Fisheries and Oceans Canada / Pêches et Océans Canada

Canadian Stock Assessment Secretariat
Research Document 98/141

Secrétariat canadien pour l'évaluation des stocks
Document de recherche 98/141

Not to be cited without
permission of the authors[1]

Ne pas citer sans
autorisation des auteurs[1]

Assessment of the Scotian Shelf silver hake population in 1997, with projection of yield to 1999.

By M.A. Showell

Department of Fisheries and Oceans
Maritimes Region, Science Branch
Bedford Institute of Oceanography
1 Challenger Drive, Dartmouth
Nova Scotia, B2Y 4A2
Canada

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

ISSN 1480-4883
Ottawa, 1998
Canada

Abstract

An analytical assessment of the Scotian Shelf silver hake stock in 4VWX was conducted using updated catch-at-age (1979-97), research surveys, and commercial CPUE. The assessment results show abundance and biomass to be increasing in recent years, but as was the case in previous years, a retrospective pattern was apparent, with estimates of population size in the most recent year inflated. With adjustment on an age-by-age basis to account for this pattern, spawning stock biomass shows an increase between 1993 and 1998, to about 115,000 t. Exploitation rate has decreased since 1994 to about 20%, which is well below $F_{0.1}$. A projection of yield based on parameters derived from the population analysis at $F_{0.1}$ is estimated to be approximately 48,000 t. However, given recent declines in survey estimates of abundance and recruitment, cold temperatures observed on the Scotian Shelf in 1997-98, and catches of small silver hake by the Canadian fleet, catches should not increase from recent levels.

Résumé

Une évaluation analytique du stock de merlu argenté du plateau néo-écossais de 4VWX a été effectuée à l'aide de données à jour des captures à l'âge (1979-1997), des relevés de recherche et des PUE de la pêche commerciale. L'évaluation montre que l'abondance et la biomasse se sont accrues au cours des dernières années mais, comme pour les années antérieures, on a noté un effet rétroactif qui donne lieu à une augmentation erronée de la valeur de l'effectif de dernière année. Après correction, âge par âge, faite pour tenir compte de cet effet, on obtient une biomasse de géniteurs qui augmente, de 1993 à 1998, à une valeur de 115 000 t environ. Le taux d'exploitation a diminué depuis 1994, à 20 % environ, ce qui est bien en deçà du $F_{0.1}$. Une projection du rendement fondée sur des paramètres tirés d'une analyse de la population au niveau $F_{0.1}$ donne une valeur de 48 000 t environ. Mais étant donné les baisses récentes des estimations de l'abondance et du recrutement indiquées par les relevés, les températures froides notées sur le plateau néo-écossais en 1997-1998 et la capture de merlus argentés de petite taille par la flottille canadienne, les captures ne devraient pas être augmentées par rapport aux niveaux récents.

The Fishery

The silver hake fishery has been conducted on the Scotian Shelf since the mid-1960's, primarily by the distant water fleets of Russia, Cuba and Japan in the early years. Prior to 1977, fishing on the Scotian Shelf was unrestricted in terms of area, mesh size and season. During this period fishing was conducted over the entire shelf, and the use of trawl mesh as small as 40 mm was common. Following the extension of jurisdiction to 200 miles by coastal states in 1997, Canada implemented the Coastal Fisheries Protection Act, which restricted fishing for this species to the seaward side of the Small Mesh Gear Line (SMGL, Fig 1), west of 60° W longitude, with a minimum mesh size of 60 mm. On an experimental basis, a portion (4-6 vessels) of the fleet was allowed to fish landward of the SMGL during 1978 and 1979. From 1980 through 1983, fishing was permitted by condition of license in an eastern extension of the Silver Hake Box as far as 57° W longitude; from 1984 to present this eastern extension has been restricted to 59° W longitude. In 1994 further restrictions were introduced to minimize incidental catches of cod, haddock and pollock in the silver hake fishery. These included a repositioning of the SMGL to prevent fishing in depths less than 190 m (Fig. 1) and the use of a separator grate in the lengthening piece of the trawl.

Canadian fishing interests have engaged in experimental harvesting of this species since 1975, although until 1995 these efforts were developmental in nature (Showell and Cooper, MS1997). From 1995 to present a commercial fishery has been conducted by the Canadian tonnage class 3 (< 65') mobile gear fleet in and around Emerald and LaHave basins (Fig. 1).

Nominal catches from this stock range from 300,000 tons in 1973 to 8,000 tons in 1994 (Table 1). Catches by the foreign fleet were generally high during the mid to late 1980's, with catches in recent years much lower (fig. 2). As the inshore Canadian fishery has developed, the proportion of the catch harvested by each fleet component has changed. The preliminary catch by Canada in 1998 is in excess of 7,500 mt, while the catch by Cuban vessels has dropped to less than 6,000 mt (Fig. 2).

Recent scientific advice (NAFO Scientific Council) , TAC's and catches ('000 tons) are as follows:

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Advice	100	167	235		100	105	75	51	79	64	50	65
TAC	100	120	135	135	100	105	86	30	50	60	50	55
Catch	62	74	91	69	68	32	29	8	18	26	16	14[1]

[1] preliminary

Removals and Weights at Age

While no foreign allocations of silver hake were caught in 1997, the fishery was conducted by two distinct fleets - Canadian flag vessels < 65' fishing in or near to Emerald and LaHave Basins, and the Cuban flagged tonnage class 7 vessels fishing seaward of the SMGL line under charter arrangements with Canadian partners. While modifications were made to the SMGL in 1994, several changes were subsequently made, and numerous exemptions granted to the fleets fishing in this area. Details of these changes are can be found in Branton, 1998.

Sampling for length composition and aging material from the Cuban vessels was conducted by Canadian observers, with 100% of the fishery covered. Sampling levels were relatively high, with more than 1,100 length samples and 1,100 otolith pairs collected. The commercial removals at age for this fishery in 1997 were calculated using the same procedures as the previous assessment, using the Canadian observer unculled length frequency data and monthly age/length keys, by sex, constructed from Canadian aging data. Regressions of lengths and weights from the Canadian July research vessel survey were used to calculate yearly alphas and betas by sex used in the calculation of sample weights and commercial mean weight-at-age. Catch-at-age for February catch by this fleet was constructed using the age/length key for March, as aging data were not available for this month.

As a result of changes in Departmental policy regarding observer coverage levels on domestic fishing vessels, observer data from the Canadian fleet were limited to two trips in 1997, both in June. Some port sampling was conducted for this species, but seasonal coverage was not sufficient to be representative of landings. However, in 1997 the major processor of silver hake landed by this fleet routinely conducted a size analysis of the landings as part of their quality control process. A sample of approximately 15 kg was collected at random from each landing, and measured to the nearest cm, unsexed. The length frequencies consisted of approximately 100 fish each, and were well distributed seasonally (Table 2). These samples were judged to represent the best available data source for calculation of removals at length for this fleet.

A comparison of the length composition of catches for the offshore foreign fleet to those of the inshore Canadian fleet, based on observer samples, was made for 1996 (Showell & Cooper, 1997), and the results indicated that the inshore fleet generally caught smaller fish than the offshore. Comparisons by month of the 1997 offshore length distributions based on observer samples to the inshore length distributions based on industry samples shows a similar, but more dramatic trend, with a the majority of the inshore catches consisting of 19-24 cm fish. This component was virtually absent from the offshore fishery (Fig. 3). July research vessel (RV) survey length frequencies show a similar pattern when strata are grouped by inshore vs offshore (Fig. 4). The differences between the two fleet components were therefore judged to be real as opposed to a sampling or other bias.

The lack of sexed length frequencies for the Industry samples represents a problem in determining catch at age, as silver hake exhibit differential growth rates between sexes and the proportion of each sex will vary according to length. To account for this, the ratio of males to females at length was estimated using Canadian observer data collected from the inshore fishery in 1995 and 1996. The curves for each year were similar (Fig. 5), and the ratio of each sex was calculated by combining the two curves, followed by smoothing with a running median function (SPSS, 1997). For each month, removals at length by sex were calculated by scaling the unsexed Industry numbers at length by the appropriate ratio. Monthly age/length keys from the offshore fishery were used to calculate numbers at age for the samples, by sex. Sample weights were calculated using length weight parameters from the summer survey, and the numbers adjusted for the total monthly catch by the inshore fleet. The results are presented in Table 3.

The removals at age for 1977-96 were taken from the previous assessment (Showell, 1997a) to provide estimates for the period 1977-97 inclusive (Table 4).

As has been noted in the past for this stock, commercial mean weight-at-age declined from 1992 to 1994, and has stayed relatively stable at this level in subsequent years (Table 5, Fig. 6).

Commercial Catch Rates

Multiplicative analysis of catch rates in the offshore component of the silver hake fishery using observer data showed no significant effect by country, month or NAFO area on catch rate (Smith & Showell, MS1996), indicating that a model with year alone has as much explanatory power as one which includes all four factors. Based on this analysis, a non-standardized catch rate series was developed using Canadian observer data (Fig. 7). The catch rates for this fleet have dropped from high levels in the period 1984-89, to relatively low levels since 1992, with the 1997 point being the lowest in the time series. Preliminary data from the 1998 fishery indicate the catch rate has risen slightly, but is still at a relatively low level.

An analysis of the effect of separator grates on silver hake catch rates by Halliday and Cooper (MS1997) indicates that the use of this equipment reduces the catch rate by about 5%. CPUE and effort, adjusted for this factor, are presented in Table 6.

The inshore fleet has been conducting a true commercial (as opposed to exploratory) fishery for silver hake, in and around Emerald and LaHave Basins only since 1995, rather than exploratory. Based on observer data, catch rates increased sharply in 1996 compared to 1995 (Fig. 8). While observer coverage in 1997 was not sufficient to calculate a reliable domestic catch rate, statistics from the commercial landings (C/L) database for TC 1-3 vessels directing for silver hake were available, with both catch per day and catch per hour showing trends similar to observer data between 1995 and 1996, and a stable catch rate from 1996-98 (Fig. 8).

Management Unit Considerations

Based on early work by Konstantinov and Noskov (1966, 1969) the Scotian Shelf silver hake population was considered to be separate from those of the Gulf of Maine, Georges Bank, and the Middle Atlantic States, and the management area was defined by ICNAF as 4VWX (Waldron, MS1988). However, examination of silver hake distribution from seasonally aggregated East Coast of North America Strategic Assessment Project (ECNSAP) data suggests a discontinuity between the Scotian Shelf and the Bay of Fundy portions of the population (Fig. 9). Further, the Bay of Fundy component is continuous with that of the Gulf of Maine, suggesting fish from this area may be associated with Northern Georges Bank/Gulf of Maine stock rather than the Scotian Shelf. These associations were investigated by comparing Canadian July RV numbers per tow from Bay of Fundy strata to those of the Scotian Shelf and to US fall numbers per tow for the northern Georges Bank/Gulf of Maine area. A significant linear regression relationship was found between the Bay of Fundy and Gulf of Maine numbers per tow (R^2=0.4, $p > 0.000$) while no significant relationship was found between the Bay of Fundy and Scotian Shelf or the Scotian Shelf and the Gulf of Maine. Together with the distribution information, these associations support the conclusion that Canadian July survey silver hake catches in the Bay of Fundy are from the Northern Georges Bank/Gulf of Maine stock. In addition, an analysis of changes in RV numbers over time was conducted to assess the ability of the July survey to track cohorts (Fig. 10). Comparisons of the results including and excluding the Bay of Fundy strata show cohorts track much more clearly at ages 1-4 with the Bay of Fundy strata excluded, indicating that silver hake from the Gulf of Maine may be confounding yearclass effects.

Canadian Bottom Trawl Surveys

The July stratified random design groundfish survey has been conducted on the Scotian Shelf from 1970 using three Canadian research vessels (A.T. Cameron, Lady Hammond, and the Alfred

Needler). A conversion factor of 2.3 is applied to the series prior to 1982 to account for the effect of vessel and gear changes between the A.T. Cameron and the other two vessels (Fanning, MS1985). No conversion factor is required between the Lady Hammond and the Alfred Needler.

As indicated previously, silver hake found in the Bay of Fundy area likely represent a portion of the Gulf of Maine/N. Georges Bank silver hake stock, rather than the Scotian Shelf stock. Survey trends in both total numbers and biomass were therefore calculated for the Scotian Shelf portion of 4VWX only, excluding strata 484 through 495.

Survey trends in both numbers and biomass show relatively high abundance in the early to mid-80's, followed by a decline to relatively low levels over the period 1988-94 (Fig 11). Abundance and biomass increased in 1995 and 1996, but has subsequently declined in 1997 and 1998.

Numbers at age for the Scotian Shelf strata only are presented in Table 7. In 1996 the one and two year old groups were above average in numbers, while the 3 year old (1994 year class) survey abundance was average, while the age four and older were below average in abundance.

Previous analysis (Showell, 1997b) has shown both condition (weight for given length) and mean length at age to have declined from 1971 to 1995, with the two factors combining to produce mean weights at age for ages 3 and 4 which were the lowest in the time series in 1994. With the addition of 1996 and 1997 survey data, a modest increase is seen over the previous low levels (Fig. 12).

Juvenile Survey

A standardized IYGPT O-group survey for this species has been conducted since 1981 (1992 excluded) during the October-November period. The stratified mean number per tow for the 1997 survey was 579, which equals the highest seen in the time series and suggests that the 1997 year class may be strong. However, as was the case with the high 1996 value, the estimate has a high coefficient of variation at 0.37. These data, as well as those of previous years for the core strata (460-478) are presented in Table 8.

Estimation of Parameters

Sequential Population Analysis

The adaptive framework (Gavaris, 1993) was used to calibrate the sequential population analysis using the Canadian July R/V survey for strata 440-483 (excludes Bay of Fundy), age disaggregated CPUE from the foreign fishery, and the O-group survey as tuning indices. An analysis of cohort strength in the RV and CPUE time series showed general correspondence for ages 1 though 4, but little tracking at ages 5 and older (Fig. 13). As a result, ages 1-4 were used to calibrate the analysis. Examination of the diagnostics from preliminary runs showed strong negative year effects in the early portion of the time series (1979-82). It was judged that these were likely artifacts resulting from changes in the July survey vessel calibration, and consequently these data were dropped from the time series. The resulting formulation was as follows:

Ca,y=catch; a=1 to 8, y=1983-1997
RVa,y=Canadian July RV; a=1 to 4, y=1983-1997
CPUEa,y=age disaggregated CPUE; a=1 to 4, y=1983-1997
Juva,y=o-group survey; a=1, y=1983-1997

Natural mortality was assumed constant and equal to 0.4, and errors in the catch at age were assumed to be without error relative to the abundance indices. F at age 8 was calculated as the average of ages 4,5,6 in the same year, and a dome was not forced.

Parameter estimates from the analysis are show in Table 9. Bias adjusted beginning of year population numbers, fishing mortality, and population biomass are shown in Tables 10, 11 and 12. Age by age residuals are shown in Table 13 for each survey, summarized in Table 14 and plotted in Fig. 14 (RV) and Fig. 15 (CPUE and O-group). Scaled residuals are plotted by year and series as a 'bubble-plot' in Fig. 16.

In past assessments of this resource, population numbers have shown changes with the addition of data in subsequent years, with a tendency for the current estimate of population size to be overly optimistic. As a result, an analysis for a retrospective pattern was conducted. The retrospective effect on population was examined for age 1 through 4 (Fig. 17). To quantify the effect of the retrospective pattern, an analysis of initial estimates of population numbers compared to the most recent estimates was conducted, and the proportion of the 1997 estimate to the initial estimate was averaged for the past 5 years. When the initial estimate was compared to the estimate with several more years data added, a difference of approximately 20% was seen in ages 1 though 4 with slightly higher levels for older ages (Table 15). Fishing mortality for the fully recruited, or near fully recruited age groups (ages 3-5) on which the fishery is conducted, was underestimated by as much as 50% in some years (Fig. 18).

Estimates of spawning stock biomass (age 2+, adjusted for retrospective), recruitment (VPA age 1), and exploitation rate from the ADAPT analysis are summarized in Table 16.

Estimates of Total Mortality (Z)

The mean numbers per tow index from the July survey was used to calculate total mortality. To reduce variability in the estimates, the results were grouped into age classes (1-2, 3-5, 6-8) and smoothed using a two year moving average (Fig. 19). Bases on this method, total mortality on 2+ fish (ie the age classes on which the fishery is conducted) has remained relatively high, despite a sharp decline in catches.

Recruiting Yearclass Sizes

Estimates of age 1 in the terminal year of the VPA are poorly estimated (Fig. 17), and cannot be relied on as an estimate of incoming year class size. The estimates of the 1995 and earlier yearclasses can be accepted from the SPA; however, the strength of the 1996 and 1997 yearclasses at age 1 must be inferred from research vessel data.

The 1998 July RV survey has been conducted, but aging is not completed. However, the mode of lengths representing age 1 fish is clear in the length frequency data, and abundance of fish < 23 cm has been shown to provide a reasonable estimate of age 1 numbers (Branton *et al.*, 1997). Using this method in conjunction with the ADAPT catchability coefficient estimated for age 1 RV, the size of the **1997 yearclass** is below average at 0.4 billion fish. This cohort was previously considered to be above average in size, based on the results of the 1997 O-group survey. However, the cold temperatures observed on the Scotian Shelf in 1997-98 (Drinkwater *et al.*, 1998) may have significantly reduced the abundance of this yearclass between the fall juvenile and July RV surveys.

The **1996 yearclass** will be fully recruited at age 3 in 1999. Based on the ADAPT catchability coefficient estimated for age 1 RV, the size of this yearclass is slightly above average, at 1.1 billion fish.

The **1998 year class** was taken as the 10 year geometric mean for age 1 fish from the VPA (750 million).

Projection

The commercial mean weights-at-age have declined sharply since 1992, and have stabilized at lower levels in recent years. This long term decline is also seen in survey data, and appears to be a biological phenomenon rather than a result of sampling or other bias. Consequently, a short series (1995-97) of weights-at-age was averaged for projection. The nature of the fishery has changed somewhat in recent years, with changes in fishing area and a requirement for the use of a separator grate introduced in

1994, and the increase in landings from Canadian vessels fishing the inshore basins. As a result, the partial recruitment was averaged for the past 3 years also. To quantify the effect of the retrospective pattern, numbers for ages 3+ from ADAPT were adjusted downwards, on an age-by-age basis, by the average proportion calculated in Table 15.

Weights at age, numbers, and partial recruitment were:

age	avg.wt	PR	numbers
1	0.05	0.06	404762
2	0.10	0.42	723658
3	0.14	0.74	362936
4	0.17	1.0	115195
5	0.21	0.74	17797
6	0.30	0.53	17686
7	0.44	0.52	12476
8	0.45	0.61	5122
9	0.66	0.61	2302

Some landings are still being made by the Canadian silver hake fishery. However, levels are low and the final catch for 1998 (foreign and Canadian fleets combined) is estimated to be approximately 14,000t. An $F_{0.1}$ value of 0.7 was used, based on yield-per-recruit analyses conducted in previous assessments. The yield in 1999 at this target fishing level is estimated to be 48,000 tons. Results of an Armstrong plot, comparing exploitation rate and biomass change at various levels of yield is presented in Figure 20. Harvesting at the $F_{0.1}$ level would result in an exploitation rate of about 40%, and reduce the population biomass by about 30%.

Acknowledgements

I thank the numerous individuals who contributed to the review of this work through the RAP working group at BIO. In particular I acknowledge the contribution of P. Fanning and Dr. R. Mohn in modifying ACON software to produce graphical diagnostics from ADAPT, and S. Gavaris who was helpful and patient with advice on ADAPT methodology. K. Zwanenburg supplied very useful graphical summaries of the ECNSAP dataset in support of the stock area question. R. Branton and Dr. R. Halliday provided useful suggestions for improvements to an earlier version of the document.

References

Branton, R, J. Black and M. Showell 1997. 1997 Summer Groundfish Survey update for selected Scotia-Fundy groundfish stocks, including a revised projection of silver hake catch using the survey estimate of the 1996 yearclass. DFO Atl.Fish.Res.Doc. 97/104. 52p.

Branton, R. 1998. Effects of Scotian Shelf small mesh gear fishery regulations on the catch rate of silver hake and bycatch rates of cod, haddock, and pollock in the period 1983-98. DFO Atl.Fish.Res.Doc. 98/139. 13p.

Drinkwater, K.F., D.B. Mountain and A. Herman. 1998. Recent changes in the hydrography of the Scotian Shelf and Gulf of Maine - a return to conditions of the 1960s? NAFO SCR Doc. 98/37, 16 p.

Fanning, L.P. 1985. Intercalibration of research survey results obtained by different vessels. CAFSAC Res.Doc. 85-3. 43p.

Gavaris, S. 1993. Analytical estimates of reliability for the projected yield from commercial fisheries. pp 185-191. In S.J. Smith, J.J. Hunt and D. Rivard (ed). Risk evaluation and biological reference points for fisheries management. CanSpec.Publ.Aquat.Sci. 120.

Halliday, R.G. and C.G. Cooper. MS 1997. The effect of codend separator grates on silver hake otter trawl catch rates. NAFO Scr.Doc. 97/51 Serial No. N2885, 14p

Konstantinov, K.G and A.S. Noskov. MS1966. U.S.S.R. Research Report, 1965. Int. Comm. Northw. Atl. Fish., Res Doc. 66/39, 26pp.

Konstantinov, K.G and A.S. Noskov. MS1969. U.S.S.R. Research Report, 1968. Int. Comm. Northw. Atl. Fish., Res Doc. 69/17, 29pp.

Showell, M.A. MS1997a. Assessment of the 4VWX silver hake population in 1996. NAFO Scr.Doc. 97/69 Serial No. N2903, 27p.

Showell, M.A. MS1997b. Trends in condition and growth of 4VWX silver hake, 1970-96. NAFO Scr.Doc. 97/75 Serial No. N2909, 14p

Showell, M.A. and C.G. Cooper, MS1997. Development of the Canadian silver hake fishery, 1987-96. NAFO Scr.Doc. 97/54, Serial no. N2888, 10p.

Smith, S.J. and M.A. Showell MS1996. Analysis of catch-per-unit effort data for Scotian Shelf silver hake. NAFO Scr.Doc. 96/17 10p.

Waldron, D.E. MS 1988. Trophic biology of the silver hake (*Merluccius bilinearis*) population on the Scotian Shelf. PhD Thesis, Dalhousie University.

Table 1. Nominal catches (mt) for 4VWX silver hake 1970-1998 (1995-1998 preliminary).

Country	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**
Bulgaria	0	0	0	0	0	1722	3088	862	606	4639	817	0	0
Canada	0	0	0	0	11	101	26	10	26	13	104	6	38
Cuba	0	0	201	0	0	1724	12572	1847	3436	1798	2287	642	11969
France	0	0	0	0	0	0	0	15	0	0	0	0	2[1]
FRG	0	0	10	0	296	106	97	684	0	0	0	0	0
GDR	0	0	0	0	0	0	0	0	3	0	0	0	0
Ireland	0	0	0	0	0	108	106	0	0	9	0	0	0
Italy	0	0	0	0	0	0	0	38	106	5	0	541	37[1]
Japan	129	8	63	88	67	54	78	19	161	219	239	120	937
Poland	0	0	0	0	0	0	0	295	2	0	0	1[1]	31[2]
Portugal	0	0	0	0	0	0	0	0	0	0	56	2044	2[1]
Romania	0	0	0	0	0	0	0	10	0	1	0	0	0
Spain	0	15	0	0	0	6	0	0	2	0	40	0	0
USA	0	1	1	1	1	7	1	14	0	0	0	3	2
USSR	168916	128633	113774	298533	95371	112566	81216	33301	44062	45076	40982	41243	47261
Total	169045	128657	114048	298621	95745	116394	97184	37095	48404	51760	44525	44600	60251

Country	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Bulgaria	0	0	0	0	0	0	0	88	0	0	0	0	0
Canada	15	10	2	9	13	9	337	10	34	4	73	57	300[1]
Cuba	7418	14496	17683	16041	20219	9016	14541	13888	23708	16528	22018	7788	16835[1]
France	0	0	0	0	0	0	0	0	0	0	0	0	0
FRG	0	0	0	0	0	0	0	0	0	0	0	0	0
GDR	0	93	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0
Italy	2[2]	0	0	0	0	0	0	0	0	0	0	0	0
Japan	649	530	120	66	144	0	194	315	781	547	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0
Portugal	378	1714	1338	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	0	0	0	0
USA	0	0	0	1	0	0		0	0	0	0	0	0
USSR	27377	57423	56337	66571	41329	65349	72917	55429	40786	14716	7139[1]	0	0
Total	35839	74266	75480	82688	61705	74374	87989	69730	65309	31795	29230	7845	17835

Observer Program Data (data not reported to NAFO)
[2] FLASH data

Country	**1996**	**1997**	**1998***
Bulgaria	0	0	0
Canada	3473	4203	7545
Cuba	2177 3[1]	11961[1]	5849[1]
France	0	0	0
FRG	0	0	0
GDR	0	0	0
Ireland	0	0	0
Italy	0	0	0
Japan	0	0	0
Poland	0	0	0
Portugal	0	0	0
Romania	0	0	0
Spain	0	0	0
USA	0	0	0
USSR	669	0	168
Total	25927	16,164	13562

[1] Observer Program Data (data not reported to NAFO)
[2] FLASH data
*incomplete

Table 2: Industry sampling of 4VWX silver hake, Port Mouton plant, 1997.

month	April	May	June	July	August	Sept
# samples	3	16	27	37	17	5

Table 3: 1997 catch at age ('000's) for Scotian Shelf silver hake by Canadian and foreign fishing vessels.

foreign 11961 ton age	Feb	Mar	Apr	May	June	Jul	Aug	Sept	total
1	17.9	48.1	295.7	1014.4	3020.5	1619.3	169.9	64.7	6250.5
2	535.5	1438.5	3119.5	8313.5	7470.5	956.7	180.7	44.9	22059.8
3	1159.2	3113.9	5686.6	11836.6	10320.1	1336.5	368.8	13.5	33835.2
4	858.7	2306.6	4268.9	7989	7473.3	1320.2	324.1	10.3	24551.1
5	108	290.1	574.2	1072.6	1115.3	257	46.8	2.5	3466.5
6	5.6	15	42	91.9	112.2	33.5	3.8	0.3	304.3
7	0.3	0.82	2.2	6.2	12.2	1.9	0.2	0.02	23.84
8	0.14	0.37	0.74	4.8	12.6	0.62	0.05	0.01	19.33
9	0	0	0.11	0.52	1.3	0.13	0.003	0	2.063

domestic 4203 tons age	Feb	Mar	Apr	May	June	Jul	Aug	Sept	total
1			160.6	3236.4	2755.4	1773.9	1055.1	900.2	9881.6
2			144.1	2941.5	3432.8	3160.8	1552.4	726.2	11957.8
3			54.5	998.2	1208.5	917	293.8	189.9	3661.9
4			13	194.3	291.9	237.9	52.1	44.1	833.3
5			2.5	23.4	39	29.6	10.9	7.5	112.9
6			0.4	8.8	8	6.6	3.1	8.5	35.4
7			0	1	1.1	0.8	0.1	1.7	4.7
8			0	0.5	0.3	0.6	0	6.6	8
9			0	0	0	0	0		0

Table 4: Commercial catch numbers at age for 4VWX silver hake.

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	17911	20940	20569	16588	2358	20189	5849	59588	14970	45598
2	72529	70302	57893	70696	25214	52976	96852	45828	130814	70269
3	59862	80196	72891	70391	109035	75876	56158	206900	98346	229126
4	15070	35025	36669	32032	37573	68400	29282	82911	128365	84097
5	2218	12709	22380	14465	11928	31752	11388	19344	34110	28635
6	725	5227	9970	5184	3234	5945	3395	4268	9327	8760
7	97	1906	3168	1431	1201	2042	819	1038	2344	1436
8	91	1168	495	451	290	465	253	183	226	497
9	4	338	374	98	141	64	88	10	85	111

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	6804	5110	24264	6516	5738	7461	31572	1651	3498	33501
2	214235	62791	85846	209620	117305	76663	83140	13265	35925	92030
3	114417	265307	158745	142862	201243	73526	70735	35250	45615	43686
4	54211	39242	145105	41215	46414	27777	35222	8847	31316	23234
5	13063	21303	20025	11741	12154	3461	5511	1283	5183	4928
6	6045	3106	9369	1648	3954	1247	595	150	457	888
7	347	2133	1569	640	290	159	71	18	58	148
8	156	208	1166	107	181	33	30	8	41	75
9	117	143	39	40	50	5	3	0	3	0

Age	1997
1	16132
2	34018
3	37497
4	25384
5	3579
6	339
7	29
8	27
9	2

Table 5: Silver hake commercial mean weights at age.

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.065	0.074	0.076	0.04	0.061	0.066	0.067	0.07	0.068	0.053
2	0.183	0.153	0.178	0.151	0.168	0.169	0.128	0.146	0.136	0.145
3	0.264	0.229	0.227	0.223	0.215	0.231	0.196	0.181	0.177	0.184
4	0.34	0.266	0.274	0.287	0.276	0.275	0.239	0.224	0.21	0.25
5	0.446	0.335	0.304	0.341	0.326	0.317	0.289	0.272	0.244	0.25
6	0.632	0.405	0.389	0.391	0.401	0.394	0.365	0.353	0.295	0.274
7	0.886	0.438	0.455	0.531	0.553	0.446	0.395	0.405	0.41	0.392
8	0.922	0.54	0.838	0.839	0.923	0.513	0.457	0.624	0.582	0.514
9	2.12	0.892	0.838	0.859	1.137	0.506	0.444	0.65	0.669	0.644

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.045	0.045	0.06	0.063	0.047	0.08	0.06	0.050	0.060	0.040
2	0.119	0.139	0.135	0.139	0.139	0.14	0.11	0.100	0.100	0.100
3	0.168	0.185	0.195	0.184	0.189	0.19	0.15	0.130	0.140	0.139
4	0.211	0.227	0.224	0.217	0.215	0.21	0.19	0.170	0.170	0.169
5	0.248	0.26	0.278	0.24	0.263	0.26	0.23	0.190	0.210	0.207
6	0.286	0.292	0.349	0.315	0.471	0.28	0.28	0.270	0.310	0.293
7	0.453	0.401	0.403	0.37	0.471	0.37	0.38	0.380	0.410	0.505
8	0.422	0.497	0.511	0.401	0.511	0.41	0.32	0.420	0.440	0.433
9	0.518	0.688	0.82	0.545	0.568	0.69	0.96	---	0.620	---

Age	1997
1	0.049
2	0.101
3	0.140
4	0.171
5	0.206
6	0.299
7	0.394
8	0.435
9	0.628

Table 6: CPUE (t/hr) and effort (hrs), raw and (corrected) for the effect of separator grates, for the Cuban and Russian 4VWX silver hake fishery, 1979-97.

year	CPUE	effort (hrs)
1979	1.71	30,271
1980	2.04	21,811
1981	1.71	26,083
1982	3.20	18,841
1983	1.76	20,406
1984	2.94	25276
1985	2.82	26,791
1986	3.48	23,755
1987	2.75	22,433
1988	2.80	26,535
1989	3.89	22,624
1990	1.89	37,288
1991	1.70	39,911
1992	1.32	24,148
1993	1.43	20,369
1994	1.36 (1.43)	5,726 (5,440)
1995	1.34 (1.41)	12,563 (11,935)
1996	1.28 (1.34)	17,532 (16,655)
1997	1.02 (1.07)	11,726 (11,140)

Table 7: Scotian Shelf silver hake July RV survey numbers ('000) at age. Strata 484-495 excluded.

sum_rv	1	2	3	4	5	6	7	8	9
1977.5	4678.4	23530.4	19417.3	4564.9	1360.5	1213.1	938.4	326.8	283.5
1978.5	23504.4	22781.4	16118.6	8922.9	6695.8	3050.0	1288.2	502.9	866.4
1979.5	69802.6	146692.0	69096.6	20340.5	11564.9	5082.7	2682.7	975.9	276.7
1980.5	11491.3	19280.5	28115.5	7884.4	4292.2	3358.0	1478.1	804.9	381.6
1981.5	31645.8	84253.6	129883.7	60438.8	16084.1	5237.5	2427.6	794.0	654.4
1982.5	177636.5	29113.1	7743.4	6201.0	3209.5	816.8	350.3	252.4	32.9
1983.5	41988.7	99362.7	38241.6	18996.2	10603.1	2779.4	882.0	400.8	332.7
1984.5	174499.2	65030.5	209274.9	39603.1	12119.9	8042.0	2872.9	1141.5	523.2
1985.5	37656.8	163469.9	33876.8	73810.7	22537.2	9947.3	2662.4	1223.6	215.2
1986.5	262382.2	73829.4	74005.9	22643.6	13551.6	4148.2	1656.1	713.5	333.6
1987.5	139672.6	253815.0	42291.4	18611.9	6067.6	4103.7	1265.8	669.1	477.2
1988.5	68465.9	87116.9	82661.9	16965.6	14225.7	2514.0	2372.5	480.7	148.2
1989.5	128835.7	60127.1	23089.7	13012.3	3549.5	1744.0	697.2	317.7	129.3
1990.5	89476.5	115013.2	46416.9	13857.3	4056.9	1154.9	406.7	207.6	81.3
1991.5	39735.5	80924.0	35098.3	13164.8	6623.8	2416.9	401.6	142.8	124.3
1992.5	25951.7	56010.5	45725.8	11076.8	4464.0	2230.3	423.3	139.4	192.1
1993.5	113930.3	89869.7	63213.9	27289.6	2530.8	807.1	583.7	97.5	37.9
1994.5	86322.8	56315.3	57237.2	25354.5	8180.1	1146.9	330.8	209.8	132.7
1995.5	90254.2	72148.1	82581.7	56654.8	15599.0	3414.7	1295.0	613.7	652.0
1996.5	94124.4	170254.7	57250.6	42983.5	10621.9	1584.3	295.4	566.6	155.6
1997.5	143033.6	122443.0	53562.3	6064.0	3663.5	594.3	87.7	76.8	20.4

Table 8: Stratified mean catch per tow for the Canada-Russia juvenile silver hake survey, core strata (60-78).

Year Class	1981	1982	1983	1984	1985	1986	1987	1988	1989
mean catch/tow	579.0	8.8	232.2	43.4	284.8	198.0	102.0	204.8	131.5
std.error	64.4	1.2	24.4	7.1	62.2	37.9	23.0	35.3	19.0
CV	0.11	0.14	0.11	0.16	0.22	0.19	0.23	0.17	0.14
number of sets	77	61	64	71	82	74	105	79	74
July RV age 1 #'s (10^6)	178	42	175	38	262	140	68	129	89

Year Class	1990	1991	1992[1]	1993	1994	1995	1996	1997
mean catch/tow	187.4	78.6	-	186.5	105.4	252.0	444.1	578.6
std.error	24.1	10.4	-	17.2	8.4	60.5	186.5	214.1
CV	0.13	0.13	-	0.09	0.08	0.24	0.42	0.37
number of sets	68	71	-	95	73	83	81	81
July RV age 1 #'s (10^6)	40	26	114	86	90	94	143	--

[1] no survey in 1992.

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET......... 0.001144
MEAN SQUARE RESIDUALS 0.305590

Estimates for parameters

	PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
1	1.38E1	3.36E-1	0.024	1.70E-3	0.000
2	1.31E1	2.74E-1	0.021	-1.44E-5	0.000
3	1.20E1	2.86E-1	0.024	-6.50E-3	-0.001
4	1.05E1	3.53E-1	0.034	-2.07E-2	-0.002
5	1.07E1	3.07E-1	0.029	-1.33E-2	-0.001
6	1.01E1	3.59E-1	0.036	-2.43E-2	-0.002
7	9.22E0	3.90E-1	0.042	-2.91E-2	-0.003
RV	-1.13E1	1.49E-1	-0.013	-2.14E-3	0.000
	-1.07E1	1.47E-1	-0.014	-1.59E-3	0.000
	-1.04E1	1.48E-1	-0.014	-1.96E-4	0.000
	-1.01E1	1.50E-1	-0.015	2.33E-3	0.000
CPUE	-1.41E1	1.49E-1	-0.011	-2.14E-3	0.000
	-1.17E1	1.47E-1	-0.013	-1.59E-3	0.000
	-1.05E1	1.48E-1	-0.014	-1.96E-4	0.000
	-1.01E1	1.50E-1	-0.015	2.33E-3	0.000
Juv	-8.45E0	1.60E-1	-0.019	-2.22E-3	0.000

Parameters in linear scale

	PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
1	9.95E5	3.34E5	0.336	5.78E4	0.058
2	4.77E5	1.31E5	0.274	1.79E4	0.037
3	1.55E5	4.42E4	0.286	5.31E3	0.034
4	3.50E4	1.24E4	0.353	1.46E3	0.042
5	4.58E4	1.40E4	0.307	1.55E3	0.034
6	2.32E4	8.33E3	0.359	9.32E2	0.040
7	1.01E4	3.96E3	0.390	4.76E2	0.047
RV	1.26E-5	1.87E-6	0.149	1.12E-7	0.009
	2.32E-5	3.42E-6	0.147	2.15E-7	0.009
	3.12E-5	4.61E-6	0.148	3.35E-7	0.011
	4.23E-5	6.34E-6	0.150	5.73E-7	0.014
CPUE	7.51E-7	1.12E-7	0.149	6.70E-9	0.009
	8.65E-6	1.27E-6	0.147	8.00E-8	0.009
	2.67E-5	3.95E-6	0.148	2.87E-7	0.011
	4.05E-5	6.06E-6	0.150	5.49E-7	0.014
Juv	2.14E-4	3.41E-5	0.160	2.24E-6	0.011

VPA using analytical bias adjusted parameters (linear scale)

Table 9: Parameter estimates from ADAPT for Scotian Shelf silver hake using Canadian July RV survey (ages 1-4), foreign commercial CPUE (Ages 1-4) and O-group index (age 1)

Table 10: Population numbers from ADAPT analysis for Scotian Shelf silver hake. ('0000's)

Population Numbers

	1	2	3	4	5	6	7	8
1983.00	802518	1003332	341179	100480	29740	6636	1600	627
1984.00	1337656	533189	594108	183359	43873	10856	1768	426
1985.00	732317	848284	320271	232916	57145	14052	3877	372
1986.00	1795325	478722	462954	135896	55182	11607	2178	766
1987.00	777489	1166396	264115	129218	25433	14403	1076	344
1988.00	737261	515635	609057	86155	43511	6740	4848	444
1989.00	1075591	490046	294841	197555	26633	12320	2056	1556
1990.00	559672	701275	259215	72649	20962	2518	1096	179
1991.00	561591	369862	302065	61410	16338	4826	407	233
1992.00	655481	371781	154008	46281	5649	1631	252	49
1993.00	625405	433317	189179	45032	9290	1082	141	45
1994.00	450242	393598	223429	70384	3377	1912	258	38
1995.00	766817	300463	253063	121300	40024	1241	1160	158
1996.00	1124494	511167	172340	132834	56150	22637	467	730
1997.00	1417532	726558	268401	80416	70293	33645	14453	195
1998.00		937086	459413	149604	33579	44214	22278	9665

Table 11: Fishing mortality from ADAPT analysis for Scotian Shelf silver hake.

Fishing Mortality

	1	2	3	4	5	6	7	8
1983.00	0.009	0.124	0.221	0.429	0.608	0.922	0.923	0.653
1984.00	0.055	0.110	0.536	0.766	0.739	0.630	1.159	0.711
1985.00	0.025	0.206	0.457	1.040	1.194	1.464	1.222	1.233
1986.00	0.031	0.195	0.876	1.276	0.943	1.978	1.445	1.399
1987.00	0.011	0.250	0.720	0.688	0.928	0.689	0.486	0.768
1988.00	0.008	0.159	0.726	0.774	0.862	0.787	0.736	0.808
1989.00	0.028	0.237	1.001	1.843	1.959	2.020	2.040	1.941
1990.00	0.014	0.442	1.040	1.092	1.069	1.423	1.148	1.195
1991.00	0.012	0.476	1.476	1.986	1.904	2.551	1.714	2.147
1992.00	0.014	0.276	0.830	1.206	1.252	2.049	1.321	1.502
1993.00	0.063	0.262	0.589	2.190	1.181	1.036	0.901	1.469
1994.00	0.004	0.042	0.211	0.164	0.601	0.100	0.088	0.288
1995.00	0.006	0.156	0.245	0.370	0.170	0.577	0.062	0.372
1996.00	0.037	0.244	0.362	0.236	0.112	0.049	0.476	0.132
1997.00	0.014	0.058	0.184	0.473	0.064	0.012	0.002	0.183

Table 12: Population biomass from ADAPT analysis for Scotian Shelf silver hake. ('000 t)

age	1	2	3	4	5	6	7	8
1983	40126	90300	61412	23110	8327	2256	624	282
1984	66883	53319	89116	38505	10968	3474	672	213
1985	36616	84828	51243	44254	13143	3935	1473	182
1986	71813	47872	74073	28538	12692	3018	741	352
1987	23325	93312	42258	25844	6358	3889	377	141
1988	22118	41251	91359	17231	10008	1820	1648	209
1989	43024	39204	47175	39511	6658	3696	699	700
1990	22387	63115	41474	15256	4821	755	395	72
1991	16848	33288	48330	12282	3921	1303	159	100
1992	45884	29742	24641	9256	1356	440	86	22
1993	31270	38999	26485	8556	2044	292	47	15
1994	18010	31488	26811	11261	642	478	85	15
1995	38341	21032	30368	18195	7605	298	383	65
1996	33735	40893	20681	19925	10669	5659	187	307
1997	42526	43593	32208	12062	13356	8411	4914	92
1998	30000	65596	55130	22441	6380	11054	8020	4156

RV_ss
Age : 1
Ln calibration constant : -11.28301

Year	Observed	Predicted	Residual	Ln Pop.
1983.50	1.43482	2.10806	-0.67324	13.39107
1984.50	2.85934	2.59569	0.26365	13.87870
1985.50	1.32593	2.00841	-0.68249	13.29142
1986.50	3.26722	2.90205	0.36516	14.18507
1987.50	2.63672	2.07550	0.56122	13.35851
1988.50	1.92375	2.02356	-0.09981	13.30657
1989.50	2.55595	2.39194	0.16402	13.67495
1990.50	2.19139	1.74521	0.44618	13.02822
1991.50	1.37966	1.76337	-0.38371	13.04638
1992.50	0.95365	1.91895	-0.96530	13.20196
1993.50	2.43300	1.85036	0.58264	13.13337
1994.50	2.15551	1.54849	0.60701	12.83150
1995.50	2.20004	2.08707	0.11297	13.37008
1996.50	2.24203	2.46689	-0.22486	13.74990
1997.50	2.66049	2.73389	-0.07339	14.01690
	Average squared residual :		0.23523	

RV_ss
Age : 2
Ln calibration constant : -10.67007

Year	Observed	Predicted	Residual	Ln Pop.
1983.50	2.29619	2.88675	-0.59056	13.55683
1984.50	1.87227	2.26170	-0.38943	12.93178
1985.50	2.79404	2.67810	0.11594	13.34818
1986.50	1.99917	2.11144	-0.11226	12.78151
1987.50	3.23402	2.97448	0.25954	13.64455
1988.50	2.16467	2.20362	-0.03895	12.87369
1989.50	1.79388	2.11387	-0.31999	12.78394
1990.50	2.44246	2.37001	0.07246	13.04008
1991.50	2.09093	1.71305	0.37788	12.38312
1992.50	1.72295	1.83456	-0.11160	12.50463
1993.50	2.19578	1.99620	0.19958	12.66627
1994.50	1.72838	2.01191	-0.28353	12.68198
1995.50	1.97614	1.68266	0.29348	12.35273
1996.50	2.83471	2.17829	0.65643	12.84836
1997.50	2.50506	2.63396	-0.12890	13.30403
	Average squared residual :		0.10081	

RV_ss
Age : 3
Ln calibration constant : -10.37423

Year	Observed	Predicted	Residual	Ln Pop.
1983.50	1.34134	2.05546	-0.71412	12.42968
1984.50	3.04106	2.45240	0.58867	12.82662
1985.50	1.22014	1.87406	-0.65391	12.24829
1986.50	2.00156	2.03310	-0.03154	12.40732
1987.50	1.44200	1.54980	-0.10780	11.92402
1988.50	2.11217	2.38250	-0.27032	12.75672
1989.50	0.83680	1.51960	-0.68280	11.89383
1990.50	1.53508	1.37137	0.16371	11.74559
1991.50	1.25557	1.30792	-0.05235	11.68215
1992.50	1.52008	0.95631	0.56377	11.33054
1993.50	1.84394	1.30759	0.53635	11.68181
1994.50	1.74462	1.66014	0.08448	12.03437
1995.50	2.11120	1.76778	0.34342	12.14201
1996.50	1.74485	1.32481	0.42004	11.69904
1997.50	1.67826	1.86576	-0.18750	12.23998
	Average squared residual :		0.18718	

Table 13: Age by age observed, predicted, and residuals from ADAPT analysis.

RV_ss
Age : 4
Ln calibration constant : -10.07159

Year	Observed	Predicted	Residual	Ln Pop.
1983.50	0.64165	1.03180	-0.39015	11.10339
1984.50	1.37632	1.46468	-0.08836	11.53627
1985.50	1.99892	1.56682	0.43210	11.63841
1986.50	0.81729	0.91014	-0.09285	10.98173
1987.50	0.62122	1.15343	-0.53222	11.22502
1988.50	0.52861	0.70531	-0.17671	10.77690
1989.50	0.26331	1.00055	-0.73724	11.07214
1990.50	0.32623	0.37584	-0.04961	10.44743
1991.50	0.27496	-0.23814	0.51310	9.83345
1992.50	0.10227	-0.12630	0.22857	9.94529
1993.50	1.00392	-0.64808	1.65200	9.42351
1994.50	0.93037	0.84363	0.08674	10.91522
1995.50	1.73439	1.28010	0.45429	11.35169
1996.50	1.45823	1.43599	0.02224	11.50759
1997.50	-0.50022	0.82153	-1.32175	10.89312

Average squared residual : 0.41479

newcpue
Age : 1
Ln calibration constant : -14.10149

Year	Observed	Predicted	Residual	Ln Pop.
1983.50	-1.24827	-0.71042	-0.53785	13.39107
1984.50	0.85739	-0.22279	1.08018	13.87870
1985.50	-0.58161	-0.81007	0.22846	13.29142
1986.50	0.65180	0.08357	0.56823	14.18507
1987.50	-1.19402	-0.74298	-0.45104	13.35851
1988.50	-1.64507	-0.79492	-0.85014	13.30657
1989.50	0.07046	-0.42654	0.49700	13.67495
1990.50	-1.74297	-1.07327	-0.66970	13.02822
1991.50	-1.93794	-1.05511	-0.88283	13.04638
1992.50	-1.17441	-0.89953	-0.27489	13.20196
1993.50	0.43825	-0.96812	1.40637	13.13337
1994.50	-1.19402	-1.26999	0.07596	12.83150
1995.50	-1.22758	-0.73141	-0.49617	13.37008
1996.50	0.46813	-0.35159	0.81972	13.74990
1997.50	-0.59784	-0.08459	-0.51324	14.01690

Average squared residual : 0.49820

newcpue
Age : 2
Ln calibration constant : -11.65753

Year	Observed	Predicted	Residual	Ln Pop.
1983.50	1.55730	1.89930	-0.34199	13.55683
1984.50	0.59498	1.27425	-0.67926	12.93178
1985.50	1.58576	1.69065	-0.10489	13.34818
1986.50	1.08451	1.12398	-0.03947	12.78151
1987.50	2.25654	1.98702	0.26952	13.64455
1988.50	0.86120	1.21616	-0.35496	12.87369
1989.50	1.33368	1.12641	0.20728	12.78394
1990.50	1.72669	1.38255	0.34414	13.04008
1991.50	1.14613	0.72559	0.42054	12.38312
1992.50	1.12655	0.84710	0.27945	12.50463
1993.50	1.40659	1.00874	0.39785	12.66627
1994.50	0.89118	1.02445	-0.13327	12.68198
1995.50	1.10194	0.69520	0.40674	12.35273
1996.50	1.50252	1.19083	0.31169	12.84836
1997.50	0.66320	1.64650	-0.98330	13.30403

Average squared residual : 0.17409

Table 13 (cont): Age by age observed, predicted, and residuals from ADAPT analysis.

newcpue
Age : 3
Ln calibration constant : -10.52949

Year	Observed	Predicted	Residual	Ln Pop.
1983.50	1.01233	1.90019	-0.88786	12.42968
1984.50	2.10243	2.29713	-0.19471	12.82662
1985.50	1.30046	1.71879	-0.41833	12.24829
1986.50	2.26644	1.87783	0.38861	12.40732
1987.50	1.62924	1.39453	0.23471	11.92402
1988.50	2.30249	2.22723	0.07525	12.75672
1989.50	1.94834	1.36433	0.58400	11.89383
1990.50	1.34313	1.21610	0.12703	11.74559
1991.50	1.68584	1.15265	0.53319	11.68215
1992.50	1.11350	0.80104	0.31246	11.33054
1993.50	1.24502	1.15232	0.09270	11.68181
1994.50	1.86872	1.50488	0.36384	12.03437
1995.50	1.34077	1.61251	-0.27174	12.14201
1996.50	0.84972	1.16955	-0.31982	11.69904
1997.50	1.09125	1.71049	-0.61924	12.23998

Average squared residual : 0.17684

newcpue
Age : 4
Ln calibration constant : -10.11541

Year	Observed	Predicted	Residual	Ln Pop.
1983.50	0.36116	0.98798	-0.62681	11.10339
1984.50	1.18784	1.42086	-0.23302	11.53627
1985.50	1.56674	1.52300	0.04374	11.63841
1986.50	1.26413	0.86632	0.39780	10.98173
1987.50	0.88211	1.10961	-0.22750	11.22502
1988.50	0.39137	0.66149	-0.27013	10.77690
1989.50	1.85848	0.95673	0.90175	11.07214
1990.50	0.09985	0.33202	-0.23218	10.44743
1991.50	0.21914	-0.28196	0.50109	9.83345
1992.50	0.13976	-0.17012	0.30988	9.94529
1993.50	0.54754	-0.69190	1.23944	9.42351
1994.50	0.48612	0.79981	-0.31369	10.91522
1995.50	0.96470	1.23628	-0.27158	11.35169
1996.50	0.18065	1.39217	-1.21152	11.50759
1997.50	0.77057	0.77771	-0.00714	10.89312

Average squared residual : 0.34150

JUV
Age : 1
Ln calibration constant : -8.45160

Year	Observed	Predicted	Residual	Ln Pop.
1984.00	5.44760	5.65483	-0.20723	14.10643
1985.00	3.77046	5.05237	-1.28191	13.50397
1986.00	5.65179	5.94910	-0.29731	14.40070
1987.00	5.28827	5.11224	0.17603	13.56384
1988.00	4.62497	5.05919	-0.43421	13.51079
1989.00	5.32203	5.43720	-0.11517	13.88880
1990.00	4.87901	4.78373	0.09528	13.23533
1991.00	5.23325	4.80092	0.43232	13.25253
1992.00	4.36437	4.95720	-0.59283	13.40880
1994.00	5.22843	4.58209	0.64634	13.03370
1995.00	5.52943	5.12119	0.40824	13.57280
1996.00	6.09605	5.51604	0.58001	13.96765
1997.00	6.36234	5.77184	0.59050	14.22344

Average squared residual : 0.29418

Table 13 (cont): Age by age observed, predicted, and residuals from ADAPT analysis.

Table 14: Summary of residuals from ADAPT analysis.

	RV				CPUE				Juv
age	1	2	3	4	1	2	3	4	1
1983.5	-0.67324	-0.59056	-0.71412	-0.39015	-0.53785	-0.34199	-0.88786	-0.62681	
1984.5	0.263645	-0.38943	0.588666	-0.08836	1.08018	-0.67926	-0.19471	-0.23302	-0.20723
1985.5	-0.68249	0.11594	-0.65391	0.4321	0.22846	-0.10489	-0.41833	0.04374	-1.28191
1986.5	0.365162	-0.11226	-0.03154	-0.09285	0.568229	-0.03947	0.388611	0.397804	-0.29731
1987.5	0.56122	0.259542	-0.1078	-0.53222	-0.45104	0.26952	0.234711	-0.2275	0.176029
1988.5	-0.09981	-0.03895	-0.27032	-0.17671	-0.85014	-0.35496	0.075254	-0.27013	-0.43421
1989.5	0.164016	-0.31999	-0.6828	-0.73724	0.497001	0.207276	0.584002	0.901753	-0.11517
1990.5	0.446179	0.072455	0.163712	-0.04961	-0.6697	0.344138	0.127026	-0.23218	0.095279
1991.5	-0.38371	0.377879	-0.05235	0.513098	-0.88283	0.420543	0.53319	0.501094	0.432324
1992.5	-0.9653	-0.1116	0.563769	0.228567	-0.27489	0.279452	0.31246	0.309881	-0.59283
1993.5	0.58264	0.199579	0.536352	1.651998	1.406373	0.397847	0.092698	1.239442	0.646337
1994.5	0.607015	-0.28353	0.084476	0.086741	0.075964	-0.13327	0.363844	-0.31369	
1995.5	0.112973	0.293479	0.343423	0.454288	-0.49617	0.406741	-0.27174	-0.27158	0.408237
1996.5	-0.22486	0.656425	0.420039	0.022236	0.819716	0.311693	-0.31982	-1.21152	0.580006
1997.5	-0.07339	-0.1289	-0.1875	-1.32175	-0.51324	-0.9833	-0.61924	-0.00714	0.590498

Table 15: Comparisons of 1997 estimates of population numbers from ADAPT to initial estimates from retrospective analysis, age by age.

		1997 est	initial est	proportion	avg
age 1	1992	655481	408486	1.60	0.83
	1993	625405	1974101	0.32	
	1994	450242	807562	0.56	
	1995	766817	873808	0.88	
	1996	1417532	1839170	0.77	
age 2	1992	371781	372103	1.00	0.80
	1993	433317	430284	1.01	
	1994	393598	642607	0.61	
	1995	300463	500176	0.60	
	1996	511167	674958	0.76	
age 3	1992	154008	223267	0.69	0.79
	1993	189179	210860	0.90	
	1994	223429	237042	0.94	
	1995	253063	357916	0.71	
	1996	172340	248769	0.69	
age 4	1992	46281	64881	0.71	0.77
	1993	45032	94005	0.48	
	1994	70384	83008	0.85	
	1995	121300	136061	0.89	
	1996	132834	145098	0.92	
age 5	1992	5649	14728	0.38	0.53
	1993	9290	20331	0.46	
	1994	3377	34387	0.10	
	1995	40024	47018	0.85	
	1996	56150	64711	0.87	
age 6	1992	1631	2213	0.74	0.40
	1993	1082	7147	0.15	
	1994	1912	8629	0.22	
	1995	1241	20777	0.06	
	1996	22637	26583	0.85	
age 7	1992	252	7065	0.04	0.56
	1993	141	187	0.75	
	1994	258	146	1.77	
	1995	1160	4992	0.23	
	1996	467	13039	0.04	
age 8	1992	49	77	0.64	0.53
	1993	45	118	0.38	
	1994	38	146	0.26	
	1995	158	326	0.48	
	1996	730	818	0.89	

Table 16: Estimates of spawning stock biomass, recruitments, and exploitation rate from ADAPT analysis.

year	SSB	age 1 #'s	exploitation rate (%)
1983	121689	802519	29
1984	145152	1337660	42
1985	177022	732326	50
1986	171289	1795348	55
1987	142880	777551	46
1988	133887	737598	46
1989	155014	1077964	69
1990	126807	560411	56
1991	101708	595884	73
1992	84686	704780	57
1993	54513	692148	63
1994	57277	493858	23
1995	62011	837317	19
1996	80636	1246202	18
1997	86433	1539090	18
1998	117663		

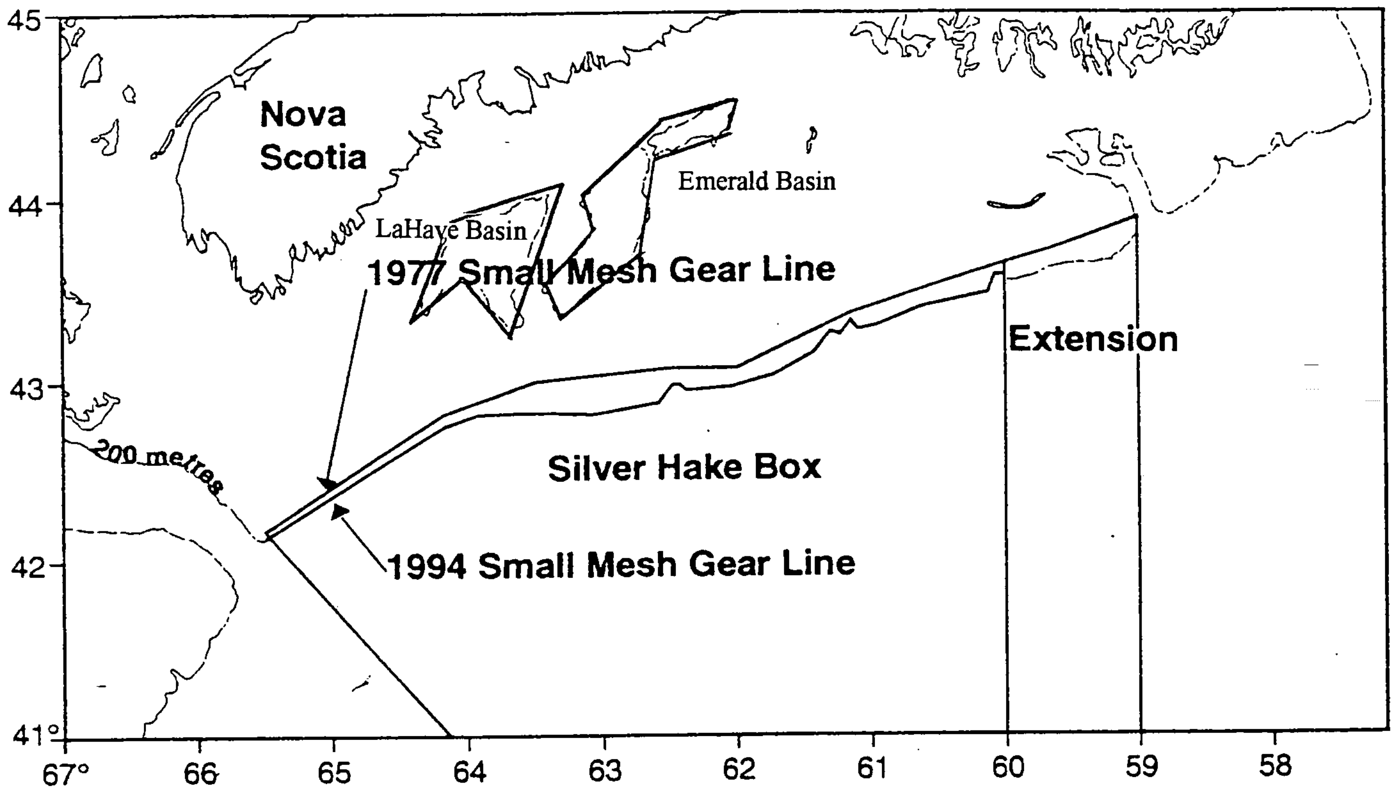
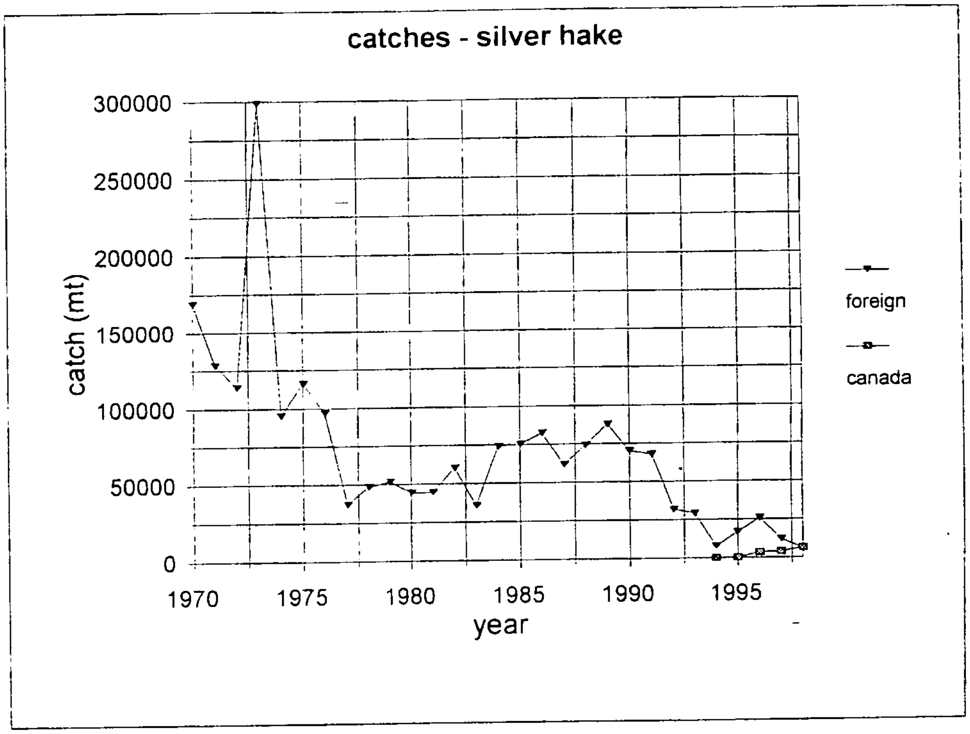


Fig. 1: Scotian shelf silver hake fishing areas.



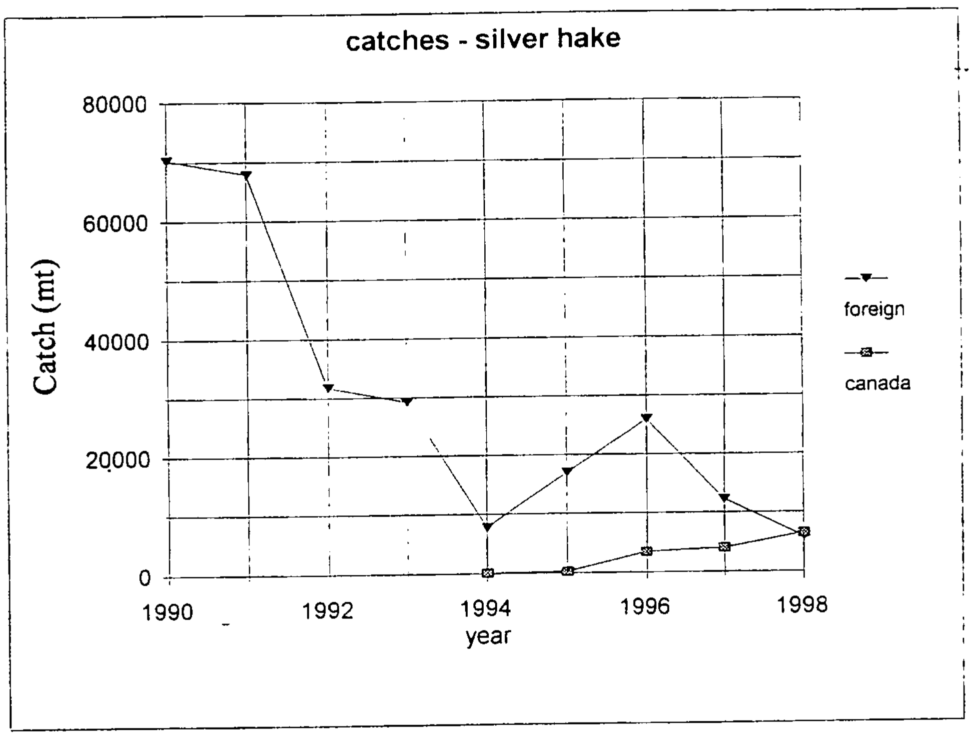


Fig. 2: Catches historical and recent catches of Scotian Shelf silver hake by Canada and foreign vessels.

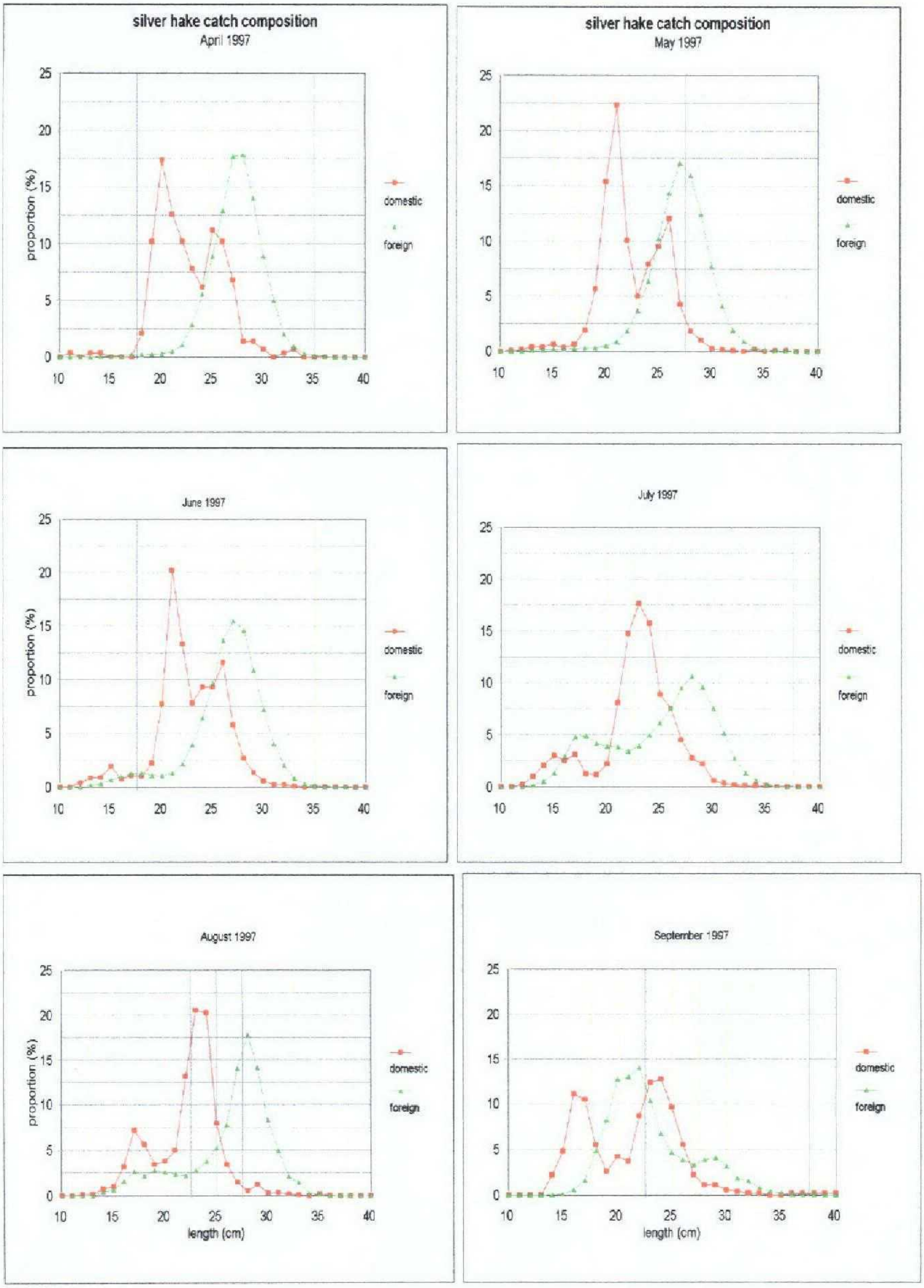


Fig 3: Monthly catch composition by length for Canadian and foreign fishing vessels. Canadian data from Industry, foreign data from Canadian observers.

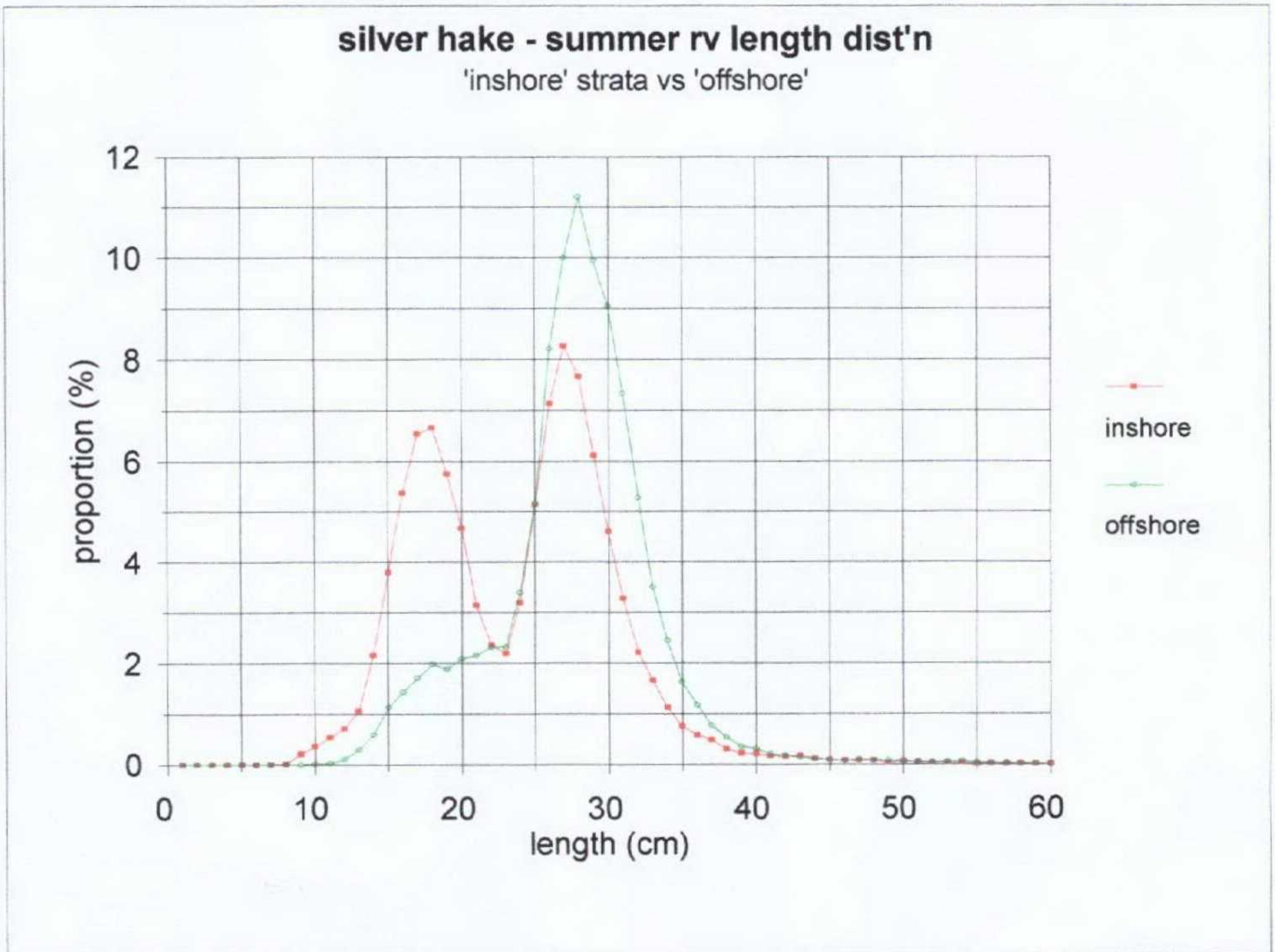


Fig. 4: Length composition of silver hake from July surveys, aggregated by inshore and offshore strata, 1970-1997.

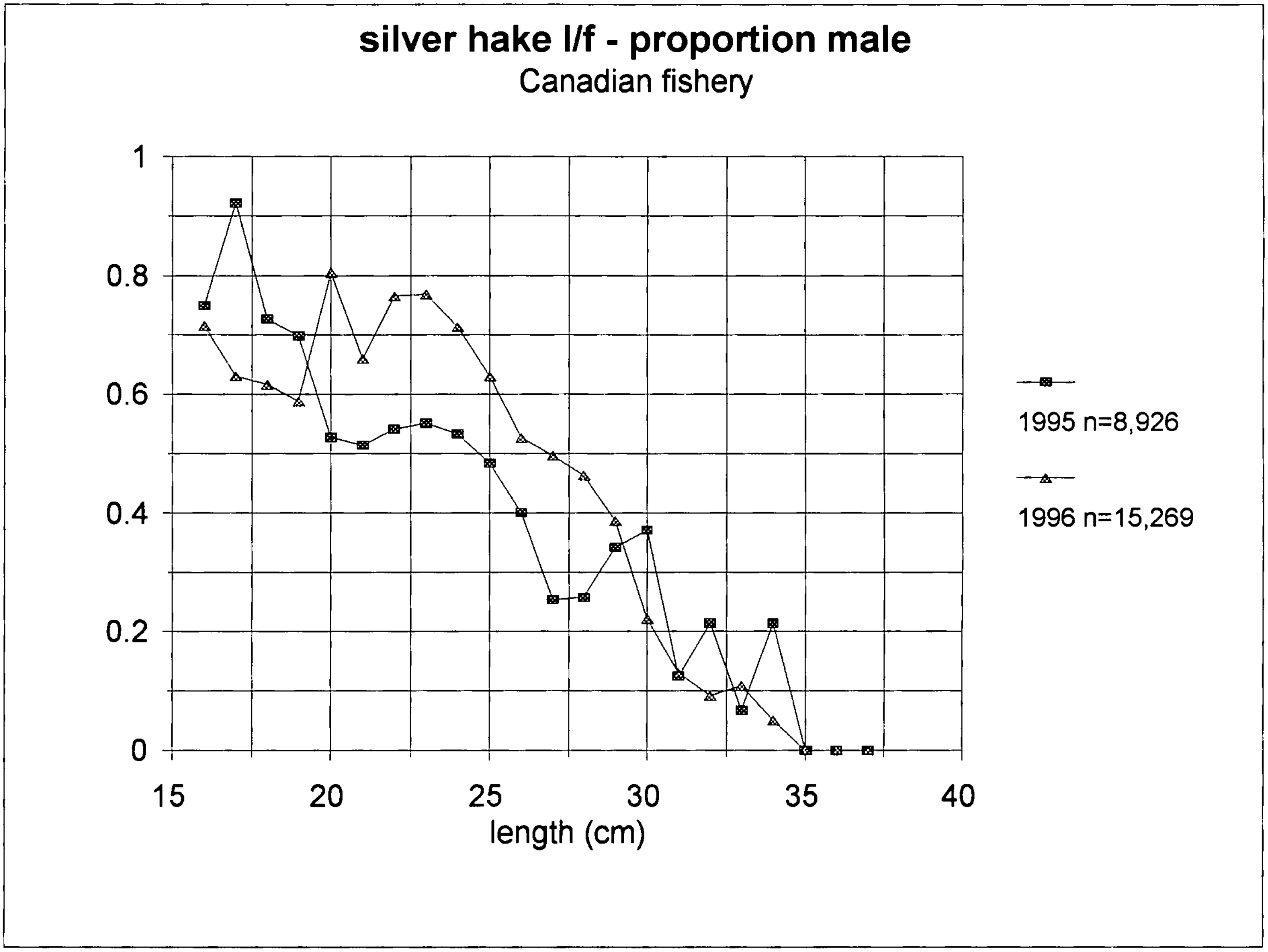


Fig. 5: Ratio of male to female Scotian Shelf silver hake, based on observer samples from Emerald Basin and LaHave Basins, collected in 1995 and 1996.

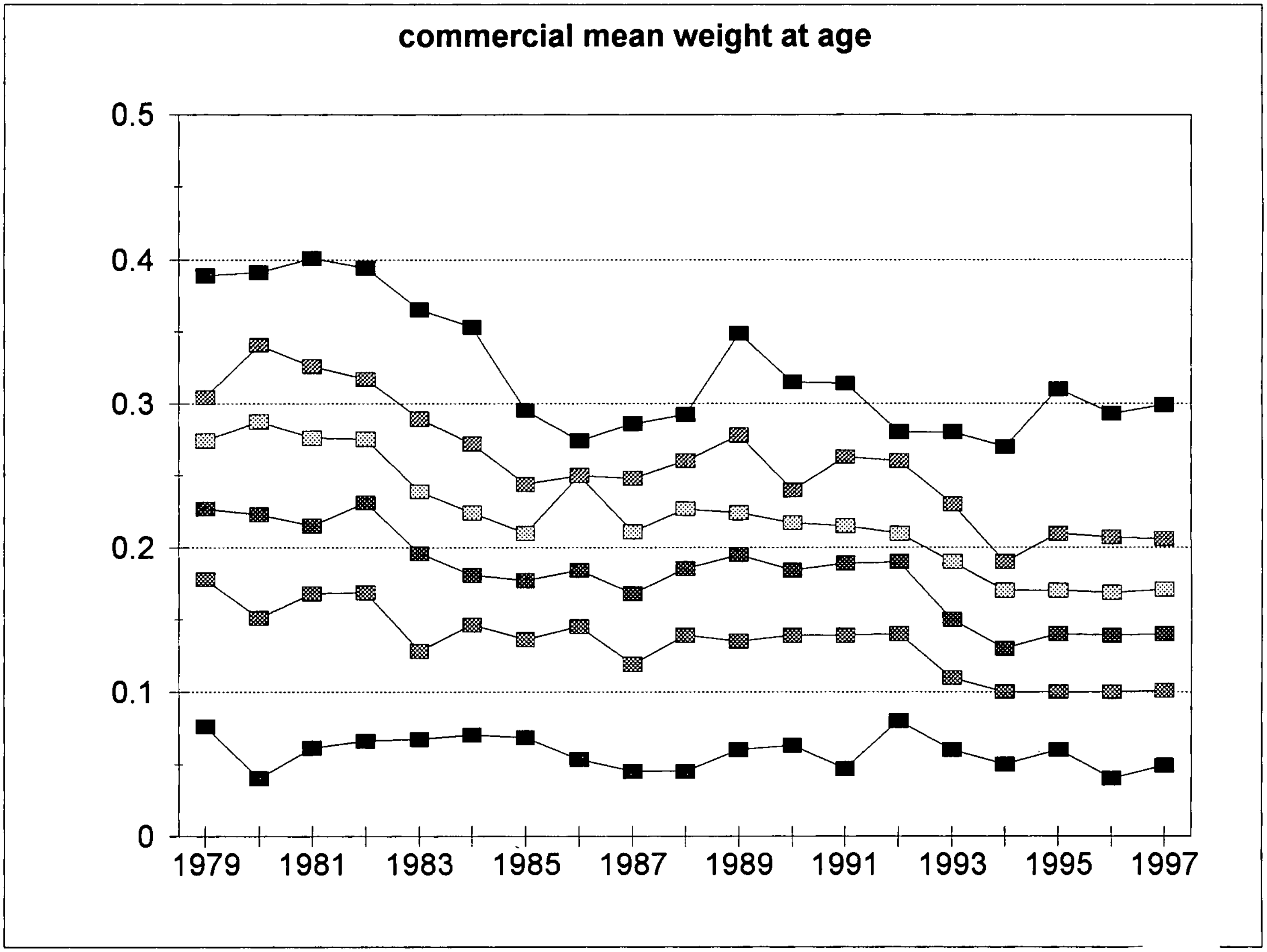


Fig. 6: Commercial mean weight-at-age for Scotian Shelf silver hake

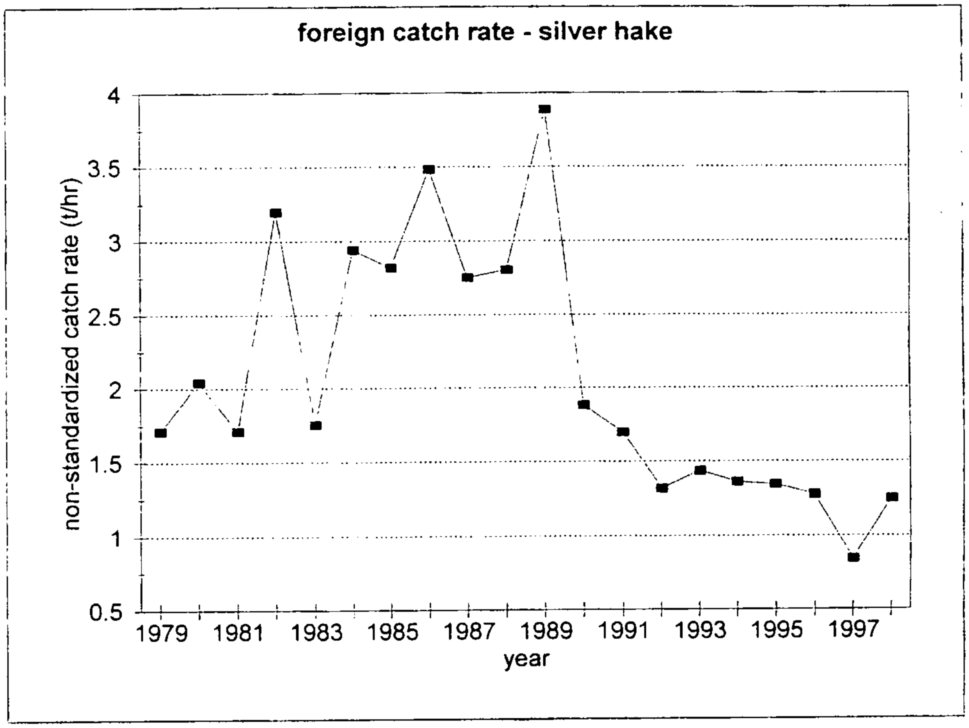


Fig. 7: Commercial catch rate by foreign vessels, 1979-98 for Scotian Shelf silver hake, from Canadian observer data

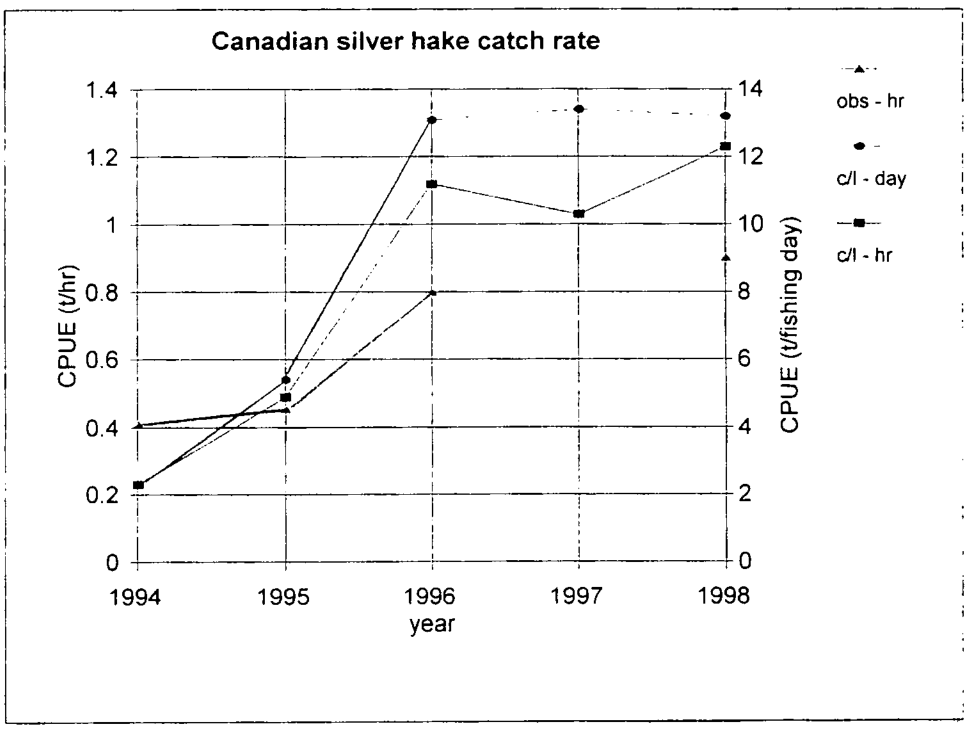
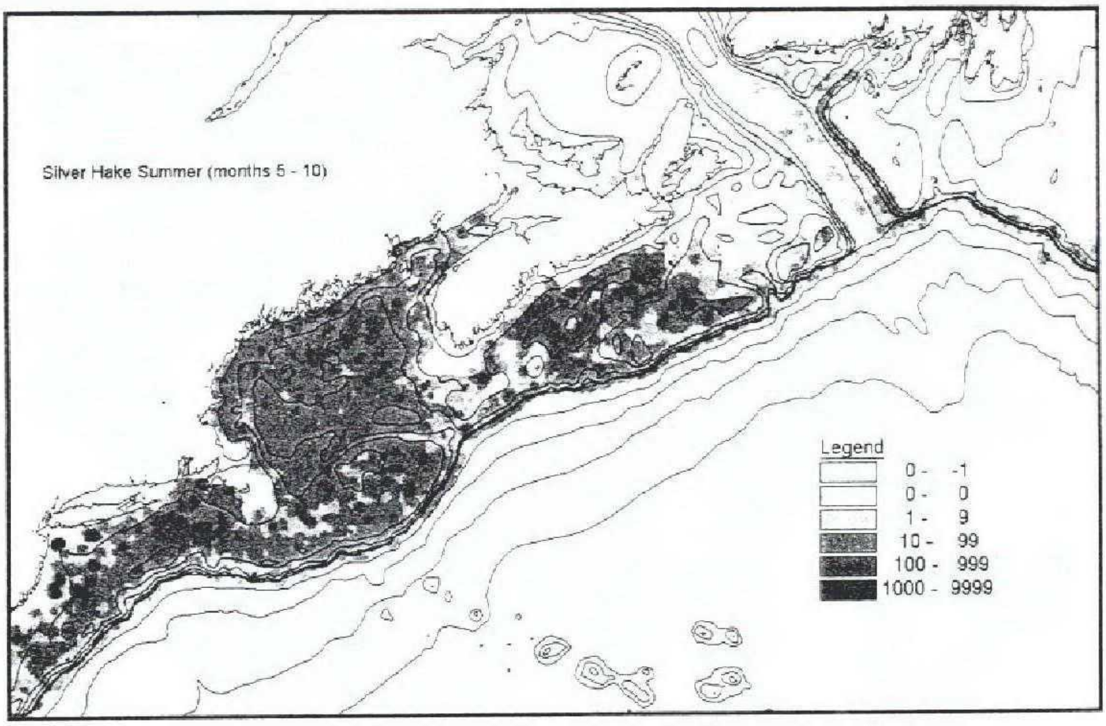


Fig. 8: Commercial catch rate by Canadian vessels, 1984-98 for Scotian Shelf silver hake, from Canadian observer data and commercial landings.



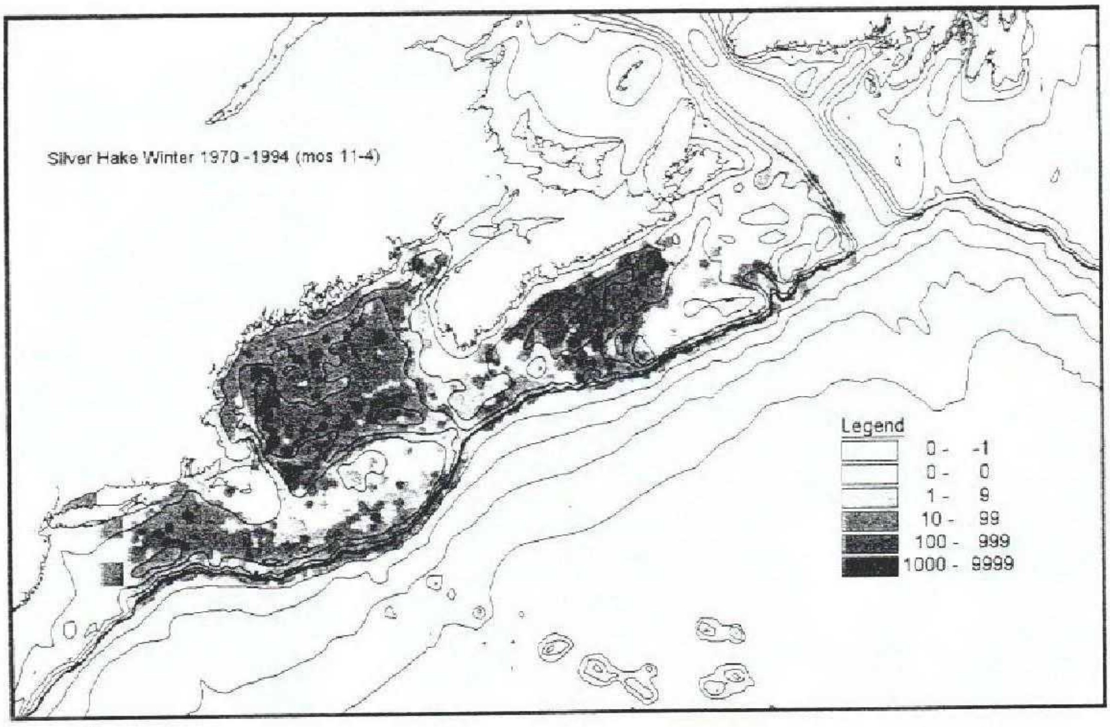
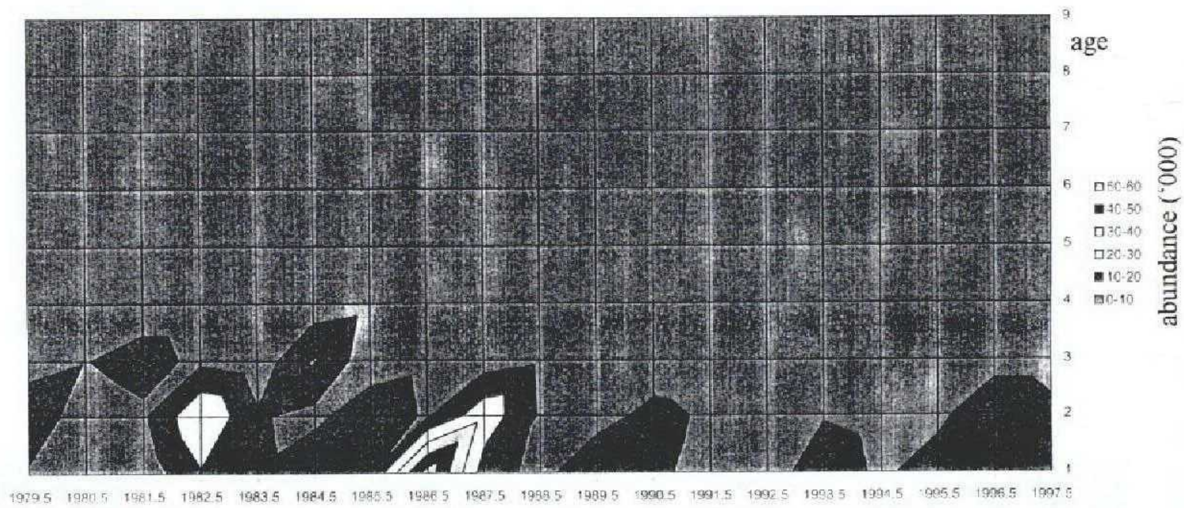
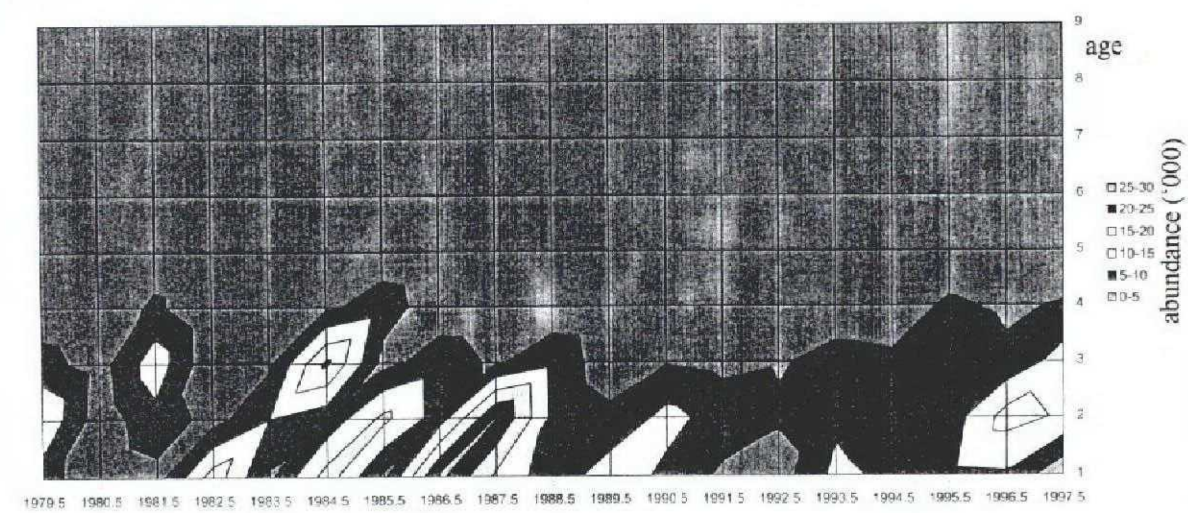


Fig. 9: Silver hake distribution (numbers) aggregated by season, from ECNSAP data set, 1970-1994.



Including Bay of Fundy strata



Excluding Bay of Fundy strata

Fig. 10: Contour plot of July RV numbers at age for Scotian Shelf silver hake, including and excluding Bay of Fundy strata.

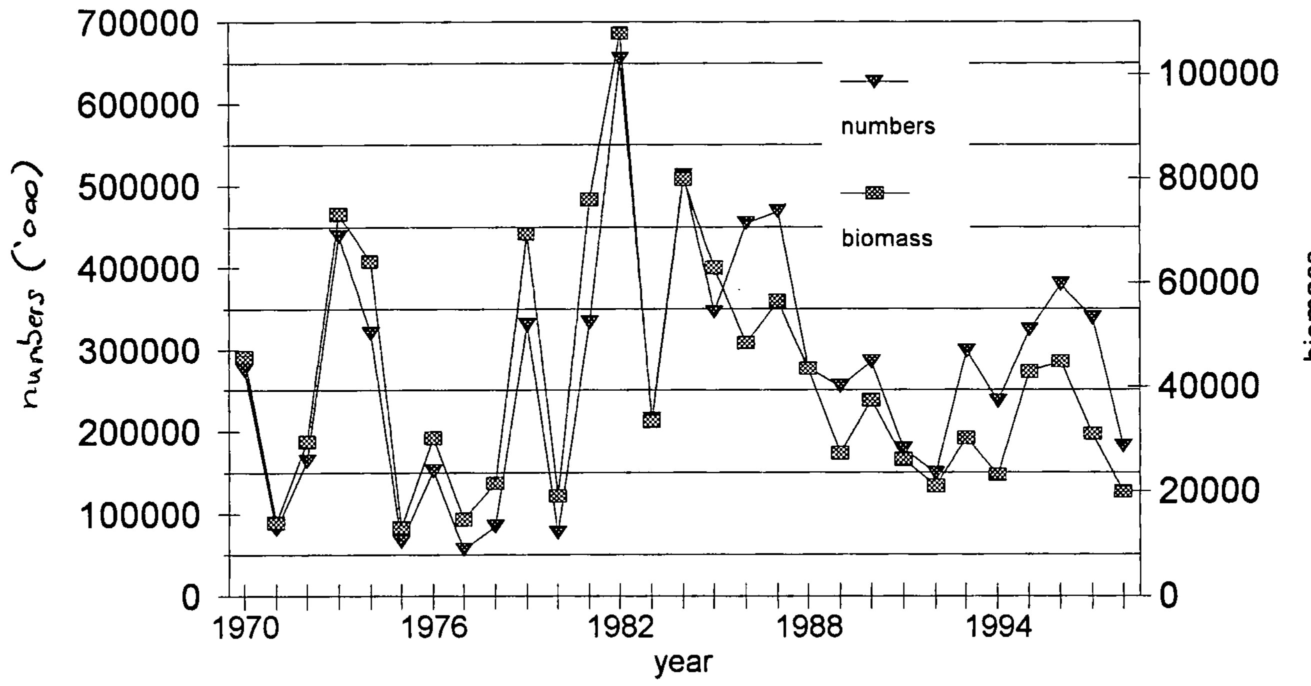
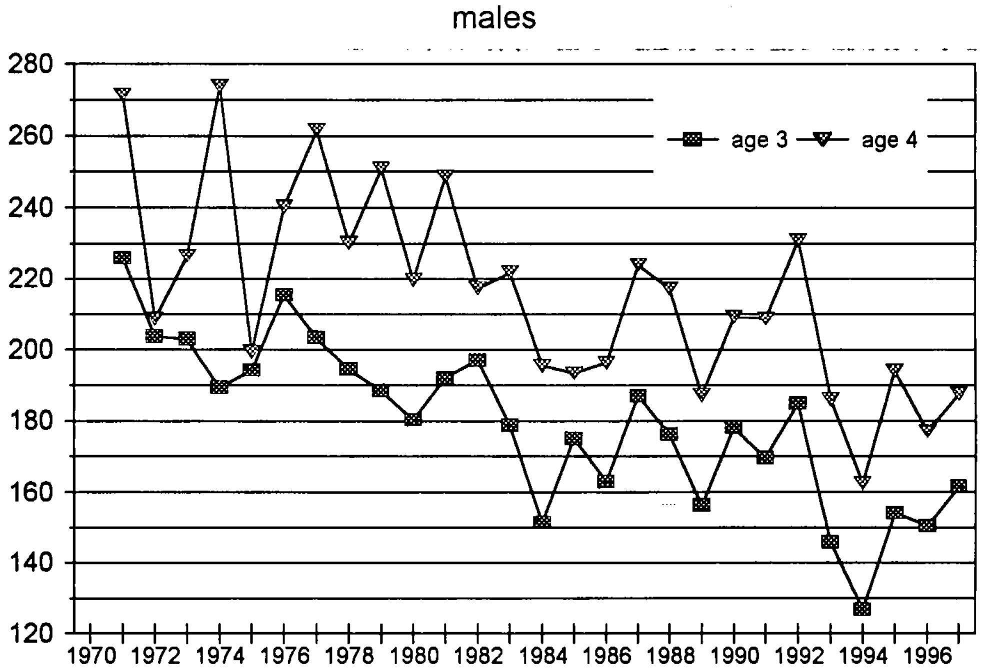


Fig. 11: Silver hake abundance and biomass estimates from Canadian July RV survey, 1970-1998 for Scotian Shelf strata 440-483 (excludes Bay of Fundy).



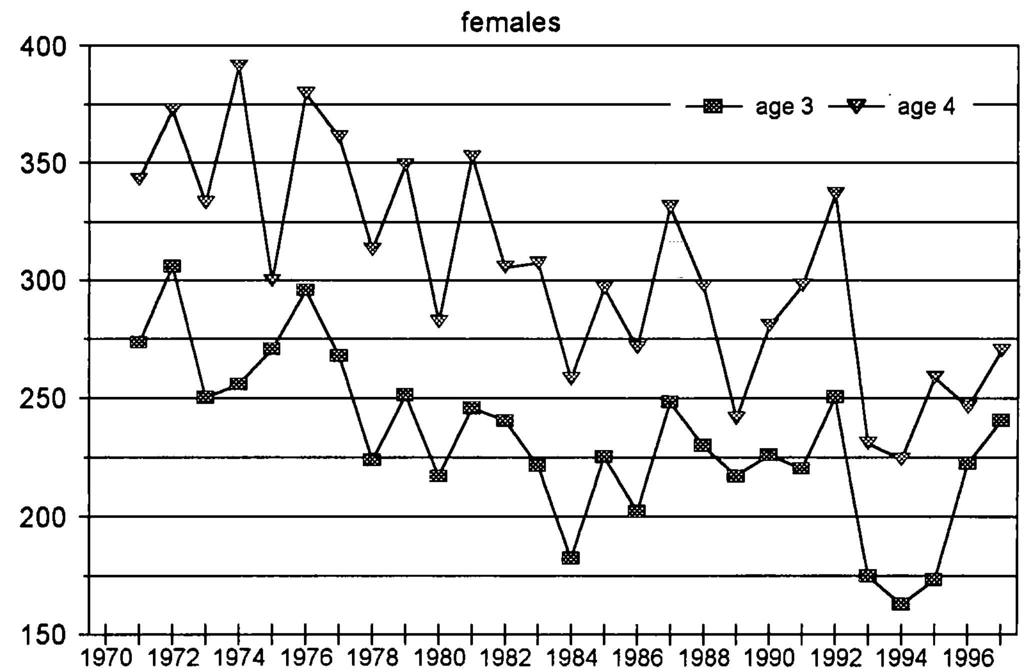
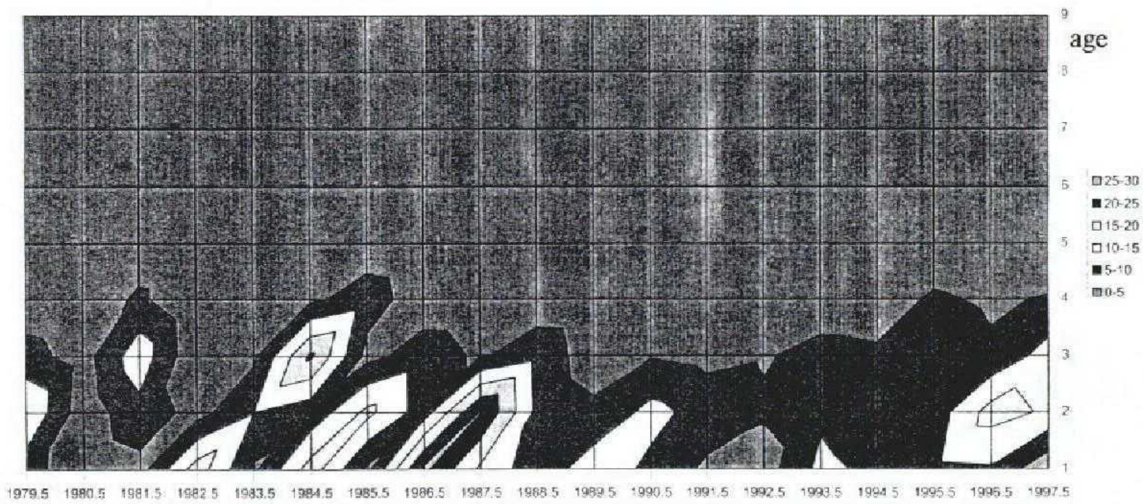


Fig. 12: Calculated weight-at-age for Scotian Shelf silver hake, from Canadian summer survey data, incorporating condidtion and mean length at age.

July RV



foreign CPUE

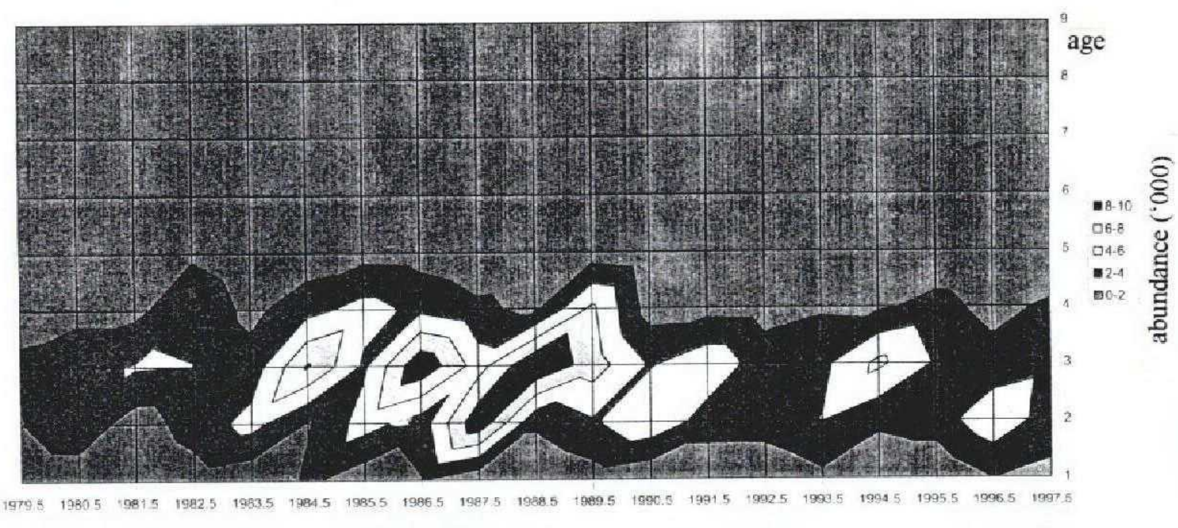


Fig. 13: Contour plots of silver hake numbers at age, over time,from Canadian July surveys and age disaggregated CPUE from the foreign silver hake fishery.

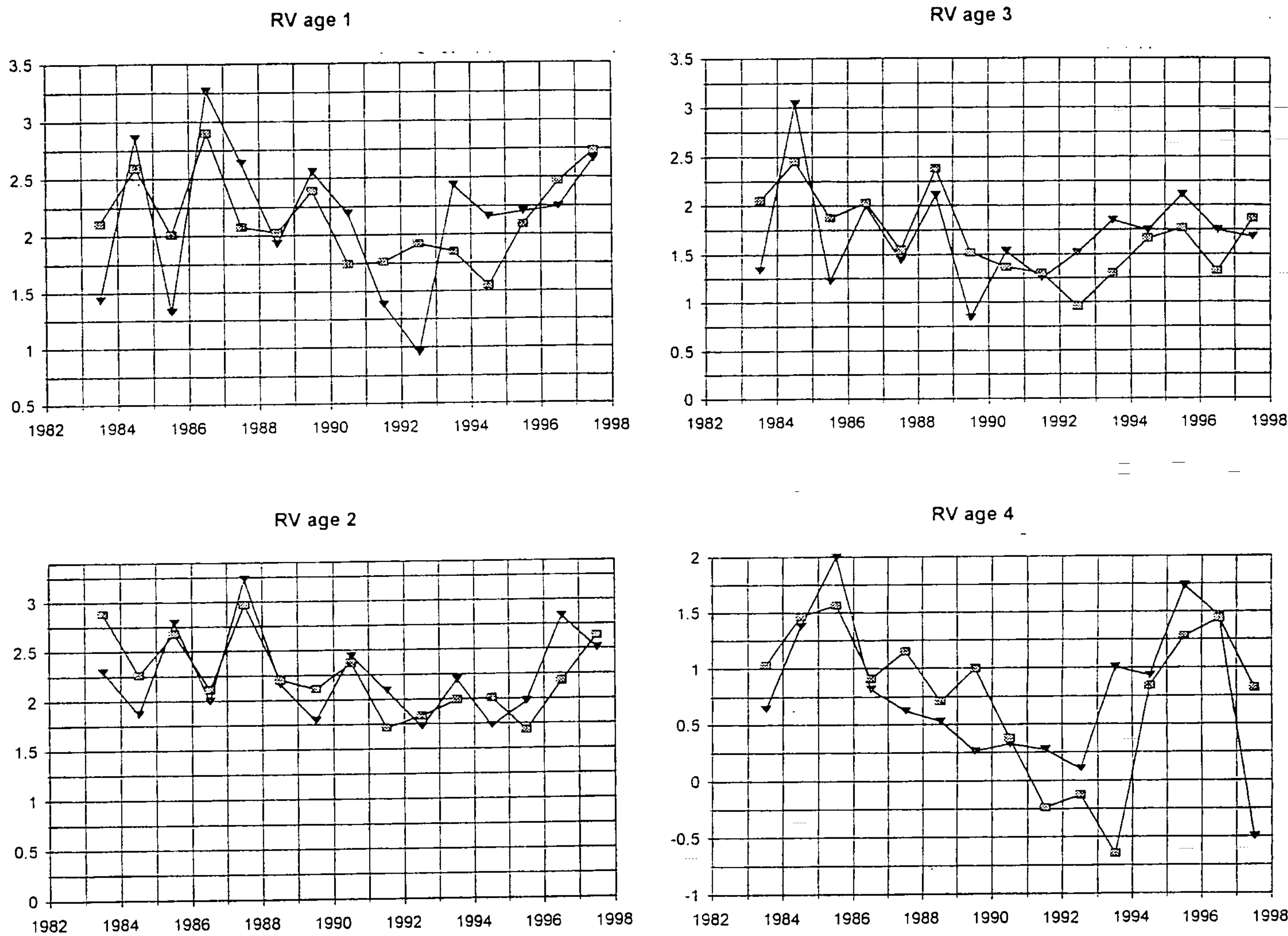


Fig. 14: Plots of residuals from ADAPT analysis, for RV survey

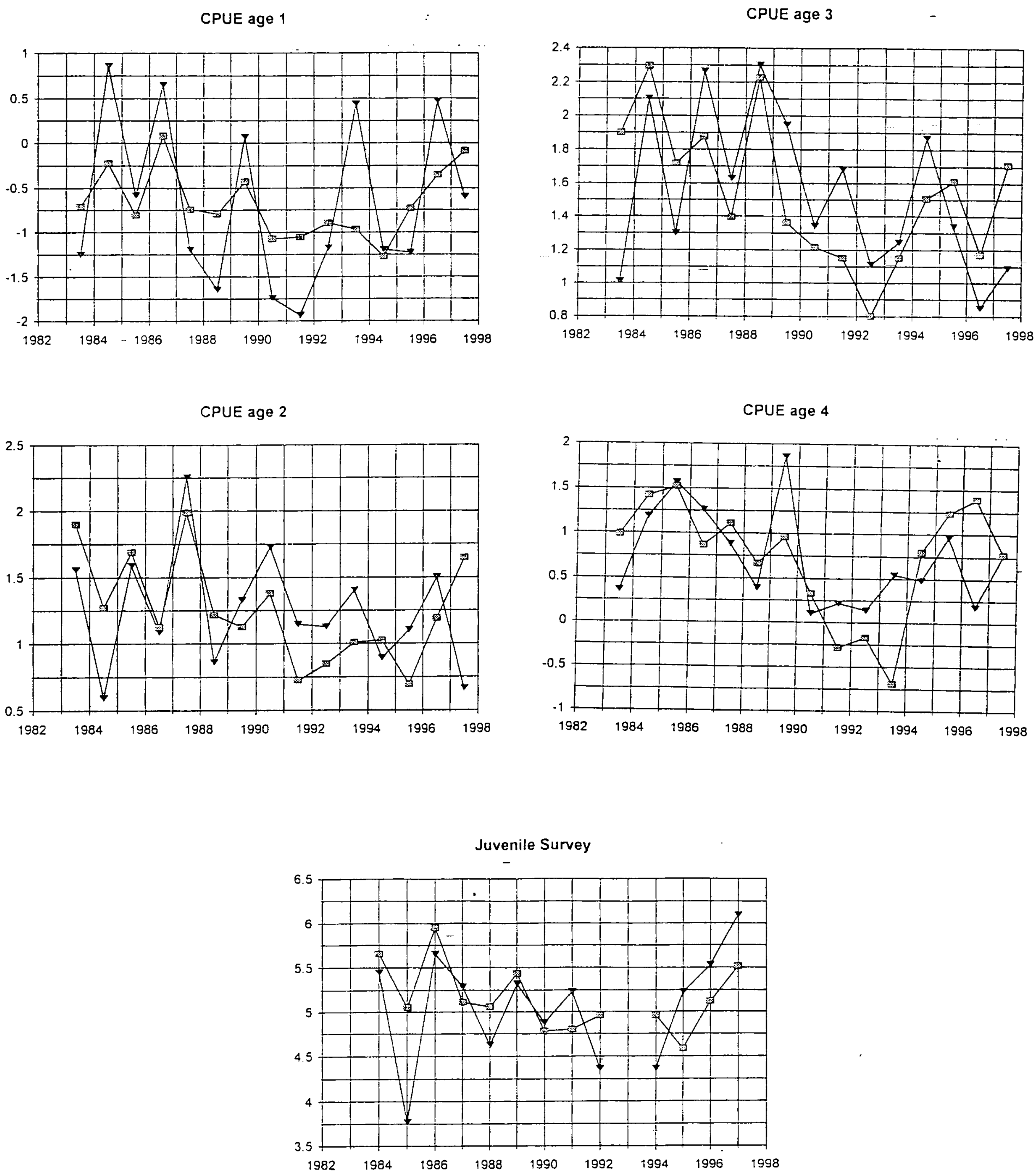


Fig. 15: Plots of residuals from ADAPT analysis, for foreign CPUE series and O-group survey.

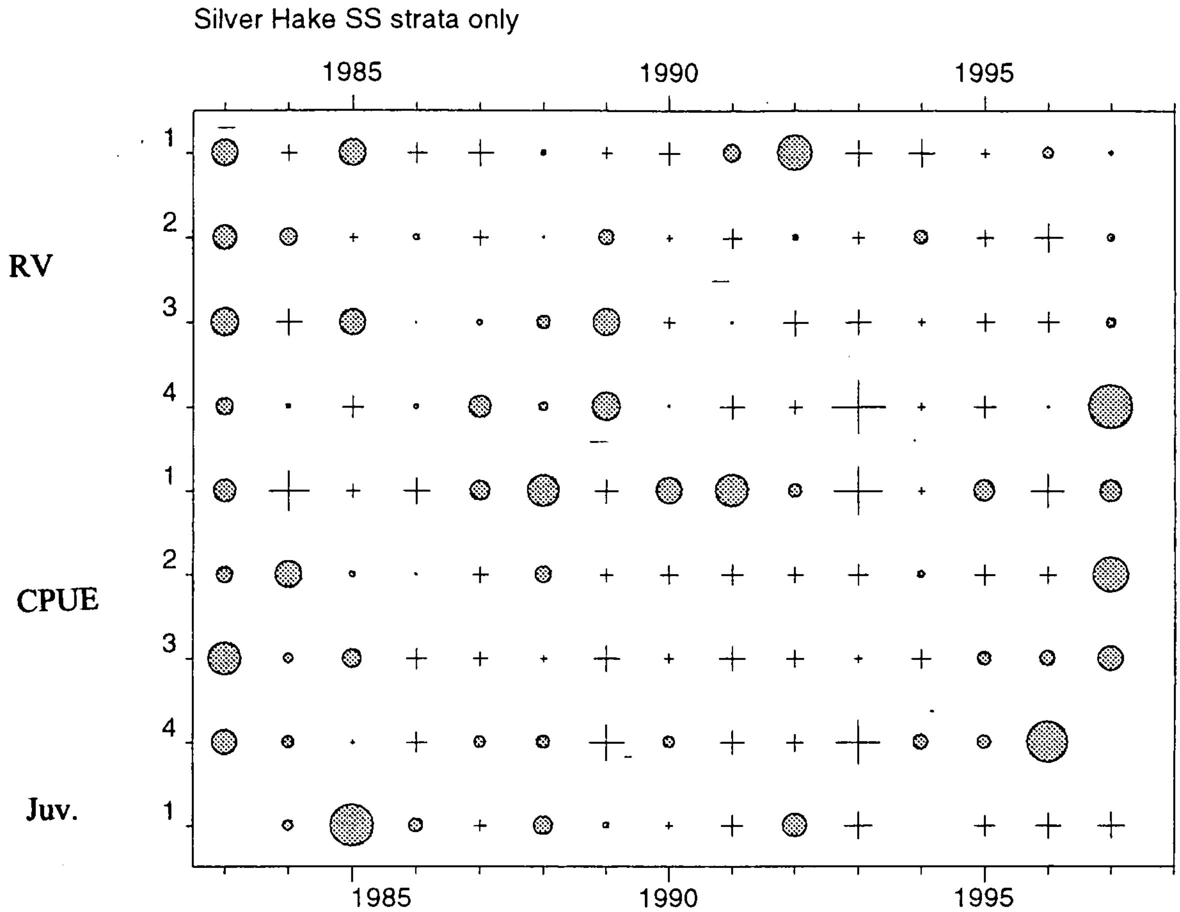


Fig. 16: 'Bubble plot' of residuals from ADAPT analysis. Plus signs indicate positive residuals, circles negative residuals. Magnitude of residual reflected in size of symbol.

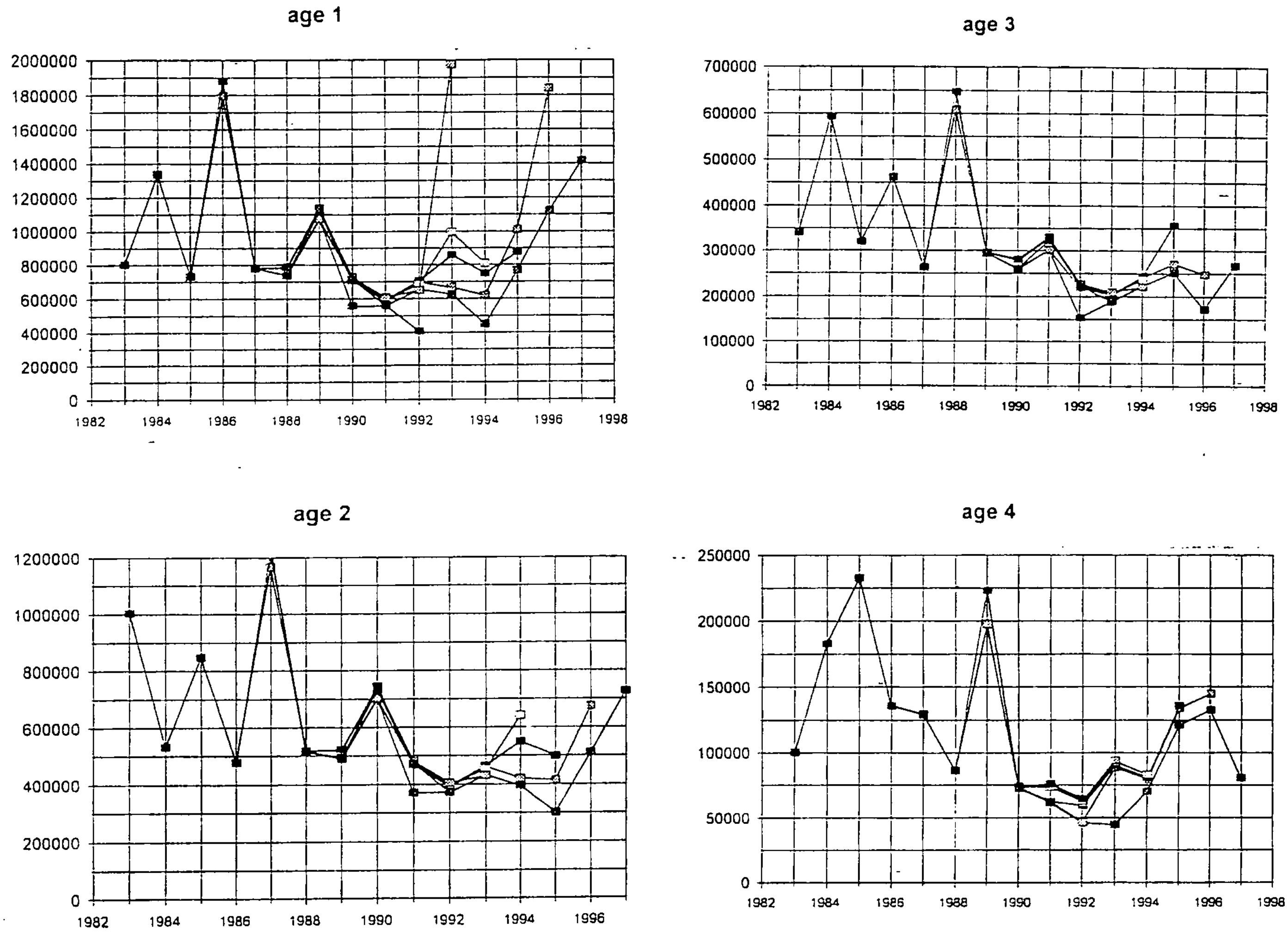


Fig. 17: Retrospective analysis of population numbers estimated by ADAPT for Scotian Shelf silver hake, ages 1-4.

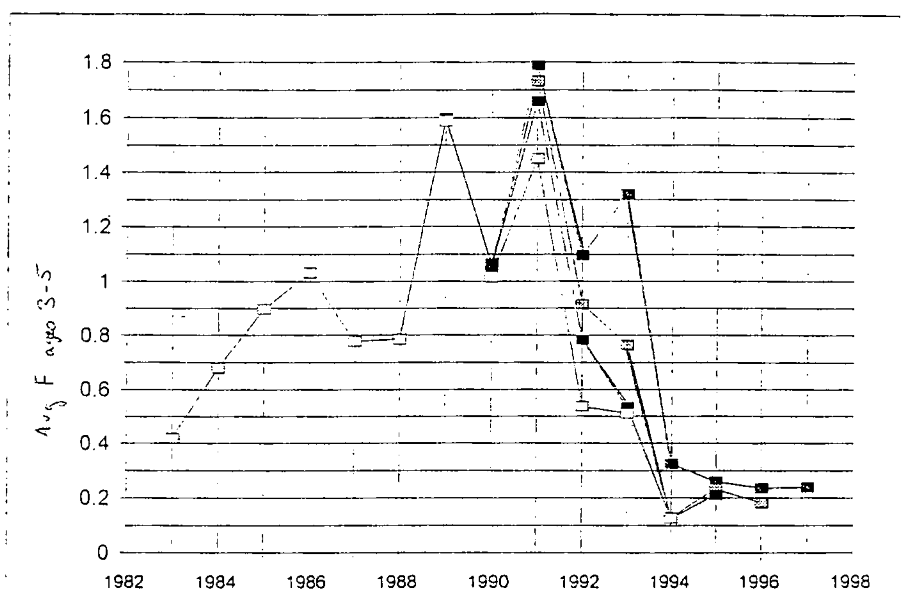


Fig. 18: Retrospective analysis of average fishing mortality for ages 3-5 estimated by ADAPT, for Scotian Shelf silver hake.

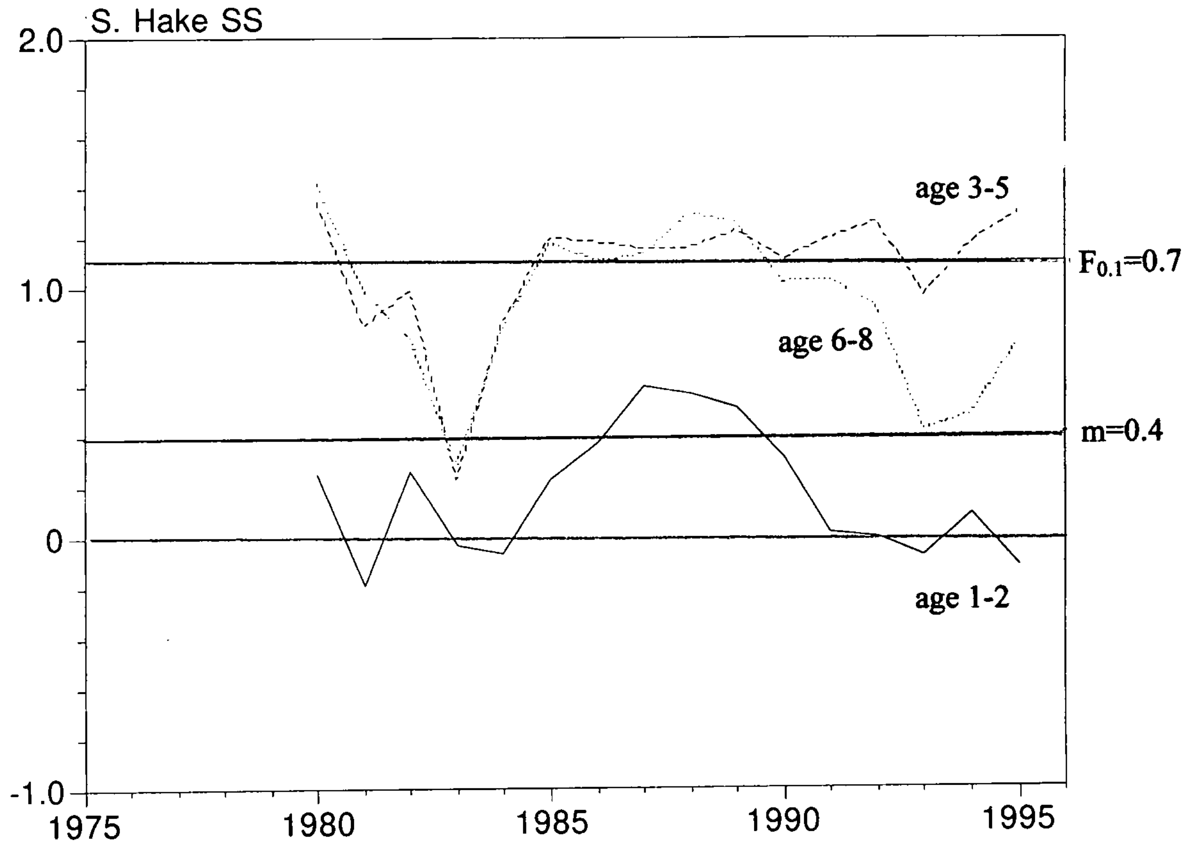


Fig. 19: Estimates of total mortality for Scotian Shelf silver hake from July RV surveys, grouped by ages 1-2, 3-5 and 6-8.

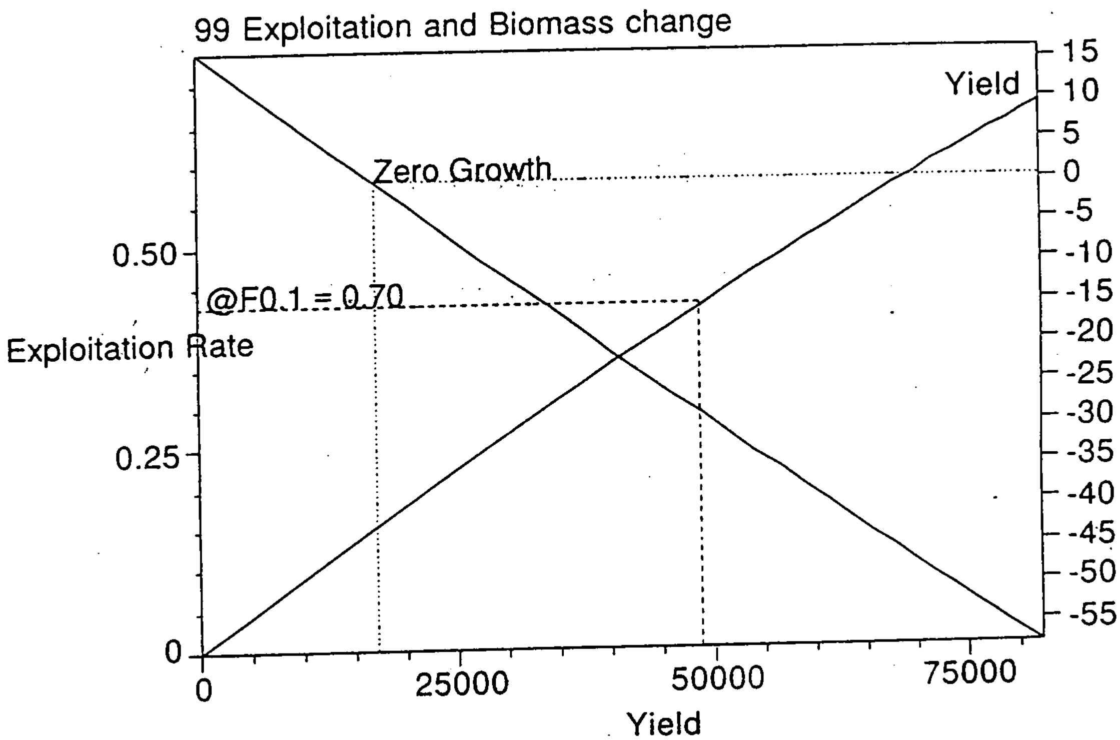


Fig. 20: **Exploitation rate and biomass change at various levels of yield for Scotian Shelf silver hake.**