

Report of the Scotia-Fundy Regional Advisory Process (RAP)

R.N. O'Boyle and K.C.T. Zwanenburg [Eds.]

**Biological Sciences Branch
Department of Fisheries and Oceans
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2**

September 1994

**Canadian Manuscript Report of
Fisheries and Aquatic Sciences No. 2252**



September 1994

**Report of the Scotia-Fundy
Regional Advisory Process
(RAP)**

1994 Spring Meeting

R.N. O'Boyle and K.C.T. Zwanenburg [Eds.]
Biological Science Branch
Bedford Institute of Oceanography
Dartmouth, Nova Scotia
B2Y 4A2

(c) Minister of Supply and Services Canada 1994
Cat. No. Fs 97-4/2252E ISSN: 0706-6473

Correct citation for this publication:

O'Boyle, R.N, and K.C.T. Zwanenburg [Eds.]. 1994. Report of the Scotia-Fundy
Regional Advisory Process (RAP). Can. Manuscr. Rep. Fish. Aquat. Sci. 2252:
xii + 208 p.

TABLE OF CONTENTS

Abstract/Resume	v
Maps	vii
1. Introduction	1
2. Overview of the Ecosystem	2
2.1 Community Structure Changes	2
<i>Phytoplankton and Zooplankton Trends</i>	2
<i>Finfish Species Trends</i>	3
<i>Finfish Species Diversity</i>	3
2.2 Groundfish Overview	4
2.3 Pelagics Overview	8
2.4 Marine Mammals Overview	9
3. Overview of Management and Issues in the Fishery	10
3.1 Management Plans and a Decision-Making Framework	10
3.2 Fisheries Management and Habitat Research	10
3.3 Some Conservation Principles	10
<i>The Age/Size Structure of the Commercial Catch</i>	10
<i>Spawning and Exploitation</i>	11
<i>Harvesting Stress on Maturity Schedules</i>	11
<i>Minimum Spawning Stock Biomass Thresholds</i>	11
3.4 Regulatory Activity	12
<i>Effort Trends Since 1977</i>	12
<i>Management Activities in 1993</i>	14
<i>National Sampling Program</i>	16
<i>Discarding and Misreporting</i>	16
<i>Industry Observations</i>	16
<i>Problems in Groundfish Data Processing</i>	17
<i>Problems in Lobster Data Processing</i>	18
4. Ocean Climate Summary	19
4.1 Mean Conditions	19
4.2 Long-Term Trends	21
4.3 Conditions During Research Vessel Surveys	23
4.4 Implications for Interpretation of Survey Trends	23
4.5 Conditions in 1993	23

TABLE OF CONTENTS (Continued)

5.	Groundfish Stock Assessments	26
	4Vn Cod	27
	4VsW Cod	37
	4X Cod	53
	5Z Cod	64
	4TVW Haddock	76
	4X Haddock	89
	5Z Haddock	100
	4VWX+5 Pollock	112
	4VWX Silver Hake	123
	4VW Flatfish	128
	4X Flatfish	141
	3NOPs4VWX Atlantic Halibut	151
	Unit 3 Redfish	158
6.	Pelagic Stock Assessments	165
	4Vn Herring	166
	4WX Herring	167
	5Z Herring	177
	Tuna and Swordfish	185
	Sharks	186
7.	Marine Mammal Assessments	192
	Harbour Porpoise	193
8.	Other Business	197
	8.1 Discussion on Surveys	197
	8.2 Comparative Fishing Analysis	197
9.	Acknowledgements	197
10.	References	197
11.	Appendices	201
	11.1 Agenda	202
	11.2 Participants	207
	11.3 Abbreviations	208

ABSTRACT

O'Boyle, R.N., and K.C.T. Zwanenburg [Eds.]. 1994. Report of the Scotia-Fundy Regional Advisory Process (RAP). Can. Manuscr. Rep. Fish. Aquat. Sci. No. 2252: xii + 208 p.

The first annual spring meeting of Scotia-Fundy's Regional Advisory Process (RAP) was held at BIO from 2-11 May 1994. This meeting replaced the peer review of finfish stock assessments normally held at this time under the auspices of the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC). The latter organization was disbanded in December 1992. In addition to stock assessments, the meeting considered a range of topics relevant to the management of the Region's ocean resources. Future meetings will expand upon this theme and offer new opportunities for multi-disciplinary collaboration.

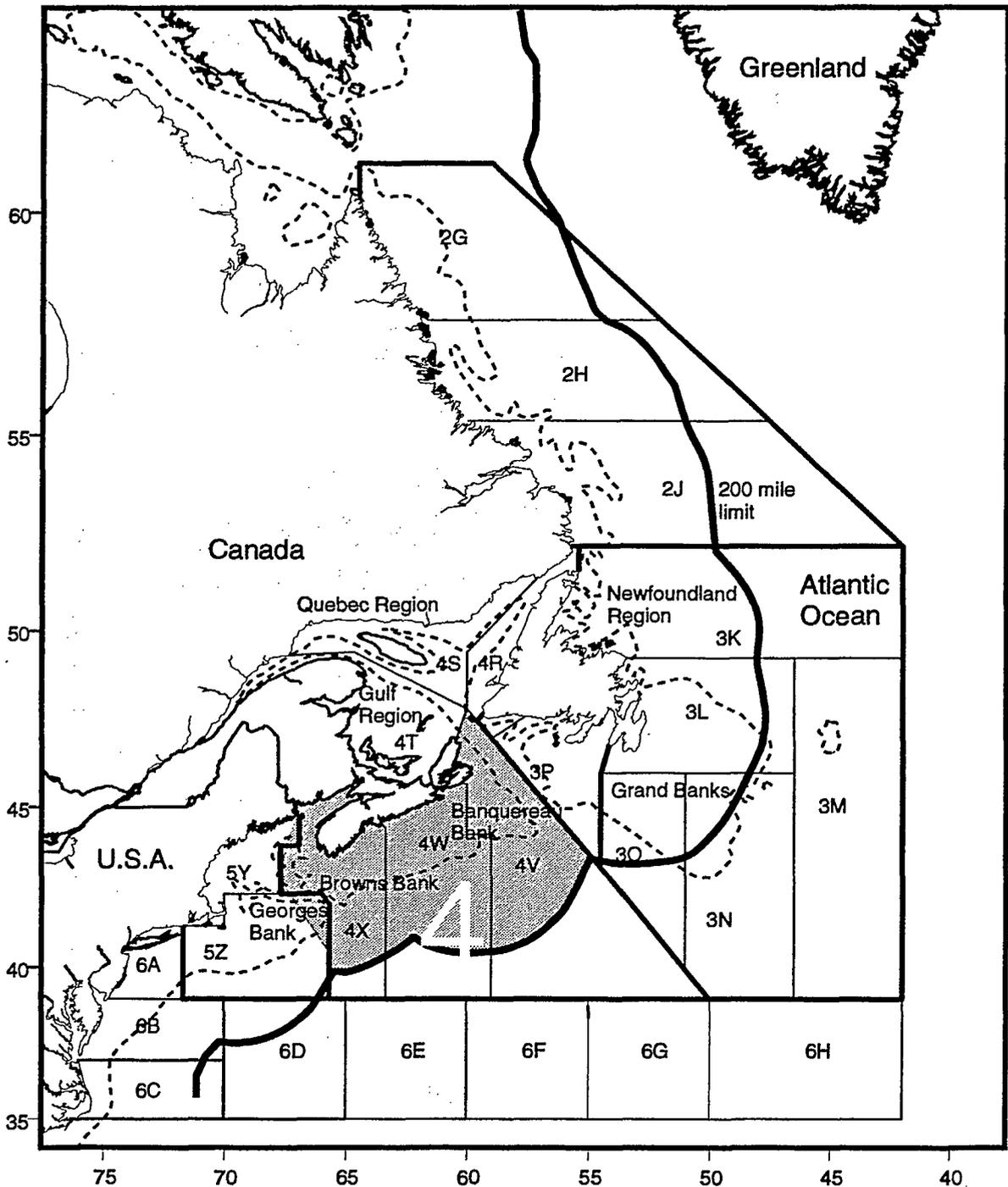
RESUME

O'Boyle, R.N., and K.C.T. Zwanenburg [Eds.]. 1994. Report of the Scotia-Fundy Regional Advisory Process (RAP). Can. Manuscr. Rep. Fish. Aquat. Sci. No. 2252: xii + 208 p.

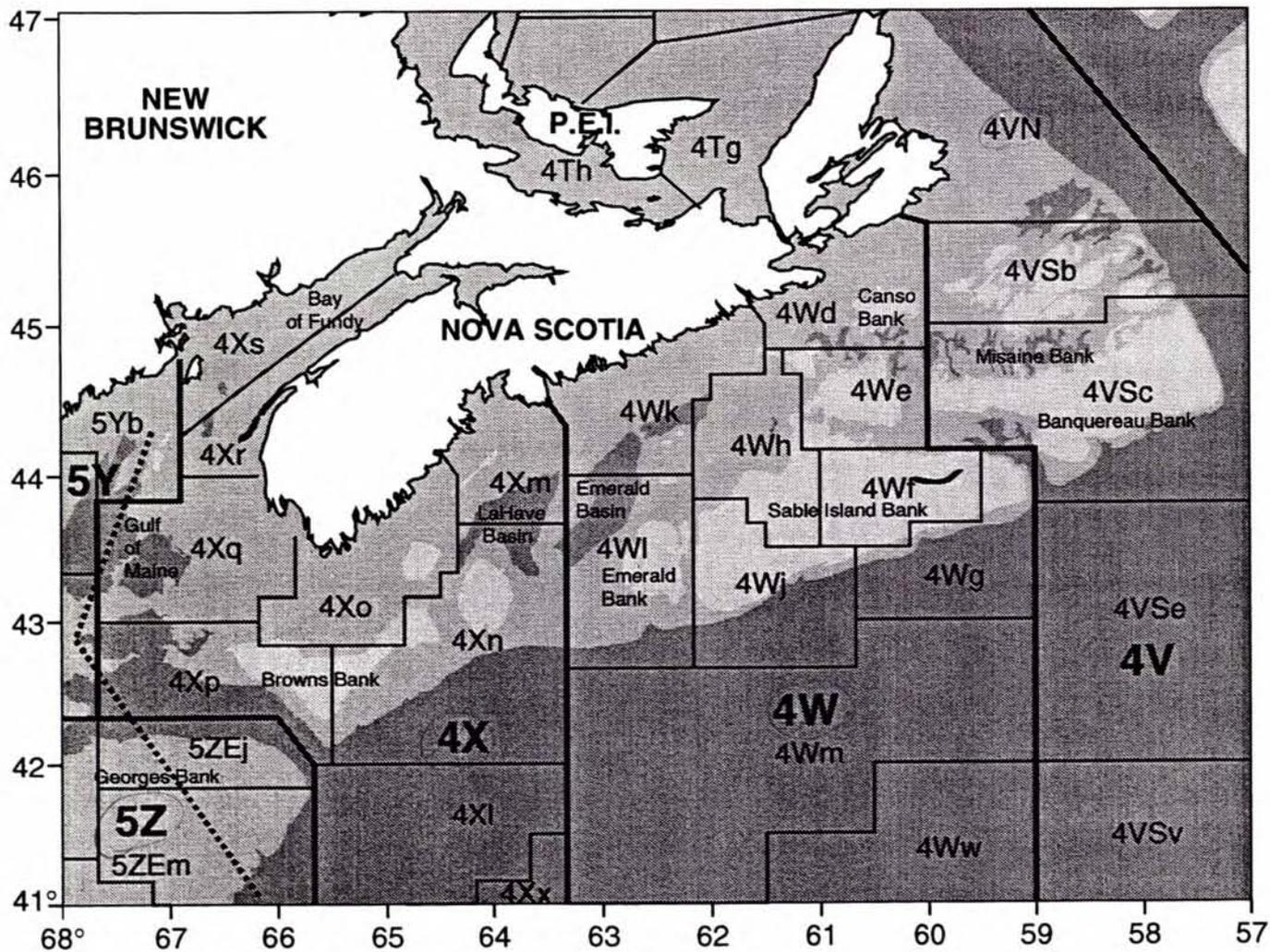
Les membres de l'Équipe consultative de la région de Scotia-Fundy ont tenu leur première réunion annuelle du printemps du 2 au 11 mai 1994, à l'IOB. Cette réunion remplaçait l'examen par les pairs auquel on soumettait auparavant les évaluations de stocks de poisson et qui se déroulait aussi au printemps sous les auspices du Conseil scientifique consultatif des pêches canadiennes de l'Atlantique (CSCPCA), organisme démantelé en décembre 1992. En plus de s'être penchés sur l'évaluation des stocks, les participants ont traité de tout un éventail de sujets concernant la gestion des ressources océaniques de la région. Leurs prochaines réunions leur donneront l'occasion d'approfondir ces sujets et de profiter de nouvelles possibilités de collaboration pluridisciplinaire.

(Blank)

MAPS

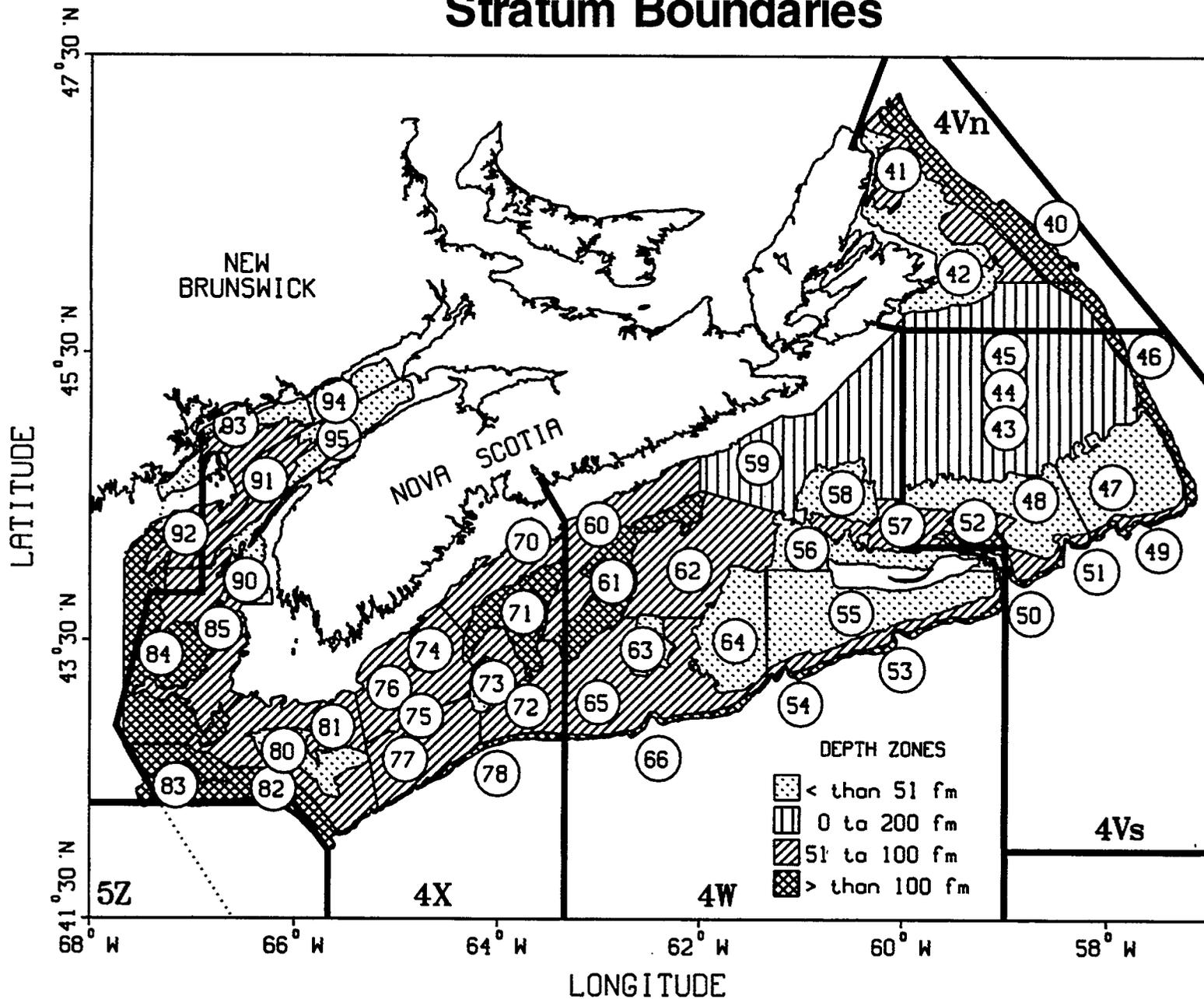


Canada's East Coast showing the Divisions used by the North Atlantic Fisheries Organization (NAFO). Scotia-Fundy Region highlighted.

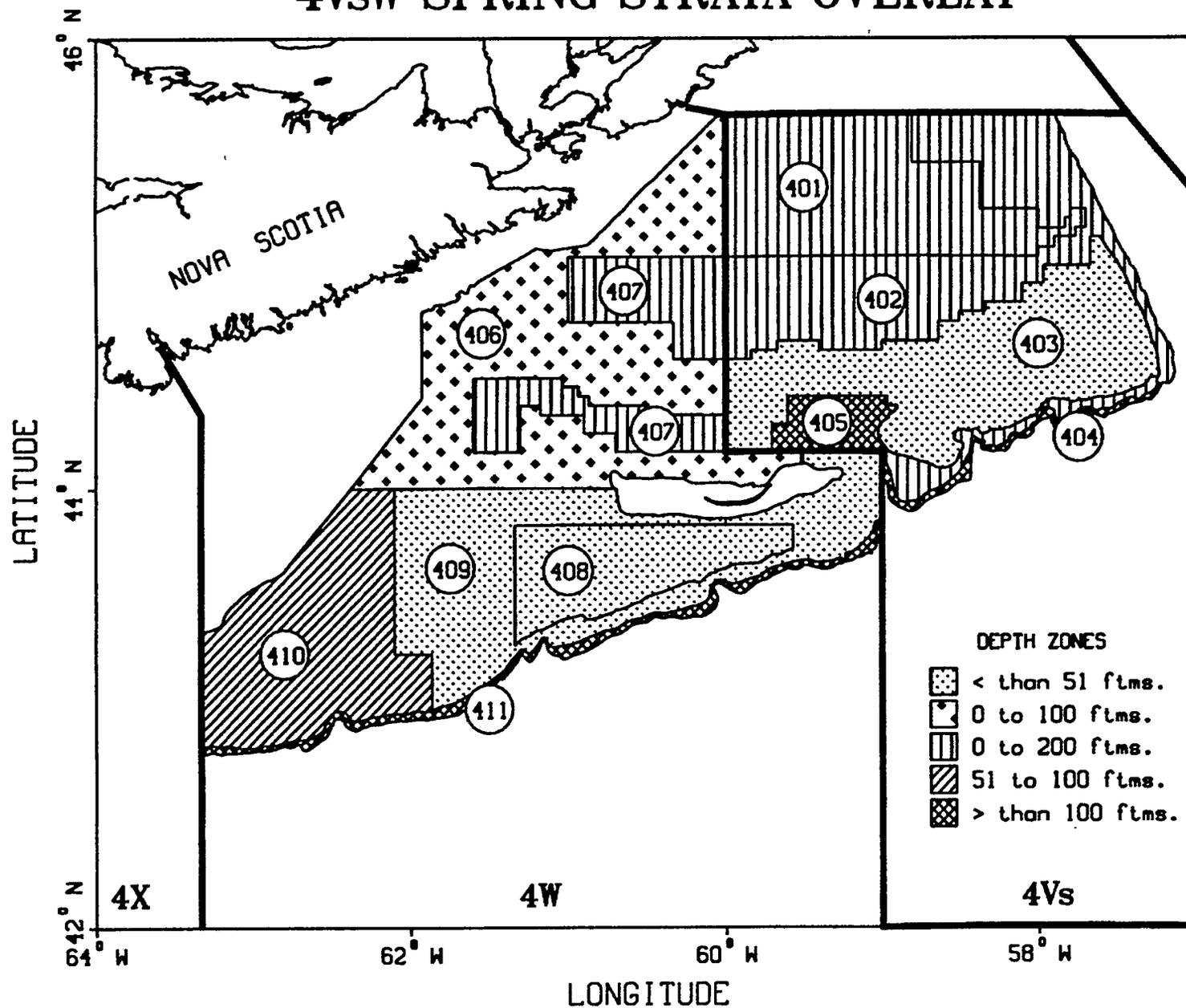


Scotia-Fundy fisheries region showing Statistical Unit Areas.

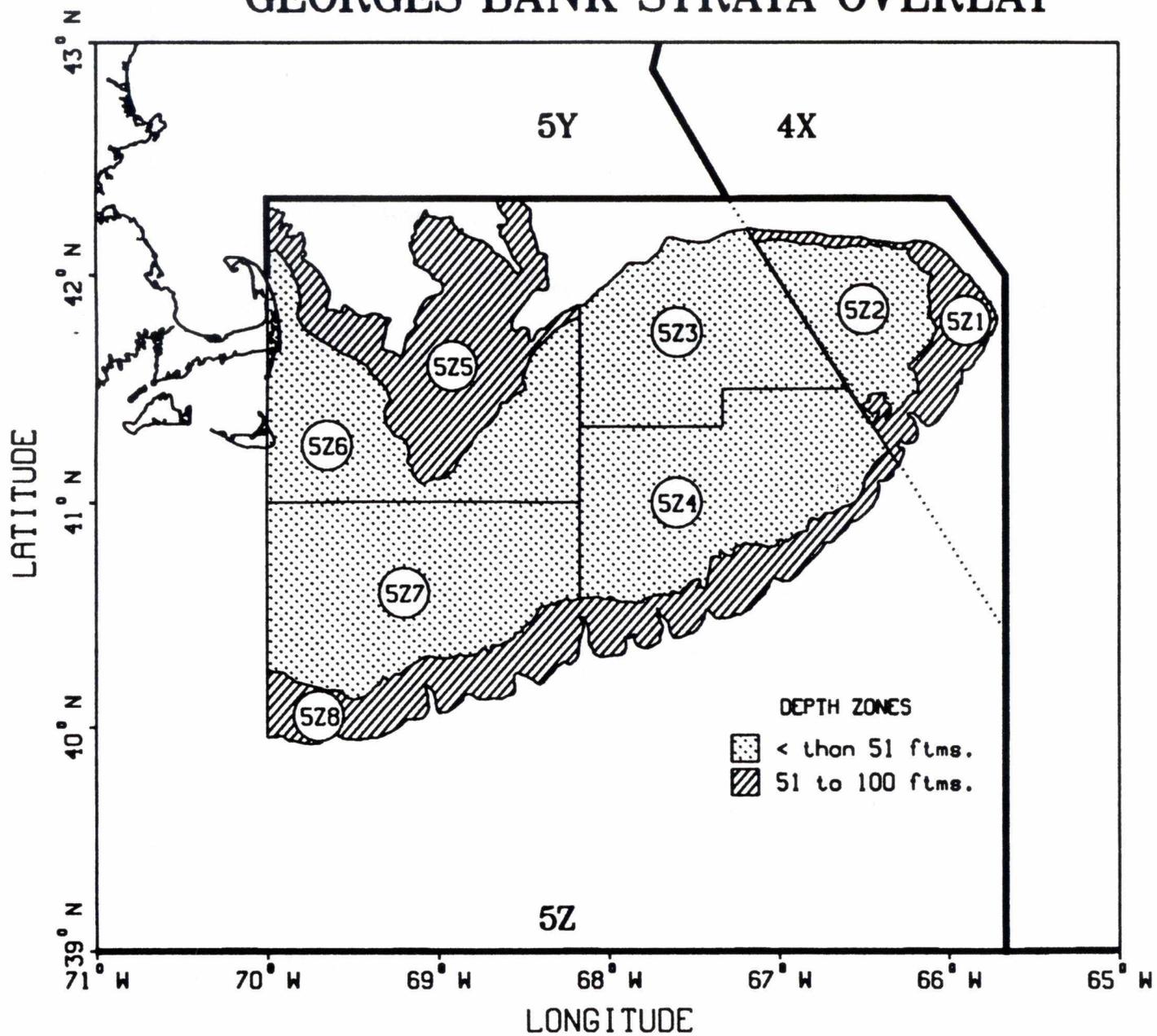
Summer Bottom Trawl Survey Stratum Boundaries



4VsW SPRING STRATA OVERLAY



GEORGES BANK STRATA OVERLAY



1. INTRODUCTION

In December 1992, the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) was disbanded. Since the extension of the 200 mile limit in 1977, this organization had been responsible for the provision of scientific advice on the harvesting of the fisheries resources on the Atlantic coast. This involved the review of stock assessments, as well as work relating to assessment methodology (surveys, sampling, etc.) and fisheries oceanography was also considered.

Due to the continuing requirement to provide peer reviewed scientific advice, the Acting Assistant Deputy Minister of Science commissioned a DFO working group in September 1993, to define a replacement for CAFSAC. The report of this working group was released in January 1994 and outlined a two-tiered peer review process. The main review of assessment advice was to be conducted by committees established within each of the four DFO Atlantic regions (Newfoundland, Scotia-Fundy, Gulf and Quebec) and not at a zonal committee as had been previous practice. More focus was to be placed on the integration of scientific information across a range of topics through the use of multi-disciplinary teams. The results of the regional reviews would subsequently be consolidated at a zonal level by the Atlantic Zone Coordinating Subcommittee (AZCS), which reports to the DFO National Science Director's Committee (NSDC). Therefore the product of the annual assessment process would be a zonal report, based on regional reports, which would all be available to clients. The supporting Atlantic Fisheries Research Documents (Res. Docs.) to these reports will be maintained by the Atlantic Stock Assessment Secretariat (ASAC) which reports to the AZCS.

While the overall framework was outlined by the zonal working group, it was left to the regions to develop the details of their peer review process. In March 1994, M. Sinclair, the Director of Biological Sciences Branch (BSB) and R. O'Boyle, the Chief of Marine Fish Division (MFD), proposed a new structure that not only met the intent of the zonal initiative, but also expanded its mandate to include the review of **all** technical matters relating to the Scotia-Fundy Region's fisheries management. This included areas relating to the economic and social objectives of the fishery, as well as consideration of the technical aspects of fisheries regulation and enforcement, topics which had not been traditionally reviewed by CAFSAC. For this reason, the regional peer review was termed the Regional Advisory Process (RAP), to highlight the fact that not only biological stock assessment was to be considered. The objectives of RAP are:

- * To provide a peer review forum for technical issues of relevance to the management of Scotia-Fundy fisheries.
- * To provide a focus for interaction on technical issues with clients such as the Management Advisory Committees (MACs) and the working groups.
- * To provide a multi-disciplinary, multi-species peer review forum for regional assessments and management science.
- * To serve as a focus for the development of fisheries management science.

This report documents the proceedings of the RAP's first meeting that was held at the Bedford Institute of Oceanography (BIO) from 2-11 May 1994. It is envisaged that there will be a spring and fall meeting of RAP each year, interspersed by smaller meetings as and when required. The agenda (Appendix 11.1) of this meeting focused on the groundfish, pelagic and marine mammal assessments necessary to provide advice for the 1995 fishery. As well, overviews of the ecosystem and its environment were presented. There was also a session devoted to regional management issues and on regional groundfish surveys.

Participants (Appendix 11.2) came predominantly from DFO Scotia-Fundy Science, although there were representatives from other regions, outside DFO, from the US National Marine Fisheries Service, and from

the Fishermens and Scientists Research Society (FSRS). Their input greatly added to the discussion and well illustrated the benefits of opening up the peer review process.

All analysis on which stock status advice is based will be available in the ASAC Research Document series. These should be consulted for detailed information. Abbreviations used throughout this report are given in Appendix 11.3.

Sections of this report have been used as the basis for the Scotia-Fundy input to the AZCS's Zonal Stock Status Report.

2. OVERVIEW OF THE ECOSYSTEM

2.1 Community Structure Changes

In this section, we summarize the most recent information on the resources in the Region by their position in the food chain. A recurring theme throughout is the striking difference between the communities on the eastern shelf and those to the south being more productive.

Phytoplankton and Zooplankton Trends

The plankton is the source of food for larval fish and pelagic species such as herring and mackerel. It has been proposed that changes in its abundance influence larval survival. Plankton monitoring of Scotian Shelf waters (as part of the continuous plankton recorder program (CPR) run by the United Kingdom) was started again in 1991 after a gap of over a decade. The recent observations are compared to those of the 1960s and 1970s. Data are only processed for 1991 and 1992. For the Gulf of Maine, the USA has been monitoring plankton using the same methodology for the past 3 decades. Data are available up to 1989.

The abundance of the dinoflagellate *Ceratium arcticum*, a cold water phytoplankton species, was the highest recorded by the CPR program in the region. The 1992 phytoplankton colour index, which is the colour due to all phytoplankton species, was above average for most months, which made 1992 an abnormal year. No other year has shown a pattern of such high phytoplankton colour for as many months in one year.

NAFO divisions 4W and 4X appear to have different temporal patterns of zooplankton abundance, which may be due to different physical influences in the two regions. The Gulf of Maine zooplankton community appears to have a different population dynamic than those seen in 4W and 4X, again probably due to the different physical influences that are operating in the Gulf.

The eastern Scotian Shelf exhibited the lowest levels of zooplankton species *Calanus finmarchicus* ever recorded on the shelf. However, in 4X the abundance of juvenile and adult *Calanus finmarchicus* was above average abundance during the summer of 1992, suggesting that 4W and 4X have different populations. This is supported by studies that show the timing of the reproductive cycle of *C. finmarchicus* is different between these two regions.

In summary, the Scotian Shelf waters during 1992 were characterized by high levels of phytoplankton "greenness" yet variable levels of zooplankton. Given the gap in monitoring, decadal scale trends cannot be described for this area. Interestingly, the moderate to above average 1992 year-class of haddock throughout the Scotia Shelf/Gulf of Maine is coincident with low abundance of the dominant zooplankton species (*Calanus finmarchicus*).

Finfish Species Trends

Temporal patterns in trawlable biomass from over 25 species of finfish were assessed from the 1970-1993 summer groundfish surveys. Species groups examined included the gadids (cod, haddock, pollock, cusk, white hake, and red hake); flatfish (yellowtail, witch, American plaice, winter flounder, and halibut); demersals (wolffish, longhorn sculpin, ocean pout, monkfish, sea raven, and lumpfish); skates (thorny, winter, little, and smooth); semi-pelagics (redfish, silver hake, longfin hake, and squid); pelagics (argentine, herring, gaspereau, and mackerel); and spiny dogfish.

Gadids dominated the fish biomass on the shelf except in Division 4X where spiny dogfish dominated. Gadid biomass was highest in 4Vn from 1981-1989. In 4Vs, gadid biomass increased to a peak in 1984 and subsequently fell to the lowest value on record in 1992. Changes in 4W have been less extreme. In 4X, biomass has remained relatively stable although the 1993 value was one of the lowest on record.

Except in 4Vs, flatfish biomass has remained relatively stable across the shelf. In 4Vs, biomass peaked in 1980 falling to its lowest observed value in 1993. Most of this decline was due to a loss in American plaice biomass. In 4W and 4X, winter flounder biomass has shown recent increases.

Although overall demersal biomass in all areas has not exhibited major trends recently, some individual species have experienced substantial change. For example, monkfish has declined dramatically in 4W since 1973-78 and Division 4X ocean pout have increased.

Skate biomass has shown a gradual decline in all areas. The 1992 and 1993 values were among the lowest on record.

The biomass of the other species groups are poorly estimated by the bottom trawl surveys and therefore tend to show much greater variation. Semi-pelagics biomass has been most variable in 4Vn with peaks in 1971, 1979 and 1989. In 4X, biomass increased in 1992 and remained above average in 1993. Pelagic biomass was even more variable. In 4Vn, there was a particularly high biomass of herring. The 1984 to present pelagic estimates in 4W have been much higher than before. In 4X, the 1992 and 1993 catches were above average.

Spiny dogfish have made a major contribution to the total biomass in 4X in recent years (since 1987). They only appear sporadically over the remainder of the shelf. The 1993 estimate in 4W is the second highest of the series.

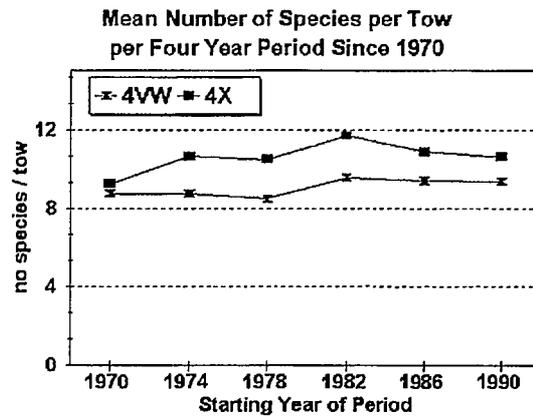
Finfish Species Diversity

Patterns and gradients of the diversity of finfish found within the Scotia-Fundy Region were investigated using the regional bottom trawl surveys database for summer (1970 to 1993), and seasonal data (1979 to 1985).

An index of diversity, the number of species reported per representative survey set, was used with positional data to create contour plots of the relative diversity found by time period, season, and region. The regions demonstrating the greatest diversity for the 1970 to 1993 summer series were found in the Bay of Fundy, and the Gully region east of Sable Island. The least diverse areas were generally found on the shallow offshore banks, especially in the LaHave, Baccaro, Roseway and Banquereau areas.

Seasonal data revealed that the greatest diversity occurred in most areas in the fall, followed by the summer and spring. However, some deeper regions demonstrate greater diversity in the spring along the shelf edge when temperatures are at the lowest.

In general, NAFO divisions 4VW were characterized by a less diverse bottom community than in 4X.



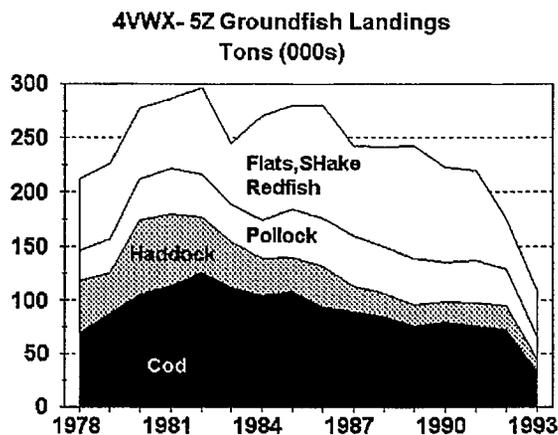
To qualify species assemblages present in offshore areas, community compositions and the frequencies of occurrence of each species were determined for regions delimited by the summer survey strata. The most diverse strata contained many species with high frequencies of occurrence; the least diverse strata were the opposite. A third group of strata had many species, all with low frequency of occurrence, and a fourth with few species of high frequency of occurrence. Generally, the Bay of Fundy strata were of the first group, the banks strata were of the second group, strata from the shelf edge were of the third group, and the basin strata were of the fourth group. Comparing the most diverse stratum (Bay of Fundy) to the least diverse stratum (LaHave Banks), the former had a greater species inventory with species of a higher frequency of occurrence, more year round residents, and a higher rate of influx of seasonal migrants.

Long-term decreases in the frequency of occurrence of 26 species were detected in the summer season; those most greatly affected were smooth skate (20 strata), thorny skate (12 strata), anglerfish (10 strata), cusk (9 strata), haddock (8 strata), halibut (6 strata) and dogfish and witch (5 strata).

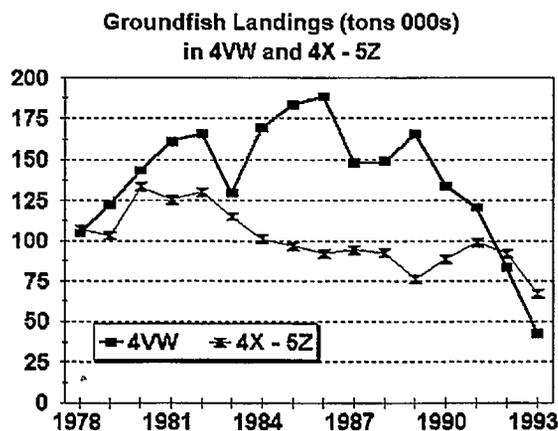
The above observations are relevant to the management of the fisheries. In areas of high diversity such as 4X, fisheries prosecute a broader range of non-directed species than areas of low diversity such as 4W. Single species fisheries are easier to manage in areas of low species diversity such as the eastern Scotian Shelf.

2.2 Groundfish Overview

The groundfish landings from the Scotia-Fundy Region from 1978 to 1993 are shown below. The major species are cod, haddock, pollock and silver hake. Five species of flatfish (Atlantic halibut, American plaice, yellowtail, witch and winter flounder) and redfish are also important. The overall landings increased between 1978 and 1982, declined gradually between 1983 and 1991, and then dropped sharply in 1992/93.



The temporal pattern in landings have been different in the eastern (4VW) and western (4X and 5Z) parts of the region. The landings in 4VW have been higher than 4X and 5, peaked in 1986 and have declined dramatically since 1989. On the western shelf the peak landings occurred in 1980, with a more gradual decline to 1993.



The above trends in landings reflect the trends in stock abundance in the diverse management units, as well as what appears to be different ecosystems in the eastern and western parts of the region. The climate conditions and grey seal predation are more severe for the eastern shelf. For example, weights-at-age have been declining throughout the 1980s for cod in 4VW, but not so much in 4X and 5. Also relative recruitment levels for cod and haddock in 4VW have been lower during the late 1980s compared to 4X and 5 (in spite of comparable levels of fishing). The tidally well mixed waters of the Gulf of Maine area (including Browns Bank and the Bay of Fundy) are more productive than the eastern Scotian Shelf. The groundfish grow quicker and mature at a younger age, and the populations are characterized by a higher frequency of moderate to strong year-classes. The water temperatures in the Gulf of Maine area are well within the preferred temperature range of the commercially important species, such that small changes in temperature are unlikely to have a major impact on population processes. The eastern shelf (with

somewhat colder waters, greater inter-annual variability in circulation and mixing, and higher seal abundance levels) may be a more "fragile" environment for groundfish stocks, and thus more sensitive to high fishing exploitation.

The temporal patterns in fishing mortality are remarkably similar for those management units which have an analytical assessment (4VsW cod, 4X cod, 5Zjm cod, 5Zjm haddock, and 4+5c pollock). Subsequent to extension of jurisdiction in 1977, fishing mortalities climbed gradually to the early 1980s, and then were relatively stable until the end of the decade. From 1990 to 1992, however, fishing mortalities increased dramatically to high levels, as the stocks declined rapidly. With the "closure" of some management units in 1993, and mid-year reductions of TACs in others, fishing mortality has declined in some cases. However, with the reduction of fishing effort on cod, haddock and pollock, the fleets have targetted on flatfish, hakes, redfish, monkfish, etc. We do not have estimates of fishing mortality for these latter species but the information available infers that some of the stocks are declining (e.g witch, American plaice, yellowtail in 4V, winter flounder in 4X). Fishing effort, in spite of the major reductions in TACs, has not declined very much in 4X and 5. Rather the effort has been redirected. As a result, there are reports of extensive discarding (of 4X haddock in particular). The fishing effort in 4VW, however, dropped sharply in 1993. In sum, single species quota management for multi-species fisheries makes it very difficult to control fishing mortalities at the target level. Fishing mortalities (for those management units for which it is estimated) have exceeded F_{max} from 1990 to 1993 (except for 4VsW cod in 1993, and for silver hake throughout the 1978 to 1993 period). In order to reduce fishing mortality to $F_{0.1}$ levels, the days fishing needs to be reduced by over 50% in the 4X and 5 management units.

The stock abundance levels and indicators of incoming recruitment are summarized below:

Management Unit	1995 Spawning Stock Abundance	Signs of Recruitment
4Vn cod	very low (no SPA)	No sign of strong year-classes
4VsW cod	critically low, possible loss of spawning components	1990 year-class looks moderate
4X cod	low	1990 year-class looks moderate
5Z cod	very low	1990 year-class looks moderate
4TVW haddock	very low	1992 year-class above average, 1993 year-class early indications of average to above average
4X haddock	low	1992 year-class above average, 1993 year-class early indications of average to above average
5Zjm haddock	low	1992 year-class above average, 1993 year-class early indications of average to above average
pollock	low	1988 year-class above average, 1989 year-class average, 1990-91 year-classes poor
4VW American plaice	declining	no index
4X American plaice	stable	no index
4VW yellowtail	declining in 4V, stable in 4W	no index
4X yellowtail	stable	no index
4VW witch	declining	no index
4X witch	declining	no index
4VW winter flounder	stable	no index
4X winter flounder	declining in the inshore areas, stable on banks	no index
Atlantic halibut	declining	no index
redfish (Unit 3)	stable	no index

In summary, for the past several years, there are very few management units for which fishing effort has been at a level low enough to allow stock rebuilding. For 1995, most stocks are at low to critically low levels of spawning biomass. For all of the haddock populations, the 1992 (and possibly 1993) year-classes look promising. For cod, however, with the exception of the moderate 1990 year-class, which is presently recruiting to the fishery, there are no signs of above average recruitment.

The 1994 TACs, 1994 and 1995 $F_{0.1}$ reference levels ('000 t) are summarized below.

	1994 $F_{0.1}$ Reference Level	1994 TAC	1995 $F_{0.1}$ Reference Level
4Vn cod	0	0	0
4VsW cod	<3	0	<5
4X cod	7	13	5
5Zjm cod	<2	6 ²	3
4TVW haddock	<2	0	<2
4X haddock	<6	4.5	<7
5Zjm haddock	2	3 ²	4
pollock	20	24	13
4VW flatfish ¹	<10	10	~2.5
4X flatfish ¹			~2.5
Atlantic halibut ¹	<3.2	3.2	~1.5
redfish (Unit 3)	10	10	10

¹ For the flatfish species, including halibut, fishing effort needs to be reduced by about half. As the stock abundance is not increasing (which appears to be the case for most species), a reduction in landings by 50% would be expected with this level of effort reduction.

² Canadian allocation.

2.3 Pelagics Overview

Two major herring resources (one spawning off southwest Nova Scotia, the other resident on Georges Bank), exist in the Region. While the TAC of the southwest Nova Scotia has been 125-152,000t since the late 1980s, recent landings have been declining so that by 1993, just over 100,000t was landed. In 1993, a new dockside monitoring program was introduced and led to the most accurate landings statistics to date, for a fishery which has been plagued by erroneous reporting. The fishery continues to be highly influenced by the roe market which has been soft in recent years. Although indices of abundance for this resource indicate a healthy population, changes in the geographical distribution, in particular the relative change in abundance at traditional spawning locations, have led to concerns that some spawning components may have been lost.

The Georges Bank herring population was fished to commercial extinction prior to extension of Canadian jurisdiction in 1977. Essentially no herring were observed on the Bank until the mid-1980s. Since that time, there have been signs of a steady recovery, such that an experimental Canada/US fishery of 5,000t has been permitted since 1992. Further increases in this experimental fishery can be expected if current stock conditions continue.

Mackerel is a seasonal inhabitant of the Scotian Shelf, on its way during the spring from the southern feeding grounds off New England to spawn in the Gulf in June-July. The return trip occurs in the late fall. Since extension of jurisdiction, exploitation by Canada and the US has been very low, with changes in abundance largely the result of natural variation in recruitment. Since the mid-1980s, stock biomass has probably been declining from the high levels experienced earlier when the particularly strong 1967 and 1982 year-classes passed through the population.

Capelin has been observed in quantity on the eastern Scotian Shelf since the late 1980s, coincident with the increased intrusion of cold water into that region. Very little is known about this resource and its affinity to adjacent populations in the Gulf and off Newfoundland.

A number of large pelagic species (bluefin tuna, albacore, swordfish and a variety of sharks) are exploited in the Scotia-Fundy Region. These species are highly migratory with the stocks inhabiting the West Atlantic in the case of bluefin and sharks, the North Atlantic in the case of swordfish and albacore, and the whole Atlantic in the case of bigeye and yellowfin tuna. Tuna and swordfish assessment advice is produced by the International Commission for the Conservation of Atlantic Tunas (ICCAT). The 1993 West Atlantic bluefin tuna TAC was about 2,400t of which Canada caught 459t. The spawning biomass has declined steadily since the early 1970s to reach the lowest observed levels. This is due to a combination of steadily declining recruitment and high exploitation during the 1960s and 1970s.

The North Atlantic albacore stock is generally experiencing low exploitation with the 1993 Canadian catch being 9t. Although Canada's 1993 harvest of Atlantic bigeye and yellowfin was only 124t and 71t, respectively, both stocks are being fished at their maximum sustainable yield and should not be considered under-utilized.

Recent North Atlantic swordfish landings have been around 15,000t annually with Canada's 1993 catch being 2,234t. Stock biomass has declined since the late 1970s and, in particular, the biomass of age 5+ fish (spawning stock) has shown a steady decline. However, reduction in catches (in the order of 30%) and fishing mortality since 1988 have slowed and may have reversed this decline. Swordfish is currently being fished at its maximum sustainable yield.

Little information exist on sharks (porbeagle, mako and blue). The 1993 landings of these species in the Canadian zone have been about 1,664t, much of this caught by foreign vessels and as by-catch to other fisheries. These catches are underestimates, as sharks have been unregulated and due to the extent of the by-catch. Sharks are long-lived, slow growing and produce relatively few young per adult female. Consequently, they are sensitive to overexploitation without good estimates of stock size and production. While there is considerable interest in developing fisheries for these resources, this has to proceed cautiously to parallel our growth in understanding of the resources and thus limit the possibility of overexploitation.

2.4 Marine Mammals Overview

Two breeding components to the northwest Atlantic grey seal population have been identified: both components breed in January-February, one on the coast and land-fast ice of the southern Gulf of St. Lawrence and the other at Sable Island on the Scotian Shelf. Limited interchange occurs between the breeding components. Although the majority of each component spends the year in their respective areas of the Gulf and eastern Scotian Shelf, portions of both components disperse into adjacent areas after the breeding season. Pup production of the Sable population is well documented and has been increasing steadily at a rate of over 12% annually since the early 1960s. This corresponds to a doubling of production in slightly less than 6 years. The estimated biomass of 4VSW cod consumed by grey seals has increased from about 1,500t in 1970 to 17,300t in 1993, much of this in age groups 1-4 (pre-recruits to the fishery). In comparison, the 1993 commercial fishery landed 3,500t of 4VSW cod.

Harbour seals are the only other seal species resident on the Scotian Shelf. They breed in May-June congregated in many small discrete breeding groups along the coast. The largest breeding colony occurs on Sable Island. Between the early 1970s and 1989 pup production on Sable Island increased at an annual rate of about 5% from less than 300 to over 600 per year. Since then, however, production has declined steadily and in 1993 about 350 pups were produced. There is as yet no explanation for this decline.

Harbour porpoise are thought to comprise three subpopulations in the Northwest Atlantic: one in eastern Newfoundland, one in the Gulf of St. Lawrence and one in the Bay of Fundy-Gulf of Maine area. Recent evidence based on mitochondrial DNA analysis indicates these to be distinct populations with only limited interchange between them. There is little historical information on the biological production of these groups. Surveys conducted in 1991 and 1992 provide an average abundance of harbour porpoise in the Gulf of Maine/Bay of Fundy area of 47,000t. Porpoise are caught as by-catch to gillnet fisheries in both Canada and the US. The limited information on this activity suggests that this by-catch is too high and needs to be reduced. Studies are currently underway to both better define the problem and find solutions.

3. Overview of Management and Issues in the Fishery

3.1 Management Plans and A Decision-Making Framework

Fisheries management plan development was discussed in the context of analysis and control of complex systems. The current process was described as a series of independent components that contribute problem solving and plan development. It was argued that this approach has lead to 1) imbalance of emphasis on loosely connected components, 2) lack of focus across components, and 3) difficulty in integrating information components. To overcome these difficulties, it was suggested that an integrated process be adopted including biological and socioeconomic analysis. A structured framework for incorporating sources of stock and fisheries information was described and discussed.

3.2 Fisheries Management and Habitat Research

It has long been recognized that the quantity and quality of habitat has a profound effect upon the abundance of freshwater and diadromous fish. Recent research indicates that the same is true for marine fish. Therefore, it is important to develop improved procedures for incorporating habitat information into marine fisheries management practices. The basic question to ask is "Can habitat quantity and/or quality affect the abundance of a particular commercial species?" To answer this question requires information on; 1) the full life history of the species in question, 2) the habitat requirements of each stage (spawning, nursery, juvenile, recruit, adult, etc.), 3) the spatial distribution of different habitat types, and 4) how human activities can alter habitat. The necessary information is not always available but should be collected. If the available information indicates that the answer is no, then there obviously is no need to consider habitat concerns further in the fisheries management process. However, if there is reason to suspect that habitat conditions will influence the abundance of a particular commercial species, then management steps should include habitat concerns. Potential management practices include gear control, establishment of areas closed to fishing activity and controlling the location and timing of pollutant discharges. To fully incorporate habitat concerns into the management process for marine species will take many years to accomplish and will require an ongoing and constructive dialogue among habitat and fisheries scientists and managers.

3.3 Some Conservation Principles

The Age/Size Structure of the Commercial Catch

The FRCC asked the Department of Fisheries and Oceans to comment on the best balance of harvesting over various year-classes. They also requested advice on the ideal age structure, and whether it varied by stock or species. The Department interpreted the question to refer to whether it was advisable to maintain a broad age structure in the exploited population. The ideal age structure and best balance of harvesting will be determined largely by the social and economic objectives. For example, it may be desirable to harvest small herring to maintain a sardine industry and a traditional weir fishery. For Atlantic groundfish, the desire to optimize yield while maintaining catch rates has been a prominent feature. Biological considerations impacting on the achievement of objectives relate to growth dynamics, i.e. yield

or value per recruit, and to reproductive dynamics. It was noted that natural variation in recruitment generally precludes achievement of ideal or stable age structure, but results are applicable on average over suitable time horizons.

Growth dynamics are relatively better understood compared to reproductive dynamics. The response in yield or value per recruit can be studied using well described models and generally depend on overall exploitation rate and age of entry to the fishery. Optimal harvest strategies, overall fishing mortality and age of recruitment to the fishery, will vary by both stock and species. Recruitment models have not been applied successfully to many marine fish, however there is understanding of fecundity relationships, maturation schedules and reproductive behaviour on which to base judgements. As a general rule, it is desirable to maintain a sufficiently low exploitation rate to permit a broad range of ages to persist in the population. This provides for the best chances of successful reproduction and stabilizes yield by dampening fluctuations caused by variation in recruitment. The recruitment at age to the fishery should be adjusted to produce optimum yield, or value, which for gadoids will generally mean permitting them to grow to about the age of sexual maturity with little fishing pressure exerted on them.

Spawning and Exploitation

In recent years, there have been calls from the industry to allow fish to grow and reach spawning age. Specifically, many in industry feel that there are conservation benefits to allowing fish to spawn at least once. This would be distinct from any benefits accrued from limiting overall fishing mortality. The FRCC required DFO Science to provide a background document on this issue.

The question as posed is very vague and needs clarification. It infers that after fish have spawned at least once, all fish can be harvested. Such a strategy would result in considerable loss of both growth and spawning potential. In relation to the latter, while the strength of the relationship between stock and recruitment is weak, there is general recognition that extremely low spawning stock abundance should be avoided. This can be done more effectively by limiting the fishing mortality on the older, mature age groups. As well, limiting overall harvesting increases the yield and, if constrained to targets such as $F_{0.1}$, has economic benefits as well.

A brief review of the current age/maturity structure of the catch, while based on very crude data, noted that with the existing regulations, most fish are allowed to spawn once, and that the real problem is limiting exploitation on the older age groups. The present management strategies with regard to exploitation pattern and level should ensure an adequate spawning stock if effectively implemented.

Harvesting Stress on Maturity Schedules

Evidence exists that heavily exploited fish stocks exhibit sexual maturity at a younger age. Although these stocks exhibit early maturity, the usefulness of monitoring maturity on an annual basis as a barometer for measuring improved stock health is equivocal. The prime reason for this is that shifts in age at maturity may lag behind improved population conditions. Strong year-classes may pass through a fishery, increasing the stock biomass, though age at first maturity may remain at a young age. There exist other indicators of stock health each of which should not be used in isolation, but together may provide a more complete characterization of stock condition.

Minimum Spawning Stock Biomass Thresholds

The concept of "minimum spawning stock biomass" was briefly discussed in the context of biological reference points for conservation objectives. It was noted that during the DFO sponsored Workshop on Risk Evaluation and Biological Reference Points for Fisheries management (1991), several preliminary spawning stock biomass reference levels were defined for Scotia-Fundy management units (Maguire and

Mace, 1993). These are shown below with the updated 1993 mid-year estimates of estimated spawning stock biomass.

	Spawning Stock Biomass ('000 t)				
	Safe	Minimum	Dangerous	1993	Assumed Spawning Age
4VsW cod	61	53	20	16	3+
4X cod	70	59	24	33	3+
5Zj,m cod	57	42	14	26	1+
4TVW haddock	53	33	8	8-16	-
4X haddock	61	52	16	-	43cm ¹
5Zj,m haddock	28	14	2	7	3+
Pollock	117	93	54	57	3+

1 = Estimated from research vessel survey assuming knife-edged maturity.

The definitions for the reference points are:

- * **Safe Spawning Stock Biomass** is the biomass at which average survival gives a strong year-class. It is calculated by dividing the abundance of a strong year-class by the mean survival rate (R/S).
- * **Minimum Spawning Stock Biomass** is the biomass at which average survival gives an average year-class, high survival gives a strong year-class and low survival gives a poor year-class. It is estimated by dividing the abundance of an average year-class by the average survival.
- * The Critical Population Biomass of Serebryakov would probably be more appropriately called the **Dangerous Spawning stock Biomass** and it is the biomass at which high survival is required to produce an average year-class. It is estimated by dividing the abundance of an average year-class by the highest survival rate.

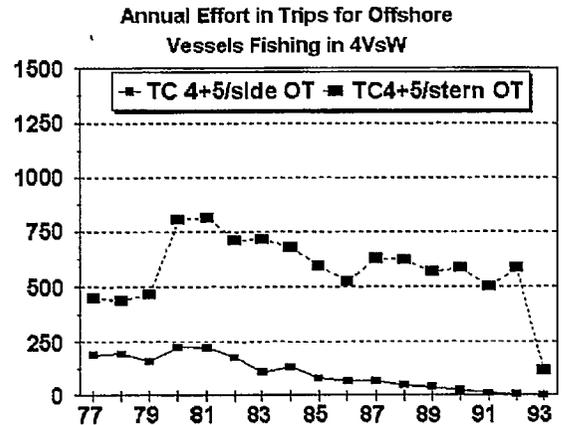
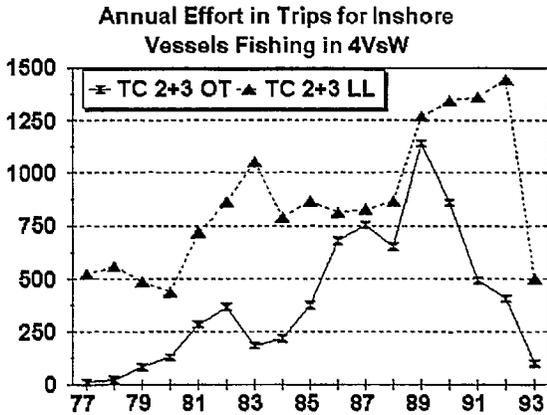
There is at present no consensus on which definition of minimum spawning stock size is most appropriate, and the definitions were not reviewed at the meeting. It is noted, however, that for several stocks the 1993 estimates of spawning stock biomass are below all of the published reference points.

3.4 Groundfish Regulatory Activity

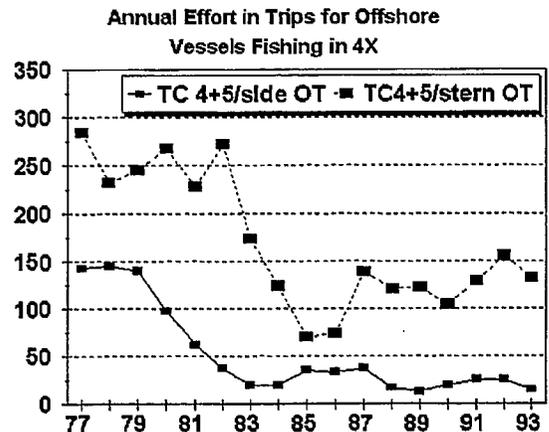
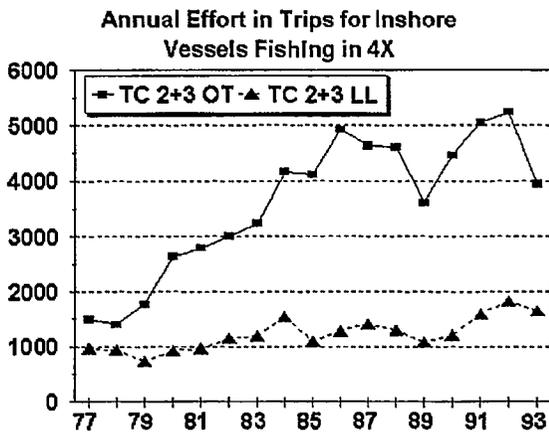
Effort Trends Since 1977

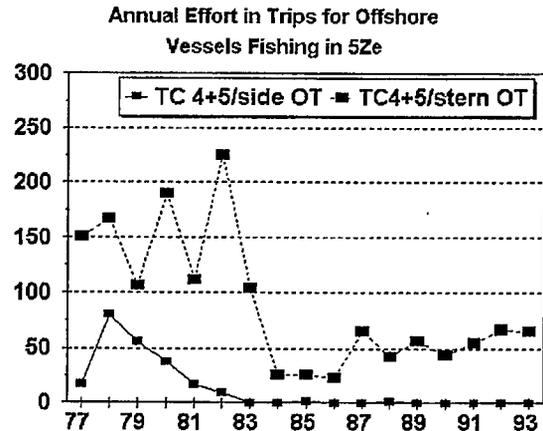
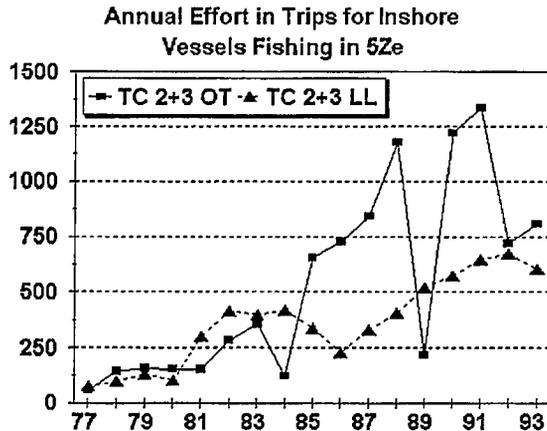
There have been substantial changes in the composition of the fishing fleets harvesting groundfish in the Scotia-Fundy Region since the extension of jurisdiction. There are a variety of problems which complicate interpretation of catch and effort data as recorded in DFO statistics. Notwithstanding this, the databases are adequate to provide a "broad brush" overview of trends in effort as measured by number of trips for tonnage classes greater than 2 (25 gross tons or greater). Much of the effort in Subdivision 4Vn is by smaller vessels, therefore no summary is given for this area. Similarly, much of the gillnet fishery is conducted by smaller vessels and no summary is given for them.

The longline effort in Subdivision 4Vs and Division 4W increased steadily since 1977 by a factor of 2 to 3 times until 1992. Longline effort increased in 4W in 1989 following the build up of the longline fleet in response to establishment of the haddock nursery area which was open to fixed gear only. The small dragger effort showed a similarly increasing pattern, but peaked in 1989 and declined thereafter. The effort of large offshore otter trawlers remained relatively constant over the time period except for a few years in the early 1980s when effort was about 50% higher. All sectors show a substantial decrease in 1993 due to closure of the fishery.



In Division 4X, the longline effort gradually increased by about 50% over the time period while the small dragger fleet shows a steady increase to the late 1980s by a factor of about 2 to 3. The offshore fleet shows a decline in effort during the mid-1980s and remained relatively constant thereafter. The effort trends on Georges Bank reflect the same pattern as those in 4X. The decrease in effort by the small dragger fleet during 1989 in 4X-5Ze reflects the closure of that fishery in mid-June of that year.





These trends provide a useful context which is referred to in the assessments.

Management Activities in 1993

The 1993 Management Plan placed particular emphasis on the protection and conservation of small fish. For groundfish fleets operating on the Eastern Scotian Shelf (ENS), conservation plans were required to ensure the protection of small fish. New management measures for 1993 included mandatory landing of all groundfish, closure of spawning areas to all fishing gear, and closure of areas containing significant amounts of small fish (less than 15% by number). Authorized by-catches were also revoked from regulations, as these would contravene the mandatory landing requirements. If a fleet sector cannot stay within their prescribed by-catch limits, the fishery can be closed. In ENS fixed gear fishermen were made aware that the 4W nursery area was now closed to all gear, not just mobile. As well, 4Vsb was closed to all gear 1 January-30 April. As in previous years, licence conditions were used to enforce by-catch percentages, seasonal quota and trip limits for cod and haddock.

Dockside monitoring was continued for the greater than 65' mobile gear fleet and a dockside monitoring system (currently government funded) was put in place for fixed gear vessels in the fall of 1993. As well, by fall of 1993 all EA companies which included the 65-100' and the greater than 100' fleets, developed a user pay monitoring system and the temporary vessel replacement program was reviewed and continued.

For the ITQ fleet, 1993 saw a loss of the 321 option for quota overruns and permanent transfers were put in place.

Given concerns over the status of the stocks, the Minister requested a mid-year review, and based on the most recent biological advice reduced TACs, or closed most stocks. This was a controversial move resulting in severe disruption to Industry from premature closures, and decreases to ITQ and EAs. For Scotia Fundy, 4X cod and 4VWX5 pollock TACs were reduced and ENS cod stocks closed 1 September 1993.

For Eastern Nova these mid-year closures allowed a directed mobile fishery for redfish and flatfish and a limited pollock fishery. Fixed gear was permitted a limited fishery for cusk, hake and halibut. All ENS fisheries were constrained to a very limited cod by-catch. The reduced TAC's resulted in the overall ITQ fleet quotas for 4X cod and 4VWX5 pollock being exceeded. Some ITQ vessels had already caught their initial quota while others had not fished their reduced quota. Various by-catch strategies were implemented

to allow limited fishing for their remaining 4X haddock quota. The fixed gear fleet in 4X continued to fish a 200lb trip limit.

By the beginning of December all fleets were completely closed to fishing, with the exception of the offshore, due to lack of quota and for reported dumping, discarding, or misreporting of cod or haddock to avoid closure. Observers were mandatory for the offshore.

On 29 December 1993, the FRCC released its report to the Minister of Fisheries on the 1994 conservation requirements for Atlantic groundfish. Overall the recommended TACs for 1994 were 60% lower than the initial TACs set in 1993. In order to implement the FRCC conservation requirements, harvesting plans were also required for 1994 with these plans requiring industry to meet by-catch provisions where stocks were closed. Regulations concerning small fish were continued and new closures and mesh regulations were put in effect. The effectiveness of these new regulations or management measures has yet to be assessed in any quantitative way. The following table lists the regulatory changes implemented in 1993/94 by area.

4X5Z	4VW
Mandatory landings - all regulated species	Mandatory landings - all regulated species
Mandatory landings - amended to exclude <32" halibut, lumpfish, skate, dogfish	Mandatory landings - amended to exclude <32" halibut, lumpfish, skate, dogfish
Elimination of by-catch percentage after quota reached (mid-year adjustments - allowed by-catch)	Elimination of by-catch percentage after quota reached (mid-year adjustments - allowed by-catch)
Small fish test fishing areas established (July)	Small fish test fishing areas established (Jan)
Test fishery not required to open	Test fishery required to open area (mobile only)
No mesh size increase, 130 square or 145 diamond equivalent allowed - 1993	Annual closure of area around Sable Island (mobile)
Georges Bank closed to all gear 1 Jan.-1 June 1994	Closure of the 4W nursery area to all gear
Mobile gear open Jan.-Feb. 5Z 1993	Mesh increase minimum 155mm diamond or 130mm square mobile <65' or 140 square for directed flatfish mobile <65', 1993, only 130 square in 1994 and 155 square for directed flatfish
Implementation of 90mm minimum mesh size for redfish - redfish area closures	140mm diamond for seiners in 1993, 145mm in 1994
Increased observer coverage	90mm mesh size - redfish (midwater gear mandatory at various times)
Recommended hook size increase to #12, #14 in 5Z spawning closure (not enforced)	155 diamond or equivalent for offshore groundfish
Browns Bank closed to all gear 1 Feb.-15 June 1994	Increased observer coverage
1994 - mesh increase to 155 square for otter trawl directed flatfisheries with 145 diamond allowed for Danish seiners	#12 hook size recommended (not enforced)
	4Vsb closed 1 Jan.-30 April (1993/1994)
	4Vn no groundfish fishery 1 Jan.-30 April for all vessels <65'

National Sampling Program

In 1993, the National Sampling Program (NSP) recorded numerous instances of misreporting by area, discarding, and transshipping. Again, these observations are qualitative, making use of the information in the assessments difficult.

A document entitled "1993 Weekly Report - National Sampling Program" was tabled and served as a reference document throughout the meeting. This report consisted of the annotated weekly observations of all the Port Technicians in the Region. These individuals are stationed in Yarmouth, Lockeport, Lunenburg, Guysborough, and Sydney, and are responsible for obtaining biological sampling information from all the regional fisheries. These data are gathered through long-standing contacts with industry participants making these individuals privy to much anecdotal and logistical information from the fisheries that is not otherwise recorded. These reports were used to help interpret some of the information used in our assessments of the regional resources. They are particularly useful in giving 1) some insights into the locations of fishing from many of the smaller vessel classes, 2) information on the general sizes of fish being caught at these locations, 3) estimates of catch rates, and 4) at-sea modifications of catches which influence the age/size structure on landing.

Discarding and Misreporting

Since 1977, there have been ongoing reports of extensive misreporting (by species and area), underreporting, discarding and dumping of fish by the fleets. What information is available was examined at the 1993 Groundfish Workshop (Angel et al., 1994). In general, these activities are all a response to management measures imposed as part of the quota regulatory package. For instance, restrictive quotas in one area would result in catch being reported in an adjacent area. More recently, the introduction of the Dockside Monitoring Program (DMP) has apparently reduced the incidence of unreported landings and misreporting by species, but has had little impact on misreporting by area, dumping, discarding and transshipping, all which occur at sea. Therefore, the absolute amount of fish coming ashore is being recorded comprehensively, but there is still doubt as to what is occurring at sea. This conclusion is supported by examination of cost/earning data and comparisons of landings to export.

Industry Observations

In 1993, as in previous years, considerable effort was devoted to consultation with members of the fishing industry on a broad range of topics. For instance, a series of formal discussions were held during October-November 1993 with participants of the fishing industry on the composition, direction and gaps in the regional groundfish research program (O'Boyle, 1993).

Discussions on the status of the resources have always been a combination of ongoing communication with selected fishermen along with formal meetings with associations. Discussions were held in Shelburne, Pubnico and Yarmouth on 21 April 1994, with representatives of the fixed and mobile gear sectors. Unfortunately, only the Pubnico meeting was well attended. DFO staff had prepared handouts illustrating the catch statistics and sampling information, surveys trend and length composition, etc., for 1993 that were distributed at the meeting. The information for each stock was discussed and debated in turn. At the end of the meeting, participants were encouraged to consider the information further and in the following week faxed their comments to BIO. As a result, a submission was received which represented the discussion on each of the stocks in 4X-5Z among five skippers. This report proved very useful in determining consistencies/inconsistencies between scientific information and views by the industry. These interactions will be further developed in 1994.

Another possible avenue for industry input into the assessment process is by questionnaire survey. Such surveys have proven useful elsewhere in the zone in cataloguing effort trends in the small inshore fleet

sector. The recently established Fishermen and Scientists Research Society has provided a pool of knowledgeable fishermen resident along the Eastern Shore of Nova Scotia, that were sent a questionnaire on catch rate differences for fish in 4VW during 1990-93. As well, they were queried on reasons for the observed patterns. Forty-eight of the 55 members polled responded.

Respondents were asked to indicate a percentage increase or decrease in the catch rates (Question 1: all sizes; Question 2: <17"), of four fish species -- cod, haddock, hake and halibut. The responses are summarized in the following table.

Species	Question	No. of Respondents	Percentage Who Indicated an Increase	Percentage Who Indicated a Decrease	Percentage Who Indicated no Change
Cod	All sizes	47	21	76	3
Cod	Less than 17"	29	48	45	7
Haddock	All sizes	36	8	92	-
Haddock	Less than 17"	26	35	55	10
Hake	All sizes	25	8	88	4
Hake	Less than 17"	13	62	31	7
Halibut	All sizes	26	12	73	15
Halibut	Less than 17"	17	35	41	24

These results are in general agreement with the available assessments for these resources. This poll is referred to in the relevant stock sections. As with the consultations in southwest Nova Scotia, this initiative proved useful in defining differences and commonalities between scientists and fishermen in eastern Nova Scotia in relation to stock trends.

The above two initiatives are in addition to input received through ongoing DFO Science activities, such as the National Sampling and Observer programs.

Problems in Groundfish Data Processing

The Statistical Coordinating Committee for the Atlantic Coast (STACAC) was established by the Atlantic Directors-General Committee in 1981 as the zonal statistical committee with the overall responsibility of assuring that the fishery statistical systems on the Atlantic Coast meet the users' requirements (STACAC Standards Document No. 1). Today we have four regional offices working diligently but independently on their respective data sets with little or no zonal coordination. Also we have huge volumes of data produced annually (1,000,000 records) while consistency in recording practices, among the regions, appears to be deteriorating.

In April 1994, the Department of Fisheries and Oceans (Science) published: 'A Renewed Process for Assessment of Atlantic Stocks'. Contained within it states: 'Assessors will verify the quality, availability and reliability of the information used'. Considering this level of accountability, many significant data concerns remain in Atlantic Canada, both intra- and inter-regionally.

A few of the data concerns are as follows:

- * no comprehensive database describing all the fishing vessels in Atlantic Canada, either presently nor historically;
- * no comprehensive Zonal coding practices (species, gears, etc.);
- * no process in place for a data user to negotiate an enhancement to the data system that would be implemented throughout the Zone; and
- * no process in place to audit data entry and manipulation practices in an effort to avoid significant analytical problems down the road.

There needs to be a more formal review of the data collected and stored among data users and their respective regions. Moreover, there needs to be the implementation of a renewed Zonal coordinating body with members from each data user community and a commitment to review the process annually. A 'process' that would allow us to catch and repair problems, a process that could ensure consistent data quality across regions and a process that would help accommodate change when required.

To assure the proper reliability and availability of catch and effort data, Science needs the cooperation and commitment of the rest of the Department. Unless the above concerns can be addressed it should be noted that we will not be in a position to ensure the quality of these data.

Problems in Lobster Data Processing

Through a comparison of lobster landing data obtained from the Lobster Table, supplementary "B" forms and Table 24 from Statistics Division, and voluntary logbooks from Biological Sciences Branch, for the 1990 to 1992 seasons (1989-90 to 1991-92 seasons for Lobster Fishing Areas (LFAs) 33 and 34), a critique of the methods involved in the collection, editing and verification of statistical data in the Scotia-Fundy Region was developed. Identified were some pervasive and specific problems that either did, or had the potential to adversely affect the quality of information present in the historical database. Sources of error were individually discussed along with the extent to which they may have had an effect.

Supplementary "B" forms are not filed for Statistical Districts 30 to 38 -- an area that accounts for about 60% of the Scotia-Fundy landings. Supplementary "B" forms are, however, filed each year for most of the remaining 40%. Potentially the most harmful oversight is the lack of an estimate of the amount of lobsters transported directly to the USA via the fishermen themselves, or sold domestically through brokers and "fly by night buyers" in such a fashion as to hide income. Interviews with LFA 34 fishermen have conservatively estimated that approximately 20% of their lobsters are sold in this manner. Investigations by Revenue Canada peg this estimate at 30% to 40%, and as high as 50% in some areas. Recent interviews with the local Protection Officers of LFA 34 using individual sales slip records suggest that approximately 30% of the landings remain unrecorded (about 3000t annually). These losses have the potential to completely mask annual trends since a change in behaviour, such as more being sold legitimately, can cause an apparent increase in landings even if catches remain the same or are decreasing.

In the statistical districts where supplementary "B" forms are completed, the methods and frequency of collecting the information used appear to be at the discretion of the data collector. Consequently, the number of different methods equals the number of individuals involved. A standard protocol for collecting information for the supplementary "B" forms would improve data quality and give users more confidence in the data. If records showed an increase in landings between successive years the data user would not have to choose between an explanation of a change in data collection or higher lobster recruitment. For best results, responsibility for data collection in all cases should be assigned to individuals rather than

offices. Each individual should know the extent of his responsibilities and be accountable for the accuracy of the information provided.

Even though the statistical record obtained from Statistics Division is of a generally good quality with respect to the information they receive, a lack of communication with local offices and little or no expertise with individual fisheries have allowed large and small omissions to remain undetected. Lack of expertise is also apparent in some computer outputs where some of the older programs were rewritten only sufficiently to run in the new computer system and obvious errors remained undetected.

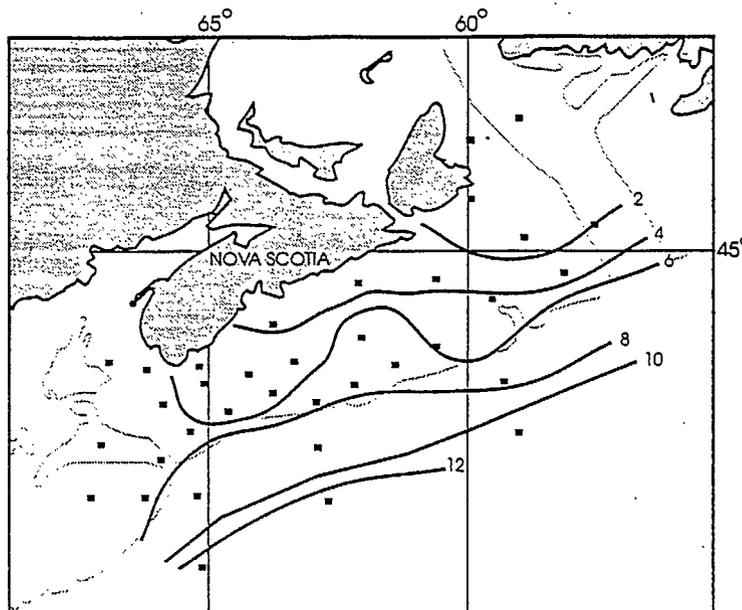
Further interviews with local Protection Officers throughout the province are presently underway to ascertain the extent of the missing landings statistics for each statistical district. From these we hope to determine by how much the present statistics need to be adjusted. A preliminary estimate is that 25% (approximately 4500 to 5500t per year) of the landed lobsters in the Scotia-Fundy Region remain unrecorded by the present system of data collection.

4. Ocean Climate Summary

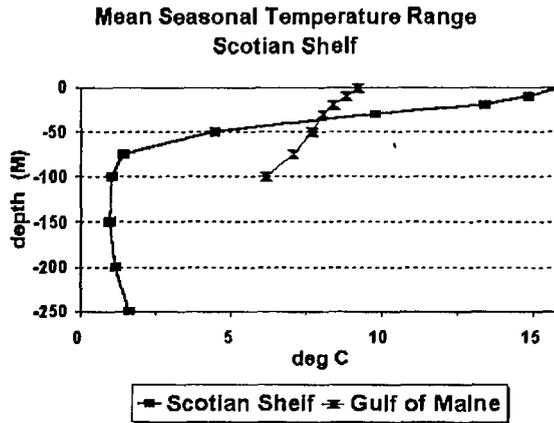
The physical oceanographic environment can affect fish distribution, catchability, recruitment, growth rates, and migration routes. Some fish species are found only within a specific temperature range and any change in temperature distribution may cause the fish to move. It is, therefore, important to monitor oceanographic conditions and to be able to describe how these conditions compare to the long-term mean or "normal" conditions. In this overview we focus upon the physical environmental conditions within the Scotia-Fundy Region, first providing a general description and then discussing the 1993 conditions including results from the groundfish survey cruises.

4.1 Mean Conditions

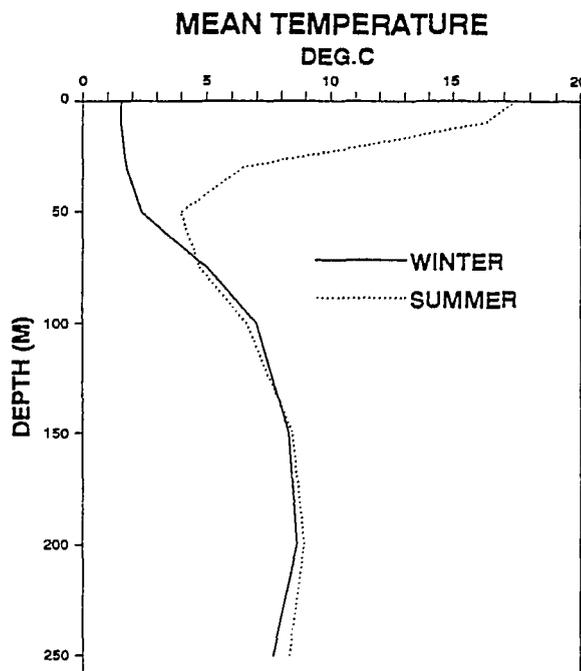
Temperature and salinity conditions within the Scotia-Fundy Region vary spatially due to complex bottom topography, advection from upstream sources (Gulf of St. Lawrence) and exchange with the offshore (Slope) waters. The water properties are also characterized by large seasonal cycles, depth differences and strong gradients both east-west and inshore-offshore. In general, temperatures and salinities tend to increase towards the west and offshore due to the greater influence of the warmer, more saline offshore waters and the reduced influence of the outflow from the Gulf of St. Lawrence.



The seasonal temperature range of the waters over the Scotian Shelf decreases with depth. At the surface, the range is of the order of 16°C but there is little or no seasonal change at depths below 150 to 200 m. The seasonal cycle in the shallow regions of the Gulf of Maine (4X, 5Z) shows much less change with depth due to vertical mixing by the strong tidal currents.

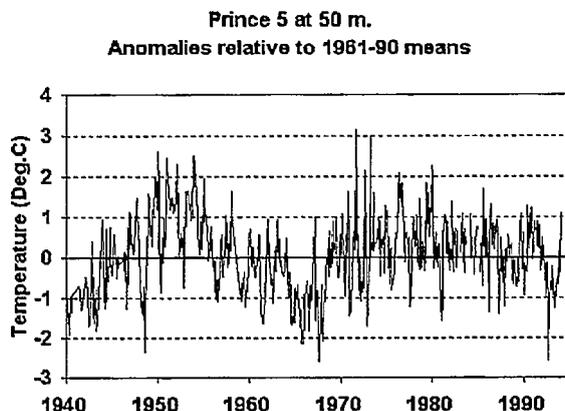


In the winter, the water column in the deep regions of the Scotian Shelf, such as Emerald Basin consists of two vertical layers. The upper layer contains relatively cold, low salinity waters and sits above a bottom layer of warm, salty water. These bottom waters originate from offshore and enter the shelf through the deep channels or gullies. In summer, there are three layers. Seasonal heating forms a thin (30-40 m) warm upper layer. The deeper, winter-cooled waters form a cold intermediate layer (CIL) and these are augmented by advection of similar waters from the Gulf of St. Lawrence. The warm bottom layer remains unchanged. In 4W, the shallow outer banks prevent the warm offshore waters from penetrating very far onto the shelf with the result that the cold waters extend to the bottom. Over most banks there is only one layer in winter and two in summer as their depths lay above the warm bottom layer. In shallow areas with strong tidal currents, there is only one layer even in summer, as water properties are vertically well-mixed.



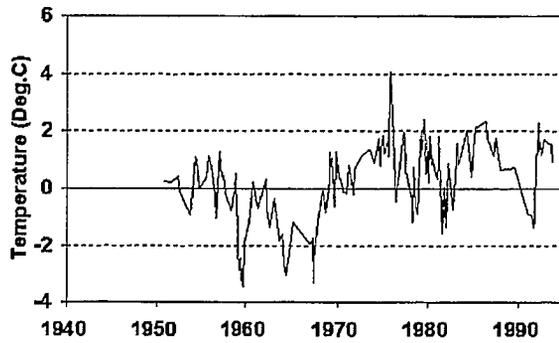
4.2 Long-Term Trends

Long-term records of coastal sea surface temperature are available at Halifax and St. Andrews. The only long-term offshore monitoring station in the region is Prince 5, located at the mouth of the the Bay of Fundy (4X). However, temperature time series have been reconstructed for other areas from data collected opportunistically.

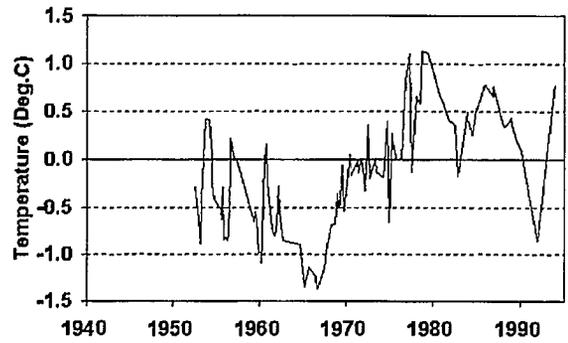


In general, temperatures throughout the water column declined during the 1950s to a minimum in the mid-1960s. Temperatures rose sharply in the late 1960s such that during the 1970s and the early 1980s they were warmer-than-normal. Since the mid-1980s, the mid-depth waters (50-100m) have cooled considerably reaching values near to or as low as those in the mid-1960s in many regions (Lurcher Shoals, Misaine Bank and eastern Georges Bank). In the deep basins and channels (Emerald Basin and Cabot Strait) the bottom water temperatures decreased in the early 1990s but, during the last two years, warmed rapidly and are now well-above normal. In the near surface layer, trends are less obvious with monthly means fluctuating about the long-term average. During recent years there has been a slight tendency towards cooler temperatures.

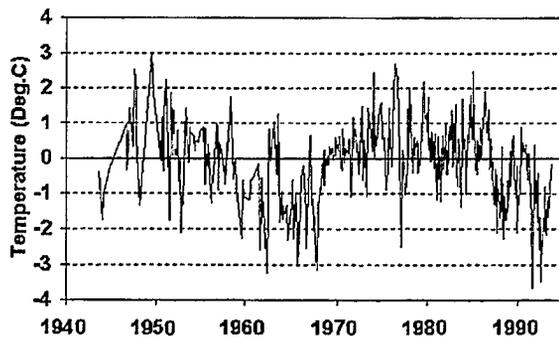
Emerald Basin at 250 m.
Anomalies relative to 1961-90 means



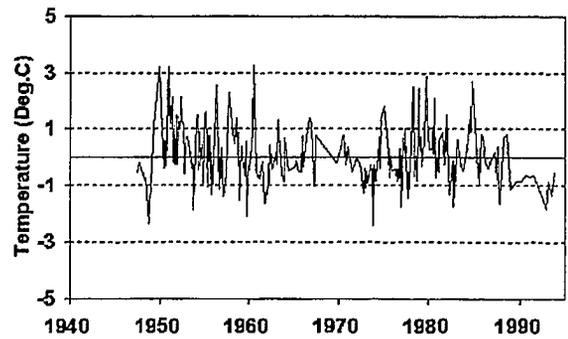
Cabot Strait at 200-300 m.
Anomalies relative to 1961-90 means



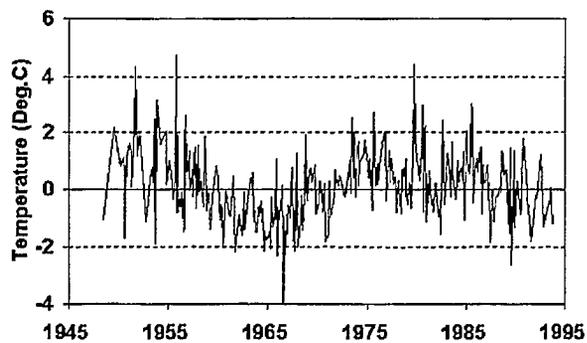
Lurcher Shoals at 50 m.
Anomalies relative to 1961-90 means



Misaine Bank at 50 m.
Anomaly relative to 1961-90 means



E. Georges Bank at 50 m.
Anomalies relative to 1961-90 means



4.3 Conditions During Research Vessel Surveys

The trends in near-bottom temperatures and salinities obtained during research vessel bottom-trawl surveys are unique to each strata. Temperatures in some strata have been increasing in recent years whereas those in other strata have been declining. These differences are due in part to differences in the bottom depths within each strata since temperature trends vary with depth.

The aggregate trends for stock areas, for example 4X and 4VsW, indicate that near-bottom temperature conditions have been relatively stable in the western Scotian Shelf area. In the eastern shelf area, the temperatures declined during the late 1980s and early 1990s, but in 1992 and 1993 they have been increasing so they are now near the long-term means. This warming is also indicated in the 1993 surveys by the lower number of sampling stations at which water temperatures were less than zero degrees.

The near-bottom temperatures observed during the spring surveys in 5Z increased from 1986 to 1991 and decreased from 1991 to 1993. The apparent trend is generated by changes in the timing of the surveys and is not indicative of any climate trend.

During the summer 4VWX research vessel surveys, the long-term trend in temperatures within the Bay of Fundy and off southwestern Nova Scotia and at approximately 100 m over the Scotian Shelf have decreased throughout the 1980s. This trend is evident within most of the shallow survey strata (42, 47, 48, 56, 58, 63, 73, 74, 75, 80) with the exception that in 1993 temperatures increased relative to 1992, in several of the strata (47, 48, 56, 58, 74, 80). In the shallow strata within the Bay of Fundy (90, 93-95) the cooling occurred only during the 1987-92 period. In many of the deep strata (40, 46, 61, 71, 78, 82, 83, 84) temperatures have been relatively stable since 1980 and as such are consistent with the long-term trends in the deep basins over the shelf. Unlike the deep basins, the temperatures in strata along the shelf edge near the Scotian Gulf (53, 66) have been increasing throughout the survey period.

4.4 Implications for Interpretation of Survey Trends

Although the amplitude of interannual variation in temperatures and salinities is of the order 1°C and 0.1‰, these can potentially be sufficient to cause changes in finfish distribution and hence estimates of abundance as well as an overlap in species distributions, which in turn, influences by-catch characteristics and fishing practices. Some finfish species are known to associate with distinct ranges of environmental conditions. For example, haddock are seldom found below 2°C and yellowtail are generally found within a narrow depth range. Preliminary analyses suggest that changes in the distribution and abundance of some species, for example haddock, and in the species composition within areas covaries with changes in temperatures and salinities.

In general, the temperatures and salinities at which cod and haddock were captured in the research surveys have changed throughout the time series of available survey data, and preliminary analyses suggest changes in the survey estimate of abundance of cod and haddock on the eastern Scotian Shelf may be associated with (although not uniquely related to) trends in the strata-specific temperature and salinity. In 5Z preliminary analyses of the survey estimates of abundance and deviations of these from SPA estimates (the residuals from ADAPT runs) does not indicate a relationship between survey timing and indices of abundance. Ongoing research is aimed at better identifying and quantifying the impacts of the hydrography on the changes in distribution and estimated abundance, and the impact on stock status estimates.

4.5 Conditions in 1993

During 1993, the atmospheric circulation patterns produced stronger-than-normal northwesterly winds over much of eastern Canada in the winter which, in turn, advected cold air masses into the region. However, at the coast in the Scotia-Fundy Region, the average temperatures for the year were less than 0.5°C cooler

than the long-term mean which represents a slight warming relative to last year. However, at Sable Island, the annual mean air temperature was warmer-than-normal by 0.2°C.

The relatively cold winter of 1993 led to severe ice conditions in the Gulf of St. Lawrence with earlier ice formation, longer duration, greater areal extent and later retreat than usual. Ice flowed out of the Gulf onto the Scotian Shelf and extended southwestward along the coast of Nova Scotia during late February and early March. The southward extent (beyond Halifax) exceeded the long-term (1962-87) maximum whereas the offshore extent on the eastern Scotian Shelf at this time was shoreward of its long-term maximum.

Ocean temperature anomalies in 1993 varied with location and depth. In the tidally well-mixed waters in the Bay of Fundy and on Lurcher Shoals the waters were colder-than-normal down to depths of 100 m. The surface waters over the Scotian Shelf were also generally cooler than normal. The cold intermediate layer (50 to 100 m depth), which has been relatively cold in recent years, has warmed slightly suggesting that conditions are moderating.

In contrast, waters in the deep basins, such as Emerald and Georges, and in the channels and gullies, such as Laurentian and Northeast channels, were warmer-than-normal. In the Laurentian Channel and in Emerald Basin, temperatures rose for the second year from very cold values observed in 1991. The source of these deep waters is the offshore Slope region which in 1993 appears to be warmer-than-normal. This may be related to the observed northward shift in the position of the boundary between the shelf and Slope waters known as the Shelf/Slope frontal boundary. A strong Gulf Stream eddy was observed in the vicinity of the mouth of the Northeast Channel from June to October. This may have led to significant exchange of water between the shelf and the slope region. The trends in temperatures at different depths and areas are summarized in Table 1.

Table 1. Summary of temperatures by depth for representative areas within each of the NAFO divisions subdivisions in the Scotia-Fundy Region. For each area the first line gives the mean temperature, the second line indicates whether 1993 was colder (-) or warmer (+) than normal (N). The third line indicates whether temperature in 1993 increased (I) or decreased (D) or were steady (S) compared with 1992. The comparison with 1992 is based on few data points and may not indicate changes in trends.

Area		Depth			
		0 m	50 m	100 m	200 m
4Vn (Sydney Bight)	Mean	6.5	1.8	1.4	4.4*
	1993 vs. mean	-	-	-	+
	1993 vs. 1992	S	S	D	I
4Vs (Banquereau)	Mean	7.5	2.7	2.8	
	1993 vs mean	Weak -	-	-	
	1993 vs. 1992	I	S	D	
4W (Emerald Basin)	Mean	8.5	4.0	6.5	8.6
	1993 vs. mean	Weak -	-	-	+
	1993 vs. 1992	S	D	S	I
4X (Roseway Basin)	Mean	7.9	4.6	4.7	
	1993 vs. mean	Weak -	-	-	
	1993 vs. 1992	S	S	I	
5Z (eastern Georges Bank)	Mean	9.4	7.6	7.1	7.8**
	1993 vs. mean	N	-	+	+
	1993 vs. 1992	S	D	I	I

* = Data from southern edge of Laurentian Channel.

** = Data from Georges Basin.

5. GROUND FISH STOCK ASSESSMENTS

Summary of Status of Sydney Bight Cod

- * The TAC has not been taken since 1989.
- * Fixed gear landings from the resident stock have declined steadily since the mid-80s.
- * Mobile gear landings maintained their catch in recent years due to a shift in fishing pattern to target the southern Gulf of St. Lawrence cod migrating into 4Vn during November and December.
- * The results of the 1993 autumn "test fishery" in 4Vn supported the interpretation that a large proportion of the November catch was comprised of fish migrating from the southern Gulf.
- * The age span in the landings is reduced, with 63% of the landings coming from the 1986 and 1987 year-classes.
- * Weight-at-age and length-at-age continue their downward trend of the past decade.
- * Catch rates for tonnage class 2 longliners has decreased since 1989.
- * Although the summer research vessel survey has not been a precise indicator of stock abundance, it has qualitatively identified the relative strength of year-classes. There has been no sign of good recruitment in the surveys since the 1987 year-class. The results of recently initiated juvenile surveys are consistent with this conclusion.
- * Although an analytical assessment has not been carried out for this management unit, the indicators from the fishery show that the stock is at a very low level of abundance with no signs of increase in the short-term.

Sydney Bight Cod
SUMMARY

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min.	Med.	Max.
Reference level '000t ²	6.1	6.2	7.5	7.5	7.5-10	<10	-	-	-	-	-
Advised catch '000t ²	6.0	6.0	7.5	7.5	7.5-10	<10	1.8	0	0 ³	7.5 ³	15.0 ³
TAC '000t ²	9.0	7.5	7.5	7.5	10	10	1.8	0	1.8 ³	7.5 ³	14.0 ³
Reported landings '000t ²	10.5	9.0	7.6	5.2	4.6 ⁴	4.5 ⁴	0.7 ⁴		0.7 ¹	8.5 ¹	12.6 ¹
Reported landings '000t (M-O)	8.9	7.9	5.8	3.2	2.8 ⁴	2.3 ⁴	0.7 ⁴				
Unreported catches											
Estimated discards '000t											
Total catches											
Total biomass '000t											
Spawning biomass '000t											
Mean - F											
1 = 1970-1993 2 = these refer to the May-December period and therefore include landings of 4T cod made during November-December 3 = 1978-1994 4 = preliminary statistics											

Catches: Catches continue to decrease, particularly in the fixed gear sector which has been unable to catch its allocation in the past four years.

Data and Assessment: Limited catch rate information and research survey data are available for this stock. The assessment was based on this information as well as qualitative observations made by industry.

Fishing Mortality: Likely above $F_{0.1}$ prior to 1993.

Recruitment: The 1987, and to a lesser extent 1986, year-classes form the bulk of this population. Little or no recruitment is indicated since 1987.

Environmental Factors: Water temperatures in the upper 100-150m have been below normal in recent years and this may have had an effect on recruitment. Temperatures in deep water of the Laurentian Channel have increased sharply over the last two years to warmer than normal.

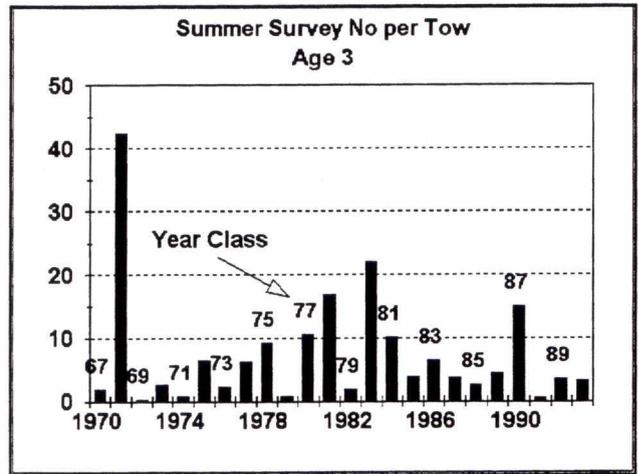
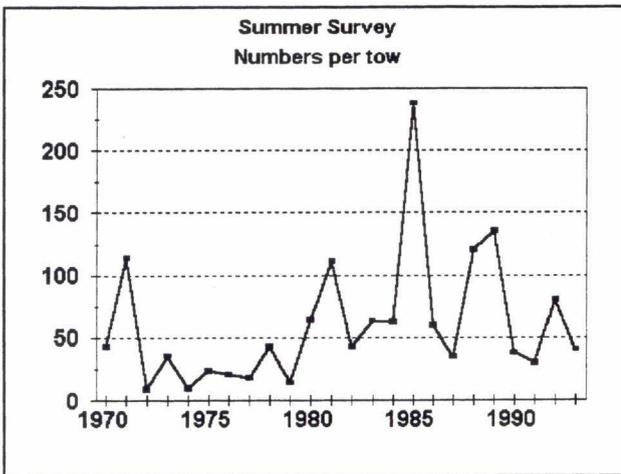
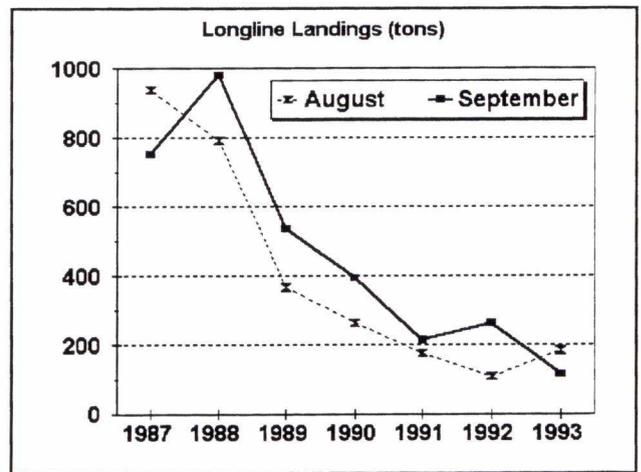
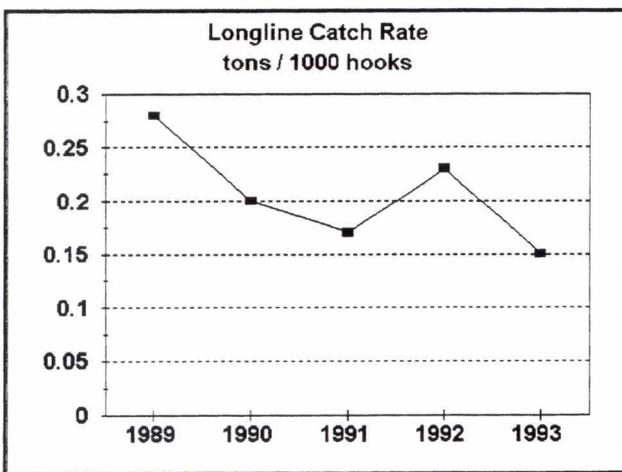
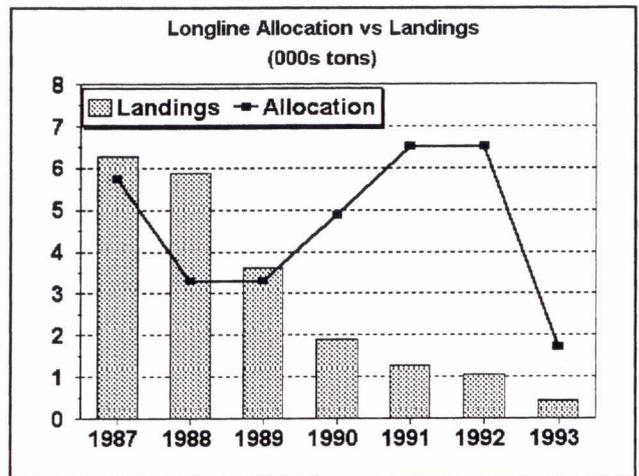
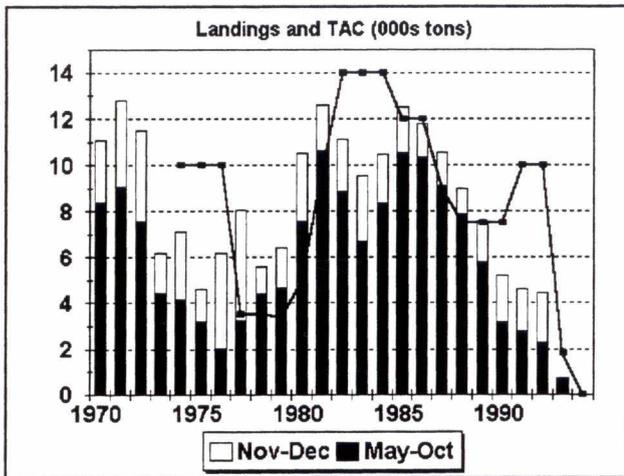
Multispecies Considerations: Sydney Bight is a migratory area for grey seals, a known predator of cod.

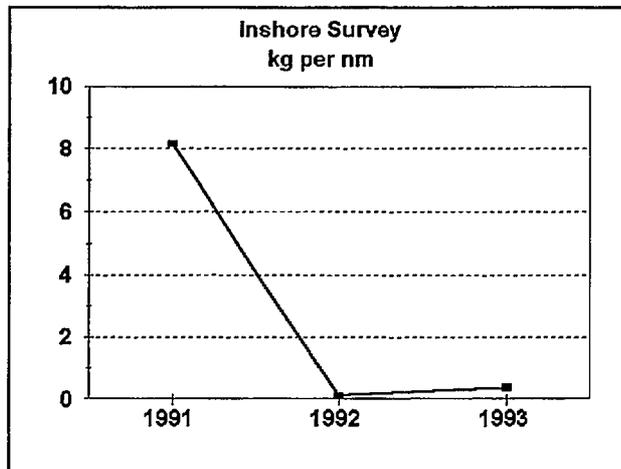
State of the Stock: The stock is probably at least as low as it was in the mid-1970s, if not lower and there are fewer age groups present now than at that time.

Forecast for 1995: The stock is at a low level of abundance with no signs of increase in the short-term.

Long-term Prospects: The stock's future depends on new recruitment. The 1987 year-class needs to be protected in order to sustain the spawning stock biomass and increase the chances of future good recruitment.

Special Comment: 4Vn is an area of mixing between 4T, resident, and 4VsW cod stocks. The dynamics of the mixing are not well defined and, given the lack of quantitative estimates of this, continue to preclude an SPA based assessment of the local stock.



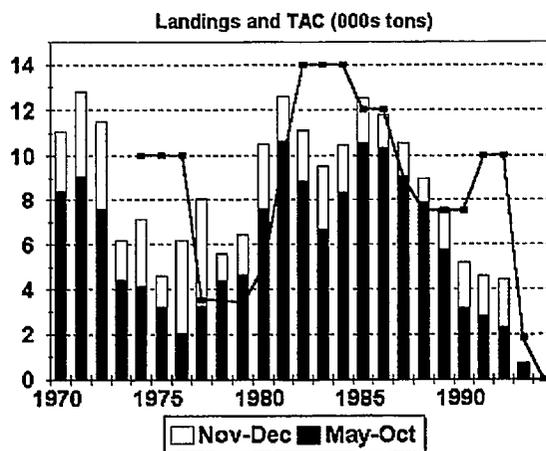


Technical Basis of Assessment of Cod in Division 4Vn (May-December)

Description of the Fishery

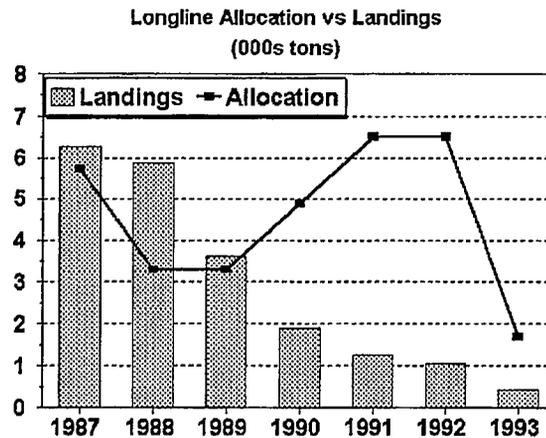
Nominal Catches

The nominal catches for the traditional management unit (4Vn May to December) for 1992 and 1993 were 4461t and 702t, respectively. The 1992 catch was less than half of the 10,000t quota. Fixed gear were allocated 6600t but managed to take only 20% of that amount; whereas, mobile gear achieved 97% of its 2700t allocation. Prior to 1989 the mobile fleet took over 80% of its annual allocation in the May to October period; however, after this date, the proportion of annual landings taken during these months fell to less than 40% as catch in November and December became the dominant part of the annual take. The catch of these pre-winter months comprised mainly Gulf of St. Lawrence (4T) cod. Cod caught in 4Vn from May to October are likely resident fish; therefore, longliners which fish mainly during this period and whose temporal fishing pattern, unlike draggers, has not changed over the years, have experienced a drastic decline in landings.



In 1992, due to the declining abundance of both 4T and 4Vn cod stocks, the fishery in 4Vn was closed in December as the winter migration was well underway and the annual stock mixing had begun, making allocation of catch to the appropriate stock difficult. At this time the quota for 4Vn for the next year (1993) was lowered to 1800 t. In 1993, midyear assessment of the status of the 4Vn stock indicated no change and as a result the fishery was closed near the end of September.

Since 1989 the allocation to the fixed gear sector has been far in excess of the landings realised. In the past this sector has demonstrated its capacity to capture the allowed amount of cod, yet its landings have continued to fall during the early 90's.



Fish Distribution

In 1993, a review of tagging information, biological characteristics of catches, and movements of the mobile fleet sector in the autumn, concluded that most of the December catch of in 4Vn comprised cod of 4T (Gulf of St. Lawrence) origin.

Then in the autumn of 1993, a "test" fishery for cod was carried out off eastern Cape Breton by six inshore longliners during a six week period from October 15 to November 30. About seventy tons (72,732 kg) of cod were taken.

Average catch rate ranged between about 100 and 1000 lb (53 & 522 kg) per 1000 hooks fished. Catch rates rose to a peak near the middle of November before falling rapidly by the end of the fishery. Although at peak, the highest catch rates were experienced in the west of the region, the most sustained catch rates were found further east.

Length frequency information showed a slight increase in average size at the beginning of the fishery with a steady decrease after about the second week. This trend was particularly evident in the extreme west of the fishing zone. This pattern in length frequency, together with trends in landings, seemed to indicate the movement of Gulf of St. Lawrence cod (which, at any given age, are smaller than eastern Scotian Shelf cod) into the Sydney Bight area.

Additional information in the form of historical longliner logbook information documenting landings from the White Point Bank area (the western boundary region of 4Vn), and fleet landing patterns in 4Tg and f (adjacent to 4Vn) indicate that many of the cod caught in the month of November also are of 4T (Gulf of St. Lawrence) origin. Landings of cod in 4Vn in December and November have been attributed to the resident stock in the past. In addition, not all 4T cod have returned to the Gulf by May and some proportion of catch in 4Vn during this month is also of Gulf origin. In light of this information, the Fisheries Oceanography Committee recently (April 1994) recommended that landings of cod from 4Vn in November and December be allocated to the 4T stock. Accordingly any landings of cod from these months were included in the 4T assessment this year.

Available Data

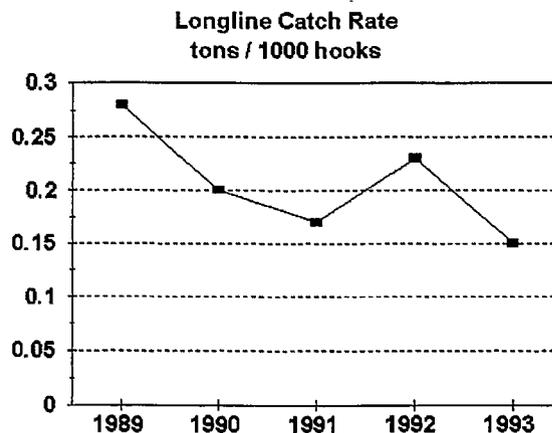
Catch and Weights at Age

In 1992 and 1993, landings were made up of 70% and 63%, respectively, of the combined 1986 and 1987 year-classes. There has been a decline in the average age of the population during the late 1980's and early 1990's as the 1987 year-class entered the fishery. Less than 3% of landed cod in 1992 and 1993 were older than age nine.

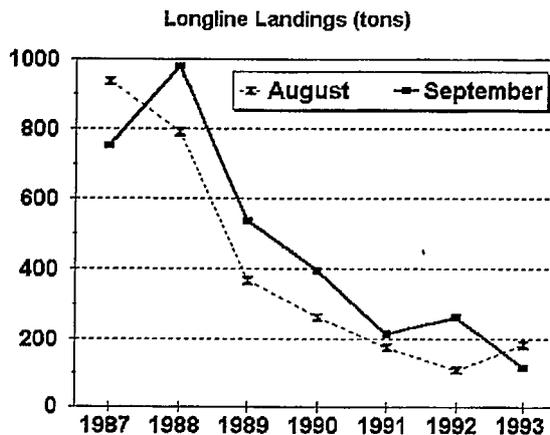
Weight and length-at-age continue their decline of the last ten years. Since 1982, the average cod in 4Vn landings is about 1.2 kg lighter and about 14 cm shorter for the same age. It is probable that this decrease may be in part a reflection of increasing proportions of 4T cod in 4Vn landings. However, this same decrease can be seen in cod taken in the July research survey when there is probably little mixing with Gulf cod relative to other times of year.

Commercial Catch Rates

Catch rates in the past, particularly for fixed gear which have taken the bulk of the catch in the past, have shown no significant trend over time. This is probably because of the small amount of catch that has been reported with information on associated effort. However, in recent years the average amount of catch reported with effort for smaller longline vessels has risen from an average of about 5% to over 10% in recent years. Since 1989, a decrease in both catch rate and effort for tonnage-class 1 and 2 longliners can be seen. This is consistent with the view of a declining stock.

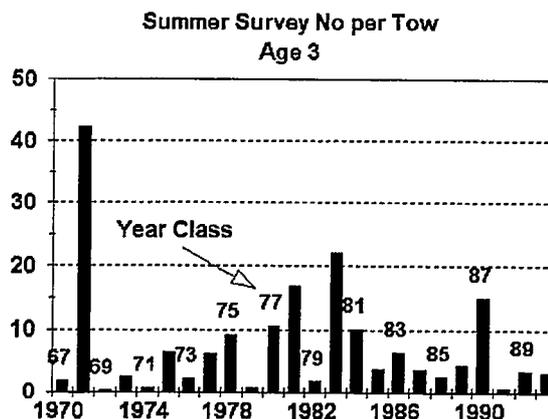
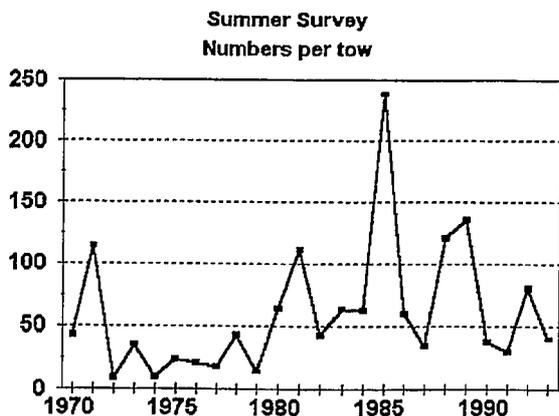


Immediately prior to the closure of the cod fishery in September 1993, there were reports of good catch rates in 4Vn; indeed the insistence of industry to prove this was a major driving force for the 4Vn "test" fishery in the fall of that year. Although fishing in localized areas (such as on Scaterie Bank) may have been better than had been seen in the recent past, this was certainly not true of the majority of 4Vn. Total catch for September was the lowest in at least 15 years and the August catch was slightly higher than for the same month the year previously. The slight increase in August landings in 1993 over 1992 was probably due to increased fishing effort in face of persistent rumours of an imminent closure. In addition, the catch rates at the beginning of the "test" fishery were around 200 kg per 1000 hks, which is about the average catch rate over the past four years.

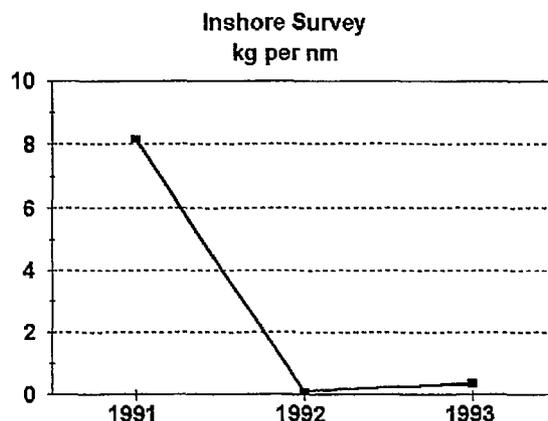


Research Survey Data

Survey catch in July was in the low end of the range of catches experienced over the years; however, this index has proven extremely variable and as a result, unreliable as an indicator of stock biomass and mortality. Despite these shortcomings however, the summer survey has been shown to be a good indicator of better than average incoming year-classes albeit with poor quantitative discrimination. As in the case of commercial landings, the 1987 year-class dominates the research catch, comprising 55% of the catch in 1992 and 37% in 1993. There has been no sign of good recruitment since 1987.



An inshore research survey has been carried out initially in the western half of Sydney Bight in 1991, and with extensions further east in the inshore region in subsequent years. Although ichthyoplankton sampling aimed at estimating cod egg production was carried out for the first two years, the major goal was to monitor the abundance of juvenile cod in the area. A region of juvenile aggregation was found near the Bird Islands. Cod in this location are invariably in the 7-15cm length (one yr-old) range. Other than a location in the Bras d'Or Lakes, this was the only place in the survey area where one year-old fish were found consistently. There has been a decrease in the abundance of one-year old fish which matches the decline in abundance of two-year-olds from the July survey.



Length at age has decreased for over ten years. This decrease is small at younger ages but quite marked at the older ages. This pattern is consistent with adjacent cod stocks where fishing mortalities have been shown to be high and population biomass greatly reduced.

Estimation of Stock Parameters

An VPA based assessment is not yet possible for this resource. Stock biomass and mortality are difficult to estimate due to the mixing of adjacent cod stocks with this stock. Furthermore, extreme variability in the research vessel index precludes the estimation of total mortality. Stock status is evaluated mainly on trends in catches of the fixed gear fleet and observations from the industry.

Prognosis

The inability of the fixed gear fleet to meet its allocation since 1990 is a clear indication of low abundance. The localized increases in catch rates in 1993 are related to local increases in abundance and not reflective of an overall increase in stock abundance. This conclusion is supported by the survey data. The inshore survey also suggests that recent recruitment has been poor.

Research Recommendations

1. A working group should be established to consider and assess the relevance and utility of the current 4Vn cod (May-October) stock assessment unit.

References

Lambert, T.C., and S. Wilson. 1994. Update on the status of 4Vn cod: 1992-1993. Atl. Fish. Res. Doc. 94/46: 24 p.

Summary of Status of Eastern Scotian Shelf Cod

- * Fixed-gear have not caught their allocation since the late 1980s. Mobile gear, however, caught their allocation until 1991 in part due to the changes in fishing pattern that targeted on southern Gulf of St. Lawrence fish overwintering in 4Vs.
- * The management unit was closed in September 1993 with estimated landings of 3,500t.
- * Since the early 1980s, weights at age have decreased.
- * Due to the inconsistencies between mobile gear catch rate time series from Observers and commercial catch effort data sets, this information was not used for SPA calibration, but is used to indicate trends in fishable biomass. Both series show a decline in recent years. Interviews with fishermen indicate severely reduced stock abundance in recent years.
- * The spring and summer research vessel surveys indicate very low fishable biomass in 1993/94, but the 1990 year-class which has not yet entered the fishery appears to be of average strength.
- * A model of seal/cod interactions provides annual estimates of cod consumption by grey seals in the 4VsW area. The estimated biomass of cod consumed by grey seals increased from about 1,500 t to 17,300 t over the 1970-1993 period. Most of this predation was on cod aged 1 - 4 (i.e. pre-recruits to the fishery). Grey seal predation is concluded to have become an increasingly important component of cod natural mortality with the increase in seal abundance and reduction in cod biomass.
- * Implication of seal predation on present and future cod population dynamics, and thus on projections of cod abundance trends, is highly dependent on assumptions concerning compensatory food-habit processes (both by other predators of juvenile cod and changes in seal feeding in response to shifting abundance levels of various components of the diet). There is presently no information available to test these assumptions.
- * The analytical assessments for this management unit show a retrospective pattern using both the ADAPT and Laurec/Shepherd techniques. The size of the retrospective discrepancy has decreased in recent years.
- * The analytical assessment (with and without seal predation) indicates that spawning stock biomass is currently at historically low levels (about 16,000t).
- * Fishing mortality increased sharply in the early 1990s to well above F_{max} (as high as 1.4 for ages 7 to 9 in 1992). With the September 1993 closure, and associated sharp reduction in fishing effort, fishing mortality declined to 0.28 (which is still above the $F_{0.1}$ target).
- * The assumptions on natural mortality at younger ages, and the changing role of seal predation, influence the estimates of the historical year-class sizes. With seal predation included in the SPA, the recruitment time series is better correlated with some environmental data that had previously been good predictors of trends in year-class sizes (i.e., the freshwater run-off from the St. Lawrence River).
- * The analytical assessment indicates that the 1990 year-class which is just entering the fishery is of average abundance. It is the strongest since the 1982 year-class and on par with that of 1987.
- * Seal predation may be reducing the yield per recruit available to the commercial fishery by up to about 50% in recent years (again depending on assumptions concerning feeding compensatory processes) and the potential yield of the 1990 year-class by up to 20%.
- * Given the increasing abundance of grey seals (doubling time of about 6 years), and the observations that young cod are a significant component of seal diet within the 4VsW area, irrespective of the assumptions concerning the degree of feeding compensation, it is concluded that the impacts of seals on cod will continue to increase over the next few years.
- * The severely reduced level of spawning stock size, and the indications of only moderate recruitment, imply that stock rebuilding will be slow even with the absence of a directed fishery.

**Eastern Scotian Shelf Cod
SUMMARY**

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min.	Med.	Max.
Reference level '000t	38	32	33.2	34	21	-	11	3	11 ²	36 ²	64 ²
Advised catch '000t	38	32	33.2	35.2	35.2	35.2	11	0	7 ²	35 ²	64 ²
TAC '000t	44	38	35.2	35.2	35.2	35.2	11	0	11 ³	44 ³	61 ³
Reported landings '000t	45.5	38.4	36.8	34.3 ^{1,4}	32.9 ^{1,4}	29.8 ¹	3.5 ¹		10 ⁵	49 ⁵	80 ⁵
Estimated discards '000t											
Total catches											
Total biomass '000t	136	111	103	90	76	65	47		47 ²	148 ²	243 ²
Spawning biomass '000t	84	70	50	33	19	19	16		16 ²	57 ²	102 ²
Mean - F (7-9)	0.54	0.67	0.56	1.31	0.74	1.37	0.28		0.23 ²	0.60 ²	1.370 ²
1 = provisional 4 = estimated 4T catches are not removed 2 = for 1979-1993 5 = for 1960-1993 3 = for 1973-1993											

Catches: Nominal catches have been near the TAC in recent years, except 1993. Only 32% of the TAC in 1993 was landed due to resource scarcity and more restrictive management measures which included tighter controls on fish size and a closure in September.

Data and Assessment: Commercial catch and a summer survey series covering 1970-93, and a March survey from 1979 to 1993 were used to tune a SPA. Commercial catch rates from Statistics and the International Observer Program were compiled, but only used for comparison to the SPA results.

Fishing Mortality: Fishing mortality averaged over ages 7-9 has increased in recent years until 1992 and was well above either $F_{0.1}$ ($= 0.22$) or even F_{max} as estimated by twice $F_{0.1}$. The 1993 fishing mortality fell in 1993 to the lowest level in recent years.

Recruitment: Recruitment has been generally below average for almost a decade with only the 1987 and 1990 year-classes being of moderate strength.

Environmental Factors: Bottom temperatures have fallen in 4Vs since the mid-1980s, while those in 4W have been relatively stable. The decline in recruitment follows the 4V temperature pattern well, but a cause and effect relationship cannot be ascribed.

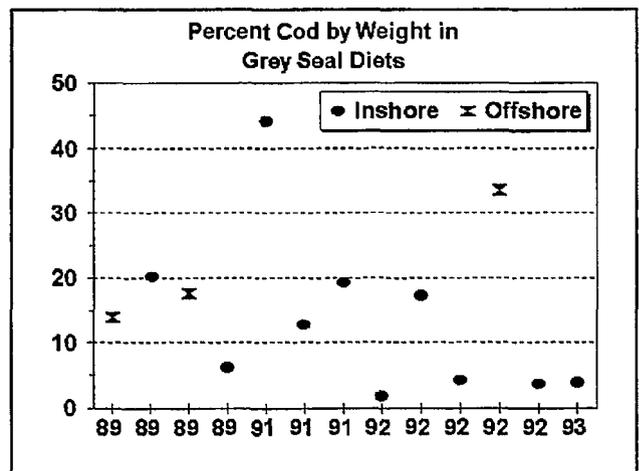
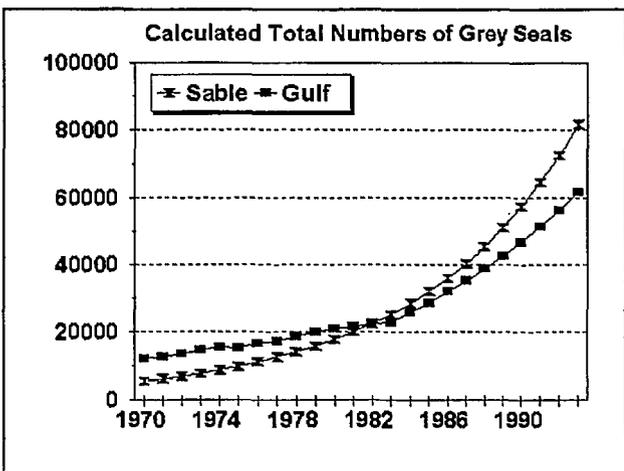
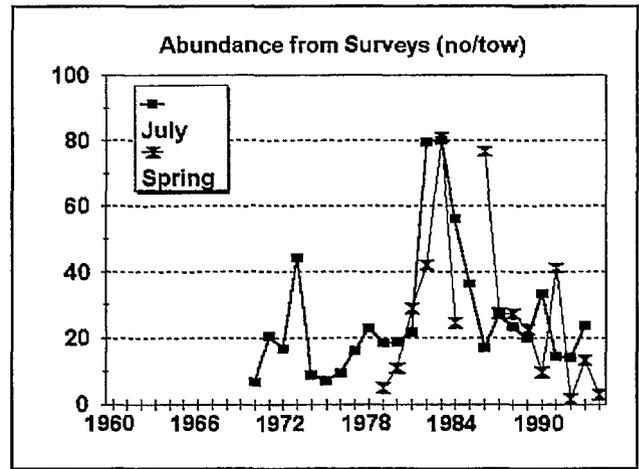
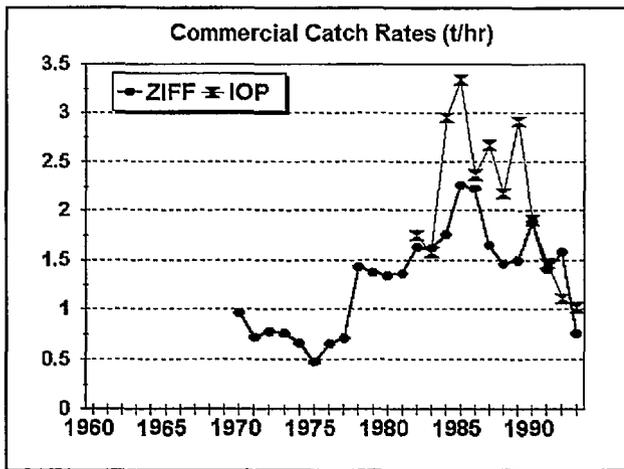
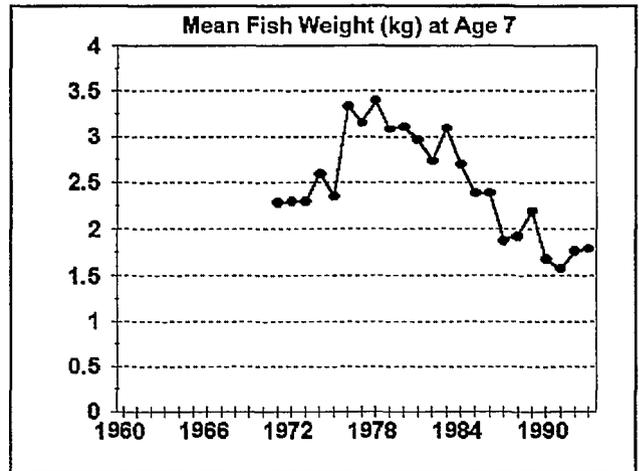
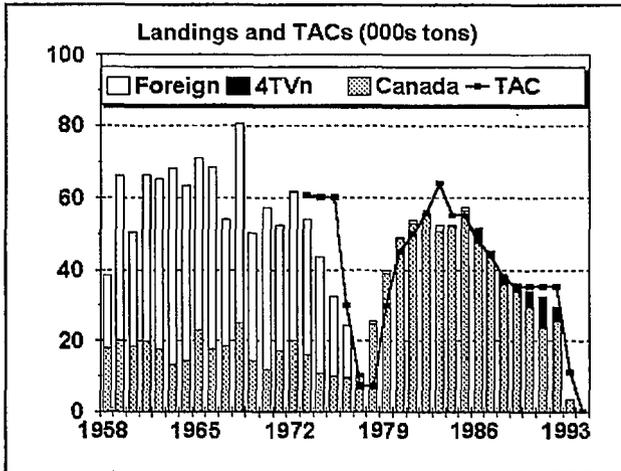
Multispecies Considerations: An analysis of seal populations and diet indicated that in 1993 grey seals consumed about 17,000t of 4VsW cod, most of which were pre-recruits. This represents an order of magnitude more than the estimated consumption by seals in the early 1970s. Cod yield per recruit determined either assuming constant ($M = 0.2$) or variable ($M = MR$) natural mortality with age indicates a reduction of about 50% in the yield per recruit, compared to the no seal situation.

State of the Stock: The stock is at its lowest biomass seen since assessments were begun. The catch contains fewer older ages in recent years, mean weight at age is decreasing, and recent recruitment has been poor.

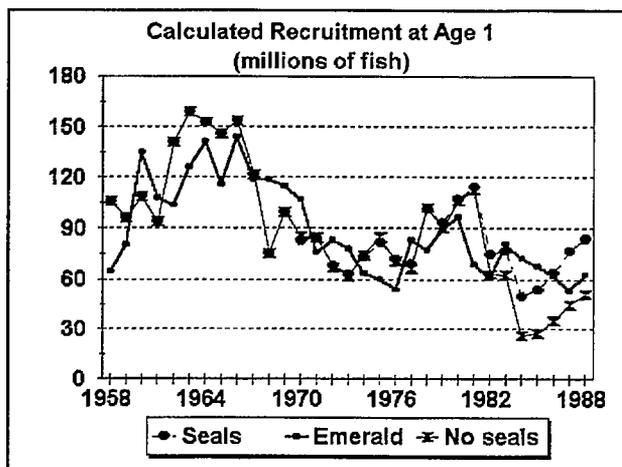
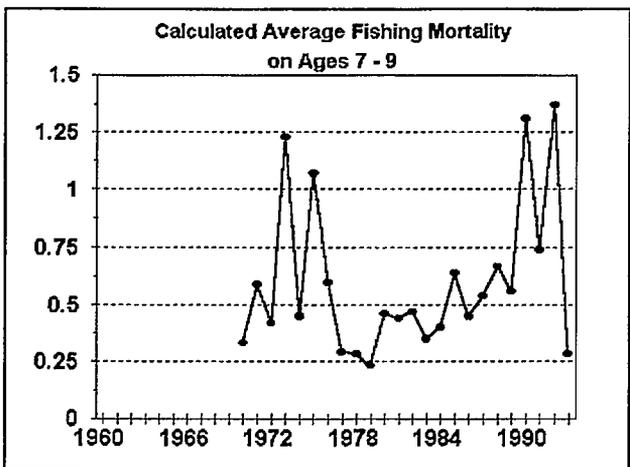
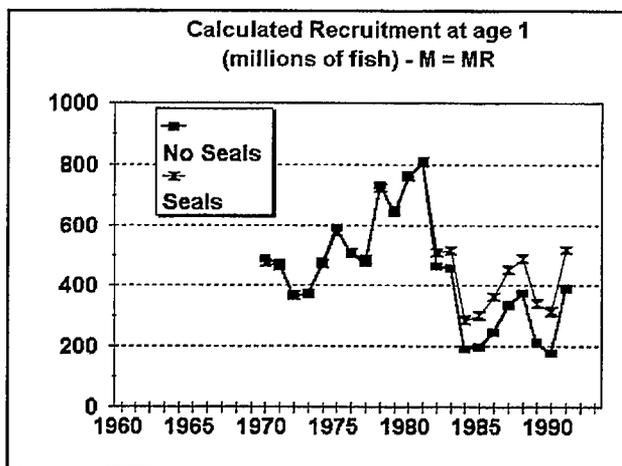
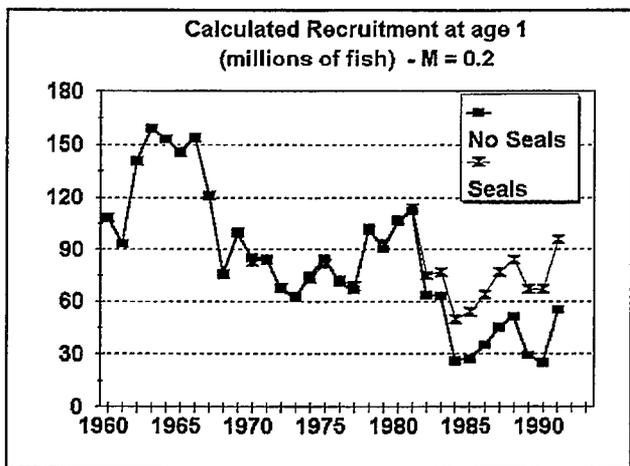
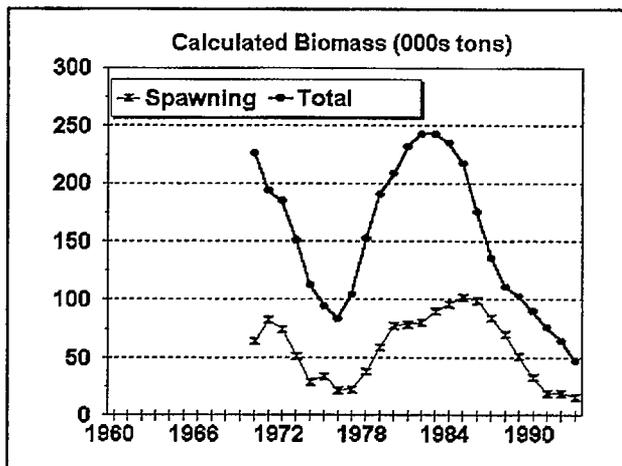
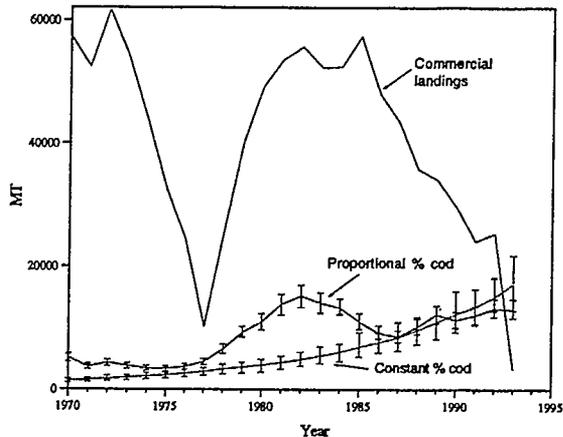
Forecast for 1995: The conjunction of overfishing, low recruitments and to some extent increasing seal population has placed this stock in jeopardy. A number of years of good recruitment will be required before the fishable and spawning stock biomass can support a fishery.

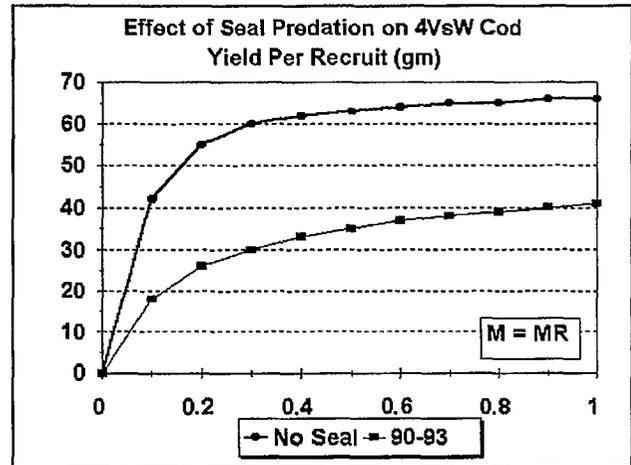
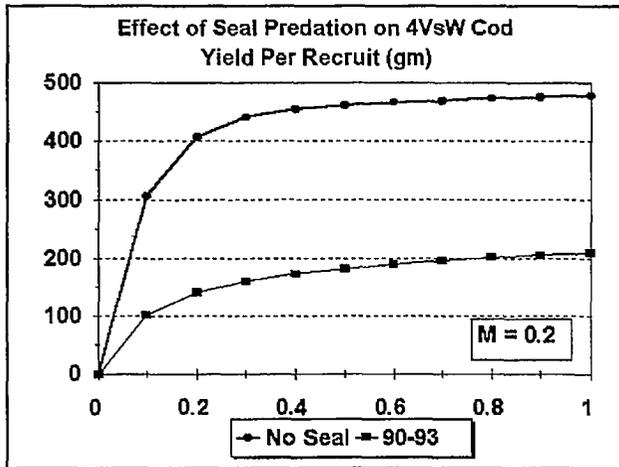
Long-term Prospects:

Special Comment:



Two models for extrapolating 4VsW cod consumption by seals with 95% error bars. The commercial landings are shown for comparison.



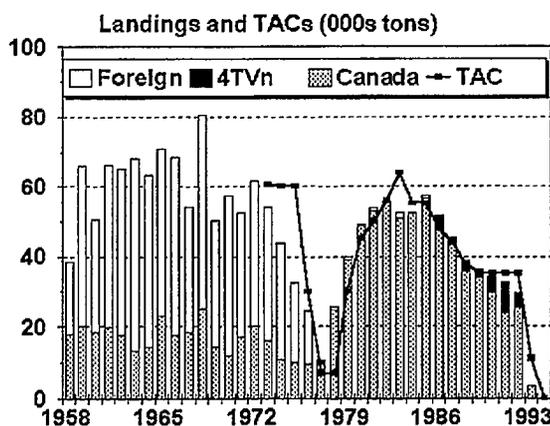


Technical Basis of Assessment of Cod in Division 4VsW

Description of the fishery

Nominal Catches

Landings of 4VsW cod ranged from 40,000t to 80,000t in the years 1958 to 1974 and then declined rapidly to a low of 10,000t in 1977. Subsequent to extension of jurisdiction the landings quickly climbed again and were at or above 50,000t from 1980 to 1986. Under quota restrictions, the TACs have been reduced and the catches have declined in recent years to 29800t in 1992, and then radically to 3,474t in 1993, the lowest catch on record. Since 1977, the foreign catch has only exceeded 1000t once and in 1993 was approximately 40t, primarily by-catch in the silver hake fishery. Prior to 1980, the total catch was dominated by the Div. 4W component. However, since 1980 the percentage of the catch coming from Subdivision 4Vs climbed from 60% to a high of 87% in 1988. The percentage has declined for the last four years and was 67% in 1993, the lowest since 1983. The fishery was closed September 1.



The proportion of the catch taken by each gear type was essentially unchanged from 1989 to 1992, with over 70% of the catch taken by otter trawls, 25% taken by longline and handline and the remainder taken primarily by seines and gillnets. However, in 1993 the longline catch was about 50% greater than the trawler catch. None of the gear sectors landed close to their quota, but large mobile gear (greater than 100') had the largest shortfall, 810t out of a quota of 6,429t. This shortfall was in part due to the closures for small fish.

In 1993 some gear sectors were complaining about the difficulty in getting legal size catch. Conversations in 1993 and early 1994 with fishermen, their representatives and DFO field staff were consistent in the view that there were few fish of any size.

Fishery Distribution

Positions from logbooks and Observes show that the fishery has contracted over the last decade and is now concentrated in a few small areas, notably the eastern end of Banquereau Bank, the Gully, and Sable Island Bank.

Environmental Conditions

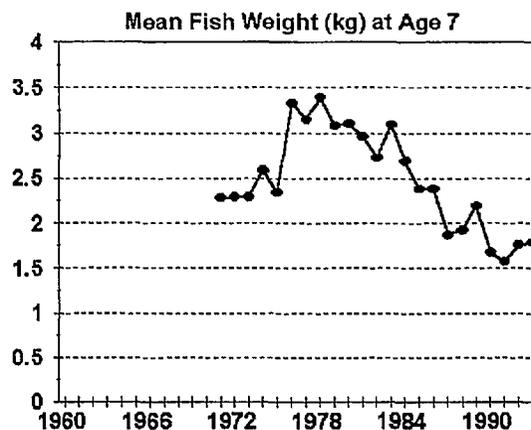
The cool temperatures seen for the last decade in 4Vs continue. Bottom temperatures from research surveys were slightly warmer in 1993 but are still below the long term average.

Available Data

Catch and Weights at Age

Because of fewer samples than in earlier years, the 1993 catch at age was constructed by using three separate keys (compared to 7 in 1992). The parameters of the length/weight relationships were estimated from the July research vessel survey. The keyed catch accounted for more than 98% of the total catch and was pro-rated to the total.

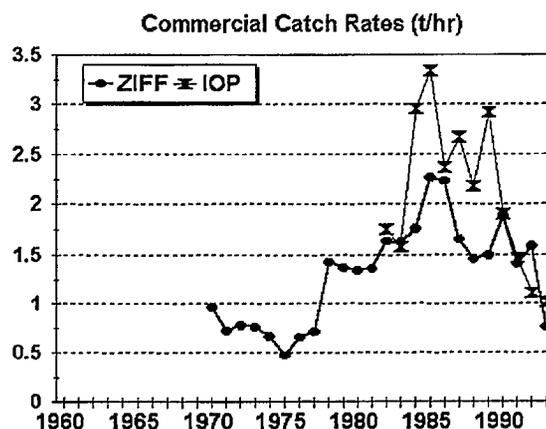
Over the previous decade weights at age have been declining for all ages. However in 1993, weights at age in the commercial catch showed larger fish in ages over 8 and no further reduction for younger fish.



A proportion of the fish in the winter 4VsW cod fishery come from the 4T stock. In recent years that proportion has been estimated by separating fish on the basis of their growth rates. 4T cod grow more slowly and so are smaller at age. An independent corroboration of the identity of fish from this fishery was recently undertaken using an examination of the otolith elemental composition. Otolith elemental composition is a natural tag, representing the accumulation of what the fish has been exposed to in its lifetime. Samples from the 1992 and 1993 winter fishery were compared with known samples from 4T and 4Vs. The otolith elemental fingerprints from the known sites (4Vsc and eastern and western 4T) differed significantly. Classification of the mixed fishery samples (4Vsc in February-March) based on the reference samples indicated the virtual absence of fish from the southwestern Gulf, but a 33-65% contribution from the southeastern Gulf or 4Vn. Because of the similarity in the environments, eastern Gulf fish are not likely to be distinguishable from 4Vn. These estimates suggest that there are more fish from the Gulf in the 4Vsc fishery than had previously been estimated. More work will be required to quantify the extent of Gulf and 4Vn fish in this fishery.

Commercial Catch Rates

The data for the years 1970-1988 were extracted from the NAFO data base and 1989-1993 were extracted from the Interzonal (ZIFF) database and aggregated into the same gear/area/month categories previously defined by Sinclair and Smith (1987). Selection criteria removed catch or landings of less than 10 units. Throughout the 1980's the CPUE remained higher than the 1970s and relatively stable, with the exception of 1985-86 which were the highest observed. The 1993 value is approximately one half of the 1992 value.



The Canadian OTB (TC 4-5) catch rates from the IOP were calculated for the years 1982-1993. The observed catch has varied between 7% and 17% of the total OTB catch during 1982-89, however, in the 1990s the IOP observed over a third of the OTB catch and about 50% in 1993. When standardized to the same basis, the CPUE based on the IOP was significantly higher than that based on the commercial statistics in 1984-89 but nearly equal in 1982, 83 and 90 on. A possible explanation for this pattern is attributed to changes induced by the introduction of the Individual Quota (IQ) program. Because of the lack of agreement in the two CPUE series, they are not included in tuning SPA's.

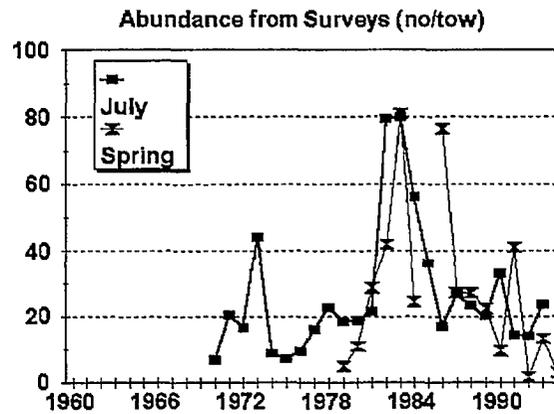
Conversations in 1993 and early 1994 with fishermen, their representatives and DFO field staff were consistent in the view that there were few fish of any size. A questionnaire to fishermen in this area showed that a large majority felt that the recruited sizes of cod had decreased over the last few years based on their catch rates. The respondents were divided on whether or not prerecruits were up or down, which reflects the 1990 year-class approaching legal size during a period of poor recruitment.

Research Survey Data

The July stratified random trawl survey of 4VsW has been conducted annually since 1970. The research vessel conducting the survey was changed in 1982 and 1983 due to the retirement of the *A.T. Cameron*, the temporary use of the *Lady Hammond* (in 1982) and the advent of the *Alfred Needler* in 1983. The cod catches from the *A.T. Cameron* and the *Lady Hammond* were adjusted by a cod conversion factor of 0.8, which is applied to the latter vessel, to account for the change in the survey vessel.

A second survey has been conducted in March from 1979 to 1992 with the exception of 1985. The same conversion factor was applied to the March surveys for the years 1979-83 when the *Lady Hammond* was the survey vessel. From time to time the estimation of abundance from the March

survey has been complicated by missing strata due to the presence of ice in the survey area. In 1993 one strata had only 1 set and 4 new strata were added in deeper water in the Laurentian Channel. The new strata are not included in the results nor in subsequent analysis.



The July survey mean catch per tow in recent years, 1987-90, was higher than all years prior to 1982 except for 1973, but well below the peak of 1982-84. The 1993 point was below the long-term average, about 10% higher than the 1991 1+ value, and about 70% higher for 3+. The general trend in the March surveys was similar although 1986 and 1990 seemed to be extremely high and low, respectively, relative to the July estimates. The March survey estimate for ages 4+ was very low in 1990, 1992, and 1994. However, in 1991 the estimate, which includes the strong 1987 year-class, is comparable to the early 1980s.

Both surveys series have indicated that the 1986 and 1987 year-classes are above average. The 1987 year-class has constituted 44% to 49% of the mean catch per tow (in numbers) in 4 of the 5 surveys available for 1989 to 1991. Both surveys have shown the presence of the 1990 year-class, which, though stronger than those since 1987, is only about average in strength and not yet available to the fishery.

Estimation of Stock Parameters

Models

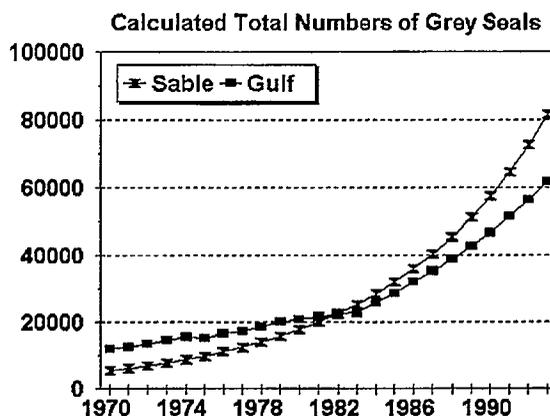
The traditional age-structured population analysis was performed for this stock. A model using the cohort equation and fitting both summer and March surveys. Nineteen parameters, 6 terminal F_s and 13 calibration coefficients were fit to 242 observations.

Additional SPAs were also run in which the estimated removals by seals were incorporated in the analysis. This essentially treated grey seals as a fleet, competing with other gear sectors for this resource. Seals predominantly eat cod before they recruit to the fishery so the analogy would be to a small mesh fishery. The results are dependent upon the natural mortality rates assumed and new values of M were assumed which are thought to be more realistic and have higher rates on small cod ($M = 1.0, 0.8, 0.6, 0.4$ for ages 1 to 4 and 0.2 for older) than the traditional $M = 0.2$. The higher age dependent rates are denoted M_R .

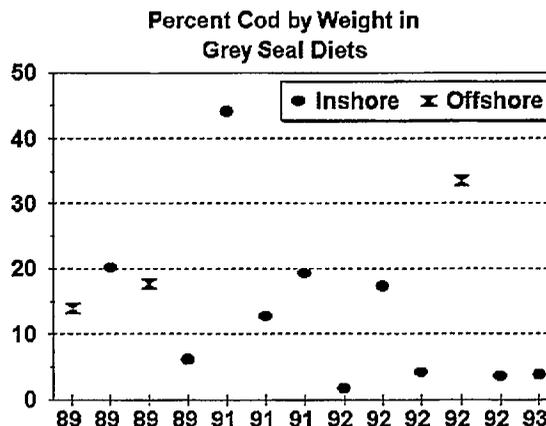
Grey Seal Consumption of Cod

Over the past 5 years, a number of studies have been conducted to improve our understanding of the interactions between grey seals and commercial fisheries in eastern Canada. Several models have recently been developed to examine trends in the consumption of the 4VsW cod stock by grey seals over the period 1970 to 1992. An age-structured model of the population dynamics of grey seals in eastern Canada and the seasonal distribution of grey seals are used to determine the number of grey seals feeding in the 4VsW study area. Estimates of the mass-specific energy requirements of seals, the fraction of three size-classes of cod in the grey seal diet, and the average energy content of the diet are then used to estimate consumption of 4VsW cod by grey seals.

Both the Gulf of St. Lawrence and the Sable Island populations of grey seals have increased over the past decade. The 1993 Gulf population is estimated at 61,900 animals, with a doubling time of about 8 years. The 1993 Sable Island population is estimated to be 81,600 seals, which is consistent with preliminary data from the 1993 aerial survey. Sable Island pup production continues to increase at about 13% per year, which corresponds to a doubling time of slightly less than 6 years.

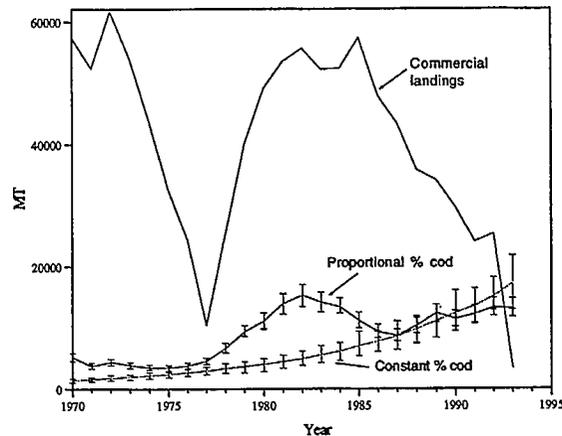


Approximately 13% of the mean food intake was cod. Cod comprised from 1.6% to 44.1% by weight of the diet in individual samples collected between late 1988 and early 1993. Although the estimates varied considerably, there was no evidence of a trend in the percentage of cod in the diet over time.



It is estimated that cod less than 30 cm, from 31-45 cm, and greater than 45 cm fork length accounted for 44%, 36%, and 20% by weight of the cod in the diet, respectively. These length classes are roughly equivalent to 0-2 year-old cod, 3 to about 50% of 4 year-old cod, and 4+ year-old cod, respectively. Mean total annual food intake by grey seals in the 4VsW area increased from an estimated 12,000t in 1970 (rounded to the nearest 1000 t) to about 138,000t in 1993. The estimated biomass of cod consumed by grey seals increased from about 1,500t to 17,300t over the period 1970-1993. Predation by grey seals prior to the mid 1980's was unlikely to have been a significant source of mortality on 4VsW cod compared to other sources of natural mortality. By 1993, grey seal predation on cod may have been about 17,300t compared to the 3,500t landed by the commercial fishery. Most of this grey seal predation was on cod ages 1-4 (i.e., pre-recruits to the fishery).

Two models for extrapolating 4VsW cod consumption by seals with 95% error bars. The commercial landings are shown for comparison.



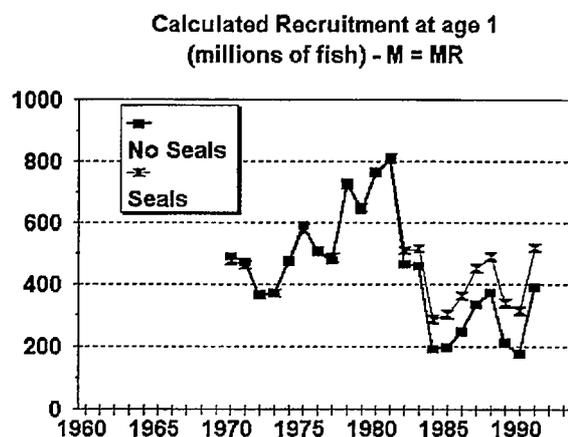
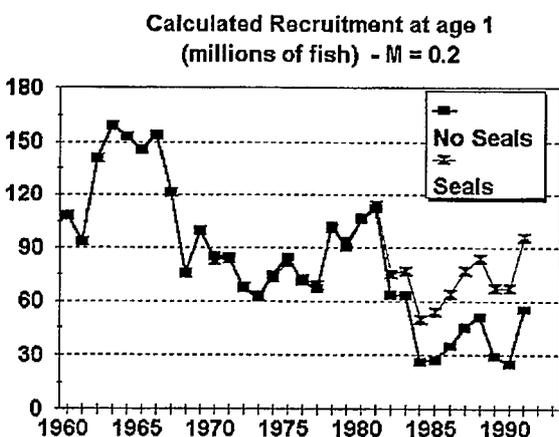
Error analysis for the seal model consisted of sensitivity analysis on the parameters describing cod consumption and bootstrapping of the principal consumption data. The sensitivity linked the percent change in cod predation to a percent change in each parameter. This analysis showed that the estimate of cod consumption was more than 5 times more sensitive to the Sable herd's size than that of the Gulf herd's. The amount of energy available to the seal from its diet, the metabolizable energy, was also very important but fortunately it is fairly well known. The percentage of cod in the diet is also quite important but, as mentioned above, is quite variable in the available data. The percentage of cod in the diet may decline as the available biomass of cod declines. The bootstrapping exercise was carried out to show the effect of this variability in the cod consumption.

A demand model was chosen for the functional form of the interaction between seal and cod for the analysis of potential impacts of seals on cod; that is that on average seals will find a certain amount of cod irrespective of its relative abundance. The amount was 12.6% of the diet by weight. Because the seal population varied by about a factor of ten over the period of investigation the cod consumption is dominated by seal abundance. This model is of course less likely as the amount of cod decreases to very low levels while seal herds increase. A second choice of functional form was chosen for comparison of the amount of cod consumed but was not used in subsequent analysis. The second form assumed that the amount of cod consumed per seal would be proportional to the cod biomass in each of the three cod size categories. The peak to trough ratio for the cod biomass is about a factor of 4 from 1970-1993 and represents a large 'signal' which is superimposed on the even larger change in seal numbers. The overlap in error bars in recent years suggests that the two models are indistinguishable from the late 1980s on. The non-overlap in earlier years shows that the assumption about the functional form of the fraction of cod in the diet is larger than the variation in the diet samples. The large changes in both predator and prey over the period of investigation may be sufficiently large to allow the determination which of the two models is more likely. Only two models for the interaction between seals and cod were investigated. Beverton (1985) and others discuss a number of alternative models for the functional response to a change in prey abundance and they may be considered in future work.

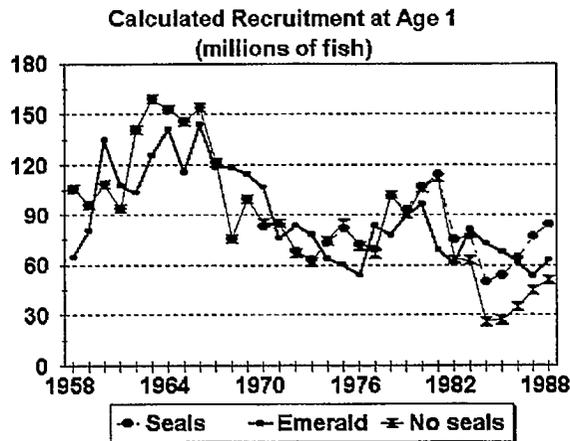
The retrospective pattern, by which successive stock assessments prove that previous assessments have consistently been optimistic, has been particularly severe for 4VsW cod. The problem was studied using the Laurec/Shepherd assessment technique and examining changes in the catchability coefficient estimates when the assessment is repeated including additional years of data. The results show that the Laurec/Shepherd assessment technique also produces a retrospective pattern in the same direction as ADAPT. The catchability coefficients are reasonably stable at first, but during most of the 1980s, especially the latter part, they increase rapidly for both the July and the March research vessel survey population estimates. The retrospective pattern has been less severe in recent years.

Recruitment

This assessment shows the presence of a relatively strong 1990 year-class, now at age 3, the youngest age in the analysis. However, this year-class is only about equal to the long term (since 1970) Geometric Mean (GM) average of 58 million. The 1990 year-class, although only poorly estimated by the SPA, may be as strong as the 1987 year-class. The July survey also suggests this, while the March survey indicates that the 1990 year-class is not nearly as strong. With the exception of the 1987 year-class, recruitment has been poor since the 1982. The estimates of recruitment arising from SPA are sensitive to the assumptions of the seal model.



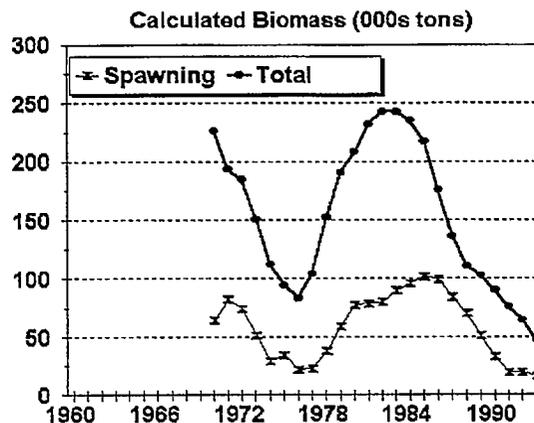
Previous studies had found a relationship for the years 1957 to 1979 between 4VsW cod recruitment and RIVSUM, the discharge from the St. Lawrence River system. RIVSUM was believed to affect cod through influences on the hydrographic properties on the Scotian Shelf. This relationship, together with recent data on river discharge, was unable to predict the rapid decline in recruitment during the late 1980s estimated by SPAs. The RIVSUM predicted instead relatively high levels of recruitment similar to those seen in the 1970s. When the recruitment series was adjusted for possible seal predation they fit the RIVSUM model better. Examination of other environmental variables shows that the highest correlation with the seal adjusted recruitment is with Emerald Basin 200m temperatures which accounts for over 50% of the variation in recruitment. When Emerald temperatures are high, recruitment tends to be low.



Assessment Results

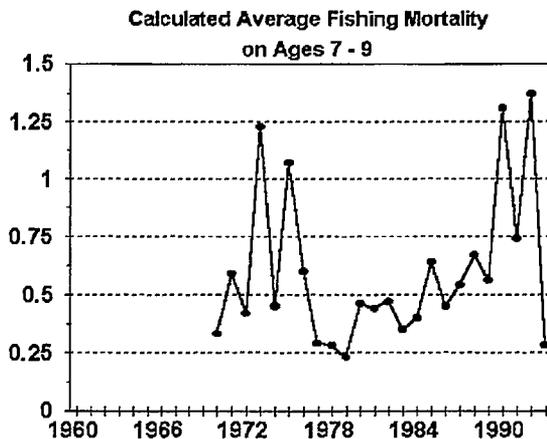
Population Biomass

Both the total biomass (47 kt) and approximate spawning stock biomass (16 kt) are the lowest since estimates have been made for this stock. Although similarly low biomasses were seen in the late 1970s the pattern is now different in that there are relatively fewer larger fish

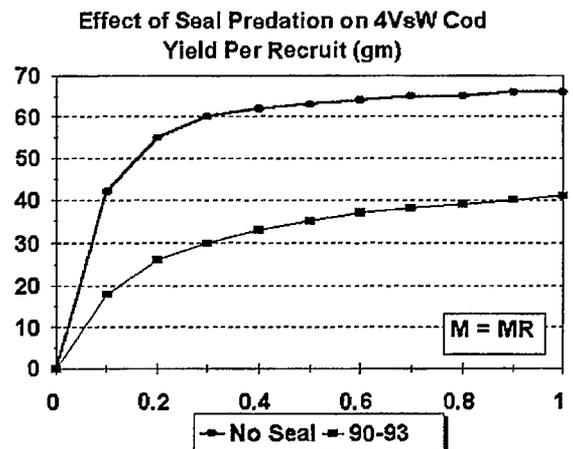
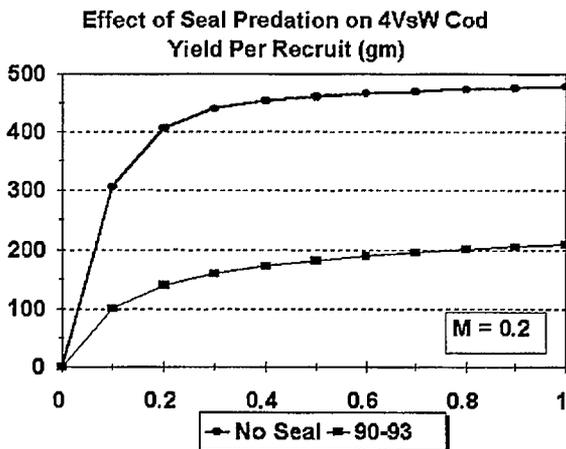


Fishing Mortality

The SPA results indicate that the average F (ages 7-9) has increased in recent years and is well above $F_{0.1}$ or F_{Max} and is indeed the highest ever seen in 1992. The closure of the fishery in September 1993 and more stringent controls brought the F to 0.28, which is still above $F_{0.1}$.



The results from the alternate models which included estimates of seal predation showed that this could have a significant effect on the recruitment to the fishery. When seals were included more cod were estimated to have been born, but fewer survive to legal size. The inclusion of seals also has potential effects on yield per recruit analysis and showed that the yield could be reduced to about a third when included in the calculations.



	No Seals	Seals	No Seals	Seals
Natural Mortality	0.2	0.2	MR	MR
Recruits (1990 YC Millions)	55	105	390	520
1+ Biomass (1993 kt)	47	83	58	155
6+ Biomass (1993 kt)	15.6	15.8	15.8	16.6
F (2-8 1993)	0.12	0.12	0.12	0.12
F by Seals (2-8 1993)		0.37		0.33
$F_{0.1}$	0.17	0.27	.17	0.29
Yield at $F_{0.1}$ (g)	400	156	54	29

The potential yield from the 1990 year-class is the product of the yield per recruit and the year-class size. Implicit in this calculation is that fishing, predation and natural mortality patterns remain constant over the duration of this year-class in the fishery, or up to about the year 2000. Because these models assume no compensation among the predators of cod, the above table may be thought of as a worst case scenario for the impact of seals for either natural mortality assumption. However, some compensation is thought to be likely, therefore the effect of seals on yield will be less than these worst case scenarios suggest.

Prognosis

These preliminary estimates of grey seal predation on 4VsW cod are sensitive to uncertainties in the underlying data, to parameter estimates derived from these data or assumed on the basis of theory, and to uncertainties in the structural form of components of the model. Among these uncertainties, the issue of compensation among the components of natural mortality must be clarified before we can have confidence in the magnitude of the impact of grey seal predation on the dynamics of 4VsW cod. It was noted that trends in total mortalities (Z) calculated from survey information were inconsistent with the purported change in M. Other issues such as how grey seal predation on cod varies with changes in cod biomass and the age structure of the cod population and with changes in the relative availability of other major prey also need to be understood.

The issue of compensation in the components of M is uncertain at present. However, we do not expect either extreme to occur; that is, we do not expect that seal predation mortality will be simply added to the existing sources of M on cod or that seal mortality simply replaces other sources of M, with no net increase in M. The effect of seal predation will fall into the middle ground with some compensation.

Although we cannot be certain of the impact of grey seal predation on the stock, it seems clear whatever the effects of grey seals might be, these effects are likely to increase over the next several years. We arrive at this conclusion for two reasons. First, there is no indication that the increasing trend in the population size of grey seals will slow in the near future. Thus, we can expect more seals feeding in the 4VsW area. Second, it is not likely that grey seals will cease to feed on cod at low cod biomass, although a decrease in the fraction of cod in the diet of grey seals may occur if there is a further decrease in cod biomass available.

The spawning stock biomass and fishable biomass are at the lowest levels seen since 1970. However, fish under legal size, mainly the 1990 year-class, are still seen in the most recent surveys. So, if the fishery remains closed, the chances for recovery are improved. The absence of any indication of even average recruitment since the 1990 year-class is a source of concern. The fishery should remain closed until there is an indication of sufficient recruitment to rebuild the spawning and fishable biomasses.

Research Recommendations

1. Investigate the survey data series for evidence of decreased survivorship of cod in recent years.
2. Estimate the number of 4T fish in 4Vs.

References

- Campana, S.E., and J.A. Gagne. 1994. Differentiation of 4T and 4Vs cod using otolith elemental fingerprints. *Atl. Fish. Res. Doc.* 94/27: 14 p.
- Drinkwater, K.F. 1994. Environment-4VsW cod recruitment relationships. *Atl. Fish. Res. Doc.* 94/63: 9 p.
- Mohn, R.K., and W.D. Bowen. 1994. A model of grey seal predation on 4VsW cod and its effects on the dynamics and potential yield of cod. *Atl. Fish. Res. Doc.* 94/64: 43 p.
- Mohn, R.K., and W.J. MacEachern. 1994. Assessment of 4VsW cod in 1993. *Atl. Fish. Res. Doc.* 94/40: 37 p.

Summary of Status of Southern Scotian Shelf and Bay of Fundy Cod

- * Landings in 1993 of 16,000t are the lowest since 1969. The majority of the reduction has been in the eastern part of the management unit with landings from the Browns Bank and Bay of Fundy areas being more stable.
- * The proportion of 3 year olds in the 1993 landings (i.e., the 1990 year-class) was higher than forecast, while fewer cod than expected were caught of the strong 1987 year-class.
- * There has been no persistent temporal trend in mean weight at age 5.
- * Commercial catch rates for tonnage class 2 and 3 otter trawlers and longliners indicate a declining trend since 1990. The rate of decline, however, is influenced by changes in fishing practices induced by regulatory changes (ITQs and trip limits).
- * The 1993 summer research vessel survey indicates a sharp decline in spawning stock biomass. Consistent with the geographic pattern in landings, the declines are more marked in the eastern part of the management unit. The surveys indicate that the 1988 year-class is very poor, with the 1989 and 1990 year-classes being about average.
- * The assessment estimates that the cycles in spawning stock biomass are of progressively shorter periods, with an overall declining trend in spawning stock biomass with time. The 1994 beginning of year biomass has increased slightly from the historically low level of 1993. This increase is due to the growth in biomass of the moderate sized 1990 year-class which is entering the spawning stock.
- * Fishing mortality has increased sharply since 1989, and has been well above twice $F_{0.1}$ from 1990 to 1993. While there was a moderate reduction in fishing mortality, analysis of catch and effort information indicates that the 1993 reduction in quota did not result in a significant reduction in fishing effort in 4X.
- * The assessment indicates that the frequency of good year-classes has declined in the 1980s compared to those estimated for the 1970s. The 1990 year-class which is presently supporting the fishery is of moderate size.
- * If the TAC of 13,000t is taken in 1994, the fishing mortality on older ages (5+) will be about 0.6.
- * The yield for 1995 at $F_{0.1}$ (0.2) would be about 6,300t. This assessment has been characterized by a retrospective pattern where successive estimates have been lower by about 25%. A catch of about 4,400t in 1995 would more closely approximate the $F_{0.1}$ catch that would be calculated in retrospect if the pattern persists.
- * Spawning stock biomass in 1993 is the lowest recorded, and other than the moderate sized 1990 year-class, indications of recruitment are poor. A lower exploitation rate would prolong the contribution of the 1990 year-class to the fishery over the coming years and promote rebuilding of spawning biomass.

**Southern Scotian Shelf and Bay of Fundy Cod
SUMMARY**

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min. ¹	Med. ¹	Max. ¹
Reference level '000t	13	9	8.2	9	NAND	NAND	8.2 ²	7			
Advised catch '000t	13	9	8	12	20	26					
TAC '000t	17.5	14	12.5	22	26	26	15 ²	13			
Reported landings '000t	19	20	20	24	28 ³	26 ³	16 ³		12.2	21.2	35.5
Unreported catches											
Estimated discards '000t											
Total catches											
Total biomass '000t	62	71	71	75	70	59	54	57	54	79	113
Spawning biomass '000t	42	51	53	64	55	42	36	39	36	60	95
Mean - F (4+)	0.63	0.68	0.45	0.62	0.77	1.05	0.86	0.6	0.27	0.50	1.05
1 = 1948-1992 2 = revised in September 3 = preliminary statistics											

Catches: The 1993 landings declined to 16,000t with most of the decrease occurring in the Scotian Shelf area while smaller decreases were observed in the Bay of Fundy area. Catches have been irregularly cyclical with peaks occurring in 1968, 1982 and 1991.

Data and Assessment: The assessment of the status of the stock was based on calibration of SPA with Canadian summer research survey abundance indices using ADAPT. Survey results showed a marked decline, particularly at older ages, for Division 4X as a whole, however the abundance in the Bay of Fundy area was more stable.

Fishing Mortality: Fishing mortality has generally fluctuated around 0.5 but increased rapidly since 1989 to about 1.0 in 1992 and decreased somewhat in 1993.

Recruitment: The 1985 and 1987 year-classes were the strongest since 1970 and sustained the recent high catches. The 1990 year-class is estimated to be about average and there are no indications of subsequent good recruitment.

Environmental Factors: Water temperatures in the upper 100m declined through the 1980s whereas the deep waters of the eastern Gulf of Maine have remained warm since 1970. Bottom temperatures within the shallow bank strata on the Scotian Shelf reflect the cooling trend.

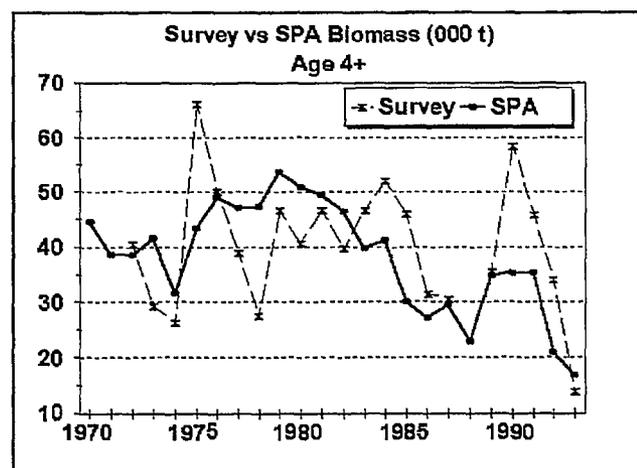
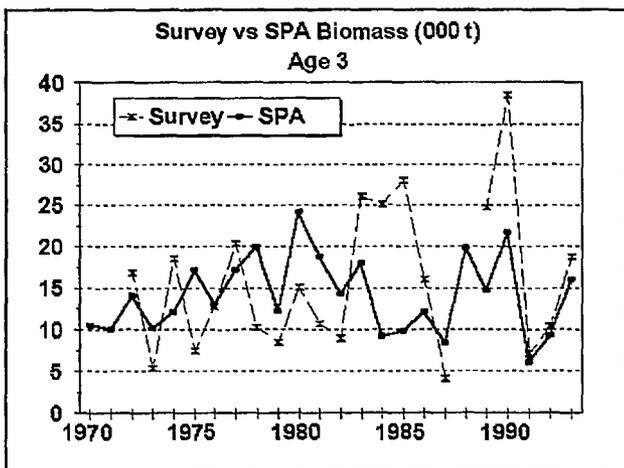
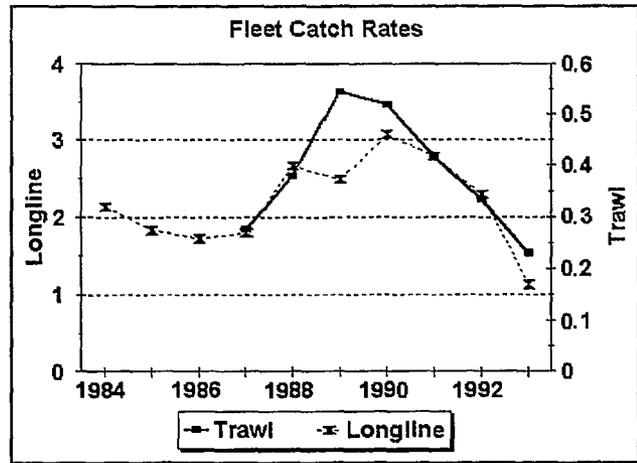
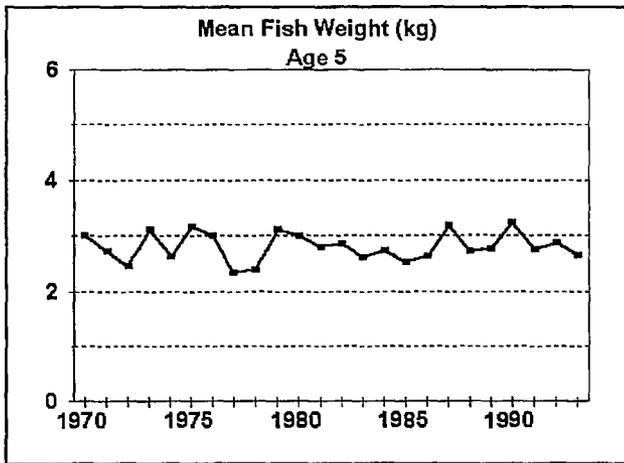
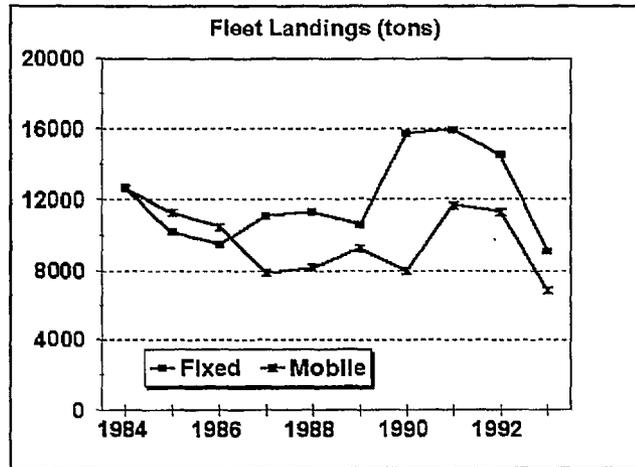
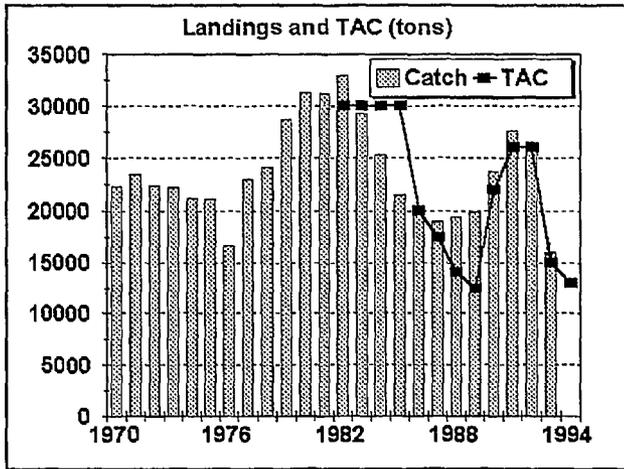
Multispecies Considerations: The distribution of herring, a common prey species, has displayed some unusual patterns in 1993, in that herring did not spawn in the traditional areas off southwest Nova Scotia.

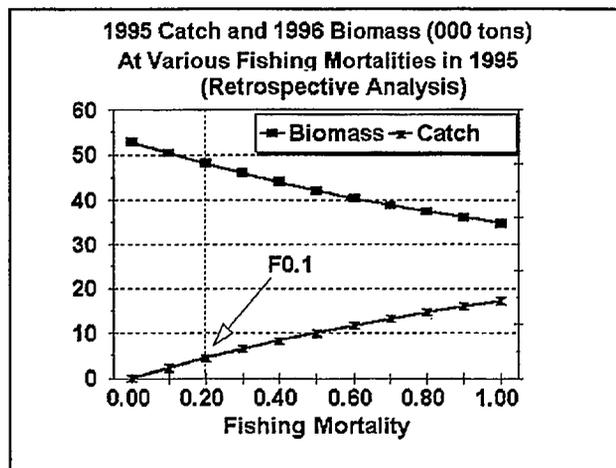
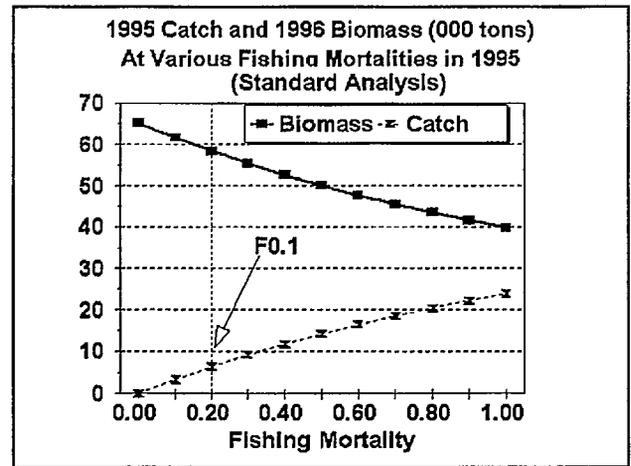
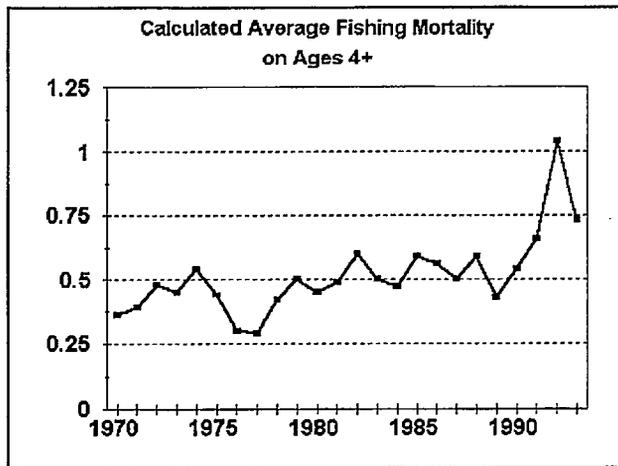
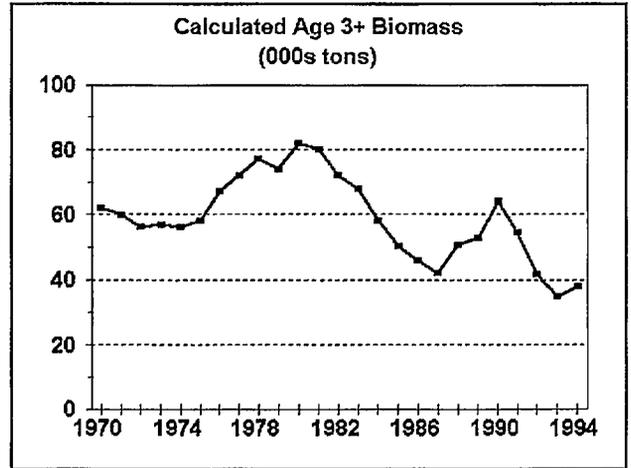
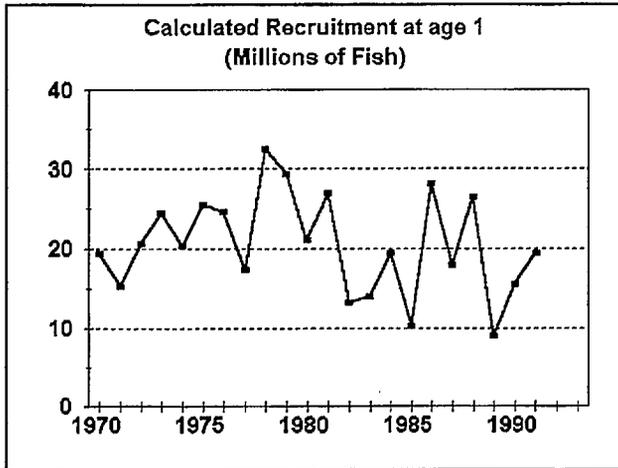
State of the Stock: The stock has decreased to its lowest abundance but the decline appears to have been arrested by the recruitment of the 1990 year-class which is estimated to be of average strength.

Forecast for 1995: The TAC of 13,000t in 1994 will result in a fully recruited fishing mortality of about 0.6, exceeding twice $F_{0.1}$. The yield for 1995 at $F_{0.1}$ would be about 6,300t. This stock assessment has displayed a retrospective pattern where successive estimates have been lower by about 25%. A catch of about 4,400t in 1995 would more closely approximate the $F_{0.1}$ catch that would be calculated in retrospect if the same pattern persists.

Long-term Prospects: The stock has shown irregular cyclical fluctuations in population abundance but the peaks have been getting progressively smaller and more peaked reflecting a contraction in the age span and an increased reliance on recruitment. Greater stability and dampening of natural fluctuations requires a lower exploitation rate and rebuilding of the adult stock biomass.

Special Comment:



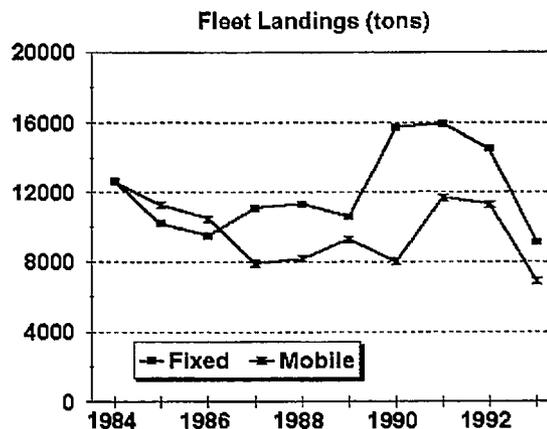
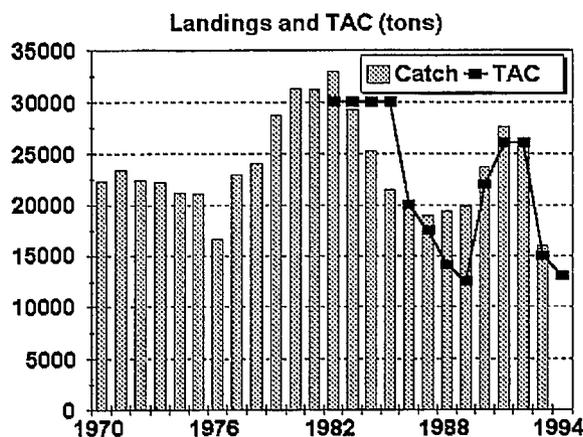


Technical Basis of the Assessment of Cod in Division 4X

Description of the Fishery

Nominal Catches

Landings of cod from Division 4X averaged about 15,000t between 1947 and 1961. With increased exploitation on the offshore banks, landings increased to a maximum of about 35,500t in 1968. Since 1969, landings have varied from a high of 33,000t to the low of 16,000t reached in 1993.



Fish Distribution

In recent years the fishery has occurred year round with highest catches during June and July and is prosecuted primarily by otter trawlers less than 65 ft and by longliners less than 45 ft. The majority of the decrease in landings during 1993 has come from the Scotian Shelf, predominantly unit area 4Xo, while landings from the Browns Bank and Bay of Fundy areas have not dropped as markedly. Mis-reporting by area and species has been considered a problem in the past but reported landings since 1990 are considered to be more accurate due to introduction of mandatory weigh-outs. Dragger fishermen from the Bay of Fundy area commented that the winter-spring fishery in 1994 showed signs of improvement.

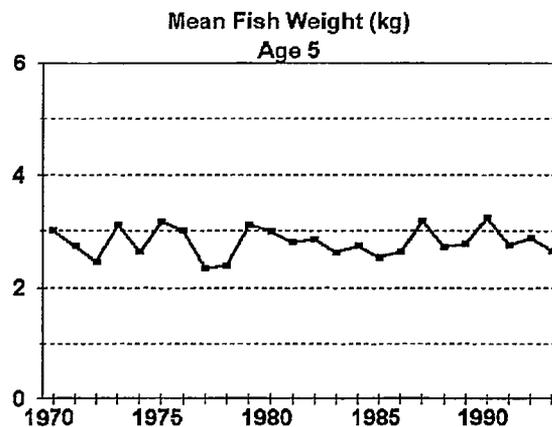
Environmental Conditions

Water temperatures in Div. 4X in the upper 100m, with the exception of the very near surface, declined throughout the 1980s whereas those within the deep waters of the eastern Gulf of Maine have remained relatively warm and stable since 1970. These conditions are reflected in the near-bottom temperatures observed during the summer research vessel surveys. The aggregated temperatures have been relatively stable during the complete 1970-93 period of the survey, indicating that waters suitable for cod have been available. However, the spatial distribution of these temperatures has changed. The temperatures within the shallow bank strata have declined in accordance with the regional 100m climate trend and those in the shallow Bay of Fundy strata declined during the 1985-1992 period. Temperatures within the deeper strata remained relatively warm and stable throughout the survey series.

Available Data

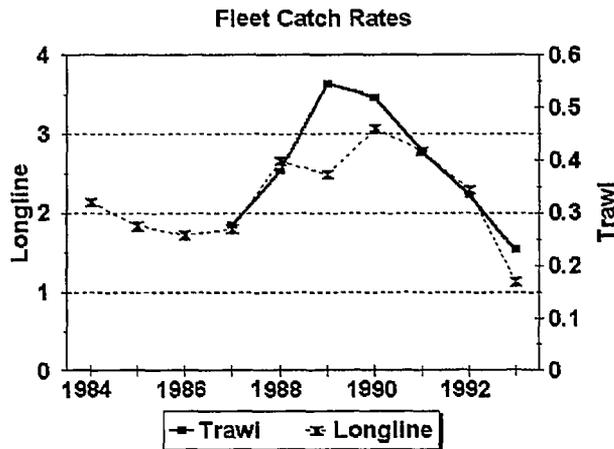
Catch and Weights at Age

The catch numbers at age for 1993 were based on 91 samples and were aggregated by gear type and quarter as has been done in recent years. The 1990 year-class, and to a lesser extent the 1989 year-class, with mean lengths of 51 and 55 cm respectively, were predominant in both otter trawl and longline catches. Fishermen from the dragger fleet commented that the bulk of the cod were between 50 and 60 cm while acknowledging the lack of steakers typically caught on the back of Browns Bank in mid-February. Port samplers also reported that fish from the shallow banks of 4Xn were smaller than those from the deep basins of 4Xo. The proportion of 2 and 3 year olds, the 1990 and 1991 year-classes, were high in comparison with the long term mean while the proportion for most other ages, barring the weak 1988 year-class, were similar to the mean. The catch for all ages over 5, particularly the 1987 year-class which has been important in recent years, were lower than was forecast from last year's assessment, with the shortfall in catch being made up by 2 and 3 year old fish. There were no marked changes in average weight at age in recent years.



Commercial Catch Rates

A multiplicative model was used to standardize catch and effort information from the tonnage class 2 and 3 otter trawlers, taking into account vessel, unit area and month effects. The catch rates peaked in 1990, and have declined steadily since then. Fishermen commented that commercial catch rates did not reflect changes in abundance due to several other factors which impact fishery performance. The two key factors identified were the change to square mesh and changes in fishing practices associated with the introduction of individual quotas. Many commented that they no longer targeted for cod and therefore their present catch rates were not comparable to past catch rates. Longline catch per trip from tonnage class 2 and 3 vessels also shows a decline during the early 1990s, but fishermen commented that variation in feeding behaviour over years greatly influences results. Neither catch rate series was used further in the analysis due to uncertainties regarding interpretation of the trends as a reflection of stock abundance.

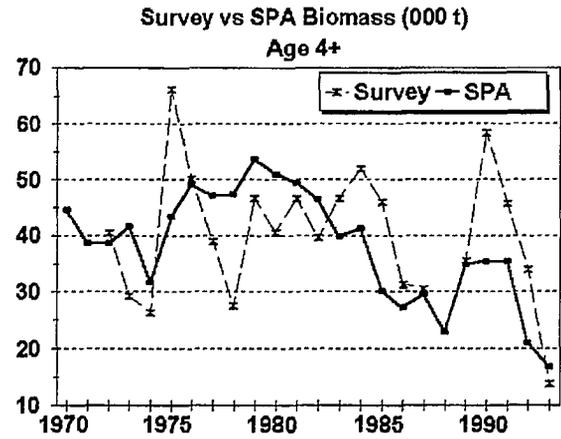
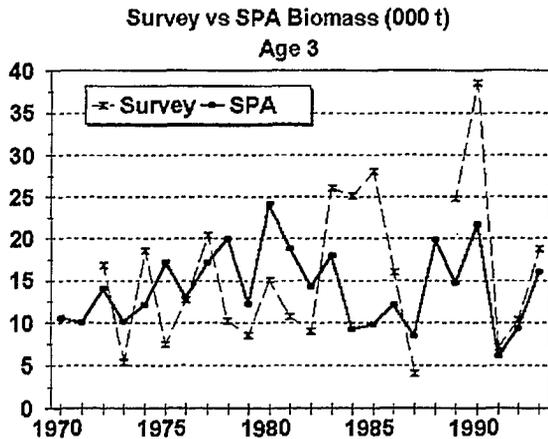


Research Survey Data

Annual stratified random surveys have been conducted during the summer since 1970. The spatial distribution of cod during the 1993 survey was similar to past years, although no areas of high abundance were detected. The 1993 survey results show a marked decline in abundance, particularly at older ages, however the abundance in strata 490 to 495 (Bay of Fundy) has remained relatively stable over the entire time period. The fraction of the total abundance occurring in the Bay of Fundy approached 50% in 1993 while in recent years it has only accounted for about 1/4 to 1/3 of the total. This result is consistent with reports from fishermen that catches have remained relatively good in this area. The 1985 and 1987 year-classes appear as relatively strong and the 1988 year-class as very poor. Indications for the 1989 and 1990 year-classes suggest that they are about average. A large part of Division 4X adjacent to the coast in southwest Nova Scotia, is not surveyed due to operational difficulties with bottom trawling. It is assumed that the proportion of the population occupying this area is constant from year to year. Variations in this proportion may be a contributing factor to the poor relationship between survey results and population abundance at younger ages as significant numbers of small fish are known to occur in these coastal waters.

Estimation of Stock Parameters

The adaptive framework (ADAPT) was used to calibrate the SPA with the research survey results. Population abundance for ages 4-12 at the beginning of 1994 were estimated and the geometric mean year-class strength was assumed for ages 1-3. The summer survey results were compared to average (mid-year) population abundance. Data from 1970 and 1971 were excluded from the analysis because of unusual patterns in the residuals while 1988 data was excluded because catchability at all ages appeared to be anomalously high. While exclusion of the 1970 and 1971 data only impacted estimates of precision, the 1988 data were influential points and their exclusion affected population abundance estimates. The estimates obtained when excluding the 1988 data were considered more appropriate. Statistical error in the survey data was assumed to be independent and identically distributed after taking logarithms and the error in the catch at age was assumed negligible. The fishing mortality rate for age 12 was calculated as the average for ages 5-7 in the same year. The relative error and bias indicate that there is substantial uncertainty in the estimates reflecting the magnitude of deviations between the population results and the abundance index.

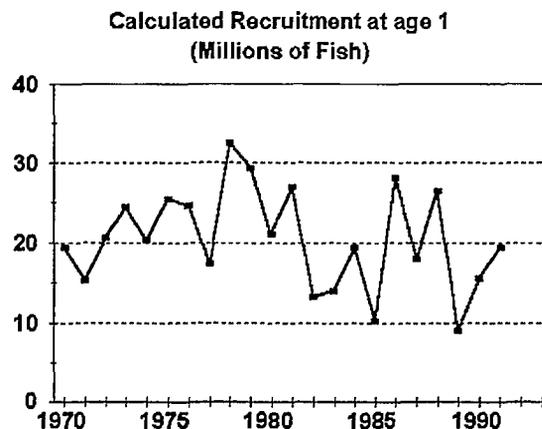


For each cohort, the terminal population abundance estimates were adjusted for bias and used to construct the history of stock status. This approach, in the absence of unbiased point estimators with well determined statistical properties, was considered more appropriate than using the biased point estimates.

Assessment Results

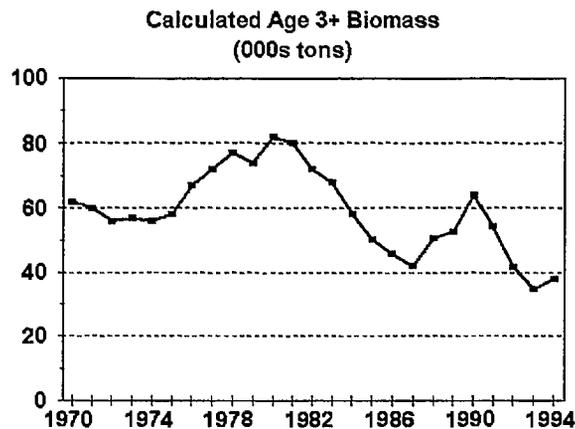
Recruitment

The analysis indicates that the 1985 and 1987 year-classes were among the most abundant since 1970 and the 1990 year-class is about average. Excluding these, recruitment during the 1980s was generally lower than recruitment in the 1970s.



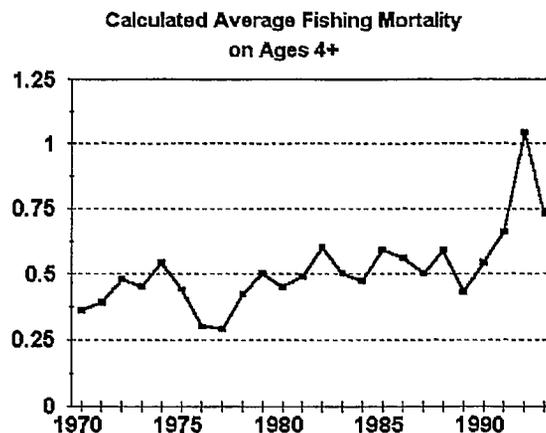
Population Biomass

The beginning of year population biomass for ages 3 and older is showing a slight increase after declining rapidly from a peak in 1990 to the lowest level in the time series. It is noteworthy that the peak during the early 1980s was sustained for a longer period corresponding to the generally better recruitment, while the peak in 1990 which was due almost entirely to the 1985 and 1987 year-classes was of short duration. Although the commercial catch rates were not used for calibration, the trends they showed were consistent with the assessment results.



Fishing Mortality

The total fishing mortality rate for ages 4 and older, which generally fluctuated about 0.5, increased rapidly since 1989 to about 1.0 in 1992 and declined somewhat in 1993. Recent fishing mortality exceeds twice $F_{0.1}$ and has likely resulted in lost yield due to capture of fish before their full growth potential has been realized. This also indicates that catch rates have been substantially lower than that which could be achieved at $F_{0.1}$. The estimate of F for 1992 from this assessment was higher than that obtained from last year's assessment.

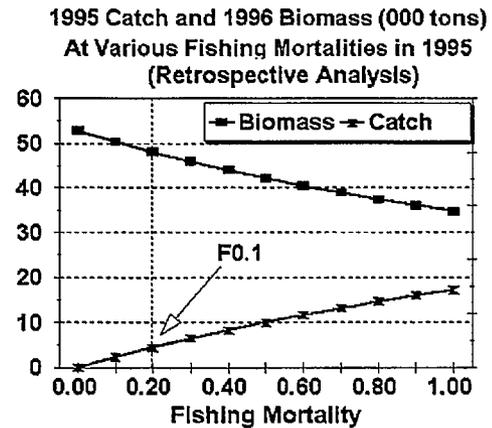
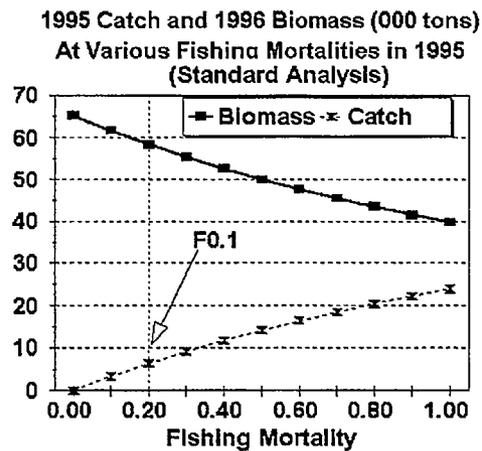


Prognosis

As with population abundance estimates, the adjustment for bias was considered more appropriate than using the biased point estimate. Due to a lack of reliable abundance indices for younger ages, the abundance of incoming year-classes (ages 1-3) were assumed to be about equal to the long term geometric mean. The partial recruitment in recent years has been variable, however, the average for 1991-93 was roughly equal to the values used in last years assessment. Projections, therefore, were done using the estimated population abundance at the beginning of 1994, the average for 1991-93 for weight at age and the same partial recruitment as was used last year.

Age	1994 Population numbers (thousands)	Weight(kg)		Partial Recruitment
		Avg. for year	Beg. of year	
1	20000	0.50	0.41	0.00
2	16000	0.84	0.64	0.05
3	12000	1.36	1.15	0.35
4	7368	1.87	1.56	0.75
5	2237	2.69	2.29	1.00
6	136	3.86	3.31	1.00
7	534	5.23	4.48	1.00
8	60	7.09	6.03	1.00
9	224	9.23	8.05	1.00
10	117	12.26	10.67	1.00
11	70	14.05	13.39	1.00
12	1	15.98	15.01	1.00
13	0		17.10	

If the TAC of 13,000t is taken in 1994, the resulting fully recruited fishing mortality would be about 0.57 and the beginning of year 1995 biomass for ages 3 and older would increase to 58,000t. The yield for 1995 at $F_{0.1}$ would be about 6,300t.



A typical retrospective pattern is evident for this stock. Population abundance estimates from successive assessments are generally lower than previous estimates by about 25% for ages 3 and older. Adjusting population abundance estimates to account for the retrospective pattern indicates that a catch of 4,400t in 1995 would more closely approximate the $F_{0.1}$ catch that will be obtained retrospectively in subsequent years.

Beginning of year biomass for ages 3 and older had fluctuated between about 50,000t and 80,000t since 1970 and it is currently at the lowest level, about 40,000t. Recent fishing mortality rates imply a loss in yield due to growth overfishing and significantly lower catch rates than could be realized at $F_{0.1}$. With no indication of good recruitment following the 1990 year-class, a lower fishing mortality rate would distribute the available yield over more years.

Certain sectors of the commercial fishery are landing a higher proportion of small cod. Small fish made up a higher proportion of the long line and hand line catches. The EA trawlers also landed somewhat more small fish than the ITQ draggers. These differences may be partially a result of different geographical distributions among fleets. Recent studies indicated that size selection for longline depended on both the hook size and the size of bait used.

Research Recommendations

1. Develop objective criteria for the exclusion of survey observation presently considered anomalous (i.e. 1970, 1971, 1980).

References

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

Summary of Status of Georges Bank Cod

- * This management unit is transboundary. The combined USA and Canadian 1993 landings of 13,000t are below the long term average. The Canadian landings in 1993 were 8,519t, well below the allocation of 15,000t. Based on an analysis of logbook information, the number of fishing trips to Georges Bank by both the mobile and fixed gear components (less than 65ft) has not declined in recent years.
- * The Canadian portion of the Georges Bank management unit has been closed to fishing for the first 5 months of 1994. The 1994 Canadian allocation is 6,000t.
- * On average, about 80% of the fishable biomass in the spring and 90% in the fall is located in the Canadian portion of the management unit.
- * Landings in 1993 were dominated by the 1990 year-class which made up 43% (by number) of the reported landings.
- * Commercial catch rates for tonnage class 2 and 3 otter trawlers and longliners have been declining sharply in recent years. Some of the rate of decline may be due to changes in fishing practices induced by regulatory changes (mesh size, ITQs, trip limits).
- * The three research vessel surveys (USA spring and fall, Canadian spring) show similar trends in the 1978 to 1994 time period with the 1993/94 observations at historically low levels. The last strong year-class (1987) has been depleted. The 1990 year-class is estimated to be of moderate size, but subsequent year-classes are below average.
- * The SPA-based assessment indicates that the spawning stock biomass is declining extremely rapidly in the 1990s, presently at the lowest level estimated.
- * Age 3+ fishing mortalities increased sharply since 1989 and have been well above twice $F_{0.1}$ during 1990-1993. Although ITQs are intended to reduce capacity, there has been only a slight decline in fishing mortality since 1990.
- * The assessment estimates that the 1990 year-class is of average size and that subsequent recruitment has been below average.
- * With a Canadian allocation of 6,000t, and expected total landings of 7,500t in 1994, the $F_{0.1}$ (0.2) catch in 1995 would be 1,836t. Restricting the 1994 total landings to the $F_{0.1}$ level of 2,616t, would increase the 1995 $F_{0.1}$ catch to 2,767t.
- * This resource is being exploited at exceptionally high levels and recruitment in the short-term will be below average. Urgent measures to protect the spawning stock are required.

Georges Bank Cod
SUMMARY

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min. ¹	Med. ¹	Max. ¹
Reference level '000t	12.5	9.9	8	8	11-22	15-22	4	3	-	-	-
Advised catch '000t											
TAC '000t	12.5 ²	12.5 ²	8 ²	-	15 ³	15 ³	15 ³	6 ³			
Reported landings '000t	17	21	14	21	20 ⁴	17 ⁴	13 ⁴	-	12	17	26
Unreported catches											
Estimated discards'000t											
Total catches											
Total biomass '000t	51	53	50	51	49	38	26	17	16	47	61
Spawning biomass '000t	26	39	33	43	33	22	21	15	14	33	41
Mean - F (3+)	.44	.53	.36	.51	.75	.69	.64		.34	.52	.76
1 = for 1978-1993 2 = Canadian allocation 3 = Canadian quota in the new management unit 4 = preliminary statistics											

Catches: Landings in 1993 were the lowest since 1978 for the USA, and Canadian landings were the second lowest, next to 1989. The total 1993 landings were 12,538t, the second lowest since 1978. Canadian landings account for about 65% of the total.

Data and Assessment: The 1993 and 1994 Canadian research surveys show a continuing decline. USA spring surveys also show a decline. The USA autumn survey estimate increased slightly in 1992, but is the lowest in the series in 1993. Canadian commercial catch rates show a substantial decline since 1987.

Fishing Mortality: Exploitation rates were above twice $F_{0.1}$ during 1978-1990 and about four times $F_{0.1}$ in 1991. Age 3+ fishing mortality decreased to 3 times $F_{0.1}$ in 1992 and 1993 (0.69 and 0.64, respectively).

Recruitment: Estimates of the 1991 and 1992 year-classes based on research vessel surveys are below average and the 1993 year-class is the lowest observed.

Environmental Factors: Water temperatures in recent years have generally been colder than normal at depths less than 75m. At deeper depths, conditions appear to be warmer than the long-term average.

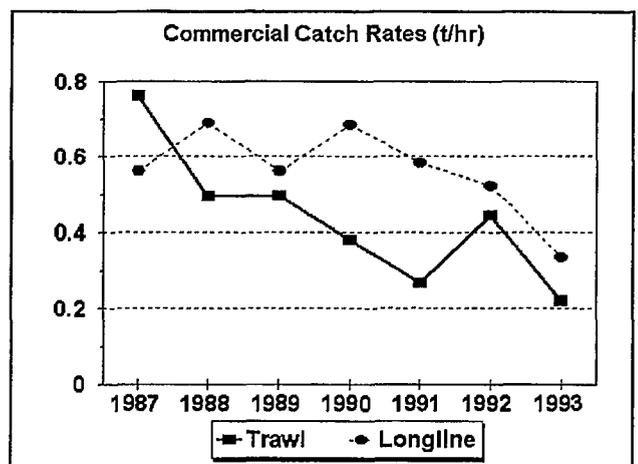
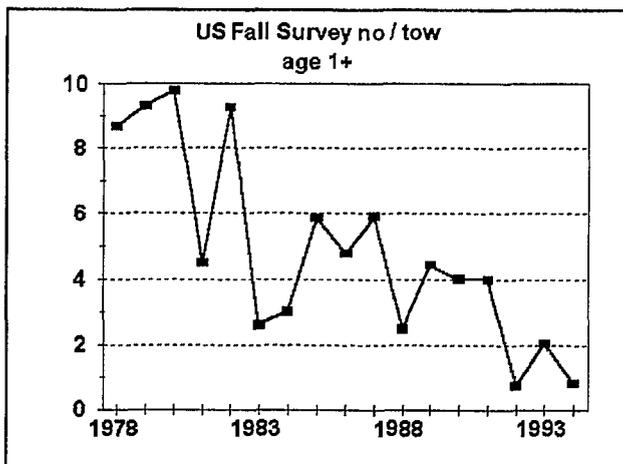
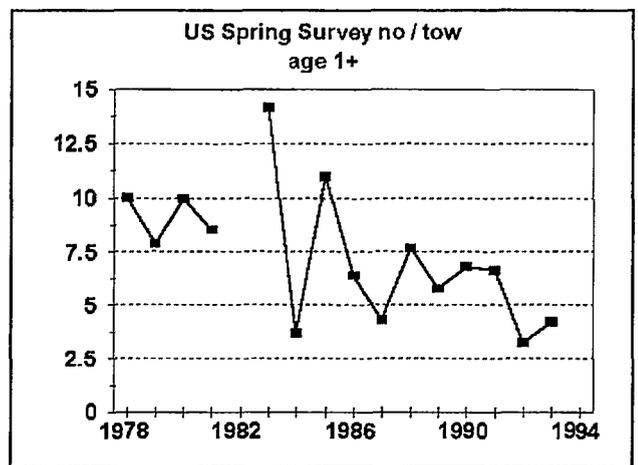
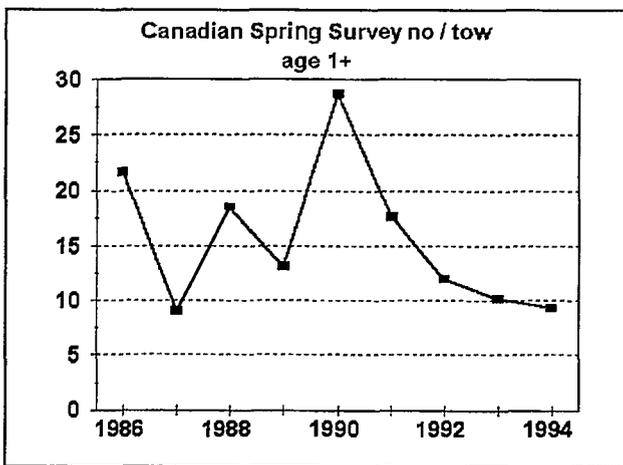
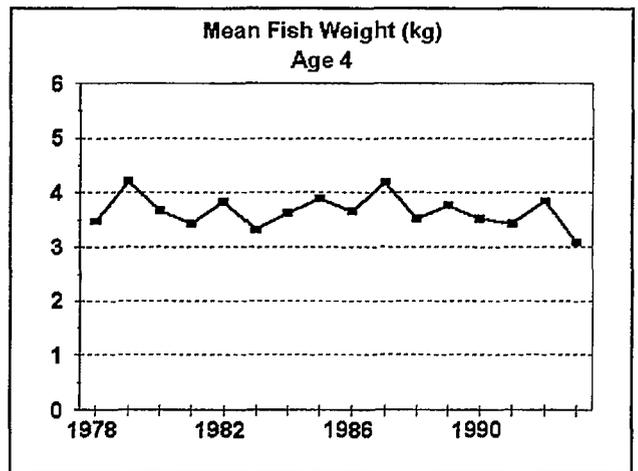
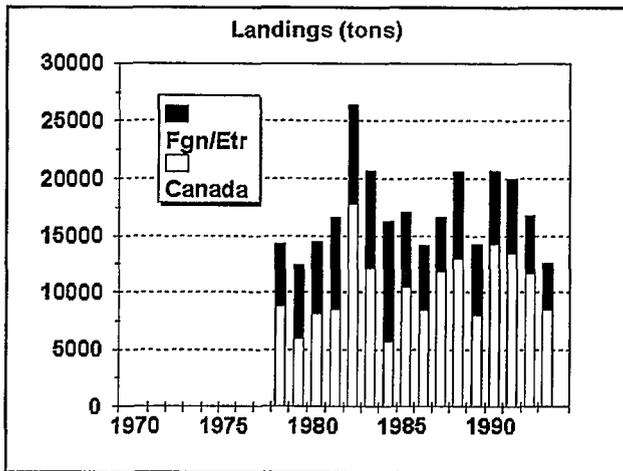
Multispecies Considerations: Available prey species for cod have changed in recent years with the increase in herring abundance and decrease in sand lance abundance.

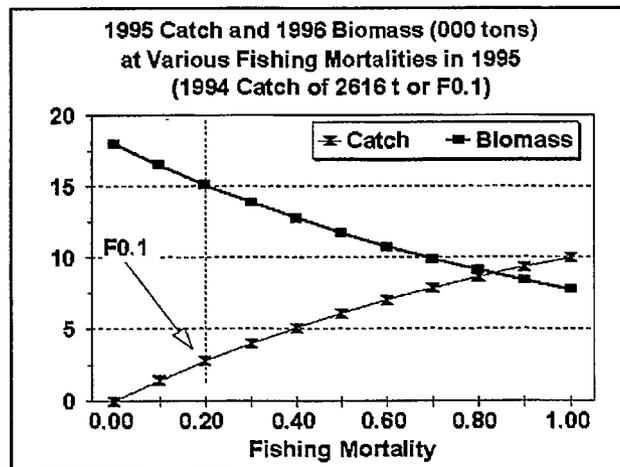
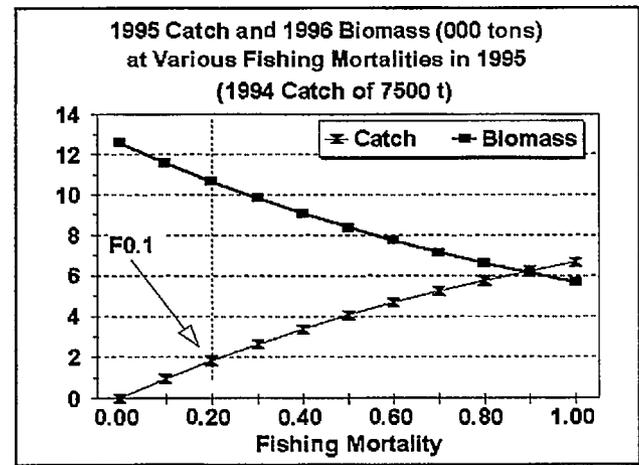
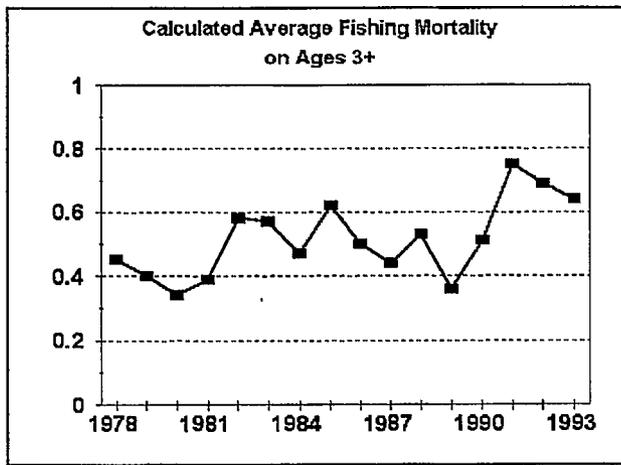
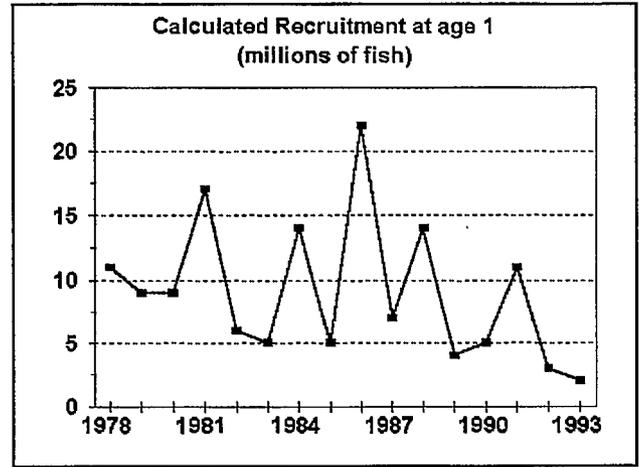
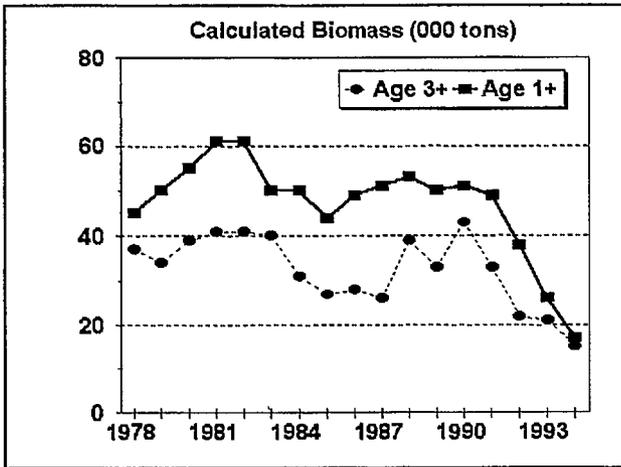
State of the Stock: Total and spawning (3+) biomasses are the lowest observed in the time series which begins in 1978. At about 15,000t in 1994, the 3+ biomass is less than 50% of the long-term average and almost equal to recent landings.

Forecast for 1995: All indications are that this stock has declined substantially since 1990 and that further reductions are expected if fishing continues at the present level. The indications are that the 1991-93 year-classes are well below average abundance and a catch equal to that of recent years will result in a very high exploitation rate of the 1990 year-class (over four times the $F_{0.1}$ reference). This year-class will have to support both the 1994 and 1995 fisheries. $F_{0.1}$ catches in 1994 and 1995 would be around 2,700t.

Long-term Prospects: Sustained stock rebuilding will require consistent management by the USA and Canada. Because of the rapid growth rate of this cod stock, if good recruitment occurs and exploitation is reduced, the biomass could increase rapidly. An immediate and substantial reduction in exploitation is required if the decline in stock biomass is to be slowed or reversed.

Special Comment:





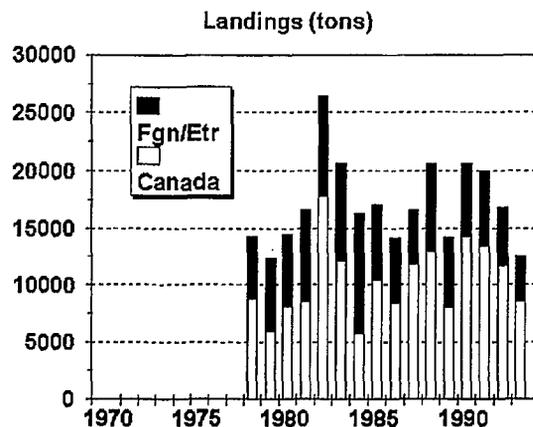
Technical Basis of the Assessment of Georges Bank Cod In Unit Areas 5Zj,m

Description of the Fishery

Nominal Catches

Only landings for the 1978-present time period are used because of mis- and under-reporting and the lack of information on the proportion of foreign catches in 5Zj,m prior to 1978.

Canadian catches of cod are taken on primarily between April and November and have been limited to the Canadian side of the international boundary since 1985. Landings have been dominated by otter trawlers, except in 1984 and since 1989 the proportion of total landings taken by fixed gears (longline and gillnet) have increased. The below average 1989 catch by otter trawlers reflects early closure of the fishery when the combined quota for Div. 4X+5 was exceeded.



In 1990, a 6,000t increase over 1989 in Canadian landings was due to a return to average catches by the OTB fleet and resulted in an overall catch of 14,310t, the second highest in the time series. Canadian landings in 1993 were 8,519t and well below the previous 15 year average (10,543t). USA landings in 1993 were 4,019t, and continue to be below the longterm average. Management of the Canadian fishery has been by individual transferable boat quotas (ITQs) for less than 65' mobile gear since June 1992, EAs for offshore fleets since 1984 and by competitive quota for fixed gears.

Fish Distribution

A study of cod distribution and migration was completed in 1994 (Gavaris et al., 1994) which concluded that substantial seasonal patterns in cod movement exist relative to the 5Zc and 5Zu zones. On average about 70% of the stock is located in the Canadian zone with a higher proportion during the spring/summer period.

Earlier studies, including analyses of tagging and research survey distributions, concluded that cod in the 5Zj,m area could be considered as a stock management unit (Hunt et al., 1989).

A tagging experiment was conducted in March, 1994 and approximately 4000 cod (and 800 haddock) were tagged and released within the 5Zc and 5Zu area. This was a cooperative research initiative with active USA participation and tags had a dual Canada/USA return address. A commercial fisherman also

assisted in the tagging operation. Tag recaptures are expected to provide new information on the movement of cod within the 4X/5Z area.

Industry Consultations

In addition to individual contacts, meetings with industry representatives were held 21 April 1994. Only the <65' mobile gear was represented. There was general agreement on the trends evident in the data presented by DFO although the impact of change to larger and square mesh since 1990 was considered to have had some impact on catch rates. It was also noted that introduction of ITQs probably changed fishing practices in order to meet individual operations objectives. One group of processors and fishing captains provided detailed written comments on their 1993 fishery and concluded that the 1993 cod fishery was an improvement over 1992 in terms of catch. There was a strong recommendation from the ITQ fleet to mandate 140 mm square mesh for the Georges Bank fishery.

Environmental Factors

Environmental conditions in the Georges Bank area during research surveys have not shown any substantial anomalous patterns in recent years. Variation in conditions may be due to the annual variation in the timing of the survey which have a range of about 30 days in the 1987-94 Canadian spring survey.

Multispecies Considerations

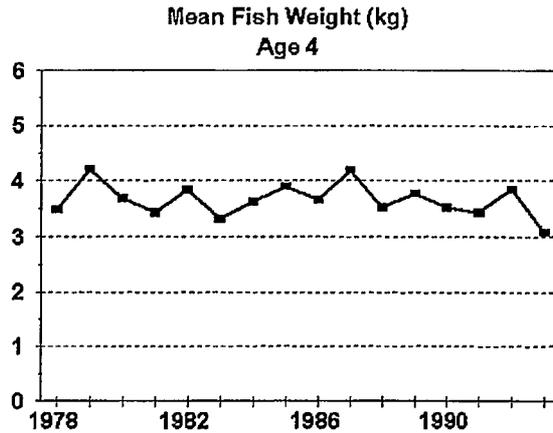
Research surveys as well as observations by fishermen indicate a substantial increase in the abundance of herring on Georges Bank. However, abundance of sand lance, considered by fishermen to be an important prey item for cod, has decline substantially in recent years. Fishermen also reported a high incidence of juvenile haddock in cod stomachs.

Available Data

Catch and Weights at Age

Estimated total removals at age in 1993 indicate that Canadian and USA landings of 5Zj,m cod were dominated by the 1990 year-class (43% by number) at age three in both the Canadian OTB and longliner gear sectors. An analysis of Observer at sea length samples and NSP shorebased samples indicates a similar length distribution for landings and catches with little discarding.

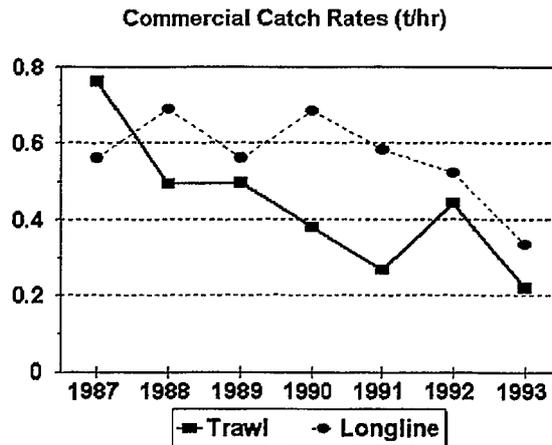
Mean length and weight at age show no trend over the 16 year time series, although mean weights at age in 1993 are below the long-term average, these may be influenced by the change in the 1993 Canadian fishery when first quarter landings were higher than normal. Further investigation of size (and weight) at age trends will be conducted.



Commercial Catch Rates

An analysis of otter trawl and longline gear catch rate was completed using a multiplicative standardization procedure. The analysis used estimates of CPUE derived from directed (cod >50%) trips and tonnage class standardization.

Results for otter trawlers catch rate standardization include over 3000 observations and reported landings in June by tonnage class 3 vessels accounted for the majority of observations. CPUE showed a general decline between 1987 and 1993 and there were significant annual differences. A catch rate at age for otter trawlers was derived by partitioning the total CPUE into the proportional otter trawler catch at age. Very low catch rates at age 1 and age 8 are probably a reflection of partial recruitment to the gear rather than abundance and catch rate at age for these age groups was not considered an index of abundance.

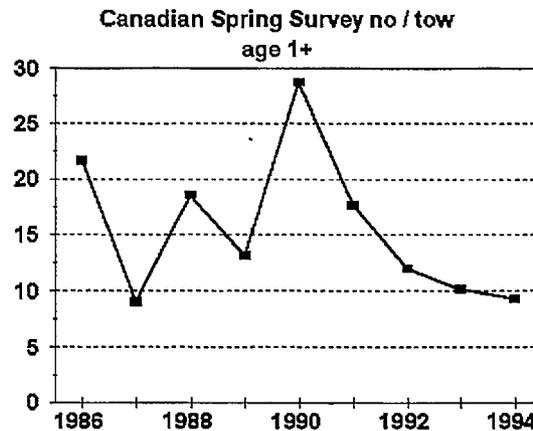


CPUE for longliners appeared to be variable without trend in the 1987-91 time period but showed a substantial decline in 1992 and again in 1993. Interpretation of these data is limited both by changes in measurement and recording of effort and by the low proportion of landings with effort data. Therefore,

longline catch rates were not considered in estimating stock status but further investigation of trends should be pursued.

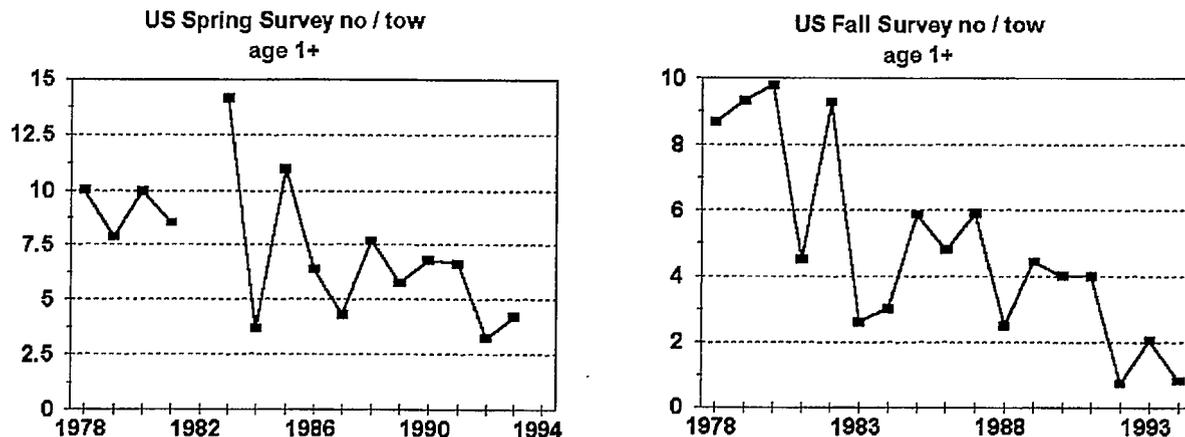
Research Surveys

Bottom trawl research surveys have been conducted by Canada since 1986 and by the USA since the spring of 1968 and the fall of 1963. Vessel and trawl door conversion factors were applied to USA surveys using reported factors. Spring surveys may have been influenced by survey timing in relation to spawning season and associated aggregations. The timing of the Canadian spring survey has varied by about 30 days from its earliest to latest start date.



The 1992-1994 Canadian surveys for ages 1-9 show a marked decline. The 1993 USA spring is at the second lowest observed value. The USA fall survey catch per tow, while showing a slight increase in 1992, is even lower than that seen in 1991. The three surveys for ages 1-9, standardized to their maximum and excluding the USA spring 1982 survey show very similar trends in the 1978-94 time period.

The fall survey is assumed to be a post-fishery index and spring surveys are assumed to be a pre-fishery index. Therefore, the fall survey is lagged by one year for comparison of indices (ie. fall 1977 age 1 vs spring 1978 age 2). In general, all three surveys appear to track year-class strength and provide a consistent index. The 1987 year-class, which had been a substantial factor in 1990-93, appears to be at the end of its contribution. The 1990 year-class also appears to be above the recent average in all three of the 1993 and the 1994 survey, but the 1993 year-class appears to be the lowest in the time series.



Estimation of Stock Parameters

The adaptive framework (Gavaris 1988) was used to calibrate the sequential population analysis with the research survey results. The integrated formulation included spring survey ages 1-8 compared to beginning of year population abundance. Fall survey results for ages 0-7 were compared to beginning of year population abundance in year $t+1$ (ie fall 1977 ages 0-7 compared to 1978 population ages 1-8). The OTB catch rate at age was compared to mid-year population abundance. Natural mortality was assumed equal to 0.2 for all age groups. The fishing mortality rate on age 8 was calculated as the unweighed average for ages 3 to 7 in the same year. Errors in the catch at age were assumed negligible relative to those for the abundance index. The errors for the log transformed abundance index were assumed independent and identically distributed.

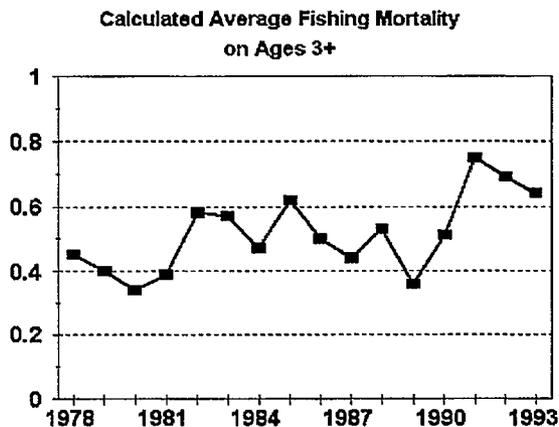
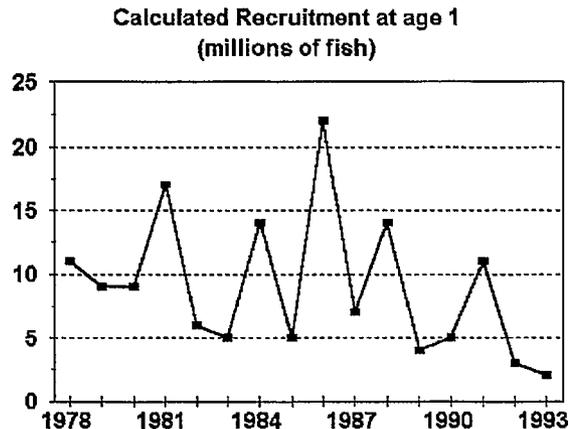
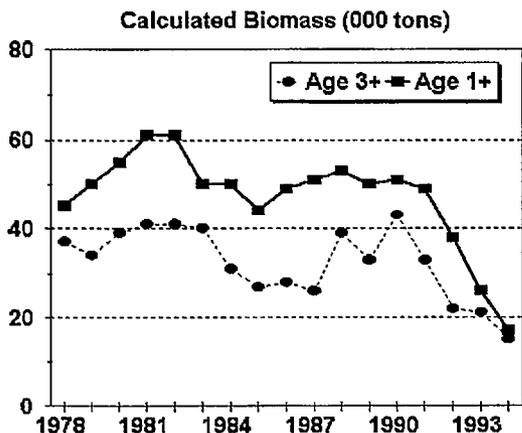
It should be noted that this is the first time the mobile gear catch rate estimate has been included as an index of abundance for 5Zj,m cod. There are some uncertainties about the influence of gear changes and the influence of management controls on interpretation of these catch rates for 1987-present time period. Although, its incorporation in the population status estimates does address the concern expressed by industry that catch rates have not been used as an index of abundance in the past, these uncertainties remain. Inclusion of these catch rates in our model does not substantially change our view of stock status.

Residuals by age for all three surveys and the catch rate appear to be reasonably well balanced and without trend. At age 2 there is no indication of a change in catchability between years in which diamond or square mesh were used. In addition, when this assessment was conducted last year there, was no evidence of a retrospective problem.

Assessment Results

The decline in adult 3+ biomass between 1990 and 1994 is substantial and the estimate in 1994, at 14,481t, is at the lowest observed since 1978 and only one third of the 1990 level. Fishing mortality increased rapidly between 1989 and 1991 to almost four times the $F_{0.1}$. The decline in F for 1992 and 1993 still results in a fishing mortality of over three times $F_{0.1}$. There are a number of concerns about the exploitation rates which this stock has experienced in recent years. There is little doubt that fishing

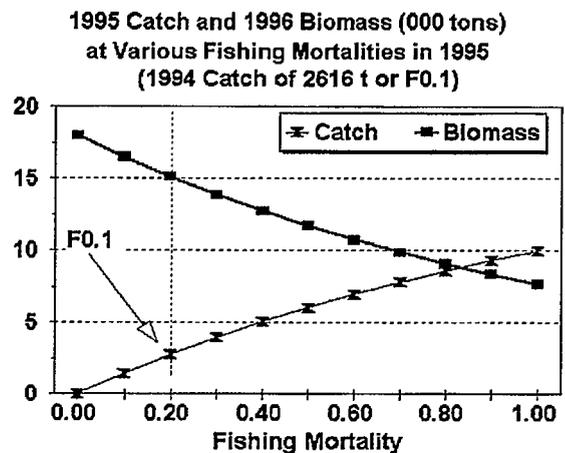
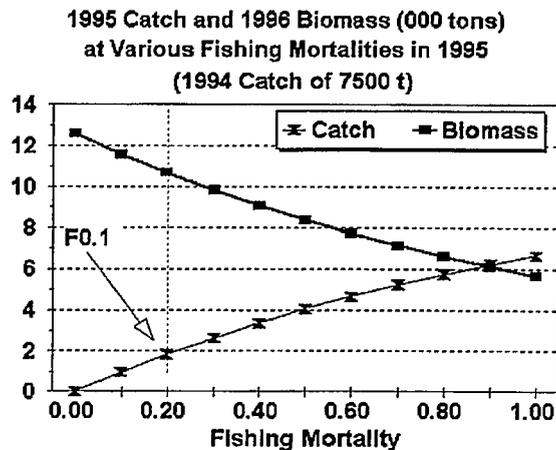
mortalities in the 1990's are well above $F_{0.1}$ and have exceeded F_{max} . The fishery, in particular the mobile gear sector, is largely dependent on recruitment. This can result in substantial mortality at age two and, since fish at this age are up to 50% immature, a loss in spawning potential for recruiting cohorts.



Prognosis

Catch projections were made using the bias-adjusted beginning of year population abundance for 1994 derived from ADAPT. Partial recruitment was derived from the 1978-93 fishing mortality matrix and mean weights at age were the 1978-93 average. Recruitment at age 1 in 1994 was not well estimated from ADAPT and therefore an average value was used. All three survey estimates of the 1993 year-class indicate very low abundance and it would be inappropriate to use the long term average of about 6 million. The geometric mean of the four smallest year-classes (1982, 1988, 1991 and 1992) was 1.6 million and thus was used to reflect the expected low abundance at age one in 1994. Recruitment for 1995 age one was set to 6 million. Inputs for the catch projection are shown below:

Age	Population Numbers (000's) for 1994	Mean Weight (kg)	Partial Recruitment
1	1600	0.74	0.005
2	1214	1.18	0.288
3	1375	1.91	0.700
4	2486	2.94	1
5	344	4.34	1
6	165	5.80	1
7	176	7.41	1
8	42	9.17	1
9+	57	11.12	1



Results of the projection indicate a combined Canada/USA yield of 2,616t in 1994 and 2,767t in 1995 at the $F_{0.1}$ reference level and a slight increase in adult stock biomass in 1995. Partial recruitment at ages 2 and 3 and mean weight at age are lower than those used in the past and may be a reflection of changes in mesh size and the use of square mesh in the OTB fishery. Projected catches in the 1993 Stock Status Report at the $F_{0.1}$ reference level in 1994 were about 4000t.

Landings in 1994 are expected to be less than those in 1993 and the 1994 Canadian management plan has not yet been finalized. Canadian and USA effort in 1994 will likely be similar to that in 1993 and could result in a catch of 7,500t, although the impact of closure of the area for both Canadian and USA fleets until June of 1994 needs to be evaluated. A projection with a 1994 catch of 7,500t was used to estimate the 1995 $F_{0.1}$ reference catch. Catches at the $F_{0.1}$ reference level in 1994 and 1995 were also estimated. Results are summarized below:

Year	Mid-Year 3+ Biomass	Yield 1+	Fishing Moratlity 3+
1994	10866	7500	0.71
1995	9130	1836	0.20
1994	14458	2616	0.20
1995	14802	2767	0.20

Management of this resource in recent years has not been based on recommended catch quotas. Introduction of ITQs in 1992 and 1993 for the OTB fleet may have changed exploitation patterns. In 1993, the OTB fleet was allowed to fish during the spawning season. Exploitation rates have increased and spawning stock biomass (3+) is much lower than the average and is at the lowest level. An immediate and substantial reduction in exploitation rates for both Canada and the USA is required if the stock is to recover to historical levels.

Research Recommendations

1. Develop objective criteria for the exclusion of survey observation presently condiered anomalous.

References

Hunt, J. J., and M.-I. Buzeta. 1994. Biological update of Georges Bank cod in unit areas 5Zj,m for 1978-93. Atl. Fish. Res. Doc. 94/30: 33 p.

Summary of Status of Eastern Scotian Shelf Haddock

- * During 1987-1992, there was a directed fixed gear fishery within the Emerald/Western Banks closed area (to mobile gear). The landings of haddock by other gear sectors were taken as by-catch in other groundfish fisheries. The closed area was expanded to all gear sectors in 1993. The landings in 1993 were 1,300t, the lowest recorded. The majority of the recent landings are from 4V and 4W, with negligible catches in 4T and 4Vn since 1989.
- * The age composition of the landings has not been derived in recent years due to problems with accurate readings of the otoliths. The catches-at-length for 1993 (peak at 42.5 cm) were well below the long-term average (peak at 46.5 cm).
- * Interviews with members of the Fishermen Scientist Research Society indicate that commercial catch rates have declined considerably in recent years.
- * The spring and summer research vessel surveys show that the present geographic distribution of mature fish is more restricted (principally in 4W) compared to earlier time periods. The estimates of spawning stock biomass are at very low levels (comparable to the early 1970s).
- * The survey results indicate that the relatively strong 1988 year-class may have either anomalously slow growth since 1992, or extremely high mortality.
- * There is some evidence that the 1992 and 1993 year-classes are of above average abundance and are broadly distributed.
- * The spawning biomass is very low, concentrated almost entirely in 4W, and is comprised predominantly of the 1988 year-class. Given the severely reduced spawning stock size, the closed area within 4W should be continued and new measures should be taken to protect juveniles in 4V.

**Eastern Scotian Shelf Haddock
SUMMARY**

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min.	Med.	Max.
Reference level '000t	5.1	4.5	6.7	6	- ²	- ²	4-6				
Advised catch '000t	5.1	0	6.7	6	0	0	0	0			
TAC '000t	- ²	- ²	6.7	6	- ²	- ²	- ²		0.0'	2.0'	23.0'
Reported landings '000t	3.9	4.5	9.1	7	5.4 ⁴	6 ⁴	1.3 ⁴		1.3'	11.5'	55.5'
Unreported catches									-		
Estimated discards '000t									-		
Total catches											
Survey #/Tow	30.9	56.2	41.6	42.4	63	28.6	27.7		3.3	34.3	85.5
Survey spawning biomass ³ '000t	19.0	26.4	20.6	15.8	18.6	7.9	7.9		2.2	16.0	30.6
Mean - F											
1 = 1954-1993 3 = assuming knife-edged maturity at 43.0 cm 2 = by-catch only 4 = preliminary statistics											

Catches: Landings averaged 26,500t per year during 1950-1969. The average during 1970-1979 was 5,000t. From 1980-1987 landings ranged from 8,000-20,000t. Since 1987, landings have come from by-catches and restricted fisheries. The 1993 total was about 1,300t.

Data and Assessment: Results of the summer research vessel survey in 1993 show little difference in overall abundance from 1992; however, the spring 1994 survey shows an increase since 1992. The bulk of the stock is concentrated in 4W with abundance in Subdivision 4V presently negligible.

Fishing Mortality: Total mortality is believed to have been high in recent years, but to have decreased in 1993.

Recruitment: The July 1993 survey showed above average catch rates of the 1993 and 1992 year-classes. The March 1994 survey also showed slightly above average catch rates for the 1993 year-class, but not for the 1992 year-class.

Environmental Factors: Bottom water temperatures in large portions of the stock area (4V) have been cold for haddock in recent years. These may have reduced growth rates, caused additional mortality, or migration. By restricting the distribution of the stock, these low temperatures may be resulting in increased fishing mortality by increasing haddock availability, and therefore increasing fishing efficiency.

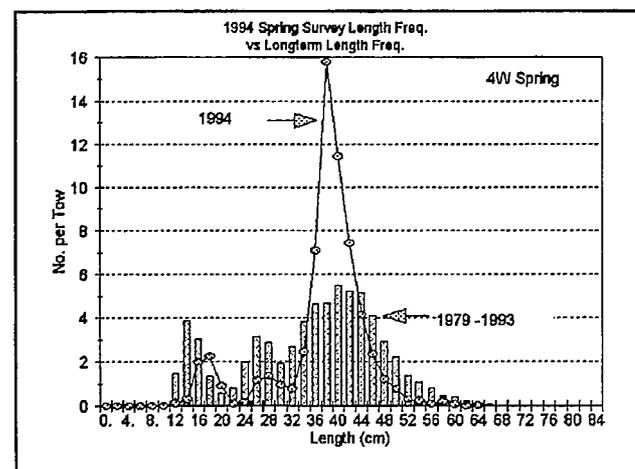
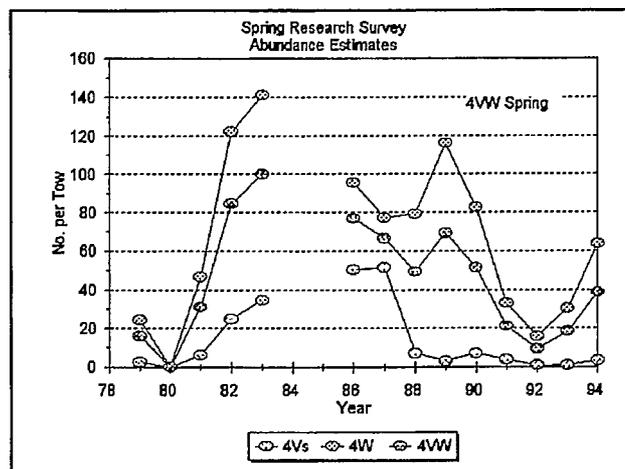
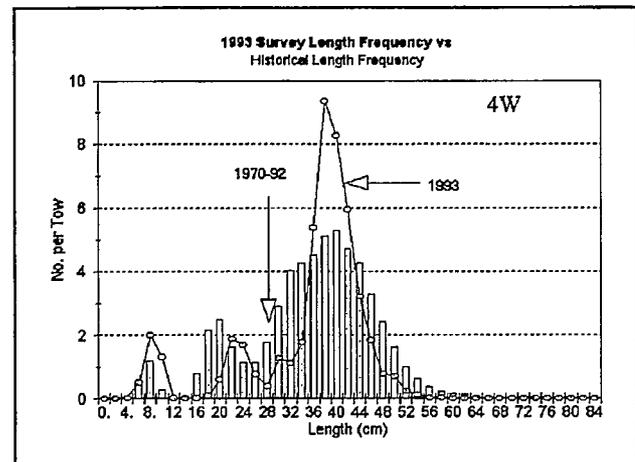
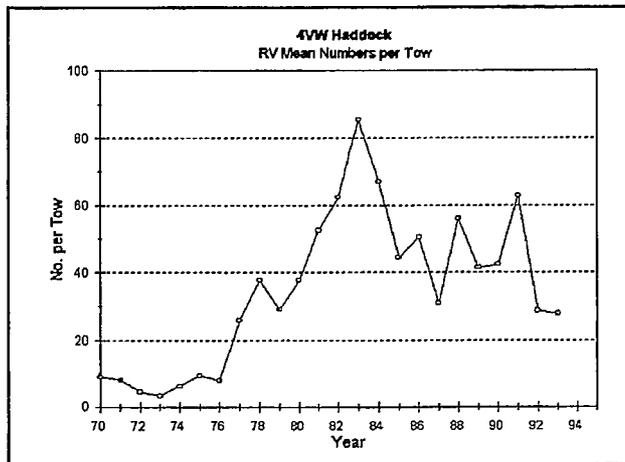
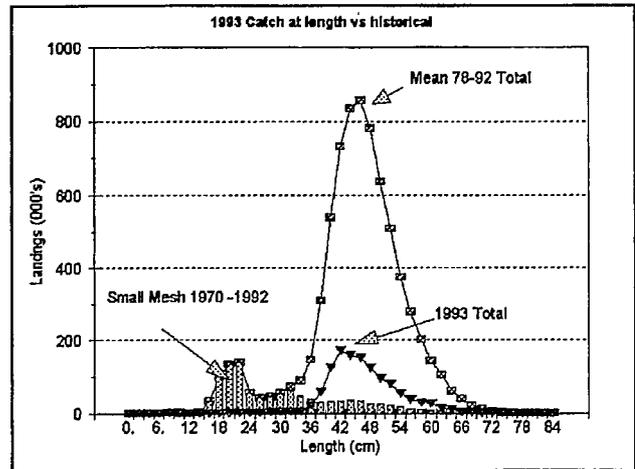
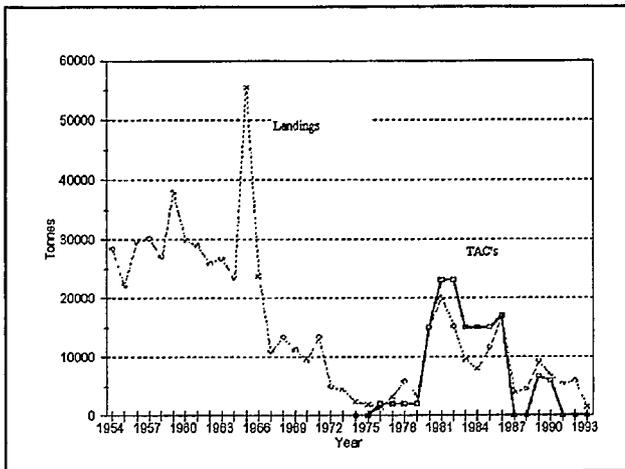
Multispecies Considerations: Grey seal diet analysis show that haddock are not eaten in significant quantities. Haddock continue to be one of the most frequently caught fish during surveys although in amounts below the long-term average.

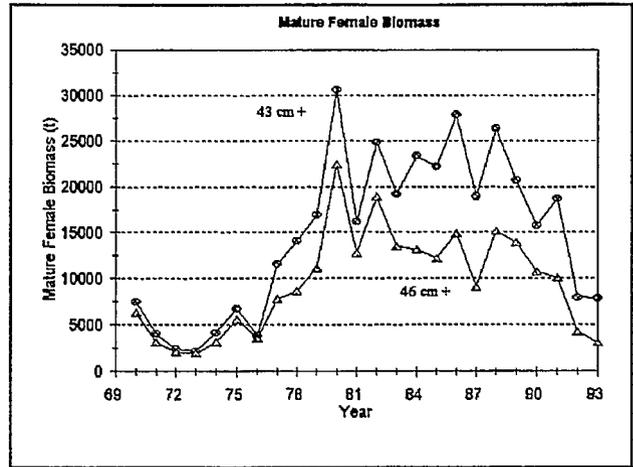
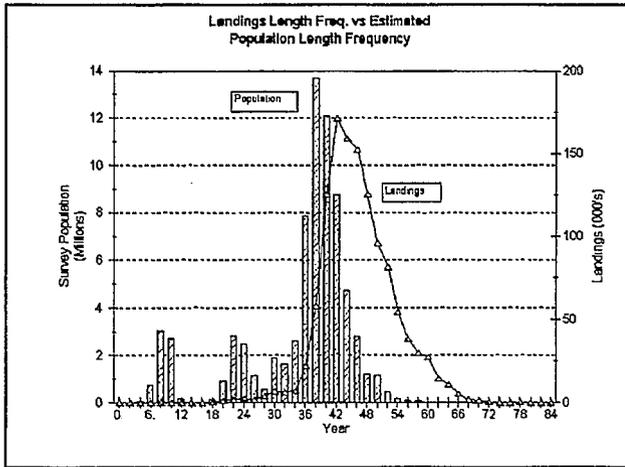
State of the Stock: This stock remains at low abundance with the 1988 year-class probably making up the bulk of the biomass of this resource. There is some indication of the 1993 year-class being of above average abundance.

Forecast for 1995: The 1992 and 1993 year-classes should be protected to allow biomass to increase.

Long-term Prospects: The stock size is lower than those which produced average catches of 25,000t or more per annum in the 1950-1969 period. It is presently not possible to predict whether the stock can rebuild to these levels. The reduction in exploitation as observed in 1993 should allow for more growth of the 1988 year-class and an increased probability of larger future year-classes.

Special Comment: The redefinition of the small mesh gear box should result in a reduced haddock by-catch in the foreign fishery.

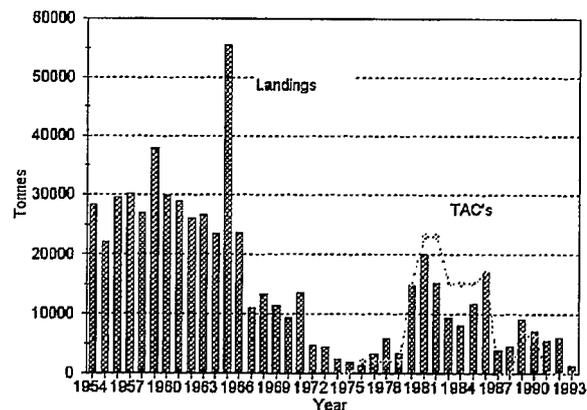




Technical Basis of the Assessment of Haddock in 4TVW

Description of the Fishery

Landings averaged 26,500t per year from 1950 to 1969, 5000t from 1970 to 1979, and ranged between 8000 and 20,000t until 1987. The year-round nursery ground closure (mainly Emerald and Western banks) imposed in 1987 remains in effect to the present. The nominal catches for 1987 through 1992 have been taken mainly as by-catch in other groundfish fisheries operating in divisions 4T, 4V and 4W, except for a directed fixed gear fishery inside the haddock closed area until 1992, and totalled approximately 1,300t in 1993.



In 1993, catches were regulated through by-catch restrictions ranging from 2500 kg trip limits to closure. Throughout the 1987 to 1992 period fixed gear vessels have been allowed to fish inside the closed area. In 1993 the closed area was closed to all fishing.

Until 1984, most of the catch from this stock was taken from Division 4W by large OTBs (TC4 and TC5) in the spring. In 1984, Division 4W was closed to trawlers from May to December to prevent the capture of the abundant early 1980s year-classes. This caused a shift in the fishery to 4Vs. From 1984 to 1986, favourable catch rates resulted in an increase in 4Vs landings to the point where they represented 40-60% of total landings. Following the exclusion of mobile gear from most of Division 4W (as a result of the imposition of the closed area in 1987) landings in 4Vs ranged from 1500 to 2500t annually, however, since 1990 landings in this area have declined to 433t. Since 1987, landings in 4W increased five-fold (from 994 to 5164 t) mainly due to the development of the fixed gear fishery inside the closed area. In 1993, following the exclusion of all gears from the closed area, landings in 4W fell to a total of 770t. Landings in Division 4T and Subdivision 4Vn have been negligible since 1989.

From 1987 to 1992 the proportion of landings taken by trawlers has decreased from 60 to 37%. In 1993 trawler landings represent 30% of the total. Longline landings have ranged from 21 to 63% over the period 1987 to 1992. Longline landings in 1993 accounted for 64% of total landings. Seiner landings represented approximately 4% of total landings in 1993. The most significant change from 1992 to 1993 was the sharp decline in overall landings mainly due to the severe restrictions on fishing activities during the first, second, and fourth quarters of the year.

Sources of Uncertainty

The preceding estimates of landings do not incorporate any estimates of misreporting by area, or non-reporting of catches as a result of dumping or discarding. Unquantified, ancillary information suggests that such practices have been significant sources of error in the landings data at a number of times in the past. Some of these reports indicate that the amount of dumping and discarding would have amounted to a significant portion of the total reported landings. The effects of these potential errors on the assessment of the status of this resource cannot be evaluated.

Information from Industry

Consultation with inshore fishermen in 4W indicate that the inshore haddock landings have declined significantly in recent years. Although a steady decline in landings has been noted over the past 15 to 25 years, a rapid decline in the past 3-7 years has occurred. Also, many individuals have reported a change in the 'migratory pattern' of 'inshore' haddock. In past years haddock would move inshore in waters westward of Country Harbour, N.S. These fish would then 'migrate' westward throughout the remainder of the summer and fall until the fishermen of the area stopped fishing when they reached Halifax Harbour and approaches. More recently it has been reported that haddock are coming inshore further westward each year, and that the numbers caught have declined substantially. All agree that these 'inshore haddock' are different from offshore haddock in terms of colour, shape, taste, and size composition (i.e. larger than offshore). A general lack of biological information of inshore resources makes it difficult to judge the accuracy of these reports. Plans for cooperative work with the inshore industry to determine the relationship between inshore and offshore haddock are underway.

A survey of members of the Fishermen Scientists Research Society also indicated that haddock catch rates in general (divisions 4VW) have declined in the past two years (1992-1993) relative to the two preceding years (1990-1991). Of the 55 members polled, 48 responded, and 92 % indicated a decline in haddock catch rates between these periods, while only 8 % felt that catch rates had increased. Those who felt catch rates had declined said that this decline was on the order of 60%, while those who indicated an increase in catch rates said that this increase was on the order of 30%. When asked whether catch rates for fish under 17 inches had changed between these two periods, 35% indicated an increase while 55% said that this had declined. Fishermen were asked whether they felt the resource had increased, or decreased. Of those indicating an increase the average estimated increase was 32%, while those saying that there had been a decline in the catches of small fish showed a decline of about 50%. A more detailed description of these results are available elsewhere in this report.

Sources of Uncertainty

None of the foregoing discussion is based on detailed examination of recorded information, instead it is based on the memories of the fishermen participants.

Available Data

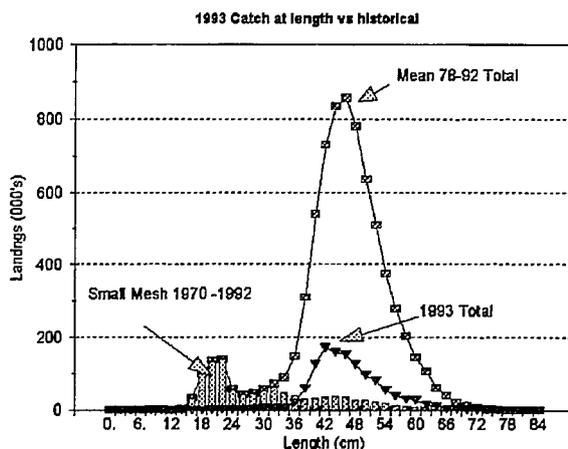
Size Composition of the Catch

The age composition of the 1993 landings is not available because a bias in the ageing of haddock was introduced in the early 1980s. The full extent of the bias has not yet been determined. Work is proceeding to establish satisfactory ageing criteria for this stock.

In the absence of estimates of catch at age, estimates of catch at length were produced for the years 1970-1993. Catch at length for removals by the domestic fisheries was developed using commercial

groundfish samples. Catch at length for the haddock by-catch from the foreign small mesh gear fishery was estimated from International Observer Program data. For catches realized prior to 1977 no IOP estimates of length-frequencies were available, and it was assumed that the length frequency of these catches was similar to that observed by the July RV surveys conducted in 4W in each of those years.

The catch at length for 1993 shows a unimodal distribution centred on 42.5 cm, smaller than the long-term average (46.5 cm). Catches of fish in all length classes were far below the long-term average (1970-1992). A comparison of the length frequencies of haddock caught by longline gear versus those caught by mobile gear show clearly that the fixed gear in 1993 landed more fish in the smaller length classes than did the mobile gear sector.



Sources of Uncertainty

These estimates of catch composition of domestic landings do not take into account any at sea adjustments to the size composition. There have been reports of discarding and high-grading that cannot be quantified. Dumping would tend to result in underestimation of total landings while selective discarding is likely to result in underestimation of removals at the smaller length classes.

Commercial Catch Rates

The restrictive nature of this fishery since 1987 does not allow for a comparison of present catch rates to those of earlier years from directed fisheries. By-catch catch rates are not considered to be representative of the abundance of this stock.

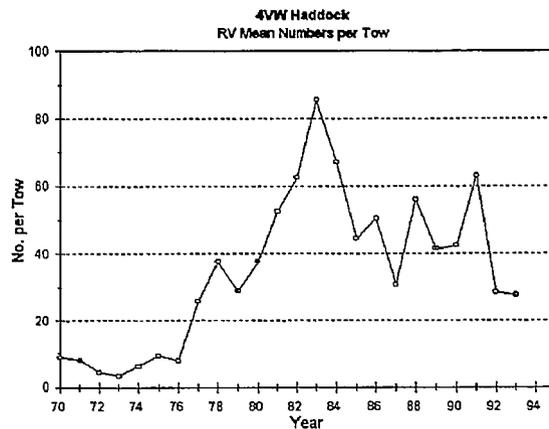
Research Survey Data

Summer Surveys

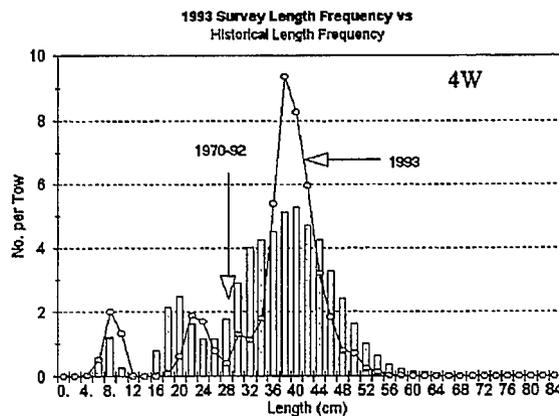
Research survey catch rates show a decline in overall abundance from 1983 to 1987 with a subsequent increase to 1991. Since then catch rates have declined to levels seen during the late 1970s. The distribution of haddock is now centred in Division 4W, similar to the pre-1984 period. Catch rates in subdivisions 4Vn and 4Vs are extremely low.

The long-term mean catch at length of Subdivision 4Vn shows modes at 20.5, 32.5, and 50.5 cm . There is no evidence of the large 1988 year-class in 4Vn. The present catch rate at length in 4Vn is well below the long-term mean.

The long-term mean catch at length in 4Vs shows modes at 16.5, 28.5 and 42.5. Catch rates at age in 1993 were well below the long-term average, except for catch rates with a modal length of 10.5 cm which probably represents the 1993 year-class. This modal length is significantly smaller than usually detected in 4Vs. Since the abundance of small (8.5 cm) haddock does not appear to be well estimated by the summer RV survey it is premature to comment on the relative size of the year-class these fish may represent.



Significantly higher catch rates exist in Division 4W compared to all the other areas in the management unit. Analysis of the catch at length for 4W shows modes at 8.5, 20.5, and 32.5 cm. The modal length of what is believed to be the 1988 year-class is apparent at 38.5 cm, smaller than would be expected based on the expected growth of this cohort. In addition to the 1988 year-class, the 1993 catch rate at length also shows slightly above average modes at 8.5 and 22.5 and 24.5 cm. These modal sizes likely represent the 1993 and 1992 year-classes.



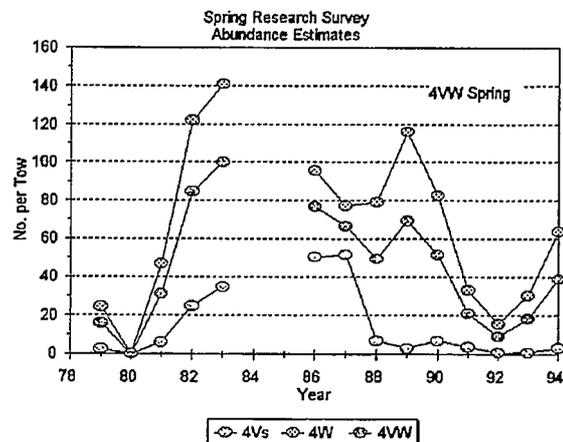
Much of industries' view of the status of this resource is consistent with the groundfish surveys results. Commercial catches of haddock in 4T and 4Vn are almost nil. The exclusion of all gears from the closed area and the closure of the fishery in 1993 has resulted in much reduced catches and decreased the availability of anecdotal information.

Distribution of Haddock from Summer Surveys

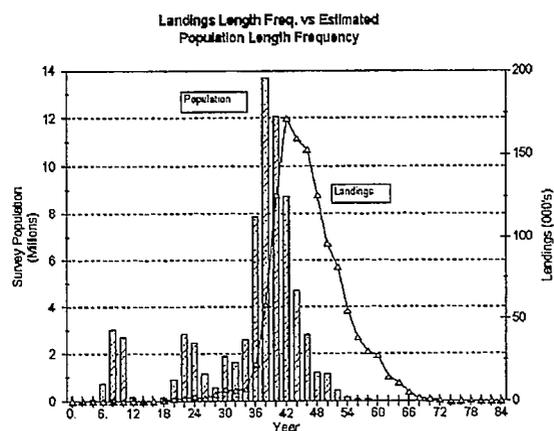
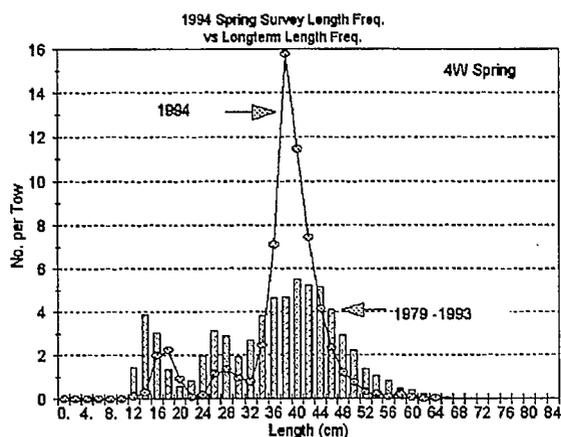
The attached map shows the long-term versus the recent distribution of haddock over the entire stock area. The 1991-1993 data are plotted as expanding symbols on the contoured data (1970-1990). The most obvious feature of this figure is the relative absence of haddock in 4V in the last few years. In 4W the areas of concentration in the recent period are no different from the areas of concentration over the long-term.

Spring Surveys

Spring surveys have been conducted annually on the eastern Scotian Shelf during March since 1979. Recent catch rates reached a low in 1992. The results of the 1993 and 1994 surveys indicate an increase relative to 1992.



The long-term spring survey catch rate at length in Division 4W shows modes at 14.5 and 26.5 cm. The 1994 results show the 1988 year-class at a modal length of 38.5 cm, these fish had a modal length of 38.5 cm in the July survey. There are two likely explanations for this observation, 1) that there has been no growth of these fish over the fall and winter of 1993/1994, 2) that rates of mortality are very high for fish of lengths in excess of 38.5 cm. We cannot at present distinguish between the two. The March 1994 survey shows above average catch rates at 18.5 cm which were preceded by a somewhat above average catch at 8.5 cm in July of 1993.



The long-term mean catch at length for 4Vs shows distinct modes at 14.5 and 24.5 cm. The 1994 results show catches at all lengths (except 18.5 cm) well below the mean. The peak at 18.5 cm as in 4W was preceded by an above average catch rate at 8.5 cm in the July 1993 survey.

Environmental Influences on Survey Results

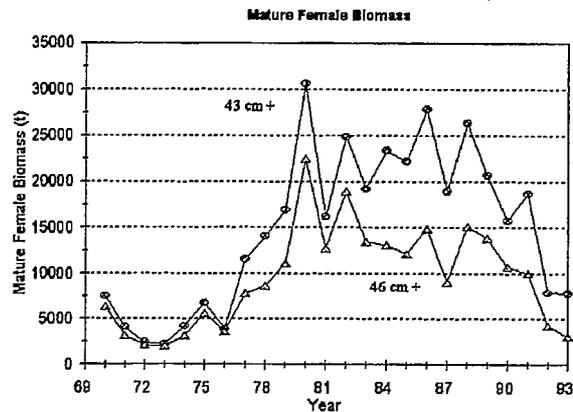
Recent studies have shown that haddock in the research surveys are associated with warm water over all seasons and areas. In almost all cases this 'preferred' water was greater than or equal to 2°C. Trends in the proportion of bottom water that was greater or equal to 2°C as seen by the survey were presented for the key strata for haddock in the 4V and 4W areas for the spring and summer surveys. There has been a decline in the proportion of the 'preferred' bottom water in 4V in spring and summer since 1985 which is coincident with the decline in the haddock survey abundance indices. Haddock in 4V in both seasons have been found in much deeper water than expected since 1987. Temperatures have been consistently warmer in 4W and neither the proportion of preferred bottom water nor the survey abundance indices have shown any trends since 1985 in the summer survey, with the exception of the Middle Bank area. In the Middle Bank area temperatures, the proportion of preferred bottom water and the survey abundance index have been decreasing since 1985-1986. Recent declines in the survey index for 4W for the spring survey follow similar decreases in the amount of preferred bottom water available. It should be noted that these results describe changes in distribution of haddock, but that the estimates of abundance remain unbiased.

Estimation of Stock Parameters

In the absence of reliable age-structured information on either the removals from the stock or the stock in general, fishing mortalities are presently more difficult to estimate than has been the case in the past. The results of both the summer and spring surveys indicate that haddock are at low abundance relative to the long-term mean, particularly larger (presumably older fish) haddock which are relatively rare at present. The stock is now concentrated almost entirely in Division 4W and it appears to be comprised of a single (1988) year-class.

Examination of the commercial catch at length for 1993 shows that significant numbers of fish were caught at sizes less than 42 cm; and that landings were well below the long-term average. A comparison of the length composition of removals to the overall length composition of the population

shows that the fishery is exploiting the least abundant length classes in the population.



The catches at length were converted to estimates of catch at age using as input the mean lengths at age from all available July RV aged haddock. This assumes that the ages of the historical data were correctly assigned and ignores the potential bias alluded to earlier. The potential problems with the growth model employed results in significant uncertainties associated with the results presented below. In spite of these differences the estimated catch at length and the survey catch rates at length were used as input to two minimization models, one using a gradient method (Marquardt) and the other using a partitioned search algorithm. The model formulations were as follows for each analysis.

Population abundance for "ages" 3-6 at the beginning of 1993 were estimated and partial selections were fixed for "ages 1, 2, and 7" in 1993. The July survey results were compared to mid-year population abundance. Statistical errors in survey estimates were assumed to be independent and identically distributed after logarithms transformation. Error in the catch at length was assumed to be negligible. The fishing mortality (F) for age 7 was calculated as the average of the F for ages 3-6 in the same year. Natural mortality was assumed to be 0.2.

Using the partitioned search algorithm resulted in the relationship between the RV index and estimated populations as shown in the graph above. Removing years successively from 1970 to 1984 results in the decline in overall residuals with apparently abrupt changes in the rate of change in the reduction of the sum of squared residuals in 1974 and 1977. Estimates of K at age for these successive runs showed a monotonic increase over the time series. A decision was made to use only those data from 1977 to 1993, because this is where the change in the sum of squared residuals from the models appears to level off and, it is the year where the composition of the fishing fleet changed significantly due to the exclusion of the foreign fleet.

The results of the partitioned search using this data series indicate a fishing mortality of about 0.2 on fully recruited ages in 1993. These analyses used an iterated selection vector which shows a decline in partial selection at ages beyond 5.

These results give reasonable estimates of F in 1993 in that they show much lower values with about 20% of the 1992 landings. It does not however, result in a satisfactory distribution of fish at ages in the estimated population particularly given that it does not track the 1988 year-class. The overall fit of the model is similar to that given above.

Results of these analyses using NLLS depend to some extent on the starting estimates of terminal F provided to the model. The results iterate to approximately the same minimum as that determined through partitioned search only for a single set of input parameters. Overall model fit does not differ significantly from that of partitioned search. Retrospective analysis using NLLS indicates that F in the current year is underestimated relative to the retrospective view.

Given the uncertainties regarding the growth model employed, the monotonic change in K with the inclusion of partial data sets, the overall poor fit of the model, and the lack of concordance between the age structure inferred from surveys and that resulting from these analyses, it remains difficult to interpret the results of these analyses. Further exploration of length-based analyses is planned.

Assessment Results

Spawning Stock Biomass

Earlier assessments of this resource indicated that the probability of producing a large year-class is related to the general level of spawning stock biomass. At a spawning stock biomass below 16,000t the probability of producing an above average year-class is considered low. Assuming a catchability of unity, present female spawning stock biomass as estimated from surveys is on the order of 4,000 - 8,000t. These calculations assume knife-edged maturity at 42.5 - 46.5 cm.

Recruitment

Since the 1988 year-class no large (above average) year-class has entered the population. The 1993 summer survey caught an above average number of fish at or around 8.5 cm which may indicate an above average 1993 year-class, but the abundance at these size classes are generally not well estimated. It also detected fish at above average catch rates at 22.5 and 24.5 cm. The 1994 spring survey detected fish at slightly above average catch rate at a modal length of 18.5 cm (probably age 1), but it is uncertain whether or not it will be estimated as above average in subsequent surveys.

Prognosis

The absence of reliable age-structured data makes it difficult to estimate the rate at which this resource is presently being exploited. There are, however, a number of indicators which would lead to the conclusion that this stock has been heavily exploited in the recent past, that environmental conditions over a significant portion of the stock range has been unfavourable, and that recruitment over the recent past number of years appears to have been below average. There is some indication of an above-average 1993 year-class, based on results from both the July 1993 and March 1994 research vessel surveys. With the exception of the potentially numerous 1993 year-class, our view of this resource has not changed since the last assessment. There is still a relative paucity of fish above lengths of 43 cm, and the remainder of the population is contained in a narrow group of size-classes relative to the long-term size structure of this population.

The reduction in the exploitation of smaller size classes apparently afforded by the closed area should be maintained to ensure the maximum possible contribution of incoming year-classes because at present, both the fishery and the reproductive potential of the stock appear to be dependent on the 1988 year-class.

Research Recommendations

1. Continue to explore length-based assessments method.
2. Investigate the potential of estimating and correcting for the ageing bias introduced in the early 1980s.
3. In future interview-style surveys, investigate use of alternative statistical analyses.
4. Compare observer and port sampling length-frequencies as potential indicators of discarding.

References

- Zwanenburg, K., J. Black, B. Charlton, and G. Young. 1994. Haddock in Division 4TVW. Atl. Fish. Res. Doc.: (in press).

Summary of Status of Southern Scotian Shelf and Bay of Fundy Haddock

- * The 1993 landings of 6,800t are well below the long-term average of about 20,000t. Discarding of haddock was a problem in early 1994 due to an unrealistically low trip limit (200 pound/trip) for the longliners.
- * Due to problems with accurate reading of the otoliths, the age composition of the landings has not been estimated in recent years. There has been an increase in the mean length in the landings of the mobile gear since the introduction of larger square mesh gear and ITQs. Over the same time period, however, there has been a decrease in the mean length in the fixed gear landings.
- * The number of fishing trips by tonnage class 2 and 3 vessels in 4X has not declined in recent years (gradual increase for fixed gear, relative stability for mobile gear).
- * Commercial longliner catch rates from the central part (Browns Bank) of 4X show slight increases during 1989-1993. Anecdotal information from interviews with fishermen indicate stable or increasing levels of fishable biomass.
- * The summer research vessel survey indicates a gradual increase in spawning stock biomass from 1987 to 1991, with a subsequent decline to the lowest recorded estimate in 1993. Analysis of geographic patterns shows that the abundance in the Browns Bank area has been relatively stable until 1992. The recent decreases in abundance has been particularly marked in the eastern portion of 4X and the mouth of the Bay of Fundy. The trends in longliner commercial catch rates and research vessel survey fishable biomass estimates for the predominant fishing area are therefore consistent.
- * The research surveys indicate that the 1992 year-class is either average or above average. This is consistent with the high proportion of the 1992 year-class seen in the foreign silver hake fishery.
- * Given the very low overall estimates of spawning stock biomass within 4X as estimated from the research vessel surveys, as well as the weak 1989, 1990 and 1991 year-classes and the potentially abundant 1992 year-class, fishing effort should not be increased in 1995.
- * Discussions are needed with the fishing industry in order to exchange information on the geographic patterns in commercial and research vessel survey catch rates. It may be that the apparent different viewpoints may be related to geographic differences in haddock abundance trends.

**Southern Scotian Shelf and Bay of Fundy Haddock
SUMMARY**

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min.	Med.	Max.
Reference level '000t	12.3			4.6			3				
Advised catch '000t	12.3	12.0	8.2	<4.6 ¹	^{2,3}	^{2,3}	-	-			
TAC '000t	15	12.4	4.6	4.6	-	-	6	4.5			
Reported landings '000t	13.5	11	6.7	7.6	9.6 ⁴	10.3 ⁴	6.8 ⁴		6.7 ¹	18.5 ¹	35.9 ¹
Unreported catches											
Estimated discards '000t											
Total catches											
Total biomass '000t											
Female spawning biomass '000t	9.5	9.9	6.3	13.7	23.7	13.3	5.0				
Mean - F											
1 = 1948-1993 3 = by-catch only 2 = lowest possible level 4 = preliminary statistics											

Catches: Long-term reported landings (1930-88) have averaged about 20,000t and exceeded 30,000t during the 1960s and early 1980s. Landings have been below the long-term average since 1984, reached a low of 6,700t in 1989, but then increased recently reaching 10,000t under a by-catch fishery. Landings decreased to 6,800t in 1993.

Data and Assessment: Commercial catch rates for longliners have increased in recent years. Survey indices of abundance are at the lowest level observed.

Fishing Mortality: Fishing mortality decreased from high levels in 1984 and has increased since 1989-90.

Recruitment: Recruitment has been average or below average since 1983. Survey results suggest the 1992 year-class may be of average abundance or above.

Environmental Factors: A trend of decreasing haddock abundance in the July research survey strata east of Browns Bank may be associated with a decreasing trend in mean bottom temperatures observed on LaHave, Roseway and Baccaro banks in recent years.

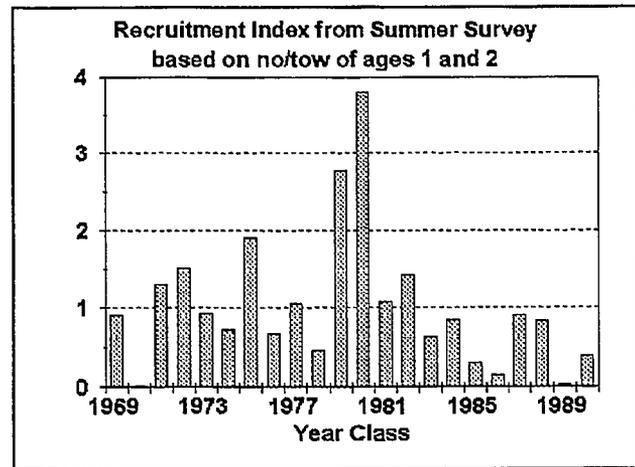
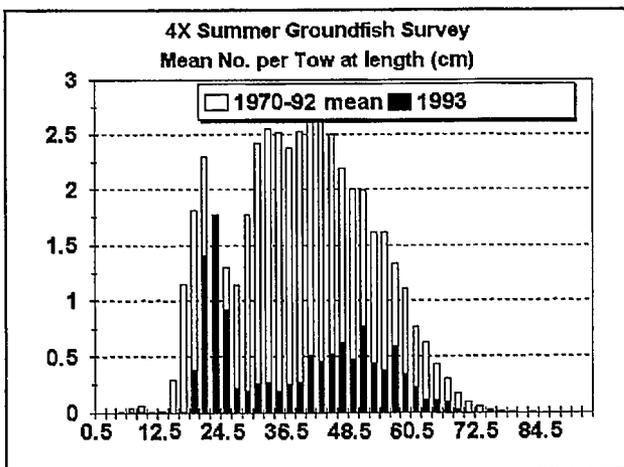
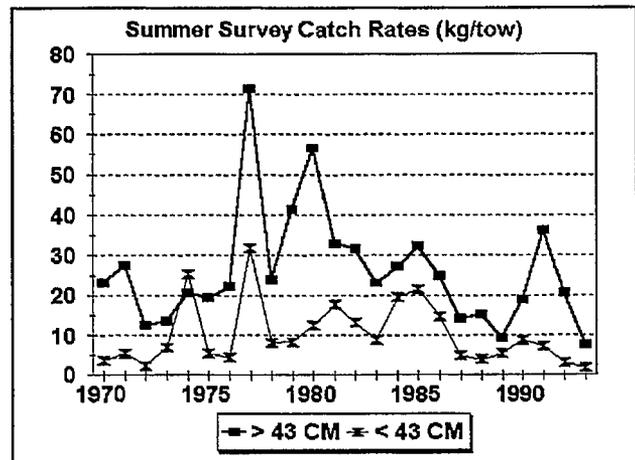
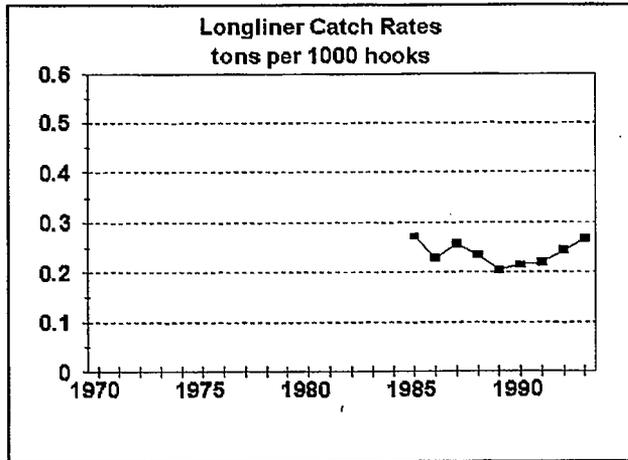
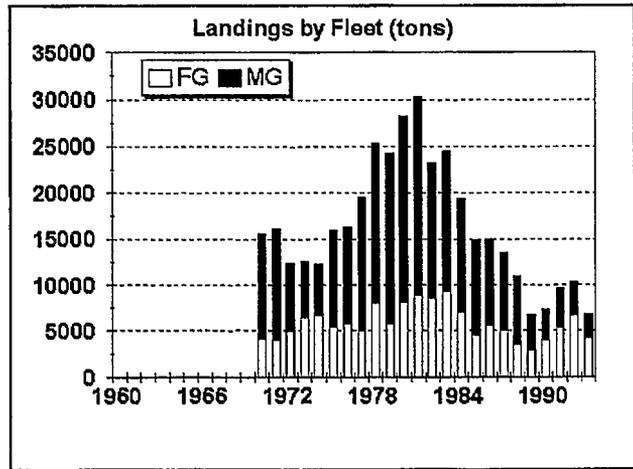
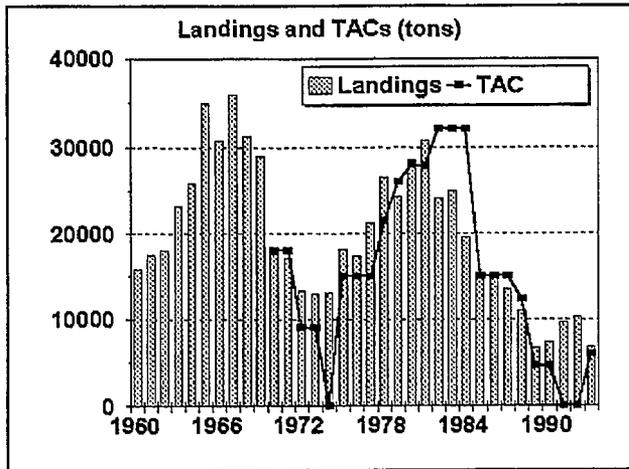
Multispecies Considerations:

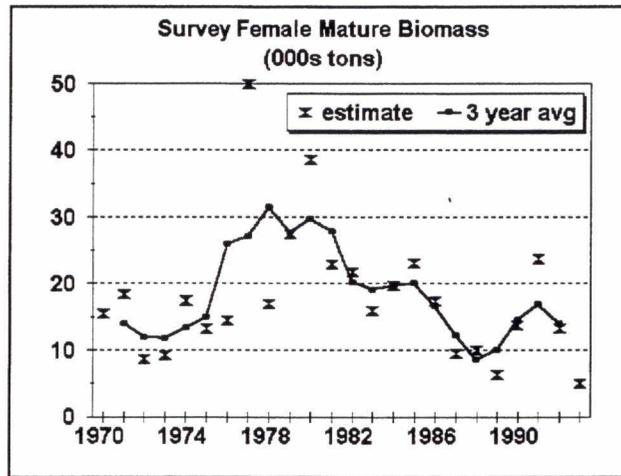
State of the Stock: Stock abundance is low, perhaps at its lowest level since estimates were initiated; however the latter is based on the very low 1993 survey result. This view of the resource is not shared by all members of industry. Stock status will be reviewed after the July 1994 survey.

Forecast for 1995: Research vessel surveys indicate very low spawning stock biomass and weak 1989, 1990, and 1991 year-classes. This differs from the view of 4X haddock stock status expressed during industry consultations. There should be no increase in fishing effort until this is resolved.

Long-term Prospects: The 1987 and 1988 year-classes were close to average but the 1989-91 year-classes are less abundant than average. Stock rebuilding is unlikely in the absence of large year-classes.

Special Comment:



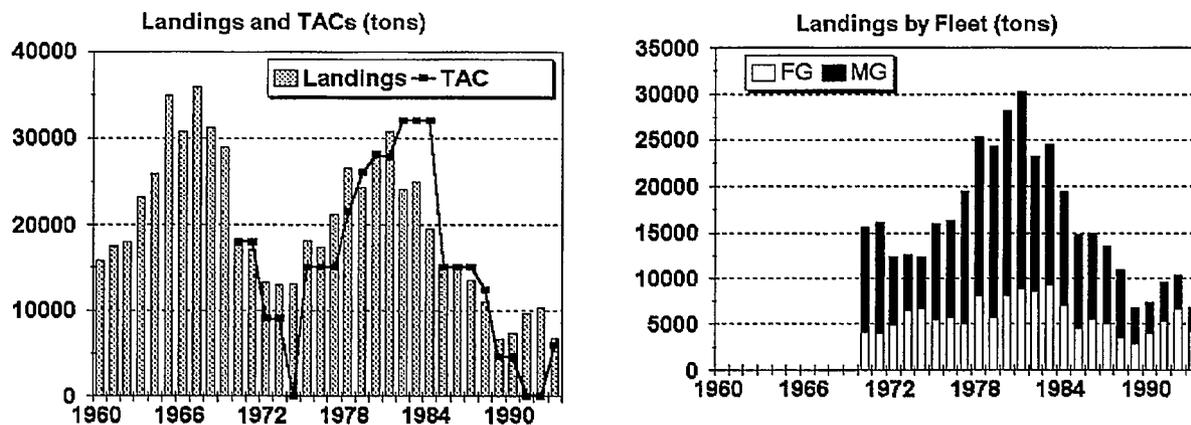


Technical Basis of Assessment of Haddock in Division 4X

Description of the Fishery

Nominal Catches

The long-term (1930-88) reported annual landings of 4X haddock have averaged about 20,000t. Landings peaked above 30,000t during the mid to late 1960s and again during the 1980s. Landings declined subsequently and have been below the long-term average since 1984. Catches reached a low of 6,700t in 1989 when it was recommended that the fishery be maintained at the lowest possible level and the mobile gear fishery was closed in mid-season. Catches increased since 1989 under a management plan that called for a by-catch fishery only. A TAC of 6,000t was implemented in 1993 and total landings were 6,832t. The fixed gear and mobile gear fisheries were closed in late November and early December when their respective allocations were taken. While this fishery has been dominated by the mobile gear historically, the proportion of the landings taken by the fixed gear has increased from 32% in 1988 to 61% in 1993.



Industry representatives have indicated that substantial misreporting occurred during 1985-88, that it was low in 1989 and has increased slightly since then. DFO estimates of misreporting indicate that it was less than 10% again in 1993. It is felt that some of this decrease is a result of Dockside Monitoring for the ITQ fleet.

Since the introduction of ITQs in the inshore mobile gear fleet in 1991, fishing strategies have changed considerably and there has been substantial consolidation of ITQs. Strategies in the ITQ fleet have continued to change with most vessels attempting to avoid haddock altogether.

Catch levels of small cod during the winter longline fishery became an issue early in 1994. Small fish closure protocols came into effect at which time observer reports indicated some catches of small haddock were also greater than 15%. The use of 200 pound haddock trip limits in this fishery in 1994 resulted in significant discarding of haddock by this fleet (up to 3000 lbs per trip).

Fish Distribution

Monthly maps of haddock catches from the mobile gear fleet showed no major changes in the distribution of haddock from 1992 to 1993. During consultations, this same observation was made by fishermen when asked if they had seen any changes in haddock distribution in 1993.

Environmental Conditions

It has been shown in an analysis of the associations between haddock, temperature and depth in the research vessel surveys that haddock are almost always associated with water greater than 2°C (Smith et al., 1994). Mean bottom temperatures in the research vessel survey strata in July on LaHave, Roseway and Baccaro Banks show a decreasing trend in recent years and appeared to be cold (2.2 to 3.0°C) in 1993 compared to the other strata in 4X. This is consistent with the indication of below average temperatures at 50m in Roseway Channel in recent years. The deeper strata in 4X have remained warm and relatively stable in recent years. Given these observations, temperatures have not limited haddock distribution in 4X.

Available Data

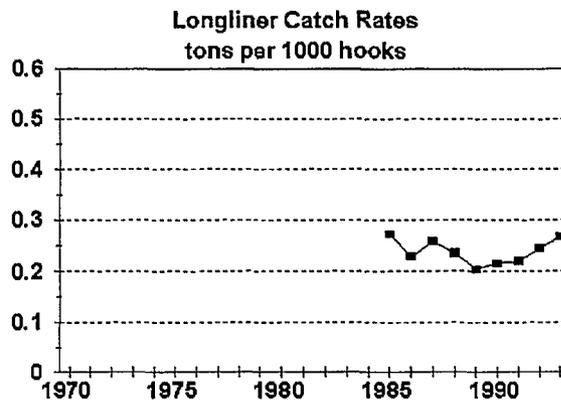
Size Composition of the Catch

Age reading of 4X haddock otoliths was suspended in 1992 when it was determined that the extant ageing protocol had resulted in a bias in haddock ages in recent years. New criteria for reading 4X haddock otoliths are still being evaluated and therefore age data are not presently available for commercial samples collected in 1992-93. Consequently, commercial sampling data were used to construct a catch at length for 1992-93 in the same manner that a catch at age would have been constructed. In addition, the catch at length for 1970-91 was also constructed using the same manner in which the historical catch at age was constructed.

Since 1990, there has been an increase in the mean length of haddock in the mobile gear catch from 48 to 54 cm in 1993. During the same period, there has been a decrease in the mean length of haddock in the fixed gear catch from 54 to 49 cm.

Commercial Catch Rates

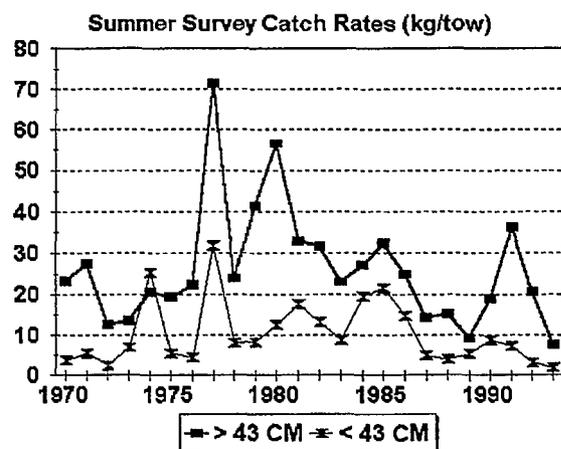
Mobile gear catch rates have not been considered a reliable index of haddock abundance in 4X due to the high and variable level of misreporting, particularly in the mid 1980s, and because of the extent of recent management changes period which have affected catch rates. However in recent years, the longline fleet has fished relatively unrestricted in the winter haddock fishery prior to the March 1 closure of Browns Bank. Catch rates (using ZIF data) of tonnage class 1-3 longline vessels fishing 4Xmnop in January and February showed an increase from 1989 through 1993; however catch rates derived from interviews of individual fishermen did not show consistent trends.



A number of fishermen, plant owners and representatives have been very cooperative in discussing the progress of the fishery through the year. Consultation has included day to day ad hoc discussions, talks on haddock biology and stock status with fishermen at public and Association meetings, interviews with individual fishermen and in some cases construction of individual catch rate histories through examination of fishing records, and dedicated meetings with fishermen and plant owners to specifically discuss stock status and the input data to be used in the assessment process. The information gained during these consultations was used to assist in the interpretation of stock trends recorded by surveys and commercial catch rates.

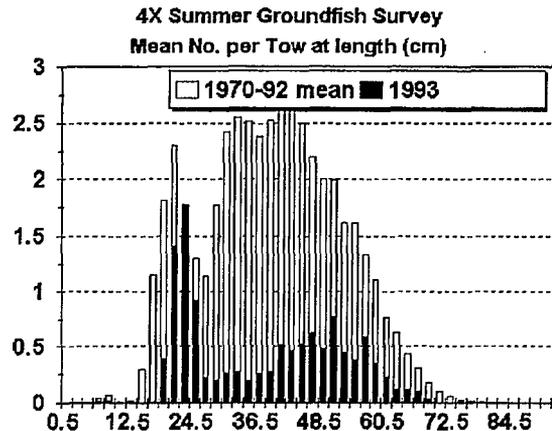
Research Vessel Surveys

Age data were not available for the 1992-93 research vessel survey. Research vessel catch rates at length were calculated for the survey series 1970-93.

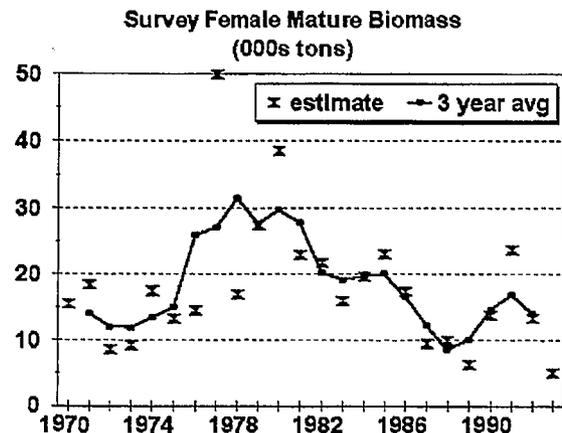
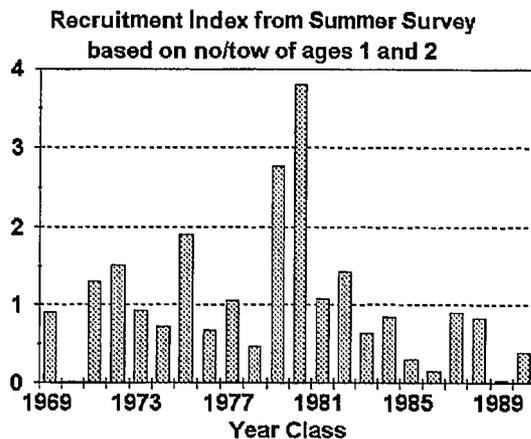


Research vessel catch rates were low during the 1970s and high during the early to mid 1980s. Catch rates declined sharply in 1985-87 to low levels, increased to 1991 and have since declined to the lowest level observed in the series. When the research vessel data are disaggregated into categories greater

than and less than 43 cm, catch rates of the less than 43 cm category increase from 1988 to 1990 as the abundant 1987 and 1988 year-classes contribute to the category. Catch rates of this category subsequently decline as these year-classes grow out of the category and are replaced by the less abundant 1989, 1990 and 1991 year-classes. Catch rates of the greater than 43 cm category increase abruptly in 1990-91, due in part to the contribution of the 1987 and 1988 year-classes as they grow into the category. Catch rates then decline as abruptly in 1992-93.



Modes in the long-term research vessel mean catch at length, corresponding to ages 1-5, are present at 20, 32, 40, 48 and 54 cm. Comparison of the catch at length for the most recent surveys with the long-term mean indicates that the 1987 and 1988 year-classes were of average abundance, the 1989 year-class was weak (perhaps the smallest in the series), and the 1990 and 1991 year-classes were below average. The catch at length in the 1993 survey would indicate that the 1992 year-class was about average in strength, but that earlier year-classes, particularly the 1987 and 1988 year-classes, had been subjected to extremely high mortalities. The size composition of haddock in an exploratory inshore survey conducted in late July/early August of 1991-93 in 4X is comparable with the regular survey result and suggests that the 1992 year-class is strong. The size composition of the haddock by-catch in the foreign small mesh gear fishery in 4X has been reflective of incoming year-class strength in the past. The size composition in the 1993 by-catch suggests that the 1992 year-class is strong.



The distribution of haddock catches in the 1993 research vessel survey was in general consistent with the inshore mobile gear fishery in the same month and was comparable to previous years. Browns Bank on average contributes approximately 50% of the survey abundance while the mouth of the Bay of Fundy contributes an additional 15%. Overall abundance on Browns Bank shows no trend until 1993 when it decreased by approximately 50%. East and west of Browns Bank, there has been a decline since the early eighties, reaching a low in the series in 1993. This pattern is consistent with distribution expanding and contracting around a focus (Browns Bank) as abundance increases and decreases. The decrease in abundance to the east of Browns Bank is also consistent with the general cooling trend on the eastern banks in 4X seen in the research vessel survey bottom temperatures.

An analysis of long-term (1970-91) trends in growth rates in 4X haddock was conducted using research vessel survey data. A distinct spatial gradient in size-at-age was evident: haddock in the Bay of Fundy were approximately 20% larger than haddock on the southwestern Scotian Shelf. Temporal trends in size-at-age also differed between the two areas. Length-at-age of haddock on the southwestern Scotian Shelf decreased to a minimum in the early 1980s then increased such that the length-at-age in 1991 was comparable to values observed in the early 1970s. Trends in length were lagged across age classes, suggesting significant differences in growth rates among year-classes. Temporal variation in length-at-age for haddock in the Bay of Fundy did not exhibit distinct trends or differences among year-classes. In previous assessments, temporal trends in length-at-age have been described using the stratified mean length-at-age estimated for the entire 4X stock unit. Pooling data across a spatial gradient has effectively filtered out the temporal trends observed for haddock on the southwestern Scotian Shelf.

These observations on the productivity of the two different areas in 4X raises questions concerning the adequacy of the present management unit. Addressing these will require further examination of the available data.

Estimation of Stock Parameters

In the absence of age data in 1992-93 and the bias in age data in recent years, a length-based VPA was attempted. Numbers at length data were converted to estimates of numbers at age using cohort slicing techniques, using long-term mean lengths at age calculated from the July research vessel survey

data. This assumes that ages were correctly assigned in the historical data and ignores the bias identified in recent years. It also ignores spatial and temporal variability in growth as identified above. The potential problems with the growth model employed results in significant uncertainties associated with the results presented below. The catch numbers at age resulting from the cohort slicing were used as inputs to two minimization models, one using a gradient technique (Marquardt) and the other using a partitioned search algorithm. The SPA was calibrated with the research survey results.

Population abundance for ages 3-6 at the beginning of 1993 were estimated and the partial selection fixed for ages 1, 2 and 7 in 1993. The summer survey results were compared to average (mid-year) population abundance. Statistical error in the survey data was assumed to be independent and identically distributed after taking logarithms. The error in the catch at length was assumed negligible. The fishing mortality for age 7 was calculated as the average for ages 3-6 in the same year. Natural mortality was assumed to be 0.2.

Using the full data series, estimated population numbers did not correlate well with the research vessel survey, particularly in the early part of the series. Removing years successively from 1970 to 1984 resulted in a decrease in overall residuals. Estimates of survey catchability at age for these successive runs showed a monotonic increase over time. Abrupt changes in the rate of reduction in residuals occurred in 1974 and 1977. It was decided to use the data from 1977-93, as the reduction in residuals appeared to level off at that point.

Partial recruitment for ages 1 to 7 in the final year from the analysis was .001 .013 .151 .557 .827 .558 1.000. The final estimated population numbers did not correlate well with the research vessel survey in the early part of the series.

The length-based analysis indicated that age 3-6 population numbers have been decreasing since 1978 to a low level in 1989, with a slight increase thereafter as the 1987 and 1988 year-classes recruited. Fishing mortalities decreased from high levels in 1984 to a low in 1989-90. Fishing mortalities have increased since. Retrospective analysis showed a pattern in F with the current year F being underestimated relative to the retrospective view.

It was considered that the resulting population numbers could not be used but that the overall trends were consistent with observations from the research vessel survey. This was a preliminary analysis using new techniques that require evaluation in a dedicated meeting. The model results were therefore not used in the prognosis.

Prognosis

The research vessel survey results in the central area of 4X (Browns Bank) are consistent with the catch rate data from the fixed gear fleet and anecdotal accounts from the mobile gear fleet with the exception of 1993. Abundance has been relatively high as the 1987 and 1988 year-classes progressed through the fishery. These have been followed by below average 1989, 1990, and 1991 year-classes. However, in 1993 the estimate decreased by 50%. Also, the research vessel survey results for strata in the eastern and western portions of 4X indicate abundance has been decreasing since the early to mid-1980s.

Overall, the 1993 survey indicates very low spawning biomass. This differs from the view of the 4X haddock stock status often expressed during consultations. Therefore, there should be no increase in fishing effort until this is resolved.

Research Recommendations

1. The present use of age/length keys for 4X haddock should be revised. Grouping strata 470-481 and strata 482-495 would better reflect the long-term spatial gradient in size-at-age than the groupings currently used (470-485, 490-495).
2. Any summary of temporal trends in 4X haddock size-at-age should differentiate between the southwestern Scotian Shelf and the Bay of Fundy.
3. The magnitude of spatial and temporal plasticity in size-at-age of 4X haddock underscores the importance of resolving problems associated with age determination.
4. Continue to investigate the efficacy of length-based assessment.
5. Investigate the feasibility of determining and correcting for the ageing bias introduced in recent years (mid-1980s).

References

- Hurley, P.C.F., P. Comeau, and G.A.P. Black. 1994. Assessment of 4X haddock in 1993. Atl. Fish. Res. Doc. 94/39: 42 p.

Summary of Status of Georges Bank Haddock

- * This is a transboundary management unit. Most of the resource is in the Canadian portion of 5Z. The combined USA and Canadian 1993 landings of 4,143t are well below the long-term average. The Canadian landings of 3,722t were not restrictive to the overall fleet (Canadian TAC 5,000t) though the mobile gear caught their allocation. The combined number of fishing trips by the Canadian mobile (less than 65 ft) and fixed gear components has not declined in recent years. The Canadian portion of the management unit was closed for the first 5 months of 1994.
- * Few ages contributed to the 1993 landings with 43% (by weight) accounted by the 1987 year-class. Discarding of juvenile haddock was not much of a problem in 1993, due to relatively weak incoming 1990/91 year-classes and the use of large square mesh gear. The Enterprise Allocation fleet, using diamond mesh gear, caught a higher proportion of small haddock during the pollock-directed fishery in quarter four. There has been no trend in age 5 weight-at-age.
- * The tonnage class 2 and 3 mobile gear (less than 65 ft) catch rates have been declining steadily since 1989. Part of the decline is attributed to changes in fishing practices due to regulatory changes.
- * The three research vessel surveys (USA spring and fall, and Canadian spring) indicate a decline in spawning stock biomass (age 3+) since 1990. Levels near the lowest in the series were recorded in 1992/93, with a slight increase in 1993/94.
- * The surveys show that the 1992 year-class is of moderate to above average abundance. There are indications that the 1993 year-class is of moderate to above average abundance but it is too early to estimate reliably.
- * The assessment indicates that the spawning stock biomass at the beginning of 1994 has increased slightly from levels near the lowest recorded.
- * Fishing mortality has been increasing sharply in the 1990s, with the 1993 estimate the highest in the time series ($F = 1.13$). This level of fishing mortality removed about 60% of the fishable biomass in 1993.
- * Combined Canadian and USA landings of 3,000t in 1994 will result in a fishing mortality rate of almost twice $F_{0.1}$. The $F_{0.1}$ yield projected for 1995 is about 4,000t with the 1992 year-class accounting for roughly half the landed weight.
- * The projected increase in haddock biomass is due primarily to recruitment of the moderately strong 1992 year-class. This year-class will only be 2 years old in 1994, and restraint should be exercised to allow these fish to grow and contribute to spawning. Continuing conservation efforts are needed to rebuild the population biomass and to expand the age structure.
- * Though haddock abundance appears to be increasing, it should be noted that this is due primarily to one moderately strong year-class. This year-class will only be 2 years old in 1994 and restraint should be exercised to allow these fish to grow and to contribute to spawning.

**Georges Bank Haddock
SUMMARY**

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min. ¹	Med. ¹	Max. ¹
Reference level '000t	8.3 ⁴	6.4 ⁴	8.1 ⁴	NA/ND	5.4	6.25	2	2			
Advised catch '000t	8.3 ³	8.3 ³	8.1 ³	3 ³	5.4	5 ³	3 ³				
TAC '000t	8.3 ⁴	8.3 ⁴	8.3 ⁴	NA/ND	5 ²	5 ²	5 ²	3 ²			
Reported landings '000t	6.1	5.7	3.8	4.5	6.4 ³	5.7 ³	4.1 ³		2.4	5.7	25.0
Unreported catches											
Estimated discards '000t											
Total catches											
Total biomass '000t	20.9	20.4	18.6	19.3	17.6	14.4	18.1	24.7	7.5	20.9	57.9
Spawning biomass '000t	13.8	15.6	11.3	17.8	15.1	10.7	6.8	7.7	2.2	12.4	42.7
Mean - F (4+)	0.52	0.53	0.39	0.41	0.49	0.85	1.13		0.19	0.43	1.13
1 = for 1969-1992				4 = Canadian allocations for the management unit used prior to 1990							
2 = Canadian quota for the current management unit				5 = for 5Z							
3 = preliminary statistics				6 = Canada only							

Catches: The 1993 landings by Canada declined to 3,722t with reductions in both mobile and fixed gear. USA landings declined to a historical low of 421t. The Canadian fishery remained closed during January to May 1994. The USA fishery was further restricted by an expansion of the spawning closed area and an extension of the closed period.

Data and Assessment: The assessment of the status of the stock was based on calibration of an SPA with research survey abundance indices (Canadian spring survey and USA spring and fall surveys) using ADAPT. Survey spawning biomass has declined since 1990, with a small increase in 1993 due to incoming recruitment.

Fishing Mortality: Fishing mortality has generally been about twice $F_{0.1}$, but shows a marked increase since 1991 and reached its highest level in 1993 which corresponds roughly to a harvest rate of about 60%.

Recruitment: Since the strong 1975 and 1978 year-classes, only the 1983, 1985 and 1987 year-classes were of moderate strength. The 1992 year-class is estimated to be comparable to that of 1987. There are early indications that the 1993 year-class may also be of moderate strength, but it is too early to estimate it reliably.

Environmental Factors: Water temperatures in recent years have generally been colder than normal at depths less than 75m. At greater depths, conditions appear to be warmer than the long-term average.

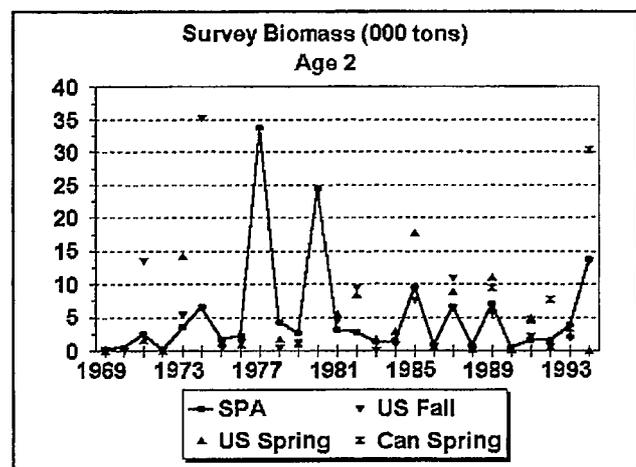
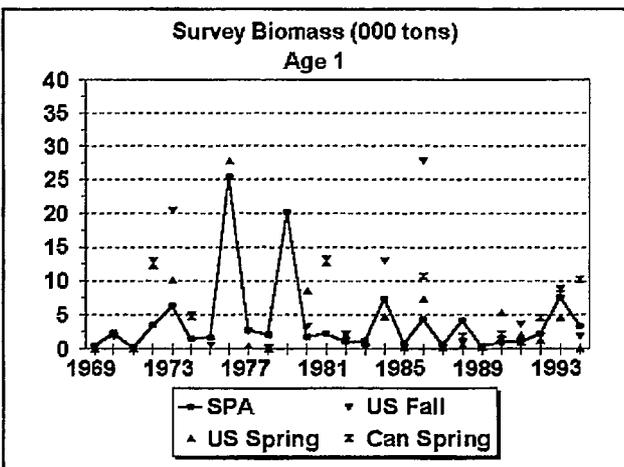
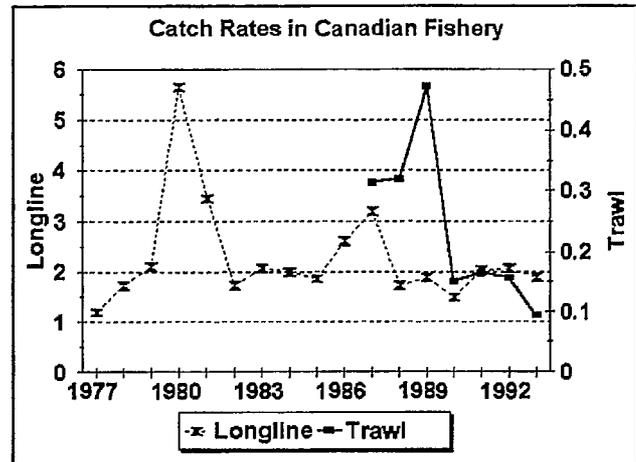
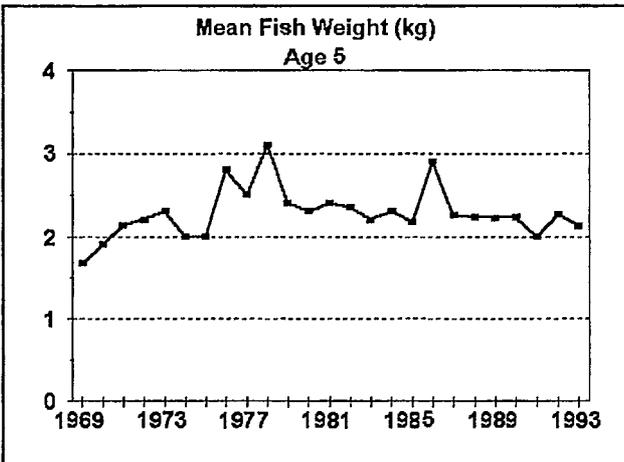
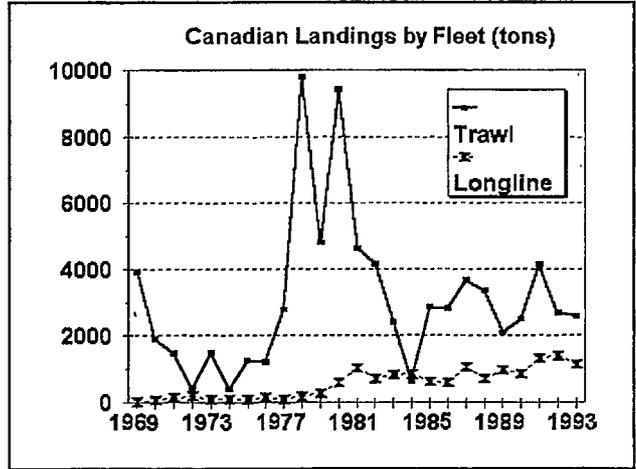
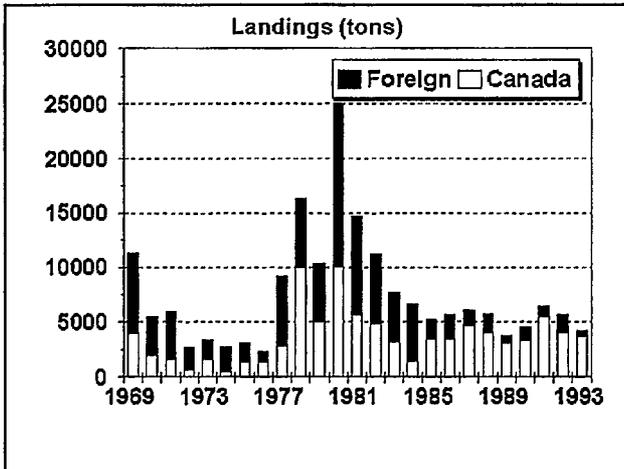
Multispecies Considerations: Herring abundance (haddock feed on herring roe) has increased in recent years while the abundance of cod (a predator) has declined.

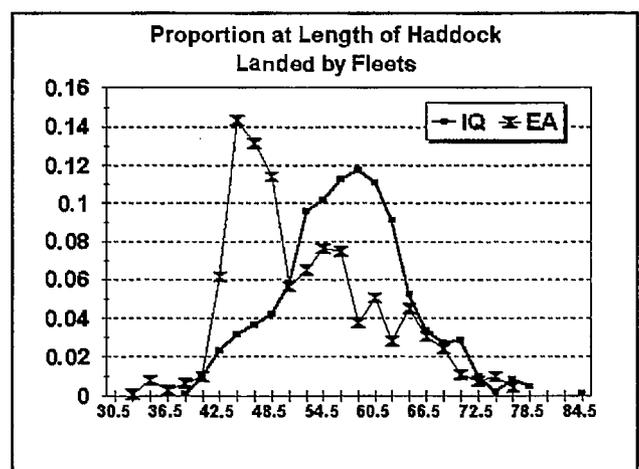
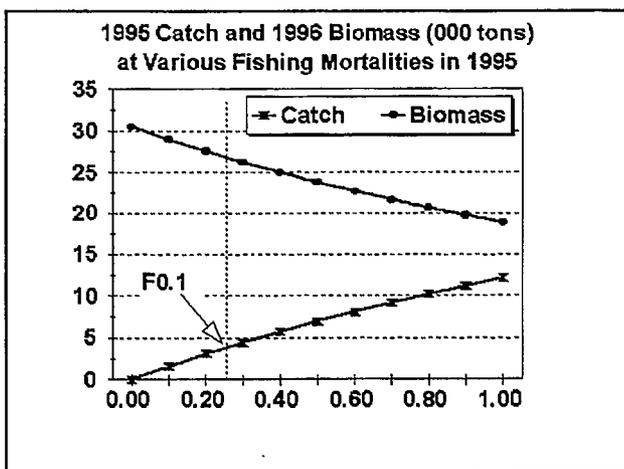
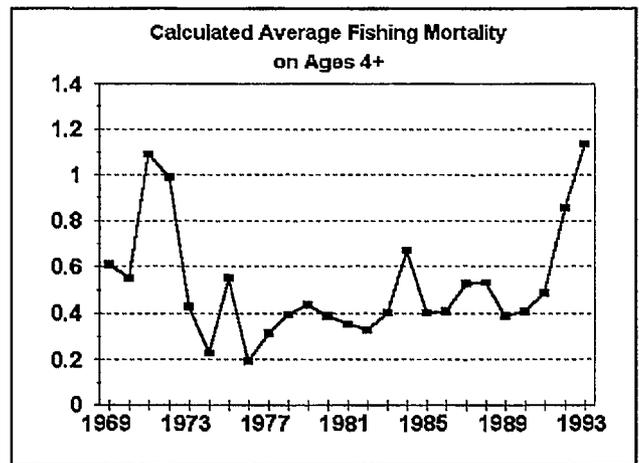
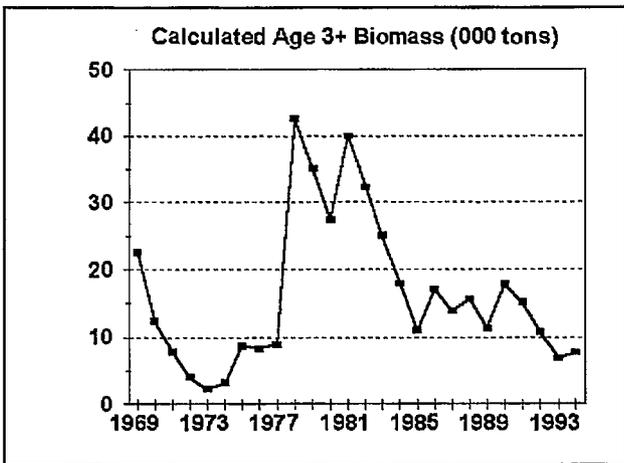
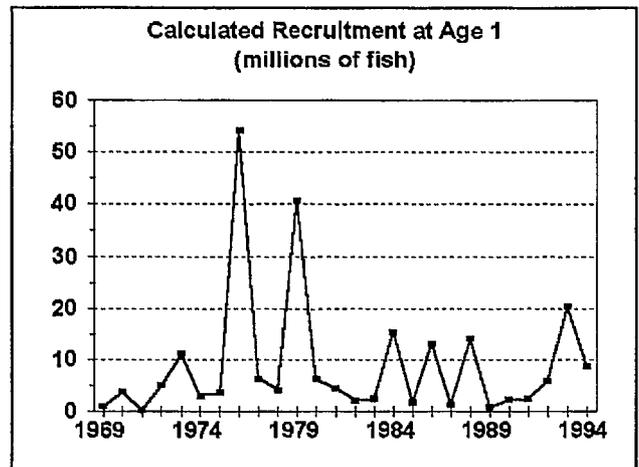
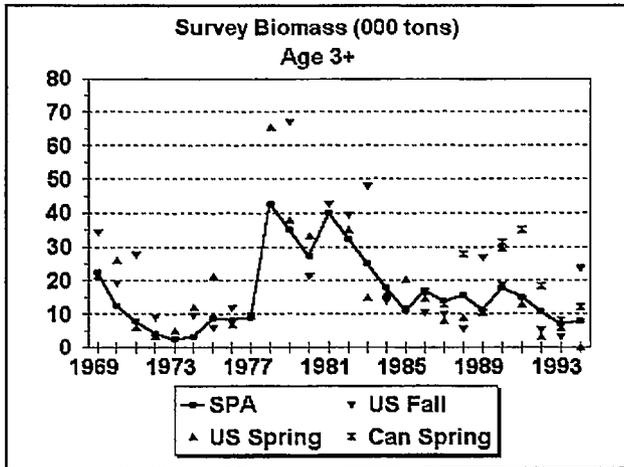
State of the Stock: The stock is near its historically lowest abundance with few older fish remaining in the population. There is an indication of improved recruitment.

Forecast for 1995: The expected catch of about 3,000t in 1994 would result in a fishing mortality of about 0.4, exceeding $F_{0.1}$ (0.25). The projected $F_{0.1}$ yield for 1995 would be about 4,000t, with the 1992 year-class accounting for roughly half the landed weight.

Long-term Prospects: Though haddock abundance appears to be increasing, it should be noted that this is due primarily to one moderately strong year-class. This year-class will only be 2 years old in 1994 and restraint should be exercised to allow these fish to grow and to contribute to spawning. Continuing conservation efforts are needed to rebuild the population biomass and to expand the age structure.

Special Comment:



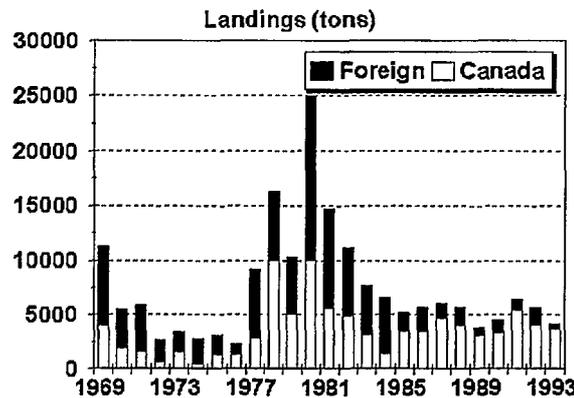


Technical Basis of Assessment of Haddock in Unit Areas 5Zjm

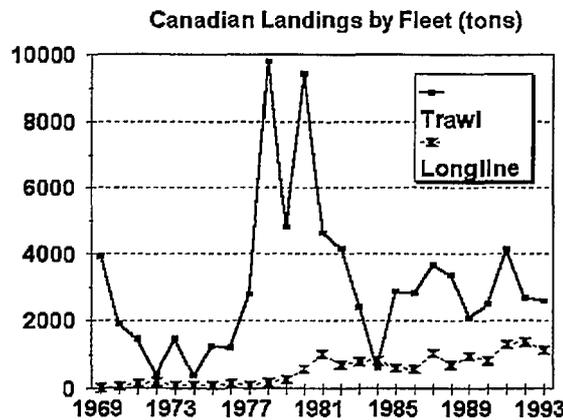
Description of the Fishery

Nominal Catches

Since 1969 landings have ranged between 2,500 and 25,000t and in recent years have fluctuated around 5,000 tons. Since 1977, only Canada and the USA have conducted haddock fisheries on Georges Bank and following the establishment of a maritime boundary in 1984 by the International Court of Justice, each country's fishery has been restricted to their respective jurisdictions.



Bottom otter trawl and longline have been the predominant gears in the Canadian fishery. During 1993 both the longline and otter trawl catches declined resulting in a total for Canada of 3722t. In recent years, landings have generally peaked during June or July. In 1993, following the introduction of ITQs, the fishery was opened at the beginning of the year and a substantial quantity was landed in January and February by otter trawls. Catches during the second half of the year were lower than in previous years. The fishery remained closed during January to May in 1994.



The USA fishery is almost exclusively an otter trawl fishery. During 1993, USA landings decreased to a record low of 421t. In 1994 the USA extended the February to May spawning season closure into June and expanded the restricted area. Initial reports indicated a continuing decline in landings in 1994 with catches in the first quarter of about 60t for all of 5Z.

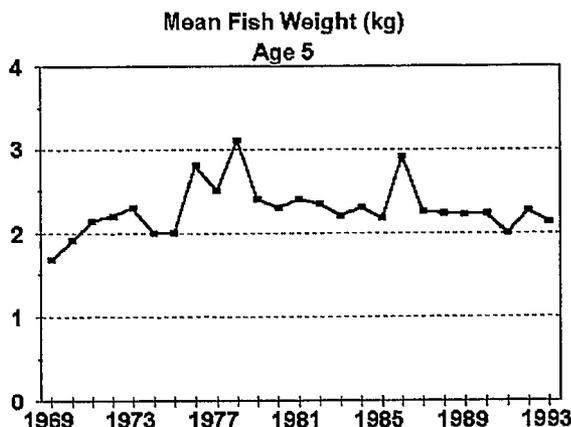
Environmental Conditions

Environmental conditions on Georges Bank have not displayed marked changes in recent years. Temperature and salinity trends observed during the Canadian spring surveys appear to be associated with timing of the survey. Fishermen have noted an increase of herring on Georges Bank and suggest that this is beneficial for haddock as they feed on herring roe. They also reported that the abundance of sand lance has declined substantially in recent years. Cod prey on juvenile haddock and the abundance of cod on Georges Bank appears to have declined substantially in recent years, however a link has not been established between haddock survival and cod abundance.

Available Data

Catch and Weight at Age

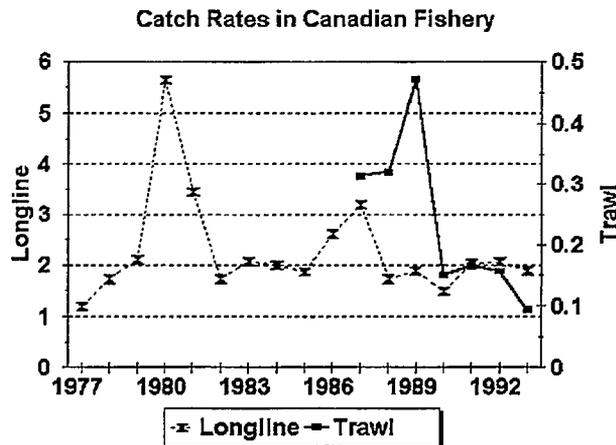
The 1993 Canadian commercial catch was well sampled for length and age composition with 43 samples taken while the reduced landings by the USA resulted in only 11 samples taken from that fishery. Both fisheries were largely supported by the 1987 year-class (average length of 62 cm) which comprised over 43% of the landed weight. This observation was corroborated by reports from fishermen that the size of haddock caught in 1993 was generally larger than in recent years. There were no persistent long term trends in weight at age however the 1989 year-class appears larger. The contribution of the 1987 year-class to the 1993 landings was greater than had been forecast from the previous assessment, in part due to the uncommon fishery which occurred in January and February when larger fish were available. Use of larger mesh by the under 65 ft dragger fleet probably also reduced the number of age 2 fish caught.



Commercial Catch Rates

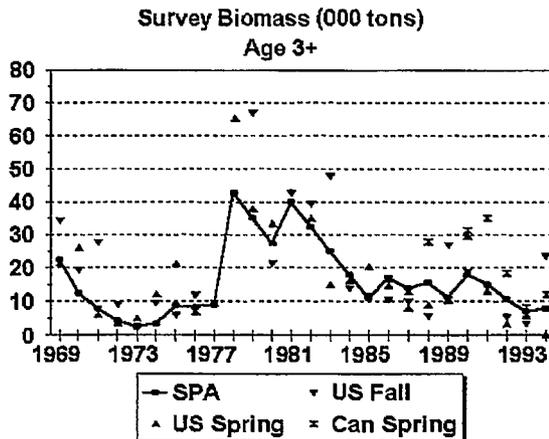
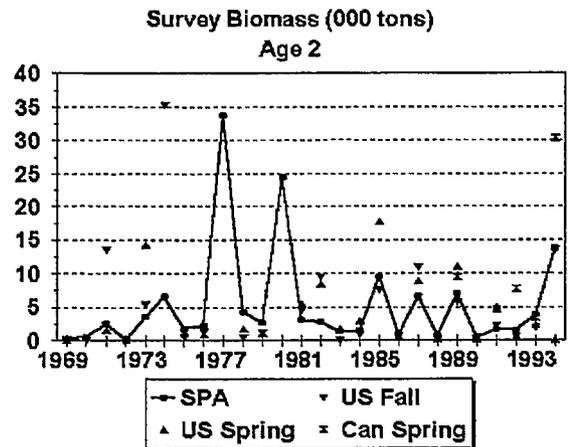
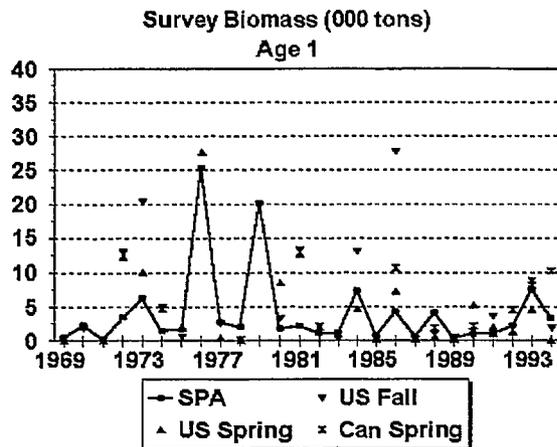
The June to September, 1987 to 1993 catch and effort data from tonnage classes 2 and 3 otter trawls were analyzed using a multiplicative model to standardize for vessel, area and month effects. The

results showed an increase in 1989 followed by a sharp decline in 1990 and a further decline from 1992 to 1993. Fishermen reported that "there appeared to be less haddock in the summer of '93 compared to the summer of '92" corroborating the results from the analysis for those two years but suggested that the change from diamond mesh to square mesh was the principal factor in the decline from the late 1980s to the early 1990s. They also indicated that the introduction of ITQs resulted in a change to their fishing patterns which affected catch rates. The high value in 1989 was attributed to the closure of the fishery after only 2 weeks of fishing in June. Longline catch per trip for tonnage classes 2 and 3 has been relatively stable since the mid 1970s except for high catch rates in 1980-81 and 1986-87. Some fishermen noted that interpretation of longline catch per trip would be confounded by behavioural differences associated with the availability of feed. Recognizing these limitations in the interpretation of commercial catch rates as an index of trends in abundance, they were not used in calibrating the SPA based analysis.



Research Survey Data

Annual stratified random surveys have been conducted by the USA in the spring since 1968, in the fall since 1963 and by Canada in the spring since 1986. They indicate a decline in adult abundance to about the lowest levels observed though there is indication of an increase in the most recent year. The abundance of ages 3 to 8 from the Canadian survey increased by about 180% between 1993 and 1994 and the abundance of ages 2 to 7 from the USA fall survey increased by an order of magnitude between 1992 and 1993. The USA spring survey results for 1994 were not available. Survey results on incoming recruitment (ages 1 and 2) identified the strong 1975 and 1978 year-classes and the moderate 1983, 1985, and 1987 year-classes. Recruitment since then has been low though the 1992 year-class appears comparable, and perhaps stronger than those of 1983, 1985 and 1987. Although not well estimated, early indications suggest the 1993 year-class may be of moderate strength. Reports from fishermen indicated that small haddock, of a length corresponding to the 1993 year-class, were seen in abundance in cod stomachs during the fishery at the end of 1993.



Estimation of Stock Parameters

The adaptive framework (ADAPT) was used to calibrate the SPA with research survey results. Population abundance at ages 1 to 7 were estimated and age 8 was calculated assuming an F equal to the average fully recruited F. Based on identification of suitable relationships, ages 0 to 5 for the USA fall survey, ages 1 to 8 for the USA spring survey and ages 1 to 8 for the Canadian spring survey were used. Survey observations which had been used to estimate discarded catch in the mid-1970s were not used for calibration due to circularity. Four observations with extreme residuals were also deleted. Exclusion of these data did not impact the population abundance estimates but it did reduce estimated variance. The spring survey results were compared to beginning of year population abundance in the same year while the fall survey results were compared to beginning of year population abundance in the following year for the respective cohort. It was assumed that the error in the catch at age was negligible and the error in the survey abundance indices was assumed to be independent and identically distributed after taking natural logarithms of the values. Natural mortality was assumed constant and equal to 0.2 and fishing mortality for age 8 was assumed equal to the arithmetic average for ages 4 to 7.

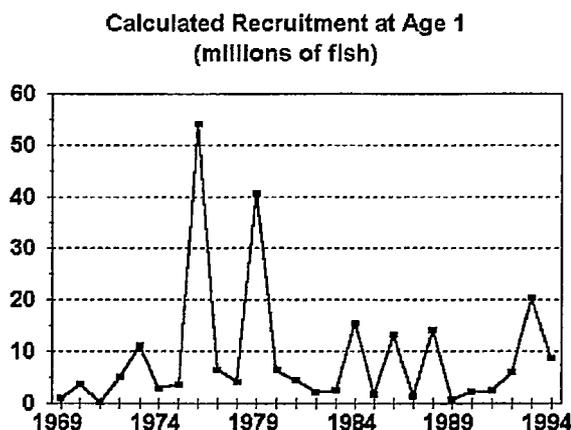
Though the magnitude of the deviations between the population estimates and the abundance indices was large, they did not indicate a serious lack of fit to the model. The large variance of the estimated population abundance coupled with the non-linearity of the models used resulted in bias.

For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias and used to construct the history of stock status. This approach for bias adjustment, in the absence of an unbiased point estimator with optimal statistical properties, was considered preferable to using the biased point estimates.

Assessment Results

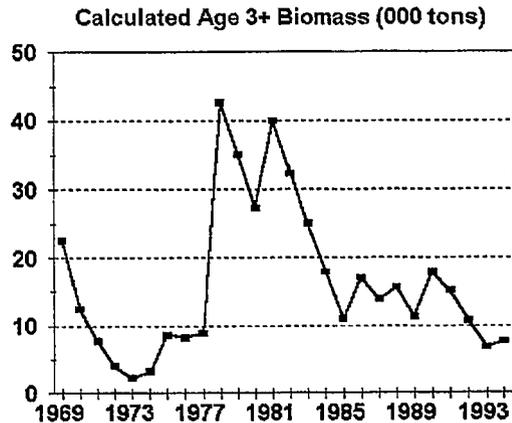
Recruitment

The 1983, 1985 and 1987 year-classes were estimated to be the most abundant since the strong 1975 and 1978 year-classes and the strength of the 1992 year-class was estimated to be comparable to these while 1988 through 1991 were weak. There are indications that the 1993 year-class may be of moderate strength as well but it is too early to estimate its strength reliably.



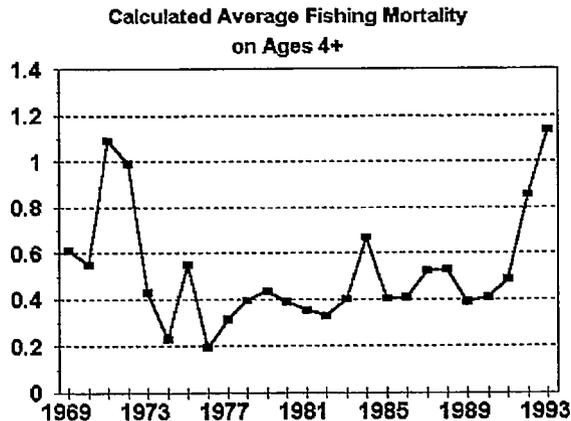
Population Biomass

As the 1985 and 1987 year-classes were fished down, adult biomass (ages 3+) declined rapidly to below 10,000t, approaching the historic low observed during the early 1970s but shows some recovery in 1994.



Fishing Mortality

The fishing mortality rate for ages 4+ in 1993 (1.13) was the highest observed, corresponding to harvesting of roughly 60% of the population, primarily exploiting the 1987 year-class. The previous occasion when the fishing mortality exceeded 0.5 was during the early 1970s when abundance was at its lowest.

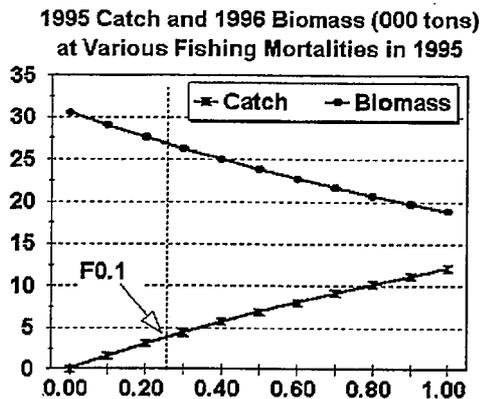


Prognosis

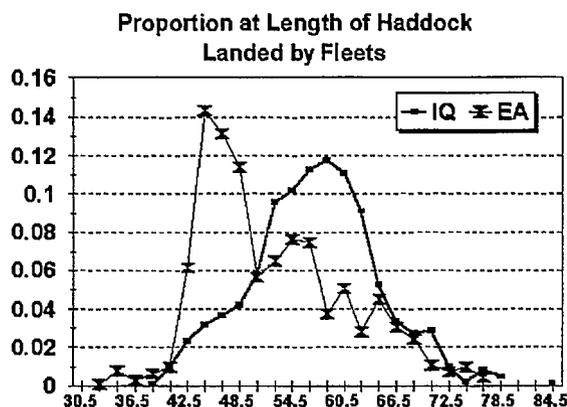
Yield projections were done using the estimated beginning of year population numbers in 1994, an average of 1991-93 for weight at age and a partial recruitment pattern consistent with recent trends to larger mesh by the otter trawl fishery.

Age	1994 Population numbers (thousands)	Weight (kg)		Partial Recruitment
		Avg. for year	Beg. of year	
1	8664	0.59	0.38	0.0
2	16588	1.16	0.81	0.2
3	3699	1.53	1.37	0.5
4	786	1.88	1.65	1.0
5	250	2.11	1.91	1.0
6	36	2.57	2.34	1.0
7	245	2.76	2.62	1.0
8	21	3.17	3.08	1.0
9	96		3.34	

As with the population abundance estimates, the adjustment for bias of the projected yield was considered more appropriate than using the biased point estimate. Projections were done assuming that the combined Canadian and USA catch in 1994 would be 3,000t. A catch of this magnitude would result in a reduction of the fishing mortality rate to about 0.4 in 1994. The projected yield at $F_{0.1}$ (0.25) in 1995 would be about 4,000t with the 1992 year-class accounting for roughly half of the landed weight. The 3+ biomass will increase to over 27,000t at the beginning of 1996 primarily due to the recruitment of the 1992 year-class. This assessment does not display a persistent retrospective pattern therefore no adjustments were attempted.



Continuing conservation efforts are needed to rebuild the population biomass and to expand the age structure. A greater proportion of small fish were retained in the fishery conducted by EA trawlers than in the ITQ fishery. The ITQ druggers were using 130mm square mesh while the EA trawlers were using double twine-diamond mesh of regulation mesh size, thus a difference would not be expected based on the results of controlled selectivity experiments. Other factors which could affect partial recruitment include net rigging, fishing location and season. Several fishermen have suggested that 140 mm square mesh should be mandatory on Georges Bank as a measure to conserve the smaller fast growing haddock. The longline fleet fishing Georges Bank uses large hooks and the size composition of their catch is similar to that of the square mesh.



Research Recommendations

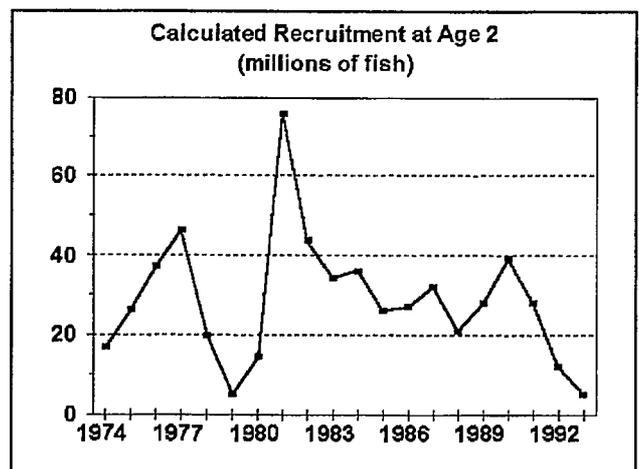
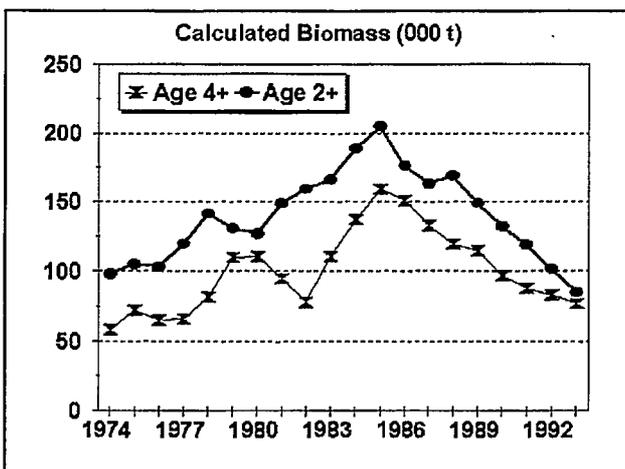
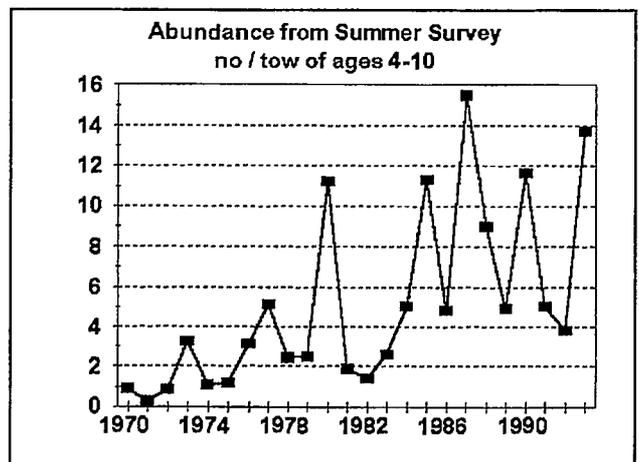
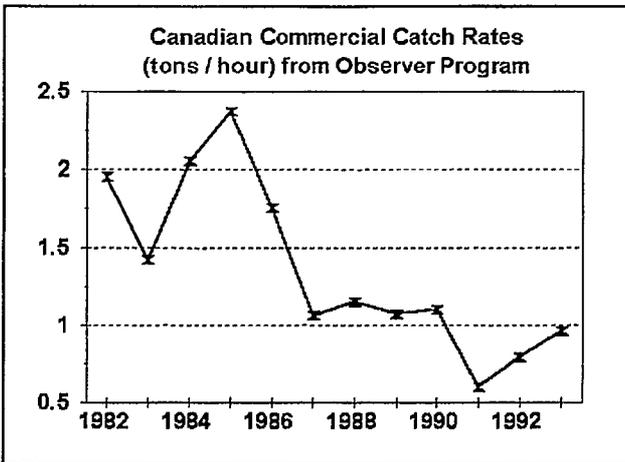
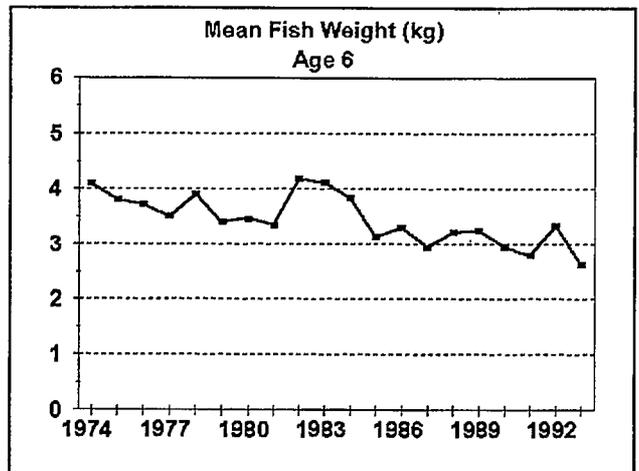
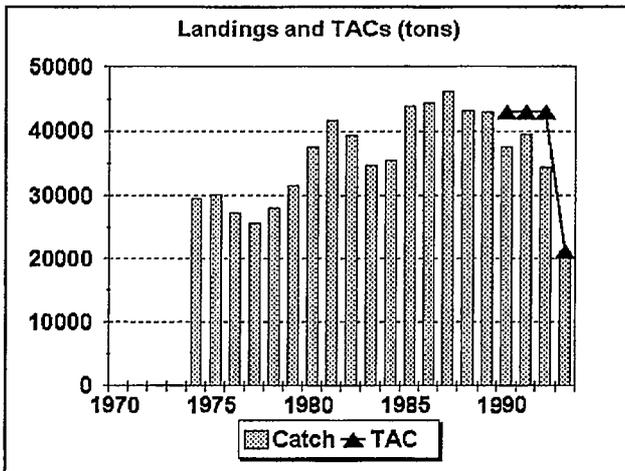
1. To develop an objective criteria for the exclusion of survey observation presently considered anomalous.

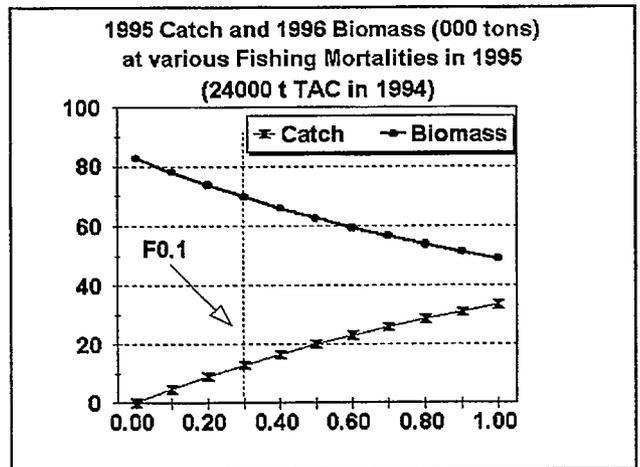
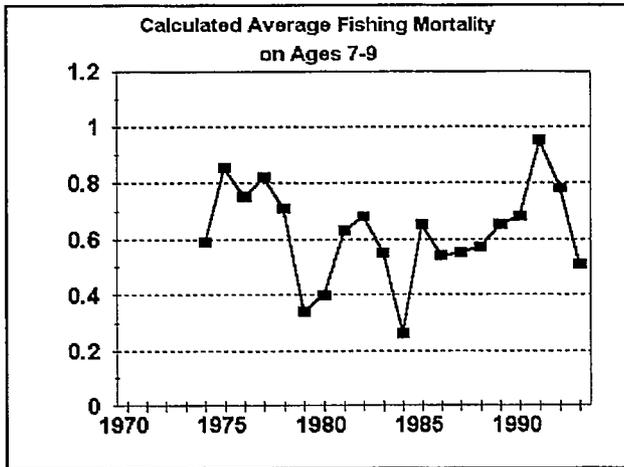
References

- Gavaris, S., and L. Van Eeckhaute. 1994. Assessment of haddock on eastern Georges Bank. Atl. Fish. Res. Doc. 94/31: 38 p.

Summary of Status of Scotia Fundy Pollock

- * From 1990 to 1992, the TAC did not restrict the overall fishery (with shortfalls of 6,800; 5,200 and 11,800t). The 1993 TAC was reduced to 21,000t from 43,000t in previous years (1987 to 1992). This TAC was reached.
- * The geographic pattern in landings indicate a marked decline in 4VW, with relative stability in 4X and 5.
- * The number of 1993 groundfish fishing trips also declined sharply in 4VW, but was relatively stable in 4X and 5.
- * The age composition of the landings show that the contribution of age 7 and older is down substantially from the mid-1980s. Weights at age have also been declining over the past decade.
- * The Observer mobile gear tonnage class 5 catch rates for ages 4-10 have been declining steadily from 1984 to 1991 with catch rates in 1992 and 1993 slightly higher than in 1991.
- * The summer research vessel survey data show high abundance in 1993 (second highest in survey). Estimates of stock size that utilized the survey data produced optimistic assessments that were inconsistent with information about fishing effort, commercial catch rates and other views of the resource. For these reasons the survey was not used to estimate abundance trends.
- * Observer tonnage class 5 catch rates were used as estimates of abundance in the assessment. Diamond mesh has not been replaced by square mesh on this fleet sector. Observer catch rates were estimated by using data from vessels fishing from April-November for which more than 50% of the catch was pollock.
- * The assessment estimates that spawning stock biomass (as estimated by age 4+) has been declining steadily from 1985 to the present and is projected to continue declining into 1995.
- * Fishing mortalities have been close to twice $F_{0.1}$ and higher since 1985 with F in 1991 being the highest at 0.95.
- * The 1988 year-class is estimated to be above average in strength and the 1989 year-class is average. Both are nearly fully recruited to the fishery in 1994. Estimates of subsequent year-classes appear weak. In the last assessment of this resource, the strength of the 1988 and 1989 year-classes were estimated to be greater.
- * If the TAC of 24,000t is caught in 1994, the resulting fishing mortality would be 0.56 (about twice the $F_{0.1}$ of 0.30). With this level of fishing in 1994, the $F_{0.1}$ catch for 1995 is estimated at 13,000t.
- * Pollock abundance is very low with poor recruitment prospects for the near future. Reduced exploitation would prolong the contribution of existing year-classes to the fishery and maintain a higher spawning biomass.

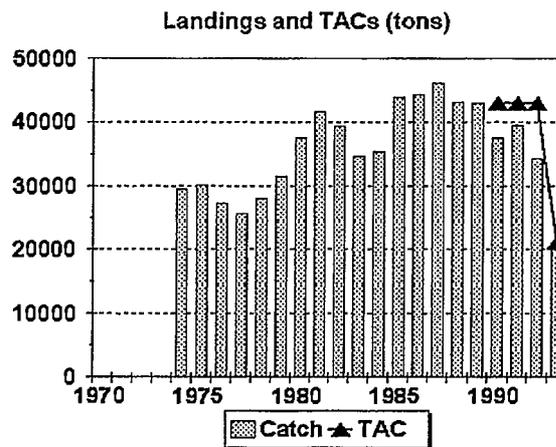




Technical Basis of Assessment of Pollock in Divisions 4V, 4W, 4X and in 5Zc

Description of the Fishery

Since 1974, pollock landings have ranged between 21,000t and 46,000t with an average of 35,000t. Landings and TACs have been relatively stable for the 1985-1989 period due to good recruitment in the early 1980s. Shortfalls in the Canadian nominal catches for 1990, 1991 and 1992 were 6,800, 5,200 and 11,800t, respectively under the TAC of 43,000t. The mobile (EA) and fixed gear fleets were below their allocations. The 1993 pollock TAC was originally set at 35,000t based on industry's request and was subsequently reduced in September to 21,000t after further advice by the FRCC.



The combined 1993 Canadian and foreign landings totalled 21,105t. Canadian 1993 pollock landings (20,285 t) account for the majority of the catch. The fishery in 4VW is dominated by large offshore vessels greater than 100ft using mobile gear, whereas the fishery in 4X and 5Zc is dominated by inshore vessels less than 65ft using mobile and fixed gear. Landings of 3,000t in 1993 in 4VW are lower than 1992 landings (9,000t) and indicate a marked decrease compared to the 1985-1990 annual landings which were in the 15,000-20,000t range. A number of factors may account for the decrease in 4VW pollock landings. Of these, the decline in 1993 was partly due to restrictive measures put on the 4VW cod fishery (i.e. after August it was a by-catch fishery only). As well, a year round restriction on small fish was enforced (no greater than 15% of catch <43 cm). 4X+5Zc landings remained relatively stable at 23,000-29,000t from the early 1980's-1992 with 1993 showing a decline to 18,000t. The reduced TAC also limited the overall catch.

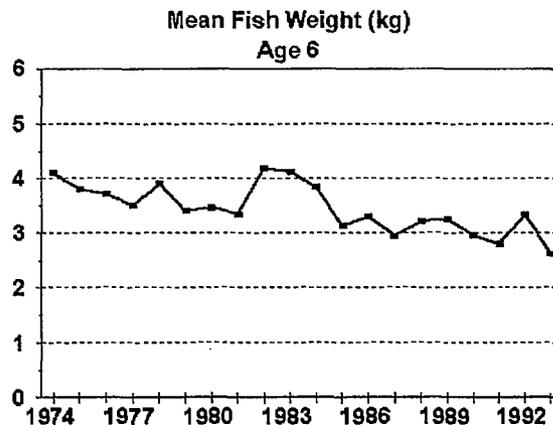
Catches by foreign fleets have been incidental with the major share taken by Cuban and Russian trawlers fishing for silver hake. The overall foreign small mesh landings have declined from 2,000t in 1992 to 860t in 1993. The usage of separator grates in this fishery became mandatory in August 1993. This will have implications in upcoming years as presumably catches of small pollock will be reduced considerably. The future use of lower partial recruitment values for the younger ages is a possible outcome for 1994 and later years.

Reports from industry indicate pollock have been declining since 1987. Also, in the 1993 fishery, vessels using diamond mesh reported good catches of 38-46 cm pollock in the Fundian channel and on the edges of Browns and Georges Bank. 4VW inshore fishermen reported a lack of pollock in recent years. A lack of large pollock in the fishery was a widespread concern.

Available Data

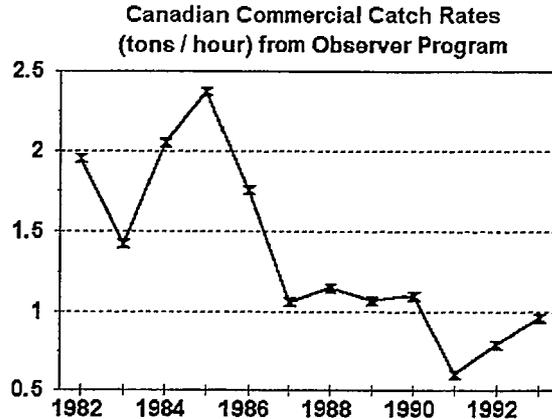
Catch and Weights at Age

As in most years, only four or fewer year-classes contributed significantly to the 1993 landings. The catches were dominated by the 1986-1989 year-classes (ages 4-7). The 1989 year-class at age 4 comprised 31% of the catch. The 1988 year-class at age 5 was 37% of the catch; the greatest proportion by numbers of any year-class in 1993. The small mesh catch at age was comprised predominantly of age 4 and 5 fish, with very few age 2 pollock captured. The catches of pollock age 7 and older are down substantially from the mid-1980's. Since the mid-1980's, weights at age have declined.



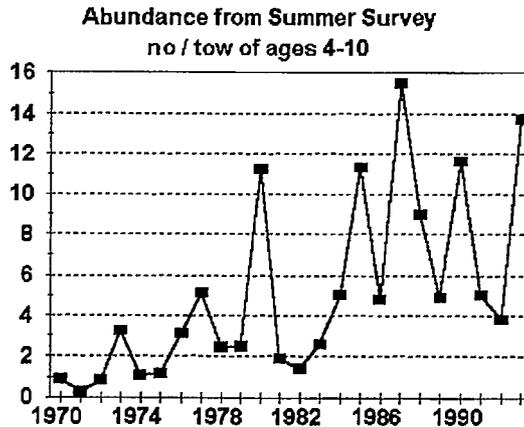
Commercial Catch Rates

Commercial catch rates were estimated using Observer data for domestic otter trawlers, tonnage class 5. In this fleet diamond mesh has not been replaced by square mesh. This analysis spanned the time period 1982-1993 as only a limited amount of Observer data existed for earlier years. The Observer tonnage class 5 catch rate estimates were made by calculating the ratio of total catch and total effort for these vessels from April-November for which >50% of the catch was pollock. Fleet effort for each year was estimated by dividing the tonnage class 4-6 catch by the catch rate of a specific year. Tonnage class 5 landings comprise a large majority of the EA fleet of tonnage class 4-6 boats. Age disaggregated catch rates were estimated by dividing catch at age for this fleet by the effort of a specific year. Tonnage class 5 catch rates have declined from the high values in the 1982-1986 period. Values in 1992-1993 are slightly higher than in 1991 but remain lower than pre-1986 levels.



Research Survey Data

The research surveys indicate an increase in the age 4-9 abundance during the early 1980's with subsequent estimates being highly variable. The 1993 age 4-9 estimate was the second highest in the 24 year time series. The 1987, 1990 and 1993 survey numbers were all years in which high numbers of pollock were captured, especially for ages 4-5. In general, the survey exhibits pronounced year effects making it difficult to estimate year class strengths, incoming recruitment and short-term changes in abundance.



Estimation of Stock Parameters

Results from ADAPT formulations that incorporated the survey data produced optimistic assessments that were inconsistent with information about fishing effort, commercial catch rates and other views of the resource. For these reasons the survey was not used to estimate abundance trends.

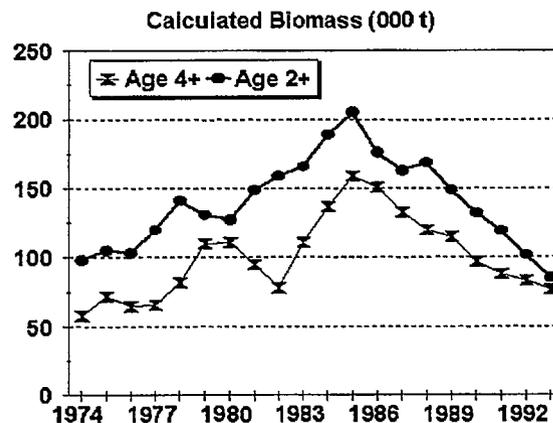
ADAPT was used to calibrate the sequential population analysis with the age disaggregated Observer tonnage class 5 catch rates. Population abundance at the beginning of 1994 for ages 5-11 were estimated by ADAPT using otter trawl catch rate data for ages 4-10. Natural mortality was assumed constant and equal to 0.2 and the F for age 11 was calculated as the average for ages 7-10. The

abundance at age 2 in 1994 was set equal to the long term geometric mean of 28 million. The abundance of ages 3 and 4 were initially calculated based on the average partial recruitment (PR) to the fishery. The partial recruitment vector was derived from the F matrix from 1990-1992. The average PR of 1990-1992 is assumed to reflect the exploitation pattern in 1993. The results for age 3 (the 1991 year class) were lower than any previously observed. Given the uncertainty surrounding the partial recruitment at this age, the strength of this year class was set to be roughly equivalent to the lowest previously observed. The change from using survey data to using commercial catch rate data to estimate population numbers marks a significant change in the formulation of the sequential population analysis over last year. Further exploration and discussion with industry in the use of catch rates to estimate population size is recommended for this resource.

Assessment Results

Stock Size

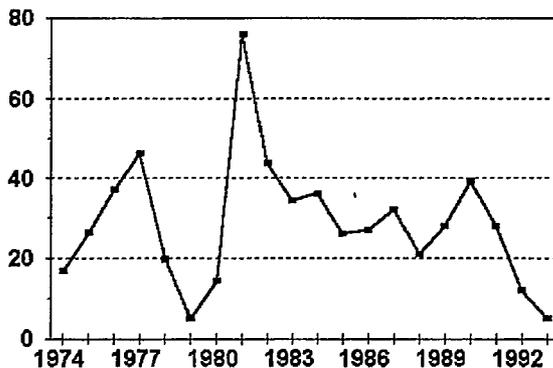
Stock biomass (age 2+) and spawning stock biomass (age 4+) have declined steadily since the mid-1980s with the movement of the strong 1979 year-class out of the fishery. The exploitable biomass of the current stock is comprised primarily of the 1988 and 1989 year-classes (ages 5 and 6 in 1994). Stock size is lower than predicted from the previous assessment of this stock primarily because of the smaller estimates of the 1988 and 1989 year classes and the below average recruitment since 1989.



Recruitment

The 1979 (76 million) year-class at age 2 is the largest observed in the 1974-1993 period. As was noted in the last assessment of this resource, the 1988 and 1989 year-classes were estimated to be well above average in abundance. In the present assessment, the 1989 year-class is estimated to be closer to the long-term average and the 1988 year-class is above average in size. These two year-classes in 1994 will be nearly fully recruited to the fishery. The 1990 year class is estimated to be amongst the weakest and the 1991 year-class was weaker than any previously observed.

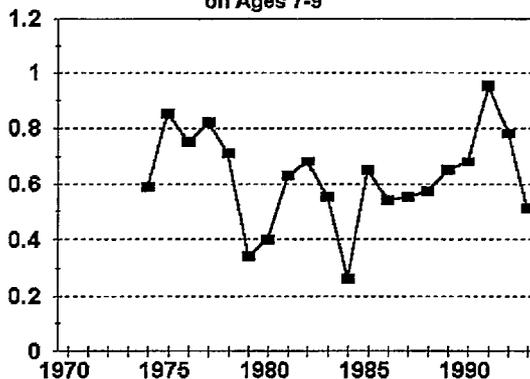
Calculated Recruitment at Age 2
(millions of fish)



Fishing Mortality

Fishing mortality on fully recruited ages (7+) since 1985 has ranged from 0.51-0.95. Fishing mortality in 1991 was 0.95 and has declined to 0.51 in 1993 remaining above the $F_{0.1}$ of 0.30. Decline in F may be due to restrictive measures put on the 4VW cod fishery, reduced quota, and mesh changes by small draggers from diamond to square mesh.

Calculated Average Fishing Mortality
on Ages 7-9



Prognosis

Catch projections were made for 1995 using the following data:

Weight* (kg)				
Age	1994 Beginning Population Numbers ('000)	Beginning of Year	Mean of Year	PR ^b
2	28,000 ^c	0.33	0.47	0.01
3	4,000 ^d	0.69	0.98	0.10
4	7,434	1.25	1.57	0.30
5	11,072	1.96	2.25	0.50
6	9,992	2.66	2.91	0.80
7	2,888	3.24	3.43	1.00
8	1,028	3.83	4.05	1.00
9	513	4.46	4.84	1.00
10	179	5.18	5.36	1.00
11	85	5.64	5.87	1.00
12	31	5.91		1.00

a = 1991-1993 average

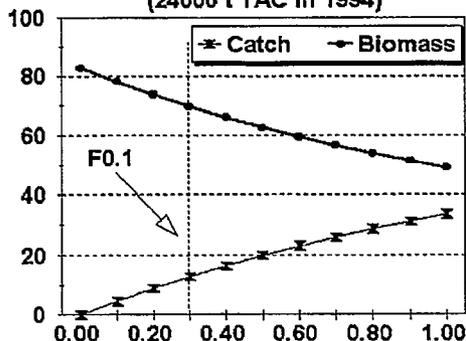
b = 1990-1992 average.

c = Geometric Mean (GM) recruitment (74-92) is 28 million

d = 1991 year class was set to the lowest previously observed

Assuming the 24,000t TAC for 1994 is caught, this would result in $F_{0.1}$ catches in 1995 of 13,000t. Catching 24,000t in 1994 would result in a $F = 0.56$ which is about twice the $F_{0.1}$.

**1995 Catch and 1996 Biomass (000 tons)
at various Fishing Mortalities in 1995
(24000 t TAC In 1994)**



Pollock abundance is very low with poor recruitment prospects for the near future. Reduced exploitation would prolong the contribution of existing year classes to the fishery and maintain a higher spawning biomass.

Uncertainties exist in the estimation of pollock abundance whether using survey data or commercial catch rate data in sequential population analysis. Difficulties in the survey data are inherent in the nature of the pronounced year effects in abundance trends in the time series and the limitations of the survey design for a "schooling" species like pollock. Factors that would influence the TC 5 catch rates include annual differences in concentration of effort between 4VW and 4X and possible changes in the way industry managers may direct the operation of the TC 5 fleet. In light of these items, and consistent with industry's view of the resource the use of commercial catch rate data was considered the best available approach for the estimation of stock size.

Research Recommendations

1. Conduct further analyses of commercial catch rates that include considerations of technological change and endeavour to include these as an indicators of stock abundance. Investigate the application of catch rate data prior to 1982.
2. Take into account of the effect that separator grates will have on the estimation of pollock partial recruitment values for the 1994 silver hake fishery.
3. The retrospective pattern for this stock should continue to be investigated with attempts to identify its causes.
4. Investigate the possibility of including both the catch rate and research survey data in the same formulation of ADAPT. Some consideration of modelling in survey year effects is recommended.
5. Investigate the cause of declining weights at age.

References

- Trippel, E.A., and L.L. Brown. 1994. Assessment of pollock in Divisions 4VWX and Subdivision 5Zc for 1993. Atl. Fish. Res. Doc.: (in press).

Summary of Status of Silver Hake

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min.	Med.	Max.
Reference level '000t	100	167	235	-	100	105	75	51	51	100	235
Advised catch '000t	100	167	235	-	100	105	75	51	51	100	235
TAC '000t	100	120	135	135	100	105	86	30	30	100	135
Reported landings '000t	62	74	91	69	68	32	29	-	29	68	91
Unreported catches	-	-	-	-	-	-	-	-			
Estimated discards '000t	-	-	-	-	-	-	-	-			
Total catches	62	74	91	69	68	32	29	-	29	68	91
Total biomass '000t	272	270	266	242	218	230	300	-	218		300
Spawning biomass '000t	158	124	77	88	78	90	-	-	77		158
Mean - F (3-5)	0.73	0.76	1.52	0.95	1.39	0.55	0.32	-	0.32		1.52

Catches: Catches dropped in recent years due to poor recruitment and low effort level.

Data and Assessment:

Fishing Mortality: Fishing mortality is estimated at 0.32 in 1994 for fully recruited age groups; will rise due to retrospective pattern in assessment. The 1992 and 1993 year-classes appear to be average in size.

Recruitment:

Environmental Factors:

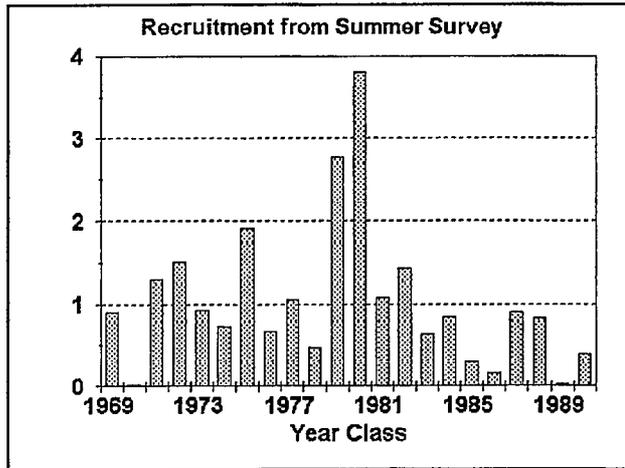
Multispecies Considerations:

State of the Stock: The stock has been low in recent years, but recovering due to improved recruitment.

Forecast for 1995: The 1995 TAC is recommended to be 79,000t; 59,000t when corrected for retrospective pattern.

Long-term Prospects:

Special Comment:



Technical Basis of Assessment of Silver Hake

Description of the Fishery

A provisional analysis of stock status was reviewed from a methodological viewpoint only. Provision of advice on stock status is the responsibility of the NAFO Scientific Council meeting in June 1994.

The silver hake fishery on the Scotian Shelf has traditionally been pursued by large (TC 7) non-Canadian fishing vessels using bottom trawls (mainly Cuba, USSR, and Japan). Canadian fishing regulations in place since 1977, restrict catches to the seaward side of the Small Mesh Gear Line. The fishery opens April 1 and closes November 15 each year; however, in recent years vessels have been allowed to commence fishing under experimental permits in March.

Since 1990 renewed attempts have been made to boost Canadian participation in fishing this species. However, attempts by Canadian fishing vessels to catch this species have met with mixed success, as long distances to the fishing ground and deeper water preferred by silver hake caused difficulty for smaller vessels. Since 1991 Canadian companies have negotiated charter arrangements with fishing companies of Cuba and the CIS (formerly USSR) to fish Canadian allocations using tonnage class 7 vessels. As a result, allocations to foreign nations have been reduced, although the overall vessel/gear composition of the fishery has remained the same as in previous years.

Nominal catches from this stock have ranged from 300,000 tons in 1973 to 32,000 tons in 1992; the provisional catch in 1993 is 29,000t. The NAFO Scientific Council advice on catch levels, the Total Allowable Catches (TACs) established, and resultant catches, from 1983 have been as follows:

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Adv.	80	100	100	100	100	167	235	-	100	105	75	51
TAC	80	100	100	100	100	120	135	135	100	105	86	30
Catch	36	74	75	83	62	74	91	69	68	32	29	NA

Data

Catch and Weight at Age

Sampling for length composition of the commercial catch in 1993 was conducted, as in previous years, by the Canadian Observer Program (IOP) while otoliths were collected by both Canada and CIS (Russia).

The commercial removals at age for 1993 were calculated from Canadian length sampling and a combined Canada/Russia age-length key. Regressions of lengths and weights from the Canadian July research vessel surveys were used to calculate yearly alpha and beta coefficients used in the calculation of sample weights and weights-at-age. The removals-at-age and weights-at-age for 1977-1992 were taken from the previous assessment (Showell et al., 1993) to provide estimates for the period 1977-93 inclusive.

Indices of Abundance

1) *Commercial Catch Rates*

The APL program STANDARD was used to standardize catch rates for the period 1977 to 1993. Catch and effort from NAFO and the IOP were categorized in a manner similar to that used in previous assessments. Examination of the regression results show year, month, and fishing regime all have a significant effect on the model. The standardized catch rate for this stock has dropped in recent years, from a peak of 5.5 t/hr in 1989 to 2.2 t/hr in 1992. In 1993 the standardized catch rate remained the same as 1992, at 2.2 t/hr. The most recent catch rates are similar to those experienced in the late 1970's and early 1980's.

2) *Canadian Bottom Trawl Surveys*

The July stratified random groundfish survey is used to provide estimates of biomass and numbers. Survey results indicate a continual decline in total numbers and biomass over the period 1986-1992. Results of the 1993 survey indicate both numbers and biomass have risen moderately. In numbers at age, the July research vessel surveys in 1991 and 1992 show the 1990 and 1991 year classes to be weak. However, the 1993 survey shows slightly higher estimates for these year classes at age 2 and 3 respectively. Further, the 1993 survey confirms initial indications that the 1992 year class is fairly strong.

3) *Silver Hake Juvenile Survey*

The standardized IYGPT 0-group survey for this species was conducted in Oct/Nov. 1993 using the Canadian R/V *Alfred Needler*. Results suggest the 1993 year class is of average size for the time series 1981-92.

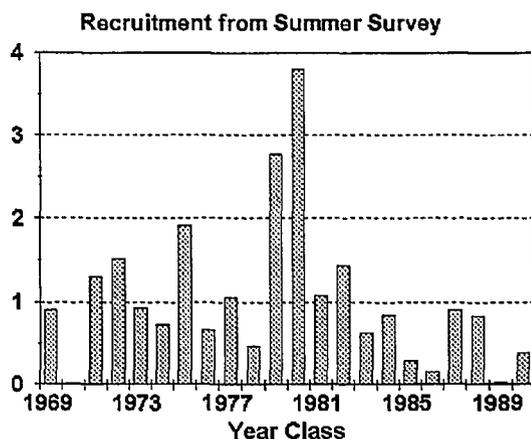
Estimation of Stock Parameters

As in previous years, a Sequential Population model was used to assess the silver hake stock. This assessment used the ADAPTive framework with a dome shaped partial recruitment pattern achieved by setting F at age 9 to 10% of that on the fully recruited ages 3-5. Canadian commercial catch-at-age, age disaggregated standardized CPUE, Canadian July Survey catch-at-age and the juvenile 0-group index were included in the analysis. Ages 3-5 were assumed fully recruited and ages 1-8 were included in the calibration block.

Recruiting Year-Class Sizes

The 1993 year-class will make a significant contribution to the catch in 1995 at age 2. Based on the 0-group survey, it appears this year class is of average strength. The 1992 year-class will also be critical at age 3 and its estimation in the SPA is based only on a single occurrence in the catch matrix. While it was decided to accept the estimates of the 1991 and earlier yearclasses as given by the SPA, the strength of the 1992 year class was inferred from July survey data.

Year-class estimates from the survey were regressed against estimates from the SPA for the 1981-90 year-classes at age 1, using the model $SPA = a + b(\ln RV)$. Data for year-classes prior to 1981 were excluded because the surveys in 1977-81 were conducted by the *A.T. Cameron*, which had a lower catch efficiency for silver hake than vessels used in subsequent years. The logarithmic curve fitted the data well ($R^2=0.84$), including that for the 1985 year-class. Prediction from this relationship gives an estimate for the strength of the 1992 year-class.



Assessment Results

As this stock will be assessed at the June 1994 NAFO Scientific Council meeting, further consideration was not given to the assessment results. Rather, several possible areas for improvement in the input data and methods were addressed and several suggestions were made. These include:

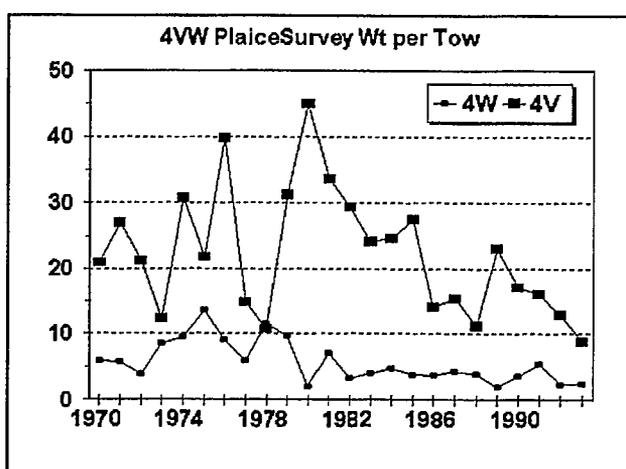
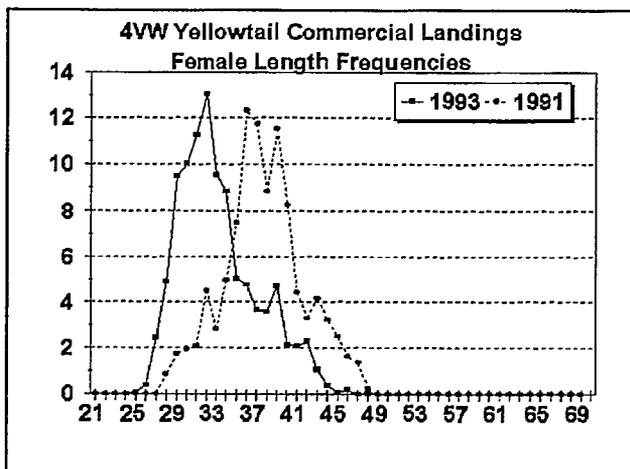
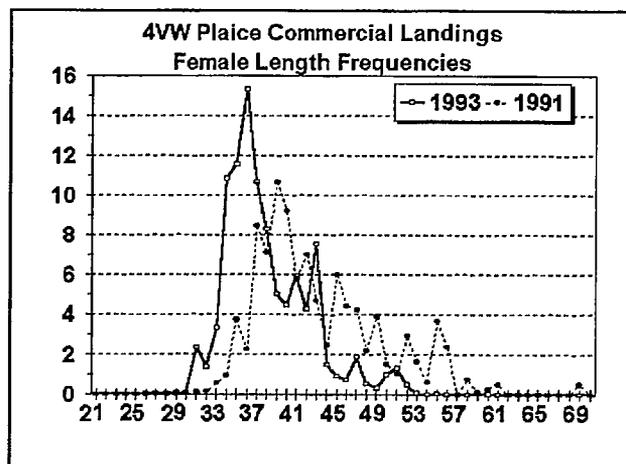
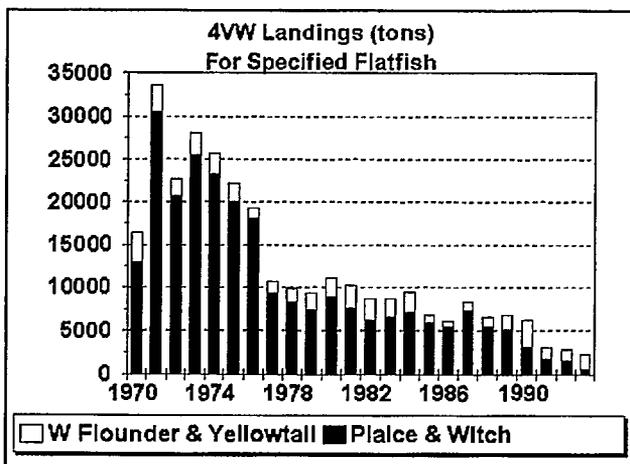
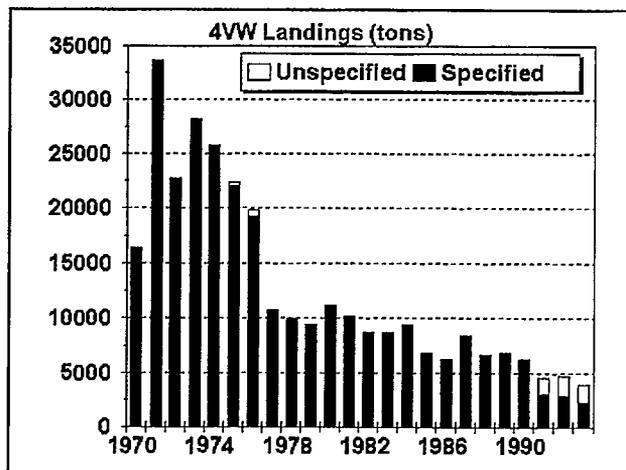
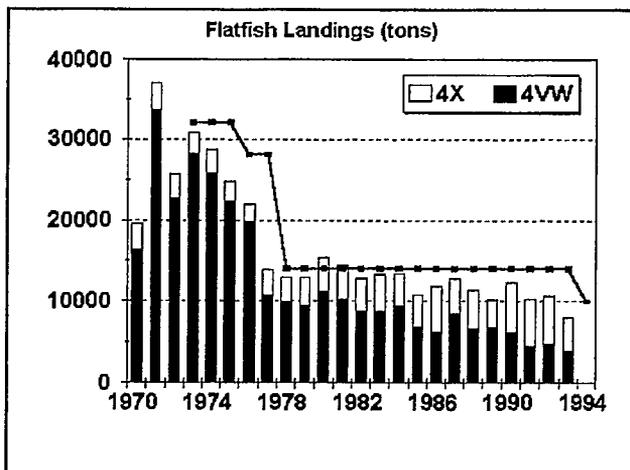
- examine k 's at age to determine effort trends in the catch/survey biomass.
- consideration of the dome - perhaps 0.1 at age 9 is too low.
- re-examine input data for standardized catch rate calculation - simplification seems appropriate.
- run a retrospective analysis using survey data only, to establish possible effects of residual patterns in CPUE data

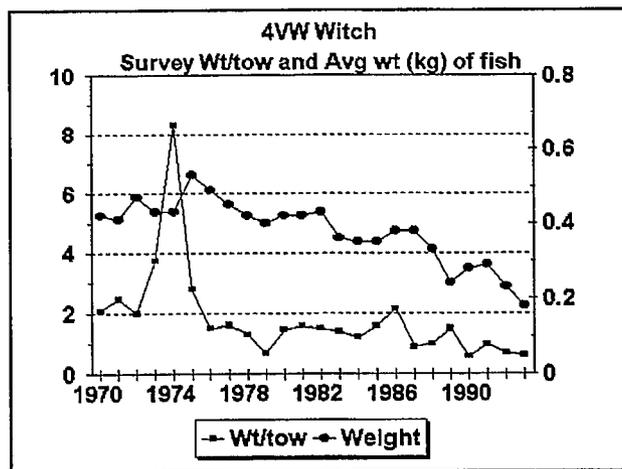
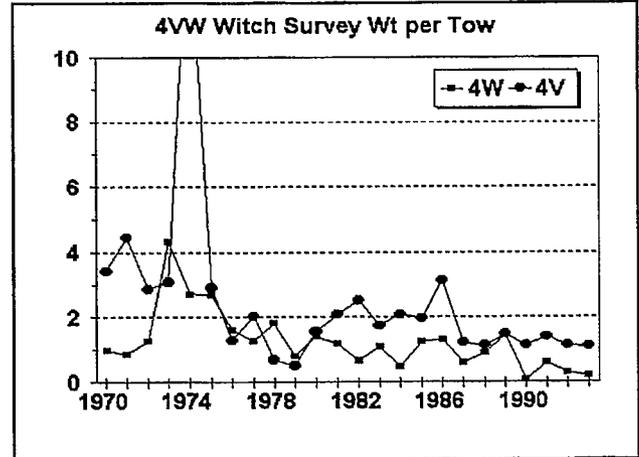
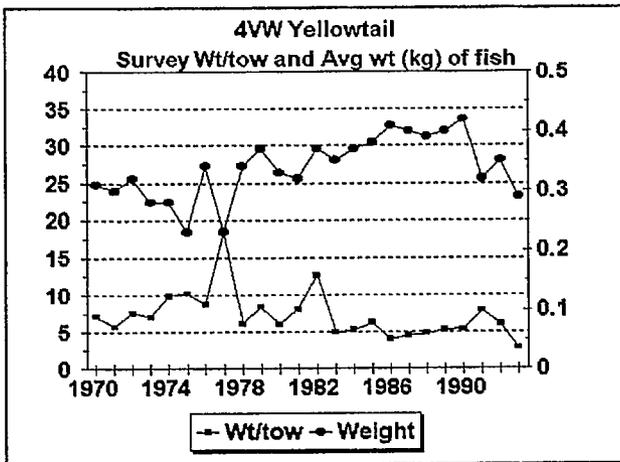
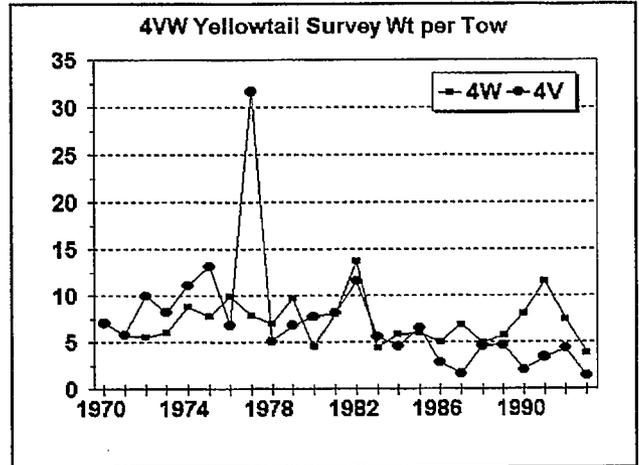
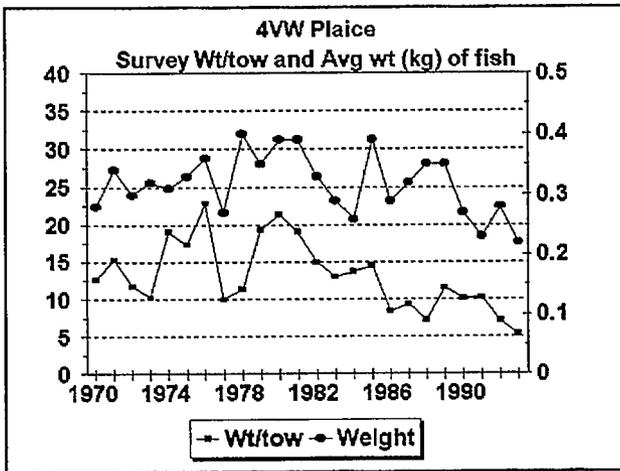
References

Showell, M.A., R. Branton, M.C. Bourbonnais, and R.G. Halliday. 1993. Status of the Scotian Shelf silver hake population in 1992, with projections to 1994. NAFO SCR. Doc. 93/102: 23 p.

Summary of Status of Eastern Scotian Shelf Flatfish

- * The combined 1993 landings of four species of flounder (American plaice, yellowtail flounder, witch and winter flounder) was 4,000t. These are the lowest landings for several decades. The landings have never been restricted by TAC, and fishing effort on flatfish by the less than 65' mobile gear sector has been increasing in recent years as gadoid stocks in 4VW have declined.
- * Length frequencies of 1993 commercial landings indicate that far fewer larger female plaice, yellowtail and witch are available than was the case in 1991.
- * Although commercial catch rate data from the catch/effort statistics are unreliable, interviews with members of the fishing industry infer that the resource is in decline and is being increasingly exploited due to the unrestrictive TACs.
- * American plaice summer research vessel survey abundance estimates for 4V (the predominant area of the fishery) have been declining since the late 1970s but have been stable in 4W. The average weight of individual plaice has been declining, indicative of a reduction in the number of large, older fish.
- * The 1993 yellowtail summer research vessel survey abundance estimate is the lowest in the 23 year time series. The average weight per tow declined sharply from 1990 to 1993. Very few yellowtail were caught during the survey in 4V, the predominant area of the commercial fishery.
- * Witch summer research vessel survey abundance estimates have been relatively stable in 4V but have decreased in 4W. There has been a steady decline in average weight of fish caught since the late 1970s.
- * Survey abundance estimates of winter flounder increased in 4W in recent years, although inshore areas where winter flounder occur, are not surveyed.
- * Qualitative information from the commercial fishery (on length composition, landings trends, and effort), as well as the summer research vessel survey estimates of abundance and size composition, indicate that present levels of fishing are causing the flatfish resource to decline and the loss of larger fish from the populations.
- * A substantial reduction in effort is required in order to reverse current trends (on the order of 50% of that required to catch the 1993 landings). The controls need to be restrictive as opposed to present regulations which do not restrict effort.



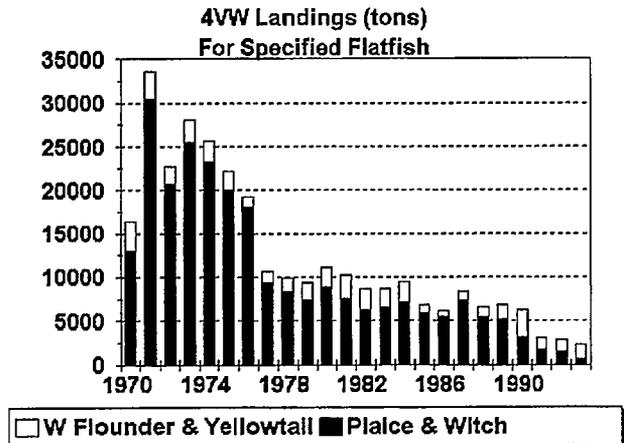
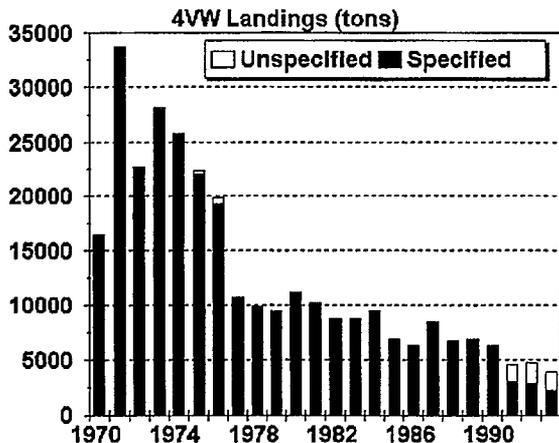
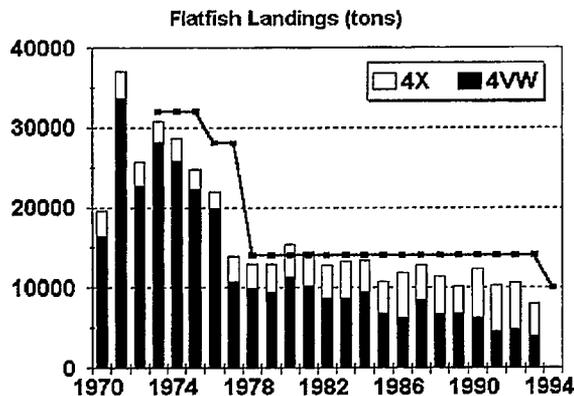


Technical Basis of Assessment of Flatfish in 4VW

Description of the Fishery

Nominal Catches

Four species of flatfish (exclusive of the halibuts) are exploited in 4VW. These include American plaice, yellowtail flounder, witch flounder and winter flounder. Of these only three are directed for, i.e. plaice, witch and yellowtail. Up to and including 1993, flounders in 4VWX were managed as one stock complex with a TAC of 14,000t. For 1994 flounders will be divided into 4X and 4VW stock components and the TAC has been reduced to 10,000t to be shared between both areas. The 1994 TAC was based on catch history and the feeling by industry that the 14,000t TAC was too high. Discussions are currently underway to review fleet shares in light of the new management units, the reduced TAC and the inclusion of winter flounder. ITQ's for mobile gear less than 65' will be implemented for flounder in 1994.



Landings by individual species are currently considered to be unreliable, due to the way statistics are collected and processed. Flatfish identification kits were distributed to mobile gear fishermen in early 1994, along with letters asking them to separate flatfish by species, in order to improve the landings data. Many fishermen have been providing estimates by species on their logs, but these data are not yet entered into the official statistics, i.e. ZIF. Unspecified flounder made up 42% of the 1993 total flounder landings in 4VW. Most of the unspecified flounder are probably plaice with varying amounts of yellowtail; witch flounder is more apt to be separated because of the price differential.

Flounder landings reached a peak of 33,637t (includes Soviet landings) in 1971, then declined to a low of 3,959t in 1993. In recent years, the less than 65' mobile gear fleet has been the only sector to pursue a directed flatfish fishery. Landings increased for the ITQ fleet to 3,477t in 1993 from 2,679t in 1992, possibly due to more vessels directing for flatfish, given the declining cod stocks in 4VW. The offshore landings dropped from 1,893t in 1992 to 323t in 1993. Because of by-catch of small cod and reduced quotas, the offshore pursued a directed redfish fishery. Fixed gear landings which are generally low, also declined in 1993.

Fishery Distribution

Distribution was examined using available logbook information, i.e. latitude, longitude and catch. Unfortunately, most of this information pertains to unspecified flounder and only a small specified subset to individual species. If this subset can be considered representative of the commercial distribution, it would suggest that American plaice is only fished in 4Vn. However, unspecified flounder assumed to be mainly plaice distributions, corroborated by industry sources, indicate that American plaice is fished throughout 4V and very little in 4W.

The yellowtail fishery distribution indicates that the fishery is carried out almost entirely in 4VSc. Industry agreed that the yellowtail fishery is centred in 4VSc, somewhat in 4V as a whole, and very little in 4W.

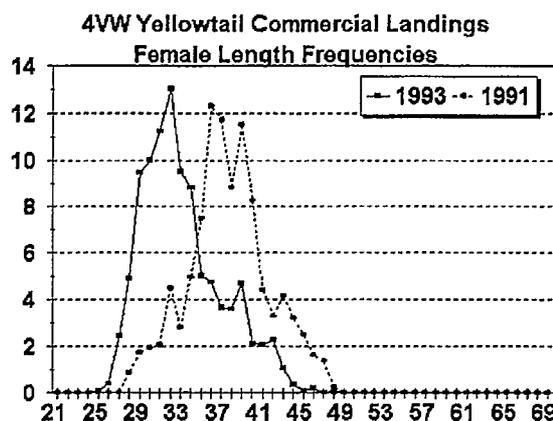
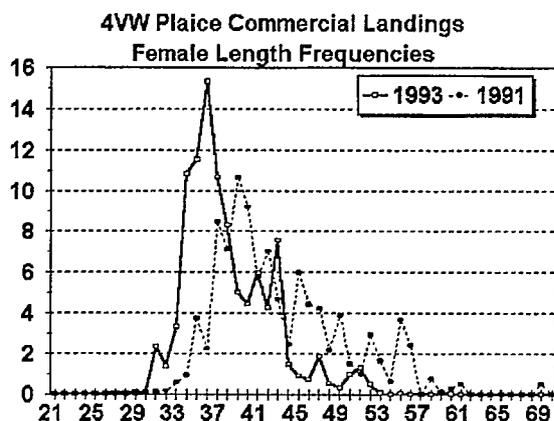
The distribution of witch flounder appears to be more ubiquitous, with more intense fishing activity in 4Vn and the 4W gully area. Recent surveys indicate that there is a potential for movement of witch between the Scotian Shelf and Gulf of St. Lawrence.

Winter flounder is not directed for in 4VW and is considered a small by-catch fishery.

Available Data

Size Composition of the Catch

Length frequencies from commercial landings (1991 and 1993) for American plaice, yellowtail and witch flounder were examined. Yellowtail samples were taken from 4VSc, plaice from 4Vn and 4VS and witch samples from 4Vn. Both plaice and yellowtail indicated far fewer large fish (greater than 35 cm) landed in 1993. This trend toward smaller fish was also noted for witch flounder.



Commercial Catch Rates

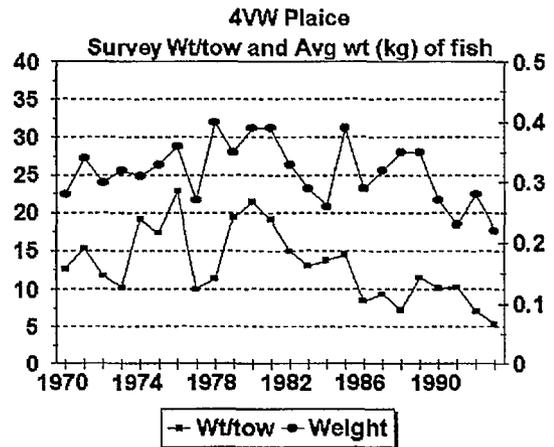
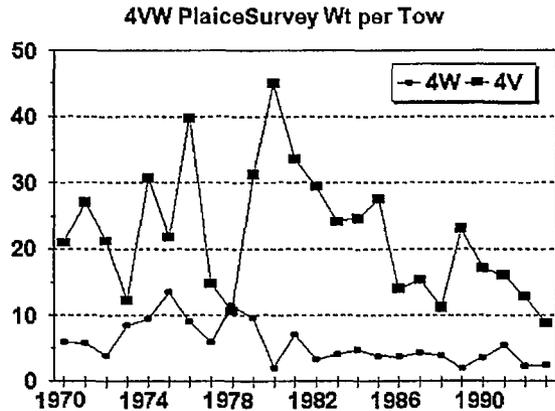
Commercial catch rates (1989-1993) were derived for the individual flatfish species including unspecified flounder, as well as a series for all flatfish combined flounder as a whole. Because of the problem with landing statistics and the by-catch nature of the fishery in the past, the use of commercial catch rates in assessing the status of flatfish stocks in 4VW is probably of limited value.

Industry discussions indicated a concern for yellowtail and plaice in particular, commenting that "the resources can't stand any more effort". They also reported that more vessels are now directing for flatfish in the 4VW area.

Research Survey Data

American Plaice

The summer research vessel survey (1970-1993) stratified mean numbers per tow for 4VW American plaice were relatively stable through the early 1980s, then declined to a series low in 1988. Since then, abundance increased to 1991 but has declined since. 4V numbers per tow have generally been declining since the late 1970s, while 4W numbers remained stable or increased over the same period. The stratified mean weights per tow in 4V declined since 1980 and in 4W declined from high levels in the 1970s, then remained stable at lower levels to the present. To provide a view of the abundance of larger and smaller fish in the area where most of the fishery takes place (i.e. 4V) an estimate of the mean weights of plaice was examined. Results indicate that the average weight of an American plaice in the survey has declined since the late 1980s to a low of 220 gm in 1993. Average weight was generally between 300 and 400 gm prior to that time.



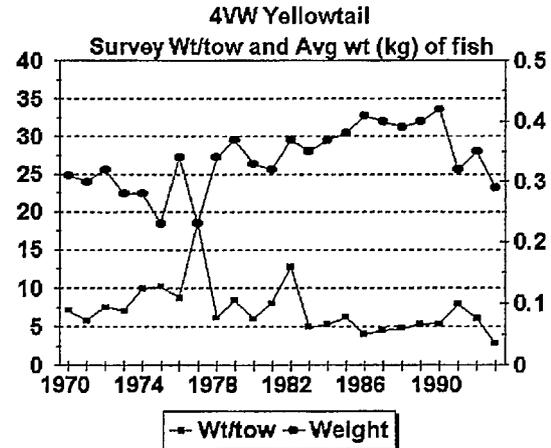
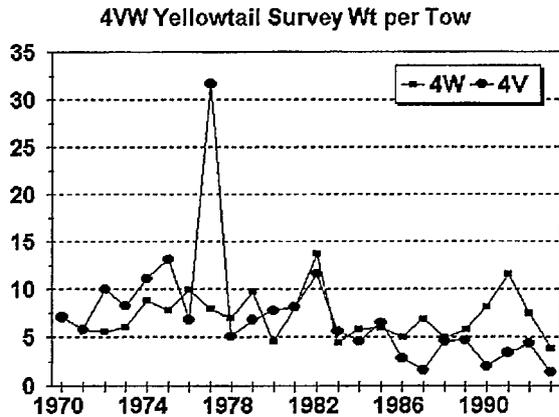
The summer survey (1993) distribution maps for American plaice catches show a similar distribution to earlier years, with major concentrations in the 4V area, although abundance is down relative to earlier years.

The spring 4VW survey (1986-1994) mean numbers per tow have declined since 1990. The magnitude of the numbers per tow is lower in the spring survey by about half than that of the summer survey. Distribution maps show spring concentrations are generally in the gully area and in the deeper waters of the Laurentian Channel.

Length frequencies from the surveys indicated a continuing decrease in numbers of large fish caught (greater than 50 cm) noted last year.

Yellowtail

The summer research vessel survey (1970-1993) stratified mean numbers per tow for 4VW yellowtail flounder declined in the late 1970s, remaining stable through the 1980s with an increasing trend through 1991. The 1993 survey point is the lowest in the 23 year time series. Mean numbers per tow have been declining since the early 1980s in 4V and have remained stable or increased in 4W. The stratified mean weights per tow in 4V declined since 1982 and in 4W declined from high levels in the 1970s remained stable during the 1980s and have declined since 1991. Because the bulk of the commercial fishery is in 4V, an estimate of the average weight of yellowtail in that area indicate that the average weight of yellowtail flounder from the survey increased since the late 1970s to a high of 420 gm in 1990 then declined to 290 gm in 1993. Average weight was generally above 350 gm during the 1980s.



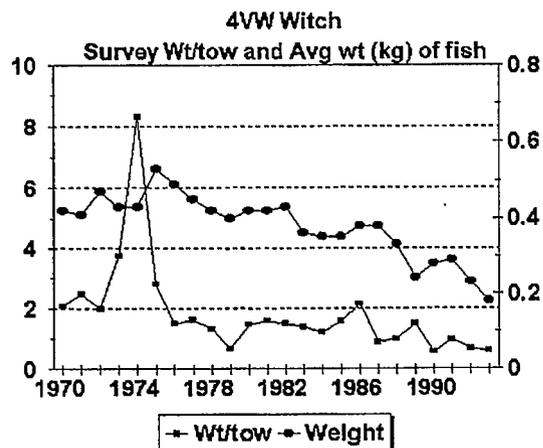
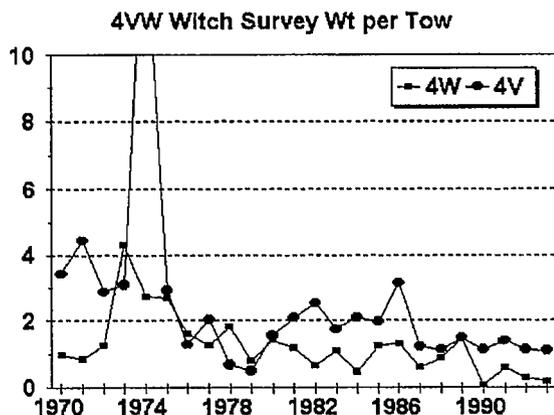
The yellowtail summer 1993 survey continues to indicate a change in distribution between 4V and 4W. Major concentrations were noted in 4W, with relatively few yellowtail caught in 4V, although most fishing activity takes place there.

The 4VW spring survey abundance decreased between 1988 and 1992; however, the 1992 point may be anomalously low with large catches of yellowtail being caught in very deep water. Abundance increased for 1993 but returned to a more average level in 1994. The spring survey distributions show very few yellowtail caught east of Sable Island.

Length frequencies in 1993 were similar in size distribution 1994; however, the length frequencies in stratum 455 and 456 (4W) indicate that yellowtail peak at 25-26 cm while in stratum 447 and 448 (4VSc) they peak at 35-36 cm. This apparent size difference may be one reason that fishermen catch yellowtail almost entirely in 4V rather than 4W. Tagging information shows movement of yellowtail between the two areas. Small yellowtail in 4W may provide recruits to the commercial fishery in 4VSc.

Witch Flounder

The summer research vessel survey mean numbers per tow for 4VW witch flounder were low but relatively stable over the time series. Mean weight per tow in 4W have declined slowly since the mid 1970s, while weights per tow in 4V have remained more stable over most of the time series. Survey distributions indicate that witch flounder are widely distributed in 4VW but in low concentrations. Localized areas of abundance occur in the Gully and in deep holes north of Banquereau and in 4Vn. The summer survey does not cover the deep waters of the Laurentian Channel and therefore may not cover the entire species distribution.



The 4VW spring survey abundance declined from 1987 to a low in 1990 and has remained stable to 1994. Spring distributions show very little witch flounder on the shelf, but larger catches were made in the deep waters of the Laurentian Channel.

Survey length frequencies did not indicate any significant change in size composition from previous years. However, examining the average weight of witch estimated from the survey weights and numbers per tow indicate a steady decline in the average weight since the late 1970s.

Winter Flounder

Winter flounder stratified mean numbers per tow in 4VW were low until 1983 and have been increasing since. The summer survey distributions continue to show increased concentrations to the west of Sable Island in 4W, Sable Island, Middle, and Western banks. It should be noted that a large portion of the survey abundance is contained within the 4W closed area.

In the spring survey, numbers per tow are very low and variable but have been increasing in the last two years. The survey found no winter flounder east of Sable Island in 1993 and 1994.

1993 survey length frequencies did not indicate any significant change in size composition from previous years.

Assessment Results

American Plaice

Both mean numbers and weights per tow for 1993 are the lowest on record in 4V. The numbers per tow are at about half the long term (1970-1992) average and weights per tow less than half the long-term average. This is cause for concern because most of the fishery takes place in 4V. If 4W mean numbers per tow are included the 1993 value is still well below the long-term average.

The average weight of American plaice in the population has been declining since the late 1980s and is currently the lowest value in the time series (1970-1993). Commercial and survey length frequencies support this observation, showing a significant decline in the number of large fish in recent years.

Yellowtail Flounder

Yellowtail presents a similar picture to American plaice; 4V mean numbers are the second lowest on record and mean weights are the lowest. They are both less than 25% of the long-term average. Most of the fishery takes place in 4VSc. 4W abundance has been more stable over the time series but has declined in the last two years. 1993 mean numbers per tow in 4VW are well below the long-term average.

The average weight of yellowtail in the population has been declining since 1990 and is currently one of the lowest values in the time series (1970-1993). Average weights were only lower during the mid 1970s when the stock was heavily exploited by foreign fleets. Commercial length frequencies show a decline in the number of large fish between 1991 and 1993.

Small yellowtail are abundant in 4W and may provide recruitment to the 4Vs area.

Witch Flounder

Witch flounder abundance in 4VW has been relatively stable; however, the survey is quite variable due to the localized concentrations of witch flounder and the lack of survey coverage in the deep waters of the Laurentian Channel. Landings of witch flounder declined in 1993, despite an increase in overall flounder landings. Indications from industry are that effort has increased on all flounders.

As well, the average weight of witch flounder in the survey has declined from over 500 gm in the mid 1970s to about 200 gm in 1993.

Winter Flounder

Winter flounder abundance in 4W has increased since the mid-1980s, however inshore areas where winter flounder may occur are not surveyed. Average weights from the survey were not examined as winter flounder is not a directed fishery in 4VW.

4VW Flounder			
1993	Increase	Decrease	Stable
American Plaice			
- survey weights/tow		X	
- average weight survey		X	
- fish size commercial		X	
- identified catch		X	
Yellowtail Flounder			
- survey weights/tow		X	
- average weight survey		X	
- fish size commercial		X	
- identified catch	X		
Witch Flounder			
- survey weights/tow			X
- average weight survey		X	
- fish size commercial		X	
- identified catch		X	
Winter Flounder			
- survey weights-tow	X		
- average weight survey			
- fish size commercial			
- identified catch		X	
Unspecified Flounder			
- survey weights/tow			
- average weight survey			
- fish size commercial			
- identified catch		X	

Prognosis

If the observed declines in flatfish abundance are related to fishing activities, then reducing catches may reverse the declines. At present we have no measure of the effects of fishing on the resource. However, for the past number of years the TAC has not been restrictive, with landings far below the TAC. A substantial reduction in effort would be required (in the order of 50% of the 1993 catches) in order to reduce fishing mortality below current levels.

Research Recommendations

1. Investigate the interaction (if any) of Gulf and Scotian Shelf witch flounder.

References

Annand, C., and D. Beanlands. 1994. An update on the status of 4VW and 4X flatfish stocks. Atl. Fish. Res. Doc. 94/34: 66 p.

Summary of Status of Southern Scotian Shelf - Bay of Fundy Flatfish

- * The combined 1993 landings of American plaice, yellowtail flounder, witch and winter flounder was 4,000t. Only witch and winter flounder are directed for in 4X. Landings have never been restricted by TAC and anecdotal information from industry indicates that fishing effort on this management unit has been expanding considerably during recent years as the gadoid stocks have declined in 4X and 5.
- * The length frequency of the 1993 commercial fishery landings indicate that there are smaller witch and winter flounder in the landings relative to 1991.
- * Interviews with representatives of the fishing industry consistently report that catch rates for the directed flounder species (witch and winter flounder) have been declining.
- * Witch flounder summer research vessel survey estimates have declined since the 1980s. There has been a sharp decline in the average weight per fish since 1990.
- * Winter flounder summer research vessel survey estimates for the offshore banks show increasing abundance until 1992, with the 1993 point dropping to half the 1992 value. The average weight of winter flounder has dropped during the past two years.
- * The inshore area of 4X, which is of considerable importance for winter flounder habitat, is not covered by the survey.
- * American plaice and yellowtail flounder are not prevalent in 4X. The survey estimates indicate relatively stable abundance with no trends in mean size in the populations.
- * The qualitative information from the fishery, as well as the summer research vessel survey results, imply that witch flounder are at very low abundance and that fishing effort is high. The fishery has been unrestricted to date.
- * The status of the winter flounder stock complex is not well understood. Data on the commercial fishery are limited and the summer research vessel survey does not cover a major part of the distributional area. Given the uncertainty, and the recent increase in the directed fishery, a prudent approach is to restrict fishing effort until there is an improved understanding of both the resource and the fishery. Given the probable existence of a number of relatively distinct populations within 4X, effort should be distributed across the area.

**Southern Scotian Shelf - Bay of Fundy Flatfish
SUMMARY**

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min.	Med.	Max.
Reference level '000t											
Advised catch '000t											
TAC '000t ²	New Management Unit - TAC to be established for each area after industry consultation										
Total landings '000t	4.2	4.6	3.3	6.0	5.8 ¹	5.9 ¹	4.0 ¹		4.0'	4.6'	6.0'
Reported landings by species '000t	.49	.54	.53	.65	.61	.83	.37				
Witch flounder	1.0	1.5	1.3	1.9	.6	.6	.3				
Winter flounder	.1	.08	.05	.08	.14	.12	.05				
Yellowtail flounder	.26	.37	.48	.47	.99	.42	.09				
American plaice	2.4	2.2	1.0	3.0	3.4	4.0	3.2				
Unspecified											
1 = 1987-1993 2 = TAC - 14,000 in 1993; 10,000 proposed 1994 3 = preliminary statistics											

Catches: Overall landings have been declining; individual species data are not reliable due to misidentification of flounder.

Data and Assessment: Catch rates from the spring and summer research vessel surveys were used as indices of abundance. Estimates of average weights from the survey along with commercial length frequencies were used to provide information on the abundance of large and small fish over time. Industry discussions and the general biology of some species were also considered.

Fishing Mortality: Fishing mortality is thought to have increased due to a redirection of effort from the cod, haddock and pollock fishery.

Recruitment:

Environmental Factors: In the Bay of Fundy/Lurher Shoals, and in depths of 50-100m, temperatures have declined since the mid to late 1980s and have been as cool as the mid 1960s. In the deep waters (>150m) temperatures have warmed slightly or remained steady in recent years.

Multispecies Considerations:

State of the Stock: Witch flounder -- Based on the survey estimates, length frequencies and average weights, the stock appears to be decreasing in abundance.

Winter flounder -- Survey estimates of abundance are relatively high, however the survey does not cover a large portion of the species distribution. Anecdotal reports indicate increased effort and lower catches - the stock may be declining. Average weight and length frequencies indicate some decrease in size of male winter flounder.

American plaice -- Stock size is stable or increasing.

Yellowtail -- Stock size is stable.

Forecast for 1995: Witch flounder -- Catches should decrease as a result of declining abundance and reduced size range.

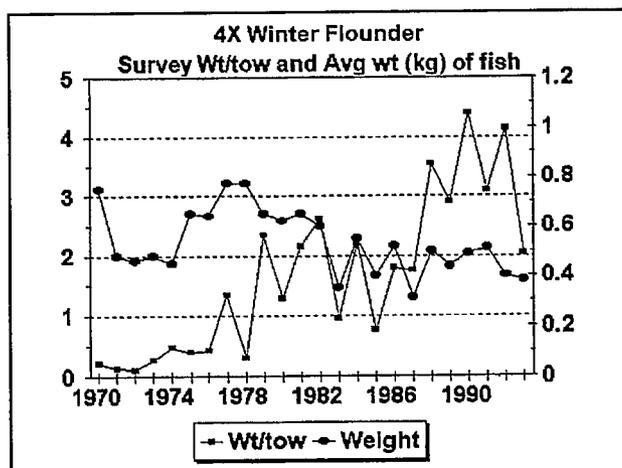
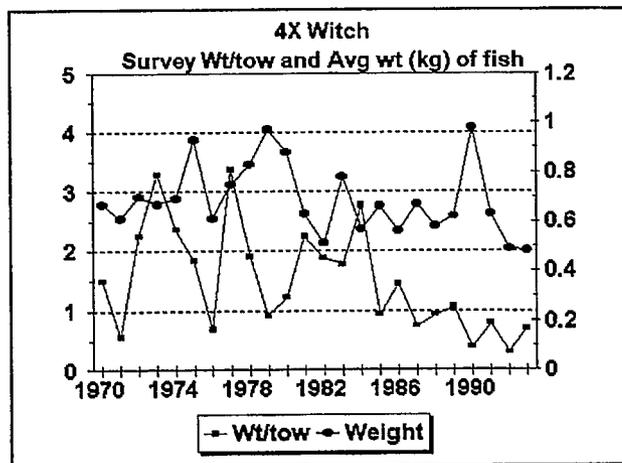
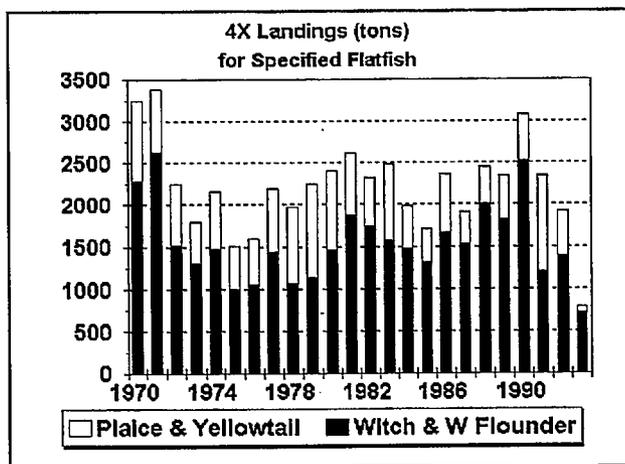
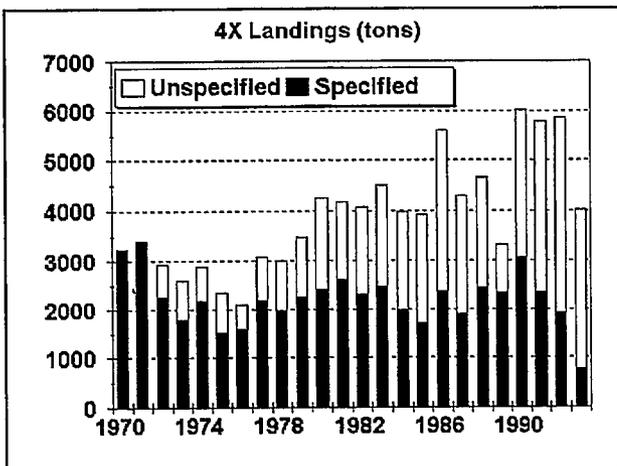
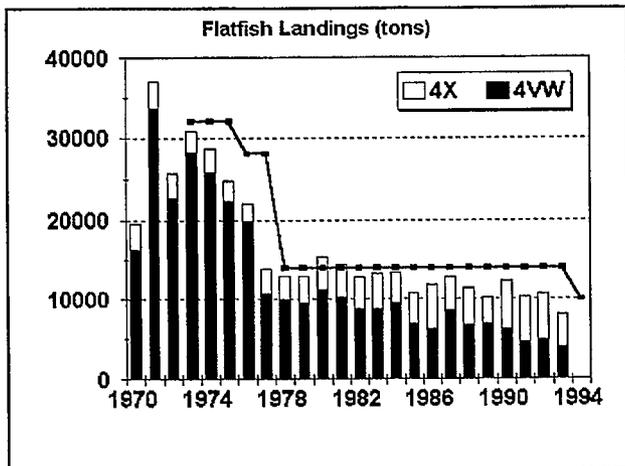
Winter flounder -- Catches may decrease, especially in localized areas, based on some decline in average weight and size and industry reports of increased effort.

American plaice -- Catches should remain stable but low.

Yellowtail -- Catches should remain stable or increase slightly.

Long-term Prospects:

Special Comment: Winter flounder is now included under the 4X flounder quota. Consideration should be given to developing a management plan for winter flounder that recognizes the possibility of several population units.

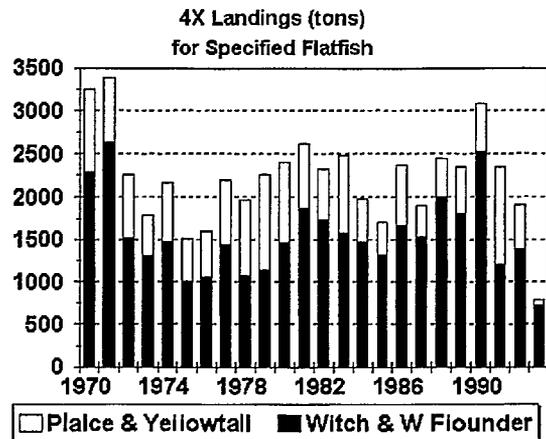
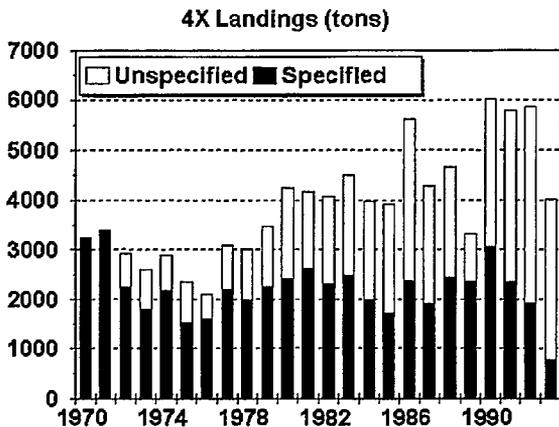
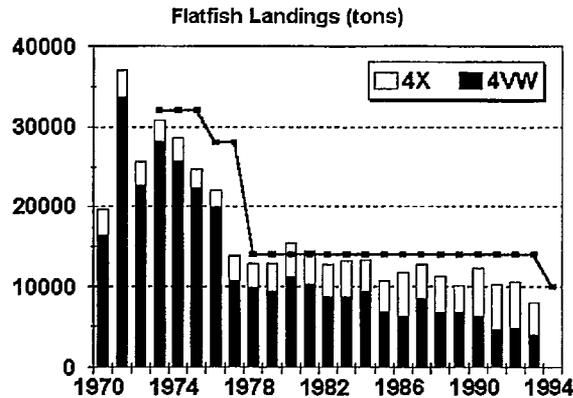


Technical Basis of the Assessment of Flatfish in 4X

Description of the Fishery

Nominal Catches

Four species of flatfish (exclusive of halibut) are exploited in 4X. These include American plaice, yellowtail flounder, witch flounder and winter flounder. Of these, only two, winter flounder and witch flounder are directed for, while yellowtail and American plaice are generally by-catch fisheries. Through 1993, flounders in 4VWX were managed as one stock complex with a TAC of 14,000t. For 1994, flounders will be divided into 4X and 4VW stock components and the TAC has been reduced to 10,000t for both areas. The 1994 TAC was based on catch history, and the feeling by industry that the current TAC was too high since landings have been below the TAC in recent years. Discussions are currently underway with Industry to review fleet shares in light of the new management units, the reduced TAC and the inclusion of winter flounder under the TAC. ITQs for mobile gear less than 65' will be implemented for flounder in 1994.



Landings by individual species are currently considered to be unreliable due to the way statistics are collected and processed. Flatfish identification kits were distributed to mobile gear fishermen during early 1994, along with letters asking them to separate flatfish by species, in order to improve the landings data. Fishermen are concerned about the lack of correct landings information and an initiative is underway by one plant to send in correct plant weightouts by species. As well, many fishermen have been providing species estimates on their logs, but these data are not yet entered into the official statistics, i.e. ZIF. Unspecified flounder made up 80% of the 1993 total flounder landings in 4X. A large portion of the unspecified flounder are probably winter flounder, with varying amounts of yellowtail and American plaice. Witch flounder is directed for and is more apt to be separated because of the price differential.

Historically very little flounder (usually between 2,500-3,500 t) was landed in 4X and total flounder landings reached a peak of 5,885t in 1992, then declined to 4,011t in 1993. In recent years the <65' mobile gear fleet has been the only sector to pursue a directed flatfish fishery. Landings declined for the ITQ fleet by about 30% from 5,549t in 1992 to 3,831t in 1993. Discussions with industry indicated that this was in part due to the midseason adjustments in quota which prevented them from participating fully in their usual fall fishery. Industry also indicated that it was requiring more effort to catch the same amount of fish as in previous years. It may be that more vessels are directing for flatfish, given the declining cod and pollock quotas. Since the implementation of ITQs, fishermen who received low ITQ's or wanted to build a history in flatfish have entered the fishery. Offshore landings are a small amount of by-catch in their very limited cod, haddock and pollock (CHP) fishery recent years. Fixed gear landings, which are generally low, also declined in 1993 from 358t to 166t.

Fishery Distribution

Distribution was examined using available log information, i.e. lat, long and catch. Unfortunately, most of this information pertains to unspecified flounder and only a small subset to individual species. If these subsets can be considered representative of the commercial distribution it would suggest that winter flounder appear to be fished around the Browns Bank area up into the Bay of Fundy. However, unspecified flounder distributions, corroborated by industry, indicate that winter flounder is fished in many small bays and inlets around the coast, especially in the inshore portion of the Bay of Fundy. The fishery distribution of witch flounder is more wide spread and industry indicated that the fishery occurred predominantly in depths greater than 100 fathoms.

Available Data

Size Composition of the Catch

Commercial length frequencies for winter and witch flounder were examined for 1991 and 1993. These years were chosen to look at possible changes in size distribution related to increased effort since ITQ implementation. Witch samples came primarily from 4Xn and 4Xo, while winter flounder samples were more widespread. Both showed smaller fish in the 1993 fishery. Because of the by-catch nature of the yellowtail and American plaice fishery, samples were not available to look at the length frequency information of these stocks.

A joint industry-DFO initiative coordinated by J. Kearney was carried out in the upper Bay of Fundy Area. The objectives of the initial pilot project were to collect length frequency information, otoliths and logbook information from participating fishermen. The observations of these fishermen who fish further inshore than the area covered by the surveys, is that the winter flounder resource has declined notably. Funding for a second phase of the study is being pursued. The second phase, if funded, will focus on stock definition and the collection of maturity data.

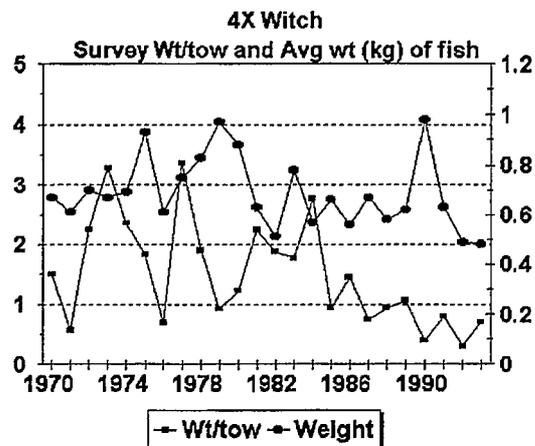
Commercial Catch Rates

Commercial catch rates (1989-1993) were derived for the individual flatfish species including unspecified flounder, as well as a series for flounder as a whole. Effort hours seemed unusually high; however, fishermen felt it was the result of fishing to make a trip pay rather than directing for any one species. The problems with landing statistics (flounder identification), probably make the use of commercial catch rates in assessing the status of flatfish stocks in 4X of limited value. Industry discussions indicated that large concentrations of witch flounder were difficult to find, and that it was generally requiring more effort to catch the same amount of fish as in previous years. The generalist fleet indicated particular concern for the winter flounder stock, citing increased effort by other mobile gear vessels as a problem.

Research Survey Data

Witch Flounder

The summer research vessel survey (1970-1993) stratified mean numbers per tow for 4X witch flounder were highly variable through the 1970s. Since the early 1980s, the survey estimate has declined. The stratified mean weights per tow in 4X also declined since 1980 and both the numbers and weights in recent years are well below the long-term mean. Average weight has been generally between 600 and 800 gm; however, for the last two years average weight dropped below 500 gm, the lowest values in the series.

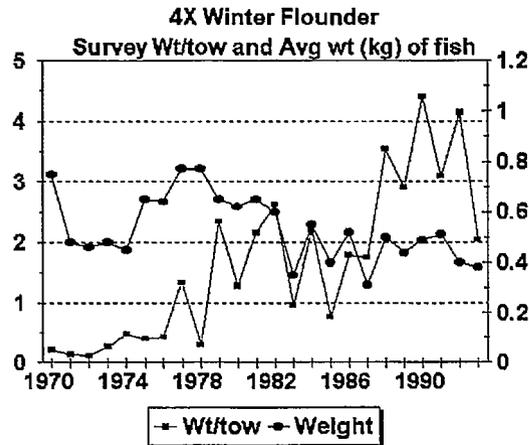


Summer survey distribution maps (1970-1992) for witch flounder catches indicate that witch are widely distributed in 4X, but in low concentrations. The 1993 distribution is similar, although the number of witch caught was very low.

Winter Flounder

The summer research vessel survey (1970-1973) stratified mean numbers per tow for 4X winter flounder have shown an increase since the late 1970s with a stable period through the 1980s and an increase to the present, although the 1993 point is approximately half the 1992 value. Mean weights per tow exhibit a similar trend. It should be noted that the summer survey does not cover the inshore portion of 4X, which is thought to contain a large portion of the winter flounder, (e.g. 650,000 lbs of winter flounder were caught over a 3-4 day period in Scots Bay in August of 1993). Industry indicated

that these fish were feeding on herring spawn and had moved from the Minas Basin as the water temperatures increased.



The mean number/tow within the strata at the head of the Bay of Fundy and the mouth of St. Marys Bay has been increasing since the early 1980s. In the offshore strata (Browns), there appears to be a decrease in abundance since 1991.

The distribution of winter flounder as estimated from surveys appears to be restricted to the Browns Bank area and the Bay of Fundy. It is uncertain whether there is mixing between these two areas. Winter flounder did not appear consistently on Browns Bank until the mid to late 1980s.

It was noted that there were no small winter flounder caught in the Browns Bank area.

Yellowtail

The summer research vessel survey mean numbers per tow for 4X yellowtail flounder have been very low and have shown little change in recent years. Mean weights per tow have increased since the early 1980s. Yellowtail survey distribution in 4X is generally limited to the Browns Bank area and the mouth of the Bay of Fundy.

Survey length frequencies indicate no significant change in size composition from previous years.

American Plaice

American plaice stratified mean numbers and mean weights per tow per tow in 4X were low, but relatively stable over the entire time series. The summer distributions as estimated by surveys show a similar pattern to earlier years with small concentrations between Browns Bank and Roseway, as well as in the Bay of Fundy.

The 1993 survey length distributions indicate no significant change in size composition from previous years.

Assessment Results

Witch Flounder

Landings of witch flounder in 4X are less than half the recorded 1992 landings. The fishery is generally not a fall fishery, thus the reduced quotas in other stocks should not have affected it significantly. Both mean numbers and weights per tow for 1993 are among the lowest observed, and well below the long-term mean. Industry reports that catches have been scarce, large concentrations more difficult to find, and that new areas are being fished.

The average weight of witch flounder in the population was relatively stable during most of the time series, but has declined to its lowest levels in 1992 and 1993, indicating fewer large fish.

Commercial length frequencies support this observation, showing a significant decline in the number of large fish in recent years (1991 vs 1993).

Winter Flounder

Winter flounder shows numerous genetically identifiable stocks associated with individual bays and estuaries providing winter spawning grounds. Stock groups may consist of several adjacent estuary spawning units. Although this has not been demonstrated, there is no reason to doubt a similar situation in 4X. Adult winter flounder seasonal movements consist of two phases, an autumn estuarine immigration prior to spawning and a late spring/summer movement to either deeper cooler portions of estuaries or to more offshore areas (McCracken 1963). Data from the flounder fishery in the upper Bay of Fundy indicate that winter flounder leave shoal areas in winter for deeper water; however, winter flounder in the Pubnico Harbour regions migrate from warm shoal areas to cooler deeper water in summer (McCracken 1963). Various tagging studies have indicated limited movement of winter flounder, i.e. 10-30 km. It has been suggested that summer distribution is related to a temperature preference of 12-15°C. Generally, spawning is thought to take place in the spring in the shallow inshore areas.

Most of the concern for this management unit is based on anecdotal information from industry and the general biology of the species. Although survey mean numbers and weights per tow have been increasing in recent years, these patterns are not consistent with fishermen's reports of increased effort with reduced catches. The lack of agreement between industry reports, and the survey may be because the survey does not cover the very inshore areas where traditional fisheries have taken place. If the winter flounder population is made up of several localized spawning groups there may be a danger of fishing out individual populations, especially with increased effort and the directed type of fishing noted in Scots Bay last August.

Commercial length frequencies showed a slight decline in the mean size of winter flounder landings from 1991 and 1993. Survey length frequencies indicated that small flounder have not been caught in the Browns Bank region. Browns Bank may be a separate population or perhaps, older fish associated with the adjacent inshore population(s) migrate there.

American plaice and yellowtail resources appear to be stable at low abundance levels.

4X Flounder			
1993	Increase	Decrease	Stable
American Plaice			
- survey weights/tow - average weight survey - fish size commercial - identified catch		X	X
Yellowtail Flounder			
- survey weights/tow - average weight survey - fish size commercial - identified catch	X	X	
Witch Flounder			
- survey weights/tow - average weight survey - fish size commercial - identified catch		X X X X	
Winter Flounder			
- survey weights-tow - average weight survey - fish size commercial - identified catch	X	X X X	
Unspecified Flounder			
- survey weights/tow - average weight survey - fish size commercial - identified catch		X	

Prognosis

If the observed declines in flatfish abundance are related to fishing activities, then reducing catches may reverse the declines. At present we have no measure of the effects of fishing on the resource. Witch flounder sustains a directed fishery in the 4X area. Total flounder TACs in the past has not been restrictive and may have to be reduced substantially in order to reduce fishing mortality.

For winter flounder, the evidence is less compelling. A large portion of the winter flounder abundance is in the unsurveyed area. However, anecdotal information indicates declines in abundance in these inshore areas. If winter flounder populations are highly localized, with the extent of mixing unclear, the catch should be broadly distributed. Consideration should be given to developing a management plan that recognizes the possibility of several population units. Seasonal and geographical restrictions could be used to manage the fishery. Management on a smaller scale than 4X as a whole may be required.

Discussions should be held with industry to develop a mechanism to deal with a series of relatively small populations within a larger flatfish resource.

References

Annand, C., and D. Beanlands. 1994. An update on the status of 4VW and 4X flatfish stocks. Atl. Fish. Res. Doc. 94/34: 66 p.

McCracken, F. 1963. Seasonal movements of the winter flounder, (*Pseudopleuronectes americanus*), (Walbaum) on the Atlantic coast. J. Fish. Res. Board Can. 20: 551-586.

Summary of Status of Atlantic Halibut (3NOPs4VWX)

- * The 1993 landings of Atlantic halibut were 1,200t. The TAC for this resource has never been restrictive. Landings are their lowest in recent decades while directed effort has been increasing as the gadoid stocks have declined.
- * Most halibut are caught by small longliners with mobile gear restricted to a by-catch fishery. A large proportion of the mobile gear catch is below the minimum size limit.
- * On the Scotian Shelf, commercial catch rates by longliners have been declining since 1981 in spite of the introduction of the more efficient circle hook. Interviews with the Fishermen and Scientist Research Society also indicate that catch rates have declined in recent years.
- * Biomass estimates from the Scotian Shelf summer research vessel surveys increased from 1983 to 1990, but have since declined. The spring eastern Scotian Shelf survey also have declined since 1991.
- * Restrictions on groundfish fishing effort are a pre-requisite to stock rebuilding.

Atlantic Halibut (3NOPs4VWX)
SUMMARY

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min.	Med.	Max.
Reference level '000t	-	3.2	3.2	3.2	3.2	3.2	3.2	1.5	1.5 ¹	3.2 ³	3.2 ³
Advised catch '000t	-	3.2	3.2	3.2	3.2	3.2	3.2	1.5	1.5 ¹	3.2 ³	3.2 ³
TAC '000t	-	3.2	3.2	3.2	3.2	3.2	3.2	1.5	1.5 ¹	3.2 ³	3.2 ³
Reported landings '000t	2.6	2.3	1.9	2.1	2.2 ²	1.3 ²	1.2 ²		1.1 ¹	1.9 ¹	4.0 ¹
Unreported catches											
Estimated discards '000t											
Total catches '000t											
Total biomass '000t											
Spawning biomass '000t											
Mean - F											
1 = 1961-1993 2 = preliminary statistics 3 = 1988-1994											

Catches: Catches have decreased slowly from a maximum of 4,031t in 1985 to 1,243t in 1993.

Data and Assessment: Commercial catch rates and biomass estimates from the survey were used as indices of abundance. The landings suggest a decreasing stock size while the commercial catch rates have decreased slowly since 1981 despite the introduction of the more efficient circle hook. Biomass estimates from the summer surveys increased from 1983 to 1990, but have declined since. The spring eastern shelf research vessel survey has been variable to 1991 but has also declined steadily since.

Fishing Mortality:

Recruitment: Browns Bank may be a nursery area for this stock.

Environmental Factors:

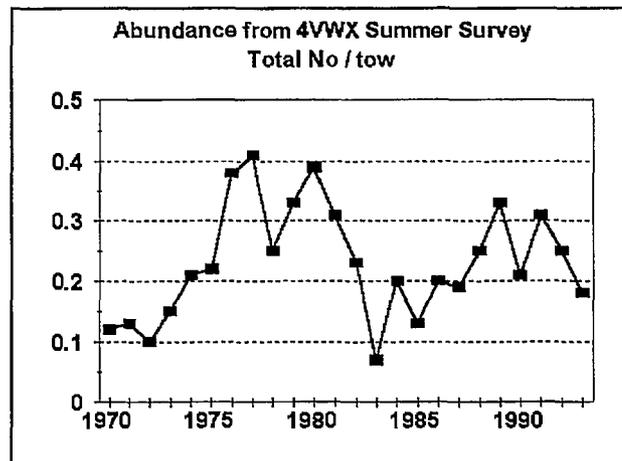
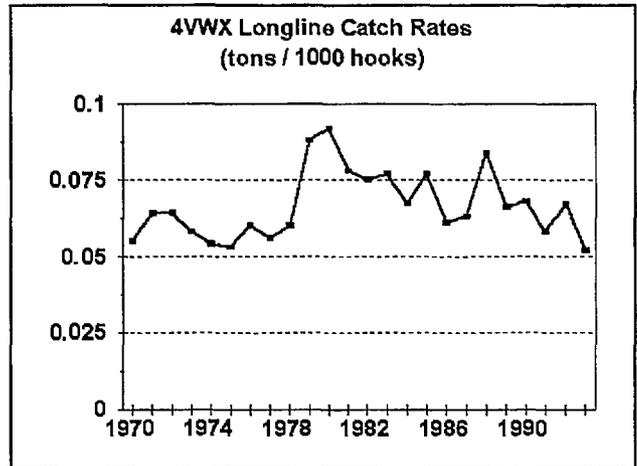
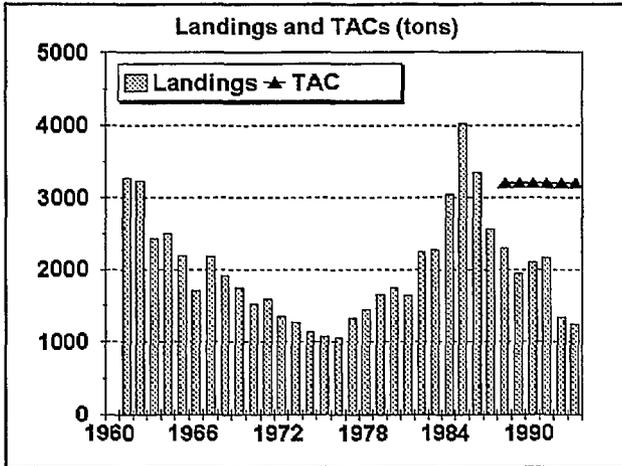
Multispecies Considerations:

State of the Stock: Based on declining commercial and survey catch rates, as well as landings, the stock is decreasing. Increased effort was noted by industry as well as a lack of larger fish.

Forecast for 1995: The Atlantic halibut stock size appears to be decreasing and catches are expected to continue to decline.

Long-term Prospects:

Special Comment: TACs on Atlantic halibut have never been met and effort has not been restricted.



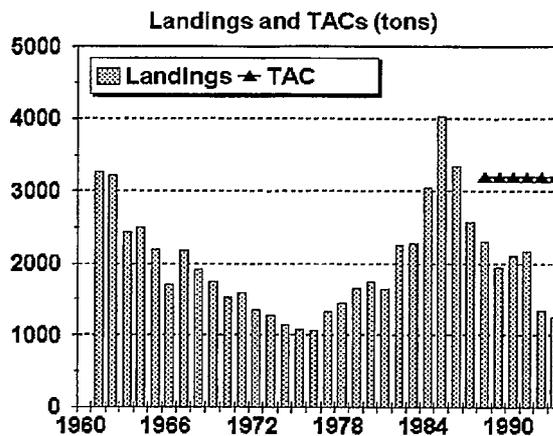
Technical Basis of the Assessment of Halibut in Division 3NOPs4VWX

Description of the Fishery

Nominal Catches

With the increasing significance of the fishery throughout the 1980s, a precautionary TAC of 3,200t was established in 1988 based largely on recent catch levels. After reviewing the information presented last year the FRCC recommended that as a precautionary measure the 1994 TAC be set at 1,500t.

Since 1961 total halibut landings have ranged between a low of 1,059 in 1976 to a high of 4,031 in 1985. Canadian nominal landings have declined from 3,531t in 1985 to 1,189 in 1993. The TAC has never been reached and the shortfall in the Canadian 1993 allocations was 2,084t. Fixed gear took less than 50% of their allocation while mobile gear generally took less than 20% of their allocation. The less than 65' ITQ fleet was the only gear sector to exceed its allocation. Foreign landings in the 3NOPs area increased significantly since 1983 but have declined in 1992 and 1993. Foreign halibut catch data are generally considered unreliable.



Small vessels (TC1-3) using longline are the dominant fleet in the Scotian Shelf fishery accounting for well over 70% of the landings while both large (TC4+) and small (TC1-3) longliners account for most of the landings in 3NOPs. Longliners are the only vessels to direct for halibut with the mobile fleets restricted to by-catch fisheries. Since 1984, special permits were given to inshore fixed gear vessels from Scotia Fundy to allow them access to the halibut fishery in 3NOPs.

A minimum size regulation of 32 inches was introduced in 1988 although not enforced until 1990. Anecdotal information indicates that landing of small halibut is still prevalent, especially for mobile gear fisheries. New management initiatives for 1993 included the introduction of mandatory landings, thus eliminating the minimum size regulation. Fixed gear interests then requested that halibut < 32 inches be exempted from the mandatory landing regulation. Regulation 93.3 was subsequently amended to permit the discarding of skate, dogfish, lumpfish and undersized halibut for all gear sectors. The mobile gear < 65' fleet exceeded their halibut by-catch quota in June 1993. In order to continue their groundfish fishery, this fleet was required to discard all halibut caught.

Fishery Distributions

The distribution of commercial fishing activity was examined using available log information, thus it is limited to the fishery distribution of the large fixed gear vessels i.e. those that keep log books. It does not reflect the by-catch nature or directed fishery of a large portion of the fishery by small longliners and mobile gear. The available data indicates that the 4X fishery by larger longliners is centred in the Browns Bank area while in 4VW it appears to be a shelf edge and gully fishery.

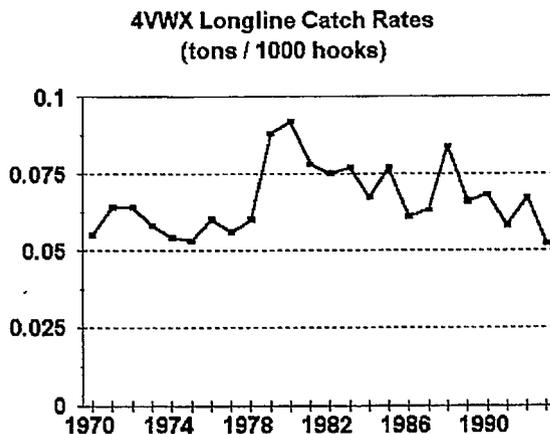
Available Data

Size Composition of Catch

Limited port and Observer sampling indicate that longline vessels catch halibut generally above the minimum size limit while mobile gear vessels continue to catch a large proportion of halibut below the minimum size limit.

Commercial Catch Rates

Catch rates were calculated for longliners directing for halibut on both the Scotian Shelf and the southern Grand Banks. For the Scotian Shelf catch rates increased from 1978 through 1980 coincident with increased landings. In 1981 catch rates began to fall and have generally declined since, despite the introduction of the more efficient circle hook. The directed effort trends in recent years look relatively stable, but industry reports increased directed effort for 1994.

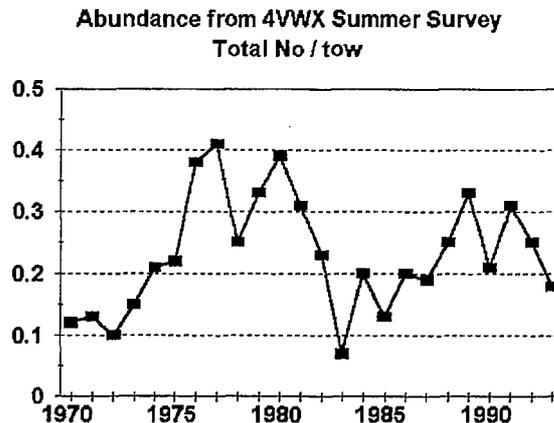


Catch rates on the southern Grand Banks indicate an increase to 1988 followed by a decline to 1993.

Discussions with industry emphasized the increased effort going into the halibut fishery as a result of the lowered quotas or closed gadid fisheries. Interviews carried out by the Fishermen and Scientists Research Society indicated that 73% of the fishermen interviewed thought the catch rates for halibut were declining. Reasons given for the decline included the closed area (many longliners fished for haddock in the closed area in 4W and caught halibut as a by-catch prior to their exclusion in 1993), directing for other species, overfishing, foreign fishing, smaller fish, cold water and fish not going inshore.

Research Survey Data

Mean numbers per tow estimated from the summer research survey on the Scotian Shelf indicate an increase for the 1970-1980 period a subsequent decline to 1983 then an increase to 1991. The survey mean numbers have declined since 1991. The spring and fall surveys (1978-1984) show a declining trend while the spring survey 4VsW (1986-1994) is variable to 1991 but has declined since. Since the survey catches a different size distribution of halibut (generally smaller) than those directed for by the longline fishery, it may be an indicator of recruitment to the commercial fishery. The 3NOPs fishery may also be dependent on Scotian Shelf recruitment as areas on the shelf notably Browns Bank (4X) and the Gully (4W) are considered important nursery grounds for immature halibut.



Survey results were not available for the southern Grand Banks.

Assessment Results

No analytical assessment is available for Atlantic halibut in 4VWX3NOPs. Assessment results are based on commercial and research survey information. Both of these sources indicate declines in the halibut resource. Anecdotal information from industry indicated an increase in commercial fishing effort.

Prognosis

Canadian catches have been declining slowly and in 1993 are the lowest since 1978 for the Scotian Shelf and the lowest since 1985 for the southern Grand Banks. Only landings in 4X have been increasing which may indicate more directed effort. Halibut by-catch especially in 4VW may decline in 1994 because of reduced trips due to reduced quotas and closed stocks. Commercial catch rates have been declining slowly over time despite the introduction of the more efficient circle hook. Survey catch rates have also declined in recent years. Industry reported increased effort in the directed halibut fishery.

The TACs through 1993 have not been restrictive and catches are at the lowest in 35 years. Catch rates are at the lowest in 25 years. It would thus seem that the lower TAC of 1,500t (recommended by the FRCC) was warranted for 1994 and that an even lower TAC should be considered for 1995 as a

precautionary measure until the good recruitment suggested by the survey becomes evident in the fishery.

References

Annand, C., and D. Beanlands. 1994. A review of the status of 4VWX,3NOPs halibut stocks. Atl. Fish. Res. Doc. 94/41: 30 p.

Summary of Status of Scotian Shelf Redfish

- * The 1993 landings of redfish in this management unit increased to 5,100t. The TAC of 10,000t has not been restrictive. Fishing effort increased in 1993 which accounted for the increased catch.
- * The commercial catch rates do not show any trends. The length frequency samples from the landings indicate that in 1993/94 more small fish (less than 20 cm) are being landed than was historically the case.
- * The summer research vessel survey shows no trends in biomass since the early 1980s. The absence of increased biomass in the 1980s/90s during a period of low fishing effort implies that the recruiting year-classes have been of low abundance.
- * There is no indication of any large year-classes about to enter the fished part of the stock and therefore stock conditions are expected to be similar to those of recent years if current fishing pressure does not change.
- * If the research vessel survey biomass estimates are taken as the actual levels (and they are likely to be underestimates) then exploitation has been about 7% during 1982-1993. The precautionary TAC of 10,000t in place since 1992 implies an exploitation rate of 15%.

**Scotian Shelf Redfish (Unit 3 -- 4Wdehkl+4X)
SUMMARY**

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min'	Med'	Max'
Reference level '000t	-	-	-	-	-	10	10	10			
Advised catch '000t											
TAC '000t'	-	-	-	-	-	-	10	10			
Rep. landings '000t	6.1	3.9	3.2	2.3	2.0 ¹	2.4 ³	5.1 ³		2.0	5.0	18.6
Unreported catches	-	-	-	-	-	-	-		-	-	-
Estimated discards	-	-	-	-	-	-	-		-	-	-
Total catches '000t	6.1	3.9	3.2	2.3	2.0 ¹	2.4 ³	5.1 ³		2.0	5.0	18.6
Total biomass '000t	-	-	-	-	-	-	-	-	-	-	-
Spawning Biomass '000t	-	-	-	-	-	-	-	-	-	-	-
Mean - F	-	-	-	-	-	-	-	-	-	-	-
1 = 1970-1993			3 = preliminary statistics								
2 = new management unit from 1993											

Catches: Catches peaked at almost 19,000t in 1974 to then decline gradually to a low of less than 2,600t in 1979. A second peak occurred in 1986 at 6,700t followed by a decline again to about 2,000t in 1991 and a rise to over 5,000t in 1993.

Data and Assessment: The 1987 CAFSAC Advisory Document, and a series of previous annual reviews, established that there was an inadequate scientific basis for an analytical assessment and for annual adjustment of TAC advice. The 1993 TAC levels for the new management units were established on the basis of the sum of the 1991 TACs for the previous units prorated by historical (1981-90) catches in the new units. This gave a Unit 3 TAC of 10,000t.

Fishing Mortality: Exploitation rate, calculated as the ratio of commercial catch to survey biomass, averaged 5% over the last 5 years, well below the 15% target which has previously been taken as equivalent to fishing at $F_{0.1}$.

Recruitment: There is no indication of any large year-classes about to enter the fished part of the stock.

Environmental Factors: Temperatures (below approximately 150m) in the deep basins, such as Emerald and Roseway, and on the outer edge of the continental shelf were warmer-than-normal and have increased over the last couple of years. On the banks, in waters shallower than 100m, temperatures were generally colder than normal.

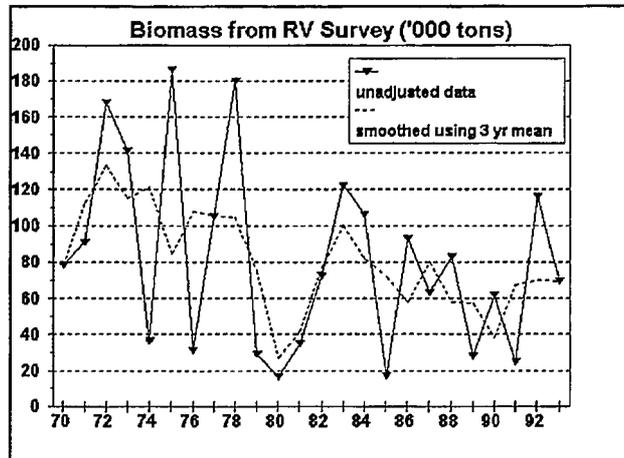
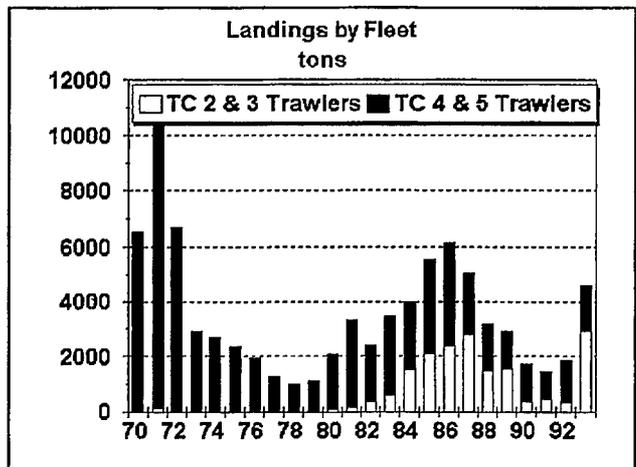
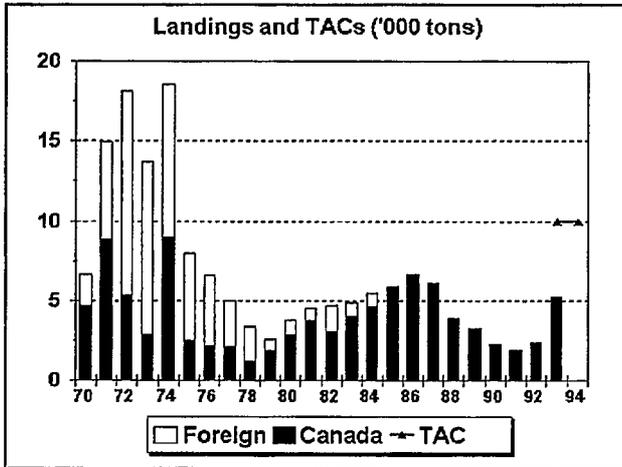
Multispecies Considerations: The majority of the redfish catch is taken on redfish directed trips. Coincidental by-catch of other species in the redfish catch was not considered.

State of the Stock: The present biomass is equal to the average over the last decade or so. Increased 1993 catches were primarily a result of increased fishing effort, reflecting decreased fishing opportunities for other species.

Forecast for 1995: Fishing and stock conditions in 1995 might be expected not to differ greatly from those in recent years.

Long-term Prospects: Biomass has been constant or declining slightly over the last 10 years with low exploitation rates. No above average year-classes have entered the population since 1970. If recruitment rates remain low, the situation of the past 10 years should continue.

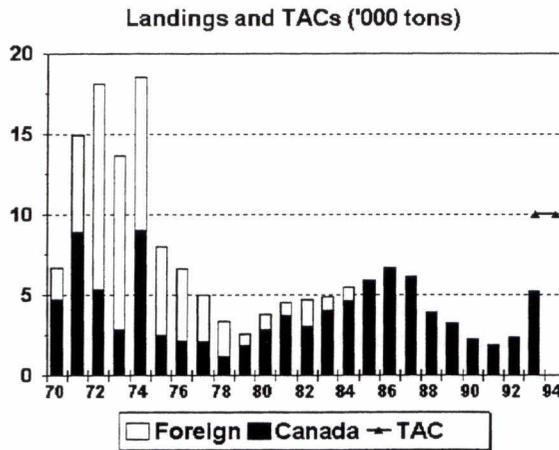
Special Comment: The Unit 3 management unit for 4Wdehkl and 4X Scotian Shelf redfish includes redfish previously managed as part of a larger 4VWX management unit.



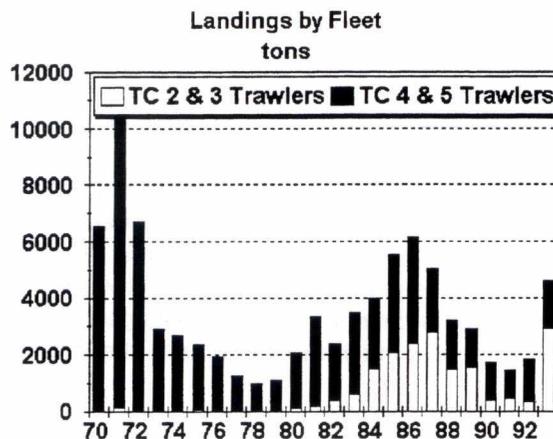
Technical Basis of Assessment of Redfish in Unit 3 (4Wdehkl and 4X)

Description of the Fishery

Commercial fishing in the period 1970-93 was consistently widespread over the statistical unit areas within the management unit. Nominal catch peaked at almost 19,000t in 1974 and then declined gradually to a low of less than 2,600t in 1979. A second peak occurred in 1986 at 6,700t followed by a decline again to about 2,000t in 1991. The provisional 1993 catch was 5,071t, a 100% increase from that of 1992 but substantially below the TAC of 10,000t. This increased catch reflected an increase in fishing effort, particularly by tonnage classes 2 and 3 vessels, rather than an increase in catch rate. Uncertainty regarding allocation of large USSR catches in Div. 4W during the early 1970s between Units 2 and 3, suggest that actual catches from Unit 3 in that period might have been higher than indicated.



Almost all the catch was taken by bottom otter trawlers, tonnage class 4 (TC4) side trawlers (150-499 grt) dominating the fishery historically. Large stern trawlers (TC5: 500+ grt) also landed significant quantities in the 1970-93 period. The smaller stern trawlers (TC2: 26-49 grt, TC3: 50-149 grt) did not enter the fishery until the early 1980s and were less important than the larger vessel classes but equalled the TC4 side trawlers catches in 1993.



The Unit 3 TAC was established in 1993 based on a CAFSAC proposal that the sum of the 1991 TACs for the previous units be prorated by historical (1981-90) catches in the new units (i.e. Units 1, 2, 3).

Available Data

Redfish Biology

There have been no studies of the biology of Unit 3 redfish specifically and few for which the results can with confidence be attributed to *Sebastes fasciatus*, the predominant species in Unit 3. The three Northwest Atlantic species of redfish do, however, all have the same general biological characteristics, the predominant ones being very slow growth after the first few years of life and a much longer lifespan than gadoids. In the Gulf of Maine *S. fasciatus* reach maturity after 5 to 6 years at a length of 20-23 cm. Redfish feed off the bottom mainly on pelagic crustaceans but fish become increasingly important in the diet as redfish grow larger and become predominant for the largest fish. Redfish, in turn, are preyed upon by cod, Atlantic halibut and swordfish. *Sebastes fasciatus* is the shallowest living of the three species, occurring predominantly in 70-200 fm although it can occur to 300 fm or deeper. Thus, the deep basins of the central and western Scotian Shelf and the Gulf of Maine provide suitable habitats.

Size Composition of the Catch

The increase in fishing effort directed towards redfish by the smaller trawlers (less than 150 grt) in 1993 was accompanied by reports, both from industry sources and DFO field personnel, that very small redfish were being landed. These reports persist into 1994. Historically, landed fish have typically ranged in size from 20 to 35 cm with a mode at about 25 cm. In the period 1970-92, redfish less than 20 cm occurred only rarely in port samples except in 1991, when they accounted for about 13%, but sample numbers were low in that year and the estimate is not very reliable. In 1993, nine samples were collected and one of these had as high as 8% of fish under 20 cm but overall the level was 2-3%. To date in 1994 six samples have been collected and the percentage of fish under 20 cm ranged from 0 to 28% with an overall average of 7.5%. Almost all of these small fish were in the range 16-19 cm. The highest percentages of small fish occurred in samples from statistical area 4Xo, north and east of Browns Bank, where a high proportion of the catch was taken in 1993. Thus, the estimated percentage of small fish in landings would be higher if the samples were weighted by statistical area of capture. There is evidence, therefore, which supports the observations that rather higher quantities of redfish less than 20 cm are being landed currently than was the case historically.

Commercial Catch Rates

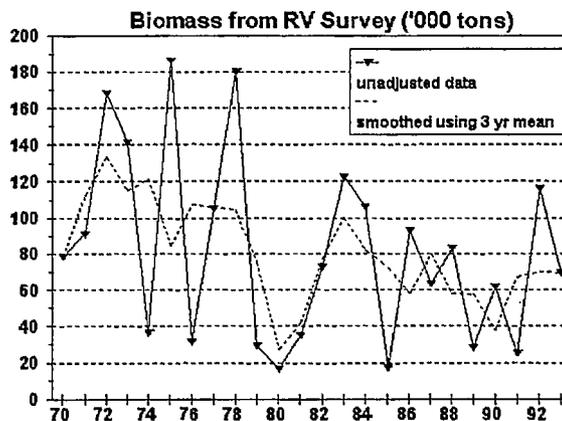
Redfish main species catch rate (tons per hour fished) did not vary greatly among the main statistical unit areas or by month. Thus, it was decided not to take these factors into account when calculating annual catch rates. The tonnage class 4 side trawlers had a persistent and substantial presence in the fishery over the entire period. The tonnage class 5 stern trawlers also fished in all years but at a low level, whereas the tonnage class 2 and tonnage class 3 vessels did not enter the fishery until the early 1980s. The catch rate of tonnage class 4 vessels showed a steady decline in the 1970s, but a substantial increase between 1979 and 1984 when many of the oldest vessels were decommissioned and the fishing strategies of the remaining vessel modified. Catch rates for 1993, although up from 1992 for tonnage classes 2 and 3 vessels, did not change much for tonnage classes 4 and 5 vessels. Fishing success for all vessel categories in 1993 was much the same as in the last several years.

Commercial Gear Selectivity

The otter trawl mesh size traditionally used in the Scotian Shelf redfish fishery is about 90 mm. Neither mesh size nor minimum fish size have been subject to regulation but the use of 90 mm mesh or larger was made mandatory in 1993 and also for 1994 through licence condition. The selection factor (SF = 50% retention length divided by mesh size) for diamond mesh bottom trawls is 2.5-2.9. Using 2.7 gives a 50% retention length for 90 mm mesh of 24 cm. Selection range (25-75% retention range) measurements for redfish are also variable, extending from 6.0-14.5 cm. Even at a selection range of 6 cm, small quantities of redfish under 20 cm could be expected in catches when using 90 mm. Conversely, 25% of redfish of 27 cm would be expected to be escaping from the net and a few even as large as 30 cm. Thus, size selection of redfish by trawl meshes is quite poor, i.e. the selection curve is not sharp, and any increase above 90 mm in order to prevent capture of small fish would have important negative effects also on the catch rates of fish in the 20-30 cm size range, and hence on the economics of fishing.

Research Survey Data

July bottom trawl surveys (1970-93) indicate that the population is widely distributed in all deepwater areas in the management unit. Biomass estimates decline from 1970 to the early 1980s and fluctuate in the 1980s-early 1990s around a level of about 70,000t. The semi-pelagic nature of redfish suggests that actual stock biomass is higher than the survey estimates (i.e. q is less than 1).



Survey length frequency data suggest that there were very few recruitment events in the 1970s but possibly several in the mid 1980s-early 1990s. Absence of increased biomass for the latter period indicate that these recruiting year-classes were of modest strength.

Estimation of Stock Parameters

Exploitation rate, calculated as the ratio of commercial catch to survey biomass of 15% was adopted for redfish by CAFSAC in 1979 as an approximation to fishing at $F_{0.1}$, when this reference point could not be calculated. Exploitation rates estimates were in the 10-20% range in the early 1970s, the actual value depending on assumptions about catch levels in that period, but averaged 7% in the 1982-93 period. The catch level equivalent to 15% of recent survey estimates is about 10,000t, the TAC level for 1993 and 1994.

Prognosis

An exploitation rate of 15% is high compared to the exploitation rate of 6% calculated to correspond to $F_{0.1}$ to the adjacent Gulf of Maine stocks of *S. fasciatus*. If the biomass estimated from surveys is accurate (i.e. $q = 1$), then exploitation has been about 7% during 1982-1993. It is likely that the survey biomass is a significant underestimate of total biomass. Therefore the precautionary TAC of 10,000t implies an exploitation rate of less than 15% and may not be at variance with the $F_{0.1}$ estimates for the adjacent Gulf of Maine resource.

Yield per recruit calculations for Unit 3 redfish are not available but at the currently low estimated exploitation rates currently prevailing yield per recruit is not sensitive to the size at first capture. Large gains in potential yield from avoiding the capture of small fish is unlikely as long as these fish are landed and can be utilized. If large quantities of small fish were being wasted at sea, or if the fishery came to depend on small fish to the exclusion of the larger fish component traditionally fished this would be a different matter.

References

- Branton, R.M., and R.G. Halliday. 1994. Unit 3 redfish population and fishery trends. Atl. Fish. Res. Doc. 94/38: 34 p.

6. PELAGIC STOCK ASSESSMENTS

Summary of Status of Sydney Bight Herring

- * Landings in the 4Vn winter (Nov/Dec) purse seine fishery were 4228t in 1992 and 3956t in 1993. Recorded landings by inshore (gillnet, traps and misc.) gear in 1993 amounted to 273t, but this is considered to be an underestimate.
- * Location and composition of the catch has changed over the history of the 4Vn fishery. The historical fishery and tagging results indicated that the area contained a mixture of fish in the winter. The restriction of the purse seine fishery to the northern portion of 4Vn in recent years was intended to increase the proportion of 4T fish taken in the catch, and reduce the catch of fish of 4WX or local 4Vn stocks. Recent sampling indicates that this has been successful, and purse seine landings from the winter fishery in the northern portion of 4Vn are to be included in the 4T herring assessment. The 4T assessment/management unit, however, should not be referred to as 4TVn, because of the presence of a resident/local spawning population of herring in 4Vn.
- * A study of the biology of Bras d'Or Lake herring spawners has been proposed by Aboriginal Fisheries Services (Eskasoni, Cape Breton), in collaboration with DFO. If conducted, it would provide useful information on several aspects of the resident population, including the degree of movement out of the Bras d'Or Lake, and degree of involvement in the winter fishery.

Summary of Status of Scotian Shelf - Bay of Fundy Herring

- * The 1993 landings were 105,000t. The 1993 TAC was 151,000t. Since at least 1987, the reported landings have not been restricted by the TAC (although landings that have been corrected for misreporting have exceeded the TAC in four of seven years). The 1993 landings are below average for recent years. The shortfall in landings was due to a new dockside monitoring program, market limitations and unusual distribution of the resource.
- * The new dockside monitoring program is estimated to have considerably reduced under-reporting of landings.
- * The geographic patterns of landings in 1992 and 1993 were unusual compared to the past decade. The "over-wintering" fishery in the Chedabucto Bay area was small, and a large portion of the winter fishery catch was taken off Halifax. In addition, fishing success at several traditional spawning areas has declined in recent years (Trinity Ledge, German Bank), and large catches were taken in areas not usually fished (off Liverpool and on the Southwest Grounds).
- * The larval herring survey abundance estimates are an index of spawning stock size. There has been an increase in larval abundance during the late 1980s, with the 1993 estimate being high.
- * The summer groundfish research vessel survey catches herring as by-catch. The 1993 survey by-catch was high.
- * Due to underreporting of catches, an SPA-based analytical assessment has not been carried out for this management unit for several years. Thus, there are no estimates of fishing mortality or stock size.
- * The two indices of abundance (research vessel surveys and larval herring) suggest that spawning stock size is relatively high. There are no indicators of the relative size of recruiting year-classes.
- * The changes in geographic distribution of the population, in particular the relative change in abundance at traditional spawning locations, is a cause for concern.
- * Given the mixed signals (i.e., high overall biomass, yet changes in relative contribution to the fishery of various spawning locations), as well as the lack of quantitative assessment to indicate the rate of exploitation, a restriction in landings to the average of recent years would be prudent (about 140,000t).
- * Fishing effort should be spread over spawning areas in order to reduce the chance of overfishing individual spawning components.

**Scotian Shelf - Bay of Fundy Herring
SUMMARY**

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min. ³	Med. ³	Max. ³
Reference level '000t											
Advised catch '000t											
TAC '000t	127	151	151	151	151	125	151	151	125	151	151
Reported landings '000t	101	125	84	102	97	100 ¹	99 ²		84	100	125
Unreported catches '000t'	56	78	17	81	39	26	7		7	36	75
Total catches '000t'	147	200	98	173	131	136	105		98	136	200
Total biomass '000t											
Spawning biomass '000t											
Mean - F ()											
1 = using backcalculation from production reports (revision from 1993) 2 = preliminary statistics 3 = 1987-1993											

Catches: Reported 1993 landings were about the same as 1992 and were well estimated with the introduction of mandatory dockside monitoring. Purse seiners accounted for 96% of the total and catch distribution was similar to previous years but with some shifts in Chedabucto Bay after December and in October away from German Bank to the Shelburne - Liverpool area.

Data and Assessment: Comparison of monitored landings in 1993 and those back-calculated from product reports, showed correspondence and were used to modify the catch matrix for recent years. Logbook coverage was much reduced from previous years (<40% landings) but was still useful for determining the distribution and timing of the purse seine fishery.

Fishing Mortality:

Recruitment: The 1989 year-class now dominates the stock catch in numbers and weight and is similar to the 1988 year-class.

Environmental Factors: Recent changes in local availability and distribution may have been the result of changes such as temperature which has been lower than average in areas of relevance to this stock.

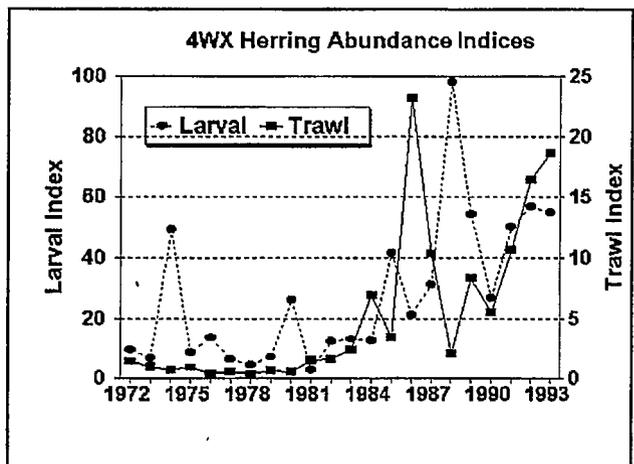
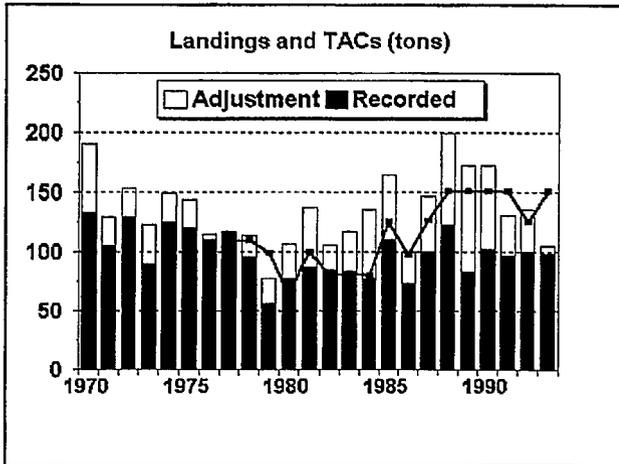
Multispecies Considerations:

State of the Stock: The larval abundance index and research vessel survey by-catch indices remain high with a general increase through the past decade and indicate above average abundance.

Forecast for 1995: No formal projection was completed.

Long-term Prospects: There are no strong year-classes recruiting to the fishery but research surveys show a continued high stock abundance.

Special Comment:

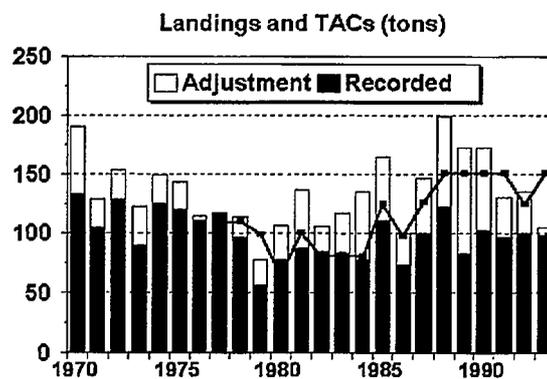


Technical Basis of the Assessment of Herring in Division 4WX

Description of the Fishery

The 1992-93 management plan for 4WX herring was similar to that of recent years. A quota of 151,200t for 4WX stock herring was divided among the purse seine fleet of 40 vessels (142,585t, or 94.4% of the TAC; including a bait quota of 2,600t), a single mid-water trawl (1,512t or 1 % of the TAC), and an allocation to "inshore" gear components (gillnets, traps and weirs) of 8,000t (or 5.3 % of TAC). 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. As in the previous year, the 1992-1993 plan allowed for a maximum catch of 10,000t in the mid/upper Bay of Fundy (Area 21; "Scots Bay fishery") as part of the 4X summer purse seine fishery, a closure of the very upper Bay (Area 22), and placed a continuous (18 day) closure Aug. 12 to Sept 2, 1993 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 1993 fishery saw a significant change in monitoring, as the purse seine fleet was placed on a complete, industry-funded, dockside monitoring program which included volumetric determination of each landing.

As in previous years, the purse seine fleet accounted for most (94,928 t; 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 (2662 t; 3 % of total stock landings for 1993), with minor catches by midwater trawl, gillnets, and traps. Significant catches (31,572 t) 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 1993. During this period, 86 % of total reported purse seine landings for the 1992-1993 fishery were taken. Other major fishing activity occurred in the purse seine fisheries on over-wintering aggregations of herring around Chedabucto Bay and off Halifax (November 1992 through February

1993; 11 % of reported purse seine landings), and off Grand Manan Island in the 4Xs fall and winter fishery (October 1992 through January 1993; 2.5 % of reported purse seine landings).

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

Nominal Catches

The implementation of a complete dockside monitoring program represents a significant change in this fishery, which has been plagued by erroneous reporting. It appears that the number of landings and the volume of fish landed are accurate. There is, however, a minor problem created by the conversion of volume (as measured in the holds) to weight of fish. The industry and DFO agreed, for the purposes of monitoring, to use a bulk density conversion (BDC) of 860 kg m⁻³. Weighouts of entire holds and density measurements in smaller containers, however, indicate that this is an underestimate, and that a higher bulk density conversion, in the order of 920 kg m⁻³, is more appropriate. This is particularly true of the OSS landings which are measured in dry (drained) volumetric pens.

Correction of the purse seine landings to a bulk density conversion of 920 Kg m⁻³ increases the 1993 landings by 6626t (6.7% of stock landings) as follows:

Portion of Fishery	Landings @ 860 (from Table 2)	Landings @ 920
4W Purse Seine	10,731 t	11,480 t
4X Fall Purse Seine	2,209 t	2,363 t
4X Winter Purse Seine	167 t	179 t
4X Summer Purse Seine	81,478 t	87,165 t
Midwater Trawl	343 t	367 t
TOTAL Mobile Gear	94,928 t	101,554 t
+ Other Stock Gear	3,535 t	3,535 t
TOTAL Stock	98,464 t	105,089 t
+ 4X NB weir/shutoff	31,572 t	31,572 t
TOTAL 4WX	130,036 t	136,661 t

Comparison of Catch Statistics with Production Backcalculation

In recent years an attempt was made to overcome the problem of poor delivery note landings data by estimating landings from other sources. Estimates for the period 1985 to 1992 were based on (1) interviews with members of the purse seine fleet, and (2) back calculation from records of processed herring products to round landed weight. Back calculation from 1993 production indicates a fishery of 107,764t. This compares very well with the recorded landings from DMP this year at 920 kg m⁻³ (105,089t).

Industry Consultations

Aspects of biology and management of the fishery were discussed informally with members of the industry, and formally in a variety of consultations including; biological presentations at the SFHAC, a formal program consultation (June in St. Andrews), and participation in annual and ad hoc sector association meetings. As in the past, these provided a useful overview of the fishery and industry concerns. Significant this year was concern expressed regarding the relatively odd distribution of herring during both summer and winter fisheries, and particularly the absence of herring during the early portion of the spawning season. Some expressed concern that there was a decrease in abundance, but others felt that the fish were simply distributed differently. Many emphasized the degree of limitation placed on the fishery by the new dockside monitoring program, combined with market restriction. There was generally agreement that DMP had been effective, and had made the fishery more discriminant regarding the size and quality of fish landed. The restriction of roe quality, large fish size required for adult shore (fillet etc) and OSS, and nightly catch limits due to production capacity during the (short) roe season all restricted landings.

Available Data

Catch and Weights at Age

Sampling in 1993 resulted in 604 length frequencies and 5,840 fish analyzed in detail of which 4,459 were aged. Biological samples were matched to landings by gear component on a monthly basis as in previous assessments, to derive numbers at age. Where there were sufficient samples, separate keys were applied for foreign over-the-side sales (OSS) and domestic markets because of the differences in fish size.

The 1989 year-class (age 4) was dominant in major stock fisheries in number (31%) and weight (28%). The strong 1983 year-class, now age 10, contributed 6% by weight to the landings. Age 2 fish again dominated the non-stock fisheries on the New Brunswick side of the Bay of Fundy in number (56%), but age 3 made up 25% of the numbers and dominated by weight (30%).

Purse Seine Fishery Logbooks

The purse seine logbook has been a major source of input from the industry with respect to location and performance of major portions of the fishery, searching activity and effort, and observations and comments from members of the fleet. Data quality has been enhanced through provision of annual feedback to contributors of all individual data provided - and it has generally been agreed that the logbook is one of the most valuable sources of information available from this dominant sector of the Scotia-Fundy herring fishery.

Unfortunately, implementation of the Dockside Monitoring Program (with its new Monitoring Document), resulted in a substantial decrease in use of the biological logbook for this year. Although submission remained a condition of licence, log submissions decreased (from complete coverage of recent years) to only 18 of the 38 vessels. Some apparently thought that the log had been replaced by the Monitoring Document, and others stopped filling it out when it was not being collected by monitors (it had been collected by Fishery Officers in the past). Considerable effort is being made to return to the very good logbook submission level of previous years through more explicit wording in license conditions, combined with the help of the seiner associations in the distribution and collection of logs.

Records from those log records which were returned in 1993 were considered to be representative of activity and events in the purse seine fishery. They documented both the consistent overall pattern of

the fishery over areas and time, and some unique occurrences and changes. In the early and late summer of 1993 there was substantial fishery activity east of Cape Sable Island, extending a feature which had developed the previous year. Logs verify the decreased contribution of Seal Island and Gannet/Dry Ledge spawning grounds and the absence of spawning fish on German Bank during the early portion of the expected roe fishery. The relative importance of Western Hole, Liverpool, S.W. Grounds and the area off Shelburne all increased. A portion of the winter fishery which had, in recent years, been confined to the vicinity of Chedabucto Bay, took place near Halifax in Jan/Feb. 1993.

Logs have been used in recent years to synthesize some anecdotal information from this fishery. Comments in 1993 indicated an increase in "feedy" fish and a number of comments related to the fish being hard to catch or not suitable for market (fish deep, shallow, small, feedy). Importantly, there was little apparent sign of a problem of overall abundance - several comments indicated large area and schools, and we recorded the first observations in the series of large areas of "eyeball larvae" (o-group).

Log records confirm the impact of market on fishing activity. The OSS market was proportionately more important than in recent years. The reduced proportion taken for roe reflects both an unexpected (late) timing and distribution of spawning (lower than expected number of fish on German Bank during the first part of the roe fishery), and market conditions (low price relative to OSS, poor roe quality early in season, rigid DMP).

Research Survey Data

a) Larval Abundance

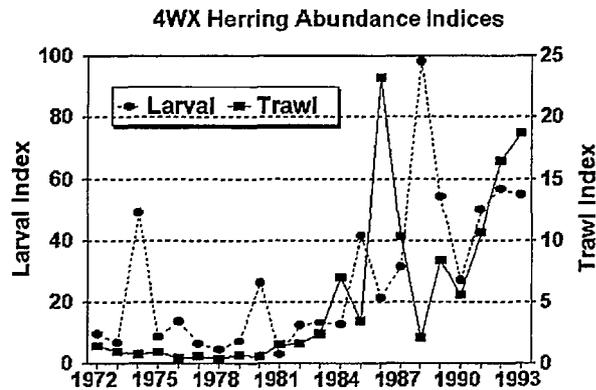
The 1993 larval herring survey was undertaken using the standard protocol, with sampling between Oct. 24 and Nov. 3.

The traditional larval index has been calculated as the mean of larval density (no. m⁻²) for a standard set of 79 standard stations. The larval abundance index has increased through the 1980's, and the 1993 survey result was high.

b) Bottom Trawl Survey Index

The summer bottom trawl survey of the Scotian shelf and Bay of Fundy has been proposed as an abundance index. A similar (stratified random) spring bottom trawl survey index has been used to tune recent U.S. assessments for the Gulf of Maine. The abundance of herring in the Canadian summer survey has been considerably higher in recent years than in the late 1970's and early 1980's, and is presumed to reflect the general increase in population size observed through the 1980's, and possibly a concurrent change in distribution of herring.

The 1993 survey estimate was high. Abundance at age for recent years reflects dominant features of this population, particularly the dominant 1983 year-class.



Environmental, Ecological and Multispecies Considerations

Recent years have seen some changes in distribution of major portions of the fishery, linked to changes in local availability of herring. These include the absence of overwintering herring in Chedabucto Bay after December, and unusual distribution of herring on summer feeding grounds. Abundance indices indicate that these are not the result of a reduction in overall population size. There is the suggestion that these may have been the result of environmental changes (such as temperature, which has been lower than average in areas of relevance to this stock in the last two years).

Estimation of Stock Parameters

An SPA-based assessment for Division 4WX herring has been precluded in recent years by lack of an appropriate catch record (due to misreporting etc.) and by problems in the analytical assessment. SPA-based assessments since 1990 have shown poor analytical resolution in tuning, and unrealistically large increases in estimated population size. In the absence of an SPA-based assessment, this evaluation is based primarily on the research survey indications regarding stock status.

Prognosis

Previous assessments indicate a peak in abundance (age 2+) above 600,000t in the late 1960's, a decrease by approximately half during the 1970's, and an increase during the late 1980's to, or perhaps beyond, the 1967 level. Projections for this fishery during the early 1980's indicated that a sustained yield in excess of 100,000t was possible, and with the improved stock status of the 1980's the stock was considered to be able to yield 150,000t.

As in previous assessments, the 4WX fishery was divided into "stock" and "non-stock" components. The non-stock component has been comprised of landings from New Brunswick weir and shutoff (considered to be migrants from Division 5Y stocks), as well as miscellaneous landings from gillnet and trap in 4Xm and 4W which were considered to be from localized stocks.

Stock fish were considered to belong primarily to the major SW Nova Scotia spawning groups, but this assessment unit also encompasses smaller local stocks (e.g. Grand Manan, Scots Bay).

Even within the major SW Nova Scotia spawning area there is additional structure, as individual spawning components are considered to be discrete on time and space scales of relevance to management. The recent history of the fishery reveals changes in the relative contribution of components of the summer fishery:

Fishing Ground	Percentage of Total Catch								
	1985	1986	1987	1988	1989	1990	1991	1992	1993
Long Island	1	6	11	12	34	25	14	5	8
Trinity	43	26	28	21	0	1	5	6	4
Seal Island	16	17	17	21	36	34	18	21	12
German Bank	19	26	24	20	13	16	34	5	13
Scots Bay	0	0	5	4	10	12	12	11	14
Grand Manan	4	6	3	0	2	1	5	5	2
Gannet, Dry Ledge	7	4	2	17	3	6	9	37	9
Yankee Bank	0	0	0	0	0	5	1	0	0
Western Hole	0	0	0	0	0	0	0	5	7
Liverpool	0	0	0	0	0	0	0	0	13
Southwest Grounds	1	4	0	0	0	0	1	0	10
Lurcher	0	0	0	3	0	0	0	3	5
Shelburne	0	0	0	0	0	0	0	0	2
N.B. Coastal	0	1	0	0	0	0	1	1	0
Other or no Area	9	10	9	0	1	0	0	0	0
TOTAL	100	100	100	100	100	100	100	100	99

Concern was expressed over the way in which this fishery seems to focus on individual spawning components. The fishery saw major erosion of the Trinity Ledge spawning component in the past, and is concerned over the potential for local overexploitation of other spawning grounds. The lack of spawning during the early part of the German Bank fishery in 1993, and the focus on a new spawning aggregation east of Cape Sable are points of concern.

Larval and bottom trawl survey indices have shown an increase over the past decade, and remain high, indicating that the stock is at above average abundance. The fishery is limited by market, and appears to have overcome the serious problem of misreporting. However there is concern regarding changes in distribution. While the changes observed in Chedabucto Bay winter and summer feeding aggregation location may be responses to environmental conditions such as temperature, changes to the relative wellbeing of spawning areas is cause for concern.

There are mixed signals from the biological indicators in this fishery which caused concern within the committee. Survey indices indicate high biomass, but there have been changes in distribution which suggest some erosion of spawning components. The Committee recommended that catches should not exceed those of recent years (i.e. 140,000t, based on adjusted figures), and that measures be put in place to avoid disproportionate effort on individual spawning grounds to maintain spawning components.

The committee further recommended that the Industry and DFO work together to develop a harvesting strategy that would spread effort across spawning components.

Major Sources of Uncertainty and Suggested Remedies

1. Evaluation of stock status requires an improved analytical basis. The committee recommended investigation of formulations of analytical assessment, or alternate methods of evaluation.
2. The committee recommended investigation of the current situation of "non stock" N.B. weir and shutoff designation. In recent years, an OSS weir component took larger fish than the traditional sardine market and therefore not only "juveniles" which were the basis for the previous assumption. An analytical assessment should investigate scenarios with and without portions of the juveniles landed in the weir fishery.
3. Lack of effective abundance indices has been a major problem in the assessment of this and other herring populations; and concern has been expressed regarding the effectiveness of assessment calibration of tuning in terms of both the validity of abundance indices, and the method in which they are used. For this reason, the committee recommended that continued emphasis be placed on evaluation of the research survey abundance indices.
4. The reduction of biological logbook coverage in 1993 resulted in an unfortunate loss of data from the purse seine fisheries. This logbook series is considered to be very valuable to the biological evaluation, and every effort should be made to improve coverage.
5. Consideration of individual spawning grounds. This fishery, especially with the current dominance of the roe market, is focused on spawning areas. These are considered to be discrete elements of the stock complex on the scales that are relevant to management. Disproportionately high effort on some spawning grounds has been considered to have been detrimental to those components (e.g. Trinity Ledge). An attempt should be made to establish the relative size of various spawning components, and further attention given to these in management.
6. Long-term planning/strategic planning. The end of the 1983 10-yr plan left this industry without a framework which can guide management plans. A recent review of the performance of the 10-yr plan showed the importance of a long term strategy in management, and suggested several improvements which could be made in a future long term plan. The committee encouraged further work on the biological basis for management of this fishery (including the development of appropriate biological reference points), and work on integrating biological considerations with socioeconomic elements in management of this fishery.

References

Stephenson, R.L., M.J. Power, J.B. Sochasky, F.J. Fife, and G.D. Melvin. 1994. Evaluation of the 1993 4WX herring fishery. Atl. Fish. Res. Doc.: (in press).

Summary of Status of Georges Bank Herring

- * The Georges Bank herring population (a transboundary resource) was fished to commercial extinction by 1977 prior to the extension of jurisdiction in 1979. Essentially no herring were observed on the Bank until the late 1980s. Given the evidence of recovery of the stock, an annual experimental fishery with a combined Canada/USA catch of 5,000t has been permitted since 1992.
- * Historical annual landings exceeded 200,000 t per year for several years prior to 1976, but at this level of fishing, the resource was not sustainable.
- * In 1993, four vessels searched the Bank but no herring were caught. It was reported that the fish were too deep to be caught with a purse seine.
- * The bottom trawl survey by-catch index increased from 1985 to 1992. The 1993 point is about half that for 1992. Present by-catch levels in these surveys exceed those observed in the 1960s and 1970s when the stock was commercially exploited.
- * Since 1986, the age composition of the by-catch has been dominated by 3 and 4 year old fish. The relative absence of older fish in the samples caused some concern, but is interpreted as being due to a gradual increasing of abundance over time.
- * The larval survey index indicates increasing abundance from 1987 to 1993. The larval concentrations are higher than those observed in the 1970s. The geographic distribution of larvae indicates that spawning is occurring at all of the historical spawning sites and early 1980s spawning areas on both sides of the International Court of Justice (ICJ) line.
- * Given the high abundance indices and the geographic patterns in herring distributions, the status of the stock is "recovering" or may be "recovered". A commercial fishery with a combined Canada/USA catch of 20,000t could now be developed on the Bank. A small commercial fishery integrated with a research function would provide additional scientific information to improve estimates of stock status and the harvesting potential.
- * Given the transboundary nature of this resource, consistent management by Canada and the USA is required in order to meet their respective objectives.

**Georges Bank Herring
SUMMARY**

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min.	Med.	Max.
Reference level '000t											
Advised catch '000t											
Exp Fishery '000t							5	5			
Reported catches '000t							0	0			
Unreported catches											
Estimated discards '000t											
Total catches '000t							0	0	2.2'	148'	374'
Total biomass '000t											
Spawning biomass '000t											
Mean - F ()											
1 = 1961-1977											

Catches: Only a single excursion occurred in 1993 with no catch. No results are available for the 1994 fishery.

Data and Assessment: Both the US bottom trawl survey and the Canadian larval abundance index are well above the long-term average, with the larval abundance index being the highest since 1987.

Fishing Mortality: Fishing mortality is expected to be low in the absence of a fishery.

Recruitment: There has been strong representation of 3 and 4 year old fish in the research survey samples since 1987 indicating good recruitment.

Environmental Factors: Temperatures in the upper 50m have been predominantly below normal in recent years, whereas in deep waters they have been steady or declining.

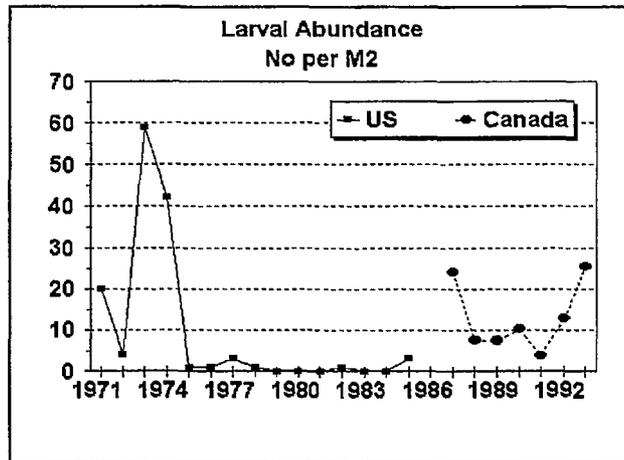
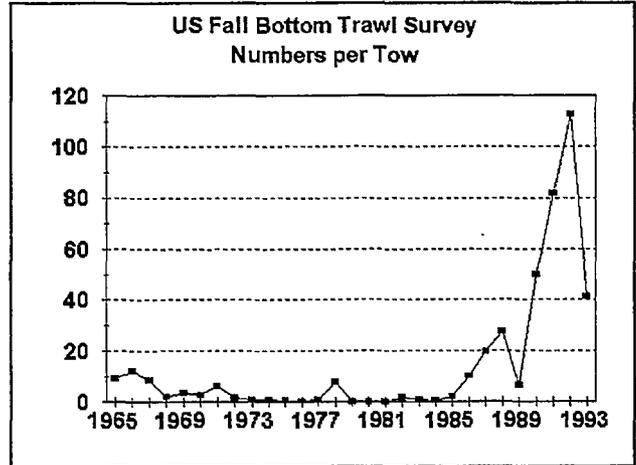
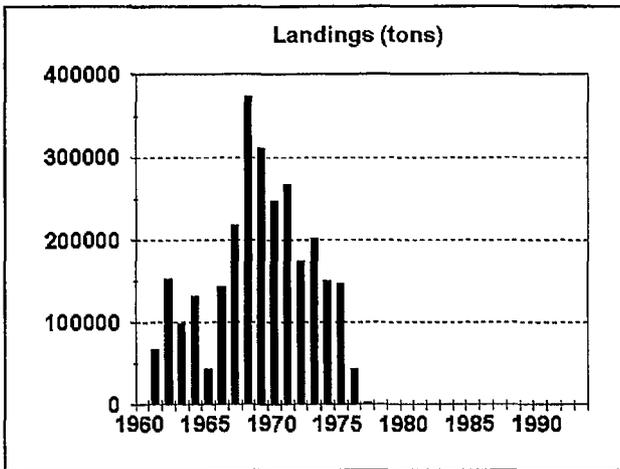
Multispecies Considerations: Many species of fish depend on herring for food.

State of the Stock: Stock abundance is likely increasing.

Forecast for 1995: It is recommended that the combined Canada/US catch be 20,000t.

Long-term Prospects: About 100,000t annually.

Special Comment: A experimental fishery of 5,000t for 1994 has been approved.

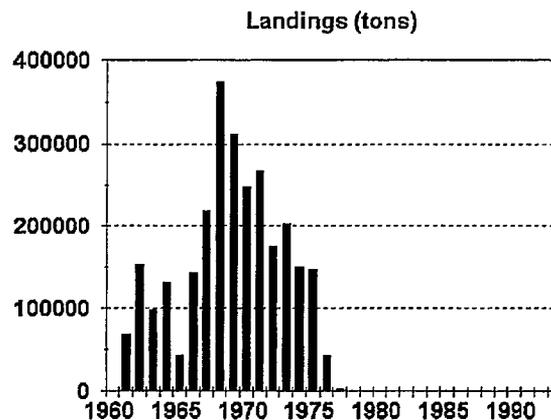


Technical Basis of the Assessment of Herring in Division 5Z

Description of the Fishery

Nominal Catches

Prior to its collapse in 1977, Georges Bank supported the largest herring fishery on the western Atlantic. During the late 1960s and early 1970s, reported commercial landings from the bank exceeded 200,000t annually. The fishery peaked in 1968 with reported landings in the 374,000t range, however it is suspected that actual landings may have been substantially higher. By 1977 reported landings had declined to less than 2,000t. The collapse has been attributed to over-fishing and poor recruitment. No directed herring fishery has operated on the bank since the collapse.



In 1993 and 1994, an experimental fishery with a combined Canada/United States catch of 5,000t was recommended for Georges Bank. No fishery occurred on the bank in 1992. In August of 1993 four vessels made a single excursion to the bank. Although no fish were caught, the lack of catch was not due to the absence of fish, but their distribution within the water column. Most herring were observed at depths too deep to capture with a purse seine.

Industry Consultations

Several formal and informal consultations with industry took place in 1993. These included presentations at both Scotia-Fundy Herring Advisory Committee meetings, a DFO/Industry program review in St. Andrews, annual meetings, ad hoc fishing excursions and the single fishing trip to Georges Bank. The industries most frequent comment regarding Georges Bank was the large number of herring on the northeastern portion of the bank being reported by other fishery sectors.

Research Survey Data

Data sources used to assess the recovery of Georges Bank herring include the US fall bottom trawl survey (1965-1993), which covered Massachusetts Bay, Nantucket Shoals and Georges Bank, and the Canadian fall Georges Bank larval/adult herring survey (1987-93). Unlike the US survey, which employed a random stratified design, the Canadian survey used opportunistic bottom trawl sets to collect adult herring samples. The larval component of the Canadian used standard bongo sampling protocol and survey originally covered only that portion of the bank which was likely show signs of a

recovery (i.e. historical spawning areas). In 1991, at CAFSAC's request, the larval survey grid was expanded eastward to include the entire Canadian portion of the bank. Survey coverage was again expanded in 1992 to the Great South Channel.

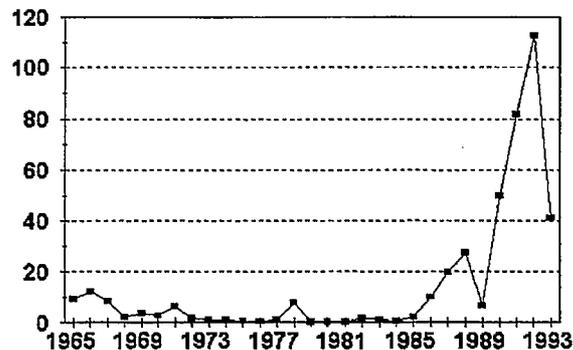
In 1993, the bottom trawl component of the Canadian survey was dropped to undertake an acoustic survey of the bank. An IGYPT mid-water trawl was used to sample adult herring and to verify acoustic backscatter. The larval component of the survey remained unchanged. Seventy-one larval stations and one mid-water trawl station were sampled in 1993.

Bottom Trawl Surveys

Bottom Trawl Abundance Index

The number of herring per standard bottom trawl tow from the US fall survey was used as an index of abundance of adult fish on the bank during spawning time. The index was relatively low during the peak period of the former fishery (1965-77). Between 1978 and 1984, few herring were collected on the bank by research surveys. However, from 1985 to 1988 the index increased rapidly, declined slightly in 1989, and then increased to a peak in 1992. The 1993 index dropped to approximately 50% of the 1992 value. A significant portion of this decline is believed attributable to the fact that the sampling design (groundfish bottom trawl survey) resulted in relatively few sets being made in areas where herring were previously found.

US Fall Bottom Trawl Survey
Numbers per Tow



Adult Distribution

In previous years the distribution of adult herring was based on the US bottom trawl survey and the trawling component of the Canadian fall survey. The fall component of the Canadian survey was terminated in 1992. Since then the occurrence of herring (1993) represents the US bottom trawl and the Canadian acoustic observations. In general the distribution of herring on Georges Bank was consistent with past observations. Adult herring appeared concentrated in an arc between the 100-200 m isobath north of Cultivator shoals to the International Boundary along the northern fringe of Georges Bank and just west of the Great South Channel. Unfortunately, in 1993 the US survey did not provide good coverage of the 100-200 m northern fringe nor the portion of the bank just east of the International Boundary where the majority of fish were observed in former Canadian surveys. It is therefore uncertain if the adult herring were present in these areas; however, a month later the acoustic survey found several schools of herring in this area.

Length Frequency

In past years, a declining trend in length frequency distribution was observed from Massachusetts Bay to Georges Bank in the US and Canadian bottom trawl samples. However, in 1993 this trend changed to a similar length distribution for Massachusetts Bay and Georges Bank. The modal length of herring on Nantucket Shoals (27 cm) was 1-2 cm larger than on Georges Bank or Massachusetts Bay. A similar length distribution was observed on Georges Bank for both the US October and the Canadian November 1993 samples.

The mean length of herring collected on Georges Bank in 1993 by both the Canadian and US fall surveys was the shortest since 1987 and significantly different from 1992. Herring collected by the US survey on Nantucket Shoal had the largest mean length (26.0cm) followed by Massachusetts Bay at 25.5 cm and Georges Bank at 24.9 cm. The mean length of fish taken by the US survey, which was conducted about five weeks earlier, and the Canadian survey, was almost identical.

Age Distribution

Age data on Georges Bank herring are available for only the Canadian bottom trawl sets (1987-1992) and the acoustic mid-water trawl (1993) samples. Since 1987 the age distribution of herring has been dominated by 3 and 4 year old fish. This trend continued in 1993 where herring samples were again dominated by 3 (59.1%) and 4 (30.4%) yr-old fish from the 1990 and 1989 year classes. There is, however, a noticeable absence of fish older than 6 in the single sample collected in 1993. Examination of the US length frequency distribution indicates the presence of fish larger than 30 cm which are likely to be the older age groups not collected by the Canadian survey. Both the 1986 and 1987 year-classes are well represented in catches prior to 1993 and the strong presence of 2-yr-old fish in 1991 can be followed forward to 1992 and 1993.

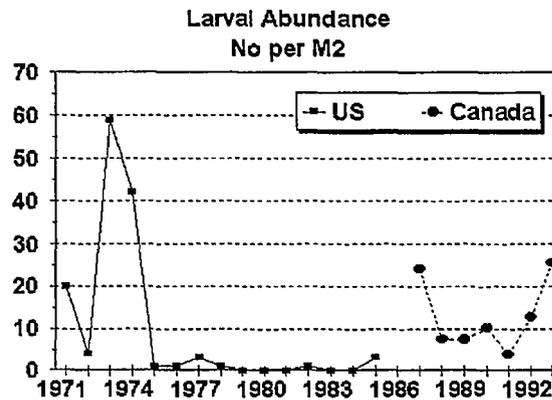
The continued strong representation of young fish (4 yr old and younger) in annual catches since 1986 provides evidence of good annual recruitment to the spawning stock and continues to support the expansion of the stock. However, in 1992 and 1993 the relative absence of older ages (7+) did cause some concern, even though sampling was limited in these years.

Larval Survey

Larval Abundance Index (LAI)

Two larval abundance indices (number of larvae/m³) from 1987 to 1993 were calculated from the Canadian fall larval surveys. In one estimates of the index were limited to stations contained within the original survey area to maintain consistency in the second the index included all stations in the expanded coverage initiated in 1991. For a historical perspective (1971-86) the number of larvae/m² were extracted from the literature (Smith and Morse, 1990).

The 1993 larval abundance index for both the original survey area (1987-90) and the expanded coverage was double the 1992 index and the highest observed in post-crash years, even though the survey was later. The observed 1991 decline is believed to be a function of late spawning relative to survey timing as the US December survey identified a spawning period which occurred after the Canadian survey was completed. It is also likely that LAIs between 1987 and 1991 are underestimated given the presence of unspawned fish on the bank during the survey.



Spawning/Larval Distribution

The geographical distribution of larvae (all sizes) collected in 1993 was similar to 1992. However, the total number of larvae collected during the survey and the concentration was more than double the 1992 observations. This is the highest number of larvae/m² observed since the Canadian surveys began.

Examination of the distribution and abundance of larvae <10 mm (generally considered an indication of spawning areas) showed a marked change from most of the other surveys. During the early years of the survey (1987-91) no small larvae were observed on the Canadian portion of the bank. In 1992 two aggregations of larvae were found just east of the International Boundary suggesting that herring had, for the first time since the collapse, reoccupied their historical spawning grounds on the eastern portion of the bank. The major difference between 1992 and 1993 was the extensive distribution and increased concentration of young larvae over the entire eastern portion of the bank.

Acoustics

In 1993 an acoustic survey was conducted on Georges Bank with survey rectangles established to cover the areas most likely to contain spawning aggregations of herring. Unfortunately, it appears from gonad samples (100% adults spent) that spawning was completed prior to the survey and that the majority of the herring may have left the spawning areas. The total estimated biomass was 26,555t. This estimate is far below (an order of magnitude) the expected spawning stock biomass and is likely a function of the lateness of the survey.

Prognosis

The 1993 data indicate that the Georges Bank herring stock is well on its way to recovering, from the collapse in 1977. The 1993 US bottom trawl survey index, although down relative to the last three years is far above earlier periods when catch levels were much higher (i.e. 1960s and 1970s). The Canadian larval abundance index was the highest observed in the time series. And, the age structure of herring collected continued to show a dominance of 3-yr-old fish in the catches, indicating successful

recruitment over the past several years, although some concern was expressed about the absence of 7+ herring in the samples. Both newly hatched (i.e. <10 mm) and older larvae in 1992 and 1993, displayed a much broader geographical distribution than in other post-crash years, including the northeastern portion of the bank. Finally, spawning on the Canadian side of the bank, which was first documented in 1992 by three independent surveys, was again observed in 1993 over much broader geographical area.

A commercial fishery could be developed on Georges Bank with a combined Canada/US catch of 20,000t. The commencement of a commercial fishery would also provide scientific information which would improve estimates of stock status. However, given the truly transboundary nature of this stock, steps must begin immediately for joint Canada/US management. Consideration should be given to the development of a strategic harvest plan for both Canadian and US fleets. It is also imperative that area mis-reporting (4WX/5Z) be minimized so catches and effort can be attributed to the appropriate stock.

Strategic Plan Considerations

As a developing fishery, it is important to be prepared for all eventualities and to anticipate changes in the Georges Bank fishery toward realizing the extent and reliability of control of the herring stocks. It is in this context that elements of a strategic plan are presented for the emerging Georges Bank herring fishery.

The purpose of the strategic plan would be to provide a proactive view to events in the fishery system over time. This would be accomplished through a more complete understanding of the source and extent of the evolving fishery, and its expected pattern of exploitation on the Bank. An important element of the strategic plan would set out objective criteria for explicit measurement of stock population status over time. The checklist of criteria, e.g., on acceptable weight at age patterns, or minimal estimates of fishing mortality, etc., would be directly related to contingent management response and alternatives for maintaining the objectives of the plan.

Operation of the strategic plan would be reinforced by well-defined procedures for continual monitoring and feedback from the fishery, including review of the strategic objectives. This process would involve all participants in the fishery system as well as defining their specific roles and contributions to consensus-building and co-management toward integrated decision making for management.

Research Recommendations

1. Future acoustic surveys be undertaken between mid and late October when most of the herring would be expected to be on the bank for spawning.
2. An industry based harvest plan be developed for the Georges Bank herring fishery.
3. Existing data be used to estimate natural mortality of this unharvested stock.
4. Historical assessments be examined to estimate current stock size.

References

- Melvin, G.D., F.J. Fife, J.B. Sochasky, M.J. Power, and R.L. Stephenson. 1994. Georges Bank (5Z) herring 1994 update. Atl. Fish. Res. Doc.: (in press).
- Smith, W.G., and W.W. Morse. 1990. Larval distribution patterns, evidence for collapse/recolonization of Atlantic herring on Georges Bank. ICES. C.M. Pelagic Fish. Comm. 1990/(H17): 1-16

Summary of Tuna and Swordfish

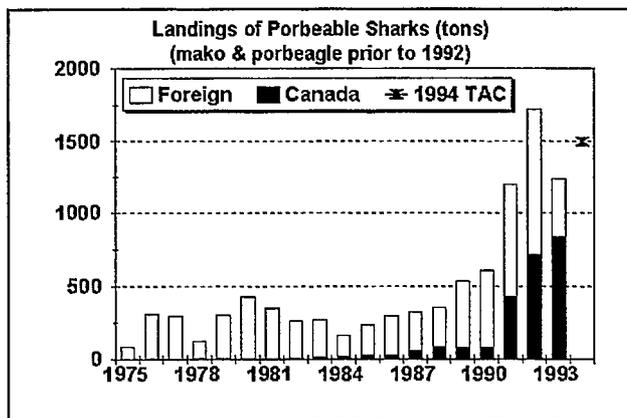
Tunas and swordfish are assessed by the International Commission for the Conservation of Atlantic Tunas (ICCAT) in autumn species group meetings. Full analytical assessments conducted for western Atlantic bluefin tuna, Atlantic yellowfin tuna, Atlantic bigeye tuna, and North Atlantic swordfish stocks indicate that all are fished at or above Maximum Sustainable Yield (MSY). All are under catch, effort or minimum size regulating recommendations by ICCAT. The Scotia-Fundy Regional Advisory Working Group recommends that Canadian management plans should reflect the status of these stocks. It was suggested that the Regional Advisory Process could provide the following reviews; 1) review of Canadian input to ICCAT prior to autumn stock assessment meetings; 2) retrospective review of SCRS stock assessment reports in order to evaluate the ICCAT advice and to provide input into future stock assessments; and 3) review or input into Canadian management plans.

References

Porter, J.M. 1994. National Report of Canada, 1992-93. Int. Comm. Conserv. Atl. Tunas, Rep. for Biennial Period 1992-93, Part II: (in press).

Summary of Status of Sharks

- * A Canadian fishery for pelagic sharks is developing in the Atlantic zone. A directed fishery for porbeagle sharks was initiated by foreign vessels in the northwest Atlantic in 1961. Otherwise shark catches in the Canadian zone have largely been bycatches, particularly in tuna and swordfish longline fisheries. The foreign directed effort has been replaced by Canadian offshore vessels and a number of inshore vessels have begun to direct for sharks in the last 3-4 years. The development of the directed fishery has been limited by available markets to date.
- * Fisheries Regulations were amended effective 4 May 1994 to include pelagic sharks and it is anticipated that a Management Plan for porbeagle, mako and blue sharks will be approved in the near future.
- * Preliminary 1993 reported landings of pelagic sharks in the Canadian zone were 1239t of porbeagle; 169t of mako, 256t of blue and 23t of unspecified sharks.
- * It was noted that it is difficult to make any comment on the stock status of pelagic sharks in the Canadian zone with the limited amount of information at hand.
- * The life history traits of sharks in general make them susceptible to over-exploitation. Anecdotal information suggests that where directed fisheries for sharks have occurred, the fishery lasted 3-4 years and collapsed; therefore extreme caution should be exercised in the development of a directed shark fishery. At this time, any directed fishery developed for these resources should be designed specifically to collect information relevant to stock status.
- * Any licenses issued for a directed shark fishery should be characterized as exploratory and not be viewed as permanent.
- * Observer coverage of the Canadian offshore vessels directing for porbeagle sharks should be given high priority.
- * Concern was expressed that the necessary surveillance, enforcement and monitoring (statistical and biological) programs were not in place to deal with the developing fishery.
- * By-catches should be included in quotas if quota management is to be employed.
- * By-catch levels should be specified that will prevent the development of new directed effort at this time.
- * Shark by-catch rates in tuna and swordfish longline fisheries should be documented through Observer coverage. Mechanisms should be explored to evaluate the survival of discarded shark by-catches in these fisheries.
- * The stock unit of each of these shark species is much wider than the Canadian zone. The management of these resources should be considered bilaterally with the USA.



Technical Basis of Assessment of Sharks

Introduction

The committee discussed the status of the developing pelagic shark fishery and reviewed the most recent draft of a Management Plan (20 April 1994) for a fishery for porbeagle, shortfin mako and blue sharks in the Canadian Atlantic. The Fisheries Regulations were amended effective 4 May 1994 to include pelagic sharks and it is anticipated that the shark Management Plan will be approved during May 1994.

It was noted that it is difficult, with the limited amount of information at hand, to make any comment on the stock status of any of these three species. The results of very limited tagging inside the Canadian zone and of a significant cooperative shark tagging program conducted in US waters, suggests that the stock unit of each of these species is much wider than the Canadian zone. Sharks are long-lived, have live birth, delayed sexual maturity and extremely low fecundity. They are therefore easily overexploited. Anecdotal information suggests that where directed fisheries for sharks have occurred, the fishery lasted 3-4 years and collapsed.

Description of the Fishery

There has been no directed fishery for either blue or mako sharks in the Canadian zone until recent years. Both are taken as by-catches in several fisheries: the Japanese tuna longline fishery, particularly in the warmer waters adjacent to the Gulf Stream; the Canadian swordfish longline fishery, particularly in the warmer offshore waters; and a variety of inshore gears during the summer and early fall. In recent years, a small number of inshore vessels have directed for blue sharks during the summer as both Federal and Provincial governments attempt to stimulate development of both market and fishery for blue sharks. Several inshore vessels have directed for porbeagle sharks in the fall. The extent of these directed fisheries is not fully known at present as sharks have not been regulated species. There was no requirement that logbooks be submitted and those landings that were reported were often recorded as shark, species unspecified. As has been the case with landings data reported by many North Atlantic countries, Canadian porbeagle and mako shark landings were combined and reported as mackerel sharks until 1992.

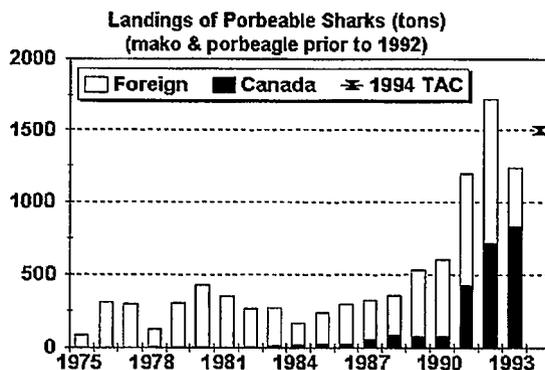
A directed fishery for porbeagle shark commenced in the northwest Atlantic in 1961 when Norwegian vessels began exploratory fishing using pelagic longline gear. These vessels had previously directed for porbeagle in the northeast Atlantic. They were joined by vessels from the Faroe Islands during the next few years. Porbeagle landings in the northwest Atlantic are reported to have increased from 1800t in 1961 to 9300t in 1964 (Casey et al. 1978). Landings then declined to about 1000t in 1968 and averaged 100-300t between 1969-77. Casey et al. (1978) observed that there was some evidence that the northwest Atlantic stocks of porbeagle were over-fished in the 1960s.

Since extended jurisdiction in 1977, Faroese vessels have continued to direct for porbeagle sharks inside the Canadian zone. Landings remained in the range of 100-300t until 1988. Through most of the 1980s, only one Faroese vessel was engaged in this fishery. Landings increased to about 600t in 1990. A second Faroese vessel entered the fishery in 1991, likely as a result of the closure of the high-seas fishery for salmon in the North Atlantic. A Canadian vessel also entered the fishery in 1991 and total landings increased to 1200t in 1991. A second Canadian vessel entered the fishery in 1992 and total landings increased to 1718t. In 1993, the Faroe Islands were given a porbeagle allocation of 400t and two vessels were engaged in the fishery. Two Canadian vessels were also engaged in this fishery and

a Faroese vessel was "Canadianized" mid-season and re-entered the fishery as a Canadian vessel. Total reported landings for 1993 were 1239t.

The Faroese vessels have been excluded from the fishery in 1994. The directed fishery for porbeagle sharks in 1994 is presently being prosecuted by three Canadian offshore pelagic longline vessels (freezer capacity) and small landings will likely be made by inshore longline vessels.

Preliminary 1993 reported shark landings in the Canadian zone were 1239t of porbeagle, 169t of mako 256t of blue sharks and 23t of unspecified sharks (excluding dogfish). The reported landings of porbeagle sharks consisted of 401t from Faroese vessels, 832t from Canadian vessels and 6t of by-catch from the Japanese tuna longline fishery. The reported landings of mako sharks consisted of 152t of Canadian catches and 17t of by-catch from the Japanese tuna longline fishery in the Canadian zone while blue shark landings consisted of 21t of Canadian catches and 235t of by-catch from the Japanese tuna longline fishery in the Canadian zone. These catches are viewed as an underestimate of actual catches, as sharks have been unregulated and a significant by-catch occurred particularly in the Canadian swordfish longline fishery.



Available Data

The Faroese vessels directing for porbeagle shark in the Canadian zone between 1977-93 were covered by Observers. Catch rate and size composition data from this period are presently being analyzed. The Canadian vessels directing for porbeagle in recent years have voluntarily submitted logbooks in most cases; however size composition data are not available except in cases when Observers were present. As this was an unregulated fishery and there was no requirement for these vessels to carry Observers, coverage has not been high. The logbook requirement in the draft Management Plan will ensure that catch rate data are collected but without the associated size and sex composition data. Tally sheets from landings will not provide the necessary spatial resolution of size and sex composition of offshore vessel catches that Observer coverage would provide, given the trip lengths and area presently covered by these vessels. Observer coverage of the offshore vessels would also provide a mechanism for detailed biological studies needed to provide information such as growth rate, size at first maturity, fecundity and gestation period. As a result, full Observer coverage of these vessels should be given high priority.

Landings of blue and mako sharks will likely be made predominantly by inshore vessels and logbooks and tally sheets specified in the Management Plan may be adequate to collect catch rate and size

composition data. However the collection of basic biological information will not be possible through shore sampling as sharks will likely be landed dressed.

Prognosis

As no new information with respect to stock abundance was available for any of these species, the Committee was unable to make recommendations concerning harvest levels; however the Committee did express a number of concerns and recommended caution in setting precautionary catch levels.

The Committee reiterated the recommendation that extreme caution be exercised in the development of a directed shark fishery and that any directed fishery developed for these resources be designed and conducted specifically to collect information relevant to stock status, such as detailed catch rate and size composition data. Any licenses issued should be characterized as exploratory and not be viewed as permanent.

It was unclear how many licenses might be issued under the draft Management Plan, but it seems likely that at least 60 fishermen/companies will qualify in Scotia-Fundy Region and at least 10 licenses will be available in each of the other Regions. Concern was expressed that the necessary surveillance, enforcement and monitoring (both statistical and biological) programs would not be in place to deal with the directed fishery that could develop under the draft Management Plan.

If quota management is to be employed in the management of this fishery, then by-catches should be included in those quotas. By-catches may provide information regarding distribution and size composition but are unlikely to result in useful catch rate data. Unrestricted by-catches will likely result in the development of directed fisheries under the guise of by-catch. At the least, by-catch levels should be specified that will prevent the development of new directed effort at this time.

In recent years, there has been an unquantified mortality due to the practice of "finning" sharks, the removal of fins and discarding the carcass; however this practice should be controlled by the prohibition of "finning" in the Management Plan.

Aside from "finning", a significant incidental mortality of blue sharks is believed to occur in the tuna and swordfish longline fisheries. It is believed that, to a certain extent, some of this mortality is deliberate. This mortality is presently unquantified. Shark by-catch rates in these pelagic longline fisheries should be documented through Observer coverage.

A shark Management Plan was implemented in the USA in 1993. The Committee also reiterated last year's recommendation that 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.

A draft of a Strategic Plan for the development of a shark fishery was reviewed. It was concluded that there was merit in this approach and that the idea should be pursued jointly with Fisheries Management and Industry.

Research Recommendations

1. Mechanisms should be explored to evaluate the survival of discards of shark by-catch in these fisheries, particularly the swordfish fishery.

2. It was also recommended that any research efforts should be conducted in consultation with USA colleagues to avoid duplication of effort.
3. It is anticipated that a species identification problem will develop, particularly for porbeagle and mako shark landings. Steps should be taken to develop criteria for discriminating between shark species after carcasses have been dressed.

7. MARINE MAMMAL ASSESSMENTS

Summary of Harbour Porpoise

Harbour porpoise are captured as by-catch in Canadian and U.S. demersal gillnet fisheries in the Bay of Fundy and Gulf of Maine. Evidence to date indicates mortality levels are high enough to be considered unsafe for the long-term sustainability of the population. Both the U.S. and Canada have initiated programs to assess the problem and provide possible solutions.

Abundance

During the summers of 1991-1993 a shipboard survey of harbour porpoise was conducted by the U.S. National Marine Fisheries. August was considered to provide the best opportunity to assess numbers of porpoise in the lower Bay of Fundy/Gulf of Maine. This is based on the assumption that this concentration originates from the population which overwinters along the New England coast south of Georges Bank. Previous surveys south of Georges Bank during August indicated very low densities present when the greatest concentrations had shifted to the southern Bay of Fundy. Mixing of porpoise aggregations between Newfoundland, Gulf of St. Lawrence and Gulf of Maine is not well known. A discrete population has been assumed to occur in the Bay of Fundy/Gulf of Maine with very limited movement of animals into or out of the area from other parts of the species range.

The U.S. National Marine Fisheries Service estimated that there are 47,200 (95% CI of 39,900-70,600) harbour porpoise in the Bay of Fundy/Gulf of Maine. This is an average of estimates derived from 1991 and 1992. Estimates for 1993 are not yet available. Estimates varied by nearly two-fold for the two years. In 1991, the estimated abundance was 37,500 (95% CI 26,700-86,400), whereas in 1992 it was 67,500 (32,900-104,600). These are not significantly different. Constraints to measure and set safe by-catch limits are in part related to the difficulty in obtaining reliable estimates of population size.

By-Catch

CANADA

In 1986 and 1987, harbour porpoise by-catch estimates in the Canadian sink gillnet fishery in the Bay of Fundy were based on casual observations and discussions with fishermen. There was no program in place that used observers and these estimates ranged from 94-116 for 1986 to 130 for 1989.

In March 1994, preliminary results of a Canadian study to find methods to reduce harbour porpoise by-catch in demersal gillnets fished in the Bay of Fundy were presented in Woods Hole at the "Scientific Workshop that Evaluated the Status of Harbour Porpoises in the Western North Atlantic."

This study was conducted from 30 July to 10 September 1993, and employed 4 observers who recorded data from 15 fishermen for 65 trips. Results indicated that a greater number of porpoise were caught per trip in nets set in inshore waters than in offshore waters. Porpoise were mainly caught near North Head, Grand Manan and in the area around Campobello and the Wolves Islands. Porpoise catches were greater in sets of longer duration (e.g. 72 hrs), and in sets that contained herring and dogfish. Differences in lead line (single vs. double) or anchor weight were not associated with porpoise by-catch. Nets set in Grand Manan Basin (mid Bay of Fundy) and on the Northeast Bank south of Grand Manan did not capture porpoise.

A preliminary estimate of the 1993 harbour porpoise by-catch for the Bay of Fundy was made from these data. Note that fishermen were not selected at random nor was there any stratification in the sampling design. Some fishermen that were considered to fish in areas where high by-catch occurred would not take observers on board.

The mean number of harbour porpoise caught per trip was estimated for fishermen of each port. It was assumed that fishermen from each port set their gear in an area that was distinct from the fishing grounds used by other ports. Based on discussions with observers this assumption was valid. The number of trips made from each port were retrieved from the landings data base. Trips were summed for the period 15 July - 30 September which represents the period when harbour porpoise-gillnet interactions occur (J. Wang, pers. comm.). The mean number of harbour porpoise captured per trip multiplied by the number of trips from each port gave an estimate of the number of porpoise caught per port (fishing area). Calculations were made by month and summed. An assumption made was that by-catch rate per port (fishing area) did not vary over the summer period. The calculation for boats fishing the Swallow Tail area off North Head, Grand Manan included one large catch of harbour porpoise ($n = 10$). Because of the large impact on estimates of this single higher catch, two estimates were made; one including the large catch of 10 porpoises and one excluding this value.

Number of trips by gillnet fishermen in areas in which harbour porpoise were captured (1993).

Location	Number of Trips			
	15-30 July	August	September	Total
Grand Manan (North Head)	34	68	17	119
Seal Cove, Ingalls Head (Northeast Bank)	-	-	-	-
Campobello (Campobello-Wolves Islands)	26	67	18	111
Metaghan (Grand Manan Basin)	-	-	-	-

Estimates of harbour porpoise by-catch in the Bay of Fundy area in 1993.

Location	Number of Harbour Porpoise			
	15-30 July	August	September	Total
Grand Manan (North Head)	108(51)	218(102)	54(26)	381(179)
Seal Cove, Ingalls Head (Northeast Bank)	0	0	0	0
Campobello (Campobello-Wolves Islands)	10	26	7	43
Metaghan (Grand Manan Basin)	0	0	0	0
TOTAL	118(61)	244(128)	61(33)	424(222)

Calculations based on mean number of harbour porpoise per trip:

Grand Manan = 3.20 (1.50 excluding trip with 10 porpoises)
Campobello = 0.39

With the inclusion of the trip with 10 porpoises in the calculation, an estimated 424 harbour porpoise were captured in the Canadian gillnet fishery in the Bay of Fundy area in 1993; 381 in the North Head, Grand Manan area, and 43 in the Campobello Island and Wolves area. This value of 424 is equivalent

to one-third of the total USA by-catch for this population in 1993. A value of 222 harbour porpoises is obtained when excluding the trip with 10 porpoises. The Canadian estimates are the highest recorded to date and are higher than those of the late 1980s when data were not pro-rated by fishing effort. The high abundance of herring in the vicinity of Grand Manan in 1993 may partly account for the high abundance of harbour porpoise in the area. Harbour porpoise feed principally on herring. Fishermen in the area indicated that harbour porpoise by-catch was higher in 1993 than in previous years.

Harbour porpoise population estimates and by-catch for the Gulf of Maine and Bay of Fundy (1986-1993). Population size estimates were made by the USA (Smith et al., 1993).

Year	Population Size	By-Catch	
		USA	Canada
1986			94-116 ¹
1989			130 ²
1990		2,900 (1,500 - 3,800)	
1991	37,500 (26,700 - 86,400)	2,000 (1,000 - 3,800)	
1992	67,500 (32,900 - 104,600)	1,200 (800 - 1,700)	
1993	NA	1,400 (1,000 - 2,000)	222-424 ³

1 = Read and Gaskin (1988)

2 = Polachek (1989)

3 = this report

UNITED STATES

Harbour porpoise by-catch in the US sink gillnet fishery in the Gulf of Maine was 2,900 in 1990, 2,000 in 1991, and 1,200 in 1992 (NEFSC 1992; Smith et al., 1993, Anon., 1994).

The estimated total combined Canadian and U.S. by-catch by gill net fisheries from the Bay of Fundy/Gulf of Maine population is approximately 1,600 to 1,800 for 1993. Even if we assumed the population was as high as 67,500 (the largest point estimate from U.S. ship-board surveys), the lowest estimate of total combined by-catch of 1,600 animals per year (or 2.4% of the population estimate) still exceeds the allowable removal rate of 2% of the population per year as recommended by the International Whaling Commission. Furthermore, the removal rate could be as great as 1,800 animals from a population of 37,500 or 4.8%.

Recommendations

1. Recommend gill net soak times of less than 24 hours, especially in the North Head, Grand Manan area.

2. If possible, avoid setting nets in the Swallow Tail, Grand Manan area, and near the Wolves Islands.
3. Encourage the scientific testing of acoustic deterrents (alarms).
4. Assess whether 1993 was an unusually high year of harbour porpoise by-catch. That is, conduct a study to estimate harbour porpoise by-catch in 1994 and subsequent years.
5. Assess seasonality of harbour porpoises by-catches.

References

- Anon. 1994. Estimating harbour porpoise by-catch in the Gulf of Maine sink gillnet fishery. NEFSC Reference Document 94-24. Northeast Fisheries Science Center, Woods Hole, MA.
- NEFSC (Northeast Fisheries Science Center). 1992. Harbour porpoise in eastern North America status and research needs: Results of a scientific workshop held 5-8 May 1992 at the Northeast Fisheries Science Center. Woods Hole, MA., NOAA/NMFS/NEFSC. NEFSC Ref. Doc. 92-06.
- Polacheck, T. 1989. Harbour porpoise in the gillnet fishery. *Oceanus* 32: 63-70 pp.
- Read, A.J., and Gaskin. 1988. Incidental catch of harbour porpoise by gillnets. *J. Wildl. Manage.* 52: 517-523 pp.
- Smith, T., D. Palka, and K. Bisack. 1993. Biological significance of by-catch of harbour porpoise in the Gulf of Maine demersal gillnet fishery. NEFSC Reference Document 93-23. Northeast Fisheries Science Center, Woods Hole, MA.

8. OTHER BUSINESS

8.1 Discussion on Surveys

Reductions in staff, operating budget and overtime over the last few years have severely constrained the regions ability to run the standard groundfish surveys or support new surveys. Inshore surveys in 4X and 4Vn which were supposed to have been funded under AFAP now have to be supported with A-base funds. Many shortcomings have been identified with the current surveys but there is no flexibility to implement and evaluate any improvements. In fact, decisions are being made at present to reduce current operations, e.g., curtailing SCANMAR operations on current surveys and cancelling the 4X inshore survey. Anticipated cuts over the next two years will probably result in more surveys being cancelled.

A preliminary review of the Summer 4VWX, February 5Z, March 4VsW groundfish surveys and the 4X and 4Vn inshore surveys with respect to objectives, problems and needed improvements was circulated to staff for comment last December. Funding restrictions delayed a meeting of staff from St. Andrews and BIO until their joint attendance at this year's RAP meeting. The findings of the review and details on findings from the 4X inshore survey were presented at the RAP. Discussion was limited due to time constraints and it was recommended that a Working Group be formed to review the costs and priorities of these surveys with respect to their research and monitoring functions. R. O'Boyle and S. Smith were tasked with coming up with membership and mandate for such a working group.

8.2 Comparative Fishing Analysis

This item could not be comprehensively discussed due to time constraints. Therefore it was deferred to the next appropriate RAP meeting.

9. ACKNOWLEDGEMENTS

This document represents the substantial efforts of DFO staff at all levels in the organization throughout the Scotia-Fundy Region. As well, the input of individuals from outside DFO was very much appreciated. Finally, it was only through the tireless effort of Valerie Myra, with help from Dianne Geddes and Theresa Dugas, that the report could be produced in a professional, timely fashion. We gratefully acknowledge the dedicated work of all those involved.

10. REFERENCES

- Angel, J.R., D.L. Burke, R.N. O'Boyle, F.G. Peacock, M. Sinclair, and K.C.T. Zwanenburg. 1994. Report of the Workshop on Scotia-Fundy Groundfish Management from 1977 to 1993. Can. Tech. Rep. Fish. Aquat. Sci. 1979.
- Annand, C., and D. Beanlands. 1994. An update on the status of 4VW and 4X flatfish stocks. Atl. Fish. Res. Doc. 94/34: 66 p.
- Annand, C., and D. Beanlands. 1994. A review of the status of 4VWX,3NOPs halibut stocks. Atl. Fish. Res. Doc. 94/41: 30 p.

- Annand, C., and J. Hansen. 1994. Management review 1993. Atl. Fish. Res. Doc. [In Prep.]
- Branton, R.M., and R.G. Halliday. 1994. Unit 3 redfish population and fishery trends. Atl. Fish. Res. Doc. 94/38: 34 p.
- Campana, S.E., and J.A. Gagne. 1994. Differentiation of 4T and 4Vs cod using otolith elemental fingerprints. Atl. Fish. Res. Doc. 94/27: 14 p.
- Drinkwater, K.F. 1994. Environment-4VsW cod recruitment relationships. Atl. Fish. Res. Doc. 94/63: 9 p.
- Drinkwater, K.F., and R.G. Pettipas. 1994. On the physical oceanographic conditions in the Scotia-Fundy Region in 1993. Atl. Fish. Res. Doc. 94/37: 32 p.
- Gavaris, S. 1994. Analysis of trends in effort: pp 76-80. In: J.R. Angel, D.L. Burke, R.N. O'Boyle, F.G. Peacock, M. Sinclair, and K.C.T. Zwanenburg. Report of the Workshop on Scotia-Fundy Groundfish Management from 1977 to 1993. Can. Tech. Rep. Fish. Aquat. Sci. 1979: vi + 175 p.
- Gavaris, S., and L. Van Eeckhaute. 1994. Assessment of haddock on eastern Georges Bank. Atl. Fish. Res. Doc. 94/31: 38 p.
- Gavaris, S., D. Clark, and P. Perley. 1994. Assessment of cod in Division 4X. Atl. Fish. Res. Doc. 94/36: 29 p.
- Hunt, J.J., and M.-I. Buzeta. 1994. Biological update of Georges Bank cod in unit areas 5Zj,m for 1978-93. Atl. Fish. Res. Doc. 94:30: 33 p.
- Hurley, P.C.F., P. Comeau, and G.A.P. Black. 1994. Assessment of 4X haddock in 1993. Atl. Fish. Res. Doc. 94/39: 42 p.
- Lambert, T.C., and S. Wilson. 1994. Update on the status of 4Vn cod: 1992-1993. Atl. Fish. Res. Doc. 94/46: 24 p.
- Lane, D.E., and R. Stephenson. 1993. A decision making framework for providing catch advice in fisheries. Univ. of Ottawa. PRISM. Working Paper. 93/62: 35 p.
- Maguire, J.-J., and P.M. Mace. 1993. Biological reference points for Canadian Atlantic gadoid stocks, pp. 321-331. In: S.J. Smith, J.J. Hunt, and D. Rivard [Eds.] Risk Evaluation and Biological Reference Points for Fisheries Management Can. Spec. Publ. Fish. Aquat. Sci. 120.
- McCracken, F. 1963. Seasonal movements of the winter flounder, (*Pseudopleuronectes americanus*), (Walbaum) on the Atlantic coast. J. Fish. Res. Board Can. 20: 551-586.
- Melvin, G.D., F.J. Fife, J.B. Sochasky, M.J. Power, and R.L. Stephenson. 1994. Georges Bank (5Z) herring 1994 update. Atl. Fish. Res. Doc.: (in press).
- Mohn, R.K., and W.D. Bowen. 1994. A model of grey seal predation on 4VsW cod and its effects on the dynamics and potential yield of cod. Atl. Fish. Res. Doc. 94/64: 43 p.

- Mohn, R.K., and W.J. MacEachern. 1994. Assessment of 4VsW cod in 1993. *Atl. Fish. Res. Doc.* 94/40: 37 p.
- NEFSC (Northeast Fisheries Science Center). 1992. Harbour porpoise in eastern North America status and research needs: Results of a scientific workshop held 5-8 May 1992 at the Northeast Fisheries Science Center. Woods hole, MA., NOAA/NMFS/NEFSC. NEFSC Ref. Doc. 92-06.
- O'Boyle, R. [Editor] 1993. 1993 consultation on the groundfish research program of DFO Scotia-Fundy Science. *Atl. Fish. Res. Doc.* 93/72: 47 p.
- Perry, R.I., and S.J. Smith. 1994. Identifying habitat associations of marine fishes using survey data: An application to the Northwest Atlantic. *Can. J. Fish. Aquat. Sci.* 51: 589-602.
- Polacheck, T. 1989. Harbour porpoise in the gillnet fishery. *Oceanus* 32: 63-70 pp.
- Porter, J.M. 1994. National Report of Canada, 1992-93. *Int. Comm. Conserv. Atl. Tunas, Rep. for Biennial Period 1992-93, Part II: (in press).*
- Read, A.J., and Gaskin. 1988. Incidental catch of harbour porpoise by gillnets. *J. Wildl. Manage.* 52: 517-523 pp.
- Simon, J.E., and P.A. Comeau. 1994. Summer Distribution and Abundance Trends of Species Caught on the Scotian Shelf from 1970-92, by the Research Vessel Groundfish Survey. *Can. Tech. Rep. Fish. Aquat. Sci.* 1953: x + 145 p.
- Showell, M.A., R. Branton, M.C. Bourbonnais, and R.G. Halliday. 1993. Status of the Scotian Shelf silver hake population in 1992, with projections to 1994. *NAFO SCR. Doc.* 93/102: 23 p.
- Smith, S.J., and F. Page. 1994. Implications of temperature and haddock associations on survey abundance trends. *Atl. Fish. Res. Doc.* 94/21: 34 p.
- Smith, S.J., R.J. Losier, F.H. Page, and K. Hatt. 1994. Associations between haddock, and temperature, salinity and depth within the Canadian groundfish bottom trawl surveys (1970-1993) conducted in NAFO Divisions 4VWX and 5Z. *Can. Tech. Rep. Fish. Aquat. Sci.* 1959: vii + 70 p.
- Smith, T., D. Palka, and K. Bisack. 1993. Biological significance of by-catch of harbor porpoise in the Gulf of Maine demersal gillnet fishery. *Northeast Fisheries Science Center Reference Document* 93-23.
- Smith, W.G., and W.W. Morse. 1990. Larval distribution patterns, evidence for collapse/recolonization of Atlantic herring on Georges Bank. *ICES. C.M. Pelagic Fish. Comm.* 1990/(H17): 1-16.
- Stephenson, R.L., M.J. Power, J.B. Sochasky, F.J. Fife, and G.D. Melvin. 1994. Evaluation of the 1993 4WX herring fishery. *Atl. Fish. Res. Doc.:* (in press).
- Trippel, E.A., and L.L. Brown. 1994. Assessment of pollock in Divisions 4VWX and Subdivision 5Zc for 1993. *Atl. Fish. Res. Doc.:* (in press).

- Woodley, T.H., and A.J. Read. 1991. Potential rates of increase of a harbor porpoise population subjected to incidental mortality in commercial fisheries. *Can. J. Fish. Aquat. Sci.* 48: 2429-2435.
- Zwanenburg, K.C.T. 1994. 1993 Weekly Reports: National Sampling Program. *Atl. Fish. Res. Doc.:* (in press).
- Zwanenburg, K., J. Black, B. Charlton, and G. Young. 1994. Haddock in Division 4TVW. *Atl. Fish. Res. Doc.:* (in press).

11. APPENDICES

11.1 Agenda

Agenda

1994 Annual Spring Meeting Scotia-Fundy Regional Advisory Process 2-11 May 1994

- I. Introduction (Sinclair)
 - A. Call to order
 - B. Objectives of meeting - The main objective is the peer review of analyses on stock status for consideration by the FRCC. As well, analyses will be considered that are important to regional fisheries management.
 - C. Meeting Report - The format for the meeting document will be presented. It will closely follow the outline provided by Parsons to facilitate input into the Zonal Stock Status Report. However, additional sections will be added to reflect the non-FRCC related items.
 - D. Schedule of meeting reports - This will be briefly discussed. Not only must there be timely production of this meeting's document, but also the associated Research Documents.
 - E. Approval of Agenda - any changes due to analysis availability.
 - F. Meeting logistics - secretarial support, photocopying, room for computing, evening at the BBYC, etc.

- II. Overview of the Ecosystem (O'Boyle)
 - A. Trends in the groundfish surveys - The results of two recent initiatives will be presented, both based on analyses of the survey information. These presentations will be short and provide background for the rest of the meeting.
 - 1. Species abundance trends (Simon & Comeau) - This documents abundance trends by species.
 - 2. Species diversity (Strong & Hanke) - This provides a view of the ecological changes but more from a community perspective.
 - B. Trends in marine mammal abundance - Two drafts on harbour porpoise in the Bay of Fundy will be presented:
 - 1. 1993 Spatial distribution of harbour porpoise by-catch in the Fundy-les region (Trippel).
 - 2. Synthesis of research on harbour porpoise in the Bay of Fundy (Brodie).

- III. Overview of Environmental Conditions (Frank)
 - A. Zonal and regional perspective (Drinkwater) - A short draft will be tabled which summarizes the analyses presented at FOC.
 - B. Analysis of survey temp/sal trends and the implications for survey interpretation (Page,Smith) - The findings as documented in recent technical reports will be presented. This discussion will be very helpful in interpreting recent fluctuations in survey abundance.

IV. Management and trends in the fishery (Sinclair)

- A. Effort trends in Scotia-Fundy Region since 1977 (Gavaris & Hanke) - An analysis of recent trends in the fishery. An early version of this work was presented at the December groundfish workshop.
- B. Management activities (Annand) - Synopsis of measures enacted in 1993 and plans for 1994. This is Chris' annual submission. It is an invaluable record of our management actions.
- C. Discarding as observed in 15% test fisheries (Showell) - These regulated fisheries may provide insight on the extent of discarding in the trawl fisheries.
- D. Update on the catch/effort statistics system (McMillan) - A brief presentation of this year's delivery of statistics, problems in regional and ZIF data will be made.
- E. Problems encountered with lobster statistics (Nolan)- A review of recent work to document the accuracy of the Region's lobster statistics.

V. Eastern Shelf Groundfish Stock Assessments (Gavaris)

- A. A model describing the interaction between 4VsW Cod and grey seals (Mohn & Bowen) - This model was internally reviewed late last year. It is necessary to review the updates made as the model is an important element of the 4VsW cod assessment.
- B. The mixing of Gulf and Shelf cod as determined through the examination of otoliths (Campana & Hamel) - The latest findings will be presented.
- C. 4VsW Cod - Two papers will be presented:
 - 1. An analysis of the retrospective pattern in the 4VsW assessment (J.-J. Maguire)
 - 2. Assessment of the stock incorporating effects of seal predation and environment (Mohn, Bowen, Black, Drinkwater, Frank, MacEachern) - The implications of seal population control will be discussed. Further analysis of stock component issue, juvenile distributions and condition factor changes will also be presented.
- D. 4Vn(may-dec) Cod (Lambert & Wilson) - Update using recent survey, aging and test fishery information. Also, presentation of closed area proposal that was provided to management.
- E. 4TVW Haddock (Zwanenburg, Smith, Black) - Length-based assessment using historical growth model. An examination of the environmental impacts on the survey information will also be presented.
- F. 4VWX Silver Hake (Showell & Bourbonnais) - The assessment will concentrate on a thorough evaluation of the input data and methodologies.
- G. 4VW Flatfish (Annand & Beanlands) - Update of fishery activities, problems in catch stats and survey trends. Plans for 1994.
- H. 3NOPs4VWX Atlantic Halibut (Annand & Beanlands) - Update of the available information.
- I. Unit 3 Redfish (Branton & Zwanenburg) - The assessment will include a description of the fishery and survey abundance trends.

VI. Southern Shelf Groundfish Stock Assessments (O'Boyle)

- A. 4X Cod (Gavaris, Clark and Perley) - Assessment of Cod on the Southwest Scotian Shelf.
- B. 4X Haddock - Two papers will be presented:
 - 1. Spatial & temporal trends in the size of 4X haddock: implications for management (Marshall) - A comprehensive analysis of the length and weight

time/space gradients will be presented.

2. Stock assessment (Hurley, Comeau, Smith) - A length-based analysis using an historical growth model will be presented as will potential environmental impacts on the survey trends.
- C. 5Zjm Cod (Hunt) - Assessment of Cod on Eastern Georges Bank.
- D. 5Zjm Haddock (Gavaris & VanEeckhaute) - Assessment of Haddock on Eastern Georges Bank.
- E. 4VWX5 pollock (Trippel & Brown) - Assessment of pollock in Div. 4VWX and Subdiv. 5Zc for 1993.
- F. 4X Flatfish (Annand & Beanlands) - Update of fishery activities, problems in catch stats and survey trends. Plans for 1994.

VII. Pelagic Stock Assessments (Stobo)

- A. 4Vn Herring (Stephenson) - Status of the stock structure issue.
- B. 4WX Herring (Stephenson et al.) - Update of 1993 analysis.
- C. 5Z Herring - Two papers will be presented:
 1. Herring larval abundance index adjusted for differences in spawning and cruise time (Melvin et al.)
 2. Stock assessment (Melvin et al.)
- D. Tuna and Swordfish (Porter) - Summary of the ICCAT/SCRS advice on large pelagics.
- E. Sharks (Hurley) - Recent management and Scientific activities. Presentation of the Strategic Plan concept.

VIII. Other business (Sinclair)

- A. A Decision-making framework for the development of management plans (Lane & Stephenson).
- B. Thoughts on applying the results of habitat research to fisheries management (Gordon).
- C. FRCC requests - Three questions have been asked by the FRCC that require analysis:
 1. Harvest strategy considerations relating to the age structure of the commercial catch (Gavaris & Neilson).
 2. The conservation characteristics of letting fish spawn at least once (O'Boyle).
 3. Shift in age-at-maturity as an indicator of stress in fish stocks (Trippel).
- D. Review of MFD groundfish surveys (Smith) - This was planned for the late winter but had to be postponed. There will be a general discussion of the survey timing and coverage to determine where improvements can be made.
- E. Influence of depth on the relative catch rates of the A.T. Cameron and L. Hammond from comparative trawling trials (Clark)

IX. Concluding Remarks (Sinclair)

	Monday May 2nd	Tuesday May 3rd	Wednesday May 4th	Thursday May 5th	Friday May 6th	Saturday May 7th	Sunday May 8th
09:00	Introduction	Cod/Seal Model	4Vn Cod	Flatfish	4TVW Haddock		
09:15							
09:30	Overview of Ecosystem						
09:45							
10:00							
10:15							
10:30-10:45	Coffee	Coffee	Coffee	Coffee	Coffee		
10:45	Overview of Environment	Cod/Seal Model	Silver Hake	Flatfish	4X Haddock	4WX Herring	
11:00							
11:15							
11:30			Redfish			4Vn Herring	
11:45							
12:00-13:00	Lunch	Lunch	Lunch	Lunch	Lunch		
13:00	Overview of Management & Fishery	Stock Mixing	Pollock	5Z Cod	Tuna and Swordfish	Sharks	
13:15							
13:30		Retrospective Analysis				5Z Herring	
13:45							
14:00		4VsW Cod					
14:15							
14:30							
14:45							
15:00-15:15	Coffee	Coffee	Coffee	Coffee	Coffee		
15:15	Cod/Seal Model	4VsW Cod	5Z Haddock	4X Cod	5Z Herring	Halibut	
15:45							
16:00							
16:15		4Vn Cod					4TVW Haddock
16:30							
16:45							
17:00							

	Monday May 9th	Tuesday May 10th	Wednesday May 11th	Thursday May 12th	Friday May 13th	Saturday May 14th	Sunday May 15th
09:00	FRCC	Decision Making					
09:15							
09:30		Habitat Management					
09:45							
10:00		Drafts					
10:15							
10:30-10:45	Coffee	Coffee	Coffee	Coffee	Coffee		
10:45	FRCC	Drafts					
11:00							
11:15							
11:30							
11:45							
12:00-13:00	Lunch	Lunch	Lunch	Lunch	Lunch		
13:00	Survey Discussion	Drafts					
13:15							
13:30							
13:45							
14:00							
14:15							
14:45							
15:00-15:15	Coffee	Coffee	Coffee	Coffee	Coffee		
15:15	Drafts	Drafts					
15:45							
16:00							
16:15							
16:30							
16:45							
17:00							

11.2 Participants

<u>Name</u>	<u>Affiliation</u>	<u>Name</u>	<u>Affiliation</u>
M. Sinclair	BSB, BIO	A. Sinclair	MFD, GFC
T. Decker	MFD, BIO	G. Chouinard	MFD, GFC
J. Fennell	MFD, BIO	L. Burke	EB, MC
W. Smith	MFD, BIO	M. Etter	SB, MC
R. Mayo	NEFC, NMFS	L. Brander	EB, MC
K. Zwanenburg	MFD, BIO	D. Gillis	Dal. Univ.
R. Halliday	MFD, BIO	M. Buzeta	GS, SABS
C. Annand	MFD, BIO	J. Pinter	TUNS
S. Campana	MFD, BIO	J. Simon	GS, MFD
R. O'Boyle	MFD, BIO	K. Drinkwater	PSCB, BIO
D. Clark	GS, SABS	S. MacPhee	Science, BIO
R. Mohn	MFD, BIO	S. Smith	MFD, BIO
G. Donaldson	MFD, BIO	J. McRuer	MFD, BIO
D. Lyon	MFD, BIO	C. Bourbonnais	MFD, BIO
J. Porter	PS, SABS	D. Bowen	MFD, BIO
E. Trippel	GS, SABS	P. Hurley	MFD, BIO
G. Melvin	PS, SABS	J. McMillan	MFD, BIO
R. Stephenson	PS, SABS	T. Marshall	Dal. Univ.
K. Frank	MFD, BIO	H. Stone	PS, SABS
A. Charles	FRCC	D. Beanlands	MFD, BIO
P. Perley	PS, SABS	D. Lane	Univ. Ottawa
S. Wilson	MFD, BIO	P. Comeau	MFD, BIO
T. Lambert	MFD, BIO	M. Power	PS, SABS
J. Neilson	BS, SABS	R. Halliday	MFD, BIO
A. Jallon	SMU	L. VanEeckhaute	GS, SABS
S. Gavaris	GS, SABS	W. Stobo	MFD, BIO
M. Showell	MFD, BIO	C. Jones	FHMB, MC
R. Branton	MFD, BIO	F. Page	MFD, BIO
M. Strong	GS/SABS	R. Losier	GS/SABS

11.3 Abbreviations

ADAPT	- The adaptive framework for SPA calibration
BIO	- Bedford Institute of Oceanography
CAFSAC	- Canadian Atlantic Fisheries Sciences Advisory Committee
C/E - CPUE	- Catch per unit of effort
CIL	- Cold intermediate layer
CPR	- Continuous Plankton Recorder
CV	- Coefficient of variation
CW	- Carapace width
DFO	- Department of Fisheries and Oceans
EEC	- European Economic Community
f	- Fishing effort
F	- Instantaneous rate of fishing mortality
F(50%)	- Fishing mortality corresponding to the 50% rule (see Section ix of Anon, 1992b)
$F_{0.1}$	- The instantaneous rate of fishing mortality (calculated from a yield-per-recruit curve) at which a unit increase in fishing effort (proportional to fishing mortality) will give an increase in yield 1/10th that of a unit of effort on the virgin stock (dynamic pool model)
FAO	- Food and Agriculture Organization
FG	- Fixed gear
F_{max}	- The instantaneous rate of fishing mortality which maximizes the yield per recruit (dynamic pool model)
FOS	- Fisheries Oceanography Subcommittee
FRCC	- Fisheries Resource Conservation Council
GM	- Geometric mean
ICNAF	- International Commission of the Northwest Atlantic Fisheries (ceased operation at the end of 1979)
IIE	- Integrated index error
IOP	- International Observer Program
ITQ	- Individual transferable quotas
M	- Instantaneous rate of natural mortality
NAFO	- Northwest Atlantic Fisheries Organization
OTB	- Bottom otter trawl
OTM	- Midwater otter trawl
PR	- Partial recruitment
PSU	- Practical salinity unit
q	- Catchability coefficient
RV	- Research vessel
SPA	- Sequential population analysis
SPM	- St. Pierre & Miquelon
SPR	- Spawning stock biomass per recruit
SSP	- Spawning stock biomass
TAC	- Total allowable catch
TC	- Tonnage class
UNEP	- United Nations Environment Program
VPA	- Virtual population analysis
XSA	- Extend survivors method of SPA calibration
Z	- Instantaneous rate of total mortality
ZIF	- Zonal interchange file