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The Status of White Hake (*Urophycis tenuis*, Mitchill) in the Southern Gulf of St. Lawrence (NAFO Division 4T) in 1996

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1 - Abstract

The white hake population in NAFO Division 4T is likely at its lowest level since the first quota was established in 1982.

Although directed fishing for white hake in NAFO Division 4T was closed in 1996, provisional landings of 154 t were recorded. The majority of these landings were made by vessels that targeted white hake in the Sentinel Fishery.

Estimates of population numbers from the 1996 research survey remain at the very low level seen since 1993. Furthermore, the estimated population biomass is at its lowest observed level. The results of the sequential population analysis (SPA) are consistent with this view, indicating that population abundance for ages 3-10 was relatively stable from 1985-1989 (12.1-13.5 million fish), but declined rapidly from 1990-1993 and reached a minimum of 1.1 million fish in 1996. Estimates of total mortality were highest in the early 1990's and declined somewhat in recent years. However, even the recent estimates remain high despite the low reported landings of white hake. The catches of recent years appear to have resulted in a high rate of exploitation.

Considering the low abundance and indications of weak incoming recruitment over the next couple of years, recovery of this stock will probably occur slowly.

Résumé

La population de merluche blanche de la division 4T de l'OPANO est sans doute à son niveau le plus faible depuis l'imposition du premier quota en 1982.

Bien que la pêche dirigée de la merluche blanche de 4T ait été fermée en 1996, des débarquements de 154 t ont été signalés. La majorité de ces débarquements avaient pour origine des bateaux pêchant spécifiquement cette espèce dans le cadre d'une pêche sentinelle.

L'effectif estimé de la population du relevé de 1996 demeure très faible depuis 1993. En outre, la biomasse estimée de la population est à son niveau le plus faible jamais observé. Les résultats de l'analyse séquentielle de population (ASP) confirment cette conclusion et montrent que l'abondance des âges 3 à 10 est relativement stable de 1985 à 1989 (12,1 à 13,5 millions de poissons), qu'elle décline rapidement de 1990 à 1993 pour atteindre un minimum de 1,1 million de poissons en 1996. La mortalité totale estimée est la plus élevée au début des années 1990 et diminue ensuite quelque peu au cours des dernières années. Les plus récentes estimations demeurent cependant élevées en dépit des faibles débarquements de merluche blanche signalés. Les captures des dernières années semblent avoir donné lieu à un niveau d'exploitation élevé.

Étant donné la faible abondance et les indices d'un recrutement peu important aux cours des deux prochaines années, ce stock ne se rétablira sans doute que lentement.

2 - Introduction

White hake (*Urophycis tenuis*, Mitchill) has historically been the third or fourth most important groundfish resource in the southern Gulf of St. Lawrence (NAFO Division 4T). Since 1960, the average annual catch of white hake in NAFO Division 4T has been 5,375 t (Table 1). This resource was not managed by a TAC (Total Allowable Catch) until the precautionary quota of 12,000 tonnes was established for the 1982 fishery. Subsequent assessments (Clay et al. 1986; Clay 1987; Clay and Hurlbut 1988) suggested long term yields in the range of 5,000 to 6,000 tonnes could be expected. The TAC was subsequently reduced on five occasions: to 9,400 t in 1987, to 5,500 t in 1988, to 3,600 t in 1993, to 2,000 t in 1994, and most recently to 0 t (moratorium) in 1995 (Table 1).

The stock structure of white hake in the southern Gulf is not completely understood. The combined evidence from a discriminant function analysis of morphometric and meristic characters (Hurlbut 1990; Hurlbut and Clay 1990A), seasonal and annual distributional studies (Clay 1991; Clay and Hurlbut 1989) and a tagging study (Kohler 1971) suggests that the management unit for white hake in NAFO Division 4T is composed of two different stock components:

(1) fish from the shallow inshore southern Gulf (depths <= 200m), principally the Northumberland Strait area (the 'Strait' component)

(2) fish from along the Laurentian Channel in depths in excess of 200 m (the 'Channel' component).

Furthermore, recent analyses of data from surveys of the southern and northern Gulf indicate that the distribution of southern Gulf white hake extends beyond the limits of the NAFO Division 4T management unit in winter, creating the potential for unaccounted catches (Morin and Hurlbut 1994).

After extensive consultations with industry, the Fisheries Resource Conservation Council (F.R.C.C.) recommended "that there be no directed fishing for NAFO Division 4T white hake in 1995 and that by-catches be kept to the lowest possible level". The council also recommended that "measures be taken to avoid catches of small hake in smelt and eel traps". In response to these recommendations, the Minister of the Department of Fisheries and Oceans (DFO) announced (Dec. 21, 1994) the closure of the fishery for white hake in NAFO 4T in 1995. He also announced conservation measures beyond the F.R.C.C. recommendations, including the closure of directed fishing for white hake in NAFO 4RS, 3Pn and 4Vn (January to April).

The present document reviews the status of white hake in NAFO Division 4T in 1996.

3 - Description of Fisheries

A) *Landings*

From 1961-1978, the landings were relatively stable and ranged from 3600-7200 t (Table 1 and Figure 1a). The landings rose sharply from 1979 to 1981 and peaked at 14,039 t in 1981. This increase in landings was attributed to increased fishing effort rather than an increase in the abundance of white hake (Anon 1982). Fishing effort increased because of changes in market conditions (Metuzals and Fullerton 1981) and the general expansion of inshore and nearshore fisheries that occurred throughout the Atlantic provinces after 1976 (Anon 1983). Landings declined almost every year after 1981 to 1,042 t in 1994. Since 1988, landings have been lower than the average of 5,375 t for the 1960-1996 period.

The difference between the revised NAFO landings statistics for 1993 and the preliminary statistics used in previous assessments was minor (2% increase from the preliminary statistics).

Although directed fishing for white hake in NAFO Division 4T was closed in 1996, provisional landings of 154 t were recorded (Table 1 - Figure 1a). The majority of these landings (105 t) were made by

participants in the Sentinel Fishery, of which most were made by longliners in St. Georges Bay, N.S., during August and September (Table 2a; Table A1 and Figure A6 in Appendix 1). The latest statistics available (16/04/97) for this assessment perhaps do not include landings by Sentinel Fishery vessels from Quebec or parts of Nova Scotia. Likewise, landings of white hake in the recreational fishery were not available for inclusion (in 1995, 4.6 t of white hake were reported landed in the recreational fishery).

Since 1960, gillnets have accounted for 30% of the landings of white hake, and bottom trawls for 26% (Table 1 and Figure 1b). Over the same time period, longlines and seines have accounted for 17% and 11% respectively. In 1996, however, 56% of the landings were taken by longliners and only 22% were taken by gillnetters (Table 1 and Figure 1b). The majority of the landings (62%) were made in August and September in 1996 (Table 2b).

The DFO statistical system determines the directed species of a fishing trip by the main species landed. A breakdown of the 1996 landings by main species and month is given in Table 2c. The majority of the hake landed in 1996 (59%) came from trips where hake was the main species landed. The remainder was taken on trips where winter flounder or cod were the main species landed.

We allocated the NAFO Division 4T white hake landings (1985 - 1996) to the 'Strait' and 'Channel' stock components by the statistical unit areas (See Map - Figure 2) in which they were landed, using the depth criteria (depths <= 200 m vs. depths > 200 m) defined by Hurlbut (1990) and Hurlbut and Clay (1990A). Unit areas in the southern Gulf where the bottom depths were less than 200 m were considered to be occupied by the 'Strait' component and those bordering the Laurentian Channel with depths that approached and exceeded 200 m were regarded as belonging to the 'Channel' component.

Since 1985, the majority (90%) of the white hake landings in the southern Gulf of St. Lawrence have been from the 'Strait' component of the stock (unit areas 4Tg, 4Th, 4Tj, 4Tl, 4Tm and 4Tn - Figure 3). In 1996, 88% of the total landings of white hake came from unit area 4Tg alone. From 1985 - 96, annual landings from the unit areas that encompass the 'Channel' component (unit areas 4Tf, 4Tk, 4To, 4Tp and 4Tq - Figure 3) have averaged 10% or less of the total landings; however, the landings for unit areas 4Tf and possibly 4Tk, probably include hake from the 'Strait' component that were caught while migrating through these unit areas, or were from the shallower parts (i.e., < 200 m depth) of these unit areas.

B) *Management Measures Relevant to the White Hake Fishery*

Directed fishing for white hake was closed in the southern Gulf of St. Lawrence in 1996. For fisheries targeting other species, a daily by-catch limit of 10% by weight, for cod and white hake was imposed by the DFO. Under the by-catch provisions, if a given fleet sector exceeded the daily limit of 10% in an area, the groundfish fishery would be closed for 10 consecutive days. The closure would then be followed by a test fishery to determine if the by-catch levels for cod and white hake in the area were less than 10%. In 1996, there were 80 closures in NAFO Div. 4T of fisheries directed at species other than white hake and cod (both fixed and mobile gears), because of high by-catches of these two species and also because of catches of undersized fish.

In addition to the by-catch protocol, the DFO enforced a small fish protocol. If a fleet sector exceeded 15% in number of "small" fish, the groundfish fishery would be closed. The target fish size agreed to by industry for white hake was 45 cm.

In 1996, the minimum mesh size for mobile gears (<14 m (45 feet)) that fished for groundfish species other than cod and white hake in the Northumberland Strait was 130 mm (square mesh) and the minimum mesh size in the Chaleur Bay/Miscou area for mobile gears directing for winter flounder was 135 mm (square mesh). For mobile vessels (<14 m (45 feet)) fishing for groundfish species other than cod and white hake in all other areas of NAFO 4T outside the Northumberland Strait, the minimum mesh size was 155 mm (square mesh).

To further minimize the by-catch of cod and white hake, the DFO implemented restrictive fishing seasons for both the fixed and mobile gear sectors directed at other species. The purpose of this management measure was to permit cod and hake migration to be completed before opening the area to any other groundfish fishing activity. As well, the fishing season for mobile gear in the eastern portion of the Northumberland Strait was adjusted to open on July 15 to allow hake to spawn.

The DFO also enforced a licensing condition that required fishers directing for smelts in the fall and winter fisheries to sort and release all groundfish (i.e., white hake and winter flounder) from their fishing gear.

In 1996, directed fishing for white hake in NAFO 4Vn was closed from January to April to minimize the exploitation of NAFO 4T white hake. Furthermore, mobile gear vessels were not permitted to direct for white hake in NAFO 4Vn at any time in 1996.

C) *Descriptions from Industry of the Fisheries for White Hake in 1996*

i) Consultation Meetings ("Science Workshops")

In November and December 1996, scientific staff from the Dept. of Fisheries and Oceans, Gulf Fisheries Centre, made presentations on the groundfish stocks of the southern Gulf of St. Lawrence at public meetings in Grande-Rivière, Québec, Caraquet, N.B., Charlottetown, P.E.I., Port Hawkesbury, N.S. and Cap-aux-Meules, Québec. The purpose of these meetings was to obtain views from fishers and fishing industry on the status of the various groundfish stocks in the southern Gulf in 1996.

Relative to the meetings in Charlottetown and Port Hawkesbury, there were very few opinions or comments expressed concerning white hake at the meetings in Grande-Rivière, Caraquet and Cap-aux-Meules. There were no comments or opinions made concerning white hake in Grande-Rivière. In Cap-aux-Meules, one fisher commented that there were fewer small hake near the coast now than when the fishery was open and another said that some small hake were caught in the smelt fishery. At the meeting in Caraquet, there was agreement with the survey information showing a contraction in the range of white hake. One fisherman involved in a mesh selectivity experiment noted an increase in hake catches off the east coast of P.E.I. and it was noted that this was consistent with catches in the sentinel fishery.

Although there was no disagreement among the participants at the Charlottetown meeting with the survey results indicating that the abundance of white hake is near the lowest historical level, especially off west P.E.I., a fixed gear fisher from east P.E.I. stated that his catches of white hake were higher than usual in 1996 on Fisherman's Bank, but were shorter in duration. Several participants suggested that the abundance of white hake may be strongly correlated with the abundance of herring and one fisher speculated that the lower catches of white hake on Fisherman's Bank in the 1996 survey may have occurred because the herring had already left the area before the survey (noting that the herring fishery ended earlier than usual - by Sept. 6-10). The survey data which indicate that the biomass of white hake in NAFO Div. 4T has continued to decline to a historical low level in 1996, despite being under moratoria, provoked several questions. Several participants suggested that the biomass may have continued to decline because of unreported catches in 1995 and 1996 and one fisher alleged that there was an active "black market" for white hake in 1996.

Numerous comments were also made at the Charlottetown meeting concerning spawning areas and the occurrence of juvenile and small white hake. Several fishers indicated that white hake were known to spawn in the vicinity of Pictou Is. and Murray Harbour (Note: The stratum containing Pictou Is. is one of the only survey strata in which juvenile white hake have been encountered during September surveys). One participant noted that requests were made to DFO to protect the Pictou Is. spawning area from damage by mobile gears, but no action was taken and dragging continued. A fisher from east P.E.I. mentioned that juvenile and small white hake (less than 6-7" (16 cm) long) commonly occur west of Pictou

Is. (but not east of Pictou Is.) in October. One fisher stated that small white hake are common in inshore areas and another speculated that they may overwinter in estuaries.

By far, the most discussion concerning white hake occurred at the meeting in Port Hawkesbury, as it had in 1994 and 1995. Several participants commented on the occurrence of juvenile and small white hake and on the problem of white hake by-catch. A fisher indicated that many (8-10/tow) small hake (but few large hake) were caught by scallop draggers west of Pictou Island over the past four years. Large by-catches of hake were also reported in the winter flounder fishery south of Pictou Island. A fisher that fished for winter flounder in St. George's Bay reported that he could keep his hake by-catch below 10% by adding chains to the headline to reduce the net opening. More small hake than usual were caught in herring nets in 1996.

There was extensive discussion regarding the migration of white hake and factors that affect their catch rates. Several fishers indicated that there are two runs of hake out of the Gulf into 4Vn: an early run in August/September and a second run in November. One participant stated that few hake were caught migrating past Bay St. Lawrence in the sentinel fishery or in the fall 4Vn sentinel fishery. Another fisher asked about the dates and times of research survey sets in St. George's Bay. He reported day/night differences in catch rates of groundfish and effects of the tide on catch rates. He stated that better catches occur at slack water and in the early morning. A change in the tidal cycle was noted for recent years, with much stronger rising tides in autumn in recent years. A fisher noted that there are usually few cod mixed with hake and suggested that cod may displace hake.

One fisher recommended a limited longline fishery in St. George's Bay. Commenting on the research survey results which indicate a decline in the abundance of white hake, a participant wondered why the FRCC was recommending a hake by-catch in 1997. Another participant stated that given the regional differences in the abundance of hake in the southern Gulf, there is a need for criteria for opening fisheries that take into account the regional differences in abundance and a need for separate east/west assessments.

ii) End of Season Telephone Survey

A survey was conducted by telephone of fishermen that participated in the groundfish fishery in the southern Gulf in 1996 (Hurlbut 1997). The primary purpose of the survey was to obtain their views and opinions on groundfish abundance for inclusion in stock assessments.

Of the 223 respondents that were interviewed, 8 indicated that they directed for white hake in 1996 to some extent (i.e., first, second or third priority), and of them, 2 fishers said that white hake was their first priority. This result is perplexing given that the fishery for white hake in the southern Gulf was closed in 1996, and that these same respondents were also asked to identify which species they directed for before the fisheries for cod and hake were closed. The participation of some of these respondents in the Sentinel Fishery may partially explain this occurrence (3 of the 8 respondents that identified hake as the species that they fished for 'most of the time' in 1996 were also participants in the Sentinel Fishery). As well, several of the respondents that identified cod as the species that they fished for 'most of the time' in 1996 indicated that they fished for cod in the recreational fishery and the same may be true for a few of the respondents that identified hake as the species that they fished for 'most of the time' in 1996.

Figure 4 shows the geographical distribution of the respondents who said they fished for white hake 'most of the time' in 1996 (white hake was either their first, second or third priority). It should be noted that only 2 of the 8 respondents were from statistical districts located in unit area 4Tg, where the majority of the hake landings occurred. Only 1 of the 8 respondents used mobile fishing gear; the remainder used fixed gears (gillnet or longline - see Figure 5). When asked to compare the amount of fishing gear used in 1996 with the amount used in previous years, more than half of the respondents who said that they fished for white hake 'most of the time' in 1996 indicated that they used less fishing gear in 1996 (Figure 6). All but one of the respondents that targeted hake, 'most of the time', reported that they spent more days

fishing for groundfish in 1996 than in 1995 (Figure 7). When the respondents were asked for their opinion concerning the abundance of white hake in the southern Gulf in 1996, 5 of the 8 fishermen considered the abundance to be low or very low but 3 considered it to be high (Figure 8a). Two of the 3 respondents who said that the abundance of hake was high in 1996 were from statistical districts in unit area 4Tg and the remainder were from statistical districts in the south-western Gulf. The final question on the questionnaire asked the respondents to compare the abundance of white hake in 1996 with its abundance during all their years fishing for white hake (Figure 8b). The responses to this question by the two fishermen who said that white hake was their first priority in 1996, were split; with one individual describing the abundance in 1996 as lower and the other describing the abundance in 1996 as higher than during all their years fishing for white hake (Figure 8b). The respondent who described the abundance in 1996 as higher, fished in unit area 4Tg, whereas, the respondent who described the abundance in 1996 as lower was from a statistical district in the south-western Gulf.

4 - Target

The TAC has been reduced on five occasions since the precautionary quota of 12,000 tonnes was established in 1982: to 9,400 t in 1987, to 5,500 t in 1988, to 3,600 t in 1993, to 2,000 t in 1994, and most recently to 0 t (moratorium) in 1995.

5 - Fishery Data

A) *Commercial Samples and Age Determination*

Commercial port samples of NAFO Division 4T white hake have been obtained according to previously established protocols (Clay et al. 1985; Clay and Hurlbut 1989; Clay and Clay 1991).

Only 5 commercial samples were obtained by DFO port samplers in 1996 (446 fish measured and 189 otoliths) because of the moratorium on the hake fishery. Three of these samples (429 fish measured and 169 otoliths) were obtained from unit area 4Tg, which is occupied by the 'Strait' component and the remaining two samples were obtained from unit area 4Tf (the 'Channel' component), and consisted of 22 fish measured for length and 21 otoliths.

As a result of the limited sampling coverage, we incorporated sampling data from the 1996 sentinel fishery. These data were obtained at sea by trained fishery observers and sentinel fishers and consisted of 32,934 measurements and 763 otoliths. All but one of the otolith samples were obtained from unit area 4Tg. The observer (i.e. sentinel) samples were collected on a set-by-set basis, whereas the commercial port samples were collected on a trip-by-trip basis. The set-by-set observer samples were weighted by the catch in the set, then combined within trips and weighted by the observer estimate of the trip catch.

Quality control tests were conducted during the entire period of age determination, either weekly or after every 500 otoliths that were read. These tests involve the ageing of two randomly selected trays (50 otoliths per tray) from the reference collection. Recently assigned ages (commercial or research vessel) are accepted if the agreement on the tests exceeds 75% and if there is no skewness (Sokal and Rohlf 1981); otherwise the ages are discarded and the reader recalibrates with otoliths from the reference collection. In 1996, agreement with the reference ager was acceptable (average of 77%) and no skewness was detected (see below).

Date	% Agreement	Skewness
22/11/96	78	None
29/11/96	75	None
09/12/96	76	None
25/02/97	77	None

B) *Catch, Weight and Length at Age in 1996*

Even though samples from the sentinel fishery were included in the analysis, it was not possible to maintain the Jan.-July and Aug.-Dec. stratification by gear, used in previous assessments, because of limited sampling coverage. Separate keys were created from gillnet and longline sampling data. A third key was created to estimate the age of mobile gear samples that combined the age/length keys for all of the gears that were sampled. A summary of the sampling data used in constructing the 1996 catch at age is given in Table 3. The conversion of length to weight was based on the length-weight regression obtained from the annual (September 1996) groundfish survey of NAFO Division 4T (Table 3). The catch-at-age, mean weight-at-age and mean length-at-age for 1996 are shown in Table 4. The time series of catches-at-age, mean weights-at-age and mean lengths-at-age from 1982-1996 are found in Table 5 and include the changes made to the 1993 data to comply with the finalised NAFO landings statistics.

The total number of fish landed in 1996 was the second lowest on record since 1982 (Table 5a and Figure 9a) and the landings were dominated by ages 4, 5 and 6 (the 1990 to 1992 yearclasses (Table 5a and Figure 9 b)).

During previous assessments of this resource, a common observation has been that it is difficult to "track" yearclasses in the commercial fishery catch-at-age. This difficulty may be the result of sexual dimorphism in white hake (Clay and Clay 1991) and the inability to obtain sexed length frequency and otolith samples from the commercial fishery. Since 1982, the landings have been composed principally of age 4+ hake, but the proportion of older hake (i.e., age 6+) has diminished since 1989, and the unusually high proportion of older hake (i.e., age 6+) noted in 1995, did not persist. The very wide confidence intervals about the estimates for most of the 1995 ages and age groups (Figure 9 b) reflect the low sampling intensity in 1995 (7 samples with 197 fish measured and 134 fish aged).

Several trends are apparent in the time series of mean weights-at-age for ages 4-9 (Figure 10). From 1982-1987, mean weights-at-age for ages 4 and 5 exhibited a decreasing trend, whereas, mean weights-at-age for ages 8 and 9 showed an increasing trend. Since 1988, mean weights-at-age have remained relatively stable for ages 4 and 7 but mean weights-at-age for ages 6 and 5 declined to minima in 1991 and 1992, respectively, after which they have tended to increase. The mean weights-at-age for age 9 hake have varied considerably since 1988, but exhibit a decreasing trend. If size-at-age varies in a density-dependent manner, we would expect that all age classes would exhibit an increasing trend in mean weight-at-age in recent years as stock size has declined. We would also anticipate an increasing trend in mean weight-at-age for most age groups in recent years with the increased mesh sizes in use. The failure to observe this trend is perplexing.

6 - Research Data

A) *Fall Groundfish Survey of 1996*

Research vessel surveys have been conducted every autumn since 1971 in the southern Gulf of St. Lawrence, to provide an index of groundfish stock abundance. A stratified random survey design has been maintained, except for the period 1984-1987, when randomly chosen fixed stations were surveyed. The surveys are conducted in the month of September, before groundfish commence their migration out of the Gulf. Survey procedures and protocols are standardised and documented in Hurlbut and Clay (1990B). The survey strata for the fall groundfish abundance survey are shown in Figure 11.

During the 1996 survey (N249), 208 valid sets were made by the research vessel *Alfred Needler* in NAFO Division 4T.

i) Geographic Distribution

During the annual (September) abundance surveys of the southern Gulf, white hake have tended to exhibit a disjunct distribution, with concentrations occurring in warmer waters, either in shallow inshore areas or in deep water along the Laurentian Channel (Figure 12). White hake have seldom been caught in the shallow, central zone adjacent to the Magdalen Islands. The main areas of concentration in 1996 were in St. George's Bay and in the Cape Breton Trough, as was found in the 1996 Sentinel Survey program (Appendix 1). In comparison to recent years, catch rates were markedly lower off the eastern coast of P.E.I. in 1996. Fewer white hake have been caught in the western part of the southern Gulf each year since 1991, suggesting that there has been a contraction of the geographic range.

The information from the 1994 and 1995 surveys, which extended into NAFO 4Vn, suggested that the distribution of white hake is continuous between this area and NAFO 4T.

ii) Length and Age Composition of Survey Catches

Length frequencies and the stratified mean catch per tow-at-age for the entire series of abundance surveys of the southern Gulf were calculated using the research vessel analysis (RVAN) programs (Clay 1989) written in SAS/IML (SAS Institute Inc. 1989) (Figure 13 and Table 6).

With the exception of 1990, when the modal length was 34 cm, the modal length varied between 40-46 cm from 1984-93. In 1995, the modal length dropped to 31 cm and remained at this length in 1996. The abundance of larger hake (>= the small fish protocol size of 45 cm) has declined to a historical low level (< 20% of the survey length frequency in 1995 and 1996). As we saw in the September 1995 survey, the length frequency for 1996 indicates the presence of small fish (less than 40 cm) and in particular of 0-group hake (less than 10 cm), but the abundance of these 0-group fish does not appear to have increased in 1996.

From 1984 to 1994, the most abundant age groups in the survey were age 3 or 4, but in 1995 and 1996, the most abundant age group was age 2 (the 1994 yearclass in 1996) (Table 6 and Figures 14 a and b). The abundance of all hake older than age 3 has declined considerably since 1989 (Figures 14 b and c).

Figure 14d illustrates how the abundance of large, old hake (5 years and older or 45 cm and longer) has declined to the lowest level observed in the history of this survey.

iii) Size-at-Age

The stratified mean weight-at-age and mean length-at-age were calculated using the research vessel analysis (RVAN) programs (Clay 1989) written in SAS/IML (SAS Institute Inc. 1989) (Tables 7 - 8).

From the late 1980's until the early 1990's, the mean weight-at-age for hake ages 5-7 declined gradually (Figure 15). For hake age 8 and 9, the mean weight-at-age has fluctuated greatly, and minima for the time series 1971-1996 were reached in 1996 for both age groups.

iv) Revisions to the Abundance Indices

Starting in 1984, three inshore strata (401-403) were added to the 24 strata (415-439) that were fished since 1971 (Figure 11). An overlap in station locations was recently discovered between strata 401 and 429. The area of overlap consisted of about 45% of the 401 area and 10% of the 429 area. The area of stratum 401 has been reduced to eliminate this overlap. Thirteen tows (over the 1984-1995 period) in the area of overlap that had been assigned to stratum 401 were reassigned to stratum 429. We recalculated the index taking this stratum reassignment into account. Corrections were also incorporated in tables of length and weight at age.

In past assessments, the abundance index for NAFO 4T hake has included strata 415-439 for the 1971-1983 period and 401-403 plus 415-439 since 1984. However, much of stratum 402 is unfishable in September due to lobster gear, and this stratum was not occupied in 1989, 1991, 1994 and 1995. To make the index more consistent over the 1984-1996 period, we recalculated the index omitting stratum 402. The effect of omitting stratum 402 from the index was negligible in all years (Figure 16).

An error was discovered in previous calculations of the abundance indices for the Strait and Channel stock components. From 1971-1988, 10-13 fixed stations were fished during the survey in addition to the randomly selected stations. From 1984-1987 the survey followed a fixed-station design, using stations chosen from the randomly-selected sites fished in the previous three years. With the advent of fishing by the Lady Hammond on a 24-hour basis, the number of stations that could be fished increased substantially. However, only the 61 stations fished each year from 1984-1987 (out of a total of 90-131 stations per year) were used in assessments prior to 1995. Following an analysis by Nielsen (1995), the Atlantic Zone Statistics, Sampling and Surveys Committee recommended including all sets in indices, treating fixed stations in the same way as randomly selected stations (For hake, it was recommended that only the first of any repeat sets at the same location should be used because of a significant difference in hake catches between the first and repeat sets). However, indices for the Strait and Channel components reported in recent assessments apparently included only the stations fished each year from 1984-1987. These indices have been recalculated to include all tows except repeat sets. This has resulted in substantial changes in some cases (e.g., the 1986 index for the Strait).

v) Abundance Indices and Biomass Estimates

The stratified mean number of white hake caught per tow (ages 0+) during the 1996 September survey decreased slightly from the 1995 level to 3.4 fish/tow, and remains near the lowest historical level (Table 9 and Figure 16). Furthermore, the stratified mean weight (kg) per tow (ages 0+) and the estimated population biomass have decreased to the lowest level in the history of this survey (Table 9 and Figure 17).

The research vessel stratified mean catch per tow, estimates of population abundance and biomass and associated variances were also calculated for the 'Strait' and 'Channel' components (separately), using the depth criteria mentioned in the introduction. Strata 403, 420-422, 432 and 433 were selected for analyses of the 'Strait' component and strata 415, 425 and 437-439 were selected for analyses of the 'Channel' component (Tables 10 and 11 and Figure 18).

This analysis revealed a substantial difference in the abundance estimates for the two components from 1984-1988, with the 'Channel' component being significantly more abundant than the 'Strait' component in 1986 and 1988, followed by a reversal for the years 1989-92. The abundance of white hake from the 'Strait' component declined to a minimum in 1996. In contrast, the abundance of white hake from the 'Channel' component reached a minimum in 1994 and increased slightly in 1996.

At meetings with the fishing industry ("Science Workshops") in Cape Breton and P.E.I. in 1994 and 1995, considerable scepticism was expressed concerning the survey estimates of the abundance of white hake in NAFO Div. 4T. The representatives of the fishing industry contended that white hake were abundant in the southeastern Gulf in 1994 and 1995, especially in St. Georges Bay. The research vessel estimates of the mean catch per tow for the area in question (survey strata 403 and 433 - see Figure 11) reveal the considerable importance of strata 403 and 433, in terms of the local abundance (density) of white hake and offer support for the contention by industry that hake were abundant in this area in 1994 and 1995 (Figure 19 and Table 12). Nevertheless, the following points must be borne in mind:

- Stratum 403 is the smallest stratum in the survey area for the southern Gulf. Because stations are allocated to strata in proportion to stratum area, the maximum number of trawl tows ever made

before 1996 in stratum 403 was 3 (only one tow was made in 1989). Consequently, abundance estimates for this stratum may have a higher variance since relatively few tows were made.
- This area appears to be the preferred area for hake in the southern Gulf. As hake abundance declines, the distribution may contract into this area. Thus, the local density may remain relatively high in this area even though the overall population size is low (as was the case in 1994 and 1995).
- The density of white hake in strata 403 and 433 reached a minimum in 1996.
- The contention that white hake were abundant in the southeastern Gulf in 1994 and 1995 was consistent with the results of the 1994 and 1995 abundance surveys which found concentrations of hake in St. Georges Bay (stratum 403) and at the eastern end of the Northumberland Strait (stratum 433) and in very few other places in the southern Gulf (See figure 12).

B) *January 1997 Survey of Cabot Strait*

A groundfish survey was conducted in the Cabot Strait from January 5-28, 1997 on board the research vessel *Wilfred Templeman*. Similar surveys were conducted aboard the *Alfred Needler* in January 1994 and 1995 (Chouinard 1994 and 1995) and aboard the *Wilfred Templeman* in 1996. The main objective of the 1997 survey was to determine the distribution of Atlantic cod and other groundfish species in the Cabot Strait area during the winter. A secondary objective of the survey was to collect samples to identify the stock origin of cod concentrations in this area.

The survey design followed a grid pattern with increased sampling intensity between 200 and 400 m and covered waters deeper than 50 m. At each location, a standard 15-minute tow (calculated from "touchdown") using a *Campelen* 1800 trawl (with 12.7 mm liner in lengthening piece and codend), was conducted (Note: the surveys in 1994 and 1995 used a Western IIA trawl). The survey was hampered by strong winds for most of the second part (Jan. 17-28). As a result, only 109 sets were attempted, of which 104 were successful.

A contoured map of the white hake catches in kg per tow (Figure 20) indicates that catches were made throughout most parts of the Laurentian Channel that were surveyed. The distribution of white hake was relatively similar to that observed in previous years (Chouinard 1994; Hurlbut et al. 1994, 1995 and 1996), with low catches in the Gulf of St. Lawrence (northern part of the survey area) and higher catches along the southern edge of the Laurentian Channel in 4Vn and in 3Ps (catches in the center of the Channel were relatively low).

C) September 1996 Juvenile Lobster Survey Near the Magdalen Islands

An inshore juvenile lobster survey was conducted off the eastern coast of the Magdalen Islands from September 5-21, 1996, during which staff from the GFC conducted groundfish sampling from September 6-10 (Morin 1997). The primary purpose of the groundfish sampling was to assess the magnitude of flatfish catches in the area surveyed and to determine whether information obtained from this survey augments that obtained from the annual, September survey of the southern Gulf. The survey was conducted aboard the *Calanus II* and used a fixed station, grid design. The survey area was off the eastern coast of the Magdalen Islands, inshore from the southern Gulf groundfish survey boundaries. Standardized sets were made with a *Nephrops* trawl with 50 mm mesh in the codend and 60 mm mesh in the lengthening piece (tows were made at a speed of 3 knots for 8 minutes). White hake were captured in 34 of the 47 sampled sets and were most abundant at two locations in the western part of the survey area, at depths of 12 and 15 m (Figure 21a). Interestingly, white hake were not captured in stratum 435 during the 1996 southern Gulf groundfish survey, but they have appeared in stratum 435 catches in four years since 1986, at catches of less than 5 hake per standard tow. The length frequency of white caught in this survey was dominated by a single group of 15-20 cm fish (Figure 21b). The frequent occurrence of white hake in this inshore survey (in 34 of the 47 sampled sets and at catch rates reaching 11 hake/100 m^2) suggests that the coastal areas of the Magdalen Islands provide nursery habitat for white hake.

D) 1996 Sentinel Survey Program

A sentinel survey (also referred to as a sentinel fishery) program (to monitor changes in abundance and obtain biological information on groundfish) was conducted in the southern Gulf of St. Lawrence in the fall of 1994 and in 1995. In 1996, the program in the southern Gulf of St. Lawrence was expanded to cover more areas, gear types and seasons. A total of 10 projects and 32 fishing vessels were involved in the 1996 program, an increase from the 7 projects and 16 vessels in 1995 and 1 project and 2 vessels in 1994 (Table A1 Appendix 1). For mobile gears, the coverage was expanded around the Magdalen Islands and Prince Edward Island. The number of fixed gear vessels increased from 6 in 1995 to 23 in 1996. For fixed gear, the coverage was expanded to the areas around P.E.I., N.B., the Gaspé Peninsula and the Magdalen Islands. In addition, the duration of the sentinel surveys was expanded. Most projects only started at the end of August in 1995, whereas in 1996, some projects started in the second week of July and all projects were underway by the end of July. In 1996, the projects were completed by early October in Gaspé and by late November in Nova Scotia.

i) Fixed Gear Projects

The fishing locations for the fixed gear projects were spread along the coastline. Each vessel fished at two traditional fishing sites selected by the participating fishermen (or the association). Figure A1 (Appendix 1) shows the locations of all fixed gear sentinel survey sites in 1996. The fishing locations were 2.5 miles in radius and at least 5 miles apart. Once the locations were determined, they remained constant over the fishing season. Each vessel fished it's gear 24 times with a maximum frequency of twice per week over the period of the fishing season. The fishing days could be consecutive within each 7-day period.

Two types of gear were used for the fixed gear projects: longlines and gillnets (once a type of gear was selected, it remained constant during the entire season). Each vessel fished only one type of gear. For longlines, a maximum of 2,500 hooks (size 12 circle, 1 fathom apart) were used (1,250 hooks at each of the two sites). The longlines could be bottom longlines or "floated" longlines (1-3 feet off bottom). The soaktime for longlines was a minimum of 4-6 hours and a maximum of 24 hours. For gillnets, a total of 500 fathoms of net (10 nets of 50 fathoms) were used, five at each location. The gillnets were of regulation mesh (140 mm) and had a depth of 25 meshes. The soak time for gillnets was a minimum of 18 hours and a maximum of 24 hours.

ii) Mobile Gear Projects

For the mobile gear projects, the same fishing areas that were identified in collaboration with fishermen in 1995 were fished. In addition, other areas (particularly on the north side and west end of P.E.I. and around the Magdalen Islands) were added. Each of these traditional fishing areas (Figure A2 Appendix 1) were subdivided into squares of 3 nm. Each vessel in the project completed 12 fishing trips over the period of the study. Each trip consisted of doing 12 fishing sets in pre-determined fishing locations (squares) within the fishing areas (generally 4 sets in each of three fishing areas). The fishing locations for each trip were selected randomly by DFO at the beginning of the projects. Normally, fishing the 12 sets in one trip and recording all the information required between 2 to 3 days at sea. Trips were spread over the fishing season with a maximum of one trip per 7 day period.

Two types of gear were used for the mobile gear project: otter trawls and Danish (Scottish) seines. Both gears used a codend with 145 mm square mesh except for New Brunswick seiners who used 145 mm diamond mesh to be consistent with previous years. On three trips (trips 4, 8 and 12), a 60 mm liner was placed in the lengthening piece and codend to retain smaller fish in order to provide an indication of the abundance of juvenile fish. The sets for trawlers were of 60 minutes duration (calculated from the time the winches were stopped to the time the gear was brought back) at each location. Seiners conducted a regular fishing set at each of the locations.

iii) Results

In total, 105 t of white hake were caught in the 1996 sentinel survey projects (Table A1 Appendix 1).

Catch rates by seines were typically low, less than 10 kg/set (Figure A3 Appendix 1). Seine catch rates were highest in October and November. This is normally the time when white hake migrate from the shallow warm waters of the southern Gulf to the edge of the Laurentian Channel where they overwinter. Catch rates for N.B. seines were about the same as in 1995. Catch rates for N.S. seines were higher in 1996 during October than in the previous years.

White hake catch rates for trawlers near P.E.I. were higher off eastern PEI than off western P.E.I. (Figure A4 Appendix 1). Catch rates off eastern PEI appeared to be higher than in 1995, particularly when liners were used. Catch rates for trawlers from the Gaspé Peninsula and Nova Scotia were also low (Figure A5 Appendix 1).

Catch rates by longlines were highest in St.Georges Bay (Nova Scotia) where catches of 1,000 kg per 1,000 hooks were frequent (Figure A6 Appendix 1). P.E.I. showed the second highest catch rates for longlines with frequent catches of 100 to 400 kg per 1,000 hooks. Elsewhere, white hake catches by longlines were very poor with no fish being caught in most instances. Gillnet catch rates showed a similar pattern to longline catches, with the largest catches realised along the western shore of Cape Breton followed by eastern PEI (Figure A6 Appendix 1). Similarly, catches were very poor along the Gaspé Peninsula and New Brunswick.

Given the low catches observed in 1995, no comparisons of length frequencies between 1995 and 1996 were conducted. Length frequencies for otter trawls in 1996 indicate some pre-recruits off eastern PEI (Figure A7 Appendix 1) The length frequencies for gillnets show that this gear tends to retain primarily fish between 50 and 80 cm (Figure A8 Appendix 1). Longline gear (#12 circle hooks) retains fish from about the minimum legal size (Figure A9 Appendix 1). There appears to be very few fish above 80 cm, although specimens over 1 meter used to be caught in the past.

iv) Summary

Catch rates for longlines, gillnets and otter trawls suggest that white hake were most abundant in St. Georges Bay and in the area between eastern PEI and Cape Breton in 1996. Catch rates were extremely low almost everywhere else. This is consistent with the information from the 1996 research vessel survey. The very high catch rates observed in the sentinel surveys were restricted to St. Georges Bay. Where comparisons can be made, the data tend to suggest some increase in catch rate over 1995, although these catch rates remain very low. The catch rates from longlines and gillnets in the eastern Northumberland Strait and St. Georges Bay may provide a better indication of trends of adult hake abundance.

7 - Estimation of Stock Parameters

A) *Sequential Population Analysis (SPA)*

Before there was evidence suggesting the existence of two stock components in the southern Gulf, SPA was conducted on all hake in this management unit. Each of the previous SPA's was calibrated with a commercial catch rate series derived from purchase slip data (Clay et al. 1985, 1986 and 1987; Clay and Hurlbut 1988 and 1989) and the research vessel abundance index was not used for calibration. In the last assessment (Hurlbut et al. 1996), we adopted a different approach which took into account the recent evidence indicating separate offshore ("Channel") and inshore ("Strait") stock components (Hurlbut 1990; Hurlbut and Clay 1990A). SPA's were conducted using the commercial catch-at-age (1984-1996) for the whole management unit (i.e., NAFO 4T), but the calibrations used the research vessel abundance index

for the 'Strait' component only (strata 403, 420-422, 432 and 433 for the years 1984-1996 - Note: Earlier surveys were not included in this analysis because sample sizes were judged to be insufficient and because they did not include stratum 403 an important area for hake). The SPA should have used the commercial catch-at-age for the 'Strait' component only, rather than the catch-at-age for the whole management unit. There was considerable uncertainty in the results from ADAPT (unbalanced residual patterns and high CV's about the parameter estimates). Consequently, for this assessment we chose to conduct SPA using the commercial catch-at-age for the 'Strait' component only and calibrated it with the research vessel abundance index for the 'Strait' component.

i) Commercial Catch-at-Age for the Strait Component

The catch-at-age for the Strait component was produced by partitioning the catch-at-age for the whole management unit into the statistical unit areas that correspond to the Strait component (Unit areas 4Tg, 4Th, 4Tj, 4Tl, 4Tm and 4Tn where the bottom depths are predominately less than 200 m). We rationalise using this approach because of the following:

From 1985-1996:
1. 90% of the landings in NAFO 4T were from Strait Unit Areas (Excluding Unit Area 4TU (Note: Unit Area 4TU is the designation for landings for which the statistical unit area was not specified)).
2. 96% of the hake measured were from Strait Unit Areas.
3. 93% of the hake aged were from Strait Unit Areas.
4. Sample weights for hake catches sampled from Strait Unit Areas were 94% of the weight of all hake catches that were sampled.
5. Catch weights for hake catches that were sampled from Strait Unit Areas were 98% of the weight of all hake catches that were sampled.

When considering methods to use, we had three concerns to address:
1. The catch weight for hake catches that were sampled from Channel Unit Areas in 1986 and 1993 was significant (7% and 19% respectively of the weight of all hake catches that were sampled in NAFO 4T (Excluding Unit Area 4TU)).
2. The 4TU landings are significant for several years. These landings could be partitioned to their respective stock components, by statistical district, for the Gulf Ziff landings only, because the Ziff data for the other regions do not record statistical district. However, the 4TU landings for the other regions are very low (never more than 3% of the total landings for NAFO 4T) and their stock origin is questionable.
3. Several samples from the commercial fishery were coded as 4TU (From 1984-1996: 5,935 measurements and 93 otoliths were designated as 4TU). Upon examination, all but one of these samples was determined to be from the Strait component).

Three approaches were considered:
1. Re-compute the catch-at-age for each year for just the Strait Unit Areas.
2. Adjust the catch-at-age for the whole management unit with the ratio:

$$\text{Strait Landings} / \text{Strait} + \text{Channel Landings}$$

(partitioning the 4TU landings with the Gulf Ziff data).
3. Combination of 1 and 2.

Ultimately, we re-computed the catch-at-age for 1986 and 1993 for just the Strait unit areas because of concern #1. Because of concerns # 2 and 3, we chose to adjust the catch-at-age for all of the other years (for the whole management unit) with the above ratio. Table 13 shows the catch-at-age matrices for the Strait component and the whole NAFO 4T management unit.

ii) ADAPT

Several formulations of the adaptive framework (ADAPT) (Gavaris 1988) were attempted to determine the stock size in 1996, but the best fit was obtained with the following formulation:

Parameters

- Terminal N estimates:
  $N_{i,\,1996}$ i = 3 to 8

- Calibration coefficients for RV numbers:
  K_i i = 3 to 8

- Structure Imposed:
  - Natural Mortality = 0.2
  - Error in the catch-at-age assumed negligible
  - F on ages 9 and 10 was set equal to the average for ages 6 - 8
  - Fitted without an intercept

- Input:
  $C_{i,t}$ i = 3 to 10, t = 1985 - 1996
  $RV_{i,t}$ i = 3 to 10, t = 1985 - 1996

- Objective Function:
  - Minimize sum of squared residuals

- Summary:
  - Number of observations = 72
  - Number of parameters = 12

The parameter estimates from the ADAPT calibration are shown in Table 14. The residual pattern (Figure 22) is unbalanced, with predominately negative residuals for 1987, 1988 and 1996 and positive residuals for 1991, 1992, 1994 and 1995 and the CV's of the parameter estimates are relatively high.

The input data to the SPA are given in Table 15a, and the fishing mortalities and population numbers (beginning of year) from the ADAPT calibration are given in Table 15b and Figures 23 and 24. This analysis indicates that fishing mortality increased in 1989 and remained at a high level until 1994, dropping to low levels in 1995 and 1996. It also indicates that population abundance was relatively stable from 1985-1989 (12.1-13.5 million fish) but declined rapidly from 1990-1993 and reached a minimum in 1996 at 1.1 million fish.

B) *Estimation of Mortality Rates by Alternate Methods*

Trends in fishing mortality-at-age (R_a), were estimated from the ratio of the commercial catch-at-age (C_a) to the RV catch-at-age (A_a).

$$\mathbf{R_a = C_a/A_a}$$

For ages 4-7, estimates of relative fishing mortality show wide annual fluctuation over the 1985-1993 period (Figure 25). Estimated values were relatively high in 1993 for ages 3 and 4, in 1992 and 1993 for age 5, and in 1992 for ages 6 and 7, declining to very low levels in 1995 for all ages. Estimates of relative F in 1996 remained at low levels for ages 3, 6 and 7, but increased to moderate levels for ages 4 and 5.

The research vessel abundance index data were also analysed using a multiplicative model to obtain information on trends in total mortality, similar to that described by Sinclair (1992). The model with age and yearclass as effects was of the form:

$$\ln(C_{ij}) = \beta_{0J} + \beta_I I + \varepsilon$$

where: C_{ij} is the catch of hake (standardised to a 1.75 nautical mile tow) of age *i* of yearclass *j*.

I = age category
J = yearclass category

Analyses used the GLM procedure of SAS (SAS Institute 1989). The research vessel time series was analysed in successive 3 or 4 year blocks (i.e., 1985-87, 1986-88, etc.) and included ages 5 to 8.

Results were compared between the index for all 4T strata and the index for the Strait component (See Figure 26). Estimates of Z fluctuated more erratically using only the 6 Strait strata than using all 26 4T strata. Most estimates were near or greater than 1. The highest values occurred in the periods ending in 1992 and 1993 (3 year windows) or 1992-1994 (4 year windows). This is consistent with the high fishing mortalities indicated for the late 1980's and early 1990's in the previous analyses. Estimated Z declined from these high values in the most recent periods. However, even these recent estimates remain at high levels, comparable to those estimated for the mid to late 1980's. This result is surprising in view of the very low landings reported in recent years.

8 - Assessment Results

There was considerable uncertainty in the SPA results, with an unbalanced residual pattern and high CV's about the parameter estimates, but it suggested that fishing mortality was high in the late 1980's and early 1990's and that the population declined rapidly in the early 1990's to very low levels in recent years. The high SPA estimates of fishing mortality in the late 1980's and early 1990's are consistent with high estimates of relative F and Z for this period, and with the disappearance of old and large fish from the population in the 1990's. Sharp declines in survey indices of abundance (both for the Strait component and for 4T as a whole) and an apparent contraction of geographic range in the early 1990's also point to a very low population size in recent years.

Despite very low reported landings of hake in 1995 and 1996, estimates of total mortality remain very high.

9 - Future Prospects

The white hake resource in NAFO Division 4T is likely at its lowest level since the first quota was established in 1982. The research survey results indicate that population biomass has declined to its lowest level in the history of this survey. Furthermore, recent research surveys suggest that there has been a contraction of the geographic range, as well as a reduction in the abundance of larger hake. Fishing mortalities were high from 1989-1992 and population abundance has declined to perhaps its lowest observed level.

Recent catches (average annual landings of 4,740 t from 1989-1992) appear to have resulted in a high rate of exploitation. Considering the low abundance and limited indications of incoming recruitment over the next few years, recovery of this stock will occur slowly. A sustainable fishery will require a significant reduction in fishing mortality from the levels seen in the early 1990's.

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Table 1. Nominal landings (tonnes) of white hake from NAFO Division 4T by gear, with the yearly TAC. All data from 1995 to 1996 are provisional statistics.

Year	Trawl	Seines	Gillnet	Longline	Other	Total	TAC
1960	479	21	3	1172	333	2008	
1961	1430	79	309	3498	7	5323	
1962	1141	97	890	4542	574	7244	
1963	1444	71	48	N/S	4987	6550	
1964	1508	82	N/S	1	4615	6206	
1965	N/S	N/S	N/S	N/S	N/S	4706	
1966	2267	205	375	1870	2307	7024	
1967	2295	128	809	948	2370	6550	
1968	795	84	1734	466	1182	4261	
1969	1030	50	1802	498	828	4208	
1970	1463	382	2149	385	1289	5668	
1971	1523	632	1622	702	1228	5707	
1972	1139	863	1190	1605	960	5757	
1973	2468	211	1265	1045	713	5702	
1974	1454	305	1098	345	414	3616	
1975	1574	306	1279	324	642	4125	
1976	1429	398	1147	183	601	3758	
1977	1227	408	1300	231	818	3984	
1978	1303	737	1829	456	500	4825	
1979	2826	912	3189	479	704	8110	
1980	3430	1615	4831	832	1715	12423	
1981	4733	1922	6174	799	411	14039	
1982	2885	994	4625	1027	245	9776	12000
1983	2141	906	2959	753	546	7305	12000
1984	1734	588	3789	865	74	7050	12000
1985	1639	1008	2480	799	88	6014	12000
1986	1094	898	1884	1068	4	4948	12000
1987	820	1505	2200	1847	0	6372	9400
1988	388	817	1923	748	11	3887	5500
1989	868	1689	1830	943	24	5354	5500
1990	771	1216	2022	1118	48	5175	5500
1991	1205	848	1292	1156	0	4501	5500
1992	955	926	914	1136	0	3931	5500
1993	175	98	469	755	0	1497	3600
1994	79	45	218	694	0	1036	2000
*1995	31	11	18	7	0	66	Moratorium
*1996	27	8	33	86	0	154	Moratorium
			1960-1996				
Average	1399	569	1613	902	763	5375	
Percent	26	11	30	17	14	100	
			1996				
Percent	17	5	22	56	0	100	

N/S = Gear Type Not Specified
* = Provisional Statistics

Table 2a. Nominal landings (tonnes) of white hake from NAFO Division 4T in 1996 in the Sentinel Fishery.
All data are provisional statistics.

			Sentinel Fishery			
Month	Trawl	Seine	Line	Gillnet	Total	Percent
July	0.0	0.0	10.9	2.4	13.4	12.8
August	0.1	0.1	27.4	5.9	33.4	31.8
September	0.2	0.0	25.2	10.2	35.6	34.0
October	0.6	0.6	15.4	5.8	22.3	21.3
November	0.0	0.1	0.0	0.0	0.1	0.1
Total	0.9	0.8	78.8	24.4	104.9	
Percent	0.8	0.8	75.2	23.2	100.0	

Table 2b. Nominal landings (tonnes) of white hake from NAFO Division 4T in 1996 by gear and month.
All data are provisional statistics.

Month	Trawl	Seine	Line	Gillnet	Total	Percent
April	0.0	0.0	0.0	0.0	0.0	0.0
May	0.0	0.1	0.0	0.0	0.1	0.1
June	0.0	2.0	0.0	2.1	4.1	2.7
July	5.5	1.5	9.5	6.2	22.8	14.8
August	7.9	0.4	33.2	7.7	49.3	32.1
September	8.8	0.1	25.5	10.9	45.3	29.5
October	4.3	4.1	17.4	5.5	31.3	20.3
November	0.0	0.0	0.0	0.8	0.8	0.5
Total	26.6	8.2	85.6	33.3	153.8	
Percent	17.3	5.3	55.7	21.7	100.0	

Table 2c. Nominal landings (tonnes) of white hake from NAFO Division 4T in 1996 by main species and month.
All data are provisional statistics.

Main Species	May	June	July	August	September	October	November	Sums	Percentage
Cod	0	0	3	5	10	3	0	21	13
Halibut	0	0	0	0	0	0	0	0	0
Plaice	0	1	3	1	0	2	0	8	5
Yellowtail	0	0	0	0	0	0	0	0	0
Witch	0	1	0	0	0	0	0	1	1
W. Flound.	0	1	5	7	9	4	0	26	17
Turbot	0	1	0	0	0	0	0	1	1
W. Hake	0	0	11	36	26	18	1	90	59
Skate	0	0	0	0	0	0	0	0	0
Dogfish	0	0	0	1	1	5	0	7	4
Totals:	0	4	23	49	45	31	1	154	100

Table 3. Age-length keys that were used in the calculation of the 1996 catch-at-age for white hake in NAFO Division 4T.

			Sample Size			
Key	Fishery	Samples	Port	Observer	Total	Catch (t)
1	GN: Jan. -Dec.	GN: Jan. - Dec. Lengths	281	8266	8547	33.3
		GN: Jan. - Dec. Ages	113	287	400	
2	LL: Jan. - Dec.	LL: Jan. - Dec. Lengths	0	23531	23531	85.6
		LL: Jan. - Dec. Ages	0	439	439	
3	OTB/SNU: Jan. -Dec.	OTB/SNU: Jan. - Dec. Lengths	165	1137	1302	34.8
		All Gears: Jan. - Dec. Ages	189	763	952	

Gear Type Abbreviations
OTB = Otter Trawl SNU = Seine GN = Gillnet LL = Longline

Length/Weight Coefficients (sexes combined) from Mission N249 (Sept. 1996)
a = 0.006860 b = 3.022476

Table 4. The catch, weight and length-at-age for white hake in NAFO Division 4T as estimated from observer and port sampling of the commercial and sentinel fisheries in 1996.

1996 CATCH #'S AT AGE (1,000's)

AGE	KEY 1	KEY 2	KEY 3	SUM	VAR
1-2	0	0	0	0	0
3	0	2	0	2	1
4	0	15	4	20	61
5	3	18	7	29	60
6	5	12	6	24	15
7	4	6	3	13	3
8	2	3	1	6	1
9	0	1	0	1	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13-16	0	0	0	0	0
SUM	15	58	22	95	

1996 AVERAGE WEIGHT AT AGE (KG)

AGE	KEY 1	KEY 2	KEY 3	WEIGHTED AVE.WGT.
1				
2				
3	0.54	0.55	0.42	0.53
4	1.47	0.86	0.94	0.89
5	1.76	1.25	1.31	1.32
6	2.13	1.88	1.77	1.91
7	2.51	2.41	2.29	2.41
8	2.71	2.45	2.35	2.50
9	2.72	3.39	2.63	3.01
10	3.56	3.91	3.14	3.59
11				
12	2.70	5.17	2.70	3.76
MEAN	2.23	2.43	1.95	

1996 AVERAGE LENGTH AT AGE (CM.)

AGE	KEY 1	KEY 2	KEY 3	WEIGHTED AVE. LT.
1				
2				
3	41.58	41.87	38.11	41.39
4	57.73	48.19	49.60	48.71
5	61.15	54.47	55.25	55.42
6	65.27	62.37	61.17	62.73
7	68.88	67.70	66.53	67.79
8	70.56	67.46	66.86	68.18
9	70.49	75.92	69.25	72.77
10	77.36	80.15	74.01	77.61
11				
12	71.00	88.00	71.00	78.26
MEAN	64.89	65.13	61.31	

Table 5. Commercial fishery catch, weight and length-at-age for white hake in NAFO Division 4T: 1982-1996 (Note: The catch and mean weight and mean length-at-age were re-calculated for 1993 to comply with the finalised NAFO landings statistics).

a. Commercial Fishery Catch-at-Age (in 1,000's) for NAFO 4T White Hake: 1982-1996.

	Year														
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993*	1994	1995	1996
1-2	0	43	2	3	0	0	0	5	0	0	0	0	0	0	0
3	5	86	58	64	2	30	0	11	34	28	127	79	25	0	2
4	159	220	319	216	204	531	39	114	604	409	1000	312	134	0	20
5	648	740	787	608	496	1357	476	574	1170	1048	1028	400	185	2	29
6	1210	939	788	592	477	900	648	810	992	859	554	217	201	9	24
7	1232	712	542	391	330	411	513	689	427	507	270	87	86	12	13
8	665	535	275	227	233	149	109	224	80	79	61	27	28	4	6
9	198	142	142	108	77	68	15	76	18	17	26	10	5	0	1
10	89	42	69	51	45	18	6	11	8	5	11	1	1	0	0
11	24	8	22	16	21	4	2	13	2	2	4	2	0	0	0
12	16	6	16	18	14	2	1	5	1	1	0	1	0	0	0
13+	16	3	7	12	9	3	1	6	1	5	1	0	0	0	0
	4261	3477	3028	2306	1908	3473	1809	2537	3337	2961	3082	1137	664	27	95

b. Commercial Fishery Mean Weight-at-Age (kg) for NAFO 4T White Hake: 1982-1996.

	Year														
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993*	1994	1995	1996
1		0.46													
2		0.60	0.53	0.95			0.21	0.21							
3	0.55	0.92	0.87	1.39	3.19	0.62	0.33	0.42	0.59	0.54	0.55	0.55	0.61		0.53
4	0.90	1.39	1.15	1.53	0.98	0.81	0.96	0.96	0.81	0.80	0.77	0.90	0.83	0.89	0.89
5	1.20	1.68	1.66	2.01	1.53	1.29	1.29	1.23	1.19	1.13	1.10	1.20	1.22	1.33	1.32
6	1.74	2.03	2.17	2.35	2.39	2.06	1.91	1.77	1.75	1.60	1.69	1.74	1.83	1.93	1.91
7	2.11	2.47	2.74	2.84	3.01	2.95	2.82	2.53	2.56	2.34	2.36	2.11	2.49	2.65	2.41
8	3.13	2.59	3.31	3.70	3.90	3.92	3.72	3.47	3.45	2.90	3.08	3.12	3.03	3.59	2.50
9	3.06	3.27	3.73	4.05	4.69	4.57	5.31	4.31	4.94	4.15	4.45	3.06	3.48	5.27	3.01
10	3.37	4.09	5.63	5.00	5.65	6.06	6.01	6.15	5.58	6.91	5.55	3.37	4.07		3.59
11	4.36	5.99	5.05	6.70	6.90	8.75	8.56	6.16	7.54	5.95	5.54	4.35			
12	4.03	7.52	7.11	6.96	6.92	9.57	10.41	9.65	9.26	7.18	6.06	4.03			3.76
13									6.83	10.04			9.55		
14															
15															

c. Commercial Fishery Mean Length-at-Age (cm) for NAFO 4T White Hake: 1982-1996.

	Year														
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993*	1994	1995	1996
1		39.69													
2		43.78	41.89	50.04			31.60	31.03							
3	48.99	50.05	47.80	55.60	70.80	44.04	36.19	38.70	43.36	41.97	42.50	42.03	43.57		41.39
4	54.95	56.97	52.28	57.36	49.61	48.16	50.49	49.97	47.82	47.85	47.52	49.59	48.02	49.00	48.71
5	58.68	60.70	58.78	62.05	57.10	55.47	55.39	54.57	54.31	53.35	53.42	54.45	54.29	55.44	55.42
6	65.18	64.32	63.60	65.17	66.02	64.00	62.41	61.21	61.59	59.55	61.66	61.81	61.94	62.74	62.73
7	67.81	68.42	68.23	68.90	70.84	71.41	70.54	68.57	69.98	67.42	68.89	65.82	68.44	69.41	67.79
8	72.11	68.69	72.17	74.73	76.83	77.80	76.89	75.96	76.78	72.07	74.93	74.65	72.85	76.33	68.18
9	74.75	74.73	74.49	76.32	81.03	80.48	85.70	80.97	86.68	81.31	84.86	73.96	76.10	86.50	72.77
10	79.05	78.92	84.32	80.97	85.52	86.99	89.17	89.75	89.65	96.28	91.38	76.67	80.46		77.61
11	77.86	91.64	81.66	89.11	92.09	100.06	99.94	89.25	99.77	91.99	91.55	83.67			
12	76.88	99.06	91.16	88.92	90.93	102.73	106.41	105.90	107.00	97.77	94.59	81.48			78.26
13	81.67								96.42	109.03			106.00		
14															
15															

Table 6. Stratified mean catch per tow (numbers) -at-age for white hake caught during research vessel surveys of the southern Gulf of St. Lawrence (NAFO Division 4T). (Note: The totals do not include catches of hake for which the age could not be determined).

Survey	P091	P106	P122	P143	P157	P172	P188	P204	P229	P244	P260	P278	P296
Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
age 0													
age 1	0.04	0.03	0.03	0.11	0.34	0.33	0.02	0.06		0.01	0.05	0.06	0.09
age 2	0.54	0.18	0.29	1.64	3.45	3.05	0.30	2.15	0.28	0.27	0.46	0.27	0.81
age 3	0.96	0.18	0.58	1.71	2.17	2.07	1.27	1.50	2.04	0.98	1.11	0.61	0.81
age 4	0.45	0.27	1.77	2.44	1.06	0.90	1.78	2.52	2.08	1.86	2.47	0.97	0.80
age 5	0.48	0.28	1.94	1.85	0.64	0.52	0.58	2.01	1.82	2.38	3.15	0.77	0.44
age 6	0.11	0.27	0.73	1.39	0.34	0.25	0.18	0.98	1.28	0.92	2.39	0.70	0.28
age 7	0.11	0.09	0.29	0.89	0.14	0.08	0.17	0.30	0.48	0.45	1.45	0.30	0.14
age 8	0.02	0.12	0.07	0.21	0.04	0.02	0.04	0.03	0.13	0.23	0.47	0.13	0.07
age 9	0.03	0.16	0.04	0.06			0.05	0.02	0.02	0.09	0.23	0.02	0.07
age 10	0.03	0.06	0.03	0.15	0.02	0.02	0.01	0.07	0.03	0.10	0.01	0.04	0.01
age 11	0.03	0.06	0.02	0.14	0.04	0.03	0.02		0.04	0.02	0.02		
age 12		0.02	0.03	0.08			0.03	0.04	0.06	0.01	0.01		
age 13		0.01									0.04		
age 14			0.01	0.02			0.02				0.02		
age 15										0.02			
age 16						0.00							
Totals:	2.80	1.72	5.83	10.67	8.24	7.27	4.46	9.67	8.25	7.33	11.88	3.86	3.52

Survey	P312	P327	H159	H179	H192	H204	H219	H232	N178	N192	N210	N230	N249
Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
age 0	0.01	0.02	0.04		0.01	0.41	0.44	0.08	0.09	0.08	0.22	0.60	0.30
age 1	0.05	0.11	0.24	0.04	0.16	1.08	0.66	0.54	0.31	0.26	0.18	0.52	0.42
age 2	0.47	0.67	1.72	0.46	1.59	2.10	2.39	2.05	1.33	0.71	0.81	1.53	1.09
age 3	1.11	2.40	2.62	1.75	2.65	4.26	2.59	2.87	2.74	0.80	0.71	0.59	0.76
age 4	1.42	2.93	4.27	2.16	3.13	2.34	1.65	1.80	2.12	0.98	0.86	0.48	0.54
age 5	1.14	0.93	2.58	1.50	2.32	1.46	1.65	1.27	0.71	0.54	0.38	0.17	0.19
age 6	0.53	0.67	0.92	0.70	0.74	0.80	0.53	0.60	0.17	0.17	0.12	0.13	0.07
age 7	0.27	0.52	0.43	0.21	0.30	0.22	0.35	0.19	0.04	0.06	0.03	0.03	0.03
age 8	0.17	0.31	0.24	0.05	0.05	0.03	0.08	0.06	0.01	0.00	0.02	0.01	0.01
age 9	0.06	0.26	0.11	0.03	0.01	0.03	0.02	0.01		0.02			0.01
age 10	0.06	0.10	0.04	0.03	0.02	0.02		0.02					
age 11	0.01	0.03	0.04			0.01		0.02					
age 12	0.01	0.04	0.03	0.03									
age 13		0.02	0.01			0.01							
age 14		0.02											
age 15		0.01											
age 16													
Totals:	5.31	9.05	13.29	6.95	10.97	12.76	10.37	9.51	7.51	3.62	3.33	4.06	3.41

Research Vessels: E.E. Prince from 1971-85 (P)
Lady Hammond from 1986-91 (H)
Alfred Needler from 1992-96 (N)

Table 7. Mean weight-at-age (kg) for white hake caught during research vessel surveys of the southern Gulf of St. Lawrence (NAFO Division 4T).

Survey	P091	P106	P122	P143	P157	P172	P188	P204	P229	P244	P260	P278	P296
Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
age 0													
age 1	0.12	0.16	0.24	0.18	0.26	0.25	0.09	0.21		0.22	0.06	0.09	0.16
age 2	0.33	0.32	0.28	0.24	0.30	0.30	0.30	0.30	0.34	0.41	0.24	0.34	0.33
age 3	0.48	0.70	0.67	0.44	0.42	0.43	0.50	0.47	0.48	0.55	0.47	0.60	0.60
age 4	0.73	0.66	1.06	0.95	0.90	0.86	0.68	1.01	0.86	1.01	0.87	1.00	1.08
age 5	1.29	1.63	1.30	1.39	1.34	1.32	1.27	1.57	1.45	1.40	1.32	1.33	1.85
age 6	1.80	2.35	1.81	2.08	1.67	1.65	1.56	2.10	1.90	1.87	1.74	1.75	2.07
age 7	2.08	2.43	2.25	2.19	2.48	2.50	1.71	2.48	2.28	2.49	2.10	2.33	3.02
age 8	2.07	2.69	4.66	4.58	2.73	2.78	2.36	3.28	2.42	3.07	2.74	2.90	3.73
age 9	2.60	2.87	4.48	3.36			3.87	2.46	3.22	3.30	2.93	3.08	3.88
age 10	2.57	6.15	3.61	3.80	3.40	3.19	2.13	2.13	2.77	5.40	3.28	3.59	5.73
age 11	8.25	3.26	5.20	5.55	2.73	4.98	9.53		5.01	4.13	10.91		
age 12		2.82	2.82	2.82			3.78	7.55	2.79	9.53	3.28		
age 13		4.13									8.69		
age 14			3.65	3.72			2.46				10.91		
age 15										3.22			
age 16						10.43							

Survey	P312	P327	H159	H179	H192	H204	H219	H232	N178	N192	N210	N230	N249
Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
age 0	0.06	0.03	0.06		0.06	0.05	0.03	0.06	0.07	0.06	0.05	0.01	0.01
age 1	0.14	0.08	0.15	0.11	0.10	0.09	0.07	0.18	0.16	0.12	0.13	0.11	0.13
age 2	0.29	0.21	0.25	0.19	0.23	0.22	0.21	0.25	0.28	0.26	0.25	0.24	0.24
age 3	0.57	0.41	0.47	0.43	0.41	0.43	0.35	0.46	0.45	0.45	0.51	0.46	0.49
age 4	0.93	0.75	0.78	0.68	0.70	0.61	0.63	0.67	0.62	0.67	0.81	0.72	0.66
age 5	1.48	1.27	1.25	1.20	1.08	1.06	0.99	1.06	0.94	0.94	1.13	1.10	1.05
age 6	2.10	1.93	1.97	2.03	1.73	1.63	1.45	1.56	1.48	1.29	1.66	1.77	1.43
age 7	2.57	2.58	2.79	2.96	2.69	2.42	2.04	2.16	1.88	1.45	2.33	2.89	1.71
age 8	3.15	3.50	3.37	3.79	3.77	3.48	3.80	3.69	2.90	2.58	3.13	3.29	1.89
age 9	2.74	4.69	4.61	6.61	6.07	5.45	4.10	4.34		4.71			1.81
age 10	6.05	3.34	6.52	6.63	9.03	6.99		6.56		0.00			
age 11	3.82	4.40	7.32			9.34		7.20					
age 12	6.60	10.28	7.93	8.23									
age 13		8.91	10.30										
age 14		10.77											
age 15		12.16											
age 16													

Research Vessels: E.E. Prince from 1971-85 (P)
Lady Hammond from 1986-91 (H)
Alfred Needler from 1992-96 (N)

Table 8. Mean length-at-age (cm) for white hake caught during research vessel surveys of the southern Gulf of St. Lawrence (NAFO Division 4T).

Survey	P091	P106	P122	P143	P157	P172	P188	P204	P229	P244	P260	P278	P296
Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
age 0													
age 1	25.4	28.0	29.4	26.4	32.5	31.8	23.4	29.5		31.0	20.8	23.3	27.8
age 2	35.0	34.3	33.2	31.3	34.1	34.1	33.6	33.6	34.8	37.0	32.5	35.7	35.5
age 3	38.9	44.6	42.2	37.7	37.7	38.0	39.6	38.6	38.6	40.9	40.0	43.0	42.8
age 4	45.3	43.0	50.9	48.9	48.0	47.5	44.1	49.8	47.2	49.9	49.0	51.3	52.5
age 5	54.1	57.9	54.4	55.2	54.6	54.4	53.3	57.3	55.8	55.6	56.2	56.3	62.6
age 6	59.9	65.6	60.2	63.3	59.0	58.7	57.1	63.1	60.8	60.9	61.5	61.7	65.2
age 7	62.3	66.0	64.8	64.4	67.0	67.1	59.3	66.3	64.7	66.5	65.2	67.4	73.8
age 8	62.8	68.6	80.4	80.4	69.2	69.6	65.7	72.4	65.5	70.6	70.5	72.7	78.4
age 9	67.9	67.7	79.2	73.9			75.9	67.0	73.0	72.2	72.2	73.4	80.2
age 10	67.9	86.8	74.9	76.3	74.2	72.7	64.0	63.7	67.4	83.1	76.0	76.3	91.0
age 11	98.4	73.2	85.0	86.8	69.2	80.3	103.0		83.9	79.0	112.0		
age 12		70.0	70.0	70.0			75.8	95.6	69.7	103.0	76.0		
age 13		79.0									103.1		
age 14			76.0	76.4			67.0				112.0		
age 15										73.0			
age 16						106.0							

Survey	P312	P327	H159	H179	H192	H204	H219	H232	N178	N192	N210	N230	N249
Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
age 0	22.0	16.7	19.7		20.8	19.2	16.5	18.5	21.7	19.3	18.5	11.6	9.9
age 1	26.9	22.8	26.9	25.7	23.8	22.9	20.4	29.0	27.8	25.3	26.4	24.9	26.1
age 2	33.8	31.1	32.0	30.6	32.3	30.9	30.8	32.7	33.9	32.6	32.5	32.0	31.8
age 3	42.2	37.6	39.0	39.5	38.6	39.1	36.3	39.8	39.7	39.4	41.0	39.6	40.1
age 4	48.9	45.8	46.0	45.3	45.6	43.6	44.2	44.9	44.2	45.1	47.5	45.8	44.2
age 5	56.6	53.9	53.6	54.1	52.1	52.0	51.1	52.0	50.7	50.3	53.0	52.3	51.4
age 6	62.9	61.7	62.0	63.6	60.4	59.7	58.1	59.0	58.8	55.9	60.0	61.0	56.9
age 7	66.8	67.2	69.2	71.6	69.6	67.7	64.9	65.7	63.9	58.2	66.9	71.1	60.2
age 8	71.2	73.3	73.2	76.7	77.1	76.2	79.5	78.0	74.1	71.0	73.6	74.2	61.1
age 9	68.6	80.0	80.0	91.9	89.7	88.2	82.0	83.0		86.6			61.7
age 10	84.9	72.6	90.1	92.0	101.7	95.6		94.9					
age 11	76.4	78.8	93.8			105.0		97.6					
age 12	88.2	103.1	96.0	98.4									
age 13		99.0	106.0										
age 14		104.9											
age 15		108.8											
age 16													

Research Vessels: E.E. Prince from 1971-85 (P)
Lady Hammond from 1986-91 (H)
Alfred Needler from 1992-96 (N)

Table 9. Research vessel estimates of the mean catch per tow (numbers and weight), population numbers and population biomass for white hake in the southern Gulf of St. Lawrence (NAFO Division 4T).

Year	Stratified Mean Number Per Tow	Variance	Stratified Mean Wt. (kg.) Per Tow	Variance	Estimated Population Numbers (000's) in NAFO 4T	Variance	Estimated Population Biomass (t) in NAFO 4T	Variance
1971	2.80	1.20	2.33	0.52	4838	3583318	4028	1552919
1972	1.73	0.23	3.24	1.59	2995	695312	5596	4758931
1973	5.83	17.46	7.60	28.98	10090	52212572	13134	86660015
1974	10.68	21.55	14.10	45.49	18470	64458299	24385	136048571
1975	8.26	15.57	5.11	1.60	14283	46551665	8837	4790655
1976	7.27	8.84	4.49	1.28	12576	26440912	7771	3823445
1977	4.47	1.59	3.77	0.84	7727	4745806	6515	2515284
1978	9.68	10.85	10.25	8.36	15711	28584269	16637	22038177
1979	8.28	6.95	9.97	8.94	14326	20794088	17243	26741492
1980	7.37	1.28	10.25	2.57	12747	3826823	17732	7688792
1981	11.88	13.55	17.89	33.68	20551	40514792	30937	100721146
1982	3.86	1.62	5.23	3.70	6677	4840525	9052	11080178
1983	3.58	0.39	4.11	0.40	6092	1130786	6989	1158737
1984	5.31	1.38	6.26	1.49	9395	4314411	11075	4658036
1985	8.99	7.61	10.60	11.23	15887	23780718	18738	35113495
1986	13.29	7.00	14.20	5.63	23492	21871241	25104	17588823
1987	6.95	2.11	7.57	2.40	12280	6588713	13381	7497788
1988	10.97	5.70	9.45	2.65	19096	17265929	16439	8019952
1989	12.73	6.74	8.03	1.71	22508	21055050	14195	5345043
1990	10.36	4.28	7.27	1.33	18320	13379505	12849	4157874
1991	9.51	9.83	6.80	3.01	16819	30727948	12021	9407318
1992	7.48	6.97	4.36	1.78	13231	21798588	7707	5578221
1993	3.62	0.71	2.31	0.34	6402	2207207	4089	1055358
1994	3.33	0.74	2.13	0.28	5892	2321388	3758	863747
1995	4.07	0.67	1.65	0.09	7196	2101322	2923	275990
1996	3.41	0.44	1.56	0.10	6025	1377045	2765	313495

Table 10. Research vessel estimates of the mean catch per tow (numbers and weight), population numbers and population biomass for white hake from the 'Strait' component (Strata 403, 420, 421, 422, 432 and 433).

Year	Stratified Mean Number Per Tow	Variance	Stratified Mean Wt. (kg.) Per Tow	Variance	Estimated Population Numbers (000's)	Variance	Estimated Population Biomass (t)	Variance
1984	8.54	25.35	11.49	26.65	2858	2840266	3846	2985351
1985	17.34	40.26	26.08	226.97	5804	4509717	8730	25425154
1986	23.55	75.00	26.82	89.68	7883	8401666	8976	10045613
1987	14.61	28.34	14.45	31.52	4889	3175050	4836	3530635
1988	12.51	37.71	8.63	19.00	3838	3549662	2647	1788625
1989	46.41	157.22	22.36	25.83	15532	17612182	7485	2893357
1990	33.23	99.27	15.55	17.71	11121	11119903	5204	1984085
1991	36.36	269.27	22.16	76.19	12168	30164381	7417	8534517
1992	29.00	189.59	15.68	47.80	9705	21237889	5249	5354791
1993	5.67	2.07	3.76	0.78	1899	231667	1258	86960
1994	12.51	17.09	8.21	6.56	4186	1914096	2747	734925
1995	13.91	14.88	5.94	2.12	4655	1667369	1987	237025
1996	4.80	0.54	1.50	0.09	1606	61022	501	10403

Table 11. Research vessel estimates of the mean catch per tow (numbers and weight), population numbers and population biomass for white hake from the 'Channel' component (Strata 415, 425, 437, 438 and 439).

Year	Stratified Mean Number Per Tow	Variance	Stratified Mean Wt. (kg.) Per Tow	Variance	Estimated Population Numbers (000's)	Variance	Estimated Population Biomass (t)	Variance
1984	28.79	33.11	30.96	37.47	5881	1382093	6325	1563934
1985	44.80	459.36	36.88	199.40	9153	19174945	7534	8323678
1986	70.35	318.43	63.76	135.48	14373	13292264	13027	5655133
1987	33.12	79.22	36.19	80.28	6767	3306891	7393	3351082
1988	69.06	323.41	59.95	134.82	14110	13499851	12249	5627639
1989	28.70	81.01	22.47	46.04	5864	3381403	4590	1921916
1990	30.35	52.70	26.95	32.08	6200	2199699	5506	1339279
1991	17.73	9.23	12.21	3.82	3623	385487	2496	159563
1992	16.05	13.26	10.23	4.96	3280	553644	2090	206946
1993	19.76	47.01	11.89	22.75	4038	1962490	2429	949542
1994	7.93	9.71	4.42	3.01	1621	405295	902	125552
1995	8.07	6.14	2.85	0.50	1650	256149	582	21037
1996	21.32	31.51	10.51	7.20	4357	1315426	2147	300618

Table 12. Research vessel estimates of the trawlable abundance (numbers) for strata 403 (St. Georges Bay) and 433 (Eastern Northumberland Strait) (separated and combined).

Year	Trawlable Abundance Stratum 403	Trawlable Abundance Stratum 433	Trawlable Abundance (Combined Areas)
1984	6.93	20.31	19.15
1985	26.67	46.75	45.01
1986	65.11	61.93	62.21
1987	21.58	36.14	34.88
1988	58.58	17.98	21.51
1989	532.66	81.68	120.85
1990	186.67	52.34	64.01
1991	80.27	77.93	78.13
1992	131.57	75.68	80.53
1993	79.93	5.16	11.65
1994	23.16	33.4	32.51
1995	189.41	14.68	29.86
1996	44.94	2.67	6.34

Table 13. Comparison of the commercial catch-at-age for the "Strait" component with the catch-at-age (thousands) for NAFO Div. 4T.

Strait Component:

AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
3	56	2	25	1	9	30	25	112	48	24	1	2
4	189	194	454	34	97	541	367	879	317	128	1	19
5	532	458	1159	413	490	1047	941	904	368	176	2	27
6	518	421	769	563	691	888	771	487	184	192	8	23
7	342	278	351	445	588	382	455	238	71	82	11	12
8	199	215	127	94	191	72	71	53	22	27	3	6
9	95	59	58	13	64	16	15	22	7	5	1	1
10+	85	73	23	8	30	10	12	14	3	1	1	1

NAFO 4T:

AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1-2	3	0	0	0	5	0	0	0	0	0	0	0
3	64	2	30	0	11	34	28	127	79	25	0	2
4	216	204	531	39	114	604	409	1000	312	134	0	20
5	608	496	1357	476	574	1170	1048	1028	400	185	2	29
6	592	477	900	648	810	992	859	554	217	201	9	24
7	391	330	411	513	689	427	507	270	87	86	12	13
8	227	233	149	109	224	80	79	61	27	28	4	6
9	108	77	68	15	76	18	17	26	10	5	0	1
10+	97	89	27	9	35	12	13	16	4	1	0	0

Table 14. Parameter estimates from the ADAPT SPA calibration for white hake using the research survey index for the 'Strait' component.

Parameter	Parameter Estimate	Std. Error	C.V.	T - Stat.	% Bias
age 3 - Abund.	100.94626	95.86595	0.94967	1.05299	45.98910
age 4 - Abund.	231.99067	162.43639	0.70019	1.42819	24.42550
age 5 - Abund.	271.92953	159.44815	0.58636	1.70544	16.89602
age 6 - Abund.	186.23650	101.97313	0.54755	1.82633	15.02915
age 7 - Abund.	158.05930	87.55515	0.55394	1.80525	14.50827
age 8 - Abund.	41.61007	26.40002	0.63446	1.57614	19.17371
age 3 - Q	0.00250	0.00072	0.28690	3.48551	3.19793
age 4 - Q	0.00261	0.00072	0.27650	3.61662	3.16258
age 5 - Q	0.00226	0.00061	0.27237	3.67149	3.26770
age 6 - Q	0.00192	0.00052	0.27153	3.68288	3.44557
age 7 - Q	0.00198	0.00054	0.27448	3.64328	4.12447
age 8 - Q	0.00271	0.00076	0.27971	3.57512	4.96246

Table 15a. Input data for the ADAPT calibration of SPA for the "Strait" component.

Commercial Fishery Catch-at-Age for the "Strait" Component: 1985-1996.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
3	56	2	25	1	9	30	25	112	48	24	1	2
4	189	194	454	34	97	541	367	879	317	128	1	19
5	532	458	1159	413	490	1047	941	904	368	176	2	27
6	518	421	769	563	691	888	771	487	184	192	8	23
7	342	278	351	445	588	382	455	238	71	82	11	12
8	199	215	127	94	191	72	71	53	22	27	3	6
9	95	59	58	13	64	16	15	22	7	5	1	1
10+	85	73	23	8	30	10	12	14	3	1	1	1

Research Vessel Catch-at-Age for the "Strait" Component: 1985-1996.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
3	4.457	3.975	4.573	2.204	17.316	8.983	10.936	10.261	0.420	1.877	2.122	0.266
4	2.269	7.144	5.036	2.681	9.527	4.138	7.537	9.649	1.208	3.248	1.923	0.256
5	1.740	4.346	2.897	2.374	3.704	2.912	4.295	2.745	1.116	1.609	0.634	0.229
6	1.926	1.598	0.893	0.612	1.618	0.562	1.781	0.626	0.549	0.578	0.438	0.157
7	1.898	0.790	0.278	0.194	0.305	0.672	0.623	0.133	0.064	0.122	0.136	0.074
8	1.425	0.446	0.125	0.066	0.055	0.223	0.106	0.014	0.121	0.098	0.063	0.018
9	1.065	0.326	0.120	0.018	0.029	0.094	0.000	0.000	0.063	0.000	0.000	0.014
10+	0.426	0.448	0.120	0.077	0.000	0.000	0.027	0.000	0.000	0.000	0.000	0.000

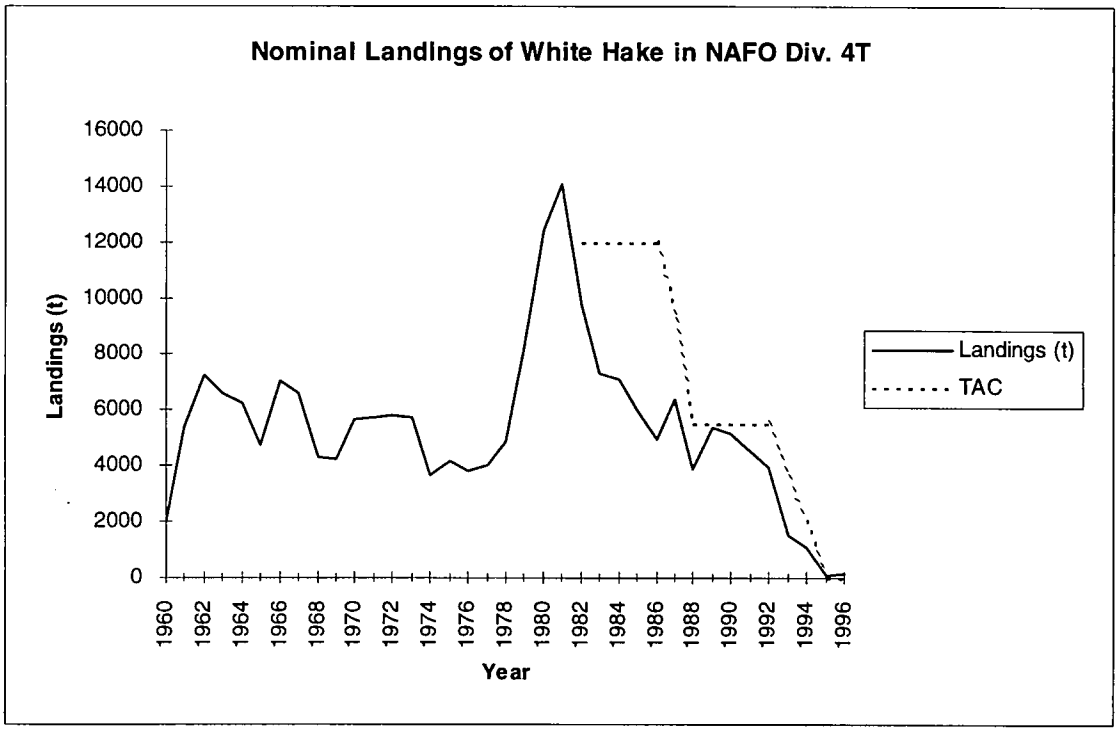
Table 15b. Estimates of fishing mortality and beginning of year population numbers for southern Gulf white hake from the ADAPT calibration of SPA.

a. Fishing mortality for white hake in the southern Gulf of St. Lawrence obtained with ADAPT.

Age/Year	85	86	87	88	89	90	91	92	93	94	95	96
3	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.10	0.09	0.06	0.00	0.03
4	0.06	0.05	0.17	0.01	0.03	0.23	0.21	0.71	0.48	0.36	0.00	0.09
5	0.32	0.21	0.51	0.23	0.23	0.57	0.80	1.22	0.75	0.53	0.01	0.10
6	0.64	0.46	0.63	0.50	0.75	0.86	1.19	1.49	0.91	1.25	0.04	0.12
7	0.63	0.89	0.92	0.98	1.80	1.40	1.90	2.01	0.95	1.65	0.19	0.08
8	0.94	1.11	1.64	0.68	2.08	1.40	1.17	1.64	1.32	1.33	0.21	0.15
9	0.73	0.82	1.06	0.72	1.54	1.22	1.42	1.71	1.06	1.37	0.13	0.10
10+	0.73	0.82	1.06	0.72	1.54	1.22	1.42	1.71	1.06	1.37	0.13	0.10
Ave. 4+	0.58	0.62	0.86	0.55	1.14	0.99	1.16	1.50	0.93	1.12	0.10	0.11
Ave. 6+	0.73	0.82	1.06	0.72	1.54	1.22	1.42	1.71	1.06	1.39	0.14	0.11
Ave. 7+	0.76	0.91	1.17	0.78	1.74	1.31	1.48	1.77	1.10	1.43	0.17	0.11

b. Beginning of year population estimates for southern Gulf white hake estimated by ADAPT calibration: 1985-1996 (numbers in 1,000's)

Age/Year	85	86	87	88	89	90	91	92	93	94	95	96
3	5102	3936	3987	4086	3557	2639	2364	1254	626	483	287	69
4	3528	4126	3221	3241	3345	2904	2134	1913	925	469	373	234
5	2119	2717	3203	2226	2623	2651	1888	1415	771	471	268	305
6	1207	1254	1810	1574	1449	1704	1223	695	340	298	226	218
7	812	520	646	786	779	561	592	304	128	112	70	178
8	360	355	174	211	241	106	114	73	33	41	18	48
9	199	115	96	28	88	25	21	29	12	7	9	12
10+	178	142	38	17	41	15	17	18	5	1	9	12
Totals	13506	13165	13174	12169	12122	10605	8352	5699	2840	1882	1261	1075



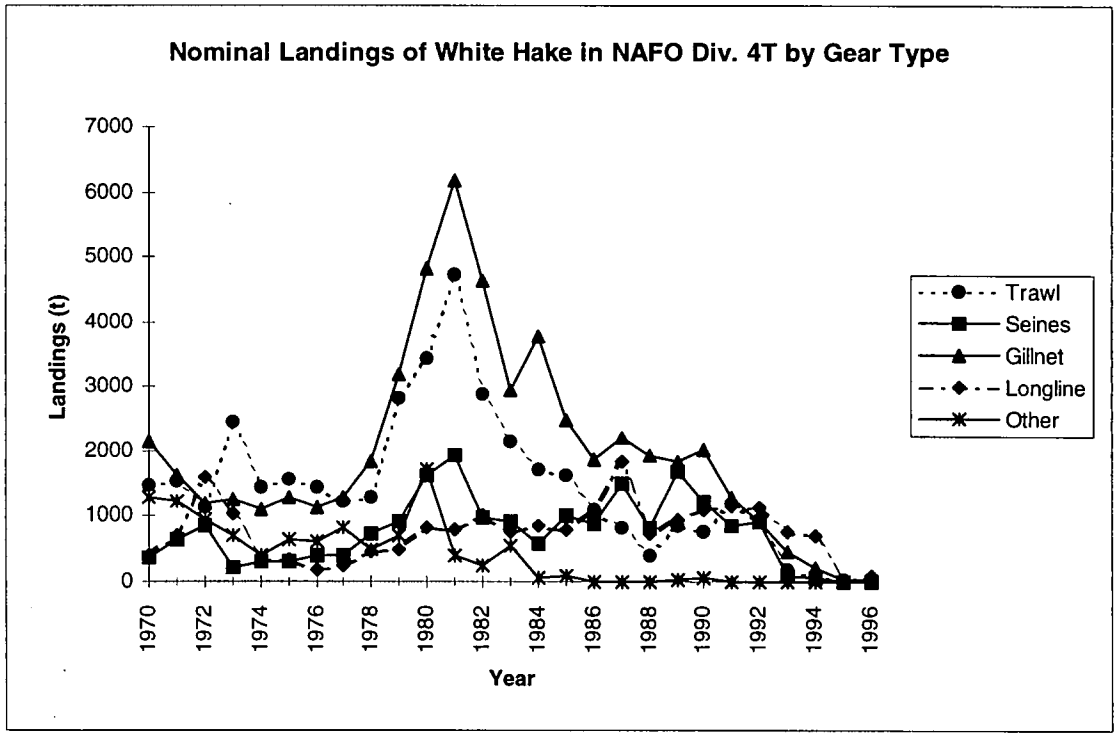


Figure 1 a. Nominal landings and TAC's for white hake in NAFO Division 4T.
b. Nominal landings by gear category for white hake in NAFO Division 4T.

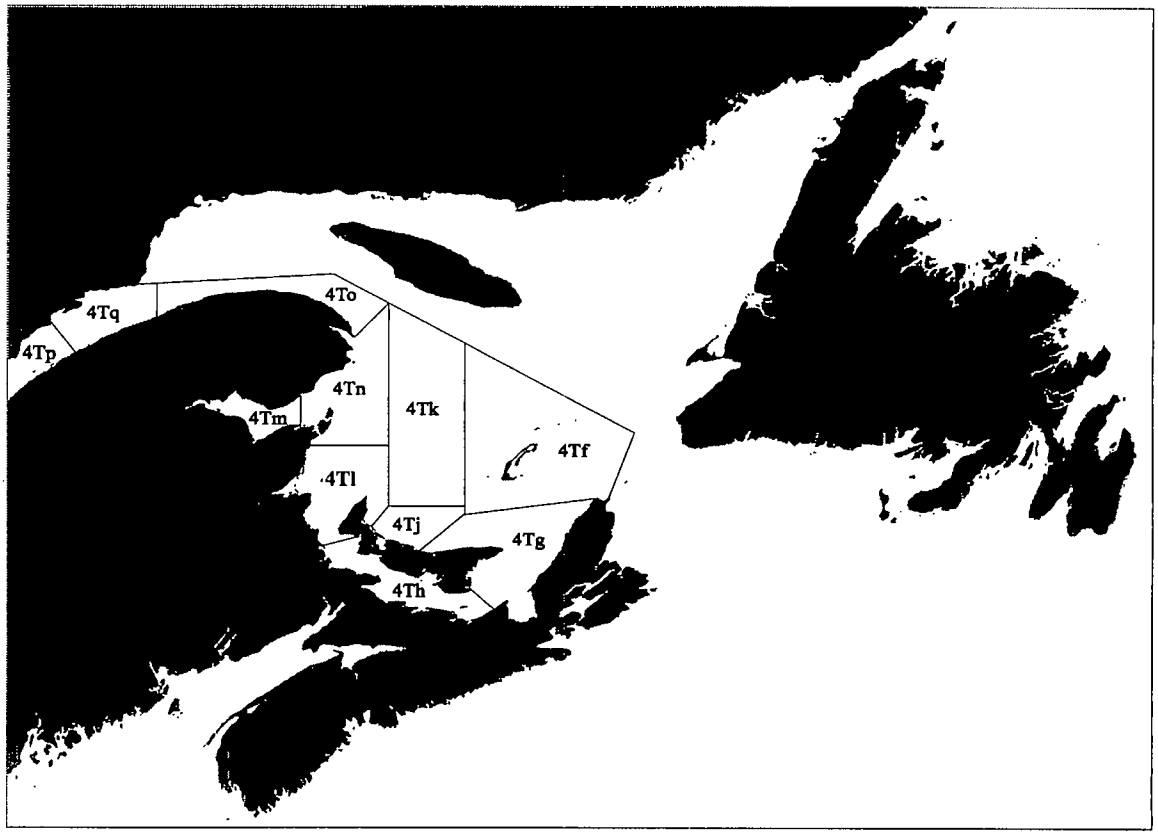


Figure 2. Statistical unit areas in the southern Gulf of St. Lawrence (NAFO Division 4T).

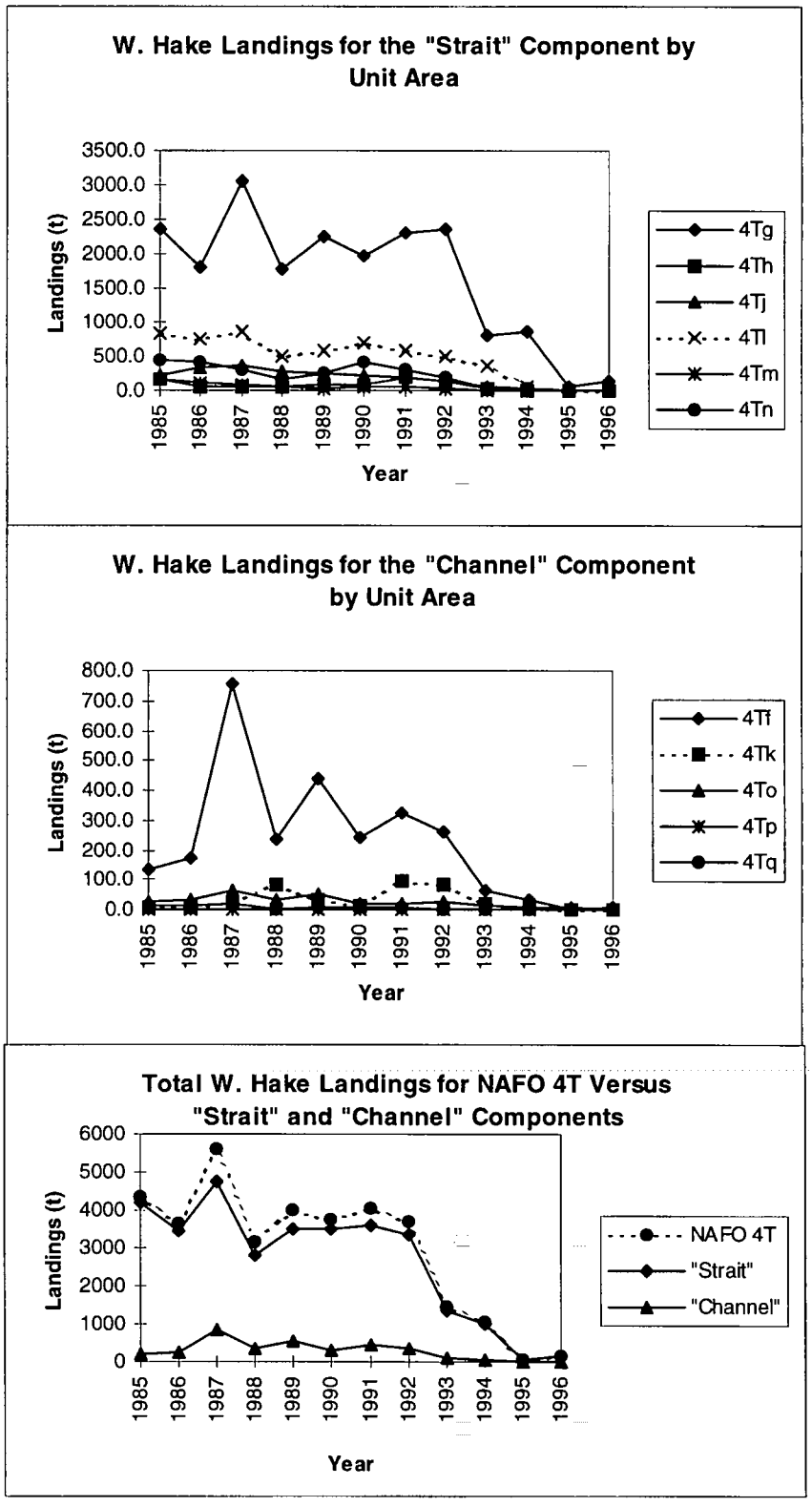


Figure 3. Comparison of landings of white hake in NAFO Division 4T by statistical unit area and stock component: 1985-1996.

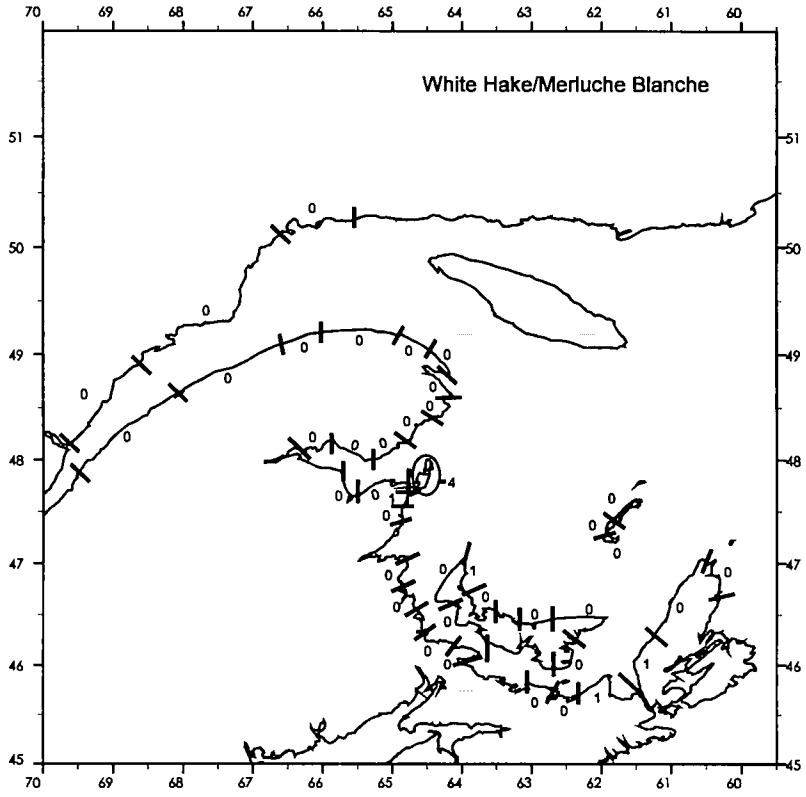


Figure 4. The geographical distribution of respondents that fished for white hake "most of the time' in 1996 (These species were either the first, second or third priority of respondents that fished for more than one species of groundfish in 1996). The lines delimit the borders of statistical districts occupied by respondents.

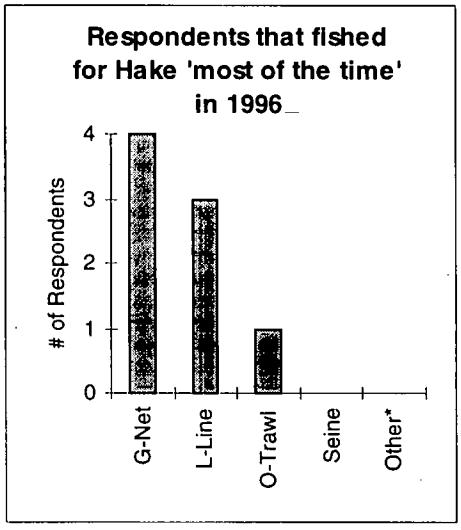


Figure 5. The fishing gears that were used by respondents who said they fished for white hake , 'most of the time' in 1996.

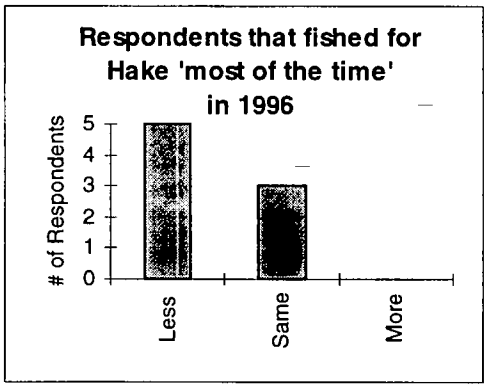


Figure 6. Comparison to previous years of the amount of fishing gear used in 1996 (Note: White hake was their 'first, second or third priority' in 1996).

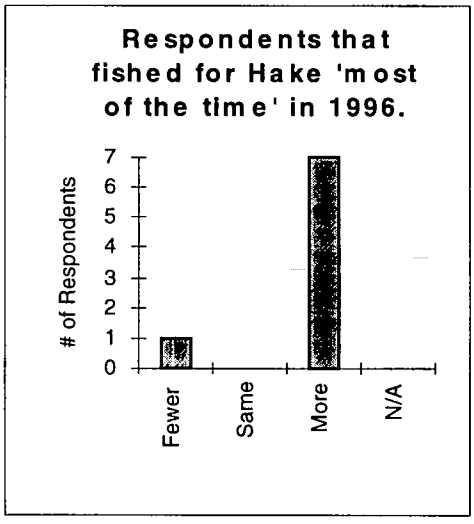


Figure 7. Comparison to 1995 of the number of days spent fishing for groundfish in 1996 (Note: White hake was their 'first, second or third priority' in 1996).

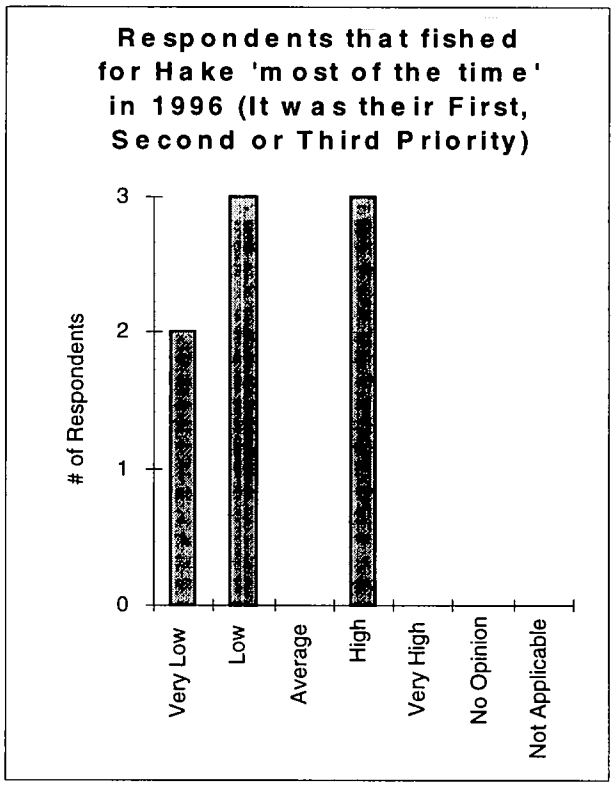


Figure 8a. Opinions of respondents concerning the abundance of white hake in 1996.

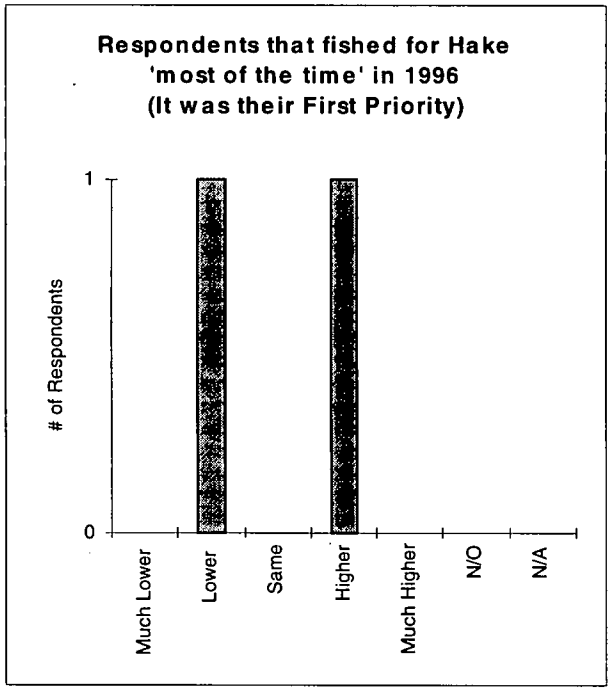
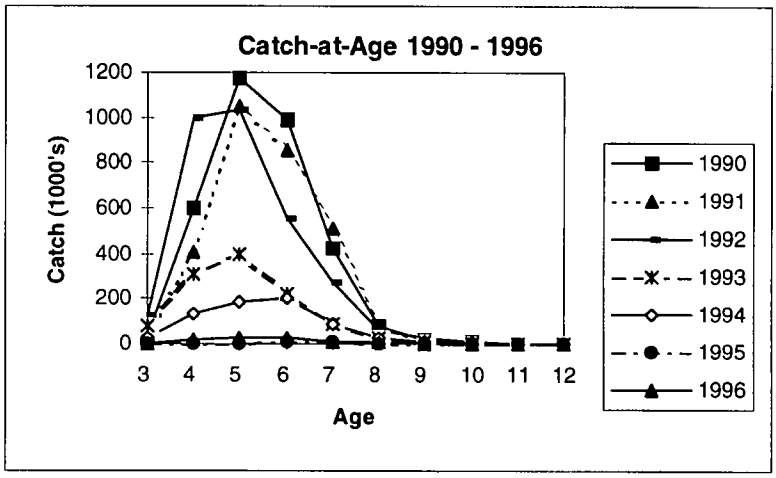
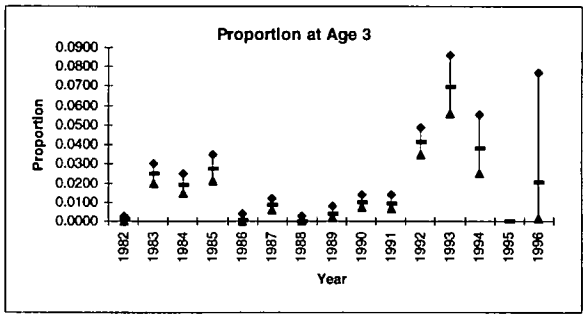
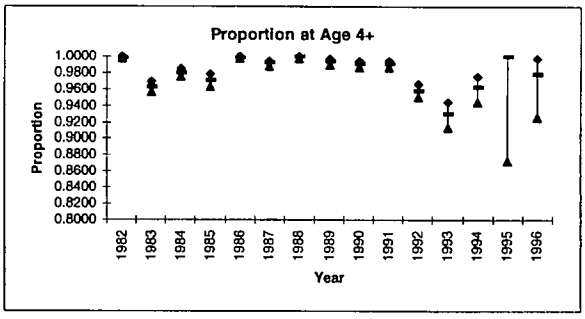
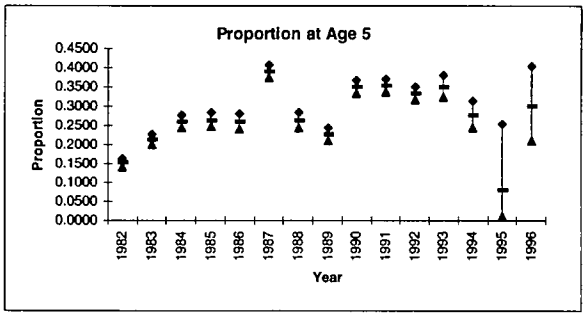


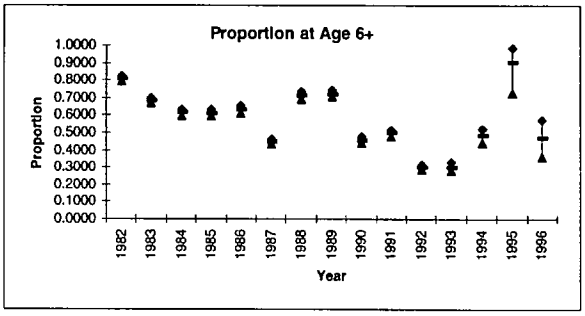
Figure 8b. Opinions of respondents asked to compare the abundance of white hake in 1996 with its abundance during all their years fishing for this species.

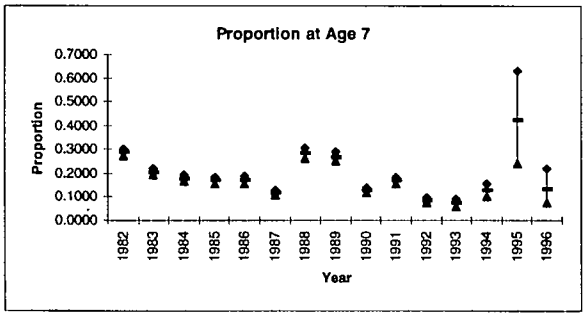












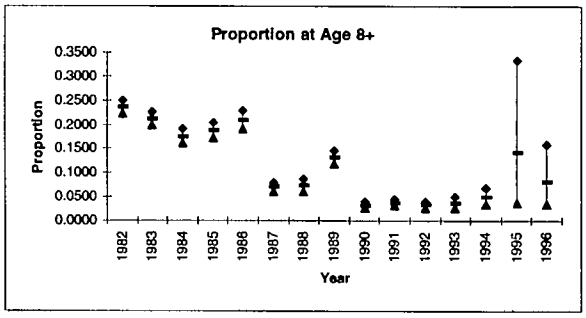
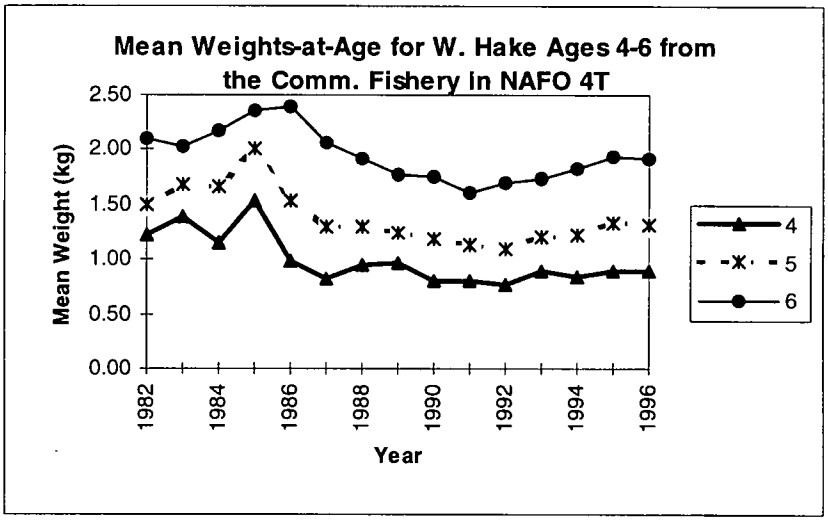


Figure 9. a. Commercial fishery catch-at-age for white hake in NAFO Division 4T: 1990-1996.
b. Proportional composition of the commercial fishery catch-at-age for white hake: Ages 3, 5 and 7 and Age Groups 4+, 6+ and 8+ with 95% binomial confidence intervals.



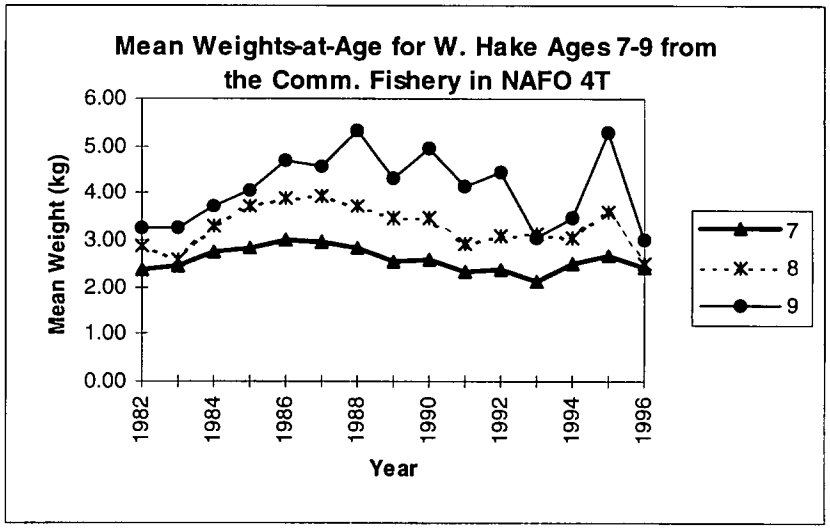


Figure 10. Trends in mean weights-at-age (kg) for white hake (Ages 4-9) from the commercial fishery in the southern Gulf of St. Lawrence.

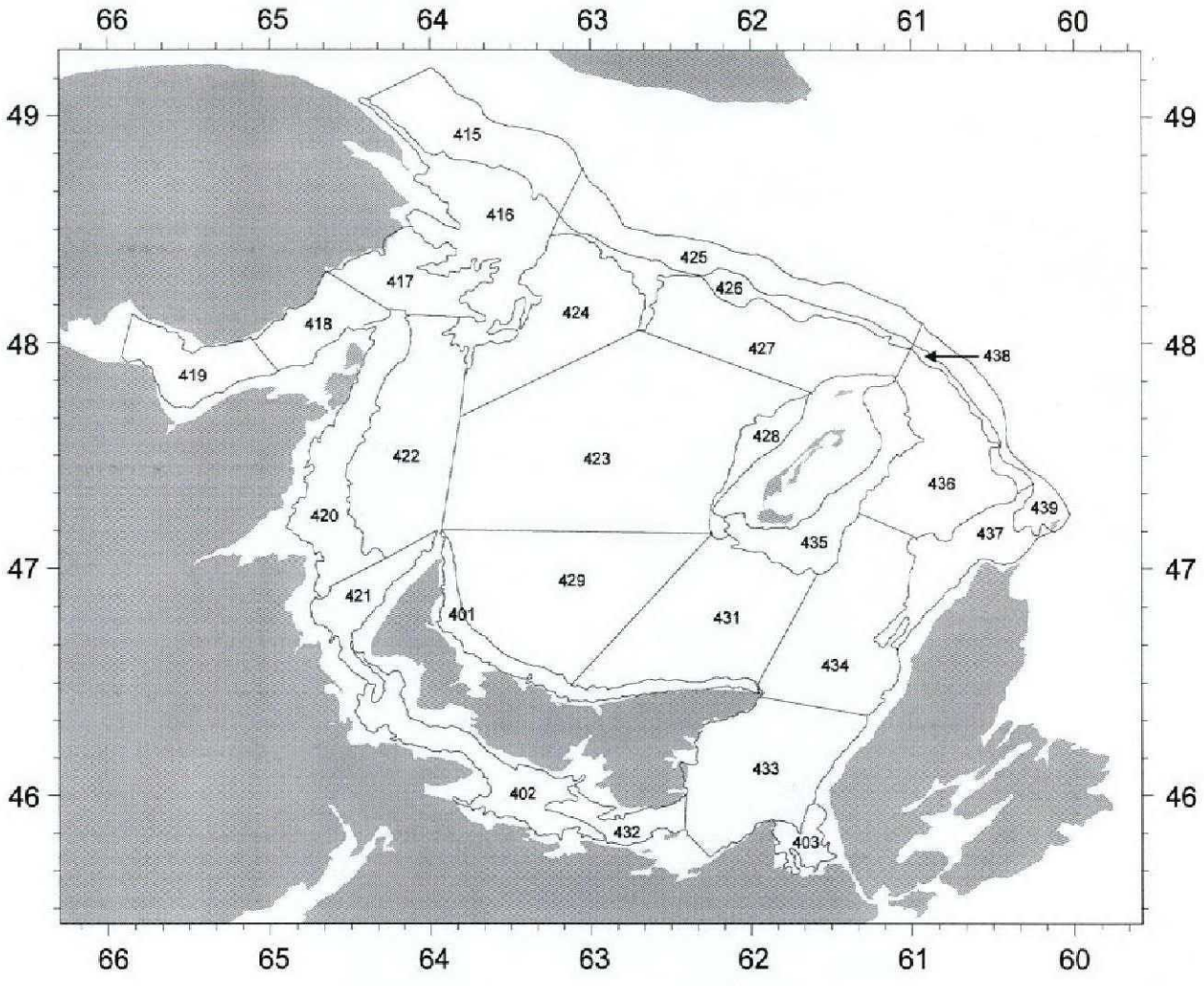


Figure 11. Stratification scheme for the annual (September) groundfish abundance survey of the southern Gulf of St. Lawrence.

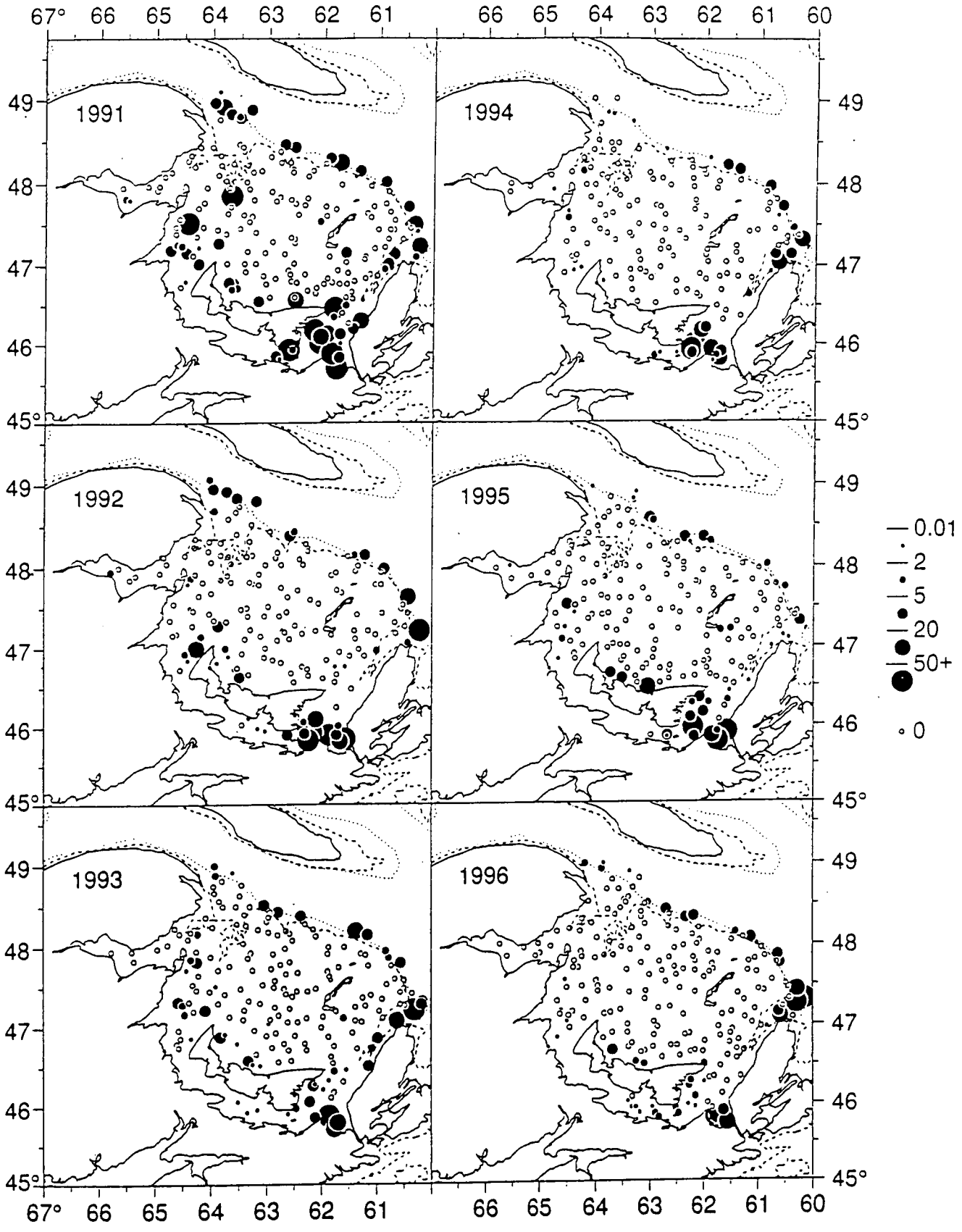


Figure 12. Location of white hake catches (kg) during six annual (September) groundfish surveys of the southern Gulf of St. Lawrence.

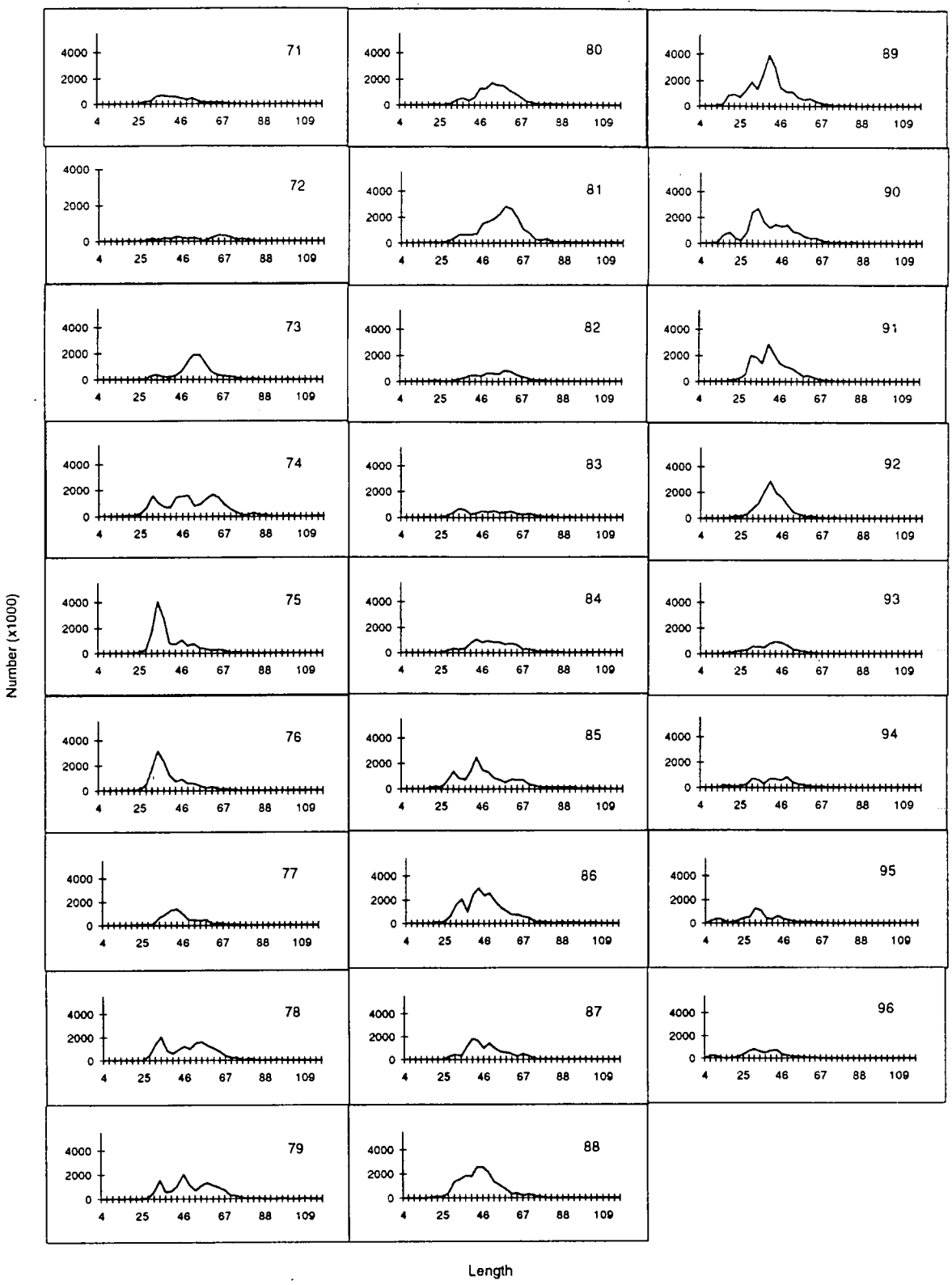


Figure 13. Annual length frequencies for white hake from September groundfish surveys of the southern Gulf of St. Lawrence: 1971-1996 (Note: Strata 415-439 for 1971-1983 and Strata 401, 403, 415-439 for 1984-1996).

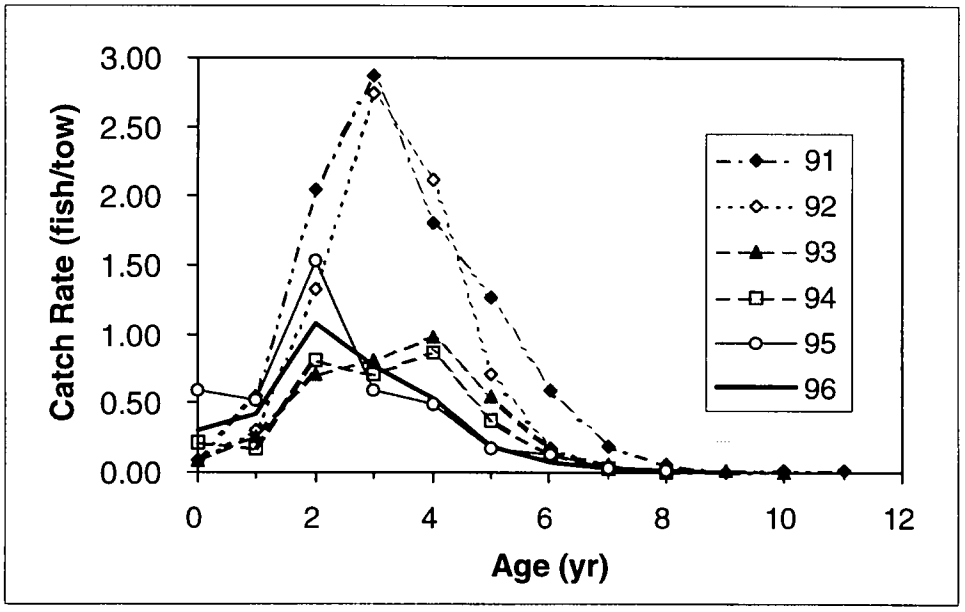


Figure 14 a. Research vessel stratified mean catch per tow-at-age for white hake in NAFO Division 4T: 1991-1996.

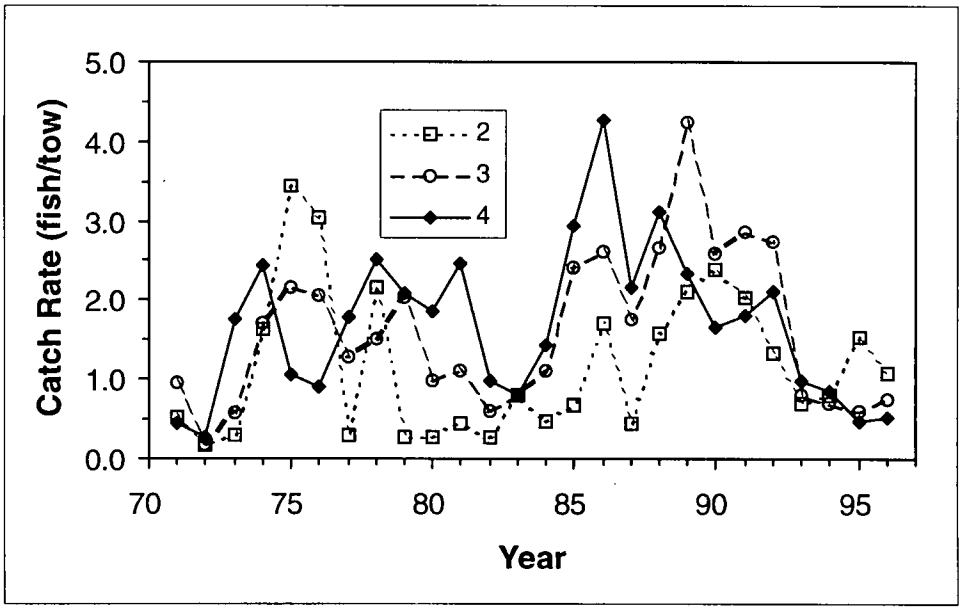


Figure 14 b. Research vessel stratified mean catch per tow-at-age for white hake in NAFO Division 4T: Ages 2, 3 and 4, 1971-1996.

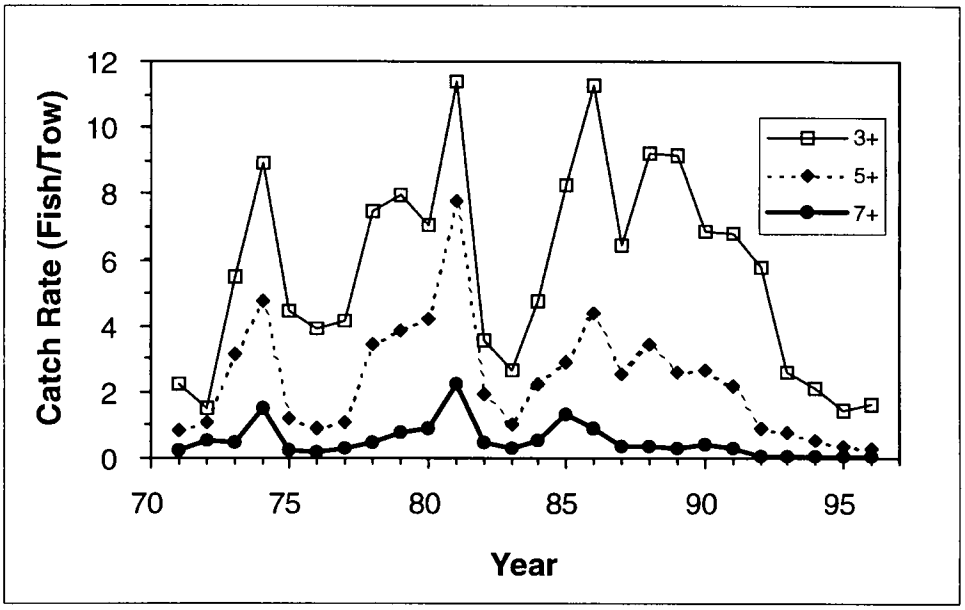


Figure 14 c. Research vessel stratified mean catch per tow-at-age for white hake in NAFO Division 4T: Ages 3+, 5+ and 7+, 1971-1996.

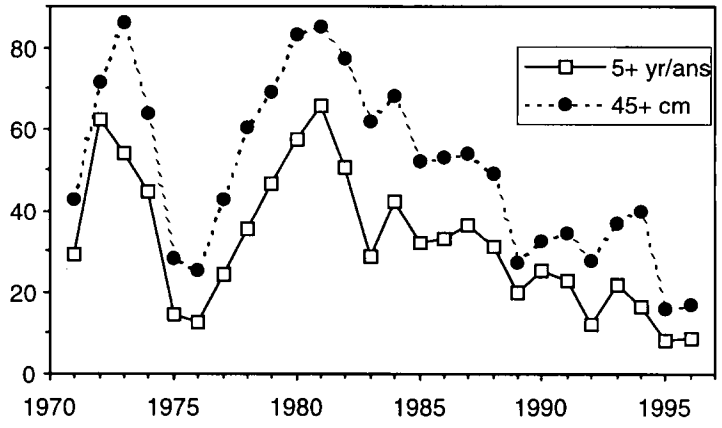


Figure 14 d. Percentage of white hake 5 years and older or 45 cm and longer from research vessel surveys in NAFO Division 4T.

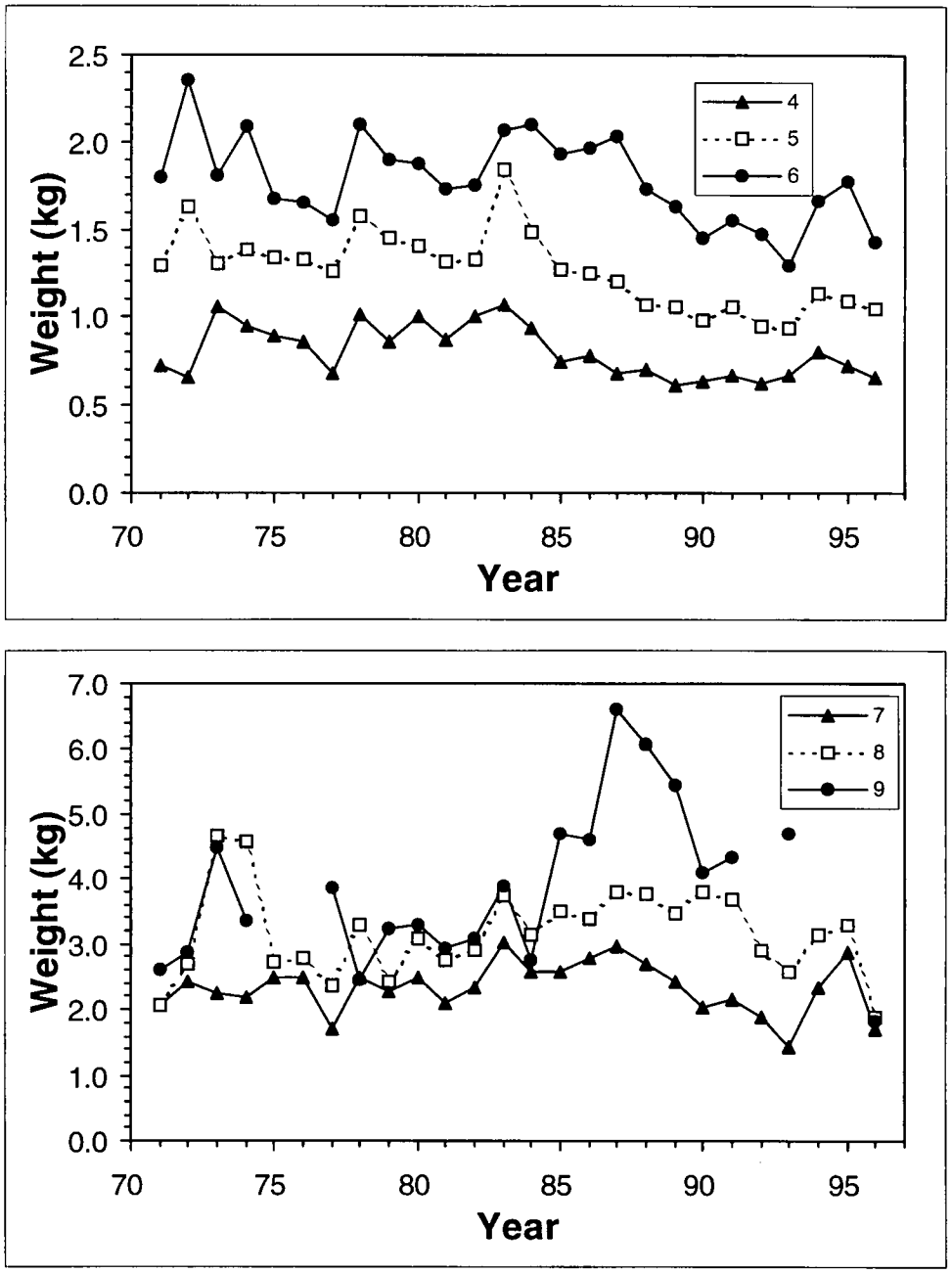


Figure 15. Trends in mean weights-at-age (kg) for white hake (Ages 4-9) from the annual (September) surveys of the southern Gulf of St. Lawrence.

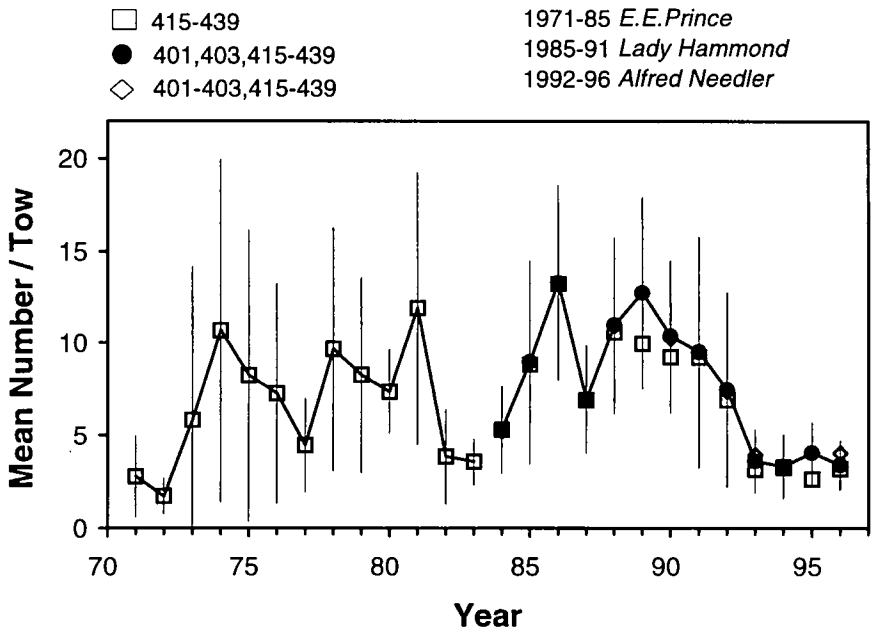


Figure 16. Stratified mean catch rate (fish/tow) of white hake in the September bottom trawl survey of the southern Gulf of St. Lawrence (NAFO Division 4T). Vertical bars show +/- 2 SD. The lines and vertical bars are for strata 415-439 in 1971-83 and strata 401,403 and 415-439 in 1984-96. The research vessels used in each of the surveys are indicated by different symbols in the legend (upper).

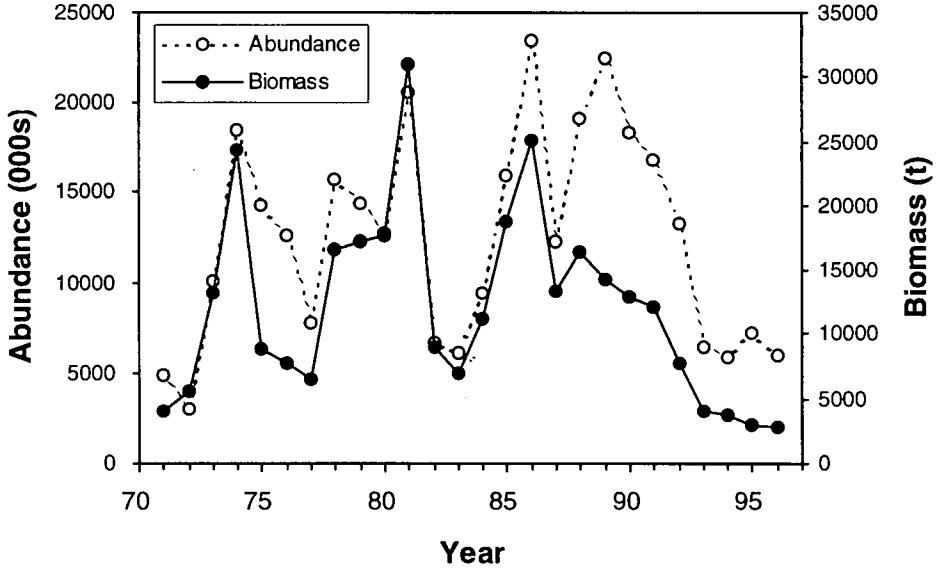


Figure 17. Estimated population numbers (1,000's) and biomass (t) for white hake in NAFO Division 4T.

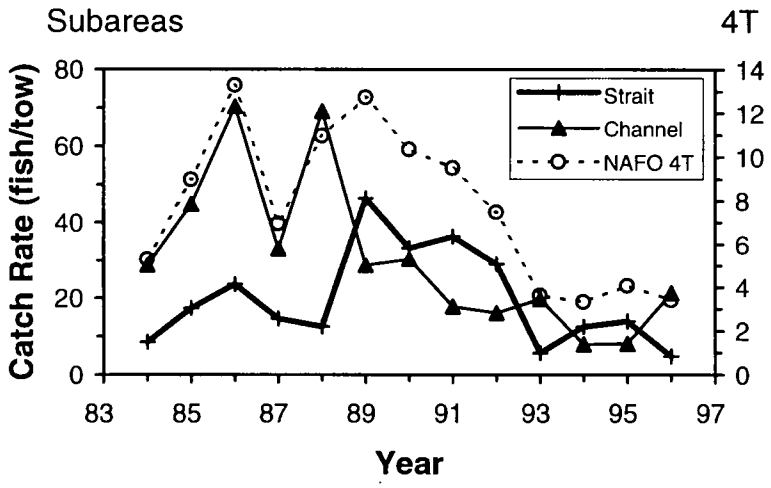


Figure 18. Comparison of research vessel abundance indices (stratified mean catch per tow) for all of NAFO Division 4T and for the Strait and Channel subareas (Note the difference in scale between the subarea indices and the overall 4T index).

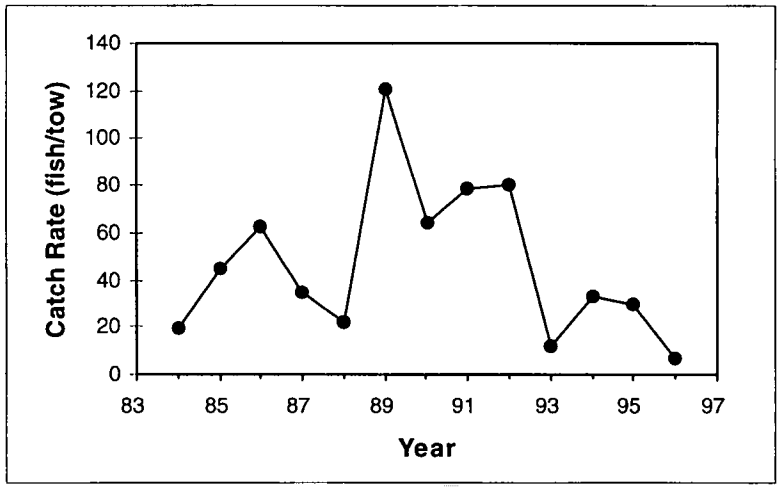


Figure 19. Research vessel estimates of the stratified mean catch (numbers) per tow for white hake in two strata in the southeastern Gulf (403 and 433).

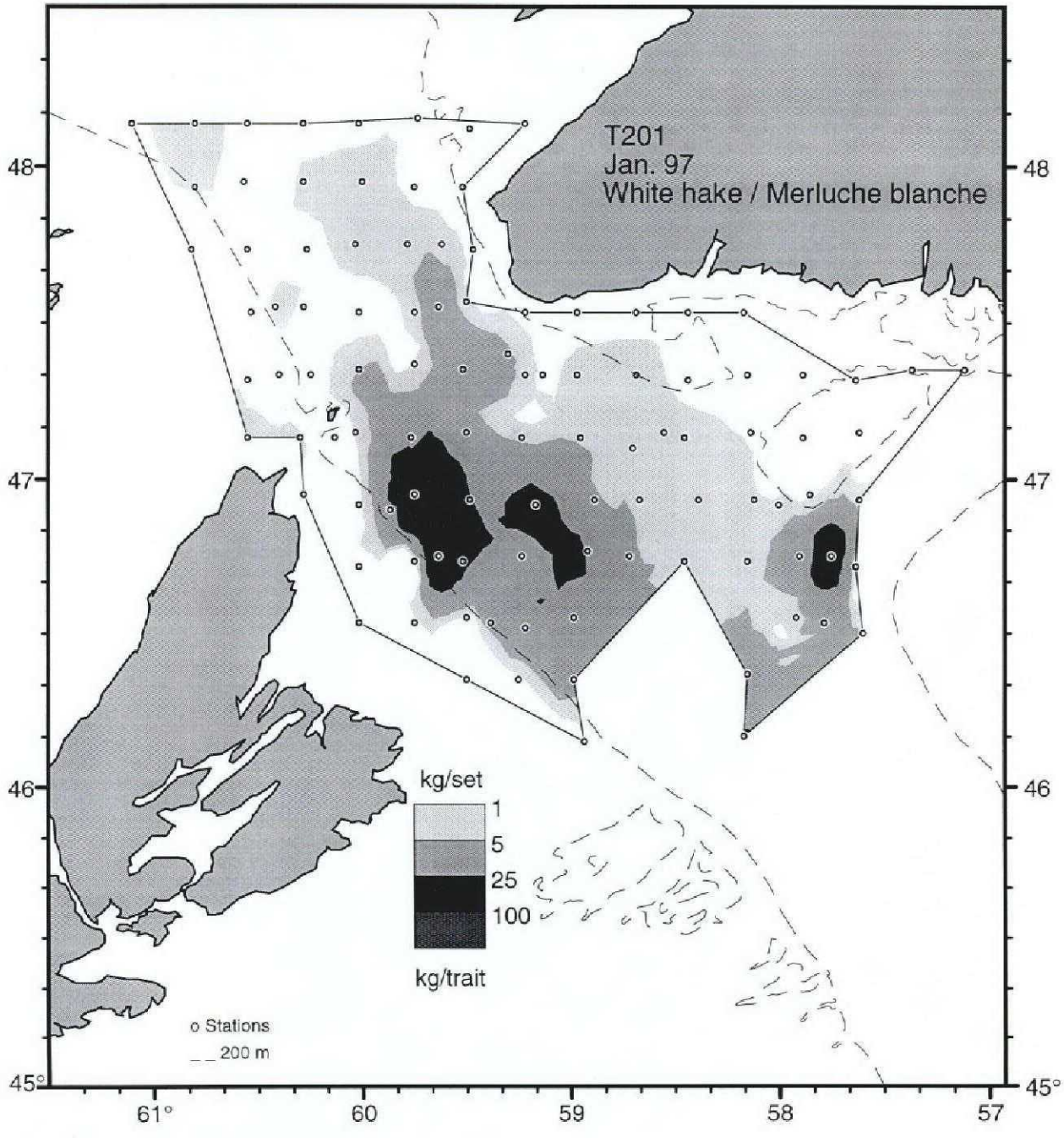


Figure 20. Catches of white hake (kg/standard tow) during the January 5-28, 1997 groundfish survey in Cabot Strait (open circles indicate set locations, dashed line is 200 m contour).

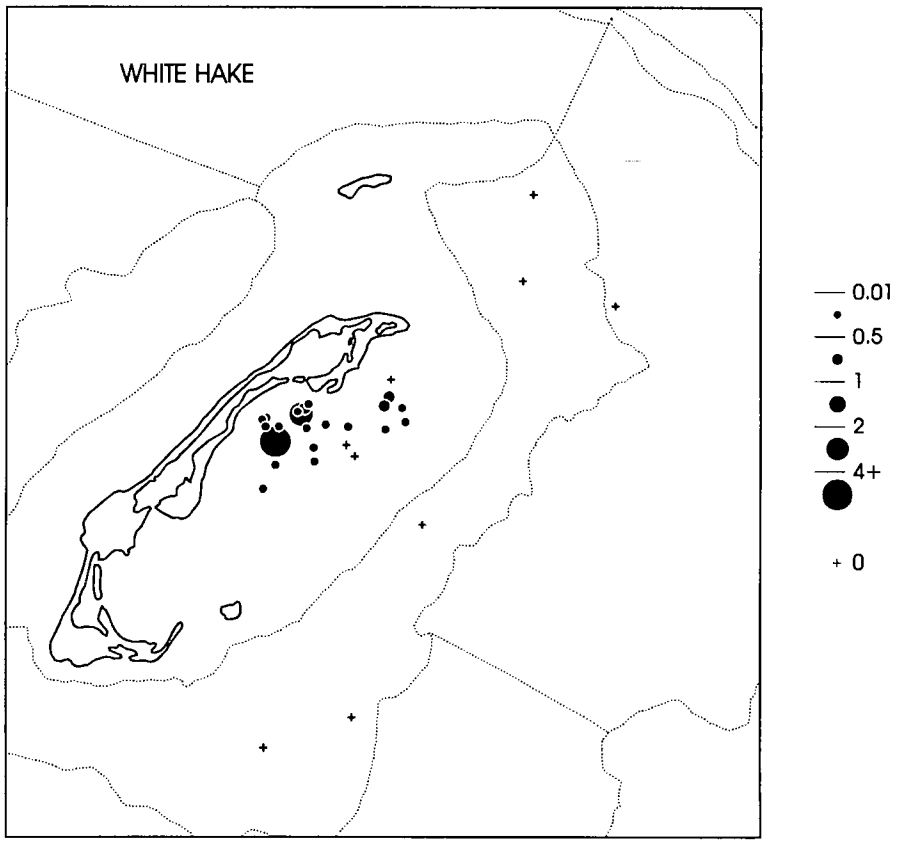


Figure 21a. Location of white hake catches (numbers) during the 1996 *Calanus II* inshore survey.

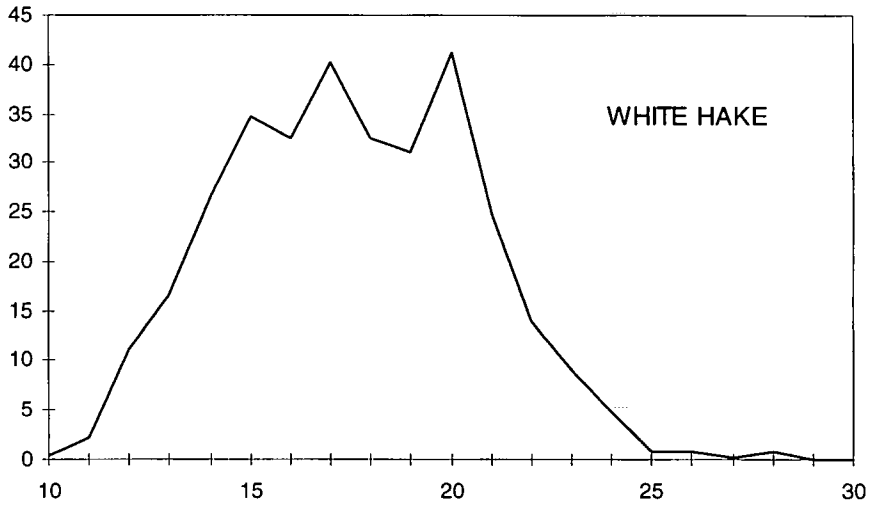


Figure 21b. Length frequency for white hake caught in the 1996 *Calanus II* inshore survey.

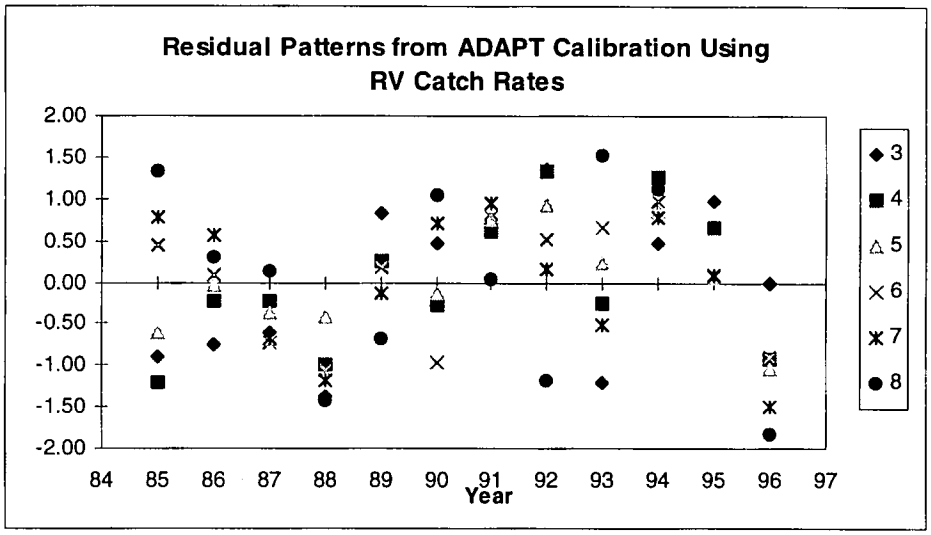


Figure 22. Comparison of residual patterns from SPA calibrations using the ADAPT tuning method and the research survey abundance index for the 'Strait' component.

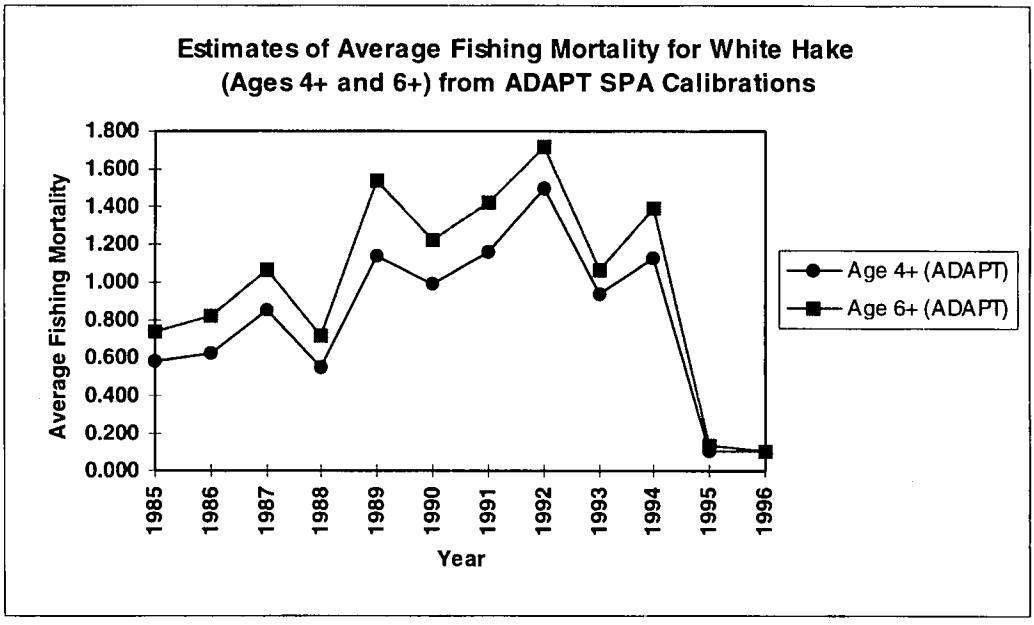


Figure 23. Comparison of estimates of fishing mortality (F) for white hake from the "Strait" component from SPA calibrations using the ADAPT tuning method.

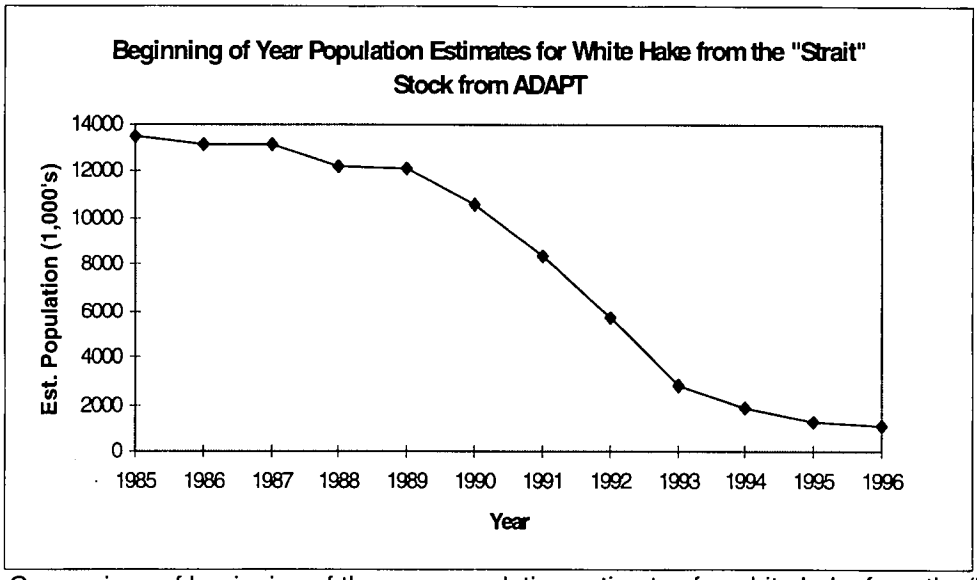


Figure 24. Comparison of beginning of the year population estimates for white hake from the "Strait" stock from SPA calibrations using the ADAPT tuning method.

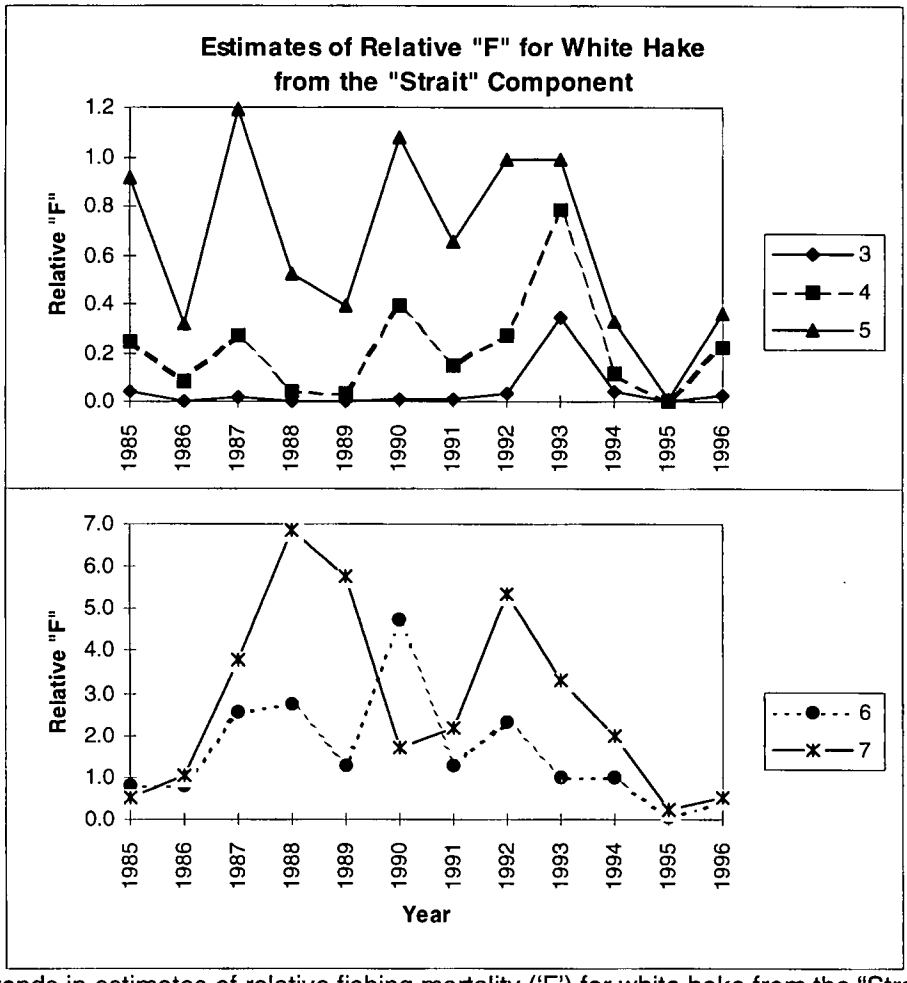


Figure 25. Trends in estimates of relative fishing mortality ('F') for white hake from the "Strait" component: 1985-96.

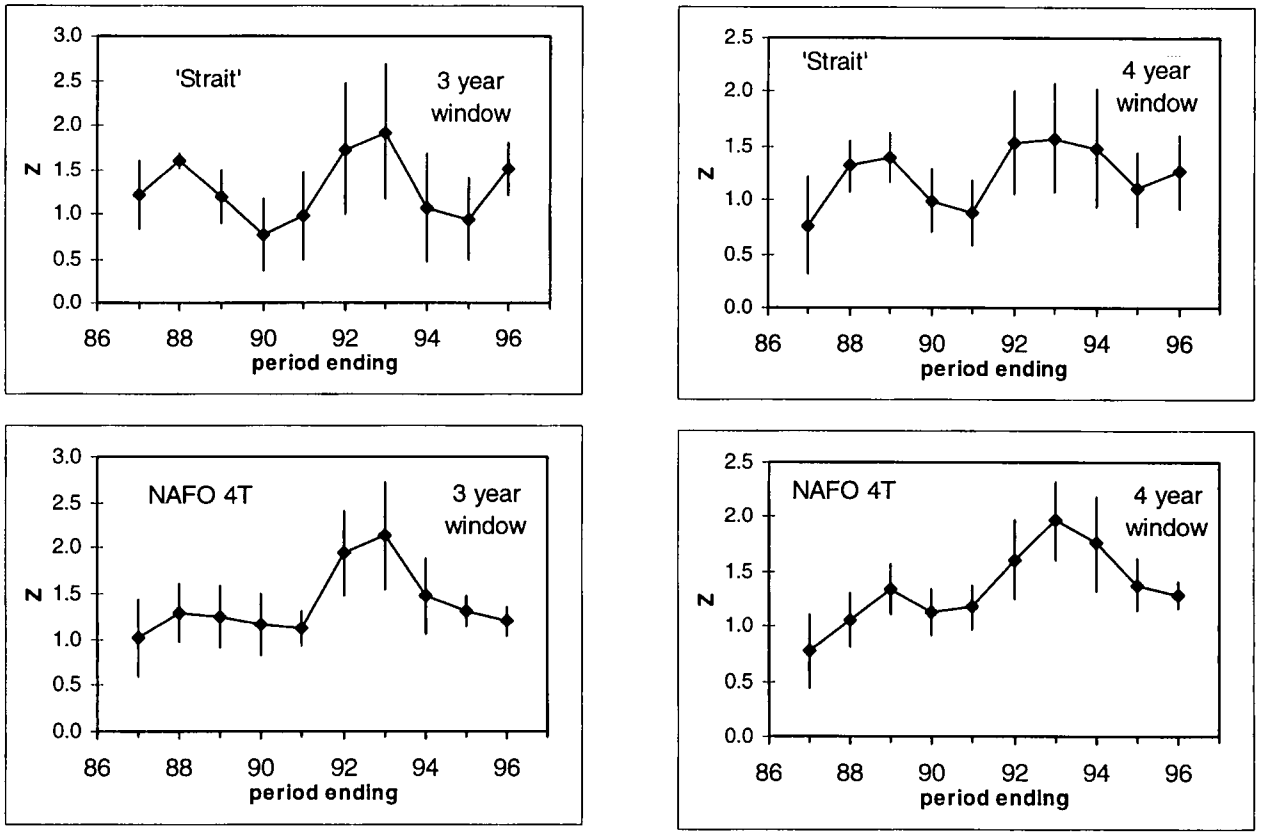


Figure 26. Estimates of total mortality (Z) for white hake in NAFO 4T (strata 401,403, 415-439) and the 'Strait' component of NAFO 4T (403, 420-422, 432, 433). Estimates are for 3 or 4 year windows ending in the year shown on the X-axis. Error bars are 2 SE.

Appendix 1 - Sentinel Surveys

Table A1. Summary of 1996 cod and hake catch results in southern Gulf of St. Lawrence sentinel surveys. GNS = gillnets, LLS = Longlines, OTB = Otter trawl, SNU = Seine, OTB-E = Otter trawl in eastern P.E.I., and OTB-W = Otter trawl in western P.E.I.

					White Hake			
Area	Gear	Liner	# trips	Amount of gear (sets, nets or 1000 hooks)	Catch (kg)	Catch rate (kg per set; kg per net or kg per 1000 hooks)	Numbers	Numbers per tow, net or 1000 hooks
GAS	GNS		48	463	0	0	0	0
GAS	LLS		48	120	0	0	0	0
GAS	OTB	no	18	216	14	0.1	2	0
GAS	OTB	yes	6	73	1	0.01	0	0
N.B.	GNS		49	479	202	0.4	104	0.2
N.B.	LLS		38	51	20	0.4	7	0.1
N.B.	SNU	no	20	233	117	0.5	131	0.6
N.B.	SNU	yes	6	60	77	1.3	40	0.7
P.E.I.	GNS		51	500	8331	16.7	3679	7.4
P.E.I.	LLS		64	130	2124	16.3	1211	9.3
P.E.I.	OTB-E	no	9	107	161	1.5	45	0.4
P.E.I.	OTB-E	yes	3	36	315	8.8	233	6.5
P.E.I.	OTB-W	no	9	105	4	0.04	1	0.01
P.E.I.	OTB-W	yes	3	36	8	0.2	4	0.1
MAG	LLS		48	121	59	0.5	12	0.1
MAG	SNU	no	11	103	61	0.6	48	0.5
MAG	SNU	yes	3	33	34	1.1	17	0.5
N.S.	GNS		48	475	15828	33.4	6260	13.2
N.S.	LLS		96	240	76642	319.4	48734	203.1
N.S.	OTB	no	9	108	17	0.2	6	0.1
N.S.	OTB	yes	3	36	362	10.1	58	1.6
N.S.	SNU	no	9	107	427	4.0	161	1.5
N.S.	SNU	yes	3	36	104	2.9	399	11.1
Total			602		104,908		61,151	

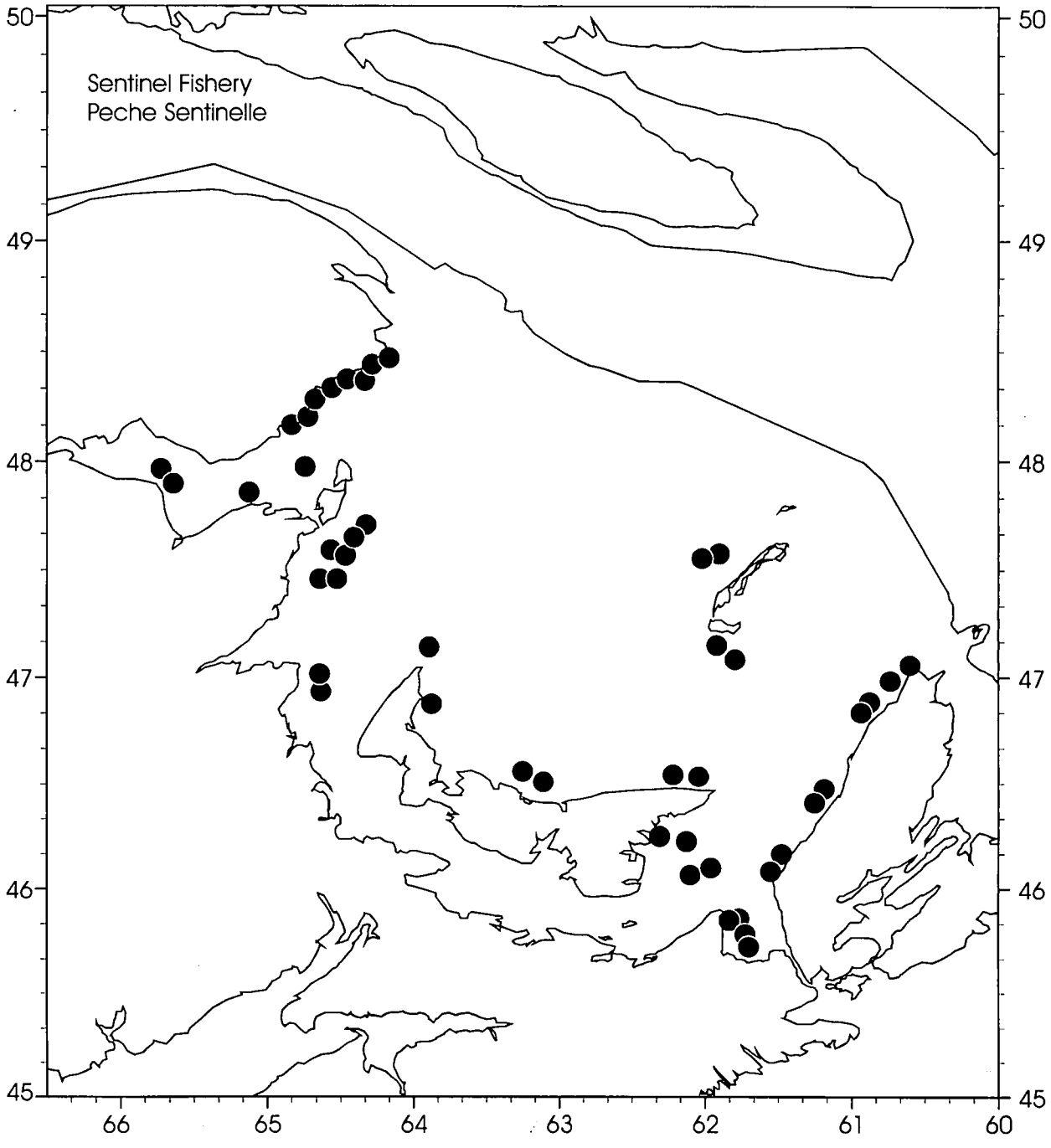


Figure A1. Locations of the fishing sites for the fixed gear sentinel fishery program in 1996.

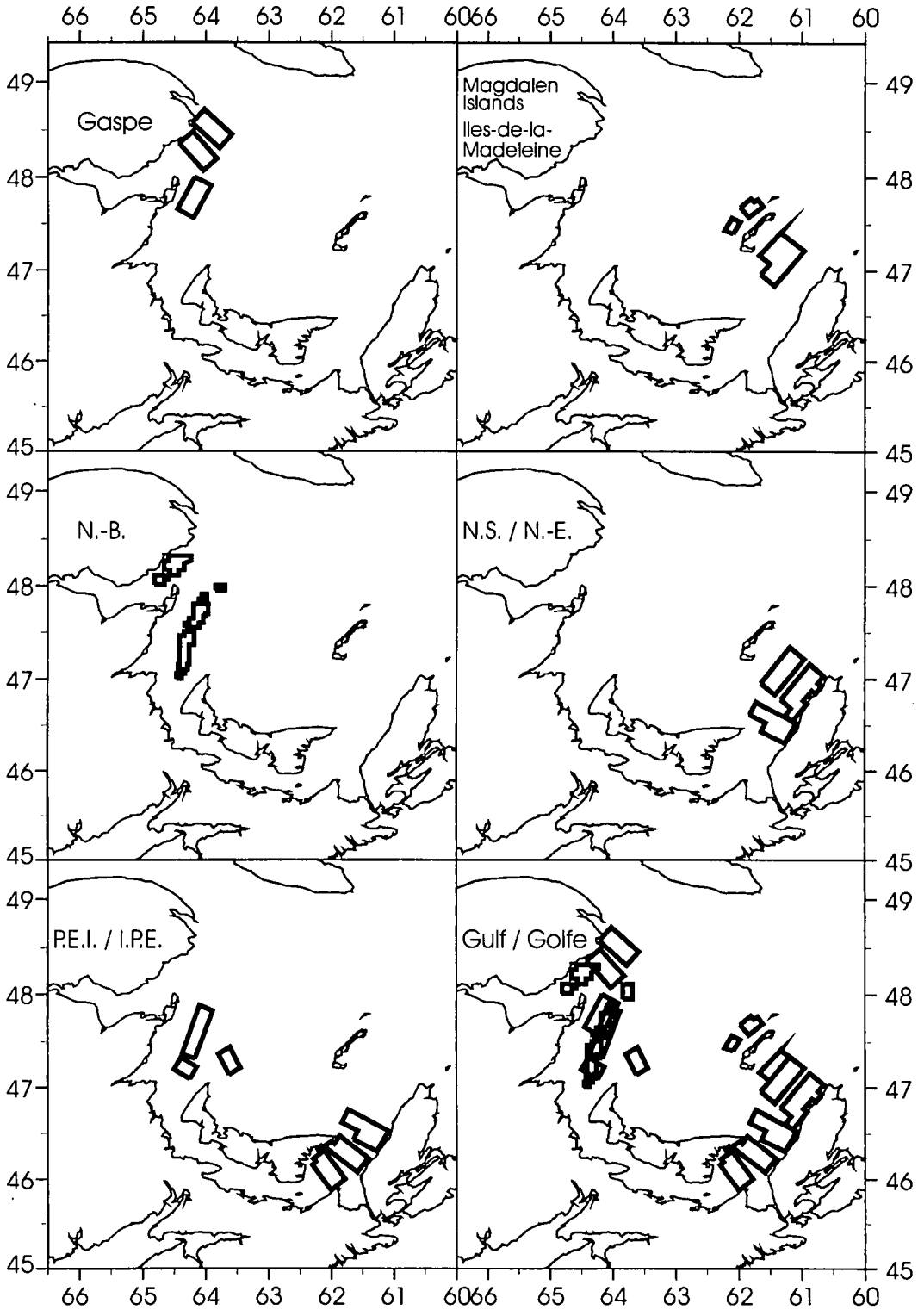


Figure A2. Locations of the fishing areas for the mobile gear sentinel fishery program in 1996.

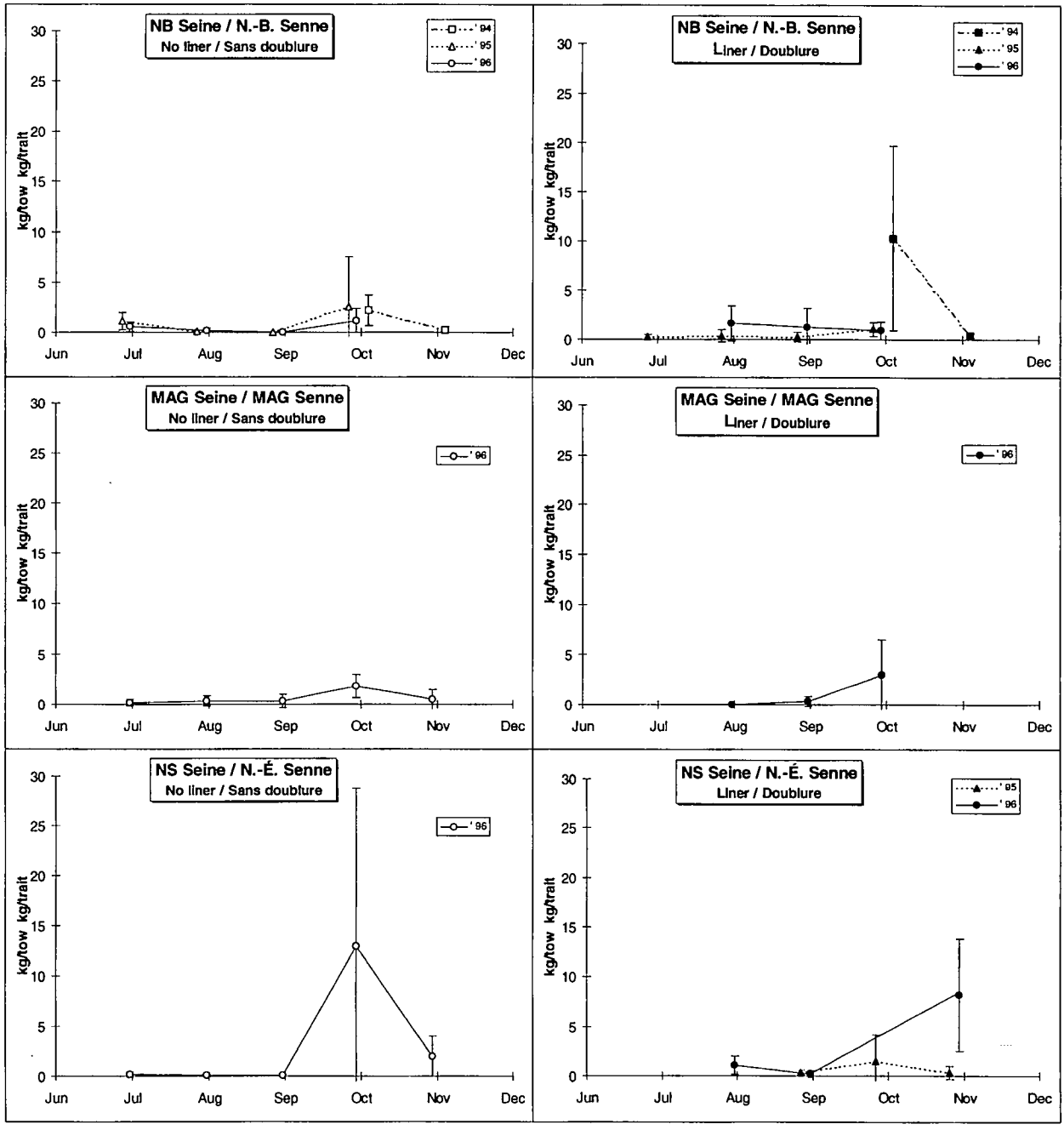


Figure A3. White Hake catch rates (+/- 1 se) for seiners.

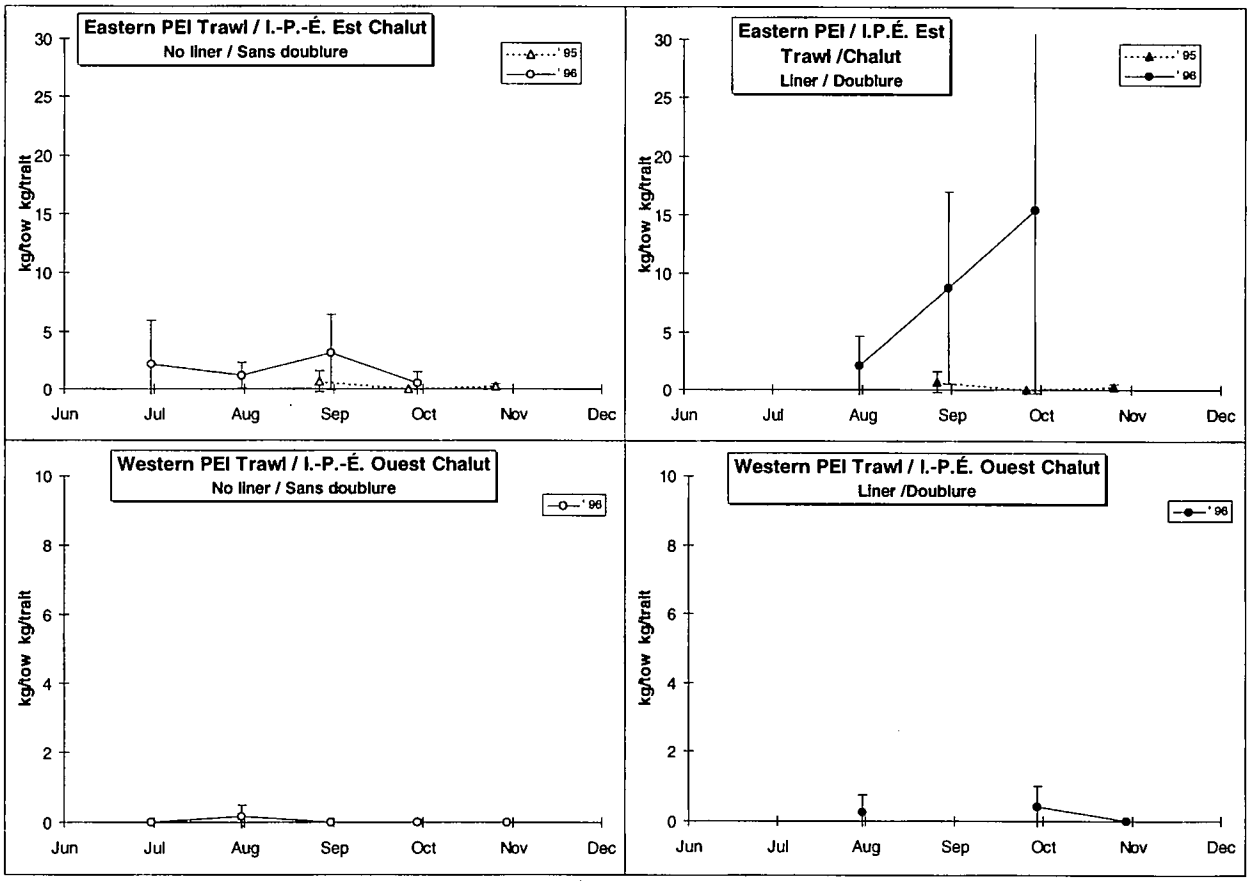


Figure A4. White Hake catch rates (+/- 1 se) for PEI otter trawls.

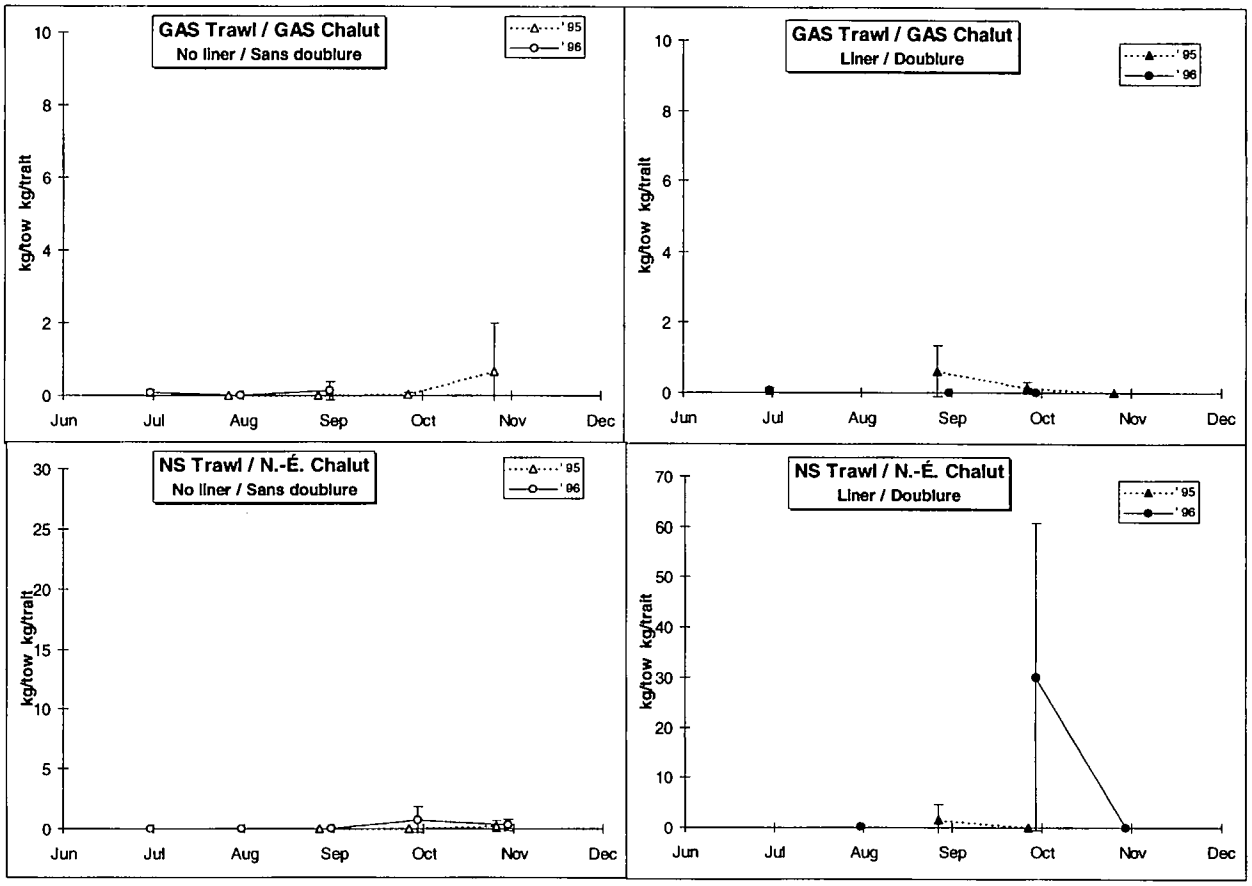


Figure A5. White Hake catch rates (+/- 1 se) for Gaspé and Nova Scotia otter trawls.

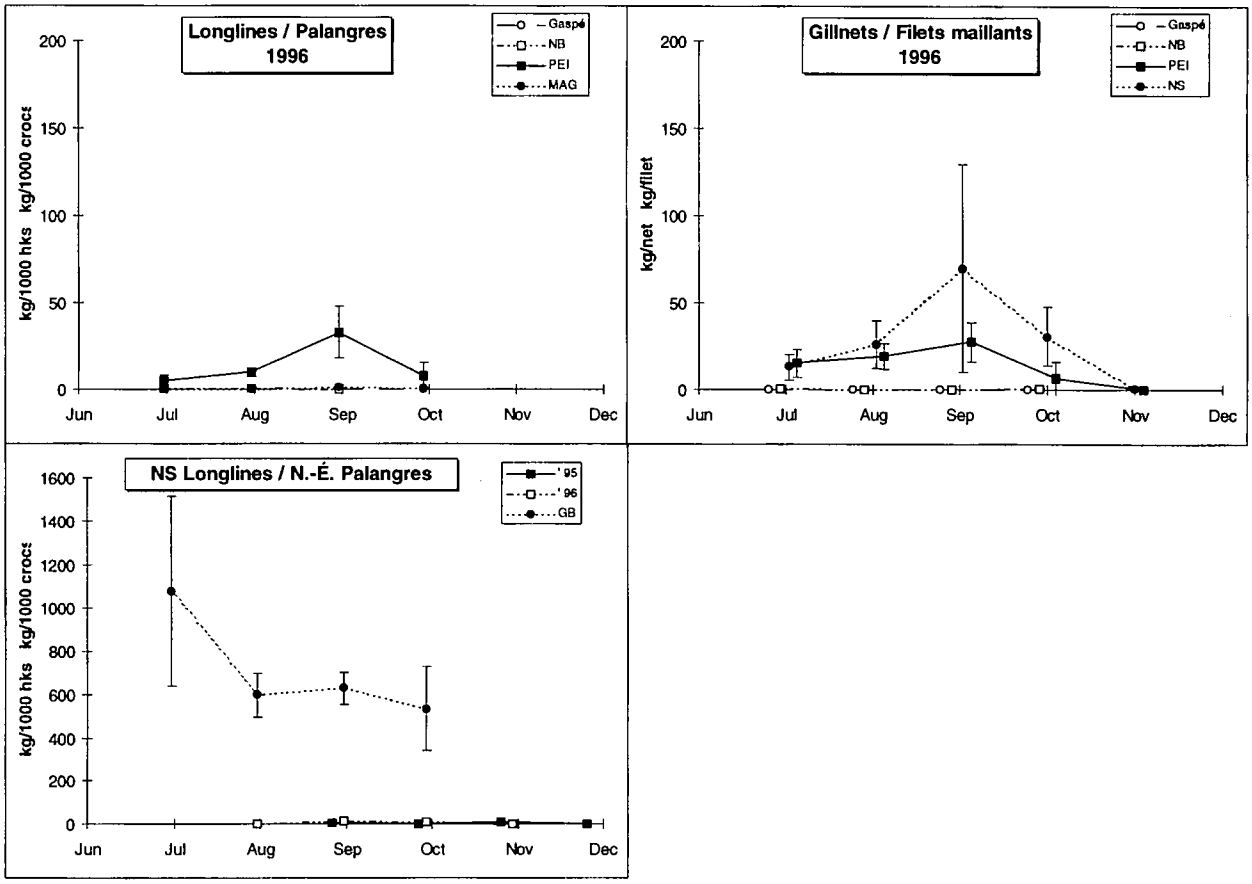


Figure A6. White Hake catch rates (+/- 1 se) for longlines and gillnets.

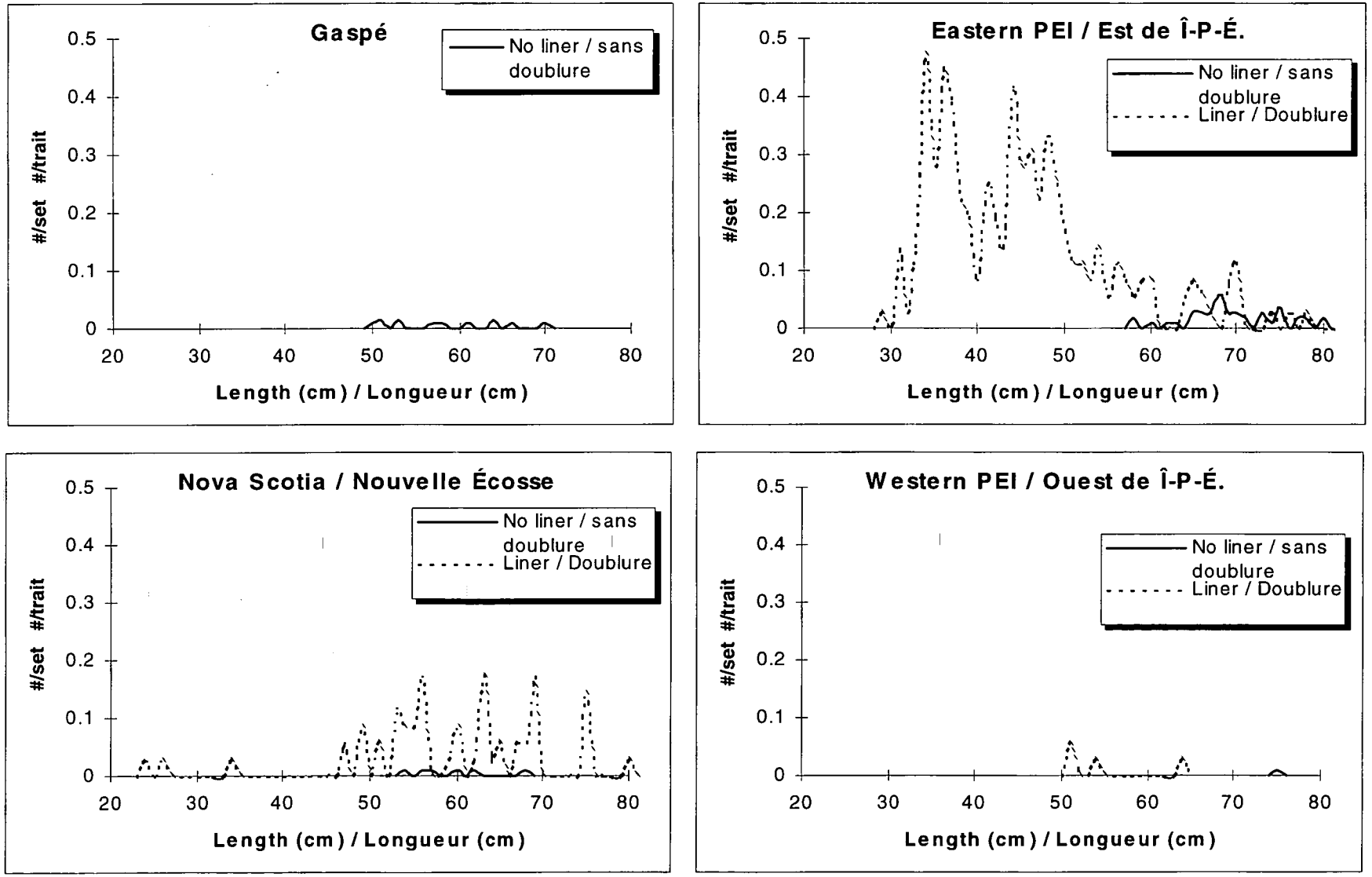
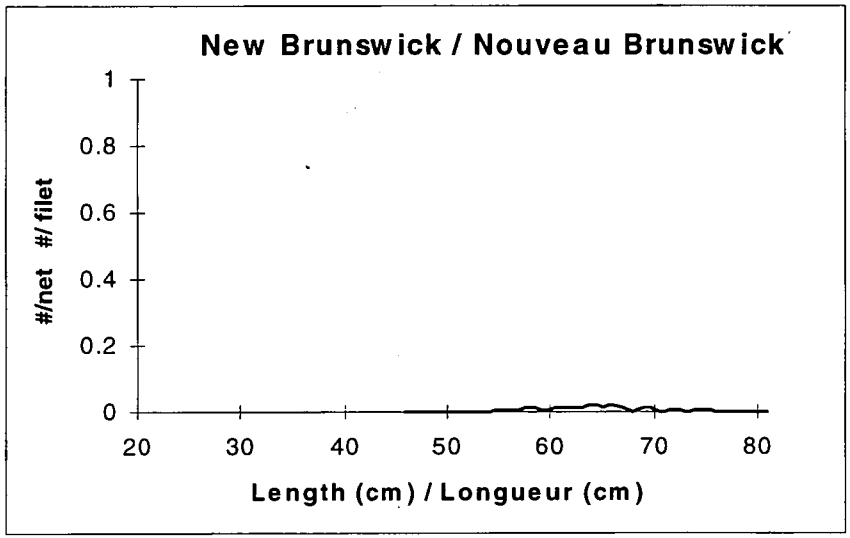
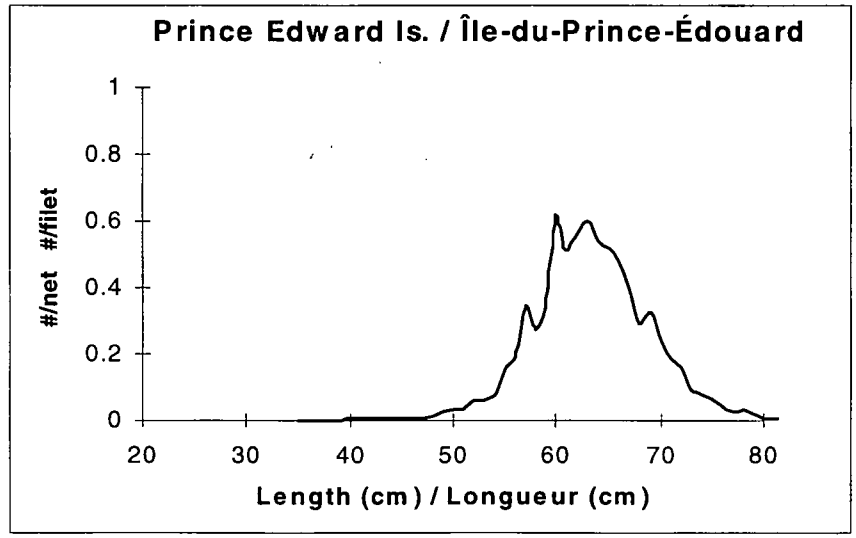


Figure A7. White hake length frequencies for the 1996 sentinel surveys (otter trawls) in the southern Gulf of St. Lawrence.





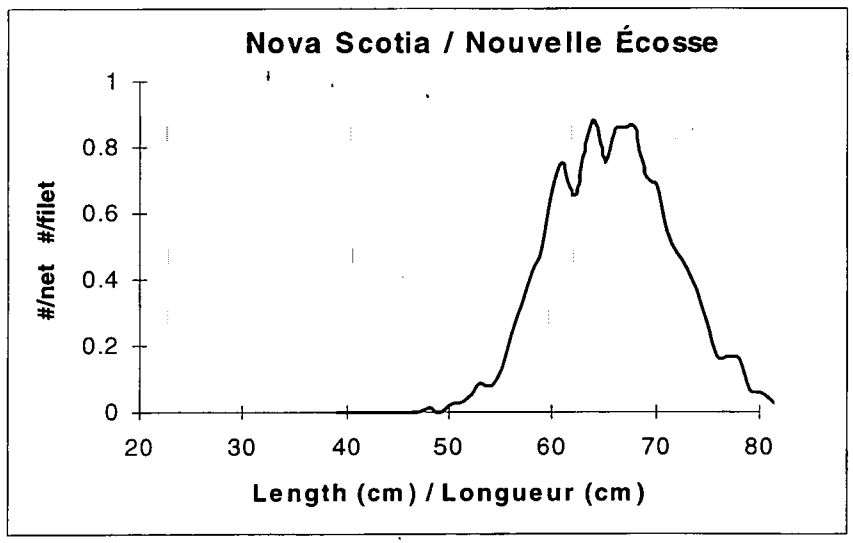


Figure A8. White hake length frequencies for the 1996 sentinel surveys (gillnets) in the southern Gulf of St. Lawrence.

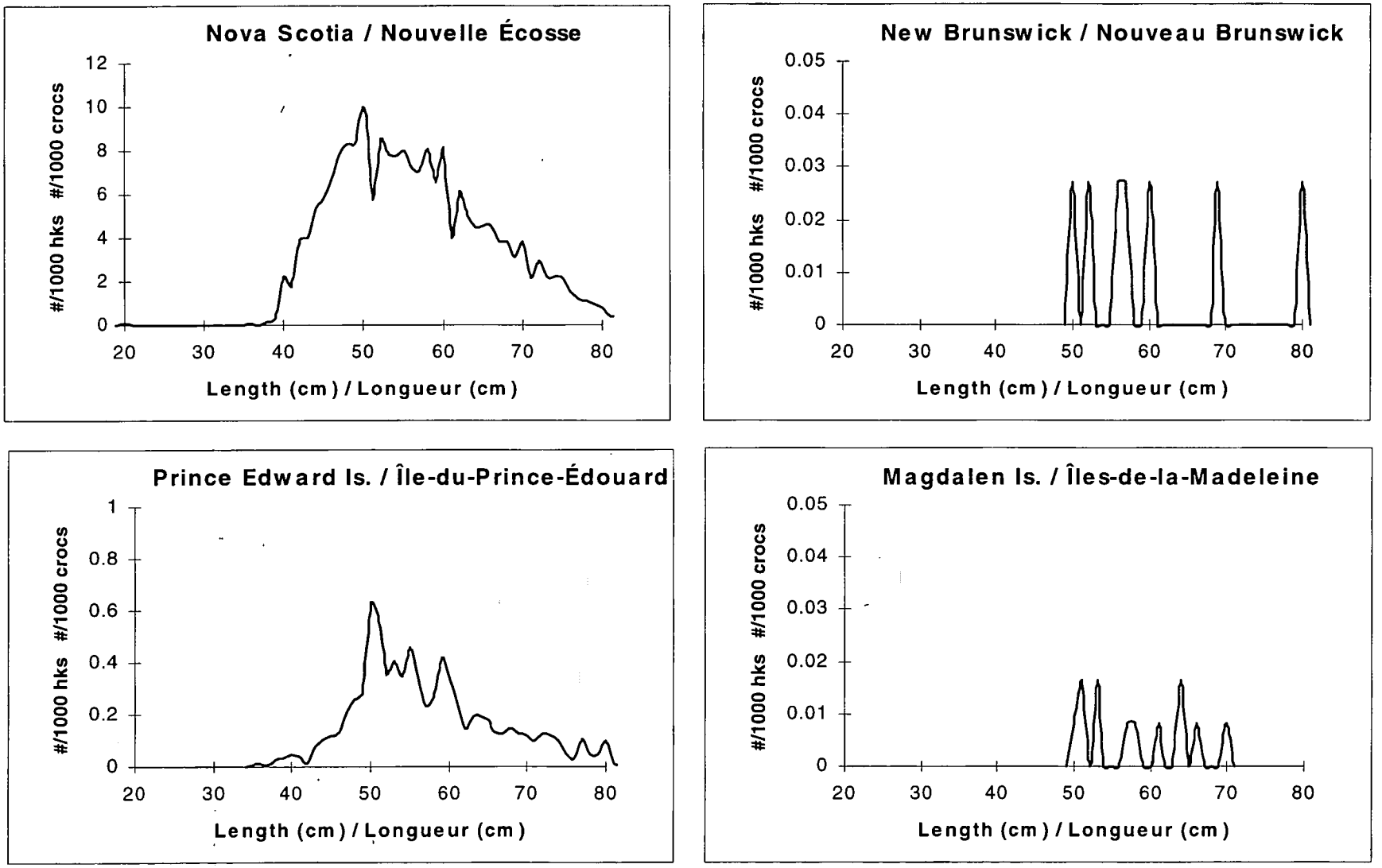


Figure A9. White hake length frequencies for the 1996 sentinel surveys (longlines) in the southern Gulf of St. Lawrence. Note the difference in scaling between graphs.