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The Status of White Hake (*Urophycis tenuis*, Mitchill) in the Southern Gulf of St. Lawrence (NAFO Division 4T) in 1995

by

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1 - Summary Sheet

Year	1989	1990	1991	1992	1993	1994	1995	1996	Min.	Med.	Max.
Reference Level - 000's t	5.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A			
TAC - 000's t	5.5	5.5	5.5	5.5	3.6	2.0	0.0	0.0	0.0[1]	5.5[1]	12.0[1]
Reported Landings - 000's t	5.4	5.2	4.5	3.9	1.5[2]	1.0[2]	0.1[2]		0.1[3]	5.3[3]	14.0[3]
Estimated Biomass - 000's t	13.9	12.9	12.1	7.7	4.1	3.8	2.9		2.9[4]	12.1[4]	30.9[4]

[1] For 1982-1995 [2] Preliminary statistics [3] For 1960-1995 [4] For 1971-1995

Description of Fisheries (Landings): Landings peaked at 14,039 t in 1981 and have declined almost every year since to a historic low of 939 t in 1994. Although directed fishing for white hake in NAFO Division 4T was closed in 1995, landings of 66 t were recorded. Since 1988 landings have been lower than the average for the period (1960-1995) which equals 5,519 t.

Target: TAC's have been set at levels approximating the $\mathbf{F_{0.1}}$ mortality level.

Fishery Data: The total number of white hake landed in 1995 was the lowest on record and the landings were dominated by ages 6 and 7 (the 1988 and 1989 yearclasses). This marks a departure from a trend that has been apparent since 1989 of decreasing numbers of older fish (i.e., age 6+) and probably reflects the use of large mesh gear in 1995 (i.e., 145 mm square).

Research Data: The mean number of white hake caught per tow (all ages) during the 1995 September survey increased slightly from the 1994 level, but remains near the lowest historical level. 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 in recent years. There has also been a decline in the abundance of white hake in the area between P.E.I. and Cape Breton and in St. George's Bay (N.S.), as well. The 1995 survey abundance (population numbers) was near the very low 1994 value, and the survey biomass was at the lowest level in the history of this survey. The abundance of large hake (> 45 cm) has continued to decline and was near the lowest level observed. Furthermore, the survey results indicate that the abundance of white hake in both stock components (the 'Strait' and 'Channel' components) declined to minimum values recently.

Estimation of Stock Parameters: Both the ADAPT and Laurec-Shepherd analyses, and the direct estimates of relative fishing mortality at age indicated relatively high fishing mortalities from 1989-1992. Results differed somewhat for 1994. The ADAPT analysis suggested a reduction in F for 1994, while the Laurec-Shepherd and relative F analyses indicated that F increased in 1994 for the older ages (i.e., 6,7 and 8). Both ADAPT and Laurec-Shepherd suggested similar declines in hake abundance in recent years, with estimated abundance remaining relatively stable from 1984-1989 and then declining rapidly in the early 1990's to low values in recent years (1993-1995). The estimates of recent population abundance from both ADAPT and Laurec-Shepherd are about 20% of the levels estimated for the mid-1980's.

Assessment Results: The white hake resource in NAFO Division 4T appears to be at its lowest level since the first quota was established in 1982. The 1995 research survey results indicate that although the estimated population numbers increased slightly from their historical low in 1994, the estimated population biomass is at its lowest level in the history of this survey. The SPA results are consistent with this view, indicating that population abundance has declined to its lowest level.

Management considerations: A monitoring program in the Miramichi estuary in the fall of 1994 and 1995 found the by-catch of small white hake in the 'openwater' fishery for smelt to be very high. Smelt fishers were required to sort and release all groundfish (including white hake) from their fishing gear. This requirement should be maintained.

Future Prospects: The catches of recent years appear to have resulted in a high rate of exploitation. Recovery of this resource will probably occur slowly given the current low abundance and indications of weak incoming recruitment over the next couple of years.

2 - 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 1995, provisional landings of 66 t were recorded. The majority of these landings probably occurred as by-catch in flatfish fisheries.

Results of the 1995 research survey indicate that although the estimated population numbers increased slightly from the very low 1994 value, 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 1984-1989 (13.8-15.6 million fish), but declined rapidly from 1990-1993 and reached a minimum of 3.1 million fish in 1995. The catches of recent years appear to have resulted in a high rate of exploitation.

A monitoring program in the Miramichi estuary in the fall of 1994 and 1995 found the by-catch of small white hake in the 'openwater' fishery for smelt to be very high. Smelt fishers were required to sort and release all groundfish (including white hake) from their fishing gear. This requirement should be maintained.

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

3 - Résumé

Les effectifs de merluche blanche de la division 4T de l'OPANO sont probablement les plus faibles observés depuis l'établissement du premier quota de cette espèce en 1982.

Bien que la pêche dirigée de la merluche blanche de cette division a été fermée en 195, des données provisoires sur des débarquements de 66 t ont été enregistrées. La plupart de ces débarquements sont probablement des prises accessoires de la pêche du poisson de fond.

Les résultats du relevé de recherche de 1995 révèlent que bien que les effectifs estimatifs aient augmenté légèrement par rapport à 1994, la biomasse estimative de la population est à son plus faible niveau observé. Les résultats d'une analyse de population séquentielle confirent cette observation, indiquant que l'abondance des âges 3-10 dans la population était relativement stable de 1984 à 1989 (13,8-15,6 millions de poissons), puis qu'elle a chuté entre 1990 et 1993 pour atteindre un minimum de 3,1 millions de poissons en 1995. Les prises des dernières années semblent avoir eu comme résultat un taux élevé d'exploitation.

Un programme de surveillance exécuté dans la rivière Miramichi au cours de l'automne 1994 et 1995 a permis d'établir que les prises accessoires de petites merluches lors de la pêche de l'éperlan en eau libre étaient très élevées. Les pêcheurs d'éperlan devaient trier leurs prises et remettre à l'eau tout poisson de fond (y compris la merluche blanche). Cette exigence devrait continuer d'être appliquée.

À la lumière de la faible abondance de la merluche blanche et des signes d'un recrutement faible dans les prochaines années, il est probable que le rétablissement du stock sera lent.

4 - 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 - Figure 1). Since 1960, the average annual catch of white hake in NAFO Division 4T has been 5,519 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 four occasions: to 9,400 t in 1987, to 5,500 t in 1988, to 3,600 t in 1993 and most recently to 2,000 t in 1994 (Table 1).

This fishery usually does not commence until May when the last of the ice has dispersed. Landings traditionally peak between July and September and decline through October and November. The hake fishery is carried out mainly by small inshore vessels, and is strongly affected by weather and local market conditions. Both fixed (gillnets and longlines) and mobile gears (small otter trawlers (< 20m) and larger seiners) are used in the hake fishery. The majority of the fishery is conducted in the Northumberland Strait, on the western end of P.E.I., and between P.E.I. and Cape Breton Island.

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) indicates 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) <u>and</u>

(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).

A formal analytical assessment (SPA based) has not been conducted since 1989 due to the lack of a reliable index of abundance and because of uncertainties concerning stock definition. The present document reviews the status of white hake in NAFO Division 4T in 1995.

5 - Description of Fisheries

A) *Landings*

Landings peaked at 14,039 t in 1981 and have declined almost every year since to 1,042 t in 1994 (Table 1 and Figure 2a). Since 1988, landings have been lower than the average for the period (1960-1995) which equals 5,519 t.

Although directed fishing for white hake in NAFO Division 4T was closed in 1995, provisional landings of 66 t were recorded (Table 1 - Figure 2a). The majority of these landings probably occurred as by-catch in the flatfish fisheries, which with the fishery for dogfish, were the only "traditional" finfish fisheries that were open. Four tonnes of white hake were landed in "Sentinel Survey Projects" (fixed and mobile gears) and it was estimated that 4.6 tonnes were landed in the "Recreational Groundfish Fishery" (fixed gears)(Table 2a).

Since 1960, gillnets have accounted for 30% of the landings of white hake, and bottom trawls for 26% (Table 1 and Figure 2b). Over the same time period, longlines and seines have accounted for 17% and 11% respectively. In 1995 however, 46% of the landings were taken by trawlers and 17% were taken by seiners (Table 1 and Figure 2b). As in previous years, the majority (87%) of the landings of white hake were made between July and October in 1995 (Table 2b).

We allocated the NAFO Division 4T white hake landings (1985 - 1995) to the 'Strait' and 'Channel' stock components by the statistical unit areas (See Map - Figure 3) 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 predominately less than 200 m were regarded as belonging to the 'Strait' component and those unit areas bordering the Laurentian Channel with depths predominately greater than 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 4). In 1995, 67% of the total landings of white hake came from unit area 4Tg alone. From 1985 - 95, annual landings from the unit areas that encompass the 'Channel' component (unit areas 4Tf, 4Tk, 4To, 4Tp and 4Tq - Figure 4) 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 in the southern Gulf of St. Lawrence was closed in 1995 and a daily by-catch limit of 10% by weight, for cod and white hake was imposed by the DFO on fisheries targeting other species. 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 1995, there were 36 closures of fisheries in NAFO 4T directed at species other than white hake and cod (both fixed and mobile gears), mainly because of high cod by-catch.

In addition to the by-catch protocol, the DFO enforced a small fish protocol, in which, 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).

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 (area 4T8) was adjusted to open on July 15 to allow hake to spawn.

The DFO also enforced a regulation 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 1995 directed fishing for white hake in NAFO 4Vn was closed from January to April to minimize the exploitation of NAFO 4T white hake during their winter residency in and migration to and from NAFO 4Vn.

Furthermore, mobile gear vessels were not permitted to direct for white hake in NAFO 4Vn at any time in 1995.

C) *Descriptions from Industry of the Fisheries for White Hake in 1995*

i) Consultation Meetings ("Science Workshops")

In November and December 1995, personnel from the Dept. of Fisheries and Oceans, Gulf Fisheries Centre, made presentations at public meetings in Grande-Rivière, Québec, Caraquet, N.B., Charlottetown, P.E.I., Port Hawkesbury, N.S. and Cap-aux-Meules in the Magdalen Islands, on the groundfish stocks of the southern Gulf of St. Lawrence. 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 1995.

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.

The only comment made in Grande-Rivière regarding white hake was that catches were very low in 1995. In Caraquet, a participant noted that the best fishing for white hake occurred in the early 1980's (especially 1980 and 1981) and another questioned whether a link existed between white hake and some of the flatfish species, noting a synchrony in their changes in abundance and distribution (especially American plaice).

At the Charlottetown meeting, there were numerous comments made regarding the occurrence of small white hake in inshore areas in 1995. Several participants noted concentrations of small hake (20 - 25 cm long) off the east and west coasts of the Island and on Pictou Island bank. A fisher described unusually high (2 - 3 times normal) catches of small hake (30 cm long) in mackerel nets off eastern P.E.I. and another mentioned that he observed noticeably more small (10 cm long) hake off of wharves in 1995. A participant speculated that there was probably less white hake caught in the silverside fishery as by-catch last year because there was less effort expended in this fishery. Another participant remarked that groundfish catches off western P.E.I. were usually dominated by hake (70 - 80%) 10 - 12 years ago, but now, catches in the same area tend to be dominated by cod. He also indicated that a similar reversal has occurred in fixed gear catches off northern P.E.I.

By far, the most discussion concerning white hake occurred at the meeting in Port Hawkesbury, as it had with many of the same participants, the year before (1994), in Chéticamp. Again many participants expressed scepticism with the results of the September (1995) abundance survey and indicated that there was an abundance of white hake in the area, especially in St. Georges Bay.

Commenting on the presentations portraying a decline in the abundance of hake, cod and plaice in the southern Gulf, one participant suggested that the decline has only occurred in the western Gulf and that this has "driven down the average for the eastern Gulf". It seemed that many fishers shared the impression that the stocks in the western part of the southern Gulf are in much worse shape than those in the southeastern Gulf. Generally, the consensus seemed to be that white hake were more abundant this year than in 1994, especially in inshore areas, but were less abundant offshore (i.e., around St. Paul's Is.). Participants from the St. Georges Bay/Port Hood area were adamant that white hake were abundant in that area in 1994 and in 1995.

There was extensive discussion regarding the stock affinities of white hake from the 4RST, 4Vn and 3Pn areas, and of the implications for management. Several fishers questioned the rationale for not closing the fishery for white hake in NAFO 4Vn, since it is generally accepted that hake from the southern Gulf (NAFO 4T) overwinter there.

A participant recommended more extensive sampling in St. Georges Bay and another commented that the hake were larger than usual there in 1995.

A fisher mentioned that he was catching 8-12 small white hake in each of his herring nets that were set in shallow water near Pictou Is. last fall. He also mentioned that small and occasionally large hake were caught in mackerel nets and rock crab traps.

A participant asked whether there is a relationship between the distribution of white hake and cod in the southern Gulf.

ii) End of Season Telephone Survey

A survey was conducted by telephone of fishers that participated in the groundfish fishery in the southern Gulf in 1995. The purpose of the survey was to obtain information on trends in fishing effort and the abundance of groundfish, as well as anecdotal information on the fishery (i.e., impact of seals, dogfish, markets, D.F.O. management actions, etc.).

The survey population consisted of all fishers that were active in the groundfish fishery in 1995, with their activity determined from a file of all purchase slips that were received by Dec. 1, 1995. Two hundred and thirty-two fishers were identified from New Brunswick, Nova Scotia, Prince Edward Island and Quebec. The interviews were conducted in both official languages from Dec. 12, 1995 to Jan. 9, 1996 (interview times ranged from 8 to 30 minutes).

Of the 232 fishers that were identified, 58 could not be reached by telephone, 28 indicated that they did not fish for groundfish in 1995 and 5 refused to participate in the interview.

Of the 138 respondents that were interviewed, 39 indicated that they directed for white hake in 1995 to some extent (i.e., first, second or third priority), and of them 19 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 1995, and that these same respondents were also asked to identify which species they directed for before the fisheries for cod and hake were closed. Nevertheless, we present some preliminary results on the views of these respondents that indicated that they directed for white hake in 1995.

When asked to compare the number of days that they spent fishing in 1995 to 1994, most (19) respondents reported fewer days, 12 reported the same number and 6 said that they spent more days fishing (2 responses were not applicable). The most commonly cited reason for spending less time fishing in 1995 was fishery management regulations (i.e., closure of fishery).

When asked to compare the amount of fishing gear that they used in 1995 to previous years, the majority (23) reported they used the same amount in 1995, 10 indicated that they used less and 4 indicated they used more (2 responses were not applicable).

When the respondents were asked for their opinion concerning the abundance of white hake in the southern Gulf in 1995, most (16) of the 39 fishers indicated that the abundance was very low, 7 said that it was low and 3 felt that the abundance was about average (Figure 5). On the same question, 5 respondents considered the abundance of white hake to be high and 5 considered it to be very high.

The final question posed to the respondents asked them to relate the state of the fishery in 1995 to:
- the fishery in 1994
- the fishery from 1990-1994
- the fishery in all the years that they fished for white hake

Most of the respondents who directed for white hake in 1995 considered the fishery to be the same or better than in 1994 (Figure 5). Only 3 respondents considered the fishery to be worse and 2 indicated that it was much worse. However, when the respondents were asked to compare the state of the fishery in 1995 to the fishery from 1990-1994, most of them (21) considered it to be the same or worse (10 considered it to be better or much better). Finally, when asked to relate the 1995 fishing season to all their years of experience, the majority (25) considered it to be the same or worse and only 4 described it as better.

6 - Target

The TAC has been reduced on four 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 and most recently to 2,000 t in 1994.

7 - 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).

Because of the moratorium on the hake fishery in 1995, only 7 commercial samples (197 fish measured and 134 otoliths) were obtained by DFO port samplers. Five of these samples (177 fish measured and 114 otoliths) were obtained from unit area 4Tg which is occupied by the 'Strait' component. The remaining two samples were obtained from unit area 4Tf (the 'Channel' component), and consisted of 20 fish measured for length and 20 otoliths.

Quality control tests were conducted during the entire period of ageing calibration and age determination, after every 200 to 250 otoliths that were read. These tests involve the ageing of two randomly selected trays (50 otoliths per tray) from the reference collection. After calibrating, recently assigned ages (commercial or research vessel) are accepted if the agreement on the tests exceeds 75% and if there is no significant bias (otherwise the ages are discarded and the reader recalibrates with otoliths from the reference collection). In 1995, agreement with the reference ager ranged from 71% to 93% with a mean of 83%.

B) *Catch, Weight and Length at Age in 1995*

The low sampling intensity in 1995 (no samples from any fixed gears (i.e., gillnet, longline, etc.)) precluded separation of the aged samples into more than one age/length key (Table 3).

To compensate for this shortfall we considered using an age/length key from the September groundfish survey (595 ages) or an age/length key that combined the age/length frequencies from the 1995 commercial samples and the September 1995 survey. We ultimately decided against both of these alternatives and used just the age/length key from the 1995 commercial samples because of differences in the protocols for sampling white hake from the commercial fishery and during research surveys (i.e., white hake are sexually dimorphic and the protocols for sampling from the commercial fishery and during research surveys originally required sexed length and otolith sampling. However, when the majority of the fishers switched from landing their hake round to gutted in the early 1980's, the commercial sampling protocol was changed to permit sampling irregardless of sex). Nevertheless, the catch-at-age was computed by the three methods mentioned (above) and the results were found to be very similar.

The catch-at-age, mean weight-at-age and mean length-at-age were calculated for the 1995 key (Table 4) using the AGELEN program (Ver 3.21) for sexes combined. The conversion of hake length to weight was based on the length-weight regression obtained from the annual (September 1995) groundfish survey of NAFO Division 4T (Table 3). As well, the catch-at-age, mean weight-at-age and mean length-at-age were re-calculated for 1992, to comply with the finalised NAFO landings statistics (Table 5). The difference in 1992 white hake landings between the revised NAFO statistics and the preliminary statistics used in previous assessments was minor (3% increase from the preliminary statistics).

The time series of catches-at-age, mean weights-at-age and mean lengths-at-age from 1982-1995 are found in Table 6.

The total number of fish landed in 1995 was the lowest on record (Table 6 and Figure 6a). In 1995, the landings were dominated by ages 6 and 7 (the 1988 and 1989 yearclasses - Table 6 and Figures 6b and c). This marks a departure from a trend that has been apparent since 1989 of decreasing numbers of older fish (i.e., age 6+) and probably reflects the use of large mesh gear in 1995 (i.e., 145 mm square mesh).

In 1995, the mean weight-at-age of hake, aged 9, increased sharply, while the weight-at-ages 4 to 8 remained comparable with the time series since 1982 (Figure 7).

8 - Research Data

A) *Fall Groundfish Survey of 1995*

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 was initially adopted and 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 groundish abundance survey are shown in Figure 8.

During the 1995 survey (N230), 183 valid sets were made by the Alfred Needler in NAFO Division 4T and 27 sets were made in SubDivision 4Vn.

i) Geographic Distribution

The distribution of white hake catches during the 1995 survey was generally similar to the pattern observed in recent years (Figure 9), with concentrations occurring in warmer waters either in shallow inshore areas or in deep water along the Laurentian Channel. The main areas of concentration were off eastern P.E.I. and in St. Georges Bay. White hake have seldom been caught in the shallow, central zone adjacent to the Magdalen Islands. 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 in recent years.

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

ii) Length Frequency Distribution of Survey Catches

Length frequencies for the entire series of abundance surveys of the southern Gulf are shown in Figure 10. With the exception of 1990, when the modal length was 33 cm, the modal length varied between 39-44 cm from 1986-93. In 1994, the modal length dropped to 31 cm and remained at this length in 1995. Examination of the length frequency for 1995 indicates the presence of small fish (less than 40 cm) and in particular of 0-group hake (less than 10 cm). Unfortunately, the abundance of larger hake has continued to decline and is near the lowest seen in the history of this survey.

iii) Size-at-Age

The stratified mean catch per tow-at-age, 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 - 9). The mean weight-at-age tended to gradually decline from the mid-1980's until the early 1990's for hake between the ages of 5-7 (Figure 11). For age 8 hake, the weight has remained relatively stable during this period except for a sharp downward spike in 1993. This spike suggests errors in the ageing of older hake (age 5^{+}) in 1993. Fortunately, the mean weight-at-age for these older hake returned to values comparable with the time series in 1994 and 1995.

iv) Abundance Indices and Biomass Estimates

The stratified mean number of white hake caught per tow (ages 0+) during the 1995 September survey increased slightly from the 1994 level to 4.1 fish/tow, but remains near the lowest historical level (Table 10 and Figure 12). Although the estimated population numbers were higher in 1995 than in 1994, the estimated population biomass was at the lowest level in the history of this survey (Table 10 and Figure 13).

From 1984 -1994, the most abundant age groups in the survey were age 3 or 4, but in 1995, the most abundant age group was age 2 (1993 yearclass) (Table 7 and Figures 14 a and b). The abundance of all hake older than age 3 has declined since 1990 (Figures 14 b and c).

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 11 and 12 and Figure 15).

This analysis revealed a considerable difference in the abundance estimates for the two components from 1986-1988, 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 1993 but increased slightly in 1994 and again in 1995. In contrast, the abundance of white hake from the 'Channel' component reached a minimum in 1994 and increased slightly in 1995.

As mentioned earlier, scepticism was expressed at consultation meetings held in Charlottetown, P.E.I. and Cape Breton in 1994 and 1995, concerning the results of the September (1994 and 1995) abundance surveys. 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. To address this issue, the research vessel estimates of the mean catch per tow for the area in question (survey strata 403 and 433 - see Figure 8) were compiled and compared to the estimates for the remaining survey area and the whole survey area (Table 13 and Figure 16).

The results reveal the importance of strata 403 and 433, in terms of the local abundance (density) of white hake and offers support for the contention by industry that hake were abundant in this area in 1995. 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 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.

- While local density remains relatively high in this area at present, it is much lower than the densities observed in the 1989 - 1992 period.
- The contention that white hake were abundant in the southeastern Gulf in 1994 and 1995 is 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 (Figure 9).

B) *January 1996 Survey of Cabot Strait*

A groundfish survey was conducted in the Cabot Strait from January 3-25, 1996 on board the research vessel Wilfred Templeman. Similar surveys were conducted in January 1994 and in 1995 aboard the Alfred Needler (Chouinard 1994 and 1995). The main objective of the 1994 and 1995 surveys was to determine the distribution of groundfish species and herring in the Cabot Strait area during the winter. The 1996 survey was part of a project to identify the stock origin of cod concentrations in the 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 19 mm liner in lengthening piece and codend), was conducted (Note: the surveys in 1994 and 1995 used a Western IIA trawl). A total of 139 sets were attempted, of which 138 were successful.

A contoured map of the white hake catches in kg per tow (Figure 17) indicates that catches were made throughout the Laurentian Channel. As in previous years (Chouinard 1994; Hurlbut et al. 1994 and 1995), catches were low in the Gulf of St. Lawrence (northern part of the survey area). Catches appeared to be higher on the southern edge of the Laurentian Channel in 4Vn. In addition, catches in the centre of the Channel were relatively low. This may indicate that the concentrations in 4Vn and those from 3Pn and 3Ps may be from different stock origins, however given the relative closeness of the concentrations, further investigations will be required to determine if this is the case.

The length frequency distributions for white hake in 1995 and 1996 (when the survey areas were relatively similar) were compared (Figure 18). Length frequencies were similar with modes at about 25 and 35-40 cm The majority of the fish caught during the survey were below the commercial size (40 cm).

C) *Surveys of the Northern Gulf of St. Lawrence*

The northern Gulf of St. Lawrence, including NAFO divisions 4R, 4S and the Laurentian Channel portion of 4T, has been surveyed every August since 1984. Strata were defined by depth intervals of less than 50 fathoms, in 50-fathom intervals up to 200 fathoms and then by depths greater than 200 fathoms (Figure 19, Pitt et al. 1981). The survey has been conducted with a stratified random sampling design, allocating the number of trawling sets proportionally to the stratum area. Sampling procedures were detailed by Schwab and Hurtubise (1987) and are similar to procedures used in surveys of the southern Gulf, described by Koeller (1981) and Hurlbut and Clay (1990B).

Although the survey sampling design and sampling procedures have remained relatively constant since 1984, important changes were made in 1990 when the vessel and sampling gear were replaced. From 1984 to 1989, the Lady Hammond was used with a Western IIA trawl. Since 1990, the Alfred Needler and a U.R.I. shrimp trawl have been in use. These changes were brought about when it became necessary to combine groundfish and shrimp surveys in the Laurentian Region. A comparative fishing experiment conducted in 1990 with the two vessels revealed significant differences in the catch rates for Atlantic cod (Fréchet et al. 1991). A similar comparison of white hake catch rates between the Lady Hammond and Alfred Needler appears not to have been made; however, we have assumed that the combined effect of changing vessels and gear is a sufficient basis for considering the two time periods (i.e., surveys) as separate.

Stratum coverage in the northern Gulf surveys has frequently been limited by the lack of trawlable bottom in some sectors. Strata 825, 826 and 834 were permanently dropped from the survey for this reason. In 1991, strata 835-841 were added to the survey, extending coverage along the coast of western Newfoundland and into the Strait of Belle Isle. Table 14 indicates the mean catches of white hake in all strata since 1984, and also illustrates the changes that have occurred in stratum coverage. Hake were not captured in strata 835-841; however, hake have been found in 45 of the remaining 46 strata (401-833). Hake have tended to concentrate in strata 401-410 and 810-819, where depths are greater than 100 fathoms.

To obtain an index of white hake abundance comparable over years in which the same vessel and gear were used, multiplicative analyses were conducted using year and stratum effects to estimate abundance in strata that were not fished in particular years. The data were the number of hake caught per standard tow of 1.8 nautical miles for the Lady Hammond and 0.8 nautical miles for the Alfred Needler. We used the same procedure as was used to estimate abundance in strata that were missed in the 3LNO survey (Brodie and Bowering 1989). Separate analyses were conducted on data from the 1984-1989 and the 1990-1995 periods, with catches weighted by the stratum area divided by the number of sets. All catches were transformed by $\log_e$(catch + 0.5) to allow logarithms of zero catches to be included in the model. Estimated values were back-transformed using the bias correction of Bradu and Mudlak (1970). Analyses were first conducted including all years and strata in each time period (1984-1989; 1990-1995), including a year*stratum effect. The interactive term was significant in both models ($P<0.05$), indicating that the abundance of hake changed differently over time in areas covered by the surveys. We therefore estimated the abundance of hake in missing strata by including neighbouring strata. Four separate analyses were conducted (Tables 15-18) with subsets of the strata necessary to estimate the mean hake abundance in the strata that were not covered during the two time periods corresponding to the surveys aboard the Lady Hammond and the Alfred Needler (i.e., 1984-1989 and 1990-1995). The estimated mean number of hake per tow for the strata that were not covered, from the multiplicative analyses, are presented in Table 19. Each of the four models was highly significant ($P=0.0001$) with non-significant year*stratum interactions ($P>0.05$). The abundance of hake in stratum 814 in 1995 was based on a multiplicative model using strata 801 and 812-814 and years 1990-1995, except 1992. The year 1992 was dropped from the model because of an exceptionally high catch in stratum 814, causing significant interaction between year and strata. Hake abundance in stratum 831 in 1991 was designated zero on the basis of observed catches in nearby strata from 1990-1995 (Table 14).

One other problem with the coverage of the northern Gulf survey is the occurrence of strata that have not been sampled with replication. Shaded cells in Table 14 indicate the cases where only one set was made in a stratum. In order to maintain a comparable index of abundance across years, we have included these strata in calculations of the stratified mean number of hake. Including strata for which the mean abundance is based on a single observation and the variance is zero, causes the estimated variance of the stratified mean to be negatively biased.

The stratified mean number of hake per tow was calculated for strata 401-833 (excluding stratum 825) according to the procedures described. Including only sampled strata and strata with or without replicate sets, or including strata with abundance estimated from multiplicative analyses, had minor effects on the stratified mean number of hake per tow (Table 20 and Figure 20). The mean number per tow in a given year differed by no more than 0.34 hake (1989). In all cases, the abundance of hake in the period 1984-1989 peaked in 1987. Since 1990, hake abundance declined to a minimum level in 1993. Some recovery is indicated since 1993, but it is apparent from Table 14 that it is due to strong catches in strata 401 and 402. Excluding stratum 402 from the 1995 estimate (sampled only once), caused the stratified mean number of hake to level off (Table 20).

When these results are compared to those for the whole southern Gulf survey (Figure 21) for the period 1984-1995, the following similarities are apparent: white hake abundance peaked in both surveys in the late 1980's and declined to minima in the early 1990's. A comparison of the results for the whole northern Gulf survey with those for the "Channel" component of the southern Gulf (Figure 21) would be misleading because the latter represents only a subset of the southern Gulf survey area. The appropriate comparison would be of the abundance indices for the "Channel" strata of both surveys, but this was not possible for this report.

D) *Correspondence Analysis of Length Frequencies of White Hake from the "Strait" and "Channel" Stock Components*

White hake from the "Strait" and "Channel" stock components have been characterised on the basis of differences in morphometric and meristic characters (Hurlbut 1990; Hurlbut and Clay 1990A). Nielsen and Sinclair (1995) used correspondence analysis to classify cod length frequencies from catches in NAFO 4T, 4Vn and 4Vs, to determine the association among samples taken from these areas during different months of the year. We wanted to determine if correspondence analysis could be used to classify white hake length frequency samples from the "Strait" and "Channel" strata, that were sampled in September, when the two stock components are thought to be well separated. This work was exploratory and the results presented are preliminary.

As with other analyses, 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. The input data consisted of individual survey set length frequencies that contained a minimum of 30 white hake. This requirement excluded most survey years before 1984, when very few hake were caught in the survey. Because white hake are sexually dimorphic, sexed length frequencies are preferred for this type of analysis. Unfortunately, the requirement for sexed length frequency sampling has not been rigidly adhered to during all annual surveys of the southern Gulf. Consequently, five surveys in which the length frequencies were not sexed were included in the analysis. The lengths were aggregated into 3 cm intervals to compensate for gaps in the length frequencies that spanned a wide length range. Because the actual shape of the length frequencies was of interest, the numbers at length were transformed to proportions-at-length to give each sample equal weighting in the analysis. For the years 1984-1988, when some stations were repeated numerous times, the repeat sets were normally added together before the proportions-at-length were calculated. Occasionally though, the repeat sets were not added together to investigate the effect on the resulting separation. As well, the effect of certain influential sets on the analyses was explored by leaving them out. These variations of the analysis are documented in Table 21. The analyses were conducted using SAS (SAS Institute Inc. 1989) "Proc Corresp".

Good separation of samples in the first two dimensions of Euclidean space indicates that the length frequencies are different in some respect. Between 50% and 87% (average 66%) of the total inertia (analogous to variability) in the samples was explained by the first two dimensions (Table 21). The number of samples was frequently limiting and compromised comparisons. For example, in 1994 (N210) and 1995 (N230), although 87% and 82% respectively of the inertia was explained by the first two dimensions, there was only one deep ("Channel") sample. In general though, the separation of the samples by depth zone (Shallow = "Strait" and Deep = "Channel") was moderately successful. When samples were reasonably separated, smaller fish of both sexes tended to be associated with shallow samples ("Strait" component) and larger, predominately female fish, tended to be associated with deeper samples ("Channel" component, Figures 22-24).

Although small numbers of samples frequently compromised comparisons in this analysis, these preliminary results suggest that correspondence analysis may classify white hake length frequency samples from the "Strait" and "Channel" strata in a manner consistent with the notion that they are separate stocks. If the patterns observed represent differences in size-at-age, then the results are indicative of stock differences. However, if the patterns observed merely represent differences in age composition (i.e., perhaps older fish prefer deeper water) then the results are not indicative of stock differences. A more detailed analysis could be conducted if sexed length frequencies could be obtained from the commercial fishery.

9 - 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 landings/purchase slip data(Clay et al. 1985; Clay et al. 1986; Clay 1987; Clay and Hurlbut 1988; Clay and Hurlbut 1989). The research vessel abundance index has not been successfully used for calibration. We adopted a different approach for this analysis because of 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 (1984-1995) for the whole management unit (i.e., NAFO 4T), but the calibrations used the research vessel abundance index for the 'Strait' component only. The 'Strait' component was used for calibration because 90% of the landings in NAFO 4T (1985-1995) were from this component and 97% of the commercial samples since 1984 have been from this component, representing 96% of the measured fish and 93% of the otoliths aged (Table 22). The index used RV catch rates for strata 403, 420-422, 432 and 433 for the years 1984-1995. Earlier surveys were not included in this analysis because we judged their sample sizes to be insufficient and because they did not include stratum 403, an important area for hake.

i) ADAPT

Several formulations of the adaptive framework (ADAPT) (Gavaris 1988) were attempted to determine the stock size in 1995, but the best fit was obtained with the following formulation:

<u>Parameters</u>

- Terminal N estimates:
  $N_{i,1995}$ $i = 3$ 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 $10t = 1984 - 1995$
  $RV_{i,t}$ $i = 3$ to $10t = 1984 - 1995$

- 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 23. The residual pattern (Figure 25) is unbalanced, with predominately negative residuals for 1984, 1985, 1988 and 1995 and positive residuals for 1986, 1989, 1991, 1992 and 1994 and the CV's of the parameter estimates are relatively high.

The fishing mortalities and population numbers (beginning of year) from the ADAPT calibrations are given in Table 24 and Figures 26 - 27. This analysis indicates that fishing mortality increased in 1989 and remained at a high level until 1992, after which it decreased continuously until 1995. It also indicates that population abundance was relatively stable from 1984-1989 (13.8-15.6 million fish) but declined rapidly from 1990-1993 and reached a minimum in 1995 at 3.1 million fish.

ii) Laurec-Shepherd

We also used the Laurec-Shepherd method to calibrate the SPA using the research vessel abundance index for the "Strait" component. As with ADAPT, the analysis used the RV index from 1984 to 1995 and ages 3 to 10. No special options (i.e., weighting, shrinking, etc.) were used.

The diagnostics from the Laurec-Shepherd analysis are shown in Table 25. The residual pattern is similar to that from ADAPT (Figure 25).

The fishing mortalities and population numbers from the Laurec-Shepherd calibration are given in Table 26 and Figures 26 - 27. The estimates of fishing mortality from this analysis followed a similar trajectory to those estimated by ADAPT from 1984-1993, but were lower in magnitude. Unlike the ADAPT estimates, this analysis indicates an increase in fishing mortality in 1994. The estimates of beginning of the year population size from this analysis closely tracked those from ADAPT, with the only difference being that population numbers reached a minimum in 1994.

B) *Estimation of Mortality Rates by Alternate Methods*

Sinclair et al. (1993) described a method for estimating trends in fishing mortality at length, using commercial and research survey length frequency data. With this method, the ratio of the commercial catch-at-length (C_l) to the RV catch-at-length (A_l) is used as a direct estimate of relative fishing mortality-at-length (R_l).

$$\mathbf{R_l = C_l/A_l}$$

A variation of this method was used to estimate trends in fishing mortality-at-age (R_a), from the ratio of the commercial catch-at-age (C_a) to the RV catch-at-age (A_a).

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

The results (Figure 28) indicate a trend of increasing fishing mortality on the age-classes that supported the fishery (ages 4^+) from 1986-92, followed by a reduction in 1993 that is consistent with a reported reduction in fishing effort due to low prices. The increase in estimated fishing mortality on hake aged 6 and 7 in 1994 is contrary to expectations with the reported reductions in fishing effort that occurred due to the cod moratorium and associated closures in 1994. The decline in 1995 is consistent with the moratorium on cod and hake fishing.

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:

$$\ln(C_{ij}) = \beta_0 + \beta_1 I + \beta_2 J + \varepsilon$$

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 5 year blocks (i.e., 1984-88, 1985-89, etc.) and included ages 1 to 11. Estimates of average total mortality (Z) for the respective periods were obtained by linear regression of the predicted values from the above model for ages 4 to 8 for the years 1984-95.

The results of this analysis indicate total mortalities (Z) near 0.9 in the mid- to late 1980's with a sharp increase to values in the 1.3 - 1.6 range in the early 1990's (Figure 29).

10 - Assessment Results

There was considerable uncertainty in the SPA results from ADAPT (unbalanced residual pattern and high CV's about the parameter estimates) but it suggested that fishing mortality increased in 1989 and remained at a high level until 1992, after which it decreased continuously until 1995.

The results from the Laurec-Shepherd analysis and the direct estimates of relative fishing mortality at age were consistent with the results from ADAPT, indicating relatively high fishing mortalities from 1989-1992. The results differed somewhat for 1994, with the ADAPT analysis suggesting a reduction in F for 1994, while the Laurec-Shepherd and relative F analyses indicated that F increased in 1994 for the older ages (i.e., 6,7 and 8). The estimates of average total mortality (Z) from the multiplicative analysis were consistent with this view of the stock (i.e., high mortality from 1990-1992) but it implied that mortality remained high in 1993.

Both the ADAPT and Laurec-Shepherd analyses suggested similar declines in hake abundance in recent years, with estimated abundance being relatively stable from 1984-1989 and then declining rapidly in the early 1990's to low values in recent years (1993-1995). The estimates of recent population abundance from both ADAPT and Laurec-Shepherd are about 20% of the levels estimated for the mid-1980's.

Finally, the SPA results are generally consistent with the survey results which indicate that population biomass is at its lowest level in the history of the survey and that the abundance of larger hake has continued to decline and is near the lowest level observed (abundance of all hake older than age 3 has declined since 1990).

11 - Management Considerations

Concern has been expressed about the by-catch and mortality of small white hake in estuarine smelt fisheries in the southern Gulf. Hurlbut et al. (1995) estimated that at least 100,000-110,000 (14,000-15,000 kg) small white hake were caught as by-catch during a 15 day sampling period in the 1994 'openwater' fishery in the Miramichi estuary.

By-catch monitoring was continued in the Miramichi estuary in 1995 and additional data from the 1994 'openwater' fishery were examined (Bradford et al. 1996).

In 1994 sampling was conducted weekly from Oct. 26 to Nov. 9, with 2 fishers each from the 'upstream' (i.e., Chatham) and 'downstream' (i.e., Loggieville) regions of the estuary visited once per week (See Map - Figure 30). A sampler accompanied one of the four smelt fishers to their traps and quantified any discarding of white hake at the trap. When the catch was brought ashore, the weight of the total unsorted catch was estimated and then subsampled for by-catch composition (n=3 crates/day). The subsampling units were fish crates that contained about 65 kg when filled (when possible crates from 3 different nets were selected). The subsamples were sorted by species and then weighed (nearest 0.5 kg) and counted and length frequencies of the by-catch species were obtained. Estimates of the total daily catch were obtained by scaling data to the total number of crates of unsorted catch. The total daily effort (nets and hours fished) was determined through interviews with other fishers.

The sampling protocol in 1995 was essentially the same except that only two fishers were visited regularly (twice weekly from Oct. 15 to Nov. 21).

The estimates of the total daily catch were standardised to a catch per unit effort (CPUE) of catch/net/day on the basis of both numbers and weight. The by-catch magnitude was estimated as the mean weekly CPUE's scaled upward to total net days/week and summed for the observation period.

The average catch per net per day of fishing in 1994 was:

White Hake	-	35.9 kg/net/day (= 246 fish/net/day)
Smelt	-	7.8 kg/net/day
Tomcod	-	27.5 kg/net/day

Thus, in 1994, the average catch rate for smelt was less than one quarter of the catch rate for white hake.

In 1995, the following catch rates were observed:

White Hake	-	16.5 kg/net/day (= 282 fish/net/day)
Smelt	-	16.3 kg/net/day
Tomcod	-	25.7 kg/net/day

Although the by-catch rate for white hake declined by almost 50% in 1995 it was still equal to the catch rate for the targeted species (i.e., smelt).

Using these catch rates, the estimated total by-catch of white hake for the 1994 "openwater" season was approximately 40 t (277,000 hake) (Table 27). In contrast, the estimated total by-catch for 1995 was approximately half (20 t = 350,000 hake). It was felt that the substantial reduction in the tonnage landed in 1995 was due to the non-occurrence of fish larger than 25 cm (Figure 31).

In summary, the by-catch of white hake in the 'openwater' smelt fishery of the Miramichi estuary in 1994 and 1995 was very high in both magnitude and relative to the catch of the directed species (i.e., smelt and tomcod). These incidental catches are extremely high given the current moratorium on directed fishing for white hake in the southern Gulf. Smelt fishers were required to sort and release all groundfish (including white hake) from their fishing gear in 1994 and 1995. Although the survival rate of such discarded hake is unknown, this requirement should be maintained.

At a consultation meeting with industry in Charlottetown, P.E.I. in the fall of 1994, we heard that many small hake were caught in fishing gear set for silversides and eels on P.E.I., earlier that fall. To investigate this report we consulted D. Cairns (DFO Science Branch, Diadromous Division, Moncton, N.B.) who conducted a monitoring program of the silverside fishery on P.E.I. in 1995. He described a fisher from Winter R., P.E.I., that maintained a logbook of his catch and effort of silversides in 1995, who indicated that his nets caught a rough average of six small hake (about 22 cm long) per day (Cairns 1996). He also mentioned a trap fisher from the Souris, P.E.I. area, the source of most silverside landings in Atlantic Canada, who said that his traps never catch hake. It would seem from these contacts that the by-catch of white hake in the silverside fishery in 1995 was probably minimal, but It should be remembered that because of limitations on markets and on suitable places to fish, only a minority of license holders actually fished in 1995. In contrast, in 1994 the silverside landings were the highest on record (543 t), and were more than four times greater than the mean of the time series. Thus, it is possible that there were significant numbers of white hake caught as by-catch in 1994, but the magnitude of the removals in this fishery seems significantly lower than those in the Miramichi smelt fishery.

12 - 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 over levels prior to 1995.

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Table 1. Nominal landings (tonnes) of white hake from NAFO Division 4T by gear, year and TAC. All data from 1993 to 1995 are provisional statistics.

YEAR	TRAWL	SEINE	GILLNET	LINE	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	172	101	454	694	45	1465	3600
*1994	81	50	217	694	0	1042	2000
*1995	31	11	18	7	0	66	MORATORIUM

1960 to 1995

	TRAWL	SEINE	GILLNET	LINE	OTHER	TOTAL
AVERAGE	**1437**	**585**	**1657**	**923**	**786**	**5519**
PERCENT	**26**	**11**	**30**	**17**	**14**	

1995

	TRAWL	SEINE	GILLNET	LINE	OTHER
PERCENT	**46**	**17**	**27**	**10**	**0**

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

Table 2a. Nominal landings (tonnes) of white hake from NAFO Division 4T in 1995 in Sentinel Survey Projects and the Recreational Groundfish Fishery.
All data are provisional statistics.

Sentinel Survey Project

TRAWL	SEINE	LINE	TOTAL
0.9	2.6	0.7	**4.2**

Recreational Groundfish Fishery

Area:	P.E.I.	N.S. (Gulf)	N.B.	Que.	TOTAL
	0.2	3.6	0.8	0.0	**4.6**

Table 2b. Nominal landings (tonnes) of white hake from NAFO Division 4T in 1995 by gear and month.
All data are provisional statistics.

MONTH	TRAWL	SEINE	LINE	GILLNET	OTHER	TOTAL	PERCENT
JANUARY	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
FEBRUARY	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
MARCH	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
MAY	0.0	0.7	0.0	0.2	0.0	0.9	**1.3**
JUNE	0.2	1.3	0.0	2.1	0.0	3.6	**5.4**
JULY	2.8	2.2	3.1	6.4	0.0	14.4	**21.7**
AUGUST	5.5	0.4	1.4	8.4	0.0	15.8	**23.8**
SEPTEMBER	10.8	2.2	1.7	0.6	0.0	15.3	**23.0**
OCTOBER	11.0	1.3	0.1	0.0	0.0	12.4	**18.7**
NOVEMBER	0.2	3.2	0.7	0.0	0.0	4.0	**6.0**
DECEMBER	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
TOTAL	**30.6**	**11.3**	**6.8**	**17.8**	**0.0**	**66.4**	
PERCENT	**46.0**	**17.0**	**10.3**	**26.8**	**0.0**	**100.0**	

Table 3. The age-length key that was used in the calculation of the 1995 catch-at-age for white hake in NAFO Division 4T.

Key #	Fishery	Period	Sample Type	Sample Source	Sample # of Observ-ations	Landings (t)
1	All Gears OTB, SNU, GN*, LL* and MISC*	Jan. - Dec.	Age	OTB/SNU Jan. - Dec.	134	66.5
			Length	OTB/SNU Jan. - Dec.	197	

Gear Type Abbreviations

OTB = Otter Trawl SNU = Seine GN = Gillnet LL = Longline MISC = Miscellaneous

* - No samples from the commercial fishery were obtained for these gear types.

Length/Weight Coefficients (sexes combined) from Mission N230 (Sept. 1995)

a = 0.00446 b = 3.133661

Table 4. The catch, weight and length-at-age for white hake in NAFO Division 4T as estimated from port sampling of the commercial fisheries in 1995.

Age	Catch (Numbers)-at-Age (000's)	Average Weight-at-Age (kg)	Average Length-at-Age (cm)
1	0.00		
2	0.00		
3	0.00		
4	0.42	0.89	49.00
5	2.18	1.33	55.44
6	9.14	1.93	62.74
7	11.67	2.65	69.41
8	3.66	3.59	76.33
9	0.23	5.27	86.50
10	0.00		
11	0.00		
12	0.00		

 # in L. Freq. = 197
 # Aged = 134
Mean Age = 6.6
Mean Weight = 2.4 kg
Mean Length = 66.9 cm

Table 5. Commercial fishery catch-at-age (numbers in 1,000's) for white hake in NAFO Division 4T.

Catch-at-age: NAFO 4T hake

Age	70	71	72	73	74	75	76	77	78	79	80	81
3	86	84	91	80	49	56	81	86	79	90	91	66
4	708	715	633	499	250	214	298	332	354	470	452	427
5	798	798	747	664	380	390	433	471	579	833	1028	1075
6	456	448	485	461	297	344	333	361	545	972	1661	1976
7	373	378	403	454	313	380	291	302	345	672	1196	1391
8	144	144	165	191	136	171	132	136	172	315	540	604
9	74	77	84	108	78	99	67	66	61	101	137	154
10	42	43	44	50	33	42	28	29	26	47	75	94
11	12	14	12	13	8	8	5	5	4	8	7	4
12	7	8	8	9	5	7	9	8	8	11	6	1
13-14	3	3	4	4	3	3	2	2	2	4	5	8

Age	82	83	84	85	86	87	88	89	90	91	92*	93
3	5	86	58	64	2	30	0	11	34	28	127	77
4	159	220	319	216	204	531	39	114	604	409	1000	304
5	648	740	787	608	496	1357	476	574	1170	1048	1028	390
6	1210	939	788	592	477	900	648	810	992	859	554	213
7	1232	712	542	391	330	411	513	689	427	507	270	85
8	665	535	275	227	233	149	109	224	80	79	61	27
9	198	142	142	108	77	68	15	76	18	17	26	10
10	89	42	69	51	45	18	6	11	8	5	11	1
11	24	8	22	16	21	4	2	13	2	2	4	2
12	16	6	16	18	14	2	1	5	1	1	0	1
13-14	16	3	7	12	9	3	1	6	1	5	1	0

Age	94	95	92 (From Previous Assessment)
3	25	0	128
4	134	0	988
5	185	2	1002
6	201	9	534
7	86	12	260
8	28	4	58
9	5	0	25
10	1	0	11
11	0	0	4
12	0	0	0
13-14	0	0	1

92* - After the NAFO landings were finalized in 1996

Table 6. Commercial fishery catch, weight and length-at-age for white hake in NAFO Division 4T: 1982-1995.

a. Commercial Fishery Catch-at-Age (In 1,000's) for NAFO 4T White Hake: 1982-1995.

	Year													
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1-2	0	43	2	3	0	0	0	5	0	0	0	0	0	0
3	5	86	58	64	2	30	0	11	34	28	127	77	25	0
4	159	220	319	216	204	531	39	114	604	409	1000	304	134	0
5	648	740	787	608	496	1357	476	574	1170	1048	1028	390	185	2
6	1210	939	788	592	477	900	648	810	992	859	554	213	201	9
7	1232	712	542	391	330	411	513	689	427	507	270	85	86	12
8	665	535	275	227	233	149	109	224	80	79	61	27	28	4
9	198	142	142	108	77	68	15	76	18	17	26	10	5	0
10	89	42	69	51	45	18	6	11	8	5	11	1	1	0
11	24	8	22	16	21	4	2	13	2	2	4	2	0	0
12	16	6	16	18	14	2	1	5	1	1	0	1	0	0
13+	16	3	7	12	9	3	1	6	1	5	1	0	0	0
	4261	3477	3028	2306	1908	3473	1809	2537	3337	2961	3082	1110	664	27

b. Commercial Fishery Mean Weight-at-Age (kg) for NAFO 4T White Hake: 1982-1995.

	Year													
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1		0.46												
2		0.60	0.53	0.95			0.21	0.21						
3	0.84	0.92	0.87	1.39	3.19	0.62	0.33	0.42	0.59	0.54	0.55	0.55	0.61	
4	1.23	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
5	1.50	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
6	2.09	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
7	2.38	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
8	2.89	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
9	3.27	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
10	3.89	4.09	5.63	5.00	5.65	6.06	6.01	6.15	5.58	6.91	5.55	3.37	4.07	
11	3.82	5.99	5.05	6.70	6.90	8.75	8.56	6.16	7.54	5.95	5.54	4.35		
12	3.75	7.52	7.11	6.96	6.92	9.57	10.41	9.65	9.26	7.18	6.06	4.03		
13	4.52								6.83	10.04			9.55	
14														
15														

c. Commercial Fishery Mean Length-at-Age (cm) for NAFO 4T White Hake: 1982-1995.

	Year													
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
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	42.02	43.57	
4	54.95	56.97	52.28	57.36	49.61	48.16	50.49	49.97	47.82	47.85	47.52	49.61	48.02	49.00
5	58.68	60.70	58.78	62.05	57.10	55.47	55.39	54.57	54.31	53.35	53.42	54.46	54.29	55.44
6	65.18	64.32	63.60	65.17	66.02	64.00	62.41	61.21	61.59	59.55	61.66	61.82	61.94	62.74
7	67.81	68.42	68.23	68.90	70.84	71.41	70.54	68.57	69.98	67.42	68.89	65.84	68.44	69.41
8	72.11	68.69	72.17	74.73	76.83	77.80	76.89	75.96	76.78	72.07	74.93	74.62	72.85	76.33
9	74.75	74.73	74.49	76.32	81.03	80.48	85.70	80.97	86.68	81.31	84.86	73.98	76.10	86.50
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	
11	77.86	91.64	81.66	89.11	92.09	100.06	99.94	89.25	99.77	91.99	91.55	83.59		
12	76.88	99.06	91.16	88.92	90.93	102.73	106.41	105.90	107.00	97.77	94.59	81.47		
13	81.67								96.42	109.03			106.00	
14														
15														

Table 7. 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).

Survey	P091	P106	P122	P143	P157	P172	P188	P204	P229	P244	P260	P278
Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
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
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
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
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
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
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
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
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
age 9	0.03	0.16	0.04	0.06			0.05	0.02	0.02	0.09	0.23	0.02
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
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

Survey	P296	P312	P327	H159	H179	H192	H204	H219	H232	N178	N192	N210	N230
Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
age 0		0.01	0.16	0.31		0.01	0.41	0.52	0.13	0.09	0.35	0.22	0.60
age 1	0.09	0.05	0.10	0.24	0.05	0.17	1.08	0.75	0.55	0.34	0.29	0.18	0.52
age 2	0.81	0.47	0.64	1.70	0.54	1.63	2.11	2.33	2.03	1.41	0.67	0.81	1.53
age 3	0.81	1.10	2.34	2.60	1.72	2.67	4.38	2.45	2.81	2.61	0.56	0.71	0.59
age 4	0.80	1.38	2.86	4.15	2.13	3.05	2.20	1.67	1.79	2.12	0.95	0.86	0.48
age 5	0.44	1.11	0.95	2.53	1.45	2.10	1.48	1.58	1.26	0.60	0.69	0.38	0.17
age 6	0.28	0.53	0.66	0.90	0.69	0.60	0.71	0.51	0.61	0.13	0.20	0.12	0.13
age 7	0.14	0.24	0.53	0.41	0.19	0.26	0.23	0.33	0.21	0.06	0.05	0.03	0.03
age 8	0.07	0.17	0.32	0.20	0.06	0.04	0.03	0.07	0.06	0.01	0.03	0.02	0.01
age 9	0.07	0.05	0.23	0.11	0.02	0.01	0.03	0.02	0.01		0.02		
age 10	0.01	0.06	0.05	0.04	0.03	0.02	0.02		0.02		0.01		
age 11		0.01	0.01	0.04			0.01		0.02				
age 12		0.01	0.04	0.03	0.02								
age 13			0.02	0.02									
age 14			0.02										
age 15			0.01										
age 16													
Totals:	3.52	5.19	8.93	13.26	6.89	10.56	12.68	10.22	9.50	7.36	3.83	3.33	4.06

Research Vessels: E.E. Prince from 1971-85 (P)
Lady Hammond from 1986-91 (H)
Alfred Needler from 1992-95 (N)

Table 8. 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
Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
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
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
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
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
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
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
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
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
age 9	2.60	2.87	4.48	3.36			3.87	2.46	3.22	3.30	2.93	3.08
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
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	P296	P312	P327	H159	H179	H192	H204	H219	H232	N178	N192	N210	N230
Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
age 0		0.06	0.01	0.02		0.04	0.05	0.03	0.07	0.07	0.04	0.05	0.01
age 1	0.16	0.14	0.07	0.14	0.11	0.09	0.09	0.07	0.18	0.15	0.15	0.13	0.11
age 2	0.33	0.29	0.22	0.25	0.18	0.24	0.22	0.22	0.26	0.29	0.27	0.25	0.24
age 3	0.60	0.57	0.41	0.47	0.42	0.42	0.44	0.35	0.46	0.45	0.40	0.51	0.46
age 4	1.08	0.92	0.75	0.77	0.68	0.71	0.62	0.64	0.66	0.63	0.62	0.81	0.72
age 5	1.85	1.50	1.31	1.26	1.19	1.09	1.07	1.00	1.05	0.96	0.85	1.13	1.10
age 6	2.07	2.05	1.91	1.97	2.03	1.81	1.63	1.46	1.55	1.49	1.32	1.66	1.77
age 7	3.02	2.67	2.61	2.86	3.02	2.76	2.39	2.08	2.15	1.99	1.11	2.33	2.89
age 8	3.73	3.22	3.51	3.40	3.92	3.82	3.48	3.54	3.71	3.13	1.25	3.13	3.29
age 9	3.88	2.93	4.95	4.60	6.79	5.86	5.47	4.10	4.34		3.84		
age 10	5.73	6.08	4.00	6.52	6.63	8.73	6.99		6.59		4.76		
age 11		4.25	7.49	7.43			9.34		7.15				
age 12		6.35	10.26	7.93	8.23								
age 13			8.91	10.30									
age 14			10.81										
age 15			12.16										
age 16													

Research Vessels: E.E. Prince from 1971-85 (P)
Lady Hammond from 1986-91 (H)
Alfred Needler from 1992-95 (N)

Table 9. 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
Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
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
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
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
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
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
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
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
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
age 9	67.9	67.7	79.2	73.9			75.9	67.0	73.0	72.2	72.2	73.4
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
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	P296	P312	P327	H159	H179	H192	H204	H219	H232	N178	N192	N210	N230
Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
age 0		22.0	12.0	13.2		17.4	19.2	15.6	20.0	22.0	16.2	18.5	11.6
age 1	27.8	27.0	21.7	26.7	26.1	23.3	23.0	20.9	29.2	27.5	26.8	26.4	24.9
age 2	35.5	33.7	31.4	32.0	30.3	32.4	30.9	31.3	33.0	34.3	33.1	32.5	32.0
age 3	42.8	42.2	37.6	39.0	39.4	38.7	39.1	36.4	39.8	39.9	37.9	41.0	39.6
age 4	52.5	48.7	45.9	46.0	45.3	45.8	43.7	44.4	44.8	44.4	44.0	47.5	45.8
age 5	62.6	56.8	54.4	53.7	54.0	52.2	52.0	51.4	52.0	51.1	48.7	53.0	52.3
age 6	65.2	62.6	61.5	62.1	63.5	61.3	59.7	58.2	58.9	59.2	56.1	60.0	61.0
age 7	73.8	67.6	67.5	69.7	72.1	70.2	67.4	65.2	65.6	65.1	53.1	66.9	71.1
age 8	78.4	71.7	73.4	73.4	77.4	77.3	76.2	77.9	78.2	76.0	55.5	73.6	74.2
age 9	80.2	70.0	81.5	80.0	92.7	88.6	88.3	82.0	83.0		80.2		
age 10	91.0	84.7	76.8	90.1	92.0	100.6	95.6		95.0		87.0		
age 11		79.0	93.9	94.3	98.4		105.0		97.4				
age 12		87.0	103.0	96.0									
age 13			99.0	106.0									
age 14			105.0										
age 15			108.0										
age 16													

Research Vessels: E.E. Prince from 1971-85 (P)
Lady Hammond from 1986-91 (H)
Alfred Needler from 1992-95 (N)

Table 10. 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	5.19	1.32	6.10	1.42	9375	4306370	11024	4633180
1985	8.87	7.30	10.22	10.71	16020	23834443	18465	34963326
1986	13.26	6.74	13.86	5.41	23954	21992371	25038	17639143
1987	6.88	2.02	7.38	2.29	12437	6590507	13326	7482536
1988	10.64	5.39	8.85	2.35	18915	17058956	15739	7429573
1989	12.66	6.73	7.86	1.70	22386	21049577	13906	5307029
1990	10.22	4.11	7.11	1.27	18469	13401710	12851	4157881
1991	9.50	9.83	6.82	3.03	16799	30732460	12065	9470256
1992	7.35	6.68	4.26	1.71	13280	21800402	7691	5577398
1993	3.90	0.78	2.29	0.32	7053	2531365	4140	1052272
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

Table 11. 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) for "Strait" Comp.	Variance	Estimated Population Biomass (t) for "Strait" Comp.	Variance
1984	8.64	25.37	11.85	26.80	2890	2842004	3967	3002462
1985	17.78	114.93	11.96	7.99	5952	12874653	4002	895574
1986	38.61	263.76	36.23	240.66	12922	29546651	12125	26959043
1987	18.69	144.68	16.53	130.82	6077	15292467	5374	13827623
1988	15.47	35.68	11.25	18.20	4745	3358539	3451	1713074
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

Table 12. 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) for "Channel" Comp.	Variance	Estimated Population Biomass (t) for "Channel" Comp.	Variance
1984	27.58	51.68	28.99	38.16	5634	2157091	5922	1592714
1985	23.23	92.48	22.61	76.98	4746	3860476	4620	3213507
1986	74.27	762.60	65.41	257.14	15173	31833010	13363	10733773
1987	41.95	155.53	50.83	97.37	8571	6492258	10386	4064504
1988	80.67	273.63	73.84	174.60	16482	11422049	15086	7288252
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

Table 13. Research vessel estimates of the mean catch per tow (numbers) for strata 403 and 433 (separated and combined), for the 'rest' of the survey area and for the total survey area.

Year	Mean No./Tow Strat. 403 (St. Georges Bay)	Mean No./Tow Strat. 433 East North. Strait	Mean No./Tow Strat. 403+433 (Combined Areas)	Mean No./Tow "Rest" of NAFO 4T	Mean No./Tow All of NAFO 4T (Total Survey Area)
1984	6.93	20.31	19.15	4.28	5.19
1985	26.67	46.75	45.01	6.52	8.87
1986	65.11	61.93	62.21	10.08	13.26
1987	21.58	36.14	34.88	5.06	6.88
1988	58.58	17.98	21.51	9.93	10.64
1989	532.66	81.68	120.85	5.62	12.66
1990	186.67	52.34	64.01	6.72	10.22
1991	80.27	77.93	78.13	5.04	9.50
1992	131.57	75.68	80.53	2.59	7.35
1993	79.93	5.16	11.65	3.40	3.90
1994	23.16	33.40	32.51	1.43	3.33
1995	189.41	14.68	29.86	2.39	4.07

Research Vessels: E.E. Prince from 1971-85
Lady Hammond from 1986-91
Alfred Needler from 1992-94

Table 14. Mean number of white hake in strata sampled in northern Gulf surveys. The *Lady Hammond* was used from 1984-1989, followed by the *Alfred Needler*. Empty cells indicate strata that were not sampled; shaded cells indicate strata that were sampled only once.

	Year											
Stratum	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
401	44.29	38.83	63.23	48.00	131.04	115.92	6.60	13.54	29.00	0.45	64.67	16.83
402	47.54	155.69	78.94	87.50	93.88	23.25	87.12	31.18	6.85	0.21	2.44	26.29
403	9.82	45.95	62.21	86.82	32.47	20.75	14.59	3.78	6.55	0.84	1.04	0.92
404	5.53	47.30	28.59	24.35	17.33	6.02	5.79	9.74	20.73	5.54	8.00	1.74
405	38.71	10.98	22.27	12.50	17.18	7.08	8.33	6.52	2.89	3.88	1.56	3.49
406	8.83	3.24	9.53	5.37	6.29	8.00	3.24	6.22	0.63	1.69	0.22	0.44
407	0.94	1.48	1.88	1.02	0.44	1.45	1.70	1.33	0.67	0.46	0.89	0.89
408	2.40	8.00	3.06	5.06	3.33	2.32	2.94	2.76	1.65	2.44	0.33	0.00
409				41.92	16.67	15.25	6.33	3.52	1.67	0.19		0.67
410			4.10		11.31	15.00	0.00	0.30	0.83	0.24	0.50	0.00
411				0.00	0.35		0.30	0.93	0.00	0.00	0.00	0.10
412				3.00	4.24		1.63	1.16	0.41	0.00	0.67	0.36
413				2.90	1.67		0.33	0.64	0.33	0.00		0.22
414				3.00	0.71		4.74	1.30	0.27	0.24	0.67	0.00
801	1.73	0.26	0.00	3.00	2.02	0.00	0.30	1.52	0.00	0.00	0.67	0.00
802	0.25	3.32	1.33	1.50	0.35	0.67	2.63	2.00	2.00	0.87	0.00	1.08
803	0.00	0.89	0.92	2.24	0.49	0.20	1.90	0.56	0.50	0.57	0.00	0.44
804	1.60	1.30	5.08	4.39	1.63	0.72	3.91	0.84	0.00	1.01	0.50	0.21
805	0.56	0.00	1.94	1.82	4.35	2.47	0.59	1.26	0.40	0.00	0.00	0.15
806	0.00	0.98	2.54	6.08	4.00	5.33	2.44	1.11	1.48	0.00	0.00	0.22
807	2.93	14.94	8.60	18.73	5.00	5.29	4.15	3.80	2.31	0.42	0.93	1.39
808	2.66	3.35	13.28	6.61	4.40	5.53	4.56	3.91	1.06	0.31	2.40	3.79
809	2.61	6.43	15.67	18.50	2.08	6.00	6.61	3.19	3.37	1.49	1.33	3.49
810	4.31	25.73	33.21	16.92	11.26	7.00	3.33	4.11	3.00	2.62	6.89	3.76
811	5.62	11.70	52.56	39.91	43.43	21.33	13.78	4.31	4.47	5.37	1.20	2.97
812	6.06	5.21	6.41	7.45	7.45	7.90	3.50	4.05	0.00	0.48	1.00	3.52
813	20.57	3.46	2.79	6.55	2.15	3.92	1.81	1.03	0.20	0.15	0.00	0.14
814	5.40	26.75	20.29	8.05	8.67	15.33	17.00	2.29	10.06	0.43	1.56	
815	1.81	5.51	13.96	13.78	8.90	7.04	5.16	3.64	1.80	0.25	0.40	0.31
816	3.79	4.47	6.12	6.85	2.30	2.30	0.62	0.56	0.09	0.21	0.33	0.00
817	1.26	1.14	1.38	1.41	1.86	6.48	1.26	0.97	0.53	0.08	0.22	0.00
818	10.85	5.17	21.13	18.74	10.14	14.69	3.96	1.37	0.32	0.00	0.22	0.00
819	7.85	11.69	13.00	7.66	3.51	2.67	3.00	3.00	2.78	0.12	1.00	1.70
820	0.63	0.36	0.00	0.00	0.71	0.33	0.00	2.37	0.33	0.22	0.00	0.00
821	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00
822	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
823	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
824	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00
825	0.00	0.50	0.26									
827		0.50	0.00	0.00	0.00			0.00	0.00	0.00	0.00	0.00
828		0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00
829		0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
830	0.53	0.50	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
831		0.28	0.00	0.00	0.32	0.00	0.00		0.00	0.00	0.00	0.00
832		0.34	0.00	0.14	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
833				0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
835								0.00	0.00	0.00	0.00	0.00
836								0.00	0.00	0.00	0.00	0.00
837								0.00	0.00	0.00	0.00	0.00
838								0.00	0.00	0.00	0.00	0.00
839								0.00	0.00	0.00	0.00	0.00
840								0.00	0.00		0.00	
841									0.00	0.00	0.00	0.00

Table 15. Analysis of variance from multiplicative model used to estimate mean hake abundance in western strata of the northern Gulf survey that were not covered by the *Lady Hammond.* The upper panel shows analysis used to estimate abundance; lower panel shows analysis with year-stratum interaction term.

Class	Levels	Values										
YEAR	6	84	85	86	87	88	89					
STRAT	11	406	409	410	411	412	413	414	805	817	831	832

Number of observations in data set = 185

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	15	2067528.4044	137835.2270	10.74	0.0001
Error	169	2168920.3855	12833.8484		
Corrected Total	184	4236448.7900			

R-Square	C.V.	Root MSE	LNCAT Mean
0.4880	9999.99	113.2866	0.4274

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	5	243357.9781	48671.5956	3.79	0.0028
STRAT	10	1824170.4263	182417.0426	14.21	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	5	158157.4207	31631.4841	2.46	0.0348
STRAT	10	1824170.4263	182417.0426	14.21	0.0001

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	41	2478498.3997	60451.1805	4.92	0.0001
Error	143	1757950.3903	12293.3594		
Corrected Total	184	4236448.7900			

R-Square	C.V.	Root MSE	LNCAT Mean
0.5850	9999.99	110.8754	0.4274

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	5	243357.9782	48671.5956	3.96	0.0022
STRAT	10	1824170.4263	182417.0426	14.84	0.0001
YEAR*STRAT	26	410969.9953	15806.5383	1.29	0.1777

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	5	46324.2950	9264.8590	0.75	0.5847
STRAT	10	1837042.8754	183704.2875	14.94	0.0001
YEAR*STRAT	26	410969.9953	15806.5383	1.29	0.1777

Table 16. Analysis of variance from multiplicative model used to estimate mean hake abundance in northeastern strata of the northern Gulf survey that were not covered by the *Lady Hammond*. The upper panel shows analysis used to estimate abundance; lower panel shows analysis with year-stratum interaction term.

Class	Levels	Values							
YEAR	6	84	85	86	87	88	89		
STRAT	8	815	816	819	827	828	829	830	833

Number of observations in data set = 189

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	12	3045386.2268	253782.1856	21.05	0.0001
Error	176	2121568.9800	12054.3692		
Corrected Total	188	5166955.2068			

R-Square	C.V.	Root MSE	LNCAT Mean
0.5894	9999.99	109.7924	0.4945

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	5	54547.1551	10909.4310	0.91	0.4791
STRAT	7	2990839.0716	427262.7245	35.44	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	5	130532.4388	26106.4878	2.17	0.0600
STRAT	7	2990839.0716	427262.7245	35.44	0.0001

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	40	3440683.0638	86017.0766	7.37	0.0001
Error	148	1726272.1430	11664.0010		
Corrected Total	188	5166955.2068			

R-Square	C.V.	Root MSE	LNCAT Mean
0.6659	9999.99	108.0000	0.4945

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	5	54547.1551	10909.4310	0.94	0.4600
STRAT	7	2990839.0716	427262.7245	36.63	0.0001
YEAR*STRAT	28	395296.8371	14117.7442	1.21	0.2317

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	5	38199.6017	7639.9203	0.65	0.6581
STRAT	7	2826114.2126	403730.6018	34.61	0.0001
YEAR*STRAT	28	395296.8371	14117.7442	1.21	0.2317

Table 17. Analysis of variance from multiplicative model used to estimate mean hake abundance in western strata of the northern Gulf survey that were not covered by the *Alfred Needler*. The upper panel shows analysis used to estimate abundance; lower panel shows analysis with year-stratum interaction term.

Class	Levels	Values						
YEAR	6	90	91	92	93	94	95	
STRAT	7	409	410	411	412	413	414	805

Number of observations in data set = 149

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	646348.0683	58758.9153	7.63	0.0001
Error	137	1055175.3650	7702.0010		
Corrected Total	148	1701523.4332			

R Square	C.V.	Root MSE	LNCAT Mean
0.3799	9999.99	87.7611	0.2559

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	5	400447.1859	80089.4372	10.40	0.0001
STRAT	6	245900.8824	40983.4804	5.32	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	5	382015.5973	76403.1195	9.92	0.0001
STRAT	6	245900.8824	40983.4804	5.32	0.0001

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	39	948205.7937	24312.9691	3.52	0.0001
Error	109	753317.6395	6911.1710		
Corrected Total	148	1701523.4332			

R Square	C.V.	Root MSE	LNCAT Mean
0.5573	9999.99	83.1335	0.2559

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	5	400447.1859	80089.4372	11.59	0.0001
STRAT	6	245900.8824	40983.4804	5.93	0.0001
YEAR*STRAT	28	301857.7254	10780.6331	1.56	0.0549

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	5	257327.8438	51465.5688	7.45	0.0001
STRAT	6	250895.3235	41815.8872	6.05	0.0001
YEAR*STRAT	28	301857.7254	10780.6331	1.56	0.0549

Table 18. Analysis of variance from multiplicative model used to estimate mean hake abundance in eastern strata of the northern Gulf survey that were not covered by the *Alfred Needler*. The upper panel shows analysis used to estimate abundance; lower panel shows analysis with year-stratum interaction term.

Class	Levels	Values				
YEAR	5	90	91	93	94	95
STRAT	4	801	812	813	814	

Number of observations in data set = 92

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	1209049.2945	172721.3278	8.74	0.0001
Error	84	1660576.1927	19768.7642		
Corrected Total	91	2869625.4872			

R-Square	C.V.	Root MSE	LNCAT Mean
0.4213	9999.99	140.6014	0.2013

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	4	488191.3297	122047.8324	6.17	0.0002
STRAT	3	720857.9648	240285.9883	12.15	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	4	498342.1187	124585.5297	6.3	0.0002
STRAT	3	720857.9648	240285.9883	12.15	0.0001

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	18	1527962.6197	84886.8122	4.62	0.0001
Error	73	1341662.8675	18378.9434		
Corrected Total	91	2869625.4872			

R-Square	C.V.	Root MSE	LNCAT Mean
0.5325	9999.99	135.5690	0.2013

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	4	488191.3297	122047.8324	6.64	0.0001
STRAT	3	720857.9648	240285.9883	13.07	0.0001
YEAR*STRAT	11	318913.3252	28992.1205	1.58	0.1237

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	4	374606.5265	93651.6316	5.10	0.0011
STRAT	3	707408.5131	235802.8377	12.83	0.0001
YEAR*STRAT	11	318913.3252	28992.1205	1.58	0.1237

Table 19. Estimated number of white hake in strata not sampled by the northern Gulf survey, based on multiplicative analyses.

Stratum	1984	1985	1986	1987	1989	1990	1994	1995
409	14.34	12.91	19.67				1.05	
410	3.86	3.44		5.81				
411	0.00	0.00	0.03		0.19			
412	1.58	1.38	2.32		3.13			
413	1.00	0.85	1.53		2.11		0.02	
414	0.57	0.47	0.95		1.37			
814								3.19
827	0.29				0.00	0.00		
828	0.00							
829	0.00							
831	0.00							
832	0.00							
833	0.00	0.37	0.42					

Table 20. Comparison of estimated stratified mean number of white hake per tow, based on sampled strata including strata with non-replicated sets (sampled n≥1), sampled strata excluding strata with non-replicated strata (sampled n>1), and all strata in the northern Gulf survey. Estimates from all strata include stratum estimates based on multiplicative analyses.

Year	Sampled n≥1	Sampled n>1	All strata
1984	4.89	5.07	4.12
1985	5.98	5.98	5.74
1986	7.55	7.38	7.35
1987	7.94	7.94	7.90
1988	6.01	6.01	6.01
1989	5.21	5.21	4.87
1990	3.42	3.42	3.31
1991	2.11	2.28	2.11
1992	1.26	1.30	1.26
1993	0.54	0.56	0.54
1994	0.88	0.88	0.88
1995	1.01	0.77	1.03

Table 21. Results of correspondence analysis of length frequencies of white hake from the 'Strait' and 'Channel' stock components. Data is from the annual (September) surveys of NAFO Division 4T.

Survey	Year	Length Freq. Sexed=S or Combined=C	Variations of Analysis	Total Inertia	Percentage of Inertia Explained by Dimension 1	Percentage of Inertia Explained by Dimension 2	Total Percentage of Inertia Explained by Dimensions 1&2
P312	1984	C	None	1.15881	48.18	23.14	71.32
P312	1984	C	Left out Set # 54	0.68130	42.93	17.24	60.17
P327	1985	S	Repeat Sets Separate	1.39999	47.38	21.11	68.49
P327	1985	S	Repeat Sets Combined	1.32641	46.54	21.89	68.43
H141	1985	C	Repeat Sets Separate	1.20305	47.41	14.03	61.44
H141	1985	C	Repeat Sets Combined	1.38501	41.19	25.97	67.16
H159	1986	C	Repeat Sets Separate	1.80718	33.88	24.18	58.06
H159	1986	C	Repeat Sets Combined	1.74863	32.92	27.07	59.99
H179	1987	S	Repeat Sets Separate	1.02505	48.84	17.31	66.15
H179	1987	S	Repeat Sets Combined	1.05911	45.77	18.22	63.99
H192	1988	C	Repeat Sets Separate	1.55288	36.48	27.09	63.57
H192	1988	C	Repeat Sets Combined	1.60793	37.89	29.93	67.82
H204	1989	C	None	1.32002	29.40	21.36	50.76
H204	1989	C	Leave out sets 98,170	1.01720	29.60	27.04	56.64
H219	1990	S	None	1.92645	32.76	25.57	58.33
H232	1991	S	None	1.52451	33.70	32.30	66.00
N178	1992	S	None	0.75220	38.79	22.72	61.51
N192	1993	S	None	0.93345	51.46	24.69	76.15
N210	1994	S	None	1.30519	67.57	19.31	86.88
N230	1995	S	None	0.96334	45.71	36.18	81.89
				Mean %	41.92	23.82	65.74

Table 22. Proportion of commercial white hake samples from the 'Strait' and 'Channel' stock components. (Note: S = 'Strait' and C = 'Channel').

Year	No. of Samples S	No. of Samples C	No. Measured in L.F. S	No. Measured in L.F. C	No. Otoliths Sampled S	No. Otoliths Sampled C
1984	235	5	24644	854	1620	40
1985	49	1	7080	127	1019	35
1986	168	11	15031	1579	940	290
1987	167	3	21045	761	852	97
1988	110	0	15421	0	616	0
1989	70	4	8698	552	1028	74
1990	40	0	6697	0	799	0
1991	33	1	6285	173	538	31
1992	42	2	7306	259	1461	63
1993	34	3	5423	404	666	77
1994	15	1	2439	212	687	60
1995	5	2	177	20	114	20
Totals	968	33	120246	4941	10340	787
Percent (1984-95)	97	3	96	4	93	7

Table 23. 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.	1219.78035	1048.12643	0.85928	1.16377	37.89972
age 4 - Abund.	878.87925	537.13680	0.61116	1.63623	19.42860
age 5 - Abund.	386.32812	211.15974	0.54658	1.82955	14.61511
age 6 - Abund.	530.17061	273.06521	0.51505	1.94155	12.71888
age 7 - Abund.	244.80005	138.69712	0.56524	1.76917	15.33186
age 8 - Abund.	62.07654	38.03204	0.61266	1.63222	18.11875
age 3 - Q	0.00165	0.00043	0.25949	3.85366	2.50796
age 4 - Q	0.00208	0.00052	0.25031	3.99505	2.51259
age 5 - Q	0.00182	0.00045	0.24715	4.04609	2.57427
age 6 - Q	0.00132	0.00033	0.24690	4.05019	2.76622
age 7 - Q	0.00135	0.00034	0.25106	3.98307	3.33458
age 8 - Q	0.00196	0.00050	0.25514	3.91941	4.04281

Table 24. 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	84	85	86	87	88	89	90	91	92	93	94	95
3	0.003	0.003	0.000	0.003	0.000	0.000	0.003	0.003	0.020	0.025	0.008	0.000
4	0.028	0.015	0.013	0.043	0.003	0.008	0.055	0.050	0.150	0.068	0.065	0.000
5	0.103	0.080	0.048	0.128	0.058	0.060	0.143	0.190	0.280	0.125	0.065	0.003
6	0.145	0.158	0.113	0.160	0.125	0.193	0.213	0.290	0.335	0.185	0.130	0.005
7	0.188	0.160	0.225	0.230	0.243	0.458	0.343	0.450	0.465	0.188	0.195	0.013
8	0.183	0.213	0.265	0.413	0.168	0.528	0.343	0.275	0.340	0.273	0.150	0.015
9	0.170	0.175	0.200	0.268	0.178	0.393	0.300	0.338	0.380	0.213	0.145	0.010
10	0.170	0.175	0.200	0.268	0.178	0.393	0.300	0.338	0.380	0.213	0.145	0.010
4+	0.958	0.960	1.050	1.465	0.948	2.023	1.640	1.880	2.180	1.195	0.830	0.055
6+	0.855	0.880	1.003	1.338	0.890	1.963	1.498	1.690	1.900	1.070	0.765	0.053
7+	0.710	0.723	0.890	1.178	0.765	1.770	1.285	1.400	1.565	0.885	0.635	0.048

b. Beginning of year population estimates for southern Gulf white hake estimated by ADAPT calibration: 1984-1995 (numbers in 1,000's)

Age/Year	84	85	86	87	88	89	90	91	92	93	94	95
3	5013	5905	4541	4523	4600	4066	3104	3019	1902	870	1084	925
4	3336	4052	4777	3716	3676	3765	3319	2511	2447	1442	642	865
5	2584	2443	3122	3727	2562	2975	2980	2171	1686	1098	906	405
6	1988	1404	1450	2107	1823	1667	1916	1381	829	450	546	574
7	1132	914	614	755	911	906	632	671	353	178	176	265
8	588	437	395	204	247	282	119	131	91	45	68	66
9	313	233	152	112	32	103	28	25	36	19	12	31
10	252	209	176	45	21	48	19	19	22	8	2	31
Totals	15207	15597	15226	15190	13873	13812	12116	9928	7365	4109	3437	3161

Table 25. Diagnostics from the Laurec-Shepherd SPA calibration for white hake using the research survey index for the 'Strait' component.

VPA Version 3.0 (MSDOS)
Laurec-Shepherd Calibration
At 23/02/1996 10:28

White Hake in Subdivision 4T
CPUE data from file hak8495.ind

Disaggregated Qs
Log transformation
No trend in Q (mean used)
Terminal F's estimated using Laurec-Shepherd

Tuning converged after 6 iterations

Total of the absolute F residuals for all ages in the
last year between iterations 5 and 6 = .000

Regression weights

1	1	1	1	1	1	1	1	1	1	1	1

Oldest age F = 1.000*average of 3 younger ages.

Fishing mortalities

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
3	0.013	0.012	0	0.007	0	0.003	0.013	0.011	0.091	0.1	0.021	0
4	0.112	0.061	0.049	0.174	0.012	0.035	0.234	0.205	0.684	0.324	0.254	0
5	0.413	0.323	0.195	0.519	0.233	0.244	0.578	0.805	1.168	0.631	0.334	0.005
6	0.577	0.631	0.453	0.643	0.506	0.775	0.861	1.186	1.557	0.83	0.802	0.024
7	0.75	0.639	0.906	0.912	0.981	1.824	1.376	1.833	1.99	1.221	1.009	0.095
8	0.72	0.845	1.042	1.63	0.663	2.082	1.356	1.112	1.493	1.5	2.829	0.106
9	0.682	0.705	0.8	1.062	0.717	1.561	1.198	1.377	1.68	1.183	1.547	0.075

Log catchability residuals
Fleet : rv mean numbers per

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
3	-1.91	-0.09	-0.17	0.18	-1.11	1.08	0.69	0.99	1.48	-1.11	-0.04	0
4	-1.16	-1.32	0.45	-0.04	-0.51	0.36	-0.24	0.62	1.18	-0.45	1.11	0
5	-0.59	-1.2	0.64	-0.54	0	-0.07	-0.16	0.67	0.62	0.07	0.55	0
6	-0.45	-0.51	0.82	-1.18	-0.54	0.28	-0.87	0.74	0.41	0.6	0.68	0
7	-0.1	-0.06	1.01	-0.7	-1.32	-0.29	0.7	0.74	-0.1	-0.16	0.28	0
8	-0.5	-0.47	0.28	0.45	-0.88	-1.18	0.82	-0.11	-1.58	1.39	1.78	0

Table 25. Diagnostics from the Laurec-Shepherd SPA calibration for white hake using the research survey index for the 'Strait' component - Continued.

SUMMARY STATISTICS FOR AGE 3

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.79	1.042	0.1661	0.0001	9.57E-02	8.24E-02	-1.795	0.289

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.000	1.04	0.000	1.04	0.000

SUMMARY STATISTICS FOR AGE 4

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.6	0.828	0.2027	0.0001	1.30E-01	5.63E-02	-1.596	0.23

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.000	.828	0.000	.828	0.000

SUMMARY STATISTICS FOR AGE 5

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.78	0.602	0.168	0.0053	9.10E-02	4.17E-02	-1.784	0.167

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.005	.602	0.000	.602	0.000

SUMMARY STATISTICS FOR AGE 6

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-2.15	0.716	0.1168	0.024	8.64E-02	5.38E-02	-2.147	0.199

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.024	.716	0.000	.716	0.000

SUMMARY STATISTICS FOR AGE 7

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-2.23	0.667	0.1078	0.0951	2.16E-02	5.58E-02	-2.227	0.185

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.095	.667	0.000	.667	0.000

SUMMARY STATISTICS FOR AGE 8

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-1.79	1.052	0.1669	0.106	9.67E-02	8.32E-02	-1.79	0.292

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.106	1.05	0.000	1.05	0.000

Table 26. Estimates of fishing mortality and beginning of year population numbers for southern Gulf white hake from the Laurec-Shepherd calibration of SPA.

a. Fishing mortality for white hake in the southern Gulf of St. Lawrence obtained with Laurec-Shepherd
Traditional vpa Terminal Fs estimated using Laurec-Shepherd

Age/Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	FBAR 93-95
3	0.003	0.003	0.000	0.002	0.000	0.001	0.003	0.003	0.023	0.025	0.005	0.000	0.010
4	0.028	0.015	0.012	0.043	0.003	0.009	0.058	0.051	0.171	0.081	0.063	0.000	0.048
5	0.103	0.081	0.049	0.130	0.058	0.061	0.144	0.201	0.292	0.158	0.084	0.001	0.081
6	0.144	0.158	0.113	0.161	0.127	0.194	0.215	0.297	0.389	0.207	0.201	0.006	0.138
7	0.188	0.160	0.226	0.228	0.245	0.456	0.344	0.458	0.498	0.305	0.252	0.024	0.194
8	0.180	0.211	0.261	0.408	0.166	0.521	0.339	0.278	0.373	0.375	0.707	0.027	0.370
9	0.171	0.176	0.200	0.265	0.179	0.390	0.299	0.344	0.420	0.296	0.387	0.019	0.234
4+	0.786	0.786	0.849	1.192	0.775	1.622	1.342	1.578	1.972	1.341	1.630	0.076	
6+	0.682	0.705	0.800	1.062	0.717	1.561	1.198	1.377	1.680	1.183	1.547	0.075	
7+	0.538	0.547	0.687	0.901	0.590	1.367	0.982	1.080	1.291	0.976	1.346	0.069	

b. Beginning of year population estimates for southern Gulf white hake estimated by Laurec-Shepherd calibration: 1984 - 1995 (Numbers in 1,000's)

Age/Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	MST 84-92	MST 84-92
3	4942	5812	4476	4433	4500	3902	2996	2722	1613	887	1306	1409	0	3705	3933
4	3306	3994	4701	3663	3602	3684	3185	2423	2203	1206	657	1047	1154	3337	3418
5	2550	2419	3075	3664	2521	2914	2913	2064	1615	910	714	417	857	2574	2637
6	1965	1382	1434	2071	1785	1636	1870	1338	756	411	397	419	340	1525	1582
7	1119	904	602	747	891	881	617	647	335	130	147	146	335	713	749
8	584	433	390	199	245	273	116	128	85	37	32	44	108	228	273
9	313	233	152	113	32	104	28	25	34	16	7	2	32	77	115
+gp	252	209	176	45	21	48	19	19	21	6	1	2	2		
TOTAL	15031	15385	15007	14935	13598	13441	11744	9365	6662	3605	3261	3484	2828		

Table 27. Seasonal catch in metric tonnes (t) and number of fish for white hake, winter flounder, smelt and tomcod and in number of striped bass per age group by year, by site (Note: Up = Chatham; Down = Loggieville) and for each year with sites combined (U+D). (From: Bradford, et al. 1996).

		Estimated Total Catch (t)				Estimated Total Catch (Fish x10³)				
Year	**Site**	**White Hake**	**Winter Flounder**	**Smelt**	**Tomcod**	**White Hake**	**Winter Flounder**	**Bass Age 0**	**Bass Age 1**	**Bass Age 2**
1994	**Up**	25.60	0.90	1.80	19.30	169.80	4.60	98.30	0.03	0.05
	Down	14.40	2.10	10.20	11.50	107.50	8.60	8.00	0.00	0.04
	U+D	**40**	**3**	**12**	**30**	**277**	**13**	**106**	**<1**	**<1**
1995	**Up**	2.82	0.80	2.69	4.87	48.5	9.6	163.9	0.6	0.03
	Down	17.59	3.40	17.67	25.86	300.0	41.8	261.9	0.3	0.00
	U+D	**20**	**4**	**20**	**30**	**350**	**50**	**425**	**1**	**<1**

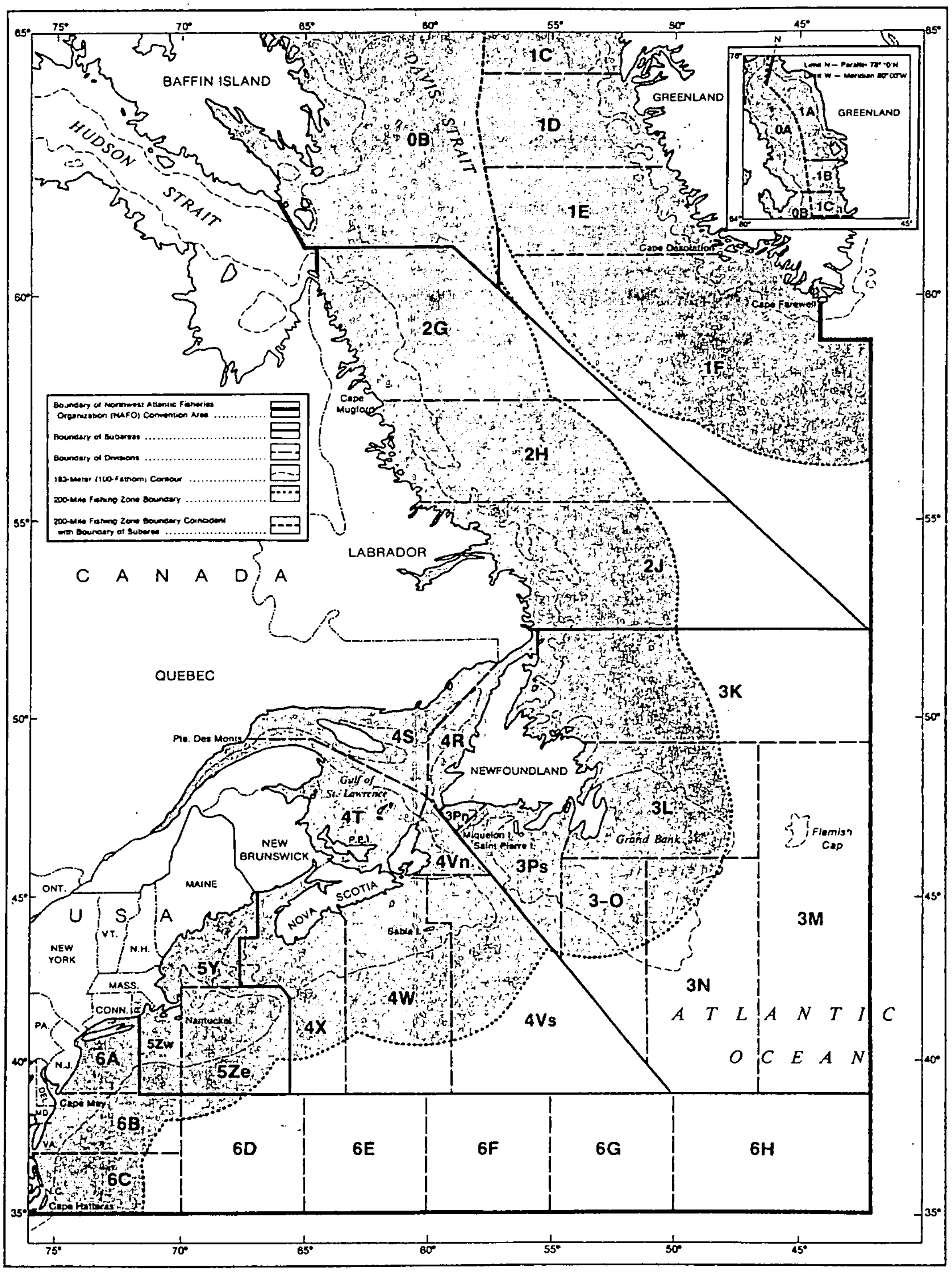
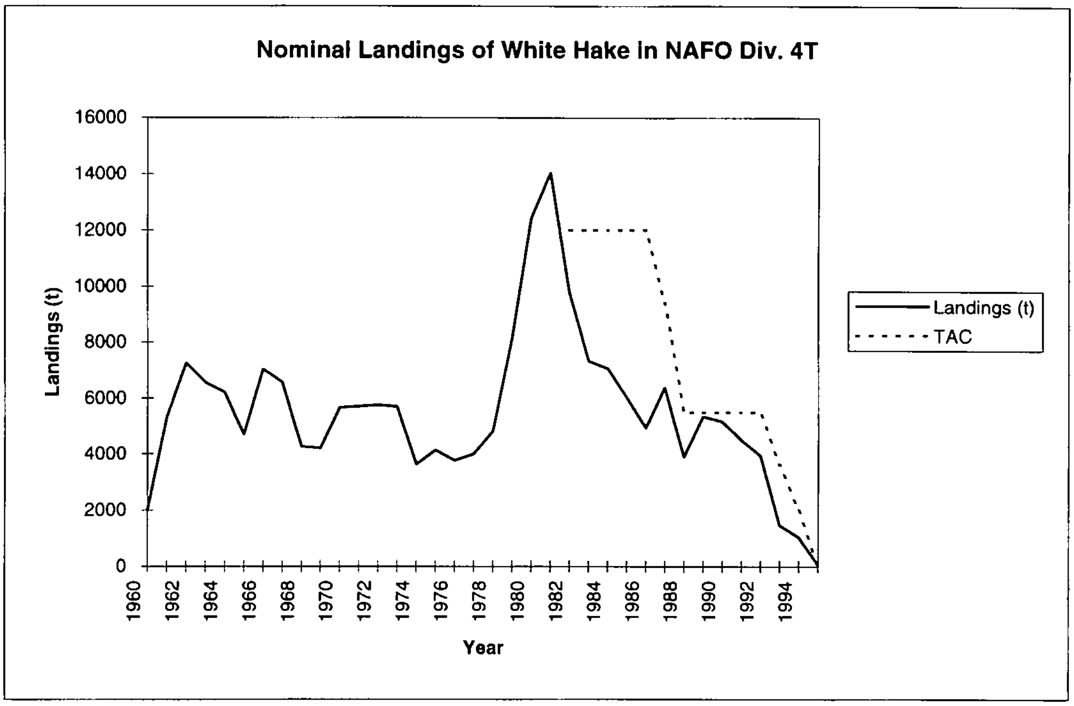


Figure 1. Subareas and Divisions of the NAFO Convention area.



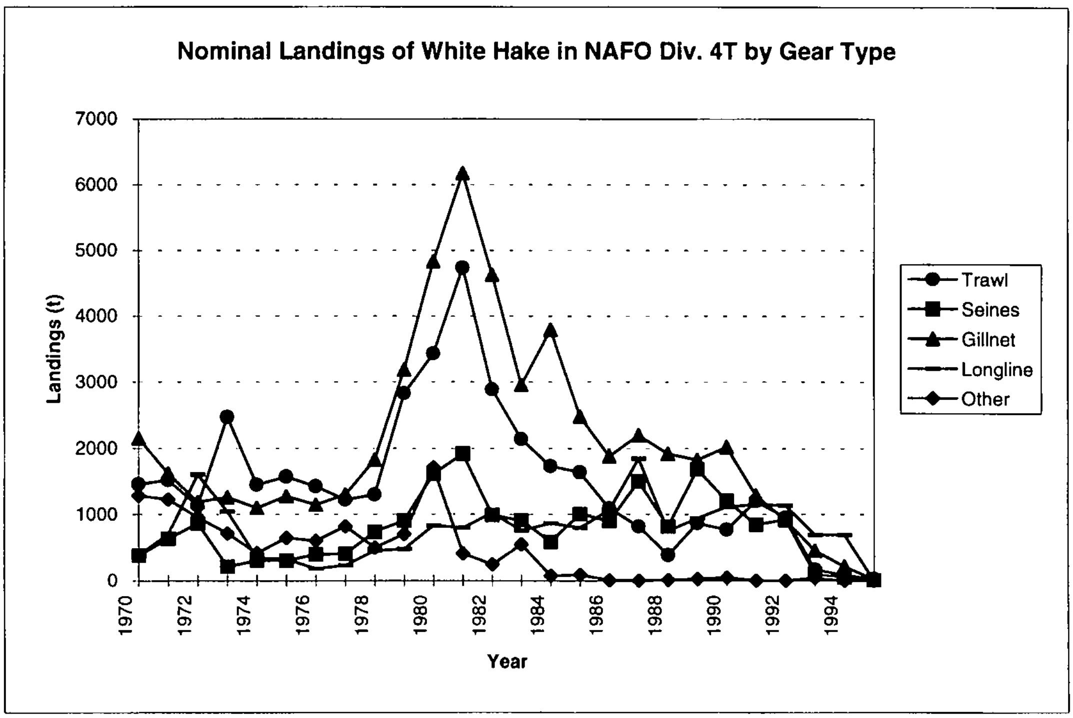


Figure 2 a. Nominal landings and TAC's for white hake in NAFO Division 4T.
b. Nominal landings by gear category for white hake in NAFO Division 4T.

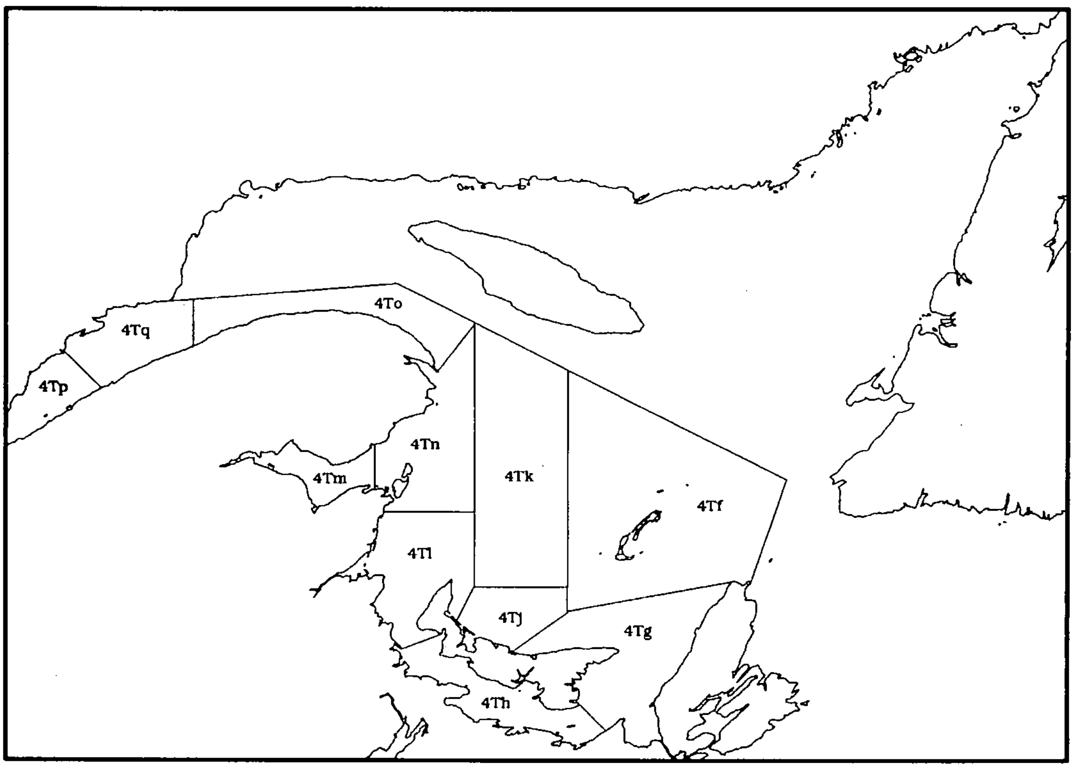
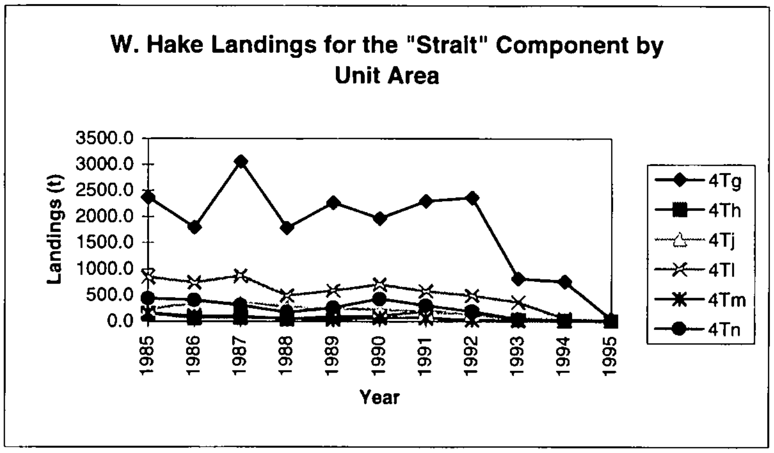
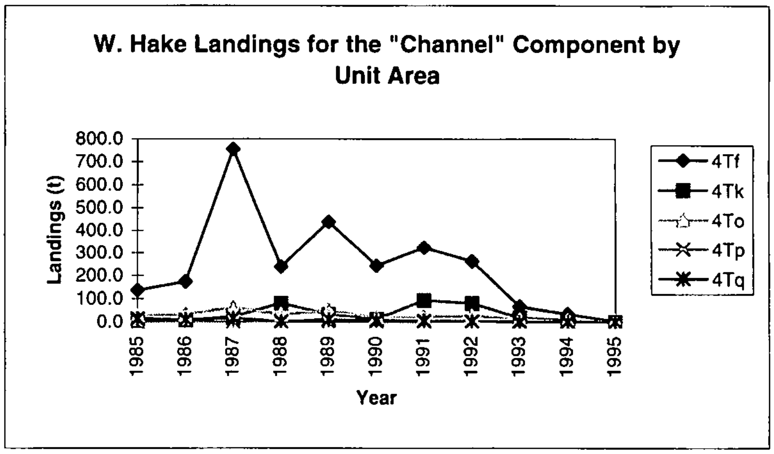


Figure 3. Statistical unit areas in the southern Gulf of St. Lawrence (NAFO Division 4T).





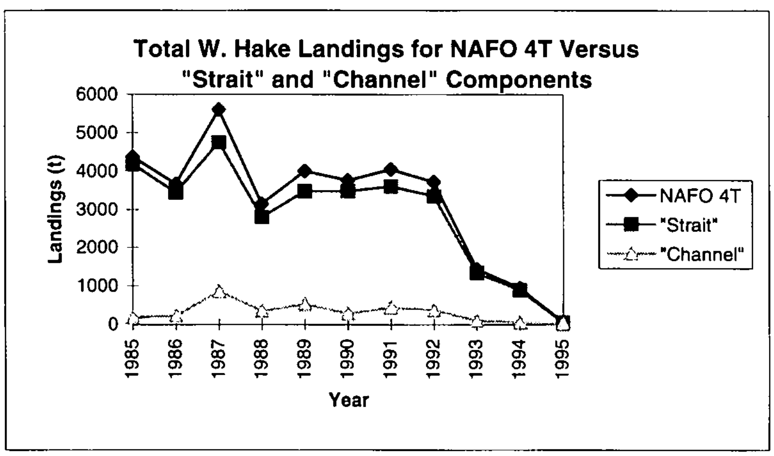
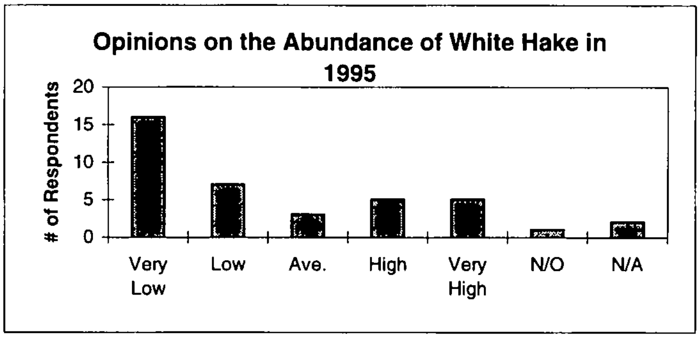
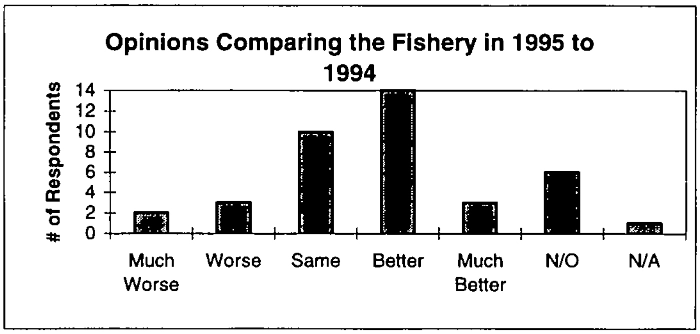
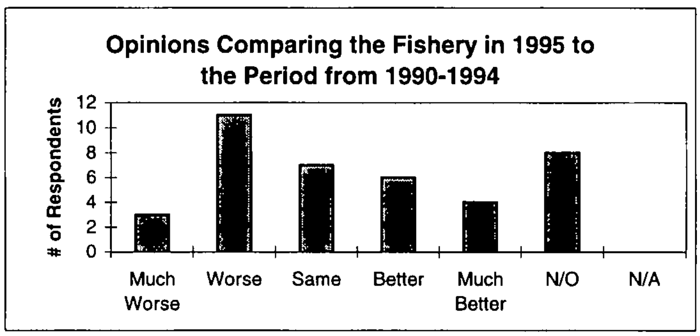


Figure 4. Comparison of landings of white hake in NAFO Division 4T by statistical unit area and stock component: 1985-1995.







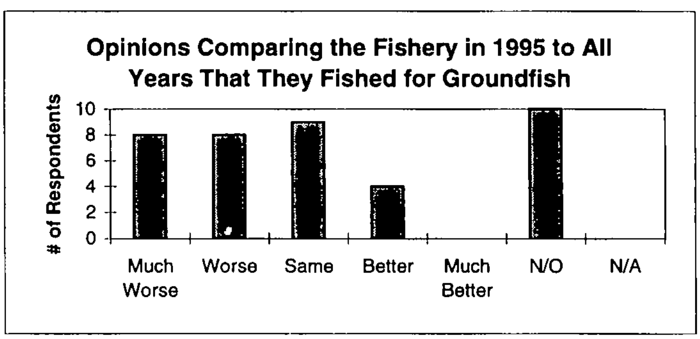
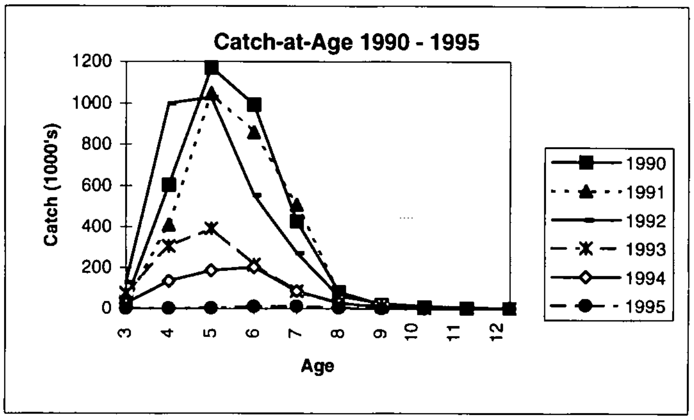
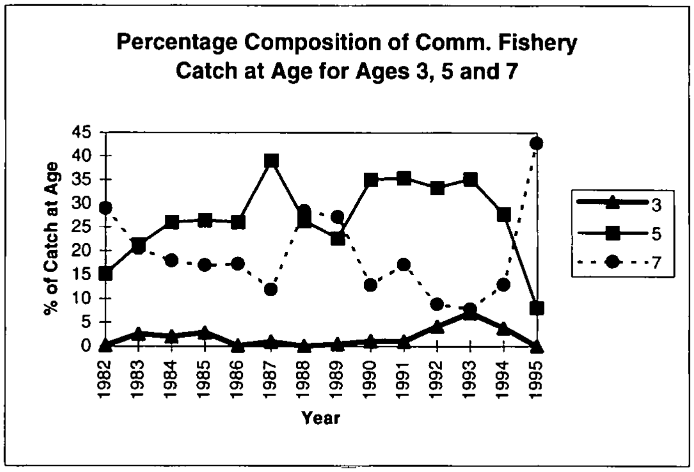


Figure 5. Some of the responses of respondents to the 1995 'End of Season' Telephone Survey. (Note: N/O = Respondent had No Opinion, N/A = Question was Not Applicable to the Respondent).

a



b



c

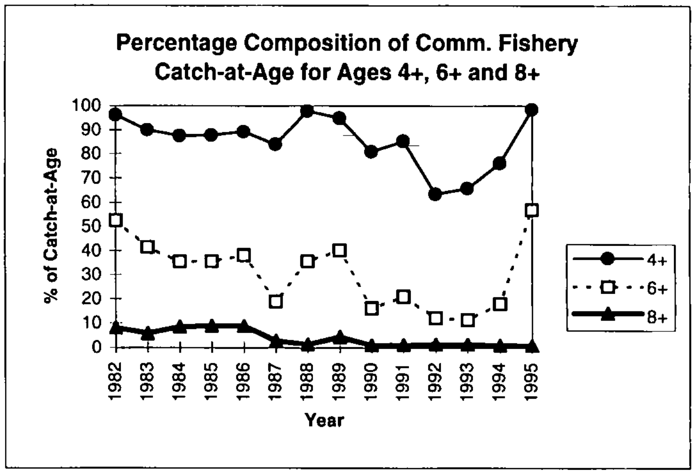
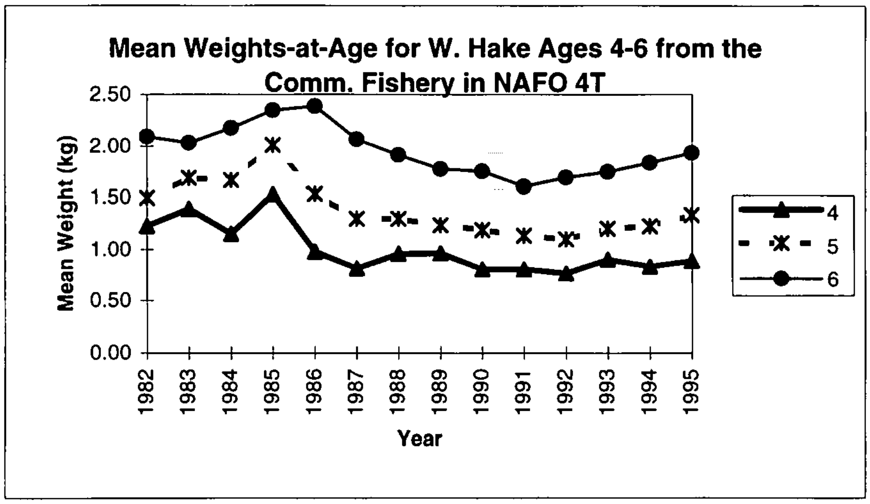


Figure 6 a. Commercial fishery catch-at-age for white hake in NAFO Division 4T: 1990-1995.
b. Percentage composition of the commercial fishery catch-at-age for white hake: Ages 3, 5 and 7.
c. Percentage composition of the commercial fishery catch-at-age for white hake: Ages 4+, 6+ and 8+.



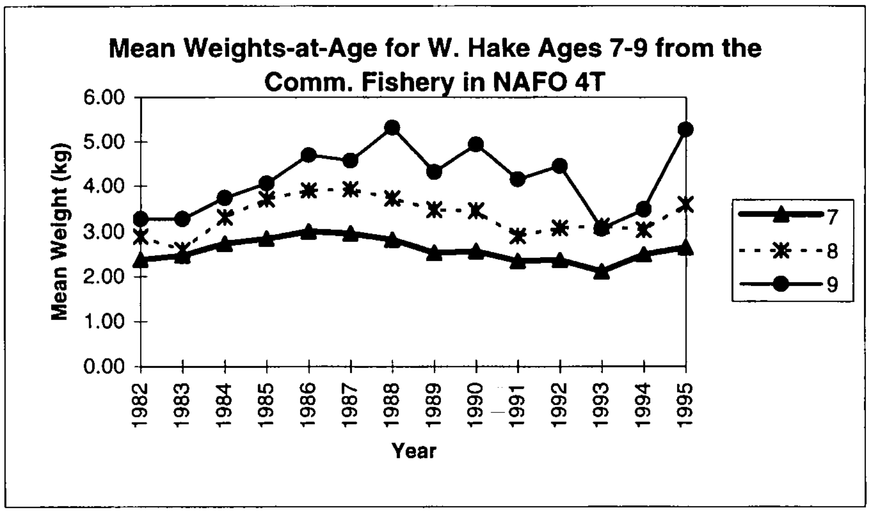


Figure 7. Trends in mean weights-at-age (kg) for white hake (Ages 4-9) from the commercial fishery in the southern Gulf of St. Lawrence.

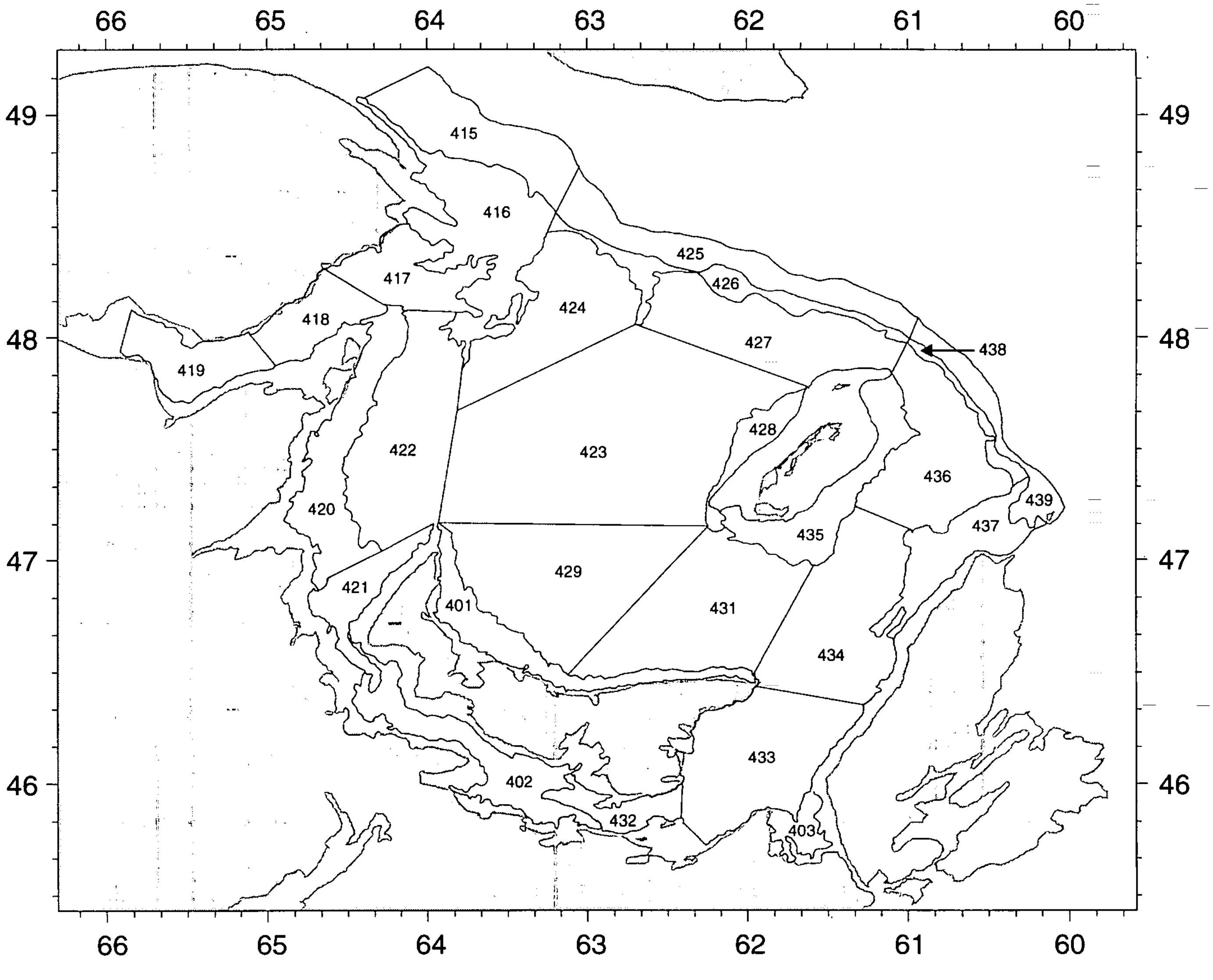


Figure 8. Stratification scheme for the annual (September) groundfish abundance survey of the southern Gulf of St. Lawrence.

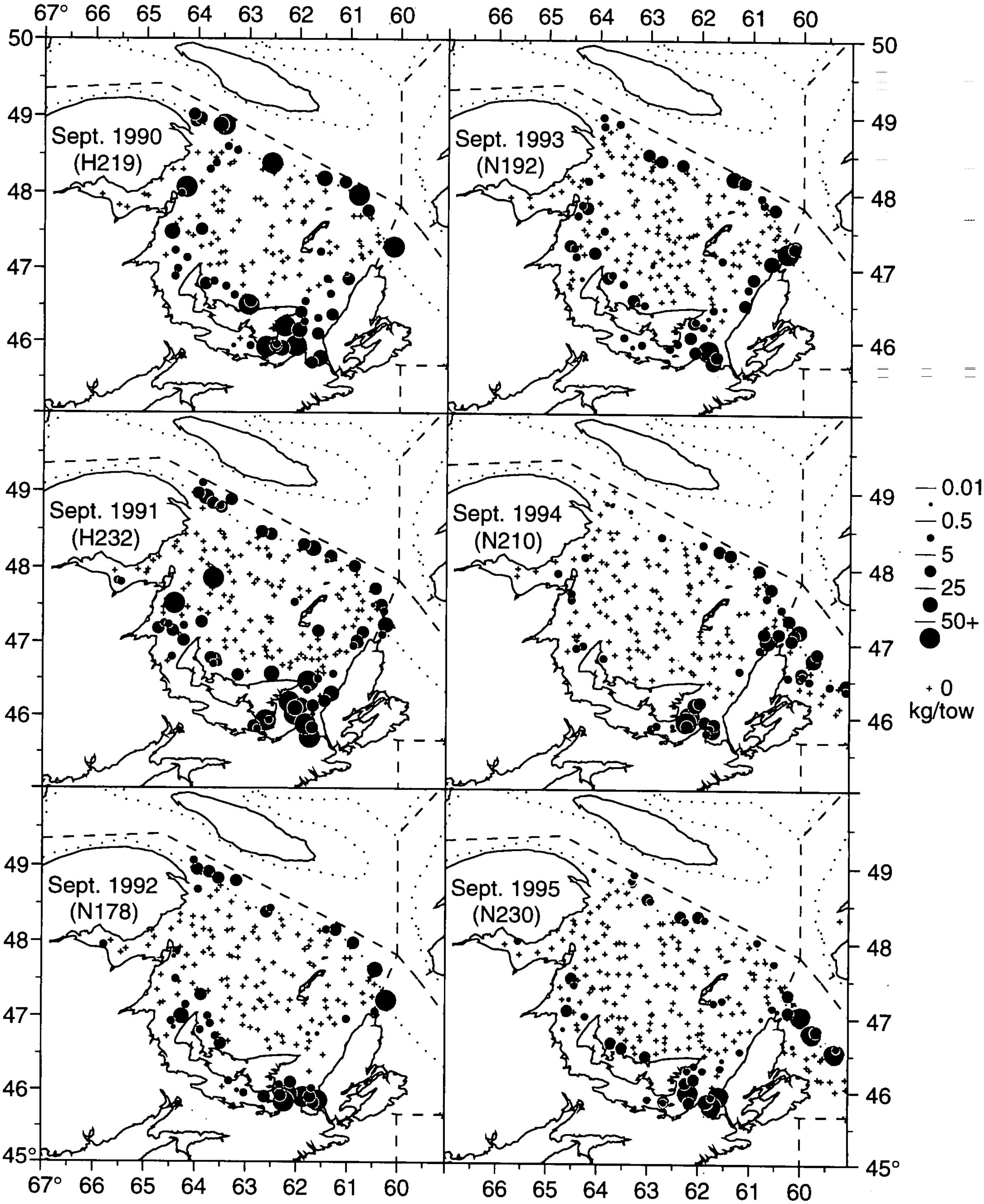


Figure 9. Location of white hake catches (kg) during six annual (September) surveys of the southern Gulf of St. Lawrence.

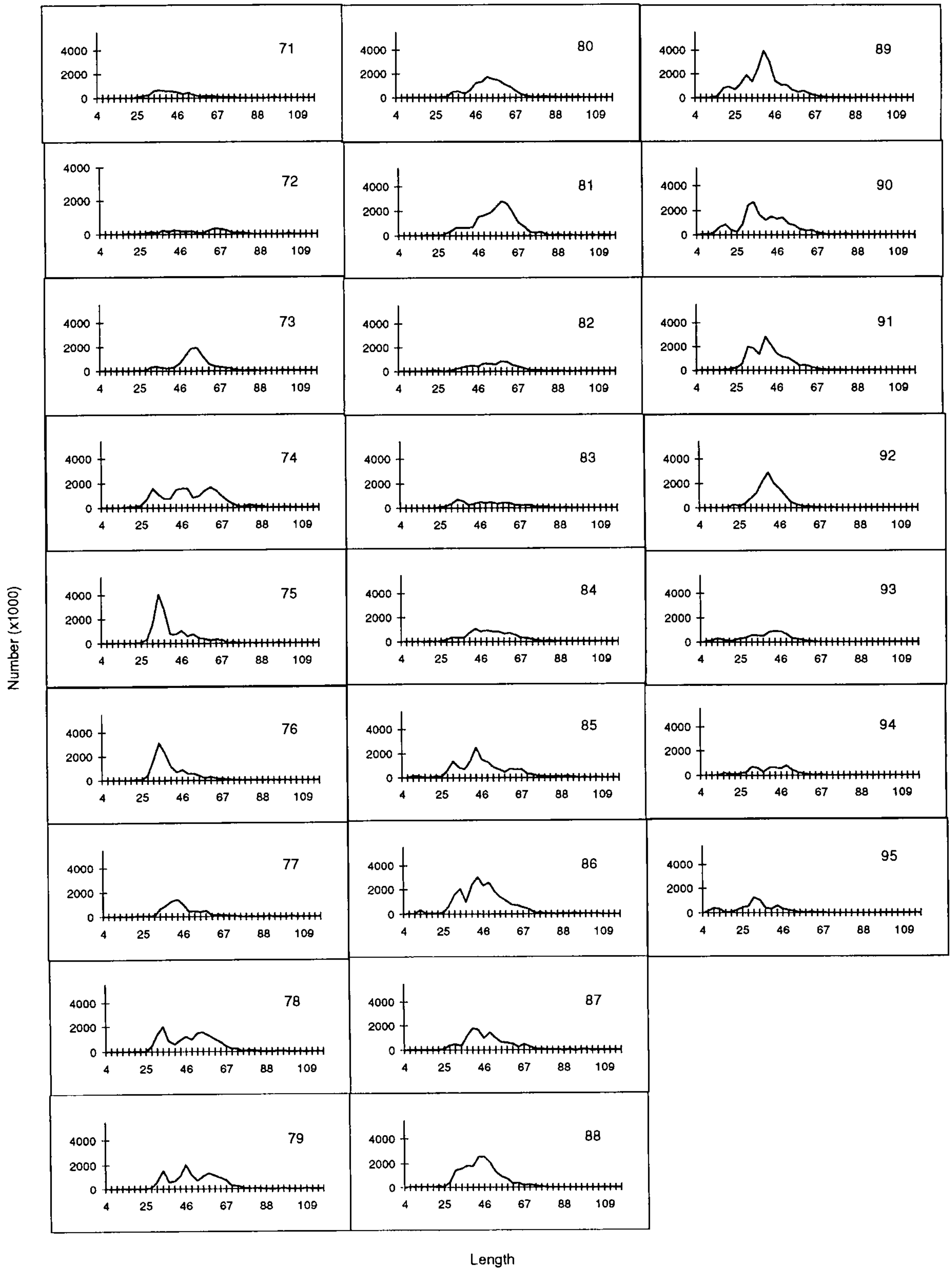
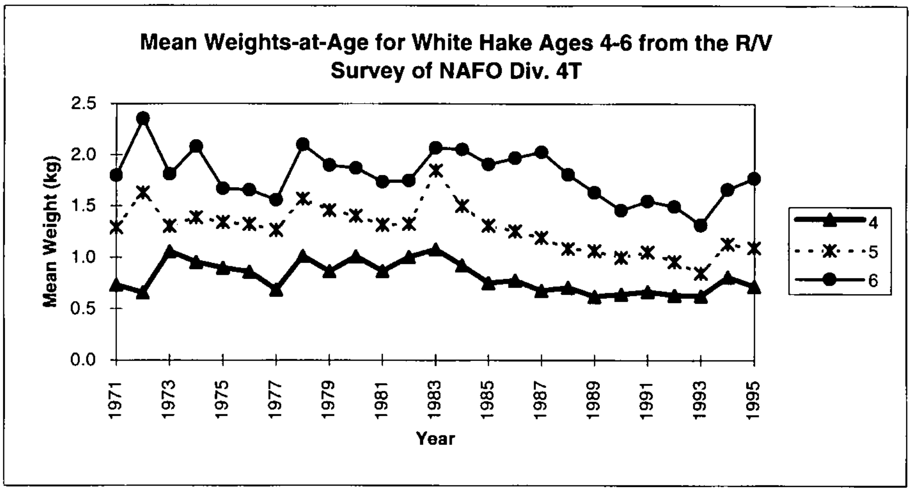


Figure 10. Annual (September) length frequencies for white hake from groundfish surveys of the southern Gulf of St. Lawrence.



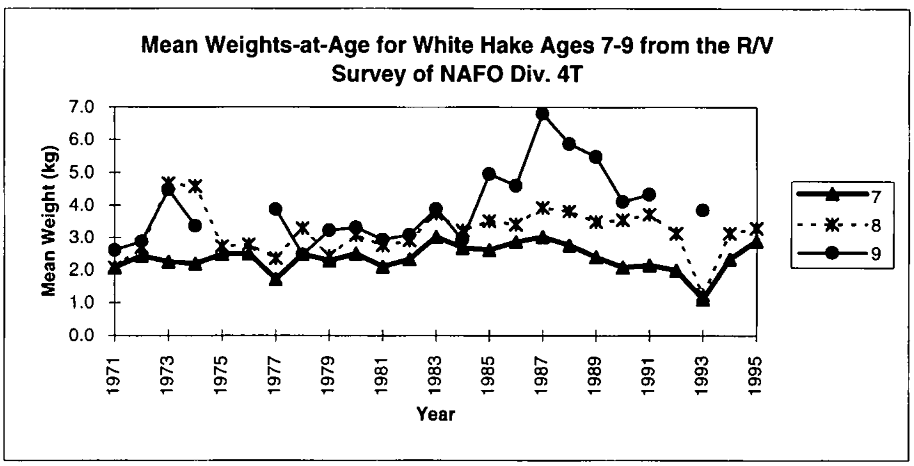


Figure 11. Trends in mean weights-at-age (kg) for white hake (Ages 4-9) from the annual (September) surveys of the southern Gulf of St. Lawrence.

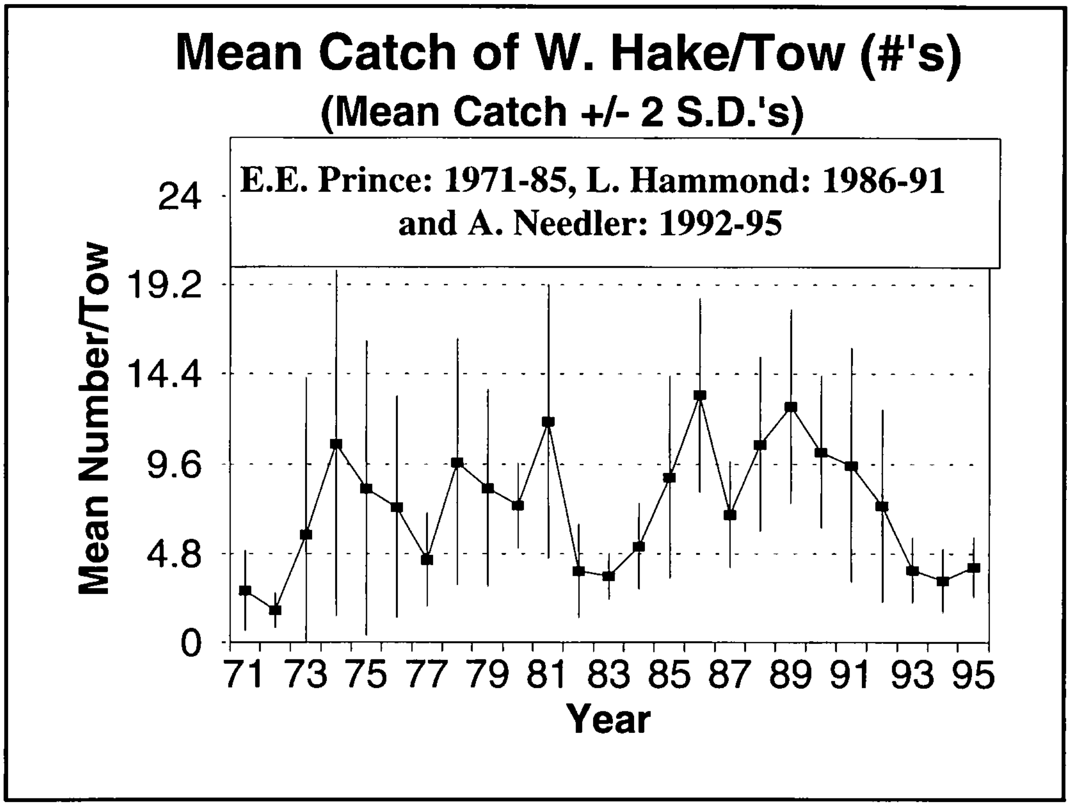


Figure 12. Research vessel stratified mean catch (numbers) per tow for white hake in NAFO Division 4T.

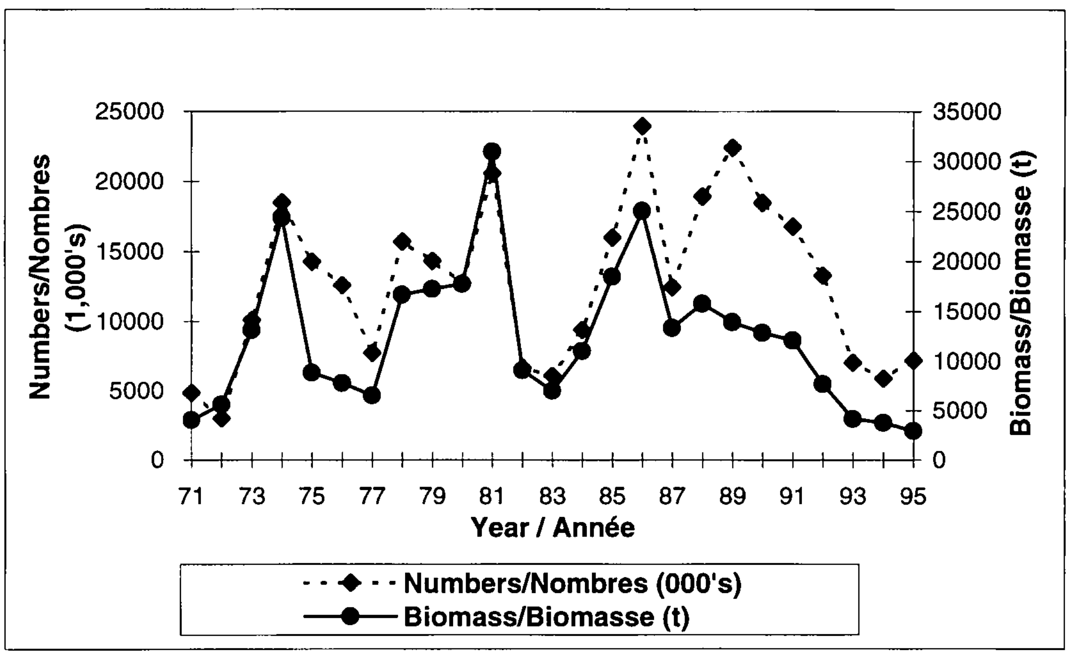
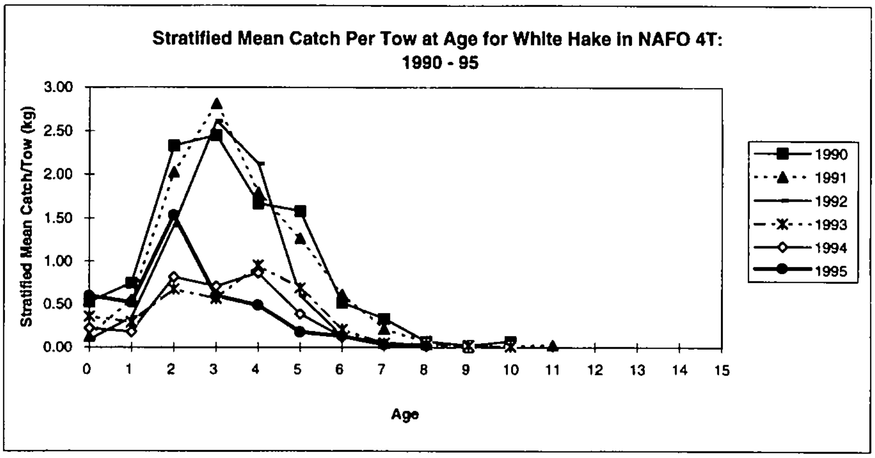
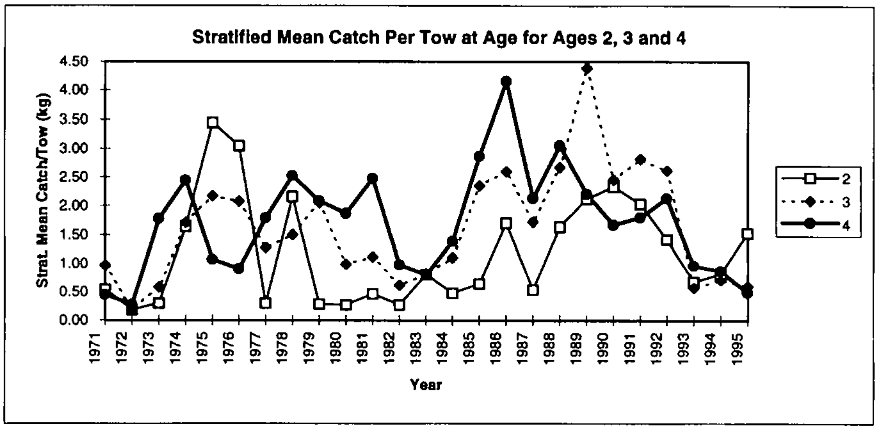


Figure 13. Estimated population numbers (1,000's) and biomass (t) for white hake in NAFO Division 4T.

a.



b.



c.

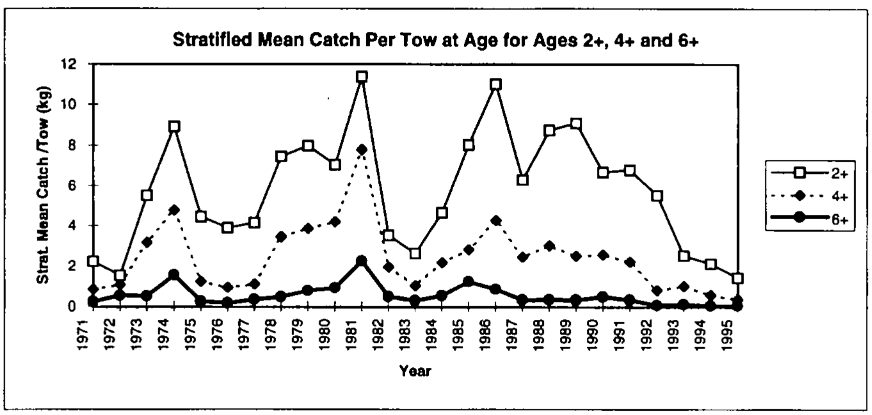


Figure 14 a. Research vessel stratified mean catch (kg) per tow-at-age for white hake in NAFO Division 4T: 1990-1995.
b. Research vessel stratified mean catch (kg) per tow-at-age for white hake in NAFO Division 4T: Ages 2, 3 and 4.
c. Research vessel stratified mean catch (kg) per tow-at-age for white hake in NAFO Division 4T: Ages 2+, 4+ and 6+.

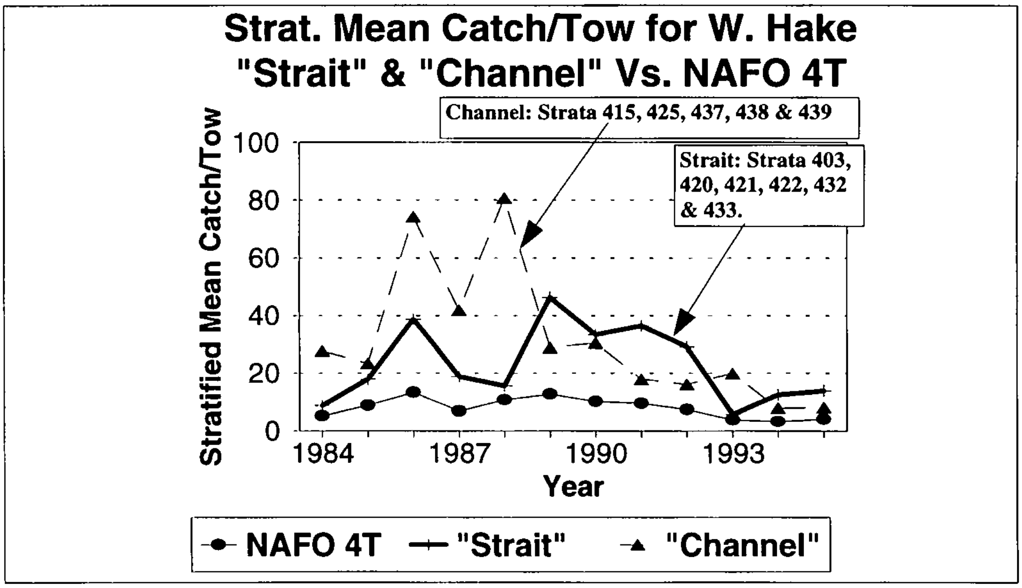


Figure 15. Comparison of research vessel stratified mean catch per tow (numbers) estimates for white hake from the 'Strait' and 'Channel' stock components and all of NAFO Div. 4T.

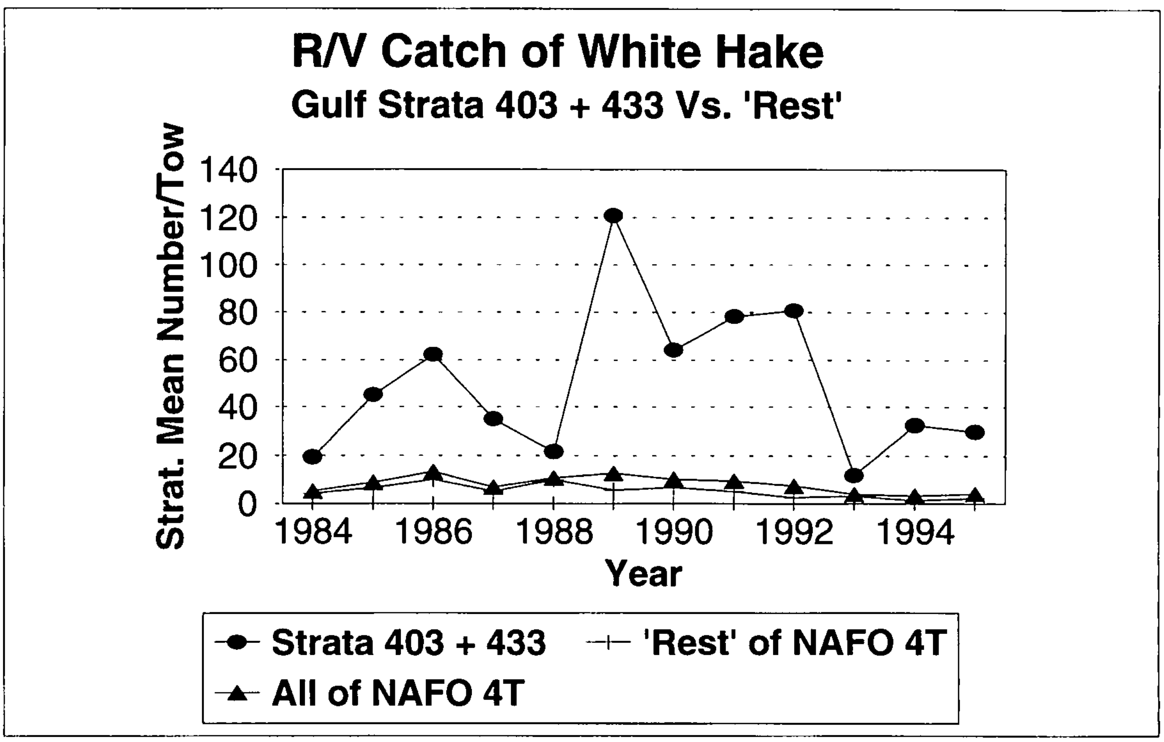


Figure 16. Comparison of research vessel stratified mean catch (numbers) per tow estimates for white hake in two strata in the southeastern Gulf (403 and 433) with estimates for the 'rest' of the survey area and the whole survey area (= All of NAFO 4T).

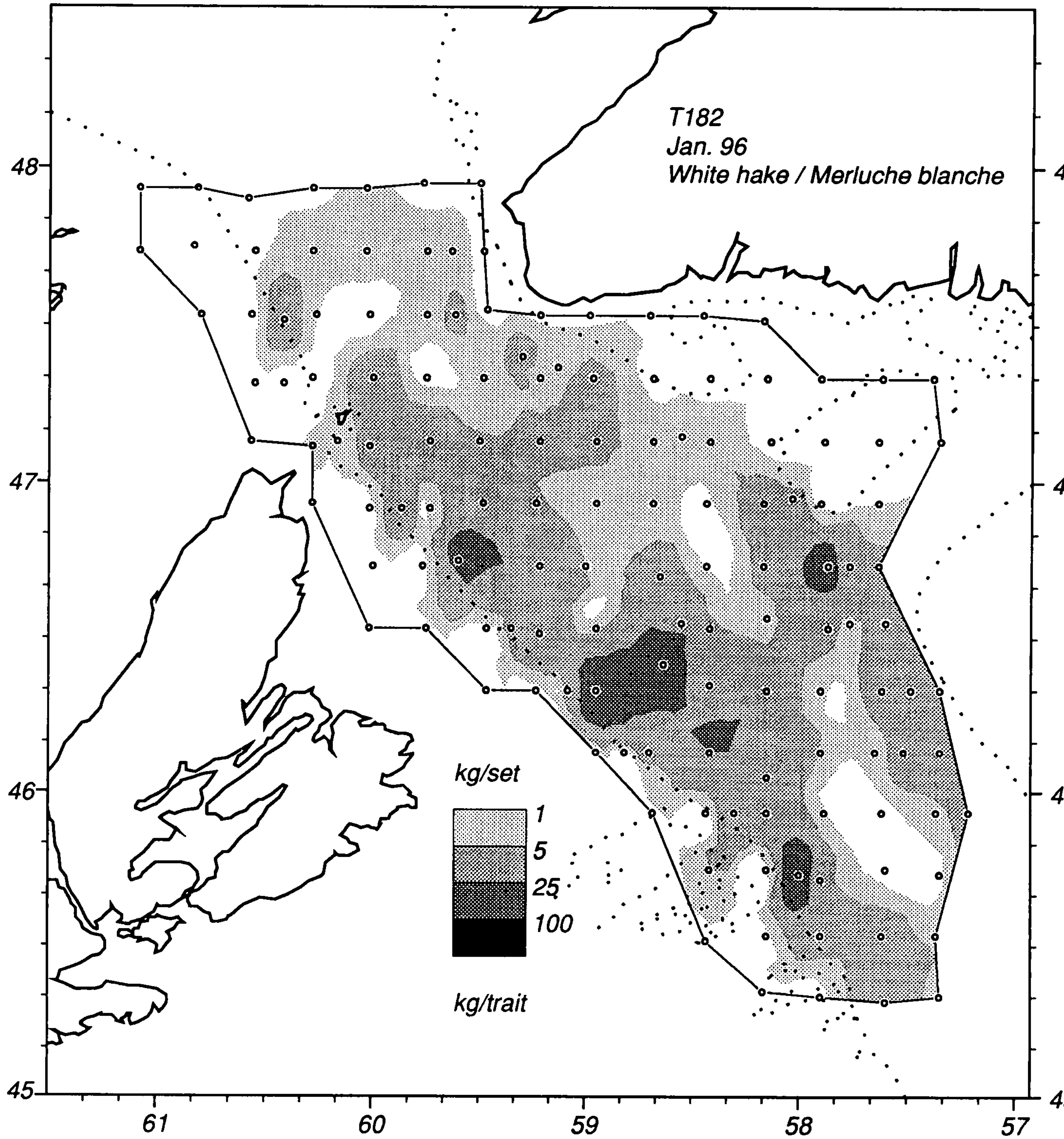


Figure 17. Catches of white hake (kg/standard tow) during the January 3-25, 1996 groundfish survey in Cabot Strait (open circles indicate set locations, dotted line is 200 m contour).

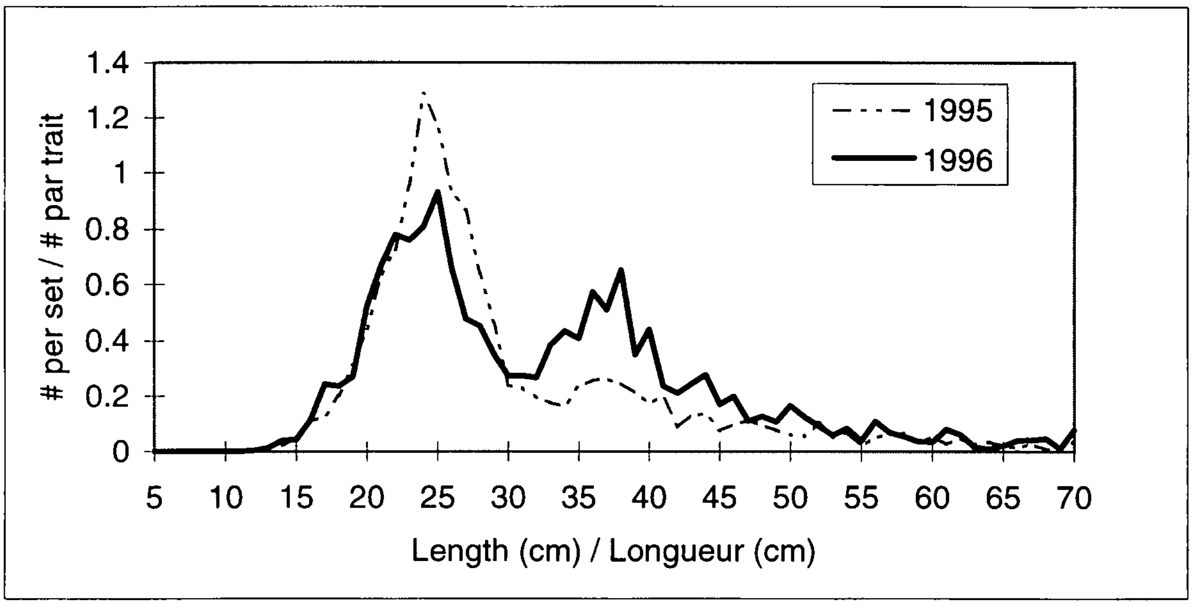


Figure 18. Length frequencies for white hake from the January 1995 and 1996 groundfish surveys of Cabot Strait.

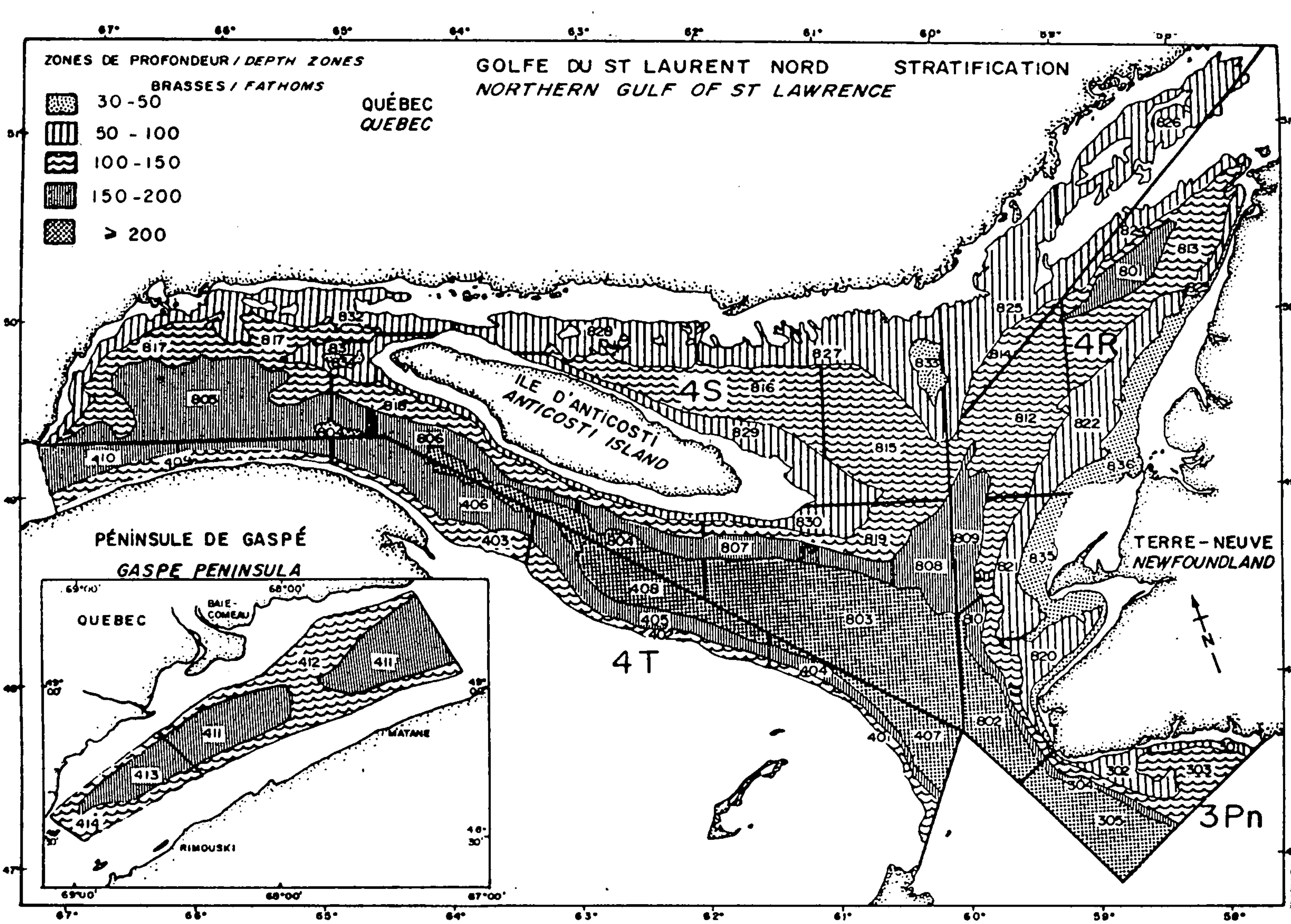


Figure 19. Stratification scheme for annual groundfish abundance surveys of the northern Gulf of St. Lawrence.

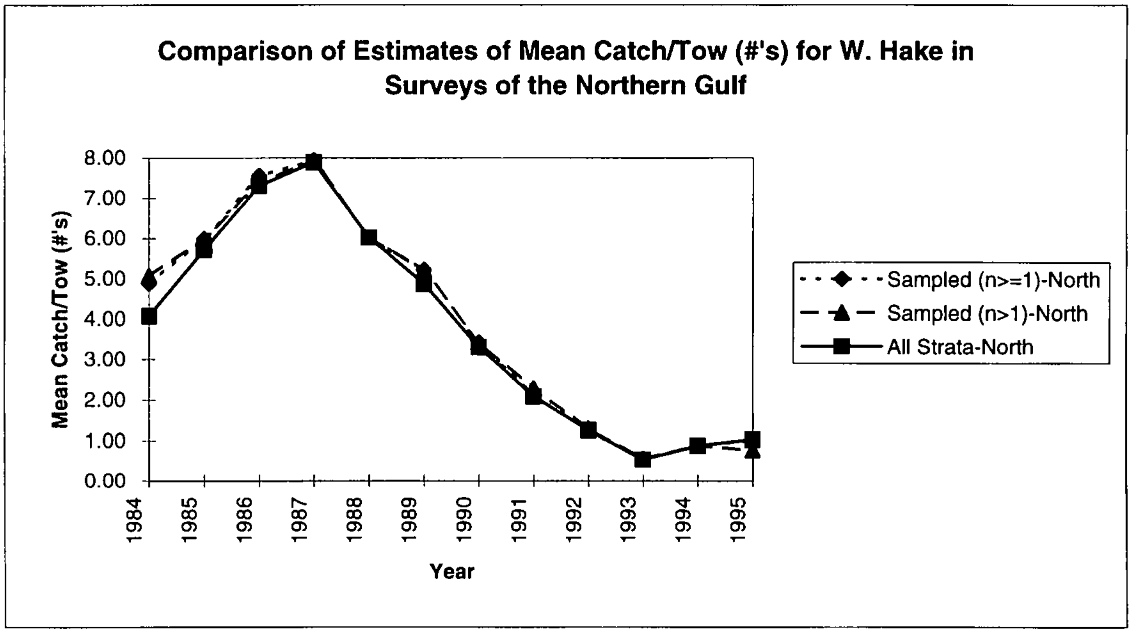


Figure 20. Comparison of different mean catch per tow estimates for white hake from surveys of the northern Gulf.

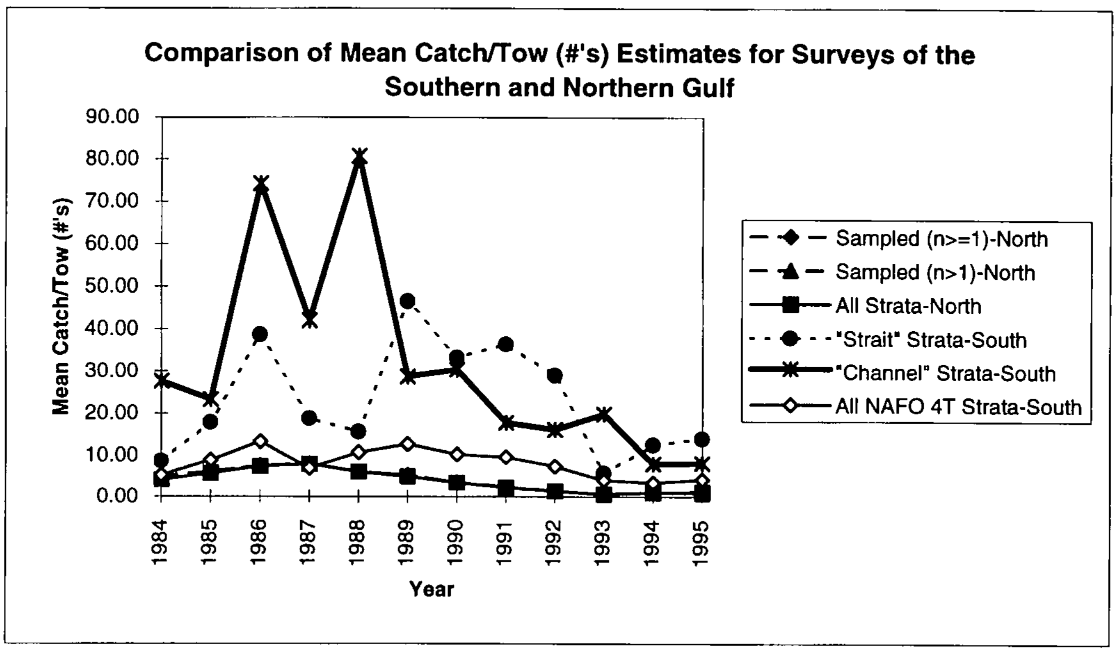


Figure 21. Comparison of the stratified mean catch per tow estimates for white hake from surveys of the southern and northern Gulf.

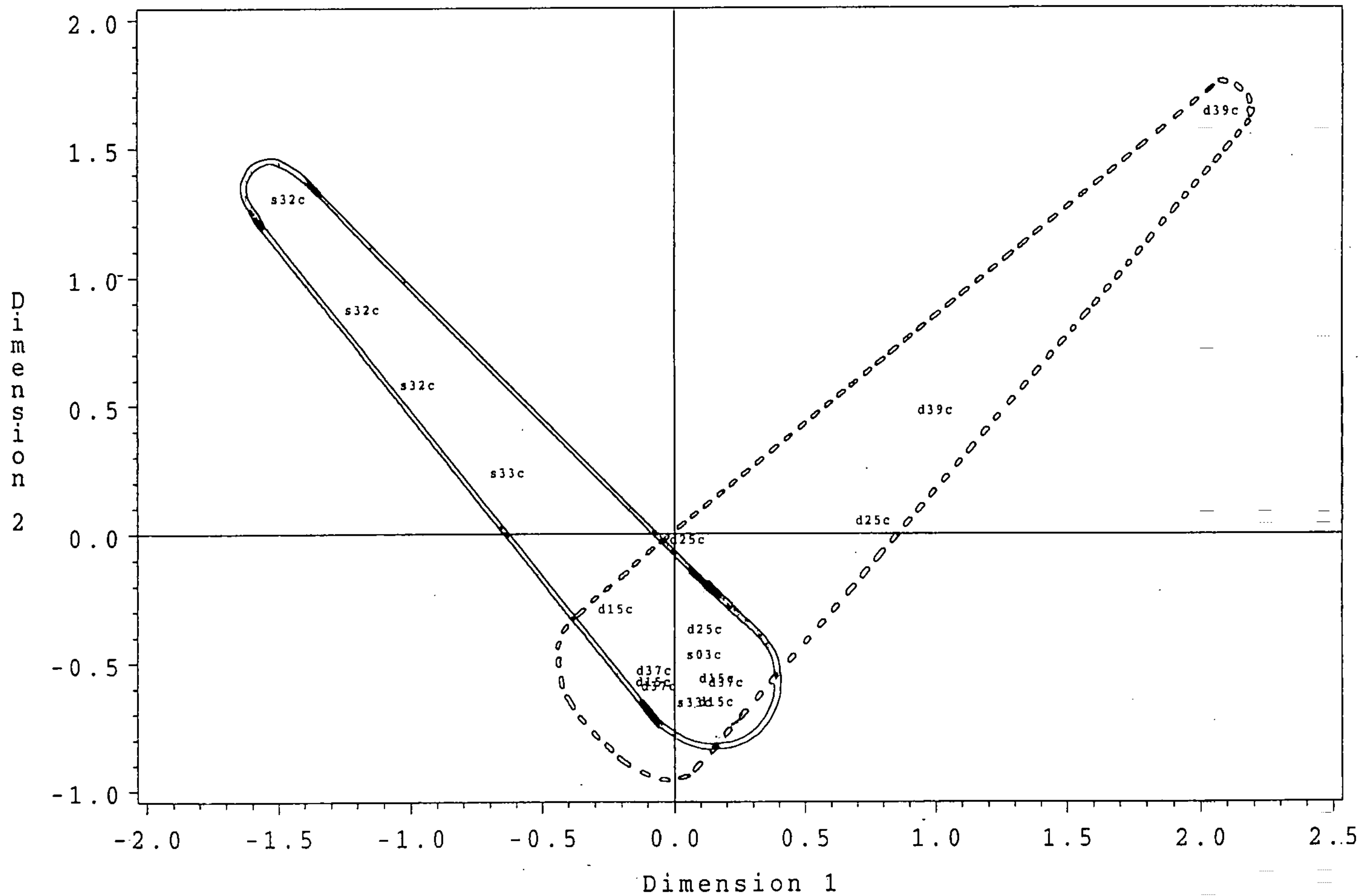


Figure 22. Results of correspondence analysis of length frequency samples from sets in survey H192. Note: Prefixes S = "Strait" and D = "Channel" Suffixes F = Female, M = Male and C = Combined).

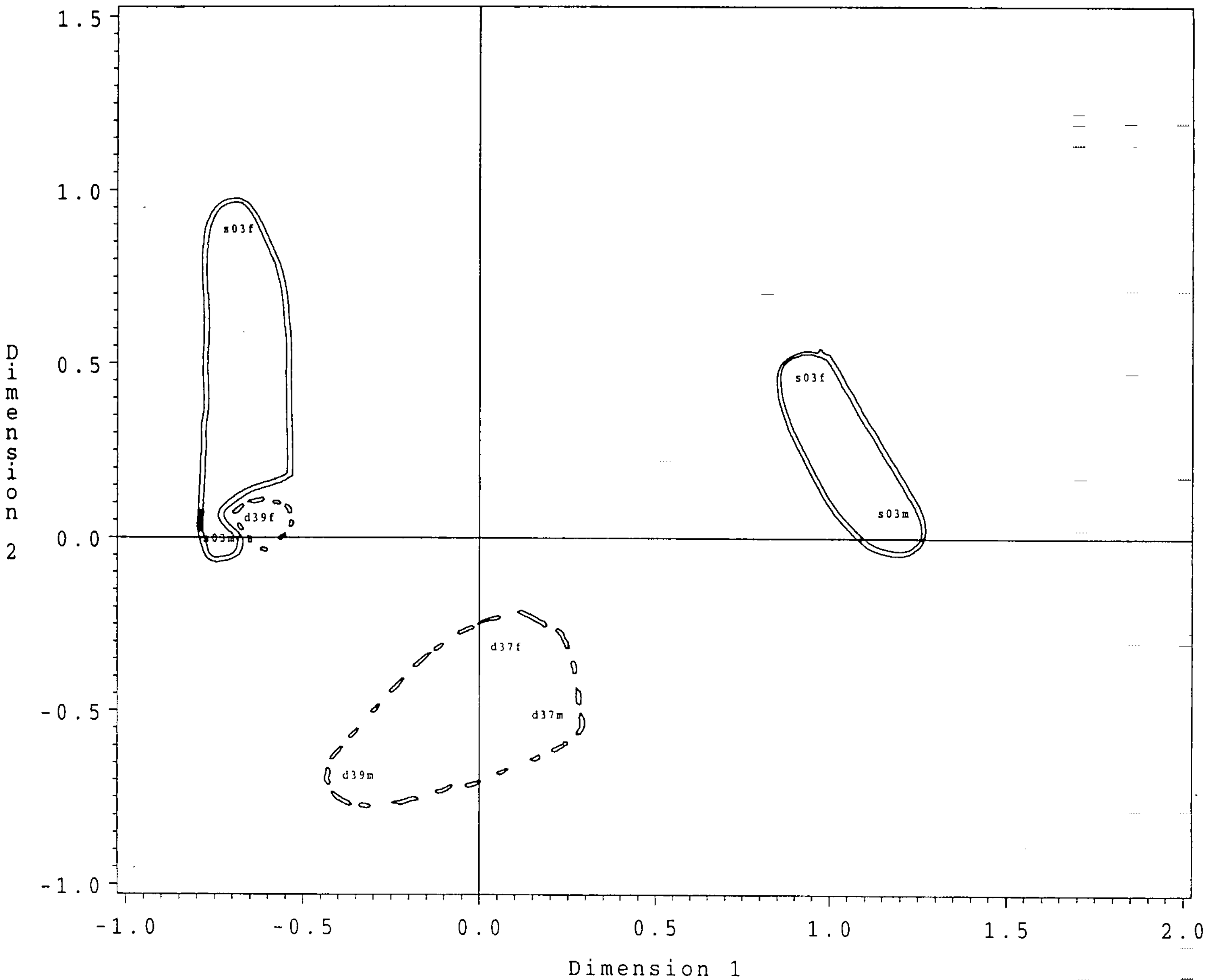


Figure 23. Results of correspondence analysis of length frequency samples from sets in survey N192. (Note: Prefixes S = "Strait" and D = "Channel" Suffixes F = Female, M = Male and C = Combined).

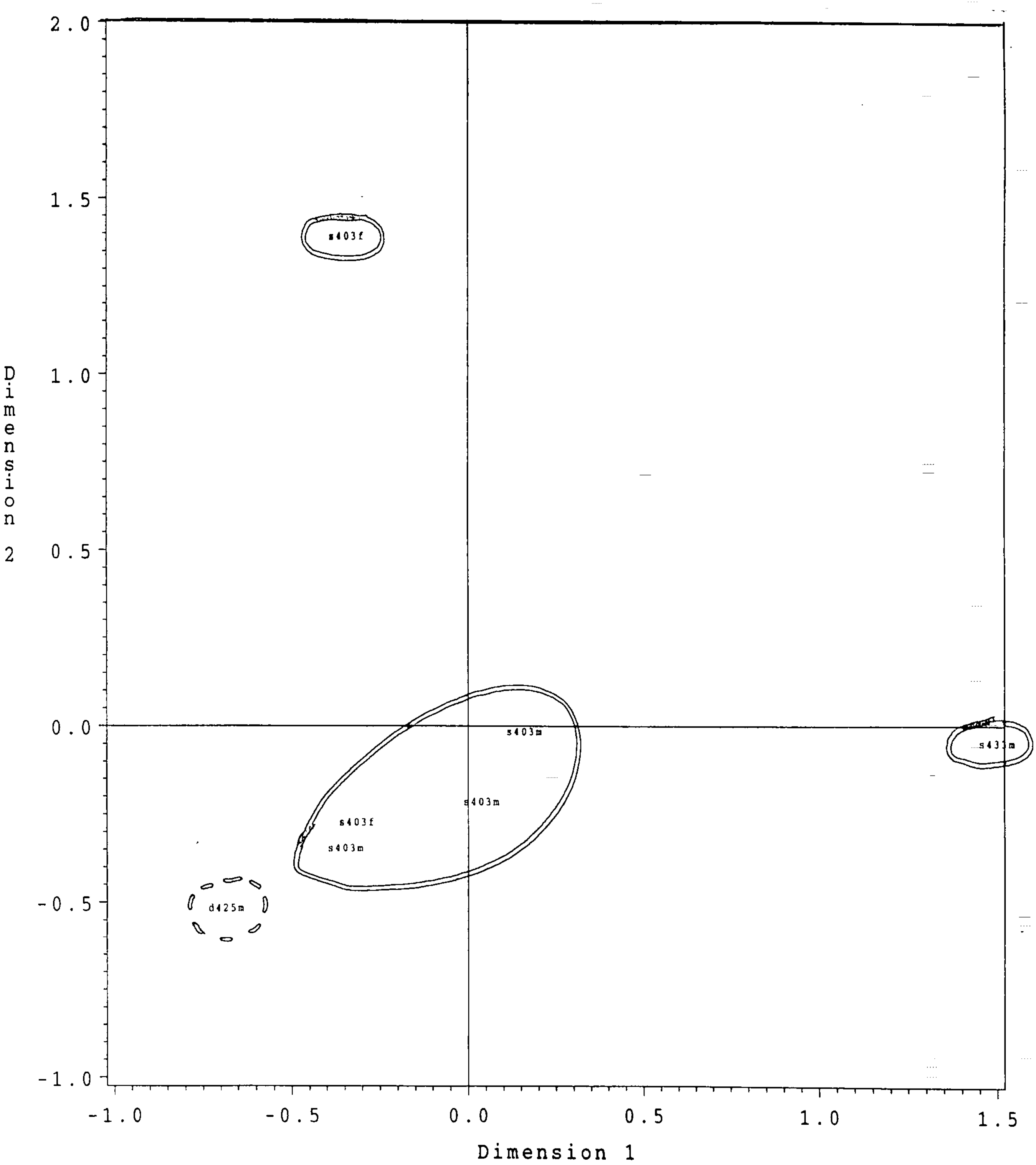
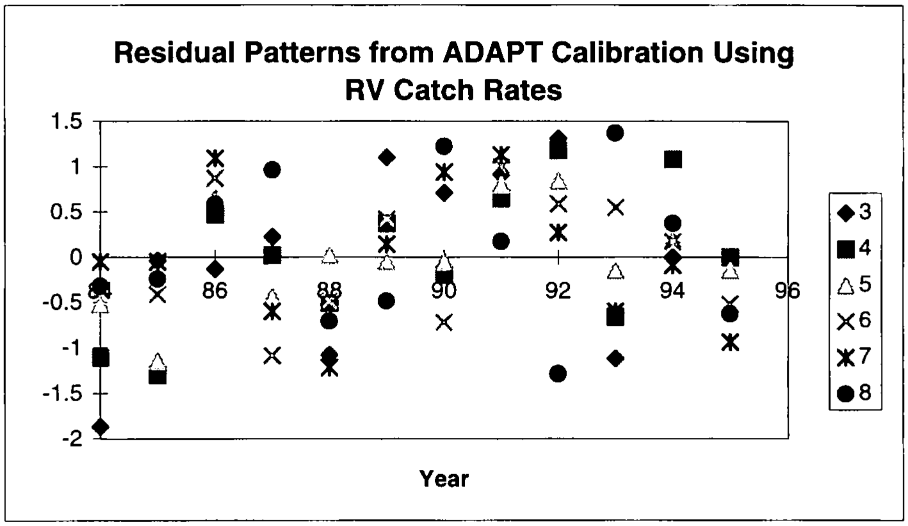


Figure 24. Results of correspondence analysis of length frequency samples from sets in survey N230. (Note: Prefixes S = "Strait" and D = "Channel" Suffixes F = Female, M = Male and C = Combined).



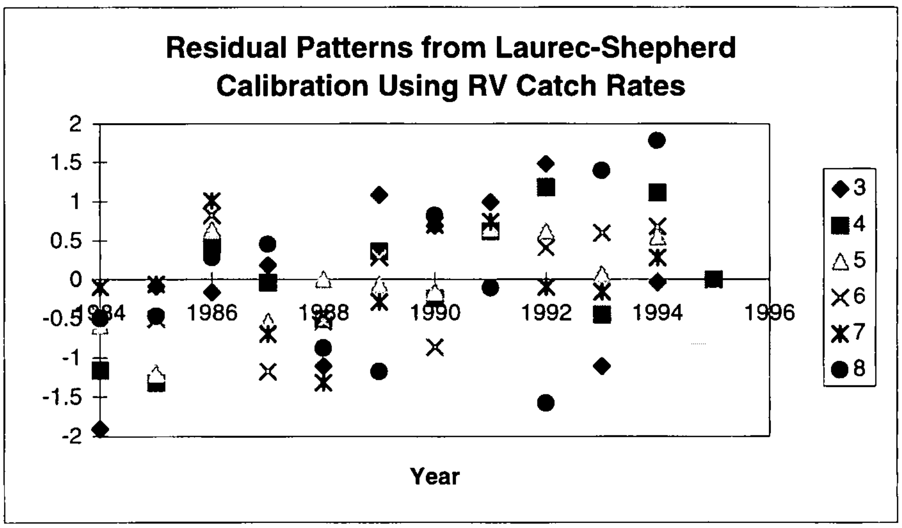


Figure 25. Comparison of residual patterns from SPA calibrations using the ADAPT and Laurec-Shepherd tuning methods and the research survey abundance index for the 'Strait' component.

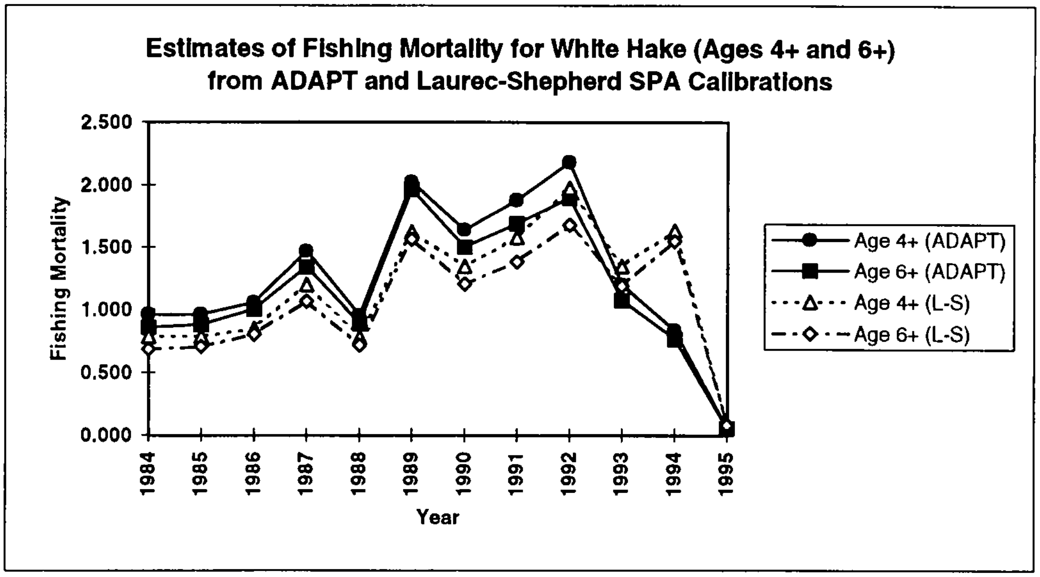


Figure 26. Comparison of estimates of fishing mortality (F) for white hake in the southern Gulf from SPA calibrations using the ADAPT and Laurec-Shepherd tuning methods.

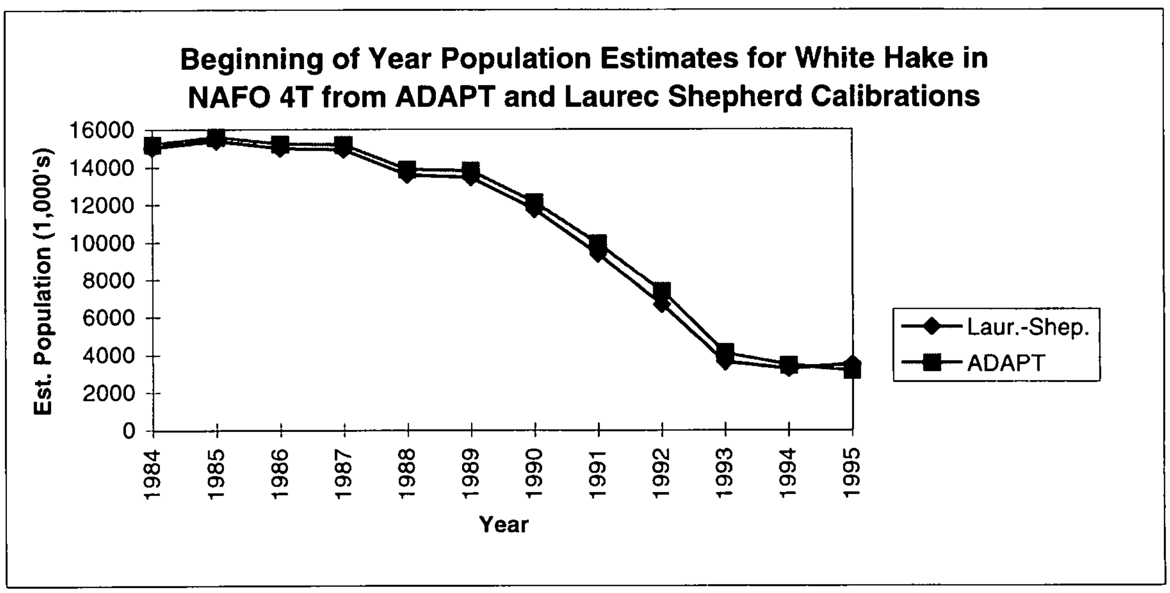


Figure 27. Comparison of beginning of the year population estimates for white hake in the southern Gulf from SPA calibrations using the ADAPT and Laurec-Shepherd tuning methods.

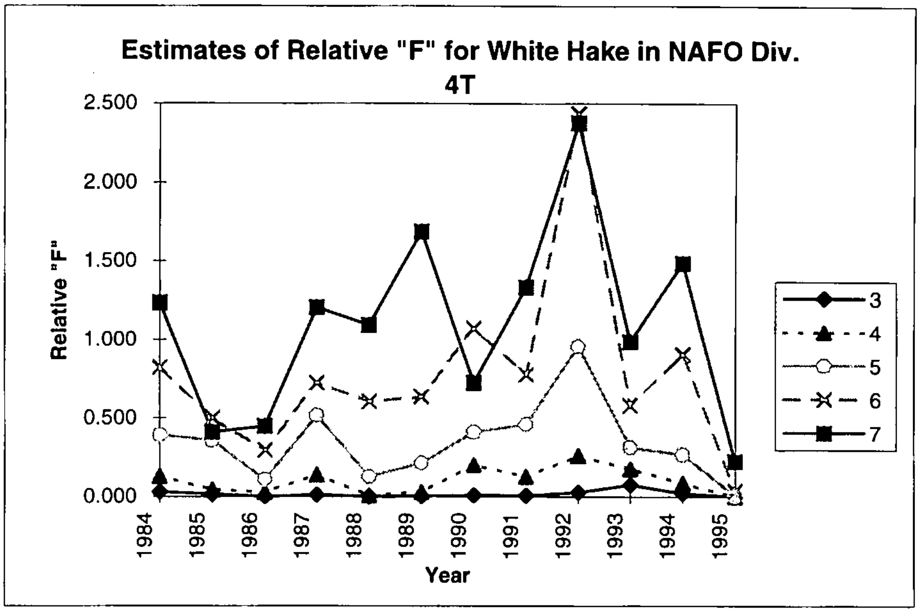


Figure 28. Trends in estimates of relative fishing mortality ('F') for southern Gulf white hake: 1984-95.

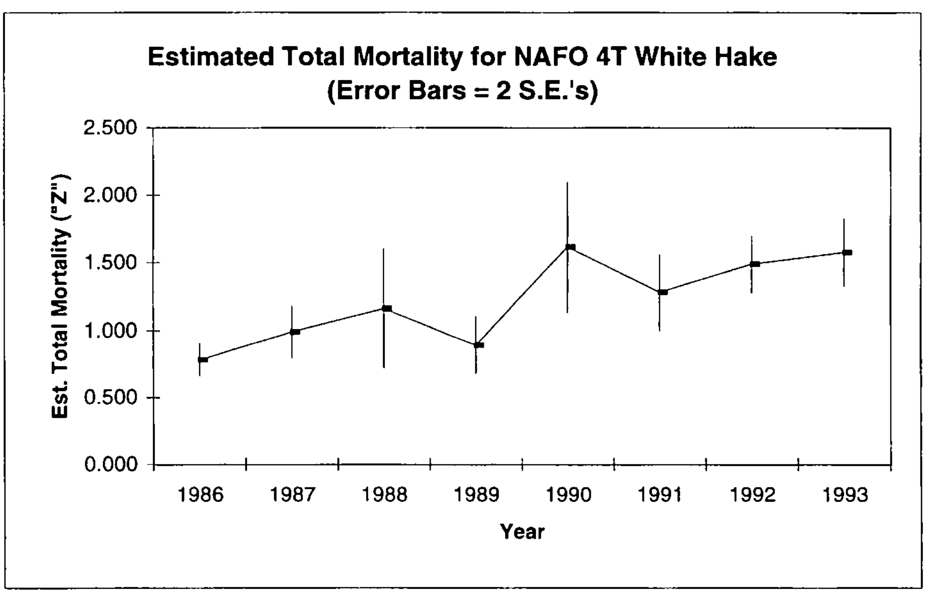


Figure 29. Estimates of total mortality ('Z') for southern Gulf white hake from separate multiplicative analyses of research survey data that covered successive 5 year intervals. The error bars give 2 standard errors of the estimated slopes.

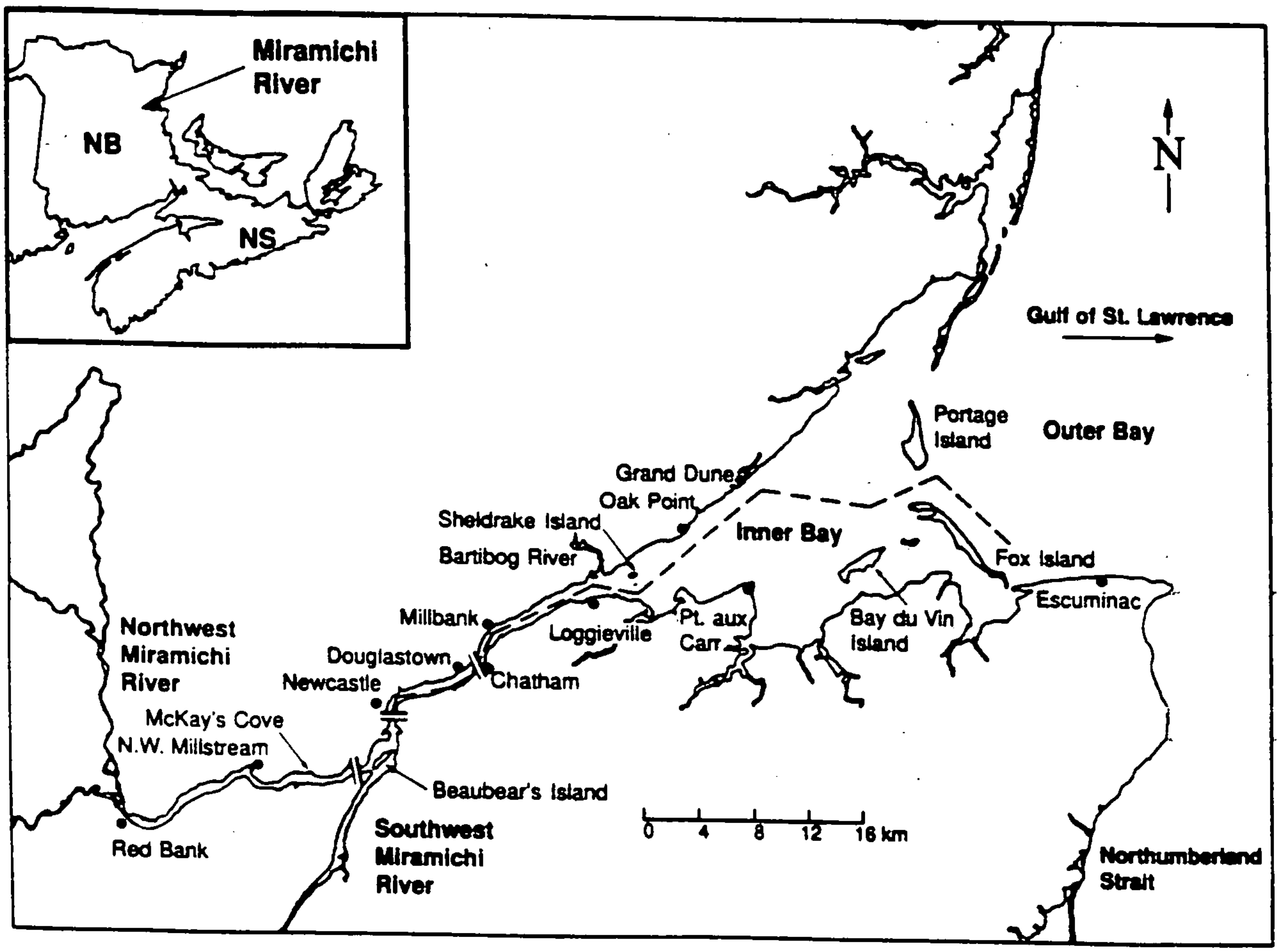


Figure 30. Map of the Miramichi Estuary showing placenames mentioned in the text.

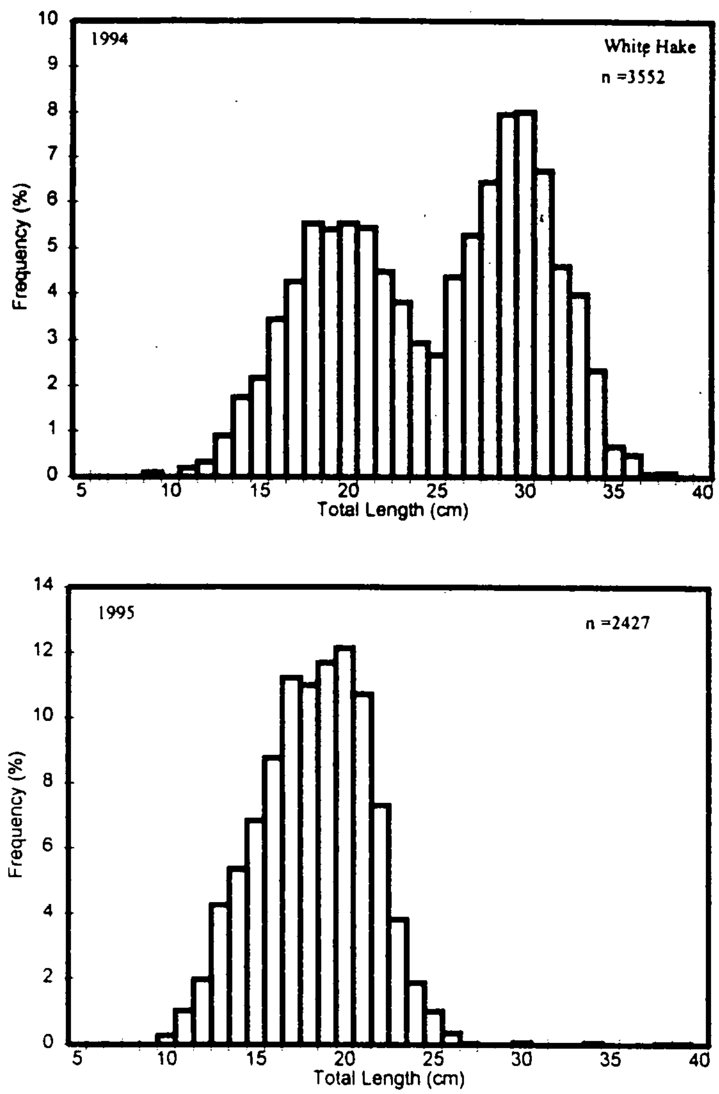


Figure 31. Length frequency distributions for white hake caught as by-catch in the Miramichi Estuary 'openwater' smelt fishery in 1994 and 1995 (from Bradford et al. 1996).