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The Status of White Hake (*Urophycis tenuis*, Mitchill) in the Southern Gulf of St. Lawrence (NAFO Division 4T) in 1997

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Abstract

The white hake population in NAFO Division 4T remains near its lowest level since the first quota was established in 1982. Although directed fishing for white hake was closed in NAFO Division 4T in 1997, provisional landings of 211 t were recorded. The majority of these landings were made by vessels that targeted white hake in the Sentinel Fishery. The stratified mean number of white hake caught per tow (all ages) during the 1997 research survey increased slightly from the 1996 level to 4.2 fish/tow, but remains near the lowest historical level. Despite very low reported landings of hake since 1995, estimates of total mortality remain very high. In contrast, estimates of relative fishing mortality declined to minima in 1995 and remain at low levels. Considering the low abundance and indications of weak incoming recruitment over the next couple of years, recovery of this stock will probably occur slowly.

Résumé

Les effectifs de la population de merluche blanche de la division 4T de l'OPANO sont pratiquement les plus faibles notés depuis l'imposition du premier quota en 1982. La pêche dirigée de cette espèce est interdite depuis 1997 en 4T, mais des débarquements de 211 t (provisoires) ont cependant été enregistrés. La plus grande partie de ces débarquements provient de bateaux ayant pratiqué la pêche de la merluche blanche dans le cadre de la pêche sentinelle. Le nombre moyen stratifié de merluches blanches capturées par trait de chalut (tous âges) au moment du relevé de recherche de 1997 a augmenté légèrement par rapport à 1996, à 4,2 poissons par trait, mais il demeure presque au niveau historique le plus faible. La mortalité totale estimée demeure très élevée, cela en dépit des très faibles débarquements de merluches signalés depuis 1995. Par contre, la mortalité relative par pêche estimée a chuté à un minimum en 1995 et continue d'être faible. Étant donné la faible abondance et les indices de faible recrutement au cours des deux prochaines années, ce stock ne devrait se rétablir que lentement.

2 - Introduction

White hake (*Urophycis tenuis*, Mitchill) has historically been the third or fourth most important groundfish resource in the southern Gulf of St. Lawrence (NAFO Division 4T). Since 1960, the average annual catch of white hake in NAFO Division 4T has been 5,239 t (Table 1). This resource was not managed by a TAC (Total Allowable Catch) until the precautionary quota of 12,000 tonnes was established for the 1982 fishery. Subsequent assessments (Clay et al. 1986; Clay 1987; Clay and Hurlbut 1988) suggested long term yields in the range of 5,000 to 6,000 tonnes could be expected. The TAC was subsequently reduced on five occasions: to 9,400 t in 1987, to 5,500 t in 1988, to 3,600 t in 1993, to 2,000 t in 1994, and most recently to 0 t (moratorium) in 1995 (Table 1).

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

(1) fish from the shallow inshore southern Gulf (depths <= 200m), principally the Northumberland Strait area (the 'Strait' component)
(2) fish from along the Laurentian Channel in depths in excess of 200 m (the 'Channel' component).

Clay (1989) inferred the annual migration pattern of white hake in the southern Gulf from six seasonal surveys (Sept. 86, Dec. 86, Jan. 87, May 87, June 87 and Sept. 87) of the southeastern Gulf. His analysis indicated that as the shallow waters of the southern Gulf cool in the fall, the inshore 'Strait' fish, which had been acclimated to warmer waters (10-15°C), migrate into the deep (> 200 m), relatively warm (4-5°C) water of the Laurentian Channel. He suggested that this is the probable overwintering area for three groups of white hake: those from both the inshore and offshore components of the southern Gulf (i.e., 'Strait' and 'Channel' groups) and those from the northern Gulf (NAFO Divisions 4R and 4S). Subsequently, six seasonal surveys (Sept. 89, Dec. 89, June 90, Sept. 90, Nov. 90 and Apr. 91) of the southwestern Gulf were conducted to describe the seasonal distribution of fish in this area. Like the surveys of the southeastern Gulf, the results from these surveys indicated that the hake left the shallow southwestern Gulf sometime between Nov. and Dec. and returned sometime between April and May.

Recently, Morin and Hurlbut (1994) conducted an analysis of the distribution of white hake from survey data for the northern and southern Gulf (fall and winter) which confirmed that hake increasingly occupy the deeper, eastern portion of the Gulf in winter and that their distribution appears to be continuous with divisions and subareas outside of the Gulf, including NAFO 4Vn and 3Pn. The results of these studies suggest that any directed fishing for white hake in NAFO 4Vn in late November and December, or before mid-June, may result in mortality and unaccounted catches to white hake that originated in NAFO 4T.

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

The present document reviews the status of white hake in NAFO Division 4T in 1997.

3 - Description of Fisheries

A) *Landings*

From 1961-1978, the landings were relatively stable and ranged from 3,600-7,200 t (Table 1 and Figure 1a). The landings rose sharply from 1979 to 1981 and peaked at 14,039 t in 1981. This increase in landings was attributed to increased fishing effort rather than an increase in the abundance of white hake (Anon 1982). Fishing effort increased because of changes in market conditions (Metuzals and Fullerton 1981) and the general expansion of inshore and nearshore fisheries that occurred throughout the Atlantic provinces after 1976 (Anon 1983). Landings declined almost every year after 1981 to 1,036 t in 1994. Since 1990, landings have been lower than the average of 5,239 t for the 1960-1997 period. The TAC has never been exceeded. The fishery for white hake in NAFO Div. 4T has been under moratorium since 1995.

Although directed fishing for white hake in NAFO Division 4T was closed in 1997, provisional landings of 211 t were recorded (Tables 1 and 2a and 2b - Figure 1a). About half of these landings (112 t) were made by participants in the Sentinel Fishery, of which most (59%) were made by longliners in St. Georges Bay, N.S., during August and September (Table 2c; Table A1 and Figure A3 in Appendix 1). The latest statistics available for this assessment (01/03/98) do not include estimates of landings of white hake in the recreational fishery (in 1995 4.6 t of white hake were reported landed in the recreational fishery).

Since 1960, gillnets have accounted for 30% of the landings of white hake, and bottom trawls for 26% (Table 1 and Figure 1b). Over the same time period, longlines and seines have accounted for 17% and 11% respectively. In 1997, however, 44% of the landings were taken by longliners and only 24% were taken by gillnetters (Table 1 and Figure 1b). The majority of the landings (65%) were made in August and September in 1997 (Table 2a).

The DFO statistical system determines the directed species of a fishing trip by the main species landed. A breakdown of the 1997 landings by main species and month is given in Table 2b. The majority of the hake landed in 1997 (56%) came from trips where hake was the main species landed. Most of the remaining landings were taken on trips where winter flounder or cod were the main species landed.

We allocated the NAFO Division 4T white hake landings (1985 - 1997) to the 'Strait' and 'Channel' stock components by the statistical unit areas (Figure 2) in which they were landed, using the depth criteria (depths <= 200 m vs. depths > 200 m) defined by Hurlbut (1990) and Hurlbut and Clay (1990A). Unit areas in the southern Gulf where the bottom depths were less than 200 m were considered to be occupied by the 'Strait' component and those bordering the Laurentian Channel with depths that approached and exceeded 200 m were regarded as belonging to the 'Channel' component.

Since 1985, the majority (90%) of the white hake landings in the southern Gulf of St. Lawrence (NAFO Div. 4T) have been from the 'Strait' component of the stock (unit areas 4Tg, 4Th, 4Tj, 4Tl, 4Tm and 4Tn - Figure 3) and in 1997, 90% of the total landings came from unit area 4Tg alone. From 1985 - 97, annual landings from the unit areas that encompass the 'Channel' component (unit areas 4Tf, 4Tk, 4To, 4Tp and 4Tq - Figure 3) have averaged less than 10% 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 White Hake in the southern Gulf in 1997*

Although directed fishing for white hake was closed in the southern Gulf of St. Lawrence in 1997, a "by-catch quota" of 500 t was announced for white hake in the 1997 Groundfish Management Plan. This quota was originally established in anticipation of a re-opening of the cod fishery in the southern Gulf in 1997. The cod fishery was not re-opened but the 500 t "by-catch quota" remained in effect during the 1997 fishing season. In accordance with this plan, representatives of the various groundfish fleet sectors

in the southern Gulf submitted Conservation Harvesting Plans that indicated their use of the 500 t allocation for by-catch purposes only. Representatives of the mobile gear sector agreed to a daily by-catch level of 10% but the fixed gear sector agreed to a limit of 20%.

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

In 1997, the minimum mesh size for mobile gears (<14 m (45 feet)) was 130 mm (square mesh) in the Northumberland Strait, 135 mm (square mesh) in the Chaleur Bay/Miscou and Magdalen Is. areas, and 155 mm (square mesh) in all other areas of NAFO 4T.

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

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

C) *Descriptions from Industry of the Fisheries for White Hake in 1997*

i) Consultation Meetings ("Science Workshops")

In November 1997, scientific staff from the Dept. of Fisheries and Oceans, Gulf Fisheries Centre, made presentations on the groundfish stocks of the southern Gulf of St. Lawrence at public meetings in Grande-Rivière, Québec, Caraquet, N.B., Charlottetown, P.E.I., Port Hawkesbury, N.S. and Cap-aux-Meules, Québec. The purpose of these meetings was to obtain views from fishers and fishing industry on the status of the various groundfish stocks in the southern Gulf in 1997.

Relative to the meetings in Charlottetown and Port Hawkesbury, there were few or no opinions or comments expressed concerning white hake at the meetings in Grande-Rivière, Caraquet and Cap-aux-Meules. In Cap-aux-Meules, a participant commented that there are no more white hake.

At the Charlottetown meeting, the participants seemed to agree that white hake were most abundant off the eastern coast of P.E.I. in 1997. As in previous science workshops in P.E.I., there were several reports of the capture of white hake in lobster traps during the 1997 lobster fishery. A participant in the 1997 Sentinel Fishery estimated that 90% of the hake that they caught were females and asked why the sex ratio was so lopsided. Another mentioned observing large numbers of juvenile hake near wharves, when they baited their longline gear. A fisher suggested that Pictou Island is an important spawning area for white hake and another asked for information on other spawning and "nursery areas" in the southern Gulf.

By far, the most discussion concerning white hake occurred at the meeting in Port Hawkesbury, as it had in 1994, 1995 and 1996. Again, many participants expressed scepticism with the results of the September (1997) abundance survey and indicated that there was an abundance of white hake in the eastern end of the Northumberland Strait, especially in St. Georges Bay. A participant reported observing significant day/night differences in his catches of white hake and expressed concern about the impact of these differences on the survey abundance index, noting that fishing is conducted on a 24 hour basis during the research survey.

ii) End of Season Telephone Survey

A telephone survey of fishermen that were active in the groundfish fishery in the southern Gulf in 1997 was conducted from Nov. 17 until Dec. 19, 1997 (Hurlbut & Stevens 1998). The primary purpose of the survey was to obtain their views and opinions on groundfish abundance for inclusion in stock assessments.

Interview subjects were selected from a list of all of the southern Gulf purchase slips that were received and processed by Nov. 1, 1997 (328 fishermen were identified from New Brunswick, Nova Scotia, Prince Edward Island and Quebec). Of the 172 respondents that were interviewed, 7 indicated that they directed for white hake in 1997 to some extent (i.e., white hake was their first, second or third priority), and of them, 4 fishers said that white hake was their first priority. All 7 of these respondents were participants in the 1997 sentinel fishery, which explains their ability to target white hake during the moratorium.

The geographical distribution of the 7 respondents who said they fished for white hake 'most of the time' in 1997 is shown in figure 4. It should be noted that 6 of the 7 respondents were from statistical districts located in unit area 4Tg, where the majority of the hake landings occurred in 1997. All 7 of the respondents used fixed fishing gears (4 used gillnets and 3 used longline).

When the respondents were asked for their opinion concerning the abundance of white hake in the southern Gulf in 1997, 4 of the 7 fishermen indicated that they considered the abundance to be low or average but 3 considered it to be high or very high (Figure 5).

The final question on the questionnaire asked the respondents to compare the abundance of white hake in 1997 with its abundance during previous years. Three of the 4 respondents who indicated that white hake was their first priority in 1997 described the abundance of white hake as higher than in 1996 (the fourth respondent felt that the abundance was the same in 1997 as in 1996 - Figure 6). When asked to compare the abundance of white hake in 1997 with its abundance during all the years the respondents fished for this species (Figure 7), three of the four respondents said the abundance was higher or much higher (the remaining respondent felt that the abundance was the same).

4 - Fishery Data

A) *Commercial Samples and Age Determination*

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

Only 13 commercial samples were obtained by DFO port samplers from NAFO Div. 4T in 1997 (1,045 fish measured and 255 otolith pairs taken) because of the moratorium on the hake fishery. Ten of these samples (820 fish measured and 248 otoliths) were obtained from unit area 4Tg, which is occupied by the 'Strait' component and the remaining three samples were obtained from unit area 4Tf (the 'Channel' component), and consisted of 225 fish measured for length and 7 otoliths.

As a result of the limited sampling coverage, we incorporated sampling data from the 1997 sentinel fishery. These data were obtained at sea by trained fishery observers and sentinel fishers and consisted of 37,092 measurements and 745 otoliths. All of the otolith samples were obtained from unit areas occupied by the 'Strait' component (20 from 4Tg and 2 from 4Tj). The observer (i.e. sentinel) samples were collected on a set-by-set basis, whereas the commercial port samples were collected on a trip-by-trip basis. The set-by-set observer samples were weighted by the catch in the set, then combined within trips and weighted by the observer estimate of the trip catch.

Quality control tests were conducted throughout the period of age determination. These tests involve the ageing of two randomly selected trays (50 otoliths per tray) from the reference collection. Recently

assigned ages (commercial or research vessel) are accepted if agreement on the tests exceeds 75% and if age bias plots do not indicate the presence of age estimation bias (Figure 8); otherwise the ages are discarded and the reader recalibrates with otoliths from the reference collection. In 1997, agreement with the reference ager was acceptable (average of 85%), and age estimation bias was not detected (see below).

Date	% Agreement With Reference Ager	Ave. C.V. Over All Ages	Age Estimation Bias
18/11/97 (Beginning of Ageing)	90.2	7.9	No
28/11/97 (After Ageing Research Otoliths)	79.4	7.21	No
6/1/98 (Completion of Ageing)	84.8	8.63	No

B) *Catch, Weight and Length-at-age in 1997*

Even though samples from the sentinel fishery were included in the analysis, it was not possible to maintain the Jan.-July and Aug.-Dec. stratification by gear, used in previous assessments, because of limited sampling coverage. Four keys were used to estimate the catch, weight and length-at-age in 1997. The first key was constructed to estimate the age of gillnet landings and combined age/length keys from gillnet and longline samples (Note: In previous assessments of this resource, catches from gillnets and longlines were combined because they were considered comparable, as were catches from otter trawls and seines). A second, separate key was created from longline sampling data. The third and fourth keys were created to estimate the age composition of mobile gear landings (otter trawls and seines) and combined age-length keys from all of the gears that were sampled. These latter two keys differed in the length frequencies that were used in their construction. The third key used length frequencies sampled from traditional mobile gear mesh sizes, whereas, the fourth key utilised length frequencies sampled from sentinel fishery vessels that used small mesh liners (60 mm) as part of their scientific protocol.

A summary of the sampling data used in constructing the 1997 catch-at-age is given in Table 3. The conversion of length to weight was based on the length-weight regression obtained from the annual (September 1997) groundfish survey of NAFO Div. 4T (Table 3). The catch-at-age, mean weight-at-age and mean length-at-age for 1997 are shown in Table 4. The time series of catches-at-age, mean weights-at-age and mean lengths-at-age from 1982-1997 are found in Table 5.

Even though the total number of white hake landed has increased each year since the establishment of the moratorium (1995), the total number landed in 1997 was the third lowest on record since 1982 (Table 5a and Figure 9a). In 1997, the landings were dominated by ages 5 and 6 ((the 1991 and 1992 yearclasses) (Table 5a and Figure 9 a)). Since 1982, the landings have been composed principally of age 4+ hake, but the proportion of older hake (i.e., age 6+) has diminished since 1989, and the unusually high proportion of older hake (i.e., age 6+) noted in 1995, did not persist.(Figure 9 c).

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

5 - Research Data

A) *Fall Groundfish Survey of 1997*

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

During the 1997 survey (N746), 214 valid sets were made by the research vessel *Alfred Needler* in NAFO Division 4T.

i) Geographic Distribution

During the annual (September) abundance surveys of the southern Gulf, white hake have tended to exhibit a disjunct distribution, with concentrations occurring in warmer waters, either in shallow inshore areas or in deep water along the Laurentian Channel (Figure 12). The constancy of this disjunct distribution pattern from year to year supports the contention that there are separate stock components inhabiting the Strait and Channel areas in September. White hake have seldom been caught in the shallow, central zone adjacent to the Magdalen Islands. The main areas of concentration in 1997 were in St. George's Bay (stratum 403), as was found in the 1997 Sentinel Survey program (Appendix 1), and in the Cape Breton Trough (strata 437 and 439). Concentrations were also present along the Laurentian Channel near the NAFO 4T/4Vn border. In comparison to 1996, catch rates were somewhat higher off the eastern coast of P.E.I in 1997. Unlike previous years, no white hake were captured in the Shediac Valley (strata 420-422) during the 1997 survey. Fewer white hake have been caught in the western part of the southern Gulf each year since 1991, suggesting that there has been a contraction of the geographic range.

The information from the 1994 and 1995 surveys, which extended into NAFO 4Vn, suggested that the distribution of white hake is continuous between this area and NAFO 4T (Hurlbut et al. 1996).

ii) Length and Age Composition of Survey Catches

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

With the exception of 1990, when the modal length was 34 cm, the modal length varied between 40-46 cm from 1984-93. In 1995, the modal length dropped to 31 cm and remained at this length in 1996. The 1997 length frequency contains three modes, with the largest at 19 cm and the second and third largest occurring at 43 cm and 31 cm respectively. The length frequency for 1997 indicates the presence of small fish (less than 40 cm) and in particular of 0-group hake (less than 10 cm), but the abundance of these 0-group fish is considerably less than observed in 1995 and 1996. The abundance of commercial size hake (>= the small fish protocol size of 45 cm) increased marginally in 1997 (22% of the survey length frequency).

From 1984 to 1994, the most abundant age groups in the survey were age 3 or 4 (Table 6). In 1995 and 1996, the most abundant age group was age 2. The catch-at-age for 1997 was bimodal, with the most abundant age group being age 4 (the 1993 yearclass in 1997) and the next most abundant group consisting of ages 1 and 2 (the 1996 and 1995 yearclasses in 1997) (Table 6 and Figures 14 a and b).The abundance of ages 3 and 4 declined sharply from 1992 to 1993 (Figure 14 a) and it appears that the abundance of age 5^+ hake declined substantially from 1991 to 1992 (Figures 14 c and d).

Figure 14d shows that the composition (i.e., percentage) of large, old hake (5 years and older or 45 cm and longer) declined to the lowest level observed in the history of this survey in the mid-1990's.

iii) Size-at-Age

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

From the late 1980's until the early 1990's, the mean weight-at-age for hake ages 5-7 declined gradually (Figure 15). For hake ages 8 and 9, the mean weight-at-age has fluctuated greatly, and minima for the time series 1971-1997 were reached in 1996 for both age groups (Note: the weight-at-age for ages 7^{+} may not be well estimated due to the low numbers of these age groups caught). In 1997, no age 9 hake were caught, but the mean weight for ages 7 and 8 increased slightly.

iv) Abundance Indices and Biomass Estimates

The stratified mean number of white hake caught per tow (ages 0+) during the 1997 September survey increased slightly from the 1996 level to 4.2 fish/tow, but remains near the historical low level reached in 1994 (Table 9 and Figure 16). The stratified mean weight (kg) per tow (ages 0+) and the estimated population biomass also increased from the historical low level reached in 1996 (Table 9 and Figure 17) but remain at very low levels.

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

Abundance trends differed somewhat between the 'Strait' and 'Channel' components (Figure 18a). Abundance of the 'Channel' component tended to be considerably greater than that of the 'Strait' component prior to 1989, but not since 1989. Abundance appeared to decline in the 'Channel' component before it declined in the 'Strait' component. In fact, abundance appeared to increase sharply in the 'Strait' component from 1988 to 1989, coincident with a sharp decline in the 'Channel' component. However, the abundance of both stock components has been at a low level since the mid-1990's. Similar patterns are seen for trawlable biomass (ages 3+), except that no general increase is apparent for the 'Strait' component from 1984-1988 and from 1989-1992 (Figure 18b). This difference between abundance and biomass trends probably reflects the younger/smaller age/size composition in the 1989-1992 period compared to the 1984-88 period.

Since 1994, scepticism has frequently been expressed at meetings with the fishing industry in Cape Breton and P.E.I., concerning survey estimates of abundance for white hake in NAFO Div. 4T. The representatives of the fishing industry have contended that white hake were abundant in the southeastern Gulf, especially in St. Georges Bay. The research vessel estimates of the mean catch per tow for the area in question (survey strata 403 and 433 - see Figure 11) reveal the considerable importance of these two strata, in terms of the local abundance (density) of white hake (Figure 19 and Table 11). Nevertheless, the following points must be borne in mind:

- Stratum 403 is the smallest stratum in the survey area for the southern Gulf. Because stations are allocated to strata in proportion to stratum area, the maximum number of trawl tows ever made before 1996 in stratum 403 was 3 (only one tow was made in 1989). Consequently, abundance estimates for this stratum may have a higher variance since relatively few tows were made.

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

B) 1997 Sentinel Survey Program

a) Description of the 1997 program

A sentinel survey (also referred to as a sentinel fishery) program to monitor changes in abundance and obtain biological information on groundfish was initiated in the southern Gulf of St. Lawrence in the fall of 1994. At first, the surveys were limited to a few areas and were of little value to monitor abundance trends for white hake. In 1996, following the recommendations of the FRCC, the program in the southern Gulf of St. Lawrence was expanded to cover more areas, gear types and seasons. A total of 10 projects comprising 36 fishing vessels (10 mobile gear and 26 fixed gear) were involved in 1997, up from 7 projects with 16 vessels in 1995 and 1 project with 2 vessels in 1994 (Table A1). For fixed gear, the coverage was expanded around P.E.I., N.B., the Gaspé Peninsula and the Magdalen Islands. In addition, the duration of the sentinel surveys was expanded. As in 1996, all projects were underway in late July and were completed by early October in Gaspé or late November in Nova Scotia.

b) Fixed Gear Projects

As in previous years, the fishing locations for fixed gears were spread along the coastline. Each vessel fished at two traditional fishing sites selected by the participating fishermen (or association). Figure A1 shows the location of all fixed gear sentinel survey sites in 1997. The fishing locations were 2.5 miles in radius and at least 5 miles apart. Once the locations were determined, they remained constant throughout the fishing season. Each vessel fished it's gear a maximum of 24 times with a maximum frequency of twice per week, during the fishing season. The fishing days could be consecutive within each 7-day period. A few fishing sites were added in 1997, including 2 in each of the following areas: Chéticamp, N.S., French River, P.E.I. and Miscou Bank.

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

c) Mobile Gear Projects

For the mobile gear projects, the same fishing areas that were identified in collaboration with fishermen in 1995 and 1996 were used. In addition, one trawler and some new fishing areas were added along the Laurentian Channel near Orphan Bank. Each of these traditional fishing areas (Figure A2) were subdivided into squares of 3 nm. Each vessel in the project completed 12 fishing trips during the study. Each trip consisted of 12 fishing sets in pre-determined fishing locations (squares) within the fishing areas (generally 4 sets in each of three fishing areas). The fishing locations for each trip were selected randomly by DFO at the beginning of the projects. Normally, fishing the 12 sets in one trip and recording all of the

information required between 2 to 3 days at sea. Trips were spread over the fishing season with a maximum of one trip per 7 day period.

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

d) Results

Total catches of white hake in the 1997 sentinel survey amounted to 112 t compared to 105 t in 1996. Effort in areas where significant catches of hake were made was about the same as in 1996, suggesting that the biomass has not increased markedly since then. A breakdown of catches is given in Table A1.

Catch rates for all mobile gears were typically very low, generally less than 10 kg/set (Table A1), and were comparable to those seen in 1996 (see Hurlbut et al. 1997).

Catch rates by longlines were highest in St. Georges Bay (Nova Scotia), where catches of just under 1,000 kg per 1,000 hooks were frequent (Figure A3). Similarly high catch rates were recorded with longlines in St. Georges Bay in 1996. P.E.I. showed the second highest catch rates for longlines with frequent catches of 20 to 50 kg per 1,000 hooks. The catch rates in P.E.I. were generally higher than in 1996. Elsewhere, white hake catches by longlines were very poor with no fish being caught in most instances. Gillnet catch rates, showed a similar pattern to longline catches with the largest catches realised along the western shore of Cape Breton, followed by P.E.I. (Figure A4). Catch rates in 1997 tended to be somewhat better than in 1996. Catches were very poor along the Gaspé Peninsula and in New Brunswick.

6 - 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 the NAFO 4T management unit. Each of the previous SPA's was calibrated with a commercial catch rate series derived from purchase slip data (Clay et al. 1985 and 1986; Clay 1987; Clay and Hurlbut 1988 and 1989) and the research vessel abundance index was not used for calibration. However, with recent evidence indicating separate inshore ('Strait') and offshore ('Channel') stock components in NAFO Div. 4T (Hurlbut 1990; Hurlbut and Clay 1990A), SPA's have been conducted on the 'Strait' component only, using the research vessel abundance index for the 'Strait' component as the calibration index (Hurlbut et al. 1996 and 1997). This abundance index includes strata 403, 420-422, 432 and 433 for the years 1984-1997 (Note: Earlier surveys were not included in these analyses because sample sizes were judged to be insufficient and because they did not include stratum 403 an important area for hake).

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

The catch-at-age for the 'Strait' component was computed by adjusting the catch-at-age for the whole management unit ('Strait' + 'Channel' components) with the ratio:

'Strait' Landings / 'Strait' + 'Channel' Landings

We rationalise using this approach because of the following:

From 1985-1996:

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

Table 12 shows the catch-at-age matrices for the 'Strait' component and the whole NAFO 4T management unit.

ii) ADAPT

Several formulations of the adaptive framework (ADAPT) (Gavaris 1988) were attempted to determine the stock size in 1997, but the best fit was obtained with the following formulation:

Parameters

- Terminal N estimates:

$N_{i,\,1997}$ $\quad$ i = 3 to 8

- Calibration coefficients for RV numbers:

K_i $\quad$ 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
  - Population numbers were adjusted to time of survey
- Input: $C_{i,t}$ i = 3 to 10, t = 1985 - 1997; $RV_{i,t}$ i = 3 to 10, t = 1985 - 1997
- Objective Function:
  - Minimize sum of squared residuals
- Summary:
  - Number of observations = 72
  - Number of parameters = 12

The input data to the ADAPT calibration are given in Table 13 and the parameter estimates are shown in Table 14a. The residual pattern (Figure 20) is unbalanced, with predominately negative residuals for 1987, 1988 and 1996 and positive residuals for 1991, 1992, 1994 and 1995. There is a strong retrospective pattern that would tend to overestimate population numbers in 1997 and may indicate that natural mortality has not been well estimated (Figure 21).

The fishing mortalities and population numbers (beginning of year) from the ADAPT calibration are given in Table 14b and Figures 22 and 23. This analysis indicates that fishing mortality increased in 1989 and remained at a high level until 1992, and then declined in 1993, but peaked in 1994, after which it dropped to a low level in 1995, where it has remained. It also indicates that population abundance was relatively stable from 1985-1989 (12.1-13.5 million fish) but declined rapidly from 1990-1993 and reached a minimum in 1997 at less than 1.0 million fish.

The estimates of beginning of year population numbers from the ADAPT calibration were compared with the population estimates for the 'Strait" component from the research vessel survey (Figure 24). These estimates, which were not adjusted for differences in catchability, were dissimilar from 1985-1989, converged in 1990, and then remained divergent from 1991-1993. The correspondence between the estimates is closest from 1994-1997.

B) *Estimation of Mortality Rates by Alternate Methods*

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

$$R_a = C_a/A_a$$

For ages 4-7, the estimates of relative fishing mortality exhibit wide annual fluctuation over the 1985-1993 period (Figure 25). Estimated values were relatively high in 1993 for ages 3 and 4, in 1992 and 1993 for age 5, and in 1992 for ages 6 and 7, declining to very low levels in 1995 for all ages. Estimates of relative F in 1997 remained at low levels for ages 3, 6 and 7 and the estimates for ages 4 and 5 decreased from the moderate levels reached in 1996.

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:

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

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

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

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

7 - Assessment Results

After extensive discussion, the subcommittee decided to reject the SPA results because of its unbalanced residuals and strong retrospective pattern. The SPA suggested that fishing mortality was high from the late 1980's into the early 1990's and peaked in 1994, and that the population declined rapidly in the early 1990's to very low levels in recent years.

Despite very low reported landings of hake since 1995, estimates of total mortality remain very high. In contrast, the estimates of relative fishing mortality declined to minima in 1995 and remain at low levels. This incongruity may indicate that all removals have not been accounted for, but there were no anecdotal reports of "black market" landings in 1997, as there were in 1996.

The recent declines in survey indices of abundance (both for the 'Strait' component and for NAFO 4T as a whole) and an apparent contraction of geographic range in the early 1990's also point to a very low population size in recent years.

8 - Future Prospects

The white hake resource in NAFO Division 4T remains near its lowest level since the first quota was established in 1982. The stratified mean number of white hake caught per tow (all ages) during the 1997 research survey increased slightly from the 1996 level to 4.2 fish/tow, but remains near the lowest historical level. 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 1989-1993 and population abundance has declined to perhaps its lowest observed level.

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

9 - Acknowledgements

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Table 1. Nominal landings (tonnes) of white hake from NAFO Division 4T by gear, with the yearly TAC. All data from 1995 to 1997 are provisional statistics.

Year	Trawl	Seines	Gillnet	Longline	Other	Total	TAC
1960	479	21	3	1172	333	2008	
1961	1430	79	309	3498	7	5323	
1962	1141	97	890	4542	574	7244	
1963	1444	71	48	N/S	4987	6550	
1964	1508	82	N/S	1	4615	6206	
1965	N/S	N/S	N/S	N/S	N/S	4706	
1966	2267	205	375	1870	2307	7024	
1967	2295	128	809	948	2370	6550	
1968	795	84	1734	466	1182	4261	
1969	1030	50	1802	498	828	4208	
1970	1463	382	2149	385	1289	5668	
1971	1523	632	1622	702	1228	5707	
1972	1139	863	1190	1605	960	5757	
1973	2468	211	1265	1045	713	5702	
1974	1454	305	1098	345	414	3616	
1975	1574	306	1279	324	642	4125	
1976	1429	398	1147	183	601	3758	
1977	1227	408	1300	231	818	3984	
1978	1303	737	1829	456	500	4825	
1979	2826	912	3189	479	704	8110	
1980	3430	1615	4831	832	1715	12423	
1981	4733	1922	6174	799	411	14039	
1982	2885	994	4625	1027	245	9776	12000
1983	2141	906	2959	753	546	7305	12000
1984	1734	588	3789	865	74	7050	12000
1985	1639	1008	2480	799	88	6014	12000
1986	1094	898	1884	1068	4	4948	12000
1987	820	1505	2200	1847	0	6372	9400
1988	388	817	1923	748	11	3887	5500
1989	868	1689	1830	943	24	5354	5500
1990	771	1216	2022	1118	48	5175	5500
1991	1205	848	1292	1156	0	4501	5500
1992	955	926	914	1136	0	3931	5500
1993	175	98	469	755	0	1497	3600
1994	79	45	218	694	0	1036	2000
*1995	31	11	18	7	0	66	Moratorium
*1996	27	8	33	86	0	154	Moratorium
*1997	56	13	50	92	0	211	Moratorium
			1960-1997				
Average	1364	555	1572	881	743	5239	
Percent	26	11	30	17	14	100	
			1997				
Percent	27	6	24	44	0	100	

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

Table 2a. Nominal landings (tonnes) of white hake from NAFO Division 4T in 1997 by gear and month.
All data are provisional statistics.

Month	Trawl	Seine	Gillnet	Line	Total	Percent
May	0.0	0.8	0.0	0.4	1.2	0.6
June	0.0	3.3	0.7	0.5	4.6	2.2
July	6.0	2.0	8.3	6.6	22.9	10.9
August	13.0	2.0	17.1	38.4	70.5	33.4
September	15.2	0.8	14.7	35.4	66.1	31.3
October	21.2	3.7	9.0	10.1	44.0	20.9
November	0.7	0.1	0.4	0.5	1.7	0.8
Total	56.2	12.7	50.3	91.9	211.2	100.0
Percent	26.6	6.0	23.8	43.5	100.0	

Table 2b. Nominal landings (tonnes) of white hake from NAFO Division 4T in 1997 by main species and month.
All data are provisional statistics.

Main Species	May	June	July	August	September	October	November	Total	Percent
Cod	0.0	1.4	3.4	5.4	8.4	4.1	0.7	23.4	11.1
Halibut	0.4	0.1	0.4	0.0	0.0	0.0	0.0	0.9	0.4
Plaice	0.1	1.7	3.1	1.0	2.6	2.6	0.0	11.1	5.3
Witch	0.7	0.9	1.0	0.3	0.3	1.8	0.3	5.3	2.5
W. Flound.	0.0	0.1	5.5	12.4	13.0	16.8	0.0	47.8	22.6
Turbot	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.4	0.2
W. Hake	0.0	0.0	9.4	51.5	41.9	15.0	0.0	117.8	55.8
Mackerel	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0
Skate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dogfish	0.0	0.0	0.0	0.0	0.0	3.7	0.7	4.4	2.1
Total	1.2	4.5	22.9	70.6	66.2	44.1	1.7	211.2	100.0
Percent	0.6	2.1	10.8	33.4	31.3	20.9	0.8	100.0	

Table 2c. Nominal landings (tonnes) of white hake from NAFO Division 4T in 1997 in the Sentinel Fishery.
All data are provisional statistics.

	Sentinel Fishery					
Month	Trawl	Seine	Gillnet	Line	Total	Percent
July	0.0	0.0	3.1	6.2	9.4	8.4
August	0.1	0.1	16.8	27.9	44.8	40.0
September	0.1	0.0	9.7	28.8	38.7	34.5
October	0.6	0.2	8.4	9.7	18.9	16.9
November	0.2	0.1	0.0	0.1	0.4	0.3
Total	1.0	0.4	38.0	72.7	112.1	100.0
Percent	0.9	0.4	33.9	64.8	100.0	

Table 3. Age-length keys that were used in the calculation of the 1997 catch-at-age for white hake in NAFO Division 4T.

			Sample Size			
Key	Fishery	Samples	D.F.O. Port	Observer/Sentinel	Total	Landings (t)
1	GN: Jan. - Dec.	GN: Jan. - Dec. Lengths	0	13396	13396	50.3
		GN/LL: Jan. - Dec. Ages	0	727	727	
2	LL: Jan. - Dec.	LL: Jan. - Dec. Lengths	0	22983	22983	91.9
		LL: Jan. - Dec. Ages	0	546	546	
3	OTB/SNU: Jan. - Dec. No Liners	OTB/SNU: Jan. - Dec. Lengths No Liners	1045	154	1199	68.2
		All Gears: Jan. - Dec. Ages	255	745	1000	
4	OTB/SNU: Jan. - Dec. Liners	OTB/SNU: Jan. - Dec. Lengths Liners	0	559	559	0.8
		All Gears: Jan. - Dec. Ages	255	745	1000	

Gear Type Abbreviations

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

Length/Weight Coefficients (sexes combined) from Mission N746 (Sept. 1997)

a = 0.003757 b = 3.175582

Table 4. The catch, weight and length-at-age for white hake in NAFO Division 4T as estimated from observer and port sampling of the commercial and sentinel fisheries in 1997.

1997 CATCH #'S AT AGE (1,000's)

L*=Liner
NoL*=No Liner

AGE	KEY 1 GNS	KEY 2 LLS	KEY 3 OTB/SNU-NoL*	KEY 4 OTB/SNU-L*	SUM	C.V.
1	0	0	0	0	0	
2	0	0	0	0	0	141.4
3	0	1	1	0	1	89.6
4	0	13	2	0	16	153.8
5	6	29	10	0	44	111.8
6	10	15	11	0	37	70.2
7	5	5	6	0	15	67.8
8	2	2	2	0	6	68.2
9	0	0	1	0	1	114.4
10	0	0	0	0	0	74.6
11	0	0	0	0	0	142.3
12	0	0	0	0	0	
13-16	0	0	0	0	0	
SUM	23	65	33	1	122	

1997 AVERAGE WEIGHT AT AGE (KG)

AGE	KEY 1 GNS	KEY 2 LLS	KEY 3 OTB/SNU-NoL*	KEY 4 OTB/SNU-L*	WEIGHTED AVE.WGT.
1					
2				0.19	
3		0.48		0.40	0.26
4	1.34	0.82	0.97	0.62	0.85
5	1.71	1.27	1.58	1.05	1.39
6	2.15	1.79	2.11	1.48	1.99
7	2.54	2.50	2.60	2.25	2.55
8	2.70	2.47	3.12	2.19	2.80
9	3.62	3.27	3.79	2.77	3.70
10	3.14	2.77	4.25		3.27
11					
12					
13					
14					
15					
16					
MEAN	2.17	1.51	2.07	0.78	

AVERAGE LENGTH AT AGE (CM.)

AGE	KEY 1 GNS	KEY 2 LLS	KEY 3 OTB/SNU-NoL*	KEY 4 OTB/SNU-L*	WEIGHTED AVE.LT.
1					
2				30.04	
3		40.41		37.97	22.84
4	55.36	47.51	50.07	43.69	47.93
5	60.13	54.52	58.46	51.31	56.07
6	64.69	60.36	64.13	56.74	62.70
7	68.03	67.40	68.33	65.37	67.95
8	69.19	57.55	72.18	65.04	66.89
9	76.20	63.47	77.33	70.44	75.98
10	72.75	60.18	79.97		70.23
11					
12					
13					
14					
15					
16					
MEAN	64.70	56.67	62.91	45.08	

Table 5. Commercial fishery catch, weight and length-at-age for white hake in NAFO Division 4T: 1982-1997.

a. Commercial Fishery Catch-at-Age (in 1,000's) for NAFO 4T White Hake: 1982-1997.

	Year															
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1-2	0	43	2	3	0	0	0	5	0	0	0	0	0	0	0	0
3	5	86	58	64	2	30	0	11	34	28	127	79	25	0	2	1
4	159	220	319	216	204	531	39	114	604	409	1000	312	134	0	20	16
5	648	740	787	608	496	1357	476	574	1170	1048	1028	400	185	2	29	44
6	1210	939	788	592	477	900	648	810	992	859	554	217	201	9	24	37
7	1232	712	542	391	330	411	513	689	427	507	270	87	86	12	13	15
8	665	535	275	227	233	149	109	224	80	79	61	27	28	4	6	6
9	198	142	142	108	77	68	15	76	18	17	26	10	5	0	1	1
10	89	42	69	51	45	18	6	11	8	5	11	1	1	0	0	0
11	24	8	22	16	21	4	2	13	2	2	4	2	0	0	0	0
12	16	6	16	18	14	2	1	5	1	1	0	1	0	0	0	0
13+	16	3	7	12	9	3	1	6	1	5	1	0	0	0	0	0
	4261	3477	3028	2306	1908	3473	1809	2537	3337	2961	3082	1137	664	27	95	122

b. Commercial Fishery Mean Weight-at-Age (kg) for NAFO 4T White Hake: 1982-1997.

	Year															
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1		0.46														
2		0.60	0.53	0.95			0.21	0.21								
3	0.55	0.92	0.87	1.39	3.19	0.62	0.33	0.42	0.59	0.54	0.55	0.55	0.61		0.53	0.26
4	0.90	1.39	1.15	1.53	0.98	0.81	0.96	0.96	0.81	0.80	0.77	0.90	0.83	0.89	0.89	0.85
5	1.20	1.68	1.66	2.01	1.53	1.29	1.29	1.23	1.19	1.13	1.10	1.20	1.22	1.33	1.32	1.39
6	1.74	2.03	2.17	2.35	2.39	2.06	1.91	1.77	1.75	1.60	1.69	1.74	1.83	1.93	1.91	1.99
7	2.11	2.47	2.74	2.84	3.01	2.95	2.82	2.53	2.56	2.34	2.36	2.11	2.49	2.65	2.41	2.55
8	3.13	2.59	3.31	3.70	3.90	3.92	3.72	3.47	3.45	2.90	3.08	3.12	3.03	3.59	2.50	2.80
9	3.06	3.27	3.73	4.05	4.69	4.57	5.31	4.31	4.94	4.15	4.45	3.06	3.48	5.27	3.01	3.70
10	3.37	4.09	5.63	5.00	5.65	6.06	6.01	6.15	5.58	6.91	5.55	3.37	4.07		3.59	3.27
11	4.36	5.99	5.05	6.70	6.90	8.75	8.56	6.16	7.54	5.95	5.54	4.35				
12	4.03	7.52	7.11	6.96	6.92	9.57	10.41	9.65	9.26	7.18	6.06	4.03			3.76	
13									6.83	10.04			9.55			
14																
15																

c. Commercial Fishery Mean Length-at-Age (cm) for NAFO 4T White Hake: 1982-1997.

	Year															
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1		39.7														
2		43.8	41.9	50.0			31.6	31.0								
3	49.0	50.1	47.8	55.6	70.8	44.0	36.2	38.7	43.4	42.0	42.5	42.0	43.6		41.4	22.8
4	54.9	57.0	52.3	57.4	49.6	48.2	50.5	50.0	47.8	47.8	47.5	49.6	48.0	49.0	48.7	47.9
5	58.7	60.7	58.8	62.1	57.1	55.5	55.4	54.6	54.3	53.4	53.4	54.4	54.3	55.4	55.4	56.1
6	65.2	64.3	63.6	65.2	66.0	64.0	62.4	61.2	61.6	59.5	61.7	61.8	61.9	62.7	62.7	62.7
7	67.8	68.4	68.2	68.9	70.8	71.4	70.5	68.6	70.0	67.4	68.9	65.8	68.4	69.4	67.8	67.9
8	72.1	68.7	72.2	74.7	76.8	77.8	76.9	76.0	76.8	72.1	74.9	74.6	72.8	76.3	68.2	66.9
9	74.8	74.7	74.5	76.3	81.0	80.5	85.7	81.0	86.7	81.3	84.9	74.0	76.1	86.5	72.8	76.0
10	79.0	78.9	84.3	81.0	85.5	87.0	89.2	89.8	89.6	96.3	91.4	76.7	80.5		77.6	70.2
11	77.9	91.6	81.7	89.1	92.1	100.1	99.9	89.2	99.8	92.0	91.5	83.7				
12	76.9	99.1	91.2	88.9	90.9	102.7	106.4	105.9	107.0	97.8	94.6	81.5			78.3	
13	81.7								96.4	109.0			106.0			
14																
15																

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

Survey	P091	P106	P122	P143	P157	P172	P188	P204	P229	P244	P260	P278	P296	P312
Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
age 0														0.01
age 1	0.04	0.03	0.03	0.11	0.34	0.33	0.02	0.06		0.01	0.05	0.06	0.09	0.05
age 2	0.54	0.18	0.29	1.64	3.45	3.05	0.30	2.15	0.28	0.27	0.46	0.27	0.81	0.47
age 3	0.96	0.18	0.58	1.71	2.17	2.07	1.27	1.50	2.04	0.98	1.11	0.61	0.81	1.11
age 4	0.45	0.27	1.77	2.44	1.06	0.90	1.78	2.52	2.08	1.86	2.47	0.97	0.80	1.42
age 5	0.48	0.28	1.94	1.85	0.64	0.52	0.58	2.01	1.82	2.38	3.15	0.77	0.44	1.14
age 6	0.11	0.27	0.73	1.39	0.34	0.25	0.18	0.98	1.28	0.92	2.39	0.70	0.28	0.53
age 7	0.11	0.09	0.29	0.89	0.14	0.08	0.17	0.30	0.48	0.45	1.45	0.30	0.14	0.27
age 8	0.02	0.12	0.07	0.21	0.04	0.02	0.04	0.03	0.13	0.23	0.47	0.13	0.07	0.17
age 9	0.03	0.16	0.04	0.06			0.05	0.02	0.02	0.09	0.23	0.02	0.07	0.06
age 10	0.03	0.06	0.03	0.15	0.02	0.02	0.01	0.07	0.03	0.10	0.01	0.04	0.01	0.06
age 11	0.03	0.06	0.02	0.14	0.04	0.03	0.02		0.04	0.02	0.02			0.01
age 12		0.02	0.03	0.08			0.03	0.04	0.06	0.01	0.01			0.01
age 13		0.01									0.04			
age 14			0.01	0.02			0.02				0.02			
age 15										0.02				
age 16						0.00								
Totals:	2.80	1.72	5.83	10.67	8.24	7.27	4.46	9.67	8.25	7.33	11.88	3.86	3.52	5.31

Survey	P327	H159	H179	H192	H204	H219	H232	N178	N192	N210	N230	N249	N746
Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
age 0	0.02	0.04		0.01	0.41	0.44	0.08	0.09	0.08	0.22	0.60	0.30	0.41
age 1	0.11	0.24	0.04	0.16	1.08	0.66	0.54	0.31	0.26	0.18	0.52	0.42	0.83
age 2	0.67	1.72	0.46	1.59	2.10	2.39	2.05	1.33	0.71	0.81	1.53	1.09	0.85
age 3	2.40	2.62	1.75	2.65	4.26	2.59	2.87	2.74	0.80	0.71	0.59	0.76	0.61
age 4	2.93	4.27	2.16	3.13	2.34	1.65	1.80	2.12	0.98	0.86	0.48	0.54	0.88
age 5	0.93	2.58	1.50	2.32	1.46	1.65	1.27	0.71	0.54	0.38	0.17	0.19	0.43
age 6	0.67	0.92	0.70	0.74	0.80	0.53	0.60	0.17	0.17	0.12	0.13	0.07	0.14
age 7	0.52	0.43	0.21	0.30	0.22	0.35	0.19	0.04	0.06	0.03	0.03	0.03	0.04
age 8	0.31	0.24	0.05	0.05	0.03	0.08	0.06	0.01	0.00	0.02	0.01	0.01	0.01
age 9	0.26	0.11	0.03	0.01	0.03	0.02	0.01		0.02			0.01	
age 10	0.10	0.04	0.03	0.02	0.02		0.02						
age 11	0.03	0.04			0.01		0.02						
age 12	0.04	0.03	0.03										
age 13	0.02	0.01			0.01								
age 14	0.02												
age 15	0.01												
age 16													
Totals:	9.05	13.29	6.95	10.97	12.76	10.37	9.51	7.51	3.62	3.33	4.06	3.41	4.19

Research Vessels: E.E. Prince from 1971-85 (P)
Lady Hammond from 1986-91 (H)
Alfred Needler from 1992-97 (N)

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

Survey	P091	P106	P122	P143	P157	P172	P188	P204	P229	P244	P260	P278	P296	P312
Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
age 0														0.06
age 1	0.12	0.16	0.24	0.18	0.26	0.25	0.09	0.21		0.22	0.06	0.09	0.16	0.14
age 2	0.33	0.32	0.28	0.24	0.30	0.30	0.30	0.30	0.34	0.41	0.24	0.34	0.33	0.29
age 3	0.48	0.70	0.67	0.44	0.42	0.43	0.50	0.47	0.48	0.55	0.47	0.60	0.60	0.57
age 4	0.73	0.66	1.06	0.95	0.90	0.86	0.68	1.01	0.86	1.01	0.87	1.00	1.08	0.93
age 5	1.29	1.63	1.30	1.39	1.34	1.32	1.27	1.57	1.45	1.40	1.32	1.33	1.85	1.48
age 6	1.80	2.35	1.81	2.08	1.67	1.65	1.56	2.10	1.90	1.87	1.74	1.75	2.07	2.10
age 7	2.08	2.43	2.25	2.19	2.48	2.50	1.71	2.48	2.28	2.49	2.10	2.33	3.02	2.57
age 8	2.07	2.69	4.66	4.58	2.73	2.78	2.36	3.28	2.42	3.07	2.74	2.90	3.73	3.15
age 9	2.60	2.87	4.48	3.36			3.87	2.46	3.22	3.30	2.93	3.08	3.88	2.74
age 10	2.57	6.15	3.61	3.80	3.40	3.19	2.13	2.13	2.77	5.40	3.28	3.59	5.73	6.05
age 11	8.25	3.26	5.20	5.55	2.73	4.98	9.53		5.01	4.13	10.91			3.82
age 12		2.82	2.82	2.82			3.78	7.55	2.79	9.53	3.28			6.60
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	P327	H159	H179	H192	H204	H219	H232	N178	N192	N210	N230	N249	N746
Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
age 0	0.03	0.06		0.06	0.05	0.03	0.06	0.07	0.06	0.05	0.01	0.01	0.04
age 1	0.08	0.15	0.11	0.10	0.09	0.07	0.18	0.16	0.12	0.13	0.11	0.13	0.07
age 2	0.21	0.25	0.19	0.23	0.22	0.21	0.25	0.28	0.26	0.25	0.24	0.24	0.23
age 3	0.41	0.47	0.43	0.41	0.43	0.35	0.46	0.45	0.45	0.51	0.46	0.49	0.43
age 4	0.75	0.78	0.68	0.70	0.61	0.63	0.67	0.62	0.67	0.81	0.72	0.66	0.62
age 5	1.27	1.25	1.20	1.08	1.06	0.99	1.06	0.94	0.94	1.13	1.10	1.05	0.90
age 6	1.93	1.97	2.03	1.73	1.63	1.45	1.56	1.48	1.29	1.66	1.77	1.43	1.28
age 7	2.58	2.79	2.96	2.69	2.42	2.04	2.16	1.88	1.45	2.33	2.89	1.71	2.02
age 8	3.50	3.37	3.79	3.77	3.48	3.80	3.69	2.90	2.58	3.13	3.29	1.89	2.36
age 9	4.69	4.61	6.61	6.07	5.45	4.10	4.34		4.71			1.81	
age 10	3.34	6.52	6.63	9.03	6.99		6.56		0.00				
age 11	4.40	7.32			9.34		7.20						
age 12	10.28	7.93	8.23										
age 13	8.91	10.30											
age 14	10.77												
age 15	12.16												
age 16													

Research Vessels: E.E. Prince from 1971-85 (P)
Lady Hammond from 1986-91 (H)
Alfred Needler from 1992-97 (N)

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

Survey	P091	P106	P122	P143	P157	P172	P188	P204	P229	P244	P260	P278	P296	P312
Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
age 0														22.0
age 1	25.4	28.0	29.4	26.4	32.5	31.8	23.4	29.5		31.0	20.8	23.3	27.8	26.9
age 2	35.0	34.3	33.2	31.3	34.1	34.1	33.6	33.6	34.8	37.0	32.5	35.7	35.5	33.8
age 3	38.9	44.6	42.2	37.7	37.7	38.0	39.6	38.6	38.6	40.9	40.0	43.0	42.8	42.2
age 4	45.3	43.0	50.9	48.9	48.0	47.5	44.1	49.8	47.2	49.9	49.0	51.3	52.5	48.9
age 5	54.1	57.9	54.4	55.2	54.6	54.4	53.3	57.3	55.8	55.6	56.2	56.3	62.6	56.6
age 6	59.9	65.6	60.2	63.3	59.0	58.7	57.1	63.1	60.8	60.9	61.5	61.7	65.2	62.9
age 7	62.3	66.0	64.8	64.4	67.0	67.1	59.3	66.3	64.7	66.5	65.2	67.4	73.8	66.8
age 8	62.8	68.6	80.4	80.4	69.2	69.6	65.7	72.4	65.5	70.6	70.5	72.7	78.4	71.2
age 9	67.9	67.7	79.2	73.9			75.9	67.0	73.0	72.2	72.2	73.4	80.2	68.6
age 10	67.9	86.8	74.9	76.3	74.2	72.7	64.0	63.7	67.4	83.1	76.0	76.3	91.0	84.9
age 11	98.4	73.2	85.0	86.8	69.2	80.3	103.0		83.9	79.0	112.0			76.4
age 12		70.0	70.0	70.0			75.8	95.6	69.7	103.0	76.0			88.2
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	P327	H159	H179	H192	H204	H219	H232	N178	N192	N210	N230	N249	N746
Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
age 0	16.7	19.7		20.8	19.2	16.5	18.5	21.7	19.3	18.5	11.6	9.9	18.1
age 1	22.8	26.9	25.7	23.8	22.9	20.4	29.0	27.8	25.3	26.4	24.9	26.1	21.3
age 2	31.1	32.0	30.6	32.3	30.9	30.8	32.7	33.9	32.6	32.5	32.0	31.8	31.7
age 3	37.6	39.0	39.5	38.6	39.1	36.3	39.8	39.7	39.4	41.0	39.6	40.1	38.9
age 4	45.8	46.0	45.3	45.6	43.6	44.2	44.9	44.2	45.1	47.5	45.8	44.2	43.6
age 5	53.9	53.6	54.1	52.1	52.0	51.1	52.0	50.7	50.3	53.0	52.3	51.4	49.1
age 6	61.7	62.0	63.6	60.4	59.7	58.1	59.0	58.8	55.9	60.0	61.0	56.9	55
age 7	67.2	69.2	71.6	69.6	67.7	64.9	65.7	63.9	58.2	66.9	71.1	60.2	62.3
age 8	73.3	73.2	76.7	77.1	76.2	79.5	78.0	74.1	71.0	73.6	74.2	61.1	66.4
age 9	80.0	80.0	91.9	89.7	88.2	82.0	83.0		86.6			61.7	
age 10	72.6	90.1	92.0	101.7	95.6		94.9						
age 11	78.8	93.8			105.0		97.6						
age 12	103.1	96.0	98.4										
age 13	99.0	106.0											
age 14	104.9												
age 15	108.8												
age 16													

Research Vessels: E.E. Prince from 1971-85 (P)
Lady Hammond from 1986-91 (H)
Alfred Needler from 1992-97 (N)

Table 9. Research vessel estimates of the mean catch per tow (numbers and weight), population numbers and population biomass for white hake (ages 0+) in the southern Gulf of St. Lawrence (NAFO Division 4T) (Note: All survey strata in NAFO Division 4T are included).

Year	Stratified Mean Number Per Tow	Variance	Stratified Mean Wt. (kg.) Per Tow	Variance	Estimated Population Numbers (000's) in NAFO 4T	Variance	Estimated Population Biomass (t) in NAFO 4T	Variance
1971	2.80	1.20	2.33	0.52	4838	3583318	4028	1552919
1972	1.73	0.23	3.24	1.59	2995	695312	5596	4758931
1973	5.83	17.46	7.60	28.98	10090	52212572	13134	86660015
1974	10.68	21.55	14.10	45.49	18470	64458299	24385	136048571
1975	8.26	15.57	5.11	1.60	14283	46551665	8837	4790655
1976	7.27	8.84	4.49	1.28	12576	26440912	7771	3823445
1977	4.47	1.59	3.77	0.84	7727	4745806	6515	2515284
1978	9.68	10.85	10.25	8.36	15711	28584269	16637	22038177
1979	8.28	6.95	9.97	8.94	14326	20794088	17243	26741492
1980	7.37	1.28	10.25	2.57	12747	3826823	17732	7688792
1981	11.88	13.55	17.89	33.68	20551	40514792	30937	100721146
1982	3.86	1.62	5.23	3.70	6677	4840525	9052	11080178
1983	3.58	0.39	4.11	0.40	6092	1130786	6989	1158737
1984	5.31	1.38	6.26	1.49	9395	4314411	11075	4658036
1985	8.99	7.61	10.60	11.23	15887	23780718	18738	35113495
1986	13.29	7.00	14.20	5.63	23492	21871241	25104	17588823
1987	6.95	2.11	7.57	2.40	12280	6588713	13381	7497788
1988	10.97	5.70	9.45	2.65	19096	17265929	16439	8019952
1989	12.73	6.74	8.03	1.71	22508	21055050	14195	5345043
1990	10.36	4.28	7.27	1.33	18320	13379505	12849	4157874
1991	9.51	9.83	6.80	3.01	16819	30727948	12021	9407318
1992	7.48	6.97	4.36	1.78	13231	21798588	7707	5578221
1993	3.62	0.71	2.31	0.34	6402	2207207	4089	1055358
1994	3.33	0.74	2.13	0.28	5892	2321388	3758	863747
1995	4.07	0.67	1.65	0.09	7196	2101322	2923	275990
1996	3.41	0.44	1.56	0.10	6025	1377045	2765	313495
1997	4.19	1.33	1.78	0.22	7406	4170707	3148	701844

Research Vessels: E.E. Prince from 1971-85 (P)
Lady Hammond from 1986-91 (H)
Alfred Needler from 1992-97 (N)

Table 10a. Research vessel estimates of the mean catch per tow (numbers and weight), population numbers and population biomass for white hake from the 'Strait' component. (Note: Only those strata corresponding to the 'Strait' component (i.e., 403, 420, 421, 422, 432 and 433) are included).

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	8.54	25.35	11.49	26.65	2858	2840266	3846	2985351
1985	17.34	40.26	26.08	226.97	5804	4509717	8730	25425154
1986	23.55	75.00	26.82	89.68	7883	8401666	8976	10045613
1987	14.61	28.34	14.45	31.52	4889	3175050	4836	3530635
1988	12.51	37.71	8.63	19.00	3838	3549662	2647	1788625
1989	46.41	157.22	22.36	25.83	15532	17612182	7485	2893357
1990	33.23	99.27	15.55	17.71	11121	11119903	5204	1984085
1991	36.36	269.27	22.16	76.19	12168	30164381	7417	8534517
1992	29.00	189.59	15.68	47.80	9705	21237889	5249	5354791
1993	5.67	2.07	3.76	0.78	1899	231667	1258	86960
1994	12.51	17.09	8.21	6.56	4186	1914096	2747	734925
1995	13.91	14.88	5.94	2.12	4655	1667369	1987	237025
1996	4.80	0.54	1.50	0.09	1606	61022	501	10403
1997	9.41	13.51	2.04	0.25	3150	1513961	684	27610

Table 10b. Research vessel estimates of the mean catch per tow (numbers and weight), population numbers and population biomass for white hake from the 'Channel' component. (Note: Only those strata corresponding to the 'Channel' component (i.e., 415, 425, 437, 438 and 439) are included).

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	28.79	33.11	30.96	37.47	5881	1382093	6325	1563934
1985	44.80	459.36	36.88	199.40	9153	19174945	7534	8323678
1986	70.35	318.43	63.76	135.48	14373	13292264	13027	5655133
1987	33.12	79.22	36.19	80.28	6767	3306891	7393	3351082
1988	69.06	323.41	59.95	134.82	14110	13499851	12249	5627639
1989	28.70	81.01	22.47	46.04	5864	3381403	4590	1921916
1990	30.35	52.70	26.95	32.08	6200	2199699	5506	1339279
1991	17.73	9.23	12.21	3.82	3623	385487	2496	159563
1992	16.05	13.26	10.23	4.96	3280	553644	2090	206946
1993	19.76	47.01	11.89	22.75	4038	1962490	2429	949542
1994	7.93	9.71	4.42	3.01	1621	405295	902	125552
1995	8.07	6.14	2.85	0.50	1650	256149	582	21037
1996	21.32	31.51	10.51	7.20	4357	1315426	2147	300618
1997	20.16	63.59	11.48	16.07	4119	2654462	2345	670628

(Note: Tables 10a and b will not sum to Table 9 because Table 9 includes additional strata).

Table 11. Research vessel estimates of the mean catch per tow (numbers) for strata 403 (St. Georges Bay) and 433 (Eastern Northumberland Strait) (separated and combined).

Year	Mean No./Tow Strat. 403 (St. Georges Bay)	Mean No./Tow Strat. 433 East North. Strait	Mean No./Tow (Combined Areas) Strat. 403+433	Mean No./Tow "Rest" of NAFO 4T	Mean No./Tow Total Survey Area All of NAFO 4T
84	6.93	20.31	19.15	4.41	5.31
85	26.67	46.75	45.01	6.65	8.99
86	65.11	61.93	62.21	10.11	13.29
87	21.58	36.14	34.88	5.13	6.95
88	58.58	17.98	21.51	10.28	10.97
89	532.66	81.68	120.85	5.70	12.73
90	186.67	52.34	64.01	6.87	10.36
91	80.27	77.93	78.13	5.05	9.51
92	131.57	75.68	80.53	2.73	7.48
93	79.93	5.16	11.65	3.10	3.62
94	23.16	33.40	32.51	1.43	3.33
95	189.41	14.68	29.86	2.39	4.07
96	44.94	2.67	6.34	3.22	3.41
97	28.80	15.06	16.25	3.41	4.19

Table 12. Comparison of the commercial catch-at-age for the "Strait" component with the catch-at-age (thousands) for NAFO Div. 4T.

NAFO 4T

AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1-2	3	0	0	0	5	0	0	0	0	0	0	0	3
3	64	2	30	0	11	34	28	127	79	25	0	2	2
4	216	204	531	39	114	604	409	1000	312	134	0	20	15
5	608	496	1357	476	574	1170	1048	1028	400	185	2	29	42
6	592	477	900	648	810	992	859	554	217	201	9	24	36
7	391	330	411	513	689	427	507	270	87	86	12	13	14
8	227	233	149	109	224	80	79	61	27	28	4	6	6
9	108	77	68	15	76	18	17	26	10	5	0	1	1
10+	97	89	27	9	35	12	13	16	4	1	0	0	1

"Strait" Component

AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1-2	3	0	0	0	4	0	0	0	0	0	0	0	3
3	56	2	25	0	9	30	25	112	48	24	0	2	2
4	189	194	454	34	97	541	367	879	317	128	0	19	14
5	532	458	1159	413	490	1047	941	904	368	176	2	27	39
6	518	421	769	563	691	888	771	487	184	192	8	23	34
7	342	278	351	445	588	382	455	238	71	82	11	12	13
8	199	215	127	94	191	72	71	53	22	27	3	6	5
9	95	59	58	13	64	16	15	22	7	5	0	1	1
10+	85	73	23	8	30	10	12	14	3	1	0	0	0

Table 13. Input data for the ADAPT calibration of SPA for the "Strait" component.

W. Hake Commercial Fishery Catch-at-Age Matrix for the 'Strait' Component: 1985-1997

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
3	56	2	25	1	9	30	25	112	48	24	1	2	2
4	189	194	454	34	97	541	367	879	317	128	1	19	14
5	532	458	1159	413	490	1047	941	904	368	176	2	27	39
6	518	421	769	563	691	888	771	487	184	192	8	23	34
7	342	278	351	445	588	382	455	238	71	82	11	12	13
8	199	215	127	94	191	72	71	53	22	27	3	6	5
9	95	59	58	13	64	16	15	22	7	5	1	1	1
10+	85	73	23	8	30	10	12	14	3	1	1	1	1
Sum	2014	1701	2967	1570	2161	2986	2657	2708	1021	634	28	91	109

W. Hake Research Vessel Catch-at-Age for the 'Strait' Component: 1985-1997

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
3	4.457	3.975	4.573	2.204	17.316	8.983	10.936	10.261	0.420	1.877	2.122	0.266	0.324
4	2.269	7.144	5.036	2.681	9.527	4.138	7.537	9.649	1.208	3.248	1.923	0.256	0.677
5	1.740	4.346	2.897	2.374	3.704	2.912	4.295	2.745	1.116	1.609	0.634	0.229	0.492
6	1.926	1.598	0.893	0.612	1.618	0.562	1.781	0.626	0.549	0.578	0.438	0.157	0.161
7	1.898	0.790	0.278	0.194	0.305	0.672	0.623	0.133	0.064	0.122	0.136	0.074	0.038
8	1.425	0.446	0.125	0.066	0.055	0.223	0.106	0.014	0.121	0.098	0.063	0.018	0.049
9	1.065	0.326	0.120	0.018	0.029	0.094	0.000	0.000	0.063	0.000	0.000	0.014	0.000
10+	0.426	0.448	0.120	0.077	0.000	0.000	0.027	0.000	0.000	0.000	0.000	0.000	0.000
Sum	15.206	19.073	14.042	8.226	32.554	17.584	25.305	23.428	3.541	7.532	5.316	1.014	1.741

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

Parameter	Estimate	Std. Error	C.V.	T - Stat.	Residual Mean Square Error
Age 3 -Abund.	4.799608	0.991217	0.206520	4.842138	0.89321
Age 4 -Abund.	4.858249	0.741206	0.152567	6.554517	
Age 5 -Abund.	5.047697	0.677872	0.134293	7.446381	
Age 6 -Abund.	5.089781	0.578646	0.113688	8.796025	
Age 7 -Abund.	4.340213	0.579946	0.133621	7.483826	
Age 8 -Abund.	4.106378	0.572040	0.139305	7.178480	
Age 3 -Q	-5.978404	0.287375	0.048069	-20.803494	
Age 4 -Q	-5.826980	0.277908	0.047693	-20.967272	
Age 5 -Q	-5.970761	0.274972	0.046053	-21.714100	
Age 6 -Q	-6.160720	0.273808	0.044444	-22.500184	
Age 7 -Q	-6.150022	0.274512	0.044636	-22.403441	
Age 8 -Q	-5.772227	0.273996	0.047468	-21.066801	

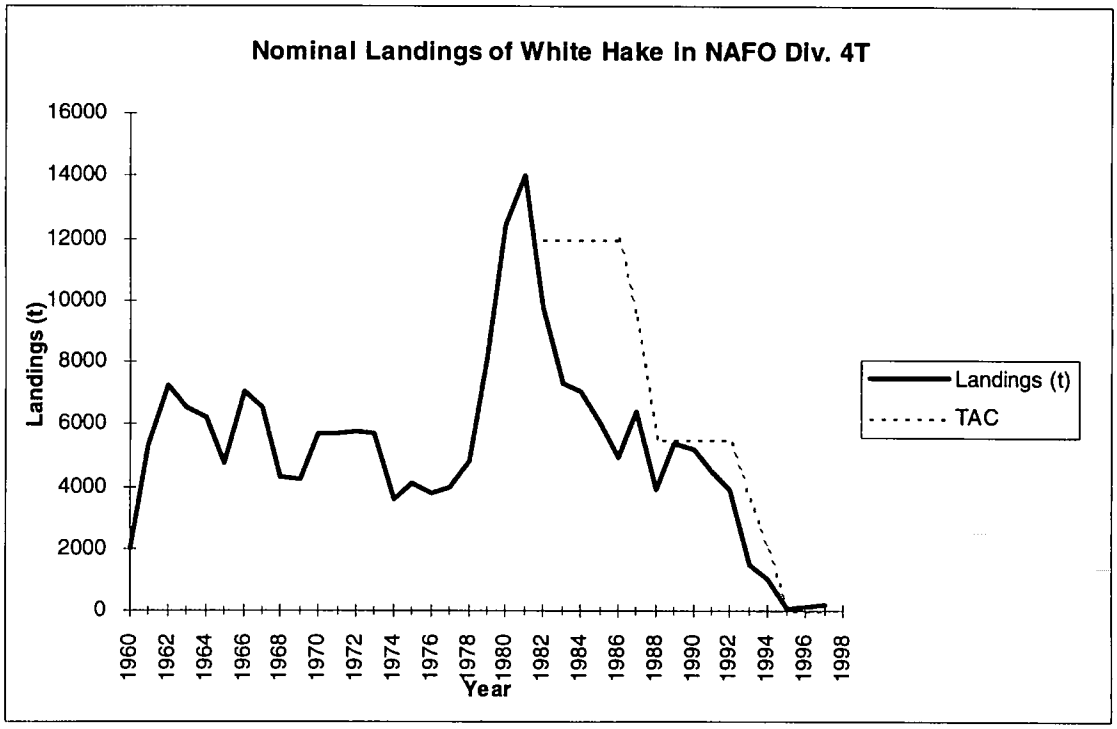
Table 14b. Estimates of fishing mortality and beginning of year population numbers for southern Gulf white hake ("Strait" Component) from the ADAPT calibration of SPA.

Fishing mortality estimates for NAFO 4T ("Strait") White Hake from ADAPT

	85	86	87	88	89	90	91	92	93	94	95	96	97
3	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.12	0.11	0.05	0.00	0.01	0.01
4	0.06	0.05	0.17	0.01	0.03	0.23	0.21	0.75	0.57	0.47	0.00	0.07	0.09
5	0.32	0.21	0.51	0.23	0.23	0.57	0.81	1.25	0.84	0.75	0.01	0.10	0.20
6	0.64	0.46	0.63	0.50	0.75	0.86	1.20	1.54	0.97	1.81	0.06	0.18	0.17
7	0.63	0.89	0.92	0.98	1.80	1.40	1.90	2.05	1.05	2.20	0.45	0.13	0.14
8	0.94	1.11	1.64	0.68	2.08	1.40	1.18	1.67	1.44	1.96	0.45	0.47	0.07
9	0.73	0.82	1.06	0.72	1.54	1.22	1.43	1.75	1.15	1.99	0.32	0.26	0.13
10	0.73	0.82	1.06	0.72	1.54	1.22	1.43	1.75	1.15	1.99	0.32	0.26	0.13
Age 4+	0.58	0.62	0.86	0.55	1.14	0.99	1.17	1.54	1.02	1.60	0.23	0.21	0.13
Age 6+	0.73	0.82	1.06	0.72	1.54	1.22	1.43	1.75	1.15	1.99	0.32	0.26	0.13

Beginning of year population estimates for NAFO 4T ("Strait") White Hake from ADAPT (1,000's)

Age/Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
3	5102	3935	3985	4083	3541	2616	2283	1104	515	500	373	213	150
4	3528	4126	3220	3240	3342	2891	2115	1846	802	378	388	304	172
5	2119	2717	3203	2226	2622	2648	1878	1399	716	370	194	317	232
6	1207	1254	1810	1573	1448	1703	1221	686	328	253	144	157	235
7	812	520	646	786	779	561	591	302	121	102	34	110	108
8	360	355	174	211	241	106	113	72	32	35	9	18	79
9	199	115	96	28	88	25	21	29	11	6	4	5	9
10	178	142	38	17	41	15	17	18	5	1	4	5	9
	13506	13164	13172	12164	12102	10565	8239	5456	2530	1646	1149	1128	995



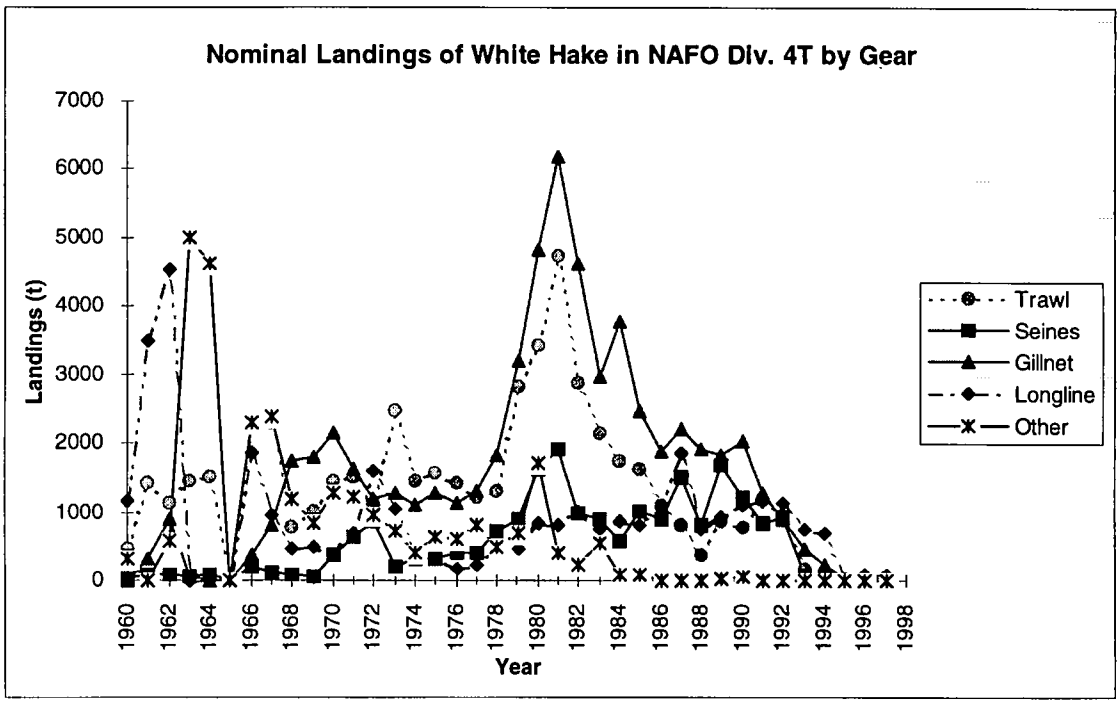


Figure 1 a. Nominal landings and TAC's for white hake in NAFO Division 4T.
b. Nominal landings by gear category for white hake in NAFO Division 4T.

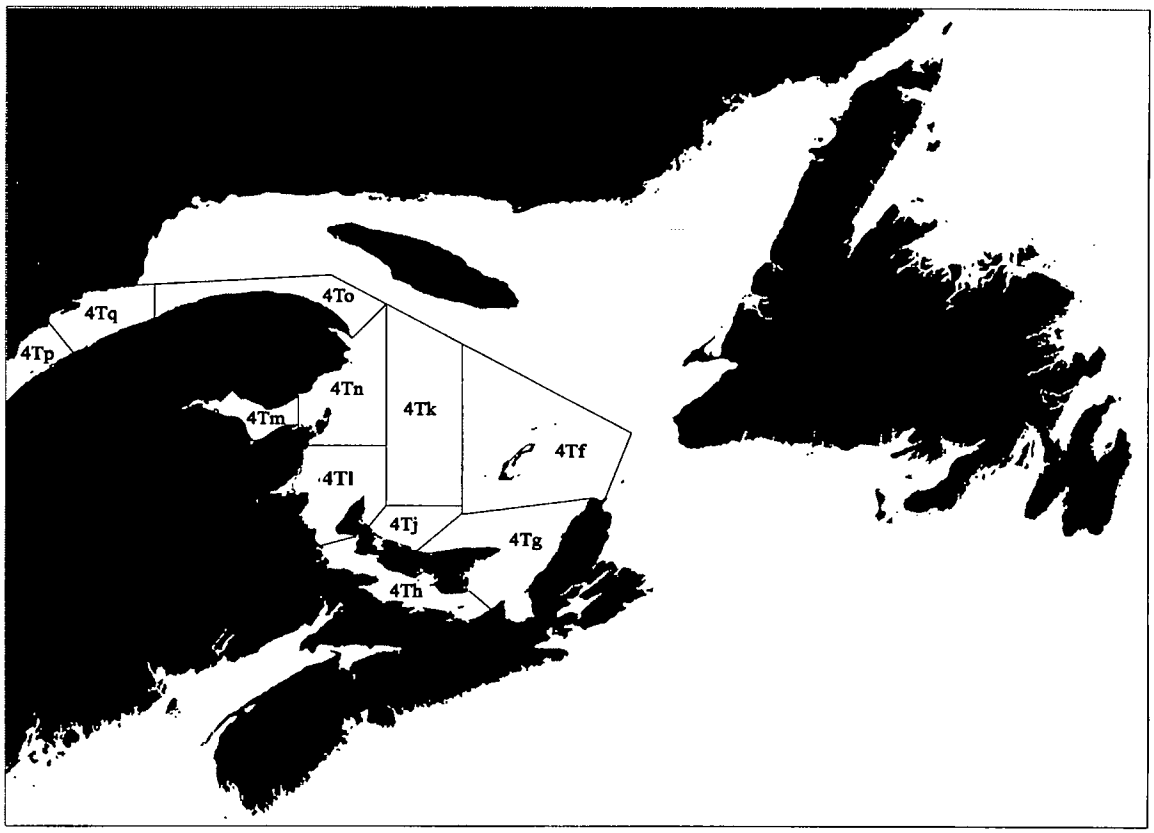


Figure 2. Statistical unit areas in the southern Gulf of St. Lawrence (NAFO Division 4T).

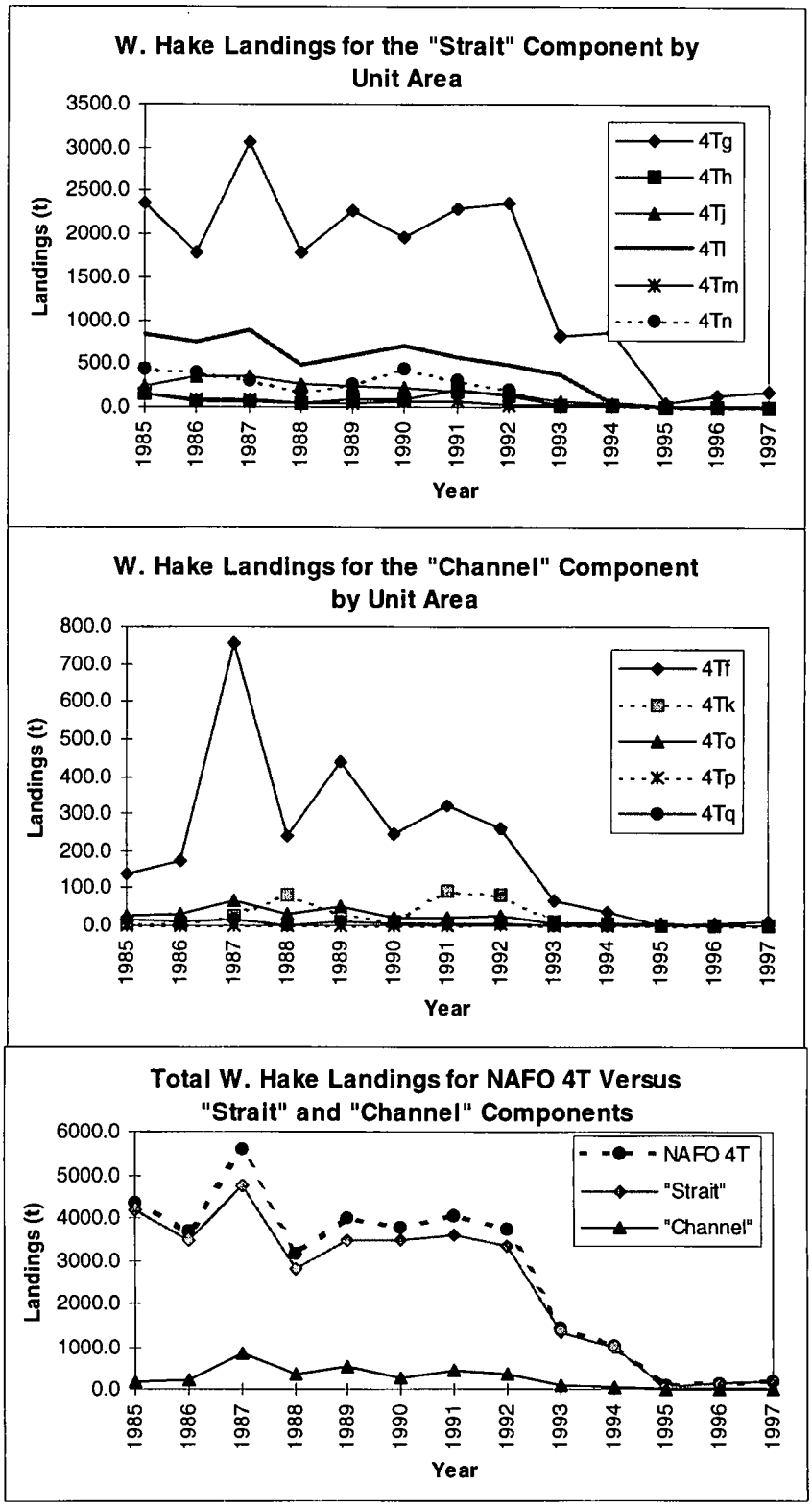


Figure 3. Comparison of landings of white hake in NAFO Division 4T by statistical unit area and stock component: 1985-1997.

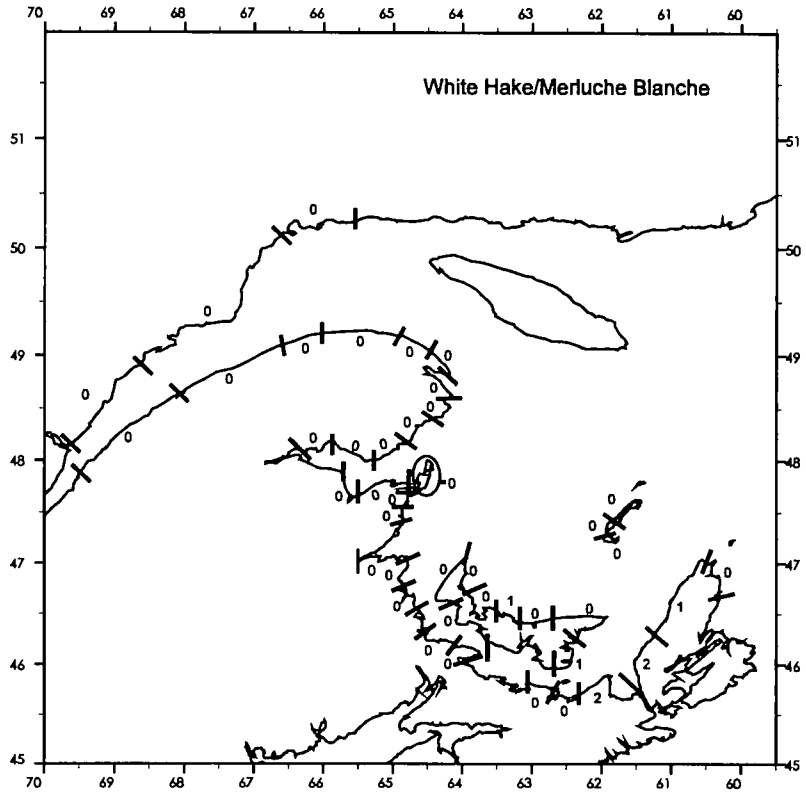


Figure 4. The geographical distribution of respondents that fished for white hake "most of the time' in 1997 (These species were either the first, second or third priority of respondents that fished for more than one species of groundfish in 1997). The lines delimit the borders of statistical districts occupied by respondents.

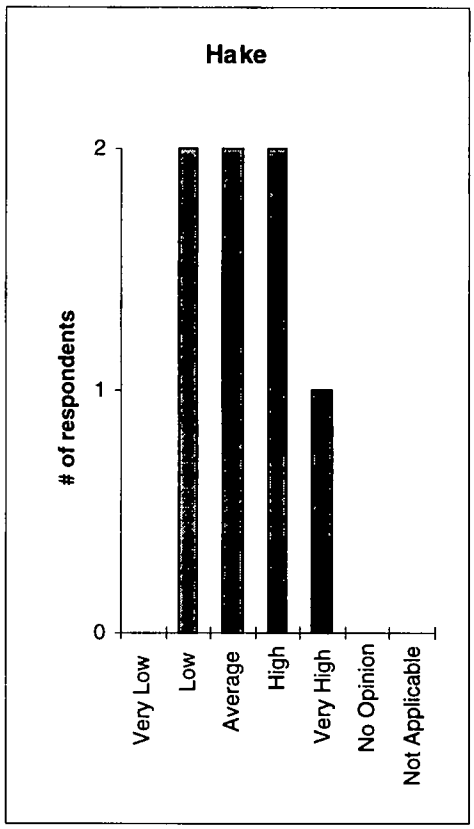


Figure 5. Opinions of respondents concerning the abundance of white hake in 1997.

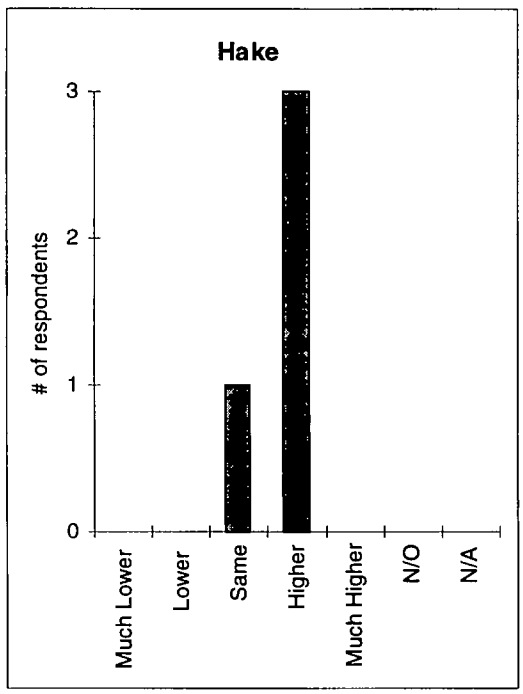


Figure 6. Opinions of respondents asked to compare the abundance of white hake in 1997 with its abundance during 1996.

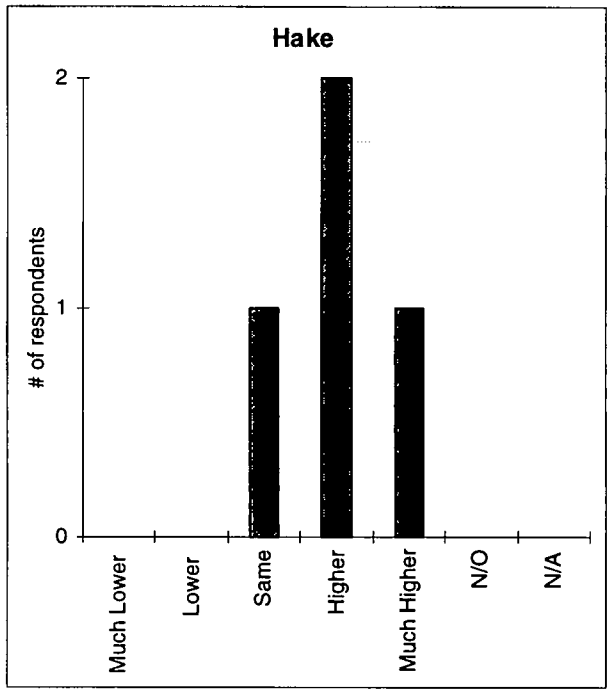


Figure 7. Opinions of respondents asked to compare the abundance of white hake in 1997 with its abundance during all their years fishing for this species.

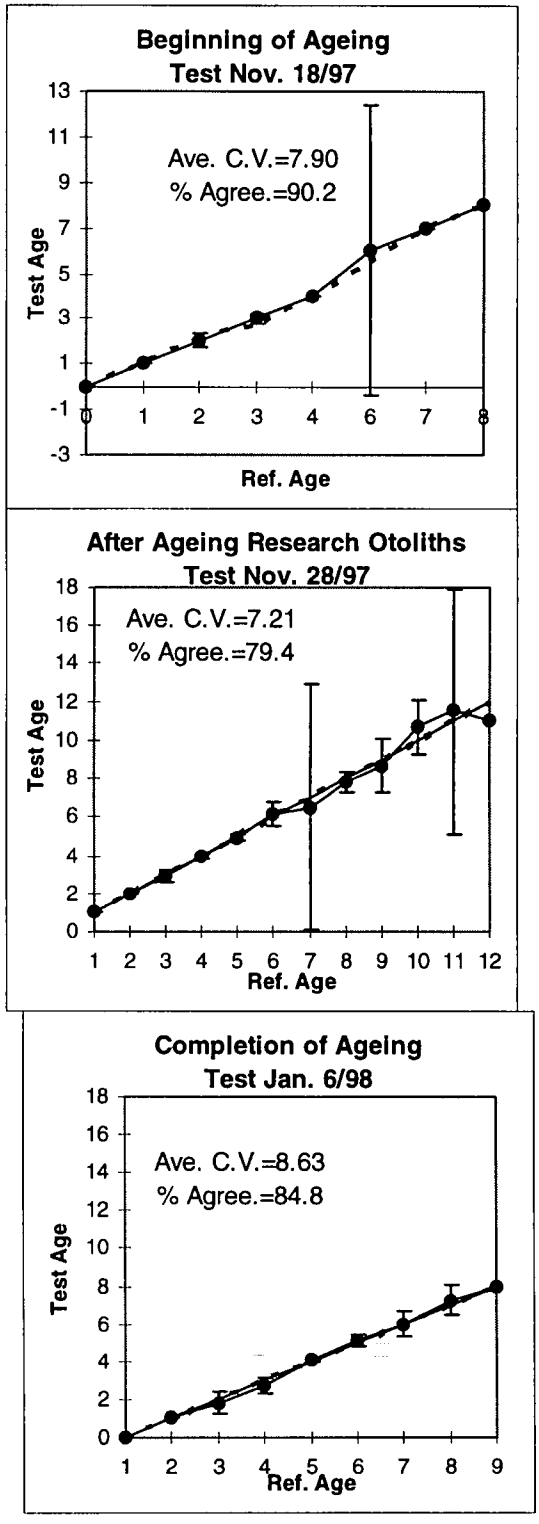


Figure 8. Age bias plots for tests of ageing consistency. Error bars indicate the 95% confidence interval about the mean age assigned by one ager for all fish assigned a given age by a second reader. The 1:1 equivalence line (dashed) is also indicated.

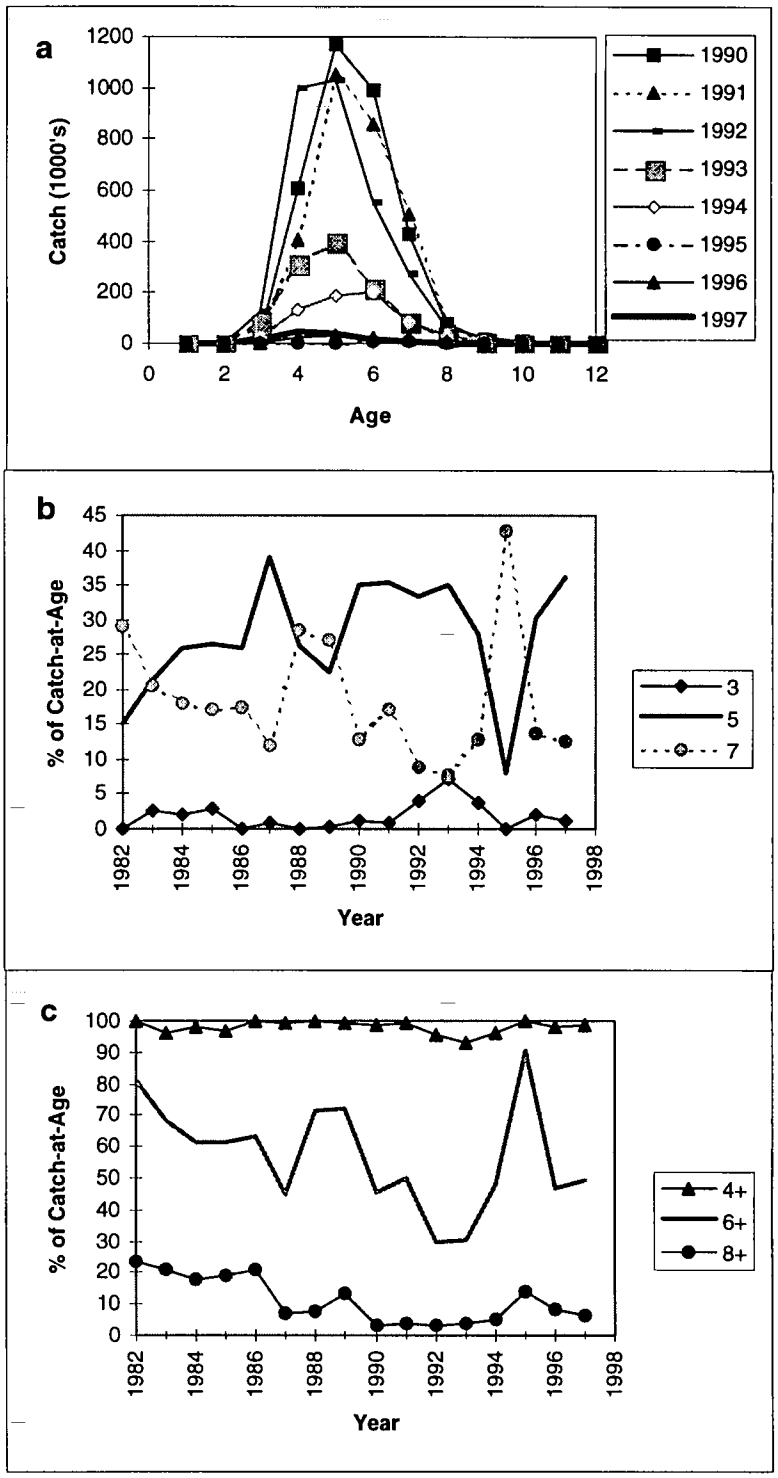


Figure 9. a. Commercial fishery catch-at-age for white hake in NAFO Division 4T: 1990-1997.
b and c. Percentage composition of the commercial fishery catch-at-age for white hake: Ages 3, 5 and 7 and Age Groups 4+, 6+ and 8+.

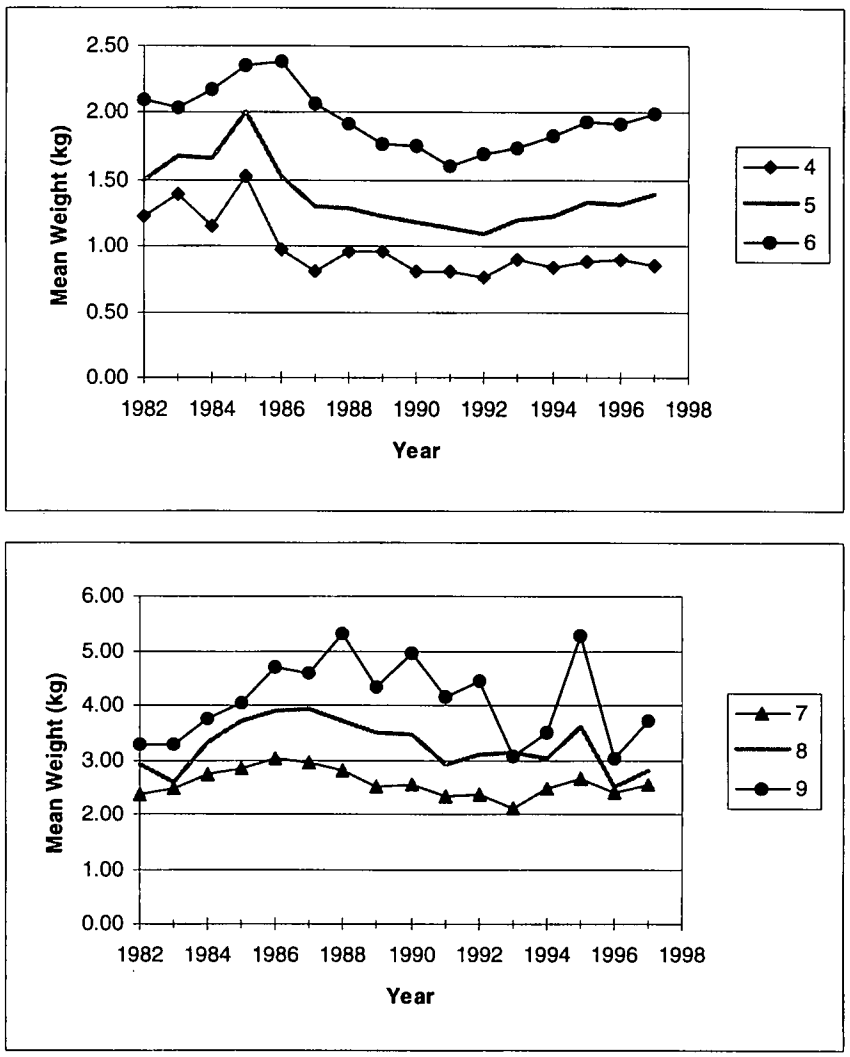


Figure 10. Trends in mean weights-at-age (kg) for white hake (Ages 4-9) from the commercial fishery in the southern Gulf of St. Lawrence.

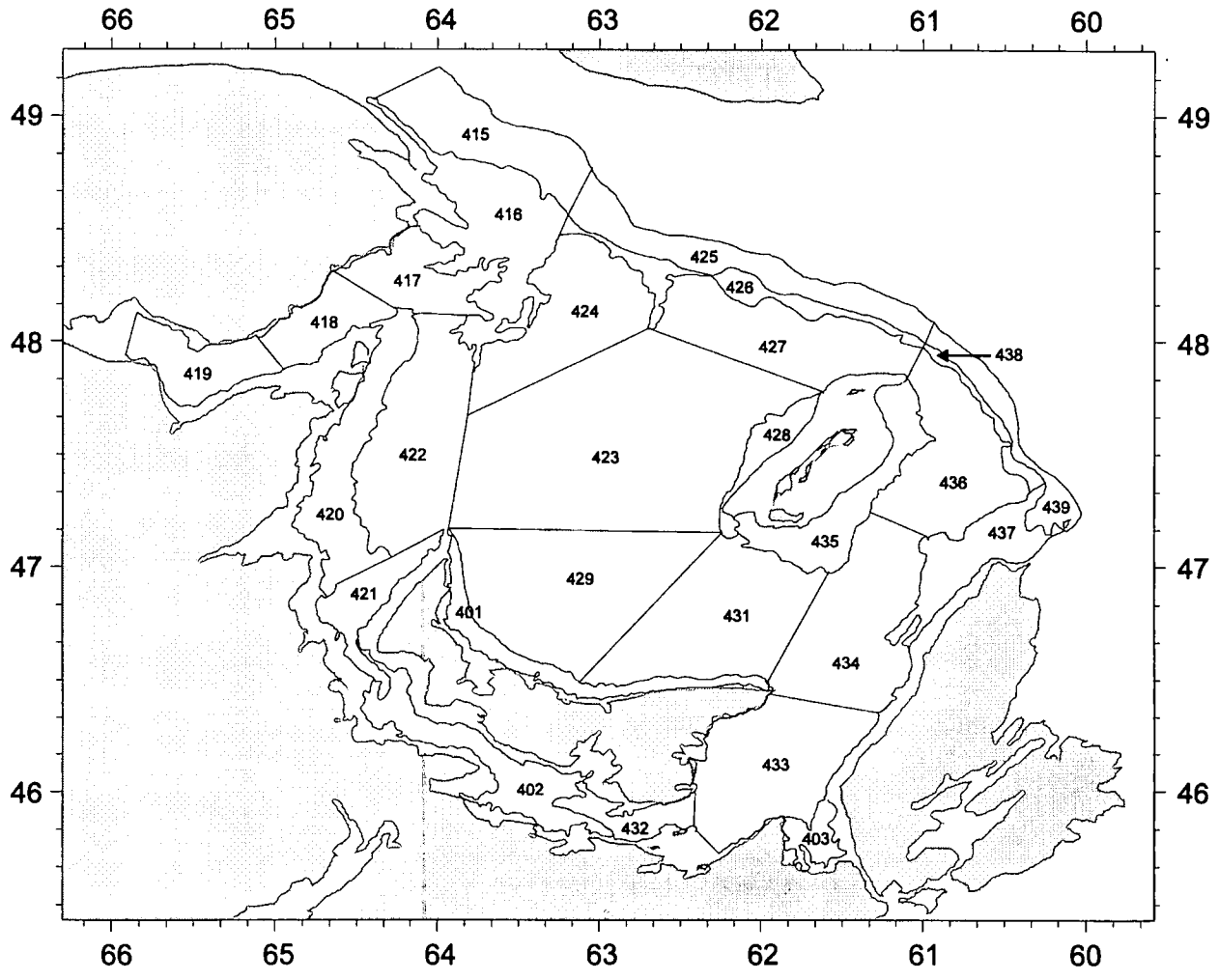


Figure 11. Stratification scheme for the annual (September) groundfish abundance survey of the southern Gulf of St. Lawrence.

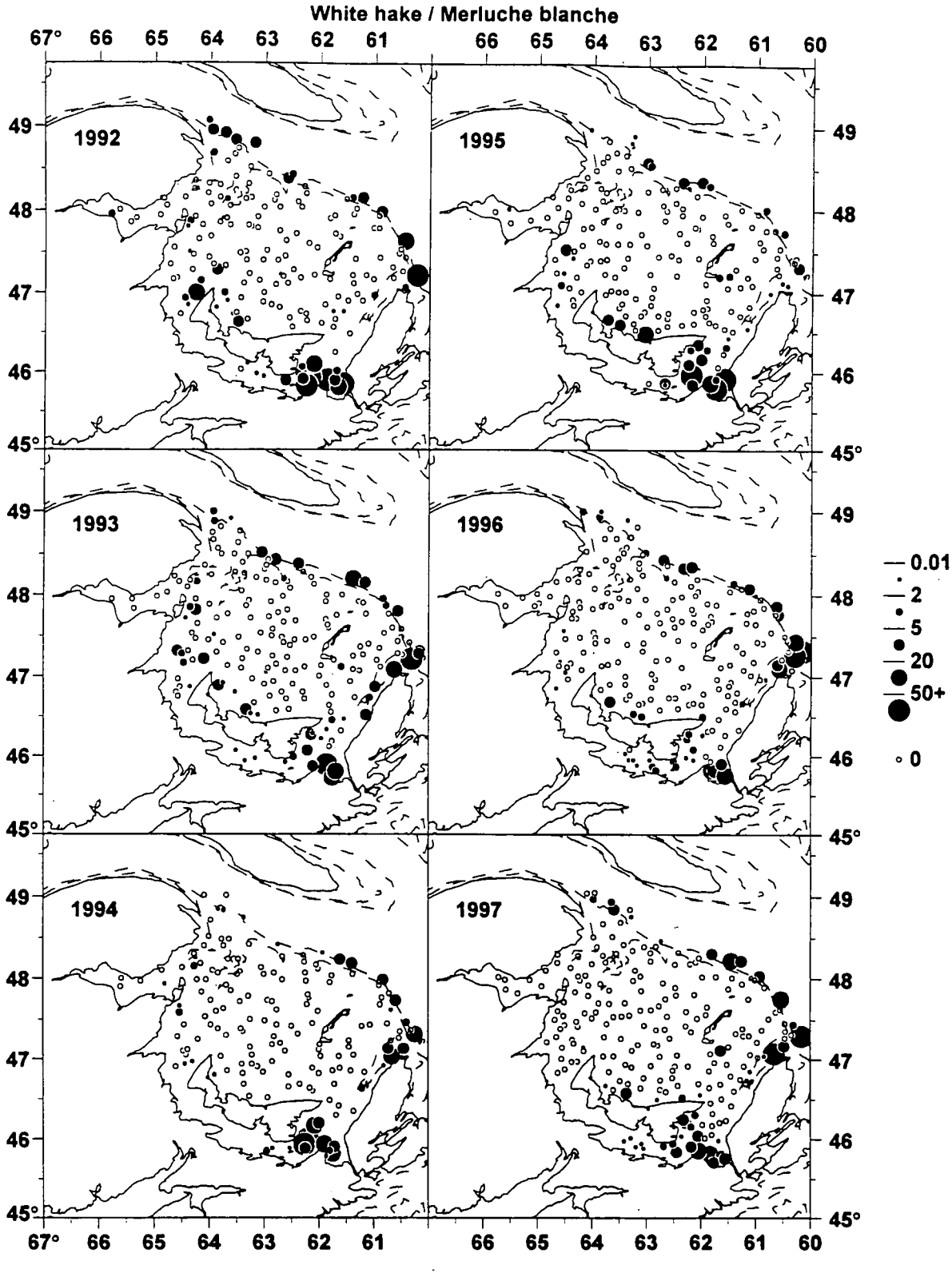


Figure 12. Location of white hake catches (kg) during six annual (September) groundfish surveys of the southern Gulf of St. Lawrence.

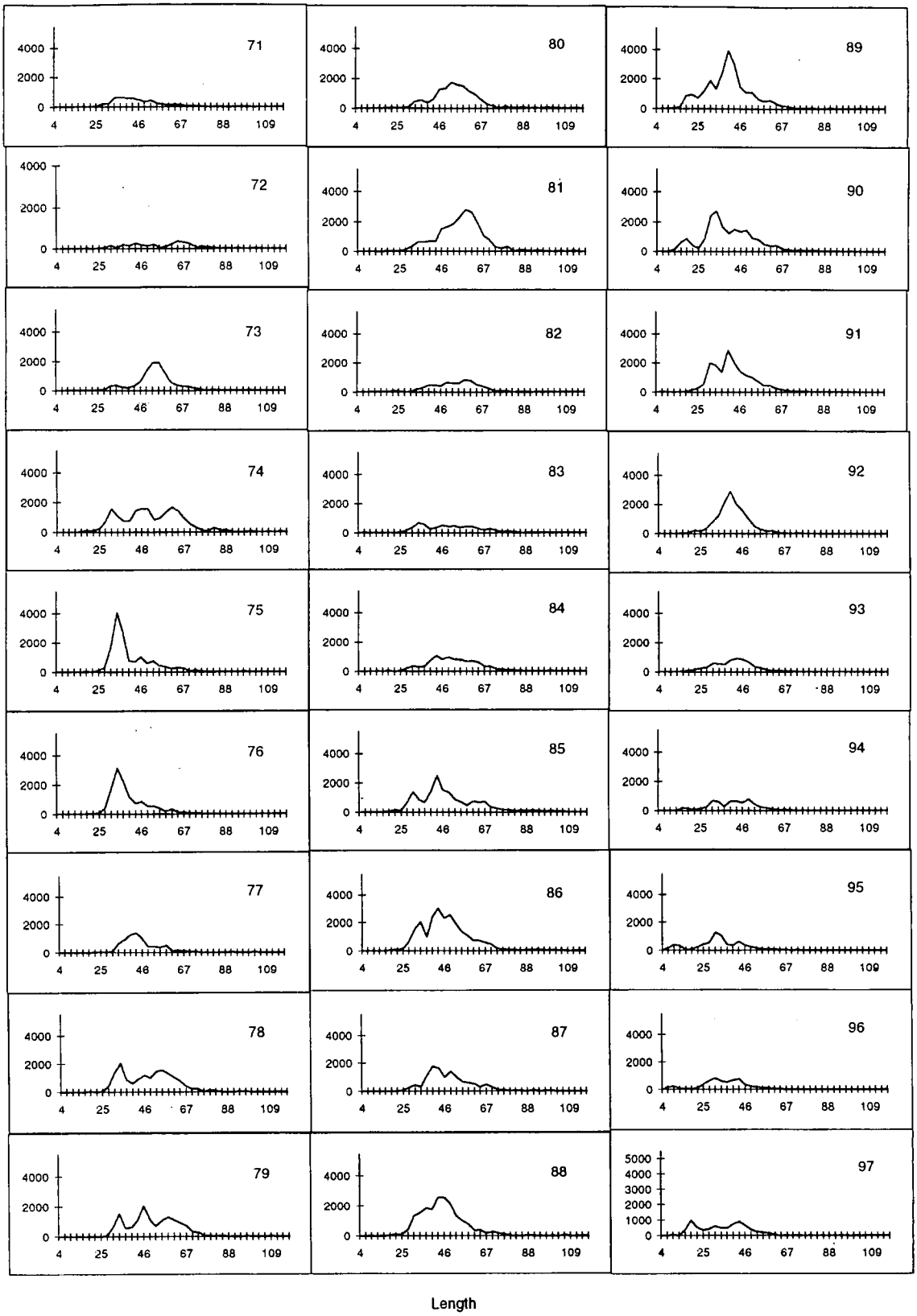


Figure 13. Annual length frequencies for white hake from September groundfish surveys of the southern Gulf of St. Lawrence: 1971-1997 (Note: Strata 415-439 for 1971-1983 and Strata 401, 403, 415-439 for 1984-1997).

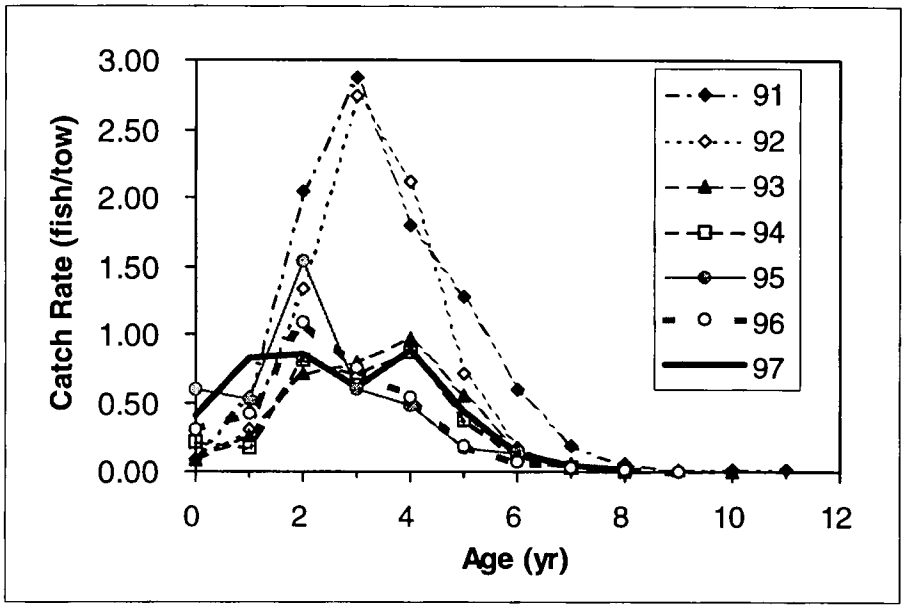


Figure 14 a. Research vessel stratified mean catch per tow-at-age for white hake in NAFO Division 4T: 1991-1997.

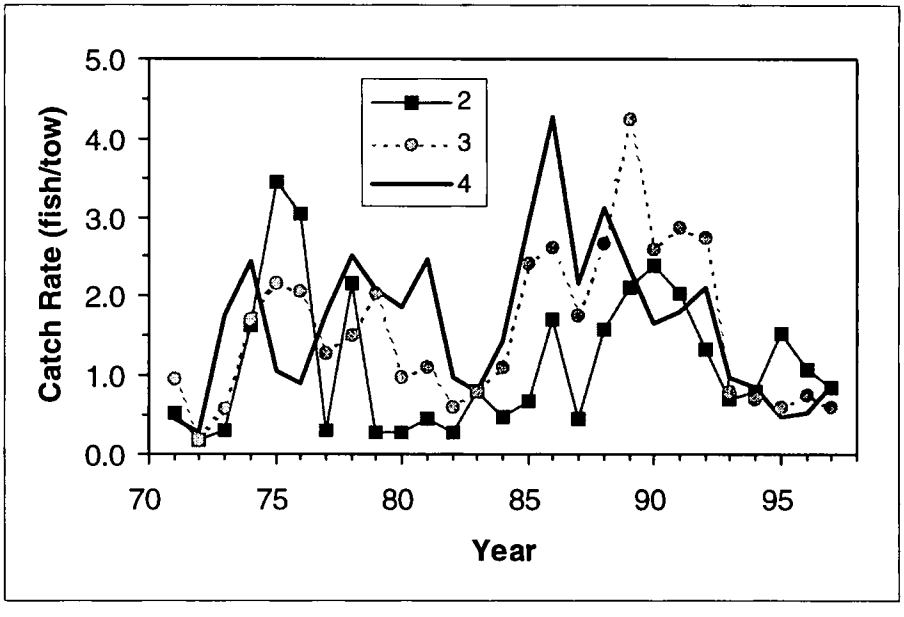


Figure 14 b. Research vessel stratified mean catch per tow-at-age for white hake in NAFO Division 4T: Ages 2, 3 and 4, 1971-1997.

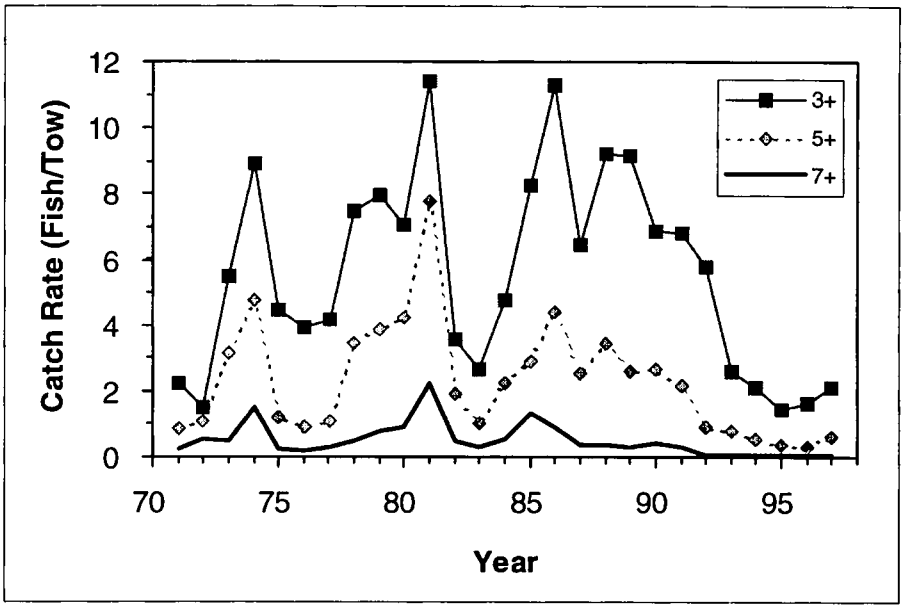


Figure 14 c. Research vessel stratified mean catch per tow-at-age for white hake in NAFO Division 4T: Ages 3+, 5+ and 7+, 1971-1997.

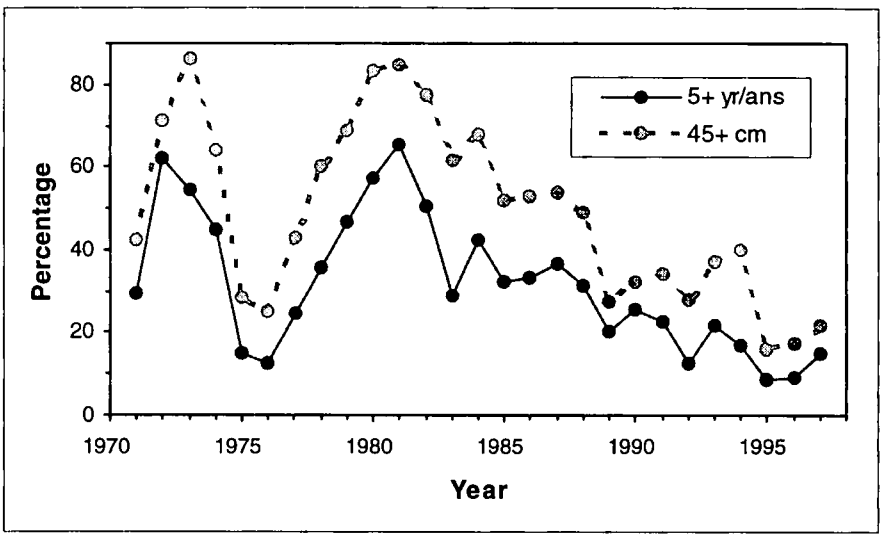


Figure 14 d. Percentage of white hake 5 years and older or 45 cm and longer from research vessel surveys in NAFO Division 4T.

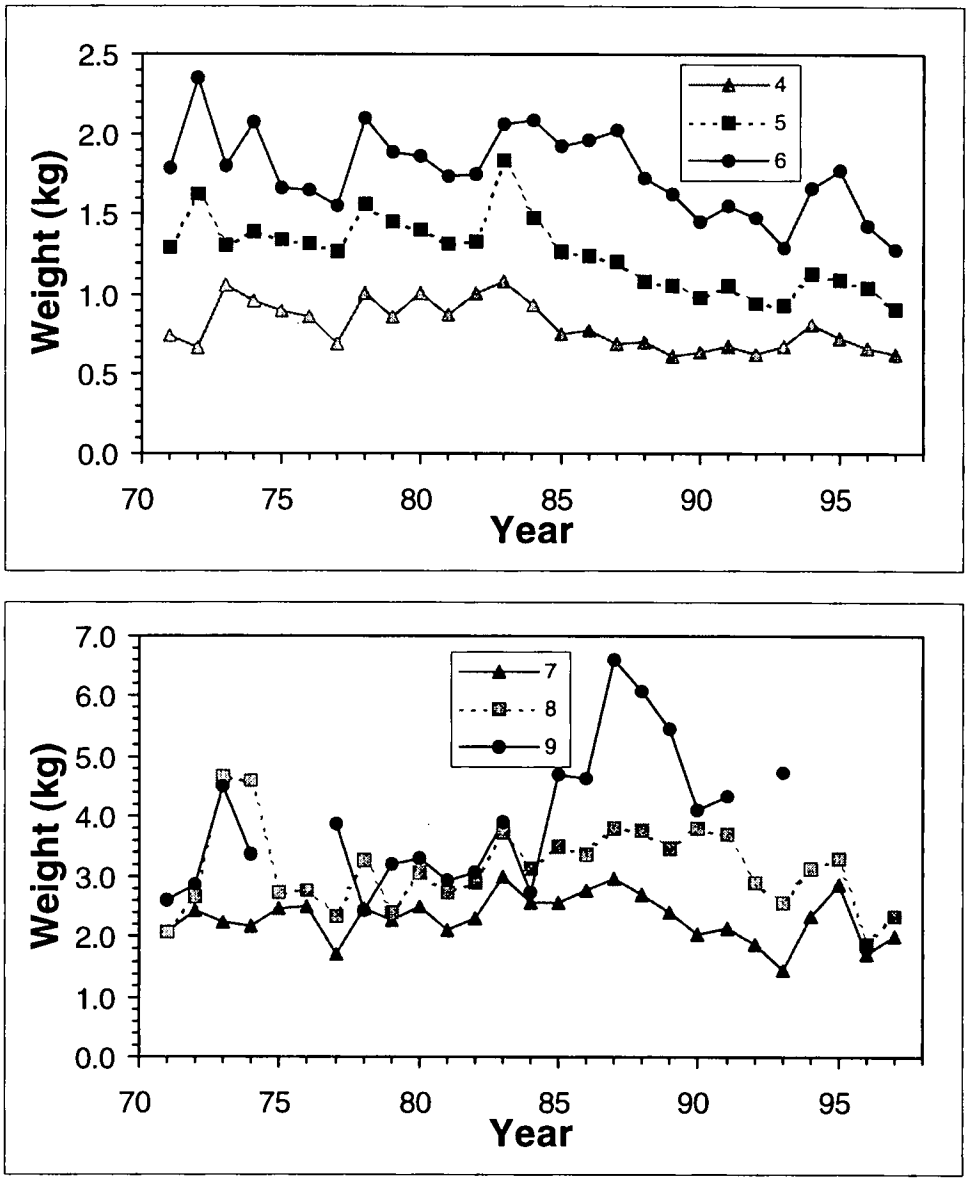


Figure 15. Trends in mean weights-at-age (kg) for white hake (Ages 4-9) from the annual (September) surveys of the southern Gulf of St. Lawrence.

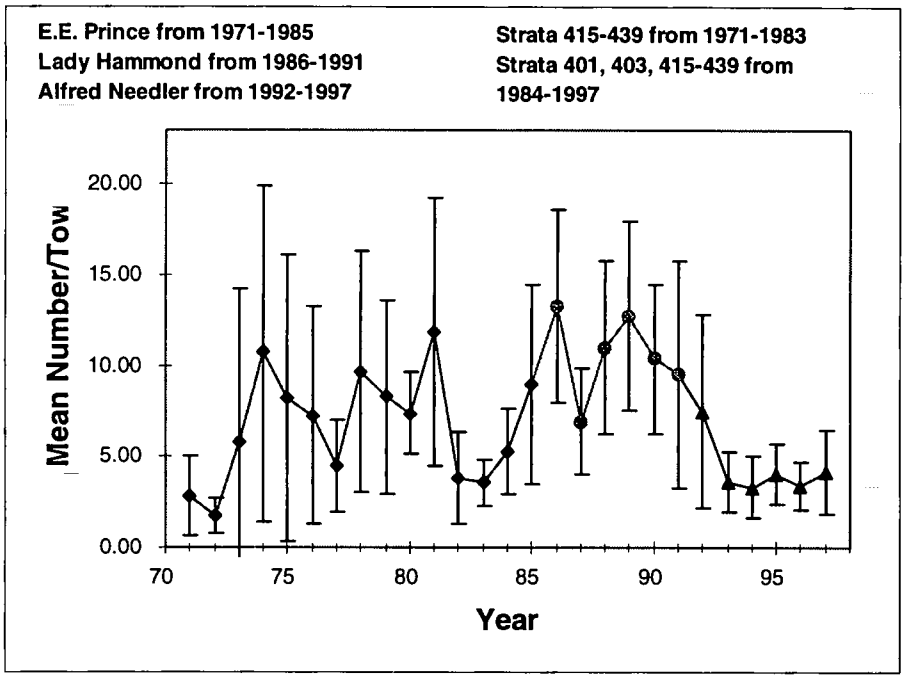


Figure 16. Stratified mean catch rate (fish/tow) of white hake (ages 0+) in the September bottom trawl survey of the southern Gulf of St. Lawrence (NAFO Division 4T). Vertical bars show +/- 2 S.D. The research vessels used in each of the surveys are indicated by different symbols. From 1971-1983 strata 415-439 were surveyed but the index since 1984 includes strata 401,403 and 415-439.

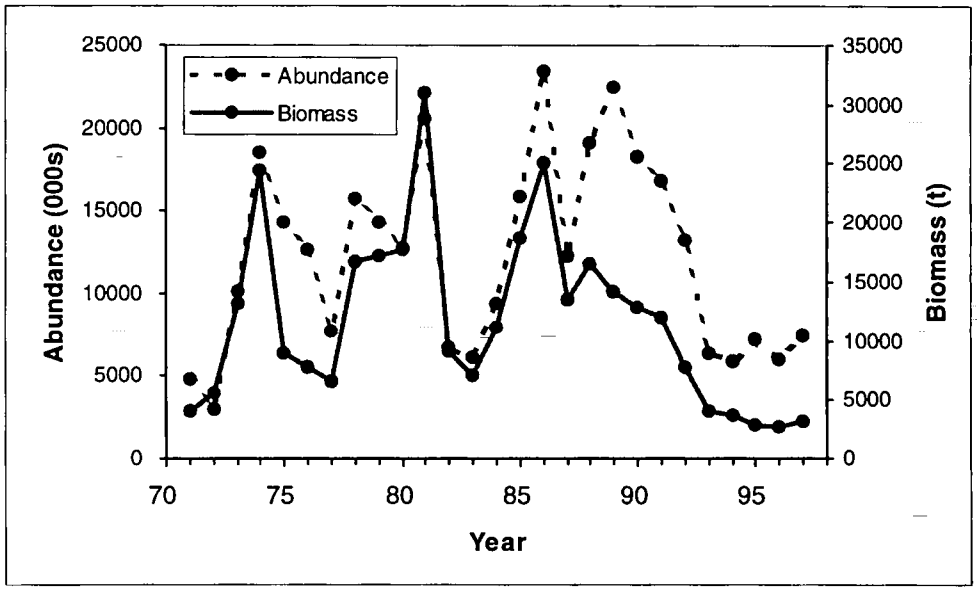


Figure 17. Estimated population numbers (1,000's) and biomass (t) for white hake in NAFO Division 4T.

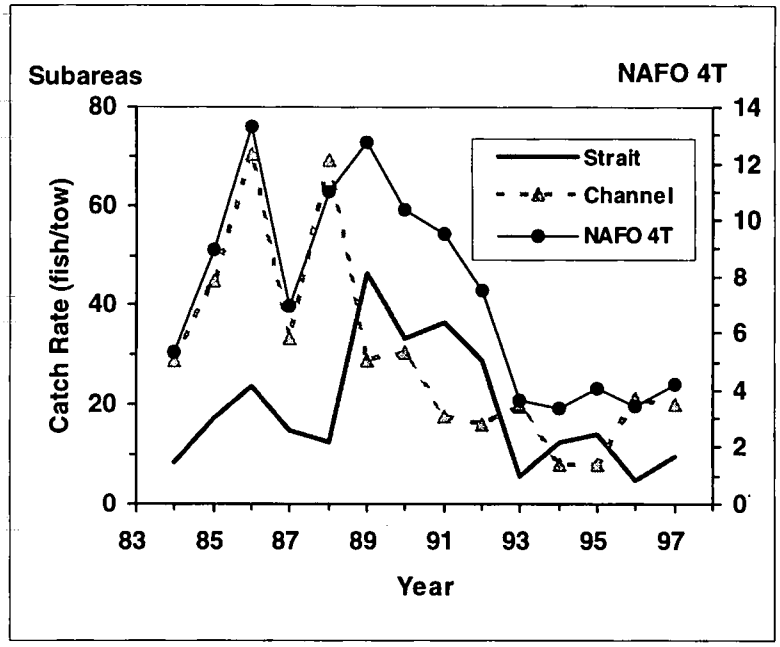


Figure 18a. Comparison of research vessel abundance indices (stratified mean catch per tow) for all of NAFO Division 4T and for the 'Strait' and 'Channel' subareas (Note the difference in scale between the subarea indices and the overall NAFO 4T index).

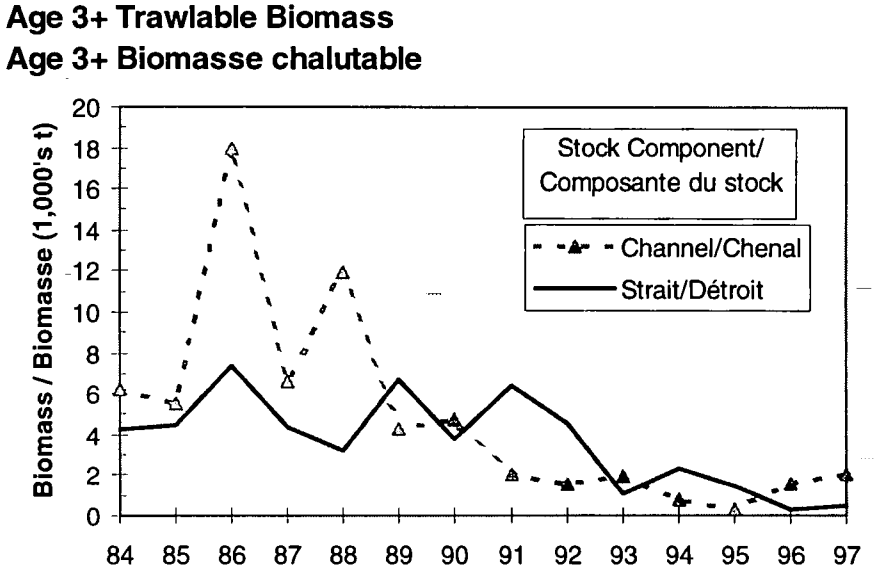


Figure 18b. Comparison of research vessel estimates of the trawlable biomass (ages 3+) for the 'Strait' and 'Channel' stock components.

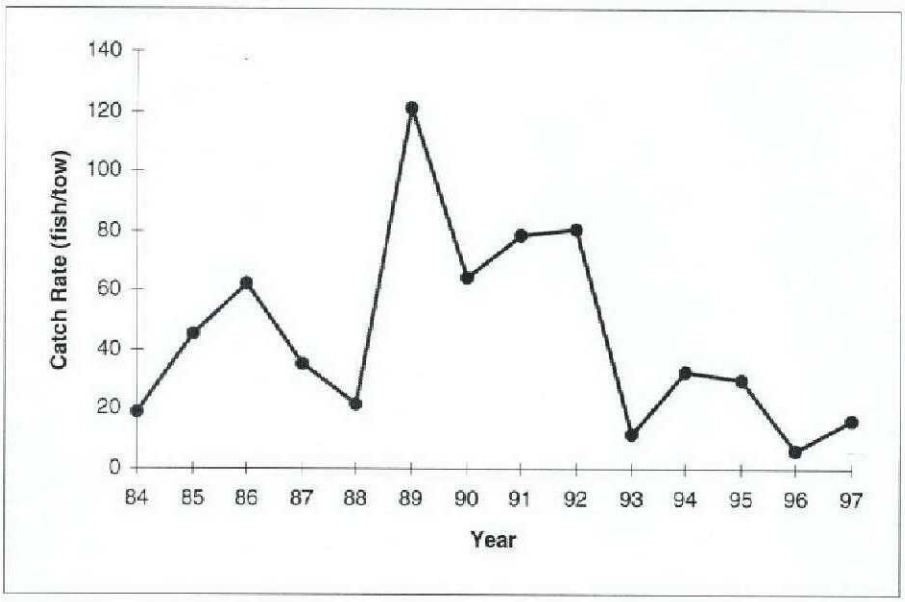


Figure 19. Research vessel estimates of the stratified mean catch (numbers) per tow for white hake in two strata in the southeastern Gulf (403 and 433).

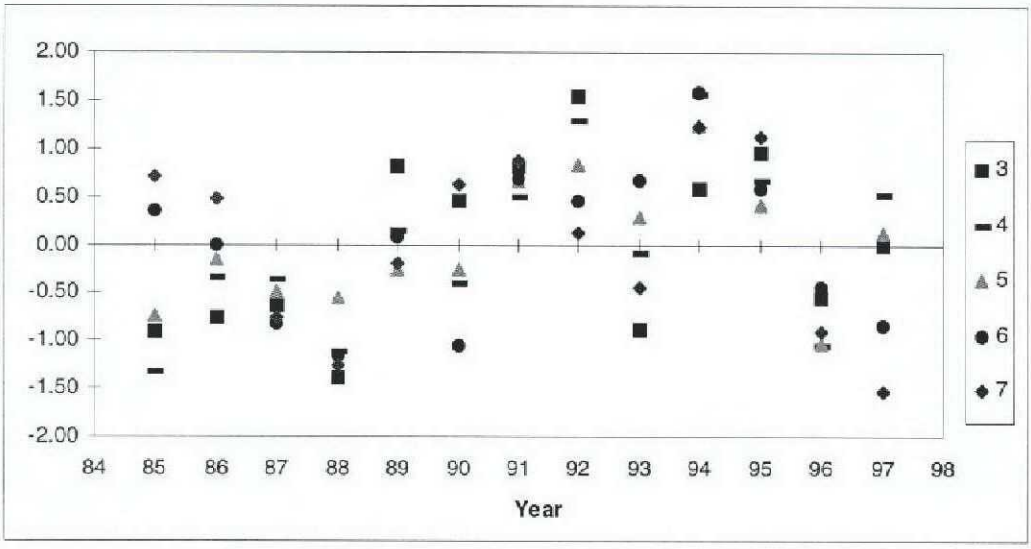


Figure 20. Residual patterns from SPA calibrations using the ADAPT tuning method and the research survey abundance index for the 'Strait' component.

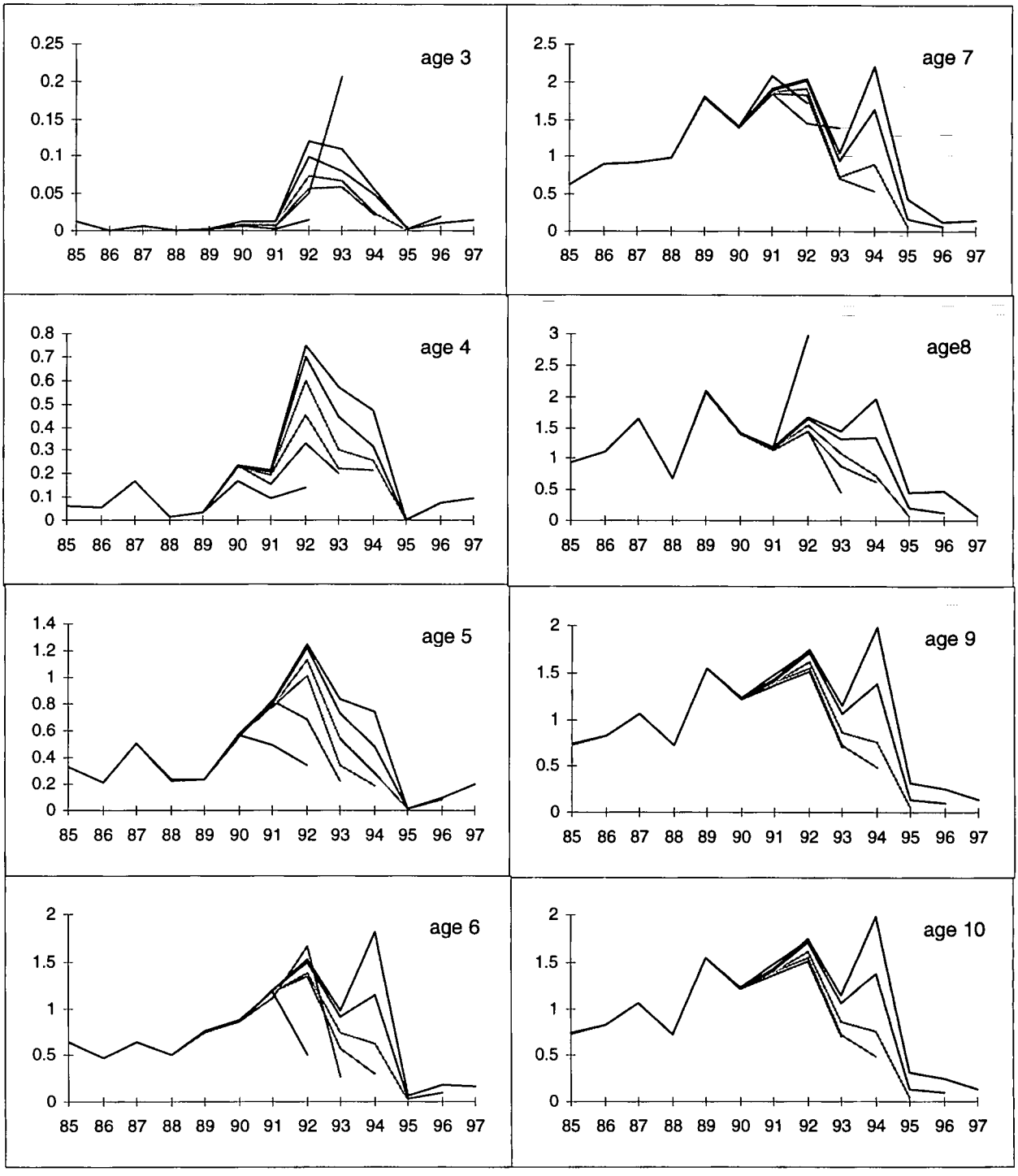


Figure 21. Retrospective patterns in fishing mortality from the ADAPT SPA calibration for white hake from the 'Strait' component.

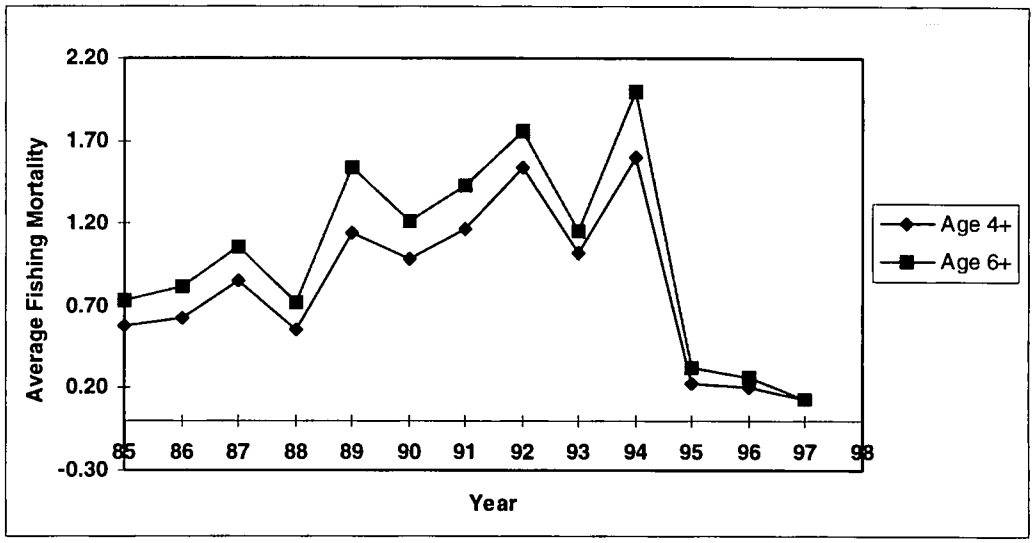


Figure 22. Estimates of fishing mortality (F) for white hake from the "Strait" component from SPA calibrations using the ADAPT tuning method.

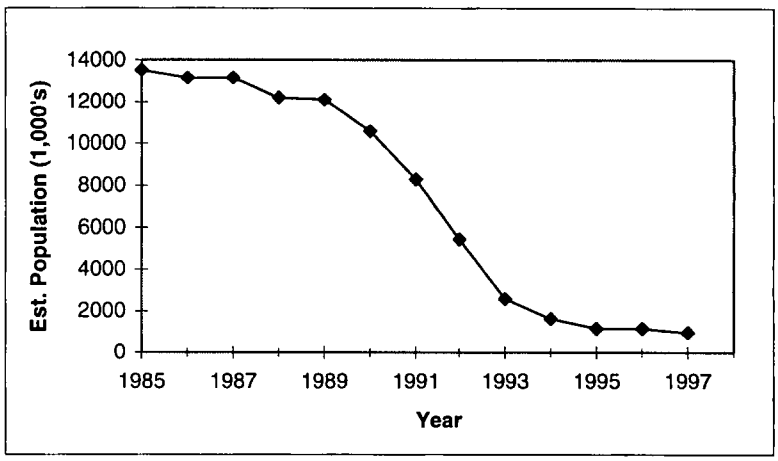


Figure 23. Beginning of the year population estimates for white hake from the "Strait" stock from SPA calibrations using the ADAPT tuning method.

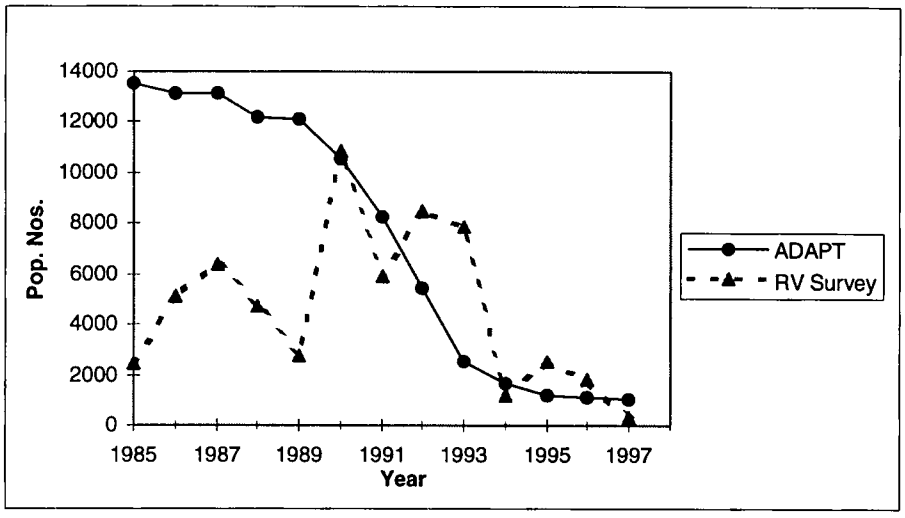


Figure 24. Comparison of beginning of year population estimates from ADAPT with population estimates for the 'Strait" component from the research vessel survey (strata 403, 420-422, 432, 433 (number of WIIA trawlable units = 334,575)). Note: Neither of the population estimates were adjusted for differences in catchability.

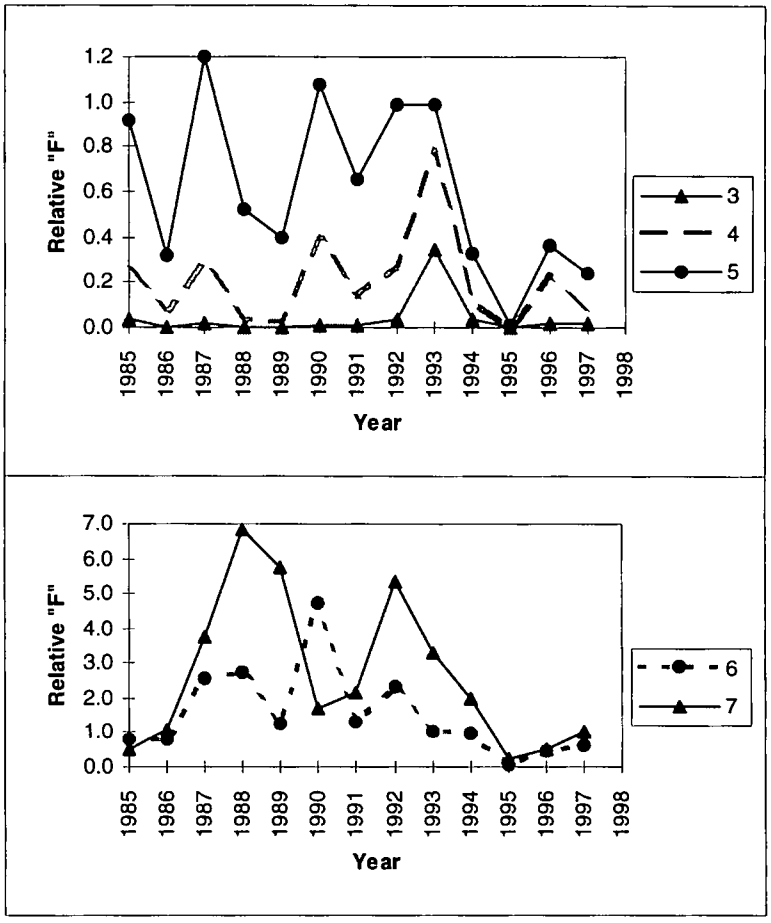


Figure 25. Trends in estimates of relative fishing mortality ('F') for white hake from the "Strait" component: 1985-96.

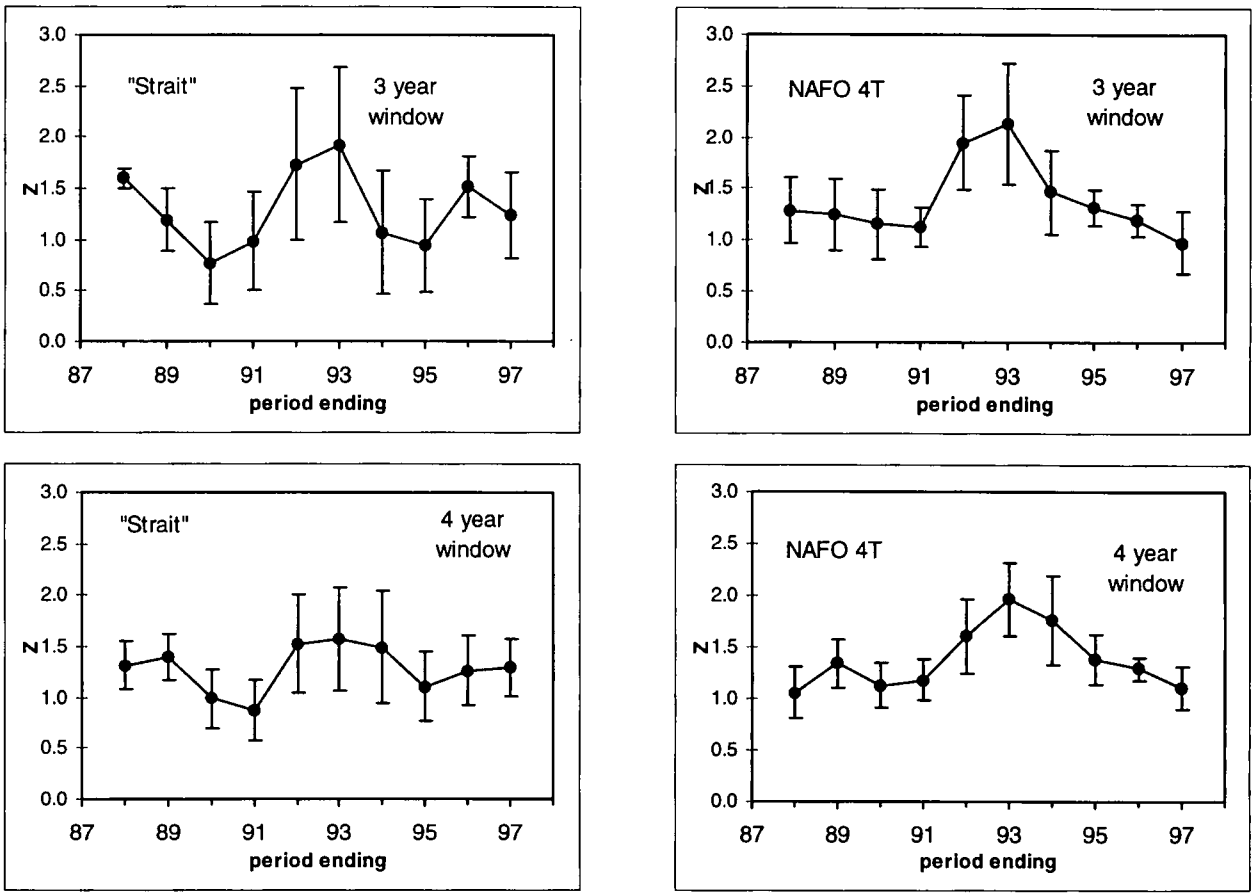


Figure 26. Estimates of total mortality (Z) for white hake in NAFO 4T (strata 401,403, 415-439) and the 'Strait' component of NAFO 4T (403, 420-422, 432, 433). Estimates are for 3 or 4 year windows ending in the year shown on the X-axis. Error bars are 2 SE.

Appendix 1

Table A1: Summary of 1997 hake catch results in southern Gulf of St. Lawrence sentinel surveys. GNS = Gillnets, LLS = Longlines, OTB = Otter trawl, SNU = Seine, OTB-E = Otter trawl in eastern P.E.I., and OTB-W = Otter trawl in western P.E.I.

1997 Sentinel Survey Hake Catches

Area	Gear	Liner	Number of trips	Effort (number of sets, nets or 1000 hooks)	*HAKE* Catch (kg)	*HAKE* Catch rate (kg per set, net or 1000 hooks)
GAS	GNS		32	320.3	7	0.02
GAS	LLS		32	77.0	0	0.00
GAS	OTB	no	16	193.0	1	0.01
GAS	OTB	yes	8	96.0	0	0.00
GAS (Miscou)	GNS		16	160.1	20	0.12
GAS (Miscou)	LLS		11	27.5	0	0.00
MAG	LLS		48	119.6	27	0.23
MAG	SNU	no	9	92.0	10	0.11
MAG	SNU	yes	4	41.0	11	0.27
NS	LLS		62	147.5	2532	17.16
NS (Georges Bay)	LLS		40	100.0	66266	662.65
NS	GNS		40	400.3	23984	59.91
NS	SNU	no	8	96.0	100	1.04
NS	SNU	yes	4	48.0	251	5.23
NS	OTB	no	8	97.0	374	3.86
NS	OTB	yes	4	50.0	232	4.64
NB	LLS		68	127.2	16	0.13
NB	GNS		70	645.6	100	0.15
NB	SNU	no	12	157.0	34	0.22
NB	SNU	yes	8	100.0	15	0.15
NB (Grand Écart)	OTB	no	4	32.0	43	1.34
NB (Grand Écart)	OTB	yes	2	18.0	17	0.94
NB	OTB	no	4	16.0	0	0.00
NB	OTB	yes	2	8.0	1	0.13
PEI	LLS		66	109.3	3849	35.23
PEI	GNS		66	660.0	13904	21.07
PEI	OTB-W	no	8	97.0	0	0.00
PEI	OTB-W	yes	4	48.0	0	0.00
PEI	OTB-E	no	8	97.0	79	0.81
PEI	OTB-E	yes	4	47.0	276	5.87
TOTALS:			**668**		**112,149**	

Appendix 1

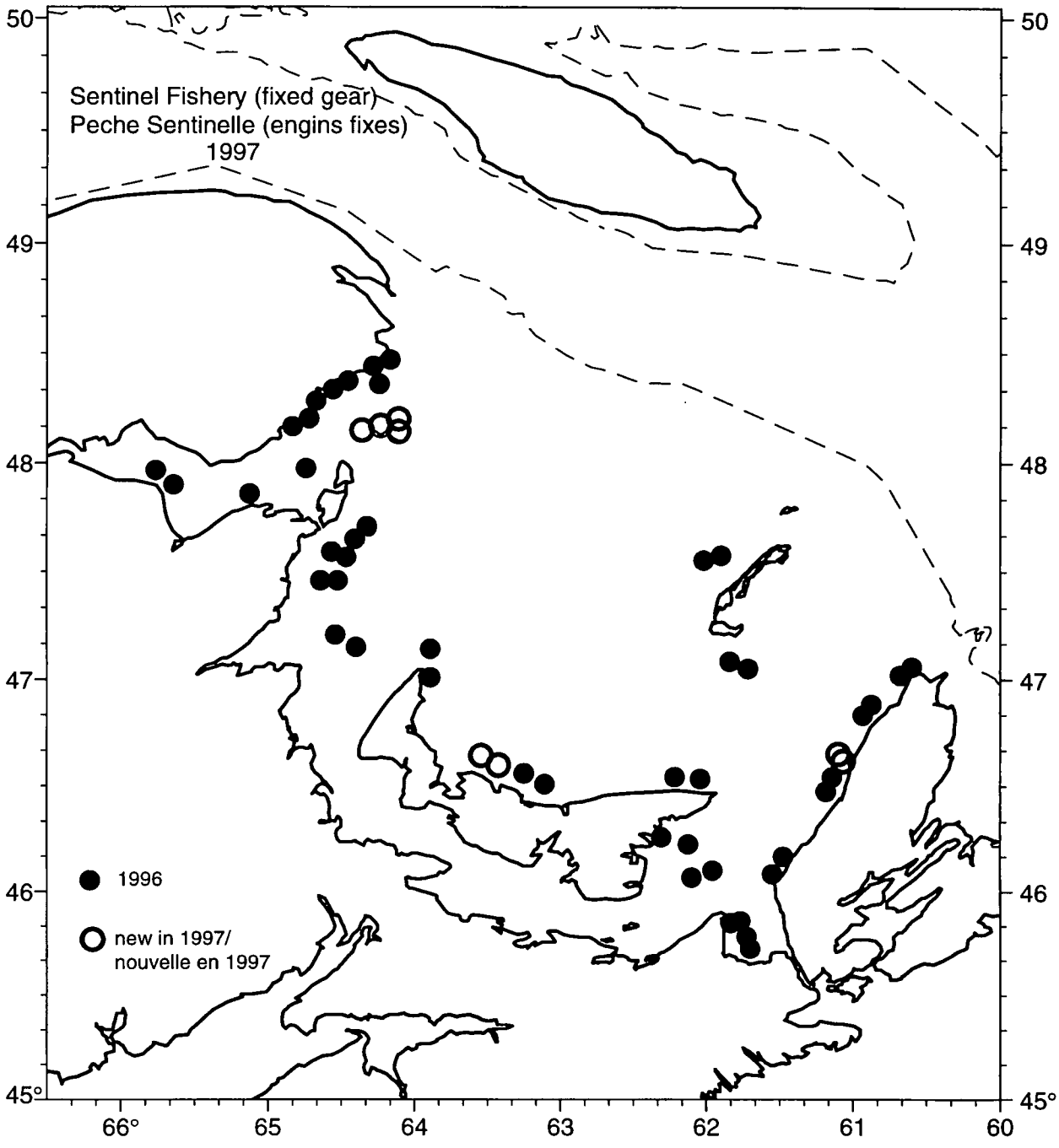


Figure A1: Locations of the fishing sites for the fixed gear sentinel fishery program in 1996-1997.

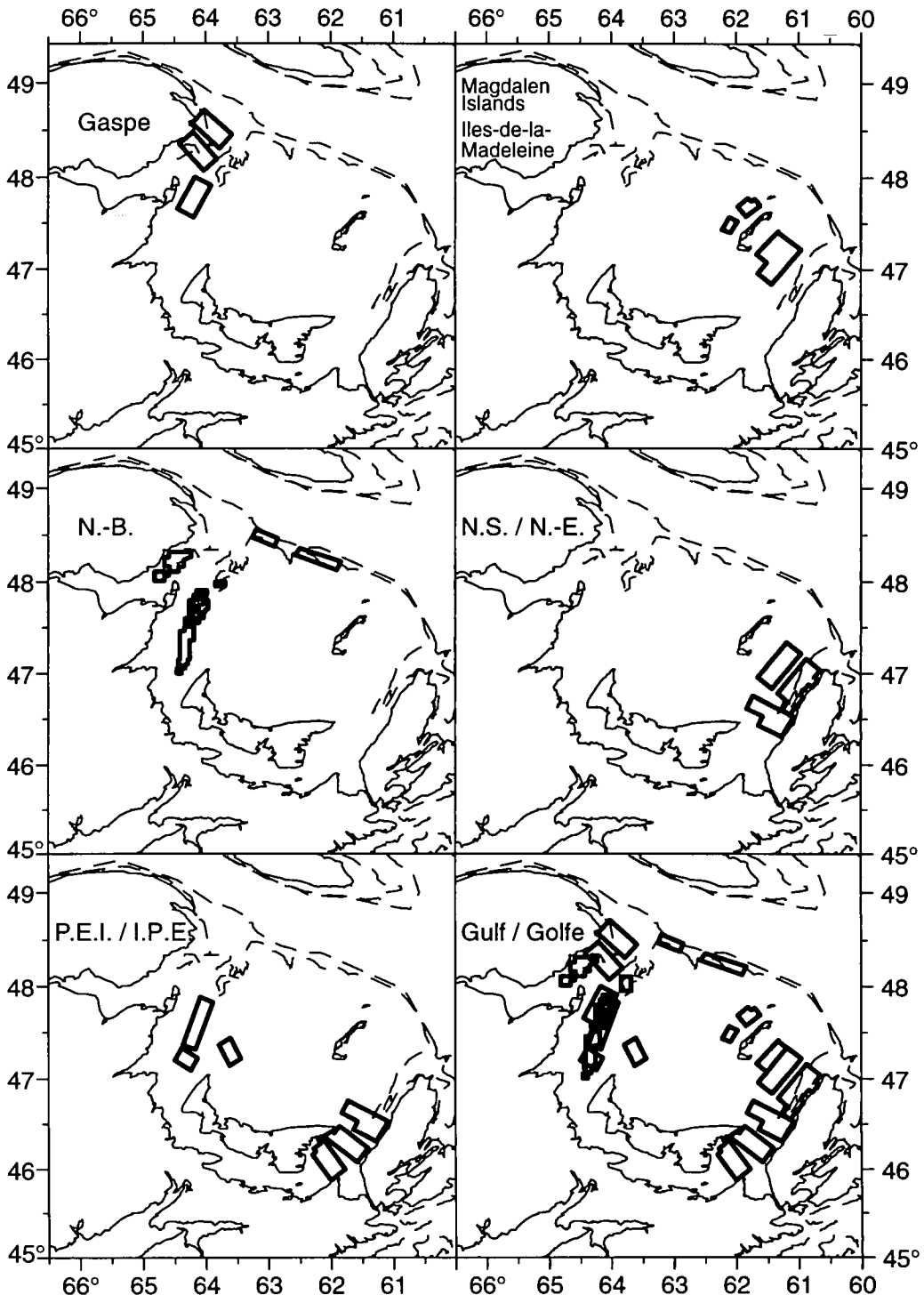


Figure A2: Locations of the fishing areas for the mobile gear sentinel fishery program in 1997.

WHITE HAKE / MERLUCHE BLANCHE

LONGLINES / PALANGRES

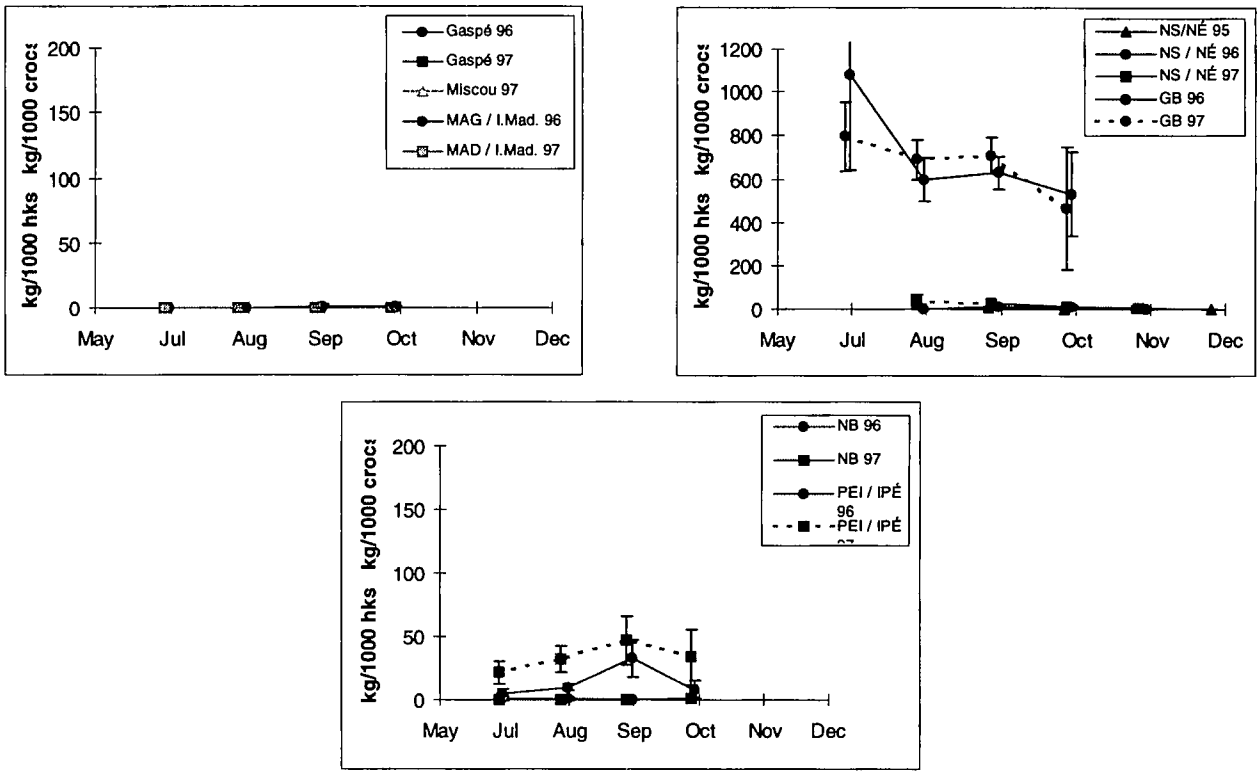


Figure A3. White Hake catch rates (+/- 1 se) for longlines (MAG=Magdalen Islands, N.S.=Cape Breton, GB=St. Georges Bay, N.B.= New Brunswick, P.E.I.=Prince Edward Island).

Appendix 1

WHITE HAKE / MERLUCHE BLANCHE

GILLNETS / FILETS MAILLANTS

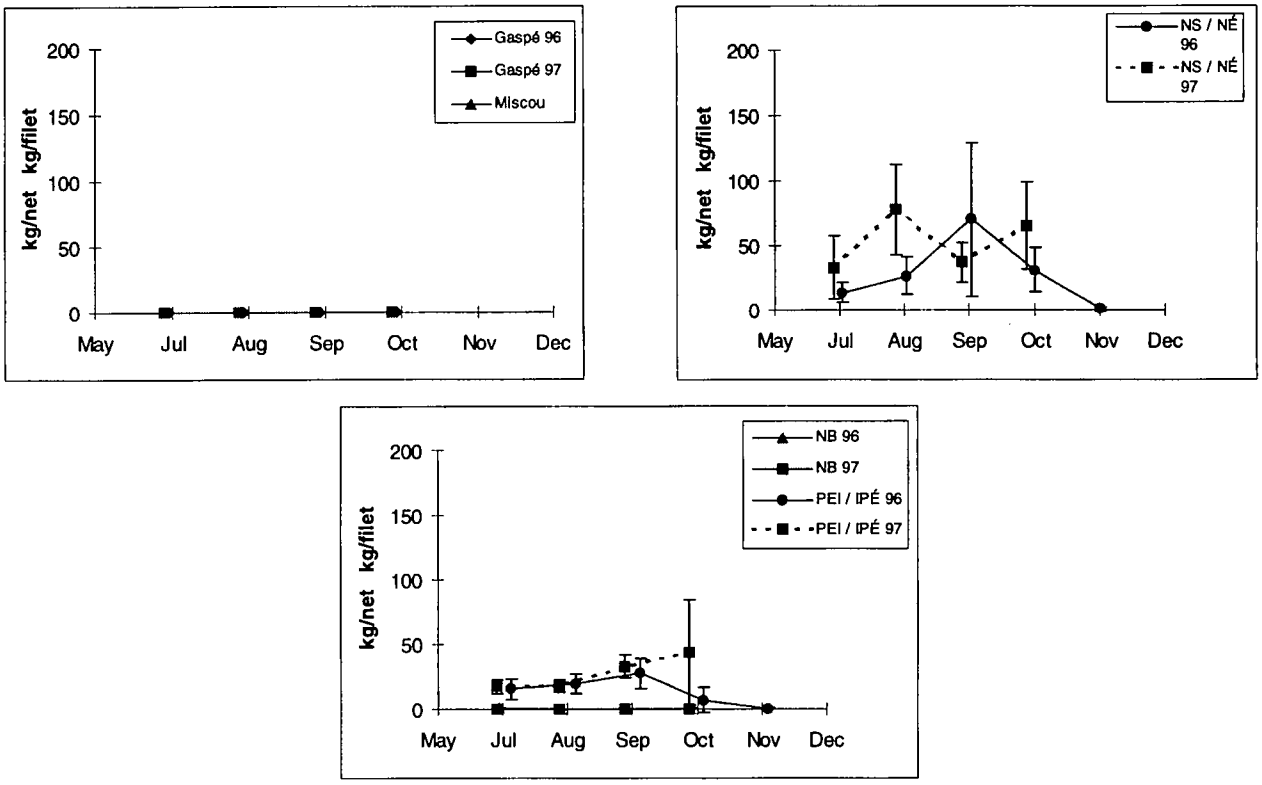


Figure A4. White Hake catch rates (+/- 1 se) for gillnets (MAG=Magdalen Islands, N.S.=Cape Breton, GB=St. Georges Bay, N.B.= New Brunswick, P.E.I.=Prince Edward Island).