the presence of a strong recruiting year-class.

The 1998 larval herring abundance index from the Bay of Fundy survey, which is considered to represent spawning stock biomass near the end of the fishery, has increased over the past four years, indicating growth of the spawning biomass to above the average of the past 25 years.

The substantial reductions in TAC and landings implemented in the past four years have had a positive impact on the rebuilding of this component. The spawning stock biomass appears to have increased from the low experienced about 1994 to above 520,000t in 1998.

The previous assessment of this component suggested that fishing mortality should remain below $F_{0.1}$ (about 20% exploitation rate) for a number of years in order to rebuild spawning stock biomass in all spawning areas and improve age composition. These improvements in stock status will take time, and it would be prudent to continue to fish below $F_{0.1}$. The long-term $F_{0.1}$ yield for this component, assuming average recruitment, is estimated to be about 110,000t. Assuming that the 520,000t observed SSB is a minimum, fishing at 105,000t in 1999 should generate an F less than $F_{0.1}$ that will allow continued growth of SSB and further improvement of age composition.

2.5 Management Considerations

The in-season management approach, which spreads the effort in the fishery spatially and temporally among spawning components, is seen as beneficial in achieving the objectives related to maintaining spawning potential.

The "survey, assess, then fish (≤20%)" decision rule was implemented as an experimental approach, in addition to the TAC, to spread the fishing effort among spawning components in proportion to their relative size. The 1998 assessment suggested that the portion of surveyed spawning biomass taken on the spawning grounds should be reduced below 20% to account for the amount that might be taken in fisheries outside the spawning season. If all the spawning fish were being surveyed, and if the 20% of each surveyed portion of the spawning component were taken, the protocol could allow disproportionate catch from some spawning areas. At present however, survey coverage is incomplete, and suballocations based on the 20% protocol have not usually been taken. While the protocol would be improved by using a percentage less than 20%, this is seen as a minor refinement of a management decision-making procedure that is very valuable as currently used.

Acoustic surveys have become critical to stock status evaluation. It is important that there be continued improvement in coverage and survey design, and attention must be paid to developing year-to-year consistency in these surveys. A plan for "structured surveys" has been proposed (Melvin and Power 1999).

3) Offshore Scotian Shelf Banks Spawning Component

3.1 Stock Structure and Management Unit

Evidence of increasing presence of herring (e.g. in research vessel surveys) and of spawning offshore from research surveys and occasional fishing excursions within the past decade have suggested that there is a discrete offshore spawning component. The presence of ripe herring in

catches in 1986, of spawning herring in research surveys in 1997, of larvae in scientific surveys (1991-93, 1997-98), and the consistent presence of large herring on the Scotian Shelf in summer trawl surveys are all consistent with the treatment of the offshore banks as a separate management unit.

An analysis of ichthyoplankton data and records of spawning herring from a compilation of all available information from the Scotian Shelf indicates that spawning takes place on central Sable Island Bank during the second half of October, although the precise location and extent of egg beds have not been determined (Harris and Stephenson 1999).

A larval herring survey was conducted in November 1997 and again in November 1998 in collaboration with the PRC and Dalhousie University and these surveys have been the only broad scale directed larval surveys for herring on the offshore Scotian Shelf since the Scotian Shelf Ichthyoplankton (SSIP) surveys ended in 1982. They confirm the presence of small herring larvae offshore, presumed to originate from spawning on the offshore banks, in addition to small larvae near-shore from coastal spawning. Fall ichthyoplankton surveys in both 1997 and 1998 (Fig. 7) showed a high concentration of recently hatched larvae in the Western/Sable Island Bank area. Maximum densities in 1998 (713 larvae/100 m^3) were an order of magnitude greater than those in 1997 (69 larvae/100 m^3) (Reiss et al. 2000 MS).

3.2 The Fishery

A foreign fishery during the period 1963-1973 is estimated to have removed as much as 60,000t in a year from the offshore Scotian Shelf banks (Stephenson et al. 1987). There had been little effort or herring catch after the extension of jurisdiction until 1996 when a fishery was initiated by the 4WX purse seine fleet and 11,745t was taken.

The 1998 fishing activities offshore occurred from May 7 to June 26. There were many reports of unusual herring behavior making the fish difficult or impossible to catch. Several commercial fishers found that, in certain areas, herring were staying very close to bottom and not exhibiting the characteristic vertical movement toward the surface. Others stated that herring were rising to the surface very quickly then dispersing making them impossible to catch by purse seine. Many of the fishers felt that these changes in behavior were due to changes in the environment, particularly ocean temperatures. Catches were focused on and around Emerald Basin, The Patch and Mackenzie Spot. The 1998 fishery for herring on the Scotian Shelf landed 5,579t, substantially less than the two previous years (11,745t in 1996 and 20,261t in 1997). The reduction in catch is attributed to changes in herring behavior and distribution.

3.3 Resource Status

The 1998 offshore banks fishery was dominated both in number and weight by the 1992 year-class (age 6; 37% by weight, 33% by number), followed in importance by 1993 and 1994 year-classes (Fig. 8). Age 6+ made up 56% of the catch by weight. The age structure in the fishery has varied over the last three years, and is not helpful in determining stock status. The age distribution from the 1998 July bottom-trawl survey was also dominated by the 1992 to 1994 year-classes (Harris and Stephenson, 1999).

Results from the summer bottom trawl survey showed few herring on the Scotian Shelf during the 1970's, but increasing amounts during the 1980's and a relatively widespread distribution recently. Offshore herring catches during the 1998 July bottom trawl survey were second highest in the 29-year time series at 96 fish per standard tow (Fig. 9). Herring were widely distributed on banks west of Sable Island (Harris and Stephenson, 1999).

There is little quantitative information on which to evaluate the status of this stock. The second year of the larval herring survey indicated spawning on the central portion of Sable Island Bank, and greater herring abundance in 1998 than in 1997

3.4 Outlook

The foreign fisheries between 1969 and 1973 did not appear to be sustainable. Landings from this time period ranged from 13,000t to 60,000t. There continues to be the need for increased industry/science surveys to estimate abundance.

3.5 Management Considerations

There is insufficient documentation of the stock size, distribution, and spawning behavior of this component. Industry, science and management are encouraged to continue to work together to develop a medium term strategy (i.e. over the next few years) for assessment and exploitation of the herring on the Scotian Shelf outer banks.
The need for decision rules for management of this fishery has been identified.

4) Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia Spawning Component

4.1 The Fishery

There has been a considerable increase in the number of active gillnet licenses in recent years. This was the third year of the fishery on spawning fish east of Halifax and the second year of a gillnet roe fishery off Little Hope. There has been a marked increase in the gillnet roe fishery off Glace Bay.

Recorded landings by gillnet along the coast of Nova Scotia totaled 4,192t in 1998, an increase of 41% from the recorded landings of 1997 (2,965t). Landings in major coastal Nova Scotia gillnet fisheries are shown in Table 8.

4.2 Resource Status

Several aspects of this component and its fishery have been documented in a recent questionnaire survey of fishers conducted by DFO Science and the PRC (Clark et al. 1999). With the implementation of mandatory log records, the landings in the inshore fishery are being documented with improved accuracy, however, apart from a few areas, there remains insufficient information to evaluate stock status. The major fisheries of this component are discussed below.

East of Halifax

The October roe fishery lasted from September 27, 1998 to October 24, 1998 and landed 1,100t. Recorded landings were lower than in 1997, due largely to bad weather that prevented the boats from fishing.

One acoustic survey involving 15 vessels was held in the Eastern Passage area on October 22, 1998. The overall estimate of the amount of herring seen was approximately 8,000t.

The fishery was dominated by age 6 (1992 year-class) followed by age 7 (1991 year-class) in both number and weight (Table 9, Fig. 10).

Little Hope

The fishery occurred in the Little Hope area, southwest of Liverpool, N.S., from September 30 to October 20, 1998. A total of 1,170t was landed by gillnet fishers, an increase of 117% over the recorded landings from 1997.

Two surveys of the area were undertaken in 1998. A mapping and acoustic survey, undertaken October 6, 1998, documented 7,000t while another mapping survey on October 17 documented a further 7,100t, for a total of approximately 14,000t.

The Little Hope fishery was sampled extensively during the 1998 fishing season with 25 length frequency samples collected. The majority of fish were ripe and running (maturity stage 6). Landings were dominated by the 1992 year-class (age 6), followed in importance by the 1991 and 1990 year-classes (Table 9, Fig. 11).

From the questionnaire survey (Clark et al. 1999) it appears that there has been little coastal herring fishing in Shelburne County in recent years, apart from the Little Hope roe fishery. The Scotia-Fundy Inshore Fishermen's Association stated that this is due to reduced abundance of herring.

Glace Bay

A new fishery has developed off Glace Bay, Cape Breton in the past two years. The 1998 fishery occurred from the Red Grounds off Sydney Mines to Scaterie Island. Gillnet fishers landed 1,730t from August to October 1998, an order of magnitude more than 1997.

No surveys were conducted in this area.

Seven samples were obtained from the fishery. The majority of the fish (92%) were ripe and running (maturity stage 5 and 6).

The 1991 year-class (age 7) was dominant in numbers and weight, followed in importance by the 1992 and 1990 year-classes (Table 9, Fig. 12).

Bras d'Or Lakes

The gillnet fishery occurred in the Bras d'Or Lakes from March 30 to May 18, with the majority of fishing activity taking place between April 20 and May 1. The duration of the fishery was similar to previous years, with the exception of the unusually short season in 1997.

A number of management measures were put into place in 1998 in an attempt to reduce landings by 50%. Overall recorded landings for 1998 were 122t, down 26% from 164t in 1997.

In 1998, there was very little ice on the Lakes allowing an early start to the season as well as the setting of nets in St. Andrew's Channel, an area that is usually covered in ice. This led to a concentration of effort in the Groves Point area in addition to the usual locations such as Baddeck Bay and the Barra Strait. Landings from the Marble Mountain to McKinnon's Point area were low in 1998, since part of the traditional fishing area was closed.

The results of egg bed surveys conducted on a continual basis were combined with information received from other sources to identify spawning sites in 1998. Spawning was reported in seven areas in 1998, an increase over three areas identified in 1997. Spawning was observed in several locations in the Northwest part of Bras d'Or Lake at Benacadie, Eskasoni Harbour and Christmas Pond, Lime Hill, Baddeck and Groves Point.

The Bras d'Or Lakes were sampled extensively during the 1998 fishing season. The majority of the fish (46%) were spent and recovering (stage 7 and 8) with 38% ripe or ripe and running (maturity stage 5 and 6). In 1998 16% of the fish were autumn spawners, a marked increase from 1997. This verified the information provided by fishers that indicated that there was a greater proportion of fall spawners in 1998 than in previous years. The 1990 year-class (age 8), 1991 and 1989 year-classes were most prevalent (Table 9, Fig. 13). The absence of recruiting herring, noted last year, is again apparent in the very small fraction of age 4-6 herring in the catch.

4.3 Outlook

There is increasing pressure to develop fisheries (especially for roe). These new fisheries are being proposed in the absence of knowledge of the current level of fishing pressure or estimates of spawning group status.

The fixed gear herring fishery in the coastal Nova Scotia spawning component has been largely unrestricted and undocumented. Recent changes to management and the recent questionnaire survey have improved knowledge, but few of the spawning areas have been studied. Age composition is known for a couple of areas, but for the most part, sampling has been inadequate. The lack of knowledge of specifics of stock structure, lack of documentation of the historical fishery, and limited survey information preclude evaluation of current fishing mortality. Individual spawning groups within this component are vulnerable to fishing because of their relative small size and proximity to shore.

4.4 Management Considerations

There was a review during the Regional Assessment Process (Sinclair 1999) of the "survey, assess, then fish" protocol. In coastal Nova Scotia there is no overall quota, and the size and historical performance of various spawning groups are poorly documented. In addition to traditional fisheries for bait and personal use there have been new directed fisheries on the spawning grounds for a roe market. The following draft guidelines were proposed to assist discussion of decision making in the range of situations encountered in the coastal Nova Scotia spawning component:

Spawning Areas with a Known History

In the case of spawning components where there has been at least 5 years of biomass estimates, where the approximate size of the fishery outside of the spawning area is known, and where the spawning components are considered to be healthy and of sufficient size, up to 10% of the surveyed biomass would be appropriate under the survey/assess/fish protocol.

Spawning Areas without a Known History and New Fisheries

For spawning components for which there are less than 5 years of biomass estimates or for new roe fisheries, the allocations should be less to reflect the greater uncertainty of the situation. It is suggested that an appropriate allocation would be a maximum of 5% of surveyed biomass if a large body of fish (greater than SSB threshold defined under objectives) has been documented, but that the allocation should be lower if only a moderate body of fish (less than threshold) is documented. These thresholds need to be defined.

Spawning Areas for which there is Concern

For spawning components for which there is concern (i.e. evidence of poor recruitment, decrease in spawning locations, low larval abundance, poor catches, narrow age distributions in the catch), surveys should be conducted, but no fishing should be undertaken.

5) Southwest New Brunswick Migrant Juveniles

The southwest New Brunswick weir and shutoff fishery has relied, for over a century, on the aggregation of large numbers of juvenile (ages 1-3) herring near shore at the mouth of the Bay of Fundy. These have traditionally been considered to be a mixture of juveniles, dominated by fish originating from Subarea 5 spawning components, and have therefore been excluded from the 4WX quota. Mature herring (ages 4+) taken in this fishery are considered to be of 4WX origin.

The number of active weirs and distribution of weirs has decreased over the past decade, due in part to the conversion of sites to aquaculture. The 1998 catch (20,091t) was very close to that of the previous year, but below the 36 year average of about 26,000t (Fig. 14).

Sampling of this fishery has been extensive. The 1998 catch was, as usual, dominated by age 2 (88% by number; 75% by weight), followed by age 3. Only a small proportion (3% by nos., 11% by weight) were ages 4+ (Table 10, Fig .15).

The recent US management plan (NEFSC 1998) assumes that all of the juvenile herring from this fishery originate from the US “coastal complex” which is considered to be at high abundance. The assumptions of stock affinity should be studied as part of the new tagging program.

References

Anon. 1997. In-season management in the 4WX herring fishery. DFO Science Stock Status Report 97/2E: 5p

Anon. 1998a. 1998 Scotia-Fundy fisheries integrated herring management plan, NAFO sub-divisions 4WX, 4Vn and 5Z. Department of Fisheries and Oceans: 105p.

Anon. 1998b. 4VWX Herring. DFO Science Stock Status Report, B3-03 (1998): 12p.

Clark, K.J., D. Rogers, H. Boyd and R.L. Stephenson. 1999. Questionnaire survey of the coastal Nova Scotia herring fishery, 1998. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/137: 54p.

Fife, F.J. 1998 MS. Mission Report N865. Department of Fisheries and Oceans, Science Branch, Maritimes Region: 4p.

Harris, L.E. and R.L. Stephenson. 1999. Compilation of available information regarding the Scotian Shelf herring spawning component. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/181: 30p.

Mace, P.M. 1985. Catch rates and total removals in the 4WX herring purse seine fisheries. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 86/74: 31 p.

Melvin, G.D., K.J. Clark, F.J. Fife, M.J. Power, S.D. Paul and R.L. Stephenson. 1998. Quantitative acoustic surveys of 4WX herring in 1997. DFO Canadian Stock Assessment Secretariat Res. Doc. 98/81: 28p

Melvin, G.D. and M.J. Power. 1999. A proposed acoustic survey design for 4WX herring spawning components. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/63: 15p.

Melvin, G.D., T. Scheidl, F.J. Fife, M.J. Power, S. Boates, K.J. Clark, and R.L. Stephenson. 1999. Evaluation of the 1998 4WX herring acoustic surveys. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/180: 31p.

NEFSC [Northeast Fisheries Science Center] 1998. Report of the 27th Northeast Regional Stock Assessment Workshop (27th SAW). Woods Hole, MA: NOAA/NMFS/NEFSC. NEFSC Ref. Doc. 98/xx: 60-74 (in press).

Paul, S.D. 1998. Fleet activity in the 1997 4WX herring fishery. DFO Canadian Stock Assessment Secretariat Res. Doc. 98/82: 29p.

Paul, S.D. 1999. Report of the 1998-1999 4VWX herring and mackerel tagging program and plans for 1999-2000. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/138: 25p.

Reiss, C.S., R.L. Stephenson, C.T. Taggart and M.J. Power. 2000MS. Resurgence of offshore Atlantic herring on the central Scotian Shelf: larval distribution in relation to dynamic circulation. (submitted to Can. J. Fish. Aquat. Sci.)

Sinclair, M. (Chair). 1997. Report of the Maritimes Region herring workshop, 18-19 February 1997. Canadian Stock Assessment Proceedings Series, 97/12: 58p.

Sinclair, M. (Chair). 1999. Proceedings of the Marine Fisheries Subcommittee, Regional Advisory Process, Maritimes Region, 29-31 March 1999. Canadian Stock Assessment Proceedings Series, 99/26: 40p.

Stephenson, R.L., D.J. Gordon and M.J. Power. 1987. Herring of the outer Scotian Shelf and Georges Bank: history of the fisheries, recent developments and management considerations. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 87/76: 23 p.

Stephenson, R.L., M.J. Power, F.J. Fife, G.D. Melvin, K.J. Clark and S. Gavaris. 1996. Evaluation of the stock status of 4WX herring. DFO Atlantic Fish. Res. Doc., 96/28: 71p.

Stephenson, R.L., M.J. Power, F.J. Fife, G.D. Melvin, and S.D. Paul. 1997. 1997 Evaluation of the stock status of 4WX herring. DFO Canadian Stock Assessment Secretariat Res. Doc. 97/61: 28p.

Stephenson, R.L., M.J. Power, K.J. Clark, G.D. Melvin, F.J. Fife and S.D. Paul. 1998. 1998 evaluation of 4VWX herring. DFO Canadian Stock Assessment Secretariat Res. Doc. 98/52: 58p.

Stephenson, R.L, K. Rodman, D.G. Aldous and D.E. Lane. 1999. An in-season approach to management under uncertainty: the case of the SW Nova Scotia herring fishery. ICES J. Mar. Sci. 56: (in press).

Table 1. 4VWX herring fishery landings (t) by month, gear sector and management unit for 1999 (calendar year).

			Month												
	Area	**Gear**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	*Total*
Coastal Nova Scotia															
(South Shore,	4Vn	Trap				9	115	39	18						181
Eastern Shore,	4Vn	Gillnet				101	21	1	3	190	872	671			1,858
Cape Breton)	4W	Gillnet				31	10	2			175	925	0		1,143
	4X	Trap						1		5	0		1		7
	4X	Gillnet					0	1	0	24	193	976	0		1,194
Coastal Nova Scotia Total						141	146	44	21	219	1,240	2,571	1		4,383
Offshore S.S.	4W	Offshore P. Seine					519	3,804	16						4,339
	4X	Offshore P. Seine					921	297	22						1,240
	4X	Bottom Trawl		1	0	0	1	2	5	1	0	2	1	0	12
Offshore S.S. Total				1	0	0	1,441	4,103	43	1	0	2	1	0	5,591
S.W. Nova Scotia	4W	Fall/Winter P. Seine											1,583		1,583
	4X/5Y	Fall/Winter P. Seine	343									1,768	318		2,429
	4X	Summer P. Seine					308	2,484	14,611	15,835	22,098	6,807			62,144
	5Y	Grand Manan P. Seine						1,889	354	14		3,932			5,289
	4X	Gillnet "Stock"					17	492	36	185	1,502				2,231
	4X	N.S. Weirs					1,614	1,783	391	359	317				4,464
S.W. Nova Total			343				1,938	6,648	15,392	16,393	23,917	11,606	1,901		78,139
Migrant	4X	N.B. Weirs					250	608	3,831	8,295	5,604	525			19,113
Juveniles	4X	N.B. Shutoff							5	174	409	391			978
Migrant Juvenile Total							250	608	3,836	8,469	6,013	916			20,092
Overall Total			343	1	0	141	3,776	11,404	19,291	25,081	31,170	15,095	1,903	0	108,205

Table 2. Southwest Nova Scotia component quota landings (t) for October 1997 to October 1998 quota year.

4WX (SW Nova Scotia)	**Period during Quota Year**	**Landings**
4W Purse Seine	Oct. 16, 1997 to Dec. 31, 1997	1,405
4X Fall/Winter P. Seine	Oct. 16, 1997 to Feb 1, 1998	1,494
4X Summer P. Seine	May to Oct. 15, 1998	67,433
4X Summer Gillnet (stock[1])	May to Oct. 15, 1998	2,231
N.B. Midwater Trawl	Jan. to Apr., 1998	
N.S. Weirs	May to Oct., 1998	4,464
Total Against Quota		**77,027**
Age 4+ from N.B. Weirs	May to Oct., 1998	2,242
Overall Total		**79,269**

[1] 4X Gillnet (stock) is defined as gillnet landings, west of Baccaro Point, in statistical districts 32 to 40.

Table 3. Historical series of nominal and adjusted annual landings (t) by major gear components and seasons of the 4WX herring fishery, 1963-1998.

Year^	4W Winter Purse Seine	4Xs Fall&Winter Purse Seine	4Xqr Summer Purse Seine	4X Summer Gillnet	4Xr Summer Weir	4WX Stock Nominal Landings	4WX Stock Adjusted Landings*	4WX Stock TAC	Non-Stock 4Xs Weir and Shutoff	Offshore Scotian Shelf Banks	Total 4WX Adjusted Landings
1963		6,871	15,093	2,955	5,345	30,264	30,264		29,366		59,630
1964		15991	24,894	4,053	12,458	57,396	57,396		29,432		86,828
1965		15,755	54,527	4,091	12,021	86,394	86,394		33,346		119,740
1966		25,645	112,457	4,413	7,711	150,226	150,226		35,805		186,031
1967		20,888	117,382	5,398	12,475	156,143	156,741		30,032		186,773
1968		42,223	133,267	5,884	12,571	193,945	196,362		33,145		229,507
1969	25,112	13,202	84,525	3,474	10,744	137,057	150,462		26,539		177,001
1970	27,107	14,749	74,849	5,019	11,706	133,430	190,382		15,840		206,222
1971	52,535	4,868	35,071	4,607	8,081	105,162	129,101		12,660		141,761
1972	25,656	32,174	61,158	3,789	6,766	129,543	153,449		32,699		186,148
1973	8,348	27,322	36,618	5,205	12,492	89,985	122,687		19,935		142,622
1974	27,044	10,563	76,859	4,285	6,436	125,187	149,670		20,602		170,272
1975	27,030	1,152	79,605	4,995	7,404	120,186	143,897		30,819		174,716
1976	37,196	746	58,395	8,322	5,959	110,618	115,178		29,206		144,384
1977	23,251	1,236	68,538	18,523	5,213	116,761	117,171	109,000	23,487		140,658
1978	17,274	6,519	57,973	6,059	8,057	95,882	114,000	110,000	38,842		152,842
1979	14,073	3,839	25,265	4,363	9,307	56,847	77,500	99,000	37,828		115,328
1980	8,958	1,443	44,986	19,804	2,383	77,574	107,000	65,000	13,525		120,525
1981	18,588	1,368	53,799	11,985	1,966	87,706	137,000	100,000	19,080		156,080
1982	12,275	103	64,344	6,799	1,212	84,733	105,800	80,200	25,963		131,763
1983	8,226	2,157	63,379	8,762	918	83,442	117,400	82,000	11,383		128,783
1984	6,336	5,683	58,354	4,490	2,684	77,547	135,900	80,000	8,698		144,598
1985	8,751	5,419	87,167	5,584	4,062	110,983	165,000	125,000	27,863		192,863
1986	8,414	3,365	56,139	3,533	1,958	73,409	100,000	97,600	27,883		127,883
1987	8,780	5,139	77,706	2,289	6,786	100,700	147,100	126,500	27,320		174,420
1988	8,503	7,876	98,371	695	7,518	124,653	199,600	151,200	33,421		233,021
1989	6,169	5,896	68,089	95	3,308	83,557	97,500	151,200	44,112		141,612
1990	8,316	10,705	77,945	243	4,049	102,627	172,900	151,200	38,778		211,678
1991	17,878	2,024	73,619	538	1,498	97,010	130,800	151,200	24,576		155,376
1992	14,310	1,298	80,807	395	2,227	100,227	136,000	125,000	31,967		167,967
1993	10,731	2,376	81,478	556	2,662	98,464	105,089	151,200	31,573		136,662
1994	9,872	3,174	64,509	339	2,045	80,099	80,099	151,200	22,241		102,340
1995	3,191	7,235	48,481	302	3,049	62,499	62,499	80,000	18,248		80,747
1996	2,049	3,305	42,708	6,340	3,476	58,068	58,068	57,000	15,913	11,745	85,726
1997	1,759	2,926	40,357	6,816	4,019	56,117	56,117	57,000	20,552	20,261	96,930
1998	1,405	1,494	67,433	2,231	4,464	77,027	77,027	90,000	20,091	5,591	102,709

^Annual landings by purse seiners are defined for the annual plan period from October 15 of the preceding year to October 14 of the current year.

All landings by other gear types are for the calendar year.

*Adjusted totals includes misreporting adjustments for 1978-1984 (Mace 1985).

Table 4. 1998 acoustic and mapping biomass estimates for the spawning components surveyed in the 4WX stock complex (from Melvin et al. 1999).

Location	1998 Estimate
Scots Bay	72,473
Trinity Ledge	6,762
German Bank	440,704
Spectacle Buoy	1,329
Total	521,268

Table 5. Summary of biological samples (by fishery and month) taken in the 1998 4VWX herring fisheries.

		Month											
Gear Name	Data	1	2	4	5	6	7	8	9	10	11	12	Grand Total
4W Purse Seine	Sum of NO_LF				3	83					12		98
	Sum of NO_MEAS				115	9,925					1,526		11,566
	Sum of Aged				48	248					194		490
5Y Purse Seine	Sum of NO_LF					57	23	4	2	9			95
	Sum of NO_MEAS					6,794	2,650	476	262	1,261			11,443
	Sum of Aged					129	163	0	0	102			394
5Y USA Purse Seine	Sum of NO_LF										1		1
	Sum of NO_MEAS										109		109
	Sum of Aged										0		0
5Z CAN Purse Seine	Sum of NO_LF				1								1
	Sum of NO_MEAS				142								142
	Sum of Aged				32								32
5Z USA Purse Seine	Sum of NO_LF	7	1										8
	Sum of NO_MEAS	834	111										945
	Sum of Aged	0	0										0
Gillnet	Sum of NO_LF			22	4	4		6	31	23			90
	Sum of NO_MEAS			3,197	523	608		1,066	3,037	2,527			10,958
	Sum of Aged			209	30	47		114	192	35			627
Midwater Trawl	Sum of NO_LF	40	48							3	16	3	110
	Sum of NO_MEAS	4,810	5,877							354	1,902	205	13,148
	Sum of Aged	0	0							0	30	20	50
N.B. Purse Seine	Sum of NO_LF	16				5	61	30	49	38	1		200
	Sum of NO_MEAS	2,086				687	7,143	3,458	5,733	4,213	122		23,442
	Sum of Aged	0				19	50	35	74	149	0		327
N.B. Shut-off	Sum of NO_LF									5			5
	Sum of NO_MEAS									502			502
	Sum of Aged									18			18
N.B. Weirs	Sum of NO_LF				6	18	79	214	107	30	1		455
	Sum of NO_MEAS				386	2,178	9,255	24,862	11,814	3,149	102		51,746
	Sum of Aged				57	86	191	163	125	134	0		756
N.S. Purse Seine	Sum of NO_LF				15	43	150	126	117	11			462
	Sum of NO_MEAS				1,862	5,747	21,052	19,621	17,077	1,472			66,831
	Sum of Aged				139	239	882	915	616	130			2,921
N.S. Weirs	Sum of NO_LF				21	28	5	8	7				69
	Sum of NO_MEAS				2,533	2,988	610	933	687				7,751
	Sum of Aged				134	158	29	54	24				399
Otter Trawl	Sum of NO_LF									1			1
	Sum of NO_MEAS												
	Sum of Aged									20			20
Research Otter Trawl	Sum of NO_LF		13		6		74						93
	Sum of NO_MEAS				620								620
	Sum of Aged		270		53		610						933
USA Shut-off	Sum of NO_LF					3	2						5
	Sum of NO_MEAS					319	190						509
	Sum of Aged					0	0						0
USA Weirs	Sum of NO_LF					1	5						6
	Sum of NO_MEAS					114	610						724
	Sum of Aged					0	0						0
Total Sum of NO_LF		63	62	22	56	242	399	388	313	120	31	3	1,699
Total Sum of NO_MEAS		7,730	5,988	3,197	6,181	29,360	41,510	50,416	38,610	13,478	3,761	205	200,436
Total Sum of Aged		0	270	209	493	926	1,925	1,281	1,031	588	224	20	6,967

Table 6. Herring catch at age for the 1998 purse seine, weir and gillnet fisheries conducted on the southwest Nova Scotia spawning component (4WX stock) in numbers caught (thousands), % numbers, weight caught (t) and % weight by age.

SW Nova Scotia Spawning Component - Catch at age (number and weight). 1998.

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
Number	137	264,901	62,322	138,751	97,065	97,464	20,679	3,856	1,730	1,288	398	688,591
% number	0%	38%	9%	20%	14%	14%	3%	1%	0%	0%	0%	100%
Catch wt. (t)	8	10,084	4,726	18,216	17,176	20,485	5,183	1,143	534	434	150	78,140
% catch wt.	0%	13%	6%	23%	22%	26%	7%	1%	1%	1%	0%	100%
Avg. wt.	61	38	76	131	177	210	251	296	308	337	376	113

Herring catch at age for 1998 southwest Nova Scotia stock component by gear type.

Catch Numbers (000's)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
4W Purse Seine	133	2,988	2,780	2,980	1,971	1,541	168	40	21	7	11	12,640
4X N.S. Purse Seine		55,154	27,162	122,477	88,856	89,410	18,640	3,205	1,435	1,040	206	407,585
4X N.S. Weir	4	124,108	13,563	2,463	1,355	1,145	163	19				142,820
4X N.B. Purse Seine		36,176	7,095	1,005	540	51	42					44,909
5Y N.B. Purse Seine		46,348	11,434	9,272	2,609	734	76	7	1			70,481
4X Gillnet		127	288	554	1,734	4,583	1,590	585	273	241	181	10,156
Total Numbers by Age	137	264,901	62,322	138,751	97,065	97,464	20,679	3,856	1,730	1,288	398	688,591

Percent Numbers	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
4W Purse Seine	1	24	22	24	16	12	1	0	0	0	0	100
4X N.S. Purse Seine		14	7	30	22	22	5	1	0	0	0	100
4X N.S. Weir	0	87	9	2	1	1	0	0				100
4X N.B. Purse Seine		81	16	2	1	0	0					100
5Y N.B. Purse Seine		66	16	13	4	1	0	0	0			100
4X Gillnet		1	3	5	17	45	16	6	3	2	2	100
Percent Numbers by Age	0	38	9	20	14	14	3	1	0	0	0	100

Catch Weight (t)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
4W Purse Seine	8	202	269	387	331	321	41	11	6	3	4	1,583
4X N.S. Purse Seine		2,547	2,390	16,107	15,816	18,783	4,682	957	438	343	80	62,143
4X N.S. Weir	0	2,943	711	307	226	232	39	5				4,463
4X N.B. Purse Seine		1,816	427	104	64	13	5					2,429
5Y N.B. Purse Seine		2,570	913	1,235	410	141	18	2				5,289
4X Gillnet		6	16	76	329	995	398	168	89	89	66	2,232
Total Weight (t) by Age	8	10,084	4,726	18,216	17,176	20,485	5,183	1,143	533	435	150	78,139

Percent Weight	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
4W Purse Seine	1	13	17	24	21	20	3	1	0	0	0	100
4X N.S. Purse Seine		4	4	26	25	30	8	2	1	1	0	100
4X N.S. Weir	0	66	16	7	5	5	1	0				100
4X N.B. Purse Seine		75	18	4	3	1	0					100
5Y N.B. Purse Seine		49	17	23	8	3	0	0	0			100
4X Gillnet		0	1	3	15	45	18	8	4	4	3	100
Percent Weight by Age	0	13	6	23	22	26	7	1	1	1	0	100

Table 7. Larval herring abundance index (average number of larvae per m² from 79 index stations) from the Bay of Fundy autumn larval herring surveys.

Larval Herring Bongo Survey No. per m² to bottom				
Year	**Cruise**	**Mean**	**SE**	**N**
70				
71				
72	P109	9.4	1.8	
73	P127	6.6	1.3	
74	P147	49.5	10.9	
75	P160	11.7	1.5	58
76	P175	13.5	2.9	
77	P190	6.3	1.0	
78	P207	4.5	0.5	77
79	P232	7.1	2.1	
80	P246	26.2	6.7	
81	P263	2.7	0.3	78
82	P280	10.6	1.2	77
83	P298	13.9	1.6	74
84	P315	12.7	1.4	78
85	P329	40.8	4.6	79
86	P344	18.9	2.1	78
87	P361	27.9	3.2	78
88	P377	100.7	11.5	76
89	P391	54.5	6.1	79
90	P408	27.2	3.1	79
91	P422	48.2	5.5	78
92	P437	57.0	6.4	79
93	P451	55.0	6.2	78
94	N211	5.4	0.7	77
95	N232	20.3	4.6	78
96	N252	9.5	1.6	77
97	N765	23.3	2.7	77
98	N865	33.6	3.8	77

Table 8. Recorded landings (t) by major Nova Scotia gillnet fisheries.

Landings (t)

	1996	**1997**	**1998**
East of Halifax	1,280	1,520	1,100
Little Hope	0	490	1,170
Glace Bay	0	170	1,730
Bras d'Or Lakes	170	160	120

Table 9. Coastal Nova Scotia fisheries catch at age for 1998.

Sept. 1998 4W Halifax Gillnet
Catch at age (number and weight)

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
Number	0	0	0	23	168	2,254	1,168	387	153	190	61	4,404
% number	0%	0%	0%	1%	4%	51%	27%	9%	3%	4%	1%	100%
Catch wt. (t)	0	0	0	5	35	517	295	111	50	66	21	1,100
% catch wt.	0%	0%	0%	0%	3%	47%	27%	10%	5%	6%	2%	100%
Avg. wt.				197	208	229	253	287	327	348	350	250

Sept. to Oct., 1998 4X Little Hope Gillnet
Catch at age (number and weight)

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
Number	0	0	0	66	400	2,860	1,105	275	87	105	41	4,939
% number	0%	0%	0%	1%	8%	58%	22%	6%	2%	2%	1%	100%
Catch wt. (t)	0	0	0	13	80	643	276	78	28	36	14	1,168
% catch wt.	0%	0%	0%	1%	7%	55%	24%	7%	2%	3%	1%	100%
Avg. wt.				190	200	225	249	285	327	346	348	237

1998 Glace Bay herring gillnet
Catch at age (number and weight)

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
Number	0	0	0	0	47	1,669	2,533	1,049	198	364	286	6,146
% number	0%	0%	0%	0%	1%	27%	41%	17%	3%	6%	5%	100%
Catch wt. (t)	0	0	0	0	10	421	674	318	68	130	112	1,733
% catch wt.	0%	0%	0%	0%	1%	24%	39%	18%	4%	8%	6%	100%
Avg. wt.					211	252	266	303	343	358	390	282

1998 Bras d'Or Lake herring gillnet
Catch at age (number and weight)

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
Number	0	0	0	0	3	18	108	156	78	35	39	437
% number	0%	0%	0%	0%	1%	4%	27%	43%	23%	11%	13%	100%
Catch wt. (t)	0	0	0	0	1	4	27	43	23	11	13	122
% catch wt.	0%	0%	0%	0%	1%	3%	22%	35%	19%	9%	11%	100%
Avg. wt.					237	229	252	273	294	314	336	278

Coastal Nova Scotia remainder (gillnet, trap, misc.) for March to Nov.
Catch at age (number and weight)

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
Number	0	720	123	254	358	464	158	32	29	12	2	2,152
% number	0%	33%	6%	12%	17%	22%	7%	1%	1%	1%	0%	100%
Catch wt. (t)	0	17	7	33	61	95	37	9	12	2	1	274
% catch wt.	0%	6%	3%	12%	22%	35%	13%	3%	4%	1%	0%	100%
Avg. wt.		23	56	129	171	204	232	266	407	204	480	127

Table 10. 1998 N.B. weir and shut-off catch at age.

1998 4X N.B. Weir and Shut-off
Catch at age (number and weight)

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Total
Number	440	387,723	36,062	9,595	3,404	1,842	297	69	25	1	0	439,458
% number	0%	88%	8%	2%	1%	0%	0%	0%	0%	0%	0%	100%
Catch wt. (t)	4	15,091	2,755	1,225	550	366	73	20	8	0	0	20,092
% catch wt.	0%	75%	14%	6%	3%	2%	0%	0%	0%	0%	0%	100%
Avg. wt.		39	76	128	161	198	245	287	302			46

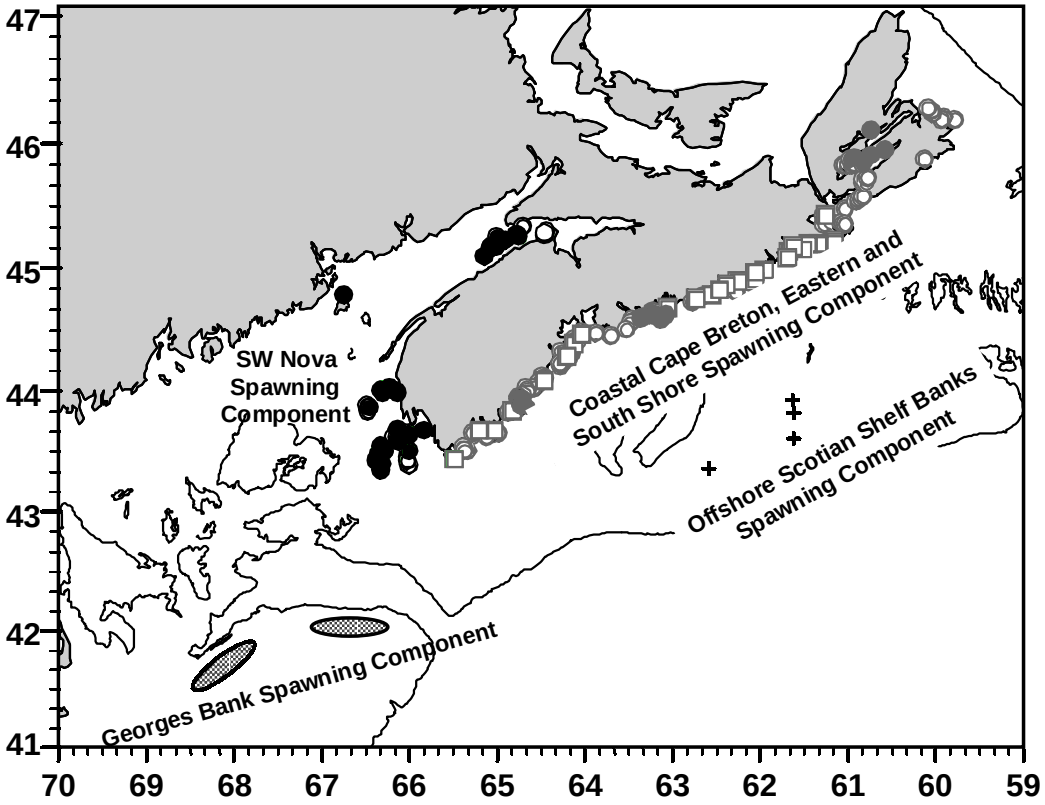

Figure 1. Management units for herring in areas 4VWX and 5 showing locations of known current (solid) and historical (open) spawning locations.

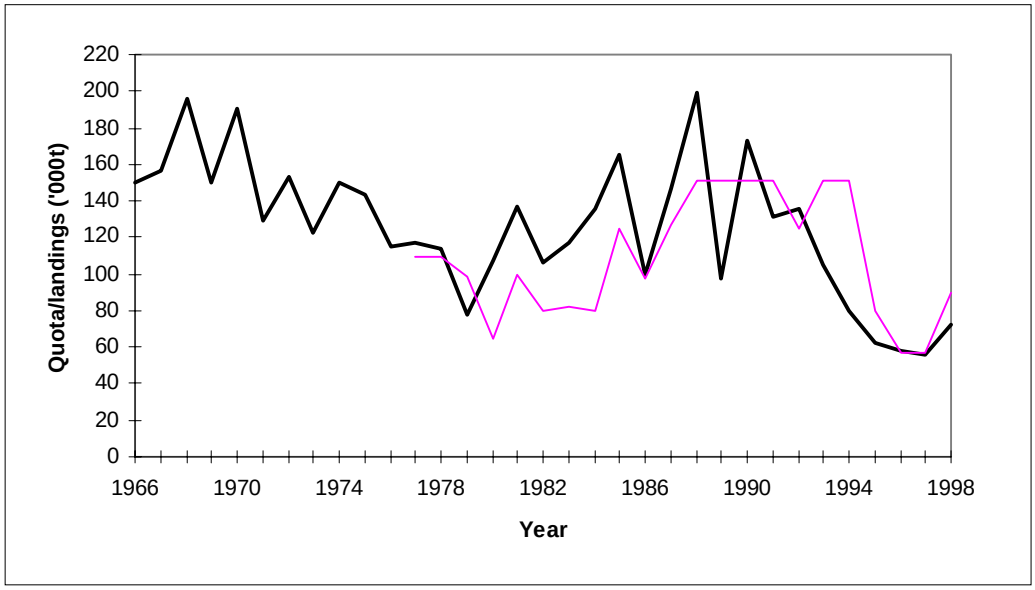

Figure 2. Annual herring landings and TAC (quota) for the southwest Nova Scotia spawning component (4WX stock).

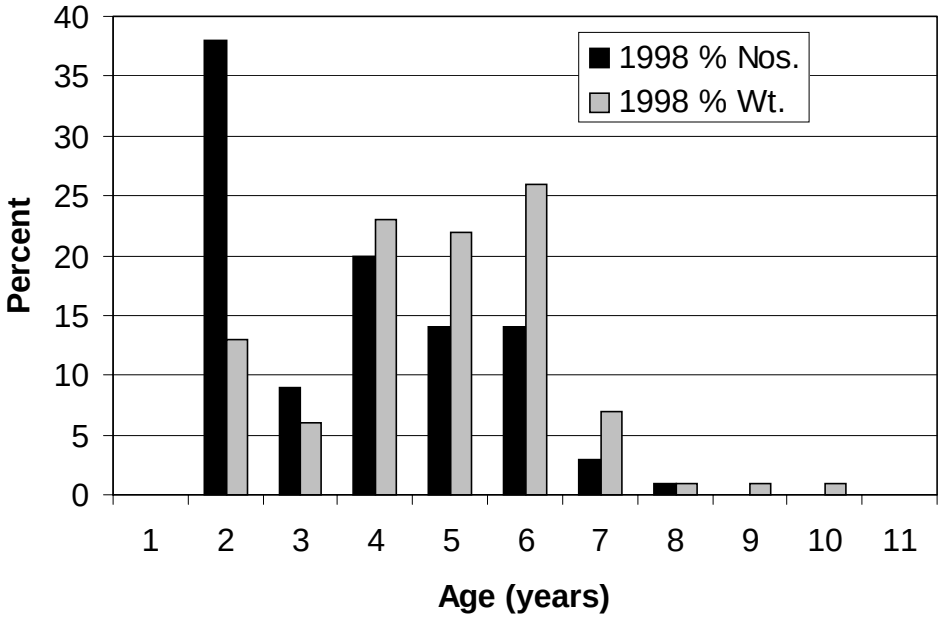

Figure 3. Catch at age in 1998 for the southwest Nova Scotia spawning component (% numbers and % weight).

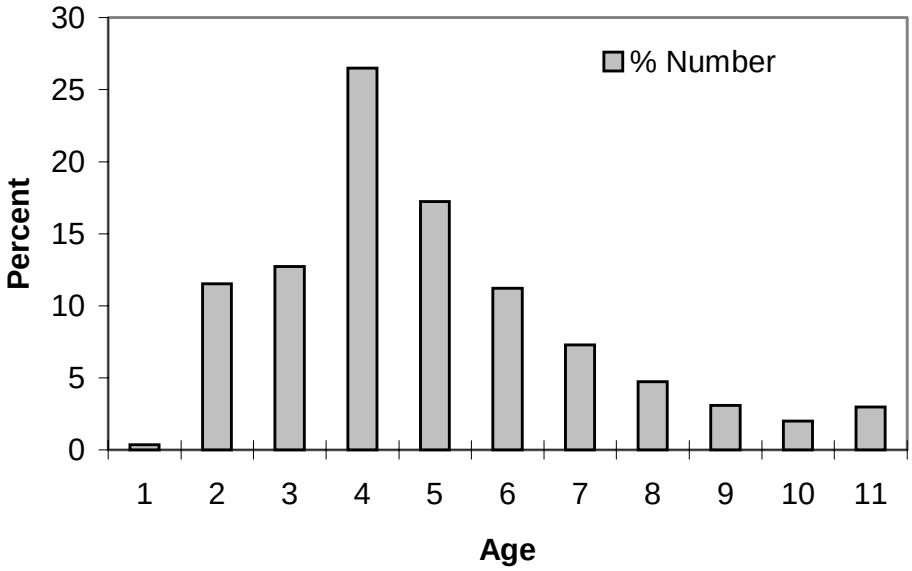

Figure 4. Expected age structure of SW Nova Scotia herring at F0.1 and average recruitment.

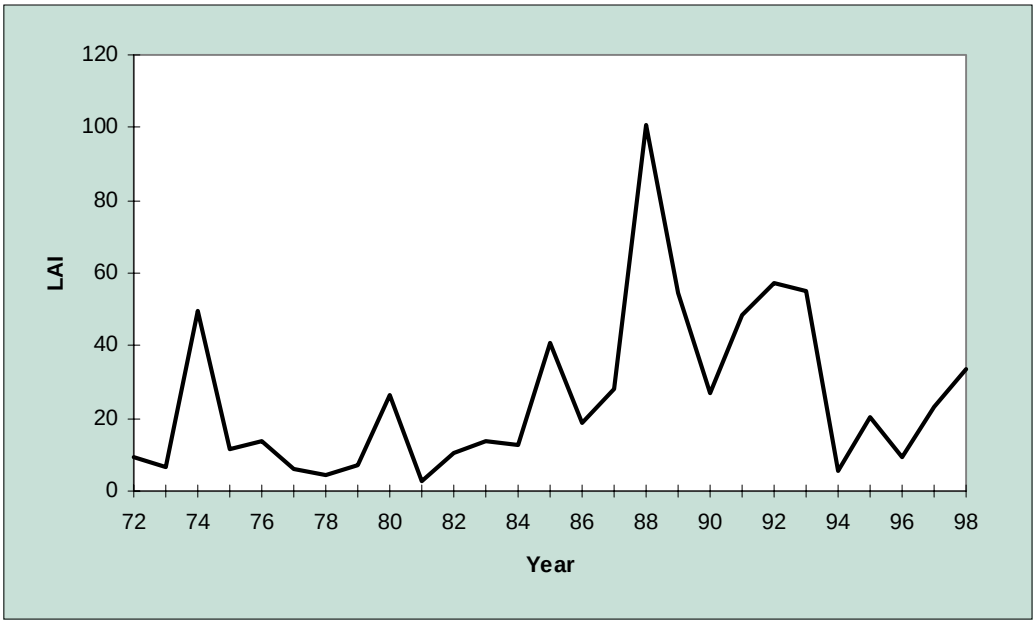

Figure 5. Abundance of herring larvae (number per m^2 to bottom) in Bay of Fundy autumn ichthyoplankton surveys 1972-1998.

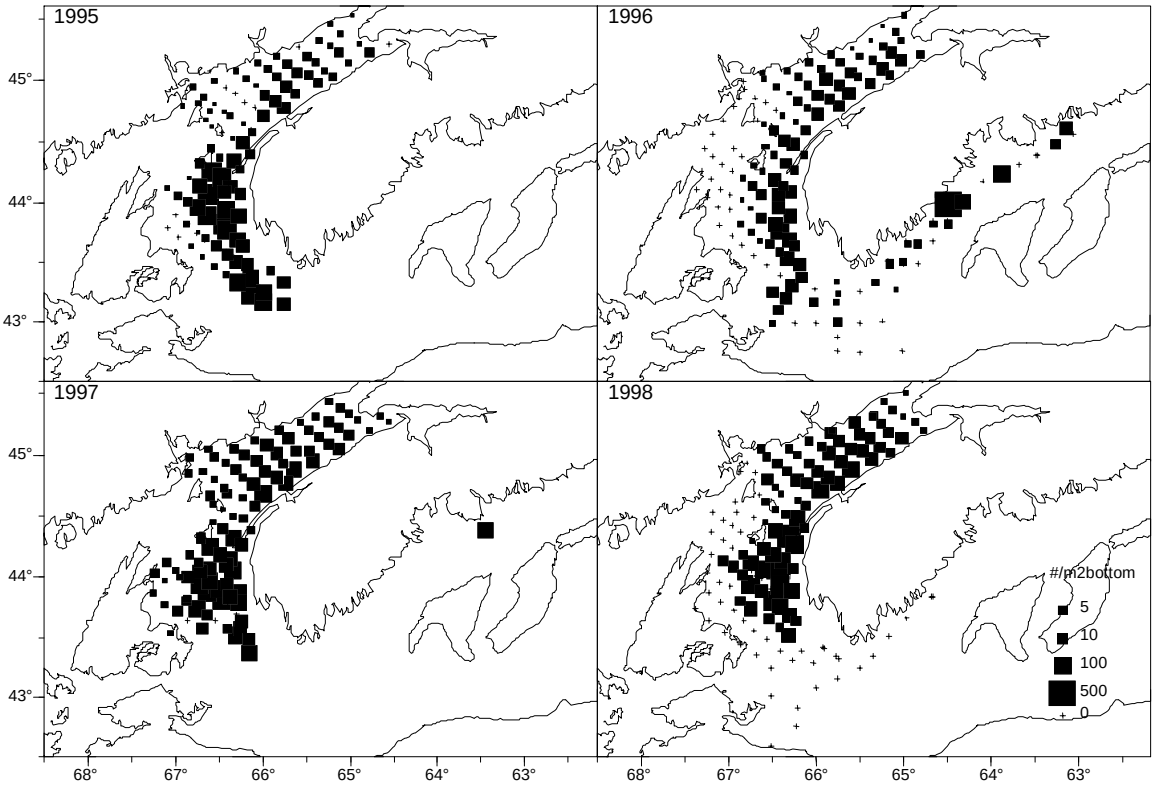

Figure 6. Distribution and abundance of herring larvae from the November 1995 -1998 Bay of Fundy larval surveys.

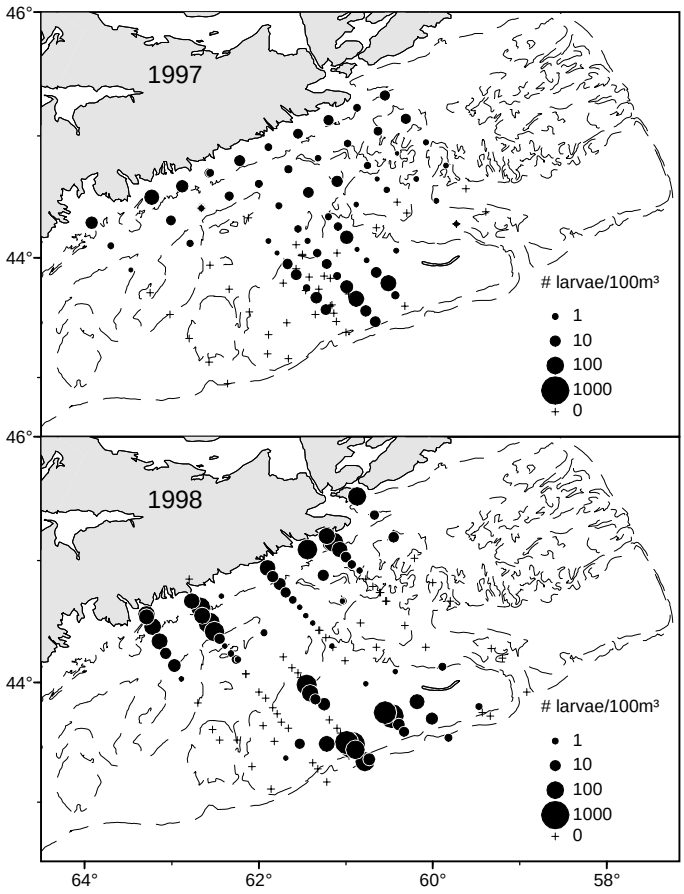

Figure 7. Distribution and abundance of herring larvae from the November 1997 and 1998 Scotian Shelf Banks larval survey (from Reiss et al. 2000 MS).

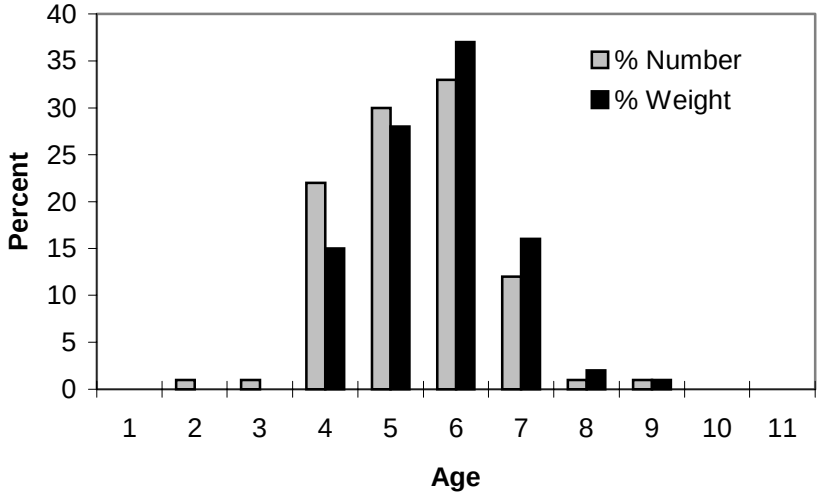

Figure 8. Catch at age for herring on the offshore Scotian Shelf Banks component from the 1998 purse seine fisheries.

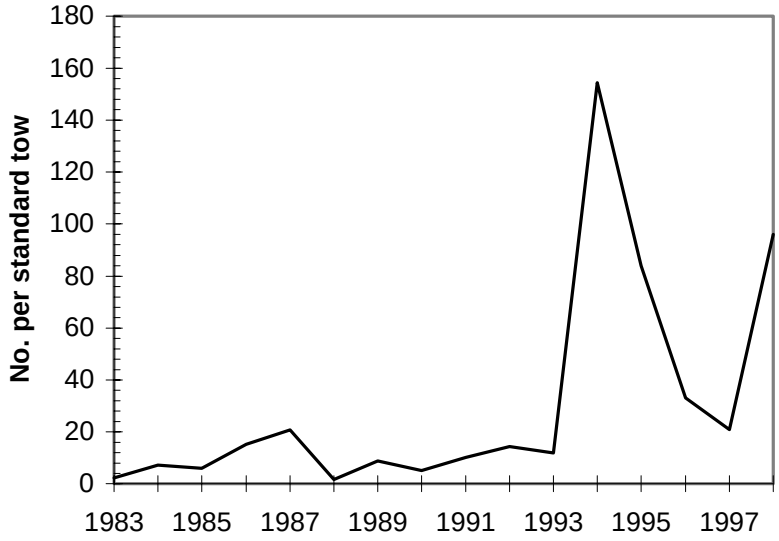

Figure 9. Number of herring caught per standard tow in the July bottom trawl survey of the offshore Scotian Shelf Banks, 1983 to 1998 (strata 55-78).

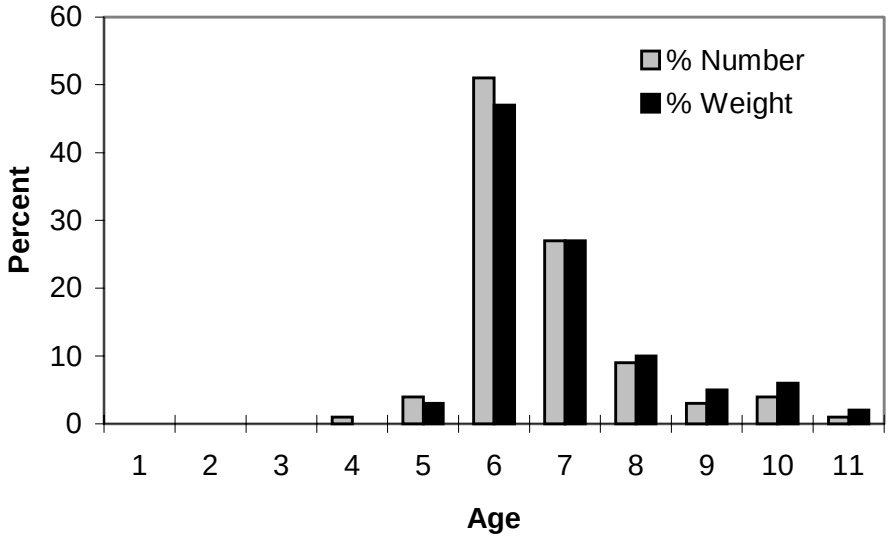

Figure 10. Catch at age (% numbers and % weight) for the fall 1998 gillnet fishery east of Halifax.

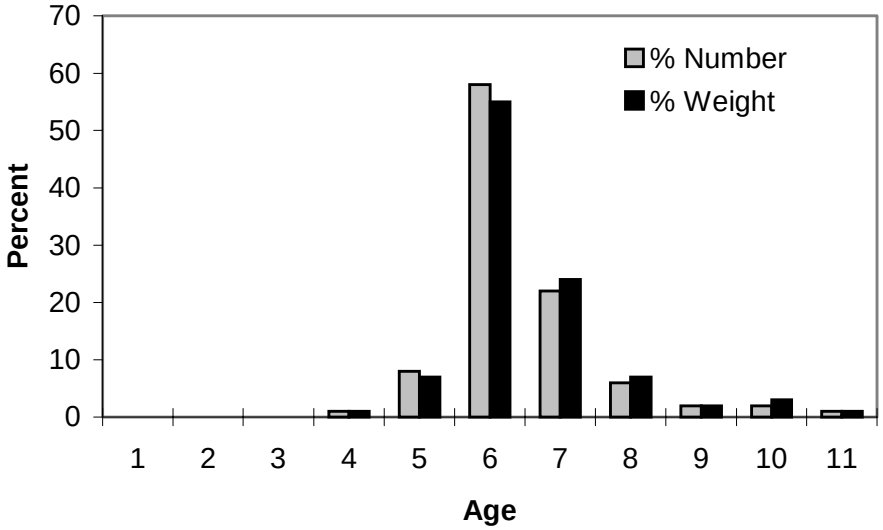

Figure 11. Catch at age (% numbers and % weight) for the 1998 Little Hope gillnet fishery.

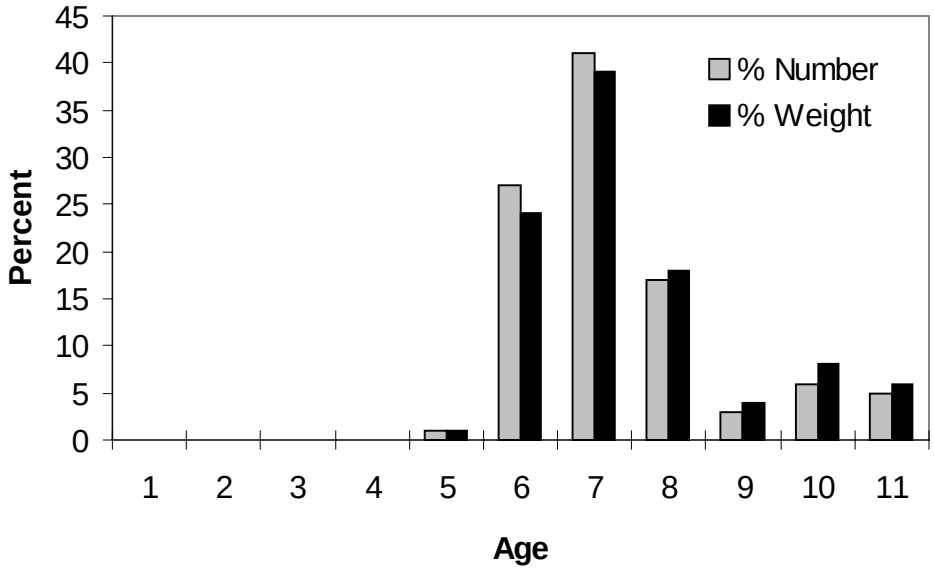

Figure 12. Catch at age (% numbers and % weight) for the fall 1998 Glace Bay gillnet fishery.

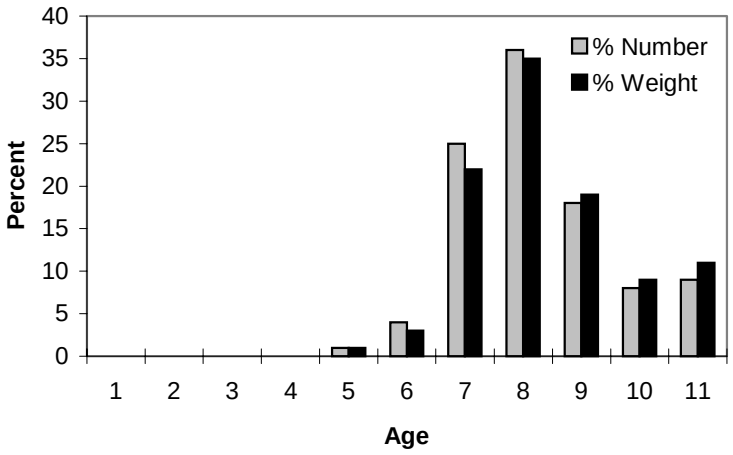

Figure 13. Catch at age (% numbers and % weight) for the spring 1998 Bras d'Or Lakes gillnet fishery.

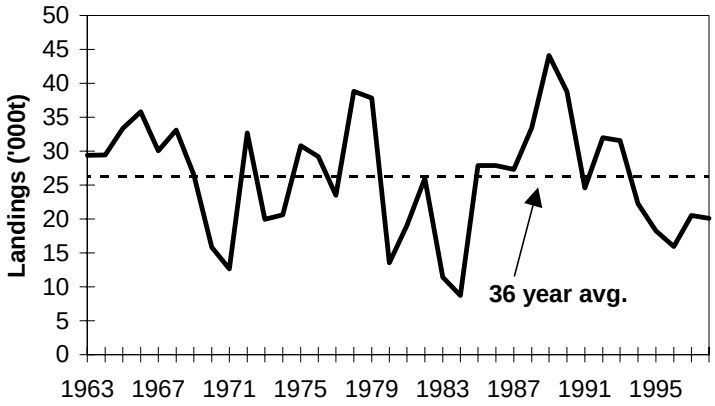

Figure 14. Herring landings from the southwest New Brunswick weir and shutoff fishery, 1963-1998.

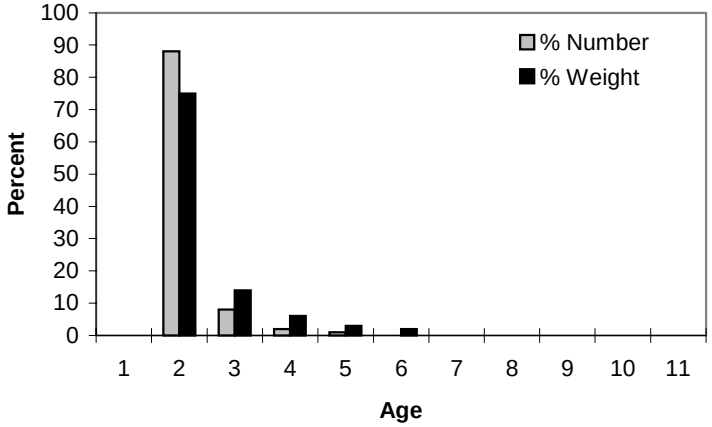

Figure 15. Catch at age (% numbers and % weight) for the 1998 southwest New Brunswick weir and shutoff fisheries.

Appendix I: Fleet Activity in the 1998 4WX Herring Fishery

S.A. Boates and M. Corporon
Pelagics Research Council

Introduction

The following report documents the 1998 4WX herring fishery based on compilation of industry records, Dockside Monitoring Program logbooks and captains search records. It is an account of the week to week fleet activity in the fisheries related to three major spawning components: The Scotian Shelf, southwest Nova Scotia and Coastal Nova Scotia (Figure 1, 2). Its purpose is to record and document the distribution of the fleet as well as important events, changes and trends that may have occurred during the season.

The bulk of the report is the product of information gathered from seiner association reports and compiled by Pelagics Research Council personnel. The representatives of the seiner associations as well as fishers have given valuable information on the week to week activity of the fleet, condition and behavior of fish. This information coupled with notes taken by the Pelagics Research Council and St. Andrews Biological Station staff throughout the field season have resulted in a more complete account of the fishery. In addition, useful information was provided by the Dockside Monitoring Program on the distribution of the fleet, and all purse seine landings in each fishing area. As part of these records, there is a section to record biological information such as fish condition, weather and school size. This information is important and is included to account for anomalies in fishing activity or conditions and abundance of fish in an area.

Herring processing plants are now actively involved in gathering biological information from fish caught during the season. Their participation and contribution of length frequency records and frozen samples of fish from major fishing areas has greatly increased the amount and quality of biological information. The length frequency sheets provide the size ranges of fish in each fishing area throughout the season while frozen samples provide age, sex and maturity of the fish being caught. Furthermore, fishers themselves have been trained and periodically contribute sampling information from a given fishing night.

Further information about fleet activity and school abundance was collected from Herring Search Records contributed by captains who are at liberty to document a school of fish at any time. This was enhanced this season by the availability of acoustic recording equipment aboard five vessels, as well as a portable system. Using this equipment the captains could record a school of fish at any time during a fishing night. Both of these methods were used during structured surveys to quantify and document the biomass of fish. This season, 2000t was taken “off the top” of the purse seine quotas and returned as a reward for survey participation. Withholding a portion from the vessels did not induce willing involvement; instead many in the fleet felt forced to comply. Furthermore spirits were down due to poor market conditions, bad weather and the hold re-calibration that occurred very early in the season. These factors resulted in fewer structured surveys than had been scheduled but this was offset, to some degree, by an increase in acoustic records from fishing nights (Table 1).

Numerous groups have contributed and participated in the documentation of the fleet in the 1998 season. The information provided was valuable in documenting the fleet as well as herring stocks and spawning groups.

1) Offshore/Scotian Shelf Banks

May 25 – May 30

Fishing started around May 25. Landings were poor the first few days. Seven boats were fishing from Halifax/Dartmouth. Fish were caught at the first of the week on Roseway and Brown's (range of 21.5 - 32.5cm with a mode at 28cm). Later in the week, fish were caught on Roseway and Baccoro Bank (range from 23.5 - 32.0cm, mode at 29.5 - 30.5cm). Fish were described as thin. Strong winds during the middle of the week slowed fishing activity and most captains sent crew home on Wednesday.

June 1 – June 6

PRC staff first deployed this week. Only about seven boats in Halifax / Dartmouth. Some fish were caught during the middle of the week but bad weather stopped fishing towards the weekend. A few fish were caught in the middle of the week on the Patch. Bad weather again stopped further fishing. Fish were deep and "wild". Successful sets were made quickly as fish rose at dusk - but captains had only "one shot" at them. On June 1, fish were caught on the Outer Banks (range 25 - 33cm, mode 30 - 31cm). On June 3 fish were caught in vicinity of the Patch (range 24 - 33cm, mode of 29.5cm).

June 7- June 13

There was more effort on all the fishing areas (The Patch, Sambro Bank, Emerald Basin, French Bank, The Bullpen). Strong concentration was on the Mackenzie Spot (50 fathoms, water temperature 51.0F), Emerald Basin and The Patch. About 12 seiners were in the area and a few good landings were reported (75-140t). Length frequency sheets showed fish ranging in size from 26 - 37cm, mode at 26cm. Captains reported that fish seemed to be "wild" and deep, only coming up for a short time. Also during this period a few daytime sets were made. Bad weather again slowed things down towards the end of the week.

June 14 – June 20

Fishing effort was very slow mainly due to bad weather. On Wednesday, seiners managed to get out and reported very large seas. Some fish were landed on Thursday morning but the landings were not constant. The Patch and Emerald Basin were still the main areas of activity. At the end of the week fishing was mainly around Emerald Basin. (fish ranged from 27 - 36 cm, mode of 31.0cm). One vessel searched the Patch and the Bullpen and reported that the fish were tight to the bottom and acting "wild".

June 21 – June 27

Early in the week landings were from Emerald Basin (range 28 - 35.5cm, mode of 30.5 - 32cm) and the Patch (range 27 - 35.5cm, mode of 29cm). Toward the latter part of the week fishing was focused more on the Patch with landings from Mackenzie's Spot (range 26 - 38cm, mode of 30.0cm). Landings from the Patch on Thursday morning (June 25) were very good. Captains reported a strong show of fish and also the fish were acting differently (bigger schools and staying up near the surface longer). On Friday (June 26), landings were down to the same level as previous weeks. No weekend

fishing occurred due to bad weather.

June 28 – July 4
Fishing effort was minimal at the first of the week. Most of the seiners left for Southwest Nova early in the week with the remainder leaving by the weekend due to low landings and the presence of fish on Brown's Bank and the Long Island Shore.

Oct 18- Oct 23
Four seiners left for the Scotian Shelf on Oct. 19. A survey of this area along with tagging and water temperature profiles were planned for this trip. Unfortunately, no fish could be tagged, (none caught), but temperature recordings were done. Weather conditions were not good, winds blowing from 20-30 kts. daily. The vessels arrived home on the evening of Oct 22.

Summary

- The 1998 offshore Scotian Shelf purse seine fishery took place between May 7 and June 26th; approximately the same time as in the previous two years (Fig 3).
- 1998 was the third year of the purse seine activity since reactivation of the offshore fishery in 1996. The focus of the 1998 fishery was the Patch and the Emerald Basin (Fig 2, 4).
- Landings in 1998 (5,579 t) were much lower than in 1997 (20,261 t) (Fig 4). Industry indicates that this was due to poor weather conditions and fish staying close to bottom.
- Fish were reported to be tight to the bottom and acting "wild". Also fish described as "thin".

2) Southwest Nova Scotia

June 14 – June 20
Some activity occurred around Grand Manan with approximately six boats fishing the Grand Manan Banks. Seiners arrived on Long Island Shore from the Halifax area. Eight to ten seiners fished from the Yarmouth/Pubnico/Digby areas.

June 21-June 27
Several boats fished on Brown's Bank. Fish seemed to be plentiful, and of mixed size. One vessel was out on Crowel's Basin but no fish were seen. Long Island Shore proved very productive with a mix of small and large fish. (June 25/26 fish ranged in size from 14.5 - 34.5cm, mode of 29.0cm, also strong size at 30.5 - 32.5cm). PRC staff were deployed in Southwest Nova from June 25 onwards. Fishing on the Northeast Bank had been ongoing since the middle of June. Landings were regular indicating a strong presence of fish. On June 22, a survey was conducted in the area using a single seiner. Good quantities were caught (fish ranged from 20 to 29.5cm, mode of 27cm). On June 22, there was a survey with the gillnet fleet at Spectacle Buoy. Approximately 10 – 12 boats participated. Three PRC personnel were involved and DNA sampling was done.

June 28 – July 4
Landings from Long Island Shore continued to be steady with good quantities landed

almost daily (range of 15.0 - 32.5cm). Maturity stages were mixed with some 2, 5 and 8's. Fishing continued around Grand Manan. Range of fish 24.5 - 30.5cm with a mode of 27.0cm.

July 5-July 11
Landings reported from Long Island Shore (mode of 29cm) and Grand Manan Banks.

July 12 – July 18
Seiners continued to fish Long Island Shore this week but on Sunday night fish were caught in the Trinity/Cape St. Mary's area. By the following night most vessels had moved to this area. Length frequency showed fish size ranged from 20.5 - 30.5cm, with a mode at 30.5cm. Not much fish were seen towards the end of the week, with some fish being released because of small size (5 - 6"). One vessel ventured to the Brazil Rock area for lobster bait and reported that there were lots around.

July 19 - July 25
One boat was fishing in Scot's Bay **(**area 21), on Sunday, July 19, and landed fish. On Monday July 20, about 13 seiners had arrived in Digby. Landings were steady but not large quantities. On Thursday July 23, 13 seiners were active in a survey of Scot's Bay (area 22). Two DFO/PRC biologists were deployed on seiners along with the PRC acoustic technician. The survey was under the direction of Gary Melvin and was the first time that the new PRC acoustic sonar (SM2000) was used. The school was estimated to be 40,000t – 50,000t.

July 26 – August 1
In Scot's Bay landings were steady but no large quantities were reported. Bad weather on July 28/29 stopped the boats from fishing. DNA samples were taken of Scot's Bay spawners on July 31.

August 2-August 7
Landings on Monday (August 3) were similar to those of the previous week. Most seiners went to different fishing grounds (Long Island Shore and German Bank) after not seeing much fish on Monday night (August 3). An attempt was made to tag herring on August 2, however no fish could be found. A survey of Scot's Bay scheduled for August 5th was canceled since no boats were fishing in this area. In Scot's bay length frequencies showed fish ranging from 24.5 - 33.5cm with a mode of 28.0 – 29.5cm. Fishing on Tongue Ground (North of German Bank), was constant from August 3 – August 7 and landings were steady (range of 17.5 – 33.0cm, with a mode of 23.0 – 27.0cm). Most boats were not fishing on the weekend of August 7.

August 9 – August 14
Fishing fleet activity was on the Tongue Ground and Brown's Bank. Long Island Shore also had some landings, fish were reported to be mixed. A length frequency from Tongue Ground on Aug. 10 showed fish size ranging from 17.5 – 31.5cm. and a mode of 26.5cm. Some redfeed was noted in the fish. From Aug 10 – 14 there was a strong effort placed on Brown's Bank. Fish size ranged from 20.0 – 33.0cm. Many fish were in the 26.0 – 28.5cm. range. Some landings from Brown's Bank also showed a strong concentration of fish in the 27.0 – 31.5cm. range. Some redfeed was noted in the Brown's Bank fish. Different sets in the same area show fish ranging from mixed to large size. Strong winds on August 12th stopped many seiners from going out, however

some fish were landed from the Blond Rock area (10km SW of Seal Isl.). Fish size from Blond Rock was 20.5 – 32.5cm with a mode of 27.0cm.

August 16 – August 21

The seiner fleet was split between Long Island Shore and German Bank. Length frequencies of fish from Long Island Shore were recorded on August 17 and August 19 and showed that fish ranged from 17.0 – 27.0cm (mode at 18.5cm). Fish size stayed roughly the same throughout the week with a similar mode of 18.5cm on August 20. Three vessels went to Scot's Bay on the 17th and caught hard fish. Only one vessel returned to that area on the 18th. Spawn herring was landed from German Bank throughout the week of August 16 –22. During this same period, the Inshore Scallop Fleet was active on German Bank and the problem of many boats on the same fishing area probably contributed to lower than normal landings. A length frequency from German Bank showed fish size on August 18, 19 and 20th, generally in the 18.0 – 35.5cm range.

August 22-August 29

Surveys of German Bank (13 vessels) and Scot's Bay (4 vessels) were conducted on August 23. No fish were available to be tagged on German Bank, and there were few roe fish. Roe fish were seen in the Scot's Bay survey, (August 23rd), and PRC personnel to tagged 1,866 fish and collected some DNA samples. On August 25th, PRC staff tagged 500 fish. Not much fish was seen on German Bank early in the week of August 23rd; bad weather contributed to the lack of fishing effort. Fish were seen on August 27 and acoustically recorded by one seiner but were reported as staying deep. Fish from this area went primarily to the bait market. A survey involving the gillnet fleet on Trinity Ledge was done on August 27th. Nine gillnet vessels were involved along with a purse seiner for tagging and DNA sampling. Two sets from the purse seiner were used for tagging (400 fish tagged) and DNA sampling. The school was described as a large group of medium to heavy density, 10 fathoms by 1 km². The biomass of the school was estimated to be 10,000t. A conference call was held on August 28 and the 1998 catch to date was reported as 41,788t for 4WX and 6,174t for Scots Bay.

August 30 – September 4

Fishing activity was split between Scot's Bay, German Bank and White Head (Grand Manan). Three to four seiners were active in the Long Island Shore area and the fish were generally the same size as in previous weeks. By the end of the week only two vessels remained in Scot's Bay. Reports were of very ripe fish, indicating the end of a spawning group. Some boats landed bait from the Whitehead area off Grand Manan. Fish were in the 6 – 8 inch range. German Bank continued to provide constant landings of roe fish (range of 17.5 - 35.0cm. with two distinct sizes at 17.5 – 22.5cm and 25.0 – 31.5cm, with an equal number of fish in each size group). Fish remained on the bottom only allowing one set per night (usually around 9-11p.m.). Towards the end of the week fish were also caught in morning sets (5-6a.m.). Approximately 1,900 fish were tagged on German Bank and DNA samples were taken. On September 3, vessels equipped with sonar recording equipment ran a set of gridlines on German Bank providing confirmation of verbal reports of large groups of fish being seen in the area. Other vessels provided paper reports.

September 6 – September 12

German Bank was the area with most fishing effort. Some bait was landed from

Whitehead (Grand Manan) and ripe roe fish were caught in Scot's Bay again. German Bank fish ranged in size from 23.5 - 35.1cm with high modes at 27.5cm and 30.5cm. Most of the fish landed were ripe but some hard fish were also caught along with some bait fish. Landings on Friday (Sept. 11) were on the low side in most cases with the fleet coming in to port in the early morning hours due to the fish staying on bottom and poor weather conditions (big seas). Tagging on German Bank continued on Sept. 8 and Sept. 9 with 2,743 fish tagged. There was a gillnet survey on Sept. 8 on Trinity Ledge. The SM 2000 was used along with survey sheets for fish density information. Eighteen gillnet vessels participated. A purse seiner designated for tagging with 3 PRC staff was sent out on Sept. 10 to Trinity Ledge but no tagging was done, as fish were not ripe.

September 13 – September 19

Most boats were still fishing German Bank. Whitehead, Grand Manan had activity (sardines), and Long Island Shore (small, bait) was fished late in the week (Thursday night). Landings from German Bank were not constant. Fish ranged from hard fish to roe fish to bait. As in previous weeks the fish stayed on bottom and only rose up once per night, usually in the early evening. Tagging on German Bank continued with 1,321 herring tagged this week. On Sept. 17 there was a survey of German Bank with 11 vessels participating. A large area of fish, extending several miles to the south, was encountered soon after the survey began. Most of the fish were tight to the bottom. All major bunches of fish were recorded with acoustic equipment and an estimation of 60,000t was made. Two surveys were done in New Brunswick (Grand Manan area). On Sept. 15, 7 boats were involved on a survey in the Grand Manan area (White Head). On Sept. 16, 5 vessels were on the second survey off Grand Manan (Cheney Island, 66.40 line).

Sept. 20 - Sept, 27

Boats were fishing German Bank until bad weather stopped them on Wednesday, Sept. 23rd. Fish were staying up and good landings prevailed until Wednesday. Length Frequencies showed fish at 23.5 - 32.0cm with a mode of 26.5cm on Sept. 20 and 22. Fish remained on bottom from Thurs. Sept. 26 to the end of the week. Landings from then on were very low. Boats fishing on Friday night, (Sept. 23), were on the way home with no fish at 10:15p.m. Some boats fished for bait off Long Island Shore, but no large amounts were caught. A gillnet survey was undertaken on Trinity Ledge on Sept. 20,. The SM 2000 was used but not much fish was seen. On Sept.27: 1,160 fish were tagged on Trinity Ledge (mode 25.5 - 27.5cm, size range 22.0 - 35.0cm). Fish were fully ripe.

September 27 - October 3

Bad weather on Sunday night, (Sept. 27), hampered the fishing effort on German Bank. Fish caught this week were the same size as late in the previous week. Bad weather in the middle of the week hampered fishing on German Bank. Many of the seiners were fishing on Brown's Bank on Thursday night (Oct.1). Not much fish was landed and the weather was not great. Fish size was described as "mixed up junk", large and small fish mixed. Some boats fished for bait on Long Island Shore. Landings were good but weekly totals were low due to bad weather. Fish were landed throughout the week from Grand Manan, either for sardines or bait. Much of the fleet was in the Grand Manan area on Sunday night (Oct.4) and landings were good for many.

October 04 - October 09
There was no activity on German Bank during this week. All seiners were fishing for bait off Grand Manan Sunday night (Oct. 4). Some boats did get some bait off Long Island Shore during the week, however the vast majority were off Grand Manan. Bad weather on Sunday and Monday evening (Oct. 4 and 5) stopped fishing activity. A small amount of bait was landed on these nights but most of the fleet was not active. Fishing resumed on Tuesday night, (Oct. 6), and bait was landed on Wednesday (Oct. 7). Some seiners were planning to go to German Bank on Thurs. night, (Oct.8), but weather conditions were poor and most of the fleet returned to port very early that evening.

Oct 11- Oct17
Boats fished for bait in most areas this week. German Bank had some roe fish mixed with bait. Poor weather made fishing operations difficult. Grand Manan still produced constant landings of smaller fish. Again, poor weather contributed to small landings and minimal fishing effort. Some fishing took place at Long Island Shore, bait being caught when the weather was right. Vessels conducted a post fishing survey of German Bank the night of Oct 13. The school was recorded both acoustically and on paper. Spawn fish were approximately 5 miles south of normal fishing area on German Bank, and there were bait fish seen elsewhere. A few vessels found spawn fish on Brown's Bank Oct 14. The weather blew up so the vessels could not stay to survey after fishing.

Oct 18- Oct 23
Some fishing was still going on off Grand Manan, fish were of a small size. Landings were very low. Weather hampered fishing operations. Fishers reported fewer fish than in previous weeks.

Oct 25 -Oct 30
Fishing continued off Grand Manan (Northeast Bank). Landings were reasonable but were affected by bad weather.

Nov 1- Dec 10
No fishing activity in southwest Nova Scotia.

Summary

- This fishery was similar in location and timing to recent years with purse seine activity on pre-spawning (Long Island Shore, Grand Manan Banks) and spawning aggregations (Scot's Bay, German Bank) (Fig. 5) and gillnet activity in nearshore areas (Spectacle Buoy, Trinity Ledge). (Fig. 6).
- Landings in the summer fishery totaled 69,664 t (67,433 t purse seine and 2,231 t gillnet).
- Large aggregations of feeding and spawning fish were recorded during fishing activities (paper and acoustic records) and during structured surveys.

3) Coastal Nova Scotia (Little Hope and Eastern Passage fisheries in which PRC staff was involved.)

Sept 27- Oct 3

Fishing started in the Little Hope area during the week of Sept. 27th. A PRC person was on a gillnet vessel the evening of Oct. 2. DNA sampling was done; fish were ripe. Because of the weather conditions many sets had to be made to catch the nightly quota. PRC staff were onboard gillnet vessels from the Little Hope area (Port Mouton) on Sept. 30. Length frequencies showed that the majority of fish were between 29.0 and 39.5cm. Fish were ripe and running. Bad weather stopped fishing on Little Hope after Sept.30. Fishing began in Eastern Passage on Sept 27th with one boat finding good ripe herring off Owl's Head. The herring were reported as spotty and not meshing well. Sept 30th was the first official night of herring roe fishing with 18 boats searching. The herring were reported as scattered with schools in different areas. The roe was a little immature. Fishing in Eastern Passage slowed towards the end of the week due to poor weather conditions and SW winds. Total catch to date in the Eastern Passage area was 226.8 t.

Oct 4- Oct 10

No boats were fishing at the beginning of the week in Little Hope (Oct. 5) Lower than normal water temperature and the full moon were given as reasons that not many fish were being seen and that what fish were seen were scattered. Some fishermen believed that more herring would be seen after the full moon. A survey and DNA sampling was done on Little Hope Tuesday night (Oct. 6). The SM 2000 was used with approximately 10 - 20 boats participating. A large area of fish was encountered near Devastation Shoal and a second smaller group was documented near the Medway ledges to the east and an initial estimate of 8,500t was made. Approximately 13 boats were out looking for herring Wed. night, (Oct. 7). Fisherman reported good signs of herring. Boats waiting for the low tide, early in the morning (approx. 6:00a.m.), got their quota. The majority of the herring were ripe, with some immature. Tagging was attempted on Little Hope (Oct. 8) using a seiner but this was precluded by poor weather conditions and a lack of fish. Twenty boats were reported fishing in the Eastern Shore area on Oct 4th. The herring were still scattered and did not mesh or settle on the bottom for long. Twenty-seven boats were fishing on October 5th. No boats were fishing mid week but activity picked up again towards the end of the week. Catch to date in this area 523t.

Oct 11 - Oct 17

DNA Sampling was undertaken at Little Hope at the beginning of the week. A survey planned for Little Hope on Oct 14 was postponed to Oct. 17 due to bad weather. The survey took place on Saturday (Oct 17) 9 gillnet boats. The fish ranged from 28.0 - 37.5 cm with a mode at 30.5cm. The fish were ripe and running. Boats searched the Devastation Shoal area in a grid fashion but did not see much fish. The vessels regrouped and searched down towards Little Hope and Dogged Ledge. Landings, when weather permitted, were still good. Eastern Shore was also affected by the weather with no boats fishing at the beginning of the week. The water was rough and it was windy. Nineteen boats went out in the middle of the week. The herring were still scattered and on the move. Most boats caught their quota. Later in the week weather again delayed fishing. On Oct 17th there was a good sign of herring and 20 boats went out. The herring were reported to be meshing better but it still took quite a few sets to land a reasonable amount. Total catch to date in the area was 802.89 t. Fishermen stated that they had a hard time receiving amended conditions from DFO and that there were problems with log entry.

Oct 18 - Oct 23

On Oct 18th, 14 boats were fishing on the Eastern Shore. It was the best weather for fishing yet and the best sign of herring for meshing, then poor weather conditions slowed fishing for the next few days and little or no fish were seen. On the 21st three boats went out searching. Two boats near Three Fathom found no fish while the boat off Eastern Passage found two schools – one large and one small. A gillnet survey took place in the Eastern Shore area on the 22nd. The SM 2000 was used along with 15 gillnet vessels. Total catch to date in the area was 1,048t. There was almost no fishing activity on Little Hope. Some gillnet boats were out during the middle of the week and saw no fish. Many fishermen were of the opinion that the end of the season was near. On the 24th fishers stated that they thought the fishery on the Eastern Shore was over.

Oct 25 - Oct30

Fishing activity along the Eastern Shore was over. Some boats went out Oct 28 but few fish were seen. The fish were located on the top of the water and were described as being in "Scrapes" as opposed to earlier reports of being seen in "chunks" Fishermen didn't expect any more fishing and noted that the season was over last year on Oct 20. The weather was bad this year and the fishermen expected to start fishing earlier next season.

"This year's Herring Roe Fishery was not what we had hoped for. The weather was unusually bad which we believed hindered this fishery. There were only 2 nights during which the fishermen felt that the herring meshed well although only at slack tide. Also the full moon and temperature dip attributed to this year's poor catches. The overall catch was down 468 ton from last year, but considering the above and the fact that there were 14 less boats actively fishing this year, we believe this explains why less herring was caught" -*Nellie Baker on the Eastern Shore Fishery in 1998.*

Summary

- Little Hope and Eastern Passage- fished by the gillnet fleet
- Landings totaled 2,337 t.

4) Overwintering Areas: Chedabucto Bay

Nov 1- Dec 10

Two seiners were fishing in the Chedabucto Bay area. Fish were caught on the Grime Shoal area. Fish were caught mostly in the daytime, from 1 p.m. – 6 p.m.. Towards the end of the fishery, fish were being caught from 3 p.m. – 5 p.m. During the mid afternoon, the fish bunched up. After 5:00pm, the fish would go to bottom and disappear from view. Good landings were made on Nov. 14, 17, 18, 19, 22, 26, and 30th. Bad weather affected the fishing effort. From a sample collected by PRC field people, fish size ranged from 20.0 - 32.5cm. There was no fishing in December and the boats returned home. It was noted that there were many tuna seen in the area.

Table 1: Summary of mapping and acoustic information collected during 1998 fishery.

Area	Date	# of vessels involved	#of Mapping records	# of Acoustic Records
Scot's Bay	23-Jul	13	10	3
	23-Aug	5	5	1
	30-Aug	1		1
	31-Aug	1		1
	01-Sep	1		1
Spec Buoy	22-Jun	14	14	
Trinity Ledge	27-Aug	9	9	1
	08-Sep	18	12	1
	20-Sep	10	10	1
German Bank	23-Aug	14	12	3
	27-Aug	1		1
	30-Aug	1		1
	02-Sep	2		1
	03-Sep	3	1	2
	04-Sep	1		1
	07-Sep	2		2
	08-Sep	1		1
	09-Sep	1		1
	10-Sep	1		1
	13-Sep	1		1
	15-Sep	1		1
	16-Sep	1		1
	17-Sep	11	11	2
	18-Sep	1		1
	20-Sep	1		1
	21-Sep	1		1
	22-Sep	1		1
	24-Sep	1		1
	29-Sep	1		1
	30-Sep	1		1
	01-Oct	1		1
	06-Oct	1		1
	09-Oct	2	2	0
	12-Oct	1		1
	13-Oct	3	3	2
Grand Manan	15-Sep - 16-Sep	6	2	
	06-Oct	1		1
	21-Oct	1		1
	04-Nov	1		1
	20-Oct	1		1
Browns	14-Oct	3	1	2
Little Hope	06-Oct	10	7	1
	13-Oct	Cancelled during survey due to weather		

Table 1: Continued

Area	Date	# of vessels involved	#of Mapping records	# of Acoustic Records
Eastern Passage	21-Oct	8	7	
Western Bank	20-Oct - 22-Oct	4	4	2
Long Island Shore	19-Aug	1		1
St Margarets Bay	20-Jul	1		1
	21-Jul	1		1
	22-Jul	1		1
	23-Jul	1		1
	25-Jul	1		1
	28-Jul	1		1
	31-Jul	1		1
	03-Aug	1		1
	04-Aug	1		1
	05-Aug	1		1
	07-Aug	1		1
	12-Aug	1		1
	14-Aug	1		1
	15-Aug	1		1
	17-Aug	1		1
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	19-Aug	1		1
	20-Aug	1		1
	21-Aug	1		1
	24-Aug	1		1

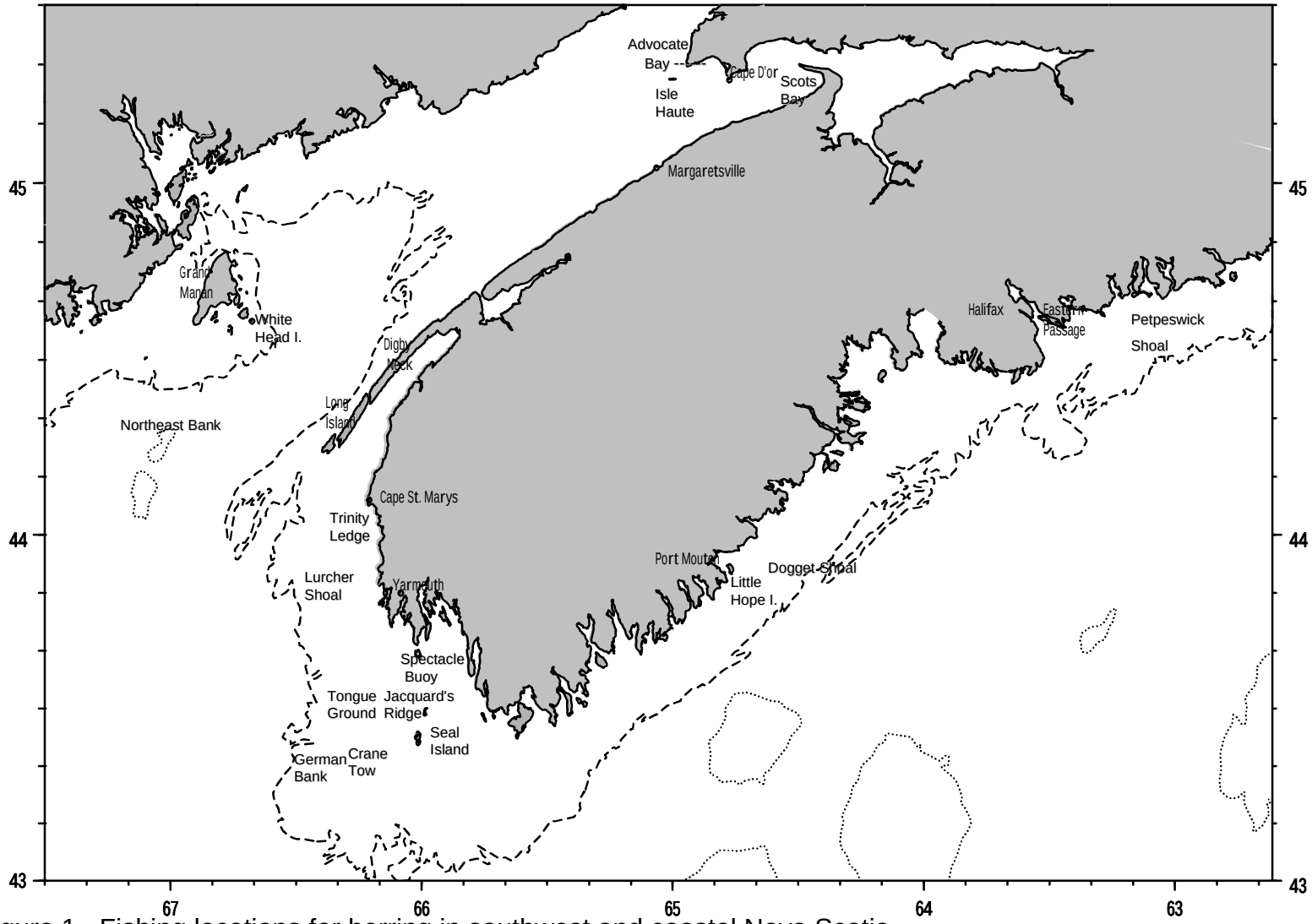


Figure 1. Fishing locations for herring in southwest and coastal Nova Scotia.

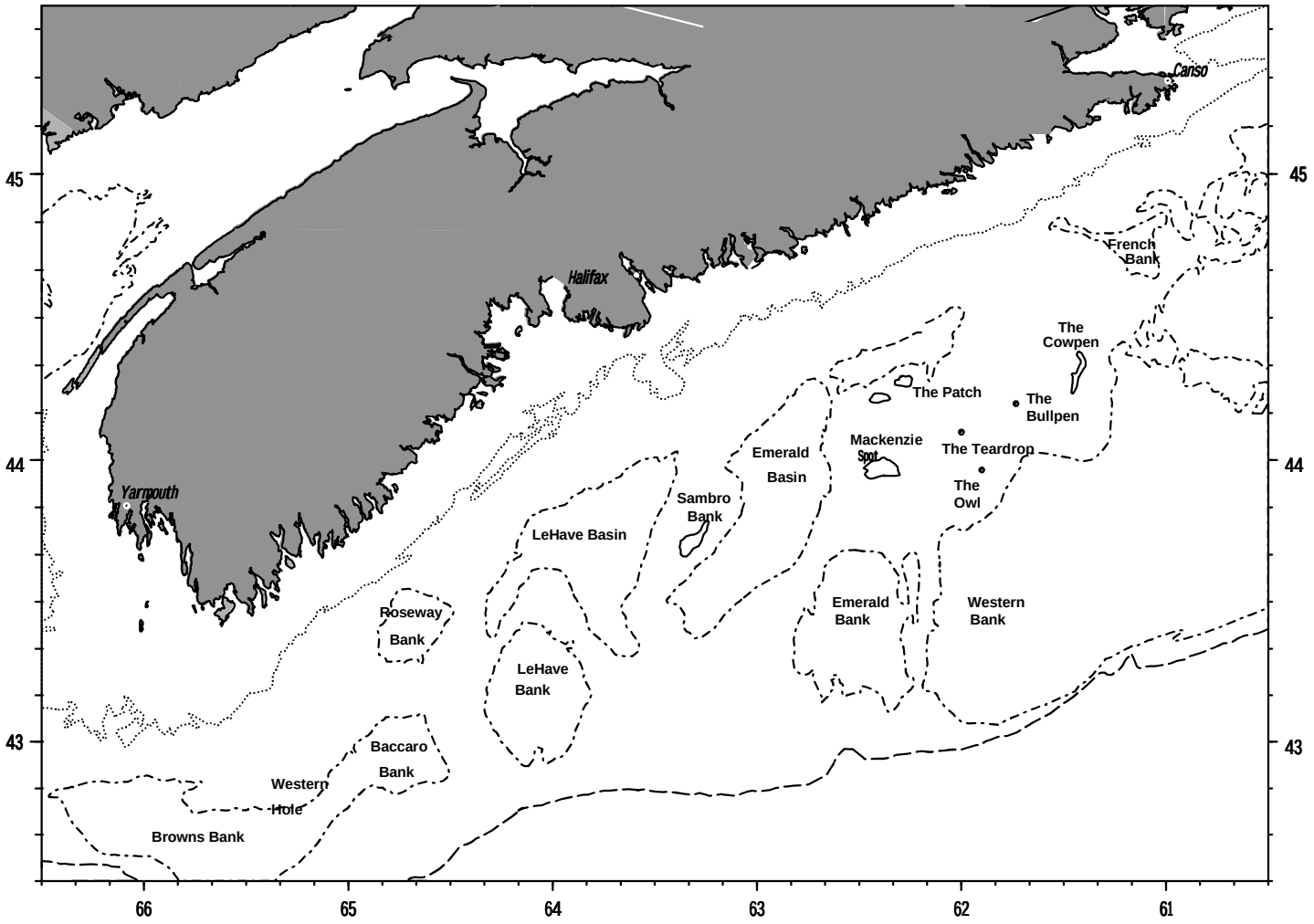


Figure 2. Fishing locations for herring on the offshore Scotian Shelf banks.

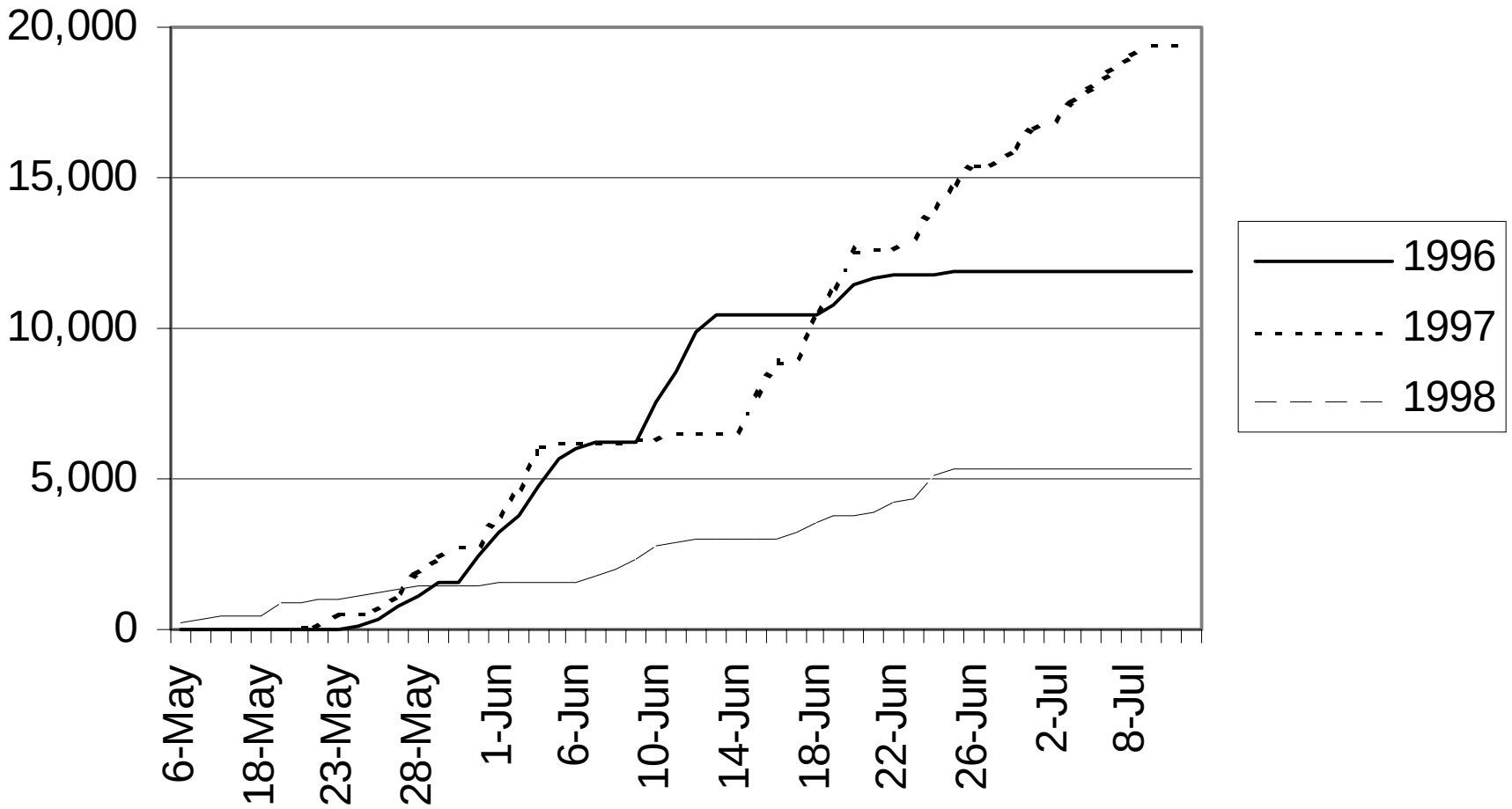


Figure 3. Cumulative catch of the offshore Scotian Shelf herring fishery (1996-1998).

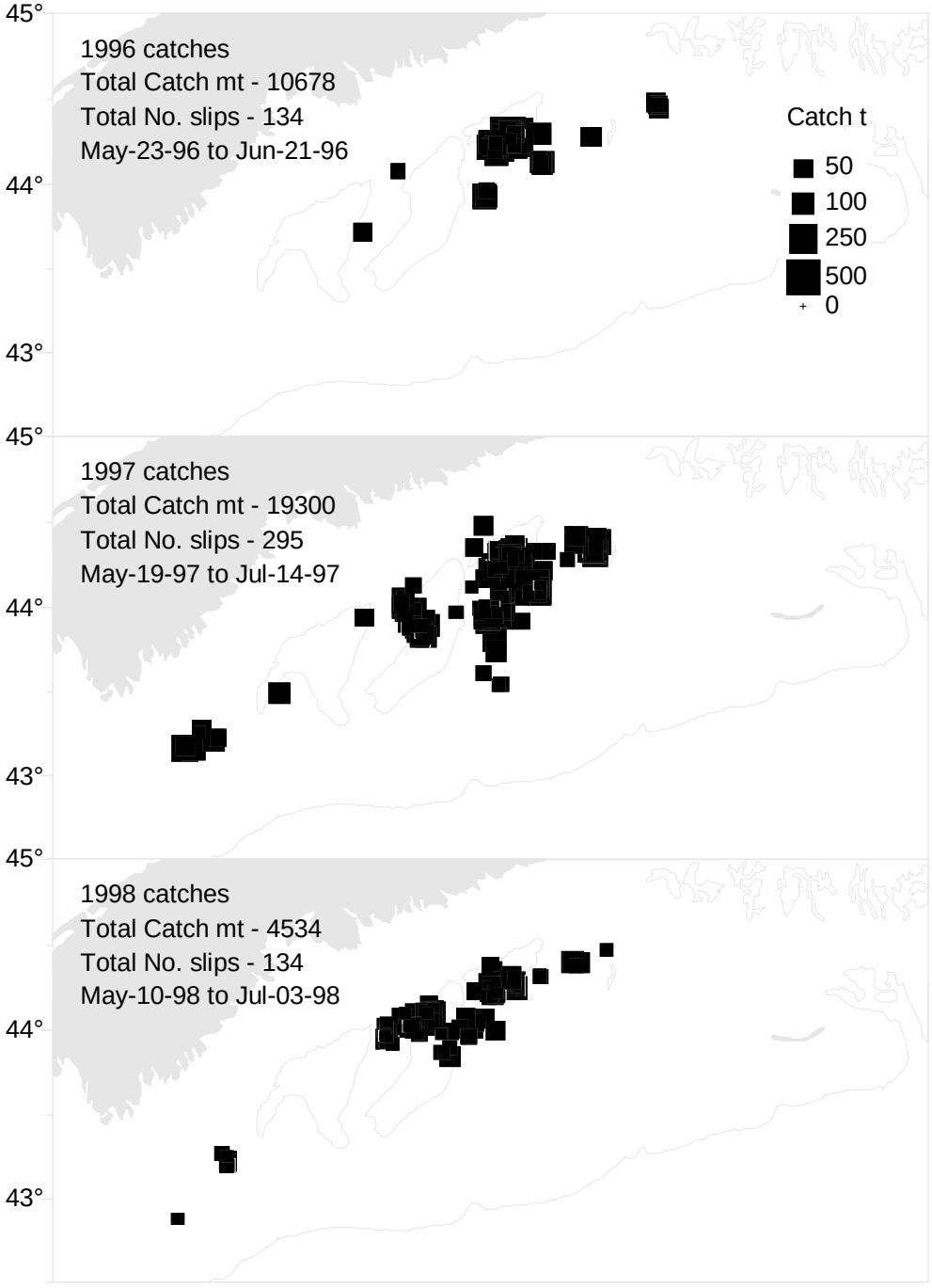


Figure 4. 1996 to 1998 herring purse seine catches (t) on offshore Scotian Shelf

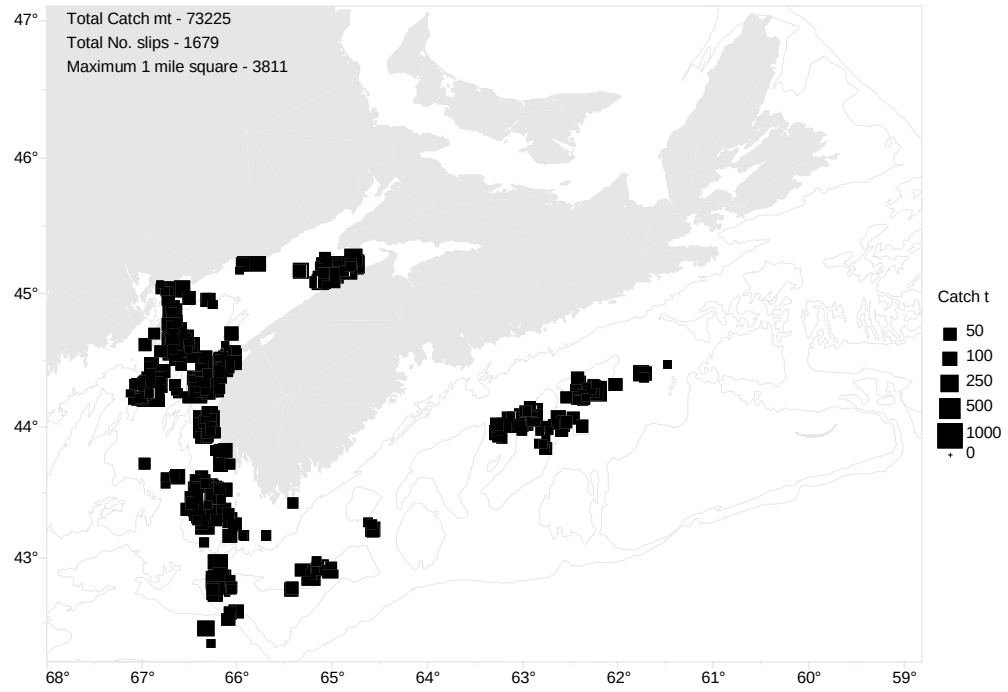


Figure 5. Overall 1998 4WX herring purse seine catches (t) aggregated by 1 mile squares.

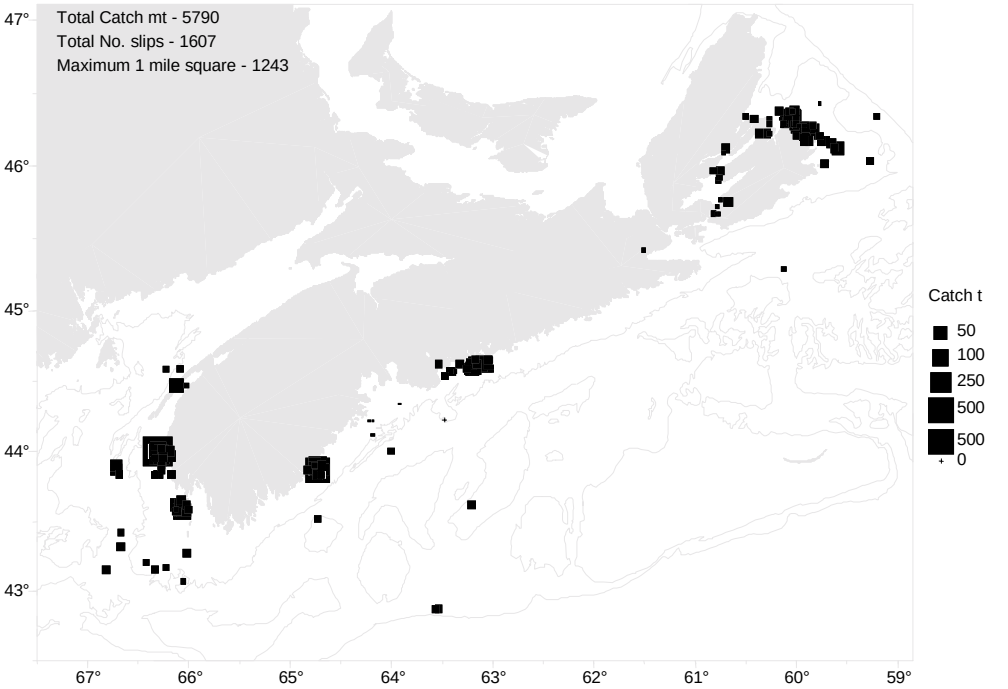


Figure 6. Overall 1998 4VWX herring gillnet catches(t) aggregated by 1 mile

Appendix II: Seasonal and Annual Variations in Fat Content in the 4VWX Herring Fishery

Introduction

For the last decade, several processing plants have documented the fat content of herring in the 4WX fishery. Fat content is important to industry because of its significant influence on the commercial value of herring in some markets. It is also of interest biologically as a reflection of condition and environmental fluctuations. This paper summarizes fat content information from three processing plants over the past decade, and explores the idea of a standardized sampling program which has been suggested by several plants in order to better document the annual fat content fluctuations.

Background

The fat content of herring has been investigated in various studies spanning nearly a century, Milroy (1906, 1907,1908), Johnstone (1915, 1918, 1919, 1920), Bruce (1924), Lovern and Wood (1937), Liem (1957), Iles and Wood (1965), Stoddard (1968), Hodder et al (1973), McGurk et al (1980), Bradford (1991), Ona (1990), Slotte (1996). The results from these studies have documented the seasonal variation of fat and its relationship to gonad development, the fat/water relation, the effect of fluctuating body fat percentages on acoustic target strength and the relationship between swimbladder volume and fat content in herring.

One of the first studies of fat content in waters adjacent to the Maritime Provinces was that of Leim (1957). Using samples taken from the Gulf of St. Lawrence, outer coast of Nova Scotia and southern and western Newfoundland, Leim reported that the fat content varied from 4.1 to 17.4 percent of the wet weight of the herring. The fat content was lowest in April and May and highest in July and August. Autumn spawners lost fat in the fall earlier than spring spawners, but no differences were seen in the fat content of male and female herring.

In 1965, Iles and Wood reported a linear relationship between percent fat and percent water and concluded that it was close enough to justify the use of percent water to estimate percent fat. They suggested the mechanism may be concerned with the maintenance of buoyancy and that possibly the accumulation of fat occurs as a method to obviate the need for drastic reductions in swimbladder volumes. This idea was further examined by Brawn (1969) who reported that a decrease in swimbladder volume occurred with an increase in fat up to 12%. In Atlantic herring, fat herring had a lower mean swimbladder volume and had to be subjected to a greater reduction in pressure to reach neutral buoyancy. Finally, she concluded that high fat content and low swim bladder volume, as well as other features, combine to allow herring rapid vertical movement and the ability to remain at considerable depths for extended periods.

Further studies of fat content of herring in Maritime waters were carried out by Stoddard (1968). The relationship between fish length and fat content was investigated but no correlation was found. Furthermore, there was no relationship found between fat content and the sex of the fish. Autumn and spring spawners were expected to show a similar decrease in percent fat during the winter and increase thereafter as food becomes more available in spring. The range of seasonal variation in percent fat is expected to be

higher for spring spawners although this difference was not apparent in Stoddard's study because of inadequate sampling. A similar initiative was undertaken by Hodder et al (1973). Using samples taken from various locations in waters surrounding Newfoundland, it was reported that in all months except May and June the percent fat of spring spawners was higher than that of autumn spawners. Again, they saw no relationship between fish length and fat and no significant difference between the sexes. The maximum fat content for both autumn and spring spawners was in December and the lowest fat content was in mid April for autumn spawners and May for Spring. Finally, they reported some indication of increasing trend with values in 1970 and 1971 being generally higher than those in 1966 and 1969 and concluded that the trend may be density-dependent, limited by the food supply. In 1977, Varga et al considered the product requirements and monthly variation of fat content of herring populations in waters adjacent to the Canadian Maritime Provinces and found that, during a single year, the fat content ranged from 1-2% to 28%. They also believed it to be influenced by the availability of food and the physiological state of the fish.

More recently, Ona (1990) investigated physiological factors that may influence the acoustic target strength of a school of fish. For the most part the swim bladder of a fish is responsible for acoustic back scattering from fish. Because of the relationship between swimbladder size and fat content in herring, the percent fat of a fish must also be considered. The variance in fat content can both negatively and positively bias the acoustic biomass estimate by 30-40% if nominal target strength relation is used. Ona (1990) concluded that fat content is an important factor that may alter the target strength significantly. Reynission (1993) documented target strength measurements of Icelandic summer spawning herring from 1985-1992. For the adult herring, a trend towards lower target strength with increasing fat content was reported. A one percent increase in fat content decreased the target strength by about 0.2 dB.

Documentation of Fat Content of 4WX Herring Over the Past Decade

In 1994, plants processing herring from the 4WX fishery noticed that fat content was unusually low and it remained consistently low throughout the season. Plants were asked to document this by providing historical fat content data to scientists at St. Andrews Biological Station. Information was collected from mid-month, from the same location each year where possible (Stephenson et al. 1995 unpublished data; Stephenson et al. 1995). It was concluded that the fat content was lower in each month of the fishery in 1994 than at any other time in the previous decade and that the unusually low fat content was accompanied by low incidence of food in the gut and a lower condition index. Furthermore, the maturity schedule was unusual in 1994 with considerably lower proportions of mature age 3 and 4's, and an unusual incidence of immature fish above age 4. Larval herring abundance in October and November of 1994 was low indicating impaired spawning. Comments were also made throughout the season regarding unusual herring behavior, including " herring acting strangely", herring remaining " hard on bottom" and being "offshore" and "deep". At that time it was presumed to be linked to odd water conditions, lack of food and low fat content (Stephenson et al. 1995). A temperature anomaly off southwest Nova and poor spawning were also reported. At that time it was noted that a standardized sampling program would be beneficial, however, limited funding and personnel did not allow it.

Comments regarding low fat content were made again during the early summer of 1998. Members of the processing sector stated on several occasions that the fat content was low and that this was having a negative impact on some markets. At the same time comments were made by the seiner sector about “wild” herring that stayed near the bottom, and scattered quickly when near the surface.

Methods

Fat content information for the years 1995 to 1998 were obtained from Comeau’s Sea Foods Limited, Scotia Garden Seafood Inc. and Connors Brothers, Limited. These were added to records obtained in 1994 for years 1987 to 1994. Currently there are at least three different methods used to determine the fat content of herring in industry (Moisture Determination, the Torrie Fat Meter and a chemical extraction method) and methodological differences among plants preclude direct between plant comparisons at this point.

Results

Figure 1 shows seasonal variations in the fat content of herring from the Scotian Shelf, Scot’s Bay, Long Island Shore, Brown’s Bank, German Bank and Trinity Ledge. The data were difficult to compare due to the change in the timing of the fisheries and the limited data available. There was some indication of low fat content in 1998, particularly early in the year, however there are more samples from early in the year in 1998 than in previous years.

Historical data from three plants were combined where possible in order to examine the variations in fat content over the last decade. Figure 2 shows annual variations in fat content for three areas (German Bank, Long Island Shore and Scotian Shelf) using samples taken from specific weeks in the fishery. For these three areas where comparable data were available, the fat content in 1998 was lower than most years, but not as low as 1994. Unlike 1994, there was no indication of impaired spawning. Spawning areas were active and, in some cases, spawning began up to 3 weeks earlier than usual and continued later.

Proposal for Future Sampling

Evaluation of fat content data collected in the past has been hampered by the use of different methods and changes in sample timing and location. It is important to standardize the sampling method and protocol for comparisons of specific areas within a year and between years. The method, the sampling area and the time of sampling should be consistent from year to year.

It is proposed that a plan be implemented whereby interested parties could participate in a standardized sampling protocol and method of obtaining fat content information throughout the fishery.

Sampling Method

Ideally all participating plants should use a single method of fat determination so that all data collected are comparable. Unfortunately this would require the implementation of a new method in most plants. If the use of a single method is not possible, plants could continue to use different methods, as long as they were used consistently with comparisons and calibrations made between different plants.

Sampling Areas and Timing

Information is most valuable if it is collected from the same areas and the same time from year to year. The areas of most interest include the Offshore Scotian Shelf, Brown's Bank, German Bank, Long Island Shore, Trinity Ledge, Scot's Bay, Eastern Passage and Little Hope.

Fat content of herring should be sampled at least once a week from each of the above mentioned areas, as long as fishing continues in the area. Furthermore, a sample should be taken and fat percent determined after each acoustic survey for future reference.

Recommendation:

That fat content of herring be collected by 1) a single method or 2) methods which are used consistently and compared and calibrated on a weekly basis, from each of the following areas: the Offshore Scotian Shelf, Brown's Bank, German Bank, Long Island Shore, Trinity Ledge, Scot's Bay, Eastern Passage and Little Hope.

Summary

- Fat content information from 1995 to 1998 was gathered from three herring processing plants. The information was combined with data previously collected from 1987 to 1994.
- Three different methods of fat extraction were used (Moisture Determination, the Torrie Fat Meter and a chemical extraction method).
- Seasonal variations in fat content were examined for six areas (Long Island Shore, Scot's Bay, Brown's Bank, German Bank, Scotian Shelf and Trinity Ledge) but the data were not sufficient to draw conclusions for all areas
- Because of changes in the timing of the fishery and the lack of available data, annual comparisons could only be made for three areas (Scotian Shelf, Long Island Shore and German Bank). In these areas the fat content in 1998 was lower than most years, but not as low as 1994, a year in which fat content was particularly low.
- It is recommended that all participating plants collect data from the same areas and at the same time on a year to year basis.
- It is also recommended that fat content of herring be collected either by a single method or by methods which have been calibrated and compared.

References

Bradford, R.G. 1991. Reproductive traits, gonad maturation and spawning of Northwest Atlantic herring Clupea harengus harengus L. . PhD Thesis. Dalhousie University: 121-154p.

Brawn, V.M. 1969. Buoyancy of Atlantic and Pacific herring. J. Fish. Res. Bd. Can. 26: 2077-2091p.

Bruce, J.R., 1924. Changes in the chemical composition of the tissues of the herring in relation to age and maturity. Biochem. J., 18: 469-485p.

Hodder, M., L.S. Parsons, G.H. Winters, and K. Spencer. 1973. Fat and Water content of herring in Newfoundland and adjacent waters, 1966-1971. Fish. Res. Bd. Canada, Tech. Rept. No. 365: 49p.

Iles, T.D. and R.J. Wood. 1965. The fat/water relationship in North Sea herring (Clupea harengus), and its possible significance. J. mar. biol Ass. U.k., 45: 353-366p.

Johnstone, J. 1915. The fat content of Irish Sea Herring. 23rd Rep. Lancs. Sea-Fish. Labs.: 154-161p.

Johnstone, J. 1918. The dietetic value of herring. 26th Rep. Lancs. Sea-Fish. Labs.: 13-59p.

Johnstone, J. 1919. The dietetic value of sprats and other clupeoid fishes. 27th Rep. Lancs. Sea-Fish. Labs.: 36-63p.

Johnstone, J. 1920. On the dietetic values of herrings and other fishes. 28th Rep. Lancs. Sea-Fish. Labs.: 16-23p.

Lovern, J.A., and H Wood. 1937. Variations in the chemical composition of herring. J. Mar. Biol. Ass. U.K., 22: 281-93p.

Leim, A. H., S.N. Tibbo, L.R. Day, D. Lauzier, R.W. Trites, H.B. Hachey, and W.B. Baily. 1957. Report of the Atlantic Herring Investigating Committee. Bull. Fish. Res. Bd. Canada. No 111: 317p.

McGurk, M.D., J.M. Green, W.D. McKone and K. Spencer. 1980. Condition indices, energy density and water and lipid content of Atlantic herring (Clupea harengus) of southeastern Newfoundland. Can. Tech Rept Fish Aquat Sci. 958, 41p.

Milroy, T.H. 1906. The food value of herring. Rep. Fish. Bd Scot.,No. 24, Part III: 83-107p.

Milroy, T.H. 1907. The food value of herring. Part 2. Rep. Fish. Bd Scot.,No. 25, Part III: 197-207p.

Milroy, T.H. 1908. Changes in the chemical composition of the herring during the reproductive period. Biochem. J., 3: 366-90p.

Ona, E. 1990. Physiological factors causing natural variatons in the acoustic target strength of fish. J. mar.biol. Ass.U.K., 70: 107-127p.

Reynisson, P. 1993. In situ target strength measurements of Icelandic summer spawning herring in the period 1985-1992. ICES CM. 1993; B:40.

Slotte, A. Relations between seasonal migrations and fat content in the Nor wegian spring spawning herring (Clupea harengus L.) ICES CM. 1996; H:11.

Stephenson, R.L., F. Page, T.D. Iles and M.J. Power. 1995. Environmental, ecological and multispecies considerations of relevance to the assesment and management of 4WX herring. Unpublished data.

Stephenson, R.L., M.J. Power, J.B. Sochasky, F.J. Fife, G.D. Melvin, S. Gavaris, T.D. Iles and F.Page. 1995. Evaluation of the Stock Status of 4WX herring.DFO Atl. Fish. Res. Doc. 95/83.

Stoddard, J.H. M.S. 1968. Fat Contents of Canadian Atlantic Herring. Fish Res. Bd. Canada, Tech. Rept. No 79: 57p.

Varga, S., G. G. Sims and T. D. Iles. 1977. The fat and moisture contents of herring populations in the waters of the Canadian maritime provinces. Fisheries and Marine Service Technical Report 723 (April 1977).

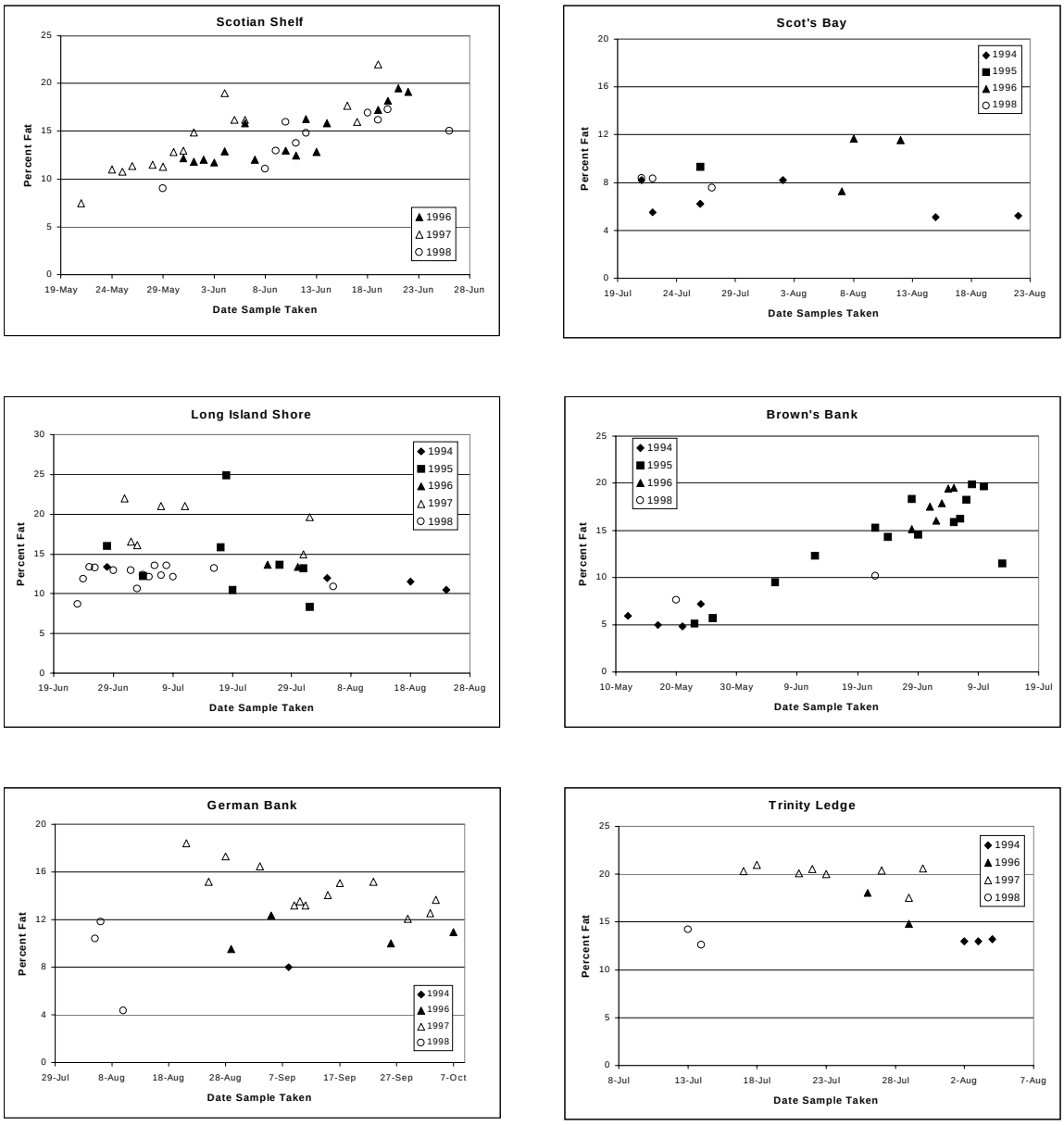


Figure 1. Seasonal variations in fat content in herring samples from the Scotian Shelf, Scot's Bay, Long Island Shore, Brown's Bank, German Bank and Trinity Ledge

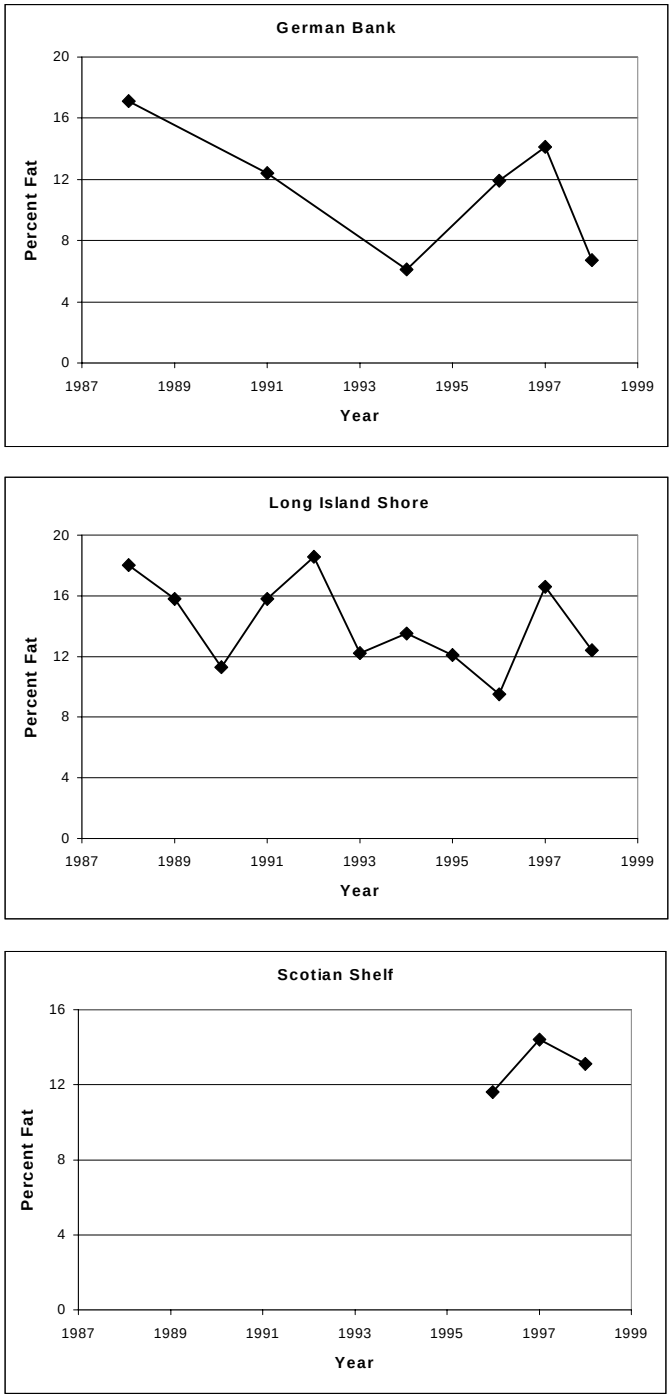


Figure 2. Annual variations in percentage of fat in herring samples taken from German Bank, the Long Island Shore and the Scotian Shelf.

Appendix III: The August distribution of whale sightings and herring purse seine sets off Brier Island, N.S.

M.J. Power[1], C. Haycock[2], M. Geddes[2] and R.L. Stephenson[1]

[1]DFO, St. Andrews, N.B.
[2]Briar Island Ocean Study, Westport, N.S.

Introduction

The waters of the lower reaches of the Bay of Fundy have long been recognized as being rich in marine life. These waters have traditionally supported one of the largest herring stock complexes in the western Atlantic, and are well known as a preferred seasonal location for many species of cetacean. The area supports an active herring fishery (using a variety of geartypes including weir, gillnet and purse seine), and more recently has become the location of a growing "ecotourism" industry featuring observation of the several species of cetacean which frequent the area.

The Brier Island Ocean Study has been collecting data on the occurrence of cetaceans in the waters off Brier Island since 1984. Historical records for the month of August have been edited and were available for analysis from the thesis research of M.Geddes (Geddes, 1998).

This working paper presents an exploratory analyses of these data and information on the distribution of herring purse seine activity, compiled by DFO. There are several reasons for initiating this study. It represents an obvious collaboration between research groups with historical data sets of interest to the Bay of Fundy ecosystem; it continues the documentation of the ecological interactions of herring, and promotes further research on cetaceans of the Bay of Fundy. It was hoped that this preliminary analysis would help guide future data collection allowing better use of observational opportunities. In addition, the distribution of cetaceans in relation to the distribution of herring and the herring fishery in the area of Brier Island, was brought to the attention of the Scotia-Fundy Herring Advisory Committee in January 1999 by members of the Digby Neck and Islands Whalewatching and Eco-tourism Association. This group made the claim that herring seining close to shore has had a negative impact on whale sightings in recent years.

Data and methods

Cetaceans were observed on whale watching trips since 1985 from Brier Island using the protocol as described in Geddes (1998). All species were identified and total numbers counted or estimated along with the point location of the observation and other details. An example data sheet is shown in Annex 1.

Herring purse seine set information for the Brier Island area since 1985 was extracted from the DFO logbook data, and more recently the Dockside Monitoring Program (DMP) which records the point location and catch (t) for each trip or set

Results

Eight species of cetaceans were recorded in the August data in 5,208 sighting events (34,491 individuals sighted) between 1985 and 1998 (Table 1,2). Of these, humpback whales, harbour porpoise, finback whales, whitesided dolphins, and minke whales were most frequently observed (as the larger whales are the 'target' species of interest) but whitesided dolphin, harbor porpoise were numerically most prevalent (Table 1a, 1b). It also appears that there were fewer trips (Table 2) in 1995 and 1998 as well as some earlier years. This is also reflected in fewer sightings and total whales (Table 1a, 1b) for those years.

In the same time period, there were 783 purse seine landings amounting to a total of 26,000t for this area (Table 3). Landings for purse seine are also presented for the Brier Island area for all months for comparison with the August period used in this analysis. In addition data for all areas for the month of August and for the entire summer fishery are presented to help show the relative size of this August Brier Island fishery.

The spatial distribution of cetacean sightings (all species) and of purse seine sets, for August of each year is presented in Fig 1. It shows varying degrees of overall interaction/co-occurrence from year to year as well as changing patterns in the overall whale and herring catch distribution. For most of the period (1985-94) the whale distribution has a consistent pattern tightly distributed along the Long Island shore and southwest of Brier Island. Since 1995 the pattern of distribution is less 'tight' along Long Island shore with dispersion into the midbay area as far as the Grand Manan basin. This has been attributed mostly to the lack of large whales in the Long Island area in recent years and the requirement for further searching/travel to areas where whales were known to occur. This also resulted in a change of the main target species from humpback and finback to North American right whale, which occur frequently in the mid-bay area. The 1997 whale distribution was especially different as a result of this change in target species. There appears to be little overlap of whale sightings or herring catches in the years 85-87 and 90-93, but 88-89, 94-95 and 98 show more co-occurrence at first glance.

These initial plots of 'all whale' species are clouded by some large numbers of sightings due to observations of porpoises or dolphins. They also include right whales, which feed on copepods and so their sightings would also be less relevant to a study of whale/herring interaction. Feeding strategies differ between the whale species but the larger species should require larger denser patches or schools of herring to feed on and so they should in theory be the ones most affected by the seine catches.

For whale watch boats, it is mainly large whale sightings that determine the success of a trip. Of the abundant species of cetacean in the study area, the humpback and finback whales would be expected to have the closest association/interaction with herring since it is one of their main food items. The cumulated August distribution for purse seine sets and each of these species and is shown in Fig 2 (humpback), and Fig 3 (finback). These species show similar patterns of overlap with herring catches. This was also seen in the overall plots (Fig 1) with a lack of co-occurrence for most years, increasing spatial spread in recent years (especially 1997 due to more widespread searching to find whales) and some more intense overlap in a few years (1995 and 1998). In general, the finback distributions seem very similar to humpback whales.

Finally, by looking at one species at a time on a daily basis we might expect to see the movement of the species in and out of the bay and events (days) when there may be a link between seine catches and lack of sightings. Daily plots of humpback whale sightings and of successful purse seine sets (recent years since 1995 only) are presented in Fig 4. Comparable plots for finback whales are presented in Fig 5.

Discussion

The August results presented in this paper represent only part of a data set which extends from June through September each year.

Both the cetacean and herring data presented here show successful sightings or sets and do not reflect the entire search area. They do not, therefore, reflect the true abundance of whales and herring.

On the basis of limited analysis there appear to be year-to-year differences in the overlap (co-occcurance, interaction) of whales and herring, and of whale watching and purse seining.

Future research should include, at least, the following:

i) analysis of aditional cetacean data (additional months)
ii) better documentation of the search patterns (i.e. areas of no sightings).

Literature Cited

Geddes, M.L. 1998 Annual variation in cetacean sightings in the Bay of Fundy, Nova Scotia. B.Sc. (Hon.) Thesis, Acadia University. 47p.

Table 1a. Whale sightings (count of number of sightings) from Brier Island whale watching trips in August.

Species Count sightings	85	86	87	88	89	90	91	92	93	94	95	96	97	98	Grand Total
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minke	8	20	19	35	25	31	36	113	136	87	20	94	28	33	685
Sei	0	0	0	0	0	0	0	0	2	2	7	4	2	0	17
Blue	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Finback	16	64	78	51	88	93	97	76	111	90	44	19	34	14	875
N. A. Right	1	0	0	2	7	0	0	0	9	7	14	41	154	9	244
White-sided dolphin	12	64	46	99	72	89	80	72	88	48	5	4	4	12	695
Humpback	21	97	136	164	132	200	170	252	79	266	36	3	15	37	1608
Harbor porpoise	18	49	31	74	47	156	96	85	215	145	49	78	27	6	1076
Pilot	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Grand Total	76	294	310	425	371	569	479	598	640	645	176	243	264	112	5202

Table 1b. Whale sightings (sum of number of animals) from Brier Island whale watching trips in August.

Species Number animals	85	86	87	88	89	90	91	92	93	94	95	96	97	98	Grand Total
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minke	8	20	22	35	28	31	36	122	147	94	23	112	29	39	746
Sei	0	0	0	0	0	0	0	0	3	3	10	5	2	0	23
Blue	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Finback	20	85	87	70	107	123	102	114	130	164	63	30	43	59	1197
N. A. Right	2	0	0	3	11	0	0	0	20	8	88	84	419	12	647
White-sided dolphin	837	1277	1755	1096	1289	3126	3784	1530	1356	783	75	107	30	650	17695
Humpback	28	142	166	274	188	324	213	402	122	390	52	3	18	66	2388
Harbor porpoise	319	369	602	319	447	1919	1145	473	1634	938	319	2095	658	457	11694
Pilot	0	0	0	0	0	0	0	0	0	0	0	0	0	100	100
Grand Total	1214	1893	2632	1797	2070	5523	5280	2641	3412	2380	631	2436	1199	1383	34491

Table 2. Whale sightings (count of number of sightings) by day from Brier Island whale watching trips in August.

Count of # obs	Year														
Day of year	85	86	87	88	89	90	91	92	93	94	95	96	97	98	Grand Total
213			22		7		15		12	27	4		6	8	101
214		17	20	7	7	23	27		13	29	16	8	8	7	182
215			5	2	19	32	35	29		24	10	5	18	15	194
216			13	2	16	27	20	21	1	20	5	15	11	6	157
217		22	6			17		21	19			9	9	8	111
218		15	12	3	19	21	15	35	35	5	13	11	27	3	214
219		10	27	11	1	27	20	40	40	32		10	2	5	225
220	1		10	28	12	20	27	58	38	21	12		13	1	241
221			5	13	21	7	31	47	8	35	6	4	2	5	184
222		2	10	22	12	13	14	63	32	36	8	1	16	1	230
223			10		27	4	7	12	59	21	2	3	6	1	152
224		21	14	30	15		32	5	10	52		8	6		193
225	14	24	10	10	12	12	12	42	21	28		12	19	11	227
226	4	19	4	24	1		16	34	52		13	17		2	186
227		17	3	36	10	23	9	43	28	22	5	13	12	2	223
228	4			7	2	24			30	19		11	9	3	109
229	6	13	5	10	17	14	21	20	5	55	21	11	8	7	213
230				37	18			9	23	27	12	12	11	3	152
231			26	27	13	6	10	9	24	30	12		10		167
232		21	10	30	13	30		4	16	17	8	11	5	2	167
233	4	31	19	7		39	14	7	42	12	15	13	7	6	216
234		24	7	4	15	45	14	5	28	13	2	10		9	176
235	5	21		25	5	25	13	5		26	10	1	13		149
236	12			19	11	33	23	19	12	40		6	8		183
237	9	2	8	15		20	26	10		16		2	2		110
238		3	15			30	15	6	6	14	2	14	10		115
239			18	17	12	20		8	18	13		7	7		120
240		4	6	15	22	9	4	6	31	5		9	8		119
241			3	6	23	4	14	8	26	1		10	7		102
242	17	13	8		22	23	27	17	11	3		5		2	148
243		15	14		19	21	18	9		2		5	4	5	112
244				18				6							24
Grand Total	76	294	310	425	371	569	479	598	640	645	176	243	264	112	5202
Count days	10	19	27	26	27	27	26	29	27	29	19	28	28	22	32

Table 3. Whale observations and herring purse seine catches for Brier Island area in August 1985-98,
Brier Island for year, August for all areas and for overall summer catches.

	Brier Island Area August Whale Observations		Brier Island Area August Purse Seine		Brier Island Area All Year Purse Seine		All Areas August Purse Seine		All Summer Purse Seine	
Year	Total Number	Count of Sightings	Catch (t)	Number of Landings	Catch (t)	Number of Landings	Catch (t)	Number of Landings	Catch (t)	Number of Landings
1985	1,214	80	2,453	62	12,772	273	27,016	607	77,741	1,647
1986	1,893	294	881	33	10,018	327	15,831	472	49,729	1,394
1987	2,632	310	517	18	12,149	356	19,388	571	63,181	1,687
1988	1,797	426	5,693	98	21,847	501	19,396	517	89,521	1,926
1989	2,070	371	1,371	47	23,759	695	10,896	322	64,224	1,609
1990	5,523	569	1,033	31	22,845	730	8,059	293	75,067	1,753
1991	5,280	479	493	18	14,096	485	14,347	379	69,244	1,735
1992	2,641	598	339	12	6,436	262	9,974	310	57,239	1,558
1993	3,412	640	117	4	3,712	113	5,020	125	33,136	742
1994	2,380	645	2,398	88	15,225	435	9,995	328	54,742	1,483
1995	631	176	4,347	137	12,945	455	6,611	195	46,685	1,008
1996	2,436	243	831	32	11,474	431	11,465	212	59,928	1,134
1997	1,199	264	1,374	72	11,353	399	11,490	245	59,795	1,292
1998	1,383	113	4,215	131	21,581	689	15,849	341	72,883	1,662
Total	34,491	5,208	26,062	783	200,212	6,151	185,337	4,917	873,115	20,630

	Brier Island Area All Year % August Brier Island Landings		All Areas for August % Aug Brier Isl. Landings		All Summer Purse Seine % Aug Brier Isl. Landings	
Year	Catch (t)	Number of Landings	Catch (t)	Number of Landings	Catch (t)	Number of Landings
1985	19%	23%	9%	10%	3%	4%
1986	9%	10%	6%	7%	2%	2%
1987	4%	5%	3%	3%	1%	1%
1988	26%	20%	29%	19%	6%	5%
1989	6%	7%	13%	15%	2%	3%
1990	5%	4%	13%	11%	1%	2%
1991	3%	4%	3%	5%	1%	1%
1992	5%	5%	3%	4%	1%	1%
1993	3%	4%	2%	3%	0%	1%
1994	16%	20%	24%	27%	4%	6%
1995	34%	30%	66%	70%	9%	14%
1996	7%	7%	7%	15%	1%	3%
1997	12%	18%	12%	29%	2%	6%
1998	20%	19%	27%	38%	6%	8%
Overall	13%	13%	14%	16%	3%	4%

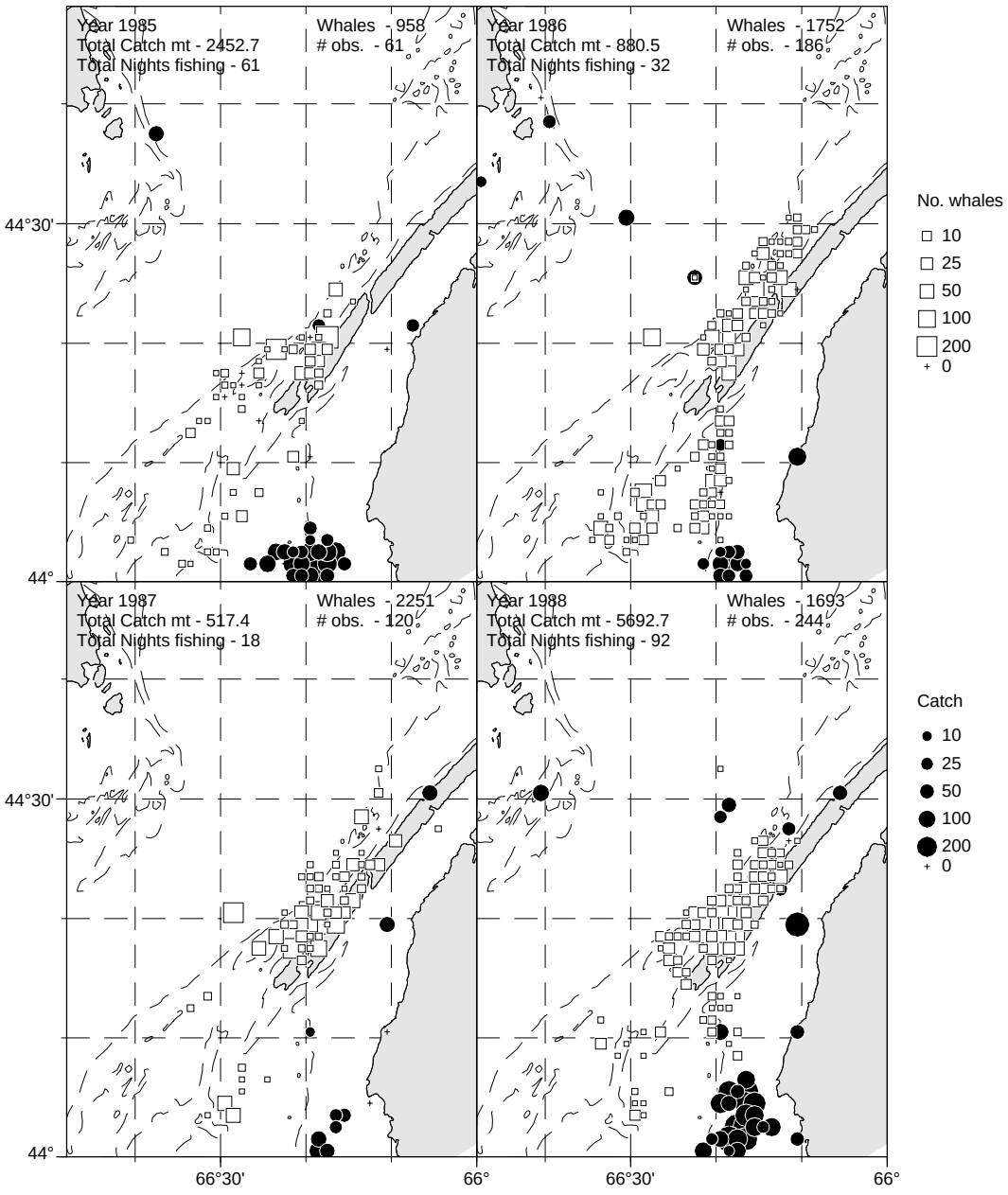
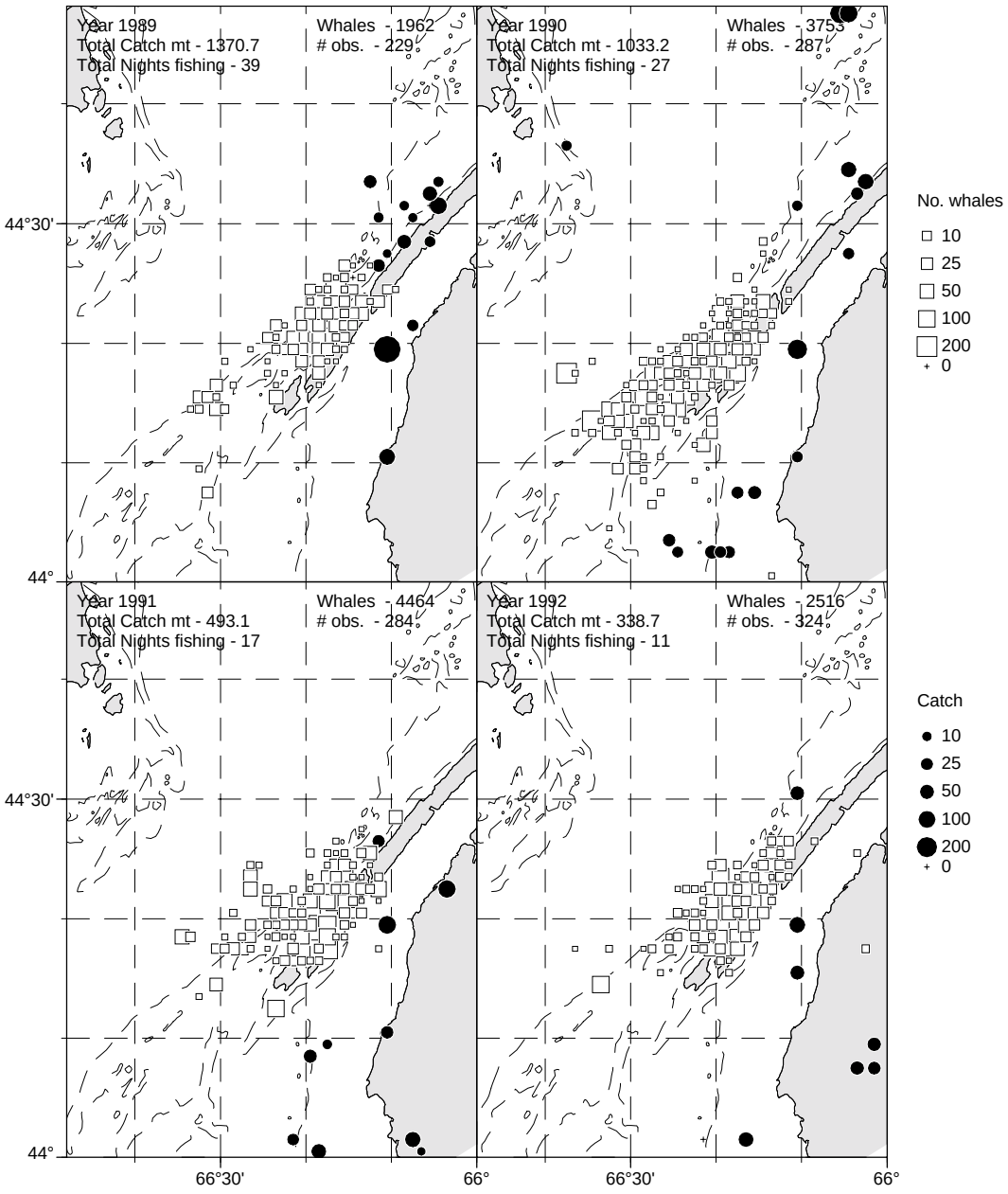


Figure 1. Whale observations (total numbers for all whales) and purse seine catches (t) for the Brier Island area in August for 1985-98.



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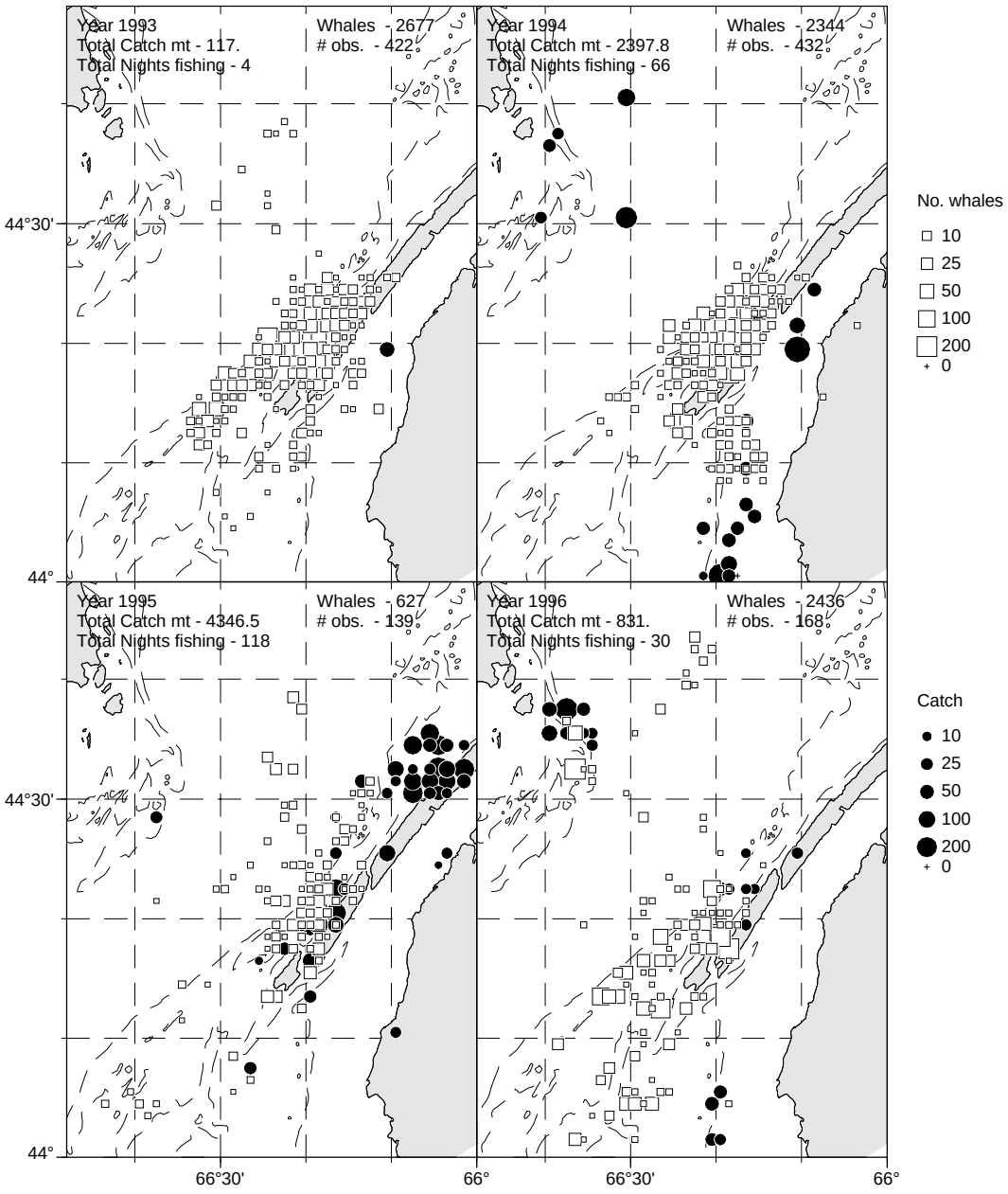

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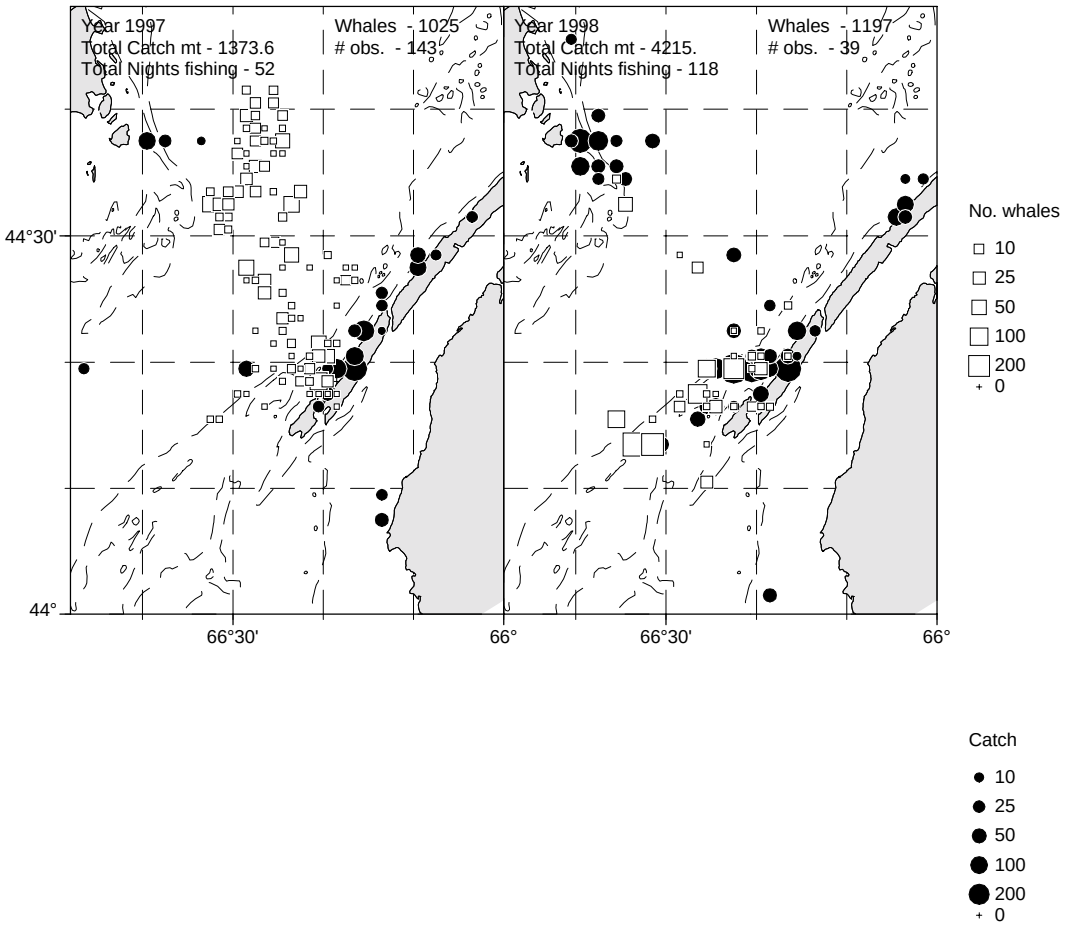

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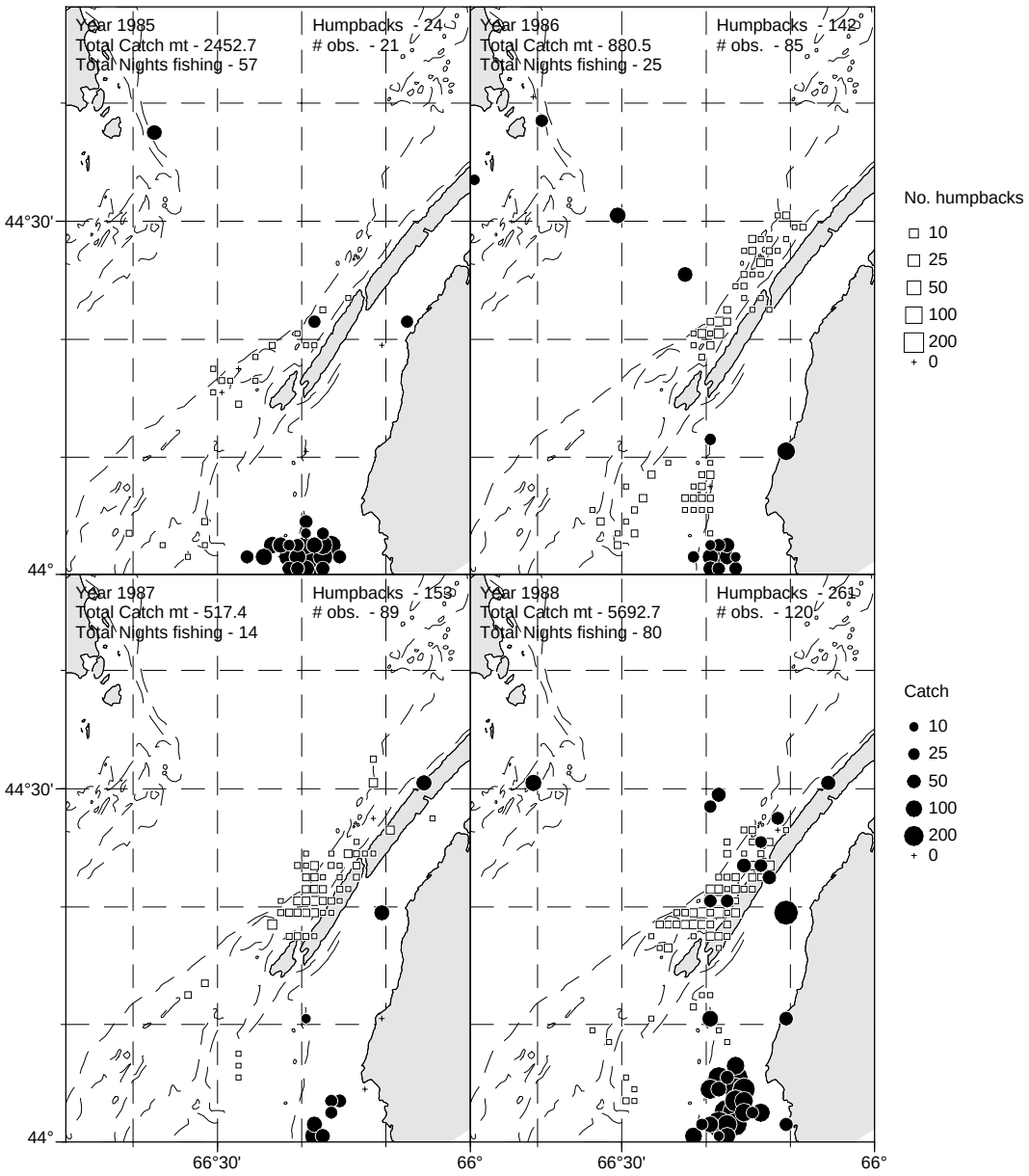
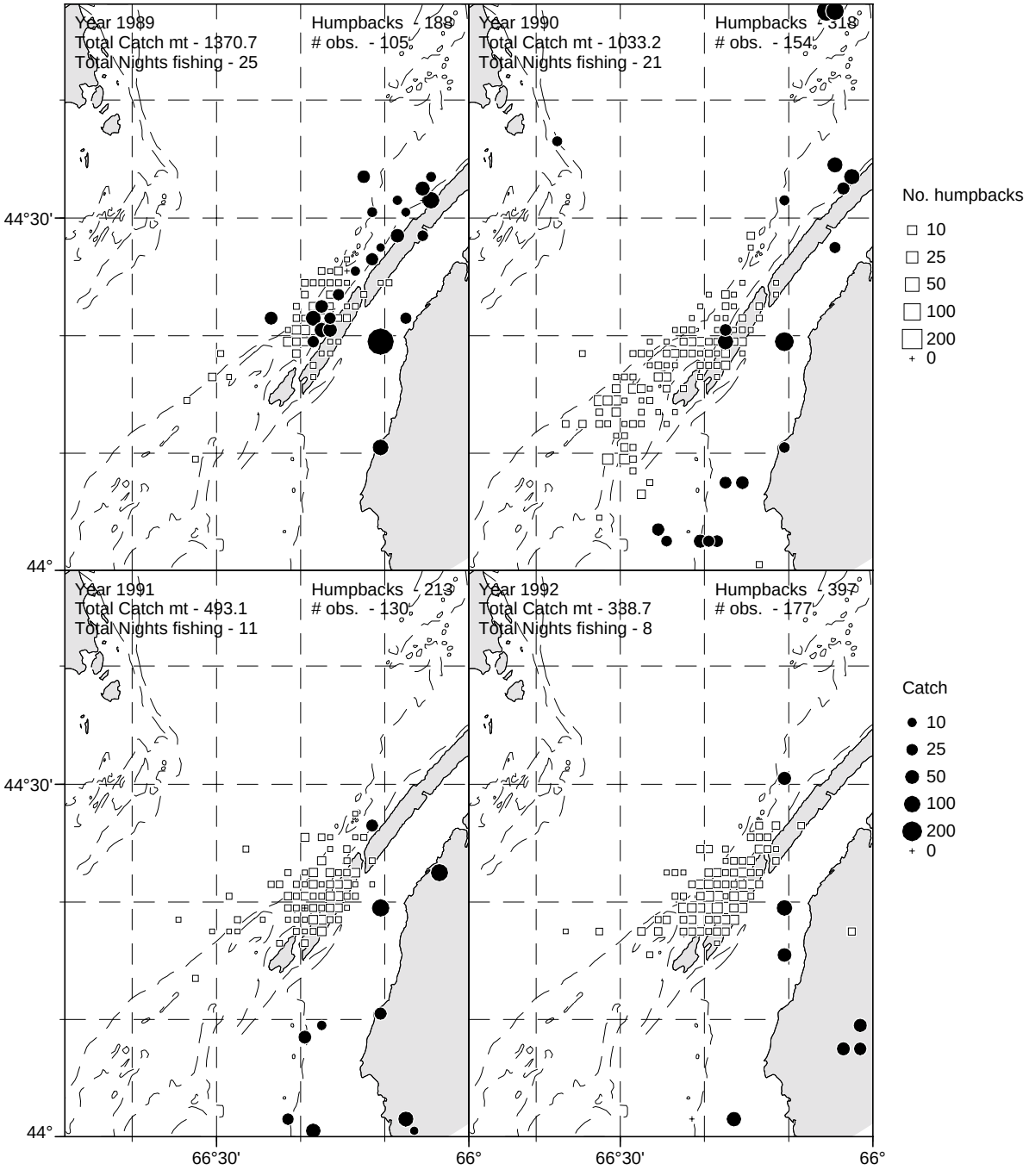


Figure 2. Humpback whale observations (total numbers) and purse seine catches (t) for the Brier Island area in August for 1985-98.



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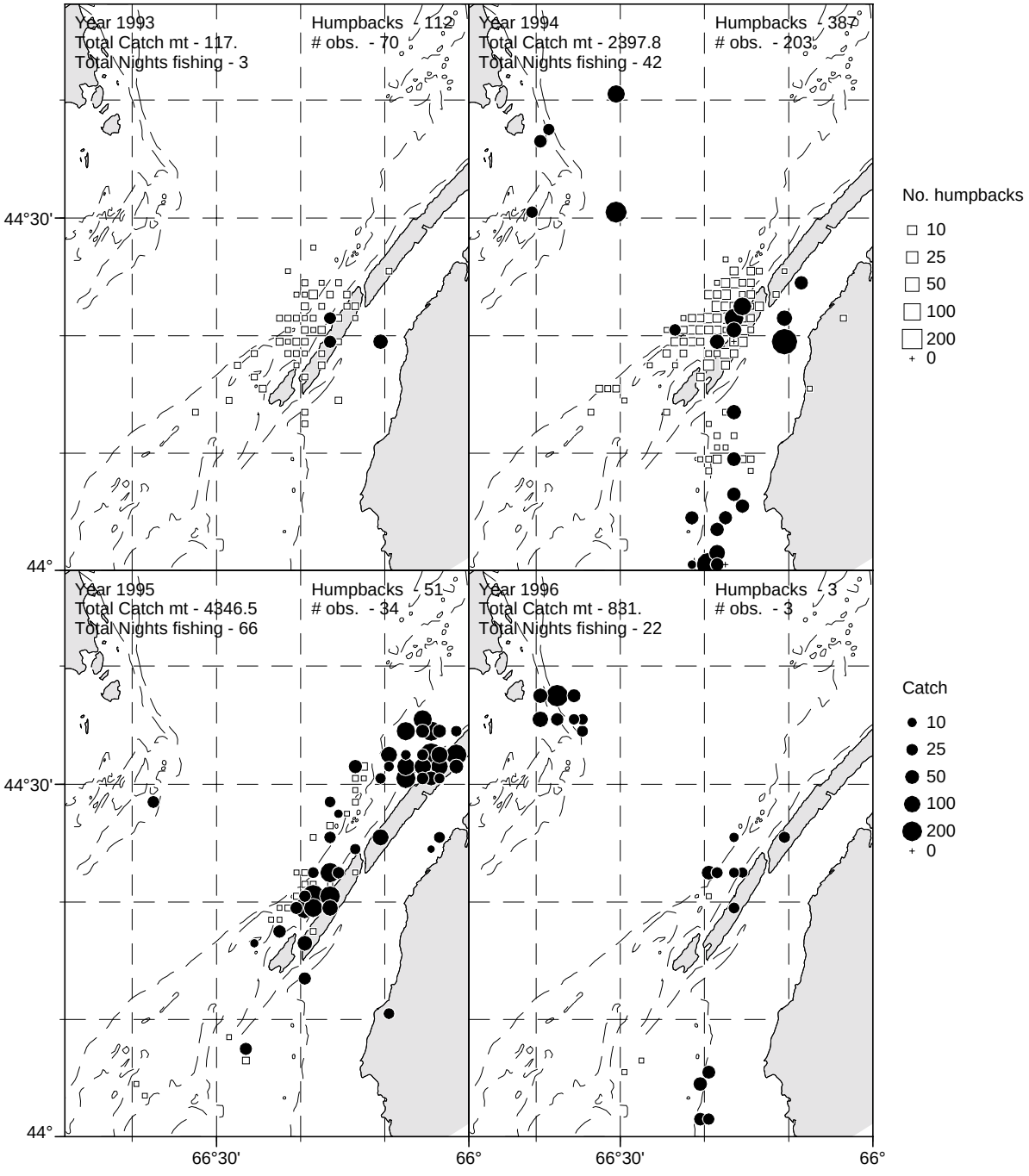

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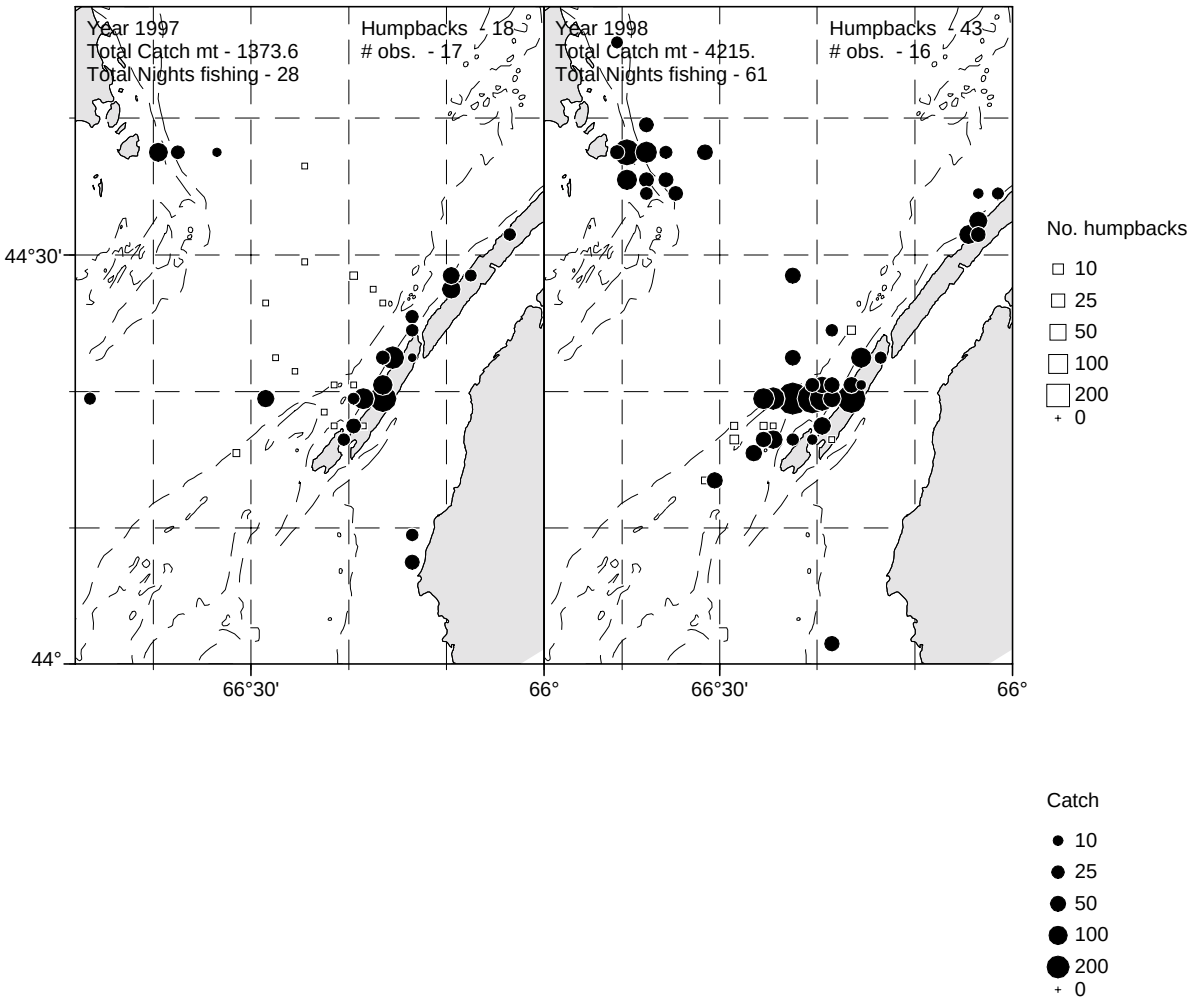

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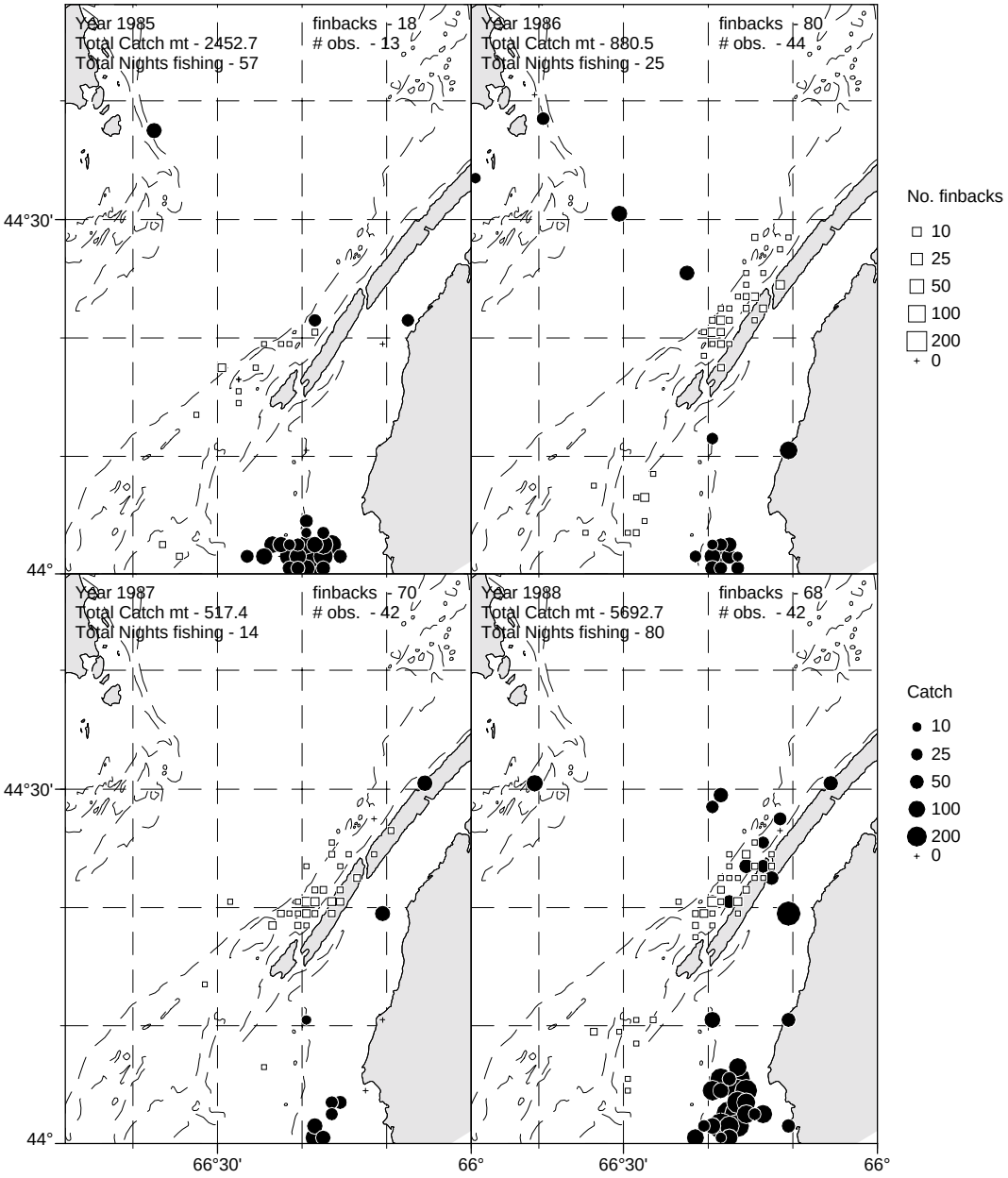
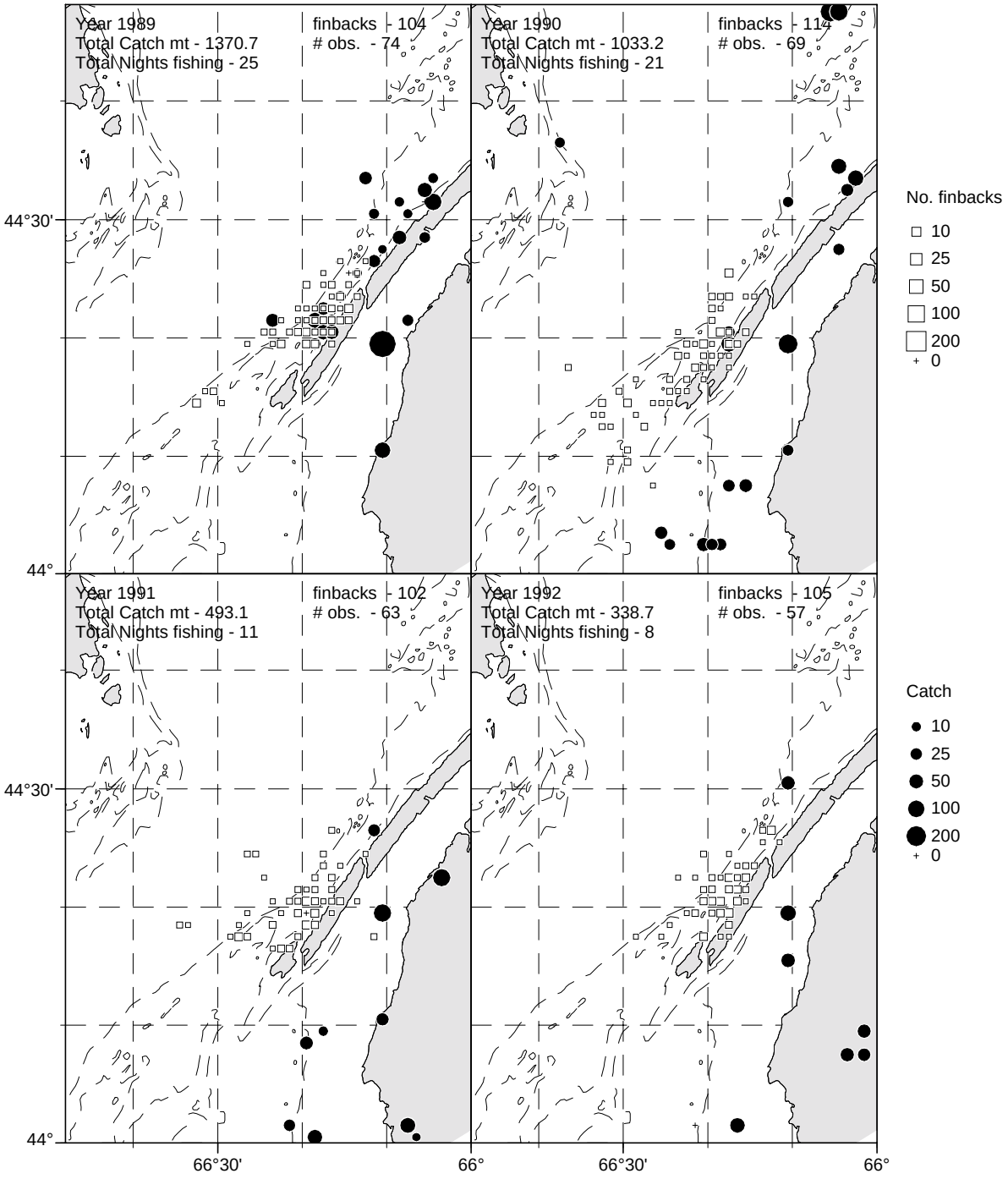


Figure 3. Finback whale observations (total numbers) and purse seine catches (t) for the Brier Island area in August for 1985-98.



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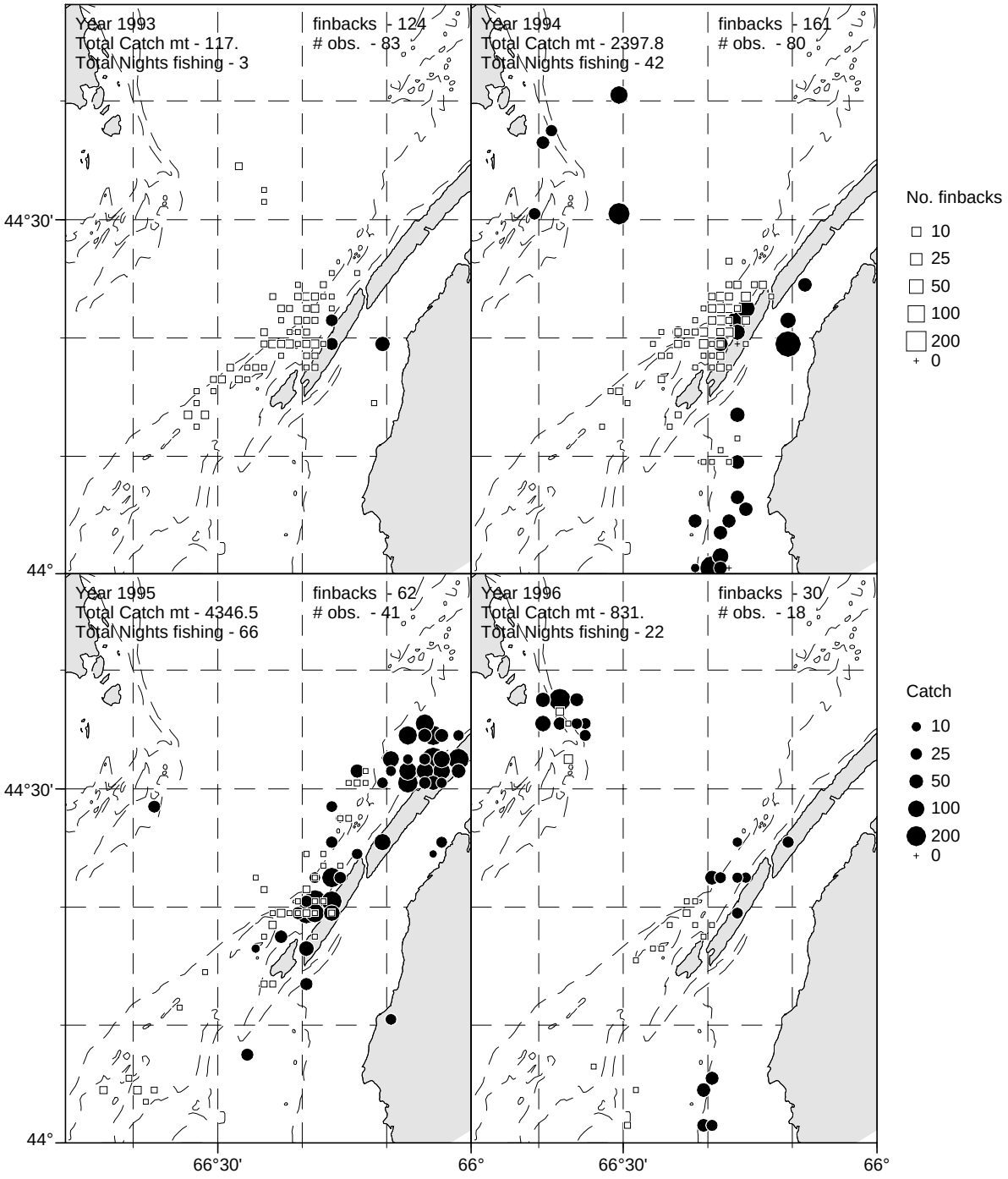

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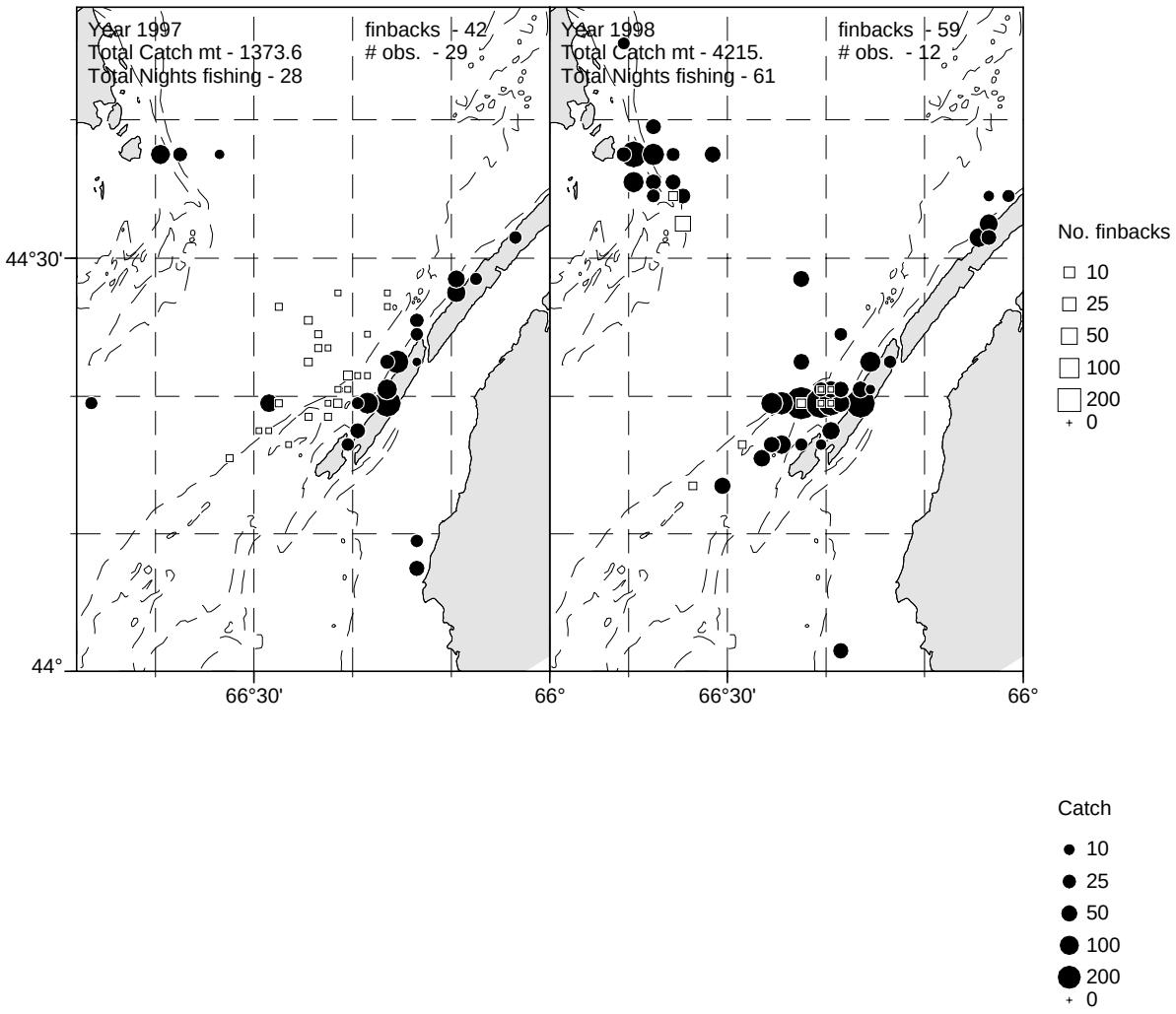

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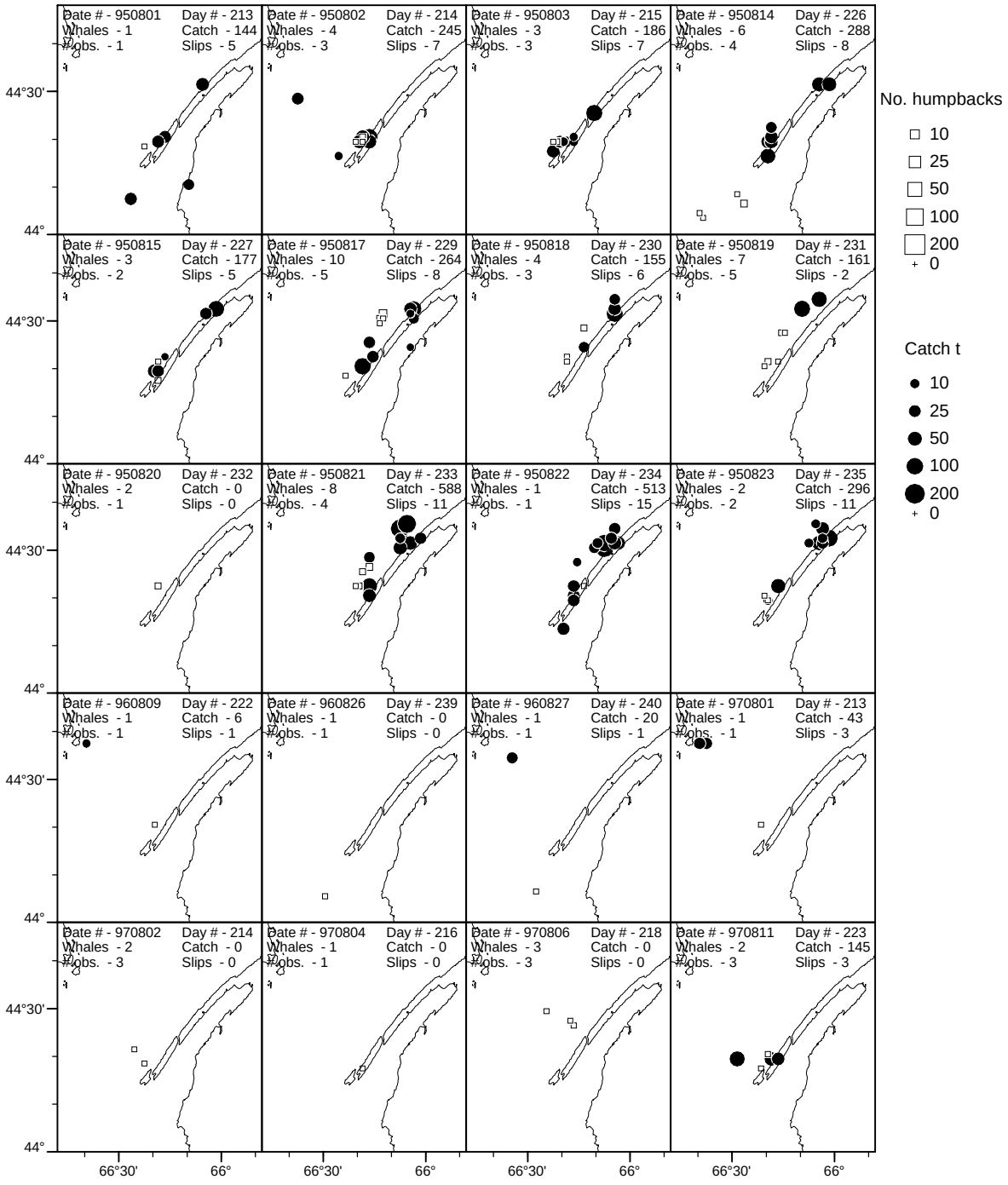
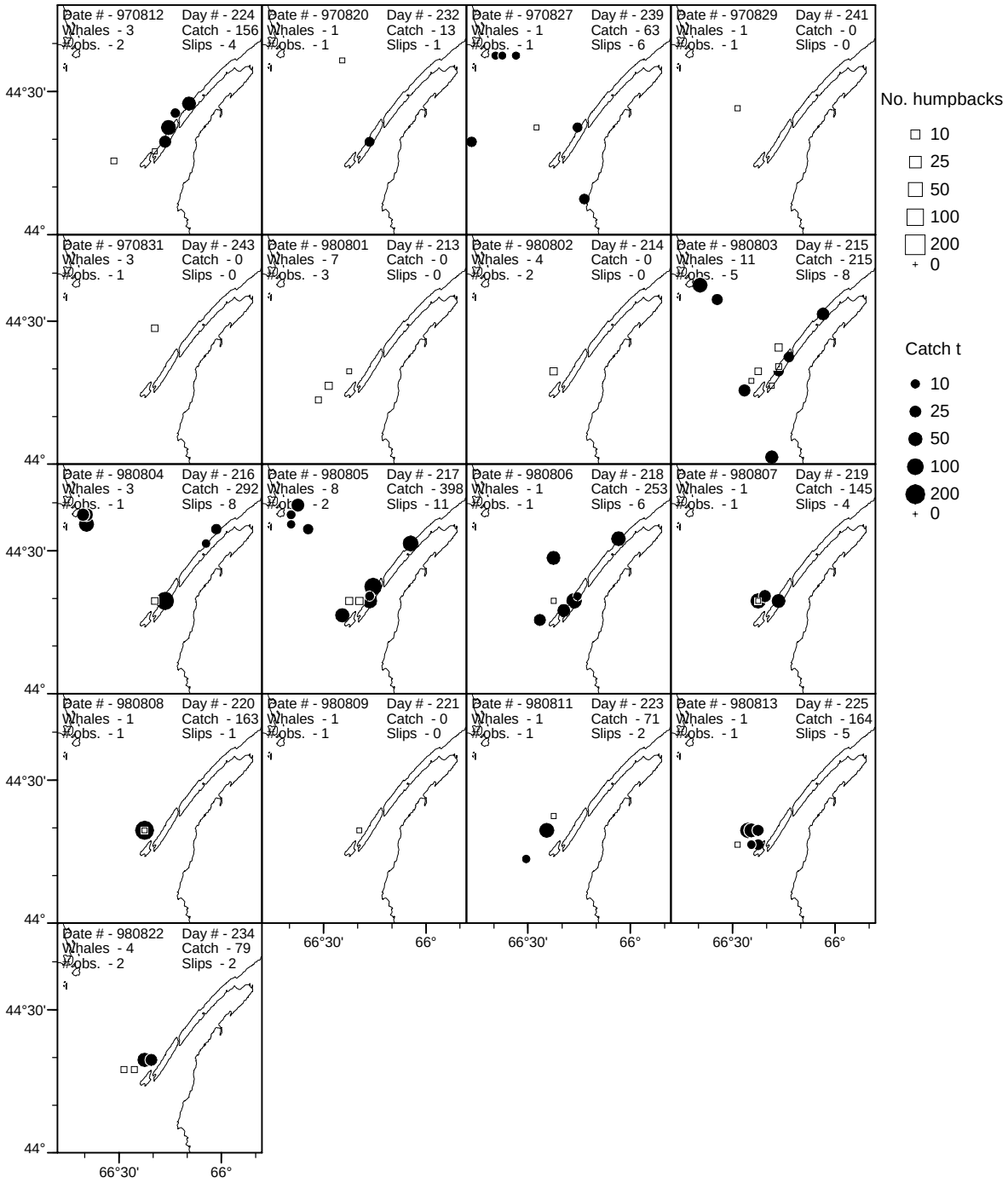


Figure 4. August 1995-98 daily humpback observations and herring catches for selected area



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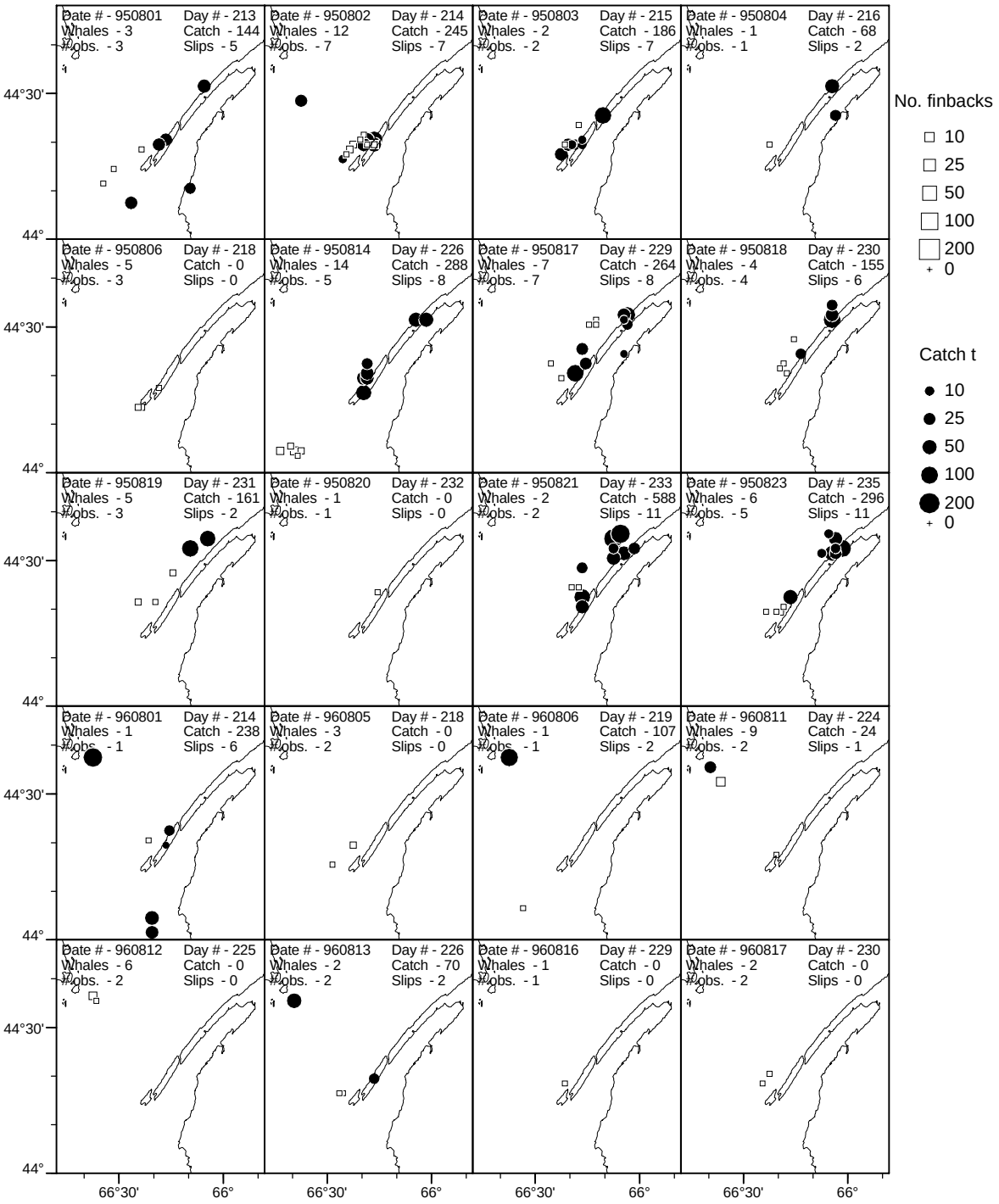
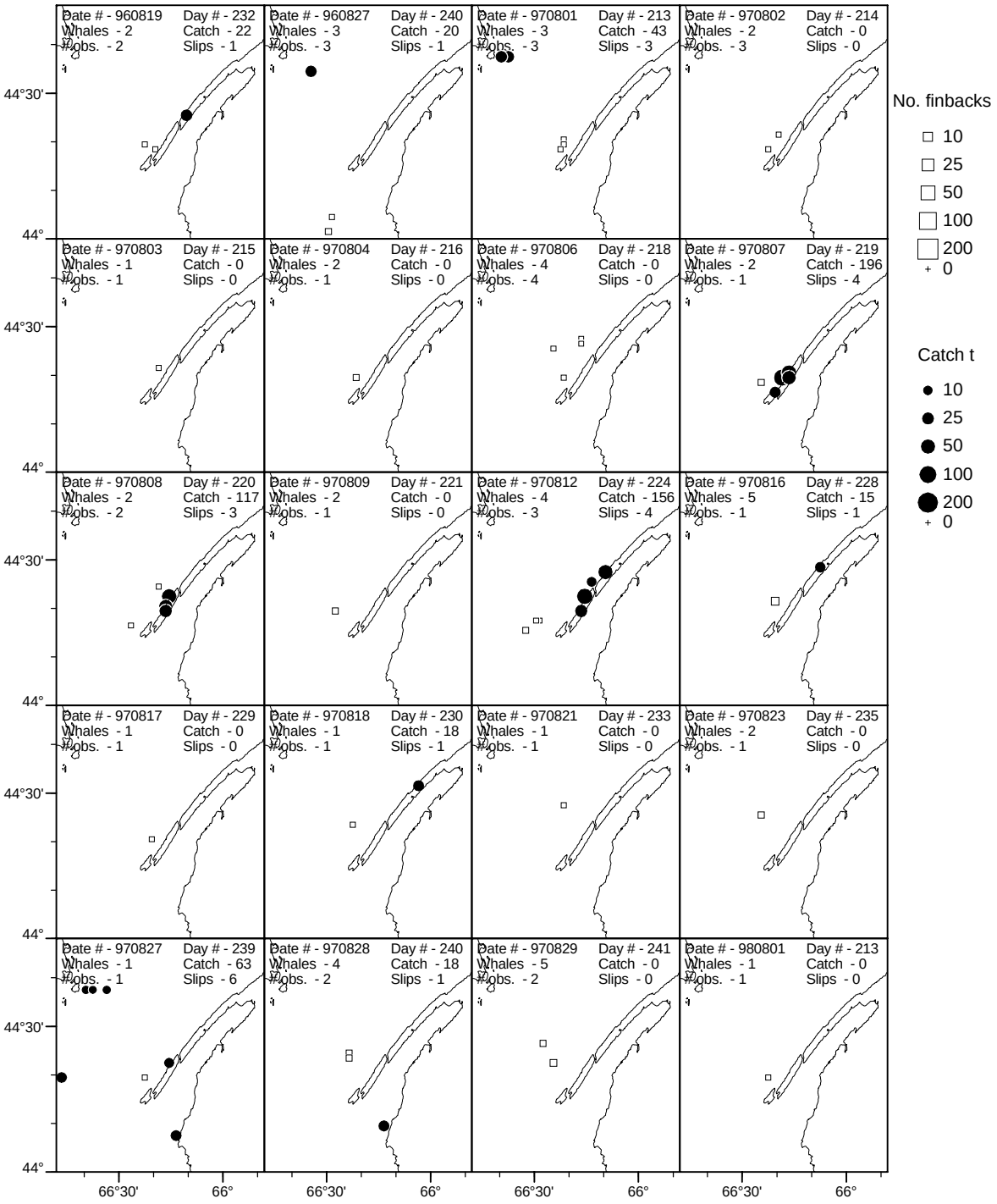


Figure 5. August 1985-98 daily finback observations (nos.) and herring catches (t) for selected area.



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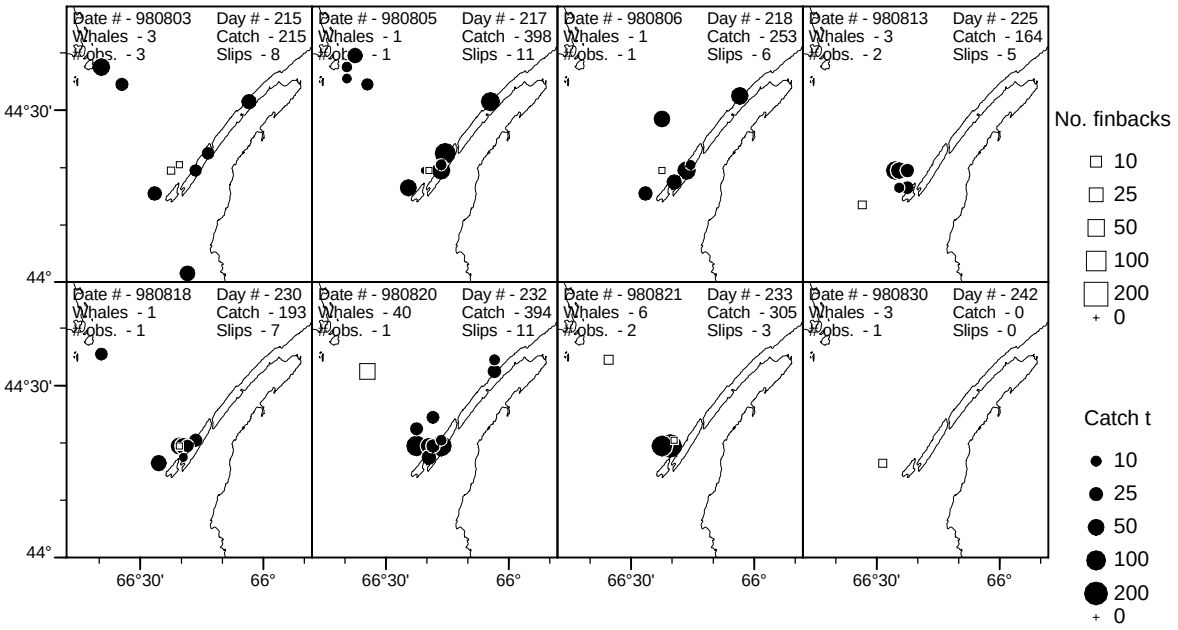

Figure 5. continued.

Annex 1. Standard Cetacean survey data sheet used throughout the study.

Brier Island Ocean Study: Cetacean Survey Sheet

Date:_____ Start Time:_____ End Time:_____ Sheet#____of____

Vessel:_____ Captain:_____ Chief Sci:_____ Assist:_____

Cruise#____ Vis:_____ Weather:_____ Cloud Cover (10ths):_____

Wind Spd & Dir:_____

Sea State: Glass / Catpaw / 3" – 1 ½' / 1 ½' – 3' / 3' – 6' / 6'+ Swell:_____

Camera	Roll	Frame

Species	#/#	Time	Position	Photo	Names, Behaviours, Comments

Appendix IV: Incidental Catch in the Herring Purse-Seine Fishery

Introduction

Minimizing by-catch is an important part of responsible fishing. The nature of the purse-seine fishery allows for targeting of herring and even for specific attributes (size, condition, and quantity) of the catch. This results in catches with very little by-catch, although some does occur. This paper describes and quantifies incidental catch from data collected by the International Observer Program (IOP), in Over-the-Side Sales (OSS) reports, and by the Pelagics Research Council (PRC) spanning 9 years or a total of 1404 sets (Table 1) of the 4WX purse-seine fishery.

Methods and Results

The catch records examined in this study were collected by independent observers from the International Observer Program and the Pelagics Research Council (Table 1).

International Observer Program

Observer Program database (1990-1998)

The International Observer Program deploys independent observers to commercial fishing vessels, some of which are herring purse-seiners. Among other responsibilities, observers are required to collect information on the distribution of fish, fish morphology, catches (including discards), and by-catch (Waldron *et al*. 1993). These data are then added to the Observer Program database. Not all observers record with equal accuracy and so estimates of by-catch from these records represent a minimum.

Catch records for purse-seine sets from 1990 to 1998 were examined. By-catch during monitored trips was low (Table 2) when compared to other fisheries covered by the IOP such as the foreign silver hake fishery (Table 3).

Over-the-Side Sales reports (1993-1994)

Observers from the IOP monitored Over-the-Side sales of herring by the Canadian purse-seine fleet to foreign vessels. In addition to the details of the transhipment, these observers documented the particulars of each set as provided by the captain of the purse seiner or carrier vessel. These reports were not entered into the IOP database until 1995. We examined the 1993 and 1994 reports for estimates of incidental catch in the herring purse-seine fishery. Both years contained many records of purse-seiner fishing activities.

Some observers frequently recorded estimates of by-catch while others made no mention of species other than herring. The latter were excluded from the analysis in order to reduce the bias. Estimates of by-catch in the OSS records should again be considered a minimum since the catch may have been sorted before transhipment, for

example, it is unlikely that any large fish would still be on board. Dogfish and mackerel were reported in the highest quantities (Tables 4 and 5).

Pelagics Research Council (1998)

During the summer and fall of 1998, staff of the PRC was aboard many commercial herring fishing trips observing operations, sampling the catch, collecting samples, and tagging. Staff members estimated by-catch of non-target species while aboard herring purse-seiners. They also estimated the percentage of pumping time observed. In this way we were able to extrapolate the total by-catch by prorating the records based on the percent pumping time observed.

The PRC staff monitored by-catch in a total of 64 sets. Species caught as by-catch included mackerel, sharks (dogfish, porbeagle, basking, and mako), cod, haddock, and several invertebrate species (Table 6).

Discussion

This documentation confirms that the herring purse-seine fishery has little by-catch. Ensuring that by-catch is low and documenting levels of by-catch are important elements of responsible fishing practice.

Although protocols required observations of by-catch, observer estimates of by-catch may be underestimated since large quantities of herring and the speed of pumping could obscure other species of similar size. It can also be difficult to quantify this incidental catch if fishing operations do not permit visual inspection of the entire catch and because it is not always possible to weigh components of the catch.

Incidence and magnitude of by-catch in the Scotia-Fundy purse fleet varied over time, but was generally low. Data quality in records from herring and the silver hake fisheries in the IOP database should be comparable since they are both collected by observers from the IOP. The overall recorded by-catch from the herring fishery from 1990 to 1998 is 0.4% while it was 12.4% in the silver hake fishery for a similar time period.

The most prevalent by-catch in the 4WX herring fishery was dogfish, mackerel, squid, haddock, and cod. The maximum observed occurrence was 27% of sets (dogfish and squid) observed in PRC sampling when specifically watching for incidental catch. Prevalence in this case was very low with an average of only 10 individual dogfish and 15 squid per 50-ton set of herring. In the Observer Program database, dogfish and mackerel were the most prevalent but these catches represented less than a percent of total catches. The OSS data had similarly low by-catch.

Large animals (whales, sharks, etc.) can be, and usually are, released from the set unharmed. Early indication of a significant by-catch often leads to release of the set (dogfish, for example, interfere with pumping and so are avoided).

Summary

- Catch composition in 1404 sets spanning 9 years of the 4WX herring purse-seine fishery was examined for incidental catch.

- The herring purse-seine fishery has little by-catch, and the nature of purse seines allows release of sets in which by-catch is detected early.
- Non-target species most frequently caught in the herring purse-seine fishery were dogfish, mackerel, cod, haddock, and squid, but the incidence and prevalence were low.

References

Anon. 1998. Bycatches in the silver hake fishery on the Scotian Shelf Slope: Evaluation of the Small Mesh Gear Line. DFO Maritimes Regional Fisheries Status Report 98/8E

Waldron, D.E., B. Wood, W.J. MacEachern, M. Showell, and A.F. Sinclair. 1993. Scotia-Fundy region International Observer Program fisheries science data collection manual. February 25, 1993.

Table 1. Number of 4WX purse-seine fleet sets examined for incidental catch in each year in the International Observer Program (IOP), the Over-the-Side Sales (OSS), and the Pelagics Research Council (PRC) data.

	IOP	OSS	PRC	Total
1998	1	0	64	65
1997	1	0	0	1
1996	2	0	0	2
1995	94	0	0	94
1994	5	331	0	336
1993	236	494	0	730
1992	89	0	0	89
1991	36	0	0	36
1990	51	0	0	51
Total	515	825	64	1404

Table 2. Incidence, weight in kilograms, and percent incidental catch from purse-seine records in the International Observer Program database.

Total caught weight (kg.) by purse-seine in Observer Program database

Incidence		Year									
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**Total**
Herring	514	0	33,250	70,000	3,206,404	48,933	7,751,570	3,643,396	2,111,940	1,751,420	18,616,913
Dogfish	44	0	0	0	8,864	186	2,687	5	0	0	11,742
Cod	23	0	0	0	3,362	4	34	0	0	0	3,400
Mackerel	19	0	1,750	35,000	2	1,100	502	185	120	160	38,819
Squid	5	0	0	0	0	0	1,000	0	65	0	1,065
Whales ns	3	0	0	0	400	0	0	0	0	0	400
Haddock	3	0	0	0	0	0	147	0	0	0	147
Pollock	3	0	0	0	0	0	9	0	0	0	9
Blue Shark	1	0	0	0	10,000	0	0	0	0	0	10,000
Monkfish	1	0	0	0	2	0	0	0	0	0	2
Alewife	1	0	0	0	1	0	0	0	0	0	1
Krill	1	1	0	0	0	0	0	0	0	0	1
% incidental catch		100.0%	5.0%	33.3%	0.7%	2.6%	< 0.1%	< 0.01%	< 0.01%	< 0.01%	

Table 3. By-catch in the foreign silver hake fishery. The silver hake fishery has the highest incidence of herring as by-catch of any fishery monitored by the IOP. Adapted from Anon. (1998).

	Observed Catch (tonnes)					
Species	**1989-93 (avg)**	**1994**	**1995**	**1996**	**1997**	**1998**
silver hake	57000	6900	16300	22400	12100	6100
pollock	1640	10	56	134	54	8
spiny dogfish	1369	14	30	92	81	9
short-fin squid	1036	1290	715	442	521	710
skates (ns)	922	16	19	33	5	11
herring (Atlantic)	912	0	6	181	227	117
mackerel (Atlantic)	593	39	58	82	109	7
hake (ns)	489	58	11	75	31	24
haddock	348	8	32	47	24	13
redfish (unseparated)	300	19	41	54	66	11
monkfish, angler	172	7	20	89	49	20
cod (Atlantic)	150	2	1	3	1	1
basking shark	105	9	20	9	3	4
argentine (Atlantic)	78	8	92	209	504	5
American plaice	64	13	18	23	11	23
cusk	58	0	0	1	1	0
halibut (Atlantic)	56	1	3	5	2	1
thorny skate	50	2	19	42	27	9
red hake	43	1	124	288	195	75
witch flounder	39	2	19	25	19	24
dog fishes (ns)	39	0	0	0	0	0
winter skate	38	1	78	122	45	41
American lobster	34	4	7	13	8	5
alewife	28	0	0	14	11	5
~300 other species	227	9	85	108	175	30
% incidental catch	13.4%	18.0%	8.2%	8.5%	15.2%	15.9%

Table 4. Summarized IOP observations of herring purse-seine by-catch in the 1993 Over-the-Side Sales (OSS) Fishery.

Species	Total catch observed (mt)	Mean by-catch per trip, when it occured (%)	Frequency of observations	Frequency of trips with observed by-catch (%)
Herring	27,237.6		494	
Dogfish	12.3	0.01	78	15.8
Mackerel	56.4	0.04	6	0.01
Lumpfish	0.1	<0.01	2	<0.01
Total		0.05		

Table 5. Summarized IOP observations of herring purse-seine by-catch in the 1994 Over-the-Side Sales (OSS) Fishery.

Species	Total catch observed (mt)	Mean by-catch per trip, when it occured (%)	Frequency of observations	Frequency of trips with observed by-catch (%)
Herring	13,159		331	
Dogfish	1.6+	1.00	26	7.9
Mackerel	159.9+	1.20	53	16.0
Lumpfish	*	*	4	1.2
Flatfish	*	*	1	0.3
Monkfish	*	*	1	0.3
Squid	*	*	5	1.5
Cod	*	*	1	0.3
American Shad	*	*	1	0.3
Silver Hake	*	*	1	0.3
Total		>2.20		

N.B. Some observer by-catch estimates were quantified in tonnage or kilograms; others provided only qualitative statements (e.g. a few, some, many, lots and numerous). * indicates a catch of unknown quantity. + indicates a catch of unknown quantity in addition to the amount indicated.

Table 6. Frequency of incidental catch in the herring purse-seine fishery in 1998. Data are from 64 sets monitored by members of the Pelagics Research Council. "Adjusted total observed" is the average number per set prorated by the amount of pumping time observed for each set where the species was caught.

Species	Frequency of observations	Total observed	Adjusted total observed	Mean no /set	% of sets observed
No other species	9				14.1
Dogfish	17	163	175	10	26.6
Squid	17	70	262	15	26.6
Haddock	10	54	330	33	15.6
Cod	10	43	44	4	15.6
Mackerel	10	35	187	19	15.6
Lobster	7	36	36	5	10.9
Porbeagle*	6	6	6	1	9.4
Lumpfish	5	8	9	2	7.8
Monkfish	4	6	6	2	6.3
Sculpin	4	5	6	2	6.3
Scallops	4	n/a	n/a	n/a	6.3
Basking shark*	3	3	3	1	4.7
Shark sp*	3	3	3	1	4.7
Alewife	2	6	6	3	3.1
Flatfish ns	2	5	6	3	3.1
Humpback whale*	2	3	3	2	3.1
Jellyfish	2	2	3	2	3.1
Saury	1	15	15	15	1.6
Skate	1	4	4	4	1.6
Mako shark *	1	1	1	1	1.6
Seal*	1	1	1	1	1.6
Starfish	1	1	2	2	1.6
Shrimp	1	n/a	n/a	n/a	1.6
Total herring caught in 64 sets			**3,161,000 kg.**		

* Large animals were released unharmed.