Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Advisory Document 90/5

Advice on the Management of Groundfish Stocks

CAFSAC provides assessments for the groundfish stocks in NAFO Subareas 2-5 identified in Table 1 while the Northwest Atlantic Fisheries Organization (NAFO) reviews the assessments for the remaining groundfish stocks, that is stocks in Subarea 0+1, those stocks overlapping the 200 mile limit in Subarea 3, and silver hake in divisions 4VWX.

In 1990, CAFSAC presented the draft results of groundfish assessments at two Atlantic Groundfish Advisory Committee (AGAC) meetings. The intention was to consult with the trade prior to finalizing the advice. Several meetings were subsequently held with industry to discuss the 2J3KL cod and other stock assessments.

In this advisory document, CAFSAC provides catch options at various fishing mortalities in the context of a proposed three-year groundfish management plan. In that framework, CAFSAC's first priority is the conservation and protection of the resource. In addition to a forecast at $F_{0.1}$ if current stock size is estimated to be high enough not to be of concern, the 50% rule option or other options are presented. Current data and methodologies do not allow catch forecasts to be made for three years in advance with a high degree of certainty. CAFSAC believes that the actual catches will either differ from those forecast or result in different fishing mortality being applied to the stock. CAFSAC will therefore closely monitor the fisheries and, should indicators suggest a change in TAC in either direction, advice to that effect will be promptly provided.

Table of Contents

1. COD IN DIVISIONS 2GH

1.1. Description of the fishery

The nominal catches for this stock since the early 1950s have ranged from 94,000 t in 1966 to 131 t in 1987 and have been less than 500 t since 1985. The highest exploitation of this stock occurred in the late 1960s and early 1970s.

Recent TACs and catches ('000 t) are as follows (Fig.1.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	20	20	20	20	20	20	20
Nominal catch	1.5	0.5	0.5	0.1	0.4	0.4	

[1]Catches are preliminary

1.2. Abundance Indices

Analytical assessments using sequential population analyses (SPA) have not been possible for this stock in recent years because indices of abundance have not been available as a result of low catches and limited sampling data. Data from research vessel surveys using a stratified-random design were available annually from 1986 to 1988 only and these were not used as indicators of cod stock abundance. Their spatial coverage was limited and the seasonal timing was not optimal because research vessels were committed to other research programs at the appropriate time.

1.3. Assessment and Forecast

Data available in recent years have been insufficient to permit an analytical assessment of this stock and consequently advice relative to the $F_{0.1}$ level cannot be provided. In 1989 CAFSAC concluded that the relevance of the previously estimated $F_{0.1}$ catch (approximately 20,000 t) could not be determined. CAFSAC suggested that future catches be regulated but a quantitative recommendation could not be provided.

The present situation is essentially unchanged and there is again no current data or analyses to support a catch of 20,000 t. Directed fishing effort has been low in recent years because other fisheries have been more economical and accessible. Catches are expected to increase in the near future because of allocations to foreign fleets and increased interest by domestic fleets resulting from reductions in TACs for other cod stocks. Despite the lack of data and analyses, CAFSAC believes that the existing TAC of 20,000 t could be extended for 1991 to 1993.

2. COD IN DIVISIONS 2J, 3K AND 3L

2.1. Description of the Fishery

Total catches from this cod stock increased fairly rapidly after 1959 as the prespawning and spawning concentrations of cod off southern Labrador and northern Newfoundland were increasingly exploited by European fleets. The total catches peaked at about 800,000 t in 1968 but declined steadily thereafter until 1978. Inshore catches decreased from about 160,000 t in 1959 to 35,000 t in 1974.

Management of this stock, as for other stocks in the area, was initially the responsibility of the International Commission for Northwest Atlantic Fisheries (ICNAF). Early management measures were limited to minimum mesh size regulations, but the stock continued to decline and total allowable catch (TAC) regulations were introduced in 1973. The TACs at the time were set with the purpose of harvesting the maximum sustainable yield and maintaining the stock biomass, but the stock nevertheless continued to decline. Following extension of jurisdiction by Canada in 1977, the fisheries were regulated at a target fishing mortality lower than the target used previously, even below $F_{0.1}$, to allow the stock to rebuild. Since 1984, the fisheries have been regulated at a target fishing mortality of $F_{0.1}$. The stock was assessed by the Northwest Atlantic Fisheries Organization (NAFO) until 1986 and by CAFSAC since 1987.

Total catches increased slowly after 1978, and during 1982-1987 they were relatively stable around 230,000 t except in 1986 when Spain and Portugal took most of the foreign catch of 61,000 t on the nose of the Grand Bank outside of the 200 miles zone. This resulted in a total catch of 252,000 t for that year. Total catches reached 266,000 t in 1988 and decreased to 240,000 t in 1989 mostly because of decreased catches by the Canadian offshore sector. The 1989 TAC of 235,000 t was exceeded by about 5,000t because of foreign overfishing on the nose of the Grand Bank despite the NAFO moratorium.

Inshore catches increased steadily between 1974 and 1982 when they reached 113,000t. They declined afterwards to 72,000 t in 1986 and have recovered since to about 100,000 t. Compared to 1988, fixed gear catches have declined in northeastern Newfoundland (Division 3K) in 1989 but they have generally increased or remained stable in divisions 2J and 3L. For the total stock area, inshore catches in 1989 were about 100,000 t, which is almost 10,000 t above the average catches since 1977 and almost 6000 t above the longer-term average since 1959. There are indications that inshore fishing effort may have increased in 1989 as a result of fixed gear vessels based in NAFO Division 4S fishing in Division 2J out of Black Tickle in Labrador.

Recent catches and TACs ('000 t) are as follows (Fig. 2.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990[2]
Inshore Catch	97	80	72	79	102	99	
Offshore Catch	135	151	179	156	164	141	
Total Catch	232	231	252	235	266	240	
TAC	266	266	266	256	266	235	197

[1]Catches are preliminary
[2]Canadian allocation

The labour dispute at Fishery Products International during 1989 disrupted the monthly distribution of catches. As a result, catches in the autumn of 1989 were proportionately more important than in previous years.

Information on the age structure of the catch is available since 1962. However, sampling of the catch was limited in the sixties and the early seventies, especially for the large foreign catches. The accuracy of the estimated age composition for those years is therefore considered low. Keeping those caveats in mind, CAFSAC notes that in those earlier years, a larger proportion, up to 20%, of the number of fish caught were age 8 or older while in recent years, these ages have generally accounted for less than 10% of the number of fish caught. This difference may be the result of poor sampling of the catch in the earlier period, of a lower abundance of larger, older cod in recent years, or of a refocussing of the fishery towards younger ages. The age composition of the 1989 fishery was unusual compared with other recent years in that ages 7 and 8 (the 1981 and 1982 year-classes) dominated in the catch, accounting for about

44% of the catch numbers. Since 1978, ages 5 and 6 usually made a much more important contribution to the total catch but the 1983 and 1984 year-classes (ages 6 and 5 in 1989) which would have normally been expected to dominate the 1989 catches, appear to be small, even smaller than estimated in last year's assessment.

2.2. Abundance Indices

The results of research vessel surveys conducted in the autumn since 1978 and data from the commercial fleet in tons per hour for the same time period have recently been used as indices of abundance for this cod assessment. Offshore foreign mobile gear catch per unit of effort is available for a longer period prior to 1978 but there is little information for those fleets after 1978. As indicated in last year's assessment, because there is very little overlap in the periods of activity of the Canadian fleet and the foreign fleets, it is not possible to reliably combine the two series into a single series covering the entire period from 1960 to 1989.

The fishing practices on the research vessel have largely remained the same over the period. The total area surveyed has been divided into various zones (stratum) based on the depth of each zone because the distribution of cod is generally related to water depth. A given number of fishing sets is allocated to each of these zones according to its size. The locations of the fishing sets are selected at random each year to ensure an unbiased coverage of the area of distribution. In divisions 2J and 3K, the surveys have always been conducted on the research vessel Gadus Atlantica while three vessels have been used for the Division 3L surveys. Appropriate adjustment factors have been applied between the three vessels in order to make the results comparable from year to year. Population indices in weight from the research vessel surveys are shown in Fig. 2.2. The results suggest that the stock has been relatively stable since 1987. There are clear indications that the cod were more available to the research trawl in 1986 and CAFSAC considers that the biomass estimate for that year is artificially high. The reasons for the increased availability are unknown but CAFSAC notes that it was a widespread phenomenon affecting other species in this area.

By contrast to the fishing practices on the research vessel surveys which have remained similar over the period 1978-1989, those of the commercial fleet have changed considerably over these years. Although an offshore Canadian cod fishery has existed for a long time in Division 3L, there were only occasional catches in divisions 2J and 3K prior to about 1978. The Canadian fishers must therefore have experienced a certain degree of learning about the location of the fish and vessel operation in these waters at least for the first two or three years, that is until about 1980-81. In addition, several other factors, of which a non-exhaustive list is given below, have all undoubtedly had an effect on catch per unit of effort of the commercial fleet albeit sometimes in opposite directions:

- the introduction of enterprise allocations in 1983;
- an increase in mesh size in the early 1980s;
- the emphasis placed on fish quality instead of fish quantity in the early to mid-1980s which resulted in the cutting of holes in trawls in an attempt to limit the catch to a desired level;
- the introduction of better navigation and fish detection equipment;
- the introduction of trawl mensuration equipment; and

- the regulation to harvest 1/3 of the allocation in each of the three divisions since 1987.

CAFSAC has attempted to quantify the effect of these factors in last year's assessment. The main factors investigated were the impact of the 1/3,1/3,1/3 regulation, the cutting of holes in the trawl and the by-catch nature of the Division 3L cod fishery. None were found to have had a significant effect and therefore CAFSAC is making no adjustment to the data in calculating the index of the success of the fishing fleet. CAFSAC considers however that the many changes in the commercial fishery, especially the learning that is bound to have happened in the first years after 1978, invalidate the use of the commercial catch per unit of effort as a consistent index of stock size over the entire time period considered. The commercial catch per unit of effort is shown in Fig. 2.3 and CAFSAC believes that the rapid increase in catch per unit of effort from 1978 to 1982 is the result only of increases in stock size but also of a learning process which allowed Canadian fishers to become more efficient harvesters of this resource. The commercial catch per unit of effort is relatively stable between 1988 and 1989.

2.3. Assessment

The present assessment uses the research vessel survey results in a way very similar to what was done in the 1989 assessment. For the commercial fleet however, and as suggested in the report of the Harris Panel on northern cod, estimates of the success of fishing in number of fish per hour have been calculated for each age. In last year's assessment an index which was aggregated over all ages in tons per hour had been used.

By examining the success of the commercial mobile gear fishery on an age by age basis, CAFSAC has been able to identify that the mobile gear catch per unit of effort at age for ages 5 to 8 could be used as an abundance index.

The ADAPT methodology was used to assess stock size. This methodology, which may appear complicated at first, provides a rigorous framework which allowed the investigation of a biological phenomenon which had remained somewhat elusive until now. This is the relative fishing mortality pattern over ages (the partial recruitment vector) which, in past assessment had been estimated to increase from ages 3 to about age 7 and remain constant for the older ages. It had long been observed, by comparing the age composition of research vessel surveys with that of the fishery, that there appeared to be more older fish in the surveys than in the commercial fishery. In fact, in a fishery like the 2J3KL cod fishery where traps and otter trawls catch mostly fish younger than age 8 or 9, it would be expected that the older ages (age 10+) are subjected to a lower exploitation rate than the middle ages (age 7 to 9) which constitute the prime target for the majority of the fishery. The examination of the preliminary ADAPT runs suggested that fish ages 10 and older were not as highly exploited as those from ages 7 to 9. The relative exploitation rate appears to be maximum at ages 7 to 9 and to decrease progressively on older ages to be about 50% on age 13.

The ADAPT methodology also helped substantiate a suspected increase in efficiency for the mobile gear fleet between 1977 and 1982. This increase in efficiency was misleading in past assessments and suggested that the stock size had increased more rapidly than it actually had. To be able to use the commercial catch per unit of effort for those earlier years would require adjusting them to take into account the increase in efficiency. Although the indications are clear that efficiency has increased during the period, CAFSAC has no basis to decide what the yearly adjustments should be. For this reason the years (1978-1982) were excluded from the analyses until a correction for the increases in efficiency can be made. CAFSAC is aware that other changes in efficiency have occurred since 1982 but these were not all in the same direction with some increasing efficiency

while others may have decreased it. In addition, as indicated in the report "Independent Review of the State of the Northern Cod Stock", it is preferable to use several indices of stock size when doing an assessment and therefore, CAFSAC elected to retain the commercial index of stock size for 1983 to 1989 despite its recognized weaknesses.

The final assessment of population size was calibrated age by age using the research vessel indices for ages 3 to 12 for 1978 to 1989 and the commercial catch per unit of effort at age for ages 5 to 8 for 1983 to 1989. The results confirm the information provided in the 1989 assessment that the exploitation rate had been underestimated in previous assessments, including the 1989 assessment. The Review Panel on Northern Cod hinted at this result in their report when they indicated that if the fishing mortality in 1988 was not F=0.45 as estimated by CAFSAC in the 1989 assessment, it was probably higher. The results of last year's assessment indicated that the biomass had reached a peak in 1984 and had remained relatively stable around one million tons since. The current assessment (Fig. 2.4) shows the same maximum biomass in 1984 but a slight decline since with the 1989 biomass being close to 800,000t.

In last year's assessment the 1983 and 1984 year-classes were estimated to be slightly lower than average. In the current assessment (Fig. 2.5), these year-classes are estimated to be about the size of the smallest year-classes observed since that of 1959. The 1986 year-class is presently estimated to be about 1.5 times stronger than the average year-class size since 1977, that is about 475 million fish.

The fishing mortality (Fig. 2.6) for ages 7 and older is estimated to have increased steadily since 1978 and to be currently similar to early 1970s, which is slightly higher than the average of about 0.50 since 1962. The fishing mortality appears to have approximately doubled during the course of the 1980s.

The reasons for the difference in the two assessments, in spite of the relative stability in the two indices used, is because more weight has been given to the research vessel survey results in the current assessment. In last year's assessment, CAFSAC was uncertain as to the appropriate way to combine the research vessel surveys population indices by age and the commercial catch per unit of effort by year for 1978 to 1988 within a single assessment of stock status without artificially giving much more weight to the research vessel surveys because of the higher number of observations. Therefore, each index was used separately thus providing two independent assessments. The research vessel index suggested a fishing mortality in 1988 about twice as high as that indicated by the commercial data for the same year. CAFSAC took the mid-distance between these two values as being consistent with the recent estimates of exploitation observed in the fishery. This was done even though the relationships with the research vessel surveys were much better than those for the commercial catch per unit of effort.

Consistent with the recommendations given in the "Independent Review of the State of the Northern Cod Stock", the present assessment used population estimates on an age by age basis not only for the research surveys but also for the commercial catch per unit of effort indices. This allowed the two indices to be combined into a single assessment and each to be weighted according to its relationship with the estimates of stock size from sequential population analyses. The statistical model used to find the best compromise between the two indices recognized the weaknesses of the commercial catch per unit of effort relationships and gave a predominant weight to the research vessel indices. In last year's assessment, the calibration of the SPA with the commercial catch per unit of effort on its own resulted in stock size estimates twice as high as those obtained by calibrating the SPA only with the research vessel surveys population indices. As anticipated in the report of the Harris Panel, the results of the calibration of the SPA using the commercial catch per unit of effort (CPUE) on

its own but on an age by age basis gives population estimates that are still larger than those obtained by calibration with the research vessel survey results alone but the difference has been cut by about half (Fig. 2.7). CAFSAC estimated the effect of not using the first 5 years of the Canadian offshore CPUE in the calibration and found that it decreased the estimates of the ages 5 to 8 populations by about 4%.

2.4. Forecast

The 2J3KL spawning biomass is estimated to be presently more than twice the lowest value observed in the mid-1970s and about equal to the spawning biomasses that produced the relatively strong 1979 to 1982 year-classes. The 1986 year-class is estimated to be strong and it will likely cause a large increase in the spawning stock biomass when it matures in 1993. In the meantime, the 1983 and 1984 year-classes are so small that the spawning biomass will decline in 1990 and 1991 even if it were decided to decrease the fishing mortality to $F_{0.1}$ immediately in 1991. However, considering the likely impact of the 1986 year-class on the spawning biomass in 1993 and thereafter, CAFSAC believes that considerations of spawning stock biomass do not require that the fishing mortality on 2J3KL cod be reduced immediately to $F_{0.1}$ in 1991.

CAFSAC is therefore providing, in the table below a range of alternative exploitation options considered biologically acceptable for 1991. In all cases, the 1990 catch is assumed to be about 225,000 t because CAFSAC recognizes that fishing on the nose of the Grand Bank is likely to occur despite NAFO's moratorium. Total catches in 1990 are therefore expected to exceed those allowed in the 1990 Groundfish Management Plan.

The following input values were used in the catch projections:

AGE	January 1990 Population numbers ('000s)	Weight (kg)	Partial Recruitment
3	300000	.47	.006
4	387485	.71	.152
5	154490	1.05	.474
6	53593	1.38	.608
7	40015	1.79	1.000
8	46866	2.07	1.000
9	27481	2.65	1.000
10	8176	3.19	.802
11	4259	4.38	.798
12	2477	5.18	.878
13	692	6.60	.500
14	645	7.99	.500
15		9.45	.500

Option	Fishing Mortality[1]	1991 Catch	1991 Net Production[2]	1991 Spawning Biomass
$F_{0.1}$	F=0.20	100,000 t	115,000 t	230,000 t
50%Rule	F=0.33	150,000 t	65,000 t	185,000 t
$2XF_{0.1}$	F=0.40	170,000 t	45,000 t	170,000 t
Surplus production		215,000 t	0	130,000 t

[1]Ages 7 and older
[2]Represent the increase in biomass between January 1, 1991 and January 1, 1992.

The surplus production is estimated at about 215,000 t for both 1990 and 1991. Therefore, if the catches did not exceed those allowed in the 1990 Groundfish Management Plan, the stock would grow slightly and up to about 215,000 t could be harvested in 1991 while keeping the biomass stable.

These options are largely dependent on the size of the 1986 year-class. CAFSAC is confident that the 1986 year-class is strong, but its actual strength will be estimated with greater accuracy when the year-class has contributed to the fishery for a few more years.

3. COD IN SUBDIVISION 3Pn AND DIVISIONS 4RS

3.1 Description of the Fishery

Landings for this stock reached a peak of 106,000 t in 1983 but have decreased since to 47,000 t in 1989, the lowest observed since 1960. The mobile gear catches from Canadian vessels were stable from 1981 to 1986, decreasing slightly thereafter. This decline can be attributed in part to a strike in the winter of 1988 and to the exclusion of Metropolitan France from the fishery in 1987. Fixed gear catches have declined drastically since 1982. The proportion of the total catch taken by the mobile fleet in 1989 is 70%.

Preliminary values for landings to date in 1990 are lower than those of the similar period in 1989. Severe ice cover hampered the winter fishery in Subdivision 3Pn with vessels being tied up for three weeks. Total catches in 1990 are expected to be lower than 40,000 t. TACs and nominal catches ('000 t) are as follows (Fig. 3.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	100	100	92.1	80.3	73.9	76.5	58
Nominal catches	104	88	80	67	48	47	-

[1]Catches are preliminary

3.2. Abundance Indices

Commercial catch rates (Fig. 3.2)

Catch rates from otter trawl tonnage class 2 to 5 vessels were analyzed using a multiplicative model. The proportion of the total catch for which effort is available is in the range of 15 to 30% in recent years. Catch rates were

stable from 1974 to 1980, increased twofold between 1980 and 1981 with a slight decline since then.

Research vessel survey data (Fig. 3.3)

Two annual groundfish surveys are conducted in the northern Gulf of St. Lawrence, one in August-September aboard the RV Lady Hammond since 1984 and another in January aboard the RV Gadus Atlantica since 1978 (except 1982). The summer survey was thought to underestimate biomass since few sets were done in the 50-100 fathom strata in the first three years. Estimates for these strata were derived using a multiple regression with year and stratum effects. The resulting biomass estimates show a gradual decline since 1984, with the 1988 and 1989 observations being the lowest in the time series. The summer survey is presently of limited use for calibration mostly because it is a short series and because waters 50 fathoms or less are not surveyed because of the presence of fixed gear. Keeping in mind these drawbacks, the trend in biomass estimates from the summer survey indicate a decline of biomass for this stock.

Estimates from the winter survey remained relatively stable between 1978 and 1983, increased by a factor of two between 1984 and 1986 and have suddenly declined in 1987. The four most recent biomass estimates are the lowest in the time series. The biomass estimates from this survey are quite variable compared to other surveys because the cod are concentrated in a small part of the survey area, resulting in large within-year variability. Past reservations about ice cover and migrations into 3Ps have been investigated. CAFSAC believes these are unlikely to be important because several sets are made each year in areas covered by ice and they yield small catches, indicating that few cod are present in the icebound unsurveyed area. Results from tagging studies suggest that there are little incursions of 3Pn 4RS cod into Subdivision 3Ps.

Population estimates for the 1986 and 1987 year-classes are the largest in both research vessels population estimates. They were first detected at age 2 in the 1988 and 1989 winter surveys respectively. The 1987 year-class estimate from the 1990 survey is second to the largest observed value. These observations are corroborated by anecdotal information from the commercial fishery in 1990 that many small fish were caught.

Stock structure

A tagging program was undertaken jointly by the Department of Fisheries and Oceans and the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec in order to evaluate claims by industry that important incursions of cod from divisions 2J, 3K, and 3L were occurring in the northern Gulf of St. Lawrence. To test this hypothesis, fish were tagged in the summer months when stocks are presumed to be mixed. Returns from the January to March period were considered to be taken from discrete stocks when they are segregated prior to spawning.

Approximately 50,000 fish were tagged during the summers of 1983 to 1986. Fish were tagged from inshore traps and from the RV Lady Hammond offshore. Tagging sites covered most of the summer distribution of the stock and were located on the west coast of Newfoundland from the Strait of Belle Isle to the Port au Port Peninsula and on the Québec north shore from the Quebec - Labrador border to the west end of Anticosti Island.

Returns of approximately 6,000 tags indicate that: 1) cod tagged at the northern tip of western Newfoundland (Quirpon-Cooks Harbour area) were recaptured predominantly in divisions 2J3KL; 2) cod tagged on the remainder of the west coast of Newfoundland were recaptured predominantly in divisions 3Pn4R with few returns from divisions 2J3KL; 3) cod tagged on the Quebec North Shore were almost

exclusively recaptured in divisions 3Pn4R; and 4) while most cod tagged at the western tip of Anticosti Island were recaptured in divisions 3Pn4R, substantial numbers were recaptured from divisions 4T, 4Vn and 4Vs. Very few cod were recaptured from Division 3Ps and those that were came from the Burgeo Bank area. The results however somewhat overestimate the contribution of 2J3KL cod to northern Esquiman Channel cod catches because a greater proportion of the total returns within the Gulf were deleted from the analysis since they were returned with incomplete information.

CAFSAC concluded that no major incursions of 2J3KL cod had taken place between 1983 and 1986 and although exchanges exist with 2J3KL in the Strait of Belle Isle, the 3Pn 4RS cod stock appears to be relatively discrete. Further, CAFSAC noted that the few returns from Division 3Ps indicate that fish tagged in the summer make limited incursions into Subdivision 3Ps.

3.3. Assessment and Forecast

The two indices of abundance when used separately to calibrate SPA, imply in very different interpretations of the abundance of this cod stock. The calibration with the trawler CPUE suggests that the stock is relatively stable and lightly exploited. The calibration with the winter survey suggests that the stock is exploited above F_{max} and declining at a rapid rate. Because of the divergent trends in the abundance indices and the shortcomings of each index, CAFSAC is unable to precisely assess the size of the 3Pn 4RS cod, although a decline in abundance is evident.

Past assessments were based entirely on commercial catch per unit of effort indices of the mobile gear fleets. However, in recent years, trends in CPUE are conflicting with all other indications from the fishery; catches from the fixed gear fishery have virtually collapsed and both surveys show an important decline in biomass. This led CAFSAC to believe more the results from the surveys which show a substantially more pessimistic view of the resource. It is difficult however, to reconcile the recent dynamics of the 3Pn 4RS cod stock with its previous history. The stock has generally produced catches in excess of 60,000 t with average catches being about 80,000 t. CAFSAC is concerned that rumoured misreporting and discarding may play a role in this apparent drastic change in productivity. Considering the past and recent dynamics of this stock, CAFSAC believes that mobile gear catches should not be allowed to increase over those of 1990 and that discards and dumping should be halted.

4. COD IN DIVISION 4T AND IN SUBDIVISION 4Vn (JANUARY-APRIL)

4.1. Description of the Fishery

Since 1950, nominal catches have ranged from a high of over 104,000 t in 1956 to a low of 22,000 t in 1977. Between 1980 and 1986, nominal catches have averaged approximately 60,000 t. Catches have varied between 50,000 and 52,000 t in the past three years. The nominal catch in 1989 was approximately 4,000 t less than the TAC. Part of the shortfall can be attributed to transfers from fixed gear to mobile gear which were made using a 2:1 ratio. TACs and nominal catches ('000 t) in recent years are presented below (Fig. 4.1.):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	67	67	60	45.2	54	54	53
Nominal catch	55	62	64	51	52	50	-

[1]Catches are preliminary

Landings in the winter fishery in 4Vn accounted for approximately 18% of the total catch and are attributed almost exclusively to otter trawlers. France caught 503 t from an allocation of 1,360 t. Landings by fixed gear were the lowest on record since 1965 at 6,655 t. Catches by mobile gear (seiners and otter trawlers) were similar to 1988. Proportions taken by the Maritimes (65%), Newfoundland (3%), and Quebec (31%) remained approximately the same as in 1988.

The system of enterprise allocations (EA) instituted in 1988 was extended to include all mobile gear vessels over 50 feet. Trip limits were imposed on mobile gear vessels less than 50 feet. Allocations were generally reached quickly for mobile gear vessels less than 45 feet.

Most gear and quarter components were adequately sampled for age with a total of nearly 81,000 fish measured and 6,700 aged. The results of age determination comparisons indicated that the level of agreement in age determinations between readers and a reference collection exceeded 70%. There was no evidence of bias with respect to the difference between readers.

The 1982 and 1983 year-classes accounted for 20.6% and 23.3% respectively of the numbers caught in 1989. The 1980 year-class has appeared in large numbers in the catch since 1985 and comprised 14.1% of the catch in 1989. The proportions observed in the fishery were in close agreement to those predicted in the previous assessment.

Weights at age for 1989 were generally higher than in 1988 at the younger ages (3-5), however the average weights of older fish (age 9+) are the lowest observed in the time series. The decrease in fixed gear catches in 1989 may have contributed to the decrease in average weight at age in the catch because weights at age for older fish are generally lower for mobile gear catches and higher in fixed gear catches.

4.2. Abundance Indices

Catch rates for otter trawlers were calculated using a multiplicative model. Catch rates decreased from 1968-75 followed by a general increase to 1987 with a subsequent decline. Current catch rates are approximately twice those observed in the mid-1970s (Fig. 4.2).

Analysis of catch rates for the fixed gear (gillnets, longlines and handlines) using purchase slips was attempted using a multiplicative model. The number of days fished appears to have decreased by 50% since 1987 but the measure of effort used (days fished) appears too crude to allow the use of fixed gear CPUE as an index of stock size. No significant yearly trends in CPUE could be detected.

Discarding Practices

Estimates of discards of cod in Division 4T from the Quebec observer program indicated a discard rate by weight of 9.2%; this is lower than the 1988 estimate of 14.6%, which is comparable to discard rates previously observed in this fishery. An analysis of data collected by the International Observer Program (IOP) of the Scotia-Fundy Region from 1985 to 1989 indicated that discard rates have increased from less than 1% in 1986 to 5% in 1989 in 4Vn (Jan.-Apr). Discards appear to be highest in the area of Scatarie Bank. Estimates of discards are available only for a few years and they have not been incorporated into the assessment.

Research vessel survey data (Fig. 4.3)

Comparisons of the results of day/night tows failed to detect a significant difference between day and night catches of cod in 4T. Consequently, day and night sets were used in 1989. This increased the number of sets used in the calculation of the abundance index to 164 in 1989 from 60 to 70 in previous years. Mean numbers per tow at age 3+ estimated from the 1989 survey are approximately 40% lower than in 1988 but at a level comparable to 1987. Coefficients of variation ranged from 11 to 14% for the most abundant age classes (4 to 12). The 1979 and 1980 year-classes are still present in large numbers in the population. As in the previous assessment, the 1982 year-class appears to be above average but the 1984 year-class does not appear as large as in previous surveys. The 1987 and 1988 year-classes appear to be above average. These juveniles were found in several sets in the lower Shediac Valley - Miramichi Bay area and the northern and eastern coasts of P.E.I.

4.3. Assessment

The sequential population analysis was calibrated by combining the two abundance indices in a single ADAPT run.

Recruitment (Fig. 4.4)

Based on the calibration, the estimate of the 1986 year-class was 140 million fish. However, the estimate was not considered precise and the size of this year-class was set equal to the geometric mean of the 1968- 1984 year-classes at 104 million. The 1984 year-class, which was estimated to be the second largest in the time series in the last assessment, is now estimated to be somewhat smaller at 127 million. The 1979-1982 year-classes are all estimated to be above the mean and the 1979 and 1980 values are the largest in the period 1947-1985.

Fishing mortality and stock abundance (Figs. 4.5 and 4.6)

The 3+ average population biomass declined from a high of 500,000 t in 1955 to approximately 100,000 t in the mid-seventies. With the reduction of fishing mortalities in 1977-78 and the recruitment of the 1974 and 1975 year-classes, the biomass increased and appears to have been stable at approximately 400,000 t since 1982. Population numbers in the 1980s are at their highest level since 1950. Although recent biomass estimates are similar to those in the early 1950s, the total population numbers since 1980 are substantially higher (Fig. 4.7) because the average weights at age is now smaller.

4.4. Forecast

Catch projections to 1993 were made using the 1990 beginning of the year population numbers. Weights at age were the average from 1987-89. The exploitation pattern over ages was derived from fishing mortalities in the period 1985-88 assuming full recruitment at age 9. Age 3 recruitment for the 1988-1989 year-classes was set at the geometric mean of the 1968-84 year-classes of 104

million. Input data are given below:

Age	January 1990 Population numbers (000)	Average Weight (kg)	Partial recruitment
3	104,000	0.389	0.005
4	85,097	0.564	0.078
5	104,203	0.745	0.269
6	63,917	0.893	0.662
7	44,893	1.039	0.775
8	33,603	1.203	0.862
9	19,898	1.441	1.000
10	25,571	1.869	1.000
11	11,569	2.210	1.000
12	3,835	2.863	1.000
13	2,058	3.375	1.000
14	696	4.374	1.000
15	225	7.997	1.000

The 1990 TAC of 53,000 t implies a fully recruited fishing mortality of 0.253. An $F_{0.1}$ catch in 1990 would result in landings of 43,000 t. In the context of multi-year advice, CAFSAC considered 3 options for 1991, 1992 and 1993. The options are presented below with the implied fishing mortality and catch.

	F(8+)					Catch('000 t)				
OPTION	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
1) 53,000 t in 1990; 50% rule in 1991; $F_{0.1}$ in 1992 and 1993	0.24	0.25	0.23	0.20	0.20	50	53	48	43	43
2) 53,000 t in 1990; 50% rule in 1991 in 1992 and 1993	0.24	0.25	0.23	0.21	0.20	50	53	48	46	43
3) 53,000 t in 1990; 1991-1993	0.24	0.25	0.25	0.26	0.27	50	53	53	53	53

CAFSAC noted that all options would result in a slight decrease in the 3+ biomass over the 1989 level. However, the estimate of recruitment of 104 million is small compared to year-class sizes observed since 1977 and the stock biomass is currently high. Therefore, CAFSAC concludes that a catch of 53,000 for 1991 to 1993 would result in a reasonable level of exploitation for this stock. However, as mentioned in the introduction, CAFSAC believes that the actual catches will either differ from those forecast or result in different fishing mortality being applied to the stock. CAFSAC will therefore closely monitor the fisheries and, should indicators suggest a change in TAC in either direction, advice to that effect will be promptly provided.

5. COD IN SUBDIVISION 4Vn (MAY-DECEMBER)

5.1. Description of the Fishery

The nominal catch for 1989 was 69 t over the 7,500 t TAC. Although there were overruns of allocations for the mobile and fixed gear < 45' early in the fishing year, shortfalls for most of the other allocation categories and a decision early in the season to manage allocations as a condition of the license resulted in a final catch essentially equal to the TAC.

There were reports from the fishermen of abundant early runs of "small" fish in the late autumn of 1989. The appearance of this run is usually taken to indicate the onset of the migration of 4T cod into Sydney Bight for the winter.

TACs and nominal catches ('000 t) are as follows (Fig. 5.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	14.0	12.0	12.0	9.0	7.5	7.5	7.5
Nominal catch	10.4	12.5	11.8	10.2	9.0	7.6	-

[1]Catches are preliminary

The 1981 to 1984 year-classes were almost equally represented (15-22%) in the longline catches, accounting for 77% of the numbers caught. The contribution of these year-classes to the otter trawl catches is exactly the same total percentage as for the longline catches but the contribution increases progressively from 9% for the 1981, 16% for the 1982, 22% for the 1983 and 30% for the 1984 year-classes. Patterns in the catch at age in 1989 were similar to those in previous years with the otter trawls concentrating on younger ages than the longlines. Decreases in average weights for ages 5-11 in 1989 over those observed for the same ages in 1988 were large. The average weight in the catch for all ages decreased from 1.97 kg in 1988 to 1.49 kg in 1989 with very little change in average age. The corresponding decrease in average length in the catch was from 65.3 cm to 60.7 cm. Fish of ages 8-11 in 1989 had the smallest average length at age for the period 1982-89. This decrease may be related to an influx of Division 4T cod.

Commercial catch rates

The catch rate series for longliners of tonnage class 2 and 3, and otter trawlers were analyzed in the last assessment of this stock and CAFSAC concluded that neither could be used as an index of abundance.

Research vessel survey data

The 1989 survey estimates of mean numbers and mean weight per tow indicated a small increase in overall abundance from 1988 (Fig. 5.2). The 1989 estimate mainly reflected the influence of two sets where large numbers of cod were caught. The annual estimates of abundance from this survey are quite variable but CAFSAC concluded that the overall lack of trend could be interpreted as relative stability since 1981. The 1981, 1982 and 1984 year-classes were the most abundant in the survey catches.

5.2. Assessment

The observation of significant decreases in size at age in 1989 from that observed in 1988 and the anecdotal information concerning the earlier appearance of the run of "small" fish suggests that cod from the 4T stock were in 4Vn earlier and possibly, in greater numbers than usual. CAFSAC concludes that the variability in the degree of mixing between the resident 4Vn cod stock and adjacent stocks makes it impossible to calibrate a virtual population analysis based assessment. The events of 1989 relating to the earlier incursion of the 4T stock into 4Vn make previous estimates of fishing mortality for this stock suspect if such events have occurred in the past.

5.3. Forecast

The information available on this stock indicates that on the average, catches of 10,000 t have been taken in 4Vn (May - December) since 1982 without any concurrent sustained decreases in the research survey index. The recent survey estimates (1982-89) are at a higher level than over the previous period of 1970-1981 when average catches were 8,000 t. Although, the fishing mortality has likely been above $F_{0.1}$ in recent years, the recent catches do not seem to be detrimental to the 4Vn resident cod stock given the survey results. In fact, if the interpretation of the research vessel surveys is correct, the stock has been relatively stable since 1982 with average catches of about 10,000 t. Catches between 7,500 t and 10,000 t are likely to be sustainable for at least the next three years.

6. COD IN SUBDIVISION 4Vs AND DIVISION 4W

6.1. Description of the Fishery

Catches of 4VsW cod ranged from 40,000 t to 80,000 t from 1958 to 1974 and then declined rapidly to a low of 10,000 t in 1977. With the extension of jurisdiction in 1977, the catches increased rapidly again and were at or above 50,000 t from 1980 to 1986. The TACs have been subsequently reduced and the catches have declined in recent years to 36,662 t in 1989. The TAC and nominal catches ('000 t) from 1984 to 1990 are (Fig. 6.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	55	55	48	44	38	35.2	35.2
Nominal catch	53	57	52	46	38	37	---

[1]Catches are preliminary

For the sixth consecutive year, 80% or more of the catch was taken in 4Vs. The split between gear sectors was slightly different from 1988 and 1987 with 70% taken by otter trawlers (down 5%) and 23% by longliners (up 4%). The remaining 7% of the catch was taken by seines and gillnets. All vessels less than 100 ft were under trip limits and by-catch regulation all year. For the first half of the year, the fishery was regulated by means of variation orders as was done in previous years, however after May, regulation was done by means of Conditions of Licence. The change in means of regulation has made it difficult to track the regulations under which the inshore vessels were operating throughout the remainder of the year. The offshore vessels greater than 100 ft operated under enterprise allocations and as such did not have trip limits imposed by the Department of Fisheries and Oceans. However company imposed trip limits and

other measures were in place throughout the year and were closely managed by the company.

The 1980 year-class was still a significant contributor to the catch (15% by weight) and was the largest year-class at age 9 in the catch at age. The 1983 year-class was the smallest catch at age 6 since 1978 although it was higher than projected. The catch of the 1986 year-class at age 3 was the largest observed at that age since the change in minimum mesh size implemented in 1983.

The weights at age in the commercial catch continued to decline relative to the previous year at most ages; however the research survey mean weights at age were higher or stable for most ages.

6.2. Abundance Indices

Commercial catch rates (Fig. 6.2)

Standardization of the commercial catch per unit of effort for otter trawlers using a multiplicative model indicated that it has declined by a factor of almost three since 1986. However, this decline may have been influenced by factors such as company imposed trip limits. The otter trawler catch has been dominated by tonnage class 5 trawlers since 1977. Since the advent of enterprise allocations in 1984 these vessels have not operated in the context of a competitive fishery. Trip limits have been used by National Sea Products (NSP) since 1984 and the limits have become more stringent in the past few years as their enterprise allocations have been reduced. Reports have indicated that National Sea Product's skippers are more concerned with obtaining the desired combination of species' catches on a trip and are therefore not trying to maximize catch rates as they used to.

Because of the way the commercial statistics on catch and effort are compiled, there is a likelihood that commercial catch per unit of effort is being underestimated. The International Observer Program (IOP) has collected set-by-set catch and effort data since its inception, although coverage was not adequate prior to 1982. The data were carefully selected such that only cod-directed sets were included in the analysis. A multiplicative model was used to standardize the observer catch per unit of effort from the tonnage class 5 otter trawler fleet. The catch rate thus obtained was considerably higher and showed a different trend than the one derived from the commercial statistics. CAFSAC concludes the commercial catch per unit of effort is not a reliable index of the abundance for 4VsW cod over the period 1970 to 1989, because among other factors, of changes in the way the fishery is prosecuted. CAFSAC will investigate further the potential usefulness of observer data to calculate an index of abundance for 4VsW cod.

Research vessel survey data (Fig. 6.3.)

The July stratified random trawl survey of the Scotian Shelf has been conducted annually since 1970. The estimates of abundance for 1970 are not utilized for this stock because of variations in gear and survey protocol. In addition the estimates were deemed inconsistent with the sequential population analysis estimates for 1970. Because of differences in age composition, stratified estimates of catch per tow at age were calculated for 4Vs and 4W separately and combined by weighting by stock area for the years 1971 to 1989. The age 4+ abundance has declined in both 1988 and 1989 although the total abundance has been stable. A survey has been conducted in March in the years 1979-1989 with the exception of 1985. The abundance index from the March 1990

survey is the second lowest of the series with only the 1979 value being lower. The eastern portion of Subdiv. 4Vs could not be surveyed in March 1990 because of ice coverage, but in the surveyed areas, cod appeared concentrated in the Sable Island Gully. The 1986 and 1987 year-classes were the most abundant, representing 66% of the total. The July survey index increased marginally from 1986 to 1990. Similar to the March survey, the 1986 and 1987 year-classes were the most abundant. The 1987 year-class was the largest at age 3 since the 1980 year-class and the 1986 year-class appears of a strength comparable to the strong 1981 year-class at the same age.

6.3. Assessment

The sequential population analysis was calibrated with ADAPT using the two surveys as indices of abundance. In an attempt to better match SPA and the survey, catch at age was calculated on a semi-annual basis. The July index was compared to July 1 population numbers and the March index with March 1 estimated numbers.

Fishing mortality and stock abundance

The stock abundance expressed in numbers or biomass (Fig. 6.4), increased from the mid-1970s to the mid-1980s, reflecting the decreased exploitation and recruitment of the strong 1978-80 year-classes. The subsequent decline in abundance resulted from the recruitment of the three poorest year-classes (1983-85) on record. The mean (ages 7-9) fully recruited fishing mortality (Fig. 6.5) was 0.38 in 1989, almost twice the $F_{0.1}$ level of 0.2, and has varied around the 1989 value since 1980. Recent fishing mortalities, however are well below those of the late 1960s and 1970s. The assessment shows the 1979 and 1980 year-classes as the strongest in the 1970 to 1990 period and the 1983 year-class as the smallest (Fig. 6.6). The 1984 and 1985 year-classes also appear small.

The estimated decline in abundance is corroborated by industry reports, particularly for the fixed gear, which indicate that cod have been scarce in 4VsW during the 1990 fishery. The 1990 fixed gear allocations will probably not be reached and there were a few reports of abundant small fish being discarded by the mobile fleet. These two observations are consistent with the present estimates of the weak 1983-85 year-classes which would be contributing to the fixed gear catches and the strong 1986 and 1987 year-classes which would start to recruit to the mobile gear fisheries.

6.4. Forecast

Catch projections for 1991 were made using the input data in the table below:

Age	January 1990 Population numbers ('000)	Average Weight (kg)	Partial recruitment
1	77,000	.067	.0001
2	63,042	.279	.001
3	60,323	.593	.01
4	48,787	.949	.16
5	20,714	1.289	.53
6	15,098	1.688	0.81
7	6,944	2.197	1.00
8	10,924	2.622	1.00
9	2,170	3.317	1.00
10	2,251	4.353	1.00
11	1,167	5.502	1.00
12	607	6.199	1.00
13	278	8.054	1.00
14	70	11.809	1.00
15	49	12.000	1.00

If the 35,200 t 1990 TAC is taken, it will induce a fishing mortality of about F=0.40, twice the $F_{0.1}$=0.20 and in fact equal to F_{max}. The projected 1991 catch at $F_{0.1}$=0.20 would be 21,000 t. The $F_{0.1}$, 50% rule and constant catch options are summarized in the text table below:

OPTIONS	F 1990	F 1991	Catch ('000 t) 1990	Catch ('000 t) 1991
1) $F_{0.1}$ in 1991;	.39	.20	35.2	20.7
2) 50% rule (0.3) in 1991;	.39	.30	35.2	30.0
3) Constant catch at 35,200 t in 1991;	.39	.36	35.2	35.2

The 1986 and 1987 year-classes are estimated to be above average but their sizes are not precisely estimated. The accumulation of another year's data will allow refinement of the estimates of these two year-classes. CAFSAC is therefore providing catch projections for 1991 only. However, should it be considered desirable to include 4VsW cod in a multi-year management plan, CAFSAC believes that the current TAC of 35,200 t applied for three years would not be detrimental to the resource.

Should the 1990 fixed gear allocations not be reached, as suggested in Section 6.3, CAFSAC believes that uncaught portions should not be transferred to the mobile gear sectors. If transfers occur, they should be made at a substantial discount because any transfers from the fixed gear will reduce the future benefits to the fixed gear from the 1986-1987 year-classes. CAFSAC warns that if rumoured discards did happen and continue to happen, the anticipated stock increases from the 1986 and 1987 year-classes may not accrue or may be smaller than would otherwise be expected.

7. COD IN DIVISION 4X

7.1. Description of the Fishery

Nominal catches of 4X cod have remained at approximately 20,000 t since 1985. Under joint cod/haddock/pollock (CHP) management, the 1989 nominal catch of 19,585 t substantially exceeded the TAC of 12,000 t. Recent TACs and nominal catches ('000 t) are given below (Fig. 7.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	30	30	20	17.5	14	12.5[2]	22
Nominal catch	25	21	20	19	19	20	---

[1]Catches are preliminary
[2]Managed under CHP regulation

The nominal catches of both fixed and mobile gear less than 65' exceeded their allocations, even though the fishery was closed to all C1 (mobile gear less than 45') specialists and C2 (mobile gear 45-65') vessels midway through the year. C1 generalists were permitted to fish on a by-catch or trip limit basis for the remainder of the year. Misreporting by the mobile gear less than 65' fleet was believed to be minimal in 1989 in comparison to the high misreporting of 1987 and 1988.

As in recent years, catches were split relatively evenly between mobile gear less than 65' and small longliners of tonnage class 1 and 2. Gillnets accounted for an additional 1,500 t of catch.

Calculation of catch numbers at age was based on samples collected from otter trawl, longline and gillnet catches. Fish of ages 3 and 4 (1986 & 1985 year-classes) made up 74% of the catch numbers and 63% of the catch weight. A comparison of the 1989 catch at age with that predicted for 1989 indicated reasonably good agreement, although the size of the 1985 year-class (age 4) was slightly underestimated. No trends in mean weights at age in the catch have been noted in the past 15 years.

7.2. Abundance Indices

Commercial catch rates

Misreporting, fishery restrictions (trip limits), and low return rate of logbooks suggest that commercial catch per unit of effort is not a reliable indicator of abundance for this stock.

Research vessel survey data (Fig. 7.2)

Survey numbers and biomass for ages 3-7 have remained relatively stable since 1970, although both declined between 1984-87. The 1988 survey appears to be anomalously high with respect to all ages. The 1985 year-class has appeared strong in the last two surveys, the 1987 year-class may also be stronger than average. Conversely, the 1984 year-class has been consistently weak.

The distribution of cod in the surveys from 1970 to 1988 indicate that most are concentrated near the mouth of the Bay of Fundy (on the eastern side) and on the offshore banks. In 1989, the abundance was also higher on the western side

of the Bay of Fundy. Cod greater than 50 cm were more widely distributed than the smaller cod (less than 43 cm) and appeared to be equally abundant in each of the above two regions. Small cod were more abundant in the Bay of Fundy than on the offshore banks.

7.3. Assessment

The sequential population analysis was calibrated with ADAPT using the research vessel survey as an index of abundance.

Despite the early closure of the 1989 fishery, fishing mortality has remained high on this stock. The 1989 estimate of F=0.36 is the lowest value in 13 years, and well below the long-term mean of 0.55 (Fig. 7.3). Nevertheless, biomass is increasing rapidly as the very strong 1985 year-class moves through the fishery (Fig. 7.4). The influence of the very weak 1984 year-class has now largely dissipated. The 1984 and the 1985 year-classes make up the weakest and the strongest year-classes, respectively, in 42 years (Fig. 7.5). Despite some uncertainty concerning the absolute strength of the 1985 year-class, its influence is likely to be felt until 1992. The strength of the 1987 year-class remains uncertain, but preliminary results suggest that it is above average. If the strength of the 1987 year-class in 4X parallels that of Georges Bank cod in the same way it did for the 1985 year-class, the outlook for upcoming recruitment is positive.

The results of the 1990 survey are consistent with this assessment. The 1985 year-class is the largest at age 5 since the survey began, while the 1987 year-class is the second largest. There are no indications that the 1990 survey should be considered anomalous; all strata were sampled, no one stratum contributed unduly to the total, and the 1984 year-class is small as expected.

Stock status as indicated by this assessment differs substantially from that of last year. Three factors contributed to the substantial change in perception. First, the strength of the 1985 year-class was underestimated last year, in part because fish of age 3 were not included in the calibration. Second, despite a fishing mortality of F=0.36, the 1989 fishing mortality is about one third less than that of previous years, largely due to the early closure of the fishery. And finally, the rapid growth and early age of recruitment in the fishery magnifies the influence of recruiting year-classes, both with respect to catch composition and population biomass. In the absence of predictions of upcoming recruitment, this problem is likely to continue, making it difficult to react to shifts in population sizes until after they have become pronounced. As an example, during the three years it generally takes to feel confident of a trend in the data, a recruiting year-class of 4X cod will go from a partial recruitment of 10% to fully recruited.

7.4. Forecast

CAFSAC estimates that the fishable biomass of 4X cod will remain relatively high through 1991 as the strong 1985 year-class moves through the fishery. Subsequent abundance will depend heavily on the strength of the incoming recruitment.

The following parameters were used in catch projections:

Age	1989 Population ('000)	Weight at age (kg)	Partial Recruitment
1	19,904[1]	0.42	0.001
2	15,937	0.89	0.067
3	18,717	1.42	0.379
4	26,569	2.00	0.704
5	2,795	2.73	1.000
6	2,238	3.92	1.000
7	344	5.25	1.000
8	300	7.78	1.000
9	196	9.49	1.000
10	62	11.00	1.000
11	26	12.79	1.000
12	21	15.20	1.000
13	3	15.40	1.000

[1]Geometric mean age 1 recruitment, 1948-88

Mean weight and partial recruitment were the mean from 1983-89 and 1983-88 respectively.

Assuming that the 1990 catch will be about 20,000 t, the 1991 catch would be in the order of 19-20,000 t if the 50% rule is applied. Although recruitment for this cod stock occurs too rapidly to include 4X cod in a three-year TAC based management plan, recent TACs appear to have had little influence on the actual tonnage of cod harvested. Therefore, CAFSAC believes that the 1991 to 1993 TACs could be set at about 20,000 t.

8. COD IN UNIT AREAS 5Zj and 5Zm

8.1. Description of the Fishery

Until 1989, the management units used by Canada for cod in the Gulf of Maine area were those established by ICNAF in the early 1960s. In 1984 the maritime boundary between Canada and the United States was defined and it divided the former management units. In recognition of the divided jurisdiction, a review was undertaken to identify management units which reflected current stock structure and fisheries while allowing Canada to pursue conservation objectives for the long-term benefits of the Canadian fishery. For cod, given practical considerations related to the availability of statistics, the review concluded that cod in unit areas 5Zj and 5Zm could be treated as a distinct unit.

Prior to 1978 when Canada and USA had both extended their jurisdiction on fisheries to 200 miles, there were substantial catches reported by foreign countries, primarily the USSR and Portugal from 5Ze. Since 1978, Canada and the USA are the only countries fishing in 5Zj,m. No TAC has been set for this new management unit and recent landings for Canada and the USA are given

below and in Fig. 8.1. ('000 t):

	1984	1985	1986	1987	1988	1989
Canada	6	10	9	12	12	8
USA	11	7	6	5	8	7
Total	17	17	15	17	20[1]	15[1]

[1]Catches are preliminary

Statistics for this new management unit have been calculated for 1978 to the present. Over this period, the maximum catch of 26,000 t occurred in 1982 and the smallest catch was 12,000 t in 1979. Catches have averaged 17,000 t. Catches by both Canada and the USA peak in the summer although catches do occur throughout the year. The USA fishery is almost exclusively an otter trawl fishery while both fixed and mobile gears are involved in the Canadian fishery. The Canadian otter trawler fleet is restricted to a June 1 opening every year.

Total catches in 1989 were about 5,000 t less than 1988 catches primarily because of the early closure of the Canadian otter trawler fishery as a result of the 4X+5 CHP (cod-haddock-pollock) Management Plan. This early closure caused Canadian mobile gear catches to account for only 25% of the Canadian total compared with its usual 60-70% during 1978-1988.

The 1990 Canadian cod fishery on Georges Bank is being managed without TAC. For the otter trawlers control is through a limited number of fishing trips coupled with trip limits and compulsory use of square mesh trawls. Based on reported catches to mid-September, total catches are expected to increase to about 22,000 t for the year with 15,000 t for Canada.

Poor sampling and suspected discarding make it difficult to reliably estimate catch at age for years prior to 1978. Therefore, catch at age was calculated since 1978, using appropriate Canadian and USA sampling of catches and age determinations. As in recent years, the 1985 year-class (40% in numbers) was the most abundant in the 1989 catches. The 1987 year-class was the second most abundant accounting for 27% of the catch numbers. The 1986 year-class made a larger contribution than was expected from the 1988 catches and survey indices. Contrary to most other cod stocks off the Canadian Atlantic, 5Zj,m cod does not exhibit annual trends in size at age.

8.2. Abundance Indices

Although commercial catch per unit of effort for both Canada and the USA generally show similar trends with a general decline since 1978, several deficiencies prevent their usage as indices of relative change in abundance.

- The USA catch per unit of effort are not available for 1988-1989.
- The composition of the Canadian otter trawler fleet has changed from primarily large vessels prior to 1982-83 to tonnage class 1-3 since then.
- Trip limits and misreporting combined with a small logbook coverage further compromise the usefulness of the Canadian catch per unit of effort otter trawl data as an index of abundance.

The USA has surveyed the 5Zj,m area in both the spring since 1968 and autumn since 1963 and Canada began a spring survey in 1986. For all three surveys, there are strata which are not entirely within the 5Zj,m area and appropriate adjustments have been made to take this into account.

The surveys were examined for anomalous tows which may have undue influence on the results of the assessment. One such tow was identified for the spring

1982 survey, but its influence is expected to be small. The Canadian 1990 survey abundance estimate is the highest of the five-year series but cod appear to have been more available to the survey trawl in that year compared with previous years. This hypothesis is based on the observation that the abundance of all age-groups increased between 1989 and 1990.

Because the autumn survey results are taken as indices of the following January abundance and the spring survey results are used for the previous January, there are three indices of the age specific January 1990 abundance. All three surveys show similar trends in year-class abundance, with the 1983, 1985 and 1987 year-classes being stronger than average and therefore causing a general increase in abundance since 1987 (Fig. 8.2).

8.3. Assessment

Population at ages 1 to 4 and 5+ in 1990 were estimated by calibrating SPA using ADAPT and the three survey indices of abundance. To assess the influence of each survey, additional analyses using combinations of the three survey indices as well as each survey index independently were made. The results suggest that all three survey indices should be included in the assessment.

The results of the assessment indicate that the 1985 year-class was the largest observed with about 30 million age 1 cod (Fig. 8.3). The 1980, 1983 and 1987 year-classes also appear to be well above the average of the 1977 to 1988 year-classes. The 1989 year-class, although not precisely estimated would also be stronger than average. Mid-year age 3 and older biomass in 1990 is about 69,000 t (Fig. 8.4) well above the 1978-1990 average of 49,000 t. Fishing mortality (Fig. 8.5) is estimated to have been F=0.29 in 1989, the lowest since 1978, mostly because of the early closure of the Canadian otter trawl fishery.

To investigate whether there were anomalies in the assessment which resulted from assessing 5Zj,m as a separate entity, the results were compared with those of a 5Ze assessment. The trends in biomass and fishing mortality were similar between the total 5Ze assessment and the 5Zj,m assessment therefore suggesting that no anomalies were introduced in the assessment although there were indications of higher exploitation rates outside the 5Zj,m area.

8.4. Forecast

The following input data were used to calculate catch projections.

Age	1990 Beginning of Year Population Numbers ('000s)	Mean Weight (kg)	Partial Recruitment
1	9,959	0.696	0.004
2	6,978	1.391	0.299
3	9,659	2.249	1.000
4	1,611	3.579	1.000
5	6,465	5.012	1.000
6	556	6.448	1.000
7	647	8.333	1.000
8	78	10.340	1.000
9	133	10.948	1.000

As indicated earlier, the results of the assessment suggested that the 1989 year-class was stronger than average. However, because the estimate is imprecise, the 1989 year-class was assumed to be equal to the geometric mean for the 1977 to 1988 year-classes.

If the expected catches of 22,000 t are taken in 1990, the fishing mortality will be about F=0.39, well above $F_{0.1}$ but similar to values in recent years. Age 3 and older biomass would decline by about 10,000 t to 59,000 t in January 1991.

CAFSAC is providing catch projections at two fishing mortalities for 1991, $F_{0.1}$, F at the 50% rule and the 1991 catch equal to the expected 1990 catch. These catch projections are for both the USA and Canadian fleets. The results are given in the text table below:

Option	F(3+)		Catch('000t)	
	1990	1991	1990	1991
1) 22,000 t in 1990, $F_{0.1}$ in 1991	.39	.20	22	11
2) 22,000 t in 1990, 50% rule in 1991;	.39	.30	22	16
3) 22,000 t in 1990 and 1991 F=0.43	.39	.43	22	22

CAFSAC believes that fishing mortality should not be allowed to increase above estimated 1990 values. This would imply catches of about 20,000 t in 1991.

Cod in 5Zj,m are fully recruited at age 3 which implies that catch forecasts are heavily dependent on estimates of or assumptions about incoming recruitment. Although the 1985 and 1987 year-classes will likely continue to contribute substantially to the catches in 1991, it is not possible to precisely forecast catches in the context of a multi-year management plan because recruitment is variable and unpredictable and will have a large influence on actual catches.

Studies are underway to estimate the relative biomasses on each side of the international boundary in 5Zj,m. When these studies are completed, it will be possible to advise on the proportion of total biomass in 5Zj,m which would be available to the Canadian fleet.

9. HADDOCK IN DIVISIONS 4T, 4V AND 4W

9.1. Description of the Fishery

From 1950 to 1969, catches averaged about 26,000 t while the fishery became almost non-existent in the early 1970s. From 1970 to 1979, catches averaged about 5,000 t. In the 1980s, catches varied between 4,000 and 22,000 t. The nominal catches for 1987 through 1989 have been taken exclusively as by-catch in other groundfish fisheries operating in Divisions 4T, 4V, and 4W, and totalled 7,750 t in 1989. This represents a 16% overrun of the advised TAC of 6,700 t for 1989.

Recent TACs and catches ('000 t) are given below (Fig. 9.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	15	15	17	-[2]	-[2]	6.7	6.0
Nominal catch	8	11	17	4.0	4.5	7.8	-

[1]Catches are preliminary
[2]No TAC - by-catch only

In 1986, the combination of poor recruitment over several successive years (1983-1985), low spawning stock biomass, and the concentration of the fishery on the only two remaining year-classes of any appreciable size (that of 1981 and 1982), resulted in the restriction of the fishery to by-catches. In 1987 the maximum by-catch was 5%; this was increased to 10% in 1988, and 15% in 1989. Management also imposed a year-round ban on mobile gear fisheries in areas identified as nursery grounds (mainly Western and Emerald banks). These nursery ground closures remain in effect to the present.

Until 1984, most of the catch from this stock was taken in Division 4W by large otter trawlers (tonnage class 4 and 5) fishing in the spring. From 1984 to 1986 Subdivision 4Vs accounted for an increasing proportion of the total catch. Since the restriction of the fishery in 1987, mobile gear landings in 4Vs have about doubled while fixed gear landings in 4W have increased approximately four-fold. During this period otter trawls have landed between 52 and 56% of the landings each year while longliners have increased their share from 19 to 29% mainly as a result of increased catches in 4W. Longline landings in 4W in 1989 exceed longline landings observed there in 1986, prior to the restriction of the fishery. Seine catches have declined from 15 to 6% of the annual total.

In 1989 there were some indications that haddock reported as caught in 4W may actually have been caught in 4X. This was the result of an early closure of the 4X fishery prompting some fishermen to obtain conditions of licence allowing them access to 4W, but continuing to fish in 4X while reporting their catches from 4W. Early in 1990 there have also been reports of haddock caught in Subdivision 4Vs being reported from Subarea 3. None of these reports indicate the quantities of fish involved.

Catch and weight at age

The age compositions of the 1989 foreign and Canadian catches were estimated in a manner consistent with recent practices. The Canadian catch at age in 1989 was composed primarily of the 1984 and 1985 year-classes (33.4% and 25.1% by numbers respectively) which made up 58.5% of the total numbers caught. By weight these year-classes accounted for 74.7% of the total catch (1984 = 47.6% and 1985 = 27.2%).

The foreign fishery in 1989 caught 680 t, approximately twice the catch in 1988. This catch contained large numbers of fish at age 1 and 2. Since this fishery is restricted to operate seaward of the small mesh gear line, the catch of small fish is not related to a change in location of the fishery. Furthermore, catches of haddock are usually avoided since the entire silver hake fishery is restricted to a 1% aggregate by-catch and the fishery is closed once this limit has been reached. This indicates that these catches may have been unavoidable as a result of the overall abundance of the 1987 and 1988 year-classes. The 1988 year-class accounted for 20% of the total 1989 catch by numbers and 1.6% of the catch by weight, while the 1987 year-class represented 9% by numbers and 2.8% by weight.

A comparison of the observed and projected catch at age for 1989 reveals discrepancies at ages 1 and 2 as a result of the small mesh gear catches. Catches at ages 3 to 5 are in relatively close agreement, while those at ages 6 and 7

show that significantly fewer fish were caught than were projected from last years assessment.

The maximum age in the catch has diminished from age 11 in 1984 to age 9 in 1989.

9.2. Abundance Indices

Commercial catch rates

The by-catch nature of this fishery since 1987 does not allow for a comparison of present catch rates with those of earlier years from directed fisheries.

Research vessel survey data

The research survey catch rates from 1970 to 1988 show a decline in overall abundance from 1983 to 1987 with a subsequent increase in 1988 and a slight decline to 1989 (Fig. 9.2). The sharp increase in 1988 is due mainly to a large catch of 2 year old fish (the 1986 year-class) in a single stratum. The 1989 estimate of this year-class shows it to be much smaller. The 1989 catch rate is still higher than that of 1987. The estimate of the 1988 year-class at age 1 shows an abundance similar to that of the abundant 1980 or 1981 year-classes and appears to be relatively well estimated.

In an attempt to better understand the dynamic of this haddock stock, CAFSAC undertook a detailed analysis of the geographical distribution of survey catches. Division 4W has traditionally been the centre of distribution of this resource as indicated by the significantly higher catch per set observed (Fig. 9.3). Age 0 fish have been observed in 13 of the past 20 years while age 1 fish are present in all years. Catches of fish aged 0-3 increased after 1977, following the exclusion of the foreign fleet. The peak in recent catch rates occurred in 1983 because of the presence of the large 1980-1982 year-classes. Catch rates at these younger ages declined from 1983 to 1987 as a result of lower recruitment and have shown an unsteady increase over the past two years. Catch rates at ages 4+, which peaked in 1984 continue to decline to the present.

The survey age composition in Subdivision 4Vn is dominated by ages 4+ (Fig. 9.4). Age 0 fish have not been observed in the survey of this area, while fish at ages 1-3 have occurred in less than 50% of the surveys. Catch rates show clearly the influx and subsequent decline of the 1980-1982 year-classes beginning in 1984. Since these three large year-classes there has been no significant recruitment to this part of the population. It should be noted that catch rates in 4Vn have been higher since the influx of the 1977 year-class in 1981 than for the preceding ten years. This year-class would have been the first one to benefit from the exclusion of the foreign fleets from the Scotian Shelf.

Subdivision 4Vs shows the presence of age 0 fish in a single year since 1970 when some fish belonging to the large 1982 cohort were found there. Age 1 fish have been observed in 16 of the past 20 years. Catch rates increased rapidly in 1982 as a result of the incursion of fish belonging mainly to the 1981 year-class (Fig. 9.5). These high catch rates have declined to pre-1982 values by 1989. As was the case in 4Vn, the presence of post 1977 year-classes became evident in the early 1980s. Since 1987, catch rates at ages 4+ have declined rapidly to the present.

The maximum age observed in the survey has been declining since the early 1980s. In 1989 the oldest fish in the survey were age 7 while in the early 1980s fish at ages 10 and 11 were observed with some as old as age 15.

Closed Area

A haddock nursery area has been closed year-round to mobile gear fisheries since 1987. The objective of the closed area is to protect incoming recruits from fishing to allow this stock to rebuild. Areas identified for closure were those which showed persistent and relatively large aggregations of young fish in the July survey series. The area encompasses all of Western and Emerald banks and extends seaward to the small mesh gear line. Fixed gear fisheries are permitted to fish inside this closed area (subject to all other regulations in effect) since these gears catch relatively older fish than mobile gear.

It is too early to establish a direct cause and effect relationship between the closed area and a subsequent change in resource status. However, in the surveys, catch rates at ages 1 and 2 of fish belonging to the 1987 and 1988 year-classes were higher than the 1983 through 1986 year-classes at these ages. These two year-classes are the first which may have benefitted from the effects of the closed area.

An age structured analysis of the spatial distribution of haddock shows that the closed area may also be the center of distribution of all age classes from age 0 to 8. This is based on the observation that the mean catch per tow at age in this area is above the overall average catch per tow at age more frequently than elsewhere in the stock area for all of these ages. The overall average catch per tow at age was calculated across all strata and years of the survey. These analyses also indicated that haddock become more widely distributed with age and abundance. Abundant year-classes were also found to be more widely distributed than small year-classes. An examination of the 1987 and 1988 year-classes at ages 1 and 2 show them to be more widely distributed than those of 1983 through 1986. These results are preliminary and the conclusions may apply only to the summer period. A similar analysis for 4X haddock suggests that the centres of distribution are persistent over seasons.

9.3. Assessment

As was the case in last year's assessment, CAFSAC was unable to reliably calibrate sequential population analysis. Several attempts have been made using either whole or half year data and examining the impact of using sequentially longer time series. In all cases, the estimated fishing mortality for a given year increased when other years were added to the data series. These results cast doubts on the validity of the estimated fishing mortality in the current year, whatever the current year is.

The data show clearly however that very few haddock survive to become older than age 4. There are indications that haddock in this area are dying faster than can be accounted for by catches. Several factors could account for or contribute to this phenomenon:

- larger, older haddock could migrate out of the stock area; and
- larger, older haddock could experience higher natural mortality.

Neither tagging results nor current knowledge of haddock biology support these two possibilities but they cannot be ruled out. A third hypothesis, which follows, is not easily verified:

- greater numbers of haddock are caught than are reported because of discarding, misreporting or non-reporting.

Fishing mortality and stock abundance

Total mortalities estimated from survey catch rates at age indicate that fishing mortality in recent years is well above $F_{0.1}$=0.25 (Fig. 9.6) and has been

increasing since the early to mid-1980s. Given the variability in survey catch rates, these estimates while indicating the overall trend in F, should be viewed as approximate. The mean weight of a fish in the catch in 1989 also points to an exploitation rate well in excess of $F_{0.1}$ (Fig. 9.7).

Recruitment

Results of the 1989 July research survey indicate that the 1988 year-class appears to be relatively strong. Its wide distribution over the stock area is similar to that of previously observed large year-classes. The 1987 year-class does not appear to be as large as that of 1988 but may be larger than the 1983 through 1986 year-classes. The 1987 and 1988 year-classes also appeared strong in the small mesh gear fishery.

9.4. Forecast

Several observations suggest that this stock has and still is being heavily exploited. Survival rates estimated from surveys are low and the average weight in the commercial catch also suggests high exploitation, consistent with the reduction in age-span seen in the survey. CAFSAC concludes that present regulations do not appear to have decreased exploitation. A reduction in mobile gear by-catch from 15 to 5% would be helpful in that regard. The present closed area should be maintained year-round to protect the 1987-88 year-classes from fishery related mortality. Considering the low abundance of 4TVW haddock and the fact that any strong incoming year-class should be protected, CAFSAC suggests that the proposed management measures be applied during 1991 to 1993. CAFSAC will monitor the fisheries closely and should events warrant a change in management measures, advice to that effect will be promptly provided.

10. HADDOCK IN DIVISION 4X

10.1. Description of the Fishery

The long-term (1930-1983) reported annual landings have averaged about 20,000 t. This level was surpassed during the mid to late 1960s and again during the 1980s when landings peaked above 30,000 t. High catches in the 1960s were based mainly on the strong 1963 year-class, and resulted in high exploitation rates and low spawning stock biomass. For these reasons, quota regulation and spawning area closure were imposed in 1970 as recommended by ICNAF. The 1970 TAC was set at 18,000 t, but was dropped to 9,000 t in 1972 with ICNAF further recommending closure of the fishery in 1974. Catches and TACs subsequently increased to a peak in 1981-82. Catches were lower than TACs during 1982-84. Total catch has been below the long-term average since 1984 with restrictive quotas in place since 1985.

There has been a general tendency over time for finer and finer subdivision of the TAC by fleet sector and season. During 1982-87, the fishery was regulated on the basis of five gear sectors: 1) mobile gear less than 65 ft; 2) mobile gear 65-100 ft; 3) mobile gear greater than 100 ft; 4) fixed gear less than 65 ft; and 5) fixed gear 65-100 ft. In 1988, the less than 65 ft gear sectors were further subdivided into less than and greater than 45 ft (ie. fixed gear less than 45 feet (A1) and more than 45 feet (A2) and mobile gear tonnage class 1 and 2). In 1989, mobile gear less than 45 ft (tonnage class 1) were further split into generalists and specialists. These fine-scale allocations resulted in significant enforcement problems. In an attempt to resolve catch reporting by species, an aggregate cod/haddock/pollock (CHP) quota system was implemented in 1989 for the mobile gear fleet less than 65 feet. In 1986, the allocation to the mobile gear was subdivided into three 4-month periods to extend the fishery throughout the year. This continued until 1989 at which time the mobile gear sector (tonnage class 1 specialists and tonnage class 2), in deciding to forego the four-month allocation system, exceeded their total CHP allocation and were shut down by the

end of June. The fixed gear sectors operated until early October at which time they went on by-catch status. In 1989, mobile gear less than 45 ft (tonnage class 1) caught 150% of their haddock allocation, mobile gear 45-65 ft (tonnage class 2) caught 130% of their haddock allocation and fixed gear less than 65 ft caught 187% of their haddock allocation. Landings by vessels greater than 65 ft were approximately 65 t.

Recent nominal catches, and TACs ('000s t) are (Fig. 10.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	32.0	15.0	15.0	15.0	12.4	4.6	4.6
Nominal catch	19.6	14.9	15.0	13.6	11.0	6.7	-

[1]Catches are preliminary

Discussions with industry representatives have indicated that substantial misreporting occurred during 1985-88. This was further corroborated by examination of anecdotal information which showed that misreporting occurred anytime in the past when quotas have been restrictive. However, it is not possible to quantify the level. This information indicated that in 1989 misreporting was generally low compared to previous years since the fishery was initially unrestricted during that period under the CHP quota system.

Catch and weight at age

Sampling of the fishery during 1989 was adequate to construct the catch at age, which was done following previous practices. As in previous years, no adjustments were possible to the total landings to account for misreporting.

In recent years, there has been a tendency for the landings to be dominated by fewer and fewer age groups. In 1982-83, five age groups (3-7) each contributed over 10% by weight to the total yield. In the following two years, four age groups dominated. During 1986-89, only three age groups have contributed significantly to the annual landings. Since 1985, older fish have become relatively rare in the catch at age and this is a sign of poor survival and the general trend in recent years is consistent with decreased abundance.

10.2. Abundance Indices

Commercial catch rates

Because of misreporting, the commercial catch per unit of effort is not considered to be a reliable index of haddock abundance in NAFO Division 4X.

Research vessel survey data

The July groundfish research survey on the Scotian Shelf from 1970-89 was used to evaluate the status of the resource. The arithmetic mean catch rates from 1970-89 for all age groups combined exhibit large inter-annual variability. Trends in weight per tow paralleled catch in numbers per tow, except for the last three years where biomass seemed to decline faster which is an indication of a preponderance of smaller fish (Fig. 10.2, 10.3). In general, total abundance was low during the early 1970s and high during the early-mid-1980s. Biomass dropped sharply during 1985-1988 and has remained low in 1989. There has also been a reduction in recent years in the number of ages seen in the survey, a trend consistent with that observed in the commercial fishery. Abundance of the 1985 and 1986 year-classes appear particularly low, possibly equalling the size of the 1970 year-class, which was the lowest on record. The abundance of the 1987 year-class at age 2 in 1989 is encouraging, and parallels a strong 1987 year-class on Georges Bank.

10.3. Assessment

Estimates of survival from the research surveys are low for fish fully recruited to the survey (ages 5 to 8). CAFSAC was unable to calibrate the sequential population analysis largely because of the poor quality of the input data. The attempts made indicated that, similar to 4TVW haddock, the estimated fishing mortalities for a given year increased as other years were added to the data series. Other problems encountered were a steady increase in availability to the survey with age and the changes in reporting practices.

The inconsistencies encountered when attempting to calibrate the sequential population analysis suggest that fish are dying faster than can be accounted for by catch. Several factors could account for or contribute to this phenomenon:

- larger, older haddock could migrate out of the stock area;
- and larger, older haddock could experience higher natural mortality.

Neither tagging results nor current knowledge of haddock biology support these two possibilities but they cannot be ruled out. A third hypothesis, which follows is not easily verified:

- greater numbers of haddock are caught than are reported because of discarding, misreporting or non-reporting.

Despite not being able to calibrate sequential population analysis, there are clear signs that the stock is experiencing very high fishing mortalities as shown by the reduction in the age range in the commercial catch and low survival in the surveys.

10.4 Forecast

CAFSAC believes that this assessment shows that there has been no increase in abundance compared with the previous assessment and stock recovery is very unlikely with present catches. Considering the low biomass of 4X haddock and the fact that any incoming year-class should be protected, CAFSAC suggests that there be no directed fishery and that by-catch regulation be applied for 1991-1993. These by-catches should be kept to the lowest possible level. CAFSAC will monitor the stock closely and should stock increases allow for a directed fishery, advice to that effect will be promptly provided.

11. HADDOCK IN UNIT AREAS 5Zj and 5Zm

11.1. Description of the Fishery

Until 1989, the management units used by Canada for haddock in the Gulf of Maine area were those established by ICNAF in the early 1960s. In 1984 the maritime boundary between Canada and the United States was defined and it split the former management units. In recognition of the divided jurisdiction, a review was undertaken to identify management units which reflected current stock structure and fisheries while allowing Canada to pursue conservation objectives for the long-term benefits of the Canadian fishery. For haddock, given practical considerations related to the availability of statistics, the review concluded that haddock in unit areas 5Zj and 5Zm could be treated as a distinct unit.

The haddock on Georges Bank have supported an important commercial fishery since the early 1920s. Before the 200 mile limit was imposed in 1977 there was a strong foreign presence with many countries fishing small mesh directed at species other than haddock. However, since 1977 only Canada and the USA have had

fisheries on Georges Bank, with each being restricted to their respective side of the maritime boundary since it was established in 1984.

High catches were taken in the mid-1960s (roughly 60,000 t) from 5Zj,m which exploited the exceptional 1963 year-class. Since then catches declined to a low of 2,400 t in 1976. Catches climbed to 19,000 t in 1980 and have declined to 3,800 t in 1989 when the fishery was closed to trawlers after only a few weeks. Although historically 5Zj and 5Zm have contributed about 40% of the total catch from Georges Bank, in recent years almost all of the haddock catch has been taken in these two unit areas.

The USA fishery has existed since the early 1900s and has been predominantly a trawler fishery for groundfish, haddock being one of the more important species. In the past the fishery has been fairly evenly distributed throughout the year but in recent years it has been concentrated during the first half of the year. The USA catch in 5Zj,m dropped to a record low of 787 t in 1989 which reflects the absence of a directed commercial fishery for haddock.

The Canadian fishery did not start making significant catches until the mid 1960s. It is mainly an otter trawl fishery but has a substantial longline component. This fishery occurs from mid-summer to early fall because of the June opening of the trawler season. Until 1984 tonnage class 5 dominated the fishery but since then tonnage classes 2 and 3 have been predominant.

The Canadian quota in 1987 and 1988 was set at 8,300 t. A combined cod-haddock-pollock quota was used for 4X-5Zc in 1989. The Canadian otter trawl fishery in that year was stopped after only a few weeks of activity when quota limits were reached. Trip limits and a limit on the number of trips have been employed during 1990 without any quota. As well, in July tonnage class 1-3 vessels were required to change to square mesh gear and to carry a DFO observer. Anecdotal information from the 1990 fishery has reports of fairly good catches of large haddock. Data from the observers comparing square and diamond mesh indicate low haddock discard rates for both gear: 1.36% for diamond vs. 0.08% for square mesh. A similar size distribution was caught by 130 mm diamond and 130 mm square mesh nets while the 140 mm square mesh indicates less retention of small haddock than the 140 mm diamond-mesh.

Since this is a new management unit, there are no past TACs. Recent catches ('000 t) are as follows (Fig. 11.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]
Nominal catch						
Canada	1.5	3.5	3.4	4.7	4.0	3.1
USA	5.1	1.7	2.2	1.4	1.7	0.8
Total	6.6	5.2	5.6	6.1	5.7	3.8

[1]Catches are preliminary

Catch at age was calculated, starting in 1969, using appropriate Canadian, USA and foreign sampling of catches and age determinations. Discards were estimated from interviews and, based on an atlas of USSR fishing activity, 40% of the small mesh landings in 5Z were assumed to have come from 5Zj,m.

In recent years, year-classes have made different contributions to the Canadian and USA fisheries. In the Canadian fishery, the largest catches generally occurred at age 2 and the 1983, 1985 and 1987 year-classes have been dominant. In the USA fishery, the 1983 year-classes has dominated until 1988 and the 1985 and 1987 year-classes do not appear to have been particularly strong. Because Canada has taken by far the largest share of the catches after 1985, the combined catch at age for recent years is very similar to the Canadian age composition.

11.2 Abundance Indices

Changes in the fleet composition, poor logbook coverage and misreporting render the commercial catch per unit of effort of little use as relative indices of changes in stock sizes.

Annual groundfish surveys have been conducted in this area by Canada during the spring since 1986 and by the USA during the spring since 1968 and during the autumn since 1963. For all three surveys, there are strata which are not entirely within the 5Zj,m area and appropriate adjustments have been made to take this into account.

All three surveys were able to detect the strong 1983, 1985 and 1987 year-classes. The Canadian survey shows these three year-classes to be stronger than the USA spring survey suggests. The 1987 autumn USA survey results appear anomalously low compared with neighbouring years, probably because of reduced availability. Both spring surveys increased in 1990 (Fig. 11.2).

11.3. Assessment

The results of a 5Z haddock assessment were compared with those of this assessment for the 5Zj,m area. The comparison did not reveal anomalies which would prevent doing an assessment for 5Zj,m.

Population at ages 1 to 4 and 5+ in 1990 were estimated by calibrating SPA using ADAPT and the three survey indices of abundance. Similar to 5Zj,m cod, combinations of the three survey indices as well as each survey independently were used to assess the influence of each index on the resulting assessment. The results suggests that all three surveys should be included in the assessment.

The adult population biomass appears to have recovered somewhat from the extremely low values it had reached during the early 1970s and again in the mid 1980s (Fig. 11.3). The recent increase has been supported by the recruitment of the 1983, 1985 and 1987 year-classes (Fig. 11.5). The reduction in fishing mortality rate (Fig. 11.4) during 1989 was because of the closure of the Canadian mobile gear fishery. It is interesting to note that the longliners alone were able to generate an exploitation rate approaching $F_{0.1}$. Fishing mortality since the maritime boundary was established, has averaged about 0.3, somewhat higher than the $F_{0.1}$=0.25. The closure of the mobile gear fishery in 1989 was a major factor in conserving the 1987 year-class until it had realized some growth potential. The change to square mesh should be a positive factor in conserving future year-classes at age 2. The analyses confirmed that the 1983, 1985 and 1987 year-classes, while not as big as the 1975 and 1978 year-classes were considerably better than recent recruitment. There are indications that the 1989 year-class is promising but it is too early to predict it with any confidence.

11.4. Forecast

Projections to 1991 were calculated using the following input data:

Age	January 1990 Population numbers (000s)	Average[1] Weight	Partial[2] Recruitment
1	7,763	0.44	0
2	531	0.89	0.5
3	12,174	1.40	1
4	240	1.82	1
5	3,289	2.12	1
6	376	2.49	1
7	1,238	2.85	1
8	100	3.83	1

[1]Average for 1987-89
[2]Partial recruitment used in yield per recruit analysis

The catch in 1991 at $F_{0.1}$=0.25 would be 5,400 t if the 1990 expected catch of 5,900 t, which also corresponds to $F_{0.1}$ for that year is not exceeded. The adult population biomass will decrease in 1991 and subsequent improvement will depend on the strength of the 1989 year-class. The 1991 projected catches are also heavily dependent on the size of 1989 year-class. CAFSAC will attempt to refine its estimate of the size of the 1989 year-class in June 1991 when additional survey information has been considered.

It is not possible to reliably calculate catch projections for several years in advance in a fishery like this where yearly catches depend heavily on recruitment and recruitment itself is highly variable from year to year. If the change to a square mesh and decreased fishing pressure result in more ages contributing to the catches, then catch projections in the context of a multi-year management plan may become possible. Although it is not possible to provide catch projections in the context of a multi-year management plan, advice framed in term of fishing effort is possible in such a context. The exploitation rate in recent years has been about 30% above the $F_{0.1}$ target and because the exploitation rate is directly related to the fishing effort, this implies that recent fishing effort has been too high by about 30% and long-term management should aim at reducing effective fishing effort by about 30%.

12. POLLOCK IN DIVISIONS 4V, 4W, 4X AND SUBDIVISION 5Zc

12.1. Description of the Fishery

Since 1982, the pollock fishery has been regulated by quotas on four gear sectors: 1) fixed gear, 2) mobile gear greater than 100 ft, 3) mobile gear 65-100 ft, and 4) mobile gear less than 65 ft. In 1988, mobile and fixed gear less than 65 ft were further divided: a) mobile and fixed gear less than 45 ft, and b) mobile gear and fixed gear 45 - 65 ft. Seasonal quotas and trip limits were introduced in 1986 for mobile gear under 65 ft in order to extend the fishery to the end of the year.

For vessels less than 65 ft in southwest Nova Scotia, the 1989 management plan combined the quota for Division 4X and Subdivision 5Zc cod and haddock and divisions 4VWX and Subdivision 5Zc pollock into a single combined quota cod/haddock/pollock. The fishery was limited by the aggregate total and individual quotas for cod and haddock were exceeded. By removing the landing restrictions from the individual species, the 1989 management plan was intended to address the problems of misreporting by species and area. While reported catch was thought to be more accurate in the early months of 1989, discarding

pollock in favour of more valuable cod and haddock was thought to be a serious problem in unconfirmed industry reports. The fleet less than 45 ft was further split in 1989 into specialist and generalist categories. These two fleets and the 45 to 65 ft fleet were regulated through license condition and trip limits. For 1989, the license condition generally replaced the variation order as a means of regulating the fishery. Under the 1989 management plan, the Divisions 4X and Subdivision 5Zc mobile gear fleet, 45 - 65 ft and the under 45 ft specialist, was closed by June 29th.

The pollock fishery is prosecuted mainly in Division 4X and Subdivision 5Zc with a smaller proportion being taken in Division 4VW, although there has been a shift in the Division 4VW fishery from Division 4W to Division 4V during 1984-1989. Division 4V landings have increased from about 5,000 t in 1984 to an average of 13,000 t for the 1985-1989 period. The fishery in Division 4VW is dominated by large offshore vessels greater than 100 ft with mobile gear and in Division 4X and Subdivision 5Zc by inshore vessels less than 65 ft with mobile and fixed gear.

Landings have been relatively stable since 1985 in response to the good recruitment of the 1979-83 year-classes. Recent catches and the TAC for 1990 are as follows ('000 t) (Fig. 12.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC[2]							43
Nominal catch	35	44	44	46	43	43	-

[1]Catches are preliminary
[2]New management unit, first TAC in 1990

Catch and weight at age

Catch and mean weight at age for the 1989 landings were estimated using samples from the commercial fisheries. The 1982-1985 year-classes were dominant accounting for 82% and 77% of the catch in number and weight respectively. The 1979 year-class at age 10 was 3% of the catch, the highest value observed at that age since 1970. Differences were noted in the age composition of the large trawler catch between Divisions 4VW and Division 4X and Subdivision 5Zc. Weight at age was similar to that observed in recent years.

12.2 Abundance Indices

Commercial catch rates

As noted last year, the catch rate trend is not consistent with observations of incoming recruitment that is the 1979-83 year-classes and their effect on fishable biomass in subsequent years. In addition, trip limits adopted by industry were thought to impact catch rates. Therefore, CAFSAC considered that these recent catch rates are not representative indices of abundance for this stock.

Research vessel survey data (Fig. 12.2)

Research surveys from 1974 to 1989 indicate an increase in the age 4-9 abundance from the early 1980s with the 1985 and 1987 numbers among the highest observed. Since the early 1980s, the survey data also show an increase in pollock abundance in divisions 4VW, notably the Gully and inshore Division 4W, with abundance in Division 4X remaining relatively constant. The 1984 and 1985 year-classes appear to be at least average, but the survey provides little information as to the size of subsequent year-classes.

12.3. Assessment

The sequential population analysis was calibrated using ADAPT and the research vessel survey population estimates at age 4 to 9. There are indications that older fish (ages 10-11) are exploited more lightly than middle ages (about 50% of ages 7 to 9).

The 1979 and the 1982 year-classes at age 2 are the largest observed in the 1974-1989 period at 83 and 54 million respectively (Fig. 12.3). The 1980, 1981 and 1983 year-classes are all above the long-term average of 31 million while the 1984 and 1985 year-classes are average. The 1986 and 1987 year-classes are relatively weak. Mid-year biomass for ages 2 and older has increased since 1983 reflecting the strong 1979-1983 year-classes and is currently at a relatively high level (Fig. 12.4). Population numbers age 4-9 have increased since 1982 and are presently at about their maximum (Fig. 12.5). Fully recruited fishing mortalities have been fluctuating with a decreasing trend toward $F_{0.1}$ (0.31) for almost the entire series and are currently estimated to be slightly below the $F_{0.1}$ target level (Fig. 12.6).

These results, of course, are directly dependent on the reported catches. If over-reporting of pollock has occurred in the past, the estimates of stock sizes based on over-reported catches would be higher than the actual stock population.

Because of the estimated change in the exploitation pattern over ages, (older fish being exploited more lightly than middle ages) the target fishing mortality at $F_{0.1}$ has been recalculated using yield-per-recruit analyses. When it was estimated that all pollock older than age 7 were equally exploited, the $F_{0.1}$ target fishing mortality was F=0.25. With the new estimates of exploitation pattern over ages, the results indicate that $F_{0.1}$ is about 0.31 for ages 7 to 9, where the fishing mortality is maximum, and would decline for ages 10 and older. Overall, the average fishing mortality on ages 7 and older pollock would still be about 0.25 except that ages 7 to 9 experience higher fishing mortalities than the older ages do.

12.4 Forecast

The following input data were used to calculate catch projections.

Age	1990 Beginning of year population	Weight[1] (kg)	Partial[2] Recruitment
2	31,000	.80	.01
3	25,335	1.32	.19
4	20,281	1.93	.49
5	14,098	2.54	.80
6	8,884	3.17	1.00
7	12,686	3.65	1.00
8	7,166	4.13	1.00
9	3,201	4.85	.85
10	1,832	5.69	.67
11	1,622	7.09	.50

[1] 1986 - 1989 average
[2] 1977 - 1986 average

The 1989 and 1990 year-classes at age 2 were set to the 1974-1987 geometric mean of 31 million fish. Catch projections to 1993 were done under two different management scenarios. Results of the projections are as follows:

	F				Catch ('000 t)			
OPTIONS	1990	1991	1992	1993	1990	1991	1992	1993
1) $F_{0.1}$ in 1991-93	.29	.31	.31	.31	43	41	38	35
2) Constant catch in 1991 to 1993	.29	.32	.37	.41	43	43	43	43

In view of these results, CAFSAC considers that catches of about 40,000 t for 1991 to 1993 would likely be difficult to distinguish from $F_{0.1}$. CAFSAC will monitor the fishery closely and should a change in catches be considered necessary, advice to that effect will be promptly provided.

13. REDFISH IN SUBAREA 2 AND DIVISION 3K

13.1. Description of the Fishery

Historical nominal landings have ranged from 187,000 t in 1959 to 19,000 t in 1987. However, the 1988 and 1989 catches were only 7,000 and 3,000 t respectively. The recent decline can be explained by low catch rates which did not allow a cost effective operation, high percentage of external parasites and bacterial infestation of the flesh resulting in unmarketable fillets. As well, there has been no directed trips by Japanese and USSR vessels for the Resource Short Plant Program since 1987.

Since the early 1980s, the fishery has been concentrated in Division 3K. This was attributable to a variety of factors, including ice cover early in the year in Division 2G and 2H and prevalence of external parasites Sphyrion in Division 2J. Landings are distributed throughout the year and are predominantly taken by otter trawl.

Recent nominal catches and TACs ('000 t) are as follows (Fig. 13.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	35	35	35	35	35	35	35
Nominal catch	24	29	27	19	7	3	-

[1]Catches are preliminary

The most abundant lengths in the catch were in the range of 29-35 cm corresponding to the year-classes of the early 1970s.

13.2. Abundance Indices

Commercial catch rates (Fig. 13.2)

The catch and effort data for 1959 to 1989 were analyzed using a multiplicative model to derive a standardized catch rate series. The resulting catch rate shows an increase from 1959-64 followed by a decrease to the lowest value estimated in 1973. A period of stability occurred from 1975 to 1981 followed by a steady increase to 1984 and a general decrease since then. CAFSAC concludes that the decline in catch rates in recent years may not be indicative of a reduction in stock biomass but may be an artifact of the limited fishing effort exerted in recent years.

Research vessel survey data (Fig. 13.3)

Stratified random surveys have been carried out in the autumn in Division 2J and Division 3K since 1977. A multiplicative model was used to obtain estimates of mean numbers and weights per tow for strata not sampled in any particular year. The historical series of mean numbers and weight from the surveys suggest a downward trend both in Division 2J and Division 3K since the early 1980s. Stratified mean number and weight per tow for Division 2GH in years when surveys were conducted, indicate a lower abundance in these more northern divisions. The length frequencies and population numbers at age estimates from the autumn surveys indicate that recruitment has been relatively poor since the surveys began in 1977.

13.3 Assessment

Redfish stocks are not easily assessed using sequential population analyses techniques because the exploitation rates are low and the exploitation pattern over age is difficult to estimate. Most often, stock sizes and future catches are estimated from general production models which are based on catch and effort data. Using these methods on 2+3K redfish resulted in potential catch estimates which were unrealistically high, far beyond the range of observed catches. CAFSAC considers that these results are unreliable.

13.4 Forecast

CAFSAC is concerned that recruitment has been poor since the year-classes of the early 1970s. If the stock were to experience good recruitment in the near future, it would take about 10 years before it would to be available to the fishery because of the relatively slow growth rate of redfish. There is no analysis available at present to determine whether the current TAC of 35,000 t is an appropriate target level. TACs have not limited the fishery in recent years but if the TAC were reached, catches of 35,000 t, if maintained for a few years, could be detrimental given the poor recruitment to the fishery after the early 1970s. TACs about equal to the catches during the 1980s, that is 20,000 t, would be more prudent for 1991-1993.

14. REDFISH IN DIVISION 30

14.1. Description of the Fishery

Over the history of this fishery, nominal catches have ranged between 5,000 and 22,000 t. Catches in 1986, 1987 and 1988 were above 10,000 t but there appeared to be a decline to 4,600 t in 1989 probably because of incomplete statistics for some countries. Canadian catches from this stock have traditionally been low, and totalled 75 t in 1989.

Beyond depths of about 500 meters, the bottom in this division is largely unfishable so the sizes of fish taken are generally smaller than those landed from other areas. This limits the Canadian fleet since it is not economical to process these small fish which are generally less than 25 cm. Other countries do take small fish from the area.

Recent catches and TACs ('000 t) are as follows (Fig. 14.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	20	20	20	20	14	14	14
Nominal catch	10	8	10	13	10	4	

[1]Catches are preliminary

14.2. Assessment and Forecast

The only new information available for this stock was an additional point in the catch rate series. As was the case in the past, the information is not adequate for the calculation of a reference catch. The long-term average catch of about 13,000 t has not resulted in any trend in catch rates over time, possibly suggesting that higher catches are possible. CAFSAC reiterates, however, that the impact of higher catches may require a number of years to detect. The current TAC of 14,000 t should be considered precautionary for 1991-1993, and it should not be changed until the impact of sustained catches nearer to the current TAC have been evaluated.

15. REDFISH IN DIVISION 3P

15.1. Description of the Fishery

Nominal catches from Division 3P have ranged between 3,600 t in 1985 and 37,000 t in 1970. The largest catches were made in Subdivision 3Ps during the mid-1960s to late-1970s. Catches from Subdivision 3Ps have been below 4,000 t since 1982. In 1989, almost 75% of the total catch of 9,992 t was taken in Subdivision 3Pn. Catches by Maritime vessels increased markedly beginning in 1986, and most of the increased effort was concentrated in Subdivision 3Pn. During the 1980s, Newfoundland vessels took approximately equal amounts from both subdivisions. Landings from Subdivision 3Pn ranged between 2,000-4,000 t over the history of the fishery but increased in 1988 and 1989 because of increased effort in the area during the first half of the year. Landings from Subdivision 3Ps are usually spread more evenly throughout the year. In both subdivisions, most of the catch has usually been taken by bottom trawls, although substantial amounts were caught in Subdivision 3Ps using gillnets and longlines. In recent years, most of the catch from Subdivision 3Pn has been taken with midwater trawls.

Nominal catches and TACs ('000 t) in recent years are as follows (Fig. 15.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	18	18	18	18	15	15	10
Nominal catch	4	4	7	7	9	10	-

[1]Catches are preliminary

In 1989, fish aged 9 to 14 dominated the catches but the presence of the older, large year-classes of the early 1970s could still be detected.

15.2. Abundance Indices

Commercial catch rates

In 1989, CAFSAC concluded that since redfish in Division 3P possibly did not represent a 'stock', the use of a commercial catch rate as an index of abundance was inappropriate. Because the issue of the definition of a redfish 'stock' in the 3P, 4RST, 4V area has not been resolved, using catch rates as an index of stock size is still inappropriate.

Research vessel survey data

Stratified random survey data from Division 3P in February-March for the period 1980-1990 were examined using a multiplicative model to estimate mean values per standard tow for missing strata. Overall, the adjusted results suggest an increase in biomass from the early 1980s to the present. This may indicate a general increase in stock size, a trend toward more Gulf redfish moving into the area in winter in recent years, or a gradual change in the distribution of redfish in the water column at the time of the survey.

Results of these surveys (Feb.-March) and those conducted in January in 3Pn4RST indicate an overwintering concentration in the 3Pn-southern 4R area. The recent increased effort in Subdivision 3Pn in the first half of the year is mainly directed on this aggregation, but the relative contribution of redfish from different areas is unknown. If these increased catches are of Division 4RST fish, then future assessments should take this into consideration. It was also observed that the winter surveys do not cover Subdivision 4Vn, so the possible extension of the concentration into this area is unknown.

Results from acoustic surveys conducted in Division 3P in the summer of 1988 and in 3P4V in 1989 confirm previous evidence, from trawling surveys, that redfish are distributed in a continuous fashion across the entire channel area of 3P4V. Therefore the present separation of stocks along the 3P4V line is inappropriate and should be discontinued. The affiliation between these fish, and those in the Gulf is still unknown, and acoustic survey coverage is insufficient at present to explore this. Estimates from the two acoustic surveys are consistent, suggesting approximately 225,000 t in Division 3P and about 350,000 t in 3P plus channel part of 4V.

15.3. Assessment and Forecast

Because of the remaining uncertainties about stock structure and the mixing of fish from different areas, CAFSAC is unable to provide an assessment and associated reference catch. However, CAFSAC believes that unlimited fishing in 3P/4V, an area of mixing, should be prevented. CAFSAC suggests an upper catch limit of 15,000 t in 3P to allow flexibility in the exploitation of what appears to be a single body of fish in divisions 3P and 4V. CAFSAC hopes to be able to suggest a new management unit for redfish in 3P-4V for the 1992 fishing year.

16. REDFISH IN DIVISIONS 4R, 4S AND 4T

16.1. Description of the Fishery

The rapid increases in the catches from less than 20,000 t in the 1950s to 130,000 t in 1973 was almost entirely the result of increased Canadian effort. TACs were introduced in 1976, as the very strong year-classes of the late 1950s had passed through the fishery. The first TAC was set at 30,000 t, and the level was subsequently reduced to 16,000 t within two years. Catches have been less than the TAC except in 1976 and 1981. In recent years some fleet components have caught their allocation.

Recent TACs and catches are listed below ('000 t) (Fig. 16.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	50.6	50.6	55.6	50	56	57	57
Nominal catch	35	28	34	34	36	43	

[1]Catches are preliminary

16.2. Abundance Indices

Catch and effort data for 1959-89 were standardized using a multiplicative model, taking into account potential differences in the fishing power of midwater trawls used before 1986 and those used since that date. The resulting catch rate series (Fig. 16.2) was similar to that calculated previously and continued to show two distinct peaks in 1967-68 and 1980-81, with the latter one being followed by an overall decline in catch rate through to 1987. The 1988 value represented an increase of 40% over the 1987 value and catch rates have continued to increase in 1989.

Biomass estimates of redfish from the summer research surveys in the Gulf of St. Lawrence appear to be relatively constant (Fig. 16.3). The length frequencies from the 1989 survey (Fig. 16.4) shows clearly the dominance of 27-28 cm redfish of the 1978-1980 year-classes. The size distribution is similar in commercial catches.

16.3. Assessment

The large number of ages in the population and the low fishing mortality in recent years renders sequential population analysis inappropriate. There are, however, adequate catch and effort data to utilize a general production model. The Gulf redfish stock is however not in a steady state, having been abundant in the mid-1960s, heavily fished and severely reduced in the mid-1970s, and now rebuilding. For that reason, a non-equilibrium version of the general production model was utilized in 1989. The results are not sensitive to the addition of one year's data and the conclusions reached in 1989 still apply.

The 4RST redfish stock is in good condition. It has been possible to follow since 1984, the year-classes that are presently contributing most to the fishery. Catch rates have increased in 1989 and are expected to remain high for the next few years.

16.4. Forecast

CAFSAC believes that the current 57,000 t TAC would be appropriate for 1991. CAFSAC plans to review the stock status of 4RST redfish in detail in 1991 and advice for a multi-year management plan will then be provided.

17. REDFISH IN DIVISIONS 4V, 4W AND 4X

17.1. Description of the Fishery

Catches ranged between 20,000 t and 40,000 t through the 1960s, then rose to a peak of 62,000 t in 1971. Thereafter they fell rapidly until 1976 (18,000 t) and since then have varied between 10,000 t and 24,000 t. The USA, which took catches of 30,000 t annually in the 1950s, and the USSR (from 1960) were the major participants until about 1975. Canadian catches have varied between 3,000 t and 30,000 t.

The TAC was initially set at 40,000 t in 1974, but was reduced to 20,000 t for 1976. It was increased to 30,000 t for 1980 on the basis of estimates of improved stock size and the demonstration that older, larger redfish occurred in waters deeper than those being fished at the time.

Recent catches (predominantly Canadian) and TACs ('000 t) are (Fig 17.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	30	30	30	30	30	30	30
Nominal catch	10	14	13	24	18	17	

[1]Catches are preliminary

In 1989, 57% of the TAC was caught, with Canada accounting for 99% of a provisional total of 17,041 t. This total represents a decrease of 3% over 1987 landings. As in recent years, Japan was allocated 1,500 t, of which a total of 122 t was caught.

In the recent past, Canadian landings have come primarily from bottom trawlers, however, midwater trawl catches constituted a significant proportion of total landings between 1972 and 1979. This gear component was not active in the fishery between 1980 and 1985, but it constituted a total of approximately 5,500 t in 1987. The midwater trawl catch in 1988 and 1989 was 4,235 t and 7,078 t.

17.2. Assessment and Forecast

The available information for this stock is not adequate for annual adjustment of the reference catch. Thus, this year's review was limited to examination of catch levels. A review for this stock in 1987 resulted in a recommended reference catch of 30,000 t. This catch was based on an exploitation rate of 15% of the trawlable biomass, estimated from surveys. Recent information suggests that a single body of redfish inhabit the 4V-3P area. CAFSAC hopes to be able to suggest a new management unit for redfish in 3P-4V for the 1992 fishing year.

18. AMERICAN PLAICE IN SUBAREA 2 AND DIVISION 3K

18.1. Description of the Fishery

The largest nominal catch reported for this stock was almost 13,000 t in 1970. From 1971 to 1981, catches averaged about 5,500 t, but have been much lower since 1981, exceeding 1,900 t only in 1986 and 1989. In 1987 and 1988, the catch was around 1,000 t, with gillnets in Division 3K taking the majority of the catch in each year. From 1976 to 1988 catches from Subarea 2 from this stock were less than 700 t per year. However, in 1989, Canadian offshore trawlers caught approximately 3,200 t of American plaice in Division 2J, resulting in an increase of the total catch to 4,187 t, the highest since 1981. The Canadian catches in Division 2J were taken mainly in October and November and were

initially in the directed American plaice fishery but later as a by-catch in the cod-directed fishery. This fishery is likely to continue, given the recent quota reductions in the American plaice stock in Division 3LNO. The inshore catch, which is almost exclusively from Division 3K, has fluctuated between 500 and 1,000 t in recent years.

In years when offshore catches were negligible, the peak landings have been in the summer months, primarily from gillnets, but when the offshore catch was substantial, for example in 1977, 1980-81, and 1986 peak catches have occurred in the February to April period. However, as noted previously, the 1989 offshore catch was taken primarily in the fourth quarter.

Recent TACs and nominal catches ('000 t) are as follows (Fig. 18.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	10	10	10	10	10	10	10
Nominal catch	1	1	3	1	1	4	

[1]Catches are preliminary

As in previous years, the commercial catch in 1988 and 1989 consisted mainly of fish ages 9-12. The mean weights at age show moderate fluctuation between years, which would be expected given the changes in timing of the fishery from year to year. Comparable data are not available for all years prior to 1984, because sampling was sometimes not available for portions of the catch in years where the total catch was low.

18.2. Abundance Indices

Commercial catch rates

Catch per unit of effort data are available from Canadian offshore trawlers for the period 1976-89. However, in four of the last six years, the directed offshore catch of American plaice from this stock has been less than 25 t. Therefore, no index of abundance can be obtained from the commercial catch per unit of effort data. Nevertheless, in years when a substantial directed fishery has taken place, for example 1981, 1986, 1989, the catch rates obtained by the offshore fleet are quite good relative to the adjacent Grand Bank stock of American plaice, although the directed fishery is usually only for a period of one month or so.

Research vessel survey data

Research vessel surveys were conducted in Division 2G in 1978-79, 1981, and 1987-88, in Division 2H in 1978-79, 1981, and 1986-88, in Division 2J from 1977 to 1989, and Division 3K from 1978 to 1989. In Division 2G, the biomass has not exceeded 3,900 t, while in Division 2H, the biomass has ranged between 4,000 t and 18,000 t. In Division 2J, the biomass declined steadily from about 90,000 t in 1982-83 to 23,000 t in 1987 and then increased to 30,000-33,000 t in 1988-89. In Division 3K the biomass fluctuated between 26,000 t and 43,000 t from 1979 to 1986, before declining to 17,000-18,000 t in 1988-89. In both divisions 2J and 3K, fish from the year-classes of the early 1980s dominated the recent surveys. The decline in biomass in Division 2J was of particular interest in this stock because it occurred in the absence of any significant commercial fishery over the same period. Work ongoing for the adjacent Grand Bank stock directed at the effects of temperature on the distribution and abundance of American plaice may be useful in explaining this decline in Division 2J.

18.3. Assessment and Forecast

Although the surveys indicate that the stock size was lower in 1989 than in the early 1980s, it appears that the biomass has stabilized in 1987-89, with an increase in Division 2J countered by a decrease in Division 3K. The total stock biomass (Subarea 2 + Division 3K) in 1988 and 1989, as measured by the surveys, was in the range of 50-55,000 t. With an exploitation rate of 20% approximating the $F_{0.1}$, this suggests that the current TAC of 10,000 t be continued in 1991. Given the recent stability in the biomass, this figure is also appropriate for 1992 and possibly 1993.

In 1988 and 1989, CAFSAC advised that consideration be given to splitting the TAC evenly between Subarea 2 and Division 3K, even though recent catches have been well below the TAC. This was based on the 1987 survey which indicated that the biomass in Division 2J had declined to about the level observed in Division 3K, and also as a result of concerns that over 80% of the landings came from Division 3K. However, the 1988-89 surveys show the biomass in Division 2J to be approximately 1.8 times higher than that in Division 3K, which is closer to the long-term average from the 1978-89 surveys. In addition, over 75% of the catch from the stock in 1989 came from Division 2J, largely a result of the offshore catches in the fourth quarter. However CAFSAC is still concerned that American plaice in Division 3K could be more easily overexploited and therefore advises that no more than 50% of the TAC should be harvested in that division.

19. AMERICAN PLAICE IN SUBDIVISION 3Ps

19.1. Description of the Fishery

Catches from this stock were highest from 1968 to 1973, exceeding 12,000 t on three occasions in this period. Catches by foreign vessels peaked at about 8,800 t in 1968, due mainly to the USSR catch, and have not exceeded 670 t since 1973. Catches by France have ranged from 200 to 665 t in recent years.

The Canadian inshore catch in 1987 (2,000 t) was substantially higher than in most other years from 1972 onward, due to the increase in the gillnet catch. However, the inshore catch declined in 1988-89 to about the level reported in 1986 (1,300 t). After a decline in the early 1980s, the catch by Canadian offshore trawlers increased in 1984-87, with most of the catch (70-90%) being taken in the first quarter. In 1988-89, the catch by this fleet declined slightly and was spread more evenly over the entire year. Overall, the total catch in 1988 was down about 800 t from the 1986-87 level, and the 1989 catch was down a further 800 t from the 1988 value, to about 3,600 t.

Recent nominal catches and TACs ('000 t) are as follows (Fig. 19.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	5	5	5	5	5	5	4
Nominal catch	3	4	5	5	4	4	

[1]Catches are preliminary

The catch at age and mean weights at age for this stock are based on sampling from the Canadian fishery, because no sampling data are available for the French catches. In 1989, the 1978 and 1979 year-classes were predominant in the catch at age, as was the case in the 1988 fishery. The mean weights at age in 1989 were similar to those observed in 1988, and no trends are apparent in recent years.

19.2. Abundance Indices

Commercial catch rates

A multiplicative analysis of commercial catch rates of American plaice for the Canadian offshore trawler fleet in Subdivision 3Ps from 1974 to 1989 was conducted. The catch per unit of effort series shows relative stability from 1974 to 1980, an increase from 1980 to 1983, followed by very large increases in 1984 and 1985. In 1987 and 1988, the catch per unit of effort declined to about the same level as in 1983, followed by a further decline of about 13% in 1989. However, the 1989 value is still about 14% higher than the mean catch rate from 1974 to 1980. The magnitude of the increase from 1983 to 1984, then 1985, and the subsequent 40% decline to 1986 suggest that the 1985 and possibly the 1984 points are anomalous.

Research vessel survey data

Stratified random surveys have been conducted by Canada in Subdivision 3Ps in each year from 1972 to 1990. Even with the values for the missing strata filled by a multiplicative model, the biomass estimates are highly variable between years with estimates from consecutive surveys often changing by more than half or double. Although the biomass was relatively stable from 1986 to 1988 at around 30,000 t, the value from the 1989 survey was substantially lower at 17,000 t, followed by a further decline to only 6,800 t in 1990. The 1980-82 year-classes were dominant in the 1989 survey, however, the age by age estimates from the 1990 survey are not yet available.

19.3. Assessment and Forecast

In the 1989 assessment of this stock, it was noted that the stock size was relatively stable from 1974 to 1988 but that the "the relationships obtained in the calibrations of ADAPT were poor and they did not give reliable estimates of stock size on a yearly basis". Therefore, no attempts were made at this time at using ADAPT to determine stock size.

The catch per unit of effort data and survey indices presented in this assessment continue to show a declining stock size. However, the catch per unit of effort for 1989 was still above that observed from 1974 to 1980, when catches averaged around 4,400 t, and fishing mortalities were between 0.3 and 0.4 in most years. Although the low biomass estimate from the 1990 survey is a cause for concern, this abundance index has been characterized by large variability in biomass between years, for example 1975-77, 1979-80, and 1983-86. Despite signs of decreased abundance, CAFSAC is not sufficiently confident in the assessment to recommend a change in the current TAC and suggests that 4,000 t be used for 1991-1993.

20. AMERICAN PLAICE IN DIVISION 4T

20.1. Description of the Fishery

Since 1965, nominal catches have varied from a high of 11,780 t in 1966 to a low of 4,987 t in 1989. A TAC of 10,000 t has been imposed on the fishery since 1977. Annual landings in the 1980s have averaged about 7,450 t. The provisional landings for 1989 is a reduction of more than 1,700 t from 1988.

Recent landings and TACs ('000 t) are listed below and shown in Fig. 20.1:

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	10	10	10	10	10	10	10
Nominal catch	9.6	9.5	7.2	7.8	6.7	5.0	-

[1]Catches are preliminary

Historically, plaice were taken as by-catch in the southern Gulf of St. Lawrence cod fishery. In recent years, a fishery directed for American plaice has taken roughly half the total landings. The gear composition has changed from mainly longlines from 1937 to 1946 to a mixed fishery of longlines, otter trawl, and Danish seines from 1947 to 1964. Since 1965, the importance of gillnets and seines have increased in the directed fishery and seines are now the dominant gear type. The proportion taken by seines increased from 38% to 46% from 1988 to 1989 while the proportion of fixed gear landings decreased from 20% to 15% in the same time period.

During 1988 and 1989, the mobile gear and fixed gear landings were substantially less than the allocations, but restrictions during 1989 in the cod fishery in Division 4T may have impacted on the fishing patterns for American plaice.

Catch and weight at age

The landings at age from 1976 to 1989 were re-calculated using length frequencies for each sex separately . Semi-annual age-length keys were used from 1984 through 1989. Because a large percentage of the catch is discarded at sea, the true catch is unknown. Estimates of the discards at age were obtained using data from the research survey series and mesh selectivity ogives. Although the method appeared to track overall discarding rates recorded in recent field observations the accuracy of estimates at each age was deemed insufficient to conduct an analytical stock assessment using sequential population analysis.

20.2. Abundance Indices

Commercial catch rates

Catch per unit of effort estimates for either the plaice directed or the by-catch fisheries were deemed to be unreliable indices of stock abundance, because of the number of changes in fishing practices over the years.

Research vessel survey data

The mean numbers per tow from the groundfish research surveys were low at the beginning of the 1970s, have climbed steadily to a peak in 1977, and declined to 1984. The total mean number per tow in 1989 was the lowest in the series. There has been a period of relative stability at a low level since 1984 (Fig. 20.2).

Discarding at sea

Several field studies dating from the late 1950s to 1984 have recorded discarding rates of between 46 and 85% of the catch by number. The most recent empirical study undertaken shortly after the change to the present 130 mm mesh size limit suggested a rate of 62% by number. Estimates of discards calculated from survey results as described above ranged from 46 to 85% of the catch.

20.3. Assessment and Forecast

Fishing mortality and stock abundance

Total mortality was estimated from research vessel numbers at age per tow from 1971 to 1988. While mortality estimates were variable from year to year there was generally higher total mortality in the 1980s than in the 1970s. Average fully-recruited fishing mortality estimated from 1984-89, was near 0.28. The 10+ fishable biomass was 26,000 t in 1988 and 22,000 t in 1989.

However, given that discarding of small plaice by mobile gear is a severe problem in this fishery, CAFSAC will attempt to quantify the gains that could be achieved if the discards were reduced. Until such time, the TAC could be kept at its present value of 10,000 t because CAFSAC believes that reducing the TAC with present enforcement and fishing practices may only result in greater discarding. The best way to enhance conservation for 4T plaice would be to reduce the catch and discarding of small plaice.

21. WITCH IN DIVISIONS 2J, 3K, AND 3L

21.1. Description of the Fishery

Catches increased from 1,000 t in 1963 to 24,000 t in 1973, subsequently declined to less than 5,000 t and have averaged about 3,500 t annually since 1979. Prior to 1977, Poland, USSR, and Canada took most of the catch. More recently, it is mainly taken by Canada and Poland primarily on spawning concentrations during the winter-spring period in Division 3K although there has been increased activity reported by EEC (Portugal) on the nose of the Grand Bank in Division 3L. The TAC was initially set at 24,000 t in 1974 and was reduced to 17,000 t for the next 7 years. It was then reduced to 8,000 t in 1981 since there was no indication of stock rebuilding despite catches having been lower than the TAC. It was reduced further to 6,000 t in 1987, 5,000 t for 1988 and 1989, and 4,000 t in 1990, largely based upon similar observations. Recent TACs and catches ('000) t are (Fig. 21.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	8	8	8	6	5	5	4
Nominal catch	5	3	4	4	4	5	

[1]Catches are preliminary

21.2. Abundance Indices

There are insufficient commercial effort data to derive a reliable catch rate series, therefore the status of this resource is mainly based upon an evaluation of research vessel survey data. Estimates of biomass from autumn research vessel surveys prior to 1986 indicate that about 80% of the stock biomass occurred in Division 3K, however, for 1986-88, just over half the stock biomass is estimated to have occurred in this division and considerably less than half from 1989 estimates. Biomass estimates from 1981 to 1984 for the three divisions combined averaged about 42,000 t and have declined to about 20,000 t in 1988, and 12,000 t in 1989, the lowest value in the time series. The magnitude of the decline is considered to be too large to be attributed solely to the fishery. The results of the survey in Division 3K suggest that there may have been migration to deeper strata which are not adequately surveyed, thus underestimating the biomass. Strata contiguous to non-sampled deep-water strata have exhibited proportionately more biomass in recent years than in the past. It is known from commercial offshore operations that, in recent years, particularly in 1988 to 1990, large concentrations of prespawning witch flounder have been located in areas of Division 3K during the winter-spring period at

depths in excess of 800 m. A preliminary examination of Canadian commercial catch rate data from the observer program for 1988 and 1989 indicated that the catch rates between the two years were similar as were the estimated area of high density. This would support the suggestion that the magnitude of the decline in stock biomass as determined from research vessel surveys may be overestimated especially when considering the depths of the commercial fishery compared to those covered by surveys. However, concentrations could not be located in these areas by the commercial fishery during the summertime and no information from the commercial fishery was available for the autumn to corroborate the extent of possible migration to deeper water as observed in the Division 3K survey data.

21.3. Assessment and Forecast

CAFSAC noted in 1986, that this stock had appeared to have established an equilibrium at a lower biomass level compared to the past. The maximum age appeared stable at about 14 years compared to 26 years in 1976. If the stock were not in equilibrium, it would be expected that the maximum age would change over time. Average catches of 4,000 t were taken during this period of stability. The present analysis also suggests that the age structure since 1985 remained relatively stable; yet, the stock is estimated at less than one-third that of the early 1980s according to research surveys. Given that the magnitude of the decline in stock size may be overestimated and is unlikely to be solely the result of fishing, a further reduction in the current TAC of 4,000 t is not advised at this time. Should a further evaluation of the resource prove the stock decline to be significant, an annual catch of 4,000 t in the short term, nevertheless, would not be harmful and CAFSAC suggests that the 1990 TAC be maintained for 1991-1993.

22. WITCH IN SUBDIVISION 3Ps

22.1. Description of the Fishery

The catches of witch flounder in Subdivision 3Ps were about 1,000 t annually during the early 1960s. Catches increased to over 4,000 t in 1967-69, then declined slowly to former levels in 1977. During the last ten years, annual catches have been most often less than 1,000 t. The provisional catch for 1989 is 840 t including catch by French vessels.

Recent TACs and catches ('000 t) are as follows (Fig. 22.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	3	3	3	3	1	1	1
Nominal catch	0.5	0.6	1.3	1.1	0.6	1	

[1]Catches are preliminary

22.2. Assessment and Forecast

In 1987 CAFSAC reported that the stock appeared to be in equilibrium with recent catches less than 1,000 t. Not only has the biomass estimated by research surveys from 1976 to 1990 been relatively stable, but the age structure is much younger in recent years than in the past and is not increasing. The maximum age in the research catches was 22 years in 1976 but was only 14 in 1980 and remained stable through 1989. It would be expected that the maximum age would have increased if the stock was increasing. A similar conclusion can be drawn from the age range of the majority of the catch that is, 9-11 year olds in 1976 and 6-8 since 1980. CAFSAC concluded in 1989 that the stock would remain relatively stable with annual catches not exceeding 1,000 t and recent information from research vessel surveys and commercial catch at age continues to support this conclusion. The current TAC could therefore be kept for 1991 to 1993.

23. WITCH IN DIVISION 4R AND 4S

23.1 Description of the Fishery

Catches have been generally less than 2,000 t except during the period between 1974-1980 when they rose to as high as 5,300 t (1976). A TAC was first established for 1977 at 3,500 t, based on average catch levels. However, because the presence of large, old fish in the population which were being landed in "jellied" condition, the TAC was increased to 5,000 t in 1979. The objective was to exploit the stock heavily in order to reduce the proportion of old fish in the population. Although the abundance of older fish was reduced, catches did not reach the new TAC and, in fact, declined. The TAC was reduced to 3,500 t in 1982. The provisional catch for 1989 is 1,066 t. Ninety percent of the catch was taken in division 4R. Recent nominal catches and TACs ('000 t) are as follows (Fig. 23.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Nominal catch	0.7	0.8	0.5	0.8	1.1	1.1	

[1]Catches are preliminary

23.2 Assessment and Forecast

The available information for this stock is not adequate for annual adjustment of the reference catch. Thus, this year's review has been limited to examination of catch levels. A review for this stock in 1987 resulted in a recommended reference catch of 3,500 t. This catch is considered the long-term sustainable yield for the stock and the TAC can be set at that level for 1991-1993.

24. ATLANTIC HALIBUT IN DIVISIONS 3N, 3O, 4V, 4W, 4X AND SUBDIVISION 3Ps

24.1 Description of the Fishery

Since 1964, when reliable statistics for this species were first available, landings have ranged from 1,204 t in 1975 to 4,190 t in 1985. The increase in landings in the mid-1980s is thought to be associated with the introduction of the circle hook to the fixed gear fishery, a more effective means of capturing halibut than the traditional J-hook. Landings in 1989 were 1,840 t, a slight decrease from the 1988 level of 2,050 t. In addition to the fixed gear component, the fishery is exploited by mobile gear. The proportion of total landings taken by the fixed gear sector has been increasing over recent years.

Within the management unit, landings from 4VWX typically comprise the largest proportion of total landings. Landings from 3NO are also significant, although the prosecution of the fixed gear fishery in that area has recently been hindered by cod by-catch regulations. Several management measures have been introduced in 1988 including a 3,200 t precautionary TAC, the establishment of a by-catch fishery only for mobile gear, and a minimum size limit (81cm) for all sectors.

Recent landings and TACs are listed below ('000 t) (Fig. 24.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	-	-	-	-	3.2	3.2	3.2
Nominal catch	3.1	3.9	3.4	2.0	2.1	1.8	-

[1]Catches are preliminary

24.2 Assessment and Forecast

Several methods were tried to assess stock size, exploitation rates and potential catches but the data were considered insufficient to use catch curves, general production and yield per recruit models. However there are indications that abundance may be decreasing as suggested by the downward trend in the catch rate. The unchanged average size of halibut taken in the fishery since 1980 and anecdotal reports from fishermen indicating good catch rates in 1990 support the view that the resource is not overexploited. However, at this time, it is not possible to determine the exploitation rate of the resource and CAFSAC suggests that the current precautionary TAC should be kept for 1991-1993.

25. ATLANTIC HALIBUT IN DIVISIONS 4R, 4S AND 4T

25.1 Description of the Fishery

Landings of Atlantic halibut in the Gulf of St. Lawrence declined from 490 t in 1970 to 90 t in 1982 and have been relatively stable in the 200-250 t range in recent years. Recent TACs and nominal catches ('000 t) are as follows (Fig. 25.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	-	-	-	-	.3	.3	.3
Nominal catch	.18	.16	.27	.25	.25	.22	

[1]Catches are preliminary

25.2 Assessment and Forecast

The information for this stock is not adequate for annual adjustment of the reference catch. A review in 1987 resulted in a recommended precautionary TAC of 300 t based approximately on average catch. CAFSAC suggests that this precautionary TAC be kept for 1991-1993.

26. GREENLAND HALIBUT IN DIVISIONS 4R, 4S, AND 4T

26.1 Description of the Fishery

The fishery for Greenland halibut in Division 4RST is prosecuted mainly by Quebec based gillnets in western Division 4S and 4T and also as a by-catch in the shrimp fishery. Catches have fluctuated since 1970 between 800 t in 1972 and 11,000 t in 1987 following two strong pulses of recruitment. Catches reached a maximum in 1987 due to a combination of strong recruitment and good prices but declined in 1988 to 7,546 t and to 5,121 t in 1989. This decline was apparent in all gear sectors involved in the fishery.

Recent TACs and nominal catches ('000 t) are as follows (Fig. 26.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	5.0	5.0	5.0	8.95	10.5	10.5	10.5
Nominal catch	2.1	2.3	6.5	11.0	7.6	5.1	

[1]Catches are preliminary

26.2 Assessment and Forecast

Catch rates from the commercial fishery and biomass estimates from the surveys suggest that stock size is continuing to decrease. There are preliminary indications, from the summer 1989 survey, of incoming recruitment but it is too early to quantify its possible contribution to future catches. CAFSAC will follow these year-classes and advise when catches may be expected to increase. The current precautionary TAC could be kept for 1991-1993.

27. FLATFISH IN DIVISIONS 4V, 4W AND 4X

27.1 Description of the Fishery

Four flatfish species (exclusive of the halibuts) are exploited commercially on the Scotian Shelf. Listed in order of decreasing landings in 1989, they include American plaice, witch flounder, yellowtail flounder and winter flounder. Of these, only American plaice, witch flounder and yellowtail flounder are under quota management. For the purposes of quota allocation and monitoring, the three species are combined. The landings of winter flounder typically are comparatively low, although locally significant along the Nova Scotian coast and in the Bay of Fundy.

The annual catch of the three main species has been as high as 54,000 t in 1968, but in only three other instances exceeded 30,000 t. Since 1975, they have been less than 20,000 t. The USSR took the majority of the catch during the period of high landings. Canadian catches increased to 24,000 t in 1968 but since 1970, have been 15,000 t or less. A combined TAC for the three species was set at 32,000 t in 1974, reduced to 28,000 t for 1976 and reduced further to 14,000 t in 1978. The latter reduction was partly related to concerns about declines in the witch and American plaice populations, but was also chosen as a conservation measure that should have allowed rapid increase in the abundance of all three species.

Landings of Scotian-Shelf flatfish under TAC management were 7,644 t in 1989 compared with 7,298 t in 1988, a 5% increase. American plaice landings have increased from 3,425 t in 1988 to 3,854 t in 1989, witch flounder landings have decreased from 2,810 t in 1988 to 2,284 t in 1989, and yellowtail flounder landings increased from 1,063 t in 1988 to 1,504 t in 1989. As has been the case since 1977, landings from 4V accounted for the largest proportion of landings by division for the three species under quota management.

The largest fraction of American plaice and yellowtail flounder landings are taken by stern otter trawl, with longliners and Danish-Scottish seiners also well represented. However, for witch flounder, Danish-Scottish seines account for the largest fraction of landings by gear type.

Recent TACs and nominal catches ('000 t) are listed below (Fig. 27.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	14	14	14	14	14	14	14
Nominal catch	11	8	8	9	7	8	

[1]Catches are preliminary

27.2 Assessment and Forecast

The catch and effort data from the commercial fleet cannot be used to provide an overall catch rate index because an increasing amount of the catch is being taken in fisheries directed for other species. Research surveys have provided inconsistent information on abundance changes for these species,

particularly when attempts are made to follow year-classes through the population from year to year.

CAFSAC notes that this fishery is largely a by-catch fishery. CAFSAC advises that future catches should be regulated, but it cannot provide a quantitative recommendation at this time. While there is no quantitative analysis to support a catch of 14,000 t in 1991, CAFSAC notes that catches between 8,000 t and 10,000 t have been sustained since the early 1980s and TACs of that magnitude could apply for 1991-1993. CAFSAC also notes that work is currently underway to redefine this management unit on a species and stock basis.

28. WHITE HAKE IN DIVISION 4T

28.1 Description of the Fishery

Landings from this small vessel inshore fishery have ranged from a high of 14,000 t in 1981 to a low of 3,600 t in 1974. In 1982 a precautionary TAC was set at 12,000 t. The 1989 nominal catch was 5,100 t a reversal of the declining trend since 1980.

Recent TACs and nominal catches are as follows ('000 t) (Fig. 28.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	12	12	12	9.4	5.5	5.5	5.5
Nominal catch	6.6	6.0	4.9	6.2	3.9	5.1	

[1]Catches are preliminary

28.2 Assessment and Forecast

In 1989, commercial catch and effort for gillnets were analyzed using a multiplicative model. The results were not considered to represent the abundance of the stock while estimates of abundance from research surveys are highly variable and show no trend. A forecast is not possible at this time. Management measures aimed at protecting juvenile fish should be encouraged.

29. ARGENTINE IN DIVISIONS 4V, 4W AND 4X

29.1 Description of the Fishery

The argentine fishery, which began in the early 1960s, has been prosecuted primarily by the USSR and Japan. TAC regulation was initiated in 1974 and, from the late 1970s, the fishery has been restricted in season and area by the Small Mesh Gear Line Regulations. In recent years, catches have been taken largely as a by-catch in the silver hake fishery, the provisional 1989 catch being about 100 t. Recent TACs and catches are ('000 t) (Fig. 29.1):

	1984	1985	1986	1987[1]	1988[1]	1989[1]	1990
TAC	10	10	10	10	10	10	10
Nominal catch	.4	.3	.2	.1	.4	.1	

[1]Catches are preliminary

29.2 Assessment and Forecast

The available information for this stock was not adequate for annual adjustment of the advised catch. Thus, this year's review has been limited to examination of catch levels. A review for this stock in 1987 resulted in a

recommended reference catch of 10,000 t. This catch is based on the long-term average yield of $F_{0.1}$ calculated from survey biomass estimates and TACs of that magnitude would be applicable for 1991-1993.

Fig. 1.1. Nominal catches and TACs for cod in Division 2GH.

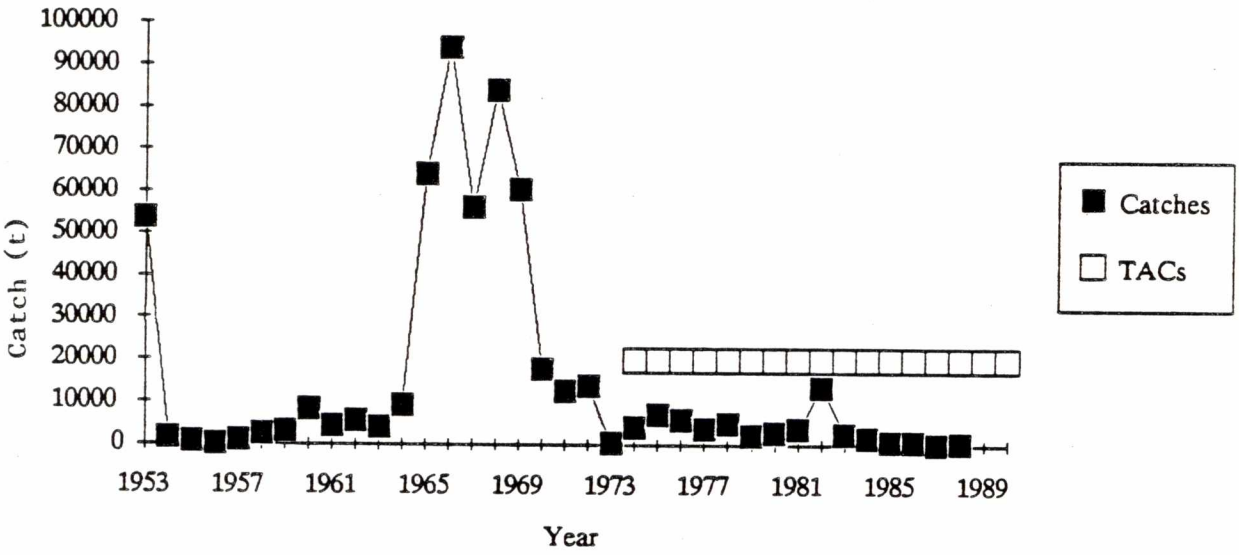


Fig. 2.1. Nominal catch and TACs for 2J3KL cod.

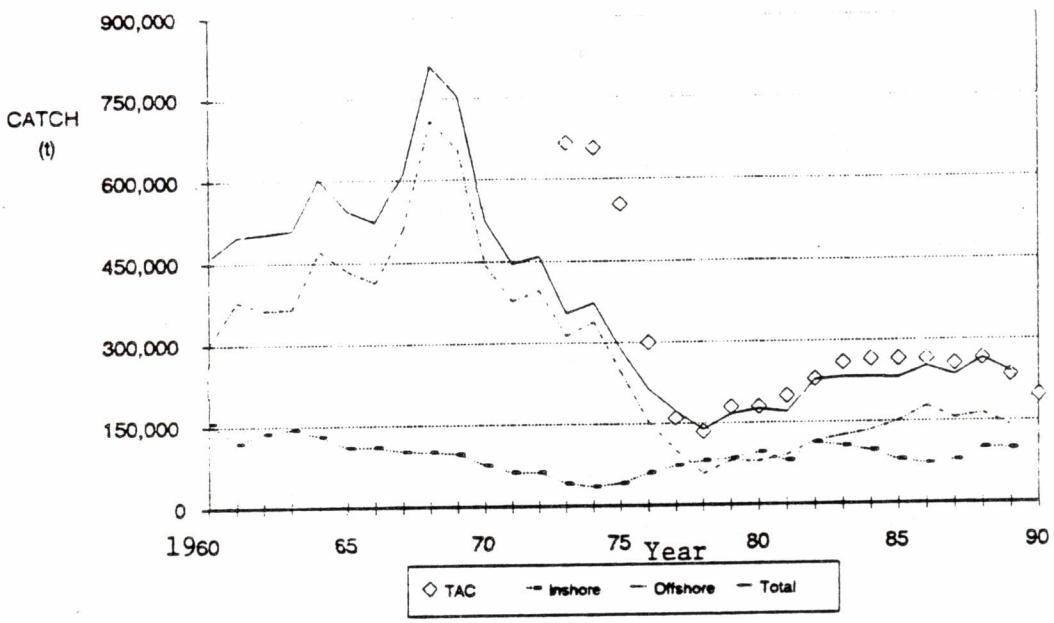


Fig. 2.2. Research vessel biomass estimates for 2J3KL cod.

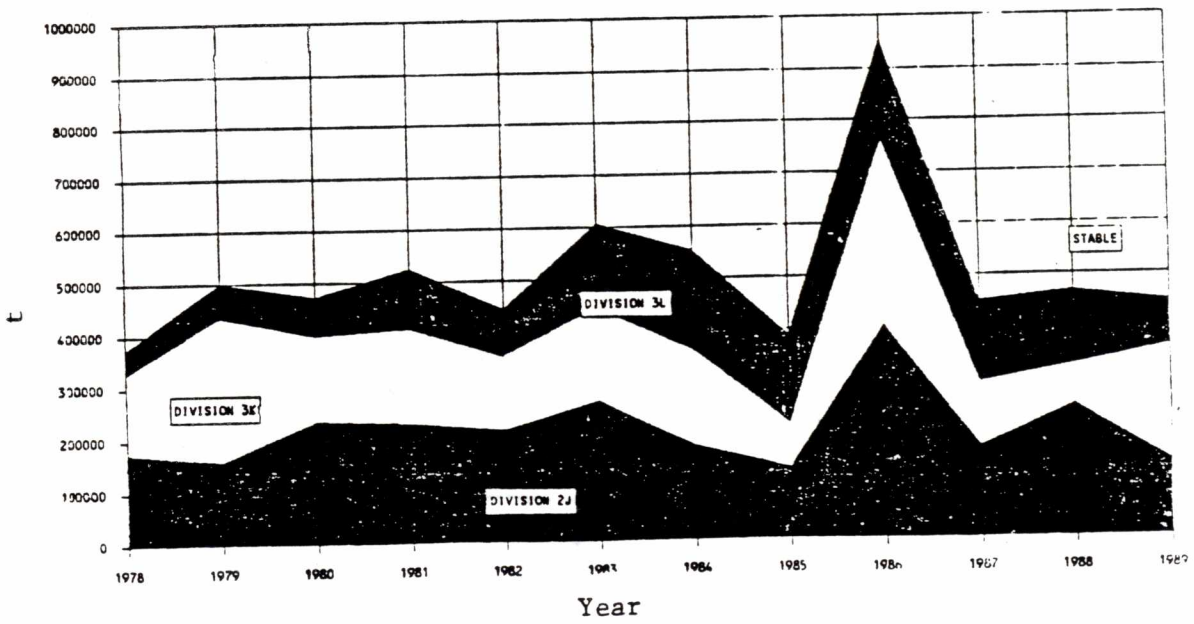
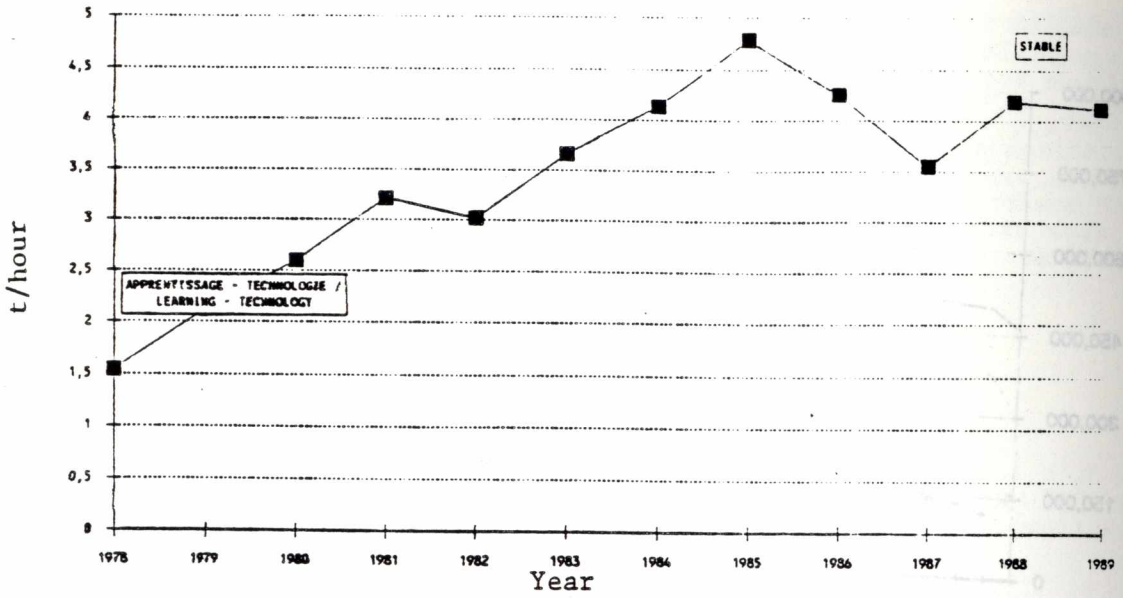


Fig. 2.3. Commercial catch per unit of effort 2J3KL cod.



Comm.

Fig. 2.4. Population biomass (January 1), ages 3+ for cod in Divisions 2J3KL.

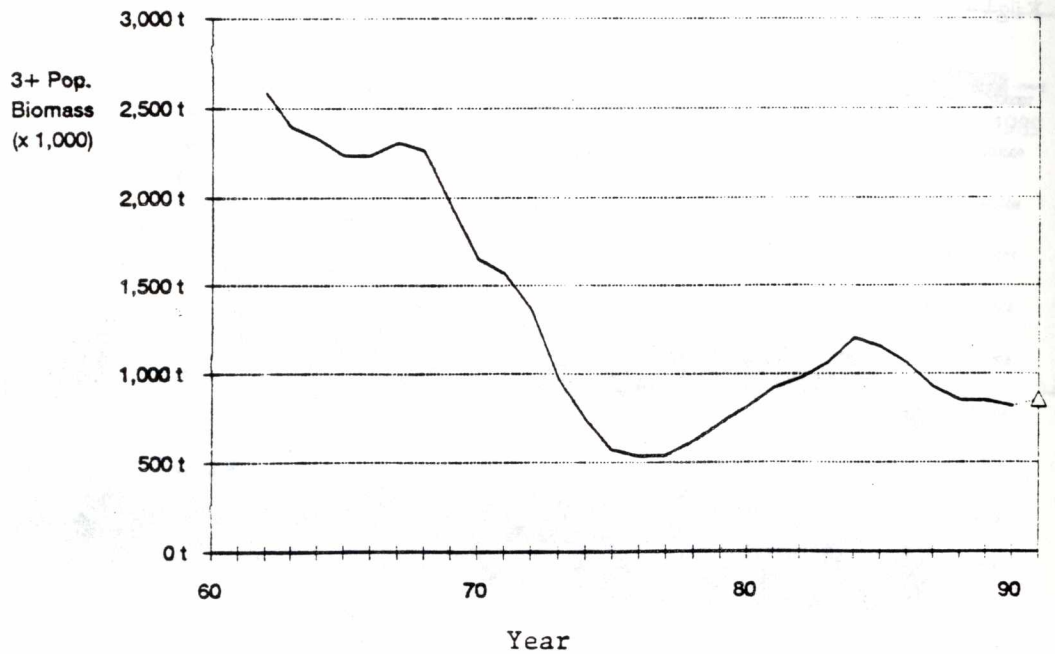


Fig. 2.5. January 1 population numbers (age 3) for cod in Divisions 2J3KL.

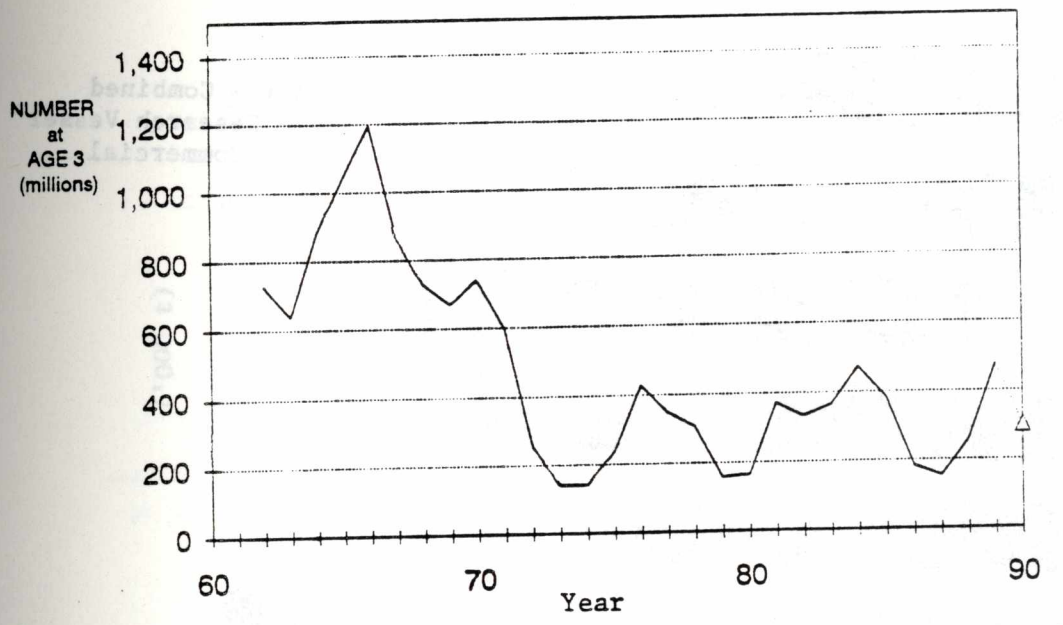


Fig. 2.6. Mean fishing mortality at ages 7-9 (weighted by population numbers) for cod in Divisions 2J3KL.

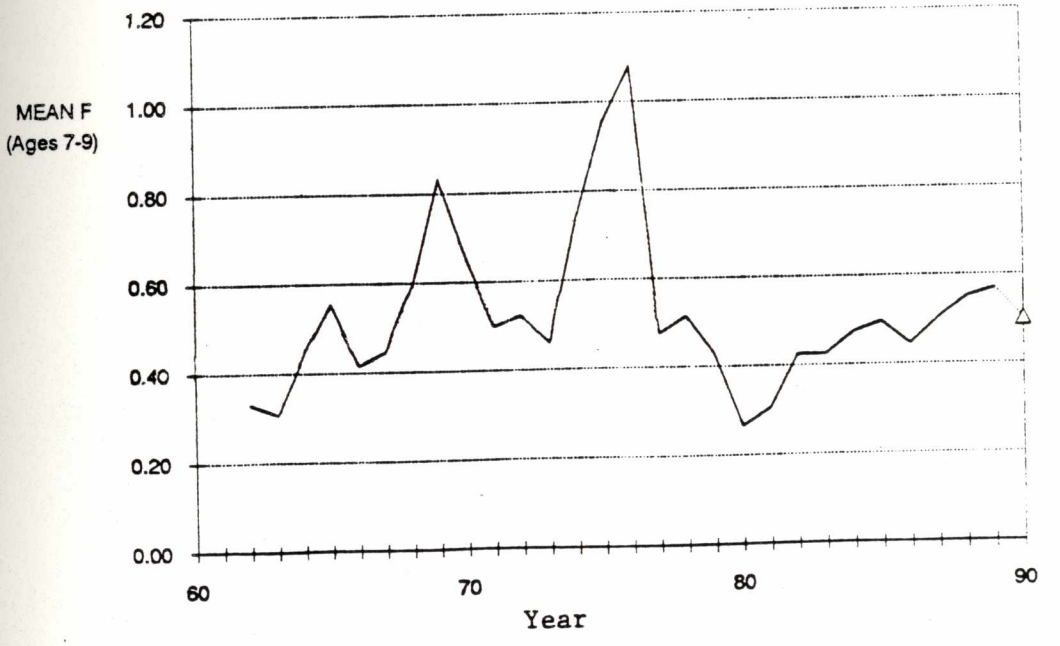


Fig. 2.7. Comparison of 1989 and 1990 assessments for 2J3KL cod.

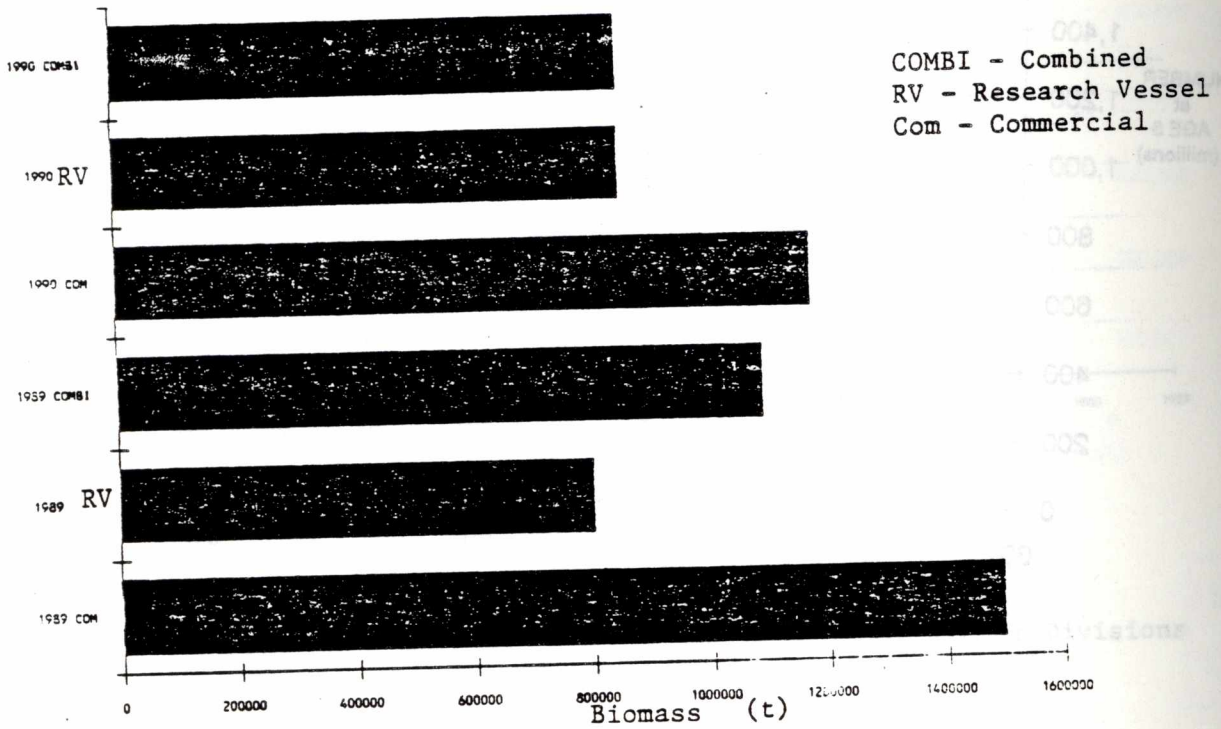


Fig. 3.1. Nominal catch and TACs for 3Pn, 4RS cod

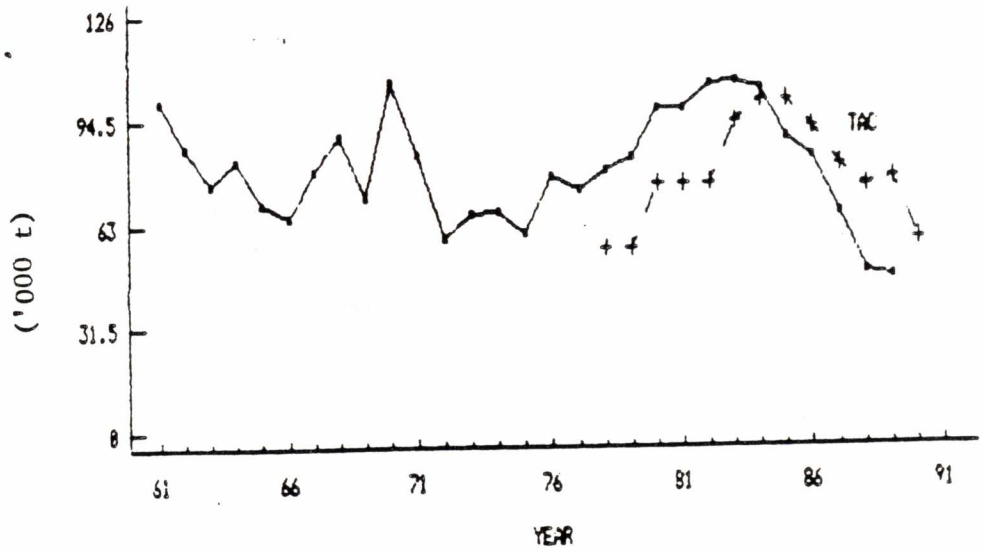


Fig. 3.2. Standardized catch rates for 3Pn, 4RS cod

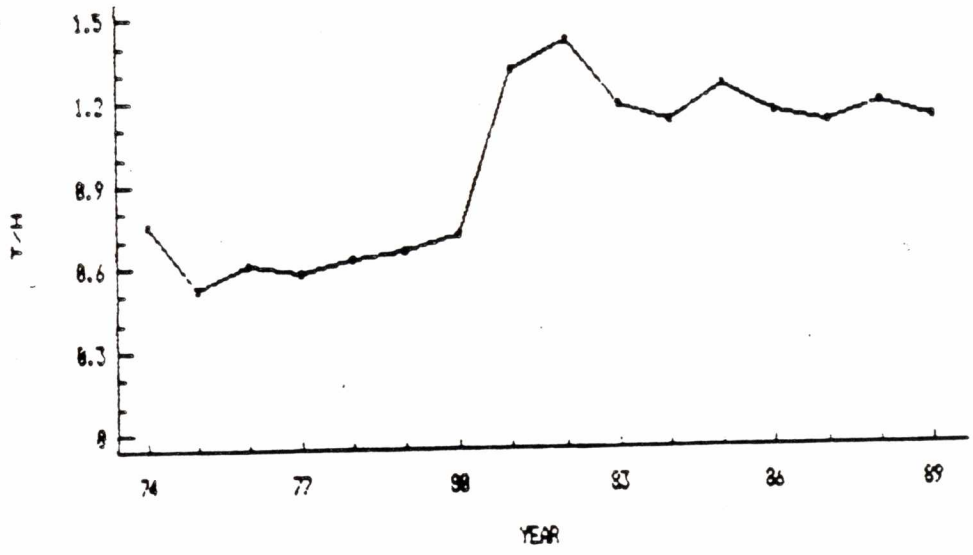


Fig. 3.3. Research survey biomass estimates for 3Pn, 4RS cod

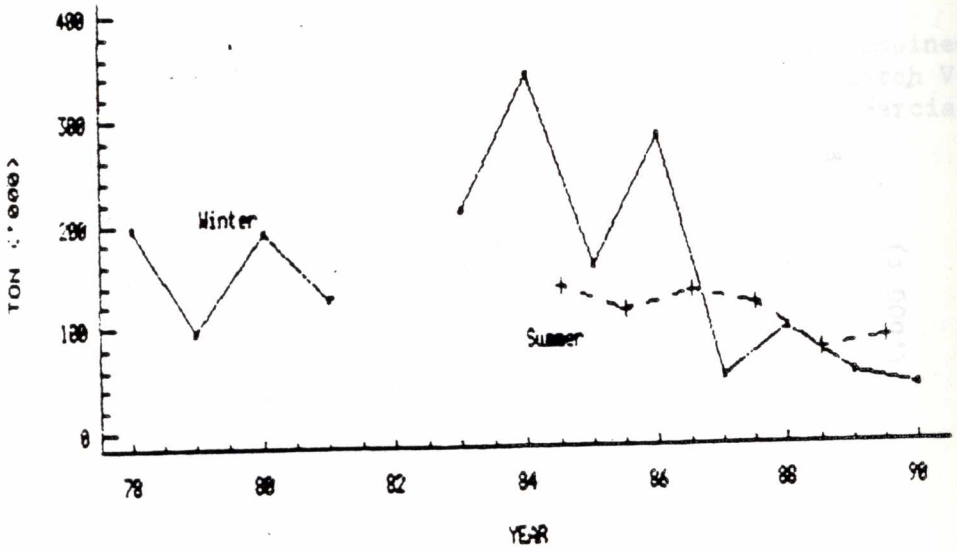


Fig. 4.1. Nominal catch and TACs for 4T-Vn (Jan.-Apr.) cod

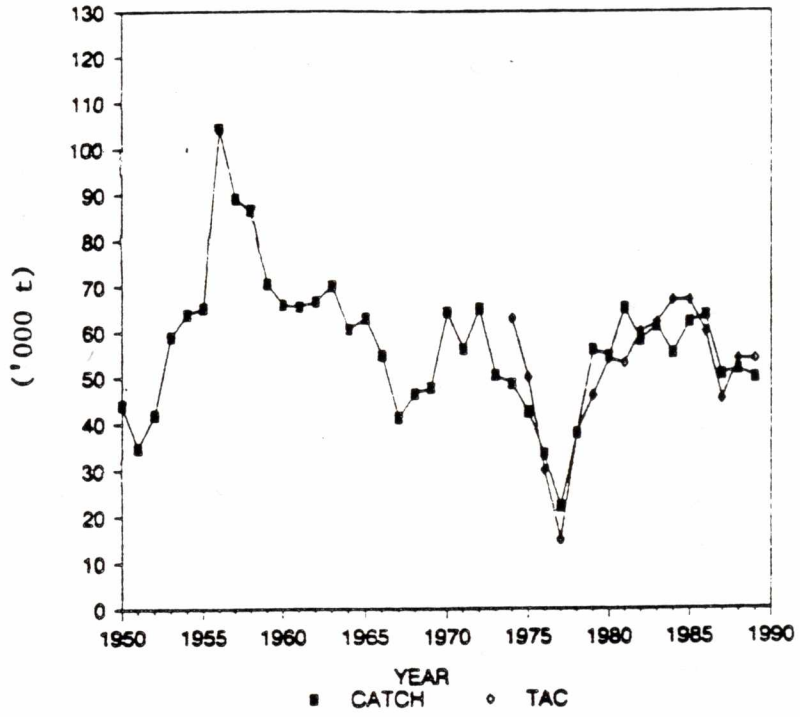


Fig. 4.2. Otter trawl catch rate for 4T-Vn (Jan-Apr) cod

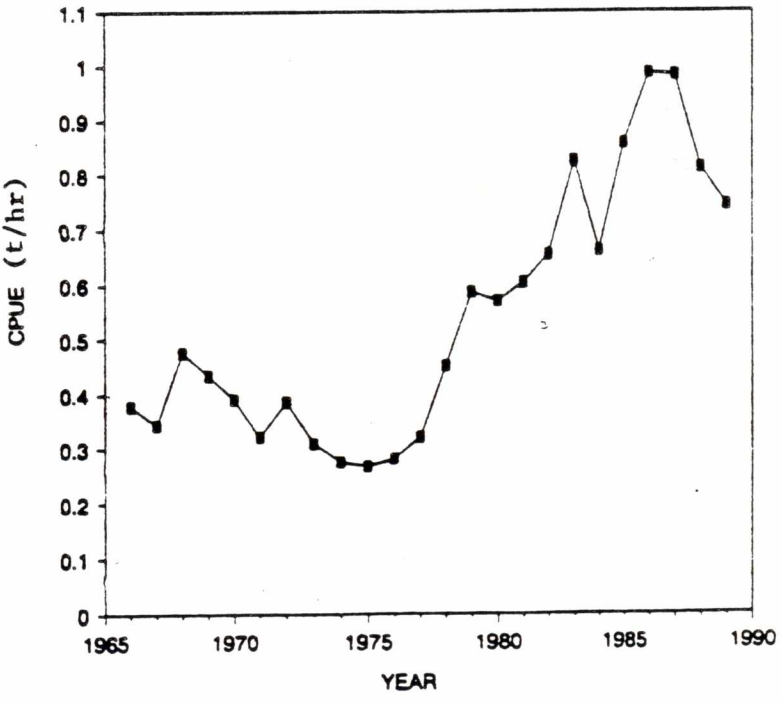


Fig. 4.3. Research vessel 3+ mean numbers per tow for 4T-Vn (Jan-Apr.) cod

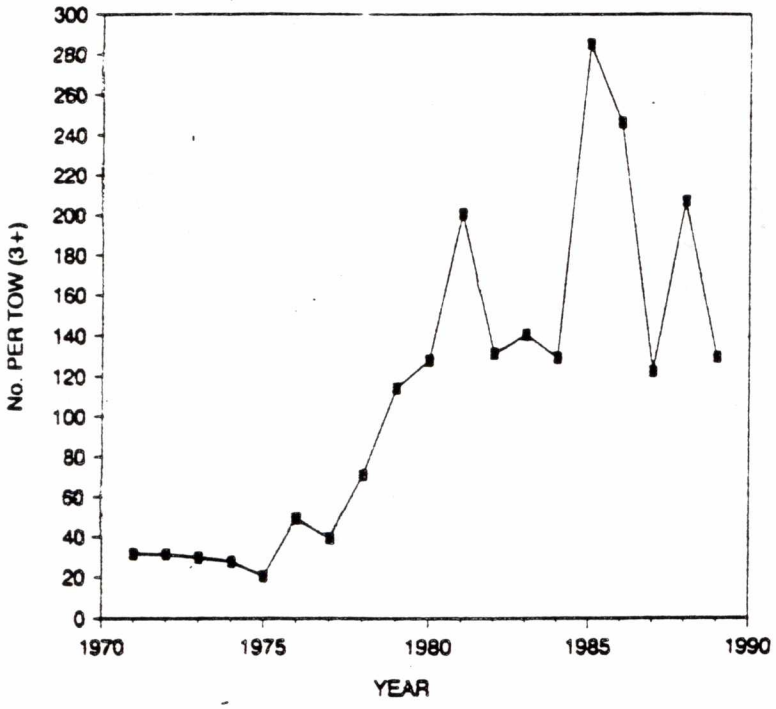


Fig. 4.4. Recrutiment estimates for 4T-Vn (Jan-Apr) cod

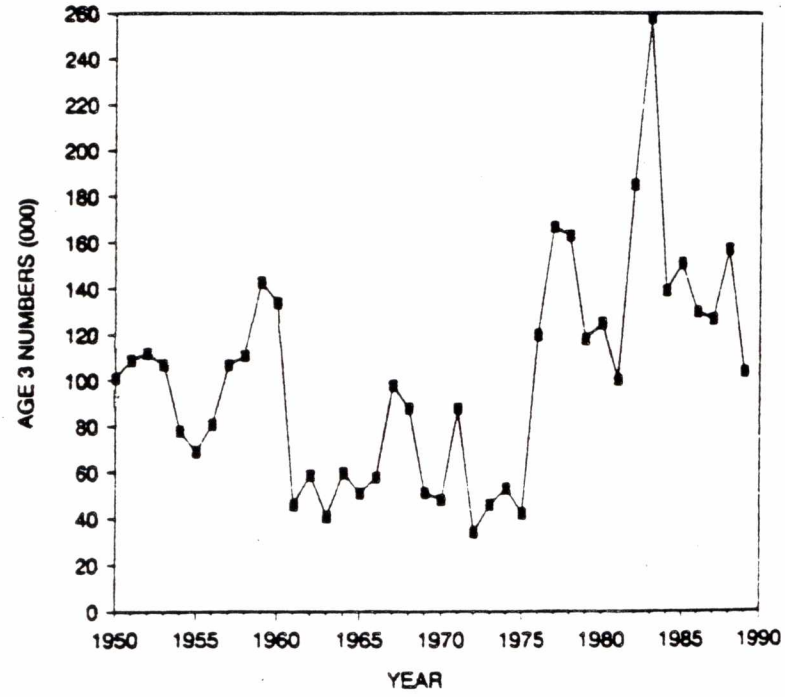


Fig. 4.5. Mean population biomass for 4T-Vn (Jan-Apr) cod

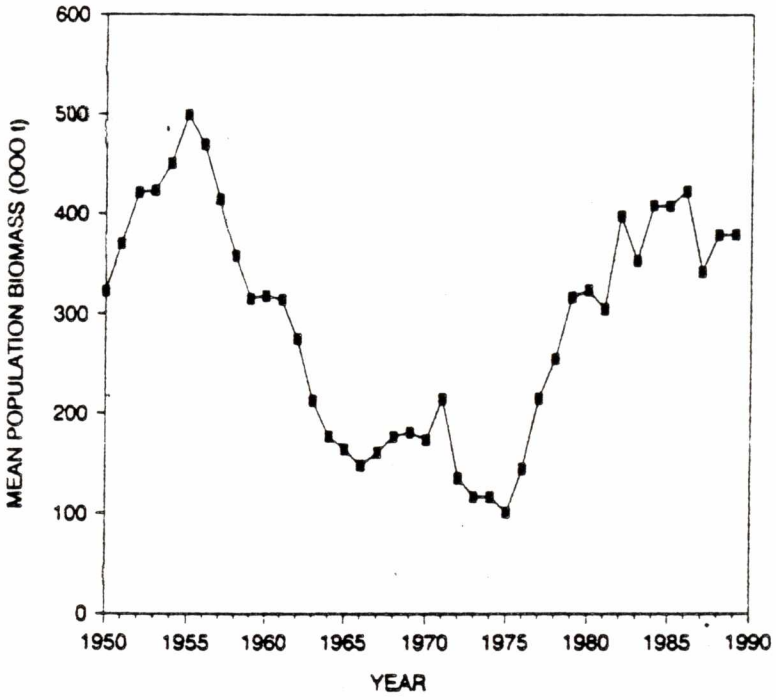


Fig. 4.6. Fully recruited (8+) fishing mortality for 4T-Vn (Jan-Apr) cod

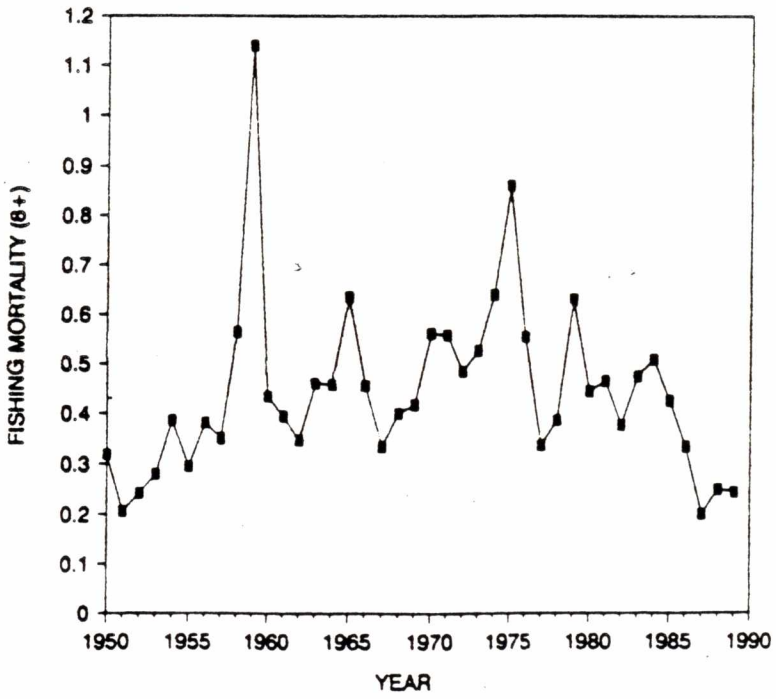


Fig. 4.7. Population numbers for 4T-Vn (Jan-Apr) cod

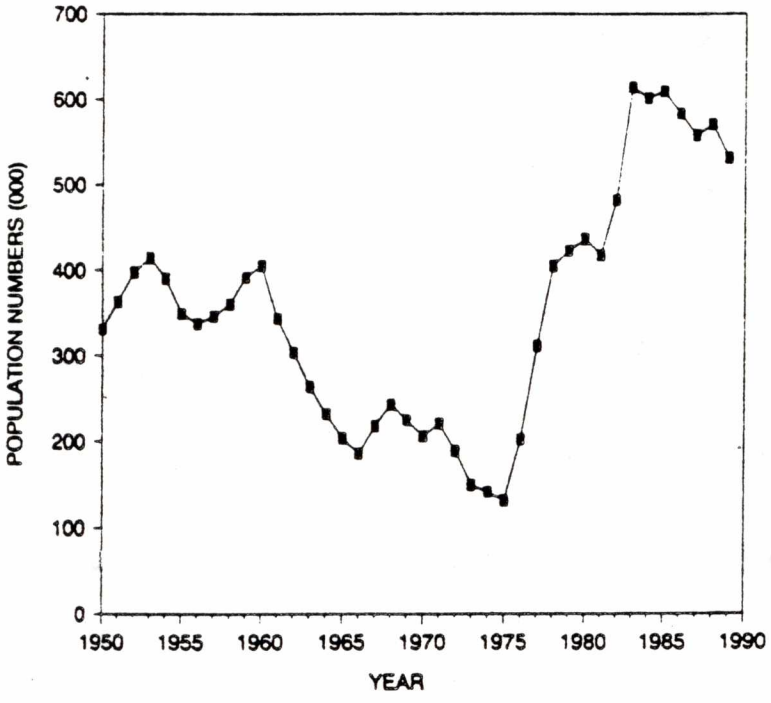


Fig. 5.1. Nominal catch and TACs for 4Vn (May-Dec.) cod

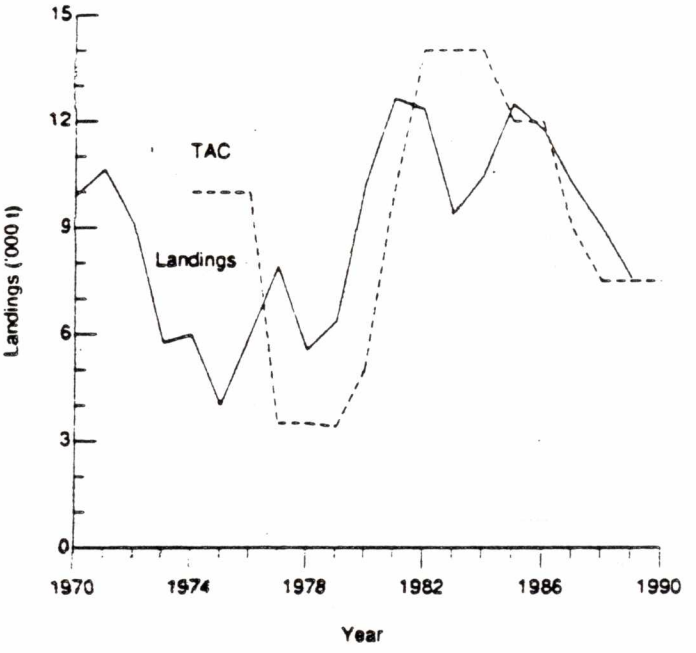


Fig. 5.2. Research vessel abundance indices for 4Vn (May-Dec.) cod

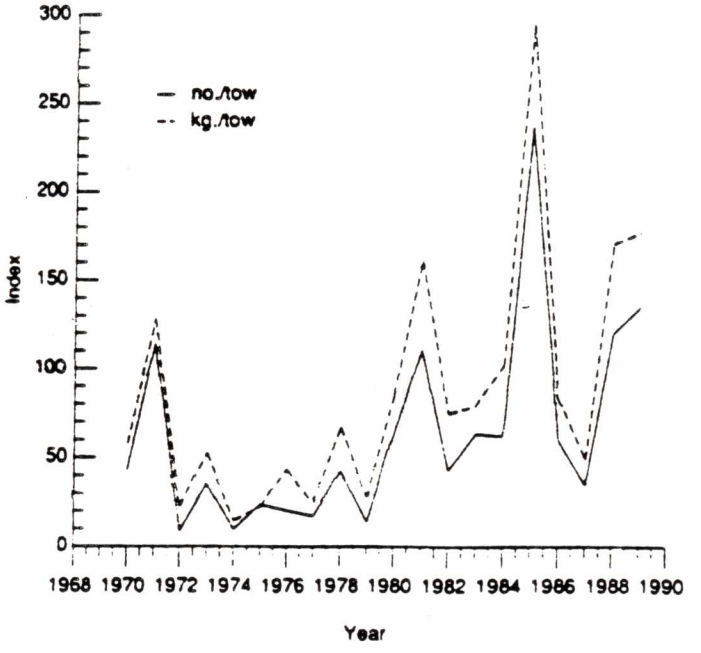


Fig. 6.1. Nominal catch and TACs for 4VsW cod

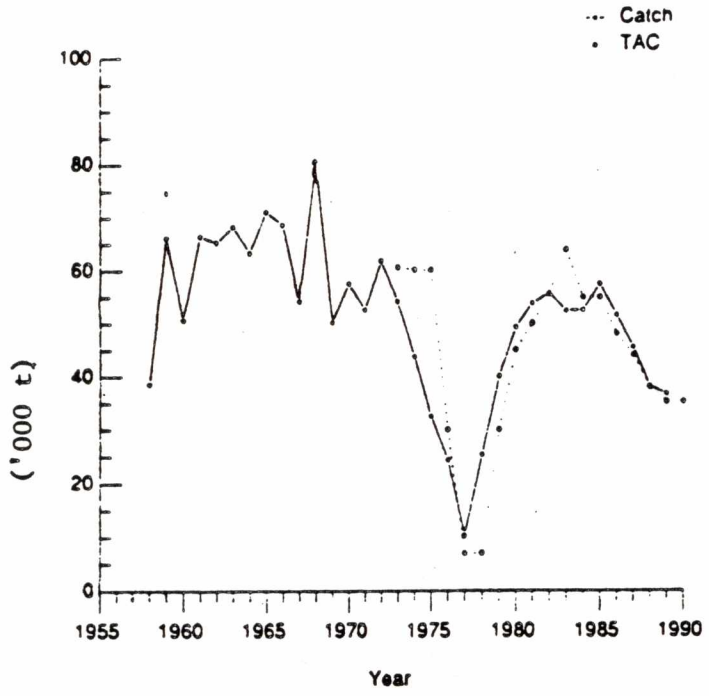


Fig. 6.2. Commercial and International Observer Program (IOP) catch rates for 4VsW cod (standardized)

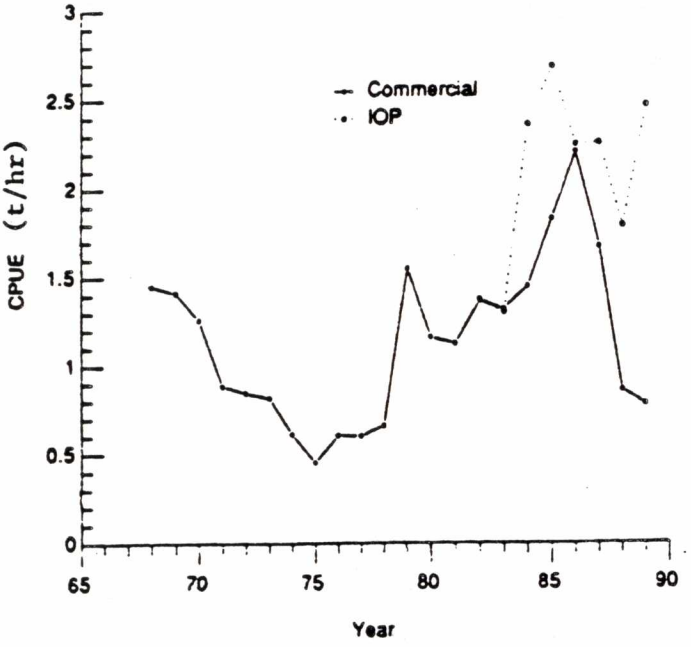
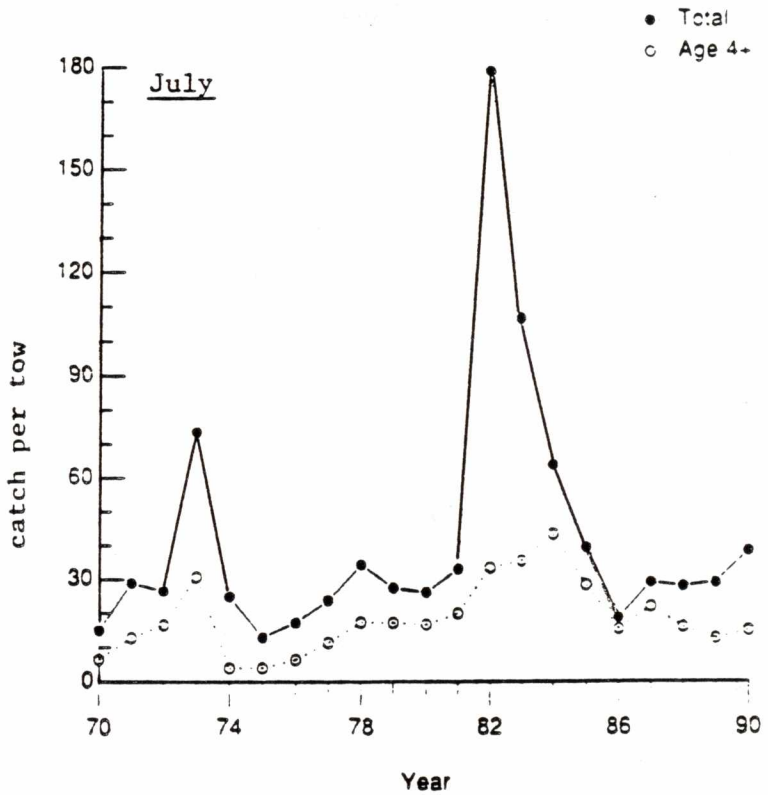


Fig. 6.3. July and March research vessel surveys for 4VsW cod.



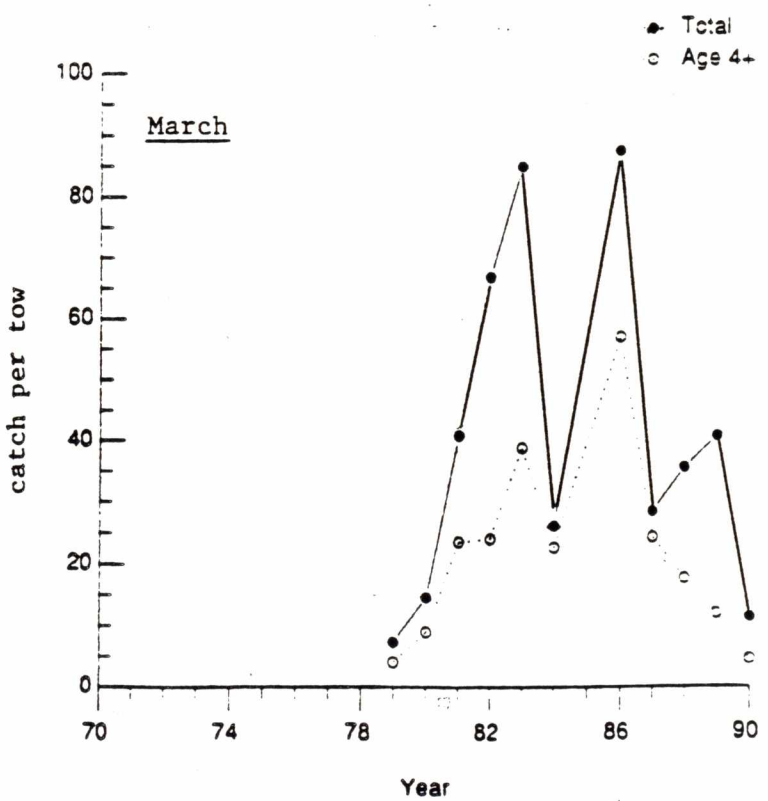


Fig. 6.4. Abundance in numbers and biomass 4VsW cod.

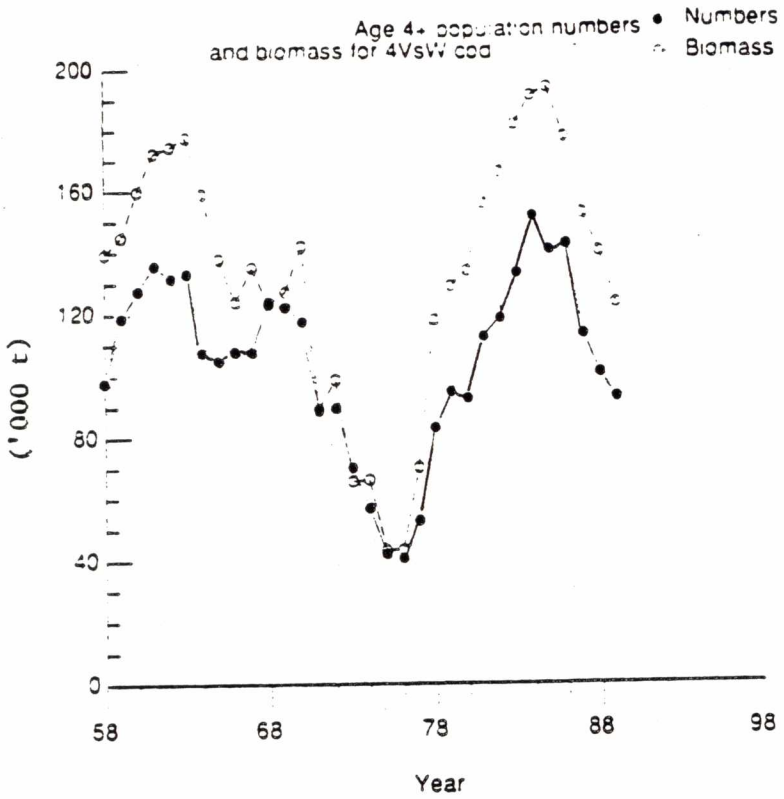


Fig. 6.5. Mean fully recruited fishing mortality (ages 7-9) in 4VsW cod.

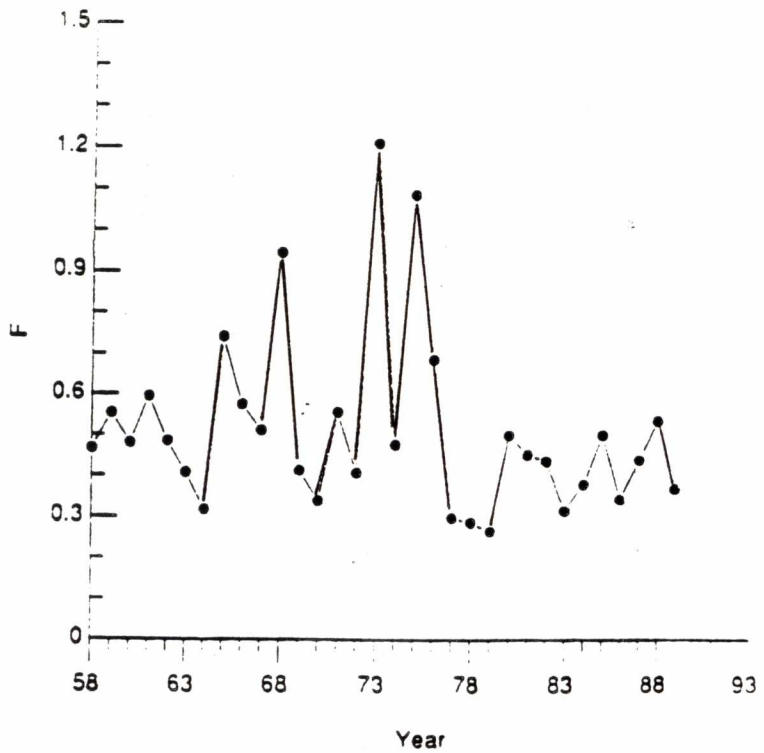


Fig. 6.6. Age 1 recruitment in 4VsW cod.

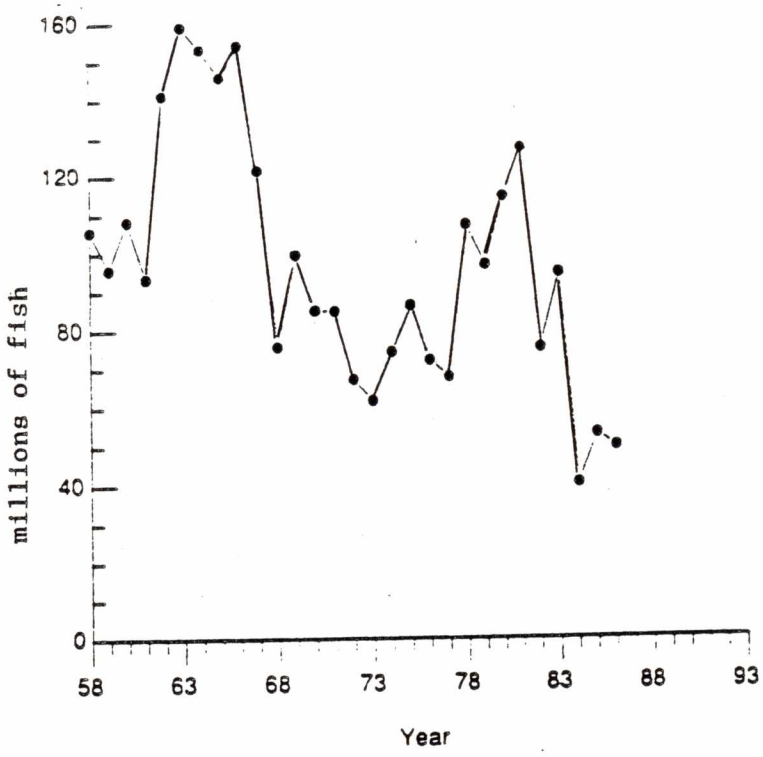


Fig. 7.1. Nominal catch and TACs for 4X cod

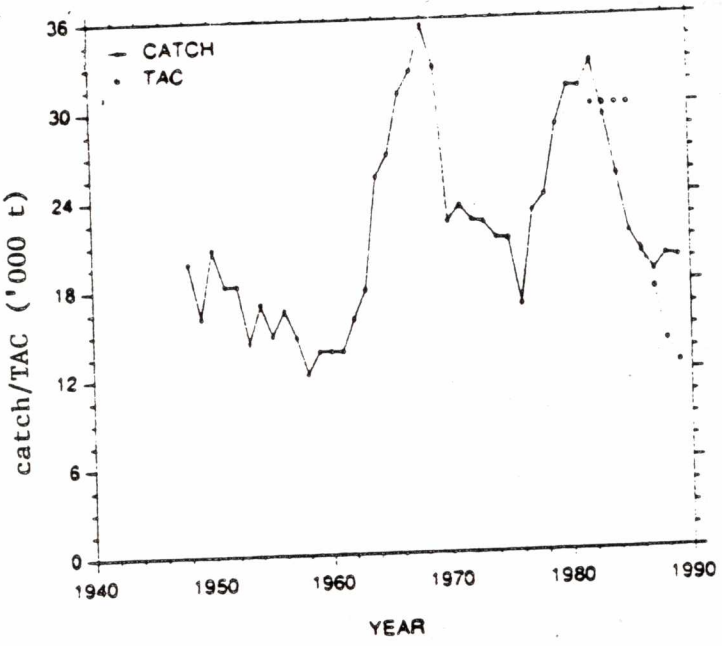


Fig. 7.2. Research vessel and scaled population for ages 3-7 for 4X cod

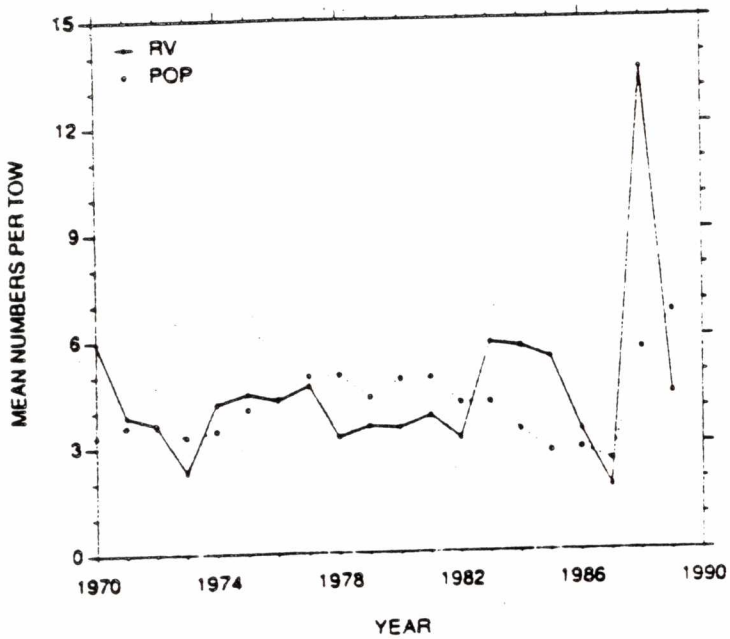


Fig. 7.3. Sequential population analysis fishing mortality (6+) for 4X cod

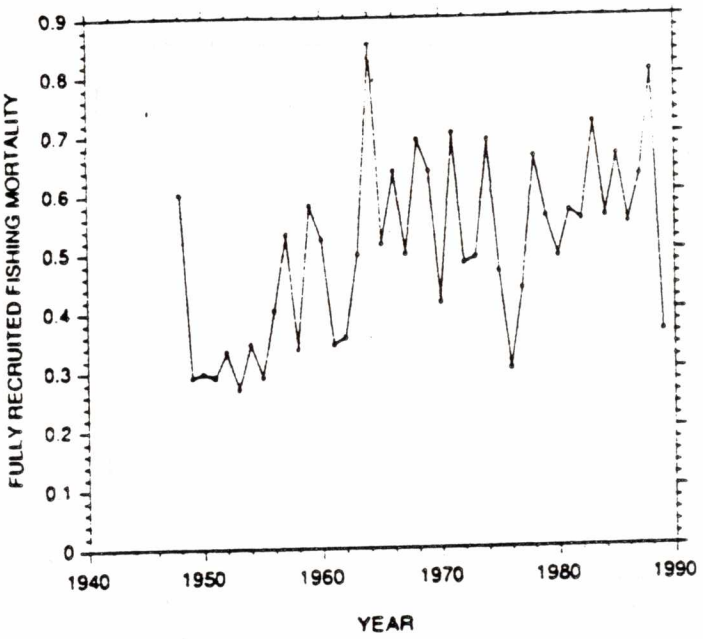


Fig. 7.4. Sequential population analysis population biomass for 4X cod

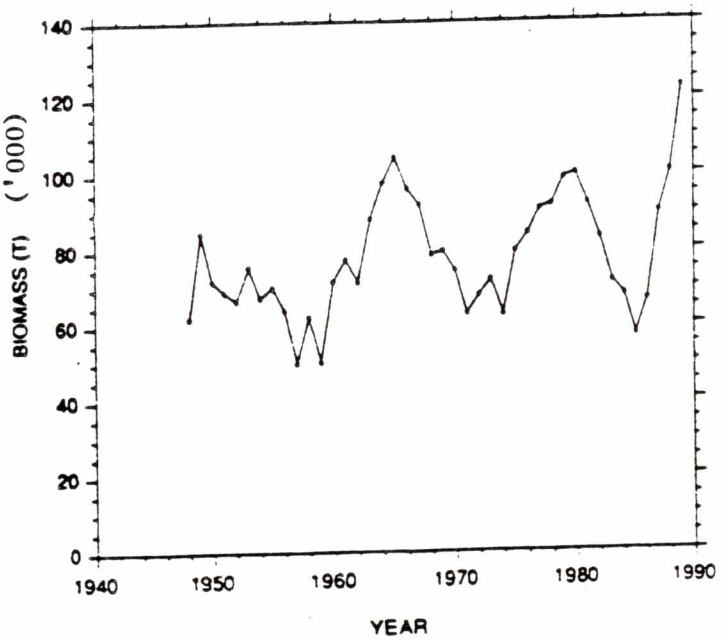


Fig. 7.5. Sequential population analysis recruitment (age 1) for 4X cod

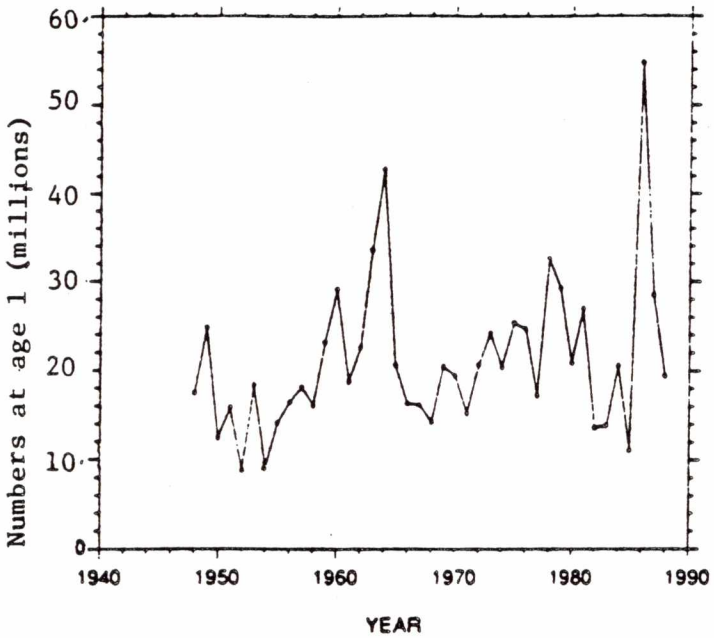


Fig. 8.1. Canadian and USA catches 5Zjm cod.

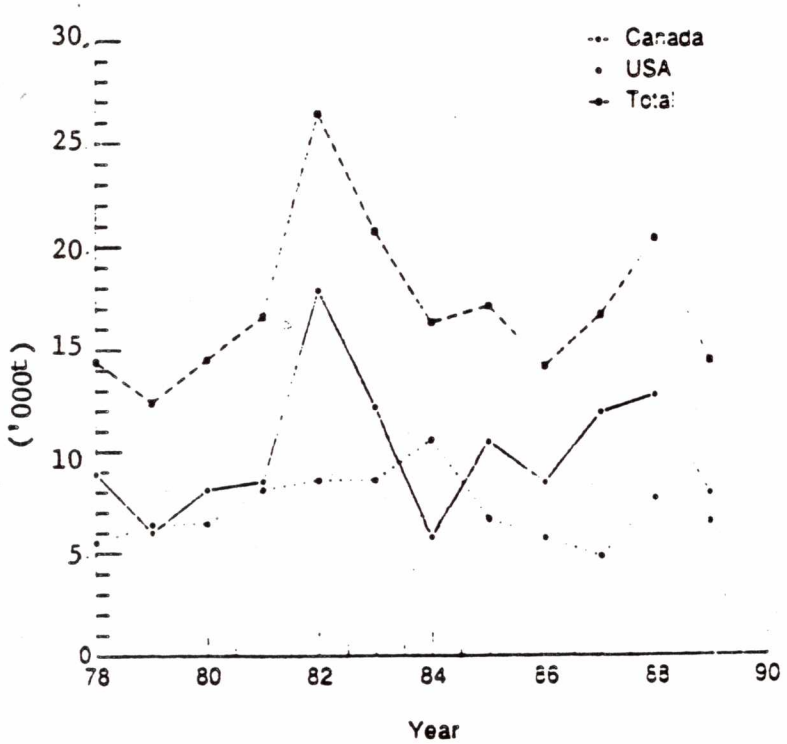


Fig. 8.2. Canadian and USA research surveys for cod in 5Zjm.

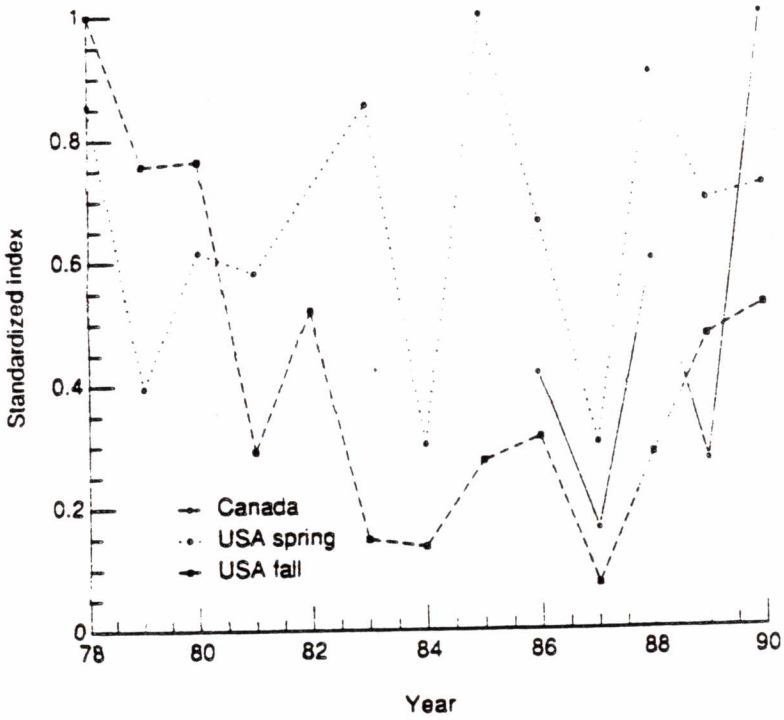


Fig. 8.3. Recruitment at age 1 for 5Zjm cod.

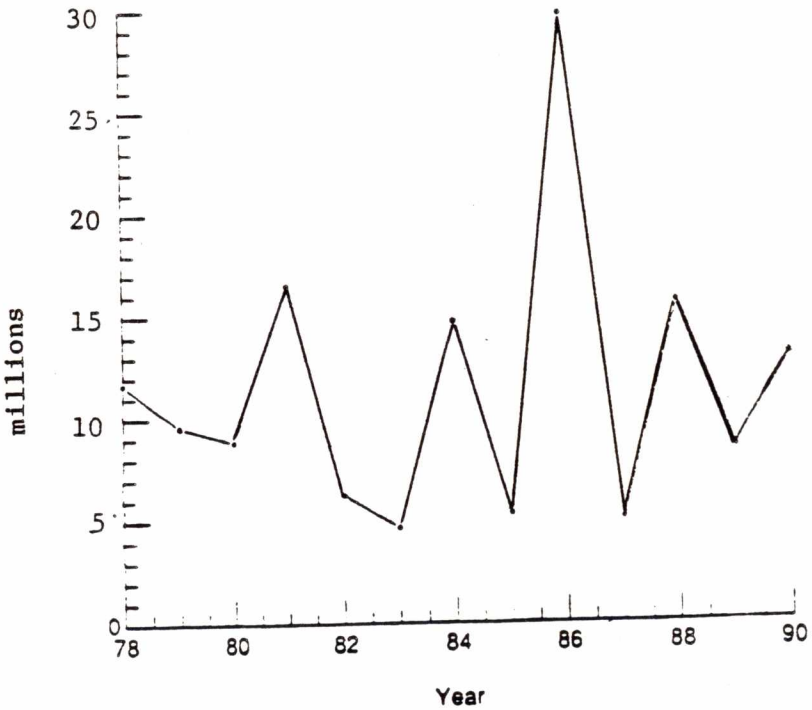


Fig. 8.4. Biomass for ages 3+ 5Zjm cod.

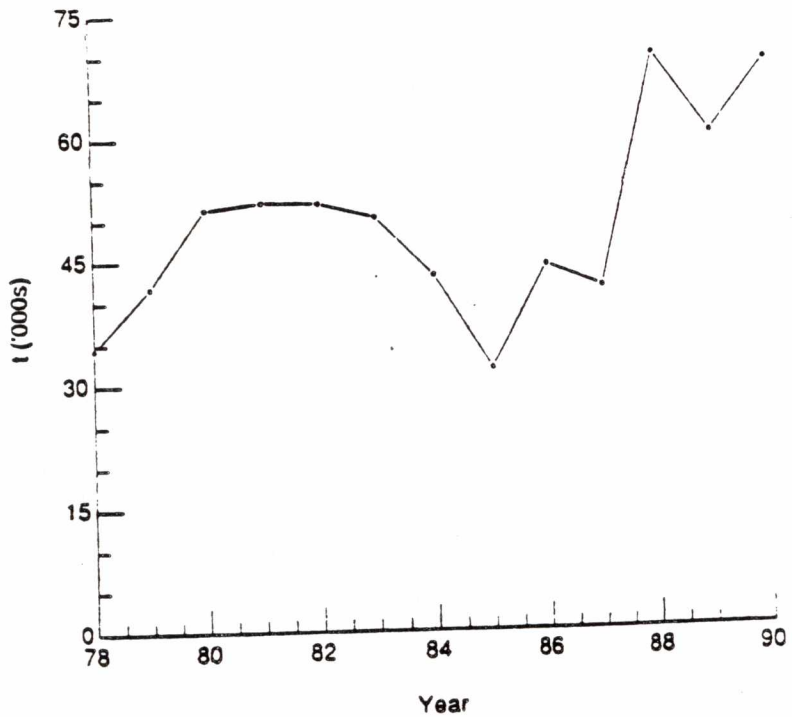


Fig. 8.5. Mean 3+ fishing mortality for 5Zjm cod.

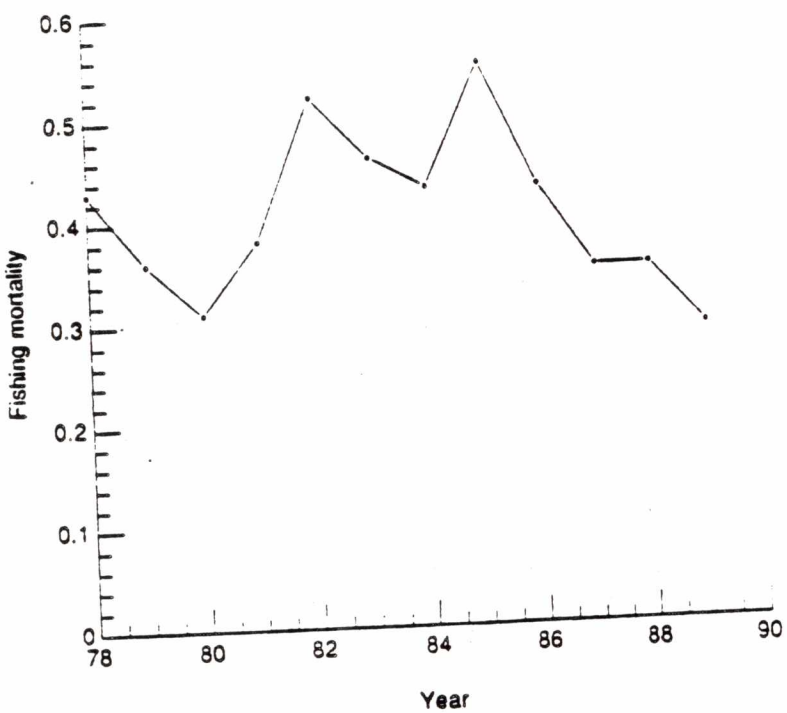


Fig. 9.1. Nominal catch and TACs for 4TVW haddock

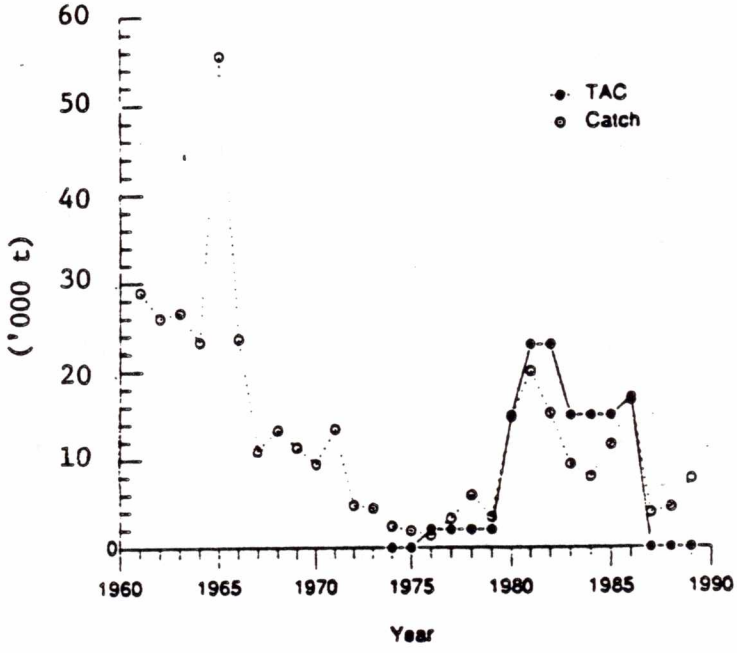


Fig. 9.2. Mean haddock catch per tow in 4VW (all ages combined)

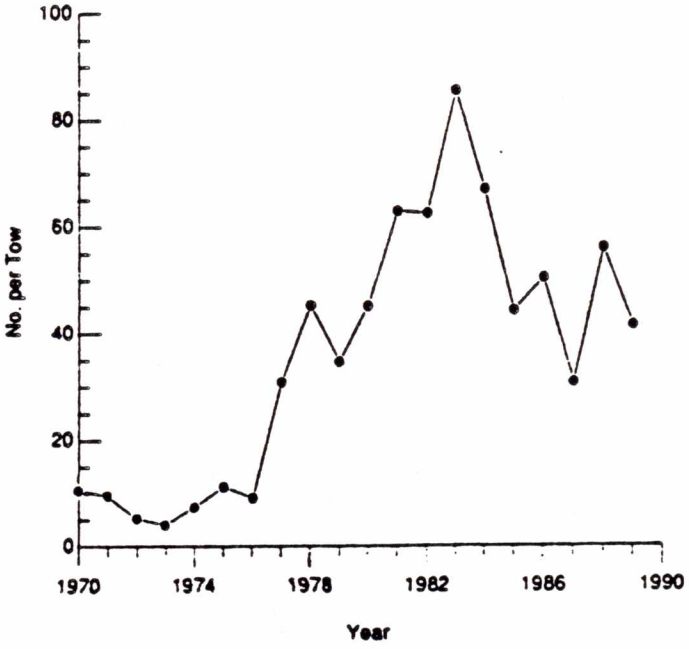


Fig. 9.3. Mean haddock catch per tow in 4W

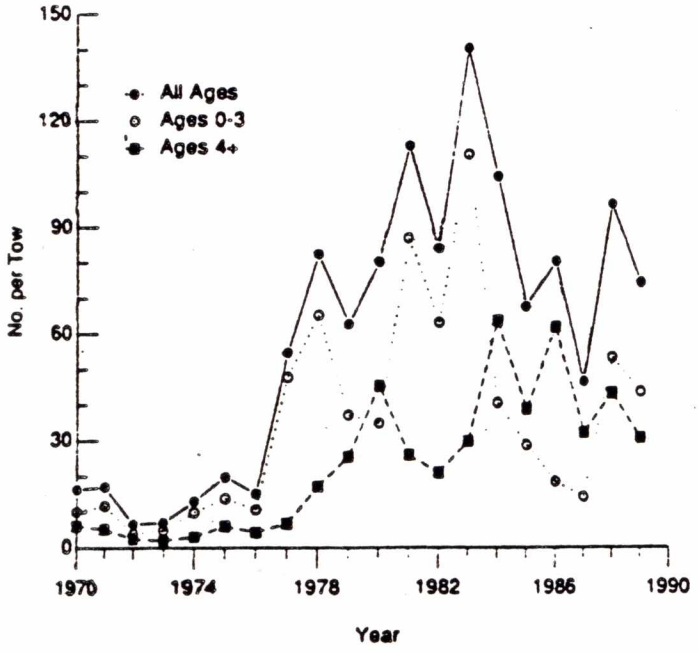


Fig. 9.4. Mean haddock catch per tow in 4Vn

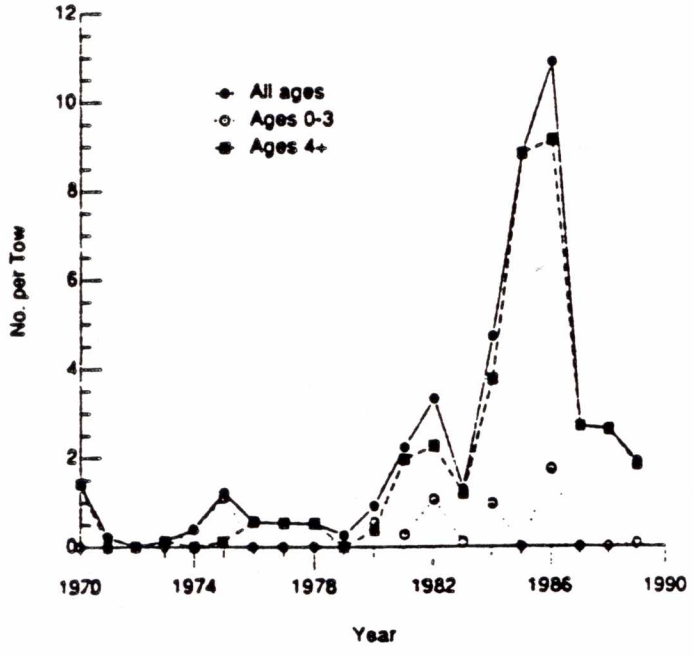


Fig. 9.5. Mean haddock catch per tow in 4Vs

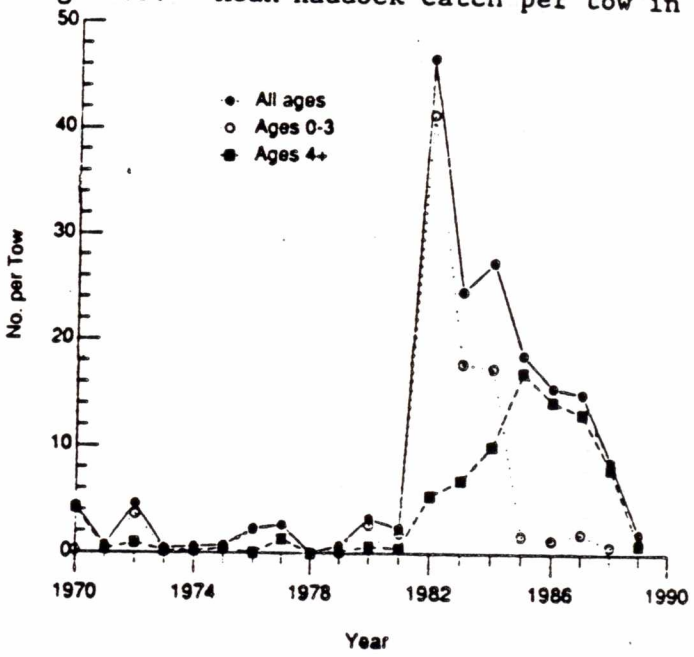


Fig. 9.6. Research vessel estimated fishing mortality (3 year running mean)

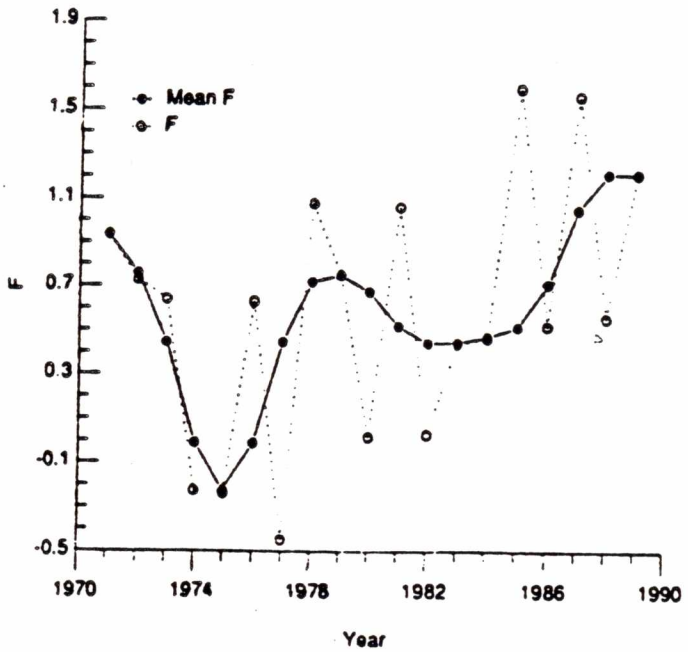


Fig. 9.7. Mean weight of a fish in the catch for 4TVW haddock

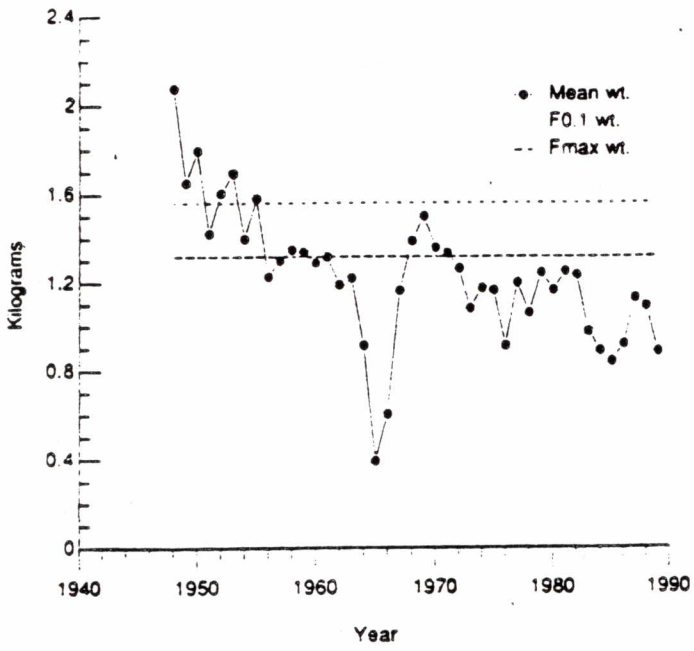


Fig. 10.1. Nominal catch and TACs for 4X haddock

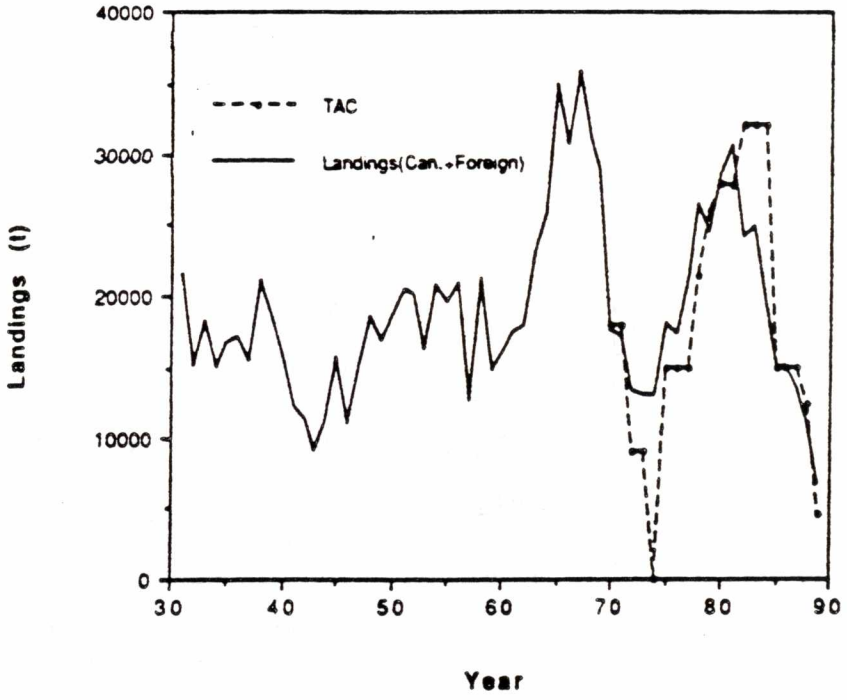


Fig. 10.2. Research vessel abundance index (mean weight per tow) for 4X haddock

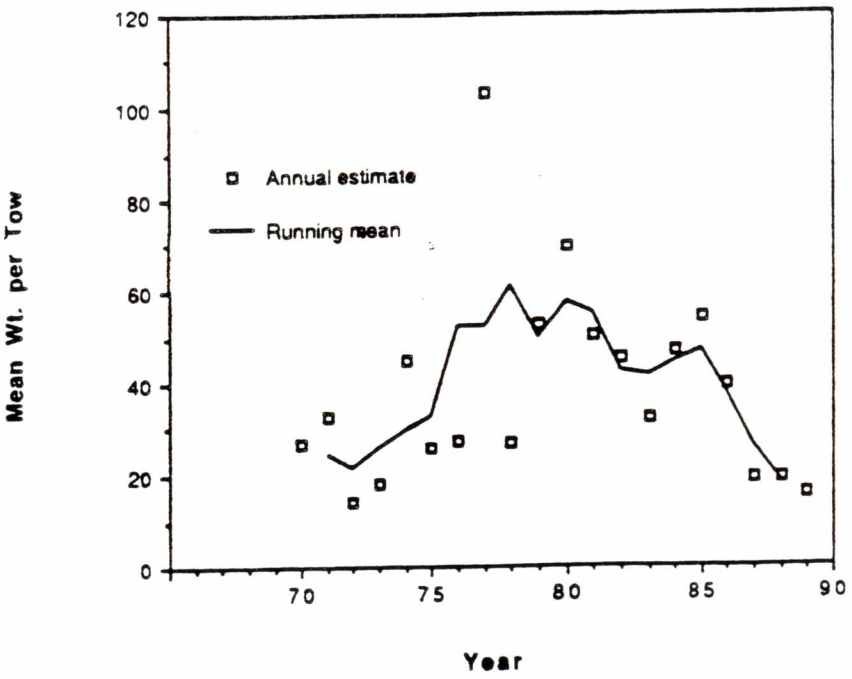


Fig. 10.3. Research vessel abundance index (mean numbers per tow) for 4X haddock

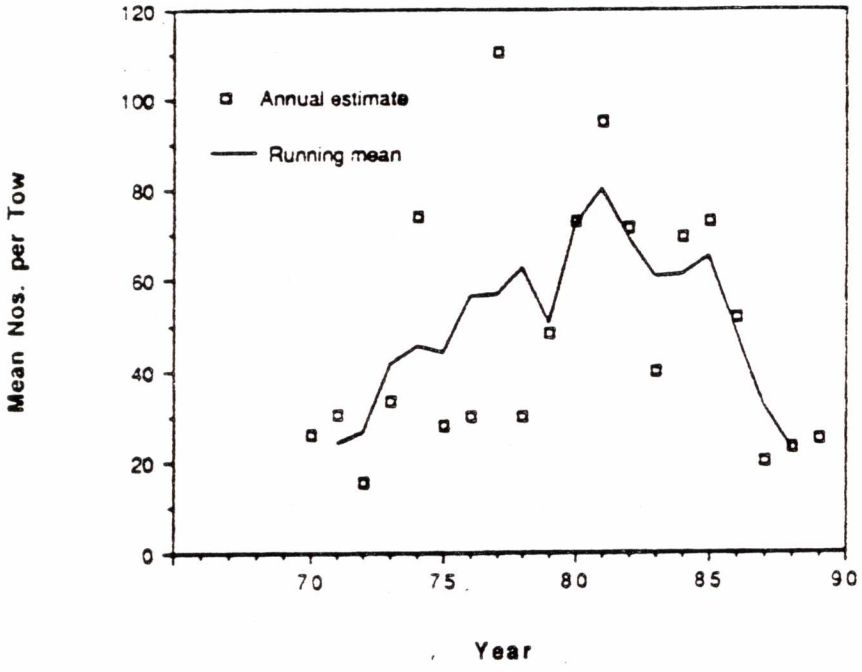


Fig. 11.1. Catch of haddock in unit areas 5Zjm.

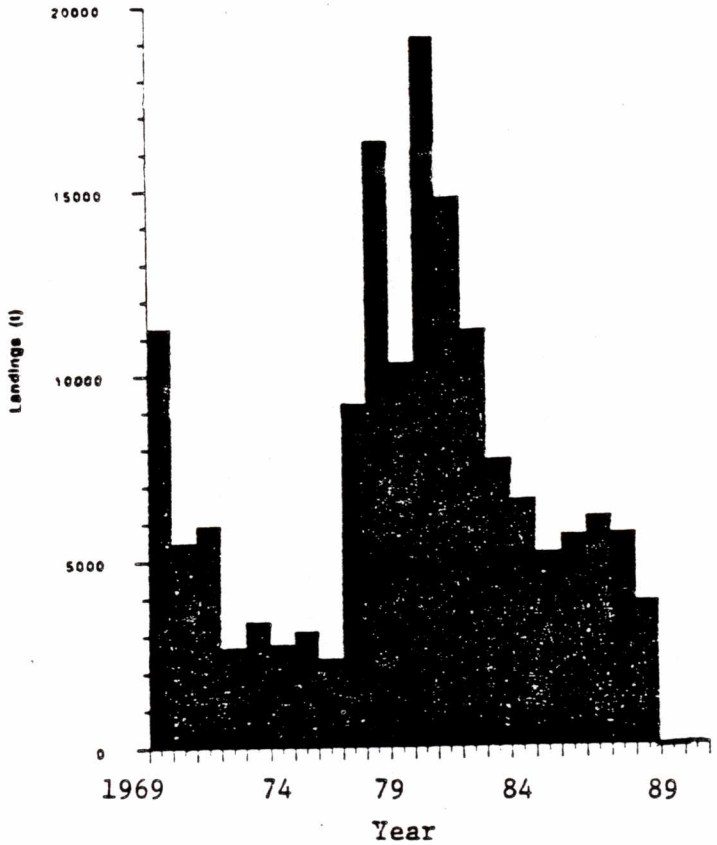


Fig. 11.2. Biomass index 5Zjm haddock.

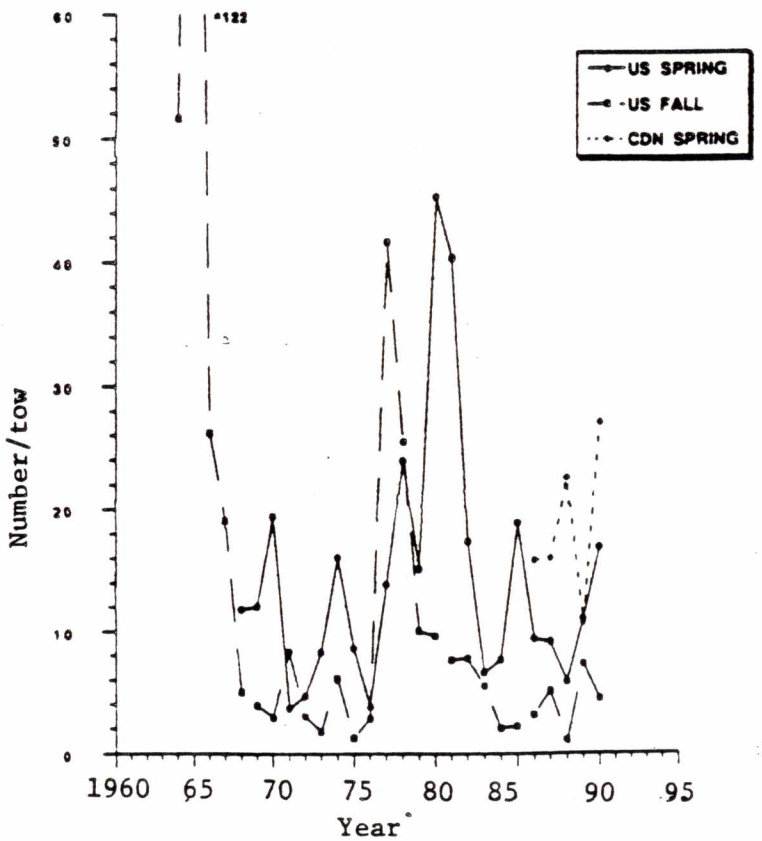


Fig. 11.3. Biomass of haddock in unit area 5Zjm.

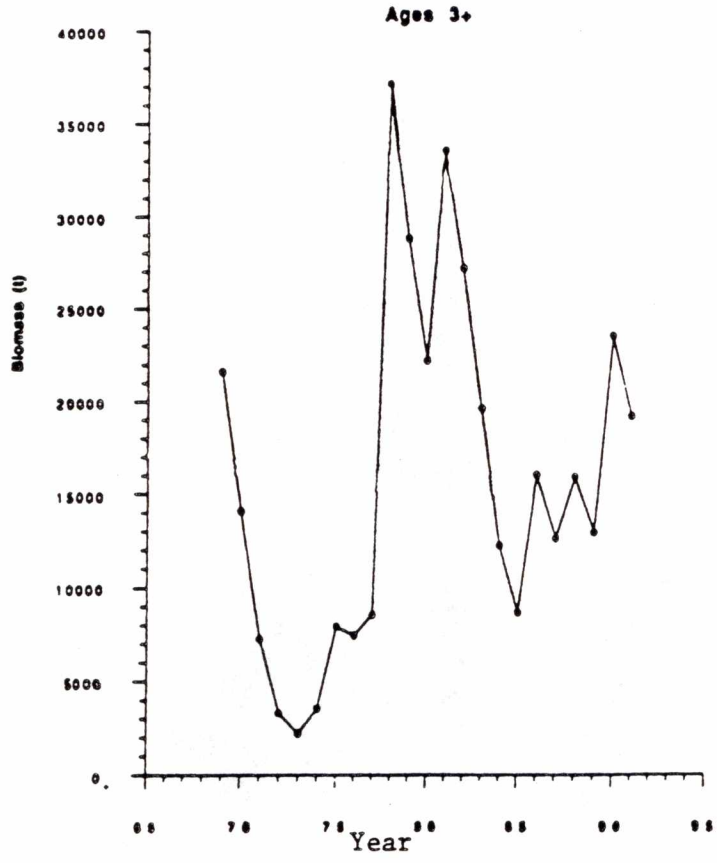


Fig. 11.4. Fishing mortality rate for haddock unit areas 5Zjm. Ages 3+ .

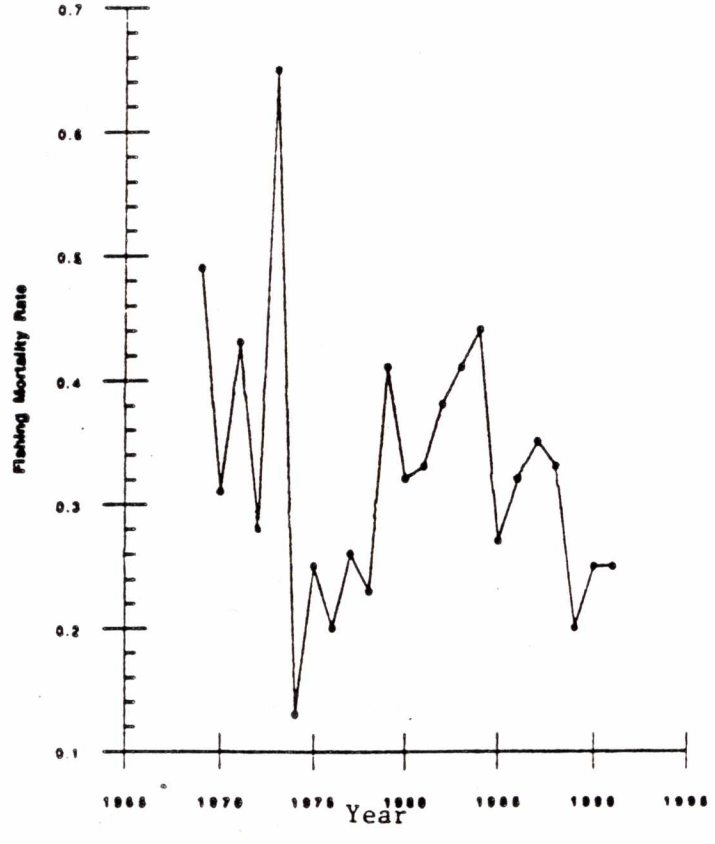


Fig. 11.5. Recruitment for haddock in unit areas 5Zjm.

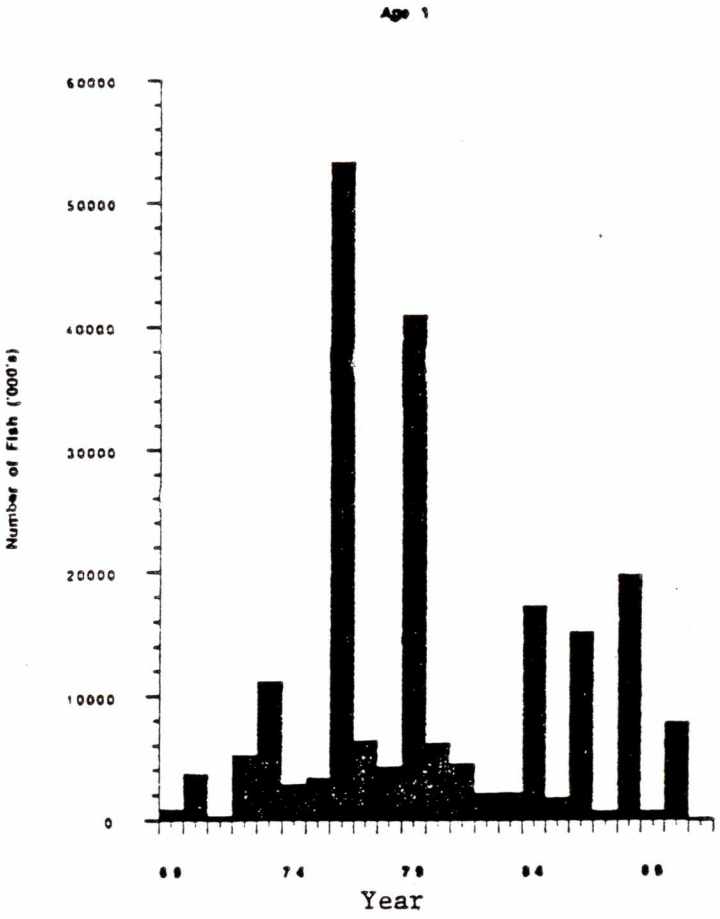


Fig. 12.1. Nominal catch and TACs for 4VWX5Z pollock

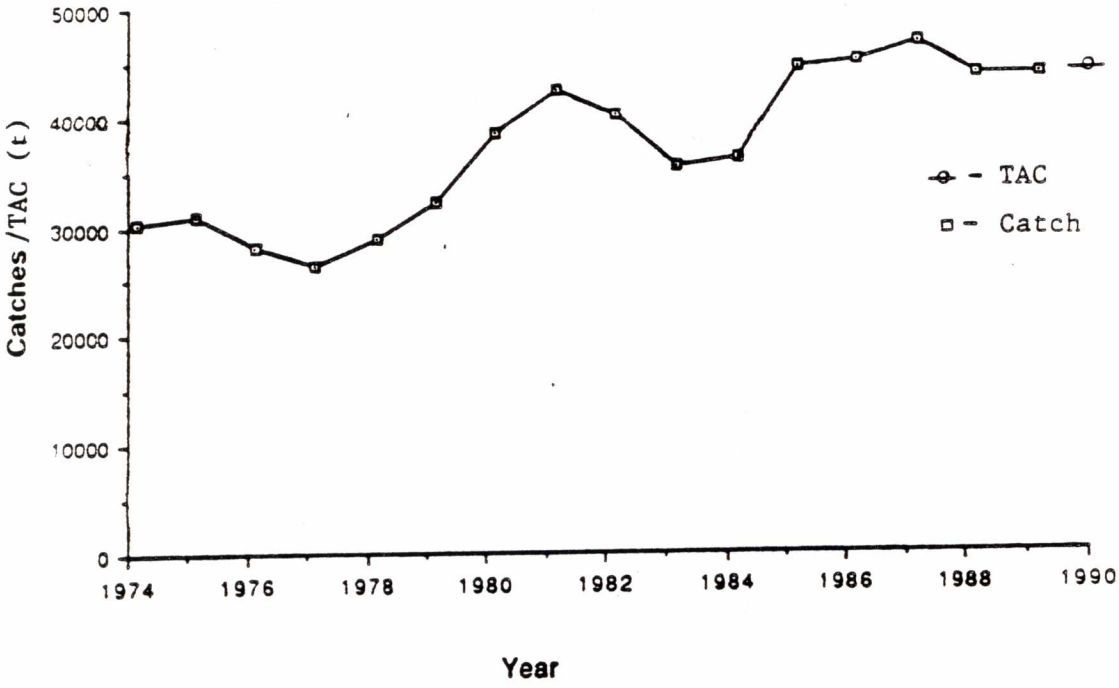


Fig. 12.2. July Research vessel stratified population estimates (ages 4-9) for 4VWX5Zc pollock.

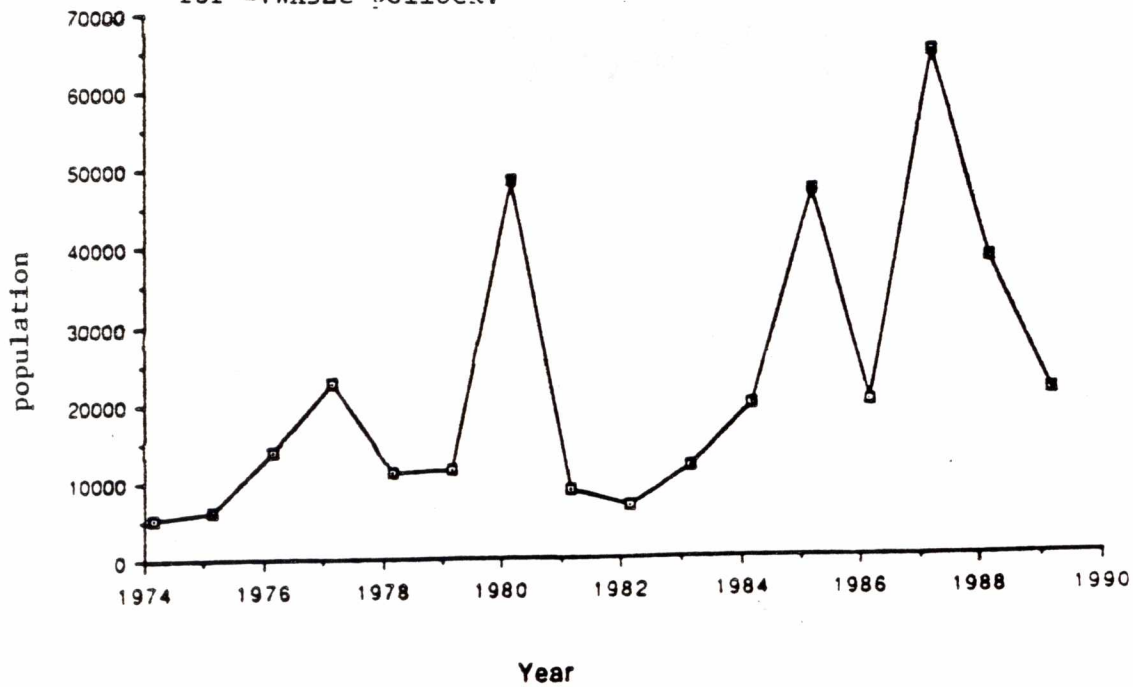


Fig. 12.3. Age 2 recruits to 4VWX5Zc pollock

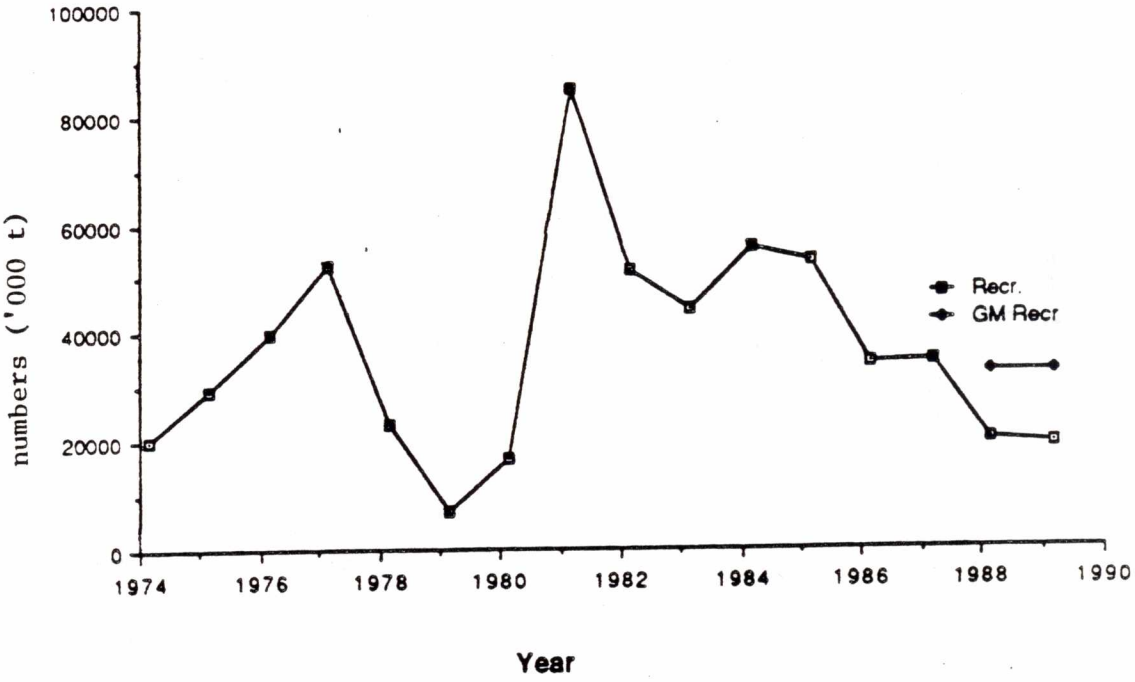


Fig. 12.4. Mid-year biomass for 4VWX5Zc pollock.

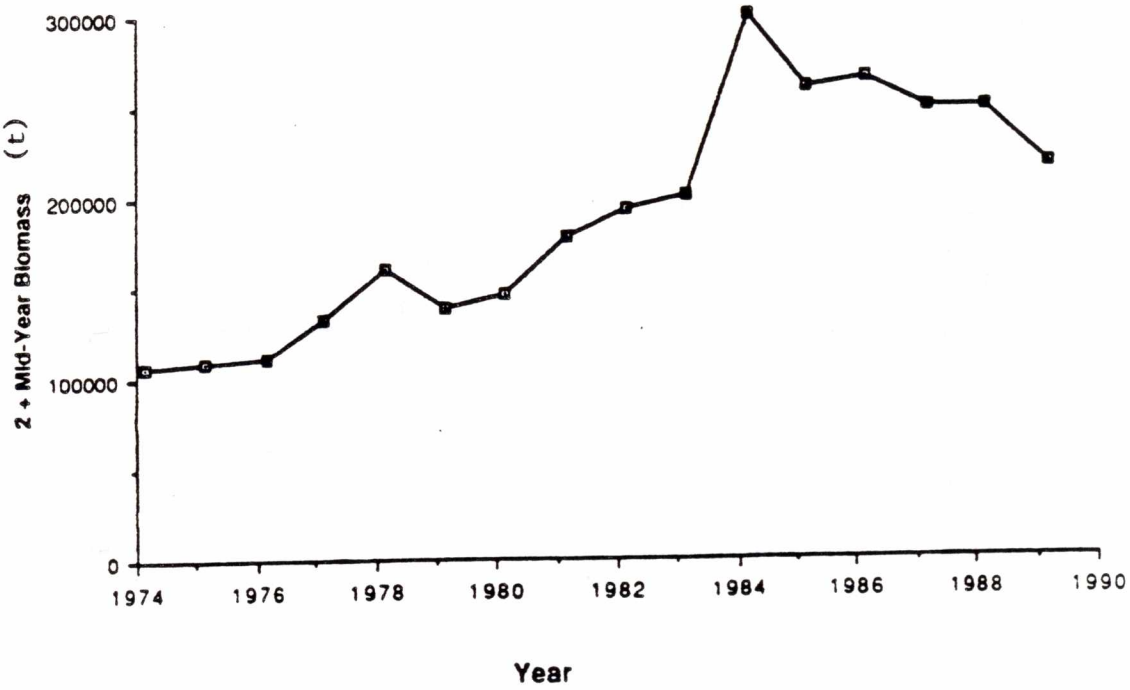


Fig. 12.5. Population numbers (ages 4-9) for 4VWX5Zc pollock.

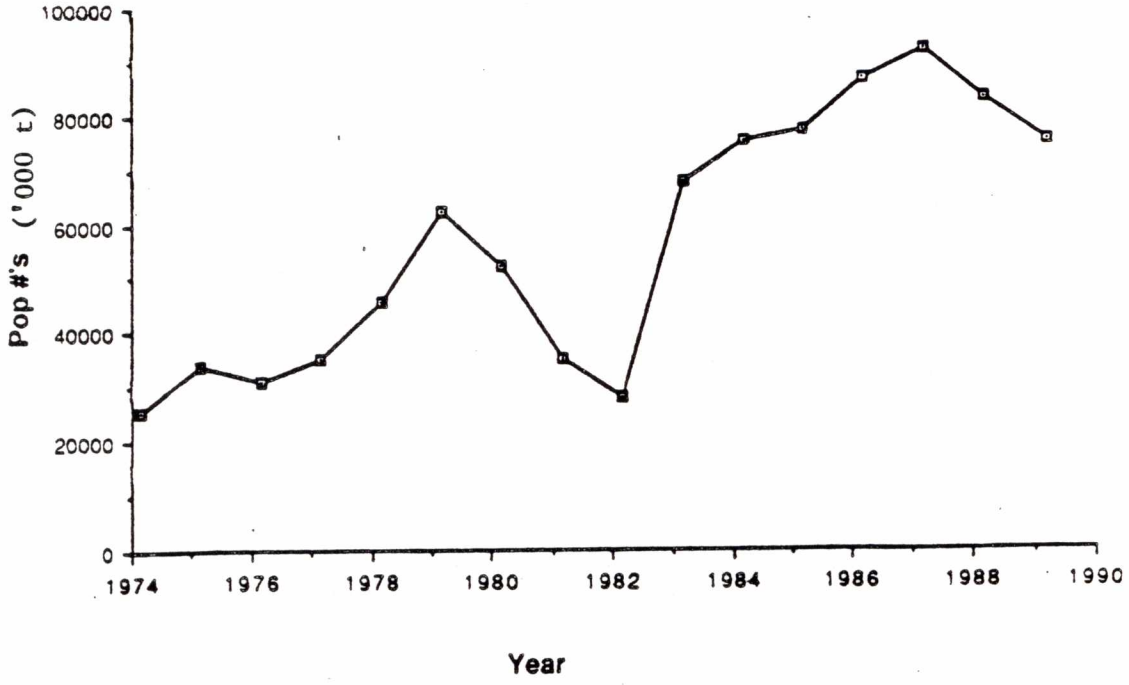


Fig. 12.6. Fully recruited F for 4VWX5Zc pollock

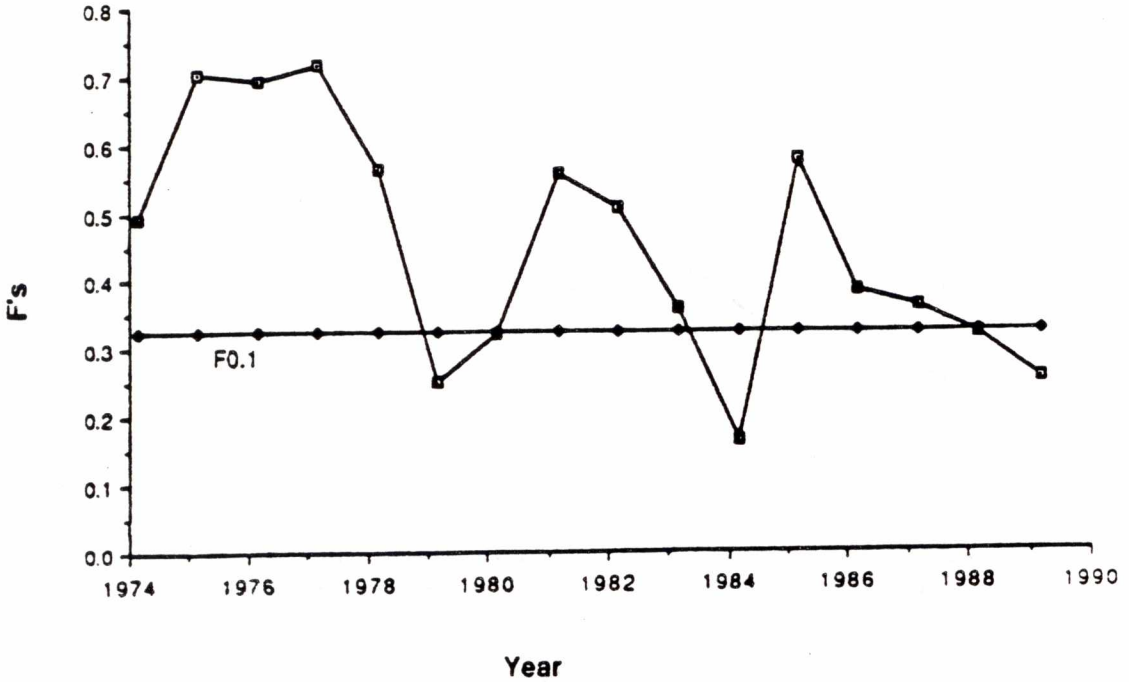


Fig. 13.1. Nominal catch and TACs for redfish in SA2 + Division 3K

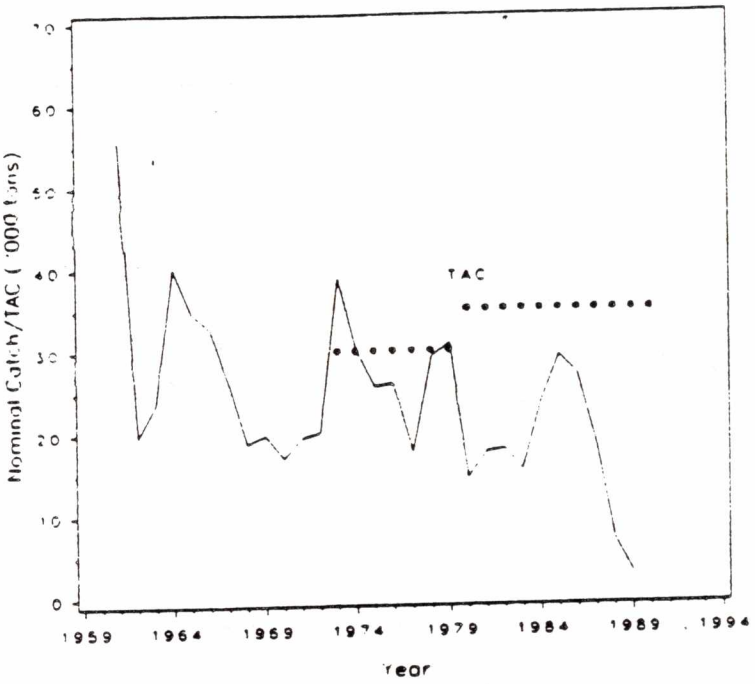


Fig. 13.2. Catch rate index for redfish in SA2 + Division 3K

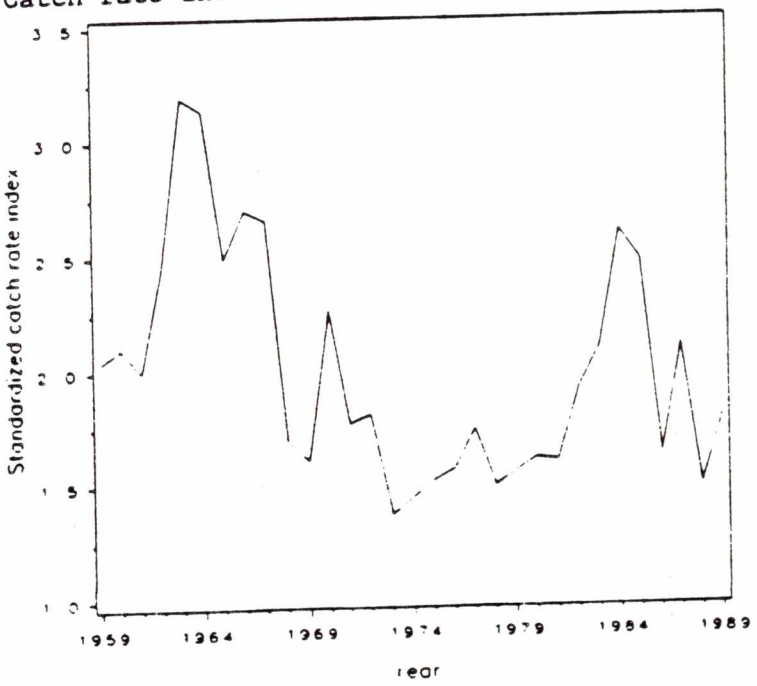


Fig. 13.3. Survey abundance index for redfish in SA 2 and Division 3K.

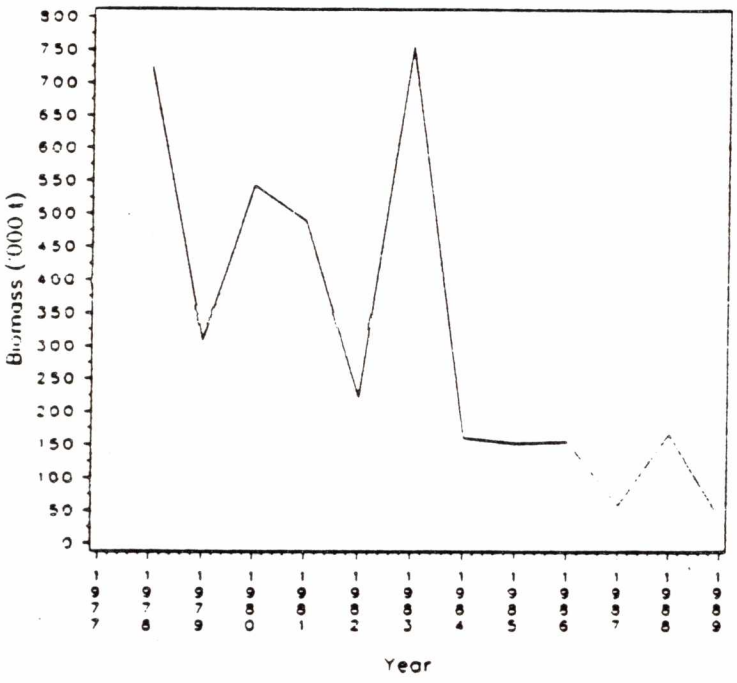


Fig. 14.1. Nominal catch and TACs for Division 30 redfish.

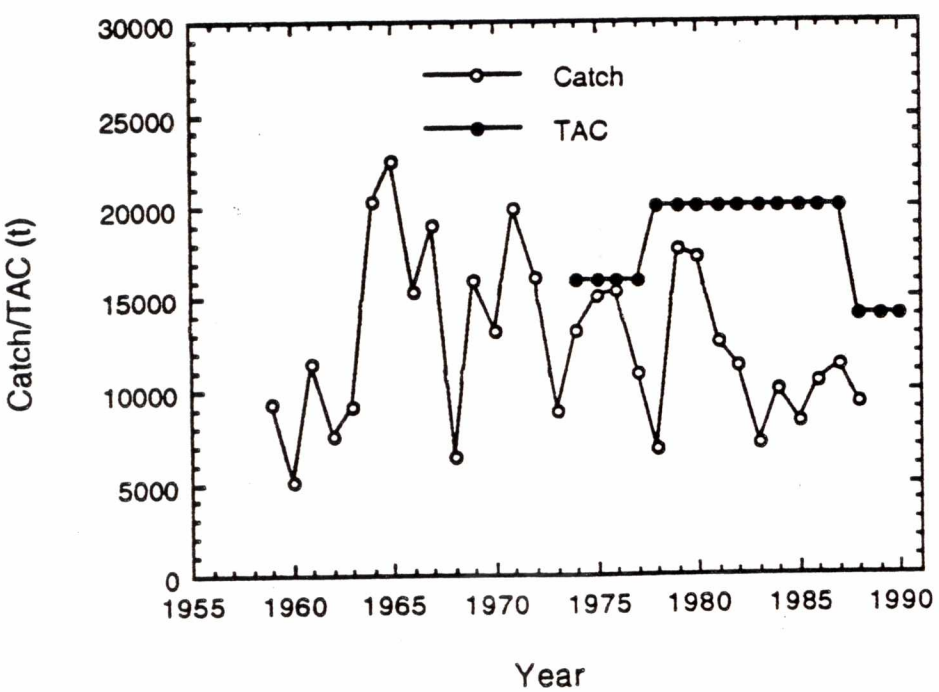
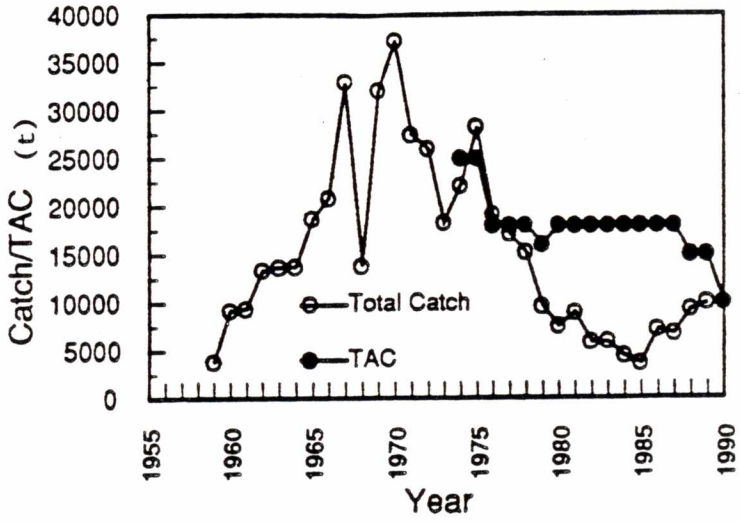


Fig. 15.1. Nominal catches and TACs for Division 3P redfish



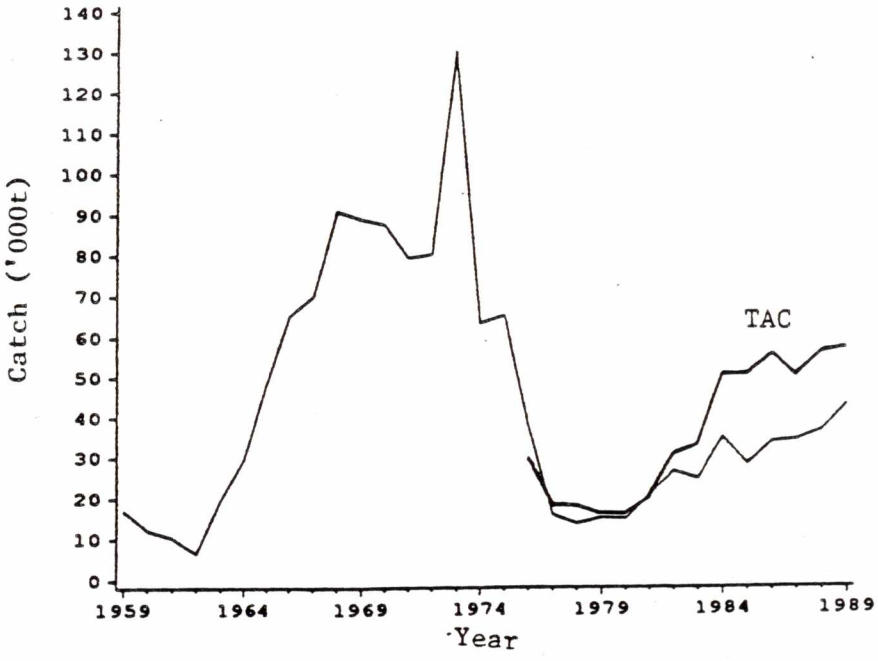


Fig. 16.1. Nominal catch and TACs for divisions 4RST redfish

Fig. 16.2. Standardized catch rates (t/hr) for redfish in Division 4RST.

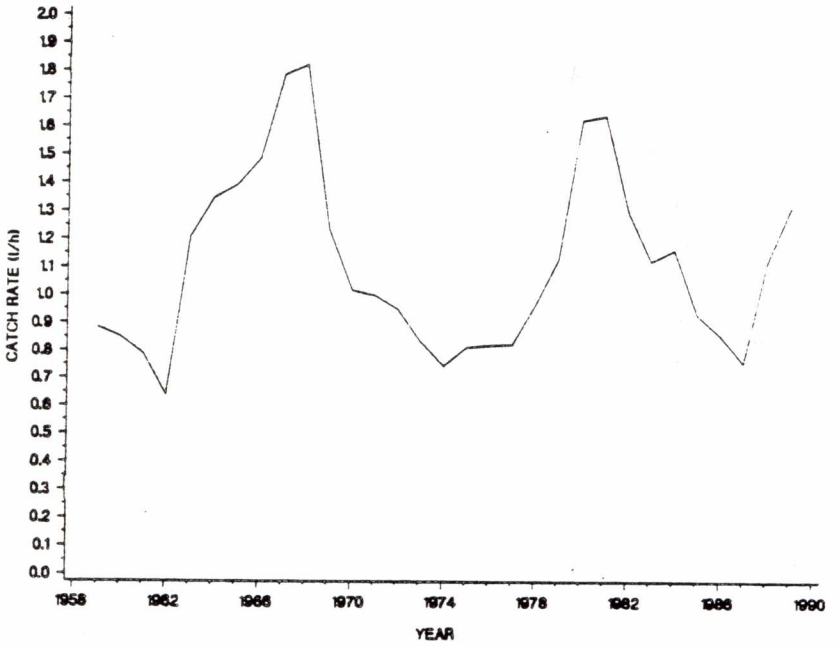
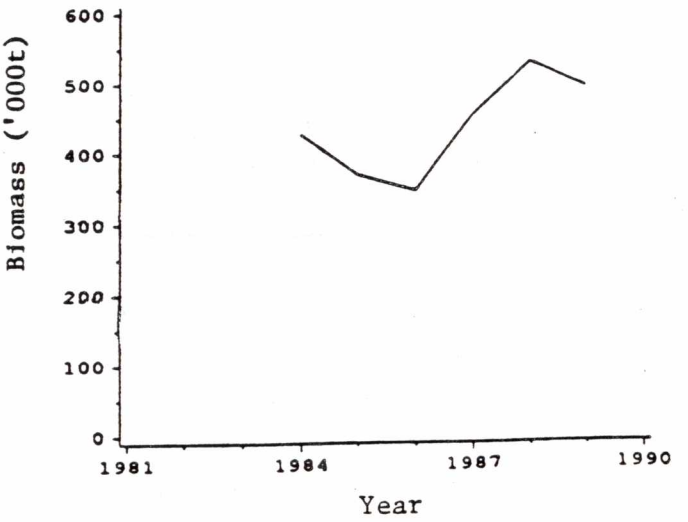


Fig. 16.3. Research vessel biomass estimates 4RST redfish



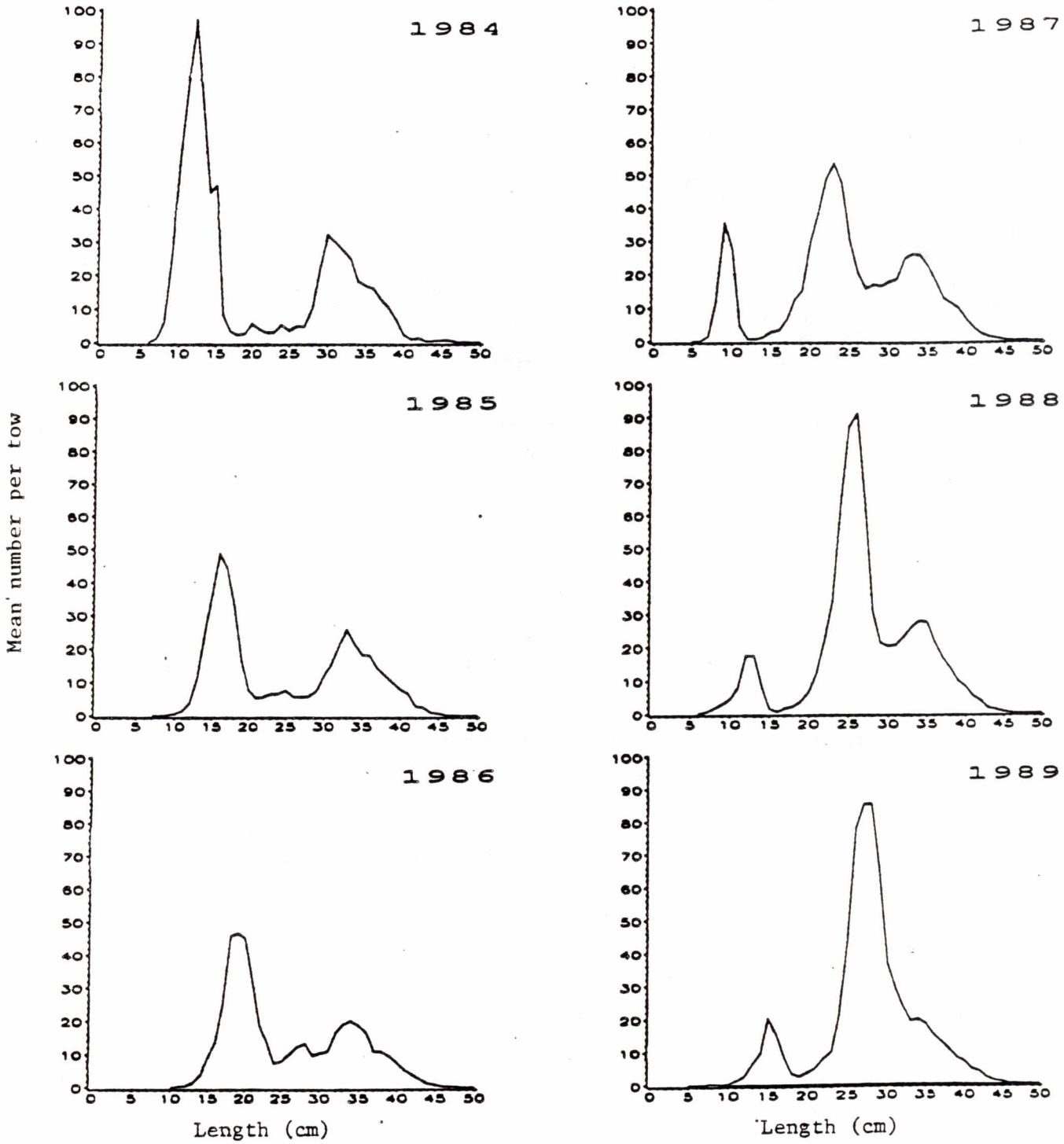


Fig. 16.4. Research vessel length frequencies 4RST redfish

Fig. 17.1 Nominal catch and TACs for divisions 4VWX redfish.

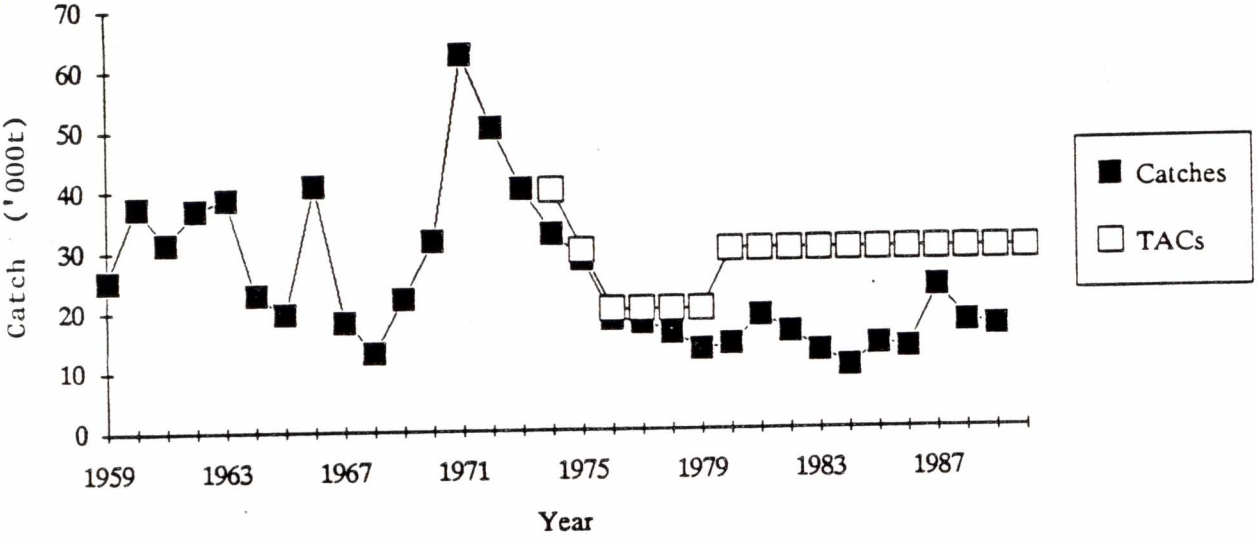


Fig. 18.1. Nominal catch and TACs for SA2 and Division 3K American plaice.

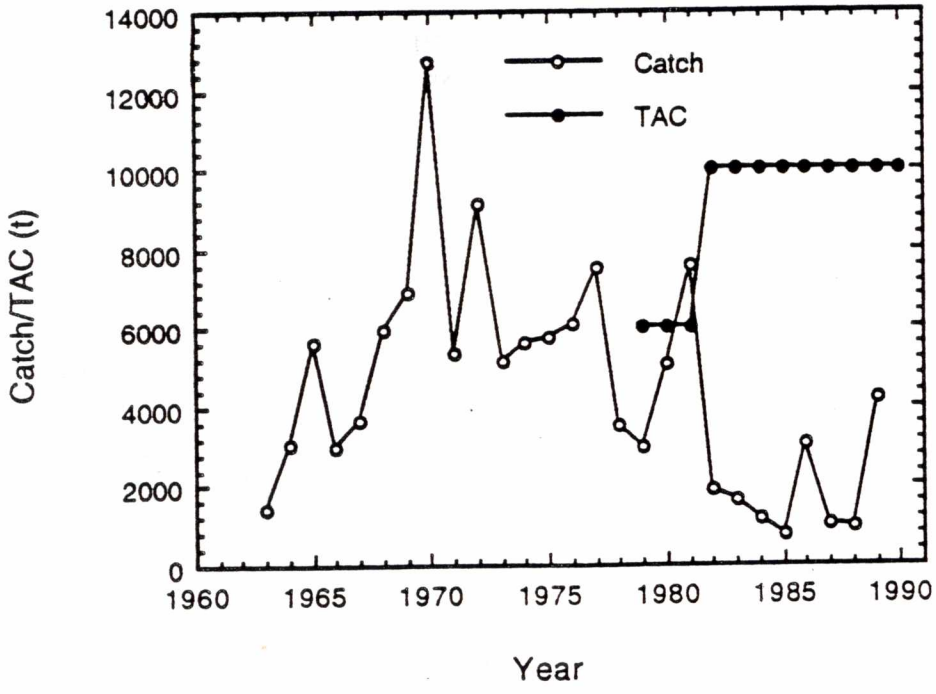


Fig. 19.1. Nominal catch and TACs for Subdivision 3Ps American Plaice

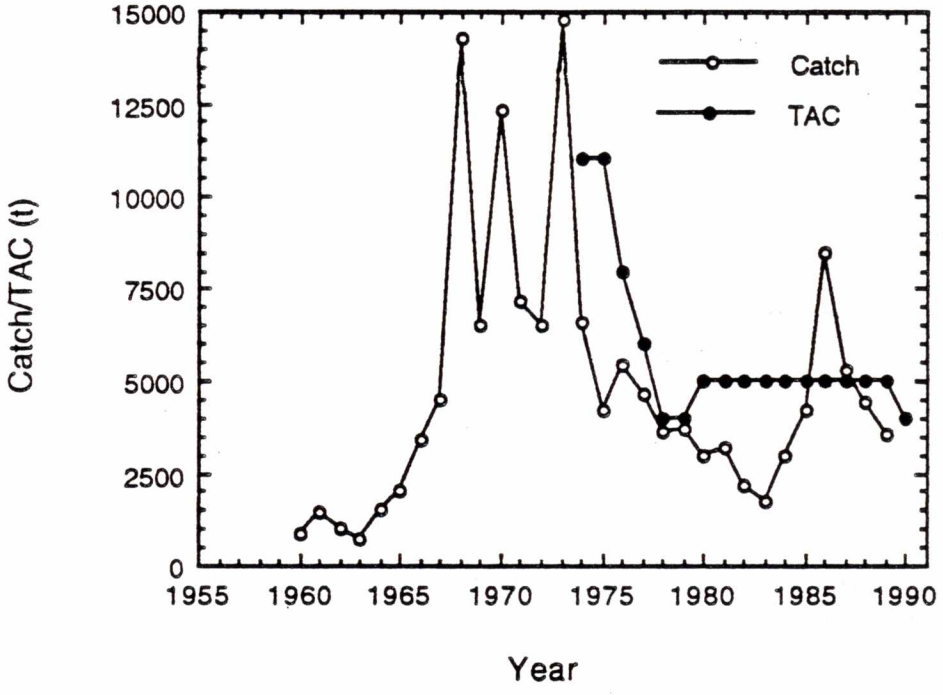


Fig. 20.1. Nominal catch and TACs for Division 4T American plaice

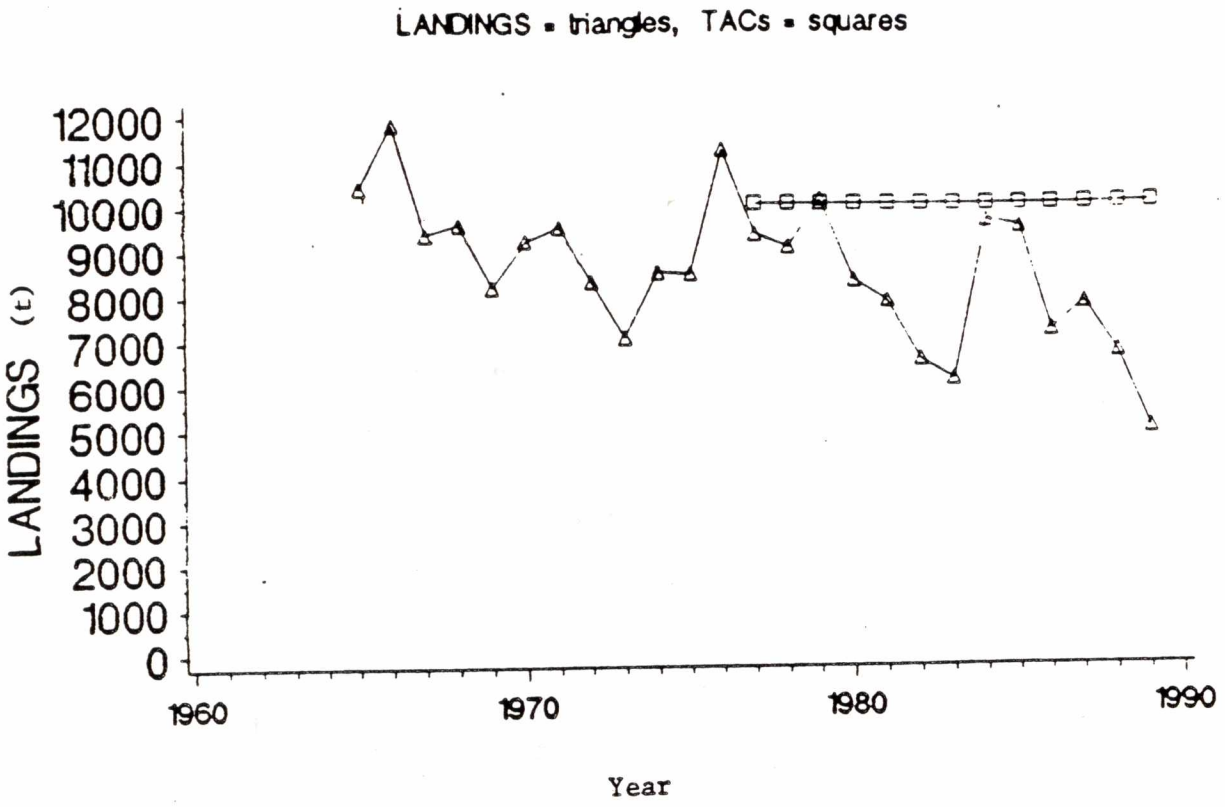


Fig. 20.2. Mean number per tow from research vessel survey for American plaice in Division 4T.

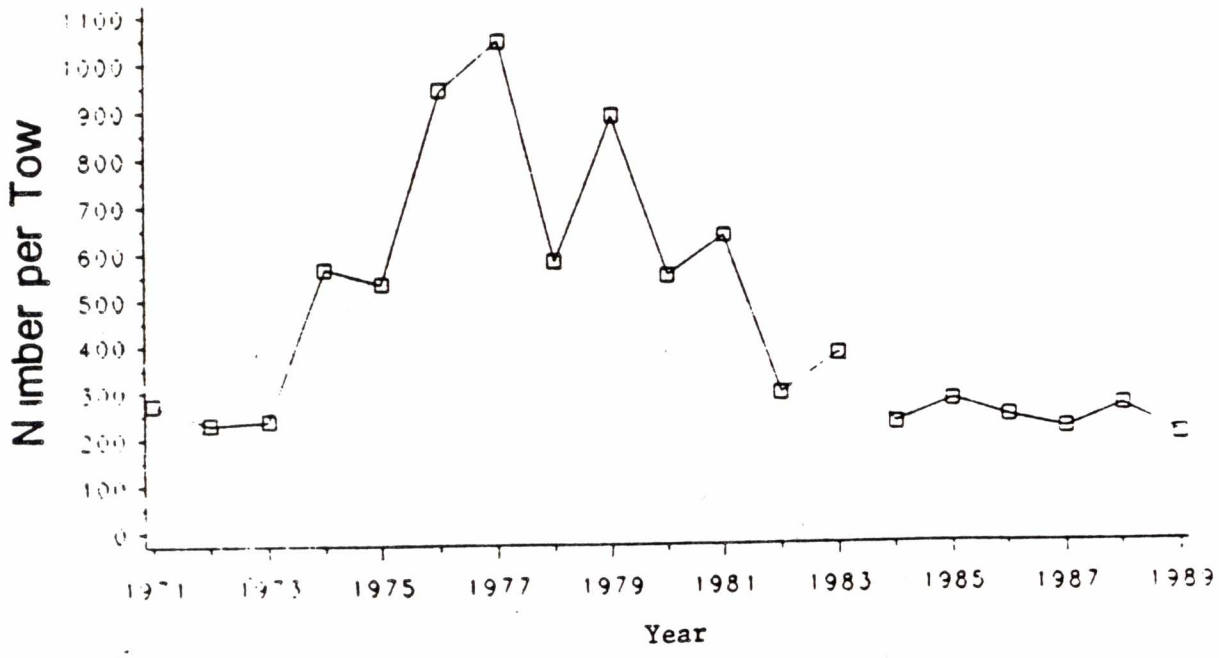


Fig. 21.1. Nominal catch and TACs for Division 2J3KL witch.

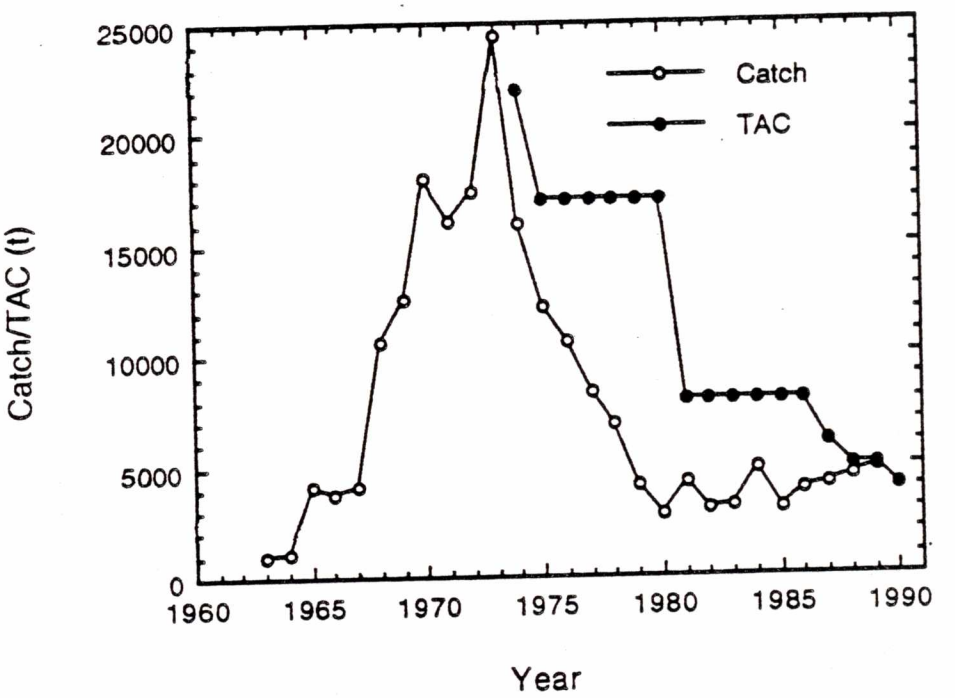


Fig. 22.1. Nominal catch and TACs for Subdivision 3Ps witch.

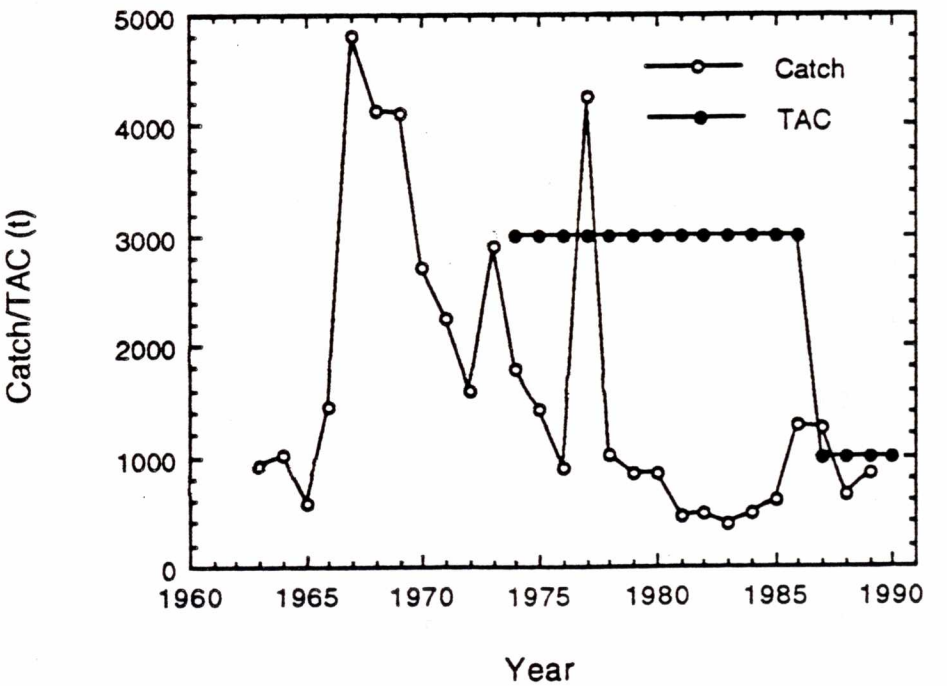


Fig. 23.1. Nominal catch and TACs for Division 4RS witch

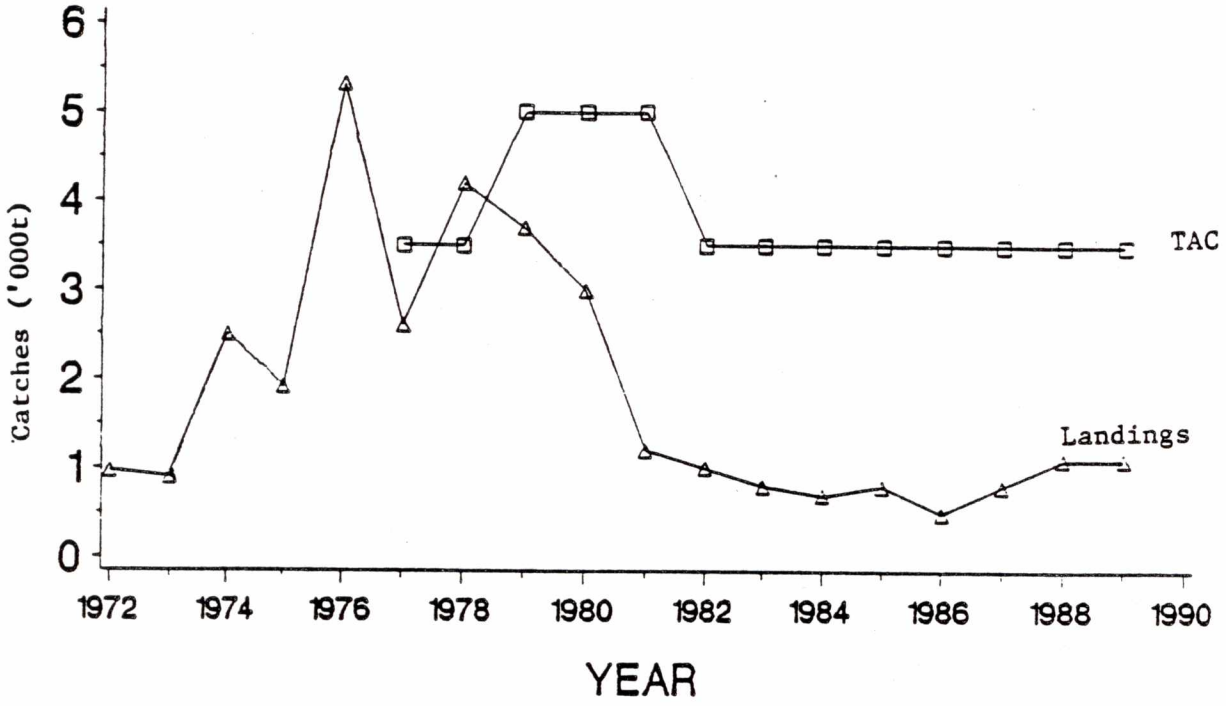


Fig. 24.1. Nominal catch and TACs for 3NOPs and 4VWX Atlantic halibut.

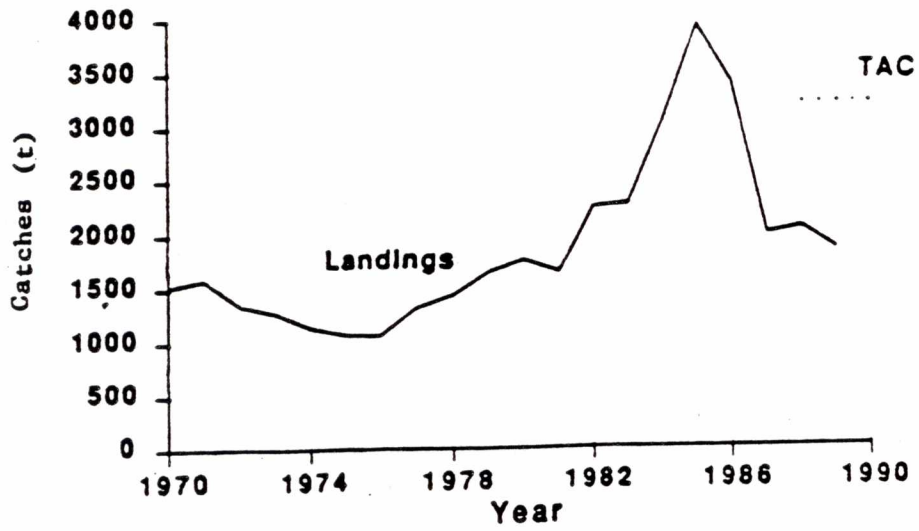


Fig. 25.1. Nominal catch and TACs for divisions 4RST Atlantic halibut

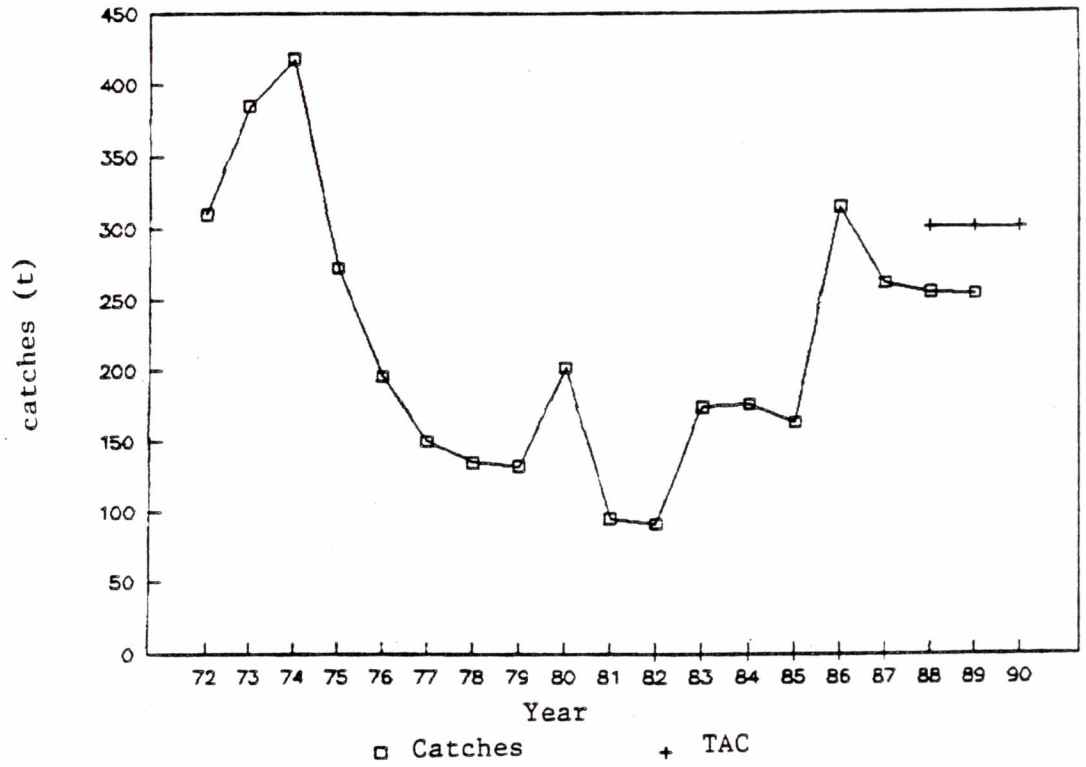


Fig. 26.1. Nominal catch and TACs for divisions 4RST Greenland halibut

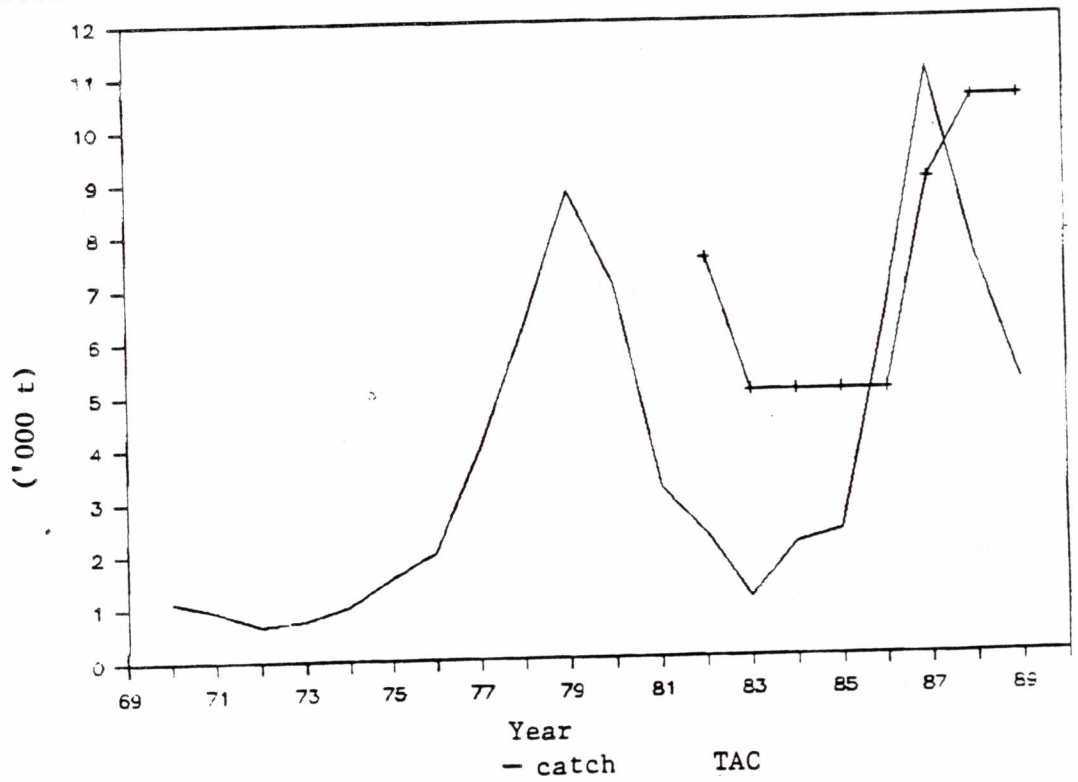


Fig. 27.1. Nominal catch and TACs for divisions 4VWX flatfish.

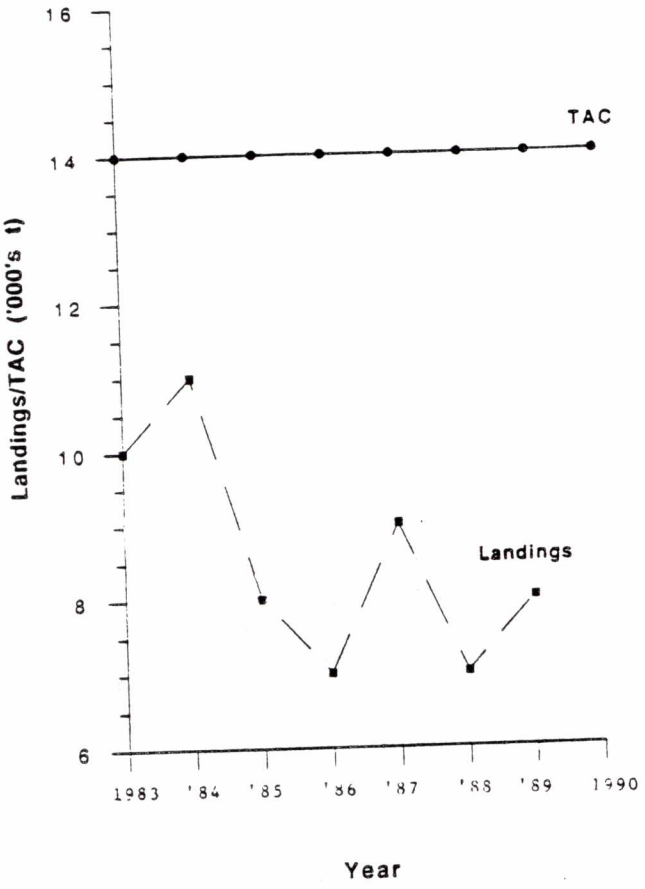


Fig. 28.1. Nominal catch and TACs for Division 4T white hake.

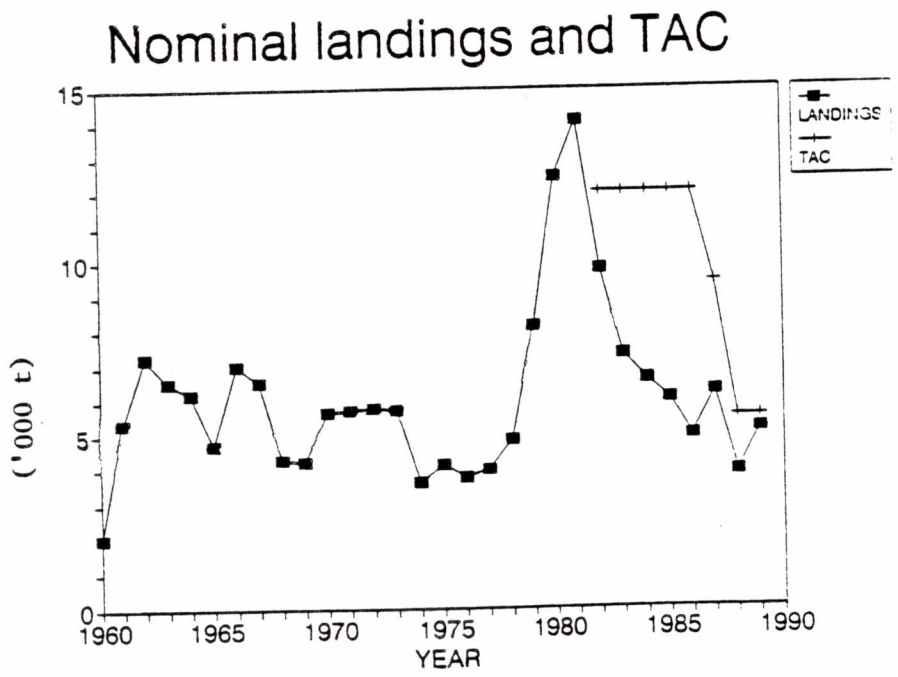
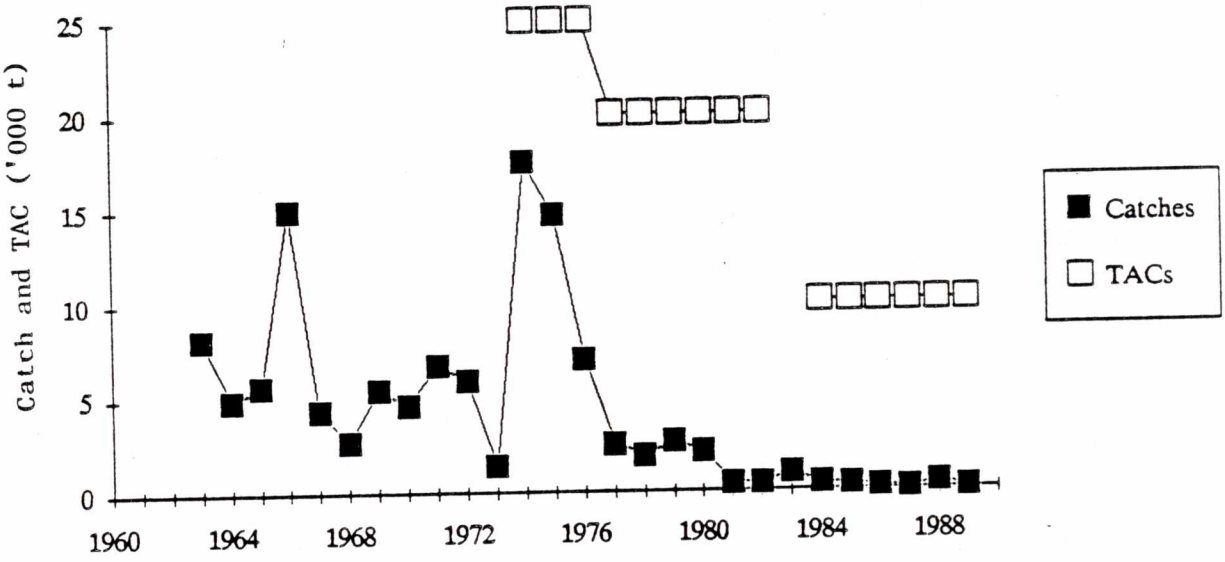


Fig. 29.1. Nominal catch and TACs for divisions 4VWX argentine.



Summary of Groundfish Advice, 1990 - Résumé des conseils relatifs aux poisson de fond, 1990.

Stock	Nominal catches/Prises nominales ('000 t)						TACs set/TPA fixés ('000 t)							Reference Level for 1991/ Niveau de référence pour 1991
	1984	1985	1986	1987[a]	1988[a]	1989[a]	1984	1985	1986	1987	1988	1989	1990	
COD/MORUE														
2GH	2	1	1	+	+	+	20	20	20	20	20	20	20	(20)[i]
2J3KL	232	231	252	235	266	240	266	266	266	256	266	235	197	(100-215)
4RS3Pn	104	88	80	67	48	47	100	100	92.1	80.3[d]	73.9[d]	76.5	58	()[o]
4TVn(J-A)	55	62	64	51	52	50	67	67	60	45.2[d]	54	54	53	(48-53)
4Vn(M-D)	10	13	12	10	9	8	14	12	12	9	7.5[d]	7.5	7.5	(7.5-10)
4VsW	53	57	52	46	38	37	55	55	48	44	38	35.2[d]	35.2[d]	(21-35)
4X	25	21	20	19	19	20	30	30	20	17.5	14	12.5[dm]	22[d]	(20)
5Zjm[c]	17	17	15	17	20	15	45[n]	25[f]	11[f]	12.5[f]	12.5[f]	8[f]	N/A	(11-22)
HADDOCK/AIGLEFIN														
4TVW	8	11	17	4	5	8	15	15	17	-[j]	-[j]	6.7	6	()[j]
4X	20	15	15	14	11	7	32	15	15	15	12.4[d]	4.6[m]	4.6[m]	()[j]
5Zjm[c]	7	5	6	6	6	4	20[n]	5.1[f]	5.1[f]	8.3[f]	8.3[f]	8.3[e]	N/A	(5.4)
POLLOCK/GOBERGE														
4VWX+5Zc[c]	35	44	44	46	43	43	53[n]	42[j]	40[j]	43[j]	43[j]	43[j,k]	43[k,d]	(43)
REDFISH/SEBASTE														
2+3K	24	29	27	19	7	3	35	35	35	35	35	35	35	(20)
30	10	8	10	13	10	4	20	20	20	20	14	14	14	(14)[g]
3P	4	4	7	7	9	10	18	18	18	18	15	15	10	(15)
4RST	35	28	34	34	36	43	50.6	50.6	55.6	50	56	57	57	(57)
4VWX	10	14	13	24	18	17	30	30	30	30	30	30	30	(30)
AMERICAN PLAICE/PLIE CANADIENNE														
2+3K	1	1	3	1	1	4	10	10	10	10	10	10	10	(10)
3Ps	3	4	5	5	4	4	5	5	5	5	5	5	4	(4)
4T[b]	10	10	7	8	7	5	10	10	10	10	10	10	10	(10)
WITCH/PLIE GRISE														
2J3KL	5	3	4	4	4	5	8	8	8	6	5	5	4	(4)
3Ps	+	1	1	1	1	1	3	3	3	3	1	1	1	(1)
4RS	1	1	1	1	1	1	3.5	3.5	3.5	3.5	3.5	3.5	3.5	(3.5)
ATLANTIC HALIBUT/FLETAN ATLANTIQUE														
3NOPs+ +4WVX+5Zc	3	4	3	2	2	2	-	-	-	-	3.2	3.2	3.2	(3.2)[g]
4RST	+	+	+	+	+	+	-	-	-	-	0.3	0.3	0.3	(0.3)[g]
GREENLAND HALIBUT/FLETAN DU GROENLAND														
4RST	2	2	7	11	8	5	5	5	5	8.9	10.5	10.5	10.5	()[i]
FLATFISH/POISSONS PLATS														
4VWX	11	8	8	9	7	8	14	14	14	14	14	14	14	(10)
WHITE HAKE/MERLUCHE BLANCHE														
4T	7	6	5	6	4	5	12	12	12	9.4[d]	5.5[d]	5.5	5.5	()[i]
ARGENTINE/ARGENTINES														
4VWX	+	+	+	+	+	+	10	10	10	10	10	10	10	(10)

[a] Provisional statistics.
[b] American plaice and 90% of those recorded as "Flatfish not specified".
[c] Catches and advice for new management unit.
[d] 50% rule applied.
[e] Canadian allocation for Subarea 5.
[f] Canadian allocations for the management unit used prior to 1990.
[g] Precautionary TAC.
[i] Information inadequate to provide advice.
[j] No TAC by-catch only.
[k] The mobile gear fleet <65' quota for 4VWX+5Zc was included under the cod/haddock/pollock management plan in 4X.
[m] Cod/haddock/pollock allocation for 1989.
[n] Includes US allocation.
[o] No increase in mobile gear catch.

[a] Statistiques provisoires.
[b] Plie canadienne ainsi que 90 % de celles inscrites en tant que "poissons plats non-identifiés."
[c] Prises et avis pour une nouvelle unité de gestion.
[d] Règle de 50 % en vigeur.
[e] Allocation canadienne pour la Sous-zone 5.
[f] Allocations canadiennes pour les unités de gestion en vigueur avant 1990.
[g] TPA préventif seulement.
[i] Renseignements insuffisants pour la formulation d'un avis
[j] Aucun TPA, prises accidentelles seulement.
[k] L'allocation de la flottille á engin mobile de moins de 65 pieds pour 4VWX+5Zc a été inclus au plan de gestion de la morue, de l'aiglefin et de la goberge en 4X.
[m] Allocation de morue-aiglefin-goberge pour 1989.
[n] Comprend les allocations réservées aux E.U.
[o] Pas d'augmentation des captures des engins mobiles.