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Evaluation of the Stock Status of 4WX Herring

by

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ABSTRACT

The 1994/95 TAC for 4WX herring was reduced to 80,000t due to a number of indications of reduced stock status observed from the 1994 fishery and reduced larval herring abundance in the 1994 survey. Management of this fishery moved further toward a spawning stock unit approach, with in-season consideration of individual spawning components and discrete fisheries. Landings in the stock portion of the 1995 4WX herring fishery declined to 62,500t, the lowest on record since 1964. An additional 18,250t was recorded from the non-stock weir and shutoff fisheries on the New Brunswick side of the Bay of Fundy. The purse seine fleet dominated landings with catches of 58,900t.

A very large portion of the stock catch was made up of fish of ages 2 - 4 (79% in number, 59% in weight). Age 3 fish (1992 year-class; approximately 25 cm length) dominated landings from the stock portion of the fishery in both number (39%) and weight (27%). Although this high proportion of small fish has been observed before, primarily during the meal fishery in the 1960s, the reduced proportion of older fish in the catch is cause for concern. Catch at age shows that while the weight of fish landed from the stock portion was less in the 1995 fishery than in 1994, the same number of fish were caught (i.e., more fish of smaller weight).

Stock status evaluation was based on sampling and analysis of the commercial fishery and the results of a larval abundance survey. The annual survey of herring larvae showed a dramatic drop in 1994 and only a moderate increase in 1995. There have been no strong year-classes since 1983 and there continues to be concern for the state of this stock. The spawning stock biomass has decreased considerably in recent years, and while it is estimated to have increased slightly in the last year, it is still estimated to be between 100,000 and 200,000t. Projections from an intermediate level within this range (terminal F=0.3) would indicate an $F_{0.1}$ yield in 1996 of about 50,000t. It is noted that a large portion of the projected biomass and yield are from recruiting year-classes. The catch in 1996 is predicted to contain 42% by number and 18% by weight, fish $\leq$ 3 years of age.

RÉSUMÉ

Le TAC 1994-1995 de hareng 4WX a été réduit à 80 000 t car les données sur la pêche pour 1994 indiquaient une baisse des effectifs et les résultats du relevé de 1994, une faible abondance de larves. La gestion de cette pêche s'est rapprochée d'une perspective axée sur les géniteurs, qui tient compte des composantes individuelles de géniteurs et des pêches discrètes en saison. Les prises récoltées dans 4WX en 1995 ont chuté à 62 500 t, soit le plus faible niveau enregistré depuis 1964. En outre, 18 250 t ont été récoltées dans les eaux de la baie de Fundy bordant le Nouveau-Brunswick dans le cadre de la pêche à la trappe à hareng et de la pêche hors-saison non axées sur un stock particulier. La flottille de pêche à la senne coulissante a récolté le plus de hareng, les prises se chiffrant à 58 900 t.

Un pourcentage très élevé des prises dans 4WX se composait d'hareng de 2 à 4 ans (79 % en nombre, 59 % en poids), le hareng de 3 ans (classe d'âge de 1992, d'environ 25 cm de longueur) prédominant dans les débarquements en nombre (39 %) autant qu'en poids (27 %). Bien que ce pourcentage élevé de petits harengs ait été observé auparavant, surtout lors la pêche minotière des années 60, le pourcentage réduit de vieux harengs dans les prises est une source d'inquiétude. Les données sur les prises selon l'âge révèlent que le poids de hareng prélevé du stock était moins élevé en 1995 qu'en 1994, bien que le même nombre de hareng ait été capturé (c.-à-d. plus de hareng d'un poids moindre).

L'évaluation de la situation du stock est basée sur l'échantillonnage des prises commerciales et l'analyse des données recueillies, ainsi que sur les résultats d'un relevé de l'abondance des larves. Le relevé annuel des larves de hareng a révélé une chute sensible de l'abondance en 1994, suivie d'une augmentation moyenne en 1995. Aucune abondante classe d'âge n'a été relevée depuis 1983, et l'état de ce stock continue d'être une source de préoccupations. La biomasse de géniteurs a diminué sensiblement dans les dernières années et, bien que l'on estime qu'elle a légèrement augmenté au cours de la dernière année, on considère encore qu'elle se situe entre 100 000 et 200 000 t. Des projections faites d'un niveau intermédiaire de cet écart (F terminal = 0,3) donnent un rendement à $F_{0,1}$ d'environ 50 000 t en 1996. On note qu'un pourcentage élevé de la biomasse et du rendement projetés se compose des classes en voie d'être recrutées. On prévoit que les prises 1996 se composeront à 42 % en nombre et à 18 % en poids de hareng de 3 ans ou moins.

EVALUATION OF 4WX HERRING

The 1994-95 Management Plan - Context for the Fisheries

Major Elements of the 1995 Management Plan

The 1995 4WX herring fishery began in a climate of uncertainty and concern. Problems in the 1994 fishery (including lack of large fish, low fat content and growth rate of those fish, and unusual fish behaviour) contributed to a decision to postpone development of the 1995 management plan in order to include the biological evaluation of the 1994 fishery.

The biological evaluation, undertaken in the spring of 1995, summarised the problems of the 1994 fishery and also documented low larval abundance arising from the 1994 spawning. That assessment extended the concern and caution expressed previously (resulting from mixed signals in recent years), to suggest that spawning stock biomass (SSB) might have declined substantially (Stephenson et al., 1995; Anon, 1995a). The stock status outlook was as follows:

> "The low 1994 larval abundance index, combined with apparent physiological and behavioural changes in herring in 1994 are cause for concern. Hypotheses...indicate reduction in spawning stock biomass and/or biological changes which could have substantial consequences for the traditional nature of this fishery. Accepting the larval index at face value suggests a spawning stock biomass as low as it was in the late 1970s (100,000 to 200,000t), which would imply an $F_{0.1}$ reference catch level of about 50,000t."

The 1995 management plan (Anon, 1995b), finalized in July 1995, was presented in the following context:

> "In recognition of these concerns, DFO has authorised a cautious approach in the management of the 4WX stock complex and has set the total allowable catch (TAC) for the 1994-95 4X stock fishery at 80,000t on an interim basis.
>
> Should the 4WX herring stock continue to show signs of decline throughout the summer fishery, the Department may, by September 1, take further conservation measures by reducing the TAC."

Much of the plan was a rollover from recent previous plans, but there was a substantial reduction in the TAC, increased attention to individual spawning components, and implementation of a system of in-season management. Major elements included:

-TAC of 80,000t
- -purse seine allocation of 75,000t (93.75%) with 75% allocated originally and the remaining 25% held until a review of the fishery at the end of August.
- -midwater trawl allocation of 800t
- -Nova Scotia fixed gear allocation of 4,200t
- -initial Over-the-Side-Sales (OSS) allocation of 5,000t

-mandatory Dockside Monitoring Program (DMP) for mobile gear using bulk density conversion of 860 $kg \bullet m^{-3}$ for 'wet' and 990 $kg \bullet m^{-3}$ for 'dry' vessel holds

-formation of a DFO/Industry Monitoring Working Group (MWG) to develop management measures for traditional 4WX spawning stock areas and to monitor in-season management

-increased consideration of individual spawning stocks
- -target catch levels for individual portions of the fishery
- -combined catch of spawning fish not to exceed 30,000t
  - -Scots Bay 5,000t; Seal Island 5,000t; German Bank 20,000t

-closure of the area east of Baccaro Point to mobile gear for the summer fishery, with the exception of 500t for an experimental tagging program in the Little Hope area

-temporary consideration of the outer Scotian Shelf banks (>25 miles off Nova Scotia) as non-stock, with an experimental allocation of 5,000t.

In-Season Management

In light of the concern for this resource, and uncertainty surrounding the biological evaluation, the resulting management plan stressed the importance of monitoring progress and signals in the 1995 summer fishery, particularly related to the spawning grounds, and required an in-season re-evaluation of fishery performance. A committee of the Scotia-Fundy Herring Advisory Committee (SFHAC) was established, the "Scotia-Fundy herring purse seine monitoring working group" (MWG), in late July to evaluate information from the fishery on an ongoing basis. The committee was made up of representatives of the purse seine fleet (Atlantic Herring Co-op Ltd. and Southwest Seiners), processing sector (Seafood Processor Association of Nova Scotia (SPANS) and Independent Seafood Processor Association of Nova Scotia (ISPANS)) and DFO.

Due to the importance of timely and effective decisions in the fishery this year, a structured decision making process was required. This necessitated new information and approaches:

1) industry and DFO needed to monitor and investigate areas of interest to gather relevant information on which to base decisions,

2) the information had to be compiled quickly, and

3) all available information had to be used in an appropriate decision making forum.

The Monitoring Working Group was seen as an appropriate forum for decision making for the remainder of the summer purse seine fishery. It had a suitable mandate, i.e. was empowered to make certain decisions, and met routinely in person or by conference call to review new information and come to some agreement on a course of action.

Criteria for In-Season Decision Making

As much of the concern was for the biological state of the fishery (and especially of the state of individual spawning grounds), it was obvious that biological observations would form much of the in-season information which would be brought forward for discussion. In order to use this information as the basis for sound decisions it seemed essential to develop criteria against which observations can be compared. A table of biological information that could be expected during the fishery and signs that may be considered positive, negative or unclear was constructed (Table 1a). This was used as the framework for discussions of biological issues and is summarised for the various fishery components in Table 1b.

Consideration of Individual Spawning Stocks

Management of this fishery moved further toward a spawning stock unit approach with separate consideration of individual spawning components (Scots Bay, Trinity Ledge, Gannet/Dry Ledge, Seal Island, German Bank) and discrete fisheries (Long Island shore, Grand Manan). The management plan allowed for up to 30,000t from spawning grounds, allocated according to the perceived relative size and state of those grounds as follows: German Bank - 20,000t; Seal Island/Gannet - 5,000t; Scots Bay - 5,000t; Trinity Ledge - closed; Little Hope - closed except for scientific tagging program.

Greater Availability of Information

Considerable progress was made on obtaining appropriate information on which to base decisions, with the initiation of surveys using commercial vessels and with efforts within DFO and industry to bring relevant up-to-date information to meetings. There was a very good record of information from the summer fishery which included:

1) Statistics: Records of all searching activity and catch locations were available on a daily basis, and were summarised and plotted from weekly updates.

2) Sampling: Very thorough coverage of the summer fishery for size and biological characteristics resulted from increased presence on the fishing grounds of biologists and observers, and from sampling by members of the industry (vessels and plants).

Length frequency by fishing ground and week were made available and discussed while the fishery was in progress.

3) Surveys: A series of surveys was undertaken of major spawning areas using commercial vessels. Sonars and sounders were used to document number, location and approximate size of herring schools. In the most successful of these surveys, several vessels worked together to provide rigorous coverage of the target areas (see later section on Industry/DFO surveys).

In-Season Management and the Monitoring Working Group

The MWG reviewed available information routinely, using the biological decision table to point out what was known and what was not, and what was positive, negative or unclear. This took considerable effort on the part of participants and it involved conference calls and meetings at least weekly and more often during the active fisheries. The MWG sought new information, which meant initiation of new surveys, and it tried the approach of reducing uncertainty by documenting what was there before fishing took place. Information was reviewed in a timely manner, the interpretations were debated, and all information was used in decision making.

In the summer fishery, there were instances of the MWG being both restrictive and non-restrictive. The MWG was restrictive in closing Scots Bay, imposing early closure on Trinity Ledge, restricting effort on Gannet/Dry Ledge, and not increasing the German Bank target allocation. On the other hand the MWG was non-restrictive in recommending, during mid-summer review, that the TAC remain at 80,000 (rather than a decrease).

Biological concerns were well served by this process, and the enormous effort is considered to have been worthwhile.

Industry Consultations

In addition to the MWG meetings, extensive consultation took place on the fishing grounds and in numerous meetings during the 1995 fishery. Formal consultation with the entire industry took place at the autumn SFHAC meeting, and at a Regional Assessment Process (RAP) data input review meeting (Yarmouth, March 26/96). Consultation on stock structure and other issues with the purse seine and processing sectors also took place at a special herring workshop on February 15/96 in Saint John, N.B.

Overview of the 1995 Fisheries

General Observations

Total landings from the 4WX stock portion of the fishery were 62,499t (Table 2), almost 20,000t lower than the previous year continuing a reduction which has seen a decrease of

about 50% since 1993 (Table 3, Fig 1). Landings in the non-stock portion of the fishery (18,248t) were 4,000t lower than in 1994, and the lowest they have been since 1984 (Table 2,3; Fig 2,3). As has been the pattern for more than a decade, landings in the stock portion of the fishery were dominated by purse seine with a relatively small amount of landings by Nova Scotia weirs, and very little by the gillnet sector (Fig 4). As in previous years, the greatest landings were in the 4X summer fishery, with relatively small amounts in the 4W and 4X winter fisheries (Figs 5,6).

Description of the Major Fisheries and Landings

The following is a more detailed description of major segments of the 1995 4WX stock fishery. The location of catches is documented in Figs 7,8,9,10 and the catch at age in Tables 4,5 and Figs 11,12,13,14. Observations from the fishery are summarised in a "biological checklist, (Table 1a ,1b) and categorised where possible as positive (+), negative (-) or unclear(?).

A - Fall and Winter 4WX Fisheries

1) Nova Scotia Winter fishery - Oct. 1994 - Feb. 1995

Less than 3,200t was taken in the 4W winter fishery, the smallest amount in over 25 years. Herring were not abundant in the traditional overwintering area in Chedabucto Bay, and were smaller than in previous years (dominated by age 3). A couple of sets contained ripe fish - indicating that some were not part of the SW Nova Scotia spawning component. Purse seine activity moved west to Halifax and Liverpool, where approximately 2,000t was taken before this fishery was closed in January 1995. The landings in these areas were also dominated by age 3, but contained a higher proportion of larger fish than from Chedabucto Bay.

Biological checklist:

- *size/age composition: dominated by age 3 (-)*
- *distribution: fewer than expected in major overwintering area of recent years (-)*
- *relative abundance: low; no large overwintering aggregations found (-)*
- *physiology/condition: ripe fish in some sets indicates presence of local spawning component (-). Resorption of gonads was observed in some fish.*

2) Nova Scotia Winter fishery - Oct. 1995 - Feb. 1996

The fishery in 4W began in November with a testing approach to avoid ripe fish (which by definition would be non-4X spawners), area restrictions to keep the mobile fishery outside of headlands, and a minimum size criterion of 26.5 cm. There were good signs of herring in the traditional area outside Chedabucto Bay early in the season, but the fish were mixed in size. A total of 2049t was recorded by the end of 1995. When the fishery resumed in January 1996, no herring were found in Chedabucto Bay, but significant quantities were

observed off Halifax. On one night an area of 4 square miles of fish was estimated to contain at least 40,000t. These fish were mixed in size, with a smaller mean length than in Chedabucto Bay. Considerable controversy about a mobile gear fishery in this area resulted in a restricted fishery of 350t in conjunction with a tagging program.

Biological checklist:

- size/age composition: mixed; dominated by age 3, but better representation of older fish than in the previous year, and similar to catch at age from the summer fishery.
- distribution: as expected early in season based on the past decade (+)
- relative abundance: better than in 1994, substantial aggregations early in season (+) but less than during the late 1980s (-)
- behaviour: normal; left the area by early January, as in recent years but earlier than in the late 1980s
- physiology/condition: no indication of local spawning groups (ripe fish) as seen in 1994

3) New Brunswick (4Xs) fall and winter fishery - Oct. 1994 - Feb. 1995

The total of 5,200t (5064 fall and 136 winter) was approximately 2,000t less than the previous year but within the range of landings from this fishery in recent history. Fish were scarce after Dec. 1994, and less than 150t was caught in the January 1995 portion of the fishery. Age 2 fish dominated the catch. Most of the purse seine activity took place in January off Halifax in the Liverpool to St. Margaret's Bay area.

Biological checklist:
- size/age composition: dominated by young fish (age 2), but normal for this portion of the fishery
- distribution: as expected from recent years
- relative abundance: normal autumn aggregations found before Dec. 1994, but few fish after Jan. 1, 1995

4) New Brunswick (4Xs) fall and winter fishery - Oct. 1995 - Feb. 1996

The total of 2404t prior to December 1995 was taken predominantly in November. Age 2 fish again dominated the catch.

B - Summer 4X Fisheries

1) Early summer feeding and pre-spawning herring

The summer fishery started slowly, with less than 700t in May, 3,700t in June, and 8,400t in July. While uncertainty about quotas prior to finalization of the plan, effort on capelin, and late plant opening (Blacks Harbour) are believed to have restricted effort to some degree,

there was also a shortage of large fish in the normal early summer feeding areas off SW Nova Scotia. Some domestic market for large fish, and OSS market available during this period went unfilled. A total of 579t was landed to OSS, by purse seiners only, with 461t in July and 118t in August. This was a dramatic decline from the 13,900t to OSS in the previous year and was mainly due to poor fish availability of proper size and condition for this market. Good catches of large fish were made offshore (west of Browns Bank; modal size 30 cm (age 6)) early in the year, but these fish quickly disappeared to the westward. Fish were most abundant on the Long Island shore. There was a high abundance which persisted later in the summer than usual in this area, but these were small (modal size of 24 cm; age 3). In comparison to recent years, there was an absence of landings from the area south of Yarmouth. Effort and landings were higher in the Grand Manan area.

Biological checklist:

- size/age composition: good on Browns Bank (+), but dominated by young fish (age 3) inshore (-)
- distribution: less than expected from traditional feeding areas south of Yarmouth (-)
- relative abundance: less large fish than usual throughout the area (except near Browns Bank early in the season) (-); higher proportion of small fish than expected, especially along Long Island shore.
- physiology/condition: normal; no sign of low fat or lack of feed seen in 1994 (+)

2) Scots Bay

A research survey with the J.L. Hart on the week of July 20, 1995 (prior to the opening of the fishery), aimed at testing experimental acoustic gear, documented small amounts (750t) of near-spawning herring with a modal size of 25.5 cm.

The fishery opened July 23 and approximately 1600t was taken by 21 seiners in 3 nights. Industry concern (that there should have been more fish present in Scots Bay) resulted in voluntary closure with the idea of testing a week or so later.

A survey was undertaken by four seiners August 8/9, 1995 The vessels surveyed four abreast; one mile apart from Margaretsville to Halls Harbour and back noting the location and estimating the abundance of any herring schools. Significant aggregations of herring were observed in two locations between Morden and Isle Haute. Captains' estimates, from sonar and sounder information, totalled 6,000t. Fish were ripe with a modal size of 25 cm.

The MWG met August 9 and decided that although a small fishery could take place on the fish that had been documented, it would be difficult to manage a fishery for such a small yield and there would be benefits to leaving these fish in the water; so the closure continued.

Another survey covered the same area with the same survey design on Aug.16-17, 1995 but found no herring.

Biological checklist:

- spawning time: normal; ripe fish observed weeks of July 25 and Aug. 8 (+)
- spawning location: normal (+)
- size/age composition: high proportion of age 4; less than desirable proportion of older ages (-)
- relative abundance: schools observed between July 18 and Aug. 8 (+); less than expected at the end of July above Area 21 closure line (-)
- behaviour: normal
- physiology/condition: some evidence of early maturation (-)

3) Trinity Ledge

The Trinity Ledge spawning component showed signs of failure in the early 1990s after receiving a disproportionately high level of fishing pressure over several years. It has been protected by a closure in recent years commencing August 15. The closure was meant to prevent a fishery during spawning, but occasional landings of ripe herring prior to and after the closure have taken place most years. In 1995, a 40t set of spawning fish was taken on August 11. Fish were between 22 and 37.5 cm with modes of 25.5 and 30 cm. The MWG met quickly on August 12 and decided to impose an immediate early closure to prevent the possibility of a large fishing effort before August 15 when the closure was scheduled to begin.

The area was surveyed by a single vessel familiar with the area on August 16. Three schools were documented, each estimated at 1,000t. Fish size was similar to August 11.

Trinity Ledge was surveyed again by a single vessel on September 16th. Schools were located in shallow water both north and south of the Ledge. These fish were in spawning condition but were smaller than the previous month (a similar mode at 26 cm, but few fish above 29 cm). Based on this information, the MWG decided to leave Trinity Ledge closed.

A third survey on September 22 by two vessels found no herring.

Biological checklist:

- spawning time: normal; ripe fish observed Aug. 11 and Sept.16 (+)
- spawning location: normal (+)
- size/age composition: good age distribution; desirable proportion of older ages, especially early in the season (+)
- relative abundance: no evidence that the spawning aggregations have recovered to the size that were characteristic of this area in the past (-)
- behaviour: normal

4) Seal Island and Gannet/Dry Ledge areas

These areas, which have made up significant portions of the roe fishery in some recent years, were considered separately by the MWG.

Approximately 1000t was taken from Gannet Ledge area Aug. 23 to 28. These fish were large, and like Trinity Ledge had modes at 25-26 and 30 cm. Fish tended to be shallow and hard to fish. The MWG discussed whether additional restrictions were required in this area. Disagreement regarding roe price slowed the fishery, and the MWG extended the weekend closure to Sept. 3 when appearance of spawning fish on German Bank diverted effort.

Virtually no catch came from Seal Island. Some fish reported on bottom Sept. 6, but none in the Sept. 30 survey. Although effort was low, there were no reports of significant aggregations from vessels coming and going. Absence of large aggregations is cause for concern.

Biological checklist - Gannet/Dry Ledge:

- spawning time normal; ripe fish Aug. 23 to 28, some hard fish remaining (+)
- spawning location: normal on Gannet (+)
- size/age composition: good age distribution from Gannet; desirable proportion of older ages (+)
-relative abundance: recognition by industry that this was not a large spawning group resulted in restriction of catch
- behaviour: normal in Gannet area

Biological checklist - Seal Island:

- spawning location: little observed at Seal Island (-)
- size/age composition:
- relative abundance: absence of documented spawning at Seal Island is cause for concern (-).
- behaviour: absent at Seal Island (-)

5) German Bank

German Bank, considered to be the largest spawning component of the 4WX complex, opened with a 20,000t initial target. Roe fish appeared in early September on the Tongue Ground and later on the German Bank "spawn tow". Surveys and observations were made Sept. 5/6, 22/23, and 29/30. In addition, there was a high level of observer coverage on this fishery.

Early in the season fleet activity focused on Tongue Ground where there were good showings of fish over a few miles most nights. Conservative estimates by experienced

skippers and biologists were placed at 30,000t Sept. 5 and 40-50,000t Sept. 22. The spawning condition of these fish indicated a progression of fish through the area. Fish were sometimes too deep to set on. Although landed sizes were predominantly 24 to 35 cm length with a mode of 27 cm, there were smaller fish on some nights which discouraged setting. A survey Sept. 29 documented fifty or more medium (hundreds of tons) and 20 larger (thousands of tons) schools.

Approximately 19,500t was taken by Oct. 3, and the MWG decided not to increase the allocation unless there was documentation of a new wave of spawning.

Biological checklist

- spawning time: normal (+)
- spawning location: normal (+), although less was observed on the spawn tow (German bank) early in the season than expected (-)
- size/age composition: higher proportion of young spawners (ages 3,4) than desirable (-). older fish were present (second mode at 30 cm) but in relatively low abundance
- relative abundance: reasonable abundance most nights in fishery and surveys, but fleet worked more closely together than in previous years when fish were more plentiful; sightings are consistent with hypothesis of reduced stock size.

6) Little Hope

Surveys of Little Hope were undertaken October 3-4 and 13-14. Both surveys encountered thin patches of herring 1-5 fathoms thick scattered throughout the area. A set in the first survey contained small herring (mode 23.5 cm, predominantly immature).

Biological Sampling

Methods

The sampling of commercial catches was stratified by area, gear and month (Hunt 1987) using the following approach:

1) Length frequencies of 180 - 250 fish were recorded from individual commercial catches through port sampling in New Brunswick and Nova Scotia, observer coverage of foreign vessels and commercial seiners, and by herring program staff during surveys and tagging operations.

2) Subsamples of one specimen per half cm size-class up to a total length of 24 cm and two specimens per class for larger sizes were retained with a target sampling level of 200 specimens per area per geartype per month from selected samples for further analysis of length, weight, sex, maturity, and age.

Sampling in 1995 resulted in 442 length frequency samples (75,341 fish measured) and 5144 fish analysed in detail (including 4344 for age). The distribution of sampling is shown in Table 6 and Fig. 15. Length frequency distributions for the major components of the 4WX herring fishery are presented in Figure 16.

Biological samples were matched to landings by gear component on a monthly basis and numbers at age were generated using the programs HERNLW02 and HERNAG09 as in previous assessments (Stephenson et al. 1994,1995). Separate keys were applied for OSS and domestic markets when numbers of samples were sufficient because of size differences of fish sought in these two markers. A correction of 2% for shrinkage due to freezing was applied to length measurements for frozen samples (Hunt et al. 1986).

Catch at Age

The age compositions for major components of the 1995 fishery are presented in Tables 4 and 5 and Figs 11,12,13 and 14. Age 3 fish (1992 year-class) dominated landings from the stock portion of the fishery in both number (39%) and weight (27%) (Fig. 14). There was a second mode (in most areas) at about 30 cm (age 6). A very large portion of the stock catch was made up of fish of ages 2 - 4 (79% in number, 59% in weight). While this high proportion of small fish has been observed before during the period of the meal fishery in the early 1970s (Table 7) the reduced representation of older fish in the catch is cause for concern. There was considerable discussion during the summer fishery about the abundance of small fish. It was generally concluded that while there were good signs of small fish, particularly in the Long Island area, large fish were scarce. Catch at age analysis shows that while the tonnage of fish landed from the stock portion was less in the 1995 fishery than in 1994, the same number of fish were caught (i.e. more fish of smaller weight).

Age 2 fish again dominated the non-stock fisheries on the New Brunswick side of the Bay of Fundy in both number (69%) and weight (58%) (Table 5). These data are presented for completeness only and are not included in the stock catch at age (Table 18) used in the analytical assessment. The proportion of age 4+ in the non-stock fishery, which had been increasing in recent years, was less in 1995 than in 1994 at only 4% by number and 18% by weight. (1994=9% by number and 34% by weight).

Lengths and weights at age are shown in Tables 8 and 9 and Fig 17. Weight at age, which was observed to have been reduced in 1994, seems to have returned to previous levels.

Research and Survey Data

Larval Survey Abundance

An annual bongo net plankton survey during late October and early November for recently hatched herring larvae in the Bay of Fundy and eastern Gulf of Maine has been conducted

since 1972. The index of larval abundance, calculated as the mean larval density (number•m^{-2} relative to bottom) for a standard set of 78 stations, is considered to reflect post fishery spawning stock biomass for the 4WX herring stock. Larval herring abundance has been shown to reflect the general state of herring stocks elsewhere, including the collapse and recovery of North Sea and Georges Bank herring .

The 1995 survey was completed successfully using the research vessel Alfred Needler for the second year in this survey time series (Power, MS1995). The larval abundance index value of 20.35 is considerably higher than the low value of the previous year and is above the series of low values during the late 1970s and early 1980s, but is below the values seen during 1989-1993 (Figs 18 and 19; Table 10).

Substantial numbers of larvae were also taken in a few non-index stations along the south shore of Nova Scotia, including large numbers of recently hatched larvae in the Little Hope area.

Bottom Trawl Survey

The July bottom trawl research vessel survey was evaluated previously (Stephenson et al. 1995) and was determined not to be a suitable abundance index for herring, but was considered useful as an indicator of distribution. The results from July 1995 and earlier years are presented in Tables 10, 11, 12 and Figs 20, 21. Note the extensive distribution over the Scotian Shelf during the survey period especially in recent years.

Acoustic Surveys

Steps were taken in 1995 to quantify acoustic signals from sonar systems. In July a survey was conducted in Scots Bay using a combined quantitative sounder and sonar. The survey was conducted between July 17 and 21 from the research vessel J.L. Hart using a towed body which housed a 120 kHz dual beam transducer and a 330 kHz Simrad (MS 900) scanning sonar.

A standard survey design was employed to estimate herring biomass. Two rectangular study areas were established within which randomly selected transects perpendicular to the shore were surveyed. Figure 22 depicts the survey grids and transects for the nights of July 20 and 21. Individual transect lengths and backscatter for each survey area are summarized in Table 13. Biomass estimates for survey area 1 and 2 were 95 and 737 t respectively (Table 14). An IYGPT mid-water trawl was used to identify targets and to collect herring samples. Herring sampled during the survey were near spawning with a modal length of 25.5 cm.

The low biomass estimates obtained during the acoustic survey and the location of herring were generally consistent with those observed by the commercial fishery two weeks later (see Scots Bay fishery).

The survey was also successful in capturing digital data from several herring schools. These data were then loaded into a 3-D visualization program for characterization of school shape. This marked the first time such data have been recorded from commercial hardware and paves the way future studies using this type of equipment to document fish distribution and possibly abundance.

An automated sounder recording instrument was tested on the research vessel Alfred Needler during the fall larval herring surveys. A study to install and evaluate similar recording equipment aboard one or two herring seiners has already been approved for 1996.

International Observer Program (IOP) Data

The distribution of herring on the Scotian Shelf from vessels documented by the IOP program in 1994 and 1995 is shown in Fig. 23. The large sets in 1995 are from the commercial Scotia-Fundy herring purse seine fleet and are independent observations of data previously presented in Fig. 7 from Statistics Division sources.

Industry/DFO Surveys

A number of surveys of spawning grounds and portions of the fishery were undertaken during the season using purse seiners (Table 15). On these surveys, vessels would search the target area with sonar and sounder recording locations and, if possible, approximate the tonnage (based on the experience of captains) of schools of herring.

Tagging

In response to the need to re-address the question of the 4WX herring stock structure and seasonal movement, DFO in collaboration with industry, initiated an opportunistic tagging project in conjunction with the seiner survey program. During 1995, 1064 herring were tagged and released in Scots Bay (302), Trinity Ledge (462) and Little Hope (300) areas.

Environmental Considerations

The warm temperature anomaly noted in 1994 was not evident in 1995. Most months were slightly cooler than the 1961-1990 mean, and all were well within the extremes noted in the past (F. Page, DFO St. Andrews, pers. comm.). The problem of low fat content observed in 1994 appeared not to be a problem in 1995.

Interestingly, there appears to have been a downturn in the stock status of 4T herring in the last two years (Claytor et al. 1996). The 4WX and 4T stocks have shown some parallel strength and weakness in year-classes in the past, indicating, perhaps response to a larger scale set of environmental conditions.

Analytical Evaluation, Stock Trends and Forecast

An analytical evaluation was undertaken for the traditional 4WX 'stock' components which includes all 4WX herring landings with the following exceptions. Catches from the New Brunswick fixed gear fisheries (weirs and shutoffs) were excluded from the 'stock'. These fisheries are presumed to target primarily juveniles that are non 4WX stock herring originating from the Gulf of Maine. Also excluded were inshore fixed gear herring fisheries along the coast of Nova Scotia, east of Baccaro, which were assumed to be small localized stocks.

Assessment Structure

The previous assessment (Stephenson et al 1995) described progress in recent years to overcome the problem of erroneous catch recording in this fishery, the subsequent revision of the catch at age matrix, and the return to an acceptable analytical assessment using ADAPT calibrated with an index of larval herring abundance.

Larval abundance, which is considered to represent spawning stock biomass near the end of the fishery was related to spawning stock biomass (SSB) (population x weight at age x maturity) at the beginning of the year following the November larval survey.

The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the sequential population analysis with the larval index survey results using the following data :

$C_{a,y}$ = catch
for ages a = 1 to 10 and for years y = 1965 to 1995 and

I_y = larval abundance index
for years y = 1972 to 1995;

The larval survey abundance results for year t were compared to beginning-of-year spawning population biomass in year + 1. The model formulation employed assumed that the error in the catch at age was negligible. Further, it is assumed that any error in the observed weight at age, $w_{a,y}$, proportion mature, $m_{a,y}$, or average partial recruitment to the fishery, pr_a, is also negligible. The error in the larval survey abundance index was assumed to be independent and identically distributed after taking natural logarithms of the values. Natural mortality, M, was assumed constant and equal to 0.2 and fishing mortality, F, for age 10 was assumed equal to the arithmetic average for ages 4 to 7.

Following Gavaris (1993), a model formulation using as parameters the ln population abundance at the beginning of the year following the terminal year for which catch at age is available was considered. The following model parameters were defined:

$\theta_{a,1996}$ = ln population abundance
for a = 5 at the beginning of the year 1996,

κ = ln calibration constant for the larval index

ADAPT was used to solve for the parameters by minimizing the sum of squared differences between the ln observed larval abundance index and the ln spawning population biomass adjusted for catchability. The objective function for minimization was defined as

$$\Psi(\theta,\kappa)=\sum_{y}\left(\ln I_y-\kappa\ +\sum_{a}\ln m_{a,y}w_{a,y}\overline{N}_{a,y}(\theta)\right)^2$$

For convenience, the mid- year population abundance $\overline{N}_{a,y}(\theta)$ is abbreviated by $\overline{N}_{a,y}$. For year y = 1996, the beginning of year population abundance was obtained directly from the parameter estimate, $N_{a,1996}=e^{\theta_{a,1996}}$ for age 5. For ages 1 and 2, $N_{1,1996}$ and $N_{2,1996}$, their abundance was assigned a fixed value of 1 million. For ages 3, 4 and 6 to 10, their abundance was derived using partial recruitment to the fishery as follows:

solve for $F_{3,1995}$ in the following catch equation using a Newton-Raphson algorithm

$$N_{4,1996}=\frac{C_{3,1995}\left(F_{3,1995}+M\right)}{F_{3,1995}\left(e^{\left(F_{3,1995}+M\right)}-1\right)}$$

compute the fishing mortality rate in 1995 for other ages using partial recruitment to the fishery

$$F_{a,1995}=F_{3,1995}pr_a$$

then compute population abundance for other ages using the catch equation

$$N_{a+1,1996}=\frac{C_{a,1995}\left(F_{a,1995}+M\right)}{F_{a,1995}\left(e^{\left(F_{a,1995}+M\right)}-1\right)}$$

In all other years, the population abundance was computed using the virtual population analysis algorithm which incorporates the exponential decay model

$$N_{a,y}=N_{a+1,y+1}e^{F_{a,y}+M}$$

where the natural mortality M is assumed and the fishing mortality $F_{a,y}$, for ages a = 1 to 9, is obtained by solving the catch equation using a Newton-Raphson algorithm

$$N_{a,y} = \frac{C_{a,y}\left(F_{a,y} + M\right)}{F_{a,y}\left(1 - e^{-\left(F_{a,y}+M\right)}\right)}$$

The fishing mortality rate for age 10 was assumed equal to the average for ages 4 to 7.

$$F_{10,y} = \sum_{a=4}^{7} F_{a,y} \Big/ 4$$

The mid-year population abundance was obtained by applying the annual fishing mortality rate at age for a time period of 0.5 years to the beginning of year population abundance in each year

$$\overline{N}_{a,y} = N_{a,y} e^{-(F_{a,y}+M)0.5}$$

Assessment Results

Calibration of the sequential population analysis with the larval abundance index using ADAPT indicated an increase of SSB through the mid-1980s to almost 600,000t followed by a substantial decline. The larval index in the last two years was much lower than the predicted value from this analysis and was preceded by a series of several years where the index was much higher than predicted. This lack of agreement between the observed larval index and the SSB from sequential population analysis raised concern about their relationship. The estimated population abundance from the calibration to the larval index was not considered representative in light of observations from the fishery in 1994 and 1995, i.e. the lack of large fish and the absence of herring from some traditional spawning grounds.

Analyses with a range of fishing mortalities in 1995 generated temporal patterns in exploitation rate that are roughly consistent with effort trends of recent years (number of trips and levels of fishing mortality). Sequential population analyses giving SSB ranging between 100,000t and 200,000t were considered to bracket the possibilities of current stock size. An illustrative SPA resulting in a SSB of 140,000t in 1996 is provided (Table 16,17,18 and Fig 24).

In this scenario the exploitation rate in 1995 is slightly above F0.1, but is below the 30-40% level of the previous 5 years (Fig. 25) There has been no strong recruitment in the past decade (Fig. 26)

Prognosis

Spawning stock biomass is not expected to fluctuate as much as is being indicated by the larval abundance index. There is reason to believe that there was a major decrease of this population in recent years (especially 1994), and there are indications that this population is still under considerable pressure, as shown by the following observations:

1. With the apparent lack of large fish, this fishery has moved further toward relying on single years of recruitment as soon as it occurs. This seems to be evident in 1995 with the high proportion of age 3 in the catch.

2. As was noted last year, there still seems to be a lack of fish in some traditional summer feeding and pre-spawning areas.

3. The apparent lack of spawning in the Seal Island area is of great concern. This area was expected to be one of the major spawning areas in 1995 but there was little catch (Table 19).

4. Signals from the 1995 fishery were mixed. The summary of individual portions of the fishery showed several aspects that were improved over 1994, but few that were as good as several years ago when stock size was known to have high.

It seems that the restrictions of 1995 were fully justified. It is recommended that the landings continue to be restrained and that special measures be taken to protect small fish.

Outlook

There continues to be concern for the state of this stock. The SSB has decreased considerably in recent years, and while it is estimated to have increased slightly in the last year, it is still considered to be between 100,000 and 200,000t. Projections from an intermediate level within this range (terminal F=0.3) would indicate a $F_{0.1}$ yield in 1996 of about 50,000t.

It is noted that a large portion of the projected biomass and yield are recruiting year-classes. This projection was done assuming full recruitment at age 3. The catch in 1996 is predicted to contain 42% by number and 18% by weight, fish ≤ 3 years of age. This may not be advisable when the stock is at a low state.

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Table 1a. Table of biological considerations used in 4WX herring fishery in-season decision making

	Positive	Negative
Spawning areas		
Times	normal	late or early
Location	all traditional areas	missing in expected locations
Relative amount	> or as expected	few
Size (age) composition		
Compare with average # at size	high abundance of large (4+ or >26cm) fish + reasonable presence of smaller fish	narrow age span; missing year-classes
Distribution		
Distributed as expected from previous years	presence in all expected areas (last 10 years)	missing in some expected areas
Relative abundance		
Observations and fishing success in expected areas	lots of fish observed; high proportion of vessels with successful sets/trips; positive cumulative catch	lack of sets; unsuccessful nights; few fish; small catches
Behaviour		
Fish behaviour as related to fishing success, and in relation to previous experience	lots of fish - but too deep/shallow or avoiding gear	fish acting abnormally; only small, scattered bunches seen
Physiology/condition		
Condition as related to previous years	feeding and high fat content at appropriate times	abnormal conditions of fat content and feed (as in '94); high proportion of small fish (<25.5 cm) mature
Environmental info		
Water temp, salinity, plankton abundance		

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modified August 25,1995

Table 1b. Summary of biological checklist for 1994-95 4WX herring fishery (indicators: + is a positive change, - is a negative change, ? is unclear or unknown)

	N.S. Winter	N.B. Winter	Early pre-spawning	Scot's Bay	Trinity Ledge	Gannet/ Dry Ledge	Seal Island	German Bank	No. of +	No. of ?	*No. of -*
Spawning -area				+	+	+		+	4	0	*0*
-location				+	+	+	-	+	4	0	*1*
-amount				-			-	-	0	0	*3*
Size & age	-	?	?	-	+	+		-	2	2	*3*
Distribution	-	?	-						0	1	*2*
Abundance	-	?	-	?	-	?	-	?	0	4	*4*
Behavior				?	?	?	-		0	3	*1*
Physiology	-		+	-					1	0	*2*
No. of +	0	0	1	2	3	3	0	2	11		
No. of ?	*0*	*3*	*1*	*2*	*1*	*2*	*0*	*1*		*10*	
No. of -	4	0	2	3	1	0	4	2			*16*

Table 2. 1994-1995 reported monthly 4VWX herring landings (t) by major fishery
(Source: DFO Scotia-Fundy Region Statistics Division.)

4WX Stock Fisheries		1994 Oct	Nov	Dec	1995 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	1995 Calendar Totals	15 mo. Totals	Quota Totals*	1994-1995 Plan Quota
1. 4W Winter Purse Seine	Note 1	154	1188	528	1311					10					2049		3370	5240	3191	
2. 4Xs Fall Purse Seine	Note 2	4049	1015															5064	5064	
3. 4X Winter Purse Seine	Note 3,7				2113	51	7							1682	686	36	4575	4575	2171	
4. 4Xqr Summer Purse Seine	Note 4,6.	7268							668	3728	9994	7429	21088	5575			48481	55749	48481	75000
5. 4X Midwater Trawl					111	76											187	187	187	800
4X Summer Gillnet		14							7	1	40	160	60	35			302	317	302	
4Xr Summer (N.S.) Weir									236	1255	1059	470	29				3049	3049	3049	4200
4X Trap				5						7	6	2	2				16	21	16	
4X Misc. Gears		1							0		0	6					6	7	6	
4W Gillnet		3	1					9	1	1	12	0					23	27	23	
4W Misc. Gears (Trap)		1									2	1		3			7	7	7	
6. 4WX Gillnet,Trap,Weir,Misc	Note 5	19	1	5				9	244	1264	1119	639	91	38			3404	3428	3404	80000
Stock Totals		11490	2204	533	3535	127	7	9	912	5002	11113	8068	21178	7295	2735	36	60018	74244	62499	
4WX Non-Stock Fisheries																				
1. 4X (N.B.) Weir		1599	30						15	244	4517	8590	3945	877	10		18198	19826		
2. 4X (N.B.) Shutoff		786	121								34	7	9				50	957		
Non-Stock Totals		2385	151						15	244	4551	8598	3954	877	10		18248	20783		
Total 4WX Landings		13875	2355	533	3535	127	7	9	927	5246	15664	16666	25132	8172	2745	36	78265	95027		
4Vn Fisheries																				
1. 4Vn Winter Purse Seine	Note 1		3176	8											3988		3988	7172	3184	
2. 4Vn Gillnet				0				139	64	73	15	7	0		0		298	298	298	
3. 4Vn Traps and Misc Gear									7	77	16						101	101	101	
4Vn Totals			3176	8				139	71	150	31	7	0		3988		4387	7571	3583	
Total 4VWX Landings		13875	5531	541	3535	127	7	148	998	5396	15695	16673	25133	8172	6733	36	82652	102598	66082	

* Reported landings against the annual plan quotas (shaded blocks) correspond to catches made in the seasonal periods (Notes 1-5).
** Non-Stock totals are for the calendar year January 1, 1995 to December 31, 1995.

NOTES

1. Quota period is November 1, 1994 to March 1, 1995
2. Quota period is October 15, 1994 to December 31, 1994
3. Quota period is January 1, 1995 to February 28, 1995
4. Quota period is April 1, 1995 to October 19, 1995
5. Inshore/Fixed and Miscellaneous Gear allocation is for the calendar year 1995.
6. Includes purse seine bait quota of 2600 t.
7. Predominantly from Halifax and Liverpool area in Jan. 1995

Table 3. Historical series of nominal and adjusted annual landings (t) by major gear components and seasons of the 4WX herring fishery 1963-1995.

	Stock Fisheries - Nominal Landings										
Year^	4W Winter Purse seine	4Xs Fall&Winter Purse seine	4Xqr Summer Purse seine	4X Summer Gillnet	4Xr Summer Weir	4WX Other*	4WX Stock Nominal Landings	4WX Stock Adjusted Landings**	4WX Stock TAC	Non-Stock 4Xs Weir and Shutoff	Total 4WX Adjusted Landings
1963		6,871	15,093	2,955	5,345		30,264	30,264		29,366	59,630
1964		15,991	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	1,690	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	77,545	243	4,049	1,769	102,627	172,900	151,200	38,778	211,678
1991	17,878	2,024	73,619	538	1,498	1,453	97,010	130,800	151,200	24,576	155,376
1992	14,310	1,298	80,807	395	2,227	1,190	100,227	136,000	125,000	31,967	167,967
1993	10,731	2,376	81,478	556	2,662	660	98,464	105,089	151,200	31,573	136,662
1994	6,245	7,399	64,546	340	2,045	161	80,099	80,099	151,200	22,241	102,340
1995	3,191	7,235	48,481	302	3,049	209	62,499	62,499	80,000	18,248	80,747

^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 geartypes are for the calendar year.

* Includes 4Xs stock catches taken by single midwater trawl, and 4WX stock catches by gillnets and traps, by foreign trawlers, and by miscellaneous gear

** Adjusted totals includes misreporting adjustments for 1978-1984 (Mace 1985) and for 1985-1993 (Stephenson et al 1994).

Table 4. Catches by age in numbers (thousands) and weight (t) from stock gear components of the 1995 4WX herring fishery.

Catch Nos.	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	0	2,014	32,501	13,725	1,926	2,380	2,101	788	1,291	900	899	58,525
4X N.S. P.Seine	1,831	76,908	102,744	77,114	32,419	31,869	19,047	5,362	2,747	1,990	2,511	354,542
4X N.B. P.Seine	0	933	63,017	17,933	1,556	776	220	104	0	0	0	84,539
4X N.S. Weirs	0	20,141	20,001	2,860	650	1,129	621	172	155	49	138	45,916
4WX Misc.	0	341	862	613	233	248	138	48	24	18	18	2,543
4X Midwater Trawl	0	13,120	652	0	0	0	0	0	0	0	0	13,772
Total Nos. by Age	1,831	113,457	219,777	112,245	36,784	36,402	22,127	6,474	4,217	2,957	3,566	559,837

% 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	0	3	56	23	3	4	4	1	2	2	2	100
4X N.S. P.Seine	1	22	29	22	9	9	5	2	1	1	1	100
4X N.B. P.Seine	0	1	75	21	2	1	0	0	0	0	0	100
4X N.S. Weirs	0	44	44	6	1	2	1	0	0	0	0	100
4WX Misc.	0	13	34	24	9	10	5	2	1	1	1	100
4X Midwater Trawl												
Overall % Nos. by Age	0	20	39	20	7	7	4	1	1	1	1	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	0	41	1,890	1,369	273	417	402	166	312	219	263	5,352
4X N.S. P.Seine	28	3,973	10,413	11,621	6,211	7,231	4,795	1,636	885	719	969	48,481
4X N.B. P.Seine	0	16	2,875	1,777	211	125	40	21	0	0	0	5,064
4X N.S. Weirs	0	534	1,329	403	125	277	186	59	59	20	56	3,049
4WX Misc.	0	14	85	92	46	58	36	15	7	6	7	366
4X Midwater Trawl	0	168	19	0	0	0	0	0	0	0	0	187
Totals Catch t. by Age	28	4,745	16,612	15,262	6,866	8,107	5,460	1,896	1,263	965	1,295	62,499

% 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	0	1	35	26	5	8	8	3	6	4	5	100
4X N.S. P.Seine	0	8	21	24	13	15	10	3	2	1	2	100
4X N.B. P.Seine	0	0	57	35	4	2	1	0	0	0	0	100
4X N.S. Weirs	0	18	44	13	4	9	6	2	2	1	2	100
4WX Misc.	0	4	23	25	13	16	10	4	2	2	2	100
4X Midwater Trawl												
Overall % by Age	0	8	27	24	11	13	9	3	2	2	2	100

Table 5. Catches at age in numbers ('000) and weight (t) for non-stock gear components of the 1995 4WX herring fishery.

Catch Nos.('000s)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+	Total
4X N.B. Weirs	57,759	259,070	39,995	14,753	1,817	1,562	1,546	30	0	0	0	376,532
4X N.B. shutoff	85	671	127	50	5	5	3	0	0	0	0	946
Total Nos. by Age	57,844	259,741	40,122	14,803	1,822	1,567	1,549	30	0	0	0	377,478

% Catch Nos.	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+	Total
4X N.B. Weirs	15	69	11	4	0	0	0	0	0	0	0	100
4X N.B. shutoff	9	71	13	5	1	1	0	0	0	0	0	100
Total Nos. by Age	15	69	11	4	0	0	0	0	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
4X N.B. Weirs	760	10,616	3,740	2,095	293	325	360	9	0	0	0	18,198
4X N.B. shutoff	1	27	12	7	1	1	1	0	0	0	0	50
Total Catch t. by Age	761	10,644	3,752	2,101	294	326	361	9	0	0	0	18,248

% 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
4X N.B. Weirs	4	58	21	12	2	2	2	0	0	0	0	100
4X N.B. shutoff	2	55	24	14	2	2	1	0	0	0	0	100
Total Catch t. by Age	4	58	21	12	2	2	2	0	0	0	0	100

Table 6. 1995 4WX herring biological sampling by gear component and month.

Year	Gearname	Month	Number LenFreq Samples	Min. LenFreq Length	Max. LenFreq Length	LenFreq Number Measured	Number Detail Samples	Min. Detail Length	Max. Detail Length	Detail Number Process	Detail Number Aged
95	4W Purse Seine	01	8	115	380	1910	7	112	374	285	285
		11	21	200	400	4283	8	200	390	452	170
	Gillnet	04	4	265	380	849	4	263	377	131	0
		05	2	275	375	498	2	271	370	71	0
	Midwater Trawl	07	3	60	365	243	3	45	355	117	115
	N.B. Midwater Trawl	01	2	105	185	946	2	107	182	37	37
		02	1	100	185	259	1	101	187	15	15
	N.B. Weirs	05	1	115	200	323	1	110	189	13	13
		07	8	110	330	2108	8	112	322	208	202
		08	12	125	330	2791	11	137	324	227	227
		09	10	95	310	1439	4	97	305	75	75
	N.S. Purse Seine	01	2	130	265	465	2	128	259	51	51
		05	2	190	330	370	2	187	330	72	72
		06	3	215	340	570	3	207	335	109	108
		07	33	120	380	7025	18	171	372	685	683
		08	22	150	375	5160	15	160	368	605	603
		09	124	100	395	24655	12	104	380	528	474
		10	64	105	300	12988	1	193	255	21	21
	N.S. Weirs	05	2	120	245	545	2	118	237	33	33
		06	13	125	385	3885	7	123	355	235	233
		07	5	155	380	1173	5	155	365	182	179
	Resrch. Misc.	07	1	55	95	199	1	53	91	20	20
	Resrch. Otter Trawl	02	3	155	375	847	3	158	376	158	158
		03	1	130	295	256	1	132	297	28	28
		06	22				13	224	380	130	103
		07	55				15	157	372	309	182
		11	13	130	320	598	13	125	308	187	187
	Trap	08	5	230	395	1147	4	224	384	182	90
****	**********	*****	-------			--------	-------			-------	------
sum			442			75341	168			5144	4344
			-------			--------	-------			-------	------
sum			442			75341	168			5144	4344

Table 7a. 4WX herring percent numbers at age for 1965 to 1995.

	Percent Numbers					
Year	1	2	3	4	≤4	≤3
1965	16	64	2	14	96	82
1966	8	46	23	4	81	77
1967	35	29	7	13	84	71
1968	5	71	7	2	85	83
1969	8	20	37	9	74	65
1970	33	27	4	13	77	64
1971	8	35	16	9	68	59
1972	0	55	6	13	74	61
1973	0	14	63	11	88	77
1974	1	42	5	44	92	48
1975	0	25	19	10	54	44
1976	0	7	26	19	52	33
1977	0	20	4	28	52	24
1978	4	47	5	2	58	56
1979	0	31	42	9	82	73
1980	0	2	13	75	90	15
1981	0	14	7	14	35	21
1982	1	17	25	4	47	43
1983	1	25	19	31	76	45
1984	0	11	31	28	70	42
1985	1	20	31	28	80	52
1986	0	16	34	36	86	50
1987	0	8	12	50	70	20
1988	0	12	9	16	37	21
1989	0	16	18	10	44	34
1990	0	17	13	17	47	30
1991	0	12	22	23	57	34
1992	0	17	14	29	60	31
1993	0	12	7	31	50	19
1994	0	18	25	9	52	43
1995	0	20	39	20	79	59

Table 7b. 4WX herring percent weight at age for 1965 to 1995.

	Percent Weight					
Year	1	2	3	4	≤4	≤3
1965	3	42	4	38	87	49
1966	1	20	26	7	54	47
1967	4	14	10	26	54	28
1968	1	34	11	5	51	46
1969	1	6	31	12	50	38
1970	3	9	4	23	39	16
1971	0	15	14	12	41	29
1972	0	19	7	19	45	26
1973	0	3	54	12	69	57
1974	0	17	5	64	86	22
1975	0	4	12	12	28	16
1976	0	1	16	17	34	17
1977	0	7	2	25	34	9
1978	0	9	4	2	15	13
1979	0	10	36	12	58	46
1980	0	0	8	76	84	8
1981	0	3	4	13	20	7
1982	0	4	16	4	24	20
1983	0	7	14	36	57	21
1984	0	2	23	31	56	25
1985	0	7	23	35	65	30
1986	0	6	28	43	77	34
1987	0	2	7	48	57	9
1988	0	2	5	14	21	7
1989	0	3	8	9	20	11
1990	0	3	6	15	24	9
1991	0	3	13	20	36	16
1992	0	3	9	28	40	12
1993	0	2	4	28	34	6
1994	0	5	14	9	28	19
1995	0	8	27	24	59	35

Table 8. Average weight (g) and length (cm) at age for stock and non-stock gear components of the 1995 4WX herring fishery.

STOCK GEAR COMPONENTS Average Wt. at Age	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
4W Purse Seine	0	20	58	100	142	175	191	211	241	244	293
4X N.S. P.Seine	15	52	101	151	192	227	252	305	322	361	386
4X N.B. P.Seine	0	17	46	99	136	161	182	199	0	0	0
4X N.S. Weirs	0	27	66	141	192	245	300	341	384	410	408
4WX Misc.	0	41	99	150	197	231	257	306	327	352	370
4X N.B. Midwater Trawl	0	13	30	0	0	0	0	0	0	0	0
Average for Stock Gears	15	42	76	136	187	223	247	293	300	326	363

Average Length at Age	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
4W Purse Seine	0.0	14.4	20.6	24.7	27.7	29.8	30.8	31.8	33.2	33.4	35.4
4X N.S. P.Seine	13.4	19.5	23.9	27.1	29.2	30.7	31.7	33.6	34.1	35.3	36.0
4X N.B. P.Seine	0.0	13.8	18.8	24.1	26.8	28.3	29.5	30.3	0.0	0.0	0.0
4X N.S. Weirs	0.0	16.1	20.7	26.2	28.7	30.9	32.7	34.1	35.3	36.0	36.0
4WX Misc.	0.0	18.2	23.6	27.0	29.3	30.7	31.7	33.5	34.2	35.0	35.5
4X N.B. Midwater Trawl	0.0	12.8	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average for Stock Gears	13.4	18.0	21.6	26.3	29.0	30.6	31.6	33.3	33.9	34.7	35.9

NONSTOCK GEAR COMPONENTS Average weight	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
4X N.B. Weirs	13	41	94	142	161	208	233	296	0	0	0
4X N.B. Shutoffs	14	41	95	137	164	202	241	0	0	0	0
Average for nonstock	13	41	94	142	161	208	233	296	0	0	0

Average length	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
4X N.B. Weirs	12.7	18.1	23.2	26.5	27.5	29.8	30.6	33.0	0.0	0.0	0.0
4X N.B. Shutoffs	13.0	18.0	23.4	26.3	27.8	29.7	31.3	0.0	0.0	0.0	0.0
Average for nonstock	12.7	18.1	23.2	26.5	27.5	29.8	30.6	33.0	0.0	0.0	0.0

Table 9 . Average weights (g.) at age for the 4WX herring fishery (weighting by stock gear components) for 1965-95.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	10	10	10	0	0	0	0	0	0	0	0	0	0	0	10	10
2	41	41	41	33	37	32	66	44	29	48	21	33	65	28	41	41
3	112	112	112	112	105	119	143	138	106	110	94	114	113	112	112	112
4	172	172	172	148	162	169	199	192	143	175	179	159	174	181	172	172
5	218	218	218	185	207	211	230	224	225	206	216	233	214	229	218	218
6	254	254	254	244	242	257	254	262	252	240	240	249	274	259	254	254
7	286	286	286	276	282	292	293	292	279	277	268	277	293	302	286	286
8	323	323	323	399	306	332	329	322	331	322	333	317	325	330	323	323
9	354	354	354	338	334	369	362	345	360	342	358	382	328	351	354	354
10	389	389	389	410	390	389	388	380	389	352	379	404	416	397	389	389
11+	389	389	389	410	390	389	388	380	389	352	379	404	416	397	389	389

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0	10	10	0	0	0	12	13	7	0	0	9	18	12	15
2	41	41	41	38	53	55	50	21	33	31	48	25	29	37	42
3	112	112	112	132	118	124	98	88	79	92	100	100	108	79	76
4	172	172	172	191	204	182	153	154	162	161	147	148	153	131	136
5	218	218	218	229	249	239	199	196	207	200	186	181	188	175	187
6	254	254	254	259	278	271	245	242	238	234	217	216	215	203	223
7	286	286	286	280	315	306	274	281	274	255	251	252	251	223	247
8	323	323	323	296	334	329	290	304	303	287	270	275	279	253	293
9	354	354	354	309	344	360	318	327	324	319	303	295	302	289	300
10	389	389	389	364	440	400	350	341	353	336	322	313	324	304	326
11+	389	389	389	364	440	400	350	371	365	364	332	333	357	326	363

Table 10. Herring abundance indices; larval abundance index (average number of larvae per m2 from 79 index stations), and herring by-catch (stratified numbers per tow) from July groundfish survey.

	Larval Herring Bongo Survey No.per m2 to bottom				Herring groundfish by-catch (mean numbers per tow)								Mean Weight (kg per tow)			
						4WX Area Combined			4W Area Only		4X Area Only		4W Area Only		4X Area Only	
Year	Cruise	Mean	SE	N	Cruise	Mean#	SE	N	Mean#	SE	Mean#	SE	MeanWt	SE	MeanWt	SE
70					A175/176	4.1	1.5	95	4.9	2.4	1.6	0.6	1.5	0.7	0.5	0.2
71					A188/189	4.0	1.9	86	2.6	1.2	3.6	2.6	0.7	0.4	1.3	1.0
72	P109	9.4	1.8		A200/201	1.4	0.6	105	1.7	1.0	0.5	0.1	0.5	0.4	0.1	0.0
73	P127	6.6	1.3		A212/213	0.9	0.3	96	0.4	0.3	1.0	0.4	0.1	0.1	0.2	0.1
74	P147	49.5	10.9		A225/226	0.7	0.3	102	0.2	0.0	1.0	0.4	0.1	0.0	0.2	0.1
75	P160	11.7	1.5	58	A236/237	0.9	0.4	104	0.8	0.4	0.7	0.4	0.3	0.2	0.2	0.1
76	P175	13.5	2.9		A250/251	0.4	0.2	103	0.1	0.1	0.5	0.3	0.0	0.0	0.1	0.1
77	P190	6.3	1.0		A265/266	0.5	0.3	106	0.0	0.0	0.8	0.5	0.0	0.0	0.1	0.0
78	P207	4.5	0.5	77	A279/280	0.3	0.3	103	0.5	0.5	0.1	0.0	0.3	0.3	0.0	0.0
79	P232	7.1	2.1		A292/293	0.6	0.5	106	0.0	0.0	1.0	0.7	0.0	0.0	0.2	0.1
80	P246	26.2	6.7		A305/306	0.5	0.5	105	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0
81	P263	2.7	0.3	78	A321/322	1.5	1.4	104	0.0	0.0	2.3	2.1	0.0	0.0	0.4	0.4
82	P280	10.6	1.2	77	H080/081	1.5	0.9	108	0.5	0.3	1.9	1.4	0.2	0.1	0.5	0.4
83	P298	13.9	1.6	74	N012/013	2.4	0.8	106	2.6	1.2	2.2	1.0	0.8	0.4	0.2	0.1
84	P315	12.7	1.4	78	N031/032	7.0	3.5	102	3.3	1.2	10.5	6.8	1.0	0.4	3.1	2.2
85	P329	40.8	4.6	79	N048/049	3.4	1.8	111	6.6	3.8	0.3	0.1	2.1	1.2	0.1	0.0
86	P344	18.9	2.1	78	N065/066	23.2	14.9	118	30.8	26.7	16.0	14.3	9.4	8.3	3.1	2.8
87	P361	27.9	3.2	78	N085/087	10.4	5.6	135	17.0	11.3	4.0	1.8	3.9	2.0	0.5	0.2
88	P377	100.7	11.5	76	N105/106	2.1	0.6	127	2.7	1.2	1.5	0.5	0.7	0.3	0.2	0.1
89	P391	54.5	6.1	79	N123/124	8.4	1.8	124	11.8	3.4	4.5	1.2	3.9	1.2	1.0	0.3
90	P408	27.2	3.1	79	N139/140	5.6	1.9	156	7.4	3.6	3.4	1.0	2.2	1.0	0.7	0.3
91	P422	48.2	5.5	78	N154/H231	10.6	5.8	137	13.0	8.8	5.0	1.8	4.3	2.9	1.2	0.4
92	P437	57.0	6.4	79	N173/174	16.5	4.9	136	16.2	6.6	40.8	15.7	5.0	2.2	5.5	2.6
93	P451	55.0	6.2	78	N189/190	18.7	4.5	137	6.3	2.5	30.4	8.5	2.0	0.8	7.1	2.0
94	N211	5.4	0.7	77	N211/222	76.4	30.2	140	108.4	58.9	45.9	18.4	29.1	13.5	8.3	3.4
95	N232	20.3	4.6	78	N226/227	63.5	24.2	140	100.5	47.9	28.4	12.8	27.1	11.9	7.5	3.9

Table 11. Abundance of herring (stratified mean number per tow) in summer groundfish research surveys of 4WX, strata 52-95, 1970-1995; (N = number per set for all sets) (N^h = number per set for sets with herring).

Year	Cruise	Date	Total sets (n)	No. sets with herring	Total herring	No./set (N)	No./set (N^h)	Stratified mean no./tow	SE
1970	A175-176	06-30/07	95*	23	383.82	4.13	16.69	4.07	1.54
1971	A188-189	29/06-22/07	86*	23	296.88	3.49	12.91	3.97	1.87
1972	A200-201	23/06-19/07	105	23	117.41	1.12	5.10	1.37	0.62
1973	A212-213	09/07-02/08	96	20	77.08	0.80	3.85	0.92	0.31
1974	A225-226	09/07-03/08	102*	15	54.77	0.54	3.65	0.72	0.25
1975	A236-237	15/07-06/08	104	12	131.09	1.26	10.92	0.89	0.36
1976	A250-251	12/07-05/08	103*	10	53.43	0.52	5.34	0.36	0.20
1977	A265-266	09/07-30/08	106	9	81.54	0.77	9.06	0.54	0.30
1978	A279-280	09-31/07	103*	4	32.03	0.31	8.01	0.34	0.32
1979	A292-293	06-27/07	106*	5	71.06	0.68	14.21	0.64	0.46
1980	A306-307	07-27/07	105	3	93.51	0.89	31.17	0.54	0.51
1981	A321-322	04-25/07	104	4	195.05	1.88	48.76	1.51	1.35
1982	H080-081	10-30/07	108	14	130.44	1.21	9.32	1.54	0.90
1983	N012-013	05-27/07	106	25	230.95	2.18	9.24	2.36	0.80
1984	N031-032	01/07-02/08	102	31	678.06	6.65	21.87	6.98	3.53
1985	N048-049	04-25/07	111	19	418.58	3.77	22.03	3.38	1.83
1986	N065-066	07-17/07	118	36	2152.13	18.24	59.78	23.20	14.92
1987	N085-087	29/07-06/08	135	33	2118.70	15.69	64.20	10.35	5.56
1988	N105-106	04-27/07	127	31	280.90	2.21	9.06	2.08	0.62
1989	N123-124	05-27/07	124	46	939.52	7.58	20.42	8.35	1.78
1990	N139-140	03/07-31/08	156*	46	779.44	5.03	16.94	5.56	1.88
1991	N154/H231	04-28/07	137	45	1149.95	8.39	25.55	10.64	5.81
1992	N173/N174	23/06-17/07	139	53	4037.08	29.25	76.17	29.04	8.72
1992	N173/N174	w/o Strat.93	136	50	1440.74	10.59	28.81	16.46	4.85
1993	N189/190	05/07-01/08	137	64	2460.15	17.96	38.44	18.65	4.51
1994	N221/222	04/07-28/07	140	76	16327.86	116.63	214.84	76.36	30.20
1995	N226/227	25/06-20/07	140	64	8231.33	58.80	128.61	63.51	24.22

*Total includes strata with only one set.

Table 12. 4WX herring by-catch age composition in summer groundfish research surveys.

Year	Percent Numbers by Age												Total
	1	2	3	4	5	6	7	8	9	10	11-17	99	
87	0.0	9.7	35.3	26.2	10.2	8.0	4.2	3.1	1.8	0.6	0.8	0.0	100
88	0.0	13.0	5.9	17.2	34.9	20.4	4.7	1.6	0.4	0.5	0.4	0.9	100
89	2.5	2.8	4.4	10.0	12.8	36.3	22.7	4.3	1.1	0.7	0.8	1.4	100
90	1.8	4.6	11.6	14.5	12.3	13.1	24.0	13.5	2.2	0.5	1.1	0.7	100
91	0.0	0.8	4.3	14.1	17.6	10.5	14.9	25.3	8.8	2.3	1.3	0.1	100
92a	0.0	39.7	4.6	6.2	9.5	14.1	7.2	6.5	8.9	1.9	1.2	0.3	100
92b	0.0	0.1	2.0	9.9	16.8	25.2	12.9	11.6	16.0	3.5	2.1	0.0	100
93	0.0	0.4	4.3	16.7	22.1	21.7	16.6	6.7	4.9	4.3	2.3	0.0	100
94a	0.0	0.2	6.7	12.3	30.1	24.1	9.4	0.7	2.0	4.9	1.8	7.9	100
94b	0.0	0.2	1.8	8.3	31.2	30.3	13.0	1.2	3.3	7.9	2.9	0.0	100
95	0.0	0.8	16.7	20.4	14.6	21.6	14.4	5.3	2.6	1.5	2.0	0.1	100

Year	Stratified Total Numbers by Age (thousands)												Total
	1	2	3	4	5	6	7	8	9	10	11-17	99	
87	14	3,060	11,187	8,306	3,236	2,539	1,336	983	562	206	267	0	31,697
88	0	830	377	1,095	2,222	1,298	298	104	28	34	26	56	6,368
89	634	720	1,122	2,561	3,274	9,293	5,821	1,109	291	184	213	367	25,588
90	291	753	1,911	2,400	2,035	2,164	3,966	2,225	363	84	188	119	16,500
91	0	273	1,397	4,614	5,734	3,418	4,874	8,245	2,865	739	435	23	32,618
92a	0	35,118	4,038	5,458	8,423	12,490	6,349	5,708	7,920	1,715	1,033	238	88,489
92b	0	52	975	4,903	8,287	12,460	6,349	5,708	7,920	1,715	1,033	0	49,400
93	0	228	2,480	9,559	12,622	12,424	9,465	3,838	2,794	2,455	1,293	0	57,158
94a	0	39	1,562	2,879	7,048	5,648	2,191	166	477	1,147	426	1,845	23,428
94b	0	205	1,931	8,685	32,718	31,852	13,622	1,258	3,453	8,285	2,998	17	105,023
95	16	1,590	32,469	39,729	28,487	41,964	28,043	10,241	5,036	2,960	3,876	277	194,687

All years and 92a, 94a: used all 4WX strata (52/95).
92b. Strata 93 (sets 36,37,38) with large catches of juveniles removed.
94b. Strata 56,58 and 93 removed (total of 8, 8 & 3 sets respectively)

Table 13. Scots Bay transect summary table for July 1995 research survey with J.L. Hart.

Stratum	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa ($/m^2$)	Biomass Density (kg/m^2)	Set Number
1	9	6.122	-36.00	-64.867	0.0013	a
	11	4.730	-36.00	-1013.739	0.0000	a
	12	4.491	-36.00	-1013.513	0.0000	a
	13	4.967	-36.00	-1013.950	0.0000	a
	14	5.575	-36.00	-82.590	0.0000	a
	15	3.120	-36.00	-1011.932	0.0000	a
2	17	5.447	-36.00	-54.502	0.0141	b
	18	5.941	-36.00	-54.035	0.0157	b
	19	5.990	-36.00	-56.543	0.0088	b
	20	6.059	-36.00	-81.239	0.0000	b
	21	5.176	-36.00	-67.165	0.0008	b
	22	5.146	-36.00	-60.072	0.0039	b
	24	3.866	-36.00	-1012.862	0.0000	b
	25	5.656	-36.00	-1014.515	0.0000	b
	26	5.835	-36.00	-60.596	0.0035	b
	27	4.521	-36.00	-59.469	0.0045	b

Table 14. Scots Bay stratum summary table for all transects

Stratum	Average TS (dB/kg)	Stratum Area (km^2)	Weighted Mean Sa ($/m^2$)	Biomass Density (kg/m^2)	Biomass Total (tons)	per Strata Standard Err (tons)	(%)
1	-36.0	342.99	-71.556	0.0003	95	74	78
2	-36.0	137.20	-58.700	0.0054	737	254	35

Mean of strata densities [kg/m^2] = 0.0017
Mean of strata Sa [dB re $/m^2$] = -63.612
Total area of all strata [km^2] = 480
Total biomass of all strata [metric tons] = 832

Table 15. Summary of scientist observations of purse seine activities - August 1995 -- January 1996.

Date	Vessel	Area	Tonnage Observed	Comments
Aug. 8-9	Eastern Fisher	Scot's Bay	6000t overall	scientific survey
	Jennifer & Boys	Scot's Bay	"	scientific survey
	Lady Cavelle	Scot's Bay	"	scientific survey
	Mari-Lynn Anita	Scot's Bay	"	scientific survey
Aug. 16-17	Ingall Sands	Scot's Bay	-a few small schools only	scientific survey
	Island Bounty	Scot's Bay	"	scientific survey
	Nova Star	Scot's Bay	"	scientific survey
	Sealife II	Scot's Bay	"	scientific survey
	Tasha Marie	Trinity Ledge	3 schools of 1000+ ton	scientific survey 1/2 night
Sept. 5-6	Dual Venture	German Bank	250 t + large school	Normal fishing operations
	Eastern Fisher	German Bank	several large schools	Normal fishing operations
	Island Pride	German Bank	large schools 1000+t	Normal fishing operations
	Margaret Elizabeth	German Bank	band of fish 12-25 ftm	Normal fishing operations
	Morning Star	German Bank		Normal fishing operations
Sept. 15-16	Tasha Marie	Trinity Ledge	3 schools 200+t each	scientific survey 1/2 night
Sept. 22-23	Eastern Phoenix	German Bank	100t school & 25t 'bunches'	scientific survey
	Island Pride	German Bank	40-50kt overall ; 20,000+t in one school	scientific survey
	Lady Melissa	Trinity Ledge	no fish	scientific survey
	Margaret Elizabeth	Trinity Ledge	no fish	scientific survey
Sept. 29-30	Leroy & Barry II	German Bank	50x100+t & 20x1000+t schools	scientific survey
	Morning Star	German Bank	no fish in different areas	scientific survey
Oct. 3-4	Eastern Fisher	Little Hope	thin layer 5-10 ftm near bottom	scientific survey
	Mari-Lynn Anita	Little Hope	2 -3x50 to 100t schools scattered	scientific survey
Oct. 13-14	Island Pride	Little Hope	thin layer 5-10 ftm near bottom	scientific survey
	Margaret Elizabeth	Little Hope	2 -3x100t schools scattered	scientific survey
Nov. 1-2	Margaret Elizabeth	Chedabucto	1-2 miles of small to med schools	Normal fishing operations
	Island Pride	Chedabucto	"	Normal fishing operations
Jan 2-3	Margaret Elizabeth	Halifax	large body of fish	Scientific Survey
Jan. 13-14	Leroy & Barry	Halifax	large body of fish	Scientific Survey
Jan. 14-15	Margaret Elizabeth	Halifax	"	Scientific Survey
Jan. 15-16	Eastern Phoenix	Halifax	"	Scientific Survey
Jan. 16-17	Margaret Elizabeth	Halifax	large body of fish	Scientific Survey
Jan. 18-19	Eastern Phenix	Halifax	"	Scientific Survey
Jan. 22-23	Leroy & Barry	Halifax	large body of fish	Scientific Survey

Table 16. Population numbers at age and total spawning stock biomass for 4WX herring from an SPA with terminal F=0.299

	1	2	3	4	5	6	7	8	9	10	11	Population Numbers (000s)	Spawning Biomass (t)
1965	3,519,816	3,855,303	997,927	1,315,178	349,390	91,813	41,148	4,346	1,282	385	0	10,176,588	186,752
1966	2,744,238	2,637,900	2,182,573	785,587	865,817	241,085	65,624	32,161	3,052	1,001	282	9,559,038	291,119
1967	6,079,240	2,107,536	1,340,495	1,383,121	577,016	420,626	156,068	41,164	19,391	995	626	12,125,652	357,280
1968	1,286,749	4,326,387	1,174,414	959,040	892,657	373,396	201,831	75,881	29,649	15,506	549	9,335,510	386,165
1969	1,753,794	905,095	1,416,148	759,115	710,246	470,528	239,954	84,291	33,533	10,516	7,619	6,383,220	369,429
1970	2,301,358	1,337,651	480,640	683,224	502,405	435,467	284,007	140,309	48,719	21,745	6,191	6,235,525	374,775
1971	7,465,345	1,256,346	579,490	324,602	303,371	231,291	248,526	132,346	77,846	20,877	11,490	10,640,040	281,280
1972	1,138,746	6,033,020	666,080	309,499	170,149	146,681	121,579	119,645	63,566	31,046	10,341	8,800,011	200,886
1973	2,344,121	932,327	4,354,157	480,452	120,861	70,343	52,905	55,642	54,391	28,737	13,095	8,493,936	138,814
1974	1,626,263	1,918,284	612,610	2,861,897	275,853	62,974	30,476	23,599	27,418	23,198	13,123	7,462,572	290,166
1975	247,238	1,314,843	885,073	417,264	1,621,579	164,497	34,426	15,779	13,427	11,032	12,621	4,725,158	376,042
1976	723,916	199,533	791,032	509,258	229,810	866,057	75,358	17,167	8,960	6,712	5,585	3,427,803	306,629
1977	4,144,386	592,476	113,445	462,115	278,951	126,408	467,884	42,432	9,060	3,805	3,648	6,240,962	255,905
1978	1,346,654	3,392,079	346,809	64,532	183,328	121,790	57,712	224,368	22,208	4,577	1,848	5,764,057	162,546
1979	457,929	1,070,602	2,431,438	247,094	41,224	42,033	38,860	19,570	86,469	8,300	1,587	4,443,519	84,658
1980	1,594,504	374,611	710,915	1,764,957	153,191	28,859	13,819	15,519	5,515	33,857	2,766	4,695,747	179,975
1981	1,679,498	1,303,357	295,418	509,475	1,019,237	100,286	19,690	7,108	6,841	1,858	18,175	4,942,768	254,463
1982	2,340,424	1,375,057	974,150	196,064	324,697	431,059	52,536	13,942	3,343	3,879	1,038	5,715,151	193,017
1983	4,188,844	1,912,935	1,033,673	661,799	140,119	177,717	164,654	29,880	9,541	1,525	2,055	8,320,687	170,256
1984	5,083,500	3,424,578	1,393,363	710,897	323,291	92,681	91,114	54,714	15,186	6,256	675	11,195,580	179,292
1985	1,880,753	4,162,017	2,723,961	921,569	380,787	134,184	55,468	55,135	19,577	3,995	3,166	10,337,446	225,800
1986	1,107,895	1,531,681	3,211,976	1,925,978	483,018	179,578	71,824	32,767	28,841	8,875	2,193	8,582,433	329,701
1987	1,449,562	907,011	1,141,025	2,380,924	1,313,173	344,147	118,583	49,105	22,935	20,961	6,045	7,747,426	536,577
1988	1,468,627	1,184,723	667,808	820,226	1,475,081	856,815	240,381	79,548	33,636	15,751	14,351	6,842,596	574,834
1989	1,953,017	1,202,274	836,246	444,841	496,191	818,001	489,503	158,524	46,080	23,767	9,483	6,468,444	481,153
1990	1,443,924	1,598,988	892,540	581,874	308,495	334,707	517,691	331,718	113,292	30,284	16,024	6,153,513	428,100
1991	753,368	1,182,185	1,148,219	613,499	322,422	171,862	183,345	243,133	166,936	64,502	15,320	4,849,471	305,065
1992	1,206,004	616,806	880,442	778,475	337,487	184,567	103,544	104,870	126,677	95,801	36,389	4,434,673	262,684
1993	1,534,558	987,384	353,629	601,386	380,379	163,023	83,597	53,880	54,154	50,917	47,476	4,262,907	206,660
1994	589,607	1,256,240	739,485	250,088	318,212	194,269	72,917	38,186	24,892	24,750	23,183	3,508,646	147,715
1995	1,223,423	482,593	934,829	477,438	156,462	154,837	94,118	27,537	17,937	12,578	10,922	3,581,752	117,619
1996	1,000,000	1,000,000	293,131	567,823	290,000	95,036	94,049	57,168	16,726	10,895	7,640	3,424,828	140,258

Table 17: Fishing mortality levels at age and average exploitation rates for 4WX herring from an SPA with terminal F=0.299

	1	2	3	4	5	6	7	8	9	10	Average F Ages 4-9	Exploitation Rate Ages 4-9
1965	0.088	0.369	0.039	0.218	0.171	0.136	0.046	0.153	0.048	0.112	0.129	12.1
1966	0.064	0.477	0.256	0.109	0.522	0.235	0.266	0.306	0.921	0.269	0.393	32.5
1967	0.140	0.385	0.135	0.238	0.235	0.534	0.521	0.128	0.024	0.395	0.280	24.4
1968	0.152	0.917	0.236	0.100	0.440	0.242	0.673	0.617	0.837	0.511	0.485	38.4
1969	0.071	0.433	0.529	0.213	0.289	0.305	0.337	0.348	0.233	0.330	0.288	25.0
1970	0.405	0.637	0.193	0.612	0.576	0.361	0.564	0.389	0.647	0.438	0.525	40.8
1971	0.013	0.435	0.427	0.446	0.527	0.443	0.531	0.533	0.719	0.502	0.533	41.3
1972	0.000	0.126	0.127	0.740	0.683	0.820	0.582	0.588	0.594	0.663	0.668	48.7
1973	0.000	0.220	0.220	0.355	0.452	0.636	0.607	0.508	0.652	0.584	0.535	41.4
1974	0.013	0.574	0.184	0.368	0.317	0.404	0.458	0.364	0.710	0.409	0.437	35.4
1975	0.014	0.308	0.353	0.396	0.427	0.581	0.496	0.366	0.493	0.481	0.460	36.9
1976	0.000	0.365	0.338	0.402	0.398	0.416	0.374	0.439	0.656	0.410	0.448	36.1
1977	0.000	0.336	0.364	0.725	0.629	0.584	0.535	0.447	0.483	0.522	0.567	43.3
1978	0.029	0.133	0.139	0.248	1.273	0.942	0.881	0.754	0.784	0.859	0.814	55.7
1979	0.001	0.209	0.120	0.278	0.157	0.912	0.718	1.067	0.738	0.899	0.645	47.5
1980	0.002	0.037	0.133	0.349	0.224	0.182	0.465	0.619	0.888	0.422	0.455	36.5
1981	0.000	0.091	0.210	0.250	0.661	0.447	0.145	0.554	0.367	0.382	0.404	33.2
1982	0.002	0.085	0.187	0.136	0.403	0.762	0.364	0.179	0.585	0.435	0.405	33.3
1983	0.001	0.117	0.174	0.516	0.213	0.468	0.902	0.477	0.222	0.616	0.466	37.3
1984	0.000	0.029	0.213	0.424	0.679	0.313	0.302	0.828	1.135	0.481	0.614	45.9
1985	0.005	0.059	0.147	0.446	0.552	0.425	0.326	0.448	0.591	0.400	0.465	37.2
1986	0.000	0.094	0.099	0.183	0.139	0.215	0.180	0.157	0.119	0.184	0.166	15.3
1987	0.002	0.106	0.130	0.279	0.227	0.159	0.199	0.178	0.176	0.179	0.203	18.4
1988	0.000	0.148	0.206	0.303	0.390	0.360	0.216	0.346	0.147	0.307	0.294	25.4
1989	0.000	0.098	0.163	0.166	0.194	0.257	0.189	0.136	0.220	0.194	0.194	17.6
1990	0.000	0.131	0.175	0.390	0.385	0.402	0.556	0.487	0.363	0.481	0.431	35.0
1991	0.000	0.095	0.189	0.398	0.358	0.307	0.359	0.452	0.355	0.372	0.372	31.0
1992	0.000	0.356	0.181	0.516	0.528	0.592	0.453	0.461	0.711	0.502	0.544	41.9
1993	0.000	0.089	0.146	0.437	0.472	0.605	0.584	0.572	0.583	0.587	0.542	41.9
1994	0.000	0.096	0.238	0.269	0.520	0.525	0.774	0.556	0.483	0.618	0.521	40.6
1995	0.002	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	25.8

Table 18. Catch at age (000's) for 4WX stock herring as used in assessment analysis.

	Age										
Year	1	2	3	4	5	6	7	8	9	10	Totals
1965	270,378	1,084,719	34,835	234,383	49,925	10,592	1,693	561	54	37	1,687,177
1966	154,323	914,093	448,940	73,382	321,857	45,916	13,970	7,722	1,690	215	1,982,108
1967	722,208	613,970	153,626	266,454	110,051	159,203	57,948	4,497	409	296	2,088,662
1968	164,703	2,389,061	224,956	83,109	290,285	73,087	90,617	31,977	15,441	5,668	3,368,904
1969	108,875	290,329	531,812	132,319	162,439	112,631	62,506	22,595	6,345	2,693	1,432,544
1970	699,720	576,896	76,532	286,278	201,215	120,280	111,937	41,257	21,271	7,039	2,142,425
1971	87,570	404,224	183,896	106,630	113,566	75,593	93,620	50,022	36,618	7,536	1,159,275
1972	-	649,254	71,984	148,516	77,207	75,384	49,065	48,700	26,055	13,792	1,159,957
1973	1,018	167,454	781,061	130,851	40,128	30,334	22,046	20,249	23,871	11,630	1,228,642
1974	18,411	766,064	93,606	803,651	68,276	19,093	10,232	6,565	12,786	7,102	1,805,786
1975	3,199	317,641	239,827	124,599	514,605	66,302	12,298	4,409	4,778	3,847	1,291,505
1976	240	55,596	206,535	153,782	68,804	268,839	21,460	5,571	3,951	2,059	786,837
1977	1,170	153,921	31,572	218,478	119,234	51,173	177,247	13,977	3,170	1,415	771,357
1978	35,381	383,611	40,887	12,906	122,108	68,410	31,088	108,975	11,082	2,425	816,873
1979	342	183,982	250,393	54,620	5,430	23,142	18,255	11,836	41,389	4,527	593,916
1980	2,339	12,503	80,518	474,091	27,930	4,373	4,692	6,560	2,985	10,641	626,632
1981	-	103,051	50,883	102,743	451,482	32,978	2,418	2,767	1,917	538	748,777
1982	3,589	102,133	150,764	22,640	98,206	211,043	14,627	2,080	1,354	1,250	607,686
1983	5,488	191,682	150,328	244,007	24,483	60,678	89,982	10,352	1,728	642	779,370
1984	-	88,433	243,542	224,354	146,096	22,716	21,654	28,299	9,515	2,183	786,792
1985	9,022	216,740	337,591	302,782	147,670	42,404	14,075	18,178	7,997	1,201	1,097,660
1986	63	125,300	275,903	292,792	56,937	31,599	10,770	4,320	2,942	1,356	801,982
1987	2,300	82,940	126,436	527,443	242,597	45,933	19,481	7,292	3,361	3,120	1,060,903
1988	151	148,399	113,208	195,096	434,192	236,089	42,533	21,208	4,186	3,797	1,198,859
1989	8	101,788	114,095	61,842	79,451	169,023	76,684	18,303	8,270	3,814	633,278
1990	-	178,532	130,176	171,560	89,922	101,066	201,901	116,788	31,466	10,572	1,031,983
1991	-	96,960	179,463	183,647	88,431	41,352	50,380	80,732	45,516	18,291	784,772
1992	9	168,561	132,642	286,923	126,510	75,473	34,458	35,369	59,136	34,558	953,639
1993	166	76,405	43,766	194,198	130,713	67,708	33,820	21,481	21,893	20,684	610,834
1994	151	103,885	142,260	53,700	118,015	72,512	36,059	14,889	8,706	10,447	560,624
1995	1,831	113,457	219,777	112,245	36,784	36,402	22,127	6,474	4,217	2,957	556,271

Table 19. Changes in the relative importance of key fishing grounds in the 4X purse seine fishery for 1985 to 1995.

		Logbook Recorded Catch t										
Fishery	Grounds	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
4Xa	Long Island	857	3,060	7,309	10,892	21,915	18,755	10,139	3,847	2,364	6,846	7,787
4Xa	Trinity	35,800	13,419	18,851	18,586	266	1,113	3,255	4,715	1,313	2,290	370
4Xa	Seal Island	13,745	8,894	11,560	18,947	23,420	25,321	13,153	16,077	3,613	2,854	465
4Xa	German Bank	15,502	13,346	16,434	17,692	8,087	11,744	24,548	3,733	4,057	9,747	19,508
4Xa	Scots Bay		36	3,649	3,949	6,583	8,925	8,750	8,554	4,352	10,722	2,063
4Xa	Grand Manan	3,584	2,984	2,217	301	968	877	3,428	3,400	521	4,752	1,913
4Xa	Gannet, Dry Ledge	5,675	2,187	1,474	14,901	2,010	4,163	6,190	27,696	2,737	2,332	2,693
4Xa	Yankee Bank				194	196	3,646	967	119		175	268
4Xa	Western Hole								3,592	2,172	1,453	108
4Xa	Liverpool							49		4,067	4,257	
4Xa	S.W. Grounds	558	1,839	184	181	223	56	565	290	2,949	5,168	6,162
4Xa	Lurcher	308			2,928	18	65	108	2,189	1,616	565	382
4Xa	Shelburne									515	161	
4Xa	N.B. Coastal		621	138	126	276	27	530	800		99	686
4Xa	Browns Bank											1,455
4Xa	Other or no area	7,294	5,240	6,443		440	214	166	352		488	4,794
	Total Log Catches	83,323	51,626	68,259	88,503	64,206	74,907	71,922	75,364	30,565	51,908	48,654
	Total Stats Catch	87,167	56,139	77,706	98,370	68,089	77,545	73,619	80,807	81,478	68,536	48,481
	Percent Log/Stats	96	92	88	90	94	97	98	93	38	76	100
		Percentage of Recorded Logbook Catches										
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
4Xa	Long Island	1	6	11	12	34	25	14	5	8	13	16
4Xa	Trinity	43	26	28	21	0	1	5	6	4	4	1
4Xa	Seal Island	16	17	17	21	36	34	18	21	12	5	1
4Xa	German Bank	19	26	24	20	13	16	34	5	13	19	40
4Xa	Scots Bay	0	0	5	4	10	12	12	11	14	21	4
4Xa	Grand Manan	4	6	3	0	2	1	5	5	2	9	4
4Xa	Gannet, Dry Ledge	7	4	2	17	3	6	9	37	9	4	6
4Xa	Yankee Bank	0	0	0	0	0	5	1	0	0	0	1
4Xa	Western Hole	0	0	0	0	0	0	0	5	7	3	0
4Xa	Liverpool	0	0	0	0	0	0	0	0	13	8	0
4Xa	S.W. Grounds	1	4	0	0	0	0	1	0	10	10	13
4Xa	Lurcher	0	0	0	3	0	0	0	3	5	1	1
4Xa	Shelburne	0	0	0	0	0	0	0	0	2	0	0
4Xa	N.B. Coastal	0	0	0	0	0	0	0	0	0	0	3
4Xa	Other or no area	9	10	9	0	1	0	0	0	0	1	10
	Total	100	99	100	100	100	100	99	99	99	100	99

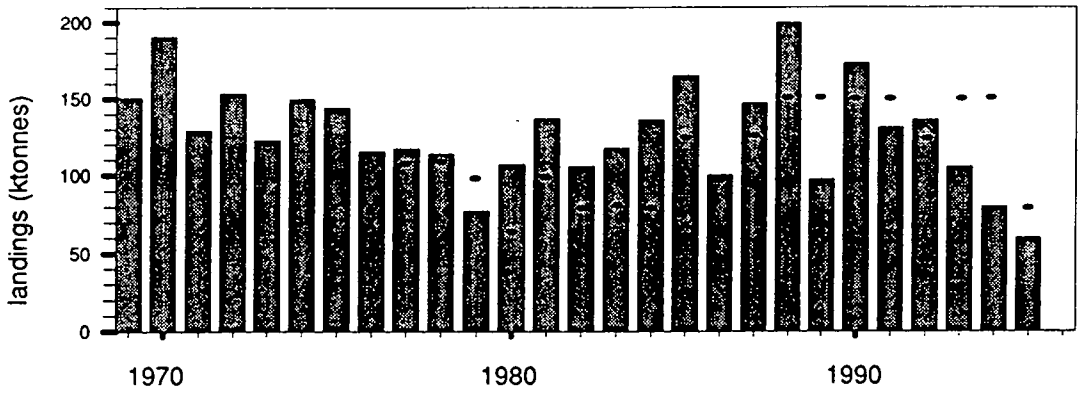


Fig. 1. Historical landings (bar) and TAC (dots) from the stock portion of the 4WX herring fishery; 1969 to 1996.

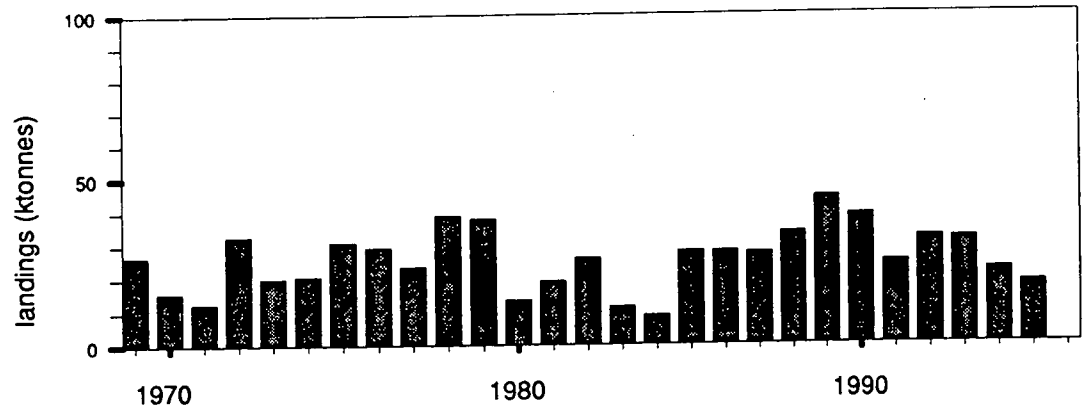


Fig. 2. Historical landings from the non-stock New Brunswick weir and shutoff herring fisheries; 1969 to 1996.

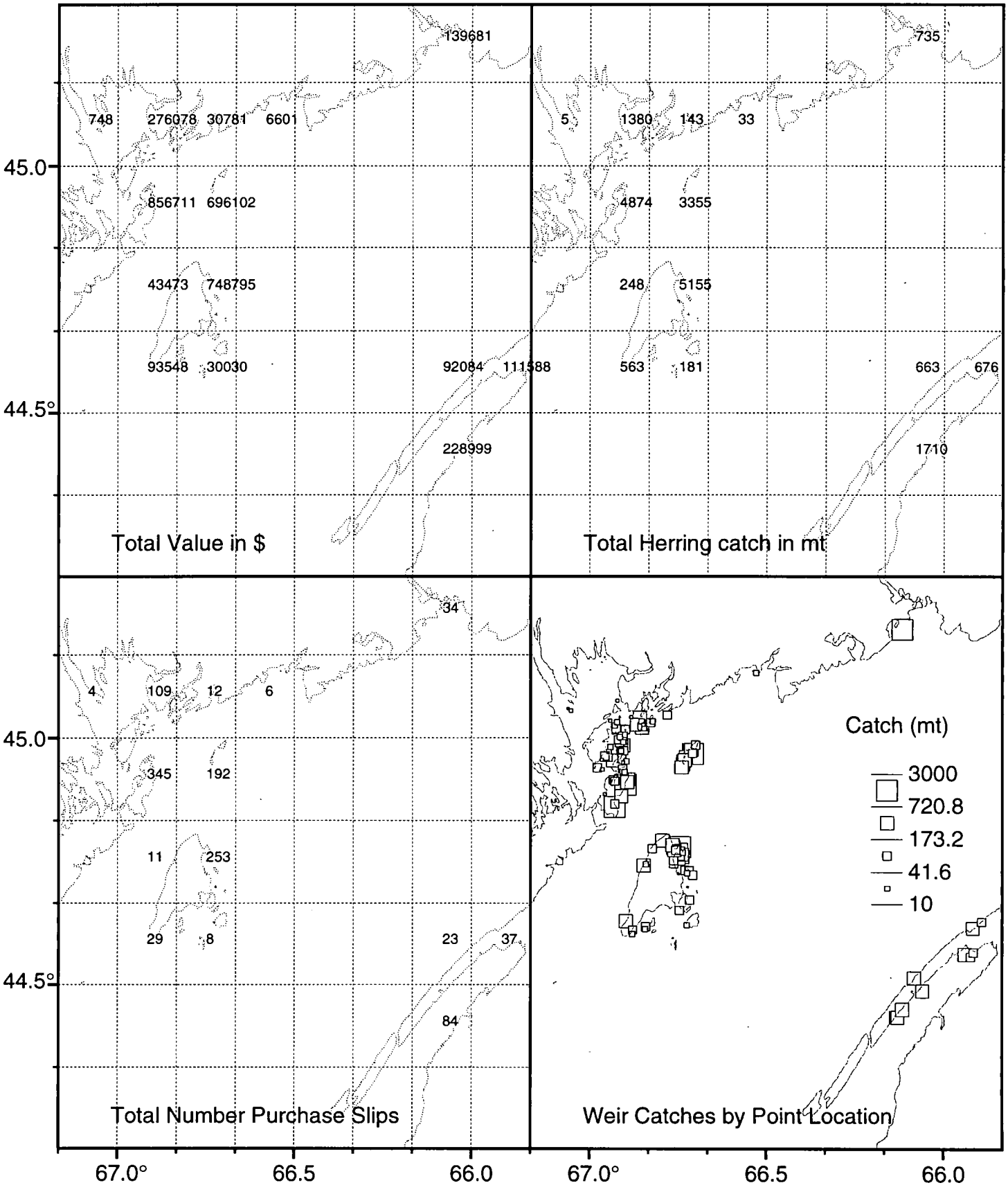


Fig. 3. Distribution of 4X weir catches for the 1995 herring fishery.

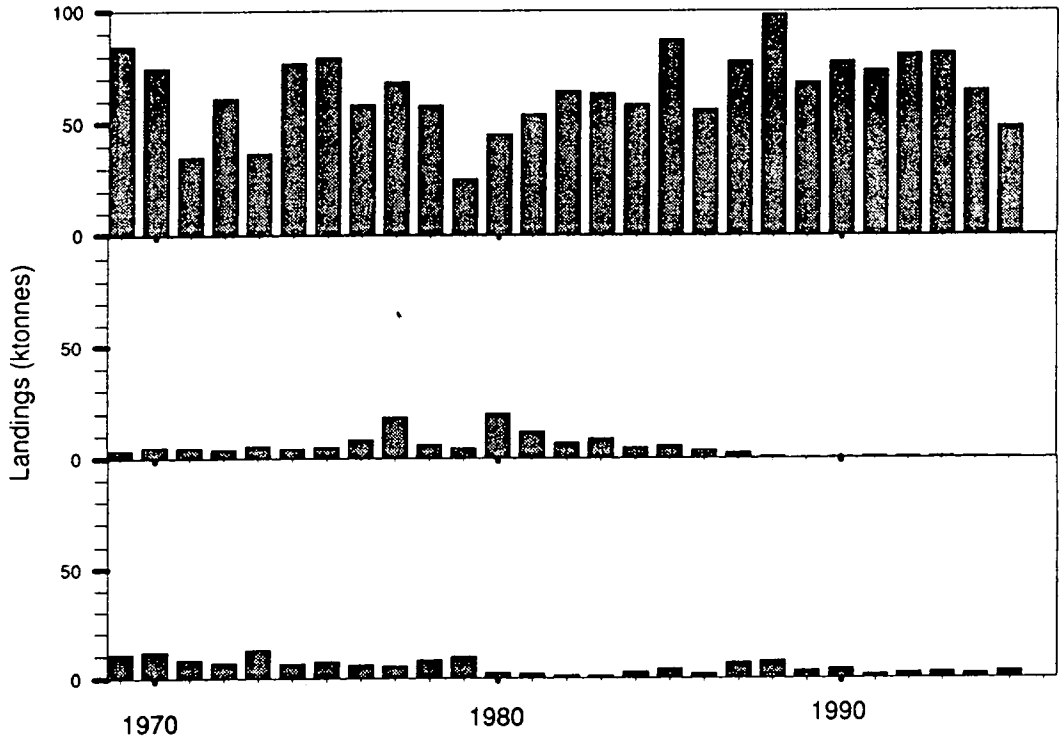


Fig. 4. Landings from the purse seine (top), gillnet (middle) and weir (lower) gear segments of the 4X summer herring fishery; 1969 to 1996.

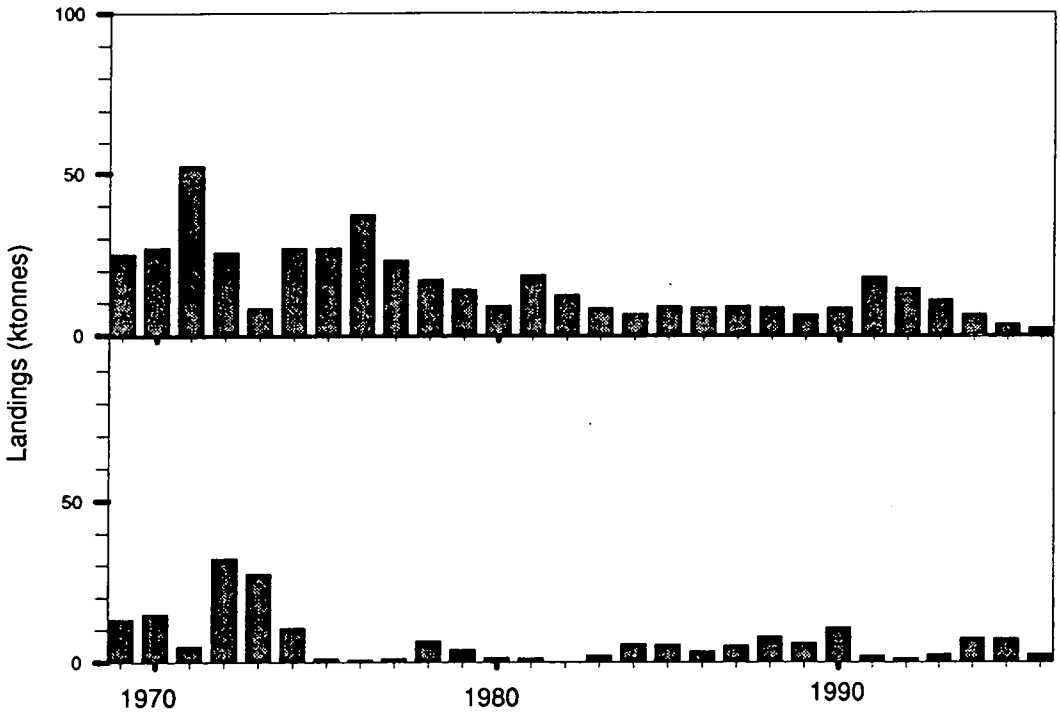


Fig. 5. Landings from the 4W winter (top) and 4Xs fall/winter (lower) purse seine herring fisheries; 1969 to 1996.

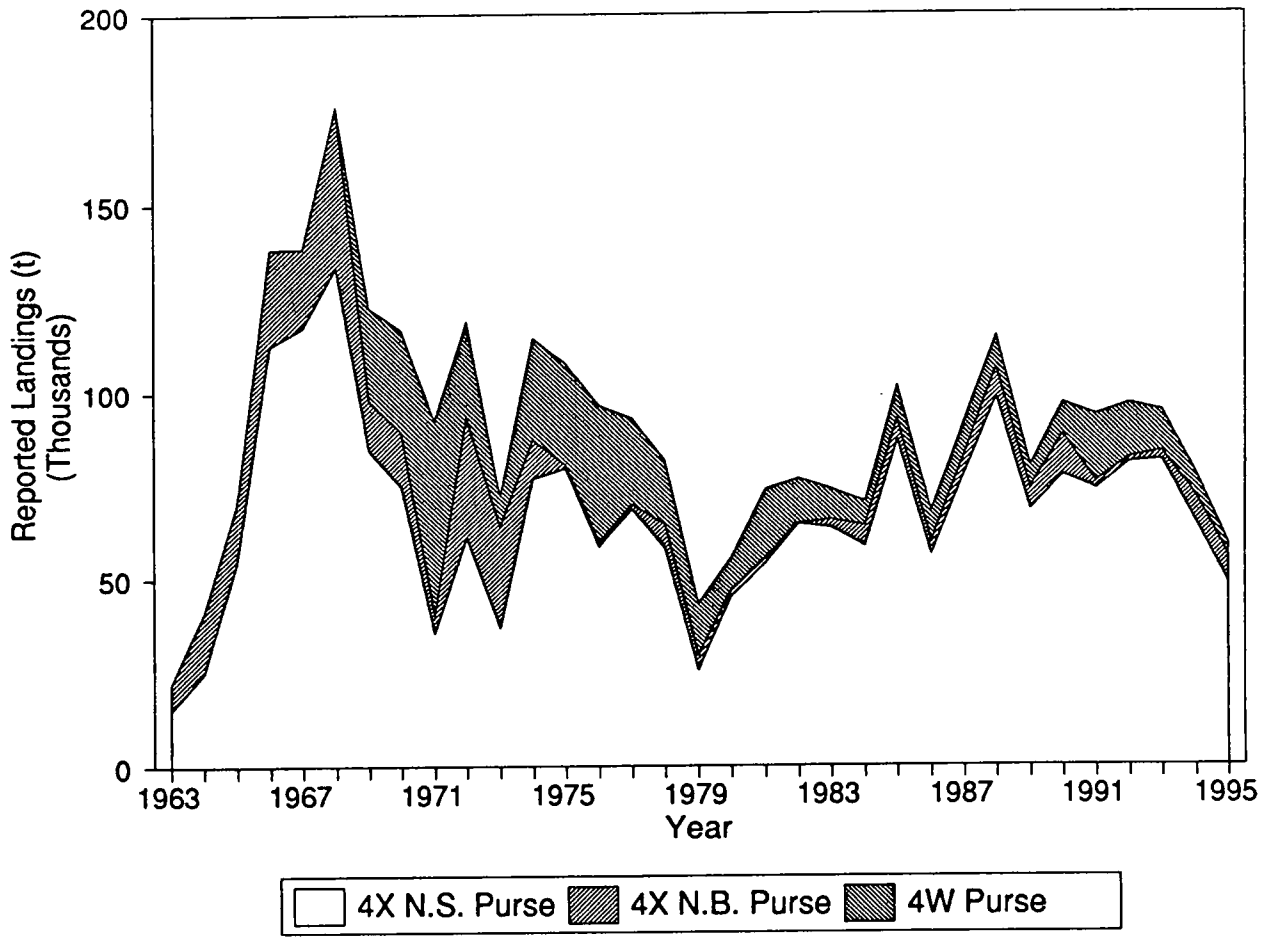


Fig. 6. Annual reported landings by area from the 4WX herring purse seine fisheries; 1963 to 1995.

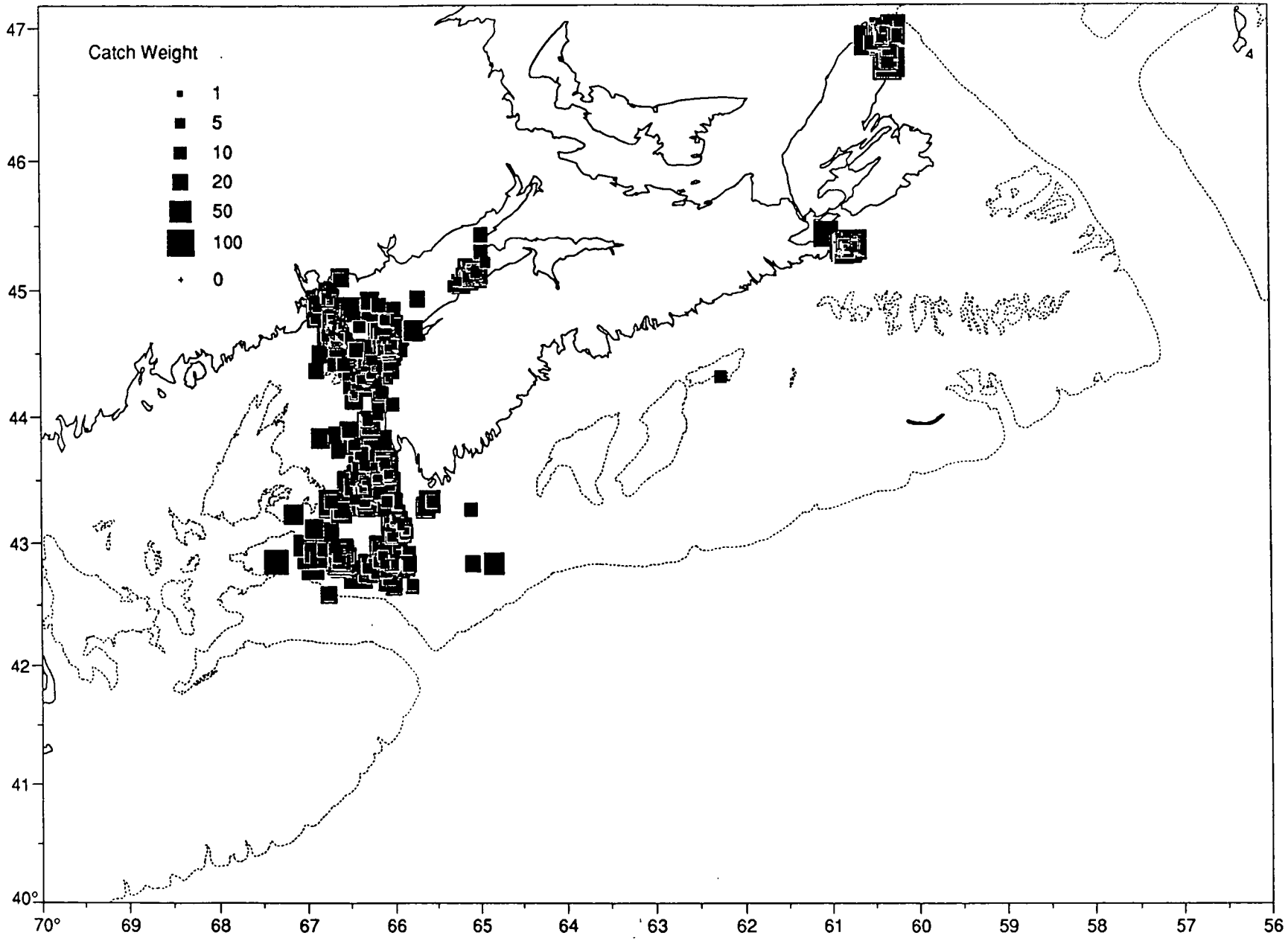


Fig. 7. Location of purse seine catches in the 1995 4WX herring fishery (source: DFO, Scotia-Fundy Region, Statistics Division.)

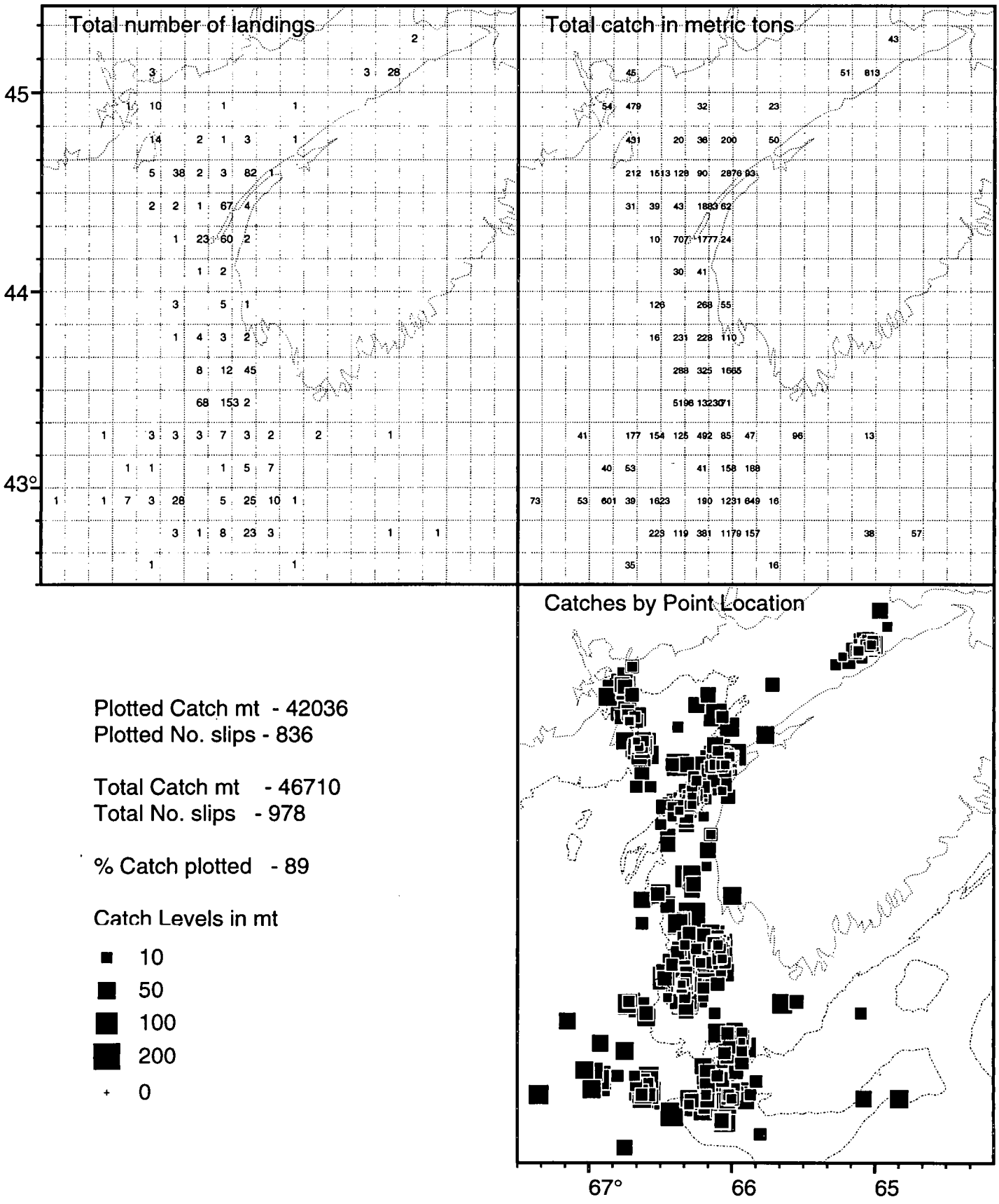


Fig. 8. Landings from the summer portion of the 1995 4X purse seine fishery.

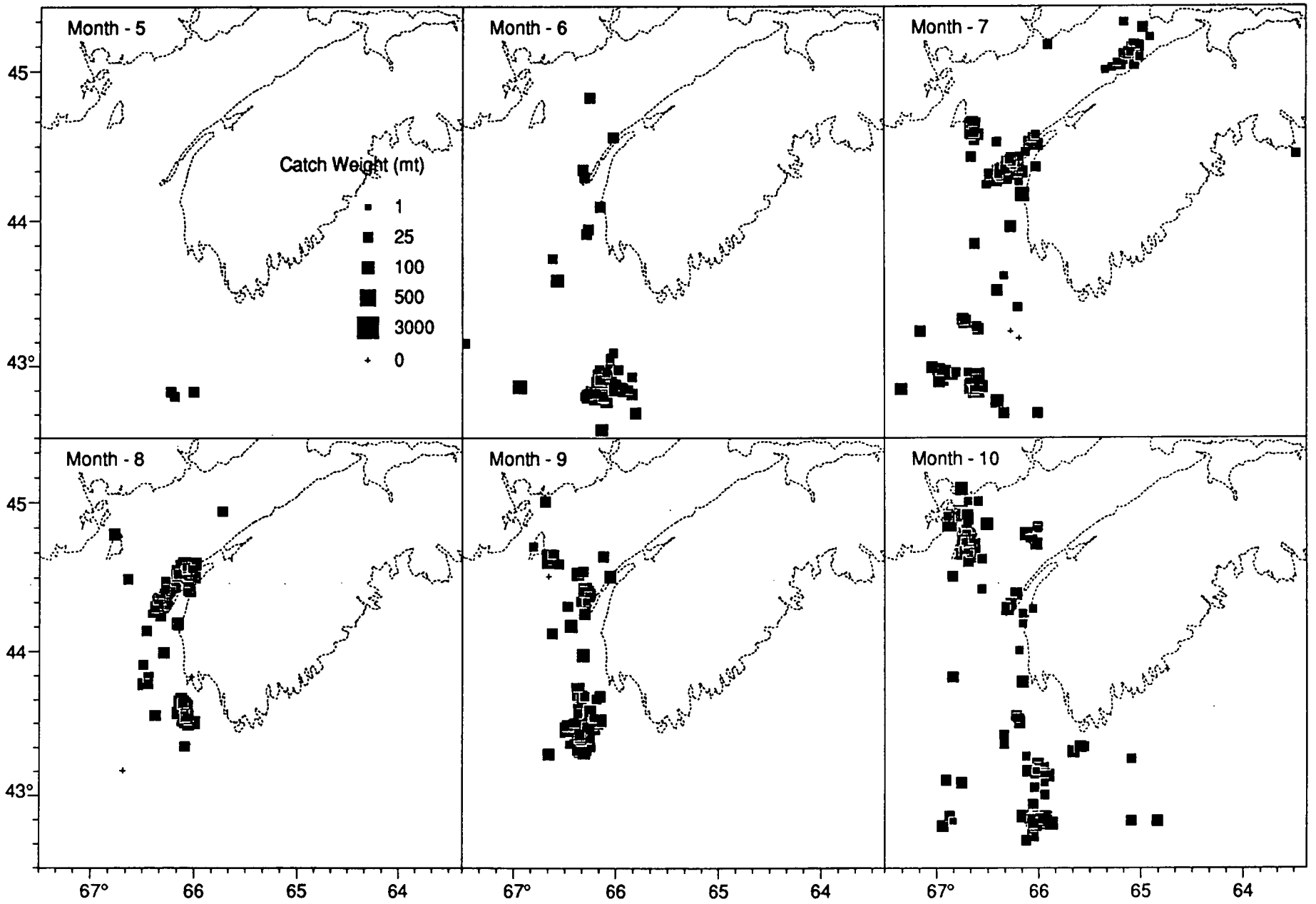


Fig. 9a. Monthly distribution of catches from the summer portion of the 1995 4X purse seine fishery.

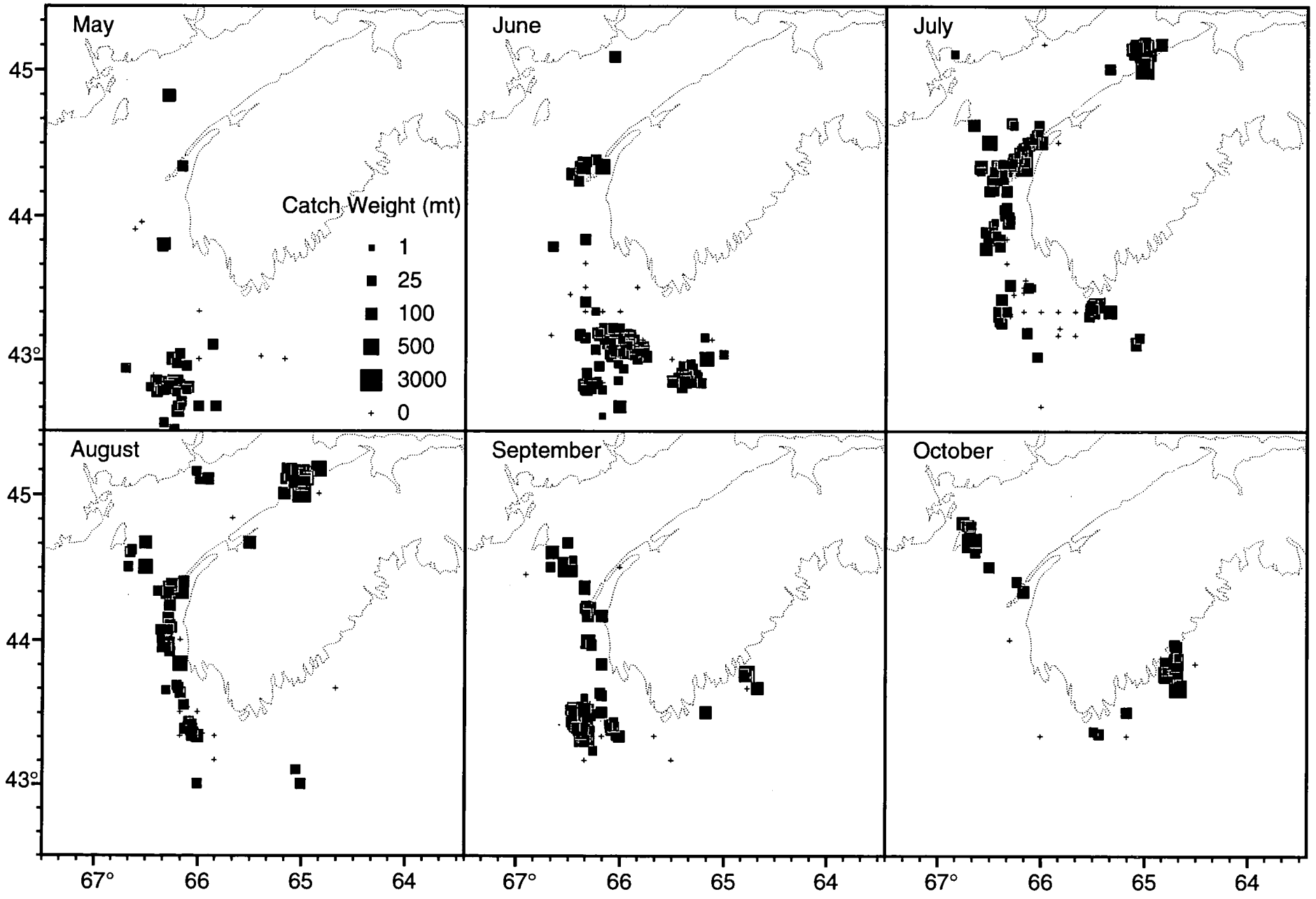


Fig. 9b. Monthly distribution of catches from the summer portion of the 1994 4X purse seine fishery.

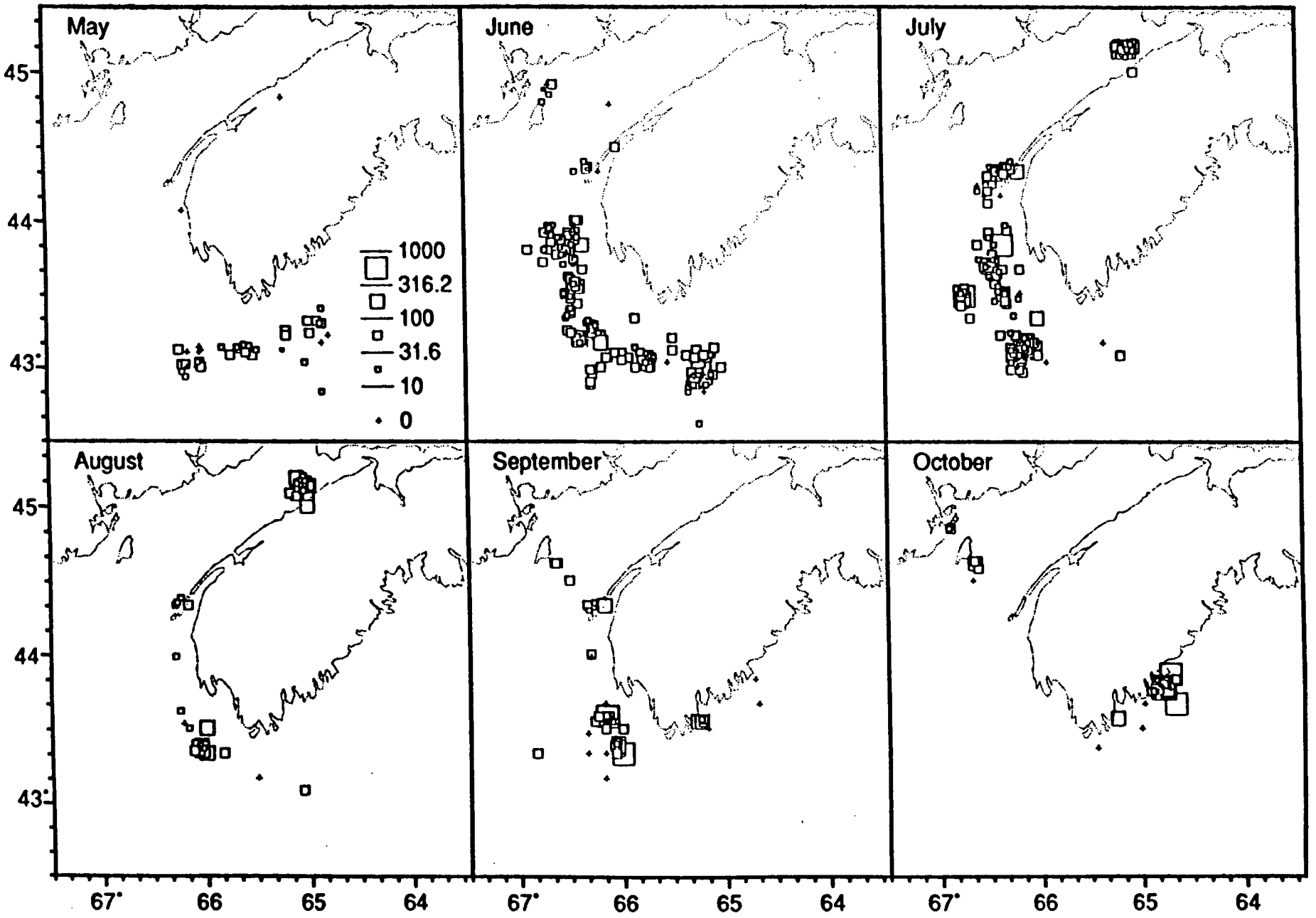


Fig. 9c. Monthly distribution of catches from the summer portion of the 1993 4X purse seine fishery.

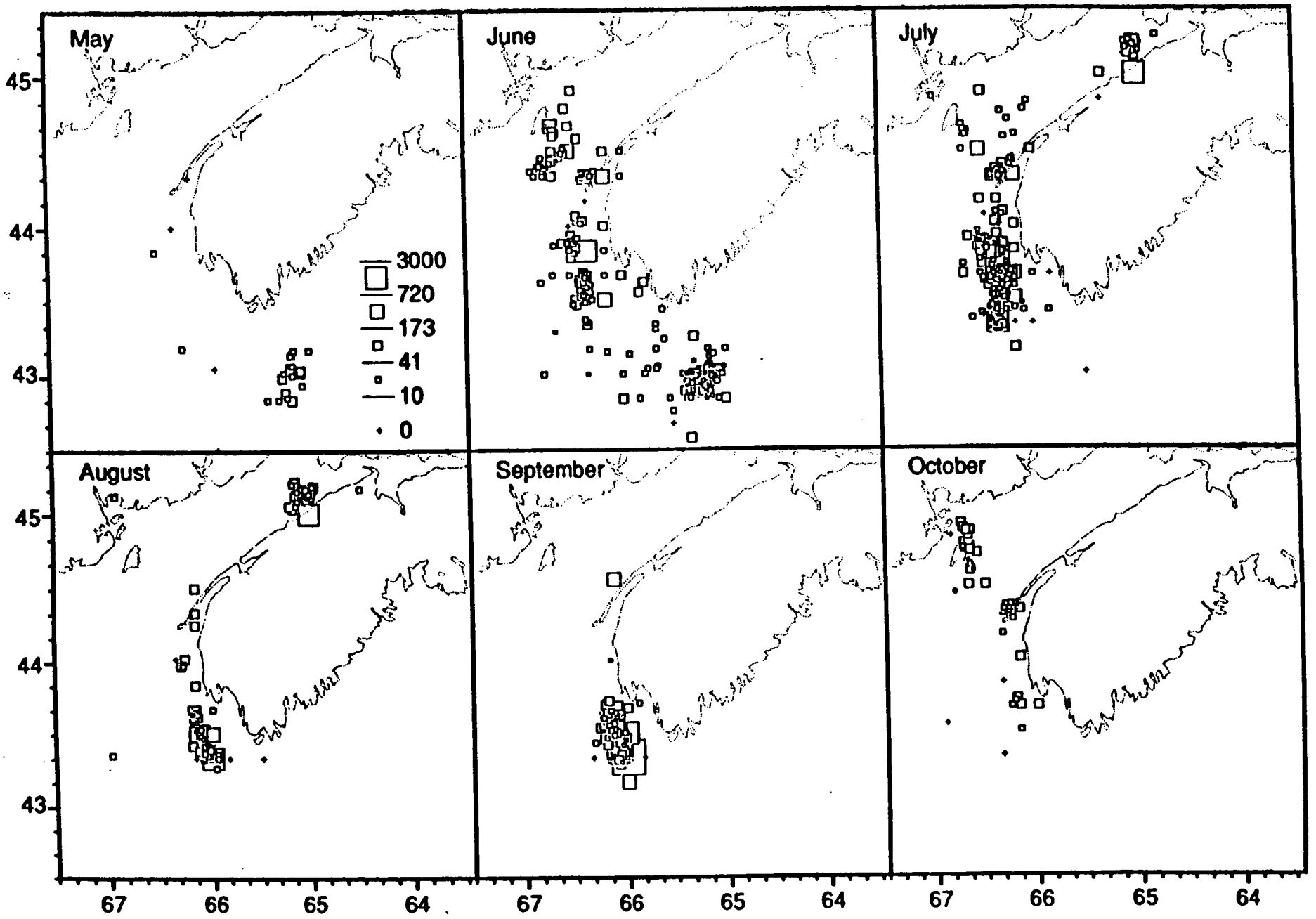


Fig. 9d. Monthly distribution of catches from the summer portion of the 1992 4X purse seine fishery.

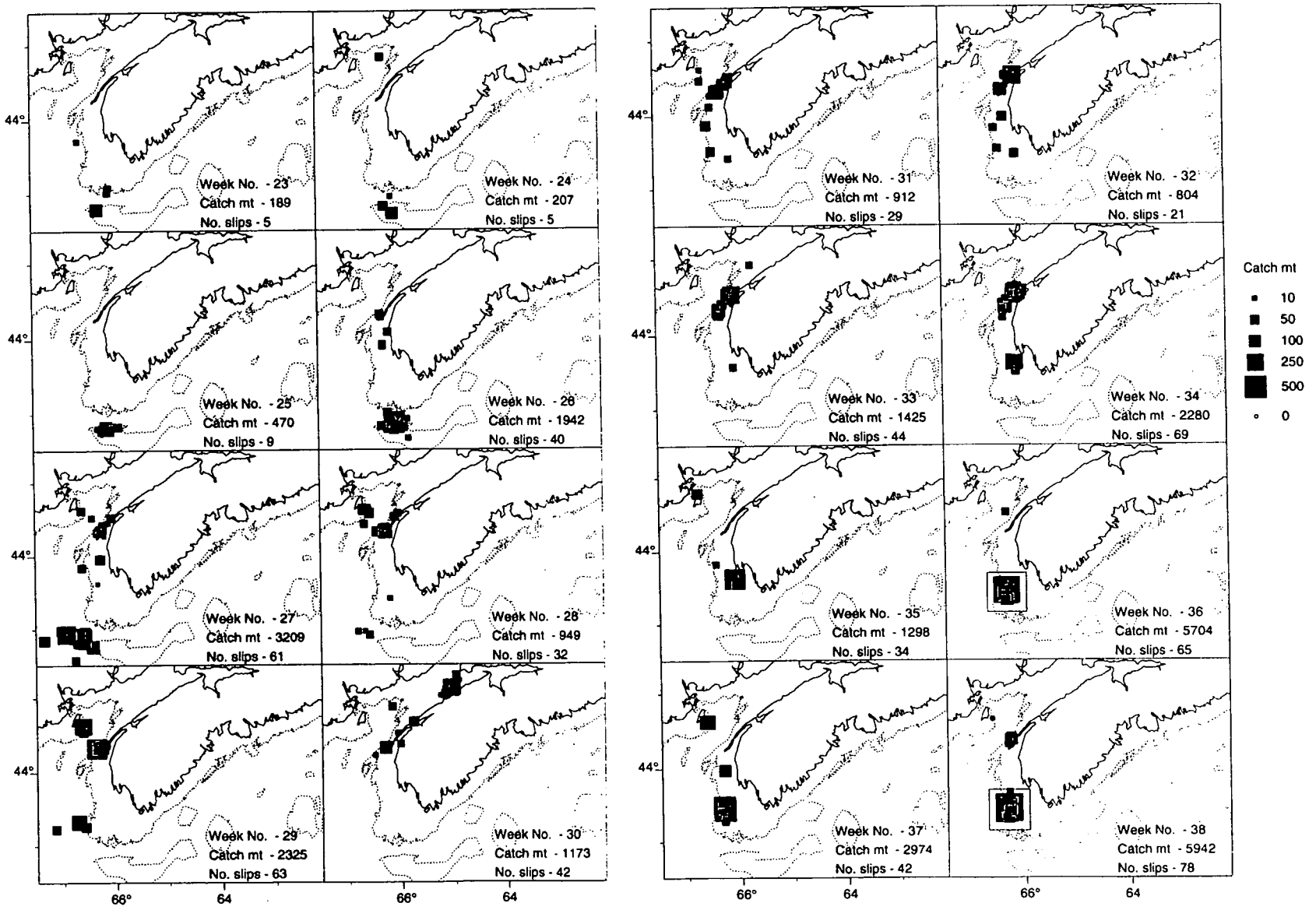


Fig. 10. Weekly distribution of catches from the summer portion of the 1995 4X purse seine fishery.

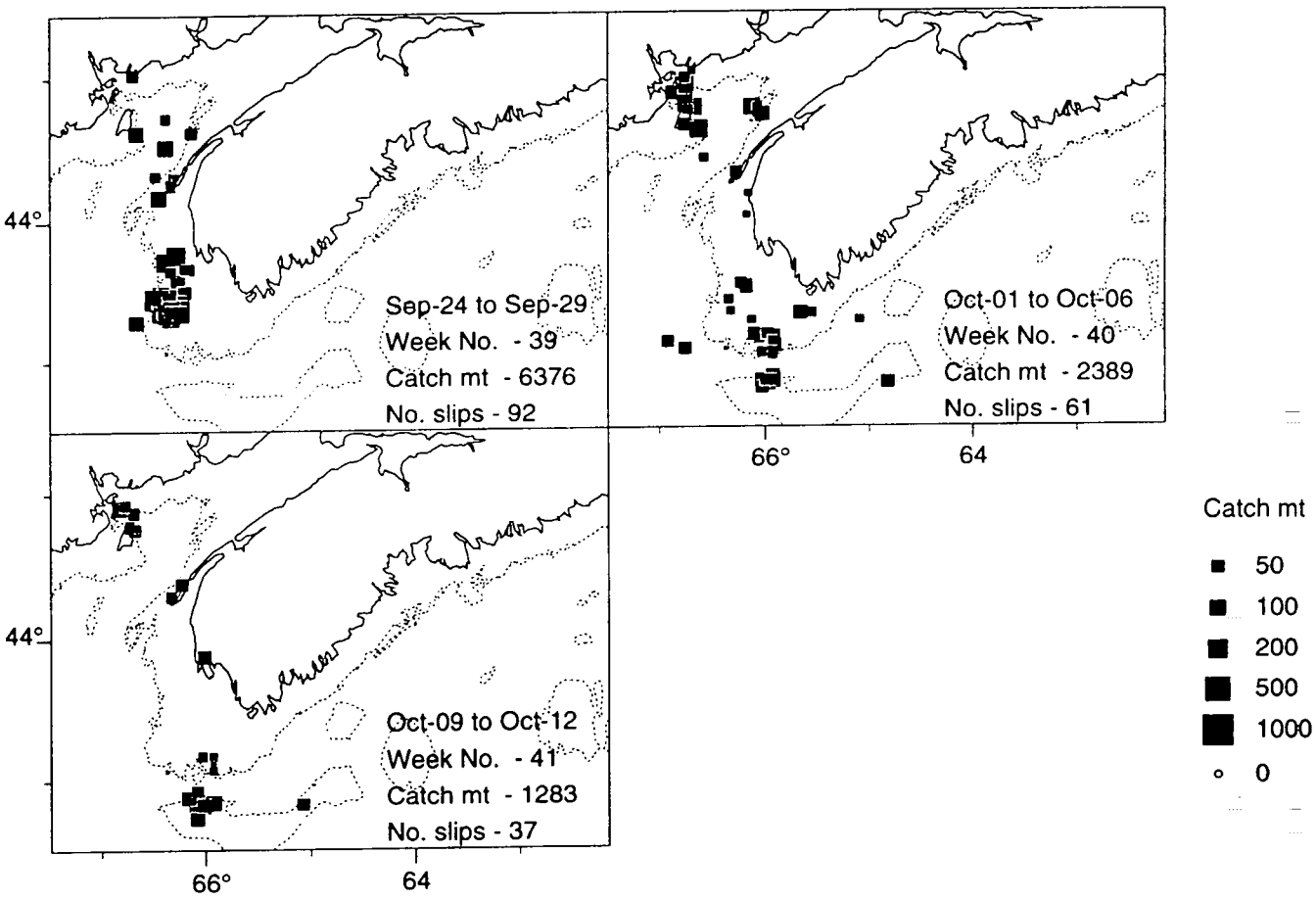

44°
Sep-24 to Sep-29
Week No. - 39
Catch mt - 6376
No. slips - 92
Oct-01 to Oct-06
Week No. - 40
Catch mt - 2389
No. slips - 61
66°
64
44°
Oct-09 to Oct-12
Week No. - 41
Catch mt - 1283
No. slips - 37
66°
64
Catch mt
50
100
200
500
1000
0

Fig. 10. Cont'd . . .

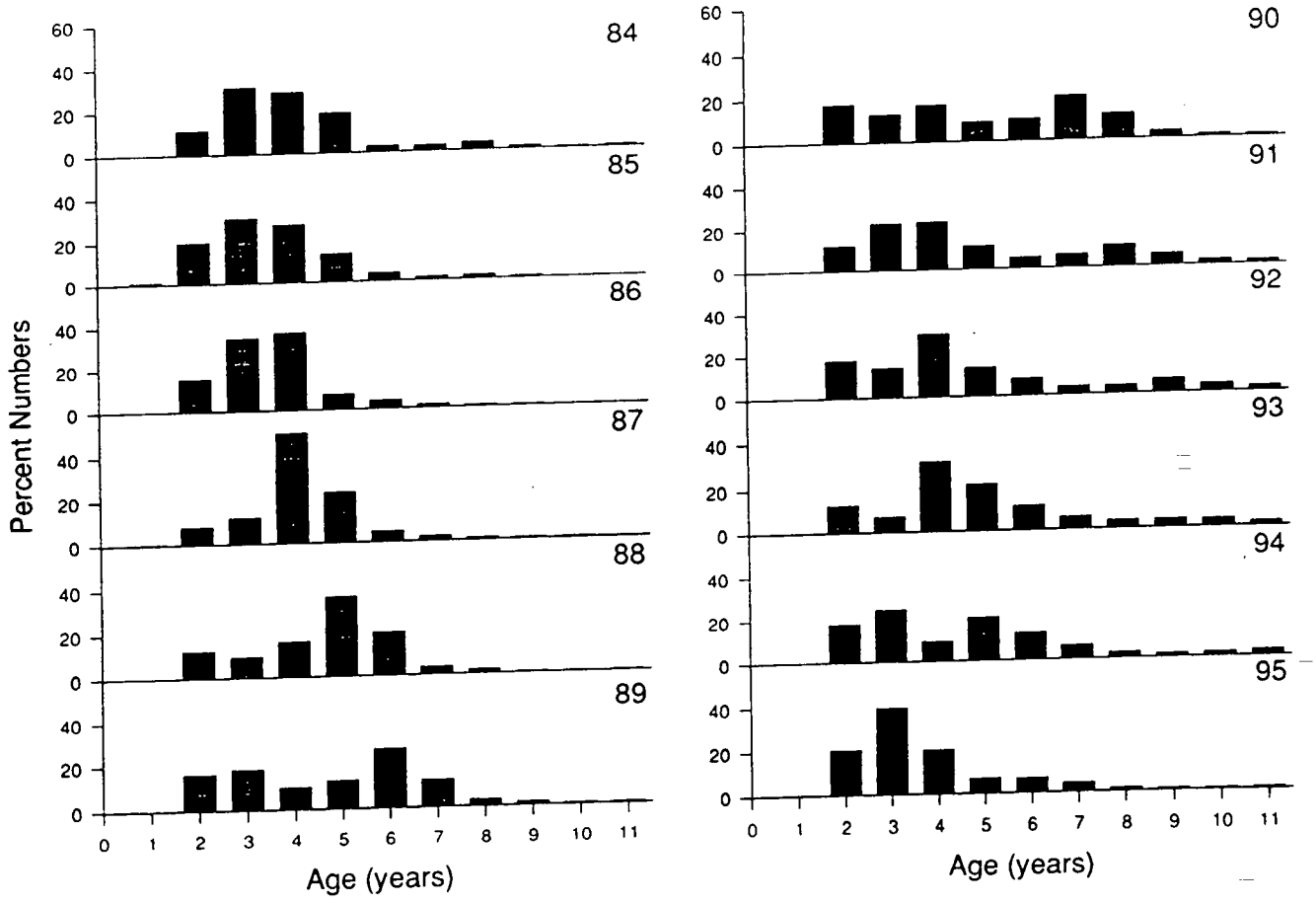


Fig. 11. Proportion (%) catch numbers at age in the 4WX herring fishery; 1984 to 1995;

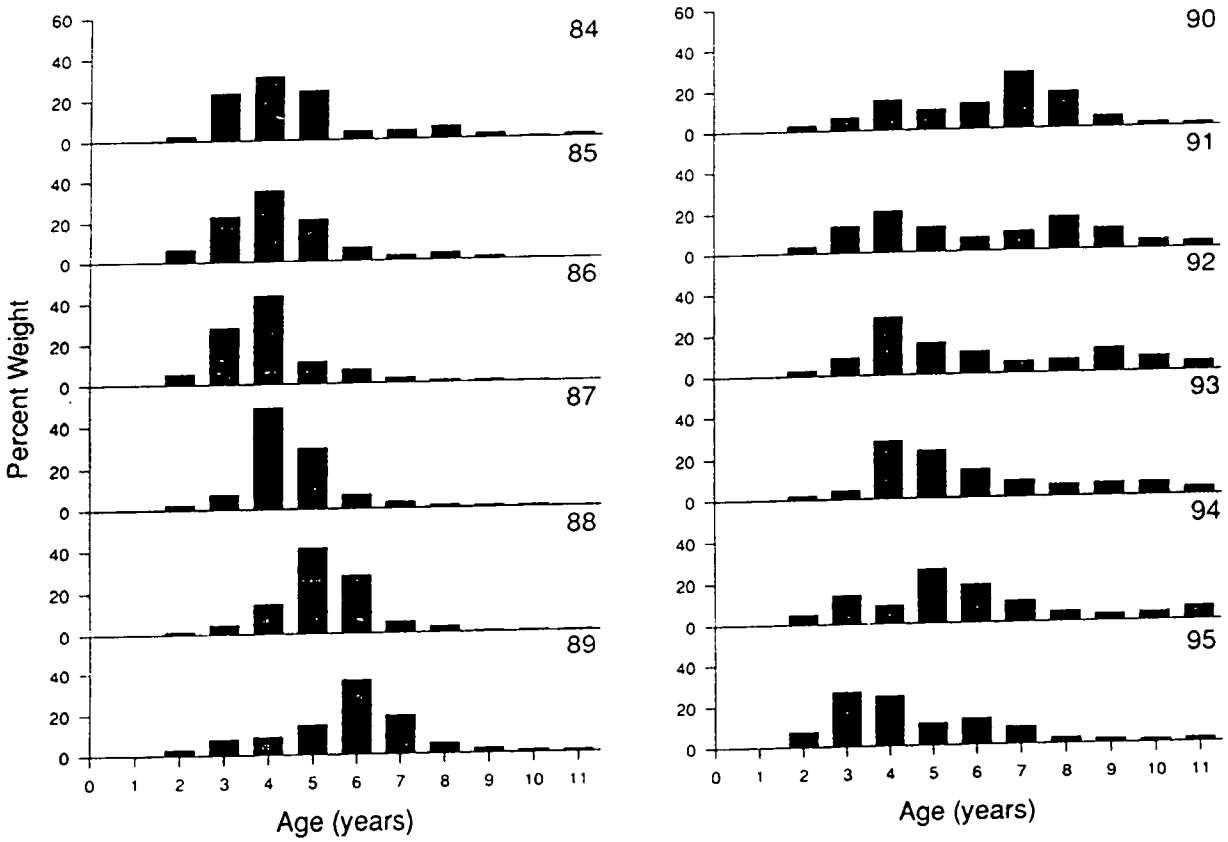


Fig. 12. Proportion (%) catch weight at age in the 4WX herring fishery; 1984 to 1995;

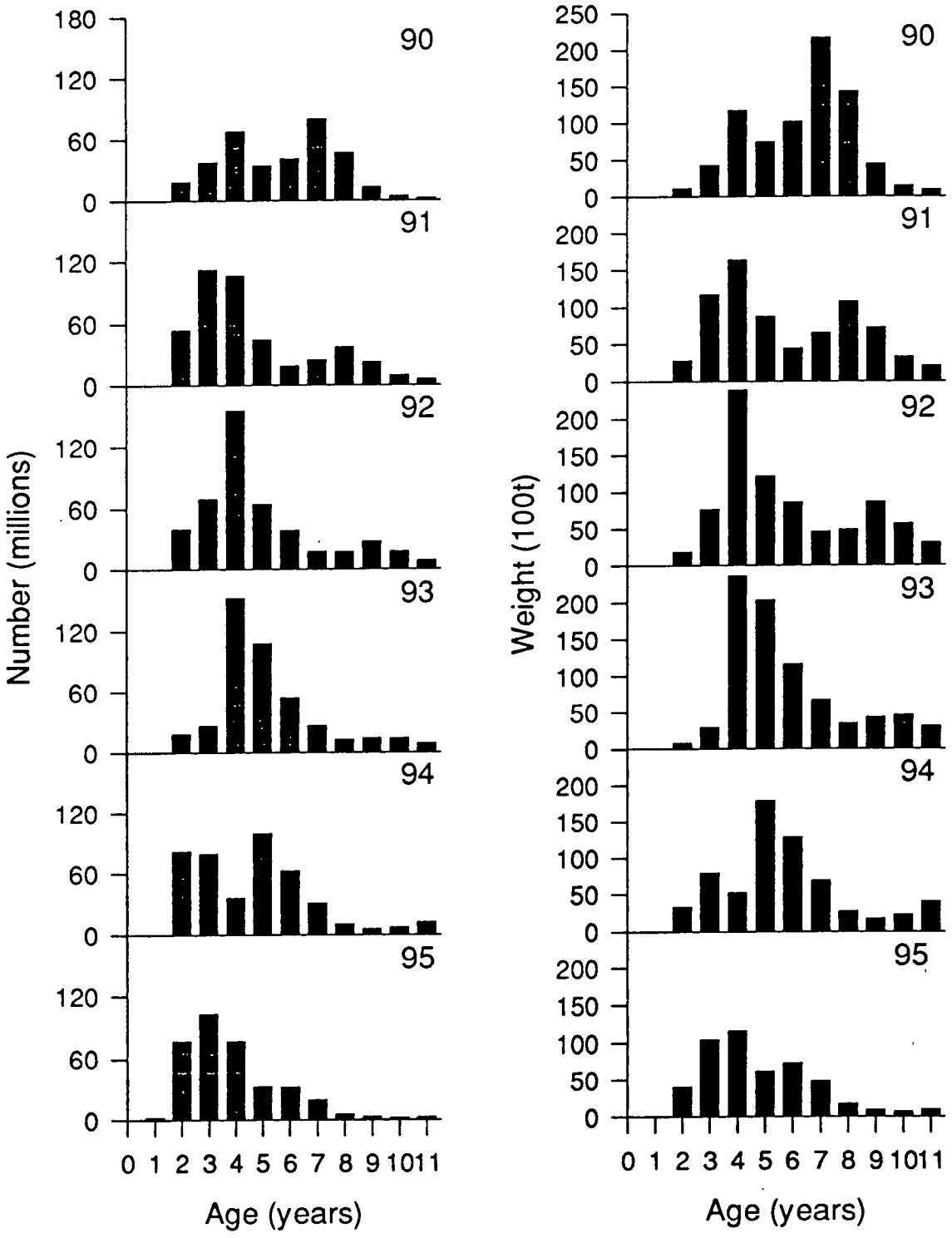


Fig. 13a. 4WX herring numbers in millions (left) and weight in 100's of tonnes (right) at age for the Nova Scotia summer purse seine fishery; 1990 to 1995.

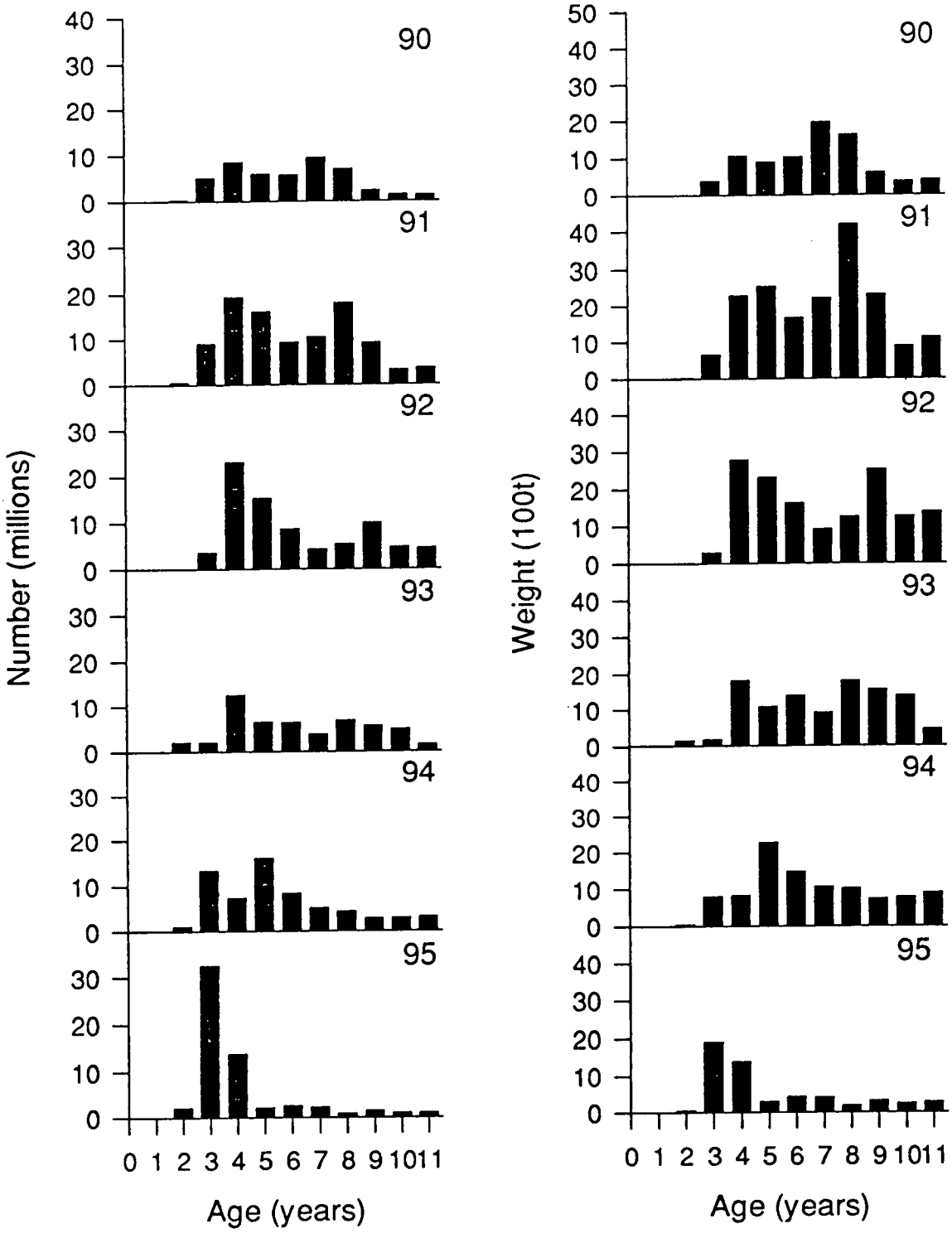


Fig. 13b. 4WX herring numbers in millions (left) and weight in 100's of tonnes (right) at age for the 4W Chedabucto Bay winter purse seine fishery; 1990 to 1995.

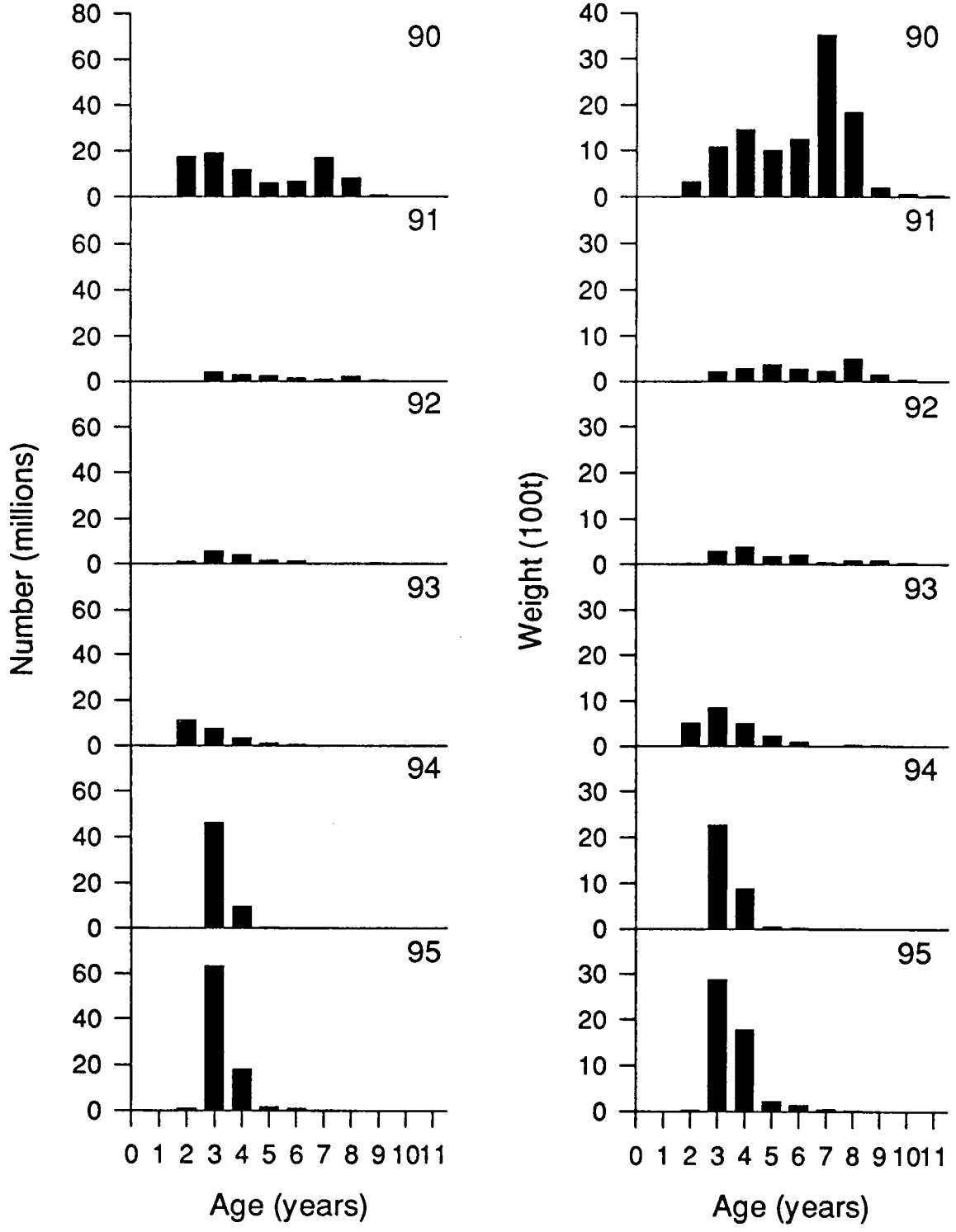


Fig. 13c. 4WX herring numbers in millions (left) and weight in 100's of tonnes (right) at age for the New Brunswick purse seine fishery; 1990 to 1995.

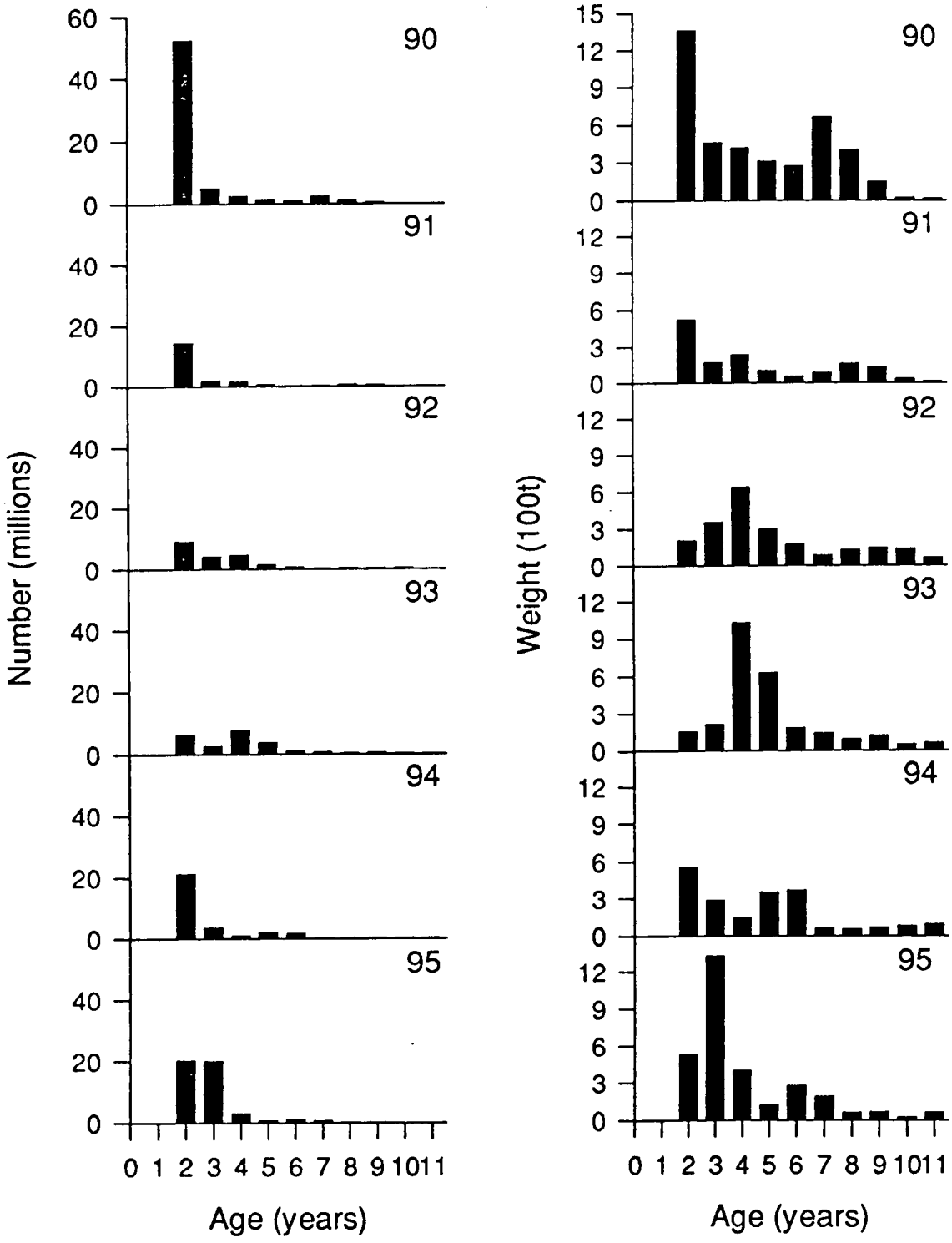


Fig. 13d. 4WX herring numbers in millions (left) and weight in 100's of tonnes (right) at age for the Nova Scotia weir fishery; 1990 to 1995.

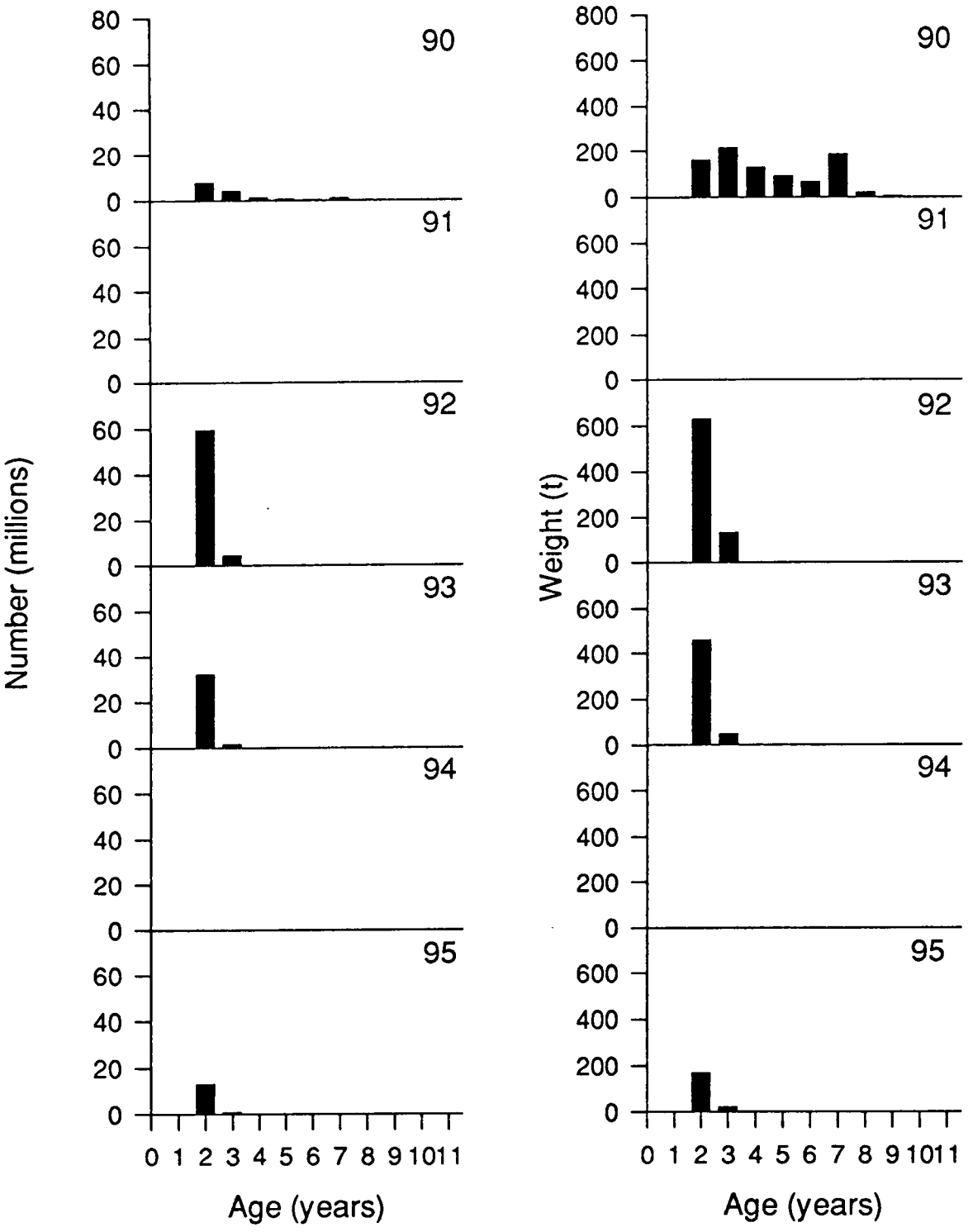


Fig. 13e. 4WX herring numbers in millions (left) and weight in 100's of tonnes (right) at age for midwater trawls; 1990 to 1995.

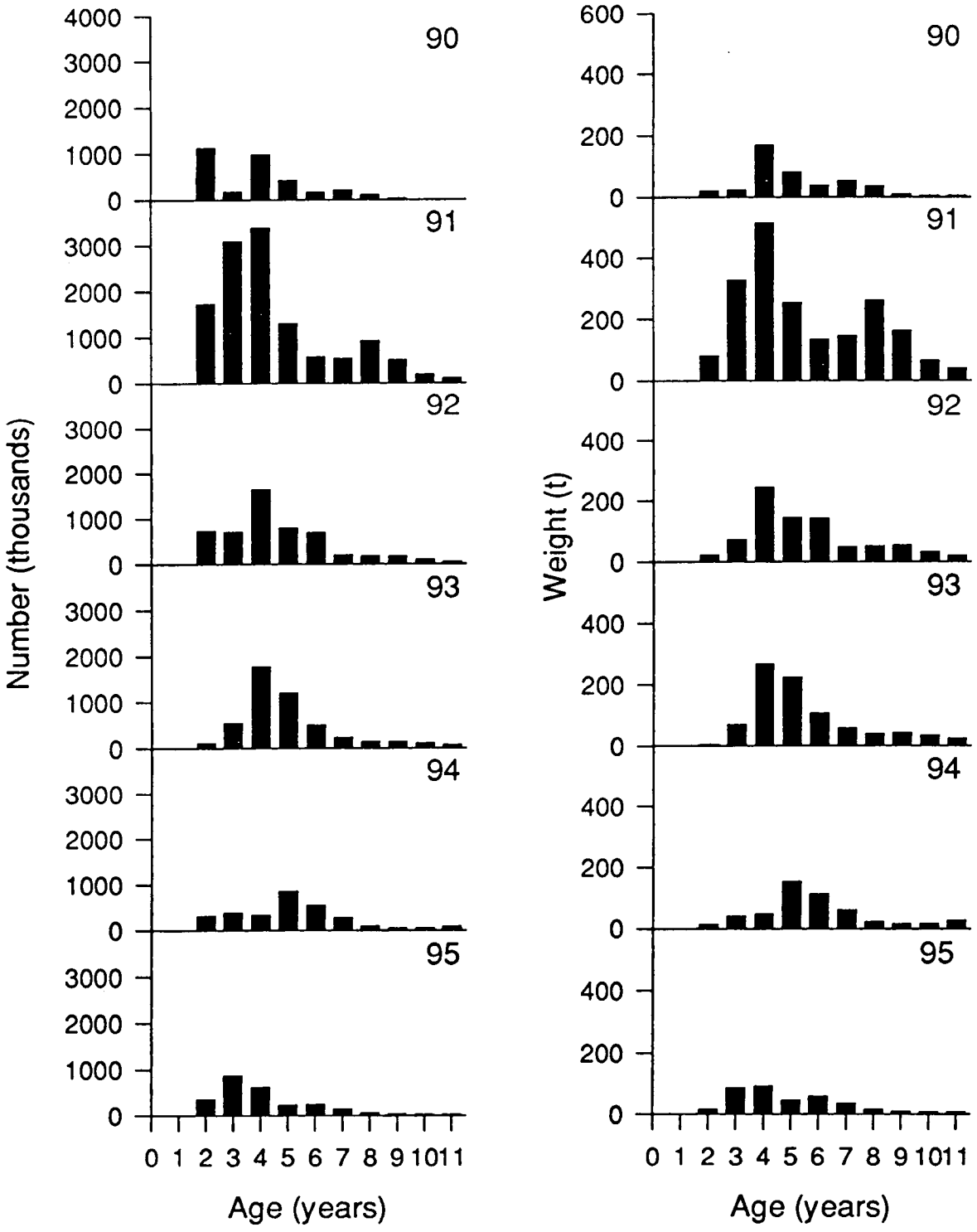
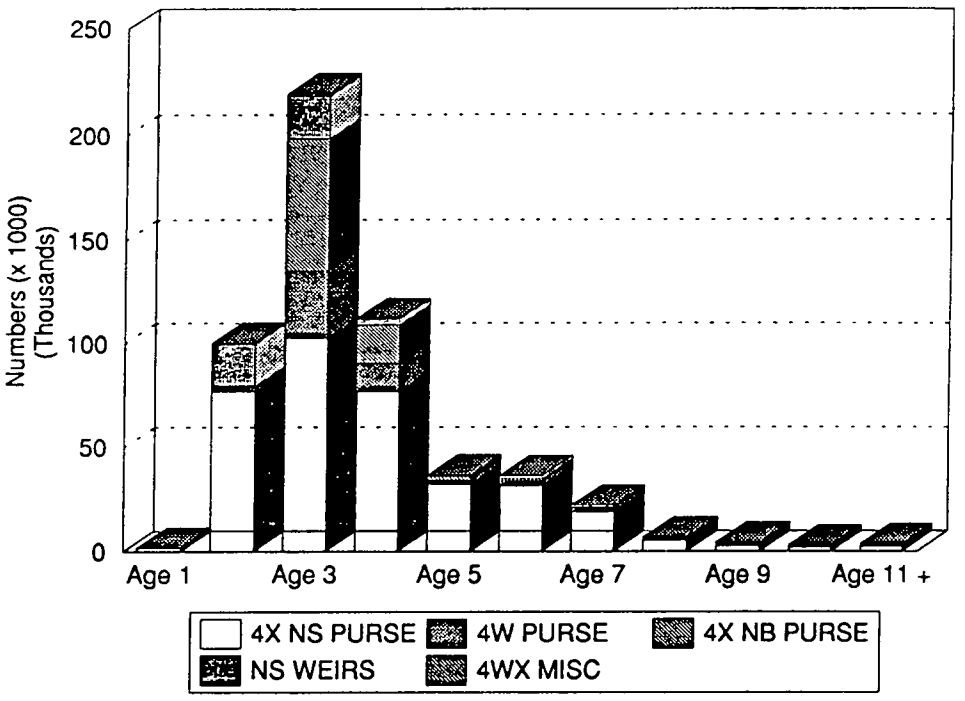


Fig. 13f. 4WX herring numbers in millions (left) and weight in 100's of tonnes (right) at age for gillnets and traps; 1990 to 1995.



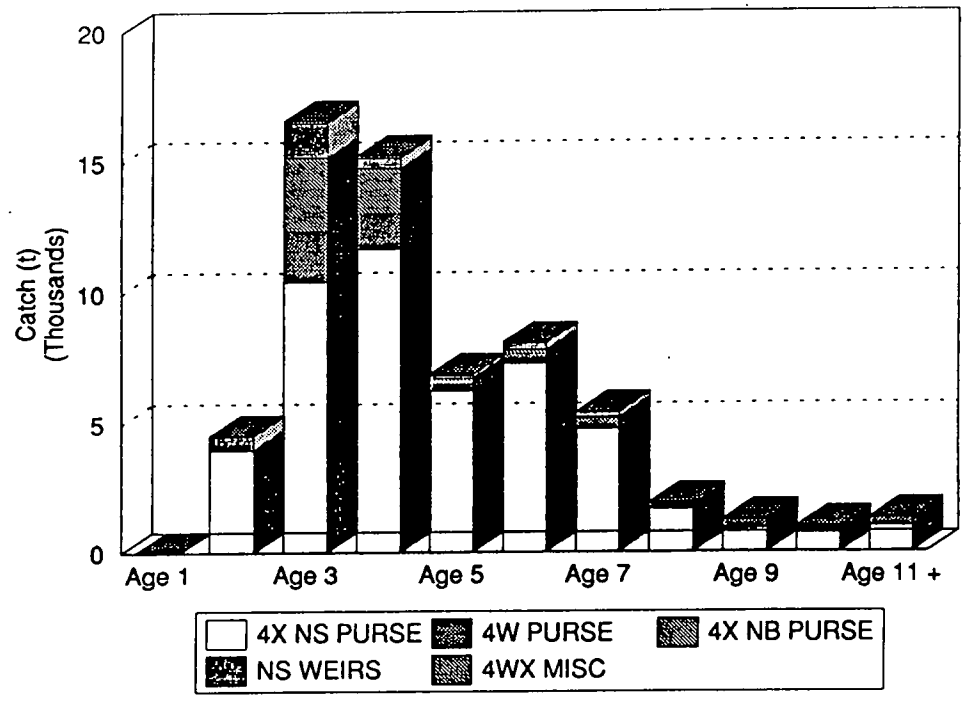


Fig. 14. Number (upper) and weight (lower) at age by geartype in the 1995 4WX herring fishery.

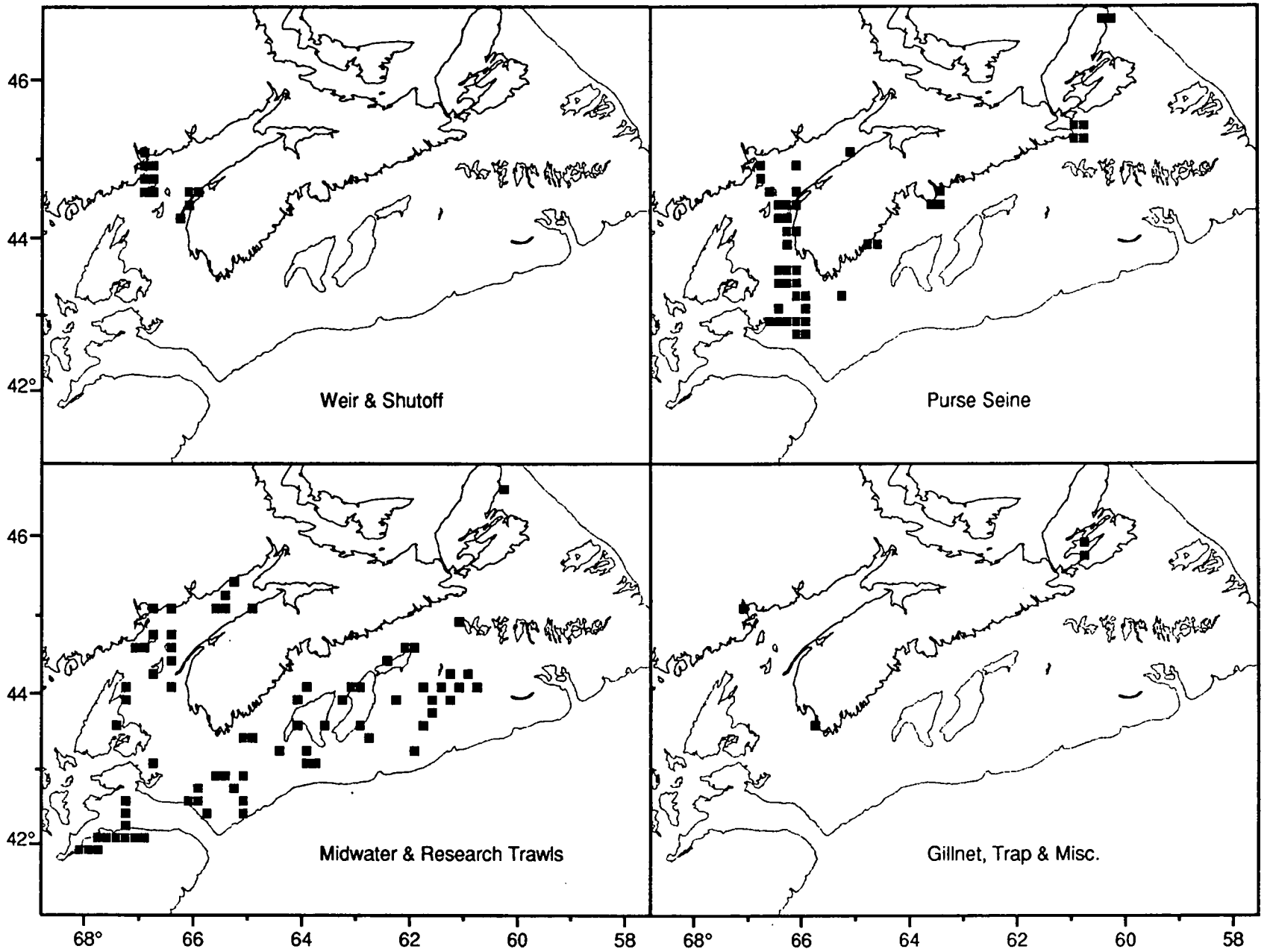


Fig. 15. Sampling coverage by 10 mile square for major geartypes in the 1995 4WX and 5Z herring fisheries.

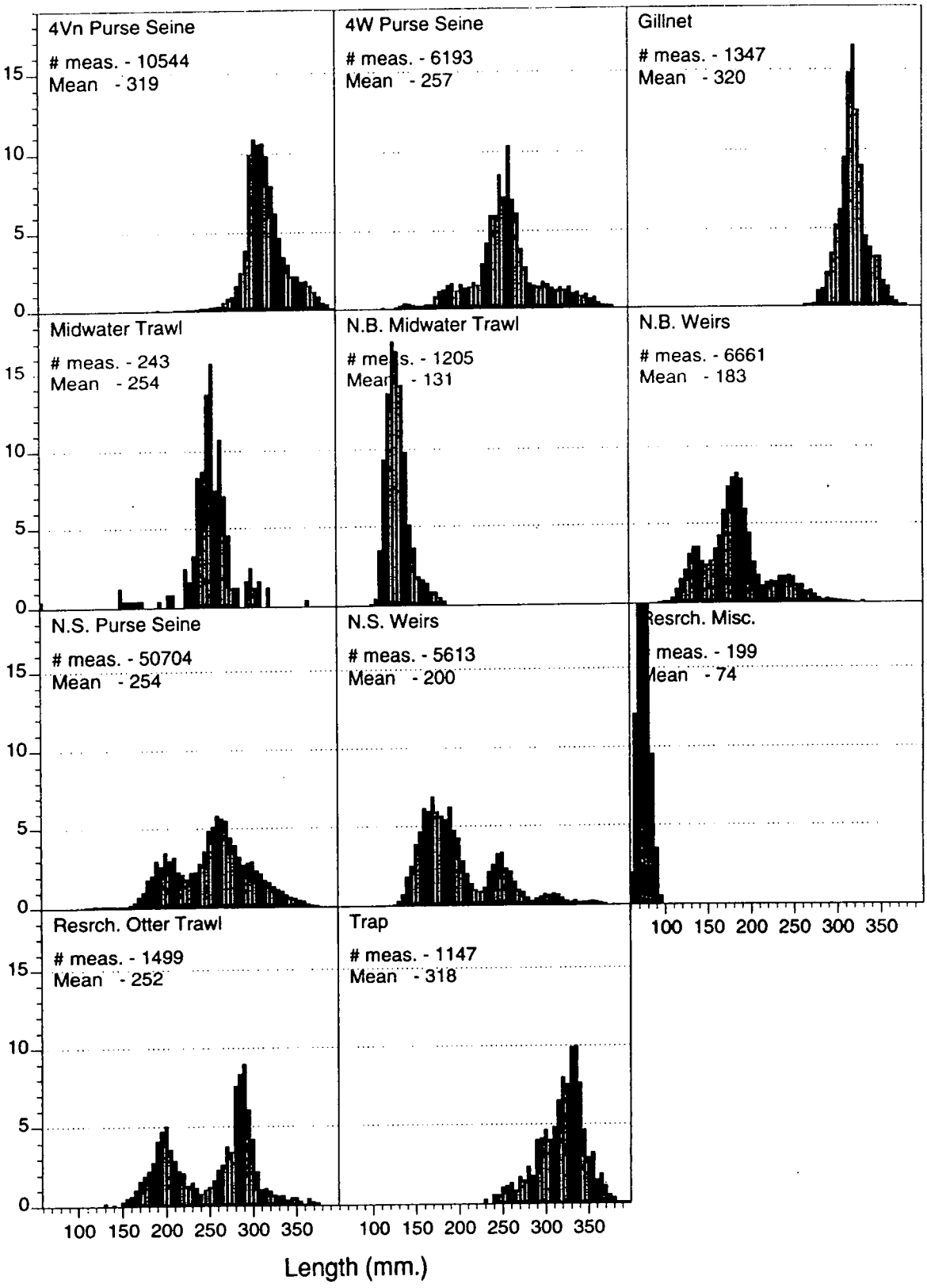


Fig. 16. Length frequencies (unweighted) of herring samples by geartype and area for 1995 in area 4VWX.

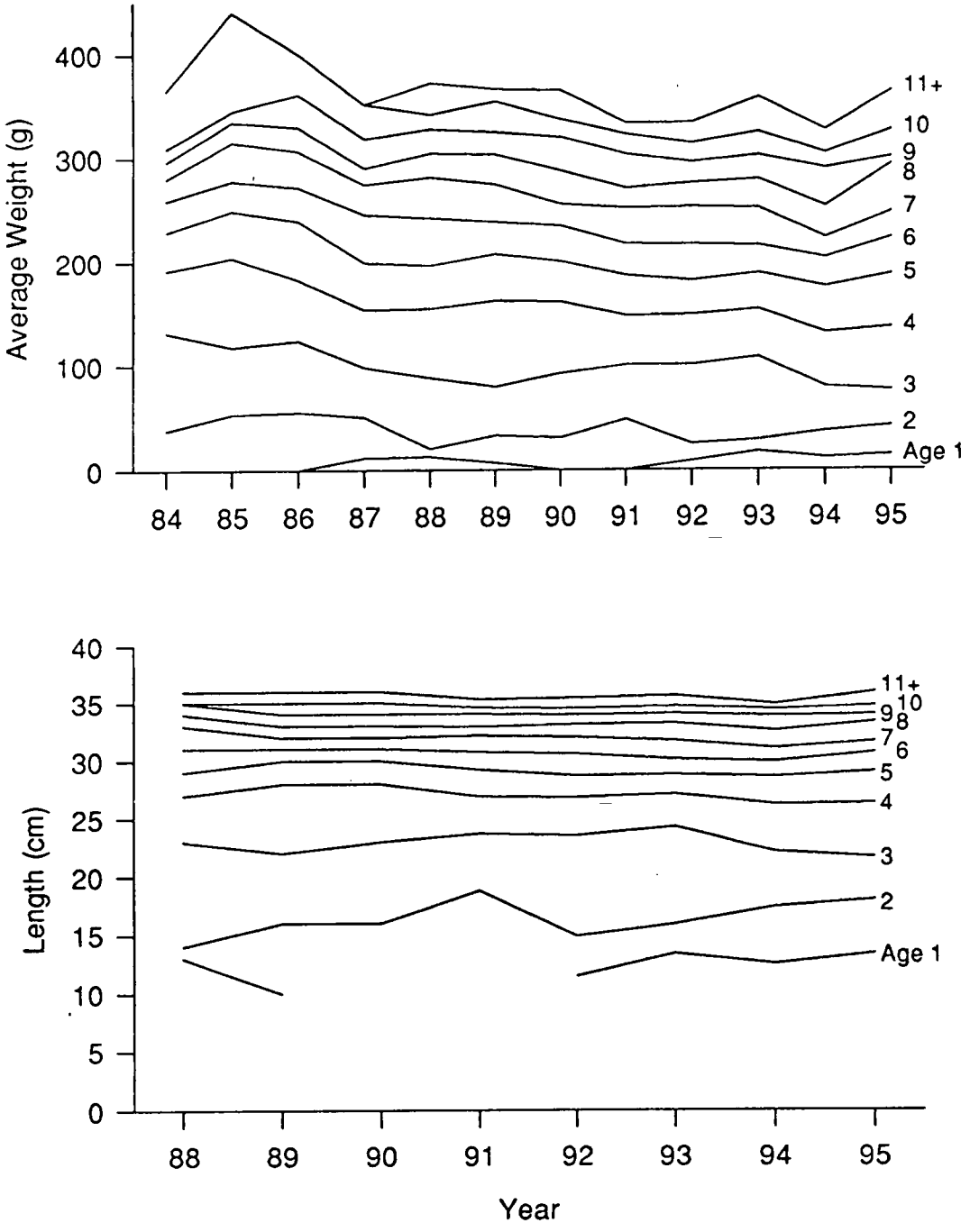


Fig. 17. Average weight at age (top) and average length at age (bottom) by year for the 4WX herring fishery (weighting by stock gear components).

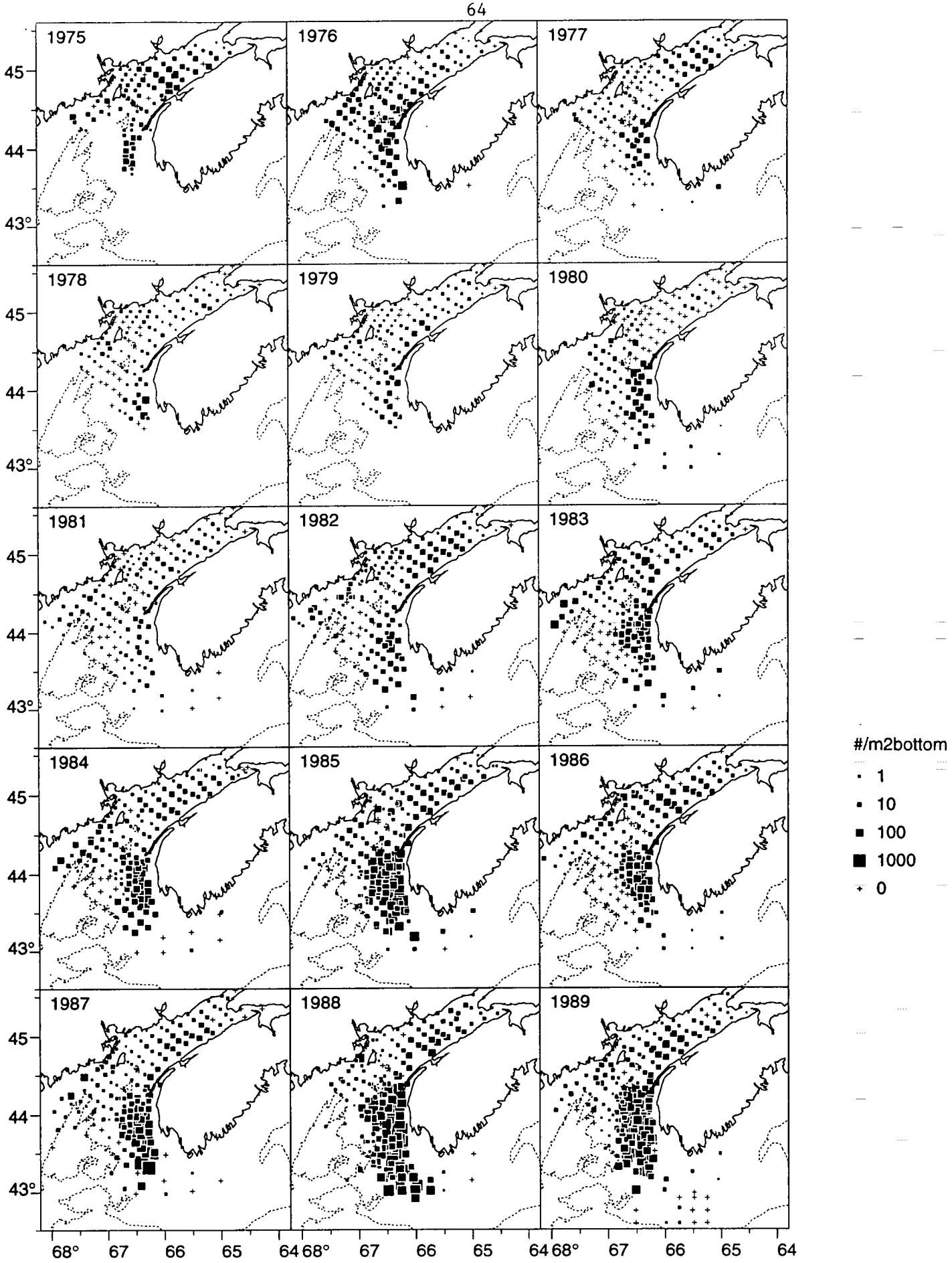


Fig. 18. Abundance of herring larvae (numbers per m^2 to bottom) in samples from the autumn Bay of Fundy ichthyoplankton survey; 1975 to 1995.

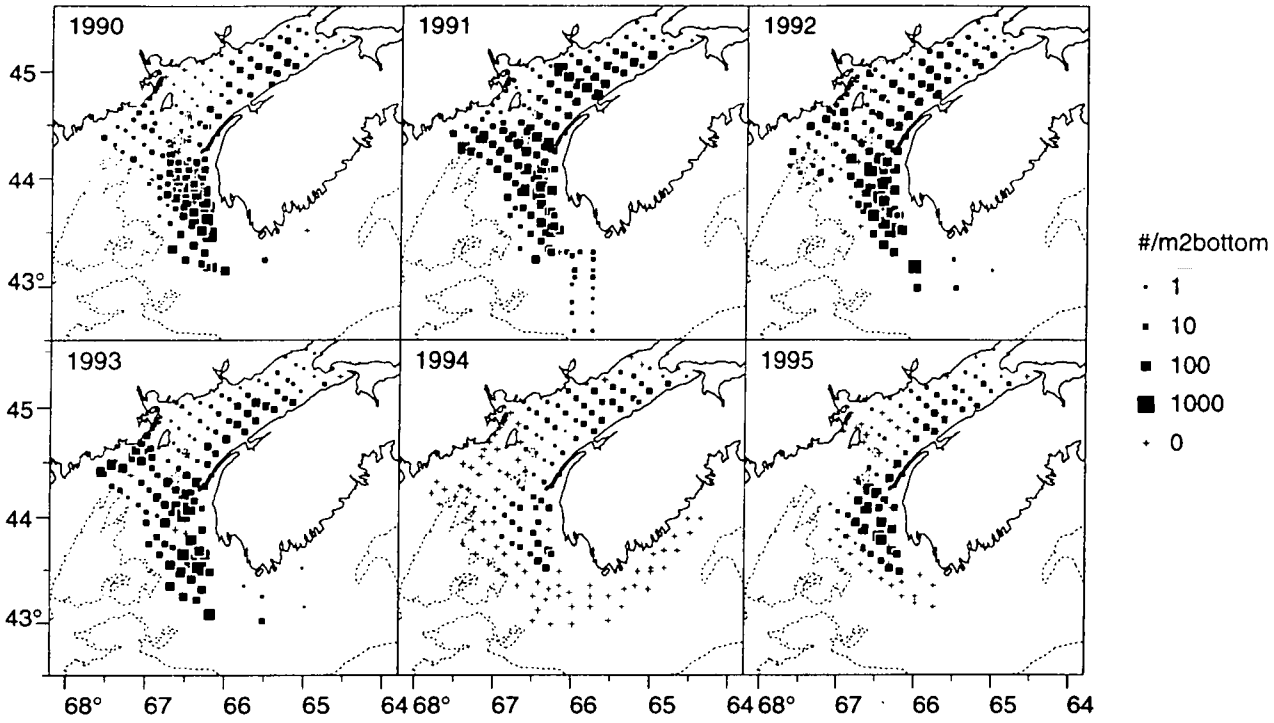


Fig. 18. Cont'd . . .

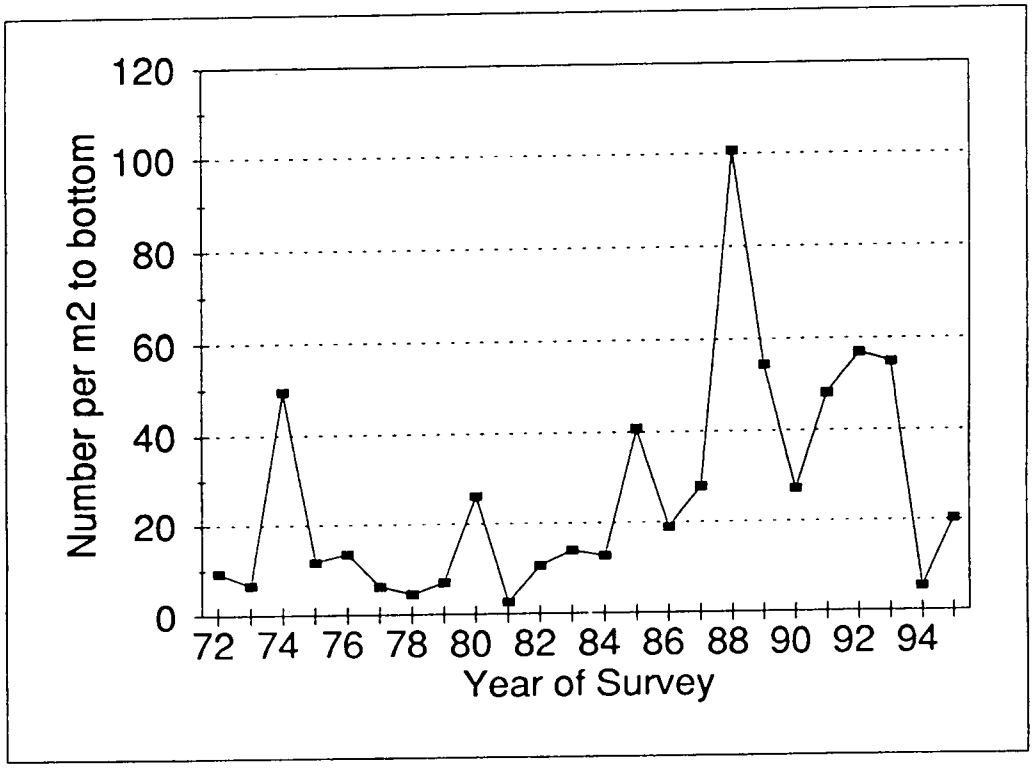


Fig. 19. Mean abundance of herring larvae from index stations in the autumn Bay of Fundy ichthyoplankton survey; 1972 to 1995.

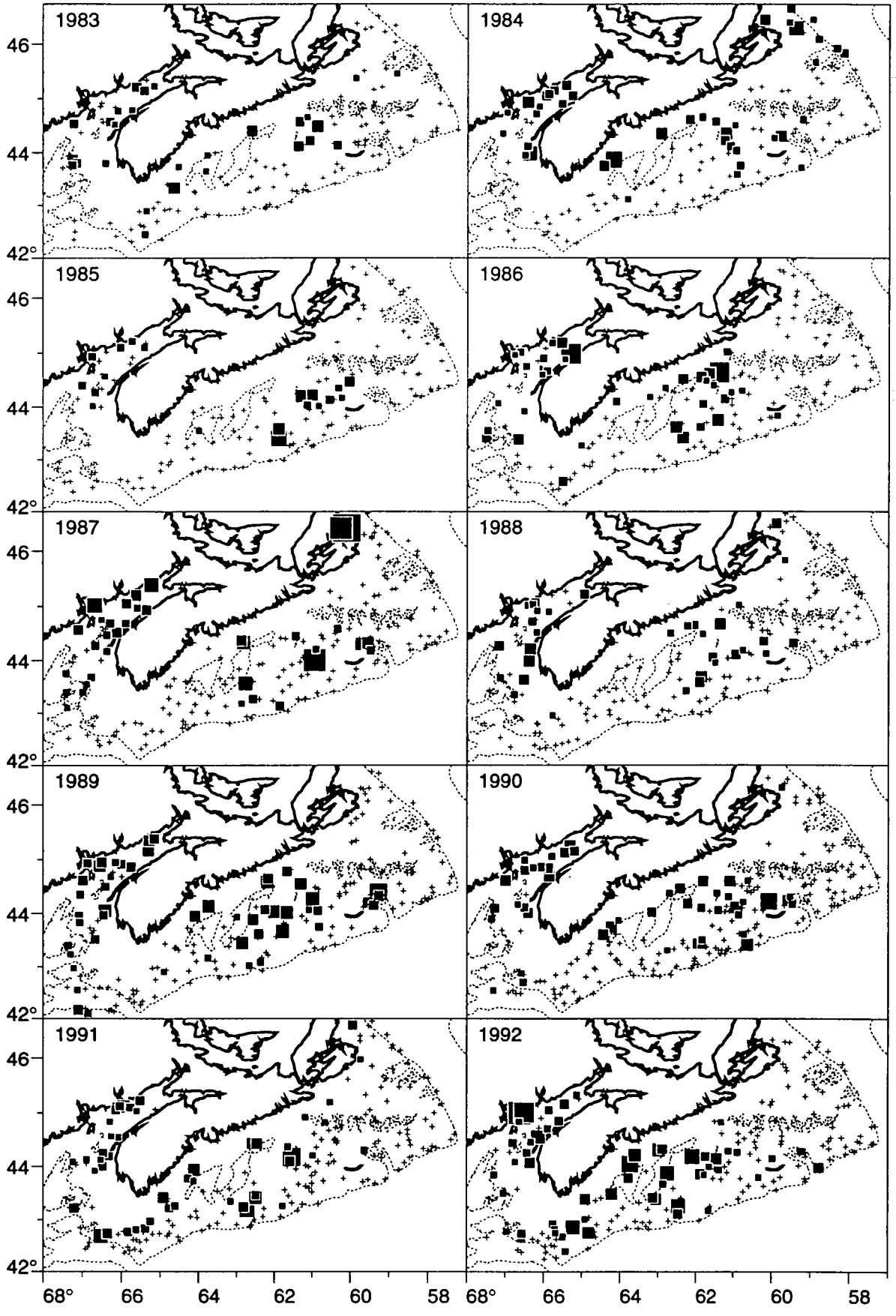


Fig. 20. Abundance of herring (number per tow) in July groundfish research survey data (bottom trawl) for 1983 to 1995.

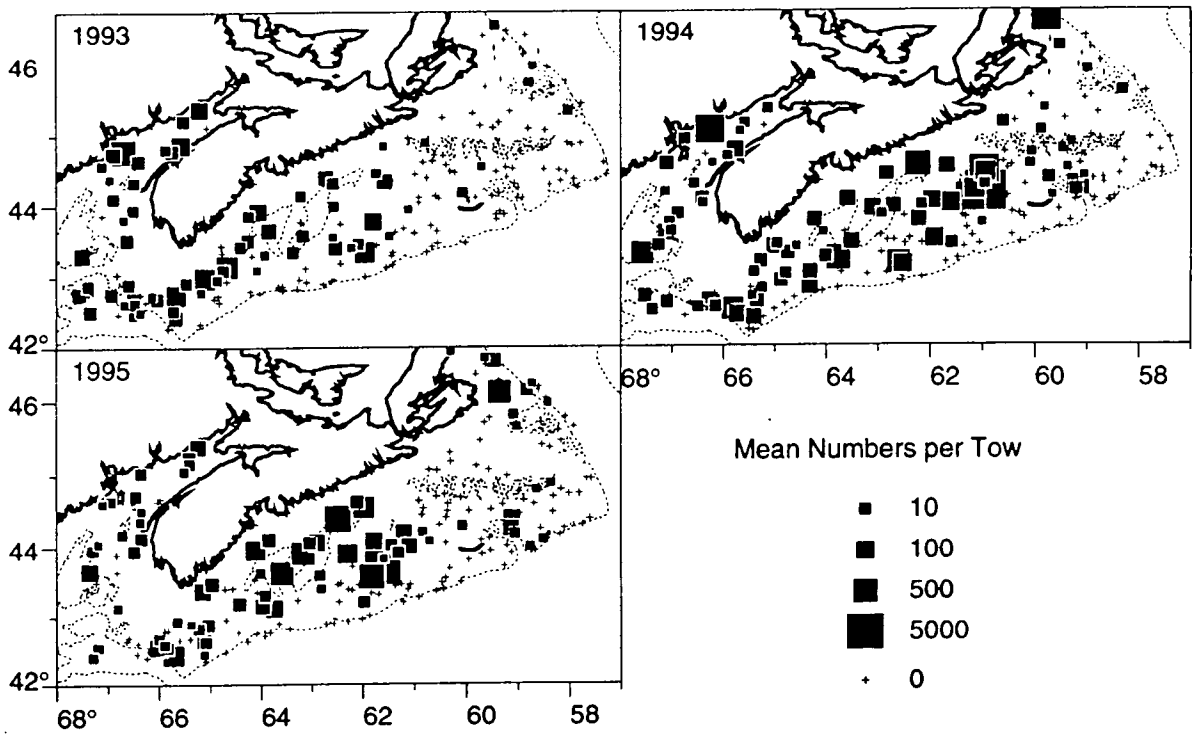


Fig. 20. Cont'd . . .

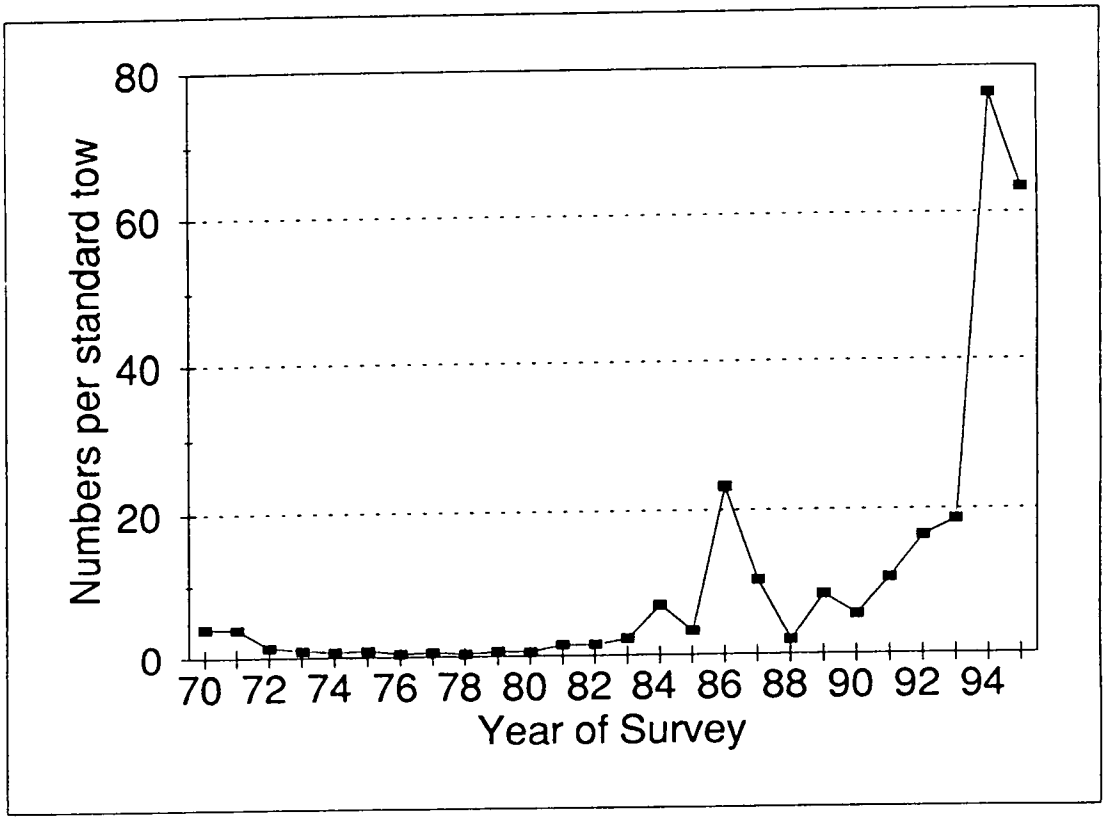
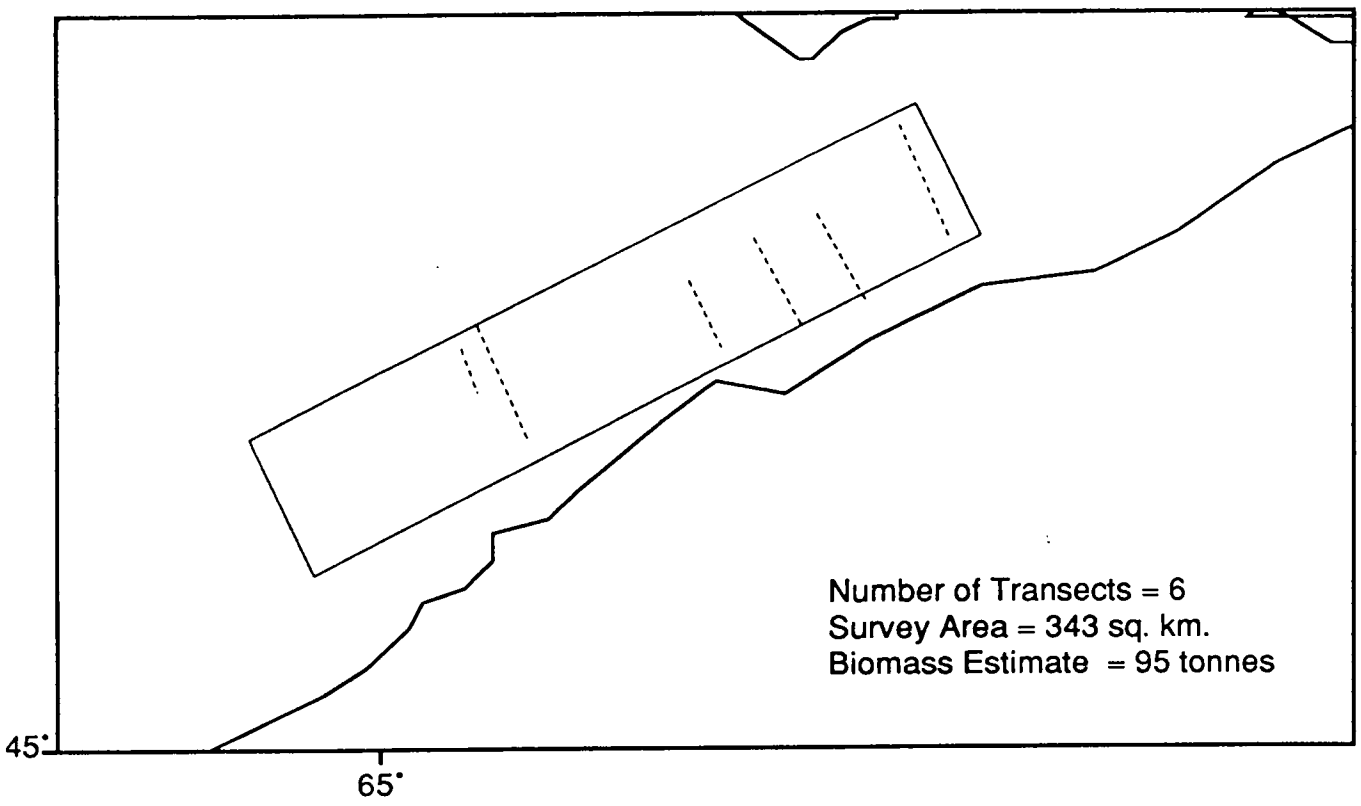


Fig. 21. Time series of herring (stratified mean number per tow) from the July groundfish research survey data (bottom trawl) for 1983 to 1995.



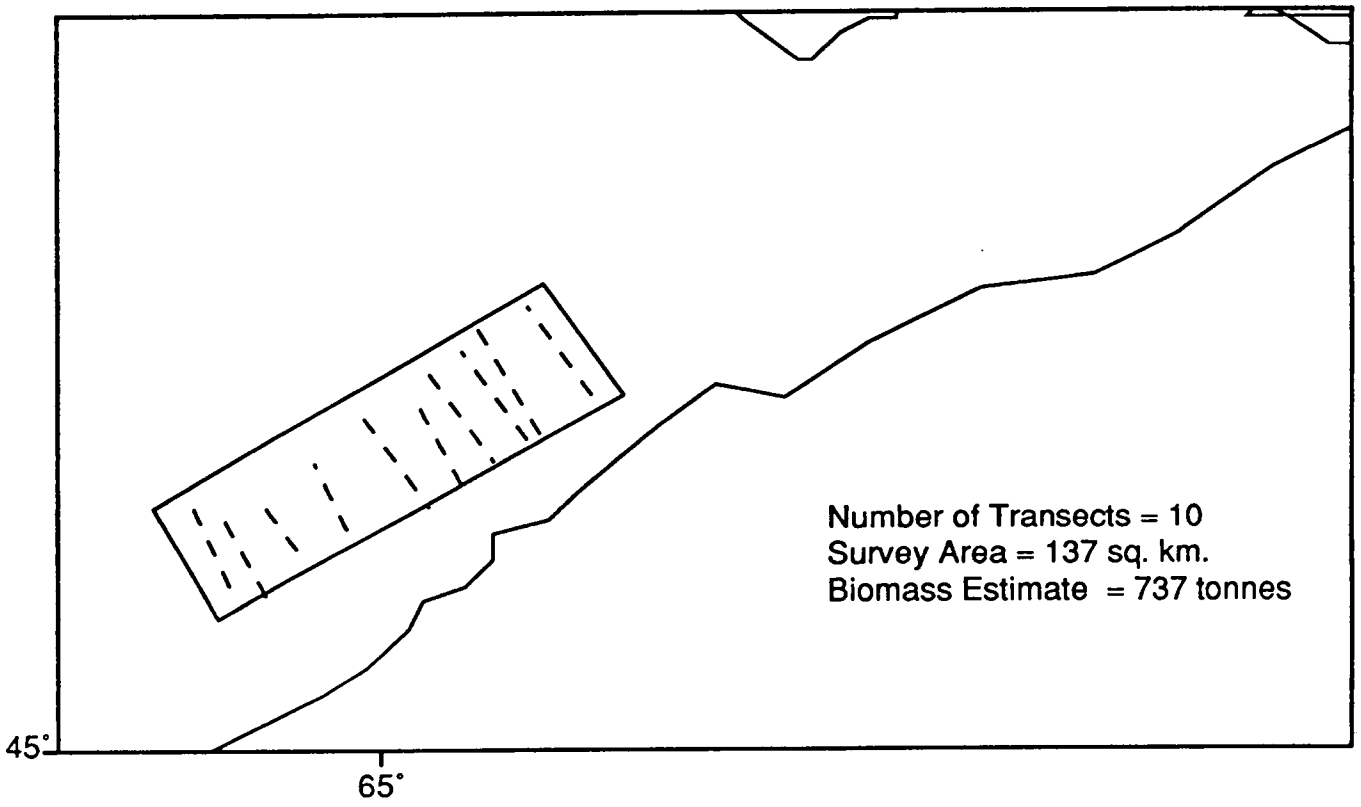
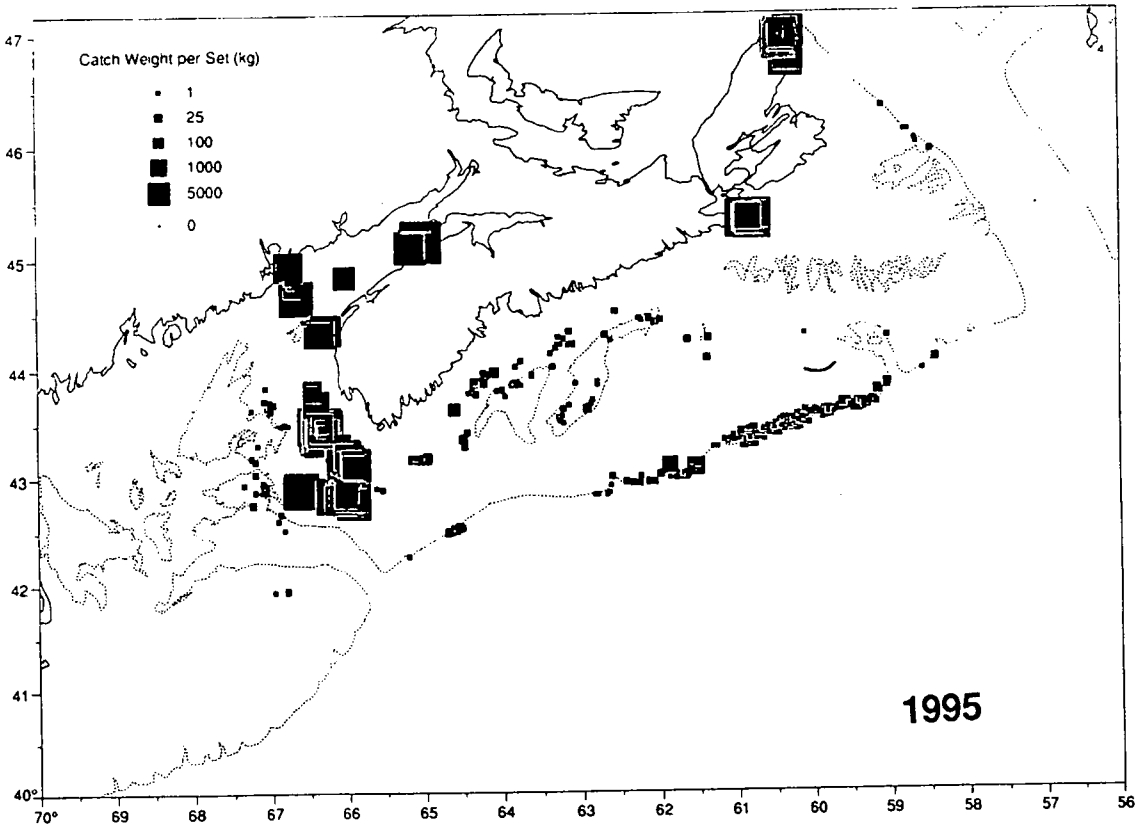


Fig. 22. Survey grid and line transects for Scots Bay acoustic survey for July 20, 1995 (top) and July 21, 1995 (bottom).



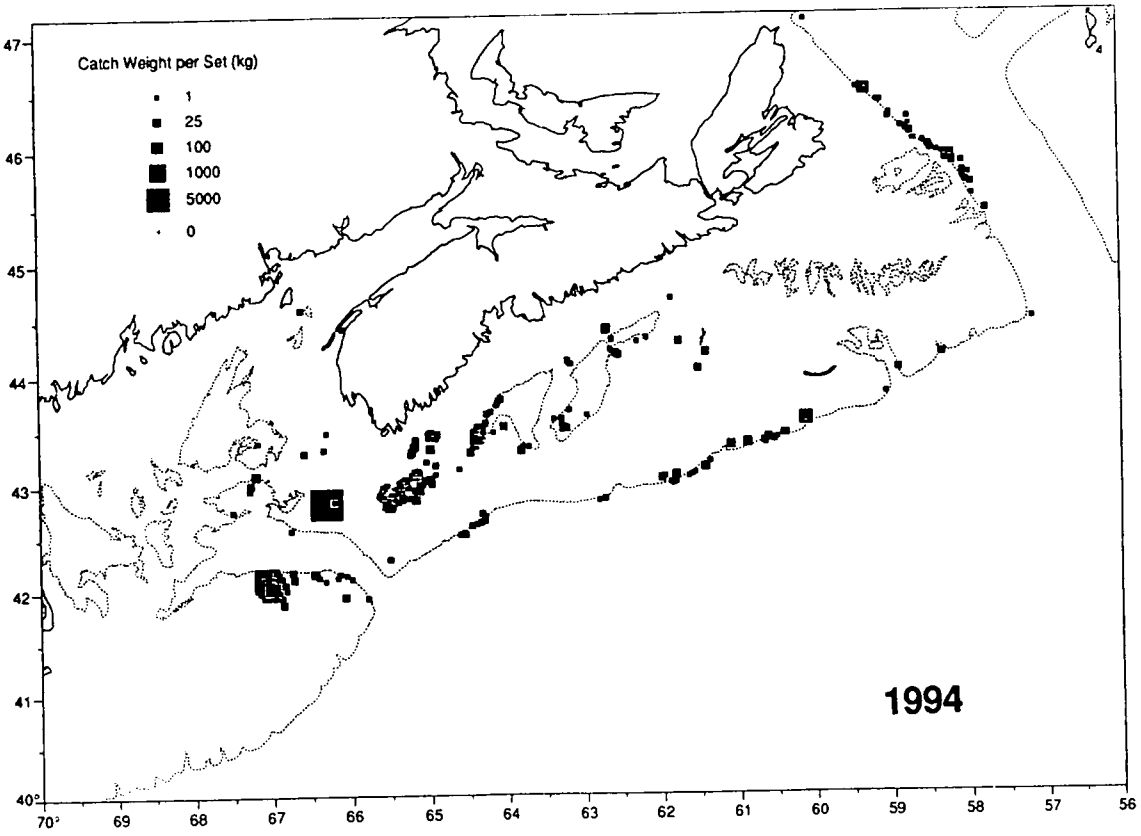


Fig. 23. Catches of herring in sets observed in 4VWX by the International Observer Program for 1995 (top) and 1994 (bottom).

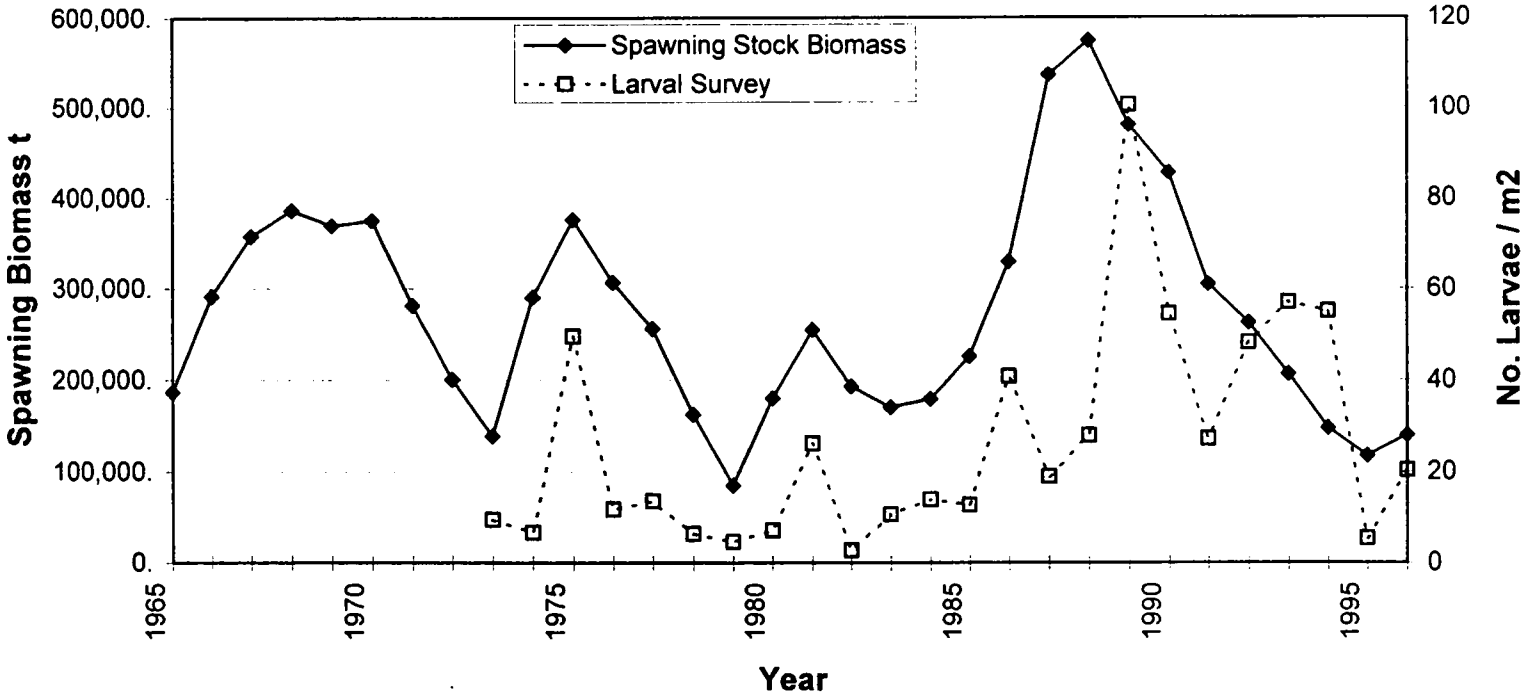


Fig. 24. Larval herring abundance index from autumn larval survey and 4WX spawning stock biomass from an SPA with terminal F=0.299.

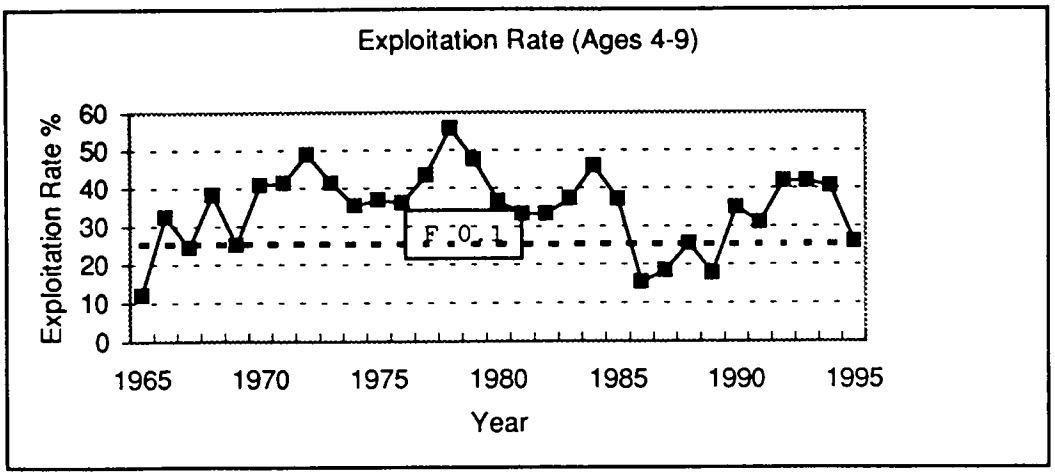


Fig. 25. Exploitation rate (average for ages 4 to 9) for the 4WX herring stock from an SPA with terminal F=0.299.

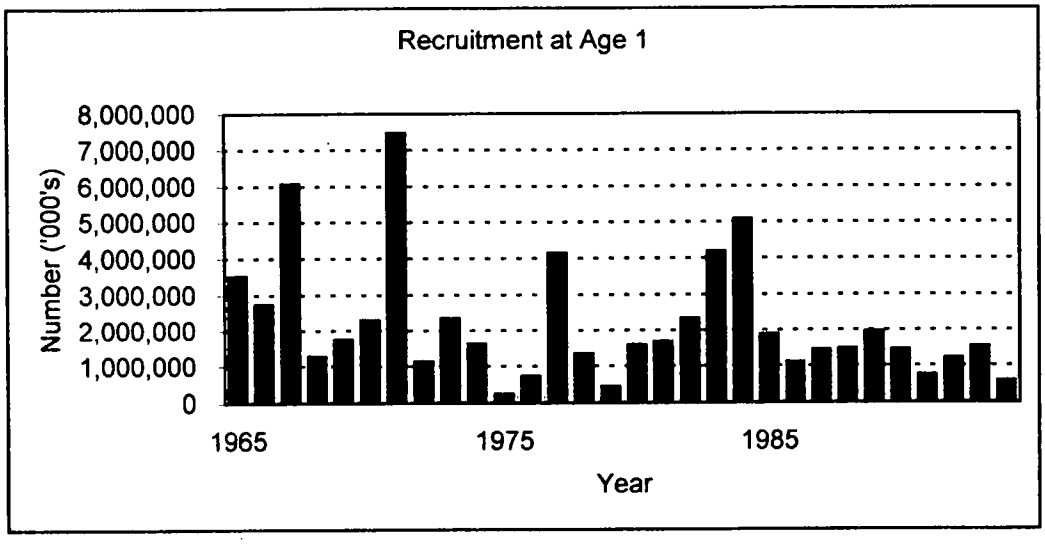


Fig. 26. Recruitment at age 1 for the 4WX herring stock from an SPA with terminal F=0.299.