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Assessment of Cod in Division 4X in 1995: Inception of a Half-Year Sequential Population Analysis

by

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ABSTRACT

Landings of cod from Division 4X have fluctuated since 1970 between 33,000t and the 1994 value of 13,000t. The quota for 1995 was reduced to 9,000t. In the first six months of 1995, 3,800t of 4X cod were landed. The fishery in the first half of 1995 was supported by ages 3-5, an improvement over the last two years when the fishery relied almost entirely on ages 3 and 4. The summer survey results indicate that abundance of 4X cod continued to increase in 1995, and suggests that the 1992 year-class is particularly strong. Abundance at ages greater than 6, however, remains low, and the 1993 year-class (age 2) appears to be weak.

The adaptive framework was used to calibrate the sequential population analysis with the research survey results. The analysis was conducted using catch at age data for half-year intervals, including the first half of 1995. Beginning of year biomass for ages 3 and older increased in 1995 from the historic low recorded in 1994, and will also increase for the beginning of 1996. The 1992 year-class is estimated to be the strongest since 1987. Fishing mortality in the first half of 1995 is the lowest in the time series, and the F for the full-year (assuming the remaining quota is caught) is expected to be 0.37; the lowest in the time series, although still well in excess of $F_{0.1}$.

The projected $F_{0.1}$ yield for 1996 is 7,400t. If an $F_{0.1}$ harvest strategy is followed, the beginning of year 1997 biomass for ages 3 and older should reach 52,000t, about the middle of the range of 30,000t to 70,000t that has been seen since 1983. Although the biomass is expected to increase, the age range which is sustaining the fishery remains quite restricted. An increase in the abundance of older age classes is required to reduce the dependancy of this fishery on recruitment.

RÉSUMÉ

Depuis 1970, les débarquements de morue en provenance de la division 4X ont fluctué entre 33 000 t et les 13 000 t obtenues en 1994. Le quota de 1995 a été réduit à 9 000 t. Au cours des six premiers mois de 1995, on a débarqué 3 800 t de morue de 4X. La pêche de la première moitié de 1995 a été alimentée par la morue des âges 3 à 5, ce qui représente une amélioration par rapport aux dernières années, alors que la pêche dépendait presque exclusivement des morues des âges 3 et 4. Les résultats du relevé de recherche d'été révèlent que l'abondance de la morue de 4X a continué d'augmenter en 1995 et permettent de croire que la classe d'âge de 1992 est particulièrement forte. Toutefois, l'abondance des morues des âges supérieurs à 6 reste faible et la classe d'âge de 1993 (âge 2) semble faible également.

On a étalonné l'analyse séquentielle de population d'après les résultats des relevés de recherche, au moyen du modèle ADAPT. L'analyse était fondée sur les données de prises selon l'âge à intervalles d'une demi-année, y compris la première moitié de 1995. La biomasse de début d'année des poissons des âges 3 et plus a augmenté en 1995, après être descendue à un seuil historique en 1994. Elle augmentera aussi pour le début de 1996. On estime que la classe d'âge de 1992 est la plus forte depuis 1987. La mortalité par pêche de la première moitié de 1995 est la plus faible dans la série chronologique et la valeur F pour l'année entière (en tenant pour acquis que la totalité du quota sera capturée) devrait être de 0,37; il s'agit là de la valeur la plus basse de la série chronologique, quoiqu'elle soit encore bien supérieure à $F_{0,1}$.

La projection de rendement à $F_{0,1}$ pour 1996 s'établit à 7 400 t. Si l'on suit une stratégie de récolte à $F_{0,1}$, la biomasse des morues des âges 3 et plus au début de 1997 devrait atteindre 52 000 t, se situant donc à peu près au milieu de la fourchette des 30 000-70 000 t que l'on connaît depuis 1983. Bien qu'il soit prévu que la biomasse augmente, la fourchette d'âges qui alimente la pêche demeure assez limitée. Un accroissement de l'abondance des plus vieilles classes d'âge est nécessaire pour réduire la dépendance de la pêche au recrutement.

DESCRIPTION OF FISHERY

Landings of cod from Division 4X (including the Canadian portion of Division 5Y; Fig. 1) averaged about 15,000 t between 1947 and 1961. With increased exploitation on the offshore banks, landings increased to a maximum of about 35,500 t in 1968. Since 1969, landings have varied between about 16,000 t and 33,000 t (Fig. 2) and declined to a low of 13,000 t in 1994. These landings are a reflection of the total allowable catch, which declined from 26,000t in 1992 to 13,000t in 1994. The 1995 quota is 9,000t, 3,800t of which were landed by July 1.

Reported landings since 1990 are considered to be more accurate due to the introduction of mandatory weigh-outs. Discarding of small fish, however, has continued, and has led to gear closures in two areas in the vicinity of La Have and Roseway Banks in 1995 due to high proportions of undersized fish (<43 cm) in catches monitored at sea.

The fishery takes place year round, with catches peaking in June and July (Table 1), and is prosecuted primarily by otter trawlers less than 65 ft, tonnage classes 2 and 3, and by long liners less than 45 ft, tonnage classes 1 and 2 (Table 2). The proportion of landings from the winter-spring fishery, prosecuted predominantly by the otter trawl fleet, has declined in recent years. The distribution of landings has also shifted to the west in recent years, with landings from 4Xmno declining to a greater degree than in other areas (Table 3).

During meetings with industry representatives, dragger fishermen commented that declines in the winter-spring fishery reflect introduction of individual quota (quota is saved as bycatch to pursue other fisheries through the year) and the Browns Bank spawning closure from February 1-June 15. Traditionally, this was a period of high catch rates for the dragger fishery during which "steak" (large) cod were caught. Longline fishermen commented that fishing was restricted in summer on Browns Bank and some traditional inshore cod areas due to the presence of large amounts of dogfish.

CATCH AND WEIGHT AT AGE

The catch numbers at age for 1995 were based on 41 samples and were aggregated by area, quarter and gear type, (Table 4). Samples were aggregated by area to account for growth differences between the Bay of Fundy (4Xqrs5Yb) and southwest Scotian Shelf (4Xmnop) and the disproportionately low number of samples taken from the Bay of Fundy. Landings in 4Xu (uspecified area) were apportioned for each statistical district according to known area landings of the respective gear type and tonnage class for that statistical district and quarter. Landings reported from 5Y from 1983 to 1986 for each statistical district were divided between Scotian Shelf and Bay of Fundy according to the same protocol. Misreporting to 5Y from 4X was identified as a problem in these years in past 4X cod assessments (Campana and Simon, 1987; 1988).

SeasonalL length-weight parameters used were those from Campana and Hamel (1992). These parameters were calculated as seasonal averages over the years for which seasonal survey information was available, and have been used since 1985 when seasonal surveys in 4X were discontinued.

In the first half of 1995, the 1992 year-class (age 3) and the 1991 year-class (age 4) dominated both otter trawl and longline catches (Table 5), but the 1990 year-class also comprised a significant

proportion of the landings. Landings of cod over age 5 have declined in recent years (Table 6) and in 1995 the proportions of landings comprised by these ages were below their long term averages (Fig. 3). The proportions of 3 year-olds was high in comparison with the long term mean, while those for fish aged 4 and 5 were close to the means for those ages. This is an improvement over 1994 when landings of age 5 were also below average (Fig. 4), and indicates that the 1990 year-class is still contributing significantly to the fishery, spreading the age range on which the bulk of the fishery is based. Landings for most ages were well predicted by last year's assessment (Fig. 5); however, landings of the weak 1989 year-class (age 6) were greater than predicted, while age 3 landings were lower than predicted.

Weight at age for commercial landings from the Scotian shelf displays no persistent trend (Table 7), however, for the Bay of Fundy, weight at age has been increasing consistently. At present weight at age for cod from the Bay of Fundy is at its highest level for the time series. This trend will be examined further using survey data.

In 1995 the minimum hook size for the longline fleet switched from circle 10 to circle 12. This is intended to reduce the landings of small cod (ages 2 and 3), although it is noteworthy that bait size is a key factor in influencing size of fish caught (Halliday and Kenchington 1993). Problems with high catches of under-size fish by the long line fleet in some areas have continued despite this change in regulations.

Data from before 1983 were excluded from the analysis, as was done in the most recent assessment of this stock. While the analysis has included data from before 1983 in previous assessments, commercial sampling in the 1970's was poor and it was concluded that the stock history could not be reliably reconstructed during this period (Clark 1996).

ABUNDANCE INDICES

Annual stratified random surveys have been conducted in 4X during summer since 1970. As in the 4X cod assessment for 1994 (Clark et. al., 1995), the sequential population analysis (SPA) for this assessment used survey information collected since 1983, when the RV Alfred Needler became the standard survey vessel. Uncertainties in relative fishing power between different survey vessels could have contributed to the residual patterns observed in past assessments (predominantly positive since 1983 and negative before 1983). Preliminary analyses excluding data prior to 1983 also indicated that this approach would eliminate the retrospective pattern. Based on these considerations, the present assessment was conducted using data from 1983-1995.

The 1995 survey results, consistent with the latter part of the time series, shows very low abundance at ages 6 and over (Table 8). Catch per tow in the Bay of Fundy was good, as in 1994, however, some large catches were also made on and around Browns Bank, unlike in the 1994 survey (Fig. 6). Catch per tow increased on the Scotian Shelf in 1995 after declining each year since 1990. Catch per tow in the Bay of Fundy was similar to 1994, and markedly higher than seen from 1991 to 1993. The Bay of Fundy has generally accounted for about 30-40% of the overall index of abundance for 4X, however, in 1994 it made up over 60% and in 1995 about 50% largely due, in both years, to good catches of ages 3 and 4.

Survey results have identified the 1988 and 1989 year-classes as below average. The 1990 and 1991 year classes are about average, while this survey suggests that the 1992 year-class is well above average. The initial indication given by this survey is that the 1993 year-class is below average.

The age 2 survey index used in the calibration includes sets at depths <50 fathoms, excluding stratum 490 (St. Mary's Bay). Relative error and bias were reduced in population estimates when stratum 490 was removed from the analyses (Clark et al, 1995), and the magnitude of the residuals also decreased.

ESTIMATION OF STOCK PARAMETERS

The adaptive framework (Gavaris 1988) was used to calibrate the sequential population analysis with the research survey results using the following data :

$C_{a,t}$ = catch for ages a=1, 2,..., 12 during the half year time periods begining at t=1983,1983.5,1984,1984.5,...,1995

$I_{a,t}$ = Canadian summer survey abundance index for ages a=2, 3,...,10 observed during time t=1983.5,1984.5,...,1995.5 (excluding 1988.5 for ages 3 and 4).

The summer survey results were compared to mid-year population abundance. Data from ages 3 and 4 from the 1988 summer survey were excluded from the analysis because catchability at these ages appeared to be anomalously high. These data were influential and their inclusion affected population estimates. Estimates obtained when these data were excluded were considered more appropriate.

Statistical error in the survey data was assumed to be independent and identically distributed after taking logarithms and the error in the catch at age was assumed negligible. Natural mortality, M, was assumed constant and equal to 0.2 and the fishing mortality rate, F, for age 12 was assumed equal to the average for ages 9, 10 and 11 in the same year.

A model formulation using ln population abundances at the middle of 1995 (t = 1995.5) as parameters was employed. Define the model parameters

$\phi_{a,1995.5}$ = ln population abundance for ages a = 2, 3,...,12, (age 1 abundance assumed equal to the long-term geometric mean recruitment 1983-93), and

κ_a = calibration constants for Canadian summer survey for ages a = 2,3,...,10

ADAPT was used to solve for the parameters by minimizing the objective function

$$Q_{a,t}(\phi,\kappa) = \sum_{a,t} (q_{a,t}(\phi,\kappa))^2 = \sum_{a,t} (\ln(I_{a,t}) - \ln(\kappa_a N_{a,t}(\phi)))^2$$

where the population abundance $N_{a,t}$, is taken at the corresponding time, t, to the survey. Since the sequential population analysis was conducted using half year catch at age data, the abundance at the mid-year time, t = y+0.5, is directly available.

For t = 1995.5, the population abundances are obtained directly from the parameter estimates,

$$N_{a,1995.5} = \exp[\phi_{a,1995.5}]$$

For all other years, y = 1983 to 1994, the population abundance was computed using the virtual population analysis algorithm which incorporates the exponential decay model

$$N_{a,t} = N_{a+\Delta t,y+\Delta t} \exp[(F_{a,t}+M)\Delta t]$$

where the fishing mortality for ages 1 to 11 is obtained by solving the catch equation using a Newton-Raphson algorithm,

$$N_{a,t} = C_{a,t}(F_{a,t} + M)\Delta t / F_{a,t}\Delta t(1 - \exp[-(F_{a,t} + M)\Delta t])$$

Analytical approximations of variance and bias for population abundance estimates and corresponding projected yield were derived following Gavaris (1993).

COMPARISON OF FULL-YEAR AND HALF-YEAR ASSESSMENT

The assessment of stock status for cod in Division 4X, as with other finfish stock assessments, has been updated early in the calendar year when the complete statistics for the most recent year's fishery became available, and the typical SPA relationships using a 1 year time interval have been employed (e.g., Clark et al. 1995). In recent years, an update on stock status has been requested following the completion of the summer survey. This update has been limited to comparing new survey results with projected results from the last assessment. An assessment conducted in summer which made use of the data from the recently completed groundfish survey would include an additional survey point and six months of catch at age data over what had been available for the previous full-year assessment; the only additional information available to the subsequent full-year assesment is the catch at age for the final six months of the year. If total landings for the year are roughly equal to the quota, then a catch at age for the final six months of the year will be reasonably well predicted for use in a mid-year assessment based on partial recruitment values. We would expect, therefore, that a mid-year assessment would offer distinct advantages over the previous full-year assesment, and would be roughly equivalent to the subsequent full-year assesment. This should improve the reliability of predictions of year-class strength in the subsequent year for all ages, and provides a survey index for one additional year-class above what was available in the previous full-year assesment. For 4X cod this means geometric mean recruitment values will not be required for projections for any ages which are important in the commercial fishery (3+); in a mid-year assessment the projection for age 3 can now be based on an estimate of year-class strength from the age 2 survey index.

When the results from a revised calibration using half-year time intervals are compared to the results from the adjacent assessments using full-year time intervals, it is apparent that where the successive full-year analyses differ, the results from a half-year analysis closely correspond with those from the subsequent full-year analysis (Fig. 7). Thus, it is apparent that the information which accounts for the bulk of any change between successive full-year assessments of year-class strength is the additional survey point. By incorporating this, and including the survey index for an additional recruiting year-

class that a new survey provides, the mid-year assessment constitutes a real improvement over the previous full-year assessment.

We conclude that the half-year assessment results will more closely approximate the results which would be obtained from the subsequent full-year assessment than do the results from the previous full-year assessment. We recommend that, subject to operational constraints, the assessment for cod in Division 4X should be updated upon availability of the latest survey results. The results from a half year assessment update which includes fishery data to the middle of 1995 and the 1995 summer survey, along with projections for 1996, are presented below.

ASSESSMENT RESULTS

The relative error and bias indicate that there is some uncertainty in the estimates of population abundance (Table 9) reflecting the magnitude of the residuals (Fig. 8). Close correspondence occurred between the survey indices, scaled by the calibration constants, and results from the sequential population analysis, though for age 2 the correspondence was lower (Fig. 9). For each cohort, the terminal population abundance estimates from the integrated model were adjusted for bias and used to construct the history of stock status (Tables 10 - 12).

The analysis indicates that the 1985 and 1987 year-classes were the strongest since 1982 (Fig. 10), and the 1992 year-class is also very strong. The 1989 and 1991 year-classes are below average, and the 1988 and 1993 year-classes are very weak. The beginning of year population biomass for ages 3 and older showed a slight increase in 1995, after declining rapidly from a peak in 1990 to the lowest levels in the time series in 1993 and 1994 (Fig. 11), and for the beginning of 1996 increases slightly again, returning to the level seen in 1992. The peak in 1990 was due almost entirely to the 1985 and 1987 year-classes and was of short duration.

The total fishing mortality rate for ages 4 and older has generally fluctuated around 0.6, lower generally, in the first half of the year, and higher in the last half (Fig. 12). F increased rapidly after 1989, peaking at 1.3 in 1992, and has declined since then. This has approached and exceeded thrice $F_{0.1}$ and has likely resulted in lost yield due to capture of fish before their full growth potential has been realized. In the first half of 1995 F dropped close to 0.2, and though it is projected to rise to 0.4 in the second half, this represents a marked reduction in fishing mortality.

PROGNOSIS

Yield projections indicated that the point estimates for projected yield were biased upward by about 10% and had a standard error of about 25% of the mean. As with population abundance estimates, the simple adjustment for bias was considered more appropriate than using the biased point estimate. The incoming year-classes were assumed to be equal to the long term geometric mean (Table 13). Average partial recruitment values from the last 3 years of 0.0, 0.6, 0.49, and 0.88 repectively for ages 1-4 were used in the projections.

Assuming the remainder of the 9,000t TAC for 1995 is landed (5,258t remain for the last half of 1995), the resulting fully recruited fishing mortality will be about 0.37. The projected yield for 1996

at $F_{0.1}$ is 7,400t. If an $F_{0.1}$ harvest strategy is followed, the beginning of year 1997 biomass for ages 3 and older will reach 52,000t, an increase of 10,000t from 1996 (Fig. 13).

Beginning of year biomass for ages 3 and older has fluctuated between about 30,000t and 70,000t since 1983. Stock biomass is now increasing from the record low seen in 1994, and will continue to increase for 1996 due to the strong 1992 year-class. The age range which is sustaining the fishery, however, remains quite restricted, and recruitment of the 1993 year-class appears to be poor. This stock appears to be poised for recovery, however some building in the size of older age classes is required to reduce the dependence of this fishery on recruitment.

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LITERATURE CITED

Campana ,S. and J. Simon, 1987. Stock assesment for the 1986 cod population in 4X. CAFSAC Res. Doc. 87/30

Campana ,S. and J. Simon, 1988. Stock status of 4X cod in 1987. CAFSAC Res. Doc. 88/26.

Campana, S, and J. Hamel, 1992. Status of the 1992 4X cod fishery. CAFSAC Res. Doc. 92/46.

Clark, D. S., 1996. Stock structure of cod in NAFO Division 4X and implications for the adequacy of historical sampling data for reconstruction of catch at age. (In prep.).

Clark, D., E. A. Trippel, and L. L. Brown, 1995. Assessment of cod in division 4X in 1994. DFO Atl. Fish. Res. Doc. 95/28.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. CAFSAC Res. Doc. 88/29: 12p.

Gavaris, S. 1993. Analytical estimates of reliability for the projected yield from commercial fisheries. p. 185-191. In S.J. Smith, J.J. Hunt and D. Rivard [ed.] Risk evaluation and biological reference points for fisheries management. Can. Spec. Publ. Fish. Aquat. Sci. 120.

Gavaris, S., D. Clark, and P. Perley. 1994. Assessment of cod in Division 4X. DFO Res. Doc. 94/36: 29p.

Halliday, R. and T. Kenchington. 1993. Size selection of groundfish longline gear. Industry Services and Native Fisheries Project Summary 40: 4p.

Table 1. Nominal catch (t) of 4X and 5Y cod by month.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1983	1664	1618	1634	1850	2728	5684	4533	2822	3146	1753	1019	709	29149
1984	1741	2013	735	788	1773	3453	3659	4522	2734	1656	1203	973	25251
1985	773	1695	941	1264	1982	2595	3200	2612	2720	1810	795	1065	21452
1986	902	1618	1756	1441	1421	1939	2737	1992	2574	1714	771	1107	19971
1987	1209	1828	1236	1050	1866	2771	2661	1821	1673	1394	882	571	18959
1988	2104	1530	534	938	1620	2926	3104	2117	2524	1441	636	1050	20526
1989	2148	2346	1360	1705	1292	3535	1830	1772	1535	1278	637	411	19849
1990	2541	2064	712	700	1516	3080	3753	3089	2574	1698	1133	826	23686
1991	1998	2641	993	1663	2315	3140	3945	2880	2967	2208	1650	1258	27658
1992	2088	1740	1297	1501	1682	3621	3366	2799	2625	2353	1478	1521	26071
1993	657	903	994	996	1617	2312	2834	2221	1804	1048	562	77	16026
1994	734	972	547	847	824	1771	2246	1503	1267	1154	726	455	13045
1995	608	229	316	825	570	1192							3740

Table 2. Nominal catch of 4X and 5Y cod by gear type and tonnage class.

	Otter Trawl						Gill Net		Long Line and Hand Line				
Year	0 & 1	2	3	4	5	>6	0 & 1	2 & 3	0 & 1	2	>3	Misc.	Total
1983	638	4735	6223	310	1091	-	2180	235	9459	2795	883	599	29149
1984	964	4198	5832	109	1513	-	1248	220	6870	2864	980	451	25251
1985	523	3954	5548	57	1185	-	1837	161	5348	1764	635	440	21452
1986	573	3662	5094	186	974	-	1453	196	4926	1961	576	369	19971
1987	312	2645	3489	516	929	41	1968	241	5663	2257	499	439	18959
1988	454	3966	3538	154	426	41	903	443	6496	3254	680	171	20526
1989	409	3933	4184	56	679	44	1267	461	5665	2341	635	205	19849
1990	505	3659	3566	104	113	60	1933	669	8826	3225	849	193	23686
1991	355	4598	5791	253	632	3	2225	615	8264	3852	853	129	27658
1992	236	4493	5709	128	717	2	1815	550	7672	3670	670	117	26071
1993	176	2778	3598	68	238	-	1368	525	5067	1792	310	45	16026
1994	132	2022	2343	138	82	-	993	421	5091	1524	231	67	13045
1995*	34	676	902	76	46	-	148	301	1153	461	81	11	3740

*January 1 - July 1 only.

Table 3. Nominal catch (t) of 4X and 5Y cod by unit area.

Year	4Xm	Xn	Xo	Xp	Xq	Xr	Xs	Xu	5Y	Total
1983	3437	1645	8537	2497	3160	3787	1674	1825	2587	
1984	2256	2251	6192	1655	2244	2959	1413	3192	3088	
1985	3006	1199	5438	1026	1999	2301	1510	3529	1443	
1986	2914	1762	4670	544	1753	1802	1500	4226	801	
1987	2675	1609	4777	1130	1240	858	1207	4983	479	
1988	1501	1086	5458	1271	1123	850	1103	7990	142	
1989	1370	1019	5506	2820	1360	1112	915	5193	555	
1990	1846	755	7915	1746	2238	1746	1722	5380	338	
1991	2552	1557	8963	2436	2763	4242	2559	2246	307	
1992	1509	1776	10296	1437	2770	3295	1489	2937	272	
1993	1339	1639	4842	1418	1949	2419	1396	775	191	
1994	828	561	4414	1128	1662	1883	892	1540	137	
1995*	66	328	574	838	780	541	132	625	28	

Table 4. Input data used for the construction of the 1995 catch-at-age matrix.

Gear	Quarter	Area	Length-weight coefficients		Number of samples	Number measured	Number aged	Landings (t)
			a	b				
Otter Trawl	Q1	mnop qrs5Yb	.0000081	3.0503	10 7	1957 1746	325 228	424 365
	Q2	mnop qrs5Yb	.0000084	3.0410	2 6	251 1569	81 145	124 802
	Q3	mnop qrs5Yb	.0000087	3.0233				
	Q4	mnop qrs5Yb	.0000063	3.1152				
Gill Net	Q2	mnop qrs5Yb	.0000084	3.0410	2 1	510 210	96 55	302 130
	Q3	mnop qrs5Yb	.0000087	3.0233				
Long Line and Hand Line	Q1	mnop qrs5Yb	.0000081	3.0503	4 -	1170 -	177 -	364 -
	Q2	mnop qrs5Yb	.0000084	3.0410	8 -	1537 530	244 62	929 301
	Q3	mnop qrs5Yb	.0000087	3.0233				
	Q4	mnop qrs5Yb	.0000063	3.1152				

Table 5. Landed numbers of 4X and 5Y cod at age (000s) by gear type.

Age	1	2	3	4	5	6	7	8	9	10	11+
OT	-	-	223	182	145	32	10	13	2	1	0
LL	-	6	413	319	176	26	9	7	1	1	0
GN	-	-	3	24	41	14	1	5	2	0	0

OT - otter trawl; LL - long line and hand line; GN - gill net

Table 6a. Catch at age (number in thousands) for cod in Division 4X (including Canadian catch in Division 5Y).

Age	1	2	3	4	5	6	7	8	9	10	11	12		1+	2+	3+	4+
1983*	**0**	156	**1665**	1255	**1075**	790	**272**	109	**72**	58	**22**	7		5483	5483	5327	3662
1983,5	**9**	875	**2025**	1177	**982**	415	**187**	95	**48**	18	**14**	3		5846	5837	4962	2938
1984	0	**33**	860	**1312**	913	**461**	256	**85**	43	**31**	12	**10**		**4016**	**4016**	**3983**	**3123**
1984,5	33	**884**	1533	**1769**	1017	**504**	209	**91**	20	**18**	17	**8**		**6103**	**6070**	**5186**	**3653**
1985	**0**	47	**468**	678	**976**	590	**266**	98	**41**	20	**13**	5		3201	3201	3154	2686
1985,5	**0**	664	**1206**	891	**1348**	694	**248**	96	**30**	33	**5**	2		5218	5218	4554	3348
1986	0	**80**	1120	**767**	438	**539**	257	**96**	59	**11**	10	**7**		**3383**	**3383**	**3304**	**2184**
1986,5	0	**171**	1669	**1174**	556	**469**	151	**105**	34	**38**	14	**14**		**4394**	**4394**	**4224**	**2555**
1987	**0**	94	**280**	1019	**729**	319	**315**	167	**78**	41	**20**	8		3069	3069	2976	2695
1987,5	**0**	767	**622**	1035	**358**	205	**196**	69	**62**	24	**13**	2		3352	3352	2585	1963
1988	0	**67**	1704	**500**	812	**353**	106	**117**	34	**34**	8	**4**		**3738**	**3738**	**3672**	**1968**
1988,5	0	**337**	1813	**1159**	741	**303**	72	**75**	51	**19**	20	**1**		**4590**	**4590**	**4254**	**2441**
1989	**7**	444	**1653**	2286	**476**	413	**145**	59	**38**	11	**9**	9		5549	5542	5099	3446
1989,5	**11**	212	**908**	1370	**156**	148	**18**	20	**22**	8	**1**	1		2874	2864	2652	1744
1990	0	**33**	1227	**1242**	1303	**175**	158	**33**	14	**16**	7	**7**		**4215**	**4215**	**4182**	**2955**
1990,5	0	**111**	1637	**1563**	1159	**322**	120	**44**	26	**23**	7	**8**		**5019**	**5019**	**4908**	**3272**
1991	**2**	79	**631**	2688	**791**	654	**74**	65	**14**	6	**10**	4		5017	5016	4937	4306
1991,5	**0**	313	**904**	2404	**986**	710	**141**	91	**18**	10	**18**	11		5605	5605	5292	4388
1992	0	**64**	991	**810**	1849	**479**	353	**32**	26	**12**	3	**2**		**4621**	**4621**	**4558**	**3567**
1992,5	0	**688**	2401	**1067**	1427	**400**	160	**30**	24	**4**	5	**2**		**6207**	**6207**	**5519**	**3119**
1993	**0**	13	**1777**	1002	**381**	388	**89**	39	**5**	4	**4**	0		3702	3702	3689	1913
1993,5	**0**	868	**1713**	1044	**279**	284	**97**	51	**9**	10	**1**	0		4355	4355	3487	1773
1994	0	**122**	1164	**1197**	383	**89**	75	**13**	7	**0**	0	**0**		**3051**	**3051**	**2929**	**1765**
1994,5	0	**353**	1116	**1036**	504	**106**	105	**29**	11	**0**	2	**0**		**3263**	**3263**	**2910**	**1793**
1995	**0**	6	**640**	526	**362**	72	**19**	25	**6**	2	**0**	0		1657	1657	1651	1011

* 1983 = first half of year; 1983.5 = second half of year.

Table 6b. Annual catch at age (number in thousands) for cod in Division 4X (including Canadian portion of Division 5Y).

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1+	11329	10118	8419	7778	6421	8329	8423	9234	10622	10828	8056	6314
2+	11320	10086	8419	7778	6421	8329	8406	9234	10621	10828	8056	6314
3+	10289	9169	7708	7527	5560	7925	7751	9090	10229	10077	7176	5838
4+	6600	6776	6034	4738	4659	4408	5191	6227	8694	6685	3686	3558

Table 7. Mean weight at age (kg) of cod from commercial landings in two sub-areas of Division 4X.

		1	2	3	4	5	6	7	8	9	10	11	12
	1983		0.76	1.22	1.81	2.50	3.93	6.09	8.22	10.76	11.83	12.22	16.59
	1984		0.96	1.30	1.69	2.34	3.37	4.68	6.83	8.60	11.06	13.21	14.03
	1985		0.60	1.07	1.47	2.00	3.06	4.55	6.70	6.89	9.00	14.16	15.66
	1986		0.78	1.13	1.63	2.21	3.47	4.69	7.15	8.83	8.81	13.11	13.10
	1987		1.23	1.40	1.83	2.61	3.46	4.99	7.33	8.36	10.66	11.80	15.85
Scotian	1988		0.94	1.30	1.90	2.69	3.98	5.23	8.06	9.88	10.93	13.05	16.04
Shelf	1989	0.78	1.23	1.57	2.21	2.75	3.96	4.88	7.86	9.46	11.95	15.04	14.81
	1990		0.82	1.29	1.97	2.86	3.72	5.59	8.10	10.46	11.93	14.12	15.24
	1991		0.76	1.13	1.73	2.50	3.54	5.08	6.44	9.44	11.19	13.73	15.74
	1992		0.78	1.14	1.63	2.58	3.58	4.44	6.50	8.37	12.10	14.50	19.15
	1993		0.68	1.25	1.62	2.24	3.44	4.67	7.01	9.13	10.97	18.08	
	1994		0.76	1.04	1.92	2.41	3.15	4.97	5.21	9.28	15.98	13.56	
	Mean	0.78	0.86	1.24	1.78	2.47	3.56	4.99	7.12	9.12	11.37	13.88	15.62
	1983	0.38	0.86	1.48	2.18	3.30	4.88	6.38	8.62	9.92	12.19	14.23	20.63
	1984	0.39	0.93	1.62	2.48	3.52	4.67	6.98	7.94	12.10	13.45	4.75	
	1985	0.37	0.84	1.48	2.26	3.43	4.53	6.54	9.45	11.46	15.12	18.23	19.52
	1986	0.37	0.80	1.41	2.33	4.30	6.24	7.36	8.18	9.50	14.25	7.99	11.98
	1987		0.84	1.57	2.56	4.17	5.33	7.04	7.92	7.94	14.31	18.56	
Bay of	1988		0.86	1.46	2.24	4.09	5.36	8.99	10.14	8.89	14.69		
Fundy	1989	0.33	0.76	1.52	2.59	3.60	6.33	7.25	10.32	10.55	14.57		11.66
	1990		1.05	1.69	2.69	3.77	4.37	7.31	8.15	11.32	11.95	12.75	14.74
	1991	0.82	1.04	1.88	2.91	4.26	6.77	8.75	11.02	13.60	14.17	15.10	17.93
	1992		1.18	1.73	2.73	4.49	6.51	8.78	9.93	13.13	14.55	11.10	
	1993		0.90	1.74	2.86	4.74	6.09	7.58	9.18	14.32	16.75	13.85	
	1994		0.98	1.75	3.19	5.72	7.96	9.31	11.61	11.56	-	17.46	
	Mean	0.44	0.92	1.61	2.58	4.12	5.75	7.69	9.37	11.19	14.18	13.40	16.08

Table 8. Summer groundfish research survey mean number per tow for cod in Division 4X.

Survey	2	3	4	5	6	7	8	9	10
1983	0.95	2.62	1.50	0.93	0.58	0.24	0.00	0.05	0.02
1984	5.90	2.25	1.50	1.23	0.45	0.32	0.04	0.04	0.02
1985	4.85	2.67	0.95	0.97	0.50	0.34	0.19	0.10	0.01
1986	1.10	1.67	0.81	0.23	0.40	0.29	0.14	0.06	0.01
1987	4.93	0.37	0.72	0.38	0.17	0.14	0.20	0.05	0.03
1988	2.40	-	-	1.08	0.33	0.13	0.19	0.04	0.00
1989	4.57	2.12	1.66	0.28	0.31	0.03	0.02	0.05	0.03
1990	0.47	3.47	1.63	1.56	0.20	0.28	0.04	0.03	0.00
1991	1.66	0.70	1.95	0.73	0.49	0.09	0.08	0.01	0.01
1992	3.72	1.08	0.44	1.07	0.34	0.29	0.07	0.03	0.00
1993	1.49	1.52	0.66	0.10	0.19	0.03	0.05	0.00	0.00
1994	3.03	1.76	1.03	0.30	0.02	0.13	0.05	0.04	0.00
1995	1.49	3.06	0.94	0.38	0.17	0.06	0.06	0.02	0.03

Table 9. Statistical properties of population abundance and survey calibration constants for cod in Division 4X.

	July survey calibration constants					Population abundance				
Age	Par. Est	Std. Err.	Rel. Err.	Bias	Rel. Bias	Par. Est	Std. Err.	Rel. Err.	Bias	Rel. Bias
2	0.1894	0.0265	0.1412	0.0011	0.0056	7865	3876	0.49	990	0.13
3	0.1970	0.0281	0.1427	0.0012	0.0062	13858	4998	0.36	935	0.07
4	0.2113	0.0300	0.1419	0.0014	0.0065	4349	1557	0.36	258	0.06
5	0.2414	0.0330	0.1365	0.0013	0.0054	2011	783	0.39	136	0.07
6	0.2588	0.0358	0.1382	0.0012	0.0045	589	245	0.42	47	0.08
7	0.3303	0.0473	0.1431	0.0016	0.0050	94	42	0.44	9	0.09
8	0.3244	0.0516	0.1591	0.0028	0.0085	193	78	0.41	15	0.08
9	0.2720	0.0436	0.1601	0.0033	0.0012	68	27	0.39	5	0.07
10	0.2123	0.0377	0.1775	0.0030	0.0014	123	40	0.32	6	0.05
11						16	9	0.54	1	0.07
12						52	27	0.53	4	0.07

Table 10. Estimated bias adjusted population numbers (000s) at the beginning and middle of year for cod in Division 4X.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	1+	2+	3+	4+
1983*	**13964**	11637	**16592**	9369	**5533**	2757	**1063**	469	**312**	144	**90**	20	**0**	61951	47987	36350	19758
1983,5	**12635**	10381	**13431**	7285	**3986**	1745	**704**	321	**214**	75	**60**	11	**0**	50849	38214	27833	14402
1984	17844	**11424**	8562	**10230**	5474	**2675**	1186	**460**	200	**148**	51	**42**	8	**58302**	**40458**	**29034**	**20472**
1984,5	16146	**10305**	6929	**8009**	4086	**1983**	829	**335**	140	**105**	35	**28**	0	**48930**	**32784**	**22479**	**15549**
1985	**9567**	14579	**8485**	4815	**5569**	2732	**1315**	552	**217**	108	**77**	15	**18**	48049	38482	23903	15419
1985,5	**8657**	13147	**7233**	3713	**4112**	1911	**938**	407	**157**	79	**58**	9	**0**	40419	31763	18616	11384
1986	27562	**7832**	11264	**5399**	2514	**2442**	1072	**613**	277	**114**	40	**47**	6	**59184**	**31622**	**23789**	**12525**
1986,5	24939	**7011**	9128	**4157**	1859	**1698**	725	**464**	194	**92**	28	**37**	0	**50331**	**25392**	**18381**	**9253**
1987	**18652**	22566	**6182**	6675	**2648**	1155	**1091**	513	**320**	143	**47**	12	**20**	60024	41372	18806	12624
1987,5	**16877**	20329	**5327**	5072	**1704**	743	**689**	305	**215**	90	**24**	4	**0**	51381	34504	14174	8847
1988	27393	**15271**	17665	**4230**	3608	**1202**	478	**437**	211	**137**	59	**9**	2	**70702**	**43309**	**28038**	**10372**
1988,5	24786	**13755**	14365	**3352**	2494	**753**	332	**285**	159	**92**	46	**4**	0	**60422**	**35636**	**21881**	**7516**
1989	**9146**	22428	**12126**	11276	**1934**	1554	**394**	232	**187**	95	**65**	22	**2**	59462	50316	27889	15763
1989,5	**8269**	19871	**9402**	8032	**1298**	1014	**219**	154	**133**	76	**50**	12	**0**	48532	40263	20391	10989
1990	14385	**7472**	17779	**7645**	5967	**1026**	777	**181**	120	**100**	61	**45**	10	**55567**	**41182**	**33710**	**15930**
1990,5	13016	**6730**	14921	**5737**	4161	**762**	552	**132**	96	**76**	48	**34**	0	**46265**	**33249**	**26519**	**11598**
1991	**16741**	11778	**5984**	11946	**3708**	2666	**385**	385	**78**	62	**47**	37	**23**	53840	37099	25321	19338
1991,5	**15146**	10582	**4815**	8256	**2603**	1792	**278**	287	**57**	50	**33**	30	**0**	43929	28783	18201	13386
1992	14246	**13705**	9278	**3498**	5191	**1422**	948	**119**	174	**35**	37	**12**	17	**48681**	**34435**	**20730**	**11452**
1992,5	12891	**12340**	7454	**2396**	2944	**833**	523	**77**	132	**20**	30	**9**	0	**39649**	**26758**	**14418**	**6964**
1993	**22967**	11664	**10512**	4468	**1158**	1314	**375**	322	**41**	97	**15**	22	**7**	52961	29994	18330	7818
1993,5	**20781**	10542	**7824**	3092	**686**	820	**255**	254	**32**	84	**9**	20	**0**	44401	23620	13078	5253
1994	9289	**18804**	8714	**5454**	1809	**356**	474	**139**	182	**21**	67	**8**	18	**45334**	**36045**	**17241**	**8527**
1994,5	8405	**16898**	6779	**3798**	1273	**238**	357	**113**	157	**19**	60	**7**	0	**38104**	**29699**	**12801**	**6022**
1995	**16357**	7605	**14954**	5073	**2453**	674	**115**	223	**75**	132	**17**	53	**6**	47738	31381	23776	8822
1995,5	**14800**	6876	**12923**	4091	**1875**	542	**86**	178	**63**	117	**15**	48	**0**	41614	26814	19938	7015

* 1983 = first half of year; 1983.5 = second half of year.

Table 11. Estimated population biomass (000 t) at the beginning of the year for cod in Division 4X.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	1+	2+	3+	4+
1983	3374	6553	17774	15297	12738	9383	5458	3370	2900	1604	1109	293	0	79852	76478	69925	52151
1984	4803	6762	9714	17161	12391	8459	5528	3046	1771	1595	632	554	148	72565	67761	60999	51285
1985	2438	8212	9515	8210	12615	8154	5556	3334	1556	1024	986	220	265	62084	59645	51433	41918
1986	6423	4246	11666	8725	5714	7810	4414	3659	2216	923	396	642	108	56941	50518	46272	34607
1987	6986	13343	6681	11242	6381	3694	5105	3117	2503	1430	491	153	242	61365	54379	41036	34356
1988	10289	10194	20089	7296	9106	4254	2167	2888	1800	1302	707	124	41	70256	59967	49774	29685
1989	3678	14928	14207	20069	4659	5512	1812	1548	1661	1045	833	309	45	70306	66628	51700	37493
1990	5387	5361	20127	14169	15877	3405	3897	1164	1123	1072	786	674	150	73190	67803	62442	42315
1991	12536	7862	6961	20952	9444	9342	1774	2590	716	727	605	546	347	74401	61865	54003	47042
1992	5863	12403	9973	5782	13148	4899	4211	725	1488	393	491	204	282	59863	53999	41597	31624
1993	8758	7085	12856	6819	2559	4538	1782	1966	352	1028	210	333	149	48435	39676	32591	19735
1994	3542	12328	8724	10083	3891	1067	2202	803	1582	278	892	124	307	45823	42281	29953	21229
1995	6402	5496	16445	8503	5638	2222	530	1338	652	1547	228	848	116	49965	43562	38066	21621

Table 12. Estimated bias adjusted fishing mortality for cod in Division 4X.

Age	1	2	3	4	5	6	7	8	9	10	11	12
1983*	**0,00**	0,03	**0,22**	0,30	**0,46**	0,71	**0,62**	0,56	**0,55**	1,10	**0,60**	0,97
1983,5	**0,00**	0,19	**0,34**	0,37	**0,60**	0,57	**0,65**	0,74	**0,54**	0,57	**0,54**	0,55
1984	0,00	**0,01**	0,22	**0,29**	0,38	**0,40**	0,52	**0,43**	0,52	**0,49**	0,58	**0,57**
1984,5	0,00	**0,19**	0,53	**0,53**	0,61	**0,62**	0,61	**0,67**	0,32	**0,40**	1,41	**0,71**
1985	**0,00**	0,01	**0,12**	0,32	**0,41**	0,51	**0,48**	0,41	**0,45**	0,42	**0,39**	0,86
1985,5	**0,00**	0,11	**0,38**	0,58	**0,84**	0,96	**0,65**	0,57	**0,44**	1,15	**0,20**	0,60
1986	0,00	**0,02**	0,22	**0,32**	0,40	**0,53**	0,58	**0,36**	0,51	**0,22**	0,56	**0,31**
1986,5	0,00	**0,05**	0,43	**0,70**	0,75	**0,68**	0,49	**0,54**	0,41	**1,14**	1,44	**1,00**
1987	**0,00**	0,01	**0,10**	0,35	**0,68**	0,68	**0,72**	0,84	**0,59**	0,72	**1,16**	2,10
1987,5	**0,00**	0,08	**0,26**	0,48	**0,50**	0,68	**0,71**	0,54	**0,71**	0,66	**1,76**	1,04
1988	0,00	**0,01**	0,21	**0,26**	0,54	**0,74**	0,53	**0,66**	0,37	**0,60**	0,30	**1,37**
1988,5	0,00	**0,05**	0,28	**0,90**	0,75	**1,09**	0,51	**0,64**	0,82	**0,49**	1,23	**0,85**
1989	**0,00**	0,04	**0,31**	0,48	**0,60**	0,65	**0,97**	0,62	**0,48**	0,26	**0,31**	1,05
1989,5	**0,00**	0,02	**0,21**	0,39	**0,27**	0,33	**0,18**	0,30	**0,38**	0,23	**0,04**	0,22
1990	0,00	**0,01**	0,15	**0,37**	0,52	**0,39**	0,48	**0,43**	0,26	**0,36**	0,26	**0,36**
1990,5	0,00	**0,04**	0,24	**0,67**	0,69	**1,17**	0,52	**0,86**	0,67	**0,76**	0,33	**0,58**
1991	**0,00**	0,01	**0,23**	0,54	**0,51**	0,60	**0,45**	0,39	**0,42**	0,21	**0,53**	0,22
1991,5	**0,00**	0,06	**0,44**	0,73	**1,01**	1,07	**1,50**	0,80	**0,79**	0,45	**1,72**	0,99
1992	0,00	**0,01**	0,24	**0,56**	0,93	**0,87**	0,99	**0,67**	0,34	**0,92**	0,19	**0,45**
1992,5	0,00	**0,12**	0,82	**1,25**	1,41	**1,39**	0,77	**1,07**	0,42	**0,41**	0,41	**0,41**
1993	**0,00**	0,00	**0,39**	0,54	**0,85**	0,74	**0,57**	0,27	**0,26**	0,10	**0,67**	0,00
1993,5	**0,00**	0,18	**0,52**	0,87	**1,11**	0,90	**1,01**	0,47	**0,67**	0,25	**0,25**	0,00
1994	0,00	**0,01**	0,30	**0,52**	0,50	**0,61**	0,36	**0,21**	0,09	**0,00**	0,01	**0,00**
1994,5	0,00	**0,04**	0,38	**0,67**	1,07	**1,26**	0,74	**0,61**	0,15	**0,06**	0,06	**0,00**
1995	**0,00**	0,00	**0,09**	0,23	**0,34**	0,24	**0,39**	0,25	**0,16**	0,04	**0,05**	0,00

* 1983 = first half of year; 1983.5 = second half of year.

Table 13. Projections for cod in Division 4X ("Number" in 000's; Biomass in tonnes).

	Fishing Mortality		Catch Number		Catch Biomass		MidYear	Population Number			Beginning	Popn. Biomass	
Ages	1995.5*	1996-97	1995	1996	1995.5	1996	Weight	1995.5	1996	1997	Year Wt.	1996	1997
1	0	0.000	0	0	0	0	0.56	14800	16500	16500	0.46	7590	7590
2	0.025	0.012	81	145	72	129	0.89	6876	13392	13509	0.71	9508	9591
3	0.202	0.098	1184	521	1657	729	1.40	12923	6145	10833	1.11	6821	12025
4	0.363	0.176	647	1550	1340	3209	2.07	4091	10569	4561	1.69	17862	7709
5	0.413	0.200	333	509	940	1435	2.82	1875	3087	7257	2.35	7255	17053
6	0.413	0.200	96	228	374	883	3.88	542	1381	2069	3.34	4611	6911
7	0.413	0.200	15	66	84	360	5.48	86	399	925	4.61	1838	4266
8	0.413	0.200	32	10	229	75	7.22	178	63	267	6.14	388	1641
9	0.413	0.200	11	22	116	225	10.40	63	131	42	8.76	1149	371
10	0.413	0.200	21	8	268	99	12.89	117	46	88	11.73	544	1031
11	0.413	0.200	3	14	39	211	14.83	15	86	31	13.56	1170	422
12	0.413	0.200	9	2	140	29	16.42	48	11	58	15.71	169	908
13								0	35	7	18.07	639	131
1+			2431	3074	5258	7384		41614	51845	56147		59544	69650
2+			2431	3074	5258	7384		26814	35345	39647		51954	62060
3+			2351	2929	5186	7255		19938	21953	26138		42446	52469
4+			1167	2408	3529	6526		7015	15808	15305		35625	40444

* 1995.5 = July 1 - Dec. 31, 1995.

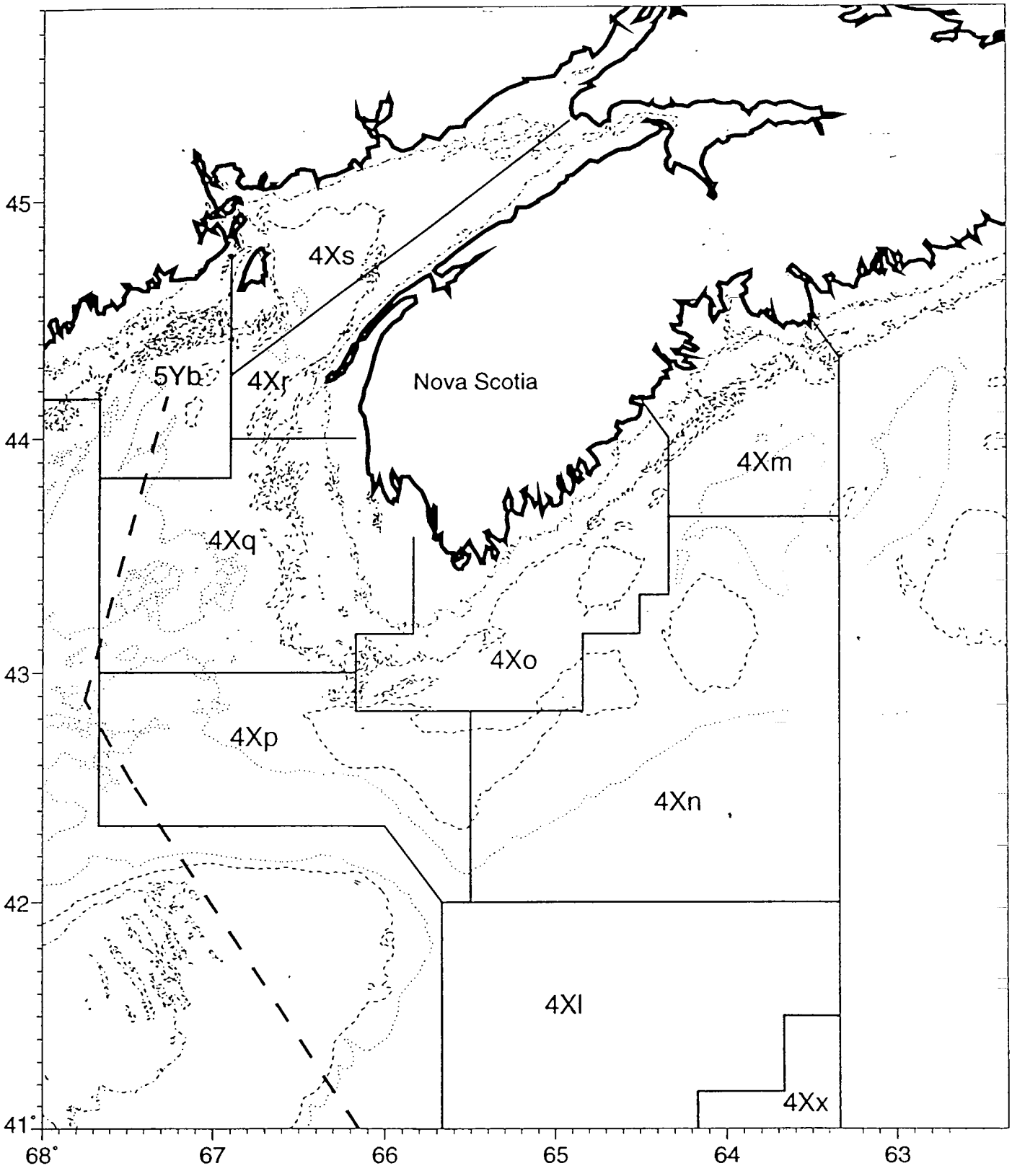


Fig. 1. Canadian fisheries statistical unit areas in NAFO Division 4X.

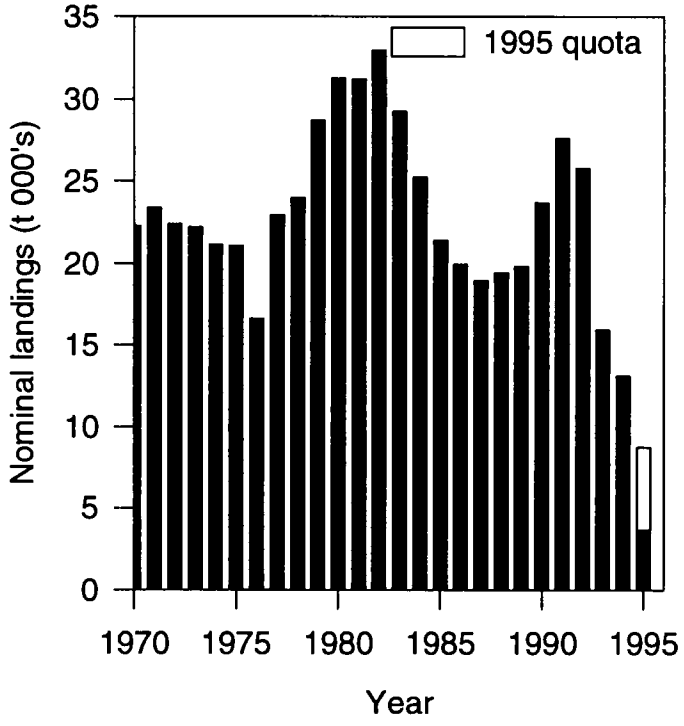


Fig. 2. Nominal landings of cod in Division 4X including catches by Canada in Division 5Y. For 1995, quota and mid-year landings shown.

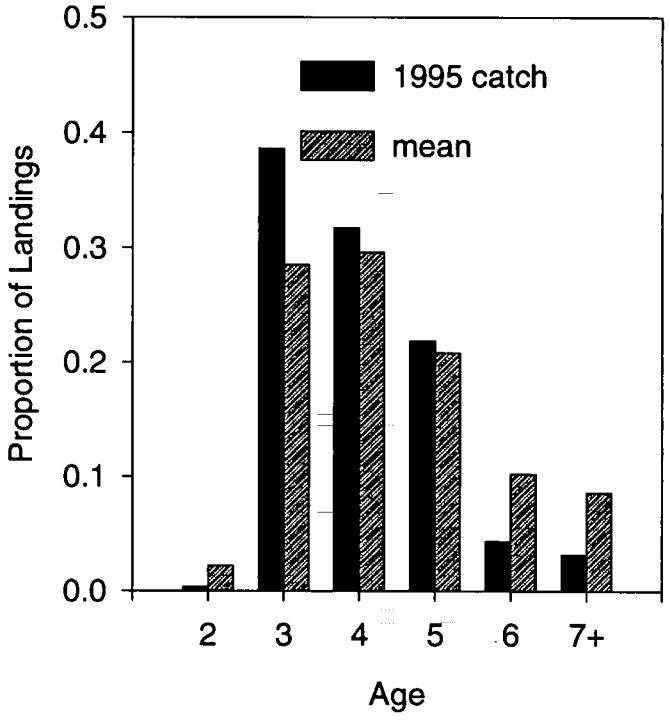


Fig. 3. Division 4X cod catch (Jan.-June) proportioned by age for 1995 compared to mean for 1983-1995.

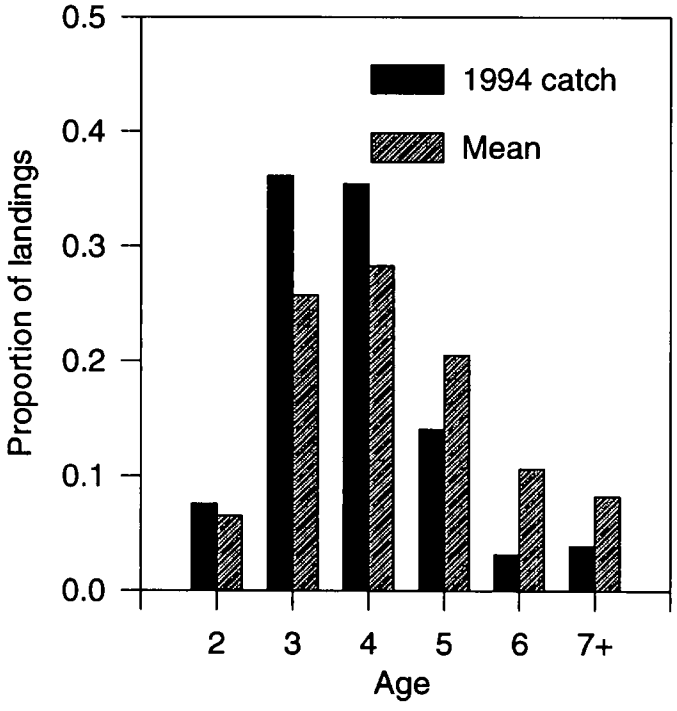


Fig. 4. 4X cod catch for 1994 proportioned by age compared to mean for 1983-1994.

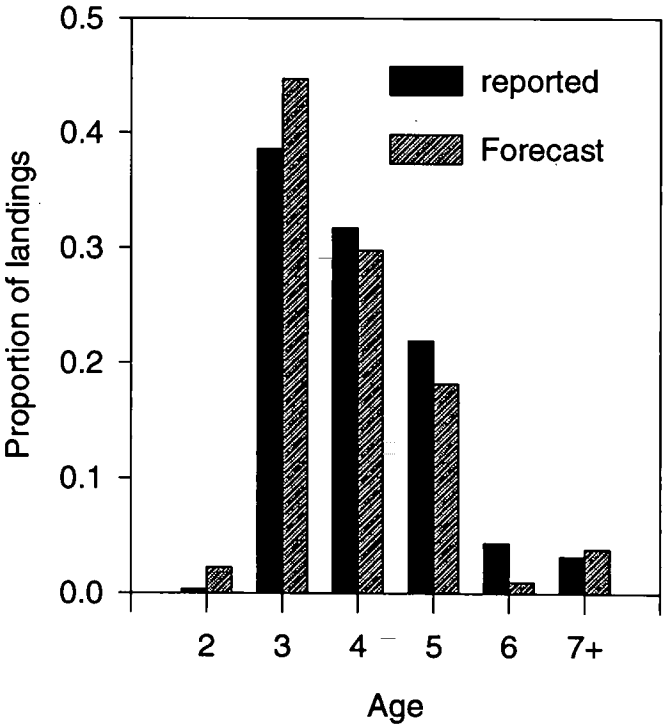
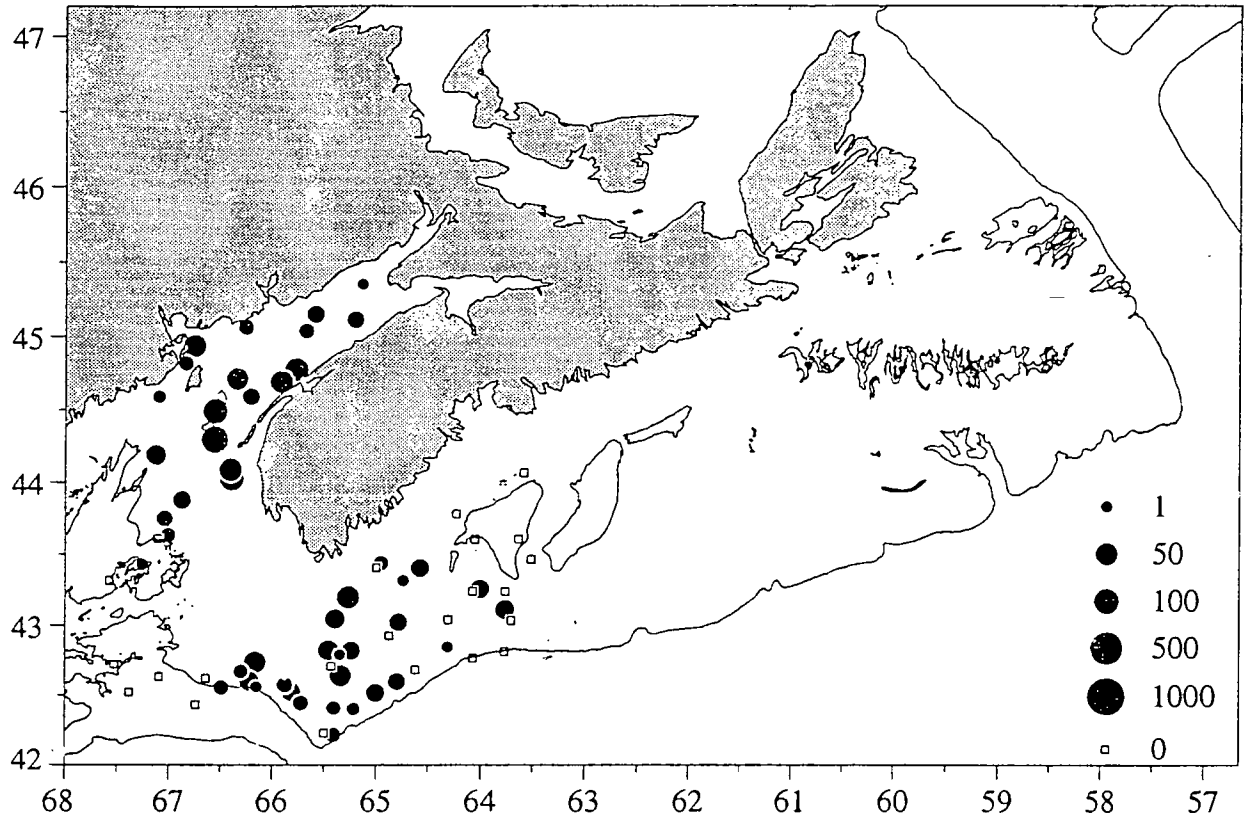


Fig. 5. Reported and forecast landings of cod in Division 4X for 1995 proportioned by age.



4X Groundfish Summer Survey Cod Biomass (kg/tow) July 1994

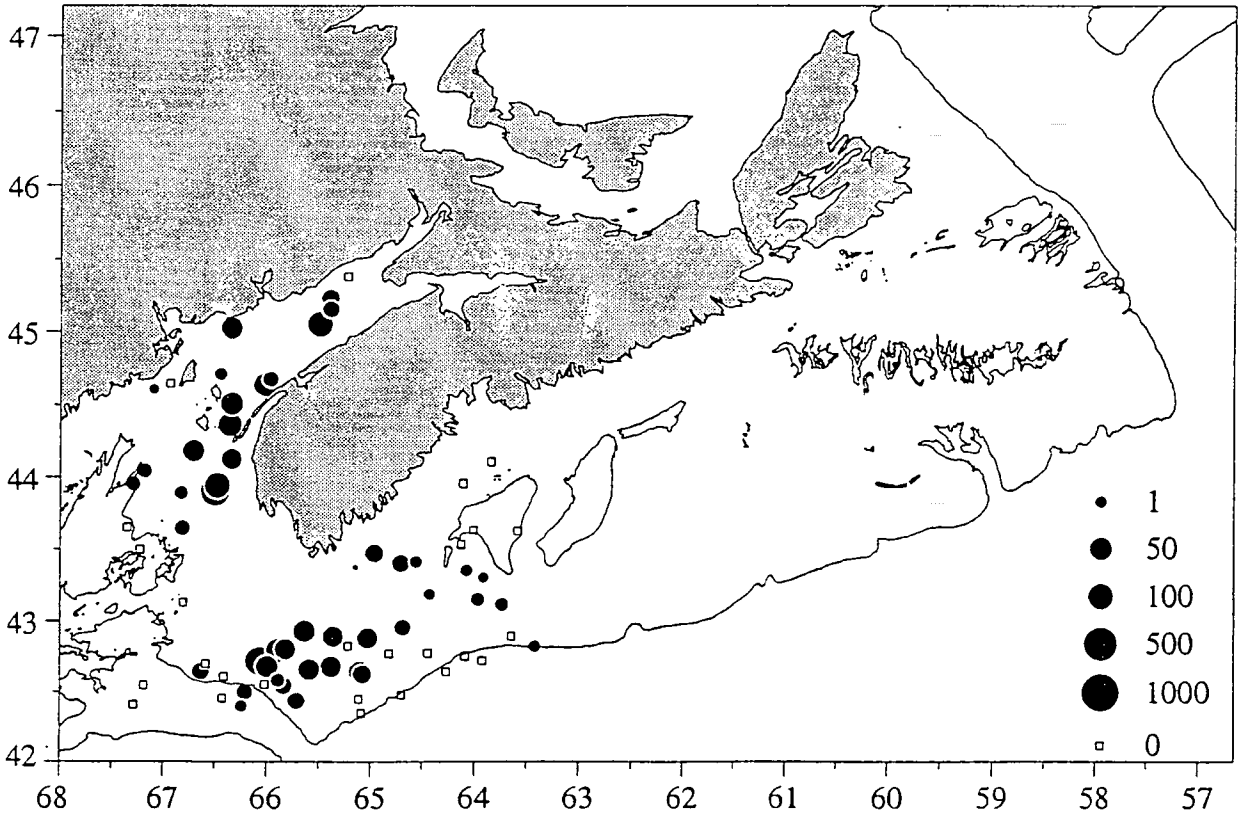
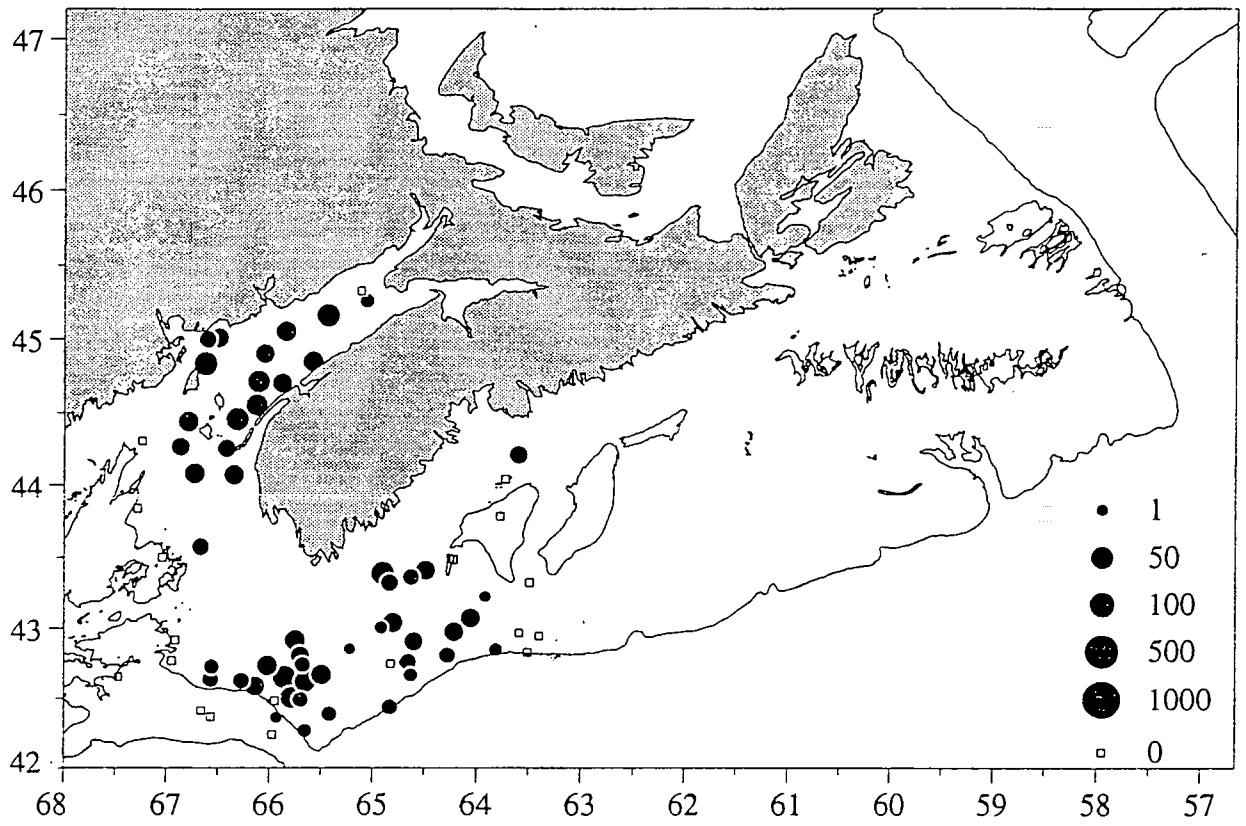


Fig. 6. 4X Groundfish Summer Survey Cod Biomass (kg/tow) July 1995



4X Groundfish Summer Survey Cod Biomass (kg/tow) July 1992

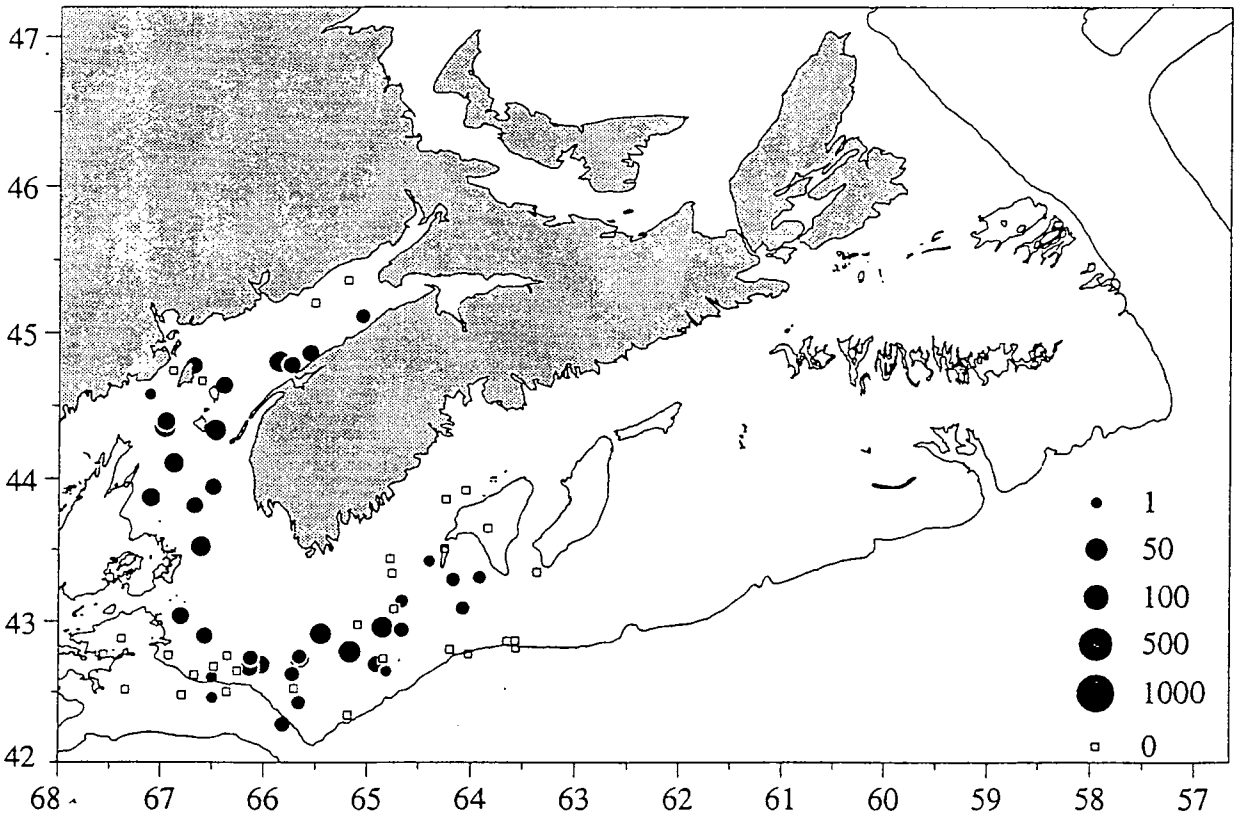


Fig. 6 (cont.). 4X Groundfish Summer Survey Cod Biomass (kg/tow) July 1993

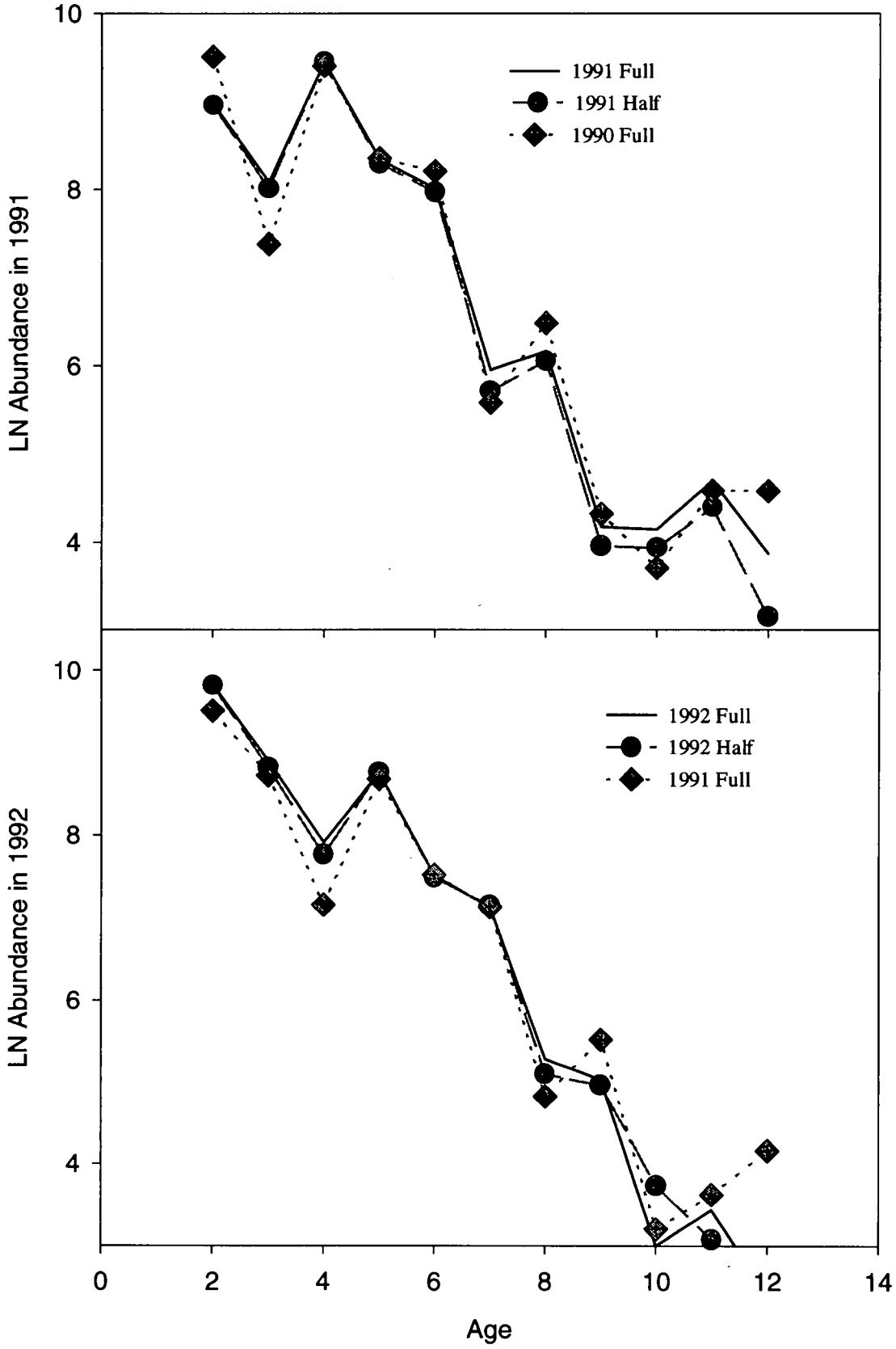


Fig. 7. Comparison of population abundance estimates at age from successive full and half-year sequential population analyses.

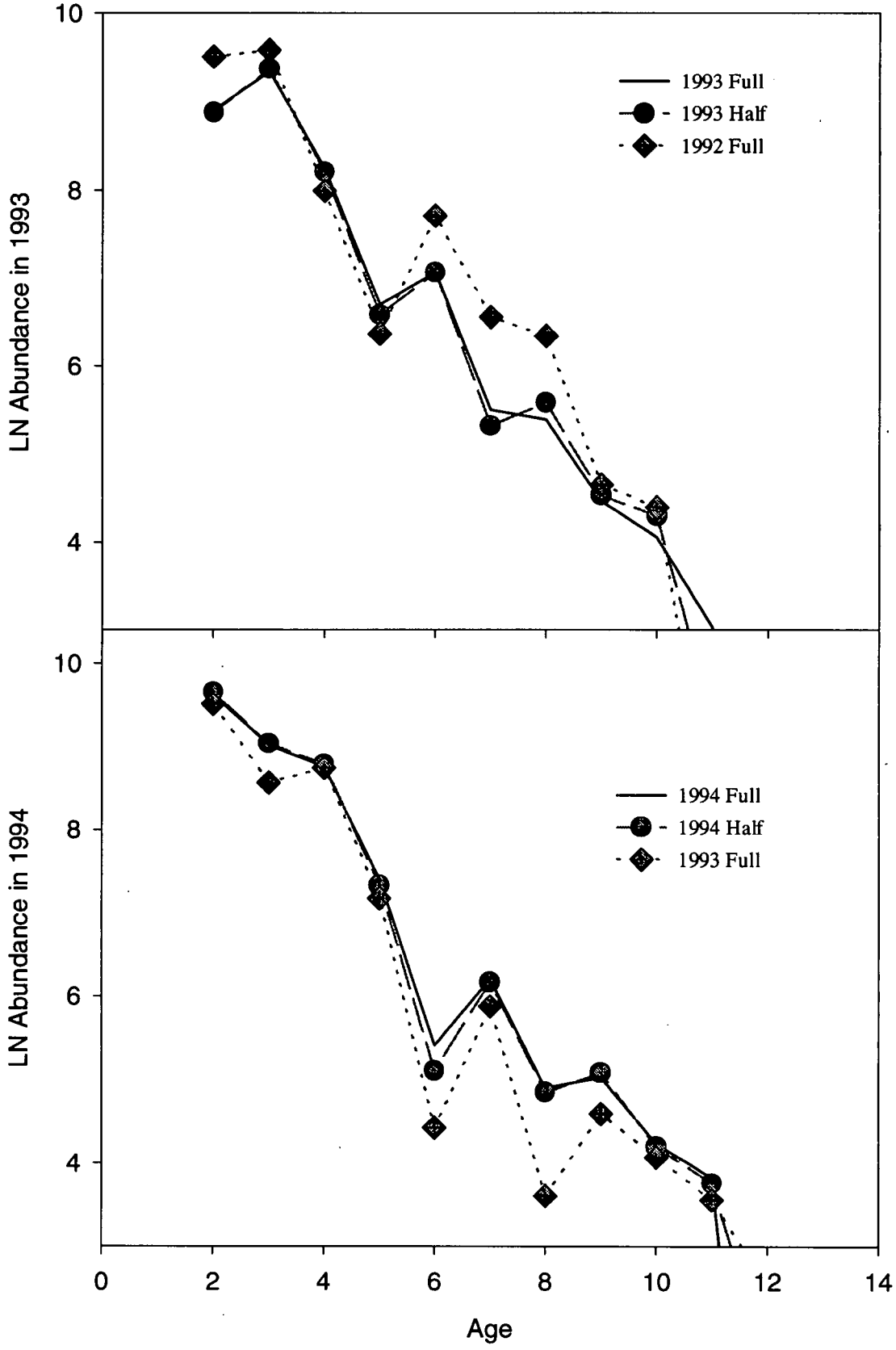

LN Abundance in 1993
10
8
6
4
1993 Full
1993 Half
1992 Full
LN Abundance in 1994
10
8
6
4
1994 Full
1994 Half
1993 Full
0
2
4
6
8
10
12
14
Age

Fig. 7 (cont.).

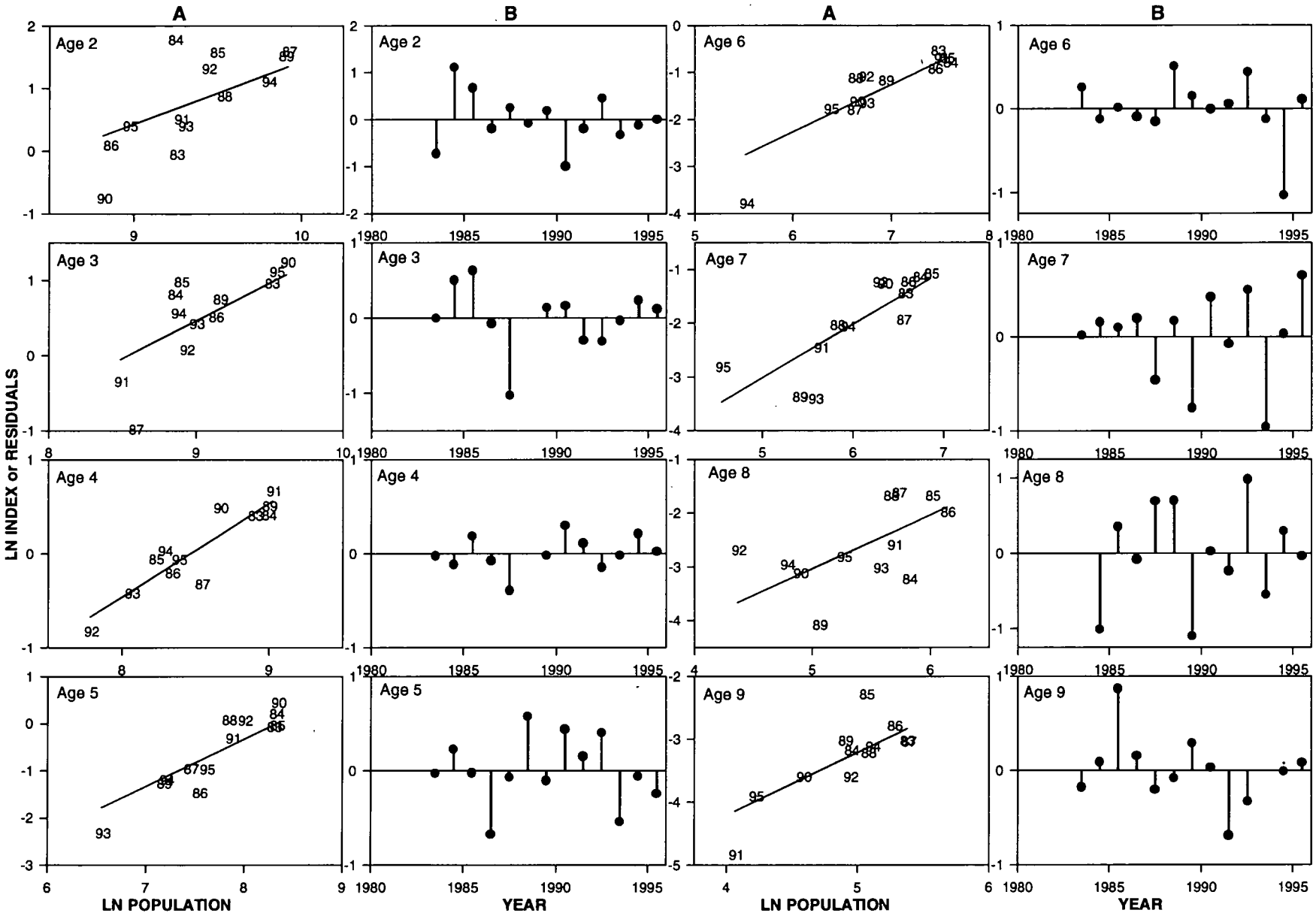


Fig. 8. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers, and B) residuals plotted against year for cod in Division 4X.

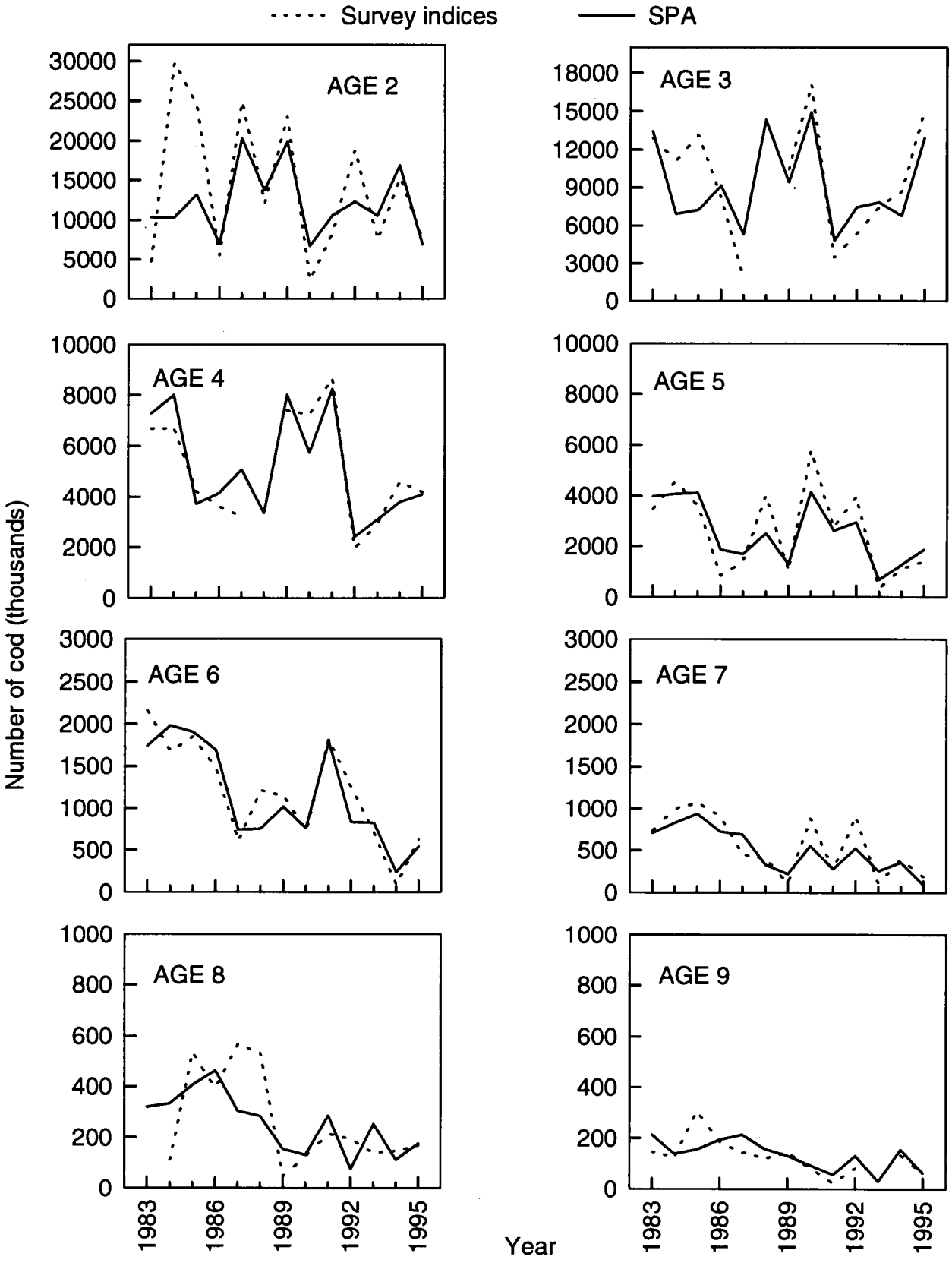


Fig. 9. Mid-year population numbers from sequential population analysis (SPA) and research survey indices (adjusted by calibration constants) for cod in Division 4X.

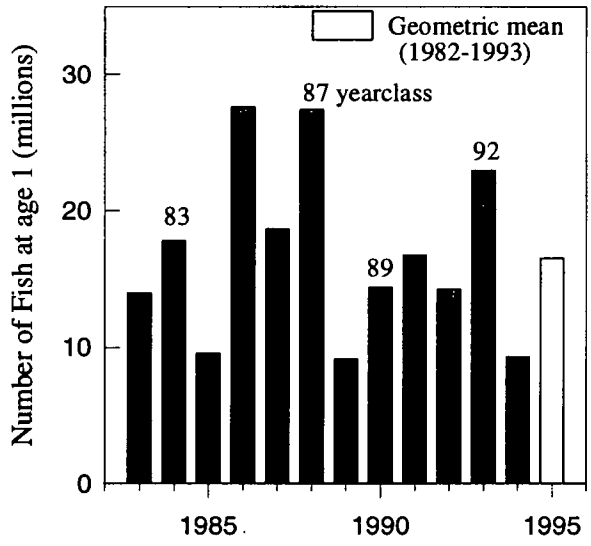


Fig. 10. Recruitment (age 1) for cod in Division 4X.

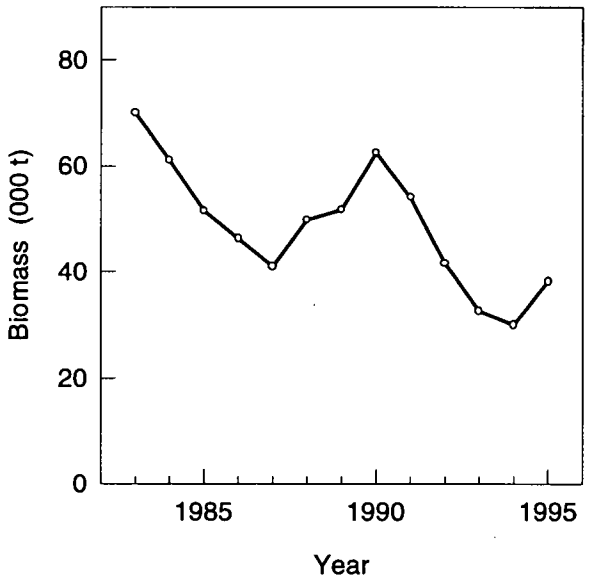


Fig. 11. Beginning of year biomass (3+) for cod in in Division 4X.

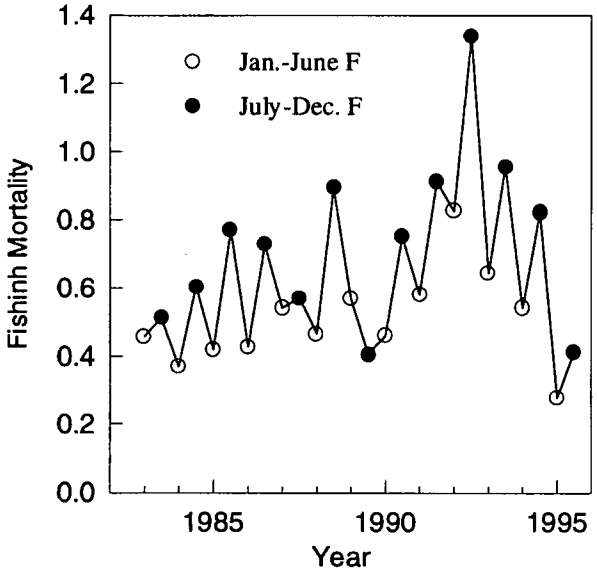


Fig. 12. Fishing mortality (4+) for cod in Division 4X.

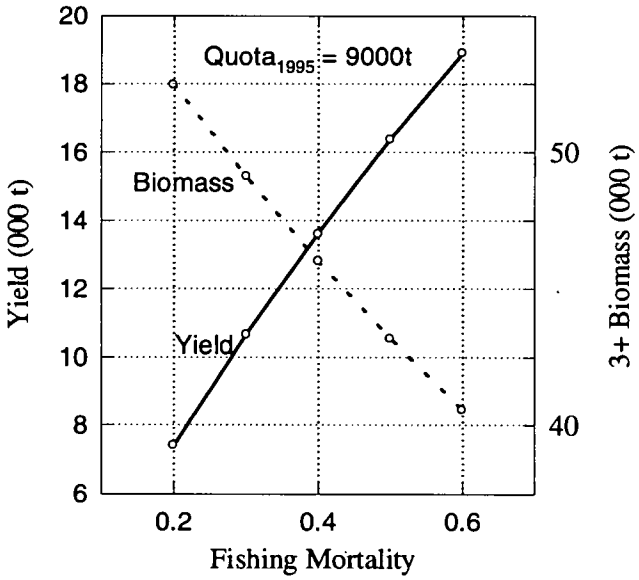


Fig. 13. Projected 4X cod yield for 1996 and beginning of year biomass in 1997.