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Assessment of 4X Haddock in 1993

by

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Abstract

The nominal catch of 4X haddock in 1993 was 6,832t in comparison to a TAC of 6,000t. While the 4X haddock fishery was dominated by mobile gear historically, the proportion of landings taken by fixed gear increased from 32% in 1988 to 61% in 1993. Consolidation of ITQs in the inshore mobile gear fleet continued in 1993 and the fishing strategy of avoiding haddock became more widespread. Although there was little change in the size composition of the overall commercial catch in recent years, mean size of the mobile gear catch has increased while there was has been a decrease in mean size of the fixed gear catch. Industry consultation was relatively extensive in 1993. There was general consensus in both the inshore fixed gear and mobile gear fleets that haddock abundance has increased in recent years and are more abundant than indicated by the 1993 survey. Commercial catch rate data from logbook information for the longline fleet indicated an increase from 1989-92 of 25% and a further increase in 1993. The 1993 research vessel survey abundance index is the lowest in the survey series. Haddock abundance in Browns Bank strata (477, 480, 481) showed no trend but dropped 50% in 1993. Abundance in strata to both the east and west have declined consistently since the early 1980s reaching the lowest levels in the series in 1993. A length-based SPA was conducted, converting numbers at length data to numbers at age using Cohort Slicing and SP-Key. A number of problems were identified with the analysis, that require further investigation. It was felt that the research vessel survey results for Browns Bank strata were not inconsistent with industry views; however the survey results for the overall management unit indicated very low spawning stock biomass and weak 1989, 1990 and 1991 year-classes. While this view differs from that often expressed during consultation, itgwas concluded that there should be no increase in fishing effort until this difference is resolved.

Résumé

Les prises nominales d'aiglefin dans la division 4X se sont établies à 6 832 t en 1993, le TAC étant de 6 000 t. Quoique la pêche de l'aiglefin dans cette division ait toujours été pratiquée majoritairement par des bateaux aux engins mobiles, la proportion des débarquements imputables à la flottille de pêche aux engins fixes est passée de 32 % en 1988 à 61 % en 1993. Le groupement des QIT dans la flottille de pêche aux engins mobiles s'est poursuivi en 1993 et la stratégie d'évitement de l'aiglefin dans les captures s'est répandue. Quoique la composition de l'ensemble des prises commerciales soit demeurée pratiquement la même ces dernières années, la taille moyenne des captures des bateaux de pêche aux engins mobiles a augmenté tandis que celle des captures de la flottille de pêche aux engins fixes a diminué. Les consultations avec l'industrie ont été relativement nombreuses en 1993. De l'avis commun des deux flottilles, l'abondance de l'aiglefin a augmenté ces dernières années et est supérieure à ce qu'indique le relevé de recherche de 1993. Les données sur les taux de prises commerciales provenant des journaux de pêche de la flottille de palangriers révélaient un accroissement de 25 % pour la période 1989-1992, et une autre augmentation en 1993. L'indice d'abondance provenant du relevé de recherche de 1993 est le plus bas de ceux de l'ensemble de la série de relevés. L'abondance de l'aiglefin dans les strates du banc de Browns (477, 480 et 481) ne révélait aucune tendance, mais accusait une chute de 50 % en 1993. L'abondance dans les strates situées à l'est et à l'ouest a constamment diminué depuis le début des années 1980, pour atteindre son plus bas niveau de la série en 1993. On a procédé à une ASP fondée sur la longueur, convertissant les nombres selon la longueur en nombres selon l'âge au moyen d'un découpage des cohortes et de la méthode SP-Key. Cette analyse a dégagé un certain nombre de problèmes. On a estimé que les résultats du relevé de recherche concernant la strate du banc de Browns ne contredisaient pas l'opinion de l'industrie, mais que les résultats du relevé pour l'ensemble de l'unité de gestion dénotaient une très faible biomasse de reproducteurs et de piètres classes d'âge de 1989, 1990 et 1991. Bien qu'il s'agisse là d'un point de vue divergent de ceux qui ont souvent été exprimés durant les consultations, on en a conclu qu'il ne devrait pas y avoir d'accroissement de l'effort de pêche tant que cette divergence n'aura pas été résolue.

Introduction

This document contains an evaluation of the NAFO Division 4X (Figure 1) haddock stock. As in the past, haddock caught in unit area 4Xs were not included in this analysis because they are believed to be part of the 5Y stock (Halliday 1974).

In a previous assessment of this stock (Frank et al. 1990), it was concluded that problems with the catch at age and/or the ADAPT formulation needed to be resolved before the results of Sequential Population Analysis (SPA) could be used as the basis for harvest advice. Since that analysis, it was determined that a bias was present in haddock ages in recent years. Ageing criteria for reading haddock otoliths for this stock are presently being evaluated and age data were not available for commercial or research vessel samples collected in 1992-93. The present analysis uses length-based data and assumes growth rates determined from the historical ageing data.

Description of the Fishery

Nominal Catches

The long-term (1930-88) reported annual landings of haddock in NAFO Division 4X have averaged about 20,000t. Landings peaked above 30,000t during the mid to late 1960s and again during the 1980s (Figure 2). Landings declined subsequently and have been below the long-term average since 1984. Catches reached a low of 6,700t in 1989 when it was recommended that the fishery be maintained at the lowest possible level and the mobile gear fishery was closed in mid-season. Catches increased since 1989 under a Management Plan that called for a by-catch fishery only. A TAC of 6,000t was implemented in 1993 and total landings were 6,832t (Table 1). The fixed gear and mobile gear fisheries were closed in late November and early December when respective allocations were taken. Inshore mobile gear (<65 ft) landings have remained low since 1989 and were 2,507t in 1993 (Table 2). Fixed gear (longline and handline) landings increased from 2,699t in 1989 to 6,468t in 1992 but decreased to 4,083t in 1993. Gillnet landings in 1993 were 97t and offshore mobile gear landings were 124t.

Allocations and management actions

Quota allocations and management actions for 4X haddock in recent years have been quite complicated, particularly during the mid to late 1980s, and were summarized in earlier assessments (Hurley et al., 1992, 1991). Annand and Hansen (1994) summarized allocations and management actions in 1993. While the 4X haddock fishery has been dominated by mobile gear historically, the proportion of the landings taken by fixed gear has increased from 32% in 1988 to 61% in 1993 (Table 2). The temporal pattern of the fishery changed in 1993

as a result of management actions (Figure 2). The winter haddock fishery that occurs in January and February in 4Xn was considerably reduced in 1993. The fixed gear landings from this fishery were reduced because they did not receive license conditions until January 28, 1993. Mobile gear landings during these months were also lower than previous years but this is likely as a result of 5Z license conditions being issued in January and February in 1993.

Since the introduction of individual transferable quotas (ITQs) in the inshore mobile gear fleet in 1991, fishing strategies have changed substantially within the fleet and there has been substantial consolidation of ITQs. Strategies in the ITQ fleet have continued to change with some vessels attempting to avoid haddock altogether.

The 4X haddock quota for 1994 was set at 4,500 t. With the reduction of 4X cod quotas in 1994, this strategy of avoiding haddock has become more widespread. Catch levels of small cod during the winter longline fishery became an issue in 1994. Small fish protocols came into effect and Observer reports indicated that some catches of small haddock were also greater than 15%. The use of 200 pound haddock trip limits in this fishery in 1994 resulted in discarding of haddock by this fleet (up to 3,000 pounds per trip).

Anecdotal information from the fishery

Discussions with industry representatives have indicated that substantial misreporting occurred during 1985-88, was low in 1989, and has increased slightly since. Attempts to quantify the levels of misreporting have been unsuccessful. DFO estimates of misreporting indicate it was less than 10% again in 1993. It is felt that some of this decrease is a result of Dockside Monitoring of the ITQ fleet.

Industry consultation regarding 4X haddock in 1993/94 has been relatively extensive. A number of fishermen, plant owners and representatives have been quite cooperative in discussing the progress of the fishery through the year. Consultation has ranged from these day to day ad hoc discussions, to discussions of stock status with fishermen at public and Association meetings, interviews with individual fishermen and in some cases construction of individual catch rate histories through examination of fishing records, to dedicated meetings with fishermen and plant owners to specifically discuss stock status and the input data to be used in the assessment process.

During consultation with fishermen prior to the review, there was general consensus in both the fixed gear and mobile gear fleets that haddock have increased in abundance in recent years and are more abundant than indicated by the 1993 July survey. Mobile gear fishermen indicated they had seen no change in the distribution of haddock in 4X in July of 1993, relative to previous years. Examination of monthly maps of haddock catches from the mobile gear fleet based on logbook data also showed no changes in the distribution of haddock between 1992 and 1993. Fixed gear fishermen trying to avoid haddock in 1994 report finding

haddock where there have not been any since the early to mid 1980s while mobile gear fishermen also trying to avoid haddock in 1994 report finding haddock deeper than usual and in areas they did not expect to find haddock.

The haddock avoidance nature of the fishery for the ITQ fleet, particularly in 1994, was stressed during consultations. Some vessels reported having switched to 155mm square mesh while directing for flatfish in an attempt to eliminate cod and haddock catches.

Data

Size composition of the catch

Age reading for 4X haddock otoliths was suspended in 1992 when it was determined that the extant ageing protocol had resulted in a bias in haddock ages in recent years. New criteria for reading 4X haddock otoliths are still being evaluated and therefore age data are not presently available for commercial samples collected in 1992-93. Consequently, commercial sampling data were used to construct a catch at length for 1993 in the same manner that would be used to construct a catch at age. The 1993 catch at length was constructed using the gear and quarter stratification shown in Table 4. A catch at length for the period 1978-92 was constructed by using the same grouping of commercial samples used previously to construct the catch at age. The catch at length for the foreign catch was calculated using samples from the International Observer Program (IOP). The catch at length was extended back to 1970 for this analysis by using the same grouping of commercial samples for the domestic catch as was used previously for the catch at age; however, in the absence of IOP sampling data, the catch at length for non-USA foreign catches for this period was constructed using the size composition from the July research vessel survey for the corresponding year. The catch at length for USA catches for the period was constructed by using the corresponding commercial samples from domestic mobile gear catches. The overall catch at length (1970-93) is shown in Table 5.

There was little change in the size composition of the commercial catch at length between 1993 and 1992 or between 1993 and the long-term 1970-92 mean catch at length (Figure 4). Modal lengths in the mobile gear and fixed gear catches in 1993 were 52 and 48 cm respectively (Figure 5). Since 1990, there has been an increase in the mean length in the mobile gear catch from 48 to 54 cm in 1993. During the same period, there has been a decrease in the mean length in the fixed gear catch from 54 to 49 cm.

Commercial catch rates

Commercial catch rates have not been considered a reliable index of haddock abundance in 4X due to the high and variable levels of misreporting, particularly in the mid-1980s, and the extent of management changes in the recent period. However in recent years, the longline

fleet has fished relatively unrestricted during January and February prior to the March 1 closure of Browns Bank. Catch rates of tonnage class 1-3 longline vessels fishing 4Xmnop in these months showed an increase of 25% from 1989 to 1992. Extension of this analysis indicated a further increase in 1993 (Figure 6). Individual catch rate histories derived from examination of fishing records through interviews of fishermen did not show consistent trends (Figure 7). During these interviews, some fishermen indicated that the 1993 values were not likely to be comparable to previous years since license conditions were not given until January 28 that year and they were restricted to 10,000 pound haddock trip limits. Most fishermen indicated that the 1994 values would not be comparable because they were limited to a single trip of 9,000 pounds or two trips of 4,500 pounds of haddock in the January/February period.

Research vessel surveys

Results of the groundfish research vessel surveys of the Scotian Shelf conducted in July 1970-93 were examined. The stratification scheme used in the survey is shown in Figure 8. Mean numbers per tow by stratum are shown in Table 6. Age data were not available for the July 1992-93 research vessel surveys. Research vessel catch rates at length were calculated for the survey series 1970-93 (Table 7).

Research vessel catch rates were low during the 1970s and high during the early to mid 1980s (Figure 9). Catch rates declined sharply in 1985-87 to low levels, increased to 1991 and have since declined to the lowest level observed in the series. Disaggregation of the survey data into categories less than and greater than 43cm shows the contribution of the 1987 and 1988 year-classes in 1988-90 and then a subsequent decline. Catch rates of the greater than 43cm category increased abruptly in 1990-91 but then declined as abruptly in 1992-93, suggesting a year effect.

Modes in the long-term research vessel survey mean catch at length corresponding to ages 1-5 are present at 20.5, 32.5, 40.5, 48.5 and 54.5cm (Figure 10). Comparison of the catch at length for the most recent surveys with the long-term mean indicates that the 1987 and 1988 year-classes were average in strength, the 1989 year-class was weak (perhaps the smallest in the series), and the 1990 and 1991 year-classes were below average. The catch at length of the 1993 survey indicates that the 1992 year-class was about average in strength, but that earlier year-classes, particularly the 1987 and 1988, were considerably reduced in abundance and implying they had been subjected to extremely high mortalities.

The distribution of haddock catches in the 1993 research vessel survey (Figure 8) was, in general, consistent with the inshore mobile gear fishery in the same month and was comparable to previous years (Table 6). The strata on and around Browns Bank (477, 480, 481) on average contribute approximately 50% of the survey abundance signal while stratum 490 in the mouth of the Bay of Fundy contributes an additional 15%. When survey strata are grouped into strata on and around Browns Bank (477, 480, 481), strata west of Browns Bank

and in the Bay of Fundy (482-495), and strata east of Browns Bank (470-476, 478), haddock abundance in the stratum grouping around Browns Bank shows no trend, varying around the mean (Figure 11). Abundance in this stratum grouping decreased approximately 50% in 1993. The stratum groupings to the east and west both show a decreasing trend since the early 1980s, each reaching the lowest level in the series in 1993. This pattern is consistent with haddock distribution expanding and contracting around a centre (Browns Bank) as overall abundance increases and decreases. The decrease in abundance in the survey strata to the east of Browns Bank is consistent with a general cooling trend on the eastern banks in 4X seen in the July research vessel survey bottom temperatures (Smith and Page, 1994). An analysis of the associations between haddock, temperature and depth in the research vessel surveys showed that haddock are almost always associated with water >2°C (Smith et al. 1994). Mean bottom temperatures in the July research vessel survey strata on Lahave, Roseway and Baccaro Banks show a decreasing trend in recent years and, in 1993, it was quite cold (2.2 to 3.0°C) in these strata compared to other locations in 4X (Smith and Page, 1994). This is consistent with the observation of below average temperatures at 50m in Roseway Channel in recent years (Drinkwater and Pettipas, 1994).

The size composition of haddock caught in an exploratory inshore survey conducted in late July/early August in 1991-93 in 4X is comparable with the regular July survey result and suggests that the 1992 year-class is strong (Figure 12).

The size composition of the bycatch of 4X haddock in the foreign small mesh gear fishery has been reflective of incoming year-class strength. The size composition of the 1993 bycatch also suggests that the 1992 year-class is strong (Figure 13).

Estimation of Parameters and Assessment Results

In the absence of age data in 1992-93 and the bias in age data in recent years, a length-based sequential population analysis (SPA) was conducted, using a modified version of the ADAPT framework (Gavaris, 1991). Three methods of converting numbers at length data to numbers at age were used: Cohort Slicing, Kimura-Chikuni and SP-Key (Keymake). The Cohort Slicing method uses only mean length at age information to slice numbers at length for each year into numbers at age. The midpoints between mean lengths are used as slicing points. The Kimura-Chikuni method uses the standard deviation of the mean length at age as distributional information in constructing an age template. The Keymake method uses the numbers at age from Cohort Slicing or Kimura-Chikuni as a starting point but then uses SPA iteratively to modify the age template to incorporate information about cohort strength from the SPA. These methods were described in more detail by Mohn (1993) together with a comparison of the results of tests of the methods using generated data.

Mean lengths at age were calculated from the July research vessel survey data, using the ageing data from 1970-91. This ignores the bias that is believed to be present in the recent 4X haddock ageing data. These mean lengths were comparable to mean lengths calculated

using the data from 1970-82 (which are free from this bias); however the standard deviations for the older ages were larger when the more recent years were included. Using mean lengths assumes a static growth model whereas spatial and temporal trends in size at age are known to exist. This will require further investigation. Mean lengths at age used were 20 31 40 48 54 58 and 60cm for ages 1 to 7 respectivley. Older ages were not used in the analysis because less than 5% of the catch has been taken from older ages, since the early 1970s, (Hurley et al. 1992) and because it is not possible to separate modes for older ages. This results in progressively less accurate slicing at the older ages.

The numbers at length used in the analysis were restricted to lengths greater than or equal to 14.5cm to eliminate young-of-the-year haddock that occasionally occur in the research vessel survey. These would otherwise have been assigned to age 1 by Cohort Slicing. Similarly the analysis was limited to haddock less than or equal to 66.5cm in length to reduce the problems associated with accumulating too many ages into a 7+ age group. The catch at length and research vessel survey numbers at length data, together with the mean lengths at age used in the slicing are shown in Figure 14 and 15 respectively.

Examination of the historical catch at age indicated that since the early 1970s at least 80% of the catch has occurred between ages 3 and 6. As a result, these ages were used as index ages in the tuning.

The length-based portions of the analysis used Cohort Slicing and Keymake (iteratively) to estimate numbers at age from the commercial and research vessel survey numbers at length. The Kimura-Chikuni method was rejected as it resulted in excessive accumulation of strong year-classes. The age-based portion of the analysis was performed using ADAPT to fit the model described as:

Parameters:

Terminal F estimates $F_{i,1993}$, i = 3-6
Calibration coefficients $K_{1,i}$, i = 3-6 for July RV survey

Structure Imposed:

Error in catch assumed negligible
Partial selection fixed for "ages" 1, 2 and 7 in 1993
F on oldest age (7) set as average of "ages" 3-6
No intercept was fitted
M = 0.2 for all ages

Input:

$C_{i,t}$ i = 1-7; t = 1977 to 1993 - full year catch at "age"
$J_{i,t}$ i = 3-6; t = 1977 to 1993 - July RV index

Objective function: Minimize

$$\Sigma\Sigma \, (\ln J_{i,t} - K_{1,i} N_{i,t})^2$$

Summary:

Number of observations = 68 for July RV (4 ages by 17 years)
Number of parameters = 8, F's estimated by NLLS, K's algebraically

Two minimization techniques were used, one using a nonlinear least squares (NLLS) gradient technique (the Marquardt algorithm) and the other using a Partitioned Search algorithm. The NLLS technique is a compiled version of ADAPT written in C. The Partitioned Search algorithm evaluates the model using a series of specified parameter estimates rather than following a gradient.

Using the full data series (1970-1993), estimated population numbers did not correlate well with the research vessel survey, particularly in the early part of the series. Removing years successively from 1970 to 1984 resulted in a decrease in overall residuals (Figure 16). Estimates of K at age for these successive runs showed a monotonic increase over time (Figure 17).

The reason for the trends in residuals and Ks as years are removed from the analysis are unknown and will require further investigation. Noticeable changes in the rate of reduction in residuals occurred in 1974 and 1977. We decided to use the data from 1977-93, as the reduction in residuals appeared to level off at that point.

A problem was encountered using NLLS to evaluate the model with this data set. The procedure iterated to different Fs in the terminal year when using different starting values of F. To investigate this, a Partitioned Search using starting values of F ranging from 0.1 to 1.0 was performed. The resulting final estimates of Fs in the terminal year and the catchability coefficients are shown in the table that accompanies Figure 20. With the exception of the series using F=0.1 as staring values, the resulting final estimates of F and of K were essentially the same. Estimated age 3-6 population numbers and the K-corrected research vessel survey numbers showed the same pattern (Figure 20).

The results of the model using NLLS and Cohort Slicing are given in Table 8 and the corresponding results using Keymake are given in Table 9. Residuals were slightly smaller and the pattern of residuals over the index ages was improved when Keymake was used. Estimated population numbers better reflected year-class strengths as indicated by the research vessel survey. Only one iteration of Keymake was used. Residuals began to increase again with further iterations. Estimates of population numbers, fishing mortality, recruitment and population biomass from the Keymake run are shown in Figure 21-24.

Initial estimates of selectivity were obtained from the most recent SPA (O'Boyle et al. 1989). New selectivities were calculated from the resulting estimates of fishing mortality in 1990-92.

Age	1	2	3	4	5	6	7
starting selectivity	.001	.012	.111	.291	.690	1.00	1.00
resulting selectivity	.001	.013	.151	.557	.827	.558	1.00

It was felt that the resulting selectivity pattern may be due to the overestimation of age 7 population numbers.

The results of a retrospective analysis using Keymake are shown in Figure 25. These revealed similar patterns in F where F in the current year is underestimated relative to the retrospective view.

These techniques are relatively new. A number of problems were identified with the analysis. These need to be evaluated further before the resulting numbers can be used; however it was felt that the overall trends were consistent with observations from the research vessel survey.

Prognosis

The research vessel survey results in the central area of 4X, those strata on and around Browns Bank (strata 477, 480, 481), are not inconsistent with the catch rate data from the fixed gear fleet and of anecdotal reports from the mobile gear fleet. Abundance has been relatively high as the 1987 and 1988 year-classes progressed through the fishery. For the overall management unit however the 1993 research vessel survey indicated very low stock biomass and weak 1989, 1990 and 1991 year-classes. While this differs from the view of 4X haddock stock status often expressed during consultations, there should be no increase in fishing effort until this difference is resolved.

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Table 1. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding Unit Area 4Xs) by country. The numbers in brackets represent the number of commercial samples collected in that year.

Year	Canada (MQ)	Canada (NFLD)	USA	USSR	Spain	Other	Total	TAC
1970	15560 (26)	-	1638	2	370	12	17582	18000
1971	16067 (29)	-	654	97	347	1	17166	18000
1972	12391 (36)	-	409	10	470	1	13281	9000
1973	12535 (30)	-	265	14	134	6	12954	9000
1974	12243 (25)	-	660	35	97	-	13035	-
1975	15985 (56)	-	2111	39	7	2	18144	15000
1976	16293 (45)	-	972	-	95	5	17365	15000
1977	19555 (79)	-	1648	2	-	12	21217	15000
1978	25299 (62)	114	1135	2	-	27	26577	21500
1979	24275 (49)	268	70	3	-	15	24631	26000
1980	28209 (56)	71	257	38	-	37	28612	28000
1981	30148 (82)	117	466	-	-	15	30746	27850
1982	23201 (92)	28	854	-	-	4	24087	32000
1983	24428 (119)	44	494	17	-	7	24990	32000
1984	19402 (97)	23	206	-	-	-	19631	32000
1985	14902 (86)	-	25	-	-	1	14928	15000
1986	14986 (78)	-	38	10	-	-	15034	15000
1987	13538 (82)	-	17	-	-	-	13555	15000
1988	10921 (79)	-	2	53	-	-	10976	12400
1989	6666 (43)	-	1	33[1]	-	-	6700	4600
1990	7297 (71)	-	32[1]	17[2]	-	3[2]	7342	4600
1991	9636 (81)	13	-	38[2]	-	3[2]	9690	-
1992	10329 (89)	5[1]	-	-	-	17[2]	10351	-
1993	6811 (86)	-	-	-	-	21[2]	6832	6000

Long-term Averages:
1930 - 60 = 16854 t
1961 - 83 = 25217 t
1930 - 83 = 20127 t

1 = NAFO Circular Letters
2 = I.O.P data

Table 2. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding Unit Area 4Xs) landed in the Maritimes split by tonnage class and gear type. The numbers in brackets represent the mean weight landed per age/size sample collected.

Year	Tonnage Class						Total
	TC 1-3			TC 4+			
	MB (OT)	FG (LL)[1]	Misc.[2]	MG (OT)	FG	Misc.	
1970	4894 (1224)	3281	767	6501 (296)	114	3	15560
1971	4289 (858)	3475 (1158)	499	7711 (367)	94	0	16068
1972	2742 (686)	4396 (440)	439	4750 (216)	63	0	12390
1973	1822 (304)	6090 (677)	324	4228 (282)	70	0	12534
1974	3949 (494)	6364 (530)	251	1622 (324)	55	0	12241
1975	6085 (320)	5193 (577)	271	4408 (157)	26	0	15983
1976	4347 (1087)	5305 (884)	445 (223)	6144 (186)	46	6	16293
1977	6178 (1030)	4328 (481)	550	8343 (130)	117	35	19551
1978	9413	6814 (568)	1084 (542)	7888 (164)	97	0	25296
1979	10171 (5086)	5127 (394)	600 (600)	8317 (252)	57	0	24272
1980	13043 (1186)	6911 (384)	1127 (376)	7045 (294)	82	0	28208
1981	14765 (328)	7846 (302)	993 (331)	6475 (809)	70	0	30149
1982	11670 (243)	7581 (345)	945 (79)	2972 (297)	32	0	23200
1983	12563 (224)	8533 (225)	754 (75)	2535 (195)	15	0	24400
1984	11828 (208)	6769 (226)	193 (193)	609 (76)	0	0	19399
1985	9834 (173)	4360 (182)	142	565 (113)	1	0	14902
1986	9201 (192)	5336 (184)	240	209 (209)	0	0	14986
1987	7952 (169)	4854 (270)	231 (21)	501 (84)	0	0	13538
1988	7074 (131)	3353 (152)	118 (118)	376 (188)	0	0	10921
1989	3656 (130)	2699 (245)	222	89 (22)	0	0	6666
1990	3183 (76)	3731 (133)	280 (280)	102	0	1	7297
1991	4061 (94)	5117 (151)	275 (275)	183 (61)	0	0	9636
1992	3365 (72)	6468 (175)	249 (125)	245 (82)	0	2	10329
1993	2507 (58)	4083 (136)	97 (14)	124 (31)	0	0	6811

1 = Includes handline.
2 = Gillnets (set, drift), traps, unspecified.

Table 3. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding unit Areas 4Xs) by gear type, tonnage class, area and quarter, 1984-93.

		OTB				LL[1]		Misc.[2]		
		mnop		qr		mnop	qr	mnop	qr	
		1-3	4+	1-3	4+	1-3	1-3	1-3	1-3	Total
1993	1	598	49	62	2	1009	13	0	0	
	2	388	49	503	4	671	220	18	5	
	3	155	3	436	11	1822	209	54	6	
	4	130	5	236	0	138	2	12	1	6811
1992	1	1006	92	76	0	1698	17	43	0	
	2	410	116	563	0	707	105	22	3	
	3	197	8	534	7	2240	256	66	51	
	4	264	8	315	14	1368	77	55	11	10329
1991	1	792	37	71	4	1800	20	10	0	
	2	305	64	766	3	451	46	27	5	
	3	200	20	627	4	1702	140	168	17	
	4	865	34	435	17	929	29	48	0	9636
1990	1	1341	42	93	1	1267	8	20	0	
	2	229	16	723	0	256	11	9	56	
	3	125	16	427	1	1447	29	115	53	
	4	128	25	117	1	707	6	27	1	7297
1989	1	2121	34	143	0	916	9	36	0	
	2	501	8	587	3	216	59	55	1	
	3	46	2	253	0	1023	36	65	1	
	4	2	42	3	0	440	0	64	0	6666
1988	1	2203	77	81	0	1368	19	25	0	
	2	1476	222	763	16	176	29	22	5	
	3	1126	17	688	4	1075	29	45	2	
	4	612	40	125	0	650	7	19	0	10921
1987	1	3026	219	108	0	2161	26	31	0	
	2	1965	163	667	5	366	58	40	1	
	3	442	42	1271	3	1201	42	85	0	
	4	89	69	384	0	995	5	74	0	13538
1986	1	2568	147	157	0	1964	5	0	0	
	2	830	20	1317	0	329	32	0	0	
	3	794	14	2284	1	1719	62	0	0	
	4	642	27	609	0	1451	13	0	0	14985
1985	1	2702	522	138	0	1926	11	12	0	
	2	2391	21	1226	0	345	46	105	29	
	3	230	17	2212	13	822	59	455	52	
	4	89	17	738	0	815	3	41	4	15041
1984	1	2280	336	188	0	2931	8	10	0	
	2	3249	334	762	0	697	34	161	17	
	3	782	85	3503	12	1350	110	462	74	
	4	164	59	815	5	1155	12	77	3	19675

1 = Includes handline.
2 = Gilnets (set, drift), traps, unspecified.

Table 4. Summary of commercial sampling for the 4X haddock fishery in 1993. Tonnes landed is followed by the number of fish measured in parentheses. The boxes represent the aggregation used in length key formation.

OTTER TRAWLS

Quarter	4Xmnop		4Xqr	
	TC 1-3	TC 4+	TC 1-3	TC 4+
1	598 (1994)	49	62 (443)	2
2	388 (1205)	49 (377)	503 (1815)	4
3	155 (211)	3	436 (1220)	11
4	130 (1992)	5	236 (701)	0

LONGLINERS/HANDLINERS

Quarter	4Xmnop		4Xqr	
	TC 1-3	TC 4+	TC 1-3	TC 4+
1	1009 (2091)	0	13 (220)	0
2	671 (788)	0	220	0
3	1822 (1848)	0	209 (250)	0
4	138 (968)	0	2	0

MISCELLANEOUS*

Quarter	4Xmnop		4Xqr	
	TC 1-3	TC 4+	TC 1-3	TC 4+
1	0	0	0	0
2	18	0	5	0
3	54 (33)	0	6	0
4	12 (114)	0	1	0

* - Longline samples applied to miscellaneous landings.

Table 5. 4X haddock catch at length (cm), 1970-1993.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.5	1	1	4	0	1	0	0	0	0	0	0	0	0	0	0	0
16.5	4	1	14	1	3	0	0	0	0	0	0	0	0	0	0	0
18.5	19	0	24	7	3	1	4	0	0	0	0	0	0	0	0	0
20.5	48	0	31	7	6	2	8	0	0	0	9	0	0	1	0	0
22.5	19	8	11	5	6	1	7	0	0	0	2	0	0	1	2	0
24.5	15	16	4	8	3	1	5	0	0	0	13	0	0	1	0	0
26.5	22	56	2	19	4	1	3	0	0	0	1	1	0	3	0	0
28.5	20	114	0	41	11	5	29	0	1	5	22	7	8	9	8	2
30.5	18	165	1	103	99	12	34	12	8	2	52	6	22	34	32	17
32.5	103	339	39	239	211	47	106	44	29	5	29	33	58	90	108	36
34.5	308	869	138	376	696	249	130	140	38	33	86	179	139	180	227	120
36.5	569	940	356	454	564	717	354	351	173	71	212	537	251	344	375	261
38.5	729	942	531	459	471	1003	389	587	415	210	318	759	420	690	552	469
40.5	743	807	578	361	803	1074	528	907	763	410	479	821	565	1092	609	687
42.5	593	652	722	312	988	1267	569	1183	1052	577	870	1035	762	1405	951	835
44.5	576	849	756	400	865	1463	741	1396	1320	1114	1098	1317	1066	1544	1244	1082
46.5	813	737	650	492	647	1520	1064	1156	1867	1586	1406	1755	1263	1415	1355	1175
48.5	1006	692	617	490	417	1395	1268	1068	2013	1816	1423	2078	1404	1402	1406	1203
50.5	1301	725	652	587	193	1103	1280	1088	2005	1816	1577	1888	1506	1495	1327	1160
52.5	1474	792	600	526	176	769	1074	1276	1792	1859	1701	1818	1451	1394	1244	1012
54.5	1247	692	619	559	248	510	946	1284	1378	1533	1745	1628	1276	1344	1135	847
56.5	1090	705	586	550	344	417	699	1177	1091	1279	1763	1522	1217	1253	927	694
58.5	696	545	573	506	490	426	553	972	988	956	1412	1203	947	972	783	478
60.5	533	494	557	353	547	387	521	602	336	717	1076	1075	837	821	577	350
62.5	360	395	414	323	446	435	369	467	637	561	855	722	681	599	381	193
64.5	209	248	286	274	367	366	310	305	464	385	504	524	452	387	247	167
66.5	123	150	184	167	258	246	235	229	340	249	317	355	302	271	165	84
68.5	45	90	97	101	188	195	181	134	164	157	212	198	202	173	97	63
70.5	8	46	55	83	133	111	76	91	81	103	106	108	123	101	87	34
72.5	8	17	25	45	43	49	48	39	44	65	59	65	78	50	32	20
74.5	17	6	4	27	28	33	42	24	22	17	24	35	41	32	14	6
76.5	5	6	2	35	40	12	1	8	17	9	7	10	12	12	11	2
78.5	3	2	1	40	4	1	8	3	8	8	5	11	10	3	1	0
80.5	7	0	0	7	1	0	1	1	3	2	1	1	3	1	0	1
82.5	0	0	0	0	0	0	0	0	0	1	4	1	2	0	0	0
84.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86.5	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
88.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12732	12104	9133	7959	9304	13818	11583	14544	17551	15547	17388	19747	15099	17122	13877	10999

Table 5. (Continued)

	1986	1987	1988	1989	1990	1991	1992	1993
0.5	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0
18.5	0	0	2	2	0	0	0	0
20.5	0	0	4	6	0	0	0	3
22.5	0	0	3	4	0	0	0	8
24.5	0	0	1	2	0	0	0	8
26.5	0	0	0	4	1	0	0	3
28.5	1	0	0	10	1	1	0	2
30.5	5	0	2	17	7	2	1	3
32.5	40	8	6	27	41	3	4	7
34.5	149	40	15	23	122	7	8	13
36.5	301	117	31	31	131	31	21	30
38.5	423	274	74	53	149	91	39	58
40.5	584	530	144	78	195	164	128	152
42.5	880	768	244	110	218	256	307	255
44.5	1305	1016	410	232	267	400	497	365
46.5	1525	1204	598	376	338	525	804	409
48.5	1519	1368	785	558	387	609	839	563
50.5	1334	1352	926	623	446	635	904	550
52.5	1071	1139	922	517	420	642	878	566
54.5	866	908	863	480	434	647	759	484
56.5	843	612	681	421	354	553	525	351
58.5	366	366	470	302	301	411	384	268
60.5	302	233	361	203	267	336	280	202
62.5	158	135	195	142	223	250	186	121
64.5	90	73	125	77	169	175	122	79
66.5	63	60	71	39	102	102	67	41
68.5	34	21	35	15	57	62	36	21
70.5	21	13	19	16	25	37	17	14
72.5	7	3	11	4	13	14	11	7
74.5	9	5	9	3	3	7	7	9
76.5	4	0	2	1	0	2	3	2
78.5	0	0	0	0	1	2	1	1
80.5	0	0	2	0	1	0	0	0
82.5	1	0	0	0	0	1	0	0
84.5	0	0	0	0	0	0	0	0
86.5	0	0	0	0	0	0	0	0
88.5	0	0	0	0	0	0	0	0
90.5	0	0	0	0	0	0	0	0
	11703	10247	7011	4378	4671	5967	6826	4595

Table 6 . 4X haddock mean numbers per standard tow by stratum in the 1970-1993 summer RV surveys.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
470	3.94	0.59	5.68	5.14	0.41	4.20	0.70	273.94	5.75	38.30	3.28	6.11
471	0.00	0.00	2.47	0.00	0.00	0.55	0.00	0.43	0.46	0.55	2.92	2.87
472	13.72	37.80	15.86	12.56	28.86	49.18	35.26	14.92	10.55	32.56	248.92	192.04
473	90.04	9.97	82.21	51.91	53.90	11.51	113.46	169.74	26.39	81.26	31.42	10.62
474	55.73	25.61	28.96	39.59	75.43	88.73	76.85	26.00	103.58	303.43	27.18	119.46
475	78.13	53.88	21.97	57.62	105.67	27.12	137.04	36.58	81.29	77.82	71.20	45.53
476	0.00	80.50	12.38	0.00	41.53	39.53	1.31	554.52	53.78	0.00	23.10	14.84
477	45.40	34.13	24.52	31.92	132.64	25.24	66.94	31.07	45.54	44.47	35.92	53.20
478	1.75	1.75	0.70	0.59	2.52	3.20	10.50	4.68	6.16	2.52	1.75	0.67
480	100.66	240.46	98.51	191.44	262.16	179.52	64.13	628.14	192.55	88.73	224.39	180.80
481	63.26	30.89	31.69	147.02	271.90	49.72	56.51	7.87	72.49	84.59	169.64	35.11
482	2.33	3.31	0.00	0.00	5.83	3.06	4.69	9.79	8.40	20.54	14.75	9.92
483	2.53	0.00	4.08	0.00	1.85	2.10	30.34	9.96	1.75	11.05	23.57	32.22
484	0.00	0.53	0.00	0.37	0.35	0.38	6.12	0.41	0.59	14.87	2.33	1.68
485	52.16	11.77	3.11	31.92	9.29	12.00	14.77	34.49	13.88	10.87	65.92	15.01
490	30.43	56.88	0.53	70.78	323.40	48.12	109.15	189.19	63.54	384.72	311.34	1481.72
491	4.15	0.00	11.39	3.91	21.08	3.01	2.58	21.30	11.52	5.21	15.37	15.48
495	16.80	13.56	9.32	4.01	20.18	1.73	4.87	33.92	48.00	31.46	6.76	8.69

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
470	0.00	35.79	12.58	0.97	41.18	6.61	6.46	4.79	1.54	0.00	0.97	0.49
471	4.89	3.89	0.46	0.00	0.51	2.57	0.00	0.00	0.00	0.00	0.00	0.00
472	141.20	39.75	49.03	73.40	73.09	28.21	34.73	37.78	17.47	19.11	7.89	7.32
473	135.88	34.31	60.70	189.10	174.07	80.29	12.01	12.32	41.51	92.36	5.83	0.46
474	135.37	57.81		134.50	52.61	3.15	1.54	1.80	31.11	6.32	6.69	8.26
475	47.98	53.94	254.51	100.85	159.04	14.13	13.90	22.10	54.47	22.48	16.04	8.75
476	5.50	62.34	8.75	369.87	22.39	25.03	9.10	9.21	5.30	8.51	11.67	2.83
477	94.15	86.47	150.81	92.13	120.41	43.99	59.48	42.02	24.37	38.58	39.23	12.84
478	2.94	16.77	16.73	20.42	9.48	25.39	11.32	0.00	13.82	0.00	3.25	3.40
480	73.74	93.29	172.05	117.45	97.60	52.54	84.96	175.59	251.54	360.13	200.97	71.76
481	170.30	41.82	70.77	18.68	168.47	31.93	25.72	29.26	18.03	37.65	25.32	41.43
482	23.33	8.58	20.90	1.46	2.06	31.63	22.73	18.19	39.56	20.86	1.50	7.29
483	70.04	5.66	33.42	14.58	13.00	11.48	20.59	1.54	36.84	41.78	4.03	3.83
484	6.04	1.28	4.12	2.94	0.69	0.00	1.37	0.97	0.97	0.00	0.00	0.70
485	24.85	11.29	26.44	80.44	35.57	2.97	9.68	1.86	13.13	87.06	20.51	8.40
490	485.53	234.97	773.65	160.56	31.56	44.66	128.41	129.52	174.02	79.27	104.55	18.53
491	30.48	32.01	29.26	16.34	2.75	1.03	0.26	0.00	0.67	1.30	3.56	4.80
495	37.55	14.84	3.09	5.22	0.00	0.00	0.98	0.00	18.05	0.00	0.00	0.00

Table 7. 4X haddock mean numbers at length per standard tow from the 1970-1993 summer RV surveys.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.11	0.01	0.13	0.15	0.12	0.06	0.00	0.12	0.00	0.07	0.00	0.00	0.00	0.03	0.01
8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.00	0.22	0.01	0.41	0.12	0.22	0.24	0.00	0.00	0.00	0.01	0.00	0.19	0.00	0.01	0.01
10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.00	0.06	0.00	0.01	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.03	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.05	0.00	0.00	0.06	0.09	0.04	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
14.5	0.06	0.01	0.11	0.03	0.07	0.00	0.00	0.00	0.37	0.03	1.36	2.16	1.72	0.42	0.13	0.18	0.04	0.01	0.04	0.02	0.00	0.00	0.13	0.00
16.5	0.17	0.02	0.56	0.16	0.19	0.21	0.19	0.22	1.26	0.17	2.94	7.56	4.63	2.18	1.11	1.12	0.80	0.20	1.23	0.51	0.00	0.21	0.65	0.01
18.5	0.94	0.00	1.44	1.37	1.47	1.03	1.24	0.97	2.06	0.67	4.56	6.87	4.34	2.59	1.50	2.76	1.66	0.20	2.20	1.45	0.00	1.32	1.11	0.39
20.5	2.48	0.05	2.11	2.68	5.55	2.06	2.20	1.59	1.76	0.86	7.15	8.61	5.05	0.84	1.38	2.17	0.60	0.45	1.23	2.22	0.04	1.27	0.55	1.41
22.5	1.42	0.09	0.80	2.30	3.89	1.75	1.07	1.98	0.65	0.28	4.41	7.60	4.54	1.21	2.24	2.06	0.46	0.17	0.57	1.33	0.04	0.88	0.38	1.77
24.5	0.71	0.43	0.34	1.04	0.95	1.15	0.83	1.45	0.13	0.57	1.72	5.24	5.13	1.06	4.31	1.31	1.18	0.18	0.77	0.55	0.13	0.47	0.27	0.92
26.5	0.03	2.21	0.11	2.26	0.93	0.57	0.58	0.98	0.06	1.40	0.47	2.28	4.35	0.81	3.20	1.25	1.86	0.28	0.78	0.68	0.47	0.11	0.32	0.22
28.5	0.34	3.55	0.01	4.99	3.28	0.60	1.07	2.01	0.51	2.53	0.62	3.02	3.67	1.02	3.32	3.35	2.02	0.44	0.57	1.53	1.52	0.11	0.69	0.20
30.5	0.51	3.17	0.02	7.21	8.48	0.81	1.27	2.85	0.99	2.76	1.22	4.63	3.54	1.52	4.99	2.97	2.68	0.38	0.54	1.95	2.34	0.14	0.58	0.26
32.5	1.14	1.56	0.10	3.30	7.97	0.92	1.44	5.94	1.14	2.70	1.80	4.43	3.63	2.68	6.92	4.16	2.94	0.55	0.55	2.18	1.91	0.16	0.54	0.27
34.5	1.67	0.54	0.34	2.19	5.18	0.72	1.10	7.67	1.34	3.23	2.11	5.32	2.89	3.19	6.25	5.14	3.66	0.81	0.44	1.39	1.94	0.42	0.24	0.19
36.5	0.80	0.53	0.70	0.48	5.58	1.00	1.39	8.03	1.25	1.88	3.21	4.80	2.22	2.57	4.12	4.59	4.21	1.41	0.47	1.19	2.39	1.35	0.46	0.25
38.5	0.54	0.75	0.73	0.15	6.21	0.60	0.92	9.49	1.71	1.31	3.92	4.37	2.38	1.87	4.27	5.86	4.06	1.61	0.77	1.00	2.56	2.57	0.37	0.27
40.5	0.74	1.06	0.79	0.18	7.42	1.64	0.45	9.95	2.65	1.54	3.21	2.29	2.54	1.68	4.08	6.34	3.62	1.76	1.02	0.99	2.76	3.07	0.83	0.51
42.5	0.78	1.28	0.56	0.14	5.47	2.24	0.90	10.13	3.63	1.76	3.08	2.18	1.95	1.96	4.08	6.49	3.92	1.42	1.54	0.68	1.98	2.90	1.44	0.46
44.5	0.71	1.40	0.31	0.39	2.84	1.37	1.07	10.56	1.93	2.64	3.00	2.27	1.97	1.67	3.79	6.49	3.85	1.80	2.05	0.70	1.51	2.94	2.08	0.52
46.5	1.19	1.15	0.38	0.32	1.82	1.54	1.65	6.72	1.45	2.93	2.57	2.62	1.81	1.72	2.67	5.06	3.27	1.63	1.49	0.89	1.21	4.44	1.94	0.63
48.5	1.48	1.51	0.40	0.87	0.69	2.12	1.74	6.13	1.42	3.04	2.36	2.96	2.26	1.36	2.48	2.54	2.91	1.37	1.28	1.20	0.98	3.59	1.51	0.48
50.5	1.84	1.28	0.57	0.93	0.85	1.69	2.39	4.95	1.75	2.64	3.87	1.92	2.84	2.11	1.86	2.59	2.56	1.34	1.36	0.80	1.46	2.99	1.36	0.77
52.5	1.63	2.19	0.80	1.06	0.70	0.99	2.28	2.92	1.54	1.95	3.80	1.42	1.91	1.42	1.53	1.48	1.37	1.29	0.87	0.86	1.06	2.56	1.52	0.44
54.5	1.69	1.79	0.75	0.77	1.19	0.78	1.22	4.66	1.45	1.99	4.07	1.58	2.07	1.48	1.27	1.14	1.58	1.00	0.94	0.59	1.14	2.72	1.24	0.38
56.5	1.45	2.13	0.64	0.55	0.79	0.54	1.19	3.61	1.40	1.83	3.59	1.41	1.68	1.04	1.26	1.08	0.75	0.72	0.56	0.44	0.94	1.75	1.34	0.59
58.5	0.77	1.55	0.73	0.80	1.05	0.35	0.69	2.98	1.62	1.81	2.72	1.40	1.41	0.97	1.13	0.79	0.79	0.48	0.37	0.38	0.67	1.20	0.67	0.35
60.5	0.70	1.12	0.61	0.58	0.60	0.51	0.52	1.54	0.83	1.66	1.94	0.80	0.92	0.76	0.71	0.81	0.38	0.21	0.40	0.18	0.45	0.79	0.49	0.23
62.5	0.60	0.81	0.60	0.58	0.61	0.36	0.43	1.34	0.55	1.03	1.58	1.34	0.75	0.51	0.48	0.48	0.11	0.13	0.21	0.17	0.66	0.57	0.50	0.12
64.5	0.57	0.33	0.34	0.30	0.59	0.87	0.19	0.72	0.26	0.95	1.23	0.52	0.67	0.39	0.26	0.43	0.12	0.06	0.18	0.04	0.42	0.24	0.36	0.11
66.5	0.34	0.17	0.18	0.23	0.39	0.06	0.20	0.87	0.13	0.74	0.67	0.44	0.51	0.31	0.36	0.32	0.23	0.06	0.15	0.03	0.38	0.24	0.13	0.10
68.5	0.25	0.17	0.07	0.08	0.22	0.38	0.17	0.35	0.09	0.31	0.53	0.22	0.12	0.15	0.15	0.05	0.07	0.02	0.13	0.02	0.11	0.16	0.16	0.03
70.5	0.10	0.05	0.05	0.03	0.02	0.12	0.13	0.18	0.07	0.21	0.31	0.20	0.10	0.06	0.10	0.14	0.05	0.00	0.06	0.01	0.09	0.10	0.02	0.00
72.5	0.03	0.11	0.05	0.00	0.04	0.11	0.03	0.11	0.02	0.22	0.05	0.10	0.04	0.00	0.10	0.11	0.06	0.00	0.03	0.00	0.03	0.07	0.01	0.00
74.5	0.00	0.02	0.00	0.00	0.04	0.00	0.01	0.06	0.05	0.02	0.02	0.15	0.02	0.04	0.00	0.00	0.04	0.00	0.05	0.00	0.02	0.00	0.00	0.00
76.5	0.00	0.02	0.01	0.01	0.02	0.00	0.03	0.02	0.04	0.06	0.00	0.11	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.04	0.01	0.00	0.00
78.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.02	0.03	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
80.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
82.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
84.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
86.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
88.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
92.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sum	25.73	31.04	15.19	35.99	75.14	27.08	28.66	111.07	34.18	46.18	74.15	91.48	72.04	40.07	70.34	73.27	51.93	20.03	22.95	23.98	29.46	39.35	21.93	11.93

Selectivity using NLLS: 0.00004 0.02 0.17 0.57 0.77 0.58 1.00

Table 8. VPA estimates of Catch Numbers using NLLS. In thousands.

	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
0	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
1	0	0	0	25	1	0	5	2	0	0	0	10	17	1	0	0	21
2	459	206	98	348	628	415	572	656	371	421	136	46	101	270	36	29	48
3	4161	3593	2329	2818	4120	2876	4817	3450	3138	3267	2617	880	481	862	919	976	838
4	3950	6781	6148	5257	6630	4899	5009	4710	4044	4914	4494	2770	1816	1381	2090	2986	1805
5	3099	3365	3742	4359	4059	3219	3294	2684	2047	2045	2090	2005	1160	998	1521	1723	1118
6	1273	1406	1315	1950	1741	1366	1383	1072	653	517	483	651	404	435	579	524	369
7	1073	1519	1305	1897	1784	1552	1397	917	535	399	325	501	321	526	593	448	301
1-7	14015	16870	14935	16653	18962	14325	16476	13490	10788	11562	10143	6862	4298	4471	5738	6686	4500

Table VPA estimates of Research Numbers using NLLS. In thousands.

	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
3	50565	12279	9264	16815	14772	9395	7823	17250	26328	16503	6943	5498	3668	9408	11818	4835	1823
4	23112	6468	11502	12840	9852	7865	5900	7775	10930	9425	4985	4565	3320	4180	12300	5570	2100
5	11676	4344	5754	11472	4440	4705	3230	3295	2960	3015	2365	1935	1460	2610	5750	3340	1190
6	4500	2442	3168	4428	2160	1870	1350	1485	1195	980	585	570	470	895	1595	915	465
3-6	89853	25533	29688	45555	31224	23835	18303	29805	41413	29923	14878	12568	8918	17093	31463	14660	5578

Table VPA estimates of Fishing Mortality using NLLS.

	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	0.01	0.01	0.00	0.02	0.03	0.02	0.03	0.04	0.02	0.03	0.02	0.01	0.01	0.03	0.01	0.01	0.01
3.00	0.16	0.15	0.11	0.14	0.25	0.21	0.37	0.28	0.23	0.24	0.28	0.13	0.08	0.11	0.12	0.20	0.33
4.00	0.27	0.42	0.40	0.40	0.59	0.53	0.66	0.75	0.62	0.70	0.62	0.54	0.44	0.33	0.41	0.70	0.68
5.00	0.41	0.39	0.44	0.54	0.64	0.65	0.85	0.96	0.90	0.75	0.75	0.63	0.45	0.46	0.75	0.73	0.61
6.00	0.28	0.33	0.26	0.44	0.44	0.45	0.65	0.76	0.65	0.60	0.39	0.55	0.25	0.30	0.54	0.63	0.32
7.00	0.54	0.62	0.58	0.73	0.91	0.88	1.21	1.31	1.15	1.10	0.97	0.89	0.58	0.58	0.87	1.08	0.93
1-7	0.24	0.27	0.26	0.33	0.41	0.39	0.54	0.59	0.51	0.49	0.43	0.39	0.26	0.26	0.38	0.48	0.41

Table VPA estimates of Population using NLLS. In thousands.

	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
1	35931	34695	31267	26422	26456	24153	25696	25441	18308	11930	10747	13991	13874	8934	4910	4439	685771
2	36396	29418	28405	25599	21610	21660	19775	21034	20828	14989	9767	8799	11446	11344	7314	4020	3634
3	31051	29383	23899	23168	20644	17125	17358	15673	16627	16717	11891	7874	7162	9279	9044	5956	3265
4	18344	21658	20806	17460	16418	13173	11418	9853	9710	10774	10730	7368	5651	5429	6818	6573	3993
5	10162	11444	11596	11472	9539	7443	6353	4816	3805	4291	4375	4719	3526	2984	3195	3691	2680
6	5800	5516	6325	6109	5448	4137	3182	2221	1515	1263	1663	1691	2050	1837	1540	1240	1463
7	2829	3597	3244	3989	3237	2886	2151	1354	849	649	566	925	796	1313	1111	737	541
1-7	140512	135710	125541	114218	103352	90576	85933	80392	71641	60613	49740	45367	44503	41120	33931	26654	701346

Table VPA Residuals using NLLS.

	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
3	0.75	-0.61	-0.71	-0.06	-0.02	-0.31	-0.41	0.43	0.77	0.30	-0.20	-0.11	-0.45	0.25	0.51	0.08	-0.22
4	0.44	-0.91	-0.32	-0.03	-0.12	-0.16	-0.23	0.25	0.52	0.32	-0.36	-0.12	-0.23	-0.02	0.88	0.29	-0.20
5	0.43	-0.69	-0.39	0.37	-0.34	-0.03	-0.13	0.23	0.33	0.14	-0.12	-0.47	-0.57	0.19	1.08	0.38	-0.40
6	0.30	-0.23	-0.14	0.33	-0.28	-0.13	-0.08	0.44	0.54	0.49	-0.42	-0.37	-0.93	-0.15	0.74	0.46	-0.56
3-6	0.48	-0.61	-0.39	0.15	-0.19	-0.16	-0.21	0.34	0.54	0.31	-0.28	-0.27	-0.55	0.07	0.80	0.30	-0.35

Selectivity using Keymake: 0.00003 0.01 0.15 0.56 0.83 0.56 1.0

Table 9. VPA estimates of Catch Numbers using Keymake. In thousands.

	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
1	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	11
2	62	28	17	85	67	66	94	109	56	41	13	14	43	38	5	2	20
3	2470	1906	1091	1544	2448	1659	2785	2311	2021	2054	1205	404	315	709	468	375	297
4	5105	6867	5846	5280	6962	5103	6186	5394	4903	5749	5288	2541	1513	1408	2208	2888	1775
5	3592	4690	4672	5212	5181	3936	4142	3412	2484	2765	2670	2632	1469	1126	1679	2355	1524
6	1590	1676	1859	2246	2241	1702	1591	1171	716	543	650	699	608	558	649	563	565
7	1196	1703	1450	2286	2063	1859	1677	1092	608	410	317	569	348	631	729	501	308
1-7	14015	16870	14935	16653	18962	14325	16476	13490	10788	11562	10143	6862	4298	4471	5738	6686	4500

Table VPA estimates of Research Numbers using Keymake. In thousands.

	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
3	48942	10925	11082	15988	19046	10669	9554	19310	25893	18389	6396	4322	4379	9873	10830	3940	1415
4	27969	8550	11351	13913	10473	8096	6080	9655	13895	11174	6325	5179	3139	4861	12441	6479	2174
5	12724	4768	7118	11279	5495	4934	3594	3938	3970	3692	2416	2719	1751	2543	5673	3824	1434
6	6964	2525	4512	6708	3431	2843	1879	1808	1606	943	818	886	862	1675	2457	1372	774
3-6	96598	26769	34064	47887	38446	26542	21108	34710	45364	34199	15954	13106	10131	18953	31400	15615	5797

Table VPA estimates of Fishing Mortality using Keymake.

	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
3.00	0.09	0.07	0.05	0.07	0.14	0.10	0.20	0.16	0.13	0.13	0.12	0.06	0.05	0.07	0.05	0.07	0.14
4.00	0.26	0.37	0.32	0.34	0.53	0.47	0.68	0.75	0.58	0.69	0.57	0.41	0.33	0.31	0.33	0.52	0.57
5.00	0.40	0.41	0.46	0.52	0.65	0.67	0.92	1.06	1.00	0.78	0.82	0.63	0.44	0.44	0.74	0.70	0.56
6.00	0.29	0.33	0.28	0.42	0.44	0.46	0.64	0.74	0.67	0.62	0.41	0.52	0.28	0.29	0.50	0.60	0.35
7.00	0.49	0.56	0.53	0.64	0.85	0.82	1.17	1.30	1.14	1.06	0.92	0.77	0.53	0.53	0.77	0.90	0.78
1-7	0.22	0.25	0.23	0.28	0.37	0.36	0.52	0.57	0.50	0.47	0.41	0.34	0.23	0.24	0.34	0.40	0.34

Table VPA estimates of Population using Keymake. In thousands.

	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
1	39085	36437	31348	28093	25184	26393	26808	27958	17351	11494	11261	17170	15254	8756	3760	2681	530370
2	38153	32000	29832	25666	23000	20619	21609	21949	22890	14206	9411	9220	14055	12487	7169	3079	2195
3	32983	31181	26174	24409	20936	18770	16822	17607	17871	18690	11594	7693	7536	11468	10189	5865	2518
4	24624	24769	23805	20442	18587	14926	13866	11253	12324	12803	13444	8402	5933	5884	8748	7918	4463
5	12022	15541	14066	14200	11959	8919	7603	5755	4332	5653	5280	6222	4579	3488	3544	5165	3869
6	7060	6592	8480	7288	6910	5103	3741	2477	1624	1299	2127	1907	2713	2420	1837	1382	2097
7	3358	4342	3880	5261	3935	3630	2638	1623	968	682	573	1153	929	1672	1476	916	622
1-7	157285	150863	137586	125359	110512	98361	93088	88621	77361	64828	53689	51767	51000	46176	36723	27007	546135

Table VPA Residuals using Keymake.

	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
3.00	0.71	-0.74	-0.57	-0.12	0.25	-0.24	-0.18	0.45	0.71	0.32	-0.26	-0.28	-0.25	0.16	0.36	-0.09	-0.23
4.00	0.41	-0.72	-0.43	-0.06	-0.13	-0.21	-0.30	0.42	0.59	0.39	-0.29	-0.12	-0.31	0.12	0.67	0.23	-0.26
5.00	0.42	-0.81	-0.28	0.20	-0.27	-0.07	-0.08	0.37	0.63	0.16	-0.17	-0.33	-0.58	0.07	1.03	0.24	-0.53
6.00	0.37	-0.55	-0.25	0.38	-0.22	-0.10	-0.10	0.33	0.60	0.26	-0.50	-0.25	-0.76	0.02	0.80	0.56	-0.58
3-6	0.48	-0.71	-0.38	0.10	-0.09	-0.15	-0.17	0.39	0.63	0.28	-0.31	-0.24	-0.48	0.09	0.71	0.23	-0.40

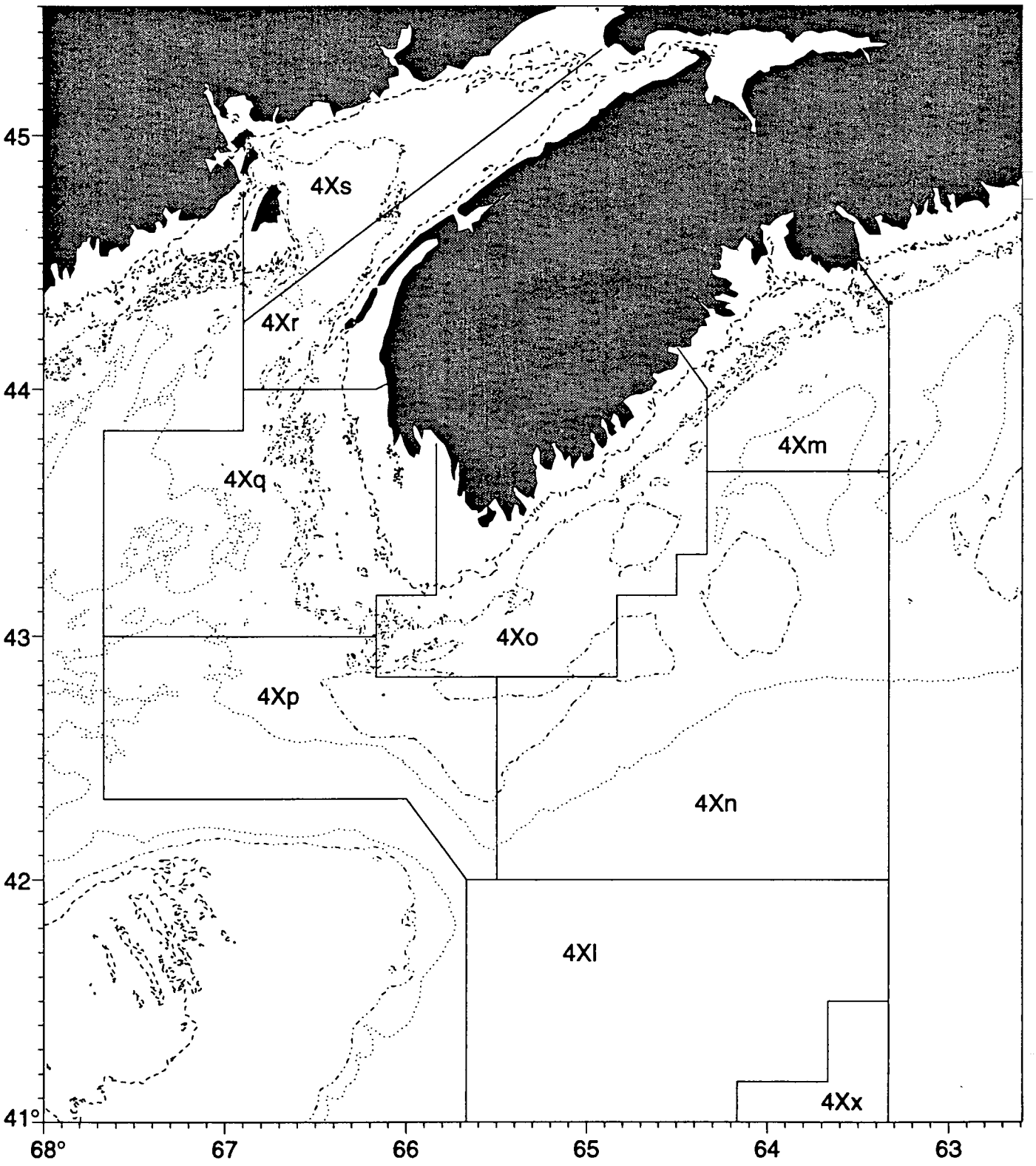


Figure 1. Canadian fisheries statistical unit areas in NAFO Division 4X.

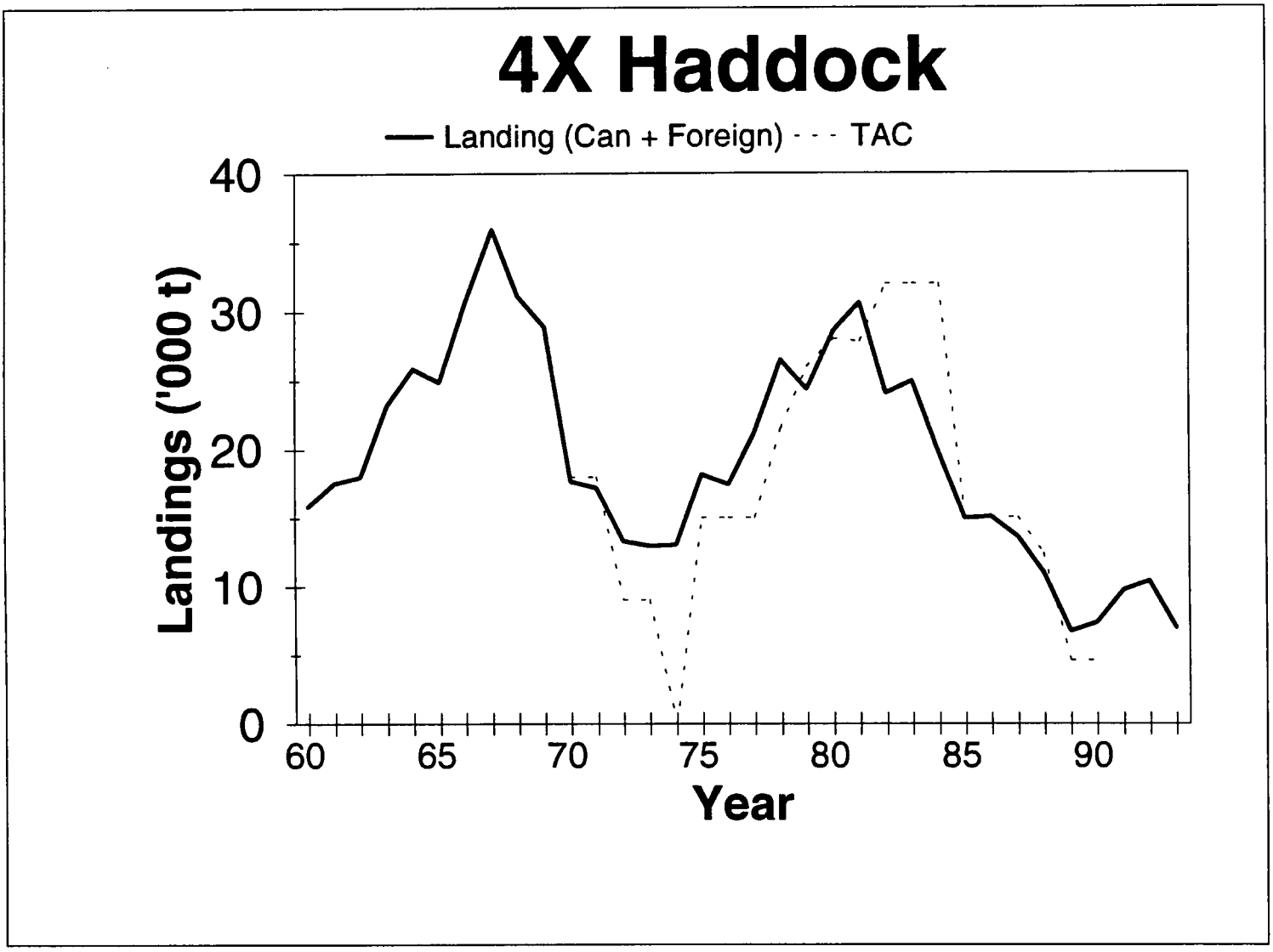


Figure 2. Long-term trends in 4X haddock landings, along with TAC.

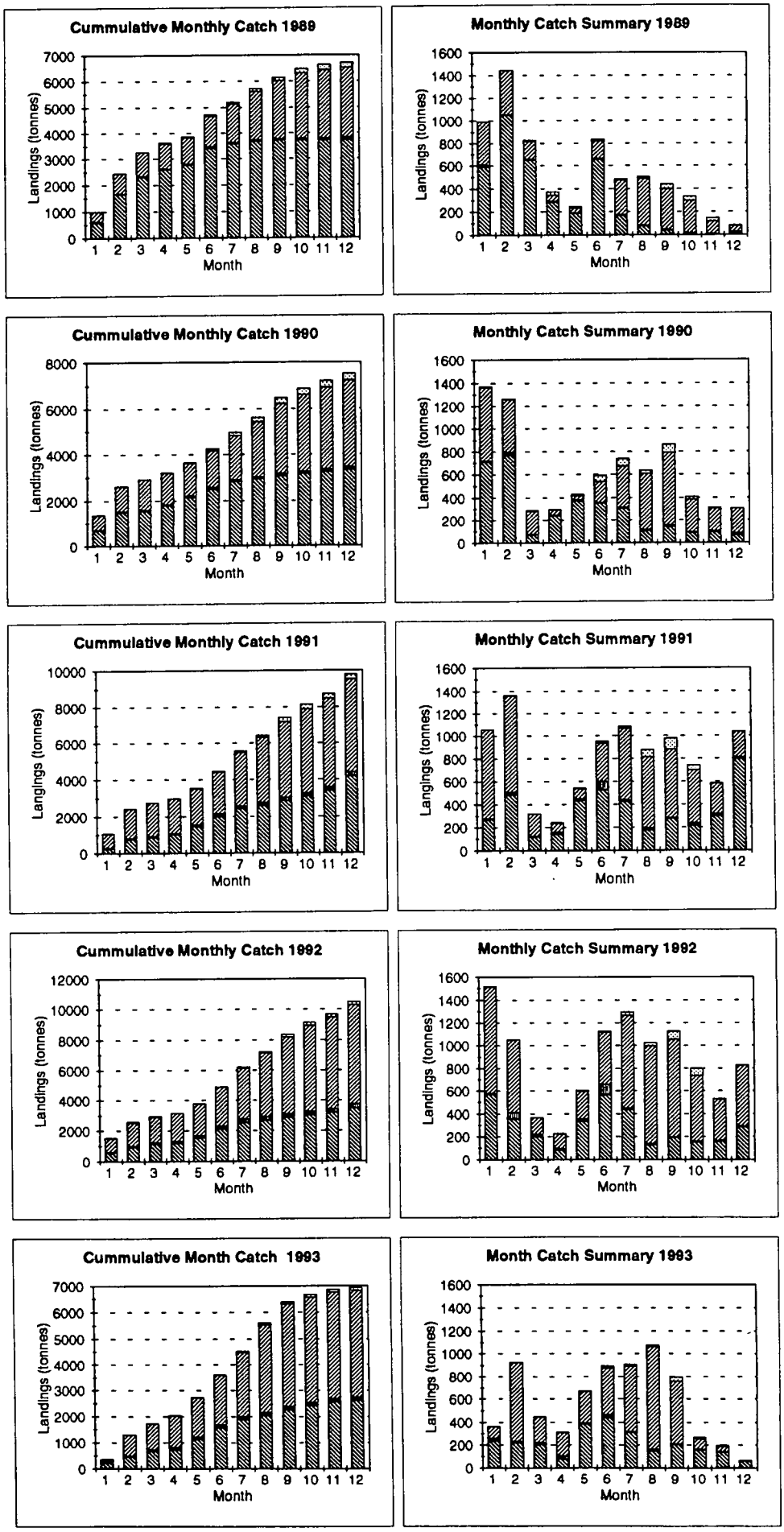


Figure 3. Monthly catch summary by gear sector, 4X haddock 1989-1993.

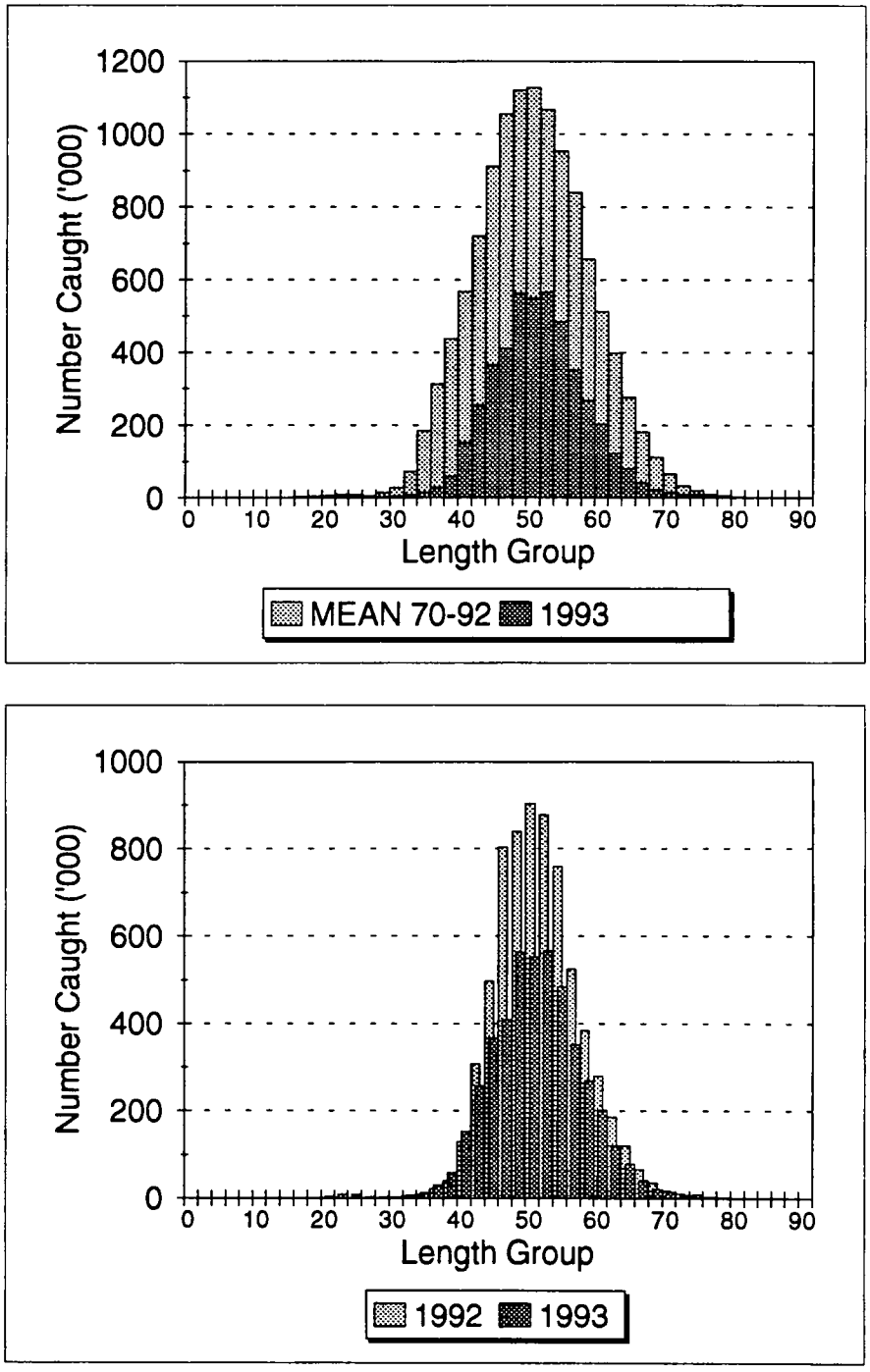


Figure 4. Commercial catch at length for 4X haddock, (a) 1993 catch compared to the 1970-1992 mean, (b) 1993 catch compared to the 1992 catch at length.

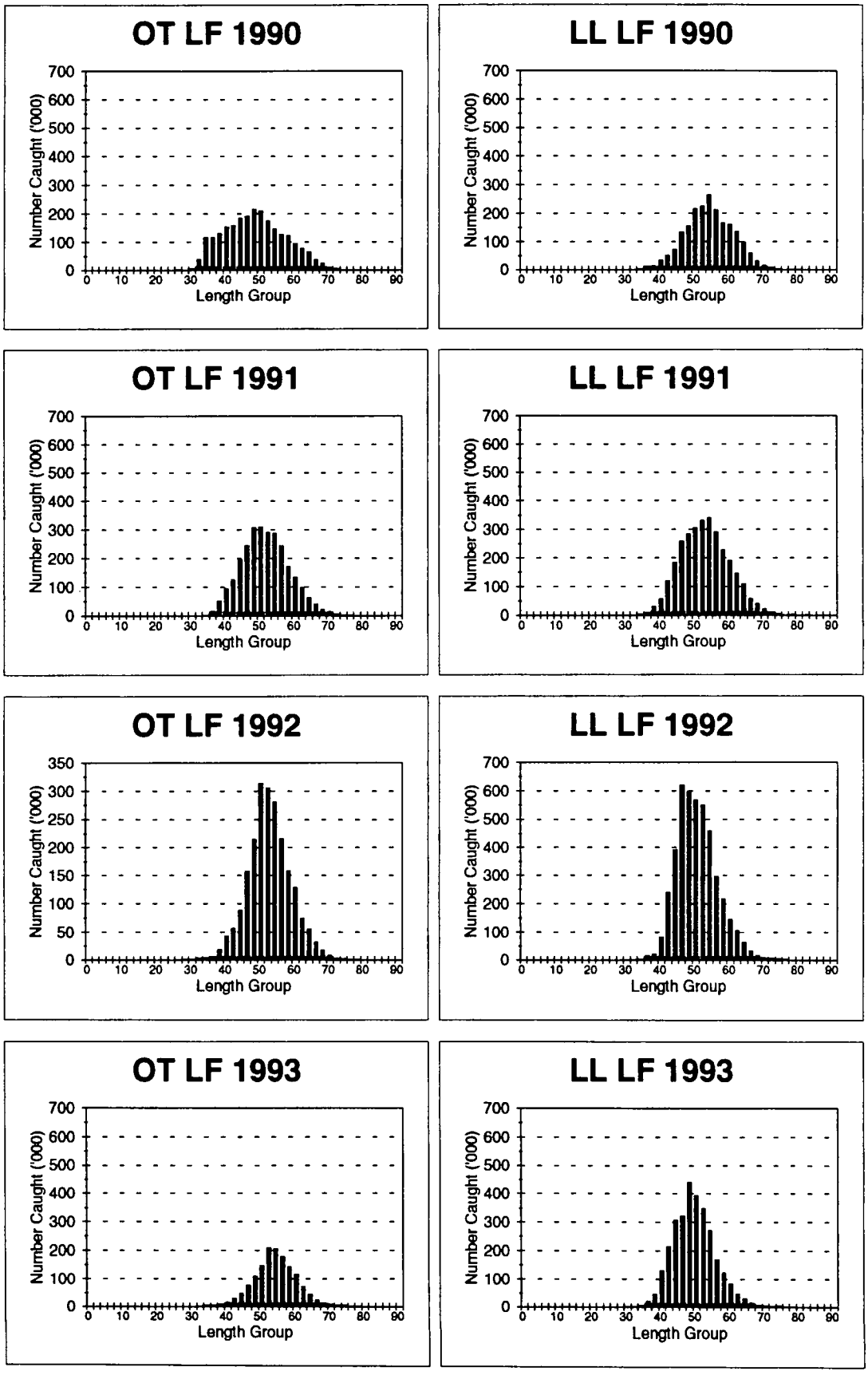


Figure 5. Catch at length for 4X haddock, 1990-1993, for otter trawl and longline gear sectors.

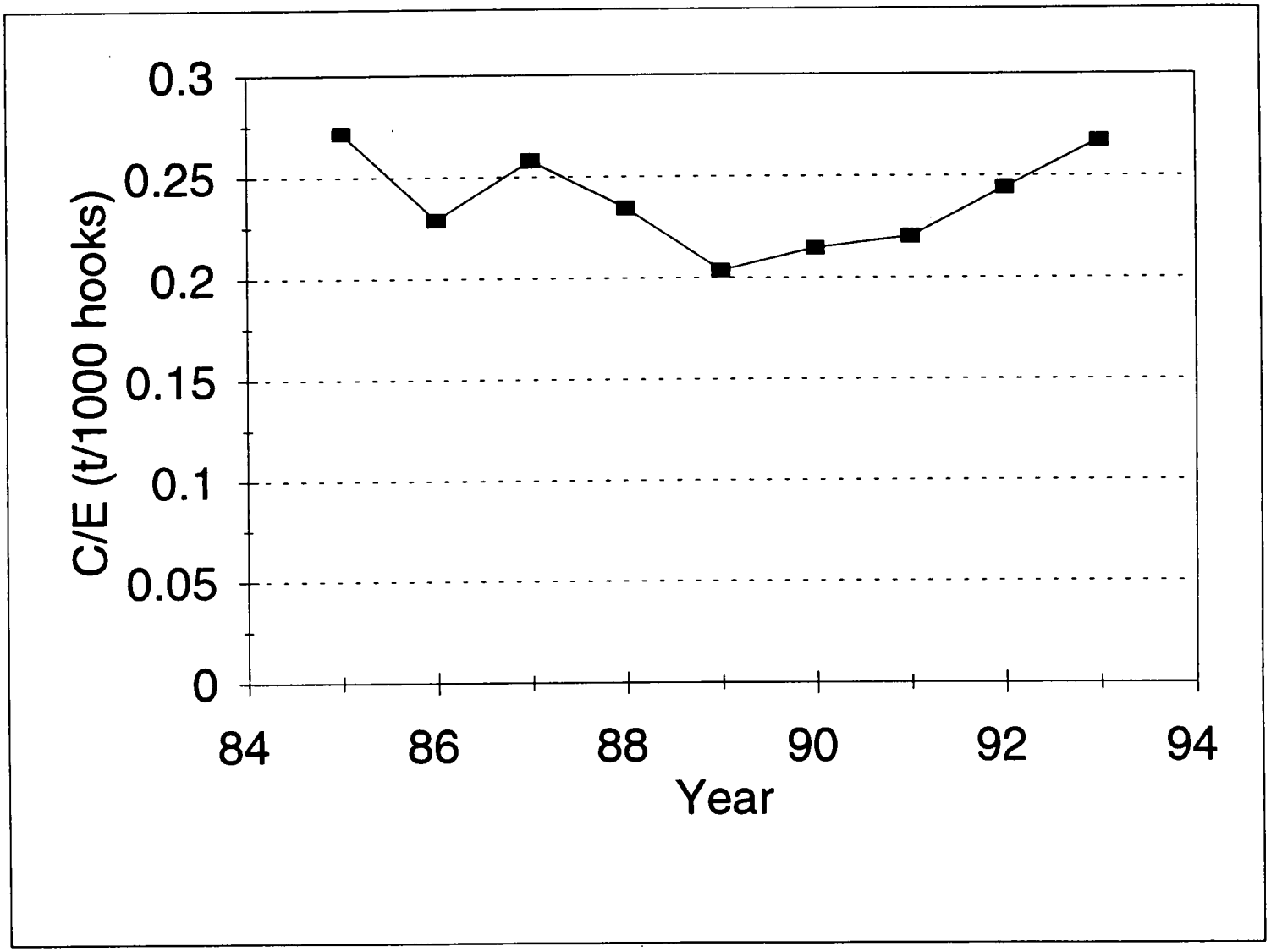


Figure 6. Catch rates for TC1-3 longliners fishing in 4Xmnop, January and February, 1985-1993.

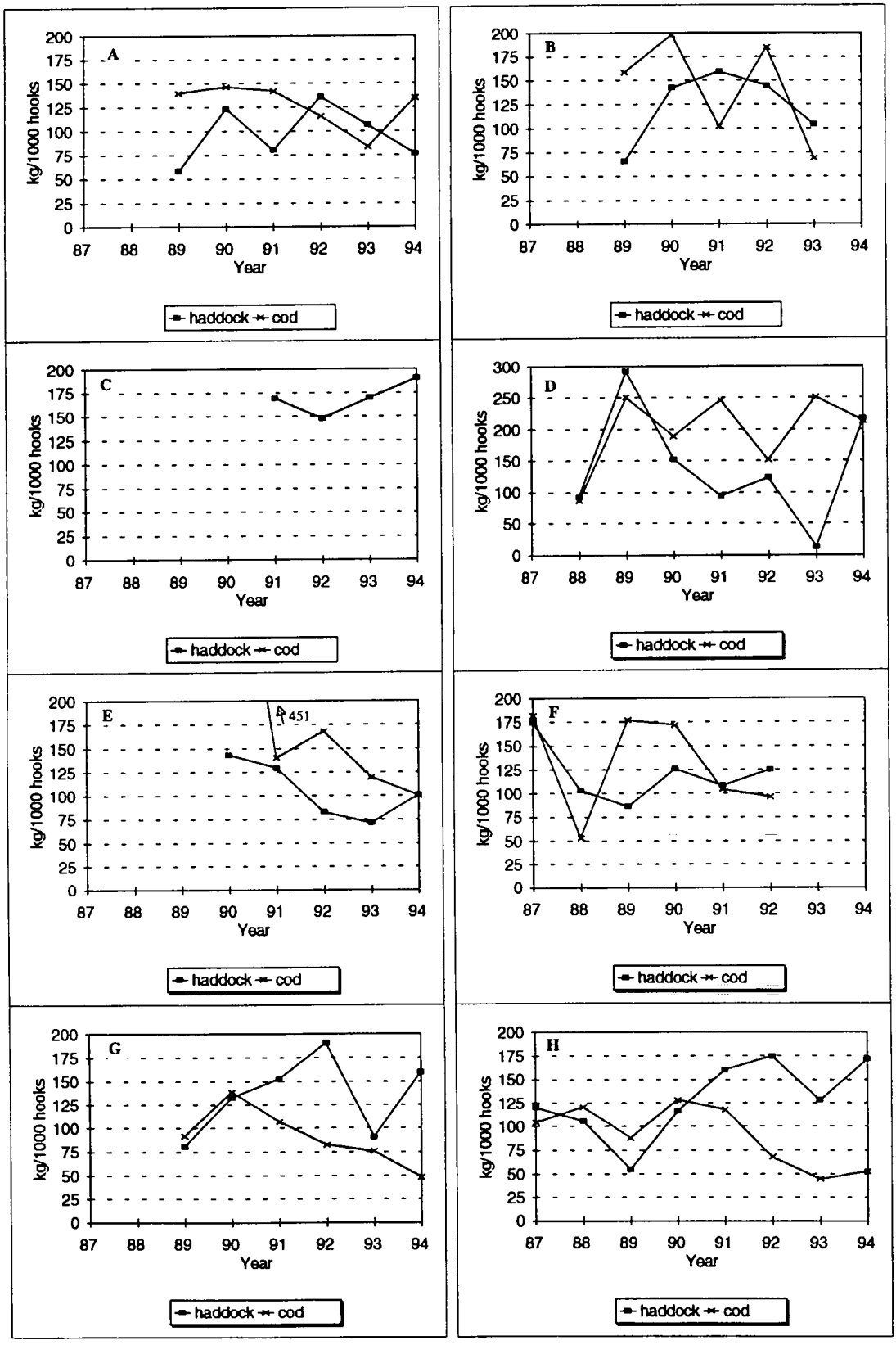


Figure 7. Catch rates from individual TC1-3 longliners fishing in 4X based on interviews.

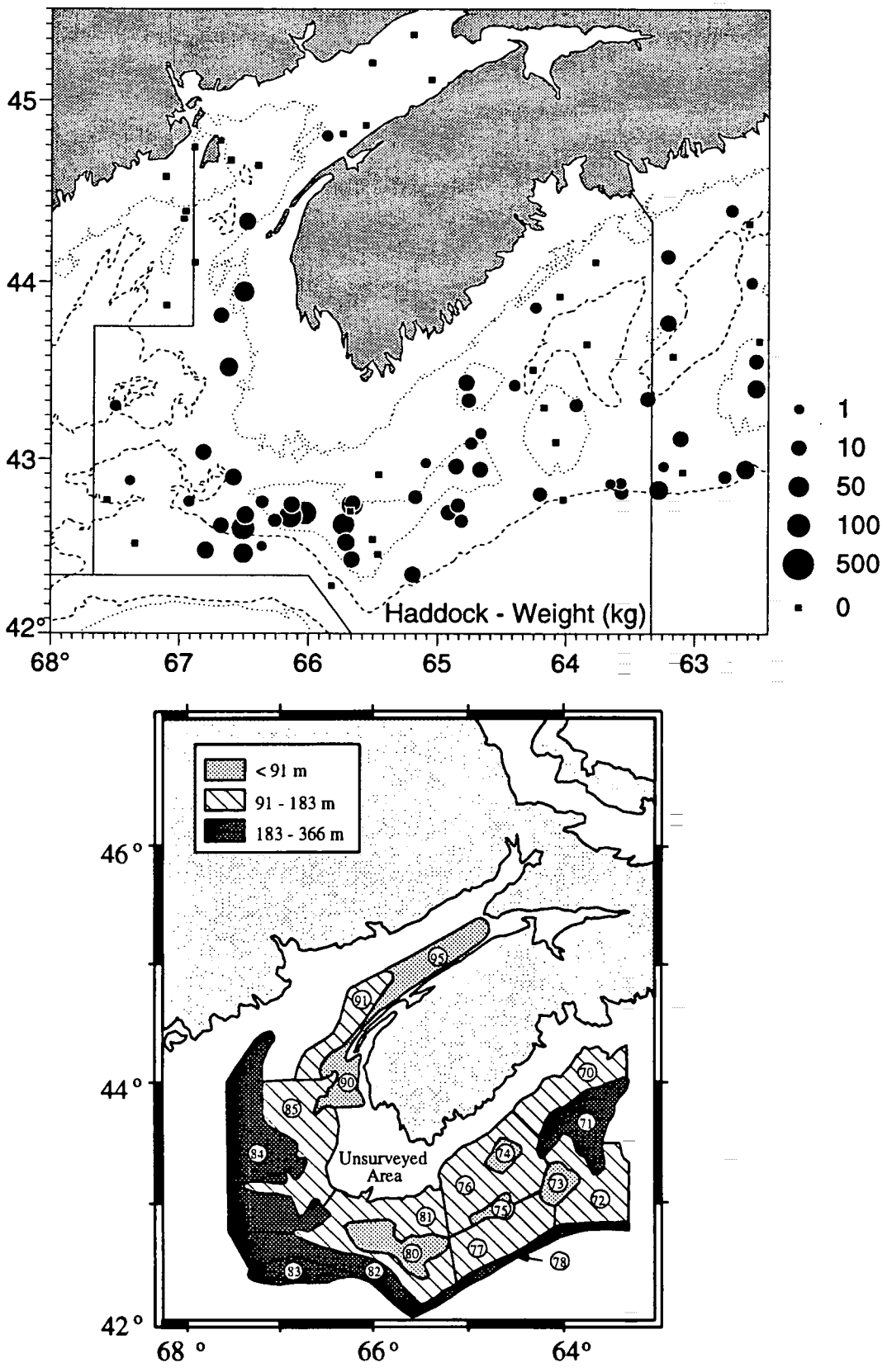


Figure 8. (a) Haddock catch and distribution in the 1993 summer RV survey. (b) RV survey strata in NAFO Division 4X.

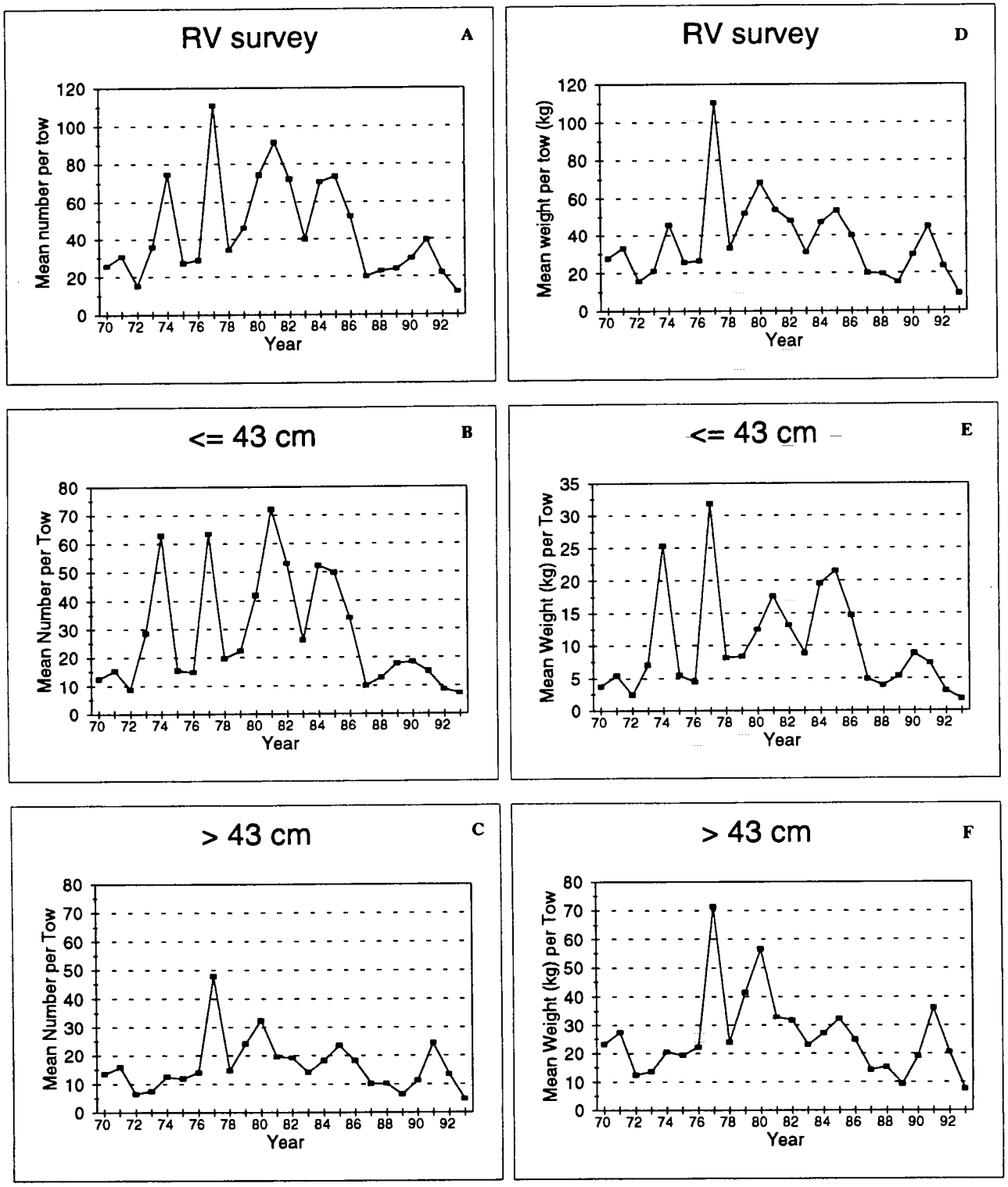


Figure 9. Summer RV survey, mean catch rate of haddock from 4X during 1970-1993 for (a) all lengths combined (nos./tow), (b) lengths <=43cm (nos/tow), (c) lengths >43cm (nos/tow), (d) all lengths combined (wt/tow), (e) lengths <=43cm (wt/tow) and (f) lengths >43cm (wt/tow).

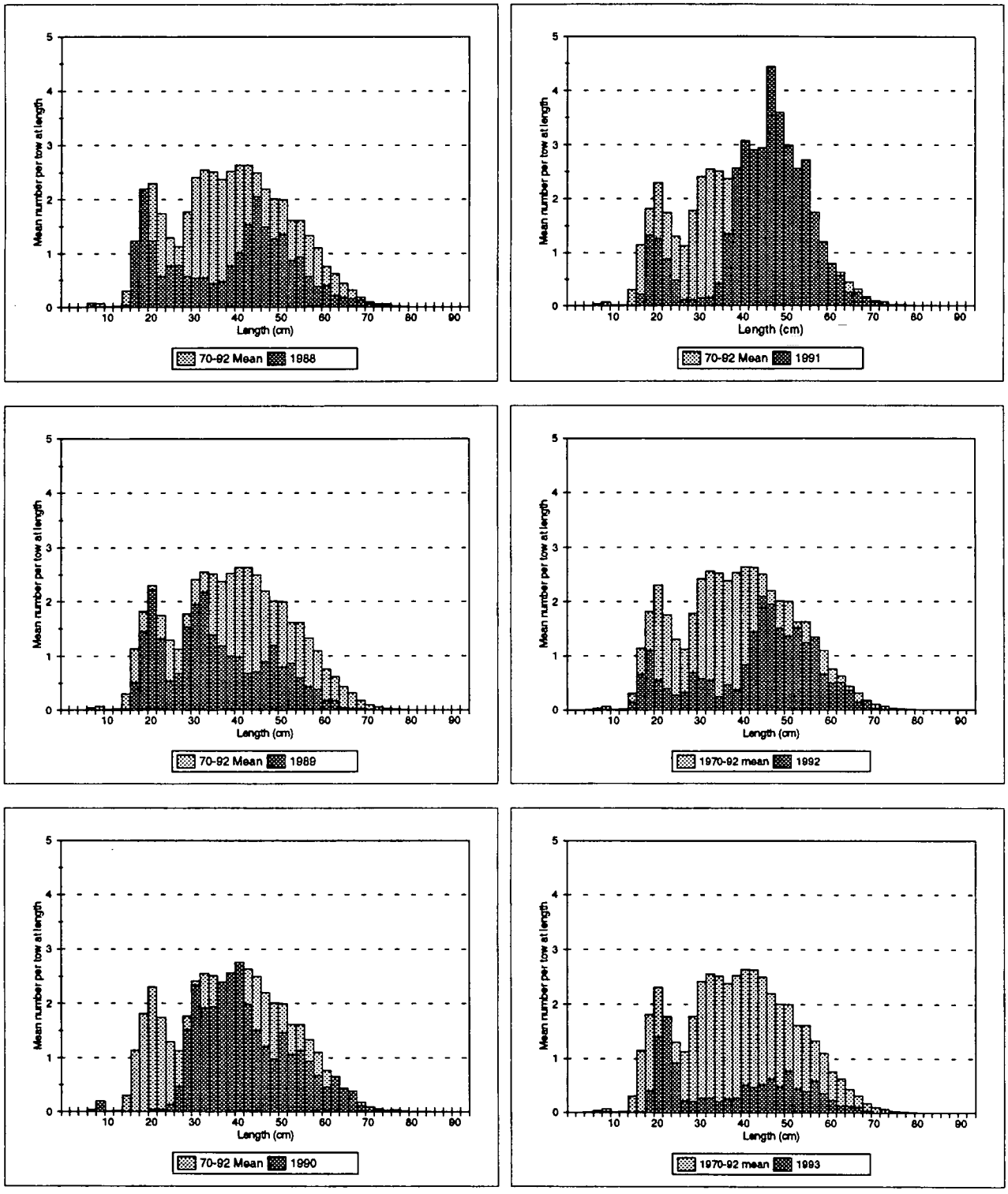


Figure 10. Summer RV survey mean number per tow by length for 4X haddock, 1988-1993, with the 1970-1993 mean.

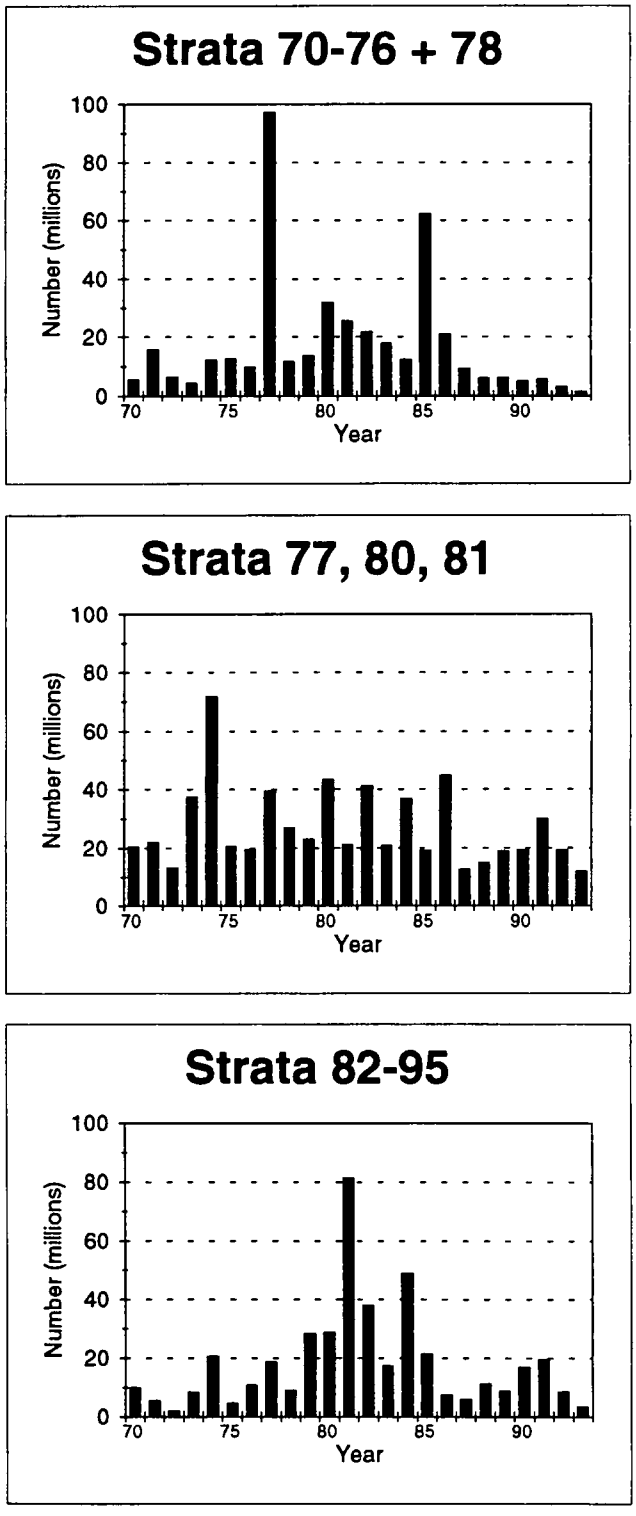


Figure 11. 4X haddock summer RV survey stratified numbers by stratum grouping.

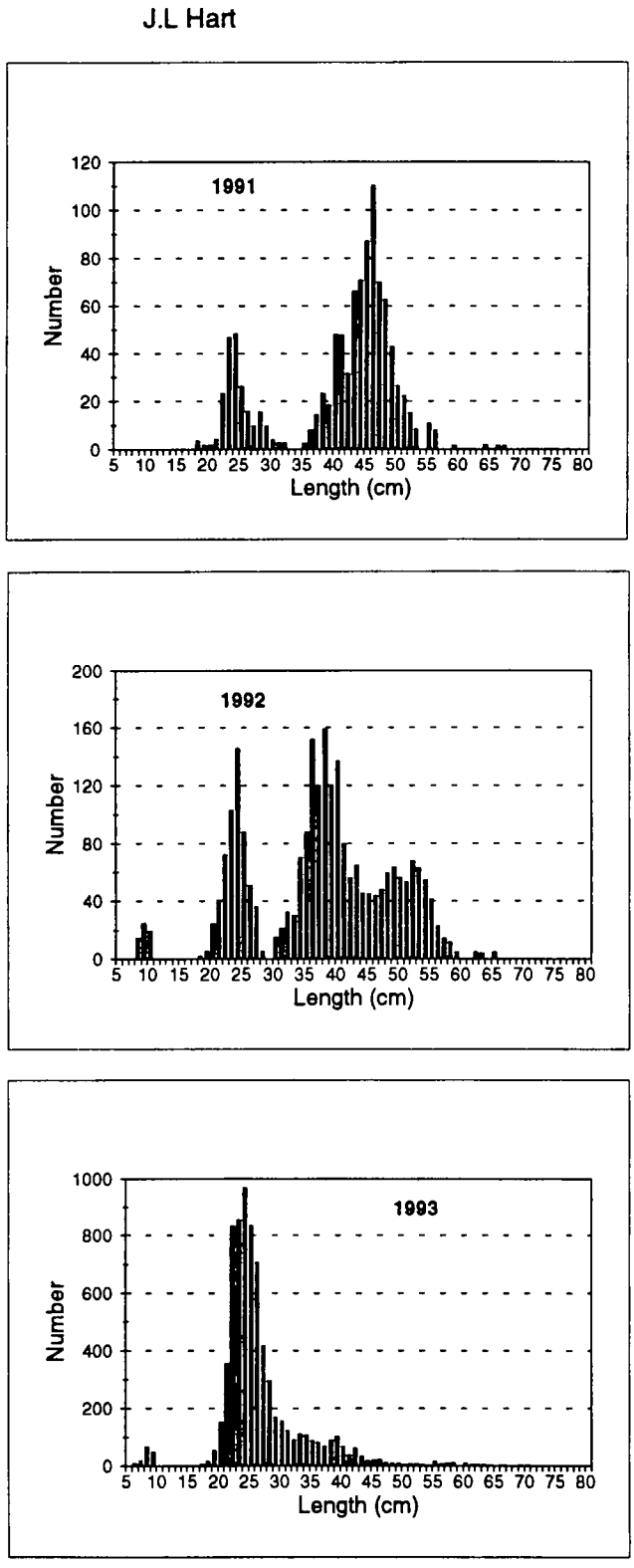


Figure 12. Size composition of haddock caught on the J.L. Hart inshore survey, 1991-1993.

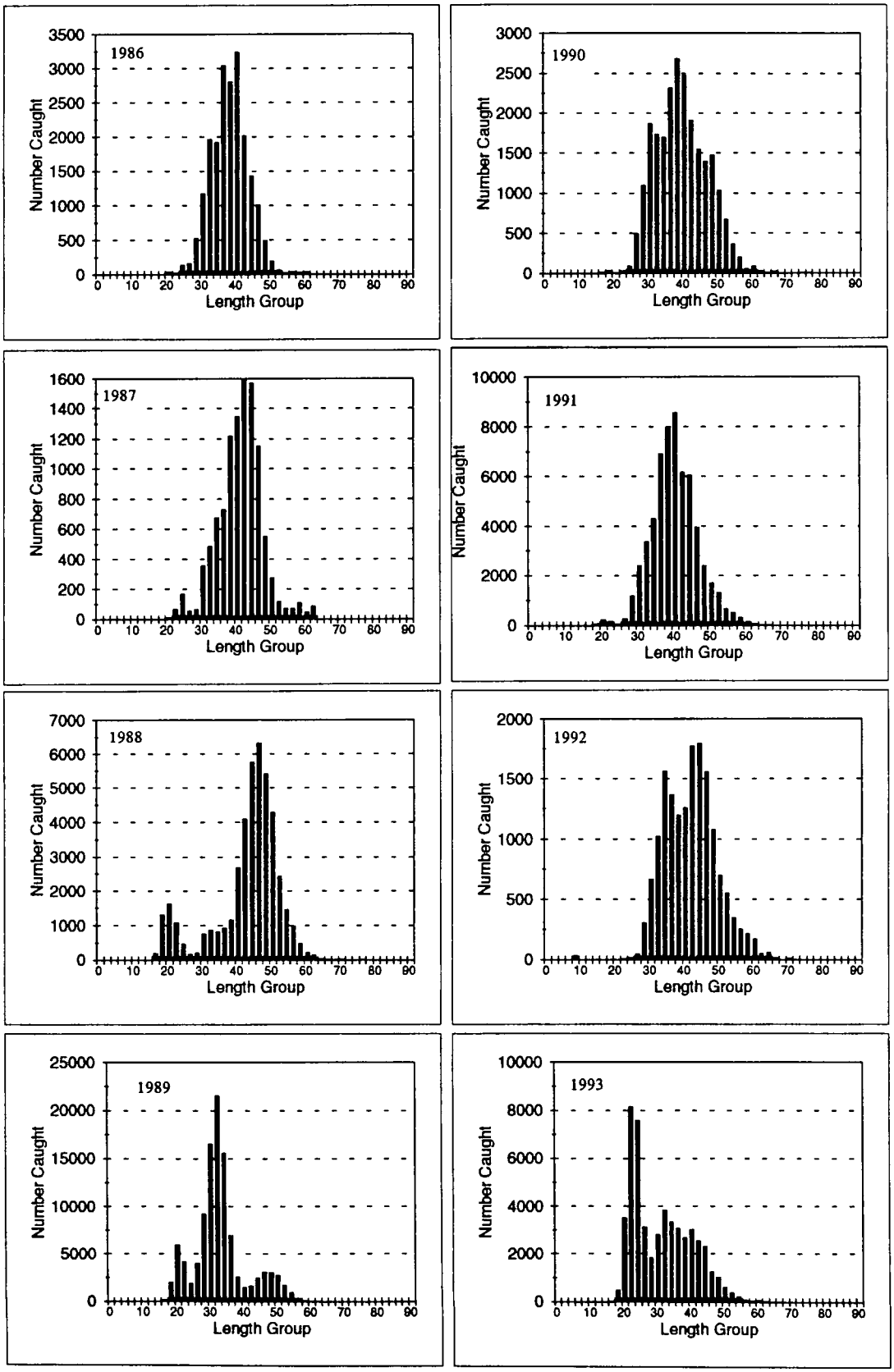


Figure 13. Size composition of 4X haddock bycatch in the foreign small mesh gear fishery, 1986-1993.

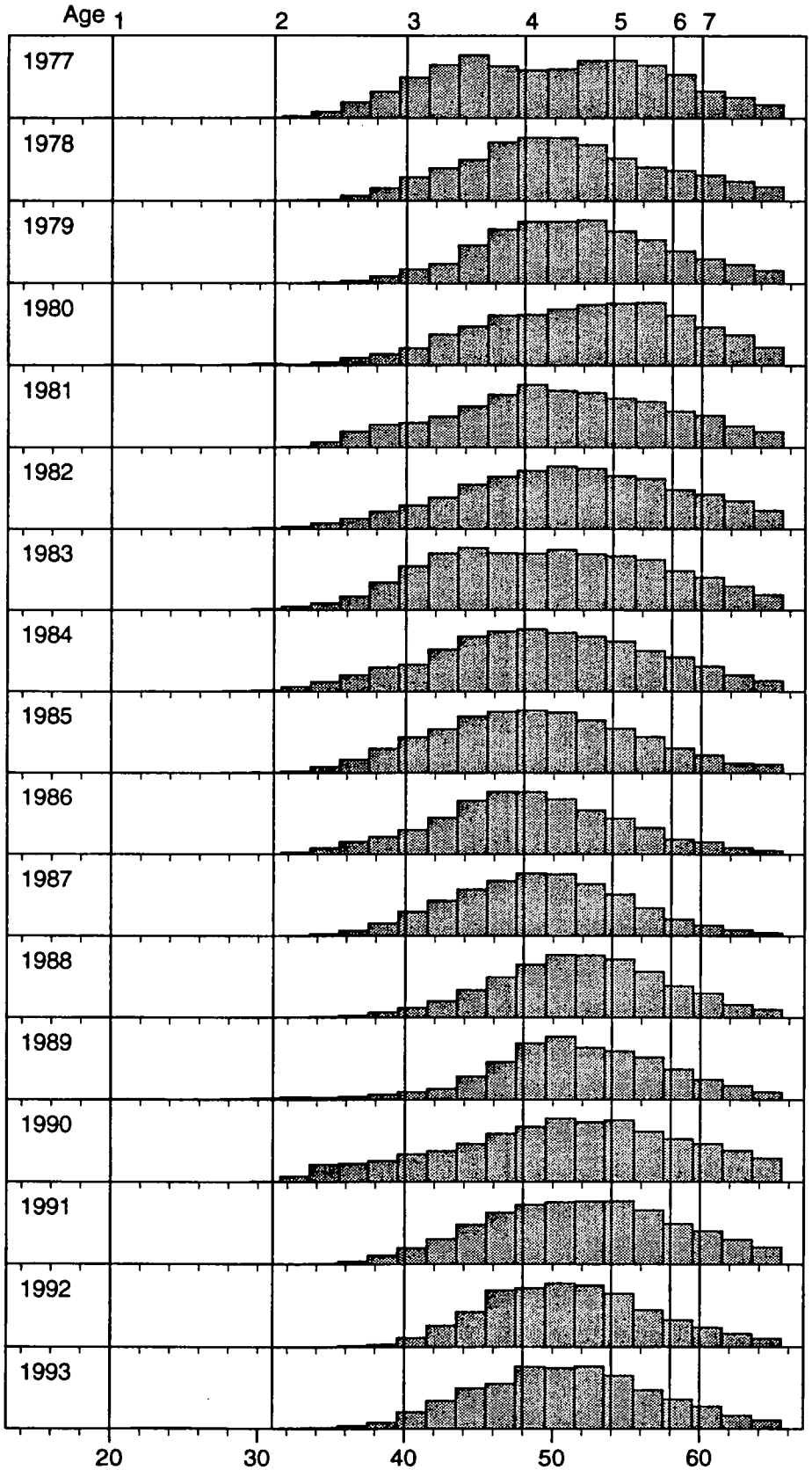


Figure 14. Normalized length frequencies of 4X commercial haddock data including mean length at age.

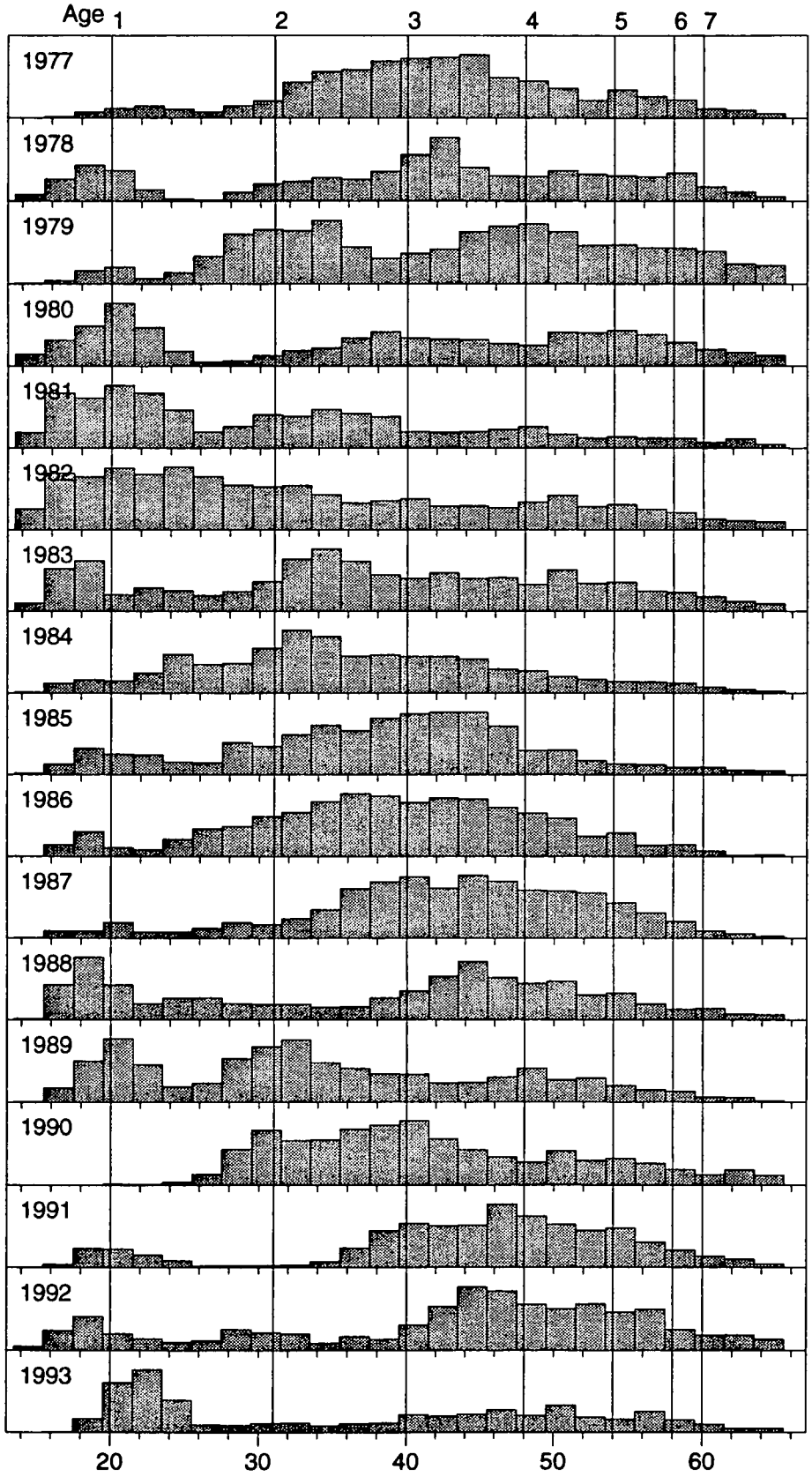


Figure 15. Normalized length frequencies of 4X research survey haddock data including mean length at age.

Figure 16. NLLS Mean Square of Residuals for 70-84/96 Index ages 3-6

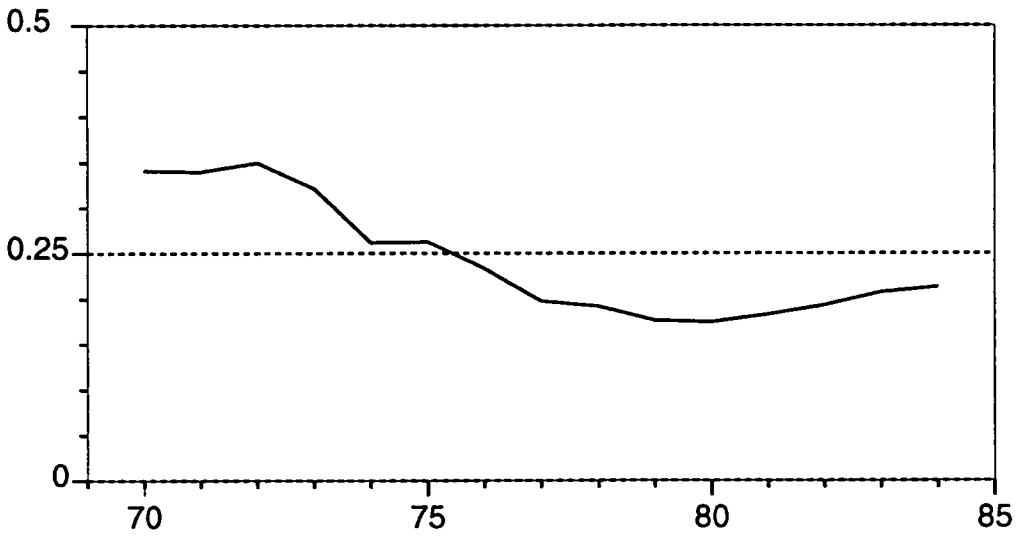


Figure 17. NLLS est. Q for 70-84/96 Index ages 3-6

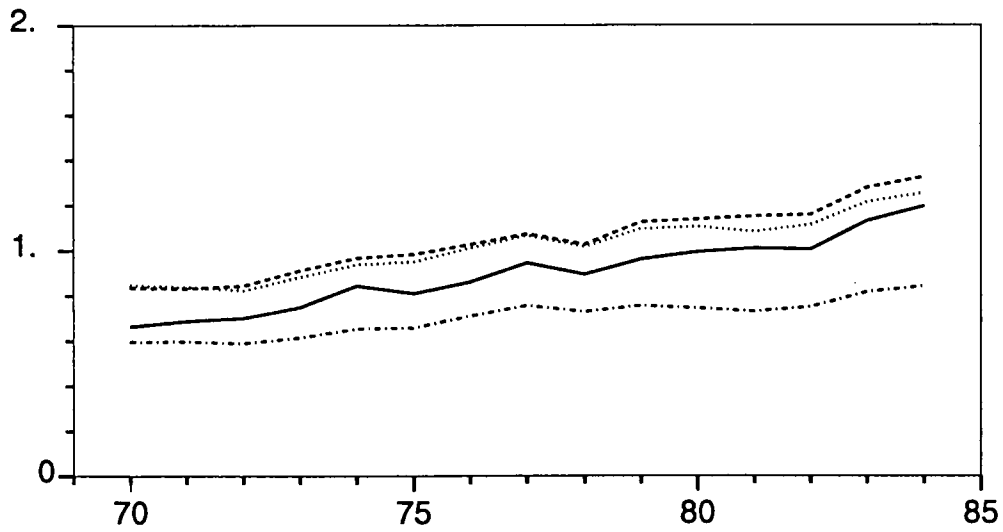


Figure 18. Keymake Mean Square of Residuals for 70-84/96 Index ages 3-6

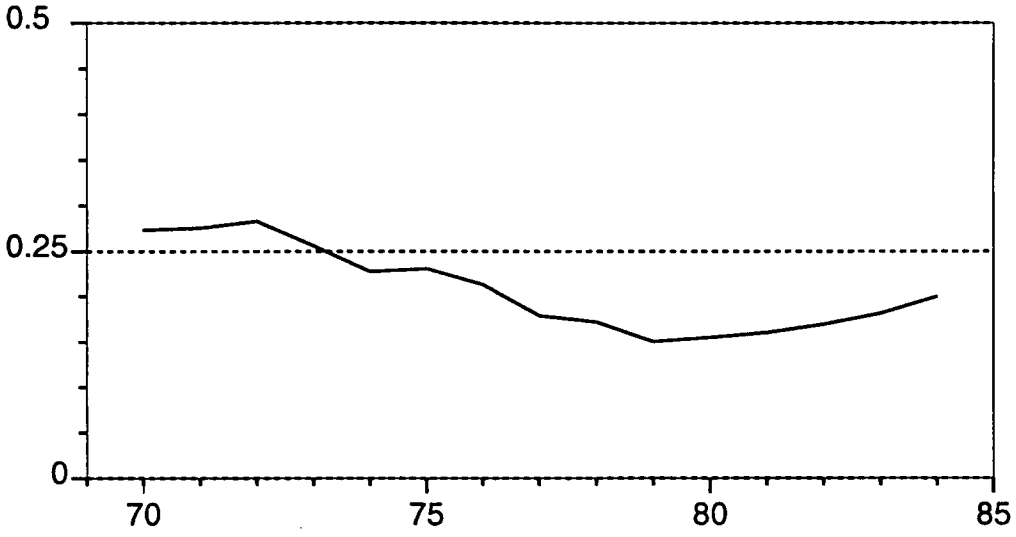
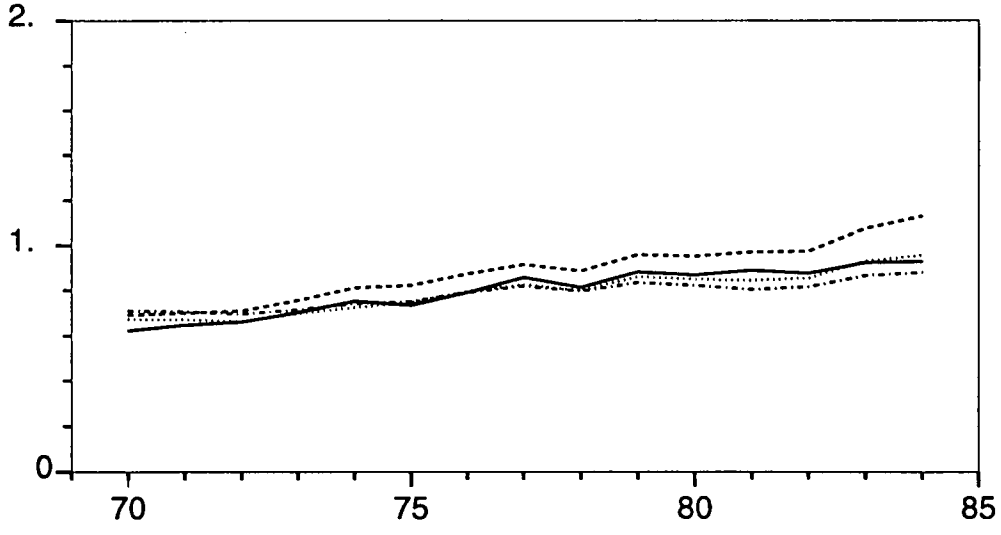
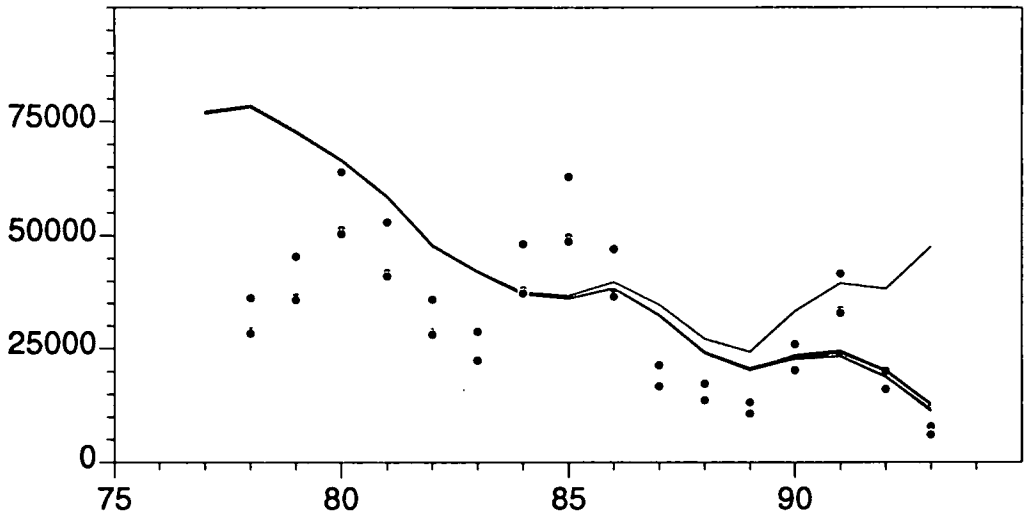


Figure 19. Keymake est. Q for 70-84/96 Index ages 3-6



Pop 3-6 77-93 NLLS Starting Pars : 0.1-1.



Starting guesses:				F's at 3 - 6				Q's			
0.1	0.1	0.1	0.10:	0.02	0.21	0.21	0.12	0.66	0.81	0.82	0.76
0.2	0.2	0.2	0.20:	0.13	0.59	0.59	0.36	0.87	0.99	0.99	0.91
0.3	0.3	0.3	0.30:	0.18	0.57	0.56	0.36	0.88	0.98	0.98	0.91
0.4	0.4	0.4	0.40:	0.16	0.60	0.57	0.36	0.87	0.99	0.99	0.91
0.5	0.5	0.5	0.50:	0.19	0.67	0.65	0.42	0.89	1.01	1.01	0.92
0.6	0.6	0.6	0.60:	0.14	0.57	0.56	0.35	0.86	0.99	0.99	0.9
0.7	0.7	0.7	0.70:	0.15	0.69	0.64	0.38	0.88	1.01	1.00	0.91
0.8	0.8	0.8	0.80:	0.14	0.57	0.56	0.35	0.86	0.99	0.99	0.9
0.9	0.9	0.9	0.90:	0.14	0.58	0.59	0.36	0.87	0.99	0.99	0.91
1.0	1.0	1.0	1.00:	0.16	0.71	0.66	0.39	0.88	1.02	1.01	0.92

Figure 20.

Figure 21. 4X Haddock Numbers 3-6 from VPA and q corrected survey

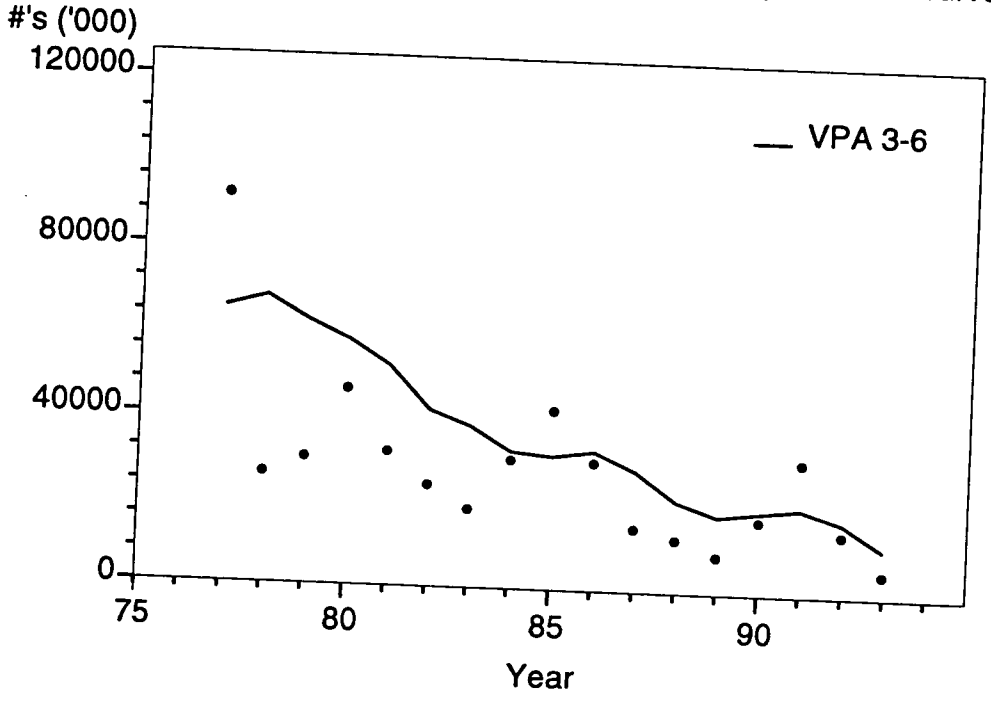


Figure 22. 4X Haddock Estimates of average fishing mortality [ave(ages 4-7)]

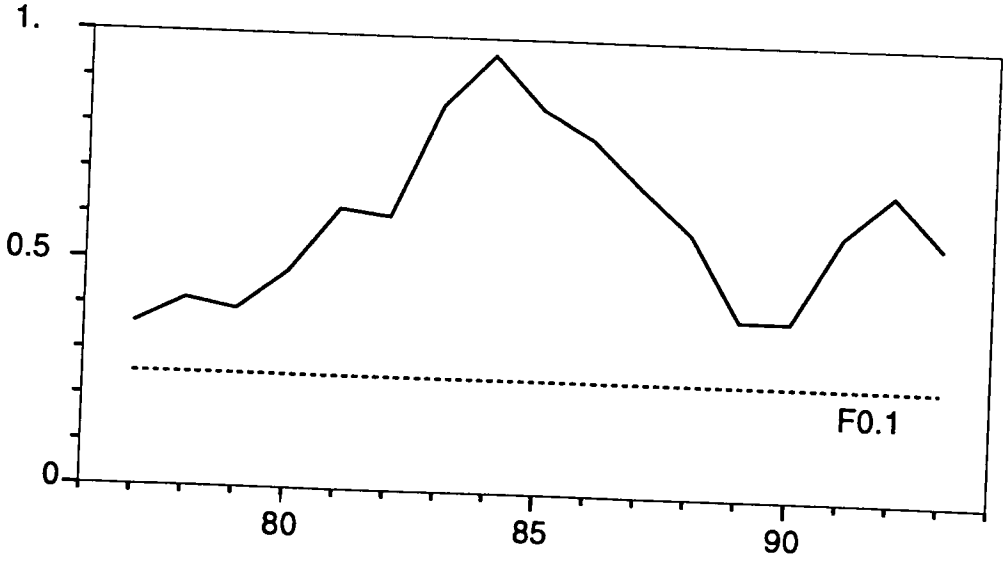


Figure 23. 4X Haddock Recruitment, Age 1 from VPA (#'s)

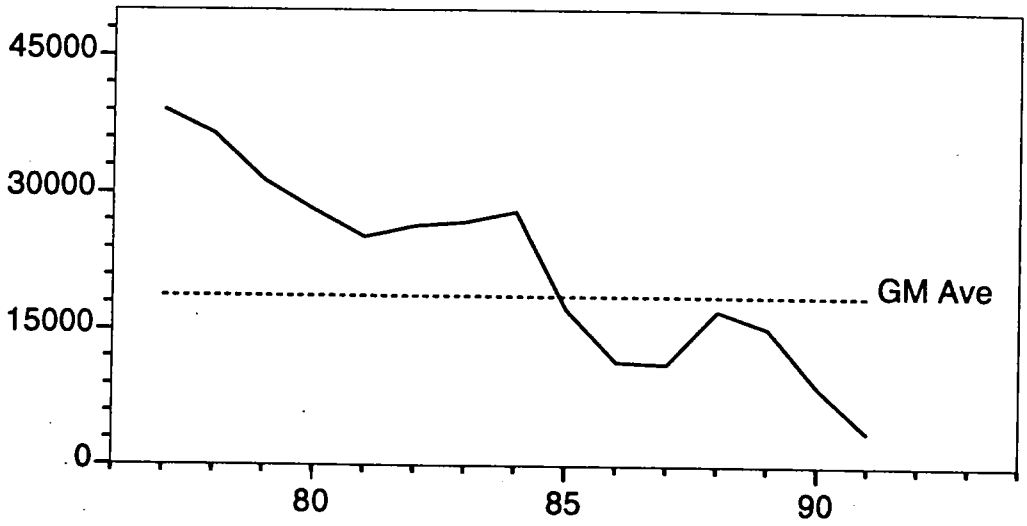


Figure 24. 4X Haddock Biomass estimates (t) from VPA

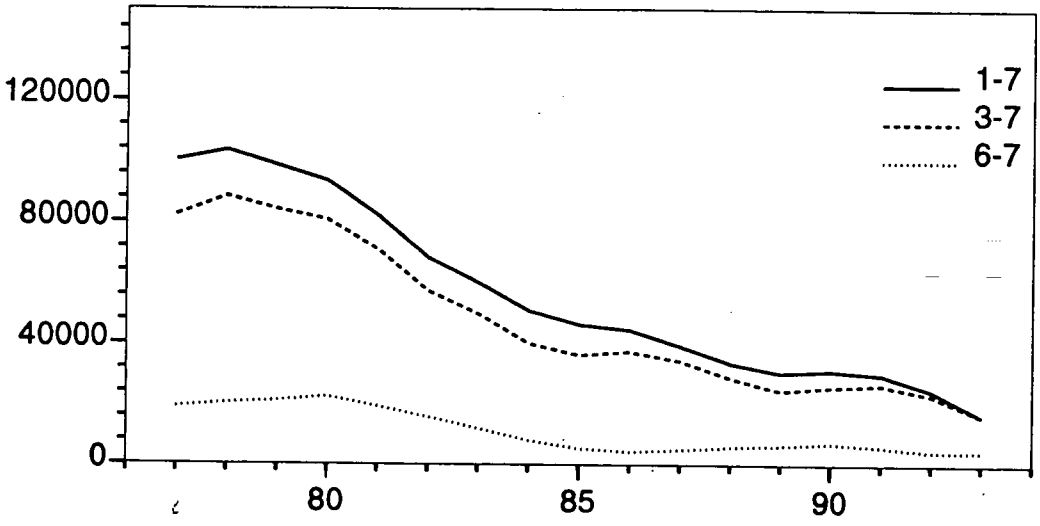


Figure 25. 4X Haddock Retrospective Analysis using Keymake