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DFO Atlantic Fisheries
Research Document 95/101

MPO Pêches de l'Atlantique
Document de recherche 95/101

Update of Information on the 4X Haddock Stock

by

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Abstract

The Spring 1995 Regional review of the 4X haddock stock reported that 1994 fishing mortality was somewhere between F_{max} and $F_{0.1}$ and that spawning stock biomass was close to its lowest observed level. However, interpretation of the data from this stock has been complicated in recent years by the discovery of a bias in the age determinations from otoliths during the period 1983 to 1991. Age reading was suspended until new criteria could be developed. In the interim, a technique known as cohort-slicing has been used to estimate age compositions from length compositions. The mean sizes-at-age for the underlying growth model were estimated using combinations of estimates from the 1970–1982 data and results from the most recent age determinations.

In this document, data from the 1995 July research vessel survey, from a resource survey conducted by the ITQ (Individual Transferable Quota) fleet in 1995 and on catches from the commercial fishery for the first two quarters of 1995 are presented. These data were used to evaluate current stock status. All of these data indicate favourable recruitment prospects for the 1992, 1993 and 1994 year-classes. However, the research survey estimates of abundance in 1995 are much greater than expected from the earlier assessment of this stock. Reconciliation of these differing views will await resolution of the age determination problem which is expected for the Spring 1996 assessment of the stock.

Résumé

D'après l'examen régional du stock de haddock de 4X réalisé au printemps 1995, la mortalité par pêche en 1994 se situait entre F_{max} et $F_{0.1}$ et la biomasse du stock de reproducteurs approchait de son plus bas niveau de tous les temps. Toutefois, l'interprétation des données relatives à ce stock s'est trouvée compliquée ces dernières années par la découverte d'une erreur systématique dans les déterminations d'âge selon les otolithes réalisées de 1983 à 1991. On a cessé de déterminer les âges jusqu'à ce qu'on puisse établir de nouveaux critères. Dans l'intervalle, une technique dite de «découpage des cohortes» a été utilisée pour estimer les compositions selon l'âge à partir des compositions selon la longueur. On a estimé la taille moyenne selon l'âge du modèle de croissance intrinsèque en utilisant des combinaisons d'estimations provenant des données de 1970–1982 et des résultats des déterminations d'âge les plus récentes.

On présente ici les données du relevé de recherche scientifique de juillet 1995, les données d'un relevé sur la ressource réalisé par la flottille de pêche selon des quotas individuels transférables (QIT) en 1995 et les statistiques de prises de la pêche commerciale pour les deux premiers trimestres de 1995. Ces données ont été utilisées pour évaluer l'état actuel du stock. Toutes dénotent des perspectives de recrutement favorable pour les classes d'âge de 1992, 1993 et 1994. Toutefois, les estimations d'abondance découlant du relevé de recherche en 1995 sont bien supérieures à ce à quoi permettait de s'attendre l'évaluation précédente du stock. Il faudra attendre une solution au problème de la détermination de l'âge, prévue pour l'évaluation du printemps 1996, pour réconcilier ces visions différentes.

Introduction

Previous investigations of the 4X haddock stock assessment data had indicated a bias in the age determinations made from otoliths during 1983 to 1991 and estimated age compositions from this period were considered to be suspect (p. 123, Sinclair 1993). New protocols for estimating ages from haddock otoliths are waiting on results from (amongst other studies) inter-laboratory comparisons of age readings. Preliminary results from the comparison study showed close agreement amongst the ages estimated by five national and international laboratories (Campana 1995). Routine age reading of 4X haddock otoliths will begin once the technicians assigned to the task have been trained on the new protocols.

In the meantime a method known as cohort-slicing had been used to derive age compositions from the length frequency data. The resultant cohort-slicing derived age compositions were used in VPA/ADAPT models to estimate fishing mortality and population biomass for 4X haddock. The results of this analysis were presented for Regional review by the Haddock Working Group in April 1995.

After presentation of the working group report to the Regional review, further work was carried out by the Haddock Working Group. A number of different growth models were explored to generate length-at-age estimates for the cohort-slicing method. Many different approaches were tried but all generally resulted in a view of the stock that had a predicted fishing mortality, F somewhere between F_{max} and $F_{0.1}$ and spawning stock biomass close to its lowest observed level. Due to the uncertainties about the actual size-at-age of haddock during the 1983 to 1994 period, it was difficult to evaluate which approach was the best to use. Although all of the approaches resulted in the same general view, each gave different estimates of fishing mortality. Resolution of the ageing problem was seen to be the only way of validating the growth model used in the cohort-slicing method and obtaining usable estimates of fishing mortality.

The 1994 research vessel survey indices suggested that the abundance of market-size fish was relatively low while 1993 and 1994 year-classes were above average and the 1992 year-class was below average (Anon. 1995). The 1993 survey had indicated that the 1992 year-class was above average. In this report we present information from the 1995 research vessel survey on the strengths of these year-classes.

We also present a preliminary analysis of trends in female haddock condition which may indicate links between condition and recruitment prospects for this fishery. In addition, preliminary results from this summer's ITQ fleet survey are provided and compared with results from the research vessel survey. Implications of the 1995 research vessel survey results on the cohort slicing/VPA model were evaluated by comparing the 1995 predicted size composition for the survey with that observed from the survey.

The Fishery

Reported landings of 4X haddock in the first and second quarters of 1995 were 1431 t and 875 t respectively, compared to 822 t and 1168 t in 1994 (Table 1). The increase in first quarter landings occurred primarily in the mobile gear sector. Consultations with industry revealed that the increase was due to vessels directing for haddock as a result of favourable haddock prices early in the year. First quarter landings in the fixed gear sector decreased slightly relative to 1994, due to extensive closures. Second quarter landings decreased in both gear sectors, as mobile gear vessels attempted to avoid haddock so as to leave quota for later in the year, and fixed gear vessels were subject to further closures.

Hurley et al. (1995) recorded an increasing trend in the mean length of haddock from 48 to 54 cm in the annual landings of the mobile gear from 1990 to 1993. They had explained this trend as being the result of the increasing use of larger mesh sizes by mobile fleet and, temporal and spatial changes in fishing effort over this period. Size compositions in the landings by this gear sector in 1994 were comparable to those in 1993 (Hurley et al. 1995). Over the same time period, the mean length of haddock in the fixed gear landings has shown a decreasing trend from 54 to 49 cm. The mean length in the landings increased to 51 cm in 1994 and this increase was attributed to a decrease in the winter longline fishery as well as discarding of undersized haddock that occurred after the small fish closures in the Spring of 1994 (Hurley et al. 1995).

Comparisons of the mean lengths and size compositions of landings in 1995 with those in 1994 were made. This comparison was confined to first and second quarter of 1995 because that was all of the information that we had available at the time of this report. First quarter mobile gear landings show a slight decrease in mean length in 1995 (54.9 cm relative to 55.7 cm in 1994) but the mean length is still larger than in earlier years (Fig. 1). The size composition in first quarter fixed gear landings in 1995 was similar to 1994 (mean of 53.5 cm). The mean length of second quarter mobile gear landings also decreased slightly in 1995 (53.7 cm relative to 55.9 cm in 1994) while in the second quarter fixed gear landings the mean increased slightly (52.5 cm relative to 50.2 cm in 1994; Fig. 2).

Information from DFO Surveillance reports indicated that discarding of < 48 cm (19 in) haddock occurred while the longline fleet was fishing under an interim fishing plan during January and that the practice was suspected to be widespread. The longline fishery was closed 31 January until a fishing plan could be developed. With the re-opening of the longline fishery in April, "small" cod and haddock were reported in catches from Roseway, LaHave and Baccaro Banks. At-sea sampling of catches conducted during DFO Surveillance boardings continued to show "small" fish on these banks and recommendations were made to close these banks to fishing. Closure was initiated 30 June 1995 (S-F Region Close Time Variation Order 1995-081) with the order to remain in effect until the end of the year. A test fishery of the closed areas during 26 July to 1 August resulted in catches of approximately 23% "small" cod and haddock. An additional test fishery was conducted 23 to 29 August using #12 hooks and 14% of the cod and 16% of the haddock caught were undersized. The results of the test fisheries have caused the closure to remain in effect.

The fishing plan for the fixed gear sector < 65′ was quite complex this year, with the sector allocation sub-divided into 15 different groups. To date, many of these groups have spent more time closed than open due to small seasonal allocations of cod and haddock.

Information from DFO Surveillance reports indicated that catches of undersize fish in the mobile gear sector had not been a problem. During industry consultations, it was indicated that many vessels continued to use 140 mm square mesh or larger to reduce catches of small fish in general and of cod and haddock specifically. The only closures for the mobile gear sector were for small mesh gear directing for redfish.

Therefore while small haddock appear to be widespread in geographical distribution, problems with discarding may have been minimized in the fixed gear fleet by small fish closures and by large mesh in the mobile gear. As a result, there does not seem to be any drastic change in the mean length in the landings over that observed in 1994.

Research Vessel Survey

Mean number per tow of haddock in the summer research vessel survey of 4X (strata 70–85, 90, 91 and 95) increased from 37 in 1994 to 93 in 1995 (Fig. 3), more than twice the long term mean of 44 haddock per tow and the second highest value in the survey series; however mean weight per tow increased from 16 kg in 1994 to only 35 kg in 1995, relative to the long term mean of 36 kg per tow. The increase in 1995 was not due to one or a few large sets, instead, relatively large catches of haddock were made over much of the survey area (Fig. 4). This substantial increase in mean numbers per tow, relative to mean weight per tow, was due to record catches of small haddock (Fig. 3b vs. 3e).

The catch of haddock at modal lengths of 18 and 30 cm, respectively (haddock aged 1 and 2 years old) was much larger than average (Fig. 5, 1995 panel). These modes are consistent with the modes of 9 and 25 cm in the 1994 survey, when these haddock were 0 and 1 years old (Fig. 5). The 1995 survey indicates that the abundance of market size haddock (> 43 cm) has also increased (Fig. 3c). The catch of haddock in the length range 38 to 48 cm was at or slightly above average, while the catch in the length range of 50 to 58 cm was slightly higher than last year but still lower than average. The catch in the length range 60 to 70 cm was still well below average and no haddock greater than 70 cm in length were caught.

Overall length frequency distributions from the 1992–95 summer research vessel surveys indicate that the 1993 and 1994 year-classes are much stronger than average and that the 1992 year-class may be average in strength.

Haddock were more widely distributed in 4X in the 1995 summer survey than in recent years (Fig. 6). Haddock were encountered in the eastern portion of the survey area and in the upper part of the Bay of Fundy, where they had not been seen in the survey in recent years. Abundance increased throughout the survey area, but the increase in the eastern and central portions of the survey area consisted primarily of small haddock (Table 2). The increase in the Bay of Fundy, however, consisted of both small and market sized haddock.

Female spawning stock biomass (SSB) was estimated using the catch-at-length data from research vessel survey and the maturity ogive given in O'Boyle et al. (1989) originally from Waiwood and Buzeta (1989). Resultant mature numbers-at-length, assuming a 1:1 sex ratio were converted to weight using the length/weight relationship given in Table 15 of O'Boyle et al. (1989). The annual estimates and smooth trends for SSB using 3 year running means and 3 year running medians are presented in Fig. 7. In general, SSB has been below the longterm mean since 1985 and the 1993 and 1994 values were some of the lowest in the series.

ITQ Survey

The ITQ Committee in cooperation with DFO Science Branch conducted a resource survey of the 4X area during the period 26 June to 7 July 1995 at the same time as the annual summer survey conducted by the DFO research vessel *Alfred Needler*. The ITQ survey was designed to cover the same areas as the research vessel survey as well as the inshore area that the research vessel cannot survey. The industry vessels used standardized gear with the same size liner as in the research vessel survey. The ITQ survey was conducted by three draggers (< 65 ft.) which completed a total of 139 sets. Sampling was conducted by observers and length samples were taken for cod, haddock, pollock, and winter flounder.

All of the total catches in numbers and weights from the three vessels were standardized to a standard distance towed and to the same wingspread. Wingspreads of the trawls used by the three ITQ survey vessels were determined using SCANMAR sensors. Location and magnitude of the catches of haddock are presented in Fig. 8. The distribution patterns of abundance from the research vessel survey (Fig. 4) and the ITQ survey (Fig. 8) appear to be similar, although the latter survey does provide much more information on the inshore area of Southwest Nova Scotia where the former survey does not cover.

Preliminary analysis of the haddock data from the ITQ survey was undertaken by comparing size compositions of the haddock catches for the two surveys. These comparisons were made for four of the major haddock survey strata from the research vessel survey (477 - south east of Baccaro Bank, 480 - Browns Bank, 481 - deep water around Browns Bank, 490 - Trinity/Lurcher area; Fig. 9). Both surveys show similar size compositions in each of the four strata. The modes for the 1994 and 1993 year-classes were evident in both surveys. The size composition of the inshore area not included in the research vessel survey also clearly shows the same modes at the lengths corresponding to age 1 and 2 as the other strata. Further work needs to be done on comparing actual numbers of haddock caught in the two surveys and the numbers presented in the figure are subject to change.

Female Condition Factor

Recent evidence from laboratory and field studies of groundfish species suggests that parental condition influences survival of offspring (DeMartini 1991, Kjesbu et al. 1991, Kjesbu et al. 1992). Both egg size and egg quality are positively correlated with maternal size and condition. Marshall (1995) suggested that this is an important consideration for 4X haddock. Consequently, it would be valuable to begin to examine the body size characteristics of spawning stocks in relation to recruitment success. Given the large numbers of young haddock collected during the 1995 July research vessel survey in 4X, it was considered useful to investigate the recent condition of spawning haddock that gave rise to these apparently large year-classes.

The condition of female haddock was evaluated from collections made during the July research vessel survey in 4X. Length (L) and weight (W) observations for adult haddock were used to fit the equation:

$$\log W = \log a + b \log L \qquad (1)$$

for each survey (1970–1995). The data set evaluated was partitioned into offshore (strata 470–481) and Bay of Fundy (strata 485, 490, 491 and 495) components. The spawning population was assumed to consist of age 3+ females. When ageing data were not available, females with lengths > 29 cm were considered to be mature. The predicted weight at 50 cm, estimated by back-transforming the prediction from equation (1), was used as an index of condition (Table 3).

Marshall (1995) assumed that haddock in the offshore component were three to four times more abundant than the Bay of Fundy component based on the proportional distribution of commercial catch in the two areas. Therefore, she concluded that the condition index for the offshore component represented the major signal for examining relationships between condition and recruitment for this stock. Consequently, we confined our analysis to the offshore component as well.

The female condition index has varied substantially over time with most of the above average values of the index occurring during 1970 to 1982 and most of the below average values occurring during 1983 to 1995 (Fig. 10). This pattern is generally consistent with the recruitment time series of 4X haddock with above average year-classes typical throughout the 1970s and early 1980s, followed by weak year-classes to 1992. The correlation between recruitment at age 1 (from the VPA in Hurley et al. 1995) and the predicted weight of 50 cm female haddock was estimated to be 0.522 ($n = 22$, $p = 0.013$) when the 1970 year-class was omitted from the analysis (Fig. 11). While much of the recruitment variation remains unexplained, this relationship is among the best predictor of recruitment for 4X haddock, exceeding attempts to explain recruitment on the basis of spawning stock biomass (SSB) or environmental factors, alone. It should be noted that when unexpectedly weak year-classes occurred at high female condition the SSB was low (e.g., 1970, 1972, 1973, 1978 and 1990 year-classes, Fig. 7).

The recent condition of 50 cm female haddock (1990 to 1995) is below the long-term mean of 1.3 kg but not the lowest in the time series. On this basis alone, the year-classes produced from these females are not expected to be large and other factors may be responsible for the recent observations of numerous young haddock in Division 4X. Given the preliminary nature of this analysis and the uncertainties surrounding it (e.g., recruitment estimates), the results must be viewed with caution. More research is required on these relationships before they can be routinely used in formulating stock assessment advice.

Comparison of 1995 Spring Assessment Results with 1995 Survey

The cohort-sliced/VPA population abundance estimates at age for 1994 (Hurley et al. 1995) were projected to the beginning of year 1995 using the reported catches. The beginning of year 1995 abundance was in turn projected to mid-year 1995 for comparison with the mid-year (July) survey, using the reported catch for the first half of 1995. The population abundance at age for mid-year 1995 was then converted to predicted survey abundance at age using the estimated catchabilities for ages 2 to 6. Catchabilities for ages 1 and 7 which were not estimated by the VPA, were assumed to be 0.0003 and 0.001, respectively, based on the linear trend for ages 2 to 6. The predicted survey abundance at age was then converted to predicted survey abundance at length using the 1994 mid-year length-at-age distributions.

The 1994 VPA estimates of abundance at length along with the two most recent surveys (1993 and 1994) that the VPA estimates were based on are presented in Fig. 12a. Projecting the 1994 VPA ahead and estimating the 1995 survey by the method described above gives the abundance at length denoted as 1995 VPA in Fig. 12b. The observed 1995 survey numbers were divided by 4 so they could be shown on the same scale as the other results. Comparison of the 1995 survey and VPA estimates indicate that the observed values at almost all lengths were greater than the predicted values. The 1995 survey mean catch per tow for fish smaller than 50 cm was higher than the VPA prediction and higher than the mean catch per tow in recent years.

Summary

Results from the 1995 July research vessel survey support our view from previous research vessel surveys that the 1993 and 1994 year-classes are above average in abundance. While there had been some uncertainty about the strength of the 1992 year-class as estimated from the 1993 and 1994 surveys, the 1995 survey supports the view that this year-class is also average in abundance. The ITQ survey in 1995 also indicated that these year-classes were abundant and like the research vessel survey showed them to be widespread in distribution over the 4X area.

The commercial fishery experienced problems with the widespread distribution of haddock smaller than market size particularly on LaHave, Roseway and Baccaro Banks. These banks were closed to fixed gear 30 June due to significant amounts of "small" haddock (and cod) in the catches. The closure is supposed to remain in effect until the end of the year or until test fisheries indicate that "small" fish are no longer a problem.

While the apparent abundance of young fish in catches from the research survey, ITQ survey and commercial fishery may promise good recruitment in upcoming years, there are still some inconsistencies in the signals coming from this stock. Although, the exact level of spawning stock biomass is not known at present, there are still concerns that it is very low compared to past values. Spawning stock biomass/recruitment relationships have not been established for this stock (O'Boyle et al. 1989, Marshall 1995) but it is interesting to note here that three average or above average year-classes appear to have been produced by probably some of the smallest spawning stocks in the history of this stock. Female haddock from the last three years exhibited some of the lowest condition factors since 1970 with these condition factors suggestive of low spawning productivity. In addition, results from the 1995 survey were dramatically inconsistent with predictions from the VPA for this survey. That is, the abundance of haddock smaller than 50 cm was much greater in the 1995 survey than expected.

Contingent upon favourable results from the inter-laboratory comparison of ages read from haddock otoliths, the next assessment of this stock, scheduled for spring 1996 should have reliable age compositions available for some or most of the 1983 to 1995 period. This information should help to improve our understanding of the status of this stock.

Acknowledgements

This research document was a group effort of the Haddock Working group (see Appendix) and all equally share the ignominy or accolades that result from it. Stratis Gavaris provided very useful comments and suggestions which greatly improved the text.

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Table 1. Reported nominal catch (tonnes, round weight) of haddock from NAFO Division 4X (excluding unit area 4Xs) by gear type, tonnage class, area and quarter for the period 1984 to 1995.

		Otter Trawl				Longliner		Misc.		
		4Xmnop		4Xqr		4Xmnop	4Xqr	4Xmnop	4Xqr	
Year	Qtr.	1–3	4+	1–3	4+	1–3	1–3	1–3	1–3	Total
1995	1	798	74	257	1	301	0	0	0	
	2	109	2	347	7	299	105	3	3	
1994	1	239	19	231	2	331	0	0	0	
	2	194	7	362	1	535	61	5	3	
	3	87	2	399	0	923	90	23	7	
	4	144	48	300	16	233	2	8	0	4272
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	1616	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

Table 2. Stratified mean numbers of haddock by length grouping for selected strata groupings from July research vessel survey.

Year	Size range	Strata Groupings			
		470–476,478	477,480,481	482–495	Total
1991	Less than 43 cm	1.57	12.23	1.16	14.97
	Greater than 43 cm	2.39	9.20	12.77	24.36
	All sizes	3.96	21.43	13.93	39.33
1992	Less than 43 cm	1.29	6.53	0.81	8.63
	Greater than 43 cm	0.79	7.24	5.33	13.35
	All sizes	2.07	13.77	6.14	21.98
1993	Less than 43 cm	0.56	6.10	0.51	7.17
	Greater than 43 cm	0.49	2.41	1.86	4.75
	All sizes	1.05	8.50	2.36	11.91
1994	Less than 43 cm	3.56	13.06	15.45	32.07
	Greater than 43 cm	1.10	2.68	2.14	5.92
	All sizes	4.66	15.74	17.59	37.99
1995	Less than 43 cm	12.36	42.40	25.20	79.96
	Greater than 43 cm	1.32	3.53	8.30	13.15
	All sizes	13.68	45.93	33.50	93.11

Table 3. Parameter estimates derived from regression analysis of length and weight of female haddock from July research trawl surveys for strata 470–481 only in NAFO Division 4X. R^2 is the coefficient of determination for the length/weight regression. Predicted weights for 50 cm haddock given in rightmost column for the relationship, predicted weight = $\log_{10}(a) + b\log_{10}(50)$.

Year	Sample size	$\log_{10}(a)$	b	R^2	Predicted weight (gm)
1970	292	-1.919	2.980	0.940	1395.70
1971	267	-2.041	3.036	0.968	1310.04
1972	292	-2.284	3.195	0.976	1395.88
1973	137	-1.930	2.981	0.965	1363.21
1974	357	-1.994	3.014	0.975	1340.99
1975	210	-2.205	3.138	0.974	1338.46
1976	224	-1.891	2.939	0.972	1267.90
1977	256	-2.062	3.055	0.975	1346.32
1978	250	-2.308	3.209	0.977	1395.59
1979	234	-2.052	3.050	0.969	1345.47
1980	244	-1.926	2.971	0.971	1322.64
1981	180	-1.875	2.945	0.957	1341.25
1982	142	-2.042	3.037	0.982	1309.24
1983	233	-2.139	3.075	0.977	1216.70
1984	198	-2.099	3.062	0.978	1268.46
1985	253	-2.034	3.016	0.975	1230.83
1986	233	-1.962	2.978	0.945	1252.42
1987	220	-1.739	2.854	0.961	1287.37
1988	156	-2.299	3.190	0.872	1318.58
1989	131	-2.013	3.014	0.964	1281.90
1990	239	-1.924	2.973	0.975	1340.68
1991	201	-2.016	3.014	0.971	1271.15
1992	183	-1.978	2.995	0.970	1287.08
1993	138	-1.942	2.966	0.978	1248.75
1994	216	-2.010	3.010	0.982	1268.30
1995	192	-2.031	3.014	0.986	1231.31

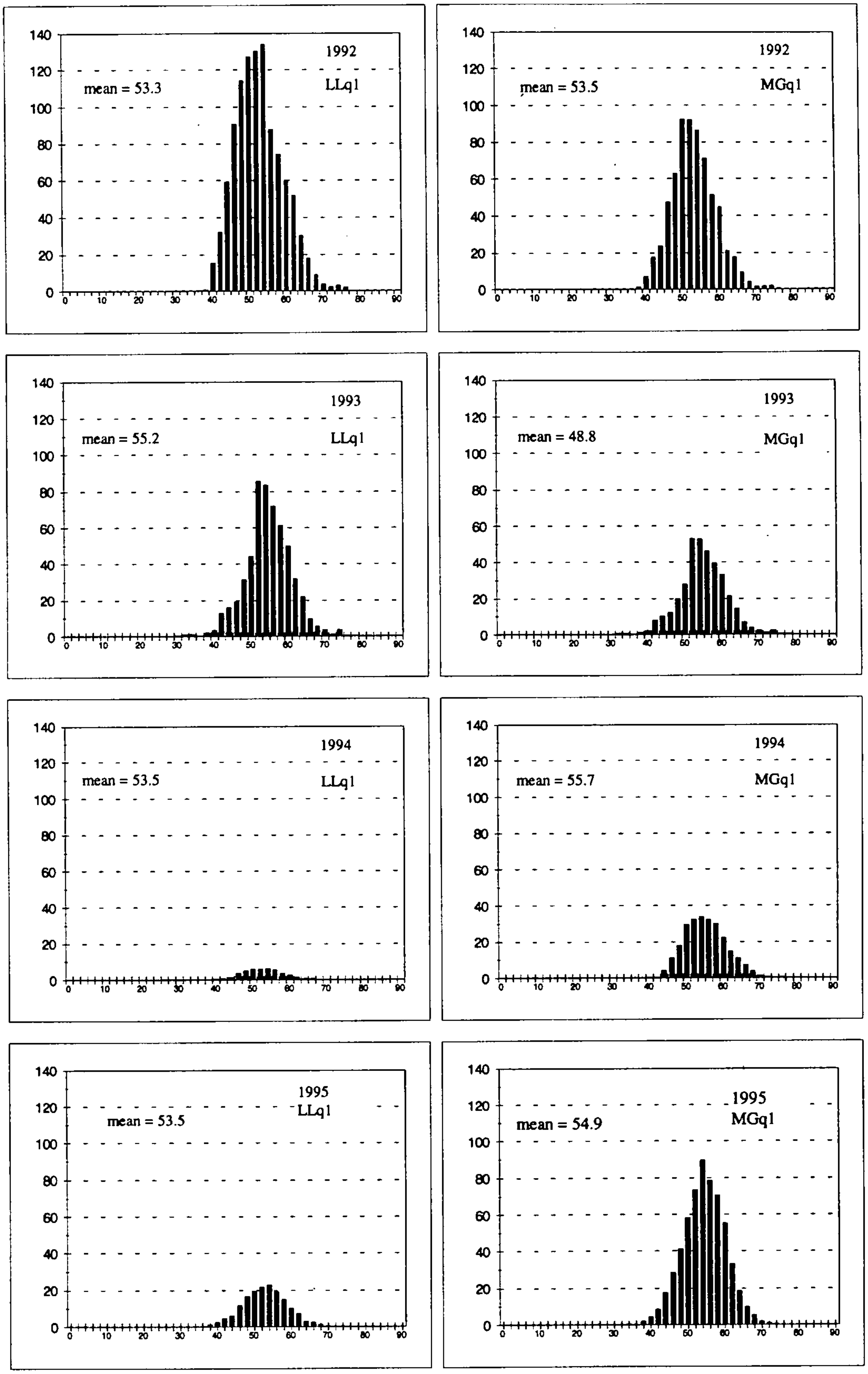


Figure 1. Catch-at-length (thousands) for 4X haddock, first quarter 1992-1995, for the mobile and fixed gear sectors.

calcomp.wb1

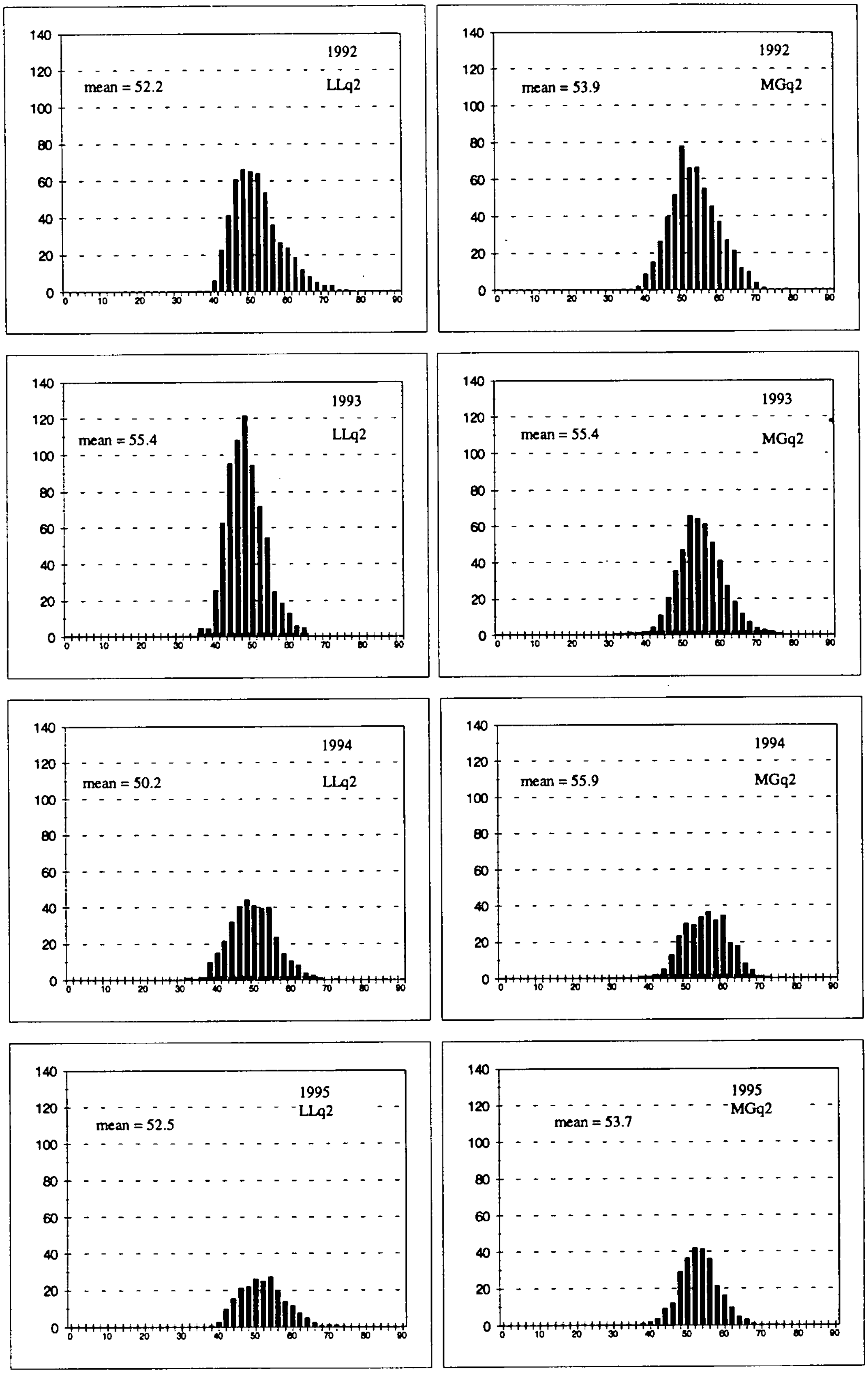


Figure 2. Catch-at-length (thousands) for 4X haddock, second quarter 1992-1995, for the mobile and fixed gear sectors.

calcomp.wb1

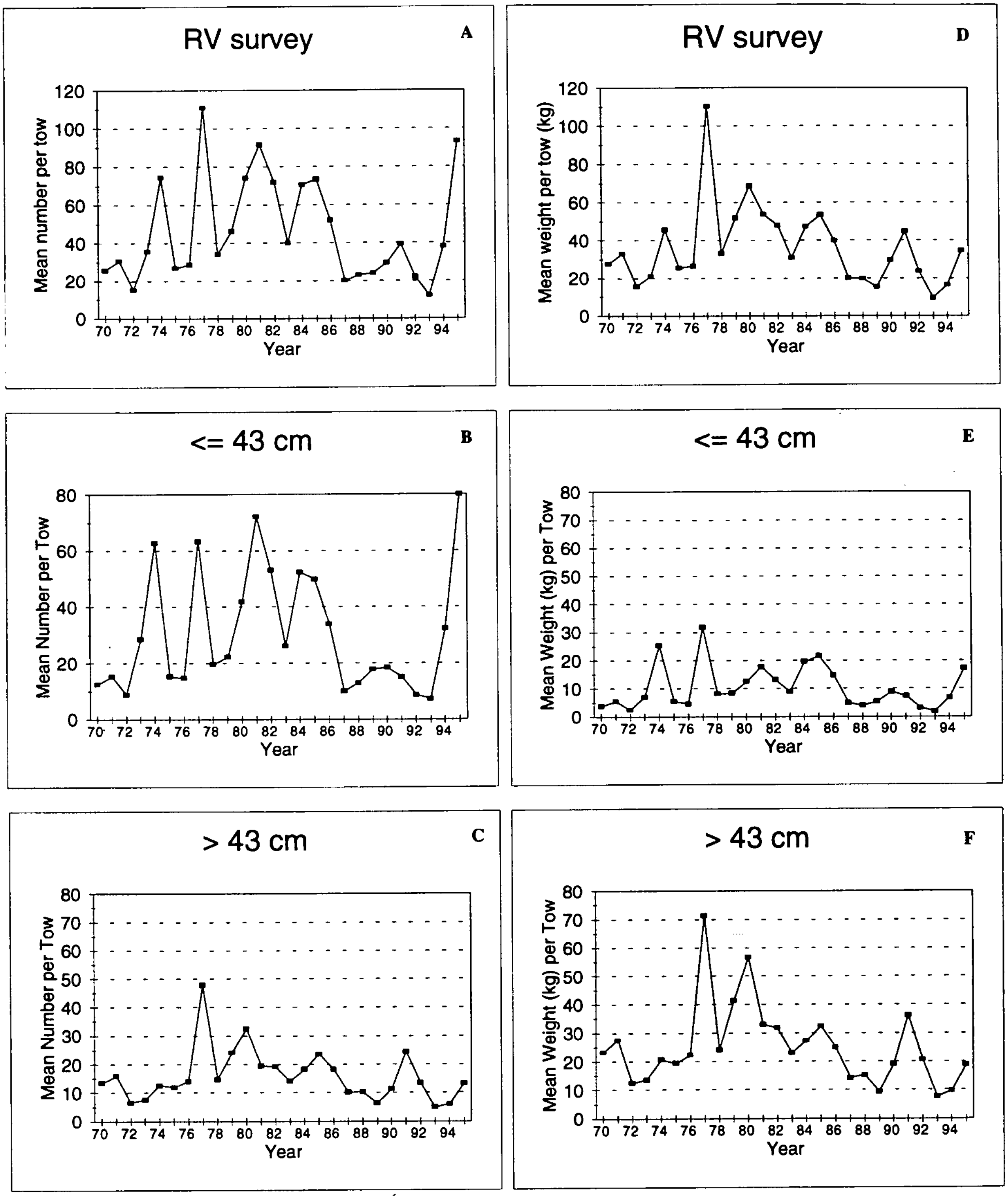


Figure 3. Summer RV survey, mean catch rate of haddock from 4X during 1970-1995 for (a) all lengths combined (nos./tow), (b) lengths <=43 (nos./tow), (c) lengths >43cm (nos./tow), (d) all lengths combined (wt/tow), (e) lengths <=43cm (wt/tow) and (f) lengths >43cm (wt/tow).

nptplot.wb1

RV Survey, June 26 - July 8, 1995

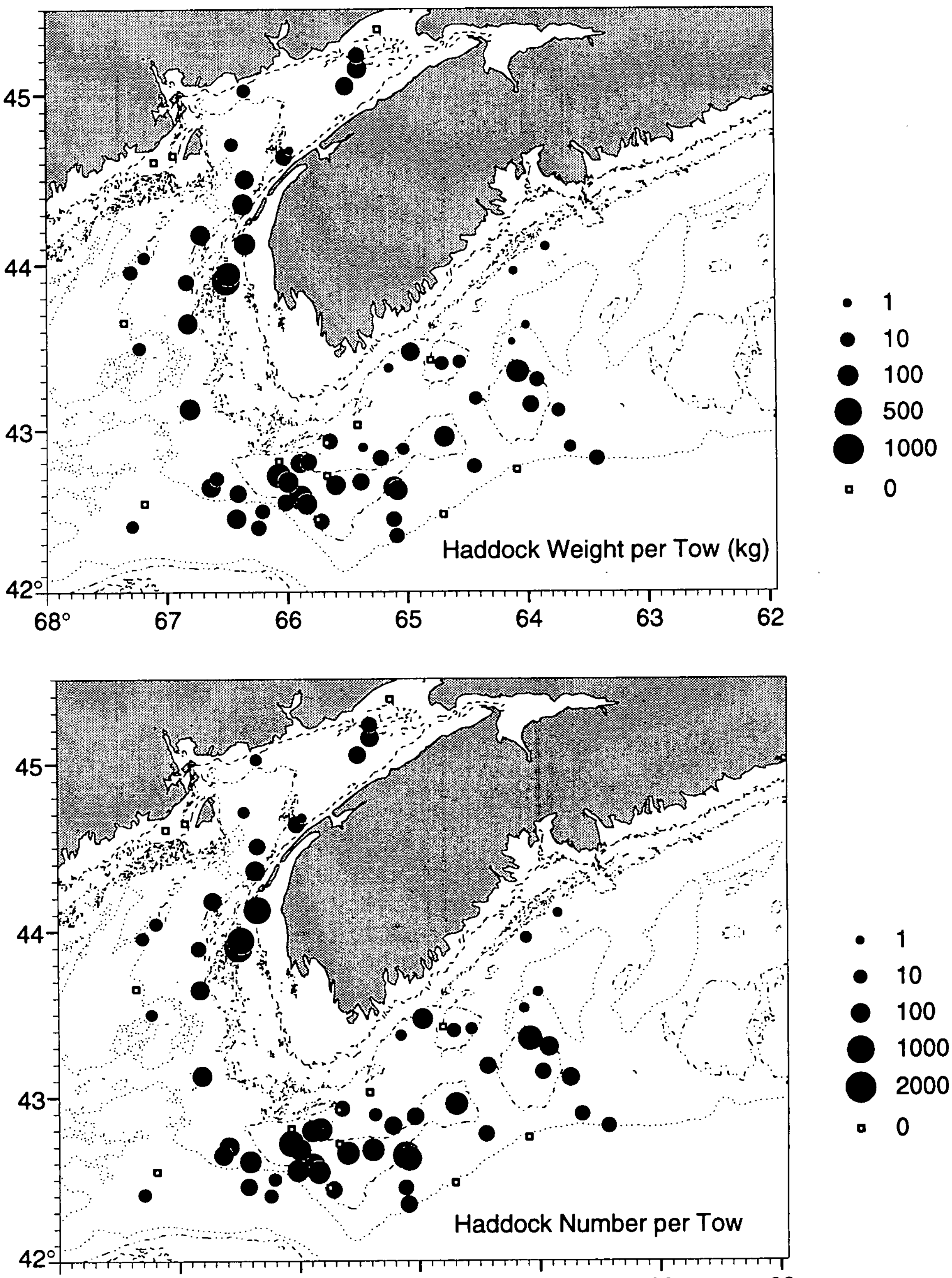


Figure 4. Haddock catches from 1995 summer research vessel survey.

4X Haddock Size composition for 1970-81

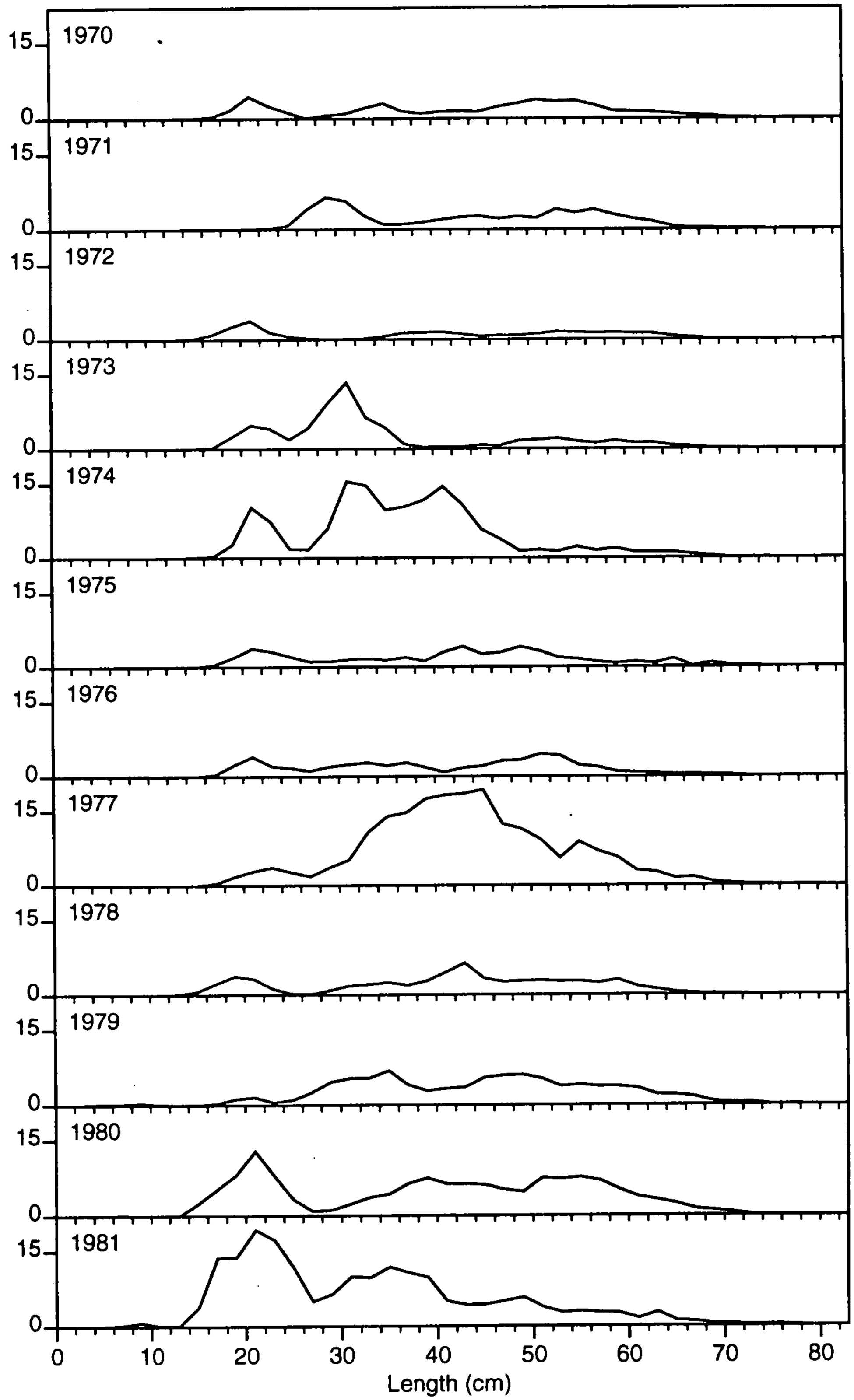


Fig. 5a. Length frequencies for 4X haddock from research surveys (1970-1981).

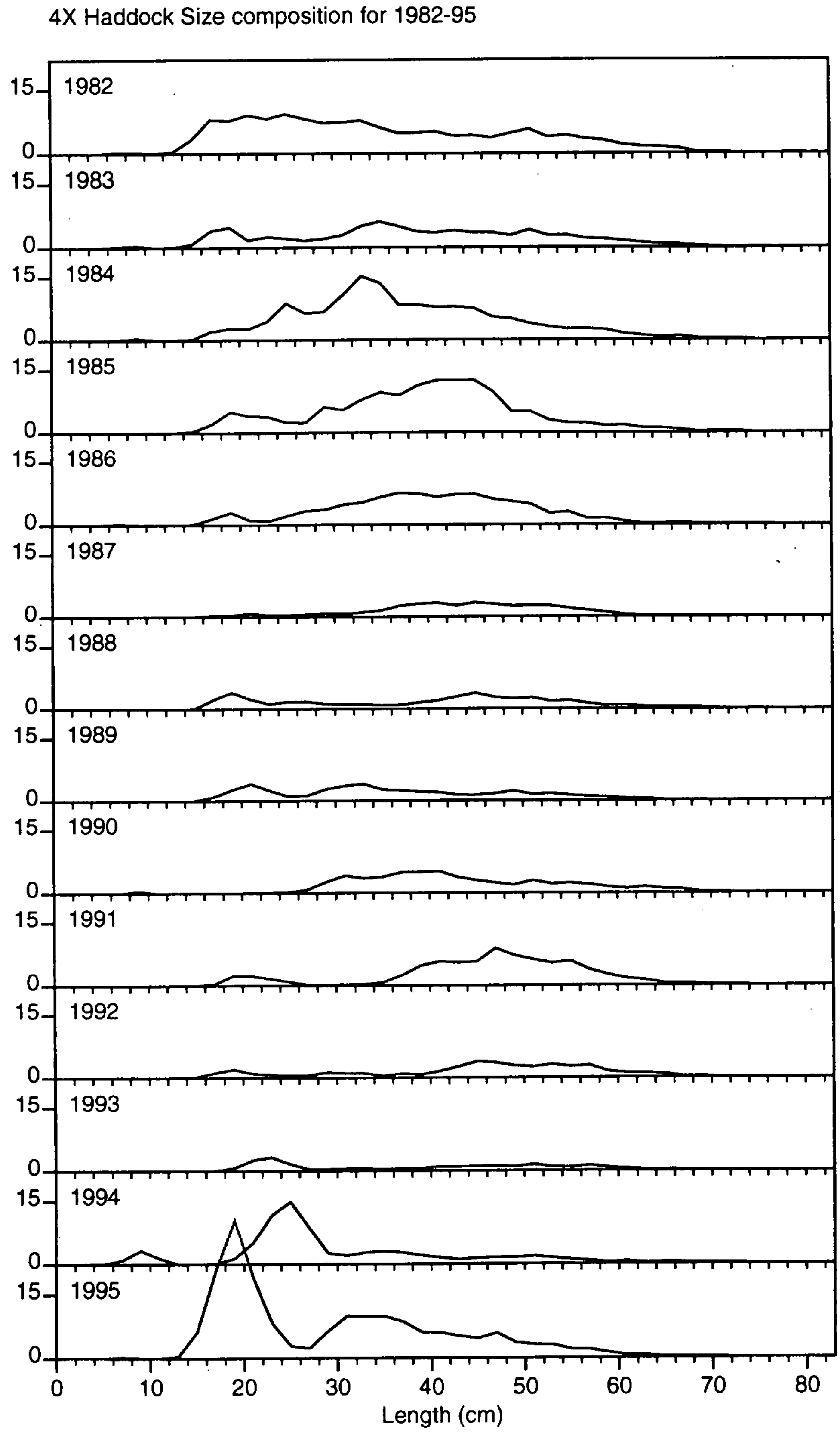


Fig. 5b. Length frequencies for 4X haddock from research surveys (1982-1995).

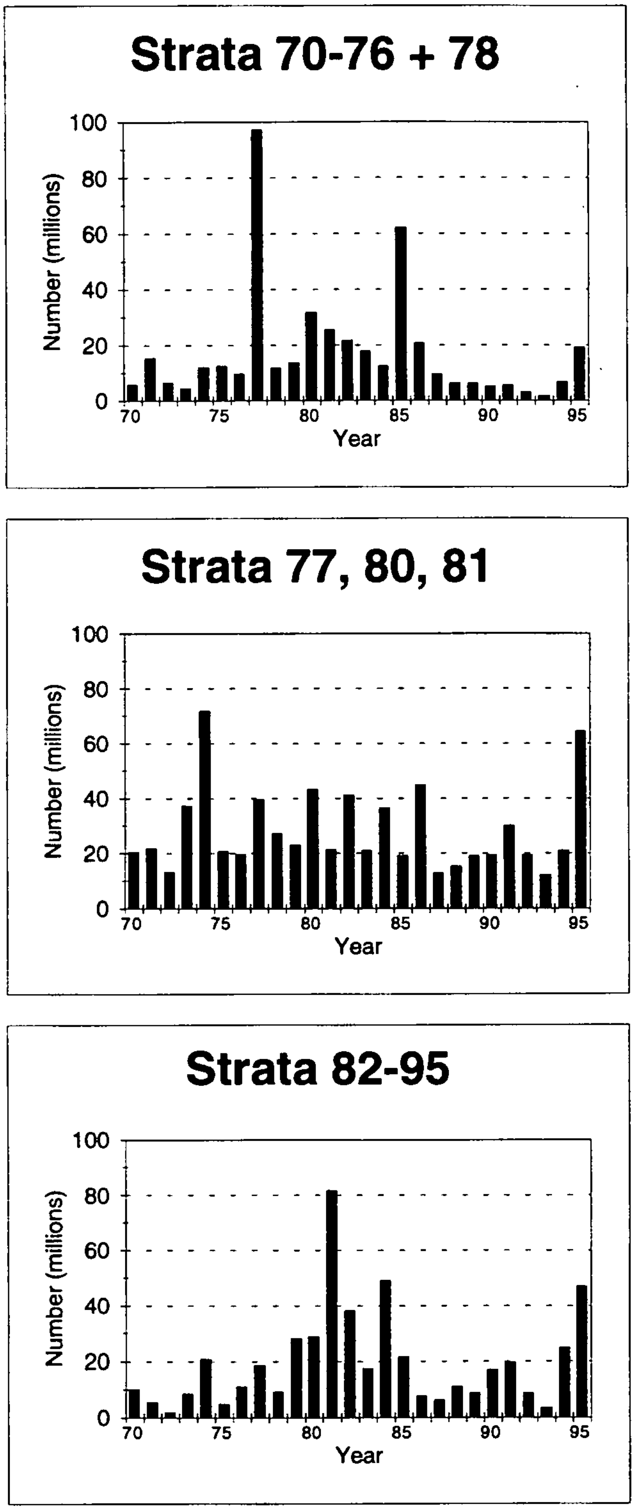


Figure 6. 4X haddock summer RV survey stratified numbers by stratum grouping

strapwin.wb1

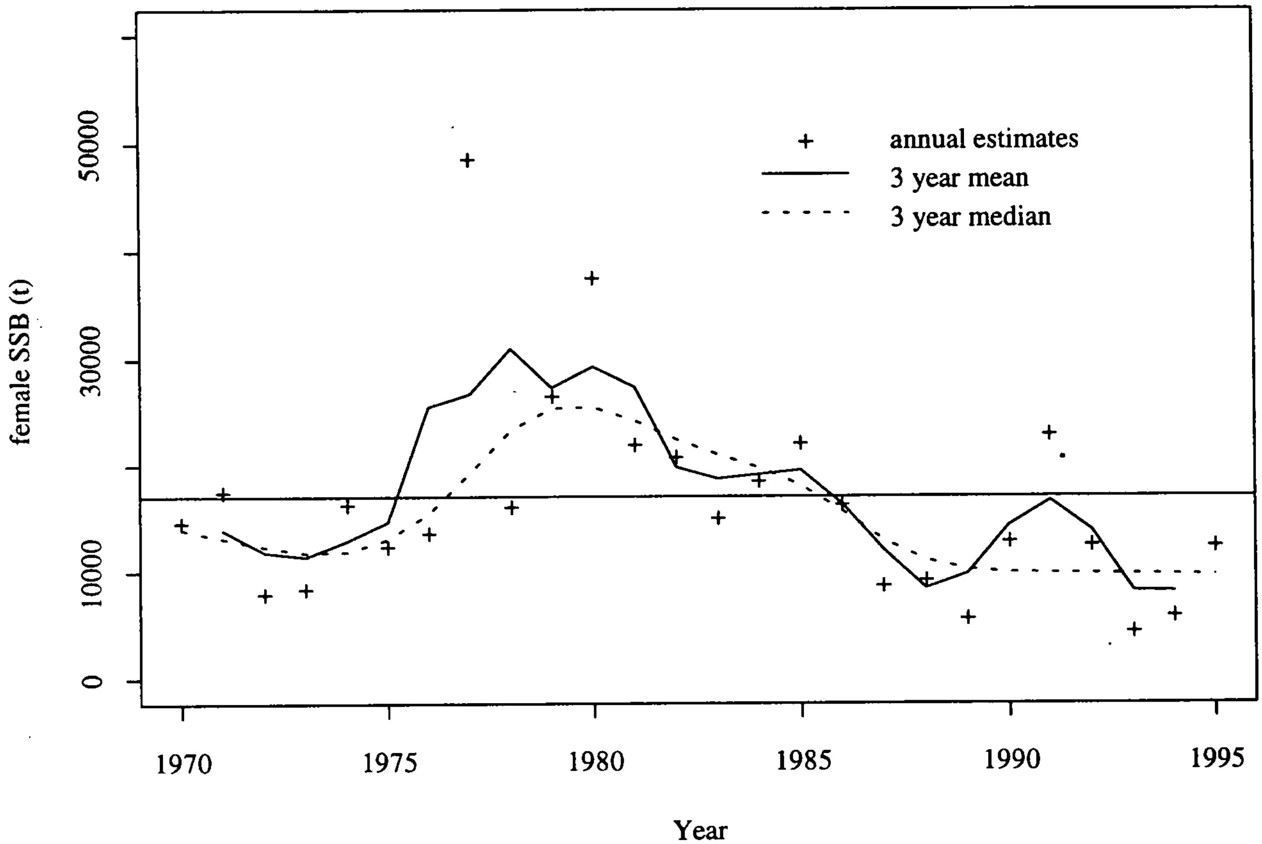
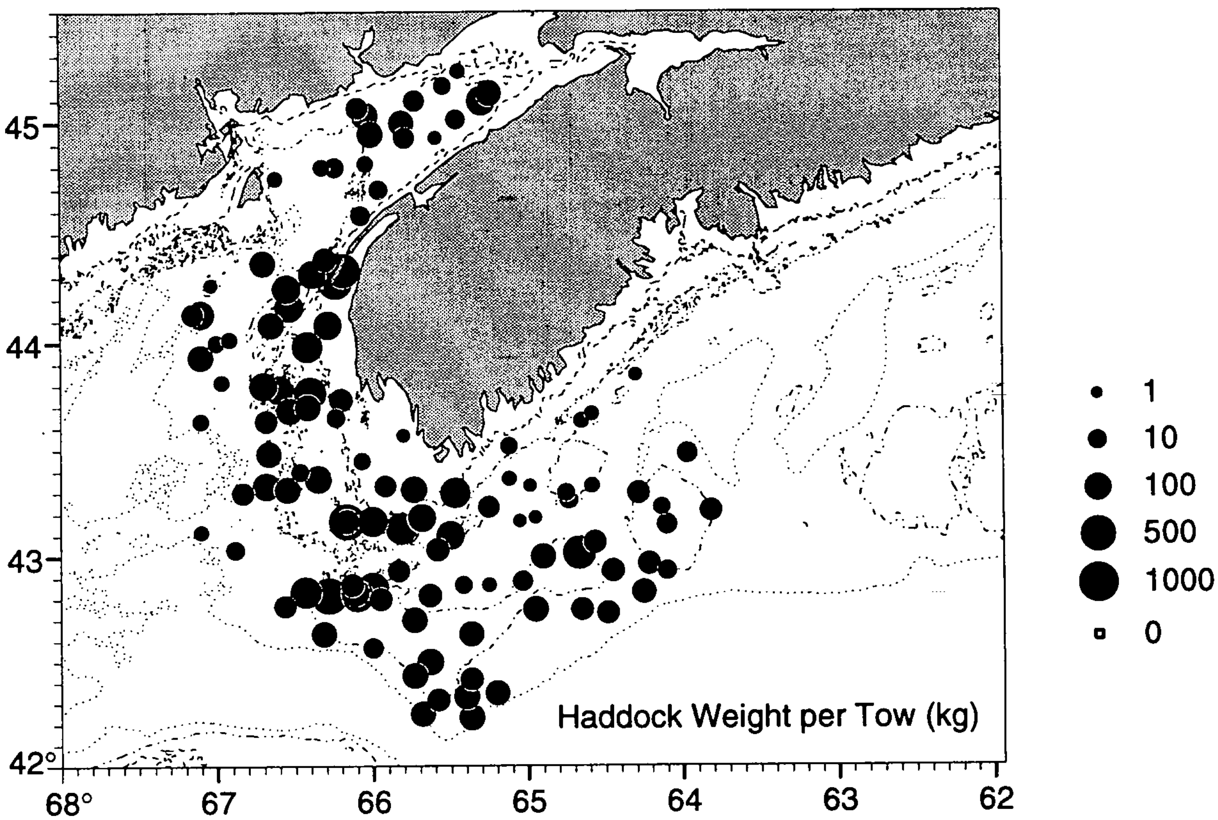


Fig. 7. Estimates of female spawning stock biomass (SSB) from July research survey catches for haddock in 4X. Horizontal line indicates longterm mean.



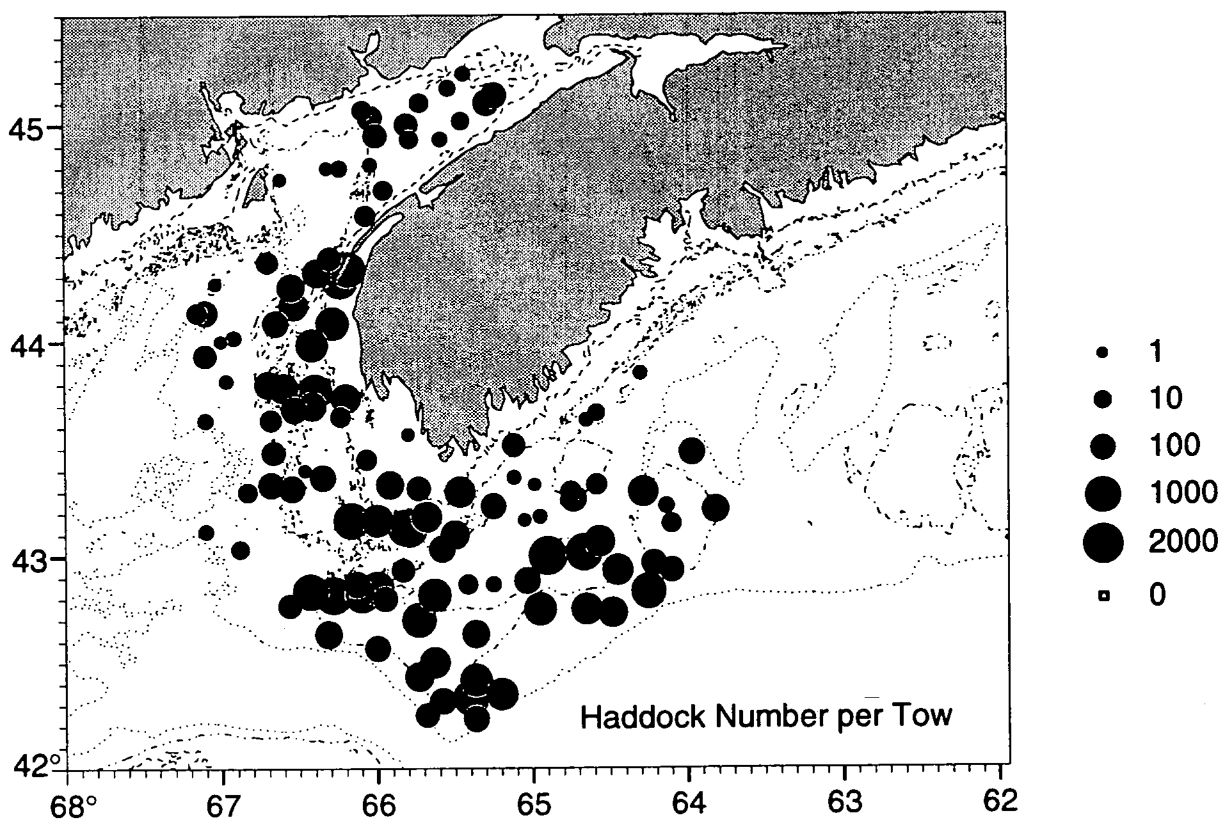


Figure 8. Haddock catches from the 1995 ITQ survey, June 26-July 7, standardized to a common wingspread and tow distance.

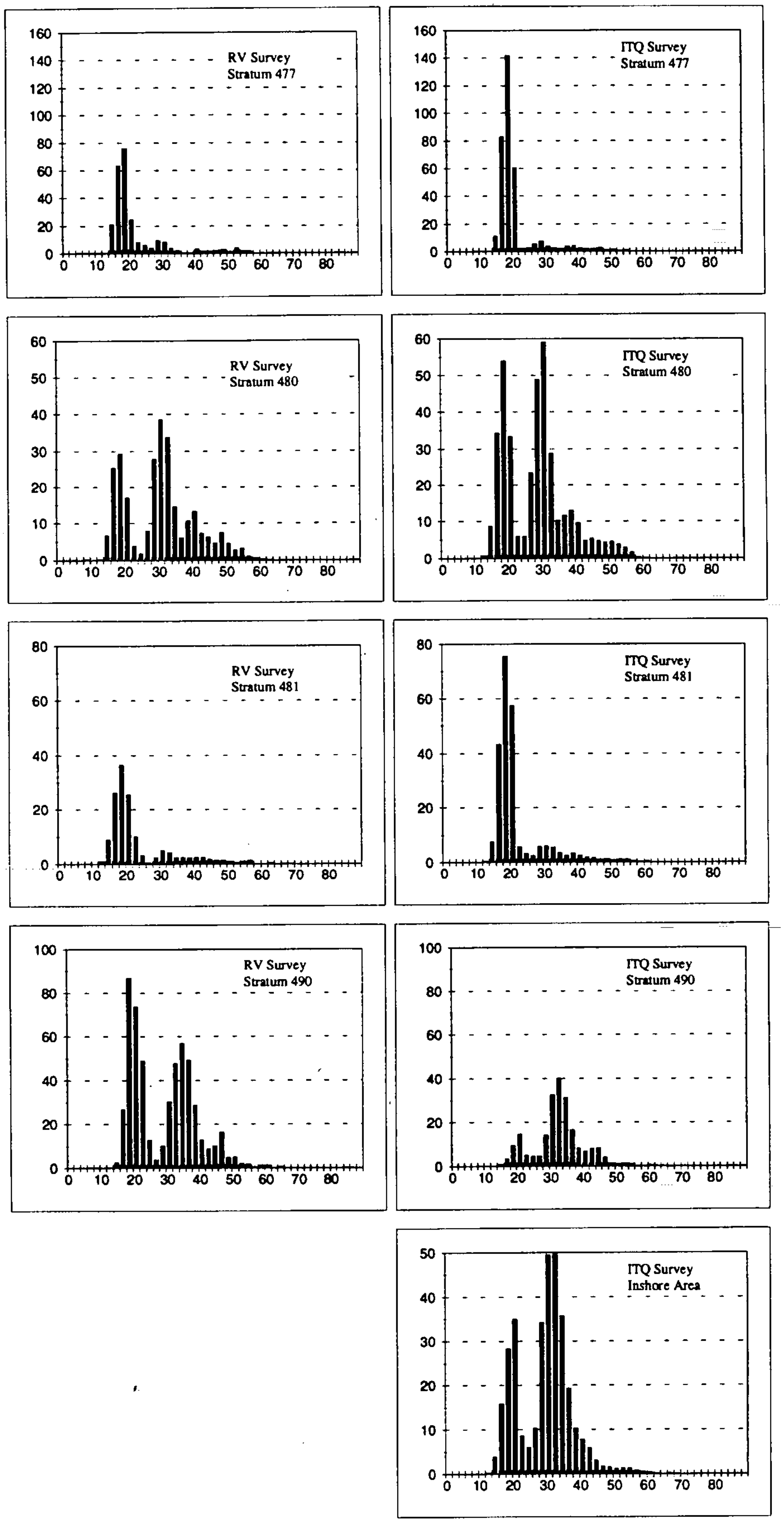


Figure 9. Length frequency distributions for selected strata from the Research Vessel Survey and ITQ Survey, June 26 - July 7, 1995.

surfcm.wb1

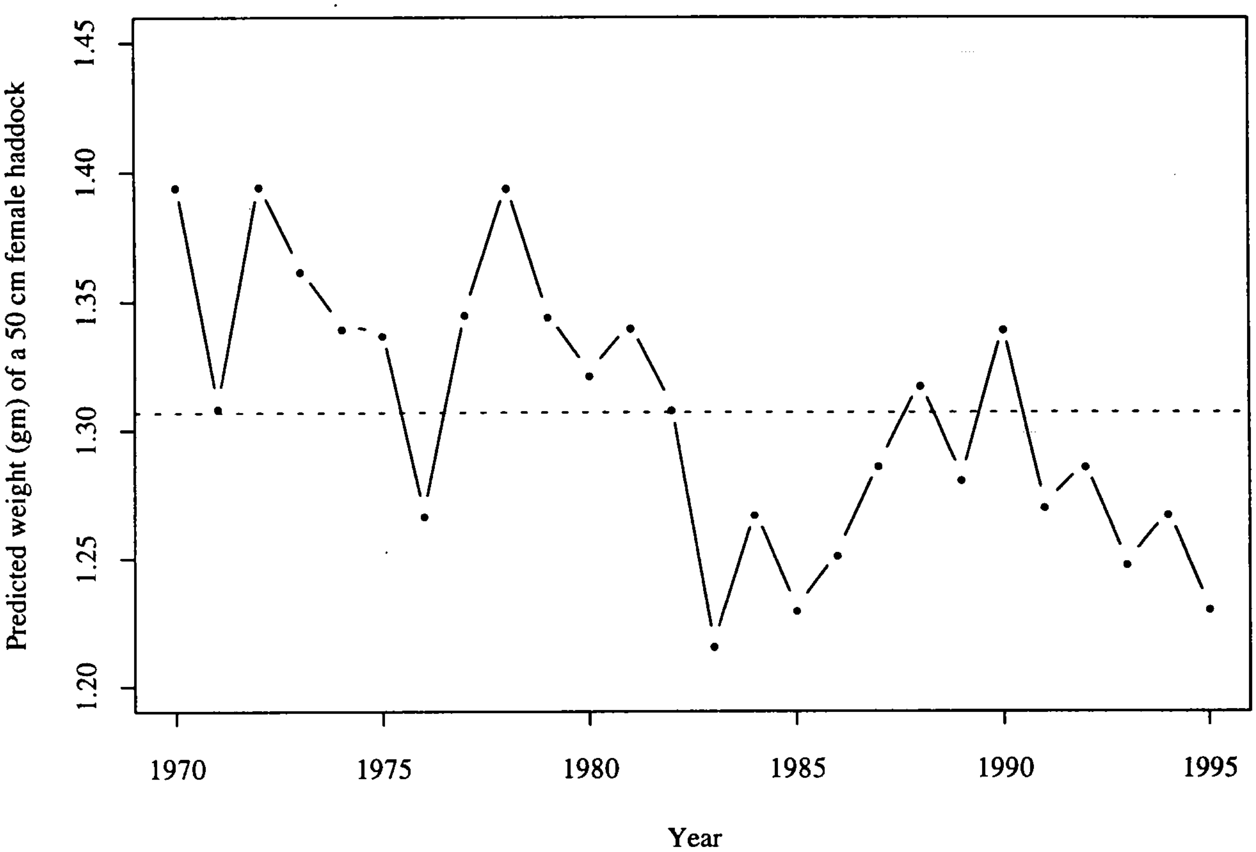


Fig. 10. Trend of predicted weight for a 50 cm female haddock in NAFO area 4X. Horizontal line gives mean of predicted weight over 1970 to 1995.

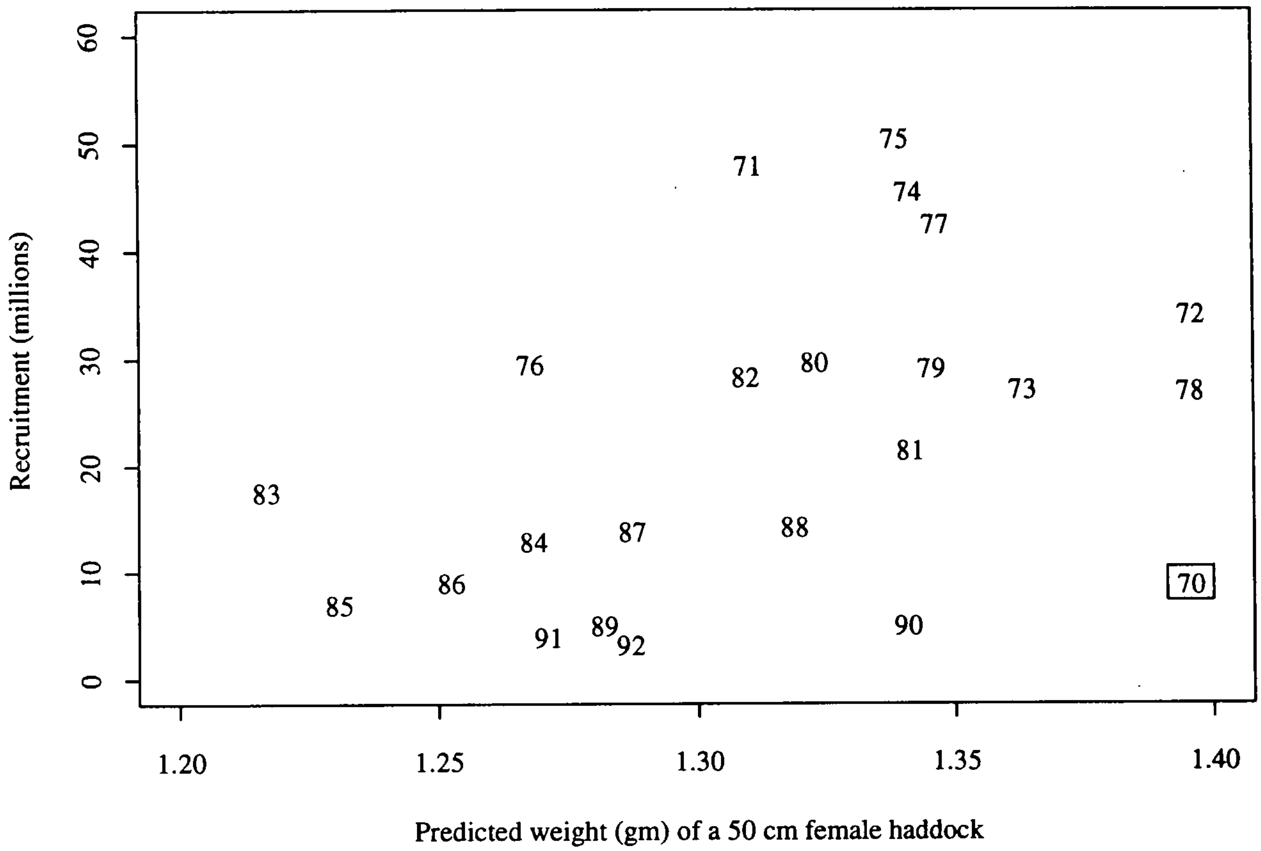


Fig. 11. Comparison of recruitment for 4X haddock from estimates of numbers at age one from cohort-slicing/VPA with predicted weight of a 50 cm female haddock. Predicted weights are for females in year of spawning of specified year-classes. Years in graph refer to year-class of recruits. 1970 has been highlighted as a possible outlier when recruitment is modelled as a function of female condition.

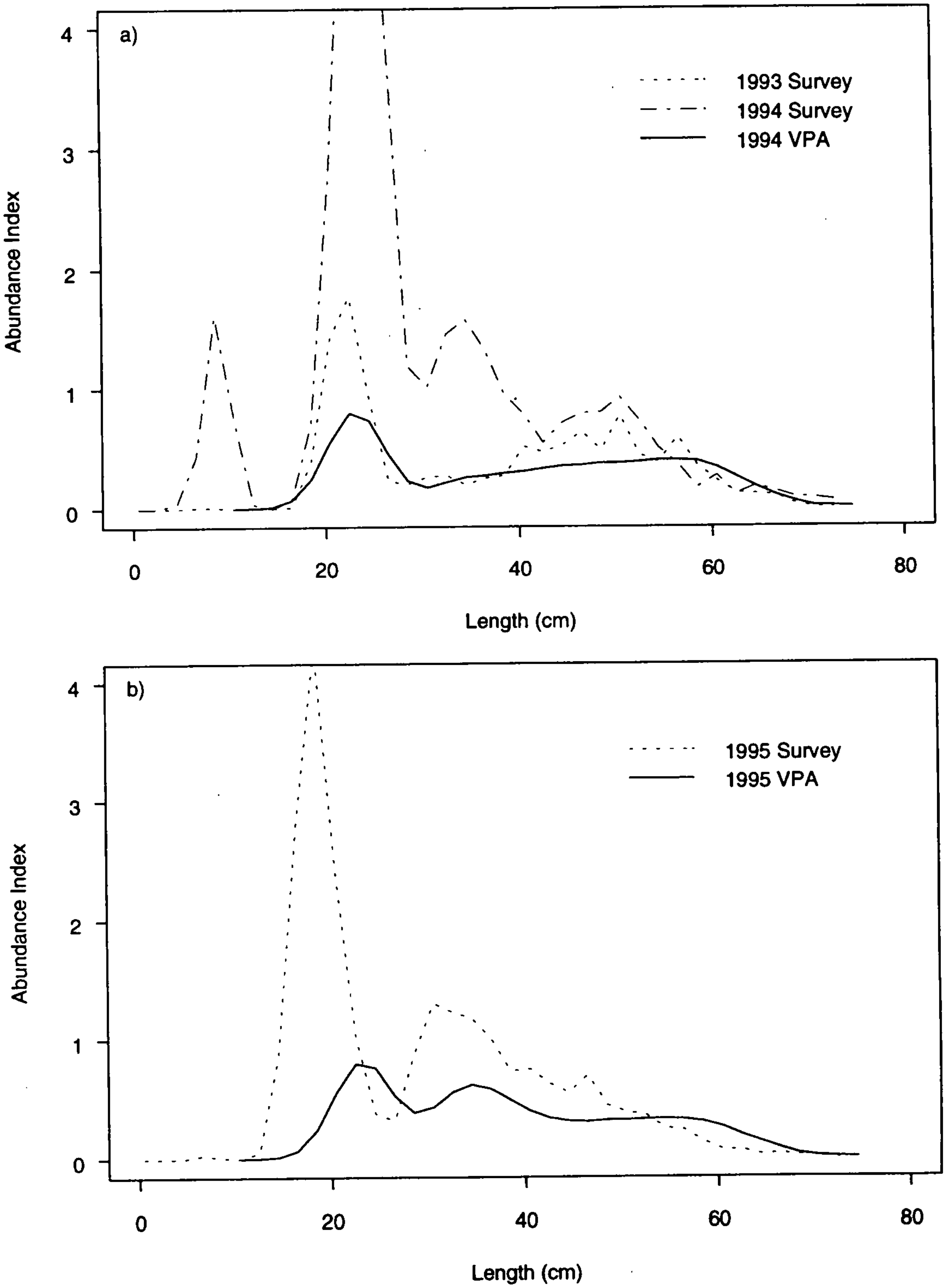


Fig. 12. Length composition observed from surveys and predicted from the VPA analysis of the cohort-slicing age compositions. Comparison of observed and predicted (from VPA) for a) 1994 survey and b) 1995 survey. The abundance index for the observed 1995 survey have been divided by 4.

Appendix 1: Working Group Participants

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Peter Comeau
Ken Frank
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Bob O'Boyle
Jim Simon
Peter Smith
Stephen Smith (Chairman)
Kees Zwanenburg