DFO Atlantic fisheries stock status report 1993/06

DFO ATLANTIC FISHERIES STOCK STATUS REPORT - PELAGIC FISHES 1993

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STATUS OF PELAGIC STOCKS IN ATLANTIC CANADA

1. East and Southeast Coast of Newfoundland Herring (Fig. 1a,b,c,d,e)

1.1. 1992 Nominal Catches

Total landings for all four stock areas decreased from 18,200 t in 1991 to 7,100 tons in 1992. This was the lowest landing since 1986 and reflected reduced fishing effort as a result of no subsidy, low price for herring, and the northern cod compensatory program which encouraged fishers not to fish.

1.2. Commercial Catch-at-Age

As in 1991, the 1987 year-class dominated the fishery in the two northern areas, White Bay-Notre Dame Bay and Bonavista-Trinity Bay, where 86% of the total catch was taken. In St. Mary's-Placentia Bay and Fortune Bay, fish aged 11+ continued to account for the bulk of the catch. There was no evidence of more recent recruitment in any of the stock areas.

1.3. Research Gillnet Program

In 1992, the research gillnet program was restricted to the spring season only. Age distribution and catch rates from the research gillnet program were not available for this report.

1.4. Acoustic Surveys

Acoustic surveys were conducted in White Bay-Notre Dame Bay and Bonavista-Trinity Bay in November-December 1992. A second survey, of Conception Bay-Southern Shore, was conducted in January 1993. This continues the program of alternate fiscal year surveys of east and southeast coast stocks begun in 1988.

1.5. Target Strength Experiments

Experimental target strength studies have been conducted since 1989. These experiments have produced a target strength-length relationship which is substantially different from that of Foote (1987) which was recommended for use (O'Boyle and Atkinson 1989). This experimental relationship has been used to convert backscatter to biomass for the Newfoundland herring acoustic surveys conducted in 1988, 1990 and 1992 (Placentia-St. Mary's and Fortune Bay stocks only).

During 1992, a new calibration technique was developed for the hydroacoustic system used for herring research in the Newfoundland Region. A detailed reanalysis of all experimental target strength results was conducted applying this technique and preliminary results indicate that the original experimental target strength-length relationship may be inappropriate. In order to confirm the new relationship, and to expand

the length range upon which the relationship is based, further experiments will be necessary. The assessment of Newfoundland herring stocks is therefore deferred to early 1994 by which time all previous acoustic surveys will be re-examined using the new target strength-fish length relationship.

2. Herring in Division 4R (Fig. 2)

2.1. Description of the Fishery

The herring stocks in NAFO Division 4R are exploited by both gillnetters and purse seiners. Fishing is prosecuted by both gear sectors from April to December on both spawning and overwintering concentrations. Since 1985, the proportion of the total catch taken by purse seiners has been in excess of 80%, and reached 96% in 1992.

TACs have been in effect since 1977. In addition, regional and seasonal allocations have been set for each gear sector. Since 1980, 55% of the TAC has been allocated to the mobile and 45% to the fixed gear sectors.

Total reported landings have ranged from a low in 1969 of 3,000 t to a peak of 27,000 t in 1973. Nominal catches by purse seines totalled 14,700 t in 1992, down from 18,900 t in 1991. Landings from the spring fishery, which had been increasing in recent years due mainly to increased over-the-side sales, decreased from 12,000 t in 1991 to 9,000 t in 1992. Landings in the late autumn Bonne Bay fishery also decreased, most likely due to an early winter migration out of the area. Recent TACs, total nominal catches ('000 t), and purse seine and gillnet catches were:

Year	1986	1987	1988	1989	1990	1991	1992	1993
Reference level	17.0	30.6	30.0	30.0	20.5	22.0	22.0	22.0
TAC	17.0	30.6	30.6	37.0	35.0	35.0	35.0	35.0
Total catch	21.4	16.6	18.1	17.7	16.9[1]	19.4[1]	15.3[1]	
Purse seine catch	19.3[2]	13.7	16.3	16.7	16.1[1]	18.9[1]	14.7[1]	
Gillnet catch	2.1	2.8	1.8	1.0	0.8[1]	0.5[1]	0.6[1]	

[1] Provisional
[2] Landings updated from industry records

2.2. Commercial Fishery Data

Industry Feedback

Gillnet fishermen in the Bay St. Georges/Port-au-Port area have complained that for the past few years, the spring-spawning herring are not coming in to spawn in the numbers seen over the past decade. Comments on written questionnaires sent to all licensed inshore herring fishermen, as well as comments from index-fishermen, showed a general consensus on this observation in the Bay St. Georges/ Port-au-Port area and equally in the southern portions of unit area 4Rb. However, north of Pointe Riche in unit area 4Ra (the major autumn-spawning area), opinions are shared between those who felt that the abundance of herring was high, and those who felt that stocks were decreasing. Representatives from the purse seine fleet also noted that adequate concentrations of the spring spawning group were difficult to locate in the 1992 spring fishery.

Catch at Age

Separate spring- and autumn-spawner catch-at-age matrices were calculated using the stage of gonadal development for spawning stock designation as in previous assessments. The spring spawners have always constituted the largest proportion of the catch. This proportion had been over 80% of the catch in numbers from 1988 to 1990 due to an active spring fishery in St. Georges Bay, but it has declined in recent years.

The spring spawner catch has been dominated by the 1968 and more recently the 1980 and 1982 year-classes. However, in 1990 and 1991, the 1987 year-class represented 22 and 26% of the catch respectively. Some inconsistencies were noted in the spring spawner catch at age, such as the 1984 year-class suddenly appearing as a strong contributor to the fishery at ages 7 and 8. These uncertainties will be investigated. The autumn spawner catch at age has been dominated by the 1979 year-class as well as a strong input from the 1986 year-class.

Length Frequencies

The strength of the 1986 autumn-spawning and the 1987 spring-spawning year-classes will be the most important factor affecting the 4R herring fishery for the near future. Length frequencies from the purse seine catches showed the presence of these recruiting year-classes as juveniles in the Bonne Bay fishery (4Rb) since 1990 although at that time the relative strength of each was unknown. These recruiting year-classes were caught further southward from 1991 to 1992, and have become dominant in the Bonne Bay autumn fishery. This indicates that the autumn-spawner 1986 year-class has been expanding southward over the past three years. However, the spring spawning 1987 year-class has only been seen in the catches in Bay St. Georges (4Rd) and Port-au-Port (4Rc) in 1992, indicating that this year-class has not influenced the catches in southern regions to the same extent as the 1986 autumn-spawning cohort.

The length frequencies of spring spawners from index gillnet fishermen fishing in the vicinity of the major spring spawning sites in the Bay St. Georges/Port-au-Port area in 1992 have shown the presence of the 1987 year-class in only limited amounts.

2.3. Abundance Indices

Logbook Catch Rates

Eleven to twelve index gillnet fishermen have been contracted each year since 1984 to complete daily logbooks, recording their catch and effort as well as their location, mesh-size, size of nets and water depth. Annual gillnet catch rates were estimated from these data and standardized using a multiplicative model. The logbook catch rate indices for this year (catch/net surface area: units standardized to the mean) are as follows:

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992
Spring	0.58	1.59	1.14	1.38	0.99	0.86	0.55	1.06	0.82
Autumn	0.45	1.63	1.31	1.07	0.55	0.88	0.35	0.70	2.06

Commercial Data

Annual gillnet catch rates were also estimated from all available purchase slips from 1981 to 1992. Prior to these analyses, slips which represented a weekly sum of landings rather than a daily trip were excluded. The estimated number of nets fished/day each year between 1981 to 1992 was obtained from licence application forms and from written surveys sent between 1984 to 1992 to all licensed fishermen along the west coast of Newfoundland.

A multiplicative model was then fitted to these catch and effort data using month and unit area as category types to yield standardized annual catch rates (catch/net: units standardized to the mean) for each spawning component:

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Spring	0.37	0.35	0.67	0.60	0.65	1.49	1.35	0.64	1.33	0.65	1.99	0.27
Autumn	0.57	0.43	0.41	0.80	0.98	1.43	0.86	0.52	1.46	0.76	0.53	1.63

Trends in Catch Rates

Spring-spawner catch rates from the logbook data showed the recruitment and subsequent decline of the 1980 and 1982 spring-spawning year-classes to the gillnet fishery. Similarly, the passage of the 1979 year-class is equally evident in the autumn-spawning series. Furthermore, the recruitment of the 1986 autumn-spawning and 1987 spring-spawning year-classes is also visible. Although the general patterns are similar, the annual estimates from the commercial data series follow these year-classes less well than the logbook series. The logbook series was preferred over the commercial series since the input data were better controlled and were less susceptible to biases related to estimates of daily catches. One signal is however clear from both data sets, the spring-spawner indices decreased substantially in 1992, while the autumn-

spawner indices increased markedly. This is the strongest indication yet that the 1986 autumn-spawning cohort is well above average, while the spring-spawning 1987 cohort is not nearly as strong, since it has already started to decline in importance in the gillnet catch at age five.

2.4. Estimation of Stock Size

Cohort analyses were calibrated age by age using the adaptive framework. A value of 0.2 was assumed for the instantaneous natural mortality rate (M). The vector of fishing mortalities for the oldest ages (F_a) was estimated by assuming that the F for age 10 is equal to the F for ages 11+ and therefore only a F value for age group 11+ in the last year is required as input. The annual weight at age for each spawning stock was estimated as the mean of the weight at age of each sample stratum and gear, weighted by their corresponding landings.

2.5. Assessment Results

Due to the uncertainties around some of the older ages in the spring spawner catch at age, it was not possible at this time to estimate the present biomass of the spring-spawning component. The present analyses nonetheless point to an increase in the fishing effort on the spring spawning stock in recent years and, according to the gillnet catch rates, as well as auxiliary information from both the inshore and the offshore gear sectors, a decrease in the amount of spring spawners in the Bay St. Georges/Port-au-Port spawning grounds. Parallel to this decline in the southern spawning areas was a decrease in the percentage of spring spawners in the mixed Bonne Bay fishery.

Fishing mortalities on the older ages (6+) of the spring spawning component has increased over that past five years relative to the previous five years and the weighted 6+ terminal F was estimated to be above 0.3 since 1990. This was expected given the increased importance of the spring Bay St. Georges fishery which concentrates on pre-spawning herring.

Although the 1987 year-class has now recruited to both the purse seine and the gillnet fisheries, several indicators concur that 1987 year-class is not sufficiently strong to support this fishery at present exploitation rates in the medium term and that this spawning stock is not rebuilding:

- the decline in the two gillnet catch rate indices in 1992;
- the generalized observation from the fixed gear sector that spring spawning in Bay St. Georges/Port-au-Port is more restricted in both time and space than over the past decade; and
- the observation by the mobile fleet that pre-spawning herring in the spring Bay St. Georges fishery are harder to locate.

In addition, it should also be noted that when the 1980 and 1982 year-classes where recruiting to the fishery, they were picked up by the purse seiners in Bay St. Georges as three and four year olds. This did not occur with the 1987 cohort, as they have been seen only sparingly even at age five.

Cohort analysis was unreliable for the autumn spawning component. Nonetheless, both catch rates indices indicated that the 1986 year-class is of substantial importance, as both abundance estimates in 1992 are the highest in their respective series. The questionnaire comments also indicate that the situation with this spawning component north of Point Riche (the major spawning zone) is relatively good. Finally, the presence of this cohort in the late autumn purse seine fishery since 1990, and its dominance since 1991, also points to a strong recruiting pulse. All these indications suggest that the autumn spawning stock has not undergone as high an exploitation rate in recent years as the spring spawning component, and seems to be rebuilding.

2.6. Prognosis

Due to the reservations concerning the catch at age, these stocks will be reviewed again in February 1994, at which time the catch at age will have been verified. Furthermore, the analysis would benefit from the addition of the 1993 spring spawner index-fishermen catch rate. In the interim, industry should be aware that the present view of the spring spawning resource suggests that caution should be exercised. More definitive statements regarding stock status and conservation measures will be forthcoming early in 1994.

3. Division 4T Herring (Fig. 3a,b,c,d,e,f)

3.1. Introduction

There are two recognized spawning groups in the 4T herring fishery, spring and autumn spawners, which are harvested primarily (80%) by gillnet fisheries in the spring and autumn and secondarily by purse seiners in the autumn.

3.2. Description of the Fishery

This fishery has been under TAC regulation since 1972. Catches of herring in 4T in 1992 were 54,000 t, 62% of the total allowable catch (TAC) and were distributed as follows: 12,474 t in the spring fixed gear fishery; 33,078 t for the autumn fixed gear fishery; 1,200 for the spring mobile gear fishery; 7,115 t for the autumn mobile gear fishery. The winter 4Vn mobile gear fishery landed 4,228 t. Catches below TACs are the result of poor markets. Recent reported nominal catches and TACs (000s t) are provided below:

	1985	1986	1987	1988	1989	1990	1991	1992	1993
TAC 4T	32.2	43.4	72.8	78.9	86.9	86.9	86.9	86.9	101.2
4Vn	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Catch 4T	38	59	78	72	57	76	48	54	
4Vn	2.4	2.6	2.1	2.6	2.1	4.7	5.0	4.2	5.0

[1]1990-1992 catches are preliminary

3.3. Commercial Fishery Data

As in the 1990 and 1991 assessments, herring caught in 4T were assigned to spring and autumn spawning groups using a gonadosomatic index (GSI), except for fish with maturity stages 6-7 when the date of capture is used and for maturity stages 1 and 2 when otoliths are used. In 1992, samples from the 4Vn winter fishery were processed by Gulf Region which provided gonad weights and consequently, spawning group designation was by GSI. In years prior to 1992, spawning group assignment was by otolith or capture date. The 4Vn fish captured in purse seines, the largest component of the 4Vn herring fishery, were considered for inclusion in the 4T analysis.

Autumn spawners comprised 74% of the total 4T+4Vn landings, by weight. In catches from fixed gear, the autumn spawner component was dominated by the 1987 year-class (age 5), 42% by number of the total catch. This is the strongest class of five year-olds recorded since 1978. In the mobile fishery, the 1987 cohort made up 48% of the catch by number.

The 1988 year-class of spring spawners was most numerous in catches of both the fixed and mobile fisheries in 4T (48% and 37% by number respectively). In fixed gear it was the strongest in the time series since 1978 and in mobile gear the highest since 1980.

There was an apparent decline in the weight-at-age of herring in 1992 relative to previous years in the time series. Mean weight-at -age declined by over 10% in 1992 relative to the 1978 to 1990 average. Verification of the estimated decline and possible causes are under investigation.

3.4. Commercial Catch Rates

An effort index is calculated each year from a telephone survey of licensed gillnetters. The average number of nets used in the herring fishery in 4T has remained relatively constant for the autumn component since 1985 but it has been more variable for the spring fishery. The variation in nets used is greater between statistical districts than between years within a district. The mesh size distribution of the nets fished has not changed from 1985 to 1992. The proportion of total spring catch sold to processors since 1988 has ranged from a high of 72% in 1988 to a low of 57% in 1990. In 1992, the percentage of the catch sold to processors was about 60% for the spring fishery. The proportion of the catch not sold to processors is used for bait. Autumn catches continued to be almost entirely sold to processors.

Catch rates, defined as catch/trip, were calculated from daily purchase slip data available from 1978-1992 for the spring and autumn fisheries. Yearly catch rates were calculated and standardized after accounting for a spatial effect (statistical district or geographic area) and an intra-annual effect (fixed-week or 10% catch interval). The autumn catch rate (kg/net/trip) was used to calculate an abundance index by age and year as input data for ADAPT runs.

Autumn Catch Rates

There has been a strong increasing trend in catch rate since 1981 and this continued into 1992 with the 1992 catch rate not significantly different from 1991. Both remained higher than the catch rate in 1987 (reference year).

Spring Catch Rates

The results are similar to those of the 1991 assessment for 1978 to 1984 and for the most part, they provide a similar directional change, but of different relative size. The largest change is evident for 1987 and 1988. Both indicated, however, increased catch rate since 1990.

3.5 Acoustic Survey

The autumn distribution and acoustic backscatter of herring in NAFO divisions 4T and 4Vn was surveyed for 1990 to 1992. The 1990 acoustic survey was held mostly in November, while the 1991 and 1992 surveys were in October. Survey effort was concentrated in Chaleur Bay and Cape Breton areas where NAFO area 4T herring congregate in the autumn. Acoustic surveys were conducted according to a stratified random design, using random parallel transects within strata. Whenever possible, coverage of inshore strata, where most herring schools are found, was done at night when fishing for species identification and biological samples was possible.

The 1992 acoustic survey, conducted from October 1-22, was the most extensive of Gulf Region acoustic surveys; furthermore, no major equipment failure or cable breaks occurred. This survey had the highest proportion of transects with backscatter recorded and was close to the 1991 value for highest mileage covered with backscatter recorded. This suggests a more widespread distribution of herring in both the Chaleur Bay area and northern Cape Breton.

The 1991 acoustic survey, conducted from October 10-24, was marred with equipment failure and cable breaks making the 1991 estimate questionable. Other indicators such as the high mileage covered with reported backscatter and a high proportion of transects with backscatter would indicate that the 1991 distribution and abundance would be similar to 1992.

The 1990 survey was held from Oct. 26 to Nov. 8 and had a biomass estimate which was high compared to 1991 and 1992. No major equipment problem occurred, although there were some cable problems and splicing was done.

The 1992 acoustic survey backscatter showed that close to 50% of backscatter was found in East Miscou stratum, another 25% came from Chaleur inshore strata, and the Cape Breton area accounted for the remaining 25% of total backscatter, mostly inshore. The 1991 acoustic survey also had 50% of backscatter from East Miscou, 35% in the Chaleur inshore strata, and Cape Breton, most of the remaining backscatter. In 1990, 80% of acoustic survey backscatter was recorded in the western part of Chaleur Bay, consisting of juvenile herring, mostly from the autumn 1987 and spring 1988 year-classes.

Results from the 1992 acoustic survey compared to previous surveys are presented below. Biomass estimates used Foote's (1987) formula for target strength. Also shown are the number of transects per stratum, the proportion of transects with backscatter, total transect length covered per strata, the total transect length showing backscatter, and the percentage of transect length covered with backscatter for the years 1988 to 1992. It is clear that the 1992 survey has been the most extensive survey to date. Herring were found in nearly 70% of transects and over a distance of 412 nautical miles, nearly 14% of the area sampled.

Year Area	Transects in survey			Total Scattering (m2/sr)			
	Number	Proportion with herring	Length (nm)	Length with herring	Total	C.V.	Estimated Biomass (t)
1992 4T + 4Vn	417	0.67	3021	412	59377	0.286	203797
1991 4T + 4Vn	267	0.46	1648	278	13419	0.330	44356
1990 4T + 4Vn	274	0.22	1309	115	410251	0.275	1128283
1989 CHALEUR	186	0.09	823	41	3029	0.308	11249
1988 4T + 4Vn	240	0.25	816	58	114757	0.240	413180

3.6 Spawning Bed Survey

These surveys provide estimates of the volume of deposited spawn and of progenitor biomass for autumn herring spawning beds off southeastern PEI.

In 1985-1987, deposition estimates were based on counts of eggs collected by divers. In 1988-1992 deposition volume was estimated with an underwater video camera which allowed penetration of a sharpened ruler into the egg mat to be noted by observers aboard the vessel. The results are as follows (dashes indicate no data):

	1985	1986	1987	1988	1989	1990	1991	1992
Fisherman's Bank - egg volume (m^3)	11,417	10,837	11,814	-	17,189	13,504	1,661	12,849
Fisherman's Bank - progenitor mass (tons)	84,786	80,479	87,734	-	127,650	100,285	12,331	95,417
The Ridge - egg volume (m^3)	-	-	-	-	-		4,431	959
The Ridge - progenitor mass (tons)	-	-	-	-	-	-	32,907	7,122

The survey indicates that average spawning biomass on Fisherman's Bank is around 100,000 t. Fisherman's Bank likely comprises < 20% of the total spawning biomass of autumn spawners in 4T. A mature biomass of 500,000 t is of similar magnitude to VPA estimates.

3.7. Groundfish Research Vessel Survey

The catches of herring during the annual groundfish cruise increased substantially in 1984 and have since remained high albeit variable. The average weight of herring caught per set has fluctuated between 20 and 80 kg since 1986, from lows of less than 10 kg per set in the 1970s. In 1992, catches were at similar levels noted in 1990 and 1985 and about half those recorded in 1991.

3.8. Estimation of Stock Size

An estimation of the stock size of the autumn spawners was considered using the catches from 4T and from the mobile fishery in 4Vn for the period 1978 to 1992. An estimation of the stock size considering only the catches from 4T was also undertaken for comparison with the results of previous assessments. Cohort analyses were calibrated age by age using ADAPT.

Autumn spawners

Population numbers in 1992 amounted to over 2,064 million fish aged 4+, which was 15% higher than the estimated size of the 4T stock when 4Vn catches were excluded. The population estimate of the 1987 cohort remains the strongest representation of 5 year olds in the time series. The age 5+ biomass in 1992 is estimated at over 480,000 t of autumn spawners, 52% of which is the 1987 cohort. F values in 1992 remained low for all ages, generally less than 0.1.

Spring spawners

An estimate of the population size of spring herring was not available in 1992 because previous problems identified for the spring herring estimate were not resolved. It was not possible to assess the impact of any quota for the spring fishery.

3.9. Industry Feedback and Environmental Conditions

The fishing effort during the spring fishery in 1992 in all areas was delayed relative to previous years in terms of the starting date and the median date. In recent years, the duration of the fishery has been shorter. Reports from index fishers emphasized four points: 1) ice conditions delayed fishery, 2) fish were not in usual locations and often found in deep water where they were hard to capture, 3) fish were small, and 4) markets were unreliable. When questioned specifically about the abundance of herring, participants in the 1992 4T Herring Gillnet Questionnaire felt that abundance was above average in all areas of the southern Gulf except western Nova Scotia and Quebec.

Delays in the autumn fishery in 1992 were evident in a few areas relative to 1990 and 1991. The duration of the fishing during the autumn has become compressed in most areas relative to the time period of 1978 to 1985 especially in the Baie des Chaleurs, Escuminac area and the eastern PEI, Nova Scotia districts.

Index fishers in the autumn emphasized the lack of markets as the major factor affecting catches. Two of them reported that buyers had imposed boat quotas below the DFO regulations. They said that the decline in effort was due to a poor market for herring, only 3 cents/pound, not worth the cost of operating a boat. Herring were reported to be late arriving in several areas and were difficult to capture. Several fisherman remarked on the relatively large amount of small herring in catches. Roe percentage was generally reported to be good. Gillnet questionnaire respondents found abundance average except in Escuminac and western P.E.I where it was reported to be above average.

Spring conditions in the Gulf of St. Lawrence were cold in 1991 and 1992, ice coverage in the Gulf was closer to maximum than median locations (1962-1987) and surpassed the median duration. September bottom temperatures in the southern Gulf of St. Lawrence were relatively warm in the 1970s and have been relatively cold since the mid-1980s. Bottom temperatures at depths of 60-149m during the 1990 to 1992 period are the coldest in the 1970 to 1992 time series.

3.10. Projections

The 1993 to 1995 quotas have been set in the new management plan at 85,000 t for the autumn spawners and 21,000 t for spring spawners, distributed as follows:

		4T	4Vn
Autumn	Fixed Gear	64,640	
	Mobile Gear	16,160	4,200
Spring	Fixed Gear	16,800	
	Mobile Gear		4,200

The estimated fishing mortality that would be imposed on autumn spawners over the next two years was assessed for the following conditions:

A - Geometric mean recruitment of age 2 herring for 1978 to 1990
- Geometric mean recruitment of age 2 herring for 1978 to 1990, excluding the 1987 cohort.

B - Average weight-at-age of herring for 1989 to 1992
- Weight-at-age of herring for 1992

The partial recruitment vector from the 1991 assessment was used. Fishing mortalities and 5+ biomass were estimated using the 1992 population estimates for 4T+4Vn combined from ADAPT. The results are

as follows:

	Recruitment Average 1978 to 1990		Recruitment 1987 excluded	
	Wts. 1989-1992	Wts. 1992	Wts. 1989-1992	Wts. 1992
5+ Numbers				
1993	1,529	1,529	1,529	1,529
1994	1,279	1,257	1,249	1,227
5+ Biomass				
1993	391,707	355,421	391,248	354,964
1994	330,311	293,164	322,568	285,929
F (7+)				
1993	0.23	0.26	0.24	0.26
1994	0.25	0.28	0.26	0.29

The fully recruited (age 7+) fishing mortalities on the 4T autumn herring stock will increase from about 0.25 in 1993 to about 0.29 in 1994. Over the 1993-1994 period, the projected fishing mortalities will be determined more by the weights-at-age of the autumn herring than any short term change in recruitment. The catches would be supported by the 1987 cohort over this time period.

3.11. Overall Stock Status

The catch rates remained high because of the recruitment of the 1987 cohort which is the strongest recorded in the time series since 1978. Total biomass has declined but the recruiting biomass to the fishery is increasing, which explains the continued rise in the catch rates. The recent cohort strengths are about average. All other indicators of abundance including the acoustic survey, the groundfish research vessel data, and spawning bed surveys indicate that the abundance of herring has remained high in the last 5 years, and has increased sharply from the low biomass levels of the late 1970s and early 1980s.

The allocations which have been established for 1993-1995 will not generate fishing mortality above the target rate of F=0.30 until at least 1994, because of the strength of the 1987 cohort. The reduced weight-at-age observed in 1992 is of concern and should be examined in more detail.

4. Herring in Divisions 4WX (Fig 4a,b,c)

4.1. Description of the Fishery

The 1991-1992 Herring Management Plan allowed a TAC of 125,000 t for 4WX stock herring, allocated to: (i) the purse seine fleet of 40 vessels (117,563 t, including a bait quota of 2,600; or 94 % of the total), (ii) a single mid-water trawl (1,250 t or 1% of the TAC), and (iii) an allocation to "inshore" gear components: gillnets, traps and weirs (6,187 t or 5 % of TAC).

Under the guidelines of the 10-Year Management Plan established in 1983 and the companion 1991-1992 annual plan, individual vessel quotas were allocated to all purse seiners as a percentage of the total TAC and included fishery area, season and vessel class designations. The 1991-1992 plan allowed for a maximum catch of 10,000 t in the upper Bay of Fundy (Scots Bay) as part of the 4X summer purse seine fishery, and placed a continuous 18 day closure beginning August 15, 1992 on the Trinity Ledge spawning grounds.

As in previous years, potential catches from the New Brunswick "fixed gear" fisheries (weirs and shutoffs) were excluded from the TAC under the annual plan on the grounds that they target primarily juveniles presumed to be non-4WX stock herring originating from the Gulf of Maine.

The 1992 4WX herring fishery was very similar to that of recent years. The purse seine fleet of 40 vessels accounted for over 96 % of the total reported catch of 4WX stock herring. The remaining landings of stock herring were taken by weirs on the Nova Scotia side of the Bay of Fundy (2 % of total stock landings for 1992), midwater trawl, gillnets, and traps. Significant catches of what have traditionally been considered non-4WX stock herring intercepted in the 4WX area were taken by weir and shutoff on the New Brunswick side of the Bay of Fundy.

The most intensive 4WX stock herring landings occurred in the purse seine 4X summer fishery on the pre-spawning and spawning aggregations off southwest Nova Scotia (subareas 4Xq and 4Xr) from June to mid-October 1992. During this period, 84% of total reported purse seine landings for the 1991-1992 fishery were taken. The spatial and temporal distribution of the major purse seine fishery was well documented by logbooks and showed only a few differences from recent years in fishing grounds and months or seasons. Notable among these were the emergence of an early (May/June) fishery in Western Hole, an increase in the prominence of the Gannet/Dry Ledge area, and a decrease in prominence of the German Bank area. Other major fishing activities occurred in the purse seine fisheries on over-wintering aggregations of herring around Chedabucto Bay (November 1991 through February 1992; 15% of reported purse seine landings), and off Grand Manan Island in the 4Xs autumn and winter fishery (October 1991 through January 1992; 1% of reported purse seine landings).

The summer fishery continued to be highly influenced by markets and was again restricted by uncertainty in the major roe market. Significant markets continued to be the adult (large fish) domestic market, juvenile herring for sardines/canned herring products, and over-the-side sales (OSS) to foreign vessels.

4.2. Catch Statistics

Reported stock landings totalled 100,228 t. Reported non-stock (N.B. weir and shutoff) landings were 31,967 t, for an area 4WX total of 132,195 t.

The historical TACs, stock and non-stock reported catch totals are as follows:

	1985	1986	1987	1988	1989	1990	1991	1992
TAC	125.0	110.6	126.5	151.2	151.2	151.2	151.2	125.0
Reported stock[1] 4WX catch	112.4	73.7	101.2	124.6	84.5	101.9	97.0	100.2
Reported total 4WX catch	141.9	101.8	130.2	159.9	129.4	141.4	121.6	132.2
[1]Excludes 4Xb weir + shutoff								

Reported statistics since 1984 were shown previously to be serious underestimates. An update on an attempt to estimate actual landings since 1984 was reviewed (when a previous correction was made) through a combination of two initiatives:

i) Interviews with purse seine captains to determine individual vessel landings over the past 7 years.

ii) Back calculation from production using Departmental records and updated conversion factors; with industry guidance on the amount of "reprocessing" of roe carcasses which typically are used for fish-meal.

Purse Seiner Survey

Purse seiner interviews resulted in revised data for 25 to 36 vessels active in each of the seven years (1985-1991). Most of the responses were based on estimates from records of fish sold, and resulted in confident statements from captains/owners about actual landings. Some, however, were from even more detailed records of fish caught per night and a few were only rough estimates. Survey estimates for each year were compared with Statistics Division totals for the same vessels for that year to calculate a ratio (survey/Stats), which was applied to the Statistics total for the year to estimate revised landings.

Revised purse seine landings, when added to landings for other gear, indicate landings 1.2 to 1.8 (stock landings) and 1.2 to 1.6 (entire 4WX landings) times those recorded by the Department. They also indicate that the quota has been exceeded in five of the past seven years.

Back Calculation from Production

Back-calculation of round weight from production was based on conversion factors obtained from industry and applied to production records kept by DFO Statistics Division. These estimates of herring utilized by domestic processors were added to totals sold in over the side sales programs and corrected for fish transported into and out of the region to obtain estimates of round herring landed for processing. The estimate from production supports the revised estimate of landings from the purse seine survey; both are considerably higher than nominal statistics:

Year	Reported stock 4WX (000s t)	Interview revised Stock 4WX (000s t)	Estimate from Product Stock 4WX (000s t)
1985	112.4	134.6	165.0
1986	73.7	134.3	100.0
1987	101.2	145.9	147.1
1988	124.7	176.8	192.9
1989	84.5	136.5	87.8
1990	101.9	166.8	172.9
1991	97.0	140.1	130.8
1992	100.2	n.a.	135.1

The two independently derived series, although requiring different assumptions, show similar trends (correlation .76). The interview-based revision is the most thorough of its type ever conducted on this fishery, but it is still considered to be an underestimate in at least some years. Although the estimate from production contains a number of potential problems (including the use of averages of conversion values with considerable variation), it is from departmental data which will be available on an ongoing basis. The production back-calculation method could be refined further, to take into account possible spatial and temporal differences in product conversion and in the degree of misreporting. It could then be used as the basis for catch revision. The discrepancies between the two official sets of statistics (landings and production) should be resolved.

4.3. Commercial Fishery Data

Catch at Age

Sampling in 1992 resulted in 536 length frequency samples and 5,749 fish aged. In a continuing attempt to rationalize sampling effort, the number of fish analyzed in detail was reduced by about 30% over the previous year.

The 1988 year-class at age 4 was most prominent in the stock catch by number and weight. The 1983 year-class which had dominated stock catch by weight for 5 consecutive years (ages 3-7) still contributed 11 % by weight at age 9. As in previous years, age 2 fish dominated the non-stock New Brunswick weir and shut-off fisheries in numbers and weight. Approximately 17,000 t of age 3+ fish were taken in the N.B. weir and shutoff fishery. As agreed during the last assessment, these are to be added to the 4WX stock catch at age.

Purse Seine Logbooks

The detailed purse seine logbook introduced in 1985 was used for the eighth consecutive year. Coverage was again high as logbook submission remained a condition of license, and as in previous years, the information was of good quality. Although landings have been under-reported on logs, other information is considered to be correct. The major summer fishery as reconstructed from logbooks was similar in spatial and temporal distribution to previous years with the following exceptions:

- major landings for the first time from the "Western Hole" area (southeast of Cape Sable) in May and June,
- a major increase over 1991 in effort (300%) and catch (400%) in the Gannet/Dry Ledge area, and
- a substantial decrease (only 20% of searching and 15% of catch of the previous year) in the prominence of German Bank.

The most apparent change in anecdotal comments was an increase in the use of "fish in shallow water", which reflects the increased fishery in the Gannet/Dry Ledge and in Seal Island areas. There did not appear to be any abnormal patterns in the reasons for released sets. The logbook information on individual components of the fishery is very valuable to the interpretation of the fishery, and the logbook effort is worth continuing.

4.4. Research survey data

Larval Abundance

The 1992 larval herring survey was undertaken using the standard protocol, with sampling between Oct. 29 and Nov. 11 (E.E. PRINCE, Cruise P437). All 79 of the traditional larval abundance index stations were sampled, as were most of the stations commonly covered in recent cruises.

An attempt was made to refine the traditional larval index (calculated as the mean of larval density [no. m^{-2} to bottom] for a set of 79 standard stations) to account for the impact of interannual differences in spawning time and/or cruise timing, by using a correction for length (age)-based mortality. Larval abundance at length was adjusted for mortality, assuming a hatching size of 5mm, growth rate of 0.24 mm/day and instantaneous rate of mortality of 0.07 per day. There was some concern with the great influence of assumed constant growth and mortality rates on the results, and it was recommended that investigation of adjustment to a common midpoint, such as 10 mm rather than to the time of hatching.

Acoustic surveys

The portion of the winter acoustic survey planned for December 1992 was cancelled because of mechanical problems with the Alfred Needler, and the survey planned for January 1993 had to be transferred to the E.E. Prince. The E.E. Prince surveyed the southern portion of Chedabucto Bay where the herring have concentrated in previous years, and a larger area between Country Island and Gabarus Bay to about 10 - 20 mi offshore, but no herring were found.

A seiner fleet of 5 boats had been catching herring in November/December 1992 in the Canso, Grime Shoal areas, but had stopped for Christmas, and could not find herring when they returned in January. The seiners left the area on January 15 and found herring in the approaches to Halifax Harbour, off Chebucto Head. The acoustic survey documented only two small schools in that area.

The lack of success in finding major concentrations of herring by acoustic surveys alone since 1991 inspired an attempt to use aerial surveys for whales as a guide to potential acoustic survey locations. Whales in these waters are generally associated with herring, and since whales can be seen a long way off, it was thought that whale surveys could be used to direct the acoustic surveys to major concentrations of herring. Two helicopter flights and two flights by DND aircraft failed to locate any aggregations of whales to assist the survey.

While there are two possible explanations for the absence of fish in the acoustic survey (a change in behaviour or a serious reduction in abundance), it is considered that a change in behaviour explains these results. It is now apparent that the Chedabucto Bay overwintering area is not an "index area" - containing "all or a constant proportion of the population" in January as had been hypothesized.

There have been previous indications that the use of Chedabucto Bay as a wintering area was changing. Herring left the Bay during the survey on some occasions, and the survey was advanced in time to compensate. This year, the survey could not be undertaken in December (as had been planned). Had the herring been aggregated in the Chedabucto Bay area, it is felt that the combination of the commercial

fishery, aerial, and acoustic survey would have located them. Further analysis of the timing of the commercial fishery in this regard is recommended.

Previous discussion of the necessity, and the difficulties, of matching the survey to particular characteristics of the stock were noted. Attempts to survey the 4WX population at other times (for example the 1991 surveys of spawning areas were done in conjunction with the commercial fleet), and have indicated that winter surveys hold the most potential, however the survey area must be expanded. Winter herring aggregations can be quantified using acoustics, if they can be located. Aerial surveys offer a possible method of pre-survey, and should be pursued further.

Bottom Trawl Survey Index

The abundance of herring in the summer bottom trawl survey of the Scotian Shelf and Bay of Fundy has been considerably higher in recent years than in the late 1970s and early 1980s. This is presumed to reflect the general increase in population size observed through the 1980s, and possibly a concurrent change in distribution of herring.

The 1992 survey result from all stations was very high, and was found to contain two sets of very large catches of juvenile herring from the western side of the Bay of Fundy (Stratum 93). Even with removal of this stratum, the 1992 result was the second highest in the time series. It was noted that the area of the intense commercial fishery in July is not covered by the trawl survey because of untrawlable bottom area, and that the survey indicates a very broad distribution of herring in offshore areas in recent years. Further research into the use of an indicator based on presence/absence, potential diel effects, contrasts in the age composition between commercial and research data, and changes in geographic distribution could be useful in assessing whether these data can be used as indices of abundance.

4.5. Stock Status and Prognosis

Preliminary reconstruction of the catch records since 1985 indicates that landings have been considerably higher than reported and have exceeded the quota in many years. However, there are still some uncertainty in the catch data, including the differences between reconstructions based on interview versus backcalculation from production, rationalization of the 1985-1992 period, and previous revisions of catch. In addition, further work is required in improving the fishery-independent indices of abundance such as the larval abundance and bottom trawl survey series used for calibration. An analytical assessment was, again, precluded by the combined problems surrounding the catch records and questions surrounding the abundance indices, but will be attempted when these revisions are complete.

The winter acoustic survey was confined to January, and appears to have missed the overwintering aggregation. It is now apparent that Chedabucto Bay, in January, is not an appropriate index area. Larval and bottom trawl survey indices were high in 1992.

While there is insufficient information to recommend a change in previous advice (i.e. that it does not appear that actual catches at the level of recent years will be detrimental to the stock in the near future), there was concern that continued uncertainties regarding the landings and in the indices preclude an

analytical assessment. It is recommended that work towards an analytical assessment continue, and that further information, if available, be reviewed in February 1994. This may result in a different view of the acceptability of status quo catches.

The current year will see a major change in monitoring, with the implementation of a mandatory dockside monitoring program (DMP), which involves measurement (dipping of calibrated holds) of all landings. It is presumed that this monitoring program, combined with a sanctions program which is in the process of being implemented, will reduce misreporting.

5. Georges Bank Herring (Division 5Z) (Fig 5a,b)

5.1. Introduction

Georges Bank supported the largest herring fishery in the western Atlantic before the fishery collapsed in 1977. During the late 1960s and early 1970s, reported commercial landings exceeded 200,000 t annually. The fishery peaked in 1968 with reported landings in the 374,000 t range (Fogarty et al. 1989).

The recovery of the Georges Bank herring stock has been monitored by annual autumn adult/larval surveys since 1986. Over this period, the data has generally indicated an increasing relative level of abundance of herring on the bank.

5.2. Data Sources

In 1992 the Canadian larval survey was further expanded to cover, geographically, not only the entire northeastern portion of the bank, but a large area west of the original survey grid. Three data sources were used to evaluate stock status: the Canadian autumn adult/larval herring survey, the US autumn bottom trawl survey, and the exploratory autumn purse seiner survey.

Major problems were encountered with vessel availability in 1992 and the Canadian survey was conducted with two ships instead of the usual one. The larval component of the Canadian survey was delayed 3 weeks, but was extremely successful with respect to coverage and larval collections. On the other hand, the ground fishing segment of the survey was not considered representative due gear and vessel differences, although the areal coverage was similar to previous years.

Adult Distribution

The United States 1992 autumn bottom trawl survey showed the distribution of adult herring to be consistent with that observed in previous years. Adult herring were concentrated in an arc from north of Cultivator Shoal along the northern fringe of the bank well into Canadian waters. Several large catches were also made further south on the eastern portion of the bank suggesting the herring have continued to extend their distribution more eastward into Canadian waters. This also agrees with the observed location of adult herring during the autumn purse seiner survey.

Age Distribution

The 1992 Canadian survey catches were dominated (72%) by 3 and 4 year-old herring. The absence of fish older than 8 years of age may in part be due to the limited catches of herring and the inability of the gear to capture larger fish. However, the strong presence of 2 year old fish in 1991 was continued forward to 1992 with 3 year old herring representing approximately 54% of the entire catch. Other year-classes such as 1983 could also be followed through the age distribution until 1992.

The continued strong representation of young fish (4 years old and younger) in annual catches since 1986 and the general presence of older fish provides evidence of good annual recruitment to the spawning stock and continues to support the view of an expanding of Georges Bank herring stock.

Spawning/Larval Distribution

In 1992, the Canadian larval survey was expanded to cover the area west of the original grid where large concentrations of larvae were thought to occur in previous years. The data show the overall distribution of larvae to be much broader in area than in 1991 when very few larvae were caught near the international boundary. Larvae were caught at almost every station sampled except for a few (6) stations in the southern portion of the northeastern peak. Larval abundance was also much higher in 1992 than in 1991 and the second highest in the time series (1987-1992). Mean larval length was greater than previously observed at 14.55 mm. Between 1987 and 1991 mean larval length ranged from 9.38 mm to 13.41 mm.

Examination of the distribution and abundance of larvae <10 mm, which delineates the spawning area, indicated several centres of concentration on the Canadian section of the bank. This is a major change from the 1991 survey and is strong evidence of herring spawning on the Canadian side of Georges Bank. Furthermore, the occurrence of larvae <10mm just east of the boundary is in the same location that spawning was documented during the autumn purse seiner survey. The US larval survey also reported large concentrations of small larvae in this area during their 1992 November survey.

Anecdotal information from ground fish and scallop fishermen has indicated large concentrations of herring on the northeastern peak throughout most of the summer and early autumn. Several reports by Canadian fishermen of herring eggs in the stomachs of groundfish and of large herring schools in the observed area of spawning were also received during 1992.

Indices

The US bottom trawl survey showed a decrease from 1991 in catch/tow for sets with herring. Yet, the index represents the second highest in the series (1986-1992) and far exceeds all catches prior to 1991, including the period 1965-1985. Increased catches/tow were observed for the Nantucket Shoal and Massachusetts Bay areas as well. The Canadian bottom trawl index was considered unrepresentative due to a vessel and gear change and very small catches of adult herring.

The larval index showed an increase from 1991 to 1992. The mean number of larvae/10m^2 of 121.2 was the second highest since 1987 with the cruise approximately three weeks late. Attempts were made to account for the differences in cruise timing by adjusting the index to number of larvae at hatching.

Unfortunately, because of the annual variability of input parameters (Z and growth) very little new information could be extracted from this exercise.

There was also concern regarding the ability of the two types of indices (larval and groundfish) to track the relative abundance of herring on Georges Bank. Large variances about mean values make it difficult to determine whether or not annual changes reflect stock abundance. It was suggested that alternate approaches such as acoustics may be an appropriate way to survey the bank and should be investigated.

5.3. Prognosis

In summary the 1992 data indicate that the Georges Bank herring stock is well on its way to recovering from its collapse in 1977. The 1992 US bottom trawl survey index is second only to 1991 and far above earlier periods when catch levels were much higher. The standard larval abundance index is also the second highest in the time series and 3 times the observed value for 1991. Although poorly sampled in 1992, the age structure of the samples continued to show a dominance of 3 year-olds in the catches, indicating successful recruitment. Both newly hatched (ie. <10 mm) and older larvae, displayed a much broader geographical distribution than in any of the post-crash years. Finally, spawning on the Canadian side of the bank was documented in 1992 by three independent surveys (autumn purse seiner, Canadian larval, and the US autumn larval).

The proposed 1993 experimental fishery of 5,000 t or less will provide further information on the distribution and age structure of fish and is unlikely to impede the stock's recovery. However, until such time as the impact of opening a fishery on Georges Bank can be evaluated, catch levels should be maintained at a minimum. For 1994, an experimental fishery with a combined Canadian and United States herring catch in the same order as 1993 is not considered to be detrimental to the continued recovery of the Georges Bank herring stock.

6. Mackerel in Subareas 2-6 (Fig 6)

6.1. Mackerel Developmental Program

It is generally recognized that Atlantic mackerel are an underexploited species. The absence of good markets is the main cause. Under the 1991-1994 Mackerel Developmental Program, a lot of effort has been made to improve this fishery. The program in 1991 was not successful as the time frame in which proposals were actually received and accepted were well into the fishing season. In 1992, for most participants, the fishery was also unsuccessful. The overall catch (2,468 t) only represents 11.3% of total allocations. The main reasons were the high incidence of herring by-catch (which led to early closure of the fishery for some participants) and the difficulty in marketing mackerel. As demonstrated by the western Newfoundland participants, there is a potential for success (their catches represented 100% of their allocation).

6.2. Commercial Landings SA 2-6

Since the adoption of the 200 miles jurisdiction, catches in Canadian waters have fluctuated between 16,000 t in 1982 to 31,000 t in 1986. Catches were 25,475 t in 1992, a slight decline of 335 t in comparison with 1991. The most important catches were made in 4T, 4R and 4X with respectively 7,657, 5,580 and 4,788 t. Catches from the east coast of Newfoundland (Divisions 3K and 3L) have been rapidly declining over the past five years, and have been around 1,000 t since 1990.

A joint agreement between US and European countries resulted in a very successful midwater trawl winter fishery along the continental shelf in SA 5-6. Catches have increased from less than 1,000 t in 1980 to a maximum of 43,000 t in 1988. Catches have been constantly declining since then and were 16,000 t in 1991. This trend is explained by a set a new regulations concerning the ratio of catches made by foreign and domestic fleets. In 1992, no foreign, no joint-venture or other sources non-USA of commercial landings were reported in US waters.

In 1992, 2,300 t of mackerel were caught by four foreign countries in divisions 4Vn, 4W and 4X (Russia, Lithuania, Cuba and Japan). Most of the catches were made during the spring and autumn by four vessels with activities concentrated particularly in subdivisions 4Wj and 4Wl. Monitoring of that fishery has been achieved by observers. Length-frequencies indicated that the amount of small fishes of year-classes I, II and III was very important.

6.3. Commercial Data

Commercial Sampling Program

No biological samples and length-frequencies were collected from the Scotia-Fundy fishery. Sampling of this component is essential if reliable catch at age for this fishery is to be constructed.

Canadian, US and Total Catch at Age

US sampling data for 1991 and 1992 have not yet been analyzed and no analytical assessment has been done for two years. Therefore, total catch at age was estimated, as in 1991, by prorating Canadian catch at age to total landings. This assumes that the Gulf samples are representative of the total stock. In 1992, 26% of commercial catch was from the dominant 1988 year-class. The 1982 year-class was still important at 21% but no longer the strongest. The 1990 and 1987 year-classes were also important with a representation of 14% and 16% of the total catch.

Otolith L_1 analysis

A preliminary analysis backcalculating length at age 1 from otolith readings was carried out on previously collected commercial samples. Mean annual length at age (L_1) showed no significant difference for the period preceding the 200 miles jurisdiction where strong fishing effort was exerted on the population. Significant differences were however noted after that period. The two lowest mean values of L_1

corresponded to the strong year-classes of 1982 and 1988. Results suggest the presence of an inverse relationship between density and growth during the first year. Length at age 1 does not affect length at older ages. Examination of otolith L_1 could provide a means of predicting the strength of a recruiting year-class.

6.4. Estimation of Stock Size

Egg Survey

The Department of Fisheries and Oceans has been conducting an annual survey of mackerel egg abundance since 1979 in order to estimate the Gulf of St.Lawrence spawning stock biomass. Egg density was lower in 1992 and despite a delay in the spring migration, spawning activities were already well engaged. Mean water temperature of the surface layers was higher than in previous years and more eggs with advanced developmental stages were found. As proposed previously, the beginning of the spawning activities is related with surface temperature. The total egg production method in 1992 gave an estimated biomass of 792,000 t as opposed to 1,331,100 t in 1991.

Correction For The Oversampled Eggs

For the past three years, a correction for oversampled eggs at the surface with oblique plankton tow has been applied. The review of historical data has been completed. Linear regressions, applied between corrected density and non corrected densities, were used to backcalculate corrected densities for each cruise leg since 1983. As a result, a mean annual reduction of 22% of egg abundance was obtained. In 1993, the study describing relationships between the egg vertical distribution and physical factors will be completed to refine the model.

Batch Fecundity

Estimation of the spawning stock size of the Gulf of St. Lawrence mackerel is calculated according to the total egg production method. In the past, this method has been proposed to overcome the problem of a lack of valid abundance index. Female fecundity, one of the most important variables to insert in this method, is determined as the number of oocytes having a diameter greater than 140 µm just before spawning. This definition of fecundity does not take into account of the loss of eggs during the spawning season through atresia and the gain by vitellogenesis.

For indeterminated serial spawners, such as the Atlantic mackerel, the best way to define fecundity consists of multiplying the number of oocytes expelled per batch by the number of batches spawned during the spawning season. For the determination of these two variables, recognition of the different phases in the oocyte development has been done . As in 1991, a research survey was conducted in Baie des Chaleurs in 1992. The data are under analysis. The importance of this project is recognized and its continuation is encouraged.

Acoustic index for mackerel in Cabot Strait

During the pre-spawning migration, the Atlantic mackerel stock is concentrated in time and space in Cabot Strait. Although Cabot Strait is 57 nautical miles (nm) wide, migratory activity of pelagic fish is restricted to the first 1.2 nm of shallow (< 160 m deep) nearshore waters on the southern side of the strait. Herring and gaspereau also occur in this area during the mackerel migration. We found that occurrence of echoes was maximum at high tide, suggesting that migratory activity is linked to the tidal cycle and that mackerel and other pelagic species use selective tidal stream transport as a migratory mechanism. Current-meters moored in the study area show that currents flow into the gulf at flood tide and that the nearshore waters are very tidally energetic, with currents as strong as 4 knots. The effect of tides on migration will need to be taken into consideration in the estimation of mackerel swimming speed, which is a required parameter to calculate a biomass index from a survey in a single point. Various problems that need to be addressed are discussed, the most important ones being the variable duration of the migratory period, the variability of migration timing, and echo validation.

6.5. Index-Fishermen Program

This program was maintained in 1992. Logbooks were distributed to selected gillnet and purse seine fishermen in Baie des Chaleurs (Quebec). The monitoring of the exploratory fishery, using purse seine, pair trawl, lampara seine and midwater trawl in Baie des Chaleurs (New-Brunswick) has been carried on and it will be extended to gillnet fishermen of the east coast of New-Brunswick. Large annual catches of mackerel are reported by these fishermen. These catches are not recorded by DFO because they are used immediately for bait. With this new program, these catches will be recorded and it will be possible to try to define a relationship between the amount of bait used and the corresponding catches of crabs or lobsters. An extrapolation for all the other fishermen in the same situation could be envisaged subsequently.

Catch Statistics in Dingwall

In 1992, catches in Dingwall were important but less than the previous year. Because of the lateness in the migration, fishing activities were maintained until the end of July. Significant catches were recorded just before the end of the season. Cumulative daily catches showed the same profile as in 1983, 1984 and 1991 where two distinct components characterized the migration and where more than one year-class was dominating the fishery. However, total catches of mackerel decreased and the migration occurred progressively earlier from 1983-1988. Subsequently the migration occurred later with a gradual increase in catches. Thermographs were fixed at the three traps as in 1990 and 1991. Temperature data will be analyzed and an investigation will be made to see if temperature is important in the timing of the migration and in the daily fluctuations of the catches. Gonads were also gathered during the first week of June, before the beginning of spawning, for histological examination.

Fat Content Analysis

At the request of the Mackerel Development Council Inc., a fat content analysis was initiated in 1991. Mackerel coming from the commercial sampling and index-fishermen programs have been used in 1991 and 1992 for the analysis. As noted last year, fat content increased toward the end of the season. However, data gathered in 1992 indicated that the increase is significant only for the spawning component of the population. The same data showed that the water content decreased during the season and a strong inverse relationship was obtained between fat and water content. This relationship could be of a practical utility to predict fat content by water content, a variable easier to calculate.

6.6. Prognosis

The US advice is based on an $F_{0.1}$ management strategy with an established minimum spawning stock size of 600,000 t to maintain or improve the recreational fishery. Foreign fishery, as it was observed for two years, was minimum. No analytical assessment was done in 1992. Catches per tow-at-age from the spring groundfish survey were high. The US assessment projections in 1990 indicated that the biomass is over 3 millions tons. No TAC has been set for Atlantic mackerel by Canada because catches are considered much lower than $F_{0.1}$. Previous estimates that 200,000 t divided equally between US and Canada would not endanger this stock still appear valid.

7. Response to Request for Advice on Shark Management Plan

Comments on the draft management plan for porbeagle, short fin mako and blue shark fisheries in the Canadian Atlantic zone were requested. In addition, comments were requested on a proposal from industry on modification to the draft plan, in particular nursery areas and minimum size regulations.

Little time was available to compile information on these issues. The only sources are the observer program and published reports since there is no active research program on sharks. Where possible specific comments have been made. Overall, the advice provided last year was reiterated, that is extreme caution should be exercised in the development of a shark fishery.

7.1. Level of Developmental Quotas

The directed fishery for porbeagle sharks began in the northwestern Atlantic in 1961. Reported landings initially rose to an historical high of 9,300 t in 1964 but thereafter declined to about 1,000 t in 1968 and averaged 100-400 t annually during 1969-88. Catches subsequently rose to 500 t during 1989-90, 1,200 t in 1991 and 1,700 t in 1992. The sharp increases in 1992 have been a consequence of increased effort, through the addition of a second Faeroese and two Canadian vessels. The plan calls for a 1,500 t total quota in 1993, of which 400 t is an allocation for the Faeroe Islands.

There are currently no reliable estimates of abundance for the shark resources. While commercial catch rates from the observer program have remained stable since the late 1980s, these are not reflective of

abundance due to the distributional characteristics of these species. Therefore, there are little data to judge the level or stability of current biomass.

The porbeagle shark fishery appeared sustainable during 1980-90 when annual landings did not exceed 530 t and averaged 340 t. There is no information to determine whether or not the 1,500 t of porbeagle is sustainable. It is important to point out that shark fisheries have generally been characterized by rapid expansion followed by collapse. This is due to the shark's schooling behaviour combined with low reproductive capability, slow growth and late maturity. Therefore, that extreme caution is required in the development of this fishery and vessels should gear-up for the short, rather than the long term.

Mako shark is not abundant in Canadian waters and is caught as by-catch to other fisheries. Therefore, the 250 t plan quota appears reasonable.

The blue shark quota of 250 t has no biological basis and must be considered precautionary. This species is abundant in the Canadian zone and thus the quota will limit the fishing in the long term. Preliminary analysis of observer information indicates that the by-catch of blue shark in the directed porbeagle fishery have typically been 1% by weight but increased to 5% in 1991 due to increased effort on the Scotian Shelf. There are reports of large by-catch of blue shark in the swordfish and offshore tuna fisheries but this is presently unquantified and needs further investigation.

7.2. Industry Proposal on Porbeagle Shark Fishery

The 2,400 t quota that is proposed is considered too high. At the very least, the level provided by the draft plan (1,500 t) should not be exceeded.

Because the reproductive capacity of sharks is much lower than for other fish, protection of females may be a useful management strategy. While this might be done through implementation of area and season closures, there is little information on which to base these. Anecdotal information from the Faeroes fishery indicates that incidence of gravid porbeagle females is higher during January/February on Georges Bank than at any other area or time of year. This should be confirmed through at-sea sampling.

Industry proposed to establish a minimum size of 32 kg round and encourage fishermen to release live sharks below this limit but it is unclear what this minimum size was based on. Using a length-weight relationship for porbeagle in the eastern Atlantic, the 32 kg minimum converts to minimum length of 130 and 143 cm for males and females, respectively. There is no biological information available to ensure that this proposed minimum represents a biological constraint e.g. length at 50% sexual maturity. Further, it is felt that a minimum size might promote discards, and given the present knowledge of catch size composition, albeit limited, it is not clear that a minimum size is necessary. More information regarding condition and survivability of longline-caught porbeagle sharks is required before implementing this regulation. Overall, implementation of a minimum size regulation is not recommended at this time.

The industry proposal indicates the need for data collection. It was considered that port sampling will provide inadequate biological information because of condition landed (frozen, gutted, headed, etc). At-sea sampling will be required and would be best accomplished by full observer coverage.

7.3. International Considerations

There is only limited evidence to suggest that shark stocks are transatlantic in distribution. Management of these resources should be considered bilaterally with the USA since there is a danger that Canada and the USA will implement plans that are either inconsistent or at cross purposes.

Landing data for sharks are typically poor, in part due to the fact that most sharks are taken as by-catch. ICCAT has recently (1991) started to collect landing statistics as part of its mandate. The further role of ICCAT in shark assessment and management needs clarification.

8. References

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Herring in Div. 4R
SUMMARY
Figs. 2

Year	1986	1987	1988	1989	1990	1991	1992	1993	Min.[1]	Mean[1]	Max.[1]
Reference Level	17.0	30.6	30.0	30.0	20.5	22.0	22.0	22.0			
TAC	17.0	30.6	30.6	37.0	35.0	35.0	35.0	35.0			
Purse seine catches	19.3	13.7	16.3	16.7	16.1[2,3]	18.9[2,3]	14.7[2,3]		2.6	9.1	20.0
Gillnet catches	2.1	2.8	1.8	1.0	0.8[2]	0.5[2]	0.6[2]		0.3	2.7	9.4
Estimated discards											
Total catches	21.4	16.6	18.1	17.7	16.9[2]	19.4[2]	15.3[2]		2.9	13.6	28.7
Total biomass											
Spawning biomass											
Mean F( )											

[1]Min, mean and max for the period 1966-1992.
[2] Preliminary statistics
[3]Adjusted according to industry records

Forecast for 1994: Caution should be exercised about the spring-spawner component which is heavily exploited and which shows no sign of short term rebuilding.

Catches: Catches are made by gillnets and purse seines. Since 1985, the proportion of catches by purse seiners has been in excess of 80%, reaching 96% in 1992. In recent years, the purse seine fishery has gradually shifted from an autumn fishery in northern 4R to a spring fishery in southern 4R, owing to the development of an OSS (over-the-side) fishery.

Data and Assessment: Gillnet and index fishers' catch rates are used for the basis of the assessment. Catch rate series for both spring and autumn spawner stock components peaked in the mid-1980s as the abundant 1980 and 1982 (spring) year-classes and the 1979 (autumn) year-class passed through the fishery. Spring spawner catch rates declined markedly in 1992, whereas autumn spawner catch rates increased substantially.

Fishing Mortality: Although it was not possible to conduct analytical assessments on either herring stock components, fishing mortalities for older spring spawners (6+) appear to have increased in the last 5 years and are estimated currently to be above 0.3. Fishing mortalities on autumn spawners appear to be substantially lower than on spring spawners.

Recruitment: The 1986 (autumn spawners) and 1987 (spring spawners) year-classes appear abundantly as juveniles in purse seine catches. The 1986 year-class has extended southward over the entire range of the stock, whereas the 1987 year-class has been restricted in the southern part of the stock area (Bay St. Georges and Port-au-Port). Index gillnet fishers in that area have caught only limited amounts of the 1987 year-class (spring spawners), indicating that it is probably much less abundant than it autumn counterpart.

State of the Stock: The 1987 year-class of spring spawners is now fully recruited and it does not appear to be sufficiently strong to sustain the fishery at current levels of exploitation. On the other hand, the autumn-spawner component does not appear to have undergone heavy exploitation recently, and the presence of the 1986 cohort points to a strong recruitment pulse.

Environmental Factors:

Multispecies Considerations:

Long-term Prospects: The spring-spawner component of the stock is declining, and in the absence of recruitment, it shows no sign of mid-term rebuilding. On the other hand, the strong pulse of recruitment for autumn spawners seem to indicate rebuilding for this component.

Herring in 4TVn Spring Spawners
SUMMARY
Figs. 3a-3f

Year	1986	1987	1988	1989	1990	1991	1992	1993	Min.[1]	Mean[1]	Max.[1]
4T Reference Level	9.1	12.9	12.8	21	16	16	16.8	16.8			
4T TAC	7.2	8.2	12.8	16.8	21	21	21	21			
4T Gillnet catches	11.3	13.2	14.8	12	9.9	11.4	12.7	12.4	5.5	9.8	14.8
4T Purse seine catches	4	4.4	6.6	4.4	3.8	2.8	2.9	3.3	0.4	4.7	14.3
4Vn Purse seine catches	1.3	0.3	0.3	0.2	0.7	1	0.3	-	0.2	0.9	1.5
Total catches	16.6	17.9	21.7	16.4	14.4	15.2	15.8	15.7	7.0	15.5	23.7
Total biomass											
Spawning biomass											
Mean F											

All catch and biomass numbers are in '000 of metric tonnes (t). Reference levels are provided for spawning group but TACs are set by fishing season. All catches are by spawning group except 1993 which is by season and is current to October 27, 1993.

[1] Min, mean and max values are from 1978 to 1992.

Forecast for 1994: It was not possible to make a quantitative forecast for 1994.

Catches: Spring spawners are harvested by gillnets during the spawning season and catches in the spring season are 99% to 100% spring spawners. Spring spawners comprise about 85% of the spring purse seine fishery catch and about 30% of the autumn purse seine fishery catch. The winter 4Vn fishery harvest about 30% spring spawners. Catches have generally been below the TAC in recent years because of poor markets.

Data and Assessment: Changes in advice are based on gillnet catch rate trends in the spring fishery. Conclusions based on these data are supported by the annual acoustic survey and the proportion of spring spawners sampled during the survey.

Fishing Mortality: Because of reduced effort due to poor markets, fishing mortality has probably been low in recent years.

Recruitment: The 1988 year-class was most numerous in fixed and purse seine fisheries (about 40% by number). In fixed gear it was the strongest since 1980. The 1987 year-class was also strong and accounted for about 18% of total landings.

State of the Stock: Catch rates indicate that the abundance of spring herring in 1992 was similar to 1991 and slightly greater than 1989 and 1990. Acoustic survey samples indicate that spring spawners are about 20% to 25% of the total 4T population. At these proportions, a catch of 15,000t would translate to an F of 0.10.

Environmental Factors: The spring fishery effort in 1992 in all areas was delayed relative to previous years in terms of the starting and median dates. The duration of the fishery has been compressed in recent years compared to earlier years.

Long-term Prospects: The spring spawning stock is likely to be dependent on two year-classes in the coming years (1987-1988).

Herring in 4TVn - Autumn Spawners
SUMMARY
Figs. 3a-3f

Year	1986	1987	1988	1989	1990	1991	1992	1993	Min.[1]	Mean[1]	Max.[1]
4T Reference Level	16	31.3	59.7	53.7	53.7	53.7	60	81.5			
4Vn Reference Level	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2			
Total Reference	20.2	35.5	63.9	57.9	57.9	57.9	64.2	85.7			
4T TAC	36.2	64.6	66.1	70.1	65.9	65.9	65.9	80.8			
4Vn TAC	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2			
Total TAC	40.4	68.8	70.3	74.3	70.1	70.1	70.1	85			
4T Gillnet Catches	37.2	50.7	39.3	32.9	56.2	27.9	32.9	21.4	5.5	24.6	56.2
4T Purse Seine Catches	6.9	9.3	10.9	10.1	6.4	5.7	5.4	5.5	1.9	8.9	25.5
4Vn Purse Seine Catches	3.1	2.0	2.3	1.9	4.0	4.0	3.9	-	1.5	2.6	4.0
Total Catches	47.2	62.1	52.5	45.0	66.6	37.5	42.2	26.9	15.4	36.1	66.6
Total biomass	589	611	593	723	827	658	564	-	119	453	827
Spawning biomass	259	281	367	369	351	304	480	-	29	205	480
Mean F	0.22	0.32	0.23	0.17	0.25	0.10	0.10	-	0.10	0.34	1.52

All catch and biomass numbers are in '000 of metric tonnes (t). Reference levels are provided for spawning group but TACs are set by fishing season. All catches are by spawning group except 1993 which is by season and is current to October 27, 1993.

[1]Min, mean and max values are from 1978 to 1992.

Forecast: The TACs for the 4TVn autumn spawning stock have been set at 85,000t per year for 1993 to 1995. Assuming that the TACs are reached, the fully recruited (7+) Fs is projected to increase from 0.25 in 1993 to 0.36 in 1995.

Catches: The autumn gillnet fishery harvests almost exclusively autumn spawners (99%). Autumn spawners are also harvested in the spring purse seine fishery (about 15% of the catch), the autumn purse seine fishery in 4T (about 70% of the catch), and the winter 4Vn fishery (about 85-95% of the catch). Catches have generally been below TACs in recent years because of poor markets and reduced effort.

Data and Assessment: The assessment is based on an ADAPT-VPA using age by age gillnet catch rates as the abundance index. Conclusions also take into account reports made by index gillnetters, acoustic survey, and spawning survey made at Fisherman's Bank.

Fishing Mortality: Fishing mortality estimated to have been below target F of 0.30 since 1986, except for 1987.

Recruitment: The 1987 year-class is estimated to be the largest seen since 1978. It comprises about 50% of the catch in fixed and mobile gear by number. The 1988 and 1986 year-classes are estimated to be below average.

State of the Stock: Biomass increased during the 1980s from very low levels in the late 1970s. 3+ biomass peaked at about 750,000t in 1990 and in 1992 was 550,000t. 5+ biomass increased slightly from 1991 to 1992 (300,000 to 450,000t) but 7+ biomass decreased slightly (200,000 to 180,000t).

Environmental Factors: Delays in the autumn fishery in 1992 were evident in a few areas relative to 1990 and 1991. The fishing effort during the autumn has become compressed in time in most areas relative to 1978 to 1985.

Long-term Prospects: The previously dominant 1983 year-class now comprises only 8% of the catch. The 1987 year-class is large but recruitment from the 1986 and 1988 year-classes is below average. The fishery will be carried by the 1987 year-class for the next few years.

Herring in Divs. 4WX
SUMMARY
Figs. 4a-4c

Year	1986	1987	1988	1989	1990	1991	1992	1993	Min.[1]	Mean[1]	Max.[1]
TAC ('000t)	110.6	126.5	151.2	151.2	151.2	151.2	125.0		80.0	130.2	151.2
Reported catches ('000t)	74	101	125	84	102	97	100		74	97	125
Unreported catches[2] ('000t)	36	56	80	17	81	39	26		17	50	81
Total catches[2] ('000t)	110	157	205	102	183	136	126		102	147	205
Total Biomass											
Spawning biomass											
Mean F											

[1]Min, mean and max values from 1984 to 1992.
[2]Using provisional backcalculation from production reports.

Forecast for 1994: Considering the substantial misreporting that has taken place in the past, it is not possible to estimate present stock size or to make forecast for 1994.

Catches: Reported landings for 1992 were higher than 1991 by about 3% but were known to be underestimated. Purse seiners accounted for about 96% of the total and catch distribution was similar to previous years but with some shifts in effort on 'Western Hole' early in the season and away from German Bank late in the season.

Data and Assessment: Revisions to the catch record based on purse seine captain interviews and departmental production reports showed substantial under reporting for 1985-1992. An analytical assessment was precluded by the combined problems of the unreported catches and questions regarding the larval and groundfish surveys by-catch abundance indices. The winter acoustic survey was limited to a January survey and appears to have missed the overwintering aggregation.

Fishing Mortality: Fishing mortality was not precisely estimated, but could be high.

Recruitment: The 1983 year-class has almost passed through the fishery but is still contributing 11% by weight at age 9. The 1987 and 1988 year-classes now dominate the catch.

State of the Stock: The larval abundance and trawl indices remain high, suggesting relatively high stock sizes.

Special Comments: Further work on resolving problems with the landings and the abundance indices with a view towards producing an analytical assessment is recommended. If available, these data will be presented at the next meeting of the Pelagic Subcommittee in February 1994.

Herring in Div. 5Z
SUMMARY
Figs. 5a-5b

Year	1986	1987	1988	1989	1990	1991	1992	1993	Min.	Med.	Max.
TACs	-	-	-	-	-	-	-	5.0			
Reported catches	-	-	-	-	-	-	-	-			
Total catches	-	-	-	-	-	-	-	-			
Total biomass											
Spawning biomass											
Mean F											

Forecast for 1994: No detailed forecast possible. However, given the continuous signs of recovery a combined Canada/United States experimental fishery in 1994, as in 1993, of 5,000t is unlikely to be detrimental to the stocks recovery. Catches should be kept to a minimum until such time as the impact of a fishery can be evaluated.

Catches: There has been no commercial fishery on Georges Bank since the collapse of the herring fishery in 1977.

Data and Assessment: Due to the lack of a commercial fishery an analytical assessment in Division 5Z is not possible. The stock status is being evaluated using larval and bottom trawl indices, as well as larval distribution to monitor spawning coverage.

Fishing Mortality: Not possible to estimate fishing mortality precisely but it is likely low.

Recruitment: Appears to have improved in the second half of the 1980s.

State of the Stock: Continued evidence of a recovering stock with the expansion of spawning distribution onto the historical spawning areas of the northeast section of Georges Bank. Groundfish survey by-catches over the past three years have shown a dominance of 3-4 year old fish indicating continued recruitment.

Special Comments: A single fishing excursion was undertaken in 1993. Although many herring were observed, no fish were caught as they remained near bottom and unavailable to the seining gear.

Mackerel in Subarea 2-6
SUMMARY
Figs. 6

Year	1986	1987	1988	1989	1990	1991	1992	1993	Min.[1]	Mean[1]	Max.[1]
Canadian Catches ('000t)	31	28	25	21	23	26	25.5		6.4	18.6	31.1
U.S.A Catches ('000t)	13	18	22	16	12	17	14		1.9	10.6	21.8
Others Catches ('000t)	26.5	37	43	37	31	16	0		0	87	396.8
Total Catches ('000t)	70.5	83	90	74	66	59	39.5		8.3	116.2	449.7
Total biomass[2] ('000t)	1500	1516	1682	1866	2422	3028	3008		175	881	2,422
Gulf of St.Lawrence Biomass[3] ('000t)	1369	785	1352	401	1082	1331	792		312	958	1,556

[1] Mln, mean and max values are from 1962 to 1992, except for Gulf of St. Lawrence biomass (1983-1992).
[2] From Northeast Fisheries Science Center Reference Document 91-03.
[3] From egg production estimates.

Forecast for 1994: It was not possible to make a quantitative forecast for 1994. It is expected that catches will depend more on fishing effort than on stock abundance.

Catches: Since 1977, Canadian catches in subareas 3+4 have fluctuated between 17,000t in 1984 and 31,000t in 1986. Catches in 1992 were 25,500t, mostly in 4T, 4R and 4X. In subareas 5+6, catches varied according to joint agreements between the USA and European countries. Catches were high (more than 40,000t) when joint agreements favored them and they decreased when the agreements were more restrictive (0 catch in 1992). The USA caught 14,400t in 1992.

Data and Assessment: Normally, age composition is derived for the Canadian and American fisheries seperately; however the age composition of landings in the USA is not available for 1991 nor 1992. Spawning biomass in the Gulf of St. Lawrence is calculated based on egg production estimates from plancton surveys. Total biomass is calculated by the USA by calibrating a sequential population analysis model with indices of abundance from groundfish trawl surveys.

Fishing Mortality: Fishing mortality is not estimated precisely, but it is believed to be low based on small catches and high biomass.

Recruitment: Based on the age composition in the Canadian fishery, the 1988 year-class appears to be reasonably strong.

State of the Stock: The stock biomass is estimated to be high, but probably decreasing.

Environmental Factors: Mackerel is a warm water species and its presence in coastal waters depends on the temperature being adequate.

Long-term Prospects: Catches in the mid-1970s peaked at above 400,000t but such high fishing intensity was not sustainable. Long term average catches since 1960 are about 100,000t.

Fig. 1a. Landings and TAC for White Bay-Notre Dame Bay

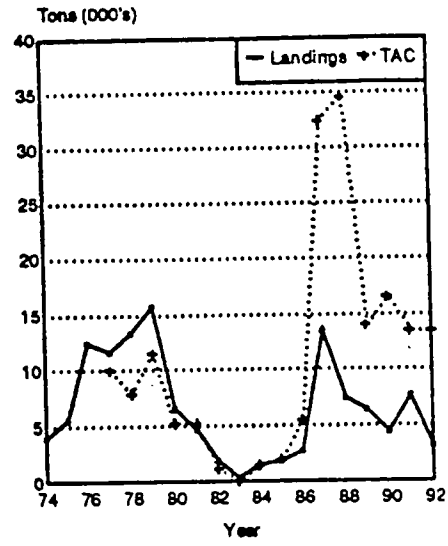


Fig. 1b. Landings and TAC for Bonavista Bay-Trinity Bay

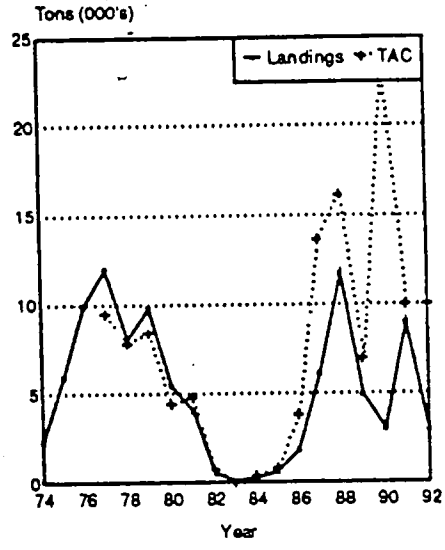


Fig. 1c. Landings and TAC for Conception Bay-South Shore

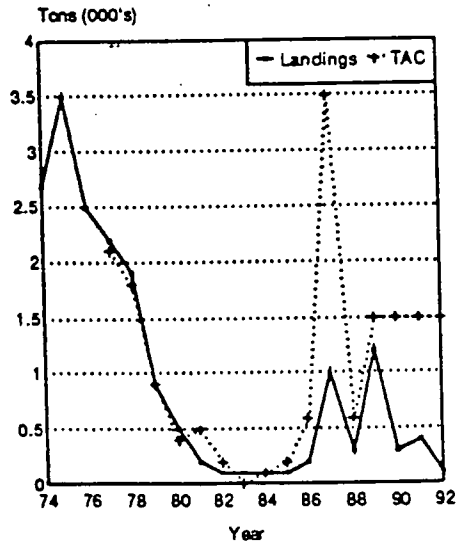


Fig. 1d. Landings and TAC for St. Mary's Bay- Placentia Bay

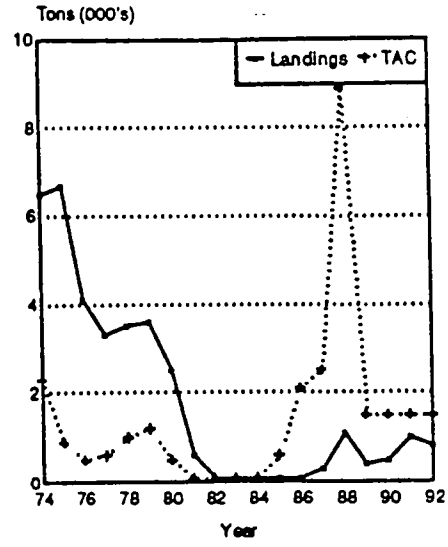


Fig. 1e. Landings and TAC for Fortune Bay

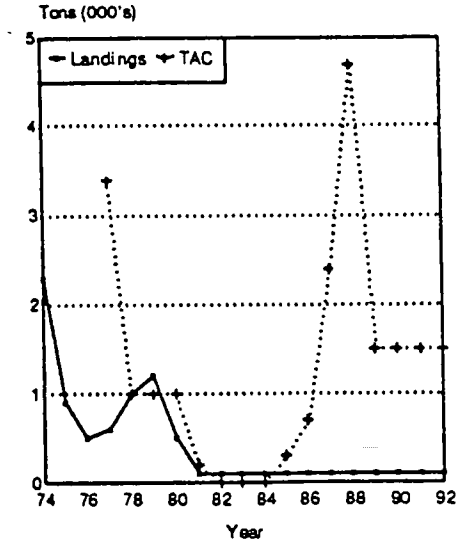


Fig 2 Landings of 4R herring

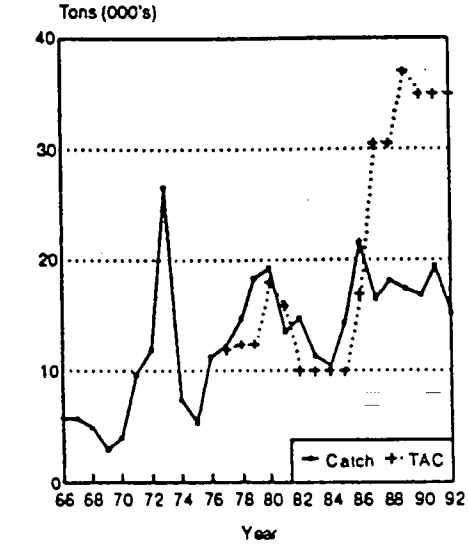


Fig 3a Landings and TAC for 4T herring

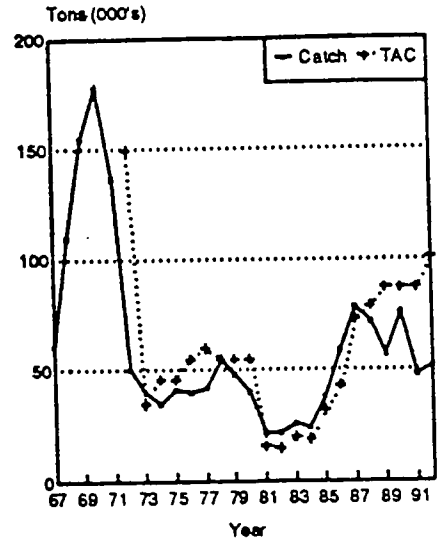


Fig 3b Landings of 4Vn herring

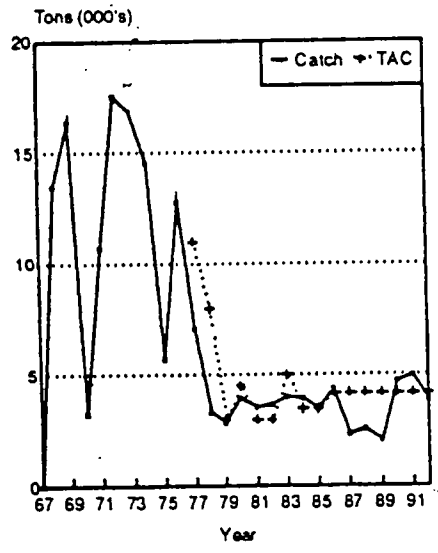


Fig 3c Purchase slip catch rates for 4T herring

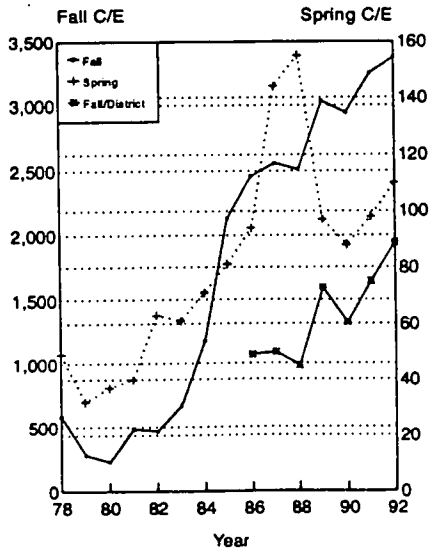


Fig 3d Fishing mortality at ages 5,6 and 7+ for 4T herring

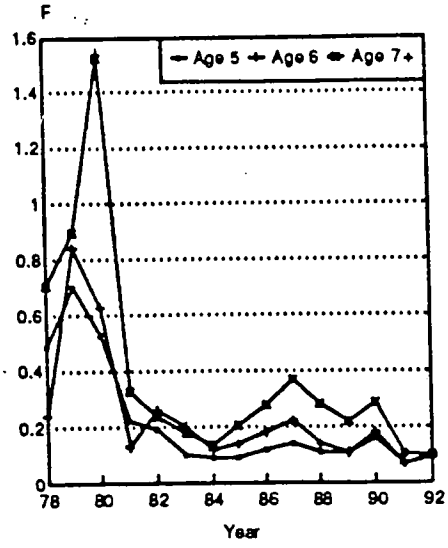


Fig 3e Biomass for 4T fall herring

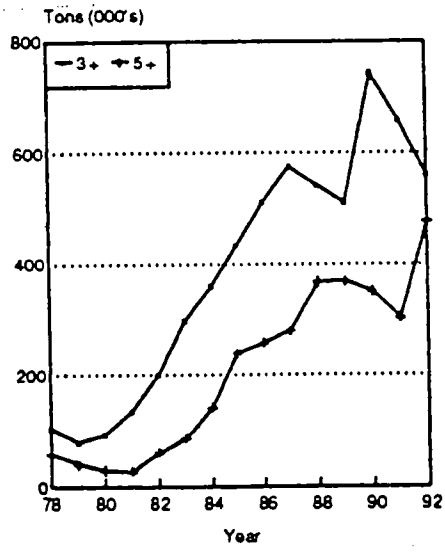


Fig 3f 4T fall spawner herring recruits at age 2

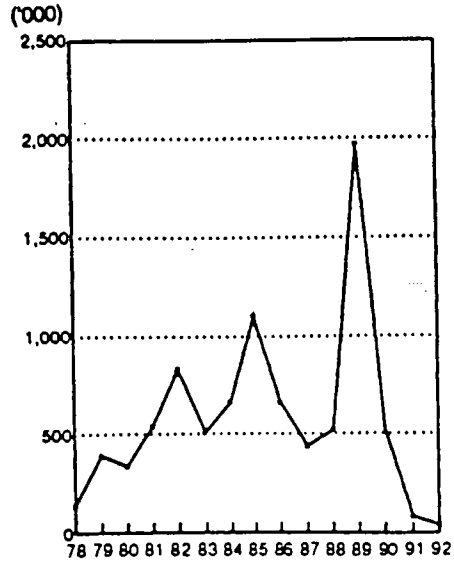


Fig 4a Landings of 4WX herring

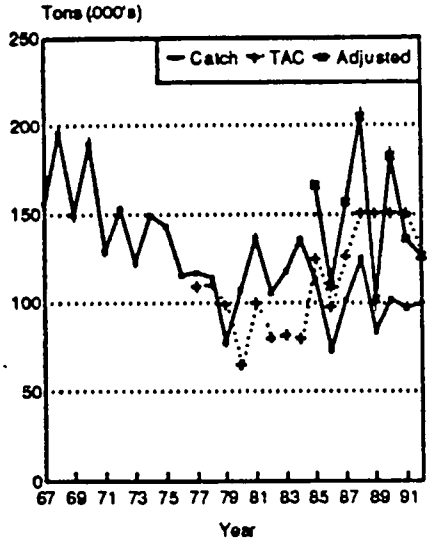


Fig 4b Index of larval abundance for 4WX herring

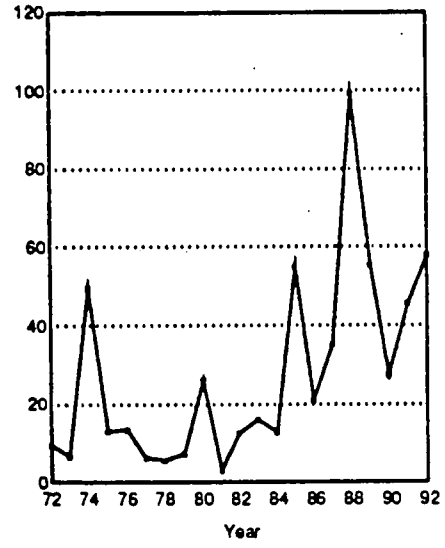


Fig 4c Comparison of reported landings of 4WX herring with estimates derived from interviews and production

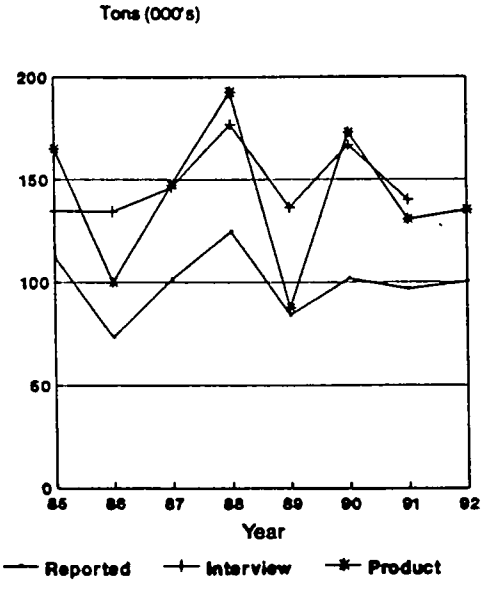
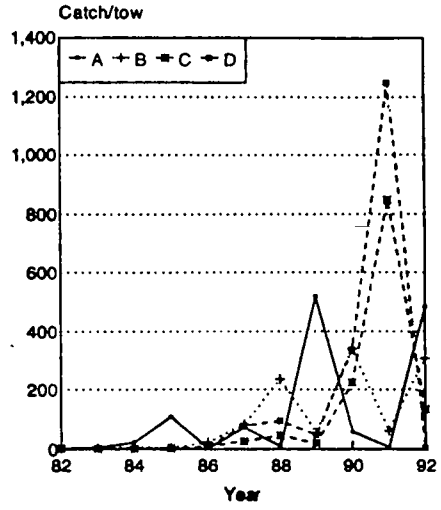


Fig 5a Catch per tow for sets with herring in USA and Canada bottom trawl surveys.



A= Mass. Bay; B= Nantucket shoals; C= Georges Bank; D= Canada

Fig 5b Herring larval abundance for USA & Canadian surveys

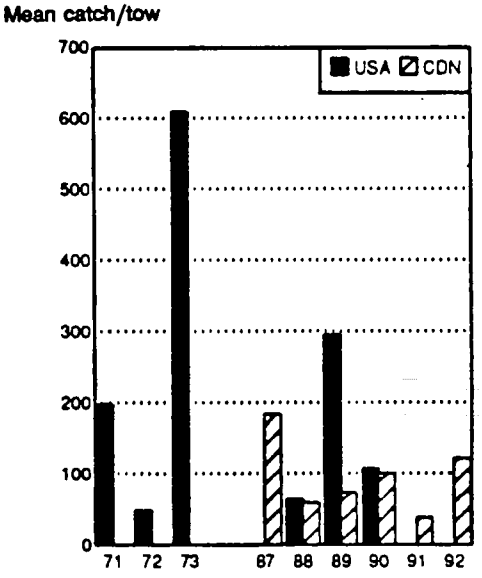


Fig 6 Landings of mackerel in SA2-6