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Assessment of cod in Division 4X in 2002

Évaluation de la morue de la division 4X en 2002

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Abstract

Landings for 4X cod have been restricted by total allowable catch to 6,000t for the 2000 –2002 fishing years to promote increase in population biomass. Recruitment to the fishery has improved starting with the 1998 yearclass, and growth rate and condition remain at or above average, providing good opportunity for biomass increase. The extent of biomass growth, however, has been less than anticipated due to higher than expected mortality. The high mortality does not appear to indicate increased natural mortality, but is consistent with anecdotal reports of discarding and unreported landings. Spawning stock biomass (age 3+) has improved as the 1998 and later yearclasses have recruited, and at current mortality levels should continue to improve in the next 2 years due to improved recruitment. Longer-term biomass increase and improvements in age structure for this stock are dependent on reductions in mortality rate.

Résumé

Au cours des années 2000 à 2002, les débarquements de morue dans 4X ont été limités à 6 000 t par le total autorisé des captures pour favoriser une augmentation de la biomasse de la population. Le recrutement s'est amélioré à partir de la classe d'âge de 1998, et le taux de croissance et la condition demeurent égaux ou supérieurs à la moyenne, ce qui offre une bonne possibilité d'accroissement en biomasse. Cet accroissement a cependant été plus bas que prévu en raison d'une mortalité supérieure aux prévisions. La mortalité élevée ne semble pas indiquer une augmentation de la mortalité naturelle, mais elle concorde avec des rapports anecdotiques faisant état de rejets et de débarquements non déclarés. La biomasse du stock reproducteur (3 ans et plus) s'est accrue grâce au recrutement de la classe d'âge de 1998 et des années suivantes. Si les taux de mortalité actuels se maintiennent, cette biomasse devrait continuer à augmenter au cours des deux prochaines années en raison d'un meilleur recrutement. L'augmentation de la biomasse et les améliorations de la structure d'âges de ce stock à plus long terme dépendent de baisses du taux de mortalité.

Description of the Fishery

Landings of cod from NAFO Subdivision 4X (including Canadian portion of 5Y; Fig. 1) increased through the 1960s as large offshore trawlers became active in the fishery (Table 1; Fig. 2). Recent landings are a reflection of the TAC which declined from 26,000t in 1992 to 6,000t in 2000. The quota has been held at 6,000t for 3 years as part of a rebuilding strategy for 4X cod. As of October 24th, 2002 4,200t of cod has been landed; this includes 80% of the <45' fixed gear quota, and 60% of the mobile gear ITQ fleet quota. This is slightly ahead of the same time in 2001.

The fishery takes place year round, peaking in June and July (Table 2). Landings from the winter declined after 1992, with many fishing sectors treating cod as a by-catch as they pursued other species. Since 2000, the quota year has run from April 1st. With this change in fishing year, and the increase in haddock quotas relative to cod, the winter haddock fishery has increased, and winter landings of cod, taken as by-catch, have also increased.

In 2001 and 2002, the cod fishery is reported to have improved in most areas. The distribution of landings is similar to recent years, with a high proportion of landings in the Bay of Fundy (4Xqrs5Y; Fig. 3), and much lower landings in inshore areas of Southwest Nova Scotia (4Xmo) than in the past (Table 3). Most groups reported no difficulty in catching their quota despite the fact that many were directing their effort primarily for haddock. Hook and line vessels in the Bay of Fundy caught their quotas in 2001 for the first time in 4 years. Fishing in inshore areas of 4Xo, however, a much larger sector of the fishery, was poor for both cod and haddock, with fishermen having to travel further offshore. In 2002, fishing is reported to have been poor in most coastal areas, but further improved in deeper water.

The number of vessels active in the fishery in 4X appears to have stabilised, except for handline, which continues to decline (Table 4). Reported fishing effort for groundfish is low for all fixed gear sectors in recent years (Table 5). Data on days fished are not available for much of the fleet prior to 1996, however the total number of trips by gear type had declined by 1996 from a peak in 1992 (Clark 1997). Effort shows a similar decline for otter trawlers (Fig 4).

Catch rates for otter trawlers have increased annually since 1999, and are now the highest since 1991 (Fig 5). Gillnet catch rates doubled in 2002, and are now more than 5 times as high as in 1996 (Fig 6). Catch rates for longline and handline vessels shows little change since 1996 (Fig 7). Due to changes in fishing patterns and the impact of management measures, it has been argued that catch rates may have limited information value regarding cod abundance.

Since 2000, fishermen in the groundfish fishery (cod, haddock and pollock) have maintained that the cod quota is very restrictive and that they have difficulty remaining within their quota for cod while pursuing other species. Mobile gear fishermen report increases in both cod and haddock abundance. Most feel that they can balance quotas by directing effort to areas where haddock are abundant, but indicate some are not making this effort and may be discarding cod. Some express frustration at the low cod quota and indicate it is leading to discarding. Fixed gear fishermen (20 fishermen interviewed) indicated that cod abundance has increased but they see little increase in haddock in the areas they fish. Many of those interviewed felt it was impossible to catch a mix of cod and haddock appropriate to their specific quotas, except during the winter, and stated that cod were being discarded and landed unreported. In 2001, the fixed gear <45' quota sector in 4X landed 97% of their cod

quota but only 77% of their haddock quota. There are, however, a wide range of cod to haddock allocation ratios among community management boards and individual quota holders; matching these ratios in landings will not be uniformly difficult for all.

Reports of cod being discarded or landed unreported to avoid exceeding the quota have increased. These anecdotal reports have been received from all sectors of the fishing fleet, with some indicating that the amount of cod recorded in landings data may be significantly less than is killed in the fishery in some areas for recent years. These reports bring into question the efficacy of quota management for cod in 4X and the reliability of analyses that are dependent on landings data. Both fishermen and DFO fisheries management indicate that enhanced enforcement in this area may have mitigated the under-reporting to some extent in 2002.

Catch and Weight at Age

Fishery Samples

Catch at age was derived following standard protocols for this stock (Clark et al, 2002). Length frequency samples were aggregated to give catch at length by gear, area and quarter-year, while age-length keys were produced for area and quarter (Table 6).

Landings

The modes in commercial length frequencies from 2001 reflect the dominant 1998 year-class (Fig. 8). Few very large cod were landed from either the Bay of Fundy or the Scotian Shelf. In the first half of 2002 the length frequencies peak higher than in 2001, and there is more dispersion in the range of lengths caught, particularly on the Scotian Shelf (Fig. 9).

In 2001 the catch at age peaked for all gear types at age 3, with ages 4 and 5 also contributing significant amounts while in the first half of 2002 the 1998 yearclass dominated the catch at age for all gear types (Table 7). The catch at age in 2001 was well predicted from the 2000 assessment (Fig. 10). The catch at age, however is skewed relative to the long term average, with older fish less well represented, and the 1998 yearclass well above average at age 3 in 2001 (Fig. 11) and at age 4 in 2002 (Fig. 12).

Commercial catch-at-age data from 1948 to 2002 were used in this assessment (Table 8). Sampling of the commercial cod landings in 4X was sparse in most years prior to 1980, and the catch at age and weights at age are, therefore, less precisely reconstructed in this period. These data, however, are sufficient for determining long-term trends in age structure and yearclass strength (Clark et al, 2002).

Weights-at-age from the commercial fishery show no strong trends, but are somewhat above average in recent years in both the Bay of Fundy and Scotian Shelf areas (Table 9).

Abundance Indices

The annual DFO Research Vessel (RV) survey, employing a stratified random survey design, and the joint DFO/industry small dragger survey (ITQ), which employs a

fixed station design, are used for abundance indices for this resource (Clark et al 2002). The annual DFO Research vessel survey has been conducted annually since 1970, however, due to uncertainties in appropriate conversion factors to apply in relation to vessel and net changes, only data after 1982 are used as indices (Clark et al 2002).

Distribution of catches in the RV survey in 2001 and 2002 was improved over 2000, when no cod were caught east of Baccaro Bank (Fig. 13). Catches in the Bay of Fundy and around Browns Bank appear to have improved in 2002. Despite the apparent improvement in distribution of survey catches, the area occupied remains very low, reflecting a relatively high proportion of sets with no cod catch (Fig. 14). The local density of cod (mean number per tow where cod are caught) is also low (Fig. 14).

The ITQ survey had fewer good catches around the mouth of the Bay of Fundy in 2002 than in other years (Fig. 15). There were more sets below the median for that location than above in 2002, with above median catches coming mainly from the Scotian Shelf and the deep waters of the Gulf of Maine (Fig. 16). The proportion of sets in this survey where cod are caught, however, has changed little over the 7-year series (Fig. 17).

Catch per tow in the RV survey in 2002 roughly doubled from the level of the previous 3 years (Fig. 18) and was above the median for the survey since 1983. The ITQ survey catch, conversely, was quite low in 2002. The RV survey catch was above the median for most lengths in the Bay of Fundy, and particularly high from 16-31 cm (Fig. 19). The ITQ survey catch, however was below the median for most lengths, although catches in this survey were also good for small cod (Fig. 20). On the Scotian Shelf, the RV survey catch was below the median for most lengths (Fig. 21), while the ITQ survey catch was near the median for most lengths, and high for juvenile cod (Fig 22).

There are no clear trends in length at age for cod from the RV survey in either the Bay of Fundy or Scotian Shelf (Fig 23). Current values are at or above average for most ages in both regions. Similarly, growth rate and condition calculated for cod caught in the RV survey have been variable over time, but without trend (Fig. 24). Condition throughout the survey period has remained good, and is unlikely to have hindered survival or reproductive success for 4X cod.

Catches were above the median for the RV survey at ages 0, 1, 2, 4 and 9, with age 1 catch the highest in the series (Table 10). The RV survey index at age 2 in 2002 is the highest in the index series (Table 11). Catches from the ITQ survey were at or above the median (1996-2002) at ages 0, 1, 4, 6, 7 and 9 (Table 12). Estimates of relative strength of recruiting year-classes have been calculated by averaging catch at ages 2 and 3 in a cohort for each survey (Fig. 25). The number of above average mature yearclasses in the RV survey can be considered an indicator of age structure. This has been low for 4X cod since 1992, increasing in 2002 (Fig. 26). The 1998 and 1999 yearclasses appear stronger than the preceding 5 in both surveys.

Estimation of Stock Parameters

Estimates of population abundance in numbers for the middle of the terminal year, the last period for which catch at age is available, were obtained by calibrating a simple Virtual Population Analysis with the two bottom trawl surveys. This class of models makes the assumption that errors in the observed catch at age are negligible compared to the errors in the abundance indices. Such an assumption allows a deterministic application of

the catch equation recursively to derive the abundance of a year-class at any time given the observed catch at age and an estimate of abundance for that year-class at only one point in time. Results that were most consistent with observations and expected biological and fishery processes were obtained with the following formulation (*a* indexes age and *y* indexes year):

Observations
$C_{a,y}$ = catch at age for *a* = 0 to 14 and *y* = 1980 to terminal year.
$I_{s,a,t}$ = survey abundance index for:
s= RV survey ages *a=2 to 8, years t = 1983.5 to present*
ITQ survey ages *a = 2 to 8, years t = 1996.5 to present*

Parameters
$\theta_{a,y}$ = *ln* abundance for *a* = 2 to 14 in *y* = terminal year, and for *a* = 14 in *y* = 1998 to terminal year.
κ_{sa} = calibration constants for RV and ITQ surveys for ages *a = 2,3,4-8.*

Structural Conditioning
Natural mortality assumed to be 0.2 for all ages and years.
Fishing mortality on age 14 for 1980 to 1997 assumed to be equal to the population number weighted average fishing mortality on ages 10-12.

Error Conditioning
Catch at age error was assumed negligible compared to the index error.
Error on the *ln* index observations was assumed to be independent and identically distributed.

Estimation
Parameters were obtained by minimizing the objective function

$$\sum_{i,a,y}\left(I_{i,a,y} - \hat{I}_{i,a,y}[\theta,\kappa]\right)^2$$

Assessment Results

For each cohort the terminal population abundance estimates from ADAPT were adjusted for bias (Table 13) and used to construct the history of stock abundance (Table 14) and biomass (Table 15).

A number of RV and ITQ survey data products, along with many of the SPA outputs may be summarized together using the traffic light methodology. This summary, along with a brief description of the methodology is presented in Appendix I.

Recruitment has improved, starting with the 1998 yearclass (age 2 in 2000; Fig. 27), following 5 very low recruitment years, but remains below average. Population biomass (age 3+) increased in 2001 and 2002 due to the contribution of the stronger recruiting yearclasses (Fig. 27).

Fishing mortality rate was high but stable at about 0.5 from 1995 to 2000, dropping to 0.35 in 2001 (Table 16). Exploitation rate remains above the reference level

of 17% which equates to $F_{0.1}$ but appears lower than all but three years since the 1950's (Fig. 28).

Surplus production is a measure of total production for the stock from recruitment and fish growth minus the amount lost to natural mortality. Surplus production declined through the 1990s to a historical low, then increased in 2000 and 2001 with improved recruitment (Fig. 29).

Dividing commercial landings by survey biomass is an estimate of relative fishing mortality. This calculation suggests that exploitation has been lower for the last 7 years than in any other year since 1970 (Fig. 30). This is a somewhat different view from that indicated by the SPA results.

Total mortality (Z) as calculated from the RV survey has considerable inter-annual variability. There is no trend apparent in total mortality, which remains high despite the reductions in reported landings (Fig. 30). The discrepancy between RV Z and relative F suggests there is additional mortality of cod in 4X above what is accounted for by catch and a natural mortality rate of 0.2. Reports of high levels of unreported catch are consistent with this.

When survey Z is calculated separately by age, temporal trends differ with age. For ages 2 and 3, Z has declined and is currently low; however, there is no trend for commercial aged cod, with Z remaining high (Fig. 31). If additional mortality was due to high predation, as has been determined for some other Western Atlantic cod stocks, the impact should be more pronounced for smaller cod, which are prominent in the diets of seals. Condition of adult cod is good; thus there is no reason to suspect high mortality of adult cod following spawning, as has been proposed in the Gulf of St. Lawrence. The apparent high mortality of commercial sized cod is, however, consistent with anecdotal reports of high levels of unreported landings and discarding of cod in the fishery.

Residuals from the assessment show some disturbing patterns, with most values positive for the RV survey at younger ages in recent years and strongly negative at older ages (Fig. 32). This reflects a more rapid inter-annual decline for each cohort than can be accounted for by the reported catch.

This population reconstruction has a pronounced retrospective problem in recent years, where population estimates for a given year decline and fishing mortality estimates increase with additional years of data (Fig 33). This pattern is quite marked since 1998, and reflects the additional mortality for 4X cod beyond what is accounted for in the data used in the analysis. If the retrospective is caused by an increase in under-reporting of the fishery catch, the tendency to over-estimate will be less severe for the abundance of recruiting yearclasses than it is for population biomass. Furthermore, the initial high estimates may be a more accurate reflection of actual recruitment than are subsequent estimates, which may be under-estimates due to missing catch.

The surplus production projected from this stock comes primarily from younger ages, and therefore should also be reasonably estimated. Surplus production in recent past years, however, will be underestimated. Surplus production can be calculated as the inter-annual change in age 2+ biomass plus the fishery catch. If catch has been underreported, recent surplus production will be underestimated by a similar amount.

Prognosis

The projection for 2003 shows 87% of the yield will come from the 1998-2000 yearclasses (Table 17). For a yield of 6000t, the exploitation rate on these ages (3-5) is estimated at 14%. If fishery removals are maintained at this low level, an increase of over 8,000t in 3+ biomass, roughly 20%, is anticipated in one year. If removals, including reported and unreported fishing mortality, are in excess of 6,000t, the expected growth will be reduced by an equivalent amount.

The principal source of uncertainty in our evaluation of stock status in 4X cod is the actual removals in each year. Reports of current and historical discarding and under-reporting indicate that these vary from year to year. Risk analyses detailing the consequences of alternative total allowable catches (TAC's), are not reliable for situations with pronounced retrospective patterns suspected to be caused by substantial problems with reported catch. Estimates of current and projected biomass must also be interpreted in light of these concerns.

Although the exact biomass may not be well estimated, the potential growth should be more accurately estimated, since the anticipated biomass growth is coming almost entirely from recruiting yearclasses. Biomass should increase for 4X cod in the short-term. Given the improvements in recruitment in the last 3 years, which are apparent from survey indices, spawning stock biomass will increase for this stock in the coming year at current levels of mortality. If recruitment continues to exceed the levels experienced in the mid-1990s, as seems indicated from survey catches, this growth will continue for the following year. The full benefits of these recruiting yearclasses towards stock rebuilding will not be realized if mortality cannot be reduced to moderate levels.

Restrictive quotas for 4X cod have not been effective at reducing total mortality. The ratio of cod to haddock fishing mortality can vary greatly among gears and areas, and it will take an active effort on the part of fishermen to change their fishing patterns to alter the relative fishing mortality for these species. This alone may not be sufficient to bring F for cod below that for haddock, as would be required were fishing mortalities for the two stocks to be brought to their respective $F_{0.1}$ levels. Fishing mortality has been higher for cod than for haddock since the early 1980's. Since that time the proportion of cod landings taken by gillnet, which catch few haddock, has increased, and the number of longliners active in the winter, when haddock are aggregated separately from cod, has decreased. Without reverting to a fishery structured similarly to that seen prior to the mid-1980's, it may be very difficult to achieve higher fishing mortality for haddock than for cod.

Longer-term biomass increase and improvements in age structure for this stock are dependent on reductions in mortality rate. If the unaccounted mortality for this stock is caused by unreported fishing mortality, this needs to be reduced substantially. For this stock to return to biomass levels observed in earlier decades, further improvement in recruitment to the long-term average is also needed.

Acknowledgements

We would like to thank the many individuals who took part in the survey that compiled fishermen's views on the resource. The continued careful attention of Laura Brown in the interpretation of aging material and the efforts of Gilbert Donaldson, Sue D'Entremont and Emelia Williams in sampling commercial landings are also appreciated.

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Appendix I.

Traffic Light Analysis

The Traffic Light table summarises a number of indicators of stock status presented in the assessment. This table shows the annual values of each indicator as a combination of three lights depending on whether they are among the best values for that indicator, among the worst or in between. For indicators such as stock biomass and recruitment, high values are good and have a green light and low values are bad and have a red light. However, for indicators such as mortality, high values are bad and are assigned a red light ⊖ whereas low values are good and receive a green light ⊕. Intermediate values (midpoint between red and green) are yellow●. A value between red and yellow is expressed as a pie with increasing amounts of red in the pie as the value approaches the red threshold or cut point. Similarly, a value between the midpoint and the green cut point becomes increasingly green in the pie as the green cut point is approached. Empty cells in the table indicate no observation for that year. Uncertainties about the appropriate cut point resulted in a broad yellow zone. These cut points, along with the rationale for their selection, are presented in table A1.

In the traffic light analysis, indicators can be summarized into groups that emphasize specific aspects of the resource. These groupings are called characteristics.

Traffic Light Table

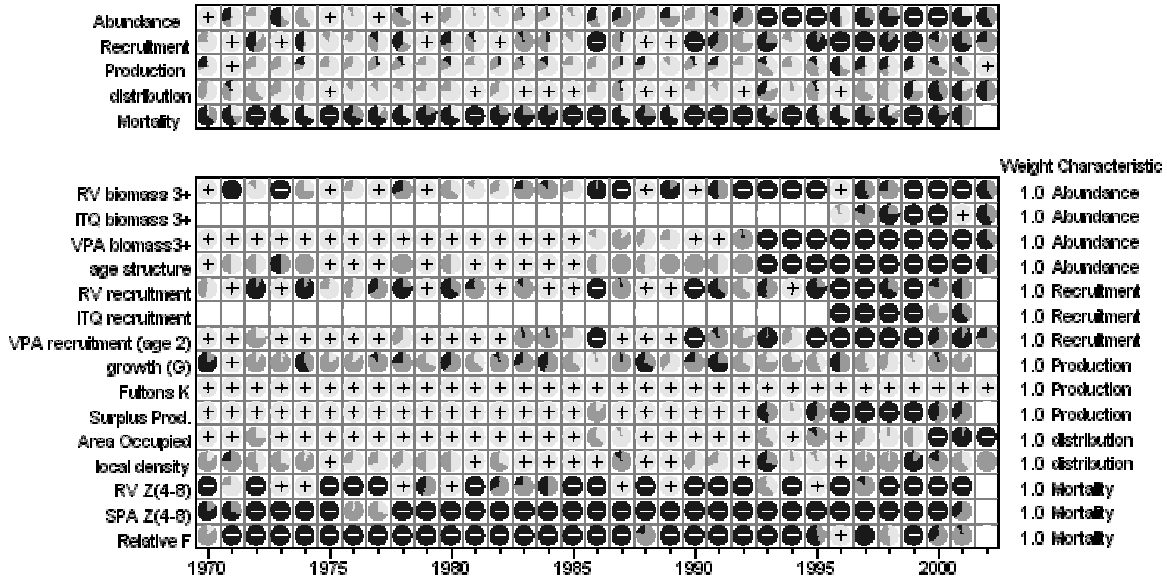

Table A1. Description of traffic light boundary points, weights and rationale for 4X cod

Indicator	Green Boundary	Red Boundary	Characteristic	Weight
Summer RV survey mean weight per tow for ages 3+	15	10	Abundance	1
	Consistent with the highest values	Consistent with the low abundance in the 1990s.		
ITQ survey mean weight per tow for ages 3+	25	17	Abundance	1
	The boundaries were set by scaling it to the RV series	scaled to the RV series		
VPA SSB (ages 3+)	50000	30000	Abundance	1
	The boundaries were set by scaling it to the RV series	scaled to the RV series		
RV survey age structure	6	2	Abundance	1
	Consistent with the highest values in the series	Consistent with the low abundance in the 1990s.		
RV survey recruitment (average for ages 2+3 in a cohort)	3000	1200	Recruitment	1
	Consistent with the largest recruitment pulses	Consistent with the smallest observed values		
ITQ survey recruitment (average for ages 2+3 in a cohort)	16,000	10,000	Recruitment	1
	Consistent with the largest recruitment pulses	Consistent with the smallest observed values		
VPA recruitment (age2)	15,000	8,000	Recruitment	1
	Consistent with the largest recruitment pulses	Consistent with the smallest observed values		
RV survey Instantaneous Growth Rate (ages 2-7)	0.25	0.1	Production	1
	Consistent with the highest observed values	Below the lowest observed value		
Condition (Fultons K)	0.9	0.8	Production	1
	Consistent with levels where condition is considered good in laboratory studies	Condition below which impared spawning success is anticipated		
Surplus production	15000	10000	Production	1
	Sufficient production to sustain a healthy fishery	Consistant with low production in the 1990's		
Design Weighted Area Occupied	0.7	0.5	Distribution	1
	Consistent with highest values observed	Consistent with lowest values observed		
RV survey local density	1.9	1.3	Distribution	1
	Consistent with highest values observed	Consistent with lowest values observed		
RV survey mortality (Z)	0.4	0.6	Mortality	1
	FRCP F target plus 0.2 for natural mortality	Double F target plus 0.2 for natural mortality		
VPA mortality (Z)	0.2	0.4	Mortality	1
	FRCP F target plus 0.2 for natural mortality	Double F target plus 0.2 for natural mortality		
Relative F (ages 4-8)	0.5	0.9	Mortality	1
	Boundary chosen for consistency in the 90's with the VPA Z	Boundary chosen for consistency in the 90's with the VPA Z		

Table 1. Nominal catch of 4X cod by gear and tonnage class for Canadian Maritimes vessels.

	Otter Trawl					Gill Net		Long Line			Hand		
Year	0&1	2	3	4	5+	0&1	2&3	0&1	2	3+	Line	Misc.	Total
1968	253	2,245	3,684	7,596	3,111	1,856	0	3,482	479	806	5,766	1,509	30,787
1969	207	1,385	2,448	4,298	3,721	926	0	3,554	513	681	4,446	1,533	23,712
1970	158	1,151	1,529	1,960	1,259	653	0	4,171	515	768	3,444	2,410	18,018
1971	81	1,097	1,611	1,799	1,220	546	4	5,472	691	1,575	4,421	1,783	20,300
1972	121	1,235	1,635	2,246	1,371	1,187	0	6,119	668	1,174	3,128	1,646	20,530
1973	100	1,214	1,232	1,350	553	669	0	7,407	1,048	1,641	3,672	1,105	19,991
1974	128	1,433	1,310	575	577	1,851	0	6,834	1,400	1,096	3,247	490	18,941
1975	129	2,666	1,298	460	601	1,482	27	6,013	1,600	781	2,526	2,001	19,584
1976	82	1,025	1,263	436	896	2,403	167	4,828	1,067	1,479	2,867	525	17,038
1977	298	1,972	2,909	527	1,065	2,052	79	6,151	1,831	907	2,943	1,254	21,988
1978	615	1,805	2,573	745	1,731	2,562	96	6,904	2,216	1,149	2,059	1,264	23,719
1979	663	1,749	2,744	1,139	1,405	3,527	116	7,517	2,051	862	4,140	2,770	28,683
1980	1,322	2,769	4,284	1,042	2,037	2,683	61	8,356	2,360	898	4,198	1,267	31,277
1981	1,165	3,086	2,989	416	1,131	2,871	114	10,302	2,555	1,235	5,174	483	31,521
1982	879	3,159	4,493	563	2,217	3,154	214	9,120	3,465	1,087	4,299	484	33,134
1983	638	4,735	6,306	518	1,118	2,180	235	5,747	2,757	883	3,750	604	29,471
1984	964	4,198	5,904	302	1,513	1,248	220	3,916	2,825	980	3,005	453	25,528
1985	523	3,954	5,562	90	1,185	1,837	161	2,617	1,740	635	2,755	440	21,499
1986	573	3,663	5,123	224	974	1,453	196	2,479	1,918	576	2,490	371	20,040
1987	312	2,645	3,504	531	929	1,968	241	3,075	2,175	499	2,670	456	19,005
1988	454	3,966	3,542	160	467	903	444	3,528	3,149	672	3,081	171	20,537
1989	409	3,933	4,184	67	713	1,254	475	2,915	2,167	623	2,937	208	19,885
1990	505	3,668	3,577	268	170	1,933	692	4,201	2,967	849	4,871	203	23,904
1991	355	4,598	5,805	298	751	2,225	619	4,712	3,679	842	3,737	128	27,749
1992	238	4,494	5,711	143	726	1,811	586	4,455	3,574	719	3,517	106	26,080
1993	176	2,778	3,598	68	241	1,387	523	2,768	1,693	310	2,439	45	16,026
1994	132	2,022	2,343	138	82	993	421	2,837	1,412	231	2,367	67	13,045
1995	100	1,387	1,619	112	75	470	507	1,632	959	182	1,706	18	8,767
1996	92	1,552	2,314	157	103	611	442	1,774	1,306	201	1,914	106	10,572
1997	79	2,094	2,430	136	35	694	471	2,013	1,255	231	1,794	6	11,238
1998	96	1,407	1,892	166	22	429	376	1,663	997	244	879	0	8,169
1999	85	776	1,254	63	11	494	404	1,480	762	119	743	0	6,190
2000	113	851	1,268	78	9	358	356	1,420	533	106	662	1	5,755
2001	120	975	1,292	29	9	383	390	1,532	423	72	409	0	5,634
2002*	113	643	1,111	0	51	0	103	279	103	23	146	0	2,572

* January 1 - June 30, 02

Table 2. Nominal catch (t) of 4X cod by month for Canadian Maritimes vessels.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Total[a]	TAC
1968	871	1,107	1,406	2,377	3,121	5,009	4,952	4,116	2,742	3,037	1,328	774	30,840		
1969	1,876	1,694	1,071	1,845	2,160	4,176	3,722	2,797	1,943	1,483	827	518	24,112		
1970	805	500	617	970	2,024	2,745	2,775	2,279	1,969	1,874	921	541	18,020		
1971	526	848	584	814	1,725	3,939	3,328	2,483	2,487	1,902	1,110	555	20,301		
1972	862	633	473	744	1,258	3,832	3,982	2871	2038	2663	925	250	20,531		
1973	1,009	925	514	1,056	1,381	3,919	2,937	2,623	2,264	1,544	818	1,001	19,991		
1974	771	397	399	695	1,335	3,583	3,150	2,538	1,968	1,765	877	1,464	18,942		
1975	648	169	394	712	3,223	3,250	3,355	2,647	1,796	1,457	668	1,267	19,586		
1976	363	555	376	581	1,220	2,824	2,869	2,064	1,968	1,399	782	1,140	16,141		
1977	580	940	861	1,580	2,232	3,782	3,366	2,444	1,740	2,048	1,443	973	21,989		
1978	862	2,042	911	1,371	1,987	3,411	3,379	2,920	2,454	1,473	1,085	1,828	23,723		
1979	889	752	1,973	1,400	1,846	4,276	3,638	3,555	3,218	2,233	2,992	1,935	28,707		
1980	706	2,188	1,704	2,485	3,317	5,316	3,433	3,346	2,603	2,876	1,547	1,756	31,277		
1981	1,649	2,451	2,529	1,533	2,881	4,093	3,845	4,067	2,253	3,119	1,728	1,373	31,521		
1982	757	2,390	2,569	1,491	3,415	5,109	4,734	3,258	3,540	2,890	1,244	1,737	33,134		30,000
1983	1,713	1,654	1,648	1,888	2,743	5,713	4,554	2,832	3,183	1,787	1,037	719	29,471		30,000
1984	1,798	2,021	752	817	1,796	3,471	3,688	4,567	2,773	1,668	1,201	976	25,528		30,000
1985	779	1,699	956	1,268	1,974	2,586	3,199	2,650	2,737	1,801	787	1,063	21,499		30,000
1986	904	1,633	1,775	1,450	1,437	1,939	2,739	1,995	2,576	1,714	771	1,107	20,040		20,000
1987	1,208	1,837	1,242	1,059	1,870	2,778	2,663	1,821	1,679	1,403	910	535	19,005		18,000
1988	2,104	1,531	535	939	1,620	2,931	3,104	2,122	2,524	1,441	636	1,050	20,537		16,000
1989	2,150	2,347	1,362	1,707	1,292	3,562	1,830	1,772	1,535	1,278	637	413	19,885		13,000
1990	2,619	2,027	707	778	1,560	3,104	3,751	3,123	2,598	1,689	1,158	790	23,904		22,000
1991	2,023	2,651	993	1,666	2,322	3,167	3,963	2,881	2,967	2,208	1,650	1,258	27,749		26,000
1992	2,088	1,740	1,297	1,502	1,685	3,622	3,366	2,803	2,625	2,353	1,478	1,521	26,080		26,000
1993	657	903	994	996	1,617	2,312	2,834	2,221	1,804	1,048	562	78	16,026		16,000
1994	734	972	547	847	824	1,771	2,246	1,503	1,267	1,154	726	454	13,045		14,000
1995	610	229	317	827	574	1,236	1,771	774	1,071	521	276	561	8,767		9,000
1996	503	331	446	531	819	1,755	1,805	1,317	880	887	679	619	10,572		11,000
1997	98	362	378	806	644	1,440	1,779	1,382	1,548	1,424	710	668	11,239		13,000
1998	285	348	402	313	511	941	1,272	953	1,125	770	520	729	8,169		9,300
1999*	186	105	124	330	414	1,047	1,269	856	854	445	324	235	6,190	7,210	7,900
2000**	215	255	556	113	368	906	1,104	755	545	507	324	107	5,755	5,868	6,000
2001	360	103	640	314	448	732	867	664	589	466	315	169	5,667	5,908	6,000
2002	374	269	561	623	491	673	829	735	545	345			5,445	4,369	

[a] total landings for quota year; may exceed sums from table where details not yet available for hailed trips with no landing slip

* Quota year Jan 1, 98 - Apr 1, 99

** Quota year for 2000 and later Apr. 1 - Mar. 31

Table 3. Nominal catch of 4X cod by unit area

	4Xm	4Xn	4Xo	4Xp	4Xq	4Xr	4Xs	4Xu	5Y	Shelf	Fundy	Foreign	Total
1968	3,251	2,059	8,159	9,341	1,327	4,785	1,849	4	65	22,810	8,030		
1969	2,413	2,923	7,355	5,523	947	3,686	1,120	59	60	18,214	5,872		
1970	2,851	1,300	6,966	2,310	1,077	2,621	847	23	26	13,427	4,594		
1971	2,750	1,728	9,029	2,157	1,395	2,355	754	13	119	15,664	4,636		
1972	3,124	1,585	8,908	1,421	1,938	2,818	977	7	52	15,038	5,792		
1973	2,130	1,478	10,180	1,228	1,742	2,186	802	179	67	15,016	4,976		
1974	2,243	1,122	9,369	955	1,526	2,839	768	1	120	13,689	5,254		
1975	81	1,374	967	1,033	864	2,867	133	12,180	86	3,455	16,130		
1976	1,973	1,408	8,267	743	1,061	2,034	601	40	16	12,391	3,752		
1977	184	1,706	1,229	1,487	907	2,686	122	13,562	105	4,606	17,382		
1978	2,812	2,864	8,522	3,591	2,286	2,246	676	341	382	17,789	5,931		
1979	6,565	2,750	10,495	1,748	2,325	2,550	1,646	229	379	21,558	7,129		
1980	5,205	3,325	9,899	1,561	3,571	4,684	2,278	47	166	20,023	10,712	541	31,276
1981	4,767	2,114	12,097	1,830	2,413	5,072	2,031	419	599	21,051	10,290	179	31,520
1982	5,255	2,922	10,451	2,079	3,715	4,571	2,009	538	1,349	20,956	11,933	245	33,134
1983	3,437	1,690	8,537	2,497	3,160	3,787	1,674	1,826	2,543	16,891	12,258	320	29,469
1984	2,255	2,251	6,192	1,655	2,244	2,959	1,414	3,583	2,698	14,110	11,141	277	25,528
1985	3,006	1,199	5,438	1,026	1,999	2,301	1,511	3,608	1,364	12,236	9,216	47	21,499
1986	2,914	1,762	4,670	544	1,754	1,802	1,500	4,469	557	11,748	8,224	68	20,040
1987	2,676	1,611	4,777	1,131	1,240	858	1,207	5,116	360	12,783	6,179	29	18,991
1988	1,502	1,086	5,458	1,271	1,124	850	1,103	7,990	142	14,814	5,711	11	20,536
1989	1,370	1,019	5,506	2,820	1,360	1,112	915	5,267	478	13,855	5,994	38	19,887
1990	1,846	764	7,915	1,746	2,238	1,721	1,722	5,404	326	15,551	8,119	222	23,892
1991	2,552	1,584	8,963	2,440	2,763	4,243	2,560	2,246	307	17,275	10,383	91	27,749
1992	1,523	1,818	10,347	1,455	2,919	3,352	1,503	2,876	278	17,556	8,515	9	26,080
1993	1,364	1,646	4,845	1,436	1,959	2,428	1,399	760	189	9,924	6,102	0	16,026
1994	828	561	4,414	1,128	1,662	1,883	892	1,540	137	8,321	4,724	0	13,045
1995	293	696	1,737	1,586	1,306	1,032	510	1,528	79	5,349	3,418	0	8,767
1996	466	813	2,787	1,484	1,608	1,659	930	654	171	6,055	4,517	0	10,572
1997	453	837	2,213	1,327	1,793	2,240	1,070	1,303	183	5,943	5,479	0	11,422
1998	477	907	1,634	1,796	983	1,284	606	331	151	5,064	3,105	0	8,169
1999	397	584	1,548	1,288	956	778	408	111	121	3,817	2,373	0	6,190
2000	291	395	1,433	1,198	1,071	680	413	151	124	3,317	2,439	0	5,756
2001	251	526	1,016	1,387	982	795	440	132	107	3,180	2,456	0	5,636
2002*	81	293	477	1,231	985	729	308	49	125	2,082	2,196	0	4,278

* Jan 1 - Jun 30, 02

Table 4. Number of fishing vessels reporting cod landings annually

Year	Otter trawl	Gill net	Longline	Handline
1996	142	205	528	779
1997	142	197	497	657
1998	129	163	398	422
1999	129	126	357	344
2000	121	101	376	326
2001	113	97	366	201
2002*	108	106	372	156

*as of November, 2002

Table 5. Fishing days by gear type

Year	Gill net	Longline	Handline
1996	4,912	5,210	9,880
1997	6,281	6,179	9,650
1998	4,234	5,483	5,881
1999	3,419	4,263	4,362
2000	2,334	3,915	3,322
2001	2,139	3,887	2,103
2002*	2,147	3,934	1,332

* 2002 effort through November 13; in 2001, 98% of effort was accounted for by this date

Table 6a. Construction of age-length keys for 4X cod in 2001.

	Fundy (4Xqrs5Y)				Shelf (4Xmnop)							
Quarter	Q1	Q2	Q3	Q4	Q1 4Xmno	Q1 4Xp	Q2 4Xmno	Q2 4Xp	Q3 4Xmno	Q3 4Xp	Q4 4Xmno	Q4 4Xp
No. Samples	5	10	7	5	7	5	8	8	5	13	4	2
No. Aged	241	375	257	273	255	238	236	311	210	329	158	158

Table 6b. Construction of 4X cod length frequencies for 2001 and age-length keys against which they are matched.

Gear	Quarter	Area	a	b	Number of samples	Number Measured	Landings (t)	ALK used
OT	1	Fundy	0.008	3.05	4	886	309	Q1_Fundy
GN					2	435	17	Q1_Fundy
LL					0	Q2_F_LL	9	Q1_Fundy
HL					0	0	0	
OT	1	4Xmno			5	1,054	190	Q1_mno
GN					0	Q4_p_GN#	3	Q1_mno
LL					5	1,344	139	Q1_mno
HL					0	0	0	
OT	1	4Xp			6	1,349	409	Q1_p
GN					2	483	23	Q1_p
LL					2	531	5	Q1_p
HL					0	0	0	
OT	2	Fundy	0.008	3.041	12	2,351	490	Q2_Fundy
GN					3	433	76	Q2_Fundy
LL					4	641	158	Q2_Fundy
HL					12	1,547	154	Q2_Fundy
OT	2	4Xmno			0	Q1_mno_OT#	10	Q2_mno
GN					0	Q4_p_GN#	22	Q2_mno
LL					7	808	146	Q2_mno
HL					3	835	105	Q2_mno
OT	2	4Xp			8	1,864	138	Q2_p
GN					12	1,944	127	Q2_p
LL					9	1,201	49	Q2_p
HL					1	317	10	Q2_p
OT	3	Fundy	0.009	3.023	6	1,303	376	Q3_Fundy
GN					4	656	312	Q3_Fundy
LL					2	265	73	Q3_Fundy
HL					0	Q2_F_HL#	44	Q3_Fundy
OT	3	4Xmno			0	Q4_mno_OT#	12	Q3_mno
GN					0	Q4_p_GN#	109	Q3_mno
LL					7	1,475	651	Q3_mno
HL					0	Q2_mno_HL#	69	Q3_mno
OT	3	4Xp			7	1,593	112	Q3_p
GN					0	Q2_p_GN#	18	Q3_p
LL					11	1,447	336	Q3_p
HL					0	Q2_p_HL#	6	Q3_p
OT	4	Fundy	0.006	3.115	5	1,098	273	Q4_Fundy
GN					2	474	33	Q4_Fundy
LL					0	Q3_F_LL#	137	Q4_Fundy
HL					0	Q2_F_HL#	2	Q4_Fundy
OT	4	4Xmno			3	586	18	Q4_mno
GN					0	Q4_p_GN#	24	Q4_mno
LL					7	1,864	356	Q4_mno
HL					0	Q2_mno_HL#	6	Q4_mno
OT	4	4Xp			1	194	89	Q4_p
GN					2	441	7	Q4_p
LL					0	Q3_p_LL#	92	Q4_p
HL					0	Q2_p_HL#	1	Q4_p

LF substituted due to absence of commercial sampling for this gear/area/quarter combination

Table 6c. Construction of age-length keys for 4X cod in 2002.

	Fundy (4Xqrs5Y)		Shelf (4Xmnop)			
Quarter	Q1	Q2	Q1_4Xmno	Q1_4Xp	Q2_4Xmno	Q2_4Xp
No. Samples	3	7	6	4	3	4
No. Aged	120	275	205	184	119	152

Table 6d. Construction of 4X cod length frequencies for 2001 and age-length keys against which they are matched.

Gear	Quarter	Area	a	b	Number of samples	Number Measured	Landings (t)	ALK used
OT	1	Fundy	0.0081	3.0503	8	1,651	459	Q1_Bay
GN					0	Q2_Bay_GN#	34	Q1_Bay
LL					0	Q1_Bay_OT#	7	Q1_Bay
HL					0	0	0	0
OT	1	4Xmno			4	696	71	Q1_mno
GN					0	Q1_p_GN#	3	Q1_mno
LL					7	1,661	141	Q1_mno
HL					0	0	0	Q1_mno
OT	1	4Xp			6	1,372	421	Q1_p
GN					3	755	67	Q1_p
LL					1	247	2	Q1_p
HL					0	0	0	Q1_p
OT	2	Fundy	0.0084	3.0410	11	2,838	773	Q2_Bay
GN					3	491	128	Q2_Bay
LL					0	Q2_Bay_OT#	140	Q2_Bay
HL					2	544	59	Q2_Bay
OT	2	4Xmno			1	253	49	Q2_mno
GN					0	Q2_p_GN#	12	Q2_mno
LL					2	593	65	Q2_mno
HL					4	672	73	Q2_mno
OT	2	4Xp			2	433	145	Q2_p
GN					4	975	279	Q2_p
LL					0	Q1_p_LL#	51	Q2_p
HL					0	Q2_mno_HL#	13	Q2_p

LF substituted due to absence of commercial sampling for this gear/area/quarter combination

Table 7a. Landed numbers of 4X cod at age by gear type for 2001.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13
LL+HL	0.0	85.3	576.9	341.2	162.1	37.3	18.1	7.5	4.3	0.2	0.2	0.0	0.0
OT	0.0	17.1	550.2	200.5	166.3	25.6	12.8	5.3	2.1	0.4	0.0	0.0	0.0
GN	0.0	1.0	74.6	55.4	49.0	10.7	8.5	3.2	3.2	0.3	0.1	0.0	0.0

Table 7b. Landed numbers of 4X cod at age by gear type for January 1 – July 1, 2002.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13
LL+HL	0	5	150	385	59	24	3	1	0	0	0	0	0
OT	0	1	102	374	74	35	6	2	2	4	0	0	0
GN	0	0	5	91	47	39	13	5	3	0	0	0	0

Table 8. 4X cod catch at age.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1980	0.0	837.4	6054.2	2358.3	1741.6	1134.8	441.7	260.8	90.8	59.7	19.0	17.2	5.1	2.5
1981	0.0	817.5	3870.2	4265.0	1843.7	1044.8	586.7	297.3	183.8	75.5	39.2	18.7	18.6	6.2
1982	0.0	904.5	2884.6	4413.8	3060.2	911.5	393.2	278.6	145.7	85.9	41.2	25.5	15.0	0.0
1983	9.1	1031.0	3689.3	2432.6	2057.0	1205.0	458.8	204.1	120.2	75.8	36.1	10.0	10.1	0.0
1984	32.7	916.9	2392.9	3080.7	1929.8	965.1	465.4	176.2	63.1	48.6	29.1	17.9	4.7	0.0
1985	0.0	710.9	1673.7	1569.1	2324.1	1284.2	514.3	193.8	71.0	52.5	18.1	7.3	6.5	0.0
1986	0.0	250.5	2788.9	1940.7	993.5	1008.4	408.8	200.4	93.4	49.5	23.1	20.3	10.1	0.0
1987	0.0	861.0	901.8	2053.0	1087.4	523.4	510.8	236.1	139.9	65.7	33.2	9.1	6.6	0.0
1988	0.0	403.3	3517.0	1659.2	1553.0	656.1	177.6	191.6	84.8	52.5	27.9	5.5	9.3	0.0
1989	17.4	655.4	2560.0	3655.6	632.4	561.5	163.3	79.2	59.7	19.1	9.9	9.9	2.0	0.0
1990	0.0	143.9	2863.3	2805.4	2461.5	496.8	278.6	77.5	39.7	38.2	14.0	15.1	1.3	0.0
1991	1.7	391.2	1535.3	5091.7	1776.9	1364.0	214.9	155.9	31.8	15.6	28.3	14.9	5.7	0.0
1992	0.0	751.4	3391.4	1877.6	3275.7	878.2	513.2	62.7	49.7	15.8	8.5	4.0	0.0	0.0
1993	0.0	880.5	3489.8	2045.3	660.3	671.9	185.9	89.9	13.6	13.8	5.1	0.0	0.3	0.0
1994	0.0	475.3	2280.4	2233.4	887.3	194.9	180.6	41.8	18.3	0.0	1.6	0.0	0.0	0.0
1995	0.0	134.9	2146.0	1081.0	582.0	130.0	28.2	39.9	10.5	5.3	0.0	0.0	0.0	0.0
1996	0.0	50.0	883.0	2594.0	441.0	212.0	29.0	16.0	8.0	2.0	1.0	1.0	0.0	0.0
1997	0.0	59.0	1126.0	1556.0	1193.0	199.0	82.0	16.0	2.0	6.0	1.0	3.0	0.0	0.0
1998	0.0	234.0	886.0	1021.0	615.0	441.0	54.0	20.0	6.0	2.0	3.0	1.0	0.9	0.0
1999	0.5	72.2	834.5	542.6	347.2	264.0	120.3	20.2	7.2	0.5	0.4	0.9	0.0	0.0
2000	0.0	218.2	575.0	905.2	247.1	189.3	66.0	26.6	8.1	1.3	0.7	0.4	0.0	0.0
2001	0.0	85.7	1055.2	562.8	366.7	68.7	38.6	14.9	9.9	0.9	0.2	0.1	0.1	0.0
2002*	0.0	6.2	257.3	850.2	180.0	97.3	22.9	8.3	4.9	1.1	0.0	0.0	0.0	0.0

* January 1 – June 30.

Table 9. Weights at age for cod in 4X by region.

		1	2	3	4	5	6	7	8	9	10	11	12
	1980		0.76	1.23	1.89	2.75	4.20	6.14	6.63	8.93	9.66	10.87	15.41
	1981		0.62	1.06	1.67	2.60	3.30	5.26	6.80	7.93	10.80	11.31	12.36
	1982		0.80	1.17	1.69	2.56	3.91	5.39	7.05	7.79	9.38	10.56	14.84
	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	
	1995		0.86	1.23	1.72	3.26	4.09	4.69	7.23	9.18	13.33	16.33	
	1996		0.75	1.21	2.06	2.96	4.77	5.53	6.39	9.80	12.02	10.12	
	1997		1.17	1.22	1.83	3.31	4.49	6.04	8.83	9.99	11.14	13.58	8.71
	1998		0.86	1.12	1.71	2.54	4.42	4.72	7.33	9.76	9.66	10.83	16.17
	1999		1.00	1.71	2.32	2.83	4.03	5.43	8.26	10.70	13.24	11.35	16.54
	2000		0.93	1.50	2.32	2.85	3.14	4.05	5.57	4.33	6.74	10.25	12.53
	2001		0.99	1.62	2.19	3.65	4.11	5.12	6.62	8.19	8.72	11.05	0.00
	2002*		0.73	1.29	2.60	3.60	5.03	6.56	8.16	9.10	11.75	0.00	0.00
	Mean	0.78	0.89	1.29	1.87	2.69	3.77	5.02	7.14	9.02	11.12	13.16	14.01
	1980		0.77	1.66	2.32	4.44	6.11	7.15	8.92	7.65	15.83	15.65	12.11
	1981		0.81	1.48	2.43	3.57	4.95	7.02	7.94	11.19	10.82	13.60	12.11
	1982		0.80	1.47	2.36	3.64	4.82	6.42	7.57	10.62	9.78	9.35	
	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	
Bay of	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
Fundy	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	
	1988		0.86	1.46	2.24	4.09	5.36	8.99	10.14	8.89	14.69		
	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	
	1995		1.29	1.91	2.78	4.38	6.01	7.76	9.84	12.49	8.57	14.32	
	1996		1.06	1.70	2.85	4.71	6.12	5.97	10.56	11.05			13.19
	1997		1.17	1.73	2.74	4.28	5.77	8.44	10.30	9.18	12.94	11.07	22.55
	1998		1.16	1.99	3.14	4.49	5.91	8.13	9.20	12.75		14.32	
	1999	0.70	1.31	1.88	2.93	4.44	6.06	7.55					14.78
	2000		1.28	2.17	3.49	3.96	5.66	7.80	8.65	11.44	13.67	10.59	11.55
	2001		0.95	2.01	3.46	4.72	6.36	8.15	8.42	11.41	11.88		
	2002*		0.82	1.83	3.36	5.02	6.61	7.13	10.51	10.58	14.27		
	Mean	0.48	1.01	1.72	2.76	4.23	5.84	7.69	9.41	11.26	13.54	13.17	15.85

* January 1 - June 30 2002

Table 10. Summer groundfish RV survey stratified total numbers for cod in Division 4X.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12+
1970	27	938	1,528	2,426	4,217	1,846	2,546	1,059	497	157	138	13	0
1971	21	363	7,079	3,934	676	1,537	707	1,054	119	0	17	0	0
1972	0	327	1,424	3,165	2,537	712	502	202	538	376	164	22	182
1973	23	114	2,197	1,174	2,141	626	253	155	33	170	63	29	26
1974	111	411	1,004	4,524	1,126	1,665	926	119	0	56	35	44	70
1975	0	1,011	2,864	1,612	2,950	2,442	985	760	158	99	0	112	35
1976	0	152	1,277	2,812	2,306	2,051	888	375	220	67	69	13	26
1977	15	251	2,281	4,211	2,541	789	1,323	325	201	38	27	59	12
1978	23	183	1,068	1,712	2,489	1,345	496	362	93	71	0	0	0
1979	0	2,728	3,521	1,814	1,890	1,764	1,019	439	307	59	62	137	0
1980	2,406	205	910	2,864	1,112	1,052	1,379	390	221	186	0	69	0
1981	62	2,269	2,366	2,387	2,496	1,345	835	470	418	98	91	27	7
1982	73	750	1,831	1,828	1,830	1,481	876	243	260	186	49	31	41
1983	208	141	1,085	4,226	2,369	1,480	946	389	0	77	37	0	6
1984	0	820	5,746	3,390	2,362	1,820	688	482	63	58	25	0	0
1985	69	495	8,760	4,331	1,527	1,451	766	483	267	165	13	0	26
1986	25	768	1,333	2,920	1,226	314	549	448	217	97	19	0	51
1987	6	392	2,348	618	1,180	528	260	245	304	75	40	63	0
1988	260	2,630	3,926	9,246	1,496	1,548	496	210	244	91	38	13	0
1989	309	794	6,089	3,420	2,549	420	489	108	27	82	37	14	0
1990	28	515	873	5,523	2,463	2,321	240	414	80	42	0	21	27
1991	34	614	1,727	1,131	3,086	1,094	751	128	116	19	21	12	0
1992	35	252	2,731	1,569	681	1,710	471	460	124	85	0	0	0
1993	14	369	955	2,518	925	129	265	52	61	0	6	41	0
1994	748	1,258	3,313	2,739	1,605	449	36	195	88	70	0	32	65
1995	1,212	122	847	4,779	1,477	598	274	94	91	34	42	7	0
1996	31	339	839	2,048	5,527	880	753	148	0	56	15	0	0
1997	95	349	569	1,189	1,444	2,462	321	194	100	0	57	0	0
1998	65	211	1,929	1,808	1,418	1,022	1,371	225	116	6	0	0	0
1999	869	382	787	1,291	882	850	194	297	46	0	0	0	0
2000	3,324	432	1,497	830	999	409	325	157	148	0	0	0	21
2001	2,170	150	1,018	2,891	951	646	44	60	0	31	0	0	0
2002	110	5,196	1,990	2,565	2,475	496	302	12	19	98	0	0	0

Table 11. Summer groundfish RV survey indices for cod in 4X.

RV index	2*	3	4	5	6	7	8
1983	223	4226	2369	1480	946	389	0
1984	1385	3390	2362	1820	688	482	63
1985	1139	4331	1527	1451	766	483	267
1986	258	2920	1226	314	549	448	217
1987	1158	618	1180	528	260	245	304
1988	564	6000	4000	1548	496	210	244
1989	1073	3420	2549	420	489	108	27
1990	110	5523	2463	2321	240	414	80
1991	390	1131	3086	1094	751	128	116
1992	874	1569	681	1710	471	460	124
1993	350	2518	925	129	265	52	61
1994	711	2739	1605	449	36	195	88
1995	350	4779	1477	598	274	94	91
1996	323	2048	5527	880	753	148	0
1997	211	1189	1444	2462	321	194	100
1998	456	1808	1418	1022	1371	225	116
1999	280	1291	882	850	194	297	46
2000	554	830	999	409	325	157	148
2001	508	2891	951	646	44	60	0
2002	1557	2565	2475	496	302	12	19

* Includes catches only from strata where depth<100fm (Clark et al 2002)

Table 12. TQ Survey catch at age for cod in Division 4X; ages 2-8 used as indices for SPA.

	0	1	2	3	4	5	6	7	8	9	10	11
1996	1	302	662	835	737	84	31	6	0	2	0	1
1997	1	225	232	727	393	265	17	24	6	2	1	0
1998	16	179	857	619	276	112	112	15	7	0	0	0
1999	8750	601	700	708	170	98	15	24	5	1	0	0
2000	5	1063	1039	351	234	62	61	15	13	0	0	0
2001	907	234	2369	3391	382	142	5	21	5	6	0	0
2002	37	380	551	510	343	63	35	21	2	4	0	0

Table 13. Statistical properties of estimates for mid-year of 2002 (except where beginning of year is indicated) population abundance (numbers in 000's) and survey calibration constants (unitless, survey:population) for cod in NAFO Division 4X obtained from a bootstrap with 1000 replications.

Age(Year)	Estimate	Standard Error	Relative Error	Bias	Relative Bias
		Population Abundance (000's)			
2	10450	4441	0.425	762	0.073
3	6157	1804	0.293	333	0.054
4	4518	1189	0.263	196	0.043
5	941	265	0.281	27	0.029
6	719	196	0.273	23	0.032
7	97	29	0.304	4	0.038
8	147	40	0.272	5	0.034
9	152	51	0.335	9	0.062
10	390	105	0.269	13	0.033
11	101	31	0.309	5	0.045
12	130	35	0.273	4	0.029
13	62	19	0.309	3	0.048
14(2001)	48	27	0.564	4	0.086
14(2000)	26	17	0.683	3	0.127
14(1999)	38	30	0.803	6	0.160
14(1998)	38	23	0.604	4	0.111
		Survey Calibration Constants			
DFO Survey					
2	0.059	0.007	0.117	0.000	-0.005
3	0.395	0.048	0.121	0.002	0.005
4 - 8	0.485	0.036	0.074	-0.001	-0.002
ITQ Survey					
2	0.132	0.028	0.212	0.003	0.021
3	0.208	0.041	0.199	0.001	0.007
4	0.152	0.030	0.199	0.002	0.013
5	0.111	0.024	0.215	0.002	0.018
6	0.052	0.012	0.229	0.001	0.023
7	0.059	0.014	0.235	0.001	0.025
8	0.022	0.006	0.271	0.001	0.032

Table 14. Population abundance (numbers in 000's) for cod in NAFO Division 4X from a virtual population analysis using the bootstrap bias adjusted population abundance.

Year	Age Group															
	1	2	3	4	5	6	7	8	9	10	11	12	13	1+	3+	4+
1983	13846	11340	16351	9262	5434	2729	1068	517	296	181	94	29	25	61174	35987	19636
1984	17280	11328	8355	10070	5398	2607	1158	465	241	135	81	44	15	57177	28568	20213
1985	9737	14118	8447	4692	5481	2691	1270	531	223	141	67	40	20	47459	23603	15156
1986	27125	7972	10918	5410	2435	2409	1057	580	261	119	68	39	26	58418	23322	12404
1987	18474	22208	6301	6433	2691	1105	1071	499	295	130	53	35	14	59309	18627	12326
1988	27138	15125	17404	4346	3426	1230	437	421	198	117	48	14	20	69926	27662	10258
1989	9035	22219	12020	11082	2073	1417	423	199	173	86	49	15	6	58798	27544	15524
1990	13586	7382	17600	7538	5792	1130	658	200	92	88	54	31	3	54154	33187	15587
1991	14887	11123	5914	11831	3660	2539	481	290	94	40	38	31	12	50940	24930	19017
1992	9847	12187	8754	3462	5135	1411	863	202	98	49	19	6	12	42045	20011	11258
1993	16689	8062	9300	4131	1163	1301	376	250	109	36	26	8	2	41451	16701	7401
1994	8120	13663	5807	4489	1558	365	466	142	124	77	17	17	6	34851	13068	7261
1995	6161	6648	10758	2713	1683	486	125	220	79	85	63	13	14	29047	16238	5481
1996	3831	5044	5321	6877	1254	856	282	77	144	55	65	51	10	23868	14993	9672
1997	6753	3137	4085	3562	3308	631	511	204	49	111	43	52	41	22486	12596	8512
1998	4833	5529	2515	2333	1525	1639	338	344	153	38	85	34	40	19407	9046	6531
1999	12357	3957	4315	1265	998	698	946	228	264	120	29	67	27	25272	8958	4643
2000	10121	10117	3174	2782	551	506	335	666	169	210	98	24	54	28805	8568	5394
2001	13089	8286	8086	2081	1466	230	244	215	521	131	170	79	19	34619	13244	5158
2002	11052	10716	6707	5669	1199	871	127	165	163	418	106	139	65	37397	15629	8922
2002.5	10500	9688	5824	4322	914	695	93	142	143	377	96	126	59	32479	12791	6967

Table 15. Beginning of year biomass (tonnes in 000's) for cod in NAFO Division 4X from a virtual population analysis using the bootstrap bias adjusted population abundance.

Year	Age Group															
	1	2	3	4	5	6	7	8	9	10	11	12	13	1+	3+	4+
1983	1509	6062	17797	14736	12132	9309	5230	3526	2711	1963	1100	389	370	76833	69261	51464
1984	1884	6056	10243	17635	12779	8543	5351	3030	2043	1420	948	590	222	70742	62802	52559
1985	1061	7547	9424	7927	12301	8132	5389	3145	1670	1266	784	536	296	59477	50869	41446
1986	2957	4262	11410	8625	5508	7929	4743	3623	2216	1113	796	523	385	54087	46869	35459
1987	2014	11872	7488	11664	7178	3903	5058	3354	2510	1367	620	469	207	57703	43818	36329
1988	2958	8085	20116	7004	7858	4137	2025	2804	1800	1235	562	188	296	59067	48023	27908
1989	985	11877	14965	21324	5221	4803	1902	1336	1593	940	573	201	89	65808	52946	37982
1990	1481	3946	21263	14146	15879	4016	3124	1357	827	988	632	415	44	68119	62692	41429
1991	1623	5946	6608	20017	8727	8382	2243	1892	771	396	445	415	178	57643	50074	43466
1992	1073	6515	10028	5593	12712	5006	3887	1178	804	485	222	80	178	47761	40173	30145
1993	1819	4310	9300	7023	2908	4554	1805	1625	894	356	304	107	30	35033	28905	19605
1994	885	7304	5807	7631	3895	1278	2237	923	1017	762	199	228	89	32254	24065	18258
1995	672	3554	10758	4612	4208	1701	600	1430	648	842	737	174	207	30142	25916	15158
1996	418	2696	5321	11691	3135	2996	1354	501	1181	545	761	683	148	31428	28314	22993
1997	736	1677	4085	6055	8270	2209	2453	1326	402	1099	503	697	607	30118	27705	23620
1998	527	2956	2515	3966	3813	5737	1622	2236	1255	376	995	456	592	27044	23561	21046
1999	1347	2115	4315	2151	2495	2443	4541	1482	2165	1188	339	898	400	25878	22416	18101
2000	1103	5408	3174	4729	1600	1977	1671	4386	1387	2012	1045	291	771	29555	23043	19869
2001	1427	4429	8086	3538	4256	898	1217	1416	4277	1255	1812	958	271	33842	27986	19900
2002	1205	5728	6707	9637	3481	3403	633	1087	1338	4006	1130	1686	928	40969	34036	27329

Table 16. Fishing mortality rate for cod in NAFO Division 4X from a virtual population analysis using the bootstrap bias adjusted population abundance. The rate for ages 4-5 is a simple average and is also shown as exploitation rate (%).

Year	Age Group														
	1	2	3	4	5	6	7	8	9	10	11	12	13	4-5	4-5 %
1983	0.001	0.106	0.285	0.340	0.534	0.658	0.633	0.564	0.585	0.610	0.547	0.478	0.582	0.437	32
1984	0.002	0.093	0.377	0.408	0.496	0.519	0.579	0.536	0.339	0.500	0.502	0.580	0.430	0.452	33
1985	0.000	0.057	0.246	0.456	0.622	0.734	0.584	0.509	0.430	0.525	0.351	0.224	0.430	0.539	38
1986	0.000	0.035	0.329	0.498	0.590	0.611	0.550	0.475	0.496	0.609	0.465	0.846	0.547	0.544	38
1987	0.000	0.030	0.171	0.430	0.582	0.726	0.734	0.724	0.727	0.796	1.142	0.336	0.761	0.506	36
1988	0.000	0.030	0.237	0.539	0.682	0.866	0.586	0.687	0.629	0.673	0.992	0.572	0.687	0.611	42
1989	0.002	0.033	0.266	0.434	0.404	0.567	0.545	0.569	0.473	0.277	0.252	1.317	0.426	0.419	31
1990	0.000	0.022	0.197	0.522	0.609	0.642	0.619	0.540	0.631	0.638	0.335	0.751	0.588	0.566	40
1991	0.000	0.040	0.335	0.634	0.752	0.858	0.629	0.873	0.438	0.546	1.584	0.714	0.714	0.693	46
1992	0.000	0.070	0.551	0.891	1.168	1.109	0.974	0.348	0.771	0.391	0.647	1.074	0.000	1.030	59
1993	0.000	0.128	0.528	0.773	0.957	0.807	0.726	0.396	0.099	0.476	0.194	0.000	0.194	0.865	53
1994	0.000	0.039	0.560	0.777	0.952	0.863	0.506	0.319	0.084	0.000	0.083	0.000	0.000	0.865	53
1995	0.000	0.023	0.247	0.569	0.469	0.334	0.279	0.184	0.097	0.000	0.000	0.000	0.000	0.519	37
1996	0.000	0.011	0.201	0.529	0.480	0.308	0.113	0.250	0.047	0.000	0.000	0.012	0.000	0.504	36
1997	0.000	0.021	0.360	0.646	0.495	0.411	0.185	0.084	0.044	0.043	0.000	0.000	0.000	0.570	40
1998	0.000	0.047	0.486	0.647	0.574	0.339	0.183	0.062	0.041	0.057	0.025	0.000	0.000	0.611	42
1999	0.000	0.020	0.237	0.629	0.475	0.516	0.143	0.095	0.028	0.004	0.015	0.009	0.000	0.552	39
2000	0.000	0.023	0.217	0.432	0.663	0.513	0.227	0.042	0.050	0.006	0.007	0.016	0.000	0.547	39
2001	0.000	0.011	0.149	0.338	0.308	0.381	0.181	0.072	0.020	0.007	0.001	0.000	0.004	0.323	25
2002	0.000	0.002	0.076	0.324	0.321	0.234	0.391	0.102	0.058	0.005	0.000	0.000	0.000	0.322	25

Table 17. Deterministic projection results for cod in NAFO Division 4X for 2003 using the bootstrap bias adjusted population abundance.

Year	Age Group																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1+	3+	4+
Population Numbers (000s)																	
2003.25	11000	9200	8251	4461	3010	636	495	72	114	119	318	83	108	51			
2004.25	11000	9200	7400	5994	2939	1983	428	363	55	91	95	260	68	89			
Partial Recruitment to the Fishery[1]																	
	0.00	0.05	0.50	1.00	1.00	0.90	0.50	0.30	0.15	0.10	0.00	0.00	0.00	0.00			
Fishing Mortality																	
2002.50	0.000	0.014	0.155	0.282	0.282	0.254	0.141	0.085	0.042	0.028	0.000	0.000	0.000	0.000			
2003.25	0.000	0.011	0.120	0.217	0.217	0.196	0.109	0.065	0.033	0.022	0.000	0.000	0.000	0.000			
Weight at beginning of year for population (kg)[2]																	
	0.11	0.53	1.00	1.70	2.90	3.91	4.99	6.59	8.21	9.58	10.66	12.13	14.28	16.20			
Beginning of Year Projected Population Biomass (t)																	
2003.25	1199	4918	8251	7584	8739	2485	2469	474	936	1140	3390	1007	1543	826	44961	38844	30593
2004.25	1199	4918	8251	10190	8533	7746	2135	2390	452	872	1013	3153	971	1442	53266	47149	38898
Projected Catch Numbers (000s)																	
2002.50	0	95	596	768	162	112	9	8	4	7	0	0	0	0			
2003.25	0	84	844	793	535	103	46	4	3	2	0	0	0	0			
Average weight at age for catch (kg)[3]																	
	0.55	1.10	1.65	2.40	3.40	4.40	5.50	7.60	8.80	10.50	12.00	14.00	15.50	16.50			
Projected Yield (t)																	
2002.50	0	104	983	1844	552	494	48	62	36	77	0	0	0	0	4200	4096	3113
2003.25	0	93	1393	1903	1819	452	254	31	29	24	0	0	0	0	6000	5907	4514

[1]smoothed average of 1993 – 2001.
[2]smoothed average from fishery adjusted to beginning of year, ages 1 and 2 from DFO survey.
[3]smoothed average of 1997-2001 from fishery.

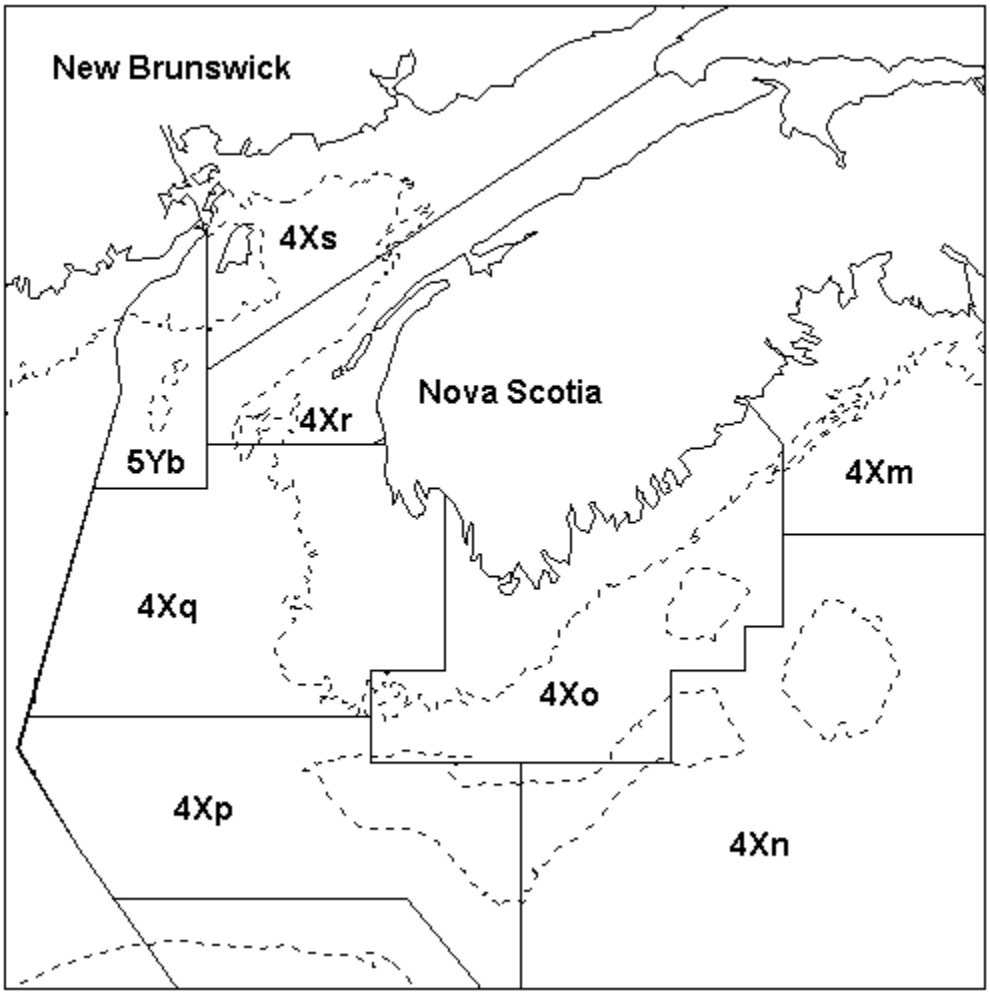

Fig. 1. Canadian statistical unit areas in NAFO divisions 4X and 5Y

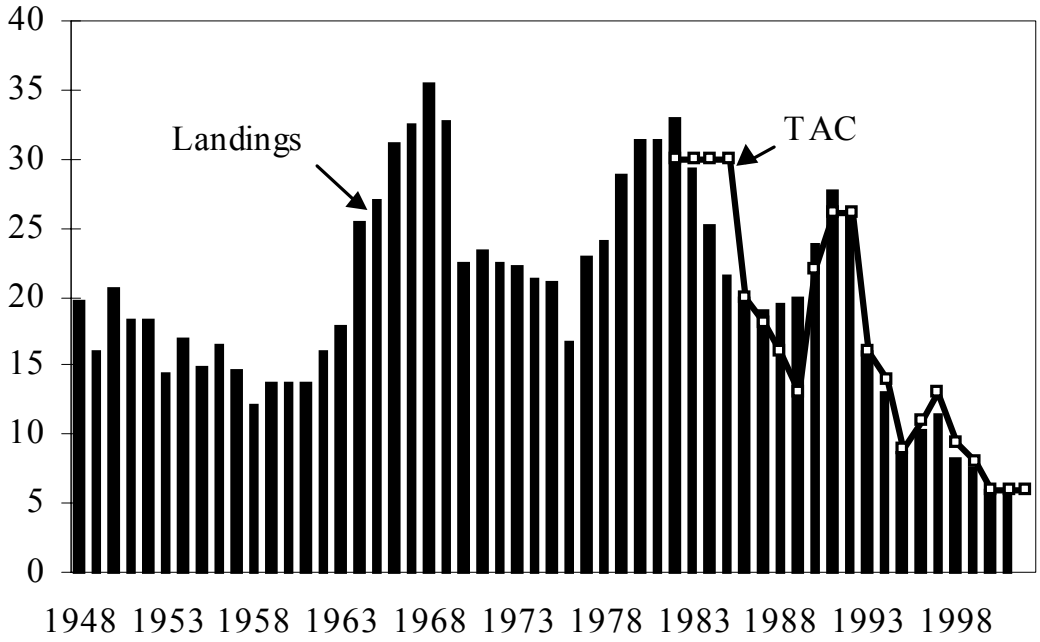

Fig. 2. Nominal landings of cod in Division 4X including Canadian landings from Div. 5Y.

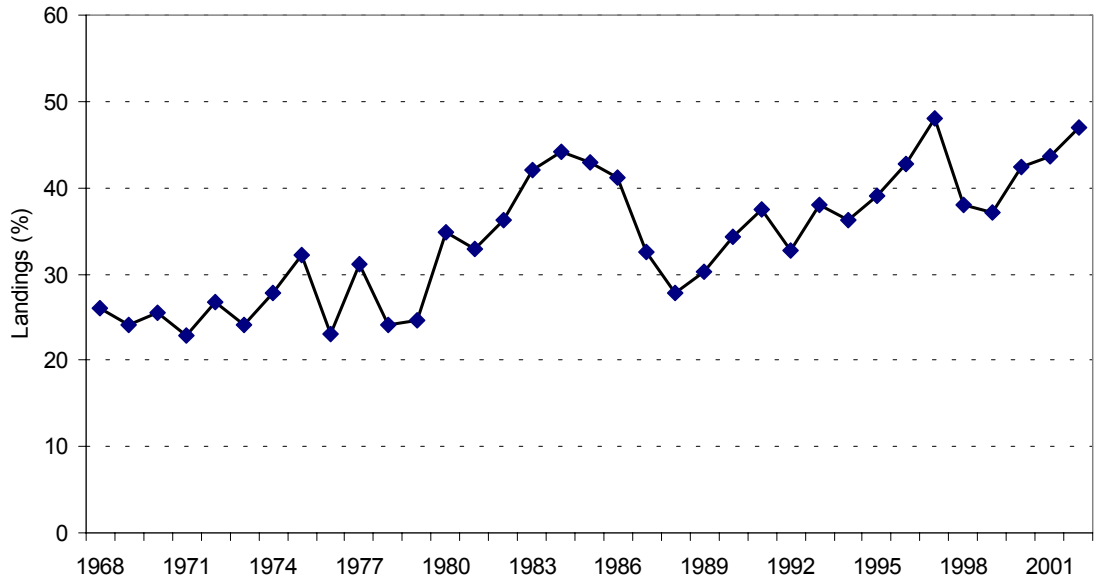

Fig. 3. Proportion of 4X cod landings taken from the Fundy region (4Xqrs5Yb).

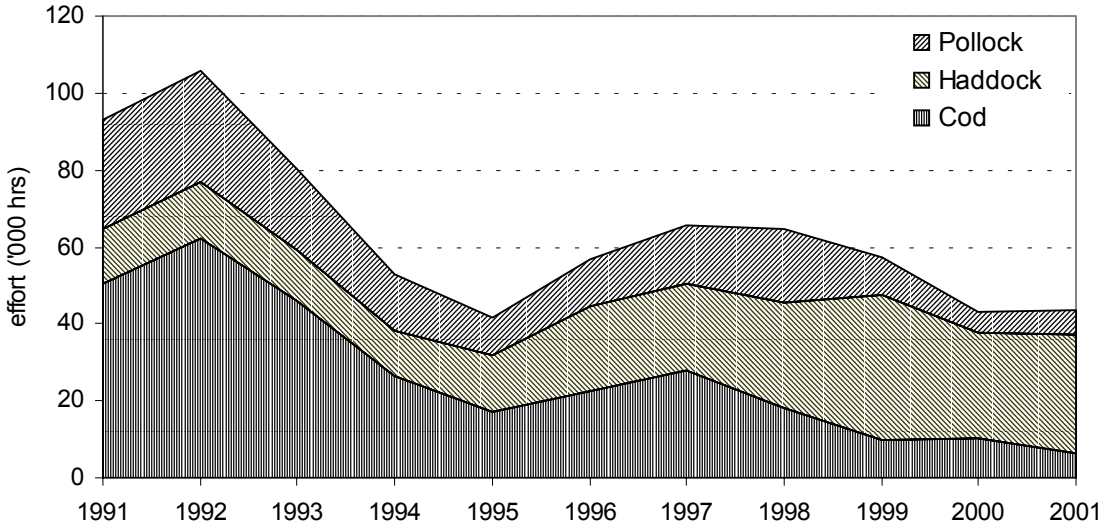

Fig. 4. Fishing effort in 4X for the small dragger (TC 1-3) fleet where the main species was cod, haddock or pollock.

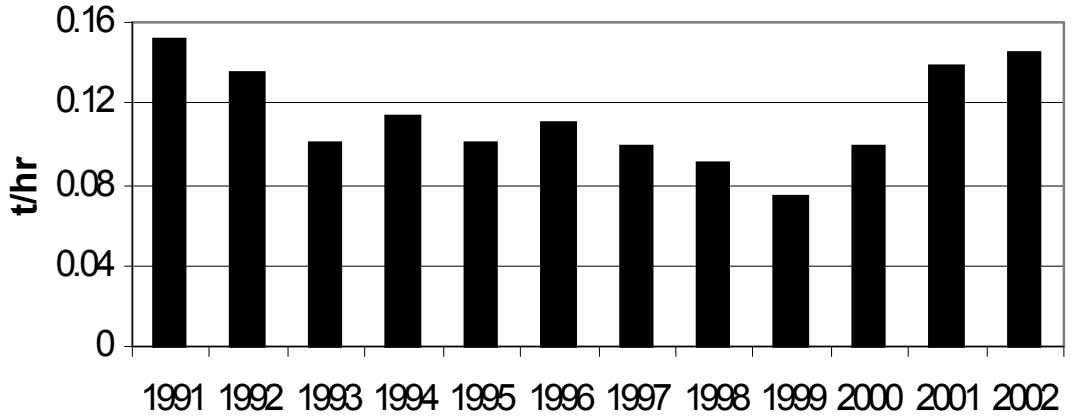

Fig. 5. Catch rates (tonnes/hour) for cod in trips where cod was the main species by TC 1-3 draggers in 4X.

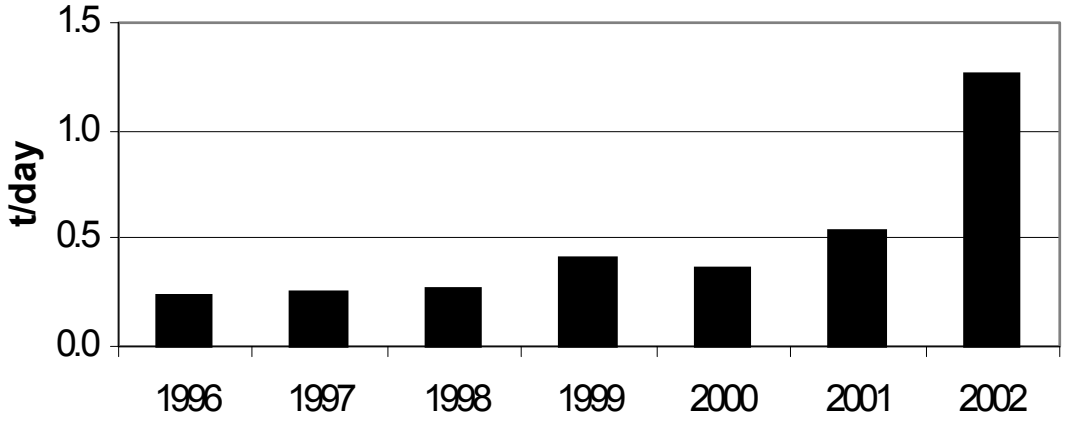

Fig. 6. Catch rates (tonnes/day) for cod in trips where cod was the main species by TC 2-3 gillnetters in 4X.

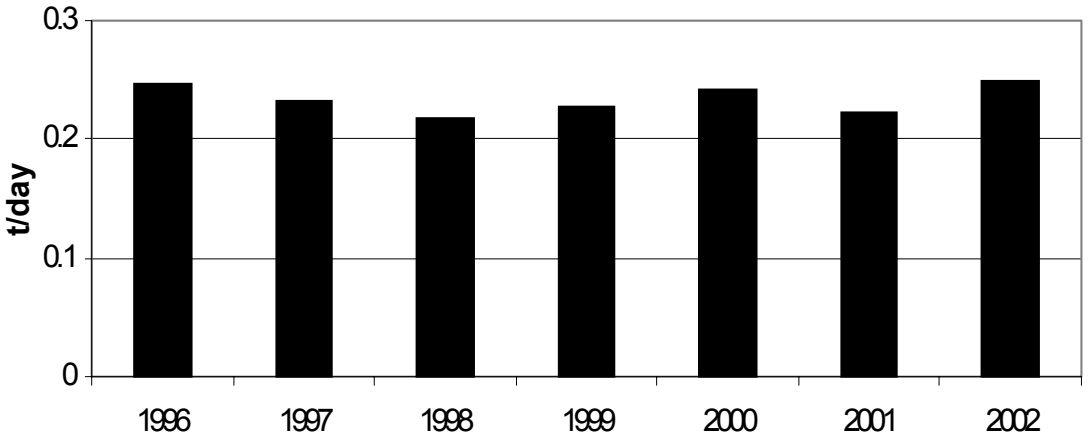

Fig. 7a. Catch rates (tonnes/day) for cod in trips where cod was the main species by handliners in 4X.

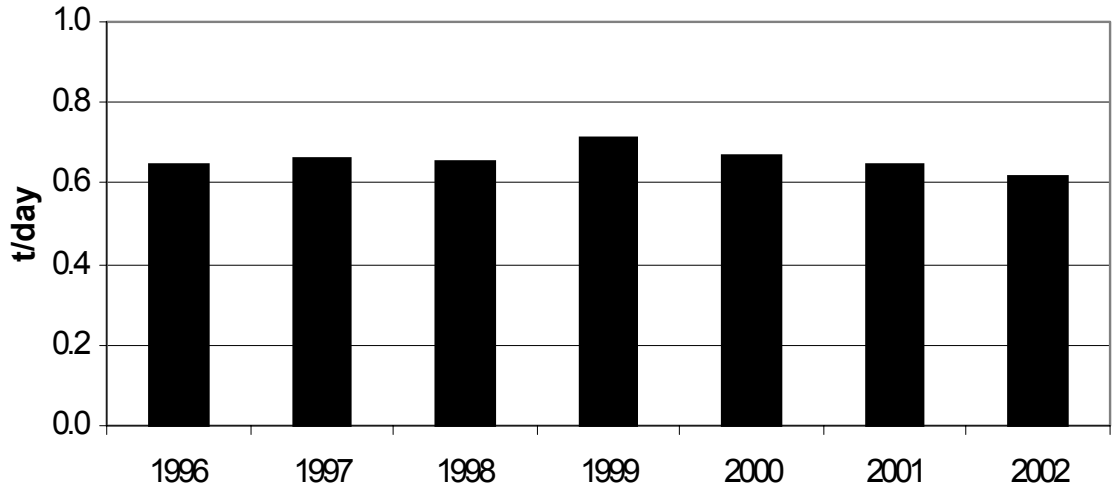

Fig. 7b. Catch rates (tonnes/day) for cod in trips where cod was the main species by TC 1 longliners in 4X.

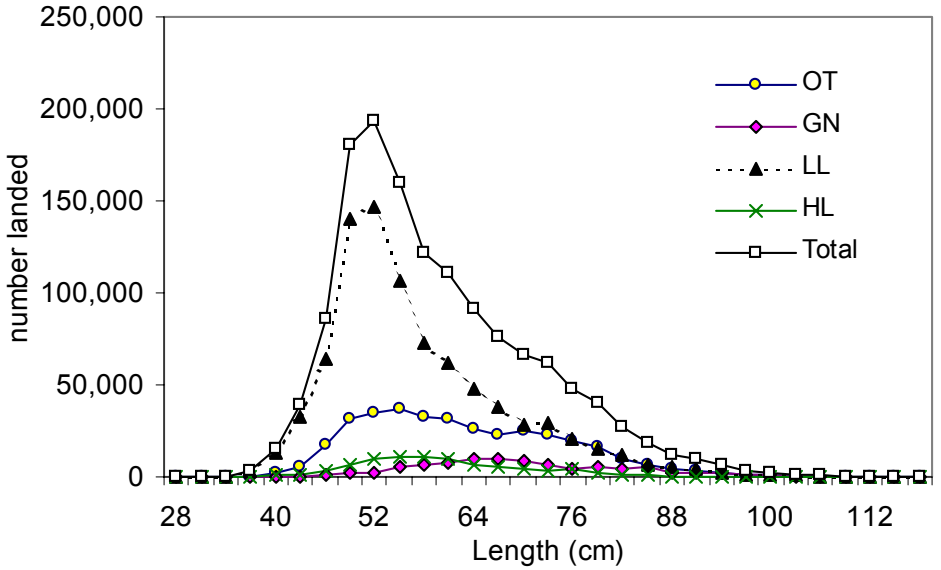

Fig. 8a. Length frequencies for 4X cod in Scotian Shelf commercial fishery for 2001.

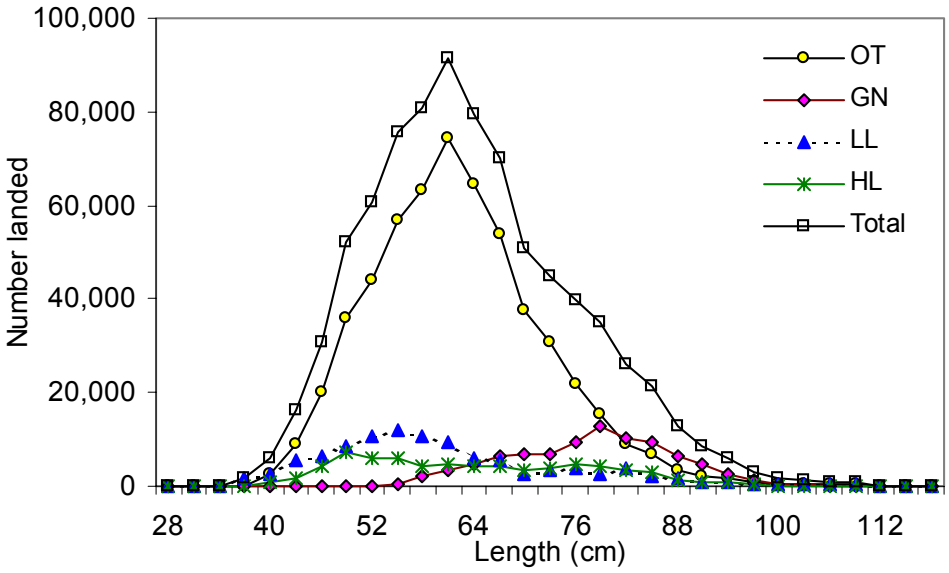

Fig. 8b. Length frequencies for 4X cod in Bay of Fundy commercial fishery for 2001.

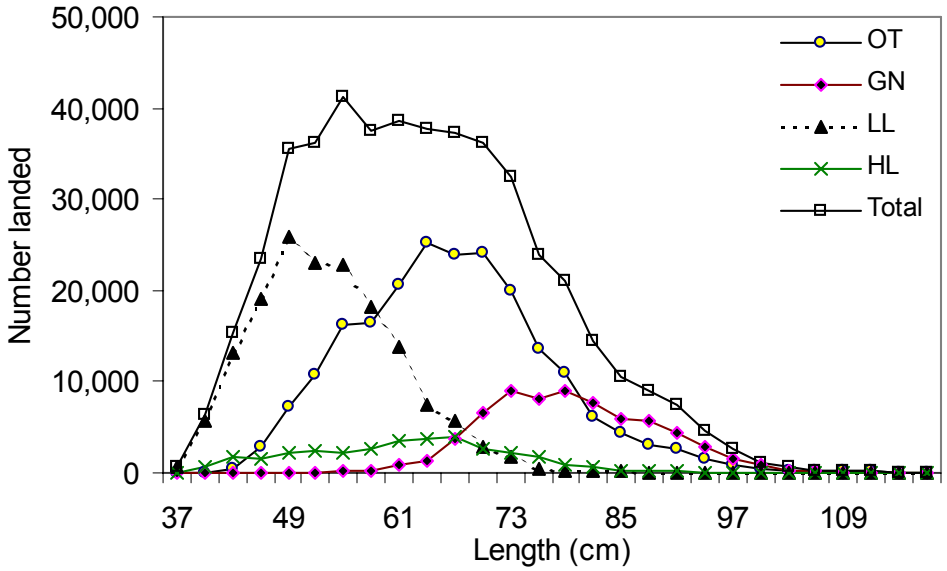

Fig. 9a. Length frequencies for 4X cod in Scotian Shelf commercial fishery for January-July, 2002.

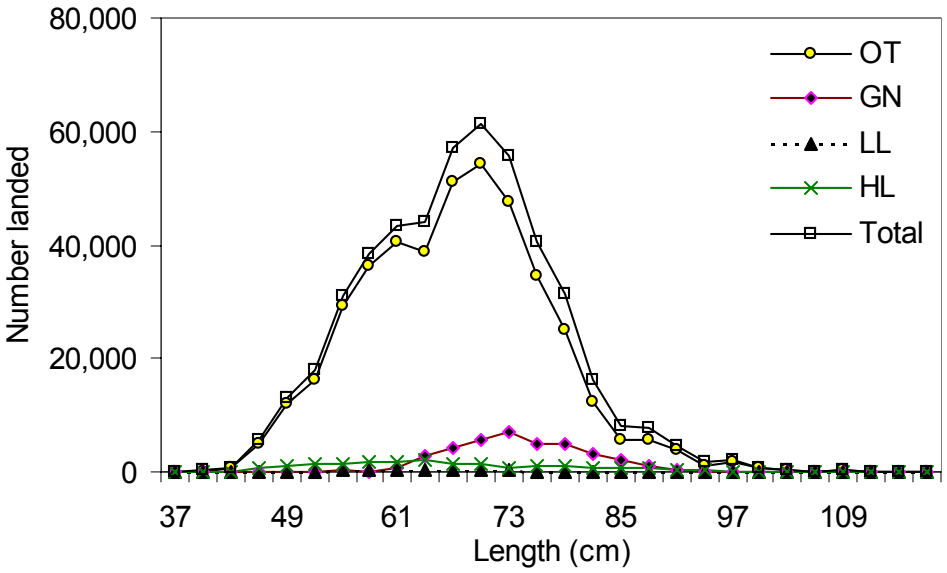

Fig. 9a. Length frequencies for 4X cod in Fundy region commercial fishery for January-July, 2002.

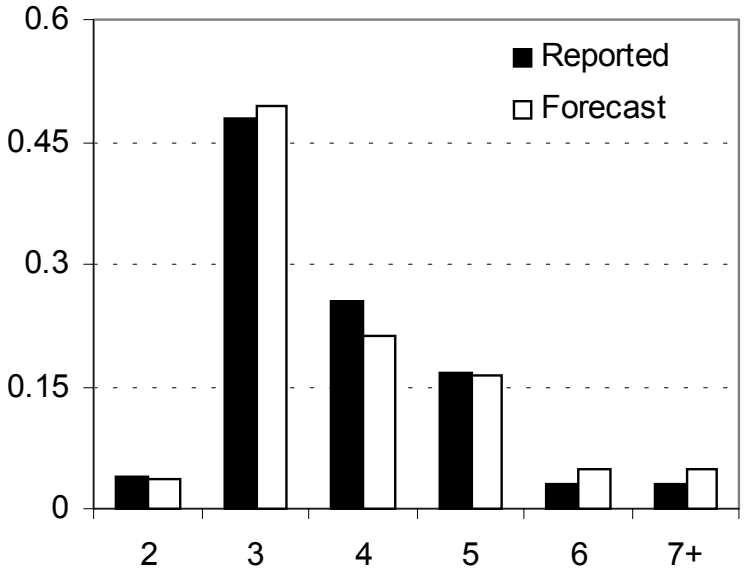

Fig. 10. Reported and forecast age composition for landings (numbger of fish) of cod in 4X for 2001.

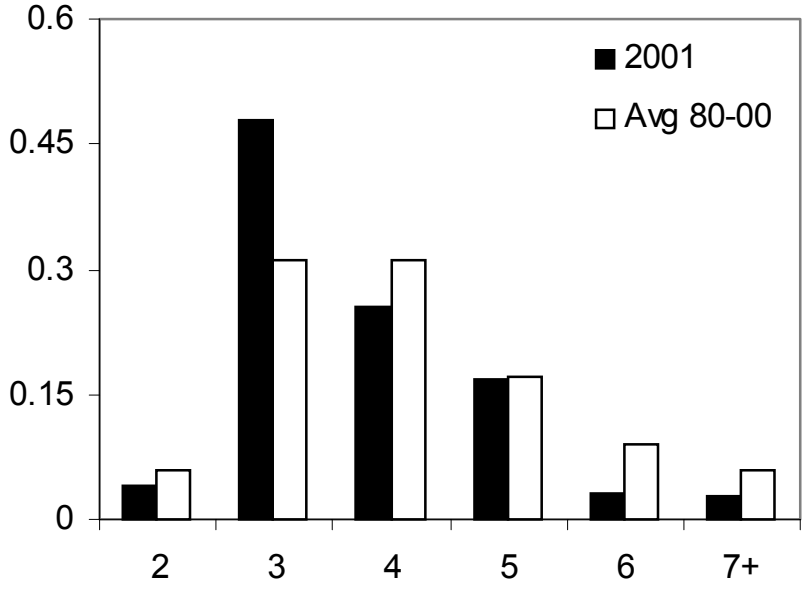

Fig. 11. Age composition for landings of 4X cod (numbger of fish) for 2001 compared to the average.

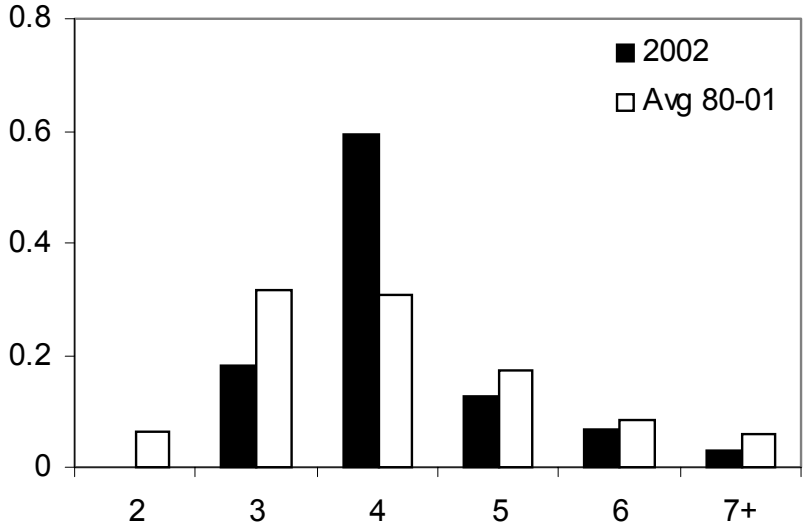

Fig. 12. Age composition for landings of 4X cod (numbger of fish) for January-July, 2002 compared to the average.

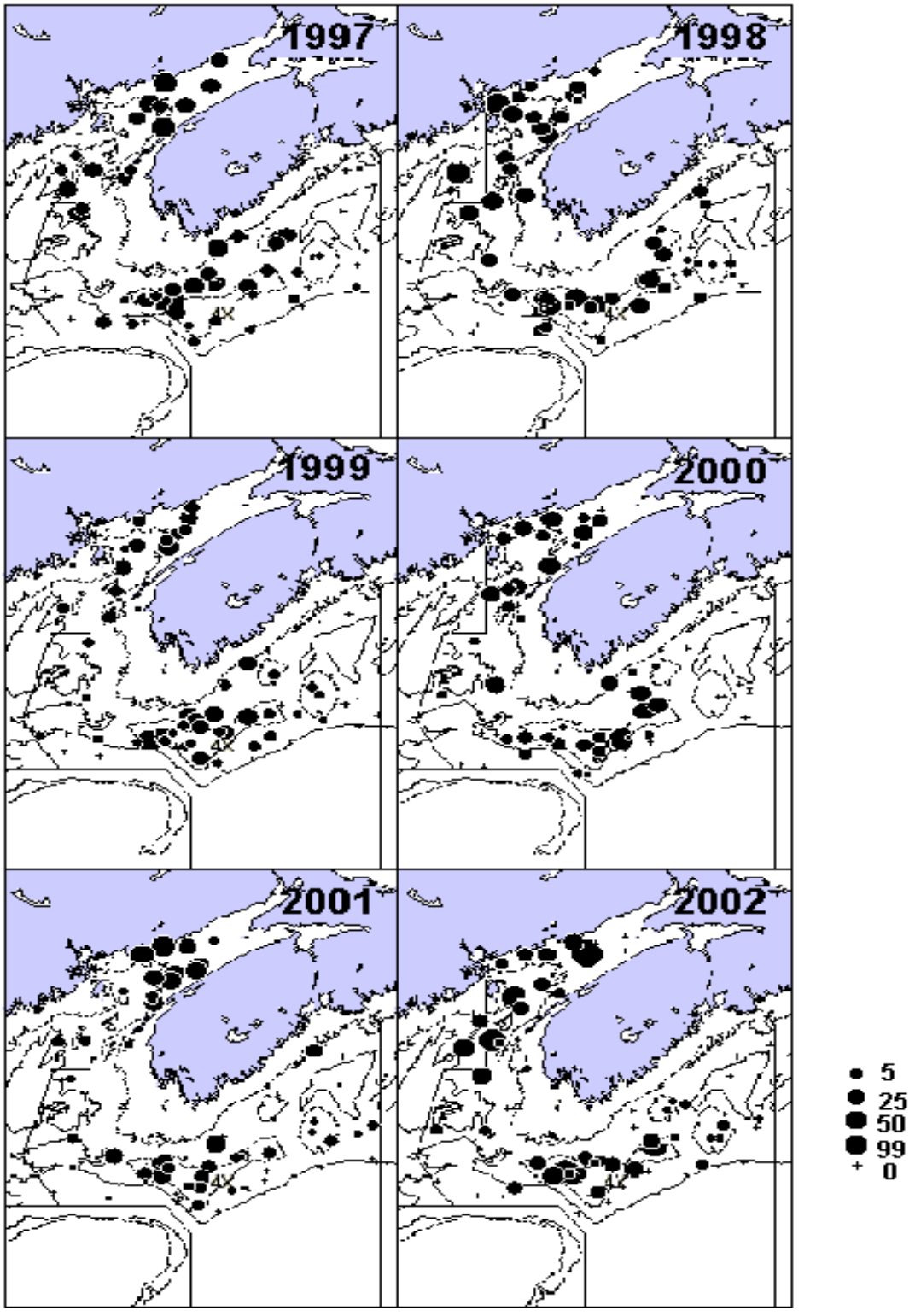

Fig. 13. Summer RV groundfish survey 4X cod catches (Kg).

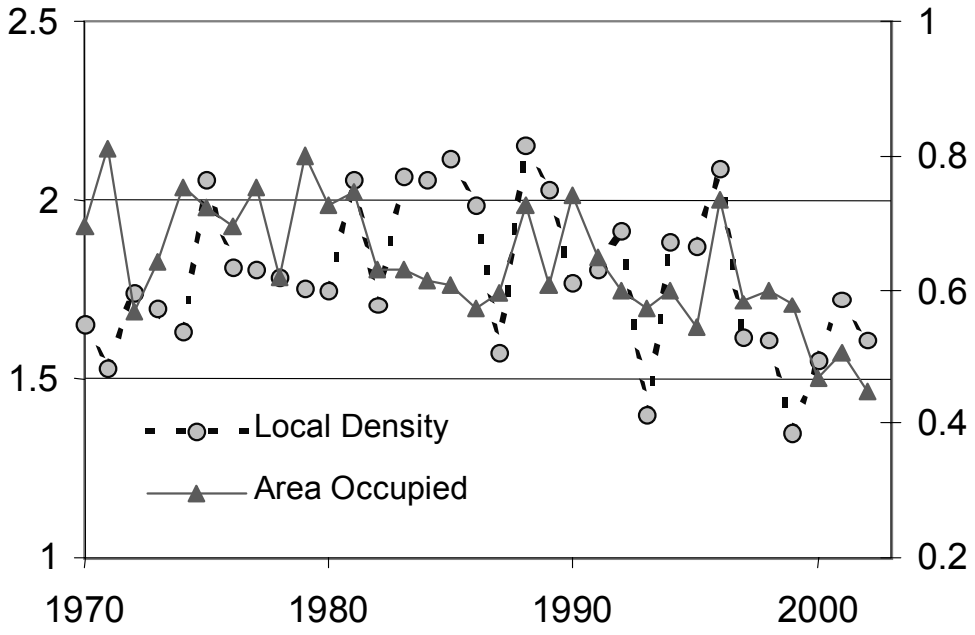

Fig. 14. Area occupied and local density for 4X cod in the summer RV surveys.

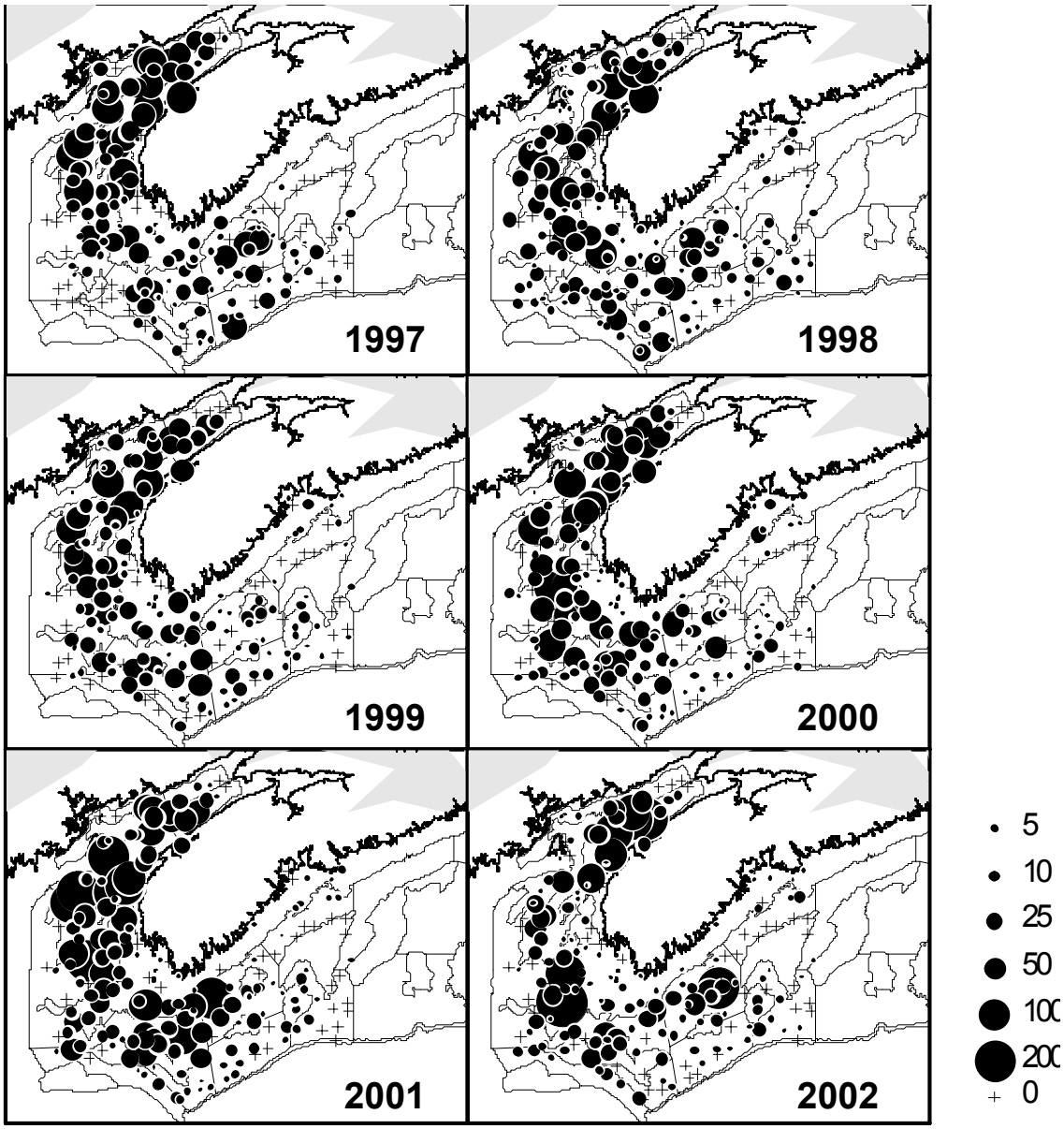

Fig 15. Summer ITQ survey 4X cod catches (Kg).

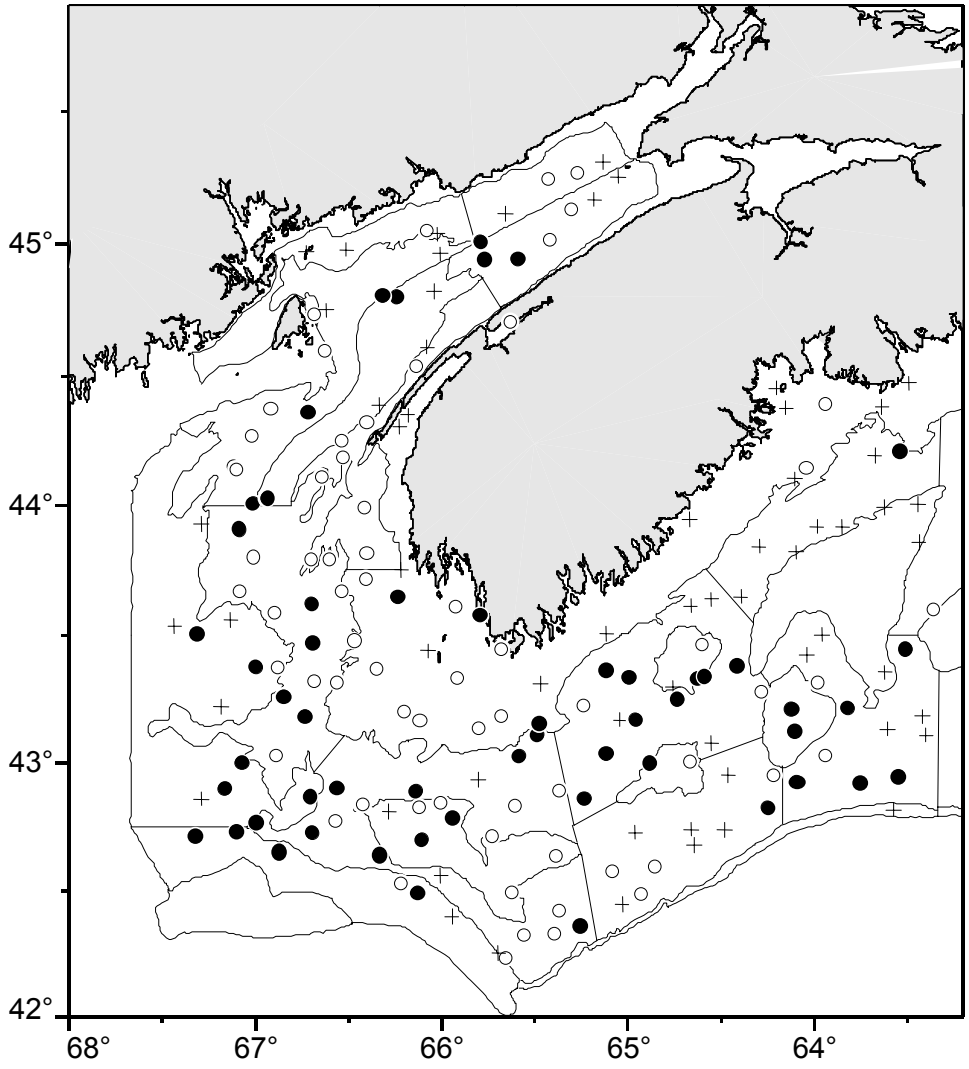

Fig. 16. A comparison of ITQ survey cod catches for 2002 with the median value for each station since 1996. • 2002 value>median; + 2002 value is within 1 of the median; o 2002 value<median.

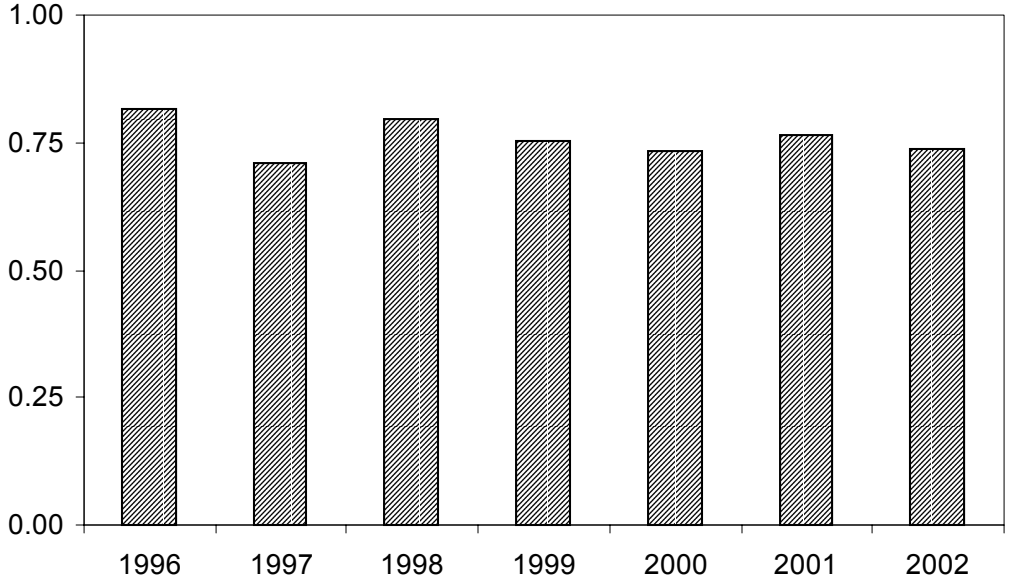

Fig. 17. Proportion of sets from the ITQ survey where cod are caught annually.

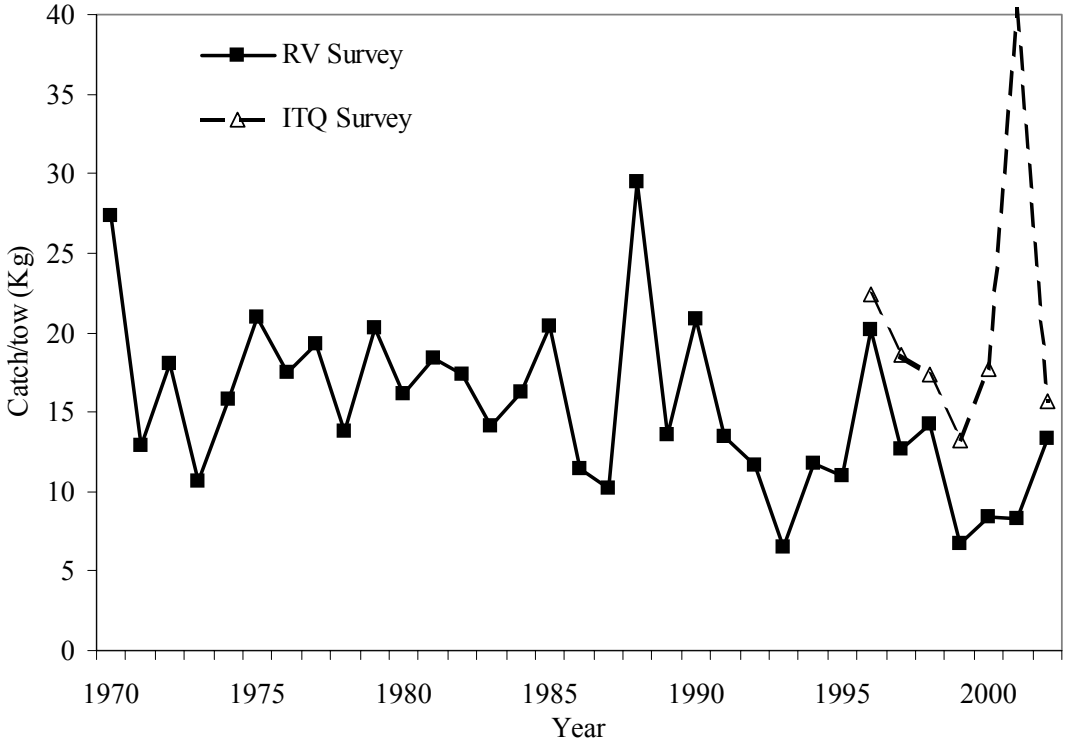

Fig. 18. Stratified mean weight/tow for 4X cod from the RV and ITQ surveys.

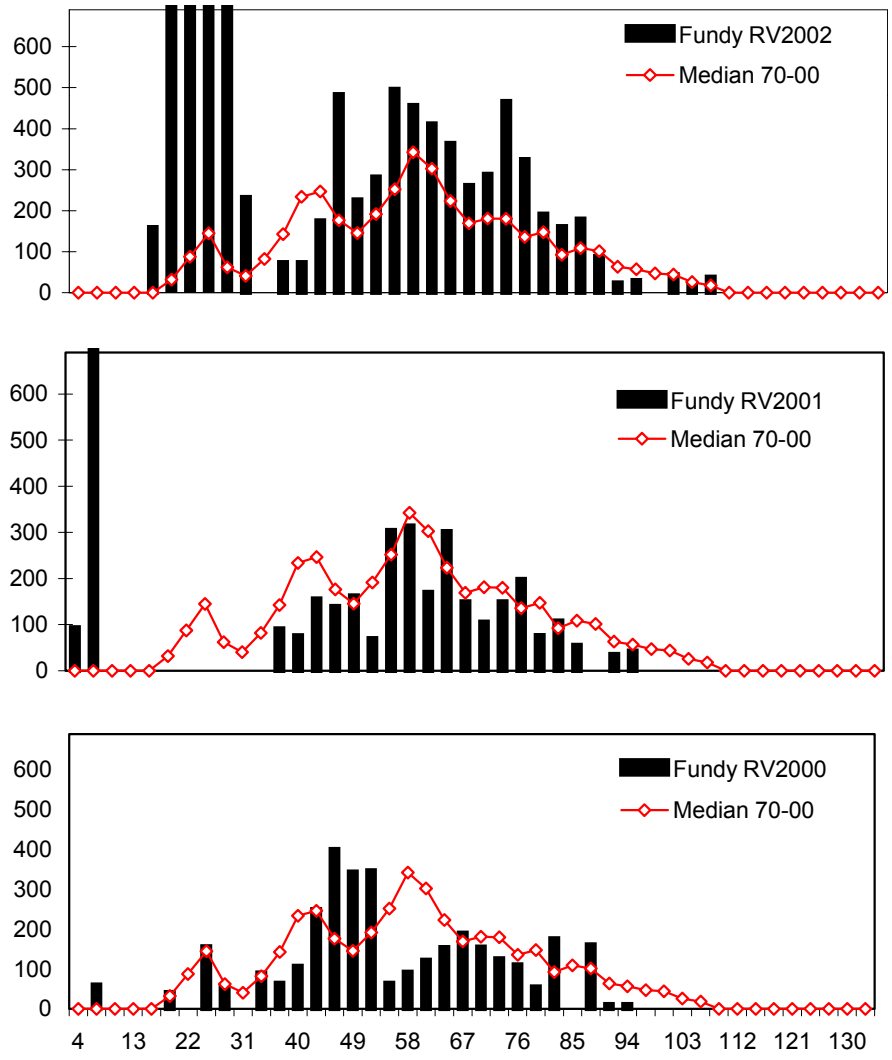

Fig. 19. Fundy length frequencies from summer RV surveys compared to the long-term median.

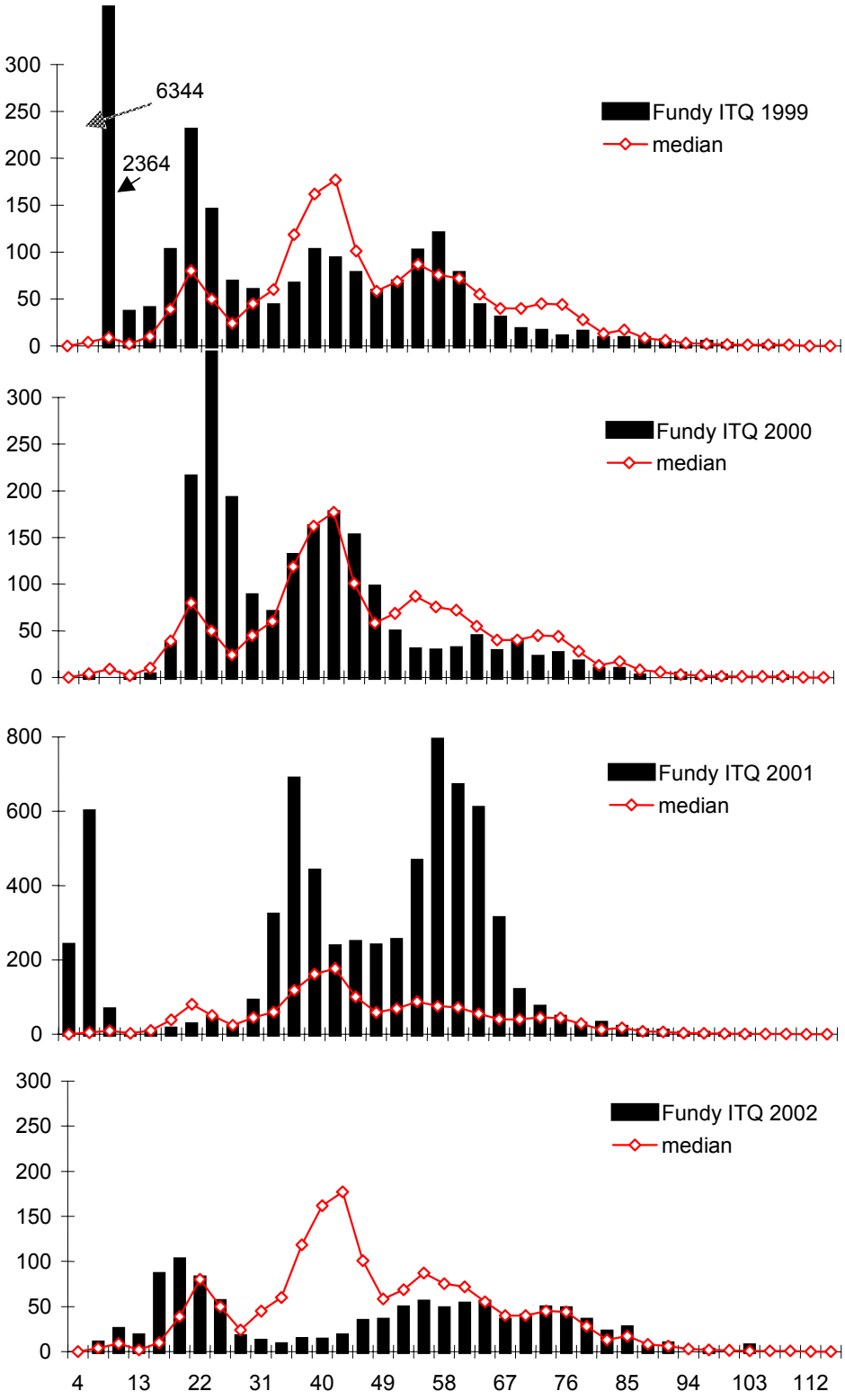

Fig. 20. Fundy length frequencies from summer ITQ surveys compared to the long-term median.

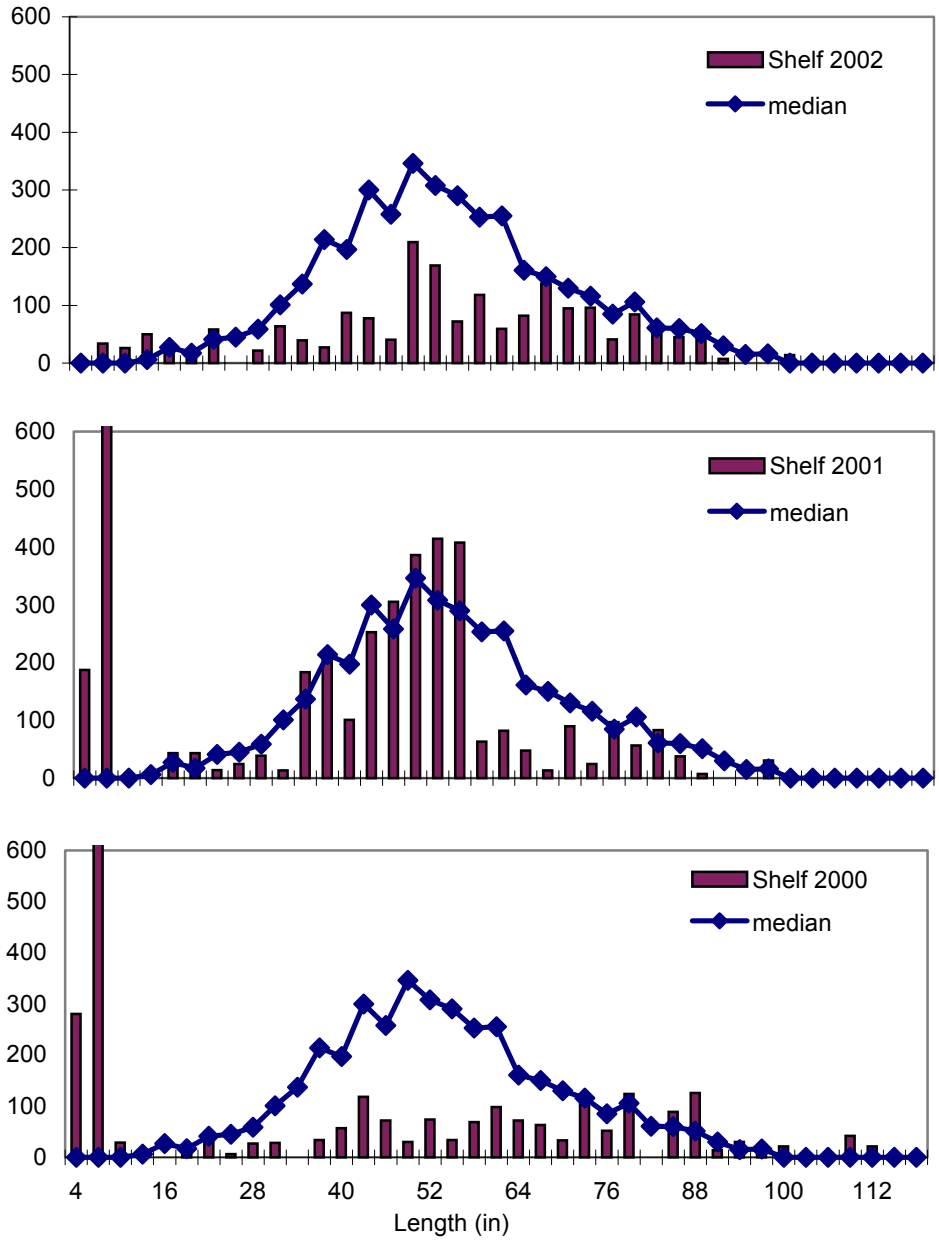

Fig. 21. Scotian Shelf length frequencies from summer RV surveys compared to the long-term median.

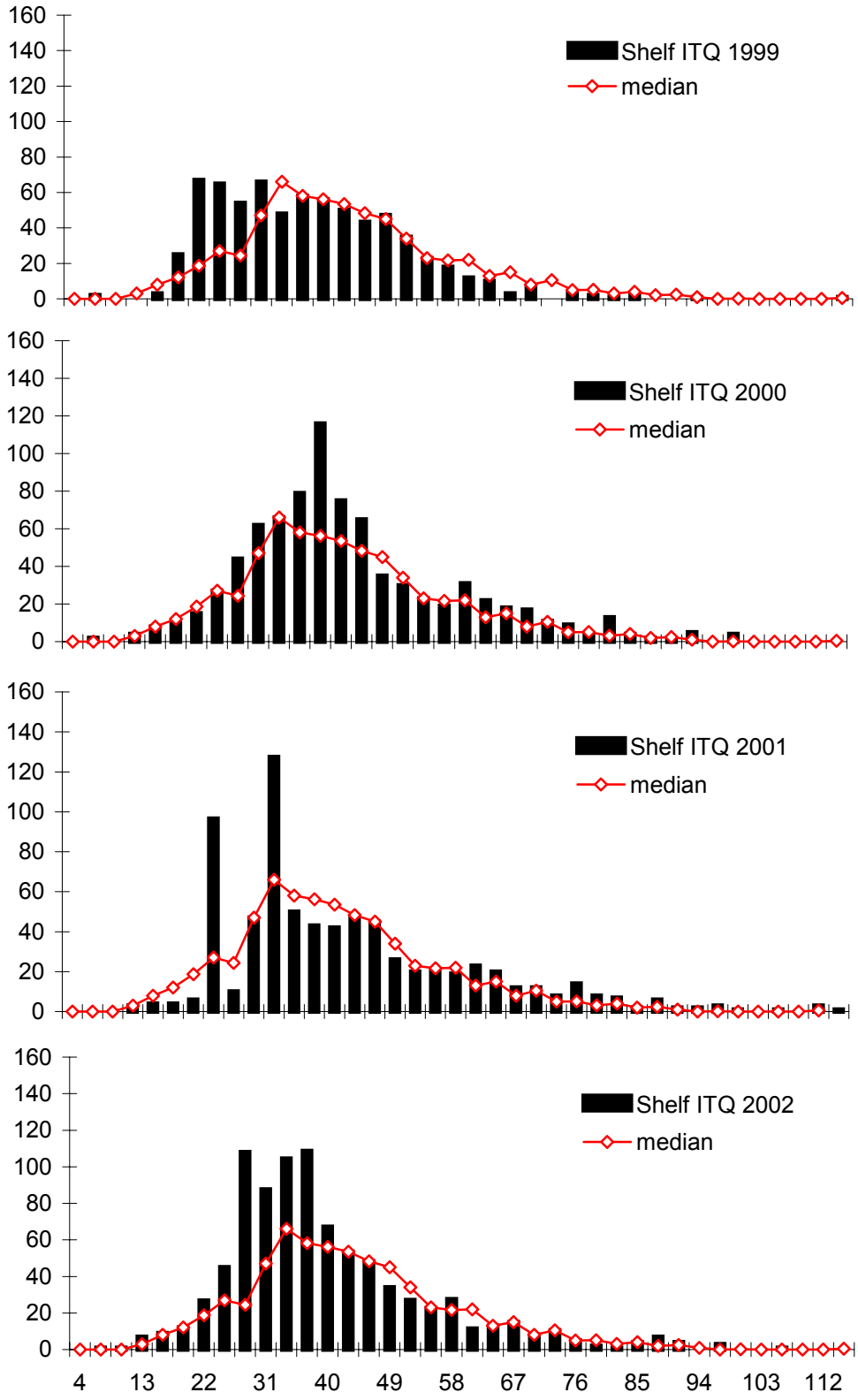

Fig. 22. Scotian Shelf length frequencies from summer ITQ surveys compared to the long-term median.

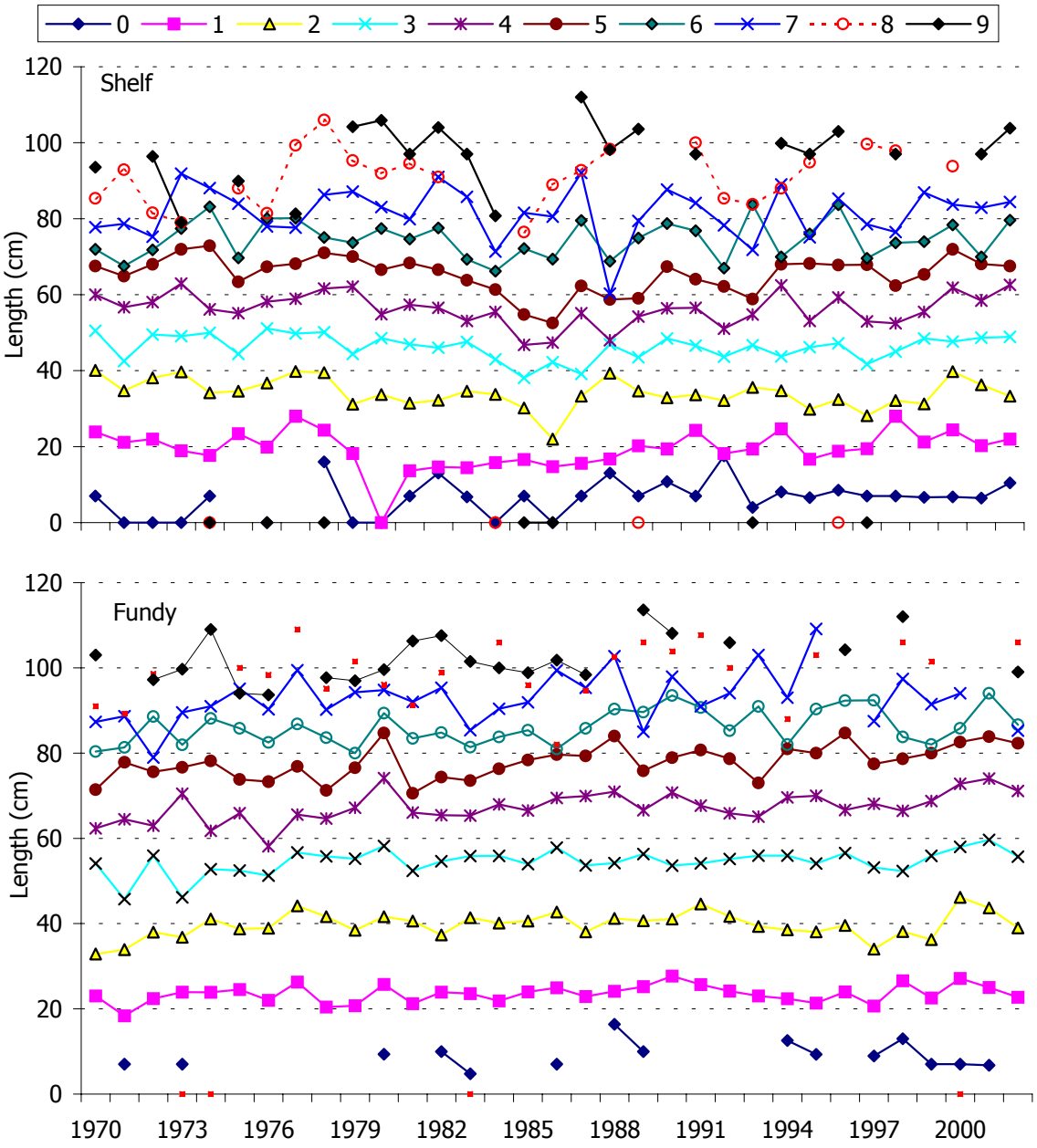

Fig. 23. Length at age for 4X cod from the summer survey in Fundy and Shelf regions.

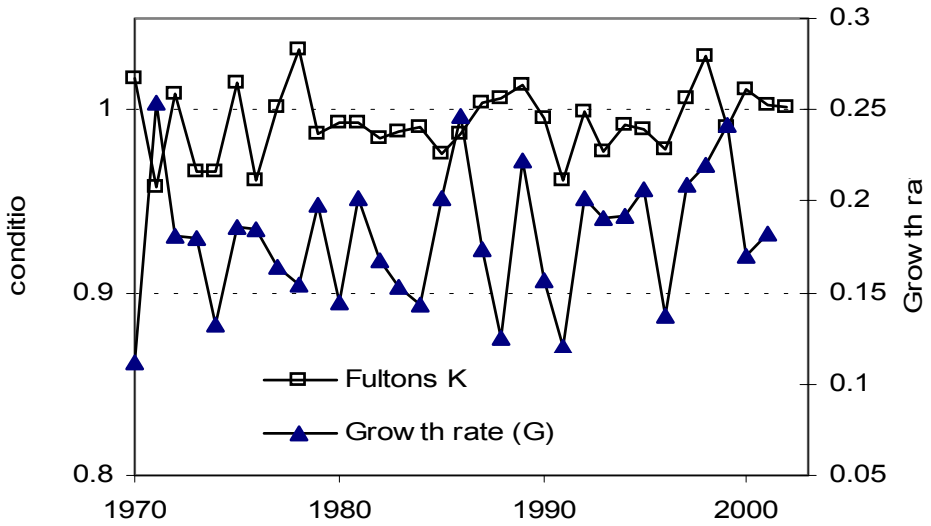

Fig. 24. Growth rate and condition for 4X cod caught in the RV survey.

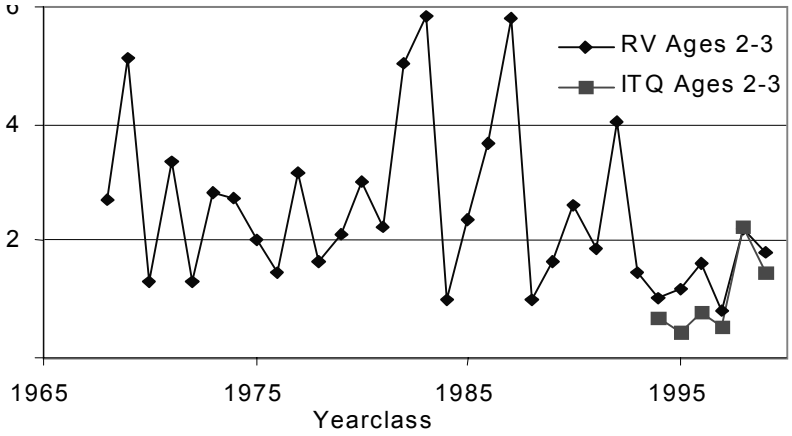

Fig. 25 Recruitment of 4X cod as the average catch for ages 2 and 3 in a yearclass for RV and ITQ surveys.

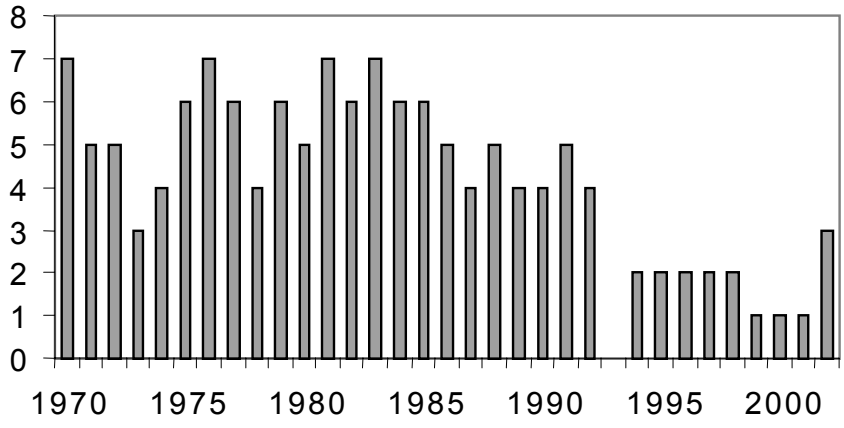

Fig. 26. Number of above average mature yearclasses (Age Structure) for 4X cod in the RV survey.

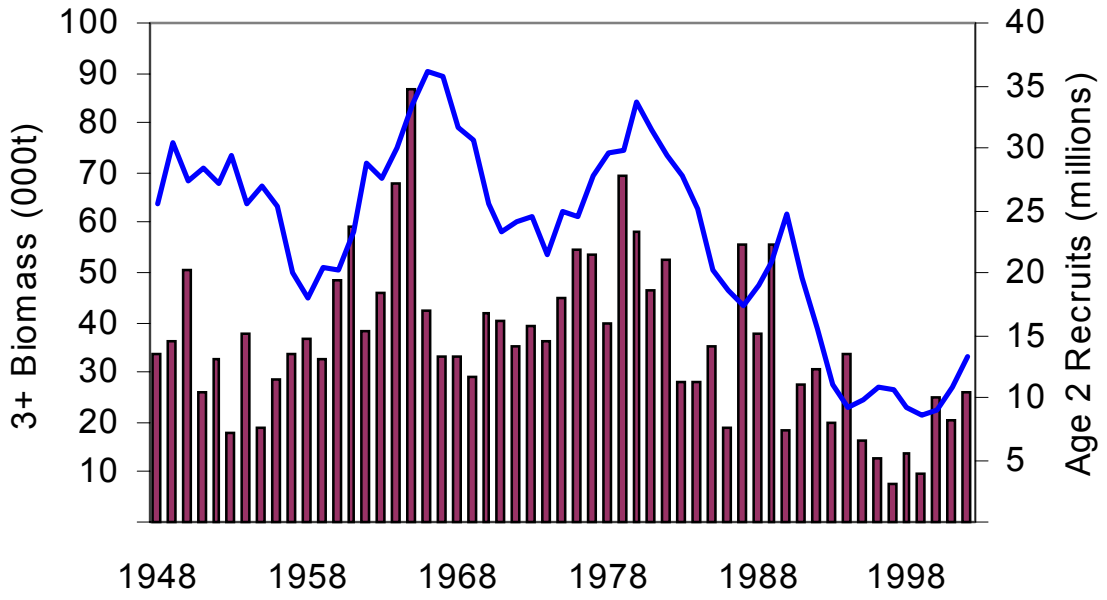

Fig. 27. Recruitment and biomass of 4X cod estimated from SPA.

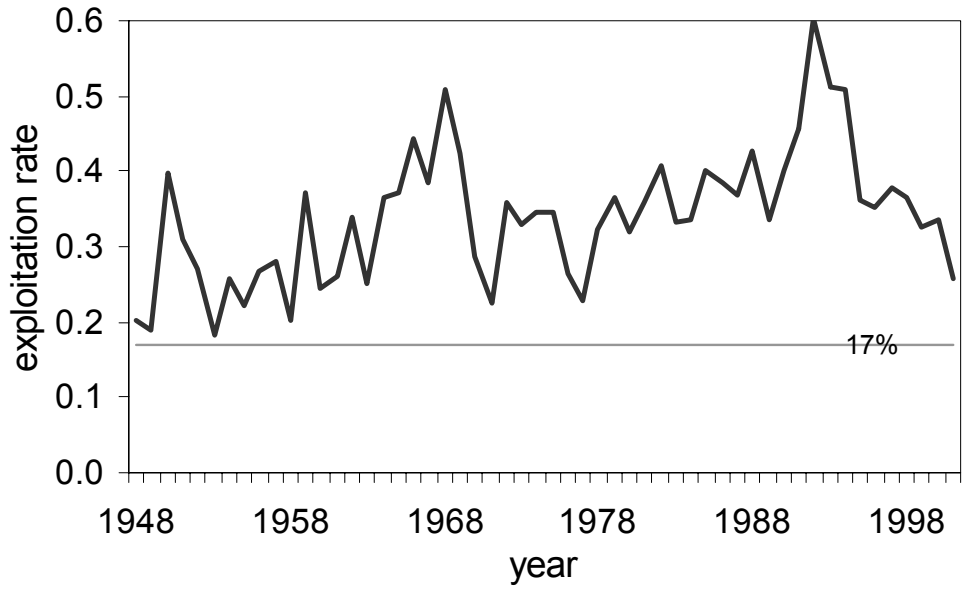

Fig. 28. Exploitation rate for 4X cod ages 4-5.

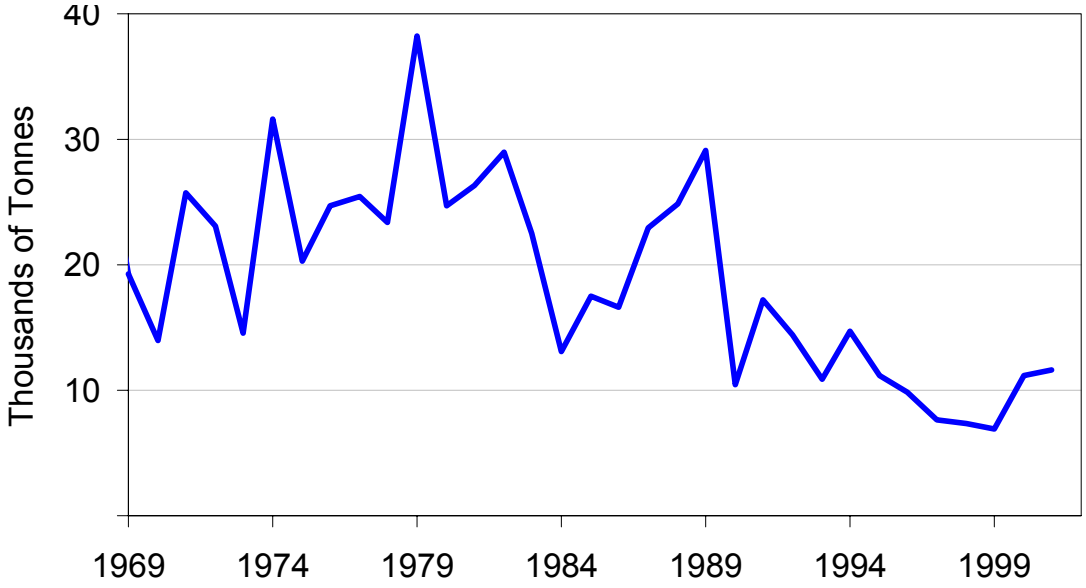

Fig. 29. Surplus production for 4X cod.

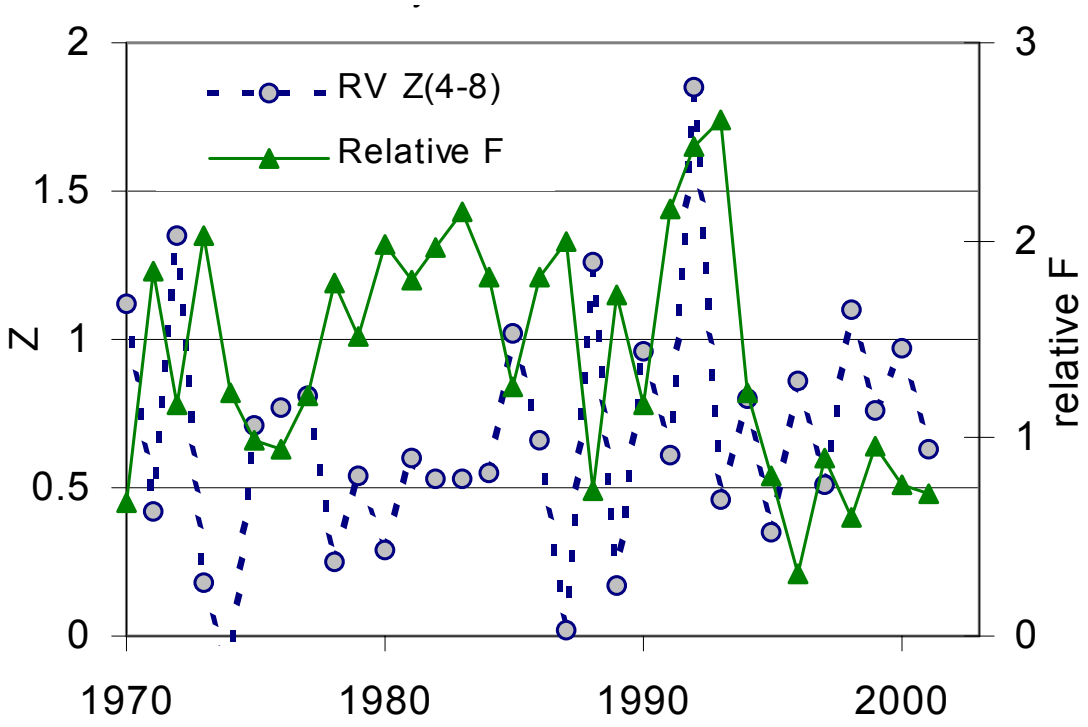

Fig. 30. Relative fishing mortality estimates and RV survey total mortality (Z) estimates for 4X cod.

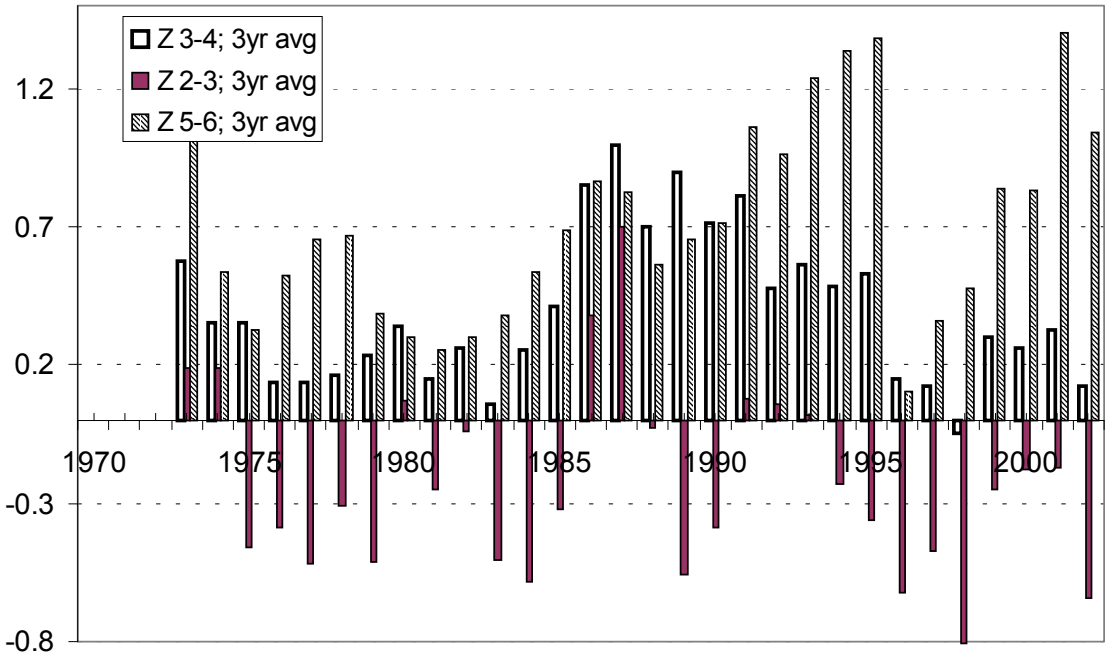

Fig 31. A comparison of total mortality estimates (Z) at age for 4X cod from the summer RV survey.

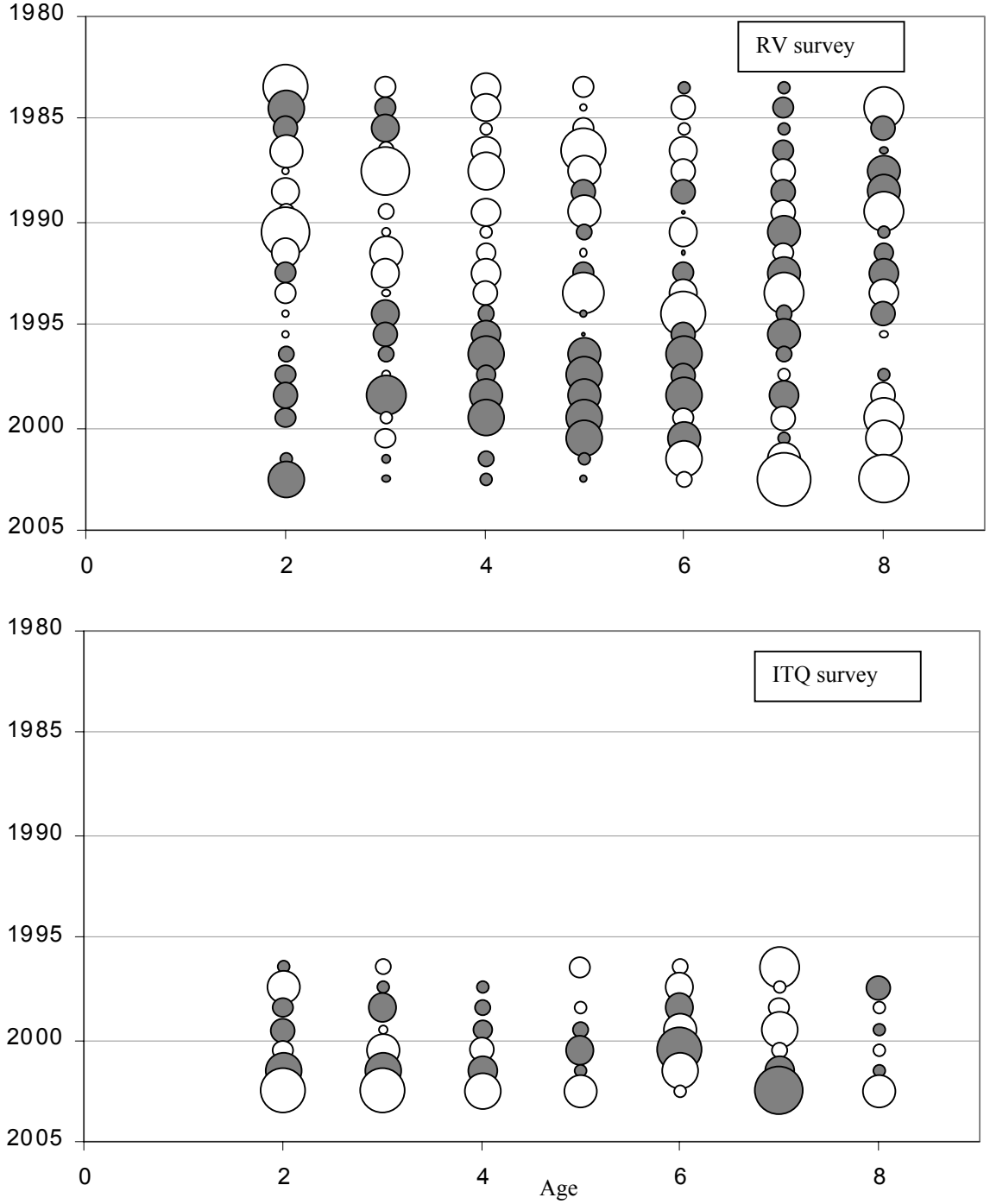

Fig. 32. SPA residuals by year and age group for the RV and ITQ surveys. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude.

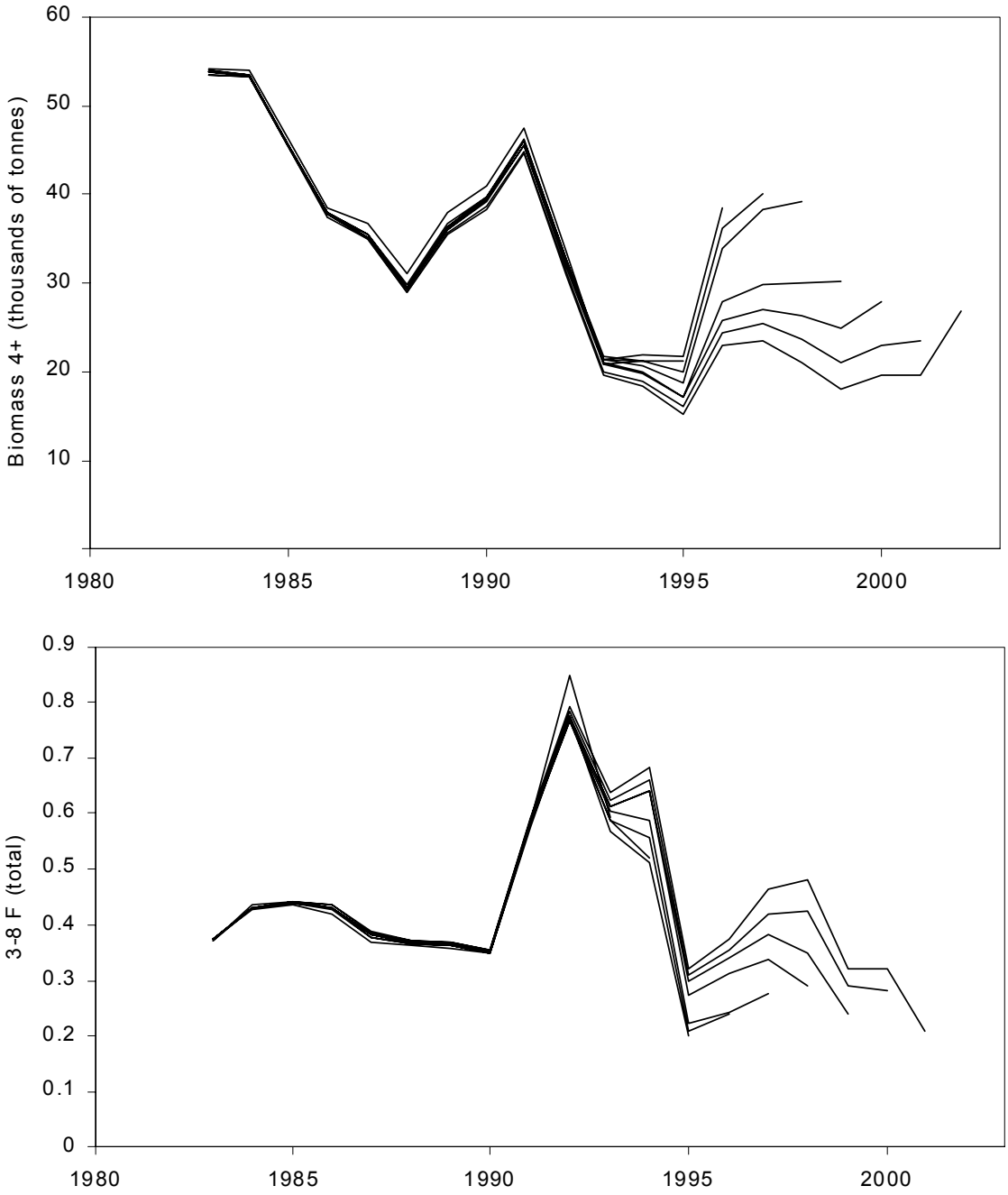

Fig. 33. Retrospective estimates of biomass and fishing mortality for 4X cod as successive years of data were excluded in the assessment.