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Report on the Assessments of Groundfish Stocks in the Canadian Northwest Atlantic May 4-14, 1993

## Editor

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## Report on the Assessments of Groundfish Stocks In the Canadian Northwest Atantic May 4-14, 1993


#### Abstract

Sinclair, A. (Editor). 1993. Report on the assessments of groundfish stocks in the Canadian northwest Atlantic, May 4-14, 1993. Can. Tech. Rep. Fish. Aquat. Sci. 1946e.

Stock assessment scientists from the Canadian Department of Fisheries and Oceans met from May 4-14, 1993 in St. John's, Newfoundland to review stock assessments of groundfish stocks within the Canadian northwest Atantic. This report presents the proceedings of this meeting and has two main purposes. Firstly, it provides the scientific basis for a report on stock status which was presented to the newly formed Fisheries Resource Conservation Council. Secondly, it provides a record of the technical discussions at the meeting, the main issues faced, decisions taken, and research recommendations for future work.


## Résumé

Sinclair, A. (Rédacteur). 1993. Rapport sur l'évaluation des stocks de poisson de fond des eaux canadiennes de l'Atlantique nord-ouest du 4 au 14 mai 1993. Rapp. tech. can. sci. halieut. aquat. 1946 f.

Les scientifiques responsables de l'évaluation des stocks au ministère des Pêches et des Océans du Canada se sont réunis du 4 au 14 mai 1993, à St. John's (Terre-Neuve), pour examiner les évaluations des stocks de poisson de fond dans les eaux canadiennes de l'Atlantique nord-ouest. Le présent rapport. qui rend compte de cette réunion, visait deux grands objectifs. D'une part, fournir les bases scientifiques nécessaires à un rapport sur l'état des stocks, qui a été présenté au tout nouveau Conseil pour la conservation des ressources halieutiques. D'autre part, relater les discussions techniques tenues et les principaux sujets traités à cette réunion, ainsi que les décisions et les recommandations de travaux scientifiques futurs qui en sont issues.


## 1. Introduction

The Science Branch of the Canadian Department of Fisheries and Oceans (DFO) has provided peer reviewed scientific advice on management measures for groundfish stocks off eastern Canada since 1977 through the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC). The advice was provided to DFO fisheries managers and the fishing industry in the form of CAFSAC Advisory Documents (e.g. Anon. 1992a) and the technical basis for the advice was documented in CAFSAC research documents. The Groundfish Subcommittee of CAFSAC provided the forum for scientific review of stock assessments, however, its reports were not made public. In December, 1992, CAFSAC was disbanded yet the need for peer reviewed information on the status of these stocks continues. While CAFSAC has not been replaced, assessment scientists met on May 4-14, 1993 at the Battery Hotel in St. John's Newfoundland to review material stemming from the 1992 fishing year. This document presents the conclusions of the meeting about the current status of these stocks, their historical trends in abundance, biomass, and exploitation patterns. The contents were used as the basis for a Stock Status Report to the recently formed Fisheries Resource Conservation Council (FRCC) which has been charged with providing formal advice to the Minister of the Department of Fisheries and Oceans (DFO) regarding management measures and fisheries management policy including total allowable catches (TACs).

The agenda of the meeting corresponds with the table of contents of the report. The participants are listed in Annex 1. A list of abbreviations used throughout the report is provided in Annex 2. A list of working papers that were presented at the meeting is given in Annex 3. These papers are produced for the purposes of the meeting only and are not citable. Interested readers should contact authors for details of the contents of working papers. In the past the majority of the working papers were upgraded to CAFSAC Research Documents and became available to the public. However, this document series was discontinued with the dissolution of CAFSAC and a new series call the DFO Atlantic Fisheries Research Documents replaces them.

Meeting participants came mainly from the Science Branches of the four Atlantic regions of DFO and Ottawa. Dr. D. Hayes from the NMFS in Woods Hole, Mass., USA attended the first week of the meeting and provided useful information on the fisheries for cod an haddock on Georges Bank. Mr. H. Clarke, the Chairperson of the FRCC also attended several session of the meeting. Their input and comments were greatly appreciated.

The meeting report is divided into several sections which reflect specific items in its terms of reference. Sections 3-5 are summaries of previous reports of the former Groundfish Subcommittee which dealt with the development of an operational definition of conservation for groundfish stocks (Sect. 3), a general discussion of ways to reduce fishing effort in groundfish fisheries (Sect. 4), and ways of avoiding the capture of small fish. Section 7 focuses on multi-species considerations in assessments. Sections $8-10$ provide the details of the stock assessments, beginning with a general and area overviews (Sect. 8), followed by one-page summary sheets on each assessment (Sect. 9), and then the technical details of each assessment (Sect. 10). The remaining sections address specific questions which required peer review at an inter-regional level within DFO.

## 2. Business Items

### 2.1. Catch and Effort Statistics

Delivery of statistics
In early January, DFO Science Directors formally requested the regional Statistics Divisions to provide catch and effort data by March 15. This date was established several years ago as the deadline for delivery of
statistics for groundfish and pelagic stocks assessments. In addition, some format changes (e.g. latitudelongitude data) and a description of the procedures used to determine main species over the last several years were also requested. Gulf, Quebec and Scotia-Fundy regions provided data on time, however the Newfoundland Region did not.

At the March 22-25 meeting of the Statistics, Sampling and Surveys Subcommittee, it was decided that the statistics for the three regions who had supplied data would be rolled-up and distributed to assessment biologists as soon as possible. Newfoundland data would be distributed when received. Following a request by DFO senior management, data were finally received from the Newfoundland Region on April 6, however none of the format changes had been implemented. The data were subsequently rolled-up with the statistics from the other regions and complete zonal statistics were available around April 10.

The rolled-up Zonal Interchange File (ZIF) statistics prepared by Science Branch were provided in the normal ASCII summarized format and also as an ORACLE database. Because of the size of the database, there were some problems in migrating data from the Bedford Institute of Oceanography (BIO) to the various regions. Some discrepancies in the ORACLE tables were also reported in the Scotia-Fundy Region. These caused further delays, such that many assessment biologists did not have data in hand until April 15.

The lateness in the delivery of statistics restricted the amount of analyses that could be conducted and some assessments were delayed. With increased demand for further analyses expected from the Fisheries Resource Conservation Council (FRCC), it is necessary that catch and effort data be available earlier. Assessment biologists suggested that data need to be available in January to allow sufficient time for the analyses, recognizing that these would be preliminary data.

Some concerns were also expressed as to the quality of the data being supplied especially given the large changes in catches and effort sometimes observed when data are finalized. It should be noted that no information has been provided on the determination of main species by any of the regions. This information is required to properly analyze catch and effort data.

## Updates to NAFO and ZIF data

The official 1989 catch and effort statistics were published by the Northwest Atlantic Fisheries Organization (NAFO) in 1992. Significant changes were noted from the preliminary information previously available for some of the stocks (e.g. 4T-Vn (J.-A.) cod. ZIF data for 1991 were also updated.

## Status of ZIF database

The Science Branches in the four Atlantic regions have undertaken a project to place the ZIF catch and effort data into a common ORACLE database. Significant progress was made on the project last year. Data for 1991 and 1992 were loaded to the database. Several difficulties were encountered during the preparation of the assessments. In particular, the size of the database has presented problems and there were some discrepancies in format as noted above. The objective is to migrate the historical ZIF data (back to 1985) into the database over the summer. A replacement for the BIO CYBER, where the database currently resides, is due shortly. This will likely facilitate the management of the database.

### 2.2. Identification of Flatfish Species

During the meeting, it became apparent that there are major problems in the identification of flatfish species during the collection of statistics. Although this is not a new problem, the situation appears to have deteriorated, particularly in the Scotia-Fundy Region in the last two years where half of the commercial
catch of flatifish is now being reported as "unspecified flounder". This problem may, for example, explain the lack of landings for 3LNO plaice for Scotia-Fundy vessels which fished in the area. The unspecified flounder category is considered to be comprised largely of American plaice, yellowtail and winter flounder. The problem is not thought to be restricted to the Scotia-Fundy Region and likely affects landing statistics of flatish in other regions to a varying degree.

Proper identification of flatish species is a basic requirement for conducting population studies and quota management. Therefore Statistics Branches should take the necessary steps to collect this information.

## 3. Definition of Conservation for Groundfish Stocks

### 3.1 Overview

Recent events, such as a court decision giving native food fisheries first right of access to natural renewable resources once conservation is assured and the formation of the FRCC, have resulted in calls for an explicit definition of conservation and the identification of associated biological reference points for groundfish stocks. The issue was discussed at the March 1993 Groundfish Subcommittee meeting and sections of these discussions are presented here.

The current management strategy used for Canadian Atlantic groundfish stocks calls for maintaining fishing mortality ( $F$ ) constant at the $F_{0.1}$ reference level. Catch quotas are used as an indirect method of controlling F. Stock assessments are conducted annually to obtain estimates of stock size and total allowable catches (TACs) are estimated for future years as a function of projected stock size and $F$. Provisions exist in the Atlantic Groundfish Management Plan to deviate from $F_{0.1}$. If it is determined that the current $F$ is higher than the target, $F$ may be reduced to the target level over several years if the spawning stock size is not threatened (using the $50 \%$ rule). Alternatively, F may be reduced to below $\mathrm{F}_{0.1}$ if the spawning stock size is in danger (see sections viii and ix of Anon. 1992b). However, there are currently no accepted rules for determining what this critical level of spawning stock may be.

The following discussion focuses on general considerations and further research is required before stockspecific targets may be established. Some issues particularly relevant to assessing the conservation status of groundfish stocks are considered to be:

- Stochasticity has important implications for the definition of conservation. For example, recruitment variability may increase at a low spawner stock size. Incorporating stochastic processes into population models and the use of these models to quantify probabilities relative to biological reference points may form an important part of assessing the conservation status of a stock.
- Genetic structure of populations at low stock size can influence the conservation status of a stock. For example, small populations can result in-breeding and raise the risk of extinction. Unfortunately, many of these processes are not well understood and it is unlikely that genetics can be incorporated into conservation models for groundfish stocks in any meaningful way at this stage.
- Population richness and the implications for conservation is an important aspect that is often neglected. Many of the groundfish stocks may be composed of a number of interacting sub-populations. Long-term declines in stock abundance may be parallelled by declines in individual sub-populations and decreases in population richness through the loss of sub-populations. Below a certain abundance, stock rebuilding may only be possible through recolonisation from adjacent areas rather than resurgence of the original resource. Spatial processes are therefore likely to be an important aspect to consider with respect to groundfish stocks.

The importance of incorporating stochastic and spatial processes into conservation models is recognized and research efforts on these issues are encouraged.

### 3.2. Biological Reference Points

Several biological reference points based on spawner stock and recruitment are in existence. Some of these reference points were briefly reviewed. Spawning stock biomass per recruit (SPR) analysis is useful in the definition of overfishing when a constant F management strategy is in place, and it may therefore be useful in the definition of conservation. This has been recognised in the USA where 60\% of the definitions of overfishing are based on SPR analysis. However, conservation cannot be defined only in terms of a target fishing mortality. Other considerations, such as spawner stock-recruit relationships, particularly spawner stock biomass (SSB) thresholds below which recruitment is reduced, have to be taken into account. It was noted that the use of maturity data to calculate spawning stock biomass and investigations into the relationship between spawner biomass and egg production were also important components of research relevant to defining conservation for northwest Atlantic groundfish stocks.

No consensus was reached on which methods are likely to be most useful in the definition of conservation for northwest Atlantic groundfish stocks. Various analyses, including tests of robustness will be necessary to determine the advantages and disadvantages of the alternative approaches.

### 3.3. Definition of Conservation

The general definition of conservation based on the World Conservation Strategy of UNEP (adopted for Atlantic salmon, see CAFSAC Advisory Document 91/15) was considered: Conservation is defined as "that aspect of renewable resource management which ensures that utilisation is sustainable and which safeguards ecological processes and genetic diversity for the maintenance of the resource concerned. Conservation ensures that the fullest sustainable advantage is derived from the resource base and that facilities are so located and conducted that the resource base is maintained."

It was considered that this definition may be applicable to groundfish stocks. However, there remains several issues that require clarification before this definition can be applied quantitatively on a stock-by-stock basis.

The merits of considering operational targets and conservation limits were discussed. Operational targets guide the management process in "normal" times (e.g. setting TACs that correspond to a fishing mortality target of $\mathrm{F}_{0,1}$ ). Conservation limits are a function of the biology of the stocks and should be determined by biologists (for example, spawning stock size below which low recruitment will occur). Operational targets require consideration of economic, social and political objectives - a biologist's role would be to examine the biological consequences, with respect to conservation limits, of various options. It was considered desirable to avoid having conservation limits become operational targets, since greater sustainable advantage may be obtained from stocks of larger sizes than critically low SSB.

Further consideration needs to be given to how SSB limits would be used for conservation purposes. Would fishing mortality be reduced in a stepwise manner as SSB approached the limits, and if so, how should the limits be determined so as to avoid the risk of passing the limits before a decision to stop fishing is reached? Alternatively, would it be more practical to target optimal, as opposed to minimal, stock biomasses?

It would be worthwhile to examine what has gone wrong with the current management system before abandoning it completely. It is impossible to evaluate whether $F_{0,}$, per se was the correct target $F$ in the northwest Atlantic, because it was never attained. An evaluation of the implementation of this strategy
would be enlightening: how successful were catch quotas as an indirect way of controlling $F$; how well could current assessment methods and monitoring activities detect reductions in recruitment and stock size; how well were quotas, gear regulations, and catch reporting regulations enforced; and how effective were vessel replacement and limited entry policies at curbing fleet capacity.

In the context of fullest utilisation of the resources, given the current depressed state of most groundfish stocks in the northwest Atlantic, and the lack of clear economic and social objectives for fisheries management, it was concluded that $F_{0,1}$ may be a reasonable operational target for conservation of groundfish stocks when SSB is not particularly low. The control for implementing $F_{0.1}$ has been the imposition of a TAC. Implementation of $\mathrm{F}_{0.1}$ in terms of effort control also needs to be considered. Further research into SPR and SSB, and consideration of how these would be used as part of a management strategy, is encouraged. Research is also recommended into the importance of stochastic processes and population richness, and the effect of ecological processes on carrying capacity. Attention should also be paid to inter-stock differences in growth, maturation, yield per recruit, SSB, and SPR when quantifying conservation on a stock-by-stock basis.

Through the course of the May 4-14, 1993 meeting, it became apparent that the majority of the stocks being assessed were at very low biomass levels. Attention was drawn to section viii of the Atlantic Groundfish Management Plan which states that if the assessment provides evidence that the current level of biomass may threaten future recruitment, fishing effort will be reduced to allow immediate growth in spawning stock biomass. An interim operational definition of this critical biomass was proposed to be a biomass below 50\% of the median observed in the available time series. It was noted that such a definition would be highly dependent on the available data, if only a short time series were available then an accurate picture of the possible resource states would not be available. It was also noted that the median biomass would decrease through time if the stock became progressively less abundant. As was the case in evaluating several alternative rules as was reported in the March meeting, no consensus was reached on this particular definition. However, there is a clear need of additional research in defining such critical biomass levels.

## 4. Implications of Moving to $\mathrm{F}_{0.1}$

### 4.1. Reduction of Fishing Effort

In 1991, DFO embarked on a multi-year groundfish management plan where TACs for the major stocks were fixed for three years. In some cases, the TACs were expected to reduce $F$ towards the $F_{0.1}$ target while in others no reduction in F was expected. At the time that these plans were formulated, assessment data were available up to and including the 1989 fishing year. However, in the ensuing years the estimates of stock size for all stocks on the multi-year plan were revised downwards based on more recent data. The multi-year plans were abandoned for all stocks with the exception of 5 Zjm cod and haddock and 4 X cod, and 1993 TACs for several stocks were set at the $F_{0.1}$ reference level. This implied substantial reduction in fishing effort, in the order of $60-70 \%$ for mobile gear fisheries for $3 P \mathrm{Pn} 4 \mathrm{RS}, 4 \mathrm{TVn}$, and 4 VsW cod for example. Since the management strategy is to maintain a constant $F$ at $F_{0.1}$, these reductions in fishing effort are for the long term. Given the magnitude of this reduction, there is a need for a permanent reduction in the current fishing fleet.

Various management measures have been used in previous years to try and reduce $F$ to the $F_{0.1}$ target, including the $50 \%$ rule and the 3 -year management plan. These have not worked, possibly because they are indirect measures, mediated through catch controls. Reported catches are often far lower than real catches and TACs are often exceeded.

The primary considerations in devising a method of effort reduction are potential effectiveness, enforceability, economic implications, and equity. With regard to equity, the measures adopted must either give all potential fishery participants an opportunity to fish or provide adequate compensation for those who
are prevented from fishing. From an economic viewpoint, measures which make fishing operations at sea less efficient prevent fishermen from utilizing alternative employment opportunities and are more costly to fishermen than those that reduce time at sea. To be effective in practice, regulations must be enforceable. Land-based enforcement is likely to be more affordable than at-sea enforcement however it may be less effective.

The relationship between fishing mortality $(F)$ and fishing effort (f) is:

$$
F=q \times f
$$

where $q$ represents the efficiency of each unit of effort. Therefore, fishing mortality can be reduced by regulatory measures directed at fishing effort and/or fishing efficiency.

Reduction in q: Methods to reduce the effectiveness of a fishing unit include closure of seasons and/or areas when/where high catch rates can be achieved. These circumstances can occur when fish form dense overwintering, prespawning, or spawning concentrations. Fishing gear can be made less efficient by limiting its overall size or its construction, e.g. number of gillnets or hooks set, increase in trawl mesh size. Vessel operations can be made less efficient, trip limits which require more port visits and hence transit time. All these measures are economically inefficient, expensive and difficult to enforce. These measures affect the variable costs of fishing operations, and they do not allow for an economic rationalization of the fleets, as they affect all vessels more or less equally. Furthermore, these measures are not usually very effective in reducing $F$ because there is a substantial scope for vessels to increase efficiency by modifying unregulated factors. Even with seasonal tie-ups, fleets can increase effort in the open season to compensate for the closures.

Reduction in f: Fishing effort is calculated for scientific purposes as hours fished, number of hooks set, etc. and often standardized for relative efficiency of vessels of various sizes. However, these effort units would be unsuitable for regulatory purposes. Days at sea, although less related to $F$, are probably the most precise measure of $f$ which could be used as a basis for effort control. Even this would be difficult or impossible to monitor or control on an individual vessel basis without ancillary measures. Closed seasons, would reduce the periods when days at sea could be used. Adoption of designated ports of landing would improve monitoring. At the next level of control, days could be controlled at a fleet sector level by allowing periodic openings of the fishery for a length of time calculated to allow the fleet to exert the target number of days.

These restrictions on days at seas are also economically inefficient but less so than measures which reduce fishing efficiency. Variable costs are unaffected by these measures, although the fixed costs will become proportionally more important, unless the number of fishing vessels is reduced. Vessels with high fixed costs are likely to be more severely affected (usually newer vessels with high capital cost). The most efficient method would be to tie up a proportion of the fleet for the whole year while allowing the rest to fish with substantial freedom.

### 4.2. The Need for a Long Term Plan

A long term groundfish management plan would put year-to-year actions in the context of broad-scale policy directions. Its effectiveness would be enhanced if both government and industry are in agreement with this plan.

A comprehensive plan would bring together all elements of groundfish management and reveal inconsistencies among components of it. In particular, this would bring together policies on participation in the fishery and fleet capacity management now under licensing and vessel replacement policy, and
resource exploitation and harvest sharing policy now under the annual groundfish management plan. Inconsistencies between these policies have been a root cause of current problems.

A comprehensive plan would also ensure that all the necessary agencies are party to the planning process and that the end product is a practical and implementable plan. Too little attention has been paid to the enforceability of the regulatory measures. There are a wide variety of measures which can be taken to control exploitation rate and size at first capture to ensure stock conservation and to optimize yields. Those currently in place, i.e. catch control and gear regulation, are the most direct and potentially most effective measures. If these cannot be effectively enforced then other, less efficient, measures such as area closures could be adopted, but only if it is established that these could be effectively enforced. Adding to an already long list of regulatory measures, a substantial number of new controls, none of which can be effectively enforced, can only be counterproductive. It would be a much more effective strategy to enforce a small number of measures well than many ineffectively.

The effectiveness of regulatory measures is ultimately evaluated on whether or not the original objective for their implementation was achieved. Measuring fishermen's response to a regulation would determine if the original intent is being satisfactorily met, or if an alternative regulation should be employed. In the present context, the extent of wastage of small fish at sea is largely unquantified and the importance of the various possible causes for this wastage cannot be evaluated. This makes it impossible to propose solutions with any assurance that these can resolve the problem. If, for example, the catch of small fish is caused by the widespread use of illegal mesh size, then an increase in regulated mesh size will do nothing to solve the problem and may, in fact, encourage the greater use of illegal meshes. Mechanisms should be put in place so that the information necessary to evaluate the achievement of objectives is available, and to ensure that evaluation occurs. This should apply equally to management and biological objectives.

Significant changes in management approaches to the Atlantic groundfish fishery have been made only in response to crises. In crises, rapidly applied solutions tend to treat symptoms rather than fundamental causes. Solutions are often piecemeal and can be in conflict with established measures. The present situation is clearly classifiable as a crisis and presents another opportunity to implement new measures. However, great care in choice of measures is required. Different fleets may require different solutions. For instance, closed area regulations may be of limited utility except in special fleet-specific cases. Direct effort control by extensive fleet tie-ups could be the most effective in the short term. It should, however, be considered and promoted only as a stop gap measure to provide time to devise a longer term solution to fleet overcapacity.

## 5. On Avoiding the Capture of Small Fish

The current reduced state of the groundfish resources raises concern for their long-term spawning potential. There might be some conservation benefits if the fish were not caught until they had a chance to spawn at least once. If the intent is strictly to avoid the capture of immature fish, then the minimum size needs to be reviewed on a stock-by-stock basis to account for differences in maturity at size. It was noted that minimum fish size regulations would not be necessary for conservation purposes if the groundfish fisheries were managed at the $F_{0.1}$ target and if current mesh size regulations were effective. $F_{0.1}$ implies an annual harvest of $15-20 \%$ of the fishable biomass, no growth overfishing, and a relatively large average spawning stock biomass.

Measures which control the size composition of the catch directly are closure of juvenile distribution areas, fishery closures and gear regulations. Indirect control is imposed by minimum fish size regulations, which if strictly enforced and coupled with effective sanctions, would encourage fishermen to avoid areas and practices which result in catches of small fish. The prevention of capture of small fish can only be assured by at-sea enforcement. This would suggest a high percentage observer coverage in problem fleets and
effective sanctions. This would provide additional benefits in preventing wastage through dumping and high-grading as well as collection of high quality information for stock assessment purposes. An alternative to a high level of observer coverage is punctual fishing closures when the catch of small fish exceeds established tolerances. Such an approach has been used in the Gulf of St. Lawrence since 1991 and was expanded to include all areas in 1993. Fisheries may be closed if the number of undersized fish ( 43 cm on the Scotian Shelf and Georges Bank, 41 cm elsewhere) exceeds $15 \%$ by numbers.

The definition of juvenile closed areas can be facilitated by incorporating observer and survey information with industry consultations. Areas of small fish generally exhibit high catch rates and these are of considerable economic importance to the fleets. Industry acceptance of closed areas would raise the level of voluntary compliance and improve enforceability.

Minimum size regulations were proposed to the Atlantic Conference of Fisheries Ministers by the province of Nova Scotia in the mid-1980s and implemented for cod, haddock and pollock ( 41 cm except 43 cm in divisions $4 \mathrm{VWXX}+5$ ). The motivation is unclear but may have been related to regulations in the USA on minimum sizes of imported fish and to considerations of the profitability of processing small fish. Cod traps were exempt from this regulation. Because mesh size regulations were not consistent with the minimum size regulations, mesh sizes were increased. For Scotia-Fundy, the Haché Task Force recommended a mesh size increase from 130 mm diamond to 140 mm square or 155 mm diamond. Due to industry concerns about reduced catch rates, this was changed in mid-1991 to 130 mm square and 145 mm diamond. Minimum size regulations were never strictly enforced. That such regulations exist indicates that minimum mesh size regulations have not been effective in controlling the size of captured fish.

Mandatory landing regulations were introduced in all regions on 1 January 1993 in an attempt to prevent large scale dumping and discarding at sea. Exemptions were made for skate, dogfish and Atlantic halibut. This regulation may be more difficult to enforce than minimum mesh sizes and may require considerable observer coverage to be effective. Minimum fish size regulations were abolished when this new regulation was implemented.

## 6. Environmental Conditions

The Fisheries Oceanography Subcommittee reviewed the ocean climate condition in the northwest Atlantic at its March, 1993 meeting. This involved analysis of broad-scale environmental data with emphasis on atmospheric and oceanographic conditions in 1992, analysis of hydrographic conditions from each region during the 1992 groundfish surveys and comparison of environmental conditions in 1992 and the recent past.

## Labrador and Newfoundland

In 1992, relatively cold conditions were observed in the waters off southern Labrador and northern Newfoundland. A cold Arctic air mass covered the region during the winter of 1991-92 which promoted early ice growth. Strong northwesterly winds pushed the ice southward so that the areal extent of ice through most of the first three months of 1992 was above normal. The offshore limits of the ice edge matched or were near their long-term maxima through much of the winter. Ice also persisted longer than normal with new records being set for the date of the presence of the last ice in the offshore regions of northern Newfoundland. Relatively high numbers of icebergs drifted south of $48^{\circ} \mathrm{N}$ during the spring and summer. Air temperatures continued to remain below normal throughout the year except in the late summer and early autumn. In response to the cold air, sea surface temperatures were generally below their longterm means. At Station 27, the monthly sea surface temperature anomalies were all below normal with the largest anomalies (near $-2^{\circ} \mathrm{C}$ ) occurring in July and October. Negative temperature anomalies also persisted throughout the water column at Station 27 during most of 1992. The near bottom temperatures ( 175 m ) were below normal for the 10 th consecutive year but a slight warming was observed during the
year. Salinities throughout the water column at Station 27 were typically fresher than normal in 1992. The area extent of the cold intermediate layer (CIL), defined by waters of temperature $<0^{\circ} \mathrm{C}$, along several transects off southern Labrador and northern Newfoundland was slightly above normal but had decreased significantly from a maxima in 1990. During the annual fall groundfish survey surface temperatures and near bottom temperatures were generally below normal. The amount of water $<-1^{\circ} \mathrm{C}$ was less in the fall of 1992 than in 1991 but was greater than the long-term mean. In general the cold air temperatures, heavy ice and cold sea temperatures observed in 1992 are similar to the previous two years and match conditions in the early 1970s and mid-1980s. These cold conditions are related to the wintertime atmospheric circulation, and specifically an intensification and/or westward shift in the strength of the Icelandic low which generates relatively strong northwesterly winds over the Labrador Sea.

## Gulf of St. Lawrence, Scotian Shelf and Gulf of Maine

Colder than normal air temperatures were also present south of Newfoundland during the winter of 1991-92. In the Gulf of St. Lawrence, the timing of the ice formation was within a week of its normal occurrence but by the end of January the ice extent was greater than normal. Ice pushed onto the northeastern Scotian Shelf in February and its areal extent exceeded the long-term median. On the Scotian Shelf and in the Gulf the ice retreat was late with new records set for the last presence of ice on the Magdalen Shallows. Sea surface temperatures on the Scotian Shelf and in the Gulf of Maine point to cold water throughout most of 1992. These reflect conditions in the upper layers ( $50-100 \mathrm{~m}$ depth) based on data from Prince 5 and Emerald Basin. In Emerald Basin, lower layer (>75m) temperatures increased dramatically over near record cold conditions last year to above normal temperatures in 1992. A similar event was observed in the deep ( $200-300 \mathrm{~m}$ ) waters in Cabot Strait. These warmer waters are believed to be related to changes in the slope waters off the continental shelf which then intruded onto the shelf during late 1991 or early 1992. In contrast, in the northern Gulf of St. Lawrence, waters of Labrador origin penetrated the Strait of Belle Isle and spilled over into the Esquiman Channel. Consequently, bottom temperatures in this region dropped by approximately $2^{\circ} \mathrm{C}$ between 1990 and 1992. On the Magdalen Shallows, temperature data collected during the September groundfish survey revealed colder than normal bottom waters at this time in 1992. The area of the waters on the Shallows with temperatures below $0^{\circ} \mathrm{C}$ was much greater than normal during the past three years. Other years of extensive cold waters were 1972 and 1984. On the northeastern Scotian Shelf, near-bottom temperatures in the summer of 1992 were also colder than their long-term means and the largest volume of cold intermediate layer water was recorded in over 20 years. Salinities at this time were typically fresher than average. Colder than normal bottom temperatures in summer were also observed off Browns Bank, southwest Nova Scotia and throughout the Bay of Fundy. On Georges Bank, temperatures recorded during the spring groundfish surveys indicated near normal bottom temperatures and salinities.

## Offshore

The shelf/slope front and the Gulf stream were generally northward of their long-term mean positions during 1992.

The conclusion of these discussions were provided to assessment scientists in advance of the assessment meeting to allow evaluation of the influence of ocean climate events on fish stock production. The results of these studies and how they may have influenced the analyses are provided in Section 10 of the report on the status of each stock.

## 7. Trends in Abundance of Other Living Marine Resources

### 7.1 Introduction J.J. Maguire

Multispecies considerations cover a wide range of biological interactions such as cod-seal-capelin interactions off Newfoundland and technical interactions such as the by-catch of plaice in the southern Gulf of St. Lawrence cod fishery. Biological interactions are extremely complex and they change over time and space.

Greater knowledge of the biological interactions is needed for a better understanding of how species relate to one another and how the overall ecosystem functions. The field of biological interactions in fisheries is more advanced in the North Sea and Baltic Sea where substantial multinational efforts have been mounted to collect and analyse in the order of 250,000 fish stomachs of all the species caught in commercial fisheries. Because small mesh nets are used in these areas, commercial data on fish abundance are available for both predators and prey species. Even with the massive sampling effort undertaken, there remains considerable uncertainties in relation to diet and species interactions in those areas. In addition, the analyses done so far using multispecies VPA have generally not changed the management approaches devised under single species models, except perhaps with regards to mesh size increase. Simulations of mesh size increases taking into account species interactions suggested that yield in some important fisheries would decrease as a result of reduced $F$ on predators of young cod and haddock (Anon 1991). For most management questions, single species models are considered adequate approximations and are sufficient to choose among alternative scenarios.

The question of technical interactions, either considered in the perspective of the effect of various fleets on one another, or from the perspective of the effects of a directed fishery on a by-catch species is both easier to study and more influential in fisheries management. A substantial amount of data exist on this subject and could be analyzed if there were a demand for information of this sort. One such analysis on the bycatches in the northern shrimp fishery is included in Section 12 of this report.

We do not specifically consider multispecies interactions because such relationships have not been identified and quantified. Some relationships have been hypothesized and showed some promise such as those between snow crab abundance in the Gulf of St. Lawrence and cod abundance, but the relationships have not been tested satisfactorily. This section describes the current stock status of marine resources other than groundfish in the Canadian Atlantic. The summaries provided are not intended to be exhaustive. They were prepared from readily available information and not all species are covered. The observation that some stocks are increasing when others are decreasing should not be interpreted as a direct cause and effect relationships. Often, the species are simply responding differently to the same ocean climate conditions.

In addition to the summaries for species other than groundfish, the results of analyses of bottom trawl surveys for both commercial and non-commercial species caught in the southern Gulf of St. Lawrence and on the Scotian Shelf are presented.

### 7.2. Biology of Marine Mammals and Trends in Abundance

Harp Seals (WP 116,117) G. Stenson
The harp seal averages 1.6 m in length and weights 136 kg . Harp seals summer in Arctic waters and move southward during the autumn. One group reaches the Gulf by early December while another group remains off the northeast coast of Newfoundland. In late February and early March, they form large whelping concentrations on ice-packs of the southern Gulf and of the Front (southeast Labrador). A smaller whelping
concentration known as the Mecatina patch can be found in the northeastern Gulf. After reproduction, they disperse and undergo a short period of feeding before congregating for the mid-April to mid-May moutt. When the moult is completed, the animals disperse again and move northward in May or June. This represent the general migration and distribution of harp seals in the northwest Atlantic.

The most recent aerial survey to estimate the abundance of harp seal pups was conducted in 1990. A total of 577,900 pups were estimated; of these, 467,200 pups were on the Front, 106,300 were in the Gulf and 4,400 off Mecatina. Using this estimate of pup production and the results of various other experiments, the total population was estimated at about 3.1 million animals. It is difficult to compare this estimate with previous estimates to quantify population growth because the method of calculation is different. However, the population now is certainly larger than in the early 1980s.

Commercial hunting of harp seals off the east coast of Canada dates from at least the mid-1800s. With the demise of the large vessel hunt in 1983, catches declined from an average of 172,000 between 1978 and 1982 to range between 19,000 in 1985 and 94,000 in 1987, averaging about 52,000 from 1983 to 1992. Except perhaps for 1987, the reported catch does not include incidental catches in fishing gear which was estimated to exceed 44,000 in 1991 in Newfoundland. Harp seals are also harvested in the Canadian Arctic and in Greenland.

An understanding of geographical and seasonal variations in distribution and diet are necessary to estimate the impact of seals on commercial fish species. Preliminary results of surveys of offshore waters conducted between 1991 and 1993, indicated that both harp and hooded seals are present in offshore waters during the winter. Although hooded seals appear to utilize the slope edge and northern areas to a greater extent than harps, the area near the 3KL border may be an important area for both species during the winter. Harp seals were particulary abundant in this area in 1992 and 1993. The results of the groundfish hydroacoustic survey indicate that high densities of cod were present in this area in 1992 but not in 1993, suggesting that the presence of seals in the area may not be linked to pre-spawning concentrations of cod, as such. By April, the distribution of both seal species shifted northward. This northward shift of harp seals continued into July, by which time hooded seals had left the area.

The diet of harp seals in 2 J 3 KL was determined by reconstructing the stomach contents of 536 preycontaining stomachs collected during 1991-1993. There are geographical differences among inshore harp seals; based on weight, sculpins were the major component of the diet of seals in 2 J , whereas Arctic cod, Atlantic herring, Pandulus shrimp and squid were the major prey in 3 KL . There was also evidence of annual variation in the diet, with harp seals depending more heavily on crustacean prey in 1992. Atlantic cod was not a major component of the diet in these inshore areas. Atlantic cod were not found in the stomachs of offshore seals collected by other means than commercial cod trawls during the summer of 1992 and the winter of 1993, although cod was present in a sample of stomachs collected during April 1992. While cod were the predominant prey of harp seals caught in cod trawls, the size of cod found in the stomachs were similar to those discarded by the trawlers.

Although preliminary, these studies show that there is considerable seasonal, geographic and interannual variation in the distribution and diet of seal species. In light of this variation, in conjunction with the relatively small sample size from offshore areas, the limited knowledge of spatial overlap between seals and their prey, and the ongoing nature of these studies, no clear assessment of the harp seal's impact in Atlantic cod stocks can be made at this time.

In 1991, the CAFSAC Marine Mammal Subcommittee noted that:
"To evaluate these interactions we need to know the following: the number of seals in each age class, their distribution in different parts of their range at different times of the year, the species and size (i.e. weight) of food eaten, how these vary by seasonal and area, how the energy content of prey varies with age and season, and the yearly energy requirements of individual seals at different ages. Finally,
we need information on the seasonal distribution and abundance of species eaten and on how the mortality caused by seals compares to other sources of mortality. It is important to appreciate that in answering the question of the impact of seals on fisheries we are essentially asking for a multispecies assessment."

## Hooded Seal

Hooded seals whelp on pack ice in the eastern Atlantic, in Davis Strait, off the coast of southern Labrador or northeastern Newfoundland ("The Front"), and in the Gulf of St. Lawrence. It is not known if there is interbreeding, but there is mixing at other times of the year. The majority of the production is at the Front. Recent pup production at the Front has been estimated at 82,000 pups. There are probably now between 400,000 and 450,000 hooded seals in the Front and Gulf combined. Catches have generally been 1,000 or less since 1986 except in 1991 when they exceeded 6,000 .

## Ringed and Bearded Seal

Ringed and bearded seals are primarily arctic species whose southern range extends down the coast of Labrador and northern Newfoundland. Ringed seals are the most common pinniped in northern Labrador and are considered to be "numerous" through most of their range. Bearded seals are solitary and are considered to be relatively rare. No population estimates are available for either species.

## Grey Seal (WP 111)

Grey seals are sexually dimorphic, males reaching 2.4 m long and up to 350 kg , while the female reach 2.0 m and weigh up to 250 kg . They occupy the Gulf and the Scotian Shelf year round. Pupping occurs on Sable Island and on the pack ice of the southern Gulf, from late December to February. After reproduction, the grey seals will disperse to near shore and offshore feeding areas primarily on the Scotian Shelf, in the Gulf of St.Lawrence, and off southern Newfoundland. There is exchange of breeding adults between the Gulf and Sable Island populations, but the amount has not been quantified.

Pup production is estimated to be about 8,000 per year in the Gulf and 12,000 per year on Sable Island, with the total population in the order of 106,000 in 1990. The Sable Island population is increasing at an annual rate of $12.5 \%$ per year.

Grey seals from both the Sable Island and Gulf stocks are seasonal migrants to Newfoundland. They have been reported from all areas of Newfoundland and Labrador as far north as Nain. Bounty returns indicate that grey seals are most common during July and August but low numbers are present all months of the year.

The potential food consumption for the entire grey seal population in the Canadian Atlantic was estimated by the Marine Mammals Subcommittee in 1992. A rough estimate of total food consumption was obtained by assuming that an 'average' grey seal requires approximately 5530 kilocalories of energy per day. Recent studies suggest that this estimate of energy requirement, based on captive animals, may be an overestimate of what a wild seal requires. Using the most recent estimate of total population, 95,000 to 134,000 animals in 1990, and assuming that grey seals feed only on fish with an average energy content of 1 kilocalorie per gram of wet weight, then the grey seals would consume about 190,000 to $270,000 \mathrm{t}$ per year. If the seals eat only fatty fish at 2.5 kilocalorie per gram wet weight, the same population would require only 76,000-108,000t."

## Harbour Porpoise

Recent surveys for harbour porpoise in the Gulf of Maine-Bay of Fundy area, suggest that harbour porpoise abundance is greater than previously believed, with about 45,000 animals in the area. It is not known if the
harbour porpoise that are found in the Gulf of St. Lawrence and around Newfoundland belong to this same population. Recent estimates of by-catch in the Gulf of Maine-Bay of Fundy area range from 1,900 to 2,600 of which less than $10 \%$ is taken in the Canadian fishery. The species was believed to be much less abundant and declining. Additional surveys will be required to estimate population trends.

### 7.3. Biomass Trends in Southern Gulf of St. Lawrence Groundfish Surveys (WP 131) G. Chouinard

Biomass estimates for various species derived from research surveys conducted in the southern Gulf of St. Lawrence between 1971 and 1992 were divided in seven groups: gadoids (cods, hakes, haddock and pollock), redfish, flatfish (turbot, American plaice, witch, yellowtail, winter flounder and windowpane), cartilaginous fishes (skates and dogfish), other groundfish (wolffish, sculpins, sea raven, ocean pout, eelpout and lumpfish), pelagic fish (herring, gaspereau, smelt, capelin and mackerel) and crustaceans (snow crab, rock crab, lobster and shrimp).

Results indicate that the bulk of the fish biomass from the surveys was composed of gadoids (mainly cod) and flatiish (mainly American plaice). Redfish accounted for only 10 to $25 \%$ because the survey covers only a small portion of the redfish distribution. The catchability of pelagic fish to the survey is likely to be low and the biomass levels indicated for these species probably only reflected approximate trends.

Over the time series, it appears that pelagic fish were more abundant in periods of lower groundfish abundance such as in the early and mid-1970s and in recent years. American plaice were abundant in the 1970s when cod abundance was low. As cod abundance increased, American plaice decreased suggesting possible biological interactions between the two species. Currently flatfish and gadoid biomasses are estimated to be low (less than 100,000t). The flatfish biomass appears to be stable while the gadoid biomass is declining. Other groundfish do not appear to be declining.

Spiny dogfish have only been caught in the southern Gulf of St. Lawrence surveys since 1985. Haddock was abundant in the period 1984-1986. Snow crab was abundant in 1990 and appear to be decreasing.

As opposed to other areas, where there has been a decrease of the abundance of all species in groundfish surveys, the decline in the southern Gulf of St. Lawrence appears to be limited to cod.

### 7.4. Biomass Trends in the Scotia-Fundy Groundfish Surveys (WP 127) K. Zwanenburg

Trends in trawlable biomass for five groups of fish species were derived from summer groundfish surveys conducted on the Scotian Shelf since 1970. The five groups were demersals (cod, haddock, pollock, the hakes, the flatfishes, cusk, wolffish and other minor species), semi-pelagics (redfish and silver hake), pelagics (herring, mackerel, capelin, argentine, shad and gaspereau), skates and dogfish.

In most years and areas, the fish biomass was dominated by the demersal group (Fig. 7.4a). In 4 Vn , demersal biomass was higher throughout the 1980s than in the previous 10 years. Peaks in biomass were only observed in 1983-84 in 4VsW and not at all in 4X. Overall demersal biomass in 1992 was comparable to the levels seen in the early 1970s.

Semi-pelagic biomass exhibited substantially more variation than that of the demersal group and thus trends were difficult to discriminate. In 4Vn, the biomass peaked in the early 1970s, the late 1970s and particularly in the late 1980s (Fig. 7.4b). In this last peak, it represented the majority of semi-pelagic biomass on the Scotian Shelf. On the Central Shelf, this group's biomass was high in the late 1970s and mid-1980s and has declined since. Only in 4 X has semi-pelagic biomass recently increased.

Pelagic biomass is not well estimated by the bottom trawl surveys, but can give indications of large changes (Fig. 7.4c). The most notable change was that pelagic biomass has been higher since 1982 than it was through the late 1970s with a particularly large estimate in 4 Vn in 1987. Since that time, the abundance of the cold water species, capelin, has increased in 4VW.

Skate biomass has shown a gradual decline in abundance over the 23 year period of the survey in all areas (Fig. 7.4d). The relative distribution of this biomass remained stable with the highest estimates occurring in 4 Vs .

Dogfish have been the dominant biomass in Div. 4X in some years during the late 1980s and remain high to date (Fig. 7.4e). Dogfish biomass in the more easterly areas has been higher through the 1980s than was observed throughout the 1970s.

Summer bottom temperatures in Div. 4V have been below $2.5^{\circ} \mathrm{C}$ since 1989, this is in contrast to temperatures around $4^{\circ} \mathrm{C}$ through the early 1980 s. Summer bottom temperatures in Div. 4 W have been at about $5^{\circ} \mathrm{C}$ since 1987 in contrast to temperatures of about $7^{\circ} \mathrm{C}$ through the late 1970 s and early 1980 s . The cooling trends in these areas have likely resulted in some redistribution of fish biomass. One notable instance is the increased prevalence of capelin in 4 V during the most recent years as noted above.

## 8. Overview of Groundfish Stocks

### 8.1. General Overview of Commercially Exploited Groundfish J.J. Maguire

The mortality rates of the cod, haddock, pollock and many flatfish resources on the Canadian Atlantic coast have recently reached very high values and stock sizes are currently low. Less than $50 \%$ of those fish of recruited age that are present at the beginning of a year are still alive at the end of the year. The catch depends on two or three age-groups at a young age while these species could easily live up to 20 years of age with many more ages contributing to the catches. The fisheries are very dependent on recruiting year-classes and the fish are harvested at a rate considerably greater than their growth rate. This means that biomass is declining steadily with no hope of sustained increase at current high mortality rates. Adult biomasses are either the lowest observed or very close to it. In all cases the estimated fishing mortality rate is substantially higher than the target rate of $\mathrm{F}_{0.1}$.

Fishing mortalities in excess of the target have been noted since at least 1987. At that time, stock sizes were high and recruitment appeared to be average or better; there was no apparent urgency to reduce fishing mortalities abruptly to $\mathrm{F}_{0.1}$ from one year to the next. The $50 \%$ rule was therefore introduced to gradually achieve the target of $F_{0.1}$. This was not successful. Fishing mortalities have continued to increase and stocks have continued to decline to reach their current historical minima.

A number of factors are responsible for the current state of the stocks. A comparison of biomass trends among cod stocks shows significant correlations ( $\mathbf{p}<0.05$ ) among northern stocks ( $2 \mathrm{~J} 3 \mathrm{KL}, 3 \mathrm{Ps}, 3 \mathrm{Pn} 4 \mathrm{RS}$, $4 \mathrm{~T}-4 \mathrm{Vn}, 4 \mathrm{VsW}$ ) which are different than the trends for southern stocks ( 4 X and 5 Zjm ). Year-class survival, defined here as the abundance of a year-class when it enters the fishery divided by the spawner biomass that produced it, in the northern stocks in the mid-to-late 1980s has been considerably lower than in previous years. This implies that the mortality between the time the eggs were produced and the time the recruits enter the fishery has increased, perhaps because of ocean climatic conditions, predation, competition, disease, or fishing (discarding). As a result, there have been several below average yearclasses produced in the 1980s, with only the 1987 year-class showing average or slightly above average strength. Growth rates have also been low. The geographical distribution of many fish stocks is now considerably smaller than in previous years making them more vulnerable to fishing. Finally, total mortality rates (fishing+natural) have been high and have increased in recent years as the stock biomasses have decreased.

TACs, in the vast majority of cases, have been set based on scientific assessments, but these have generally overestimated potential catches. This is partly due to methodological deficiencies, not unique to Canadian fisheries science, such as the inability to predict future weights at age and recruitment which have both been declining almost steadily over this period. However there are also serious problems with the data that have been used. It is widely accepted that misreporting, dumping and discarding have been major problems in groundfisheries from at least 1985. The severity of misreporting, dumping and discarding has probably decreased in recent years as a result of better enforcement, but it still existed in 1992 and remains unquantified. The scientific assessments are critically dependent on the accuracy of catch data. Inaccuracies in reported catches have therefore caused major problems in assessing the size of the stocks.

Fishing is not the only cause of mortality. The sudden decrease in biomass estimates from research surveys observed from one year to the next in several cod and flatfish stocks cannot be attributed entirely to fishing. Changes in migration and shrinking geographical distributions, increases in natural mortality because of harsh climatic conditions, combined with poor feeding, predation by seals and other predators or competition with them are additional possible causes of increased mortalities. Given these added causes of mortality, the remaining stocks should be given as much protection as is possible in order to take advantage of better survival conditions when they occur.

The immediate and medium term prospects are poor. Recent year-classes appear to be weak and will therefore not contribute substantially to stock rebuilding. Even if the 1992 year-classes in those stocks were to be strong, they would not make significant contributions to spawning until 1997 at the earliest. Stock rebuilding will be slow and it will depend on future recruitment which will be influenced largely by climatic conditions. However, even if nature were to produce good recruitment, this would not lead to sustained rebuilding unless fishing mortality is decreased substantially and permanently.

Controlling catches is a necessary prerequisite to reducing fishing mortality, but it is not sufficient on its own. It is now widely accepted (for example, in the North Sea and in New Zealand) that attempting to reduce fishing mortalities only by controlling catches, without some direct control on the fishing effort exerted will be unsuccessful in fisheries with severe overcapacity problems such as those of the Canadian Atlantic coast. The Georges Bank cod and haddock fisheries are good examples of the potential to exert fishing mortality; in 1989, the mobile gear fleets fished for only one month and this was sufficient to exceed $\mathrm{F}_{0.1}$. The necessary drastic reductions in fishing mortalities can only be achieved by substantially decreasing fishing effort and these reductions need to be permanent. As stocks recover, catches will increase and there will be pressure from the industry to increase fishing effort. However, these pressures will have to be resisted if the benefits of an $\mathrm{F}_{0.1}$ management strategy are to be realized.

Decreasing the fishing mortality however does not mean that the stocks will increase forever. There will still be variability in year-classes and stocks will still fluctuate. However, dangerously low stock sizes such as those currently estimated for our Canadian Atlantic groundfish resources will be less likely to happen.

The principal index of abundance used to paint the grim picture above comes from the research vessel surveys DFO conducts to estimates biomass. These surveys are statistically designed, similar to opinion polls or tree abundance estimation in forestry, to provide unbiased estimates. However a number of factors may influence the results of any one year quite importantly. The results are notably variable from one year to the next, with some years overestimating abundance while others underestimate it. It is therefore possible that the stocks could be higher than described in this document, although there is no question that the stocks are very low.

### 8.2. Overview of Commercially Exploited Groundfish on the Newfoundland Shelf and on the Grand Banks D.B. Atkinson

The groundfish fisheries in the waters around Newfoundland exploit three main species groups: the gadoids (mainly cod with some haddock, pollock and hake), the flatfishes (American plaice, yellowtail flounder, witch flounder, Greenland halibut and Atlantic halibut) and the others consisting of species such as redfish and grenadiers. The relative importance of the different species and stocks has varied over time, but recently cod, American plaice, yellowtail flounder, witch flounder, Greenland halibut and redfish have been the most important.

Of these, cod has historically dominated the catches. Most important has been the Div. 2J3KL or "northern" cod stock but important cod fisheries also take place on the southern Grand Banks (Div. 3NO stock) and off the south coast (Subdiv. 3Ps stock). Cod catches from all of these areas gradually declined after peaking in the 1960s. In 1976, the last year before extension of jurisdiction, catches were 6,000t from 2GH, 214,000 from $2 \mathrm{~J} 3 \mathrm{KL}, 24,000$ from 3 NO and $37,000 \mathrm{t}$ from 3Ps. Although some of the reduction was due to quota management through ICNAF, the declines generally reflected stock reduction because of overfishing. Since extension of jurisdiction, the trajectories of the stocks have shown both similarities and differences. The resource in Div. 2GH has almost disappeared based on recent survey estimates (1991). A number of possible causes have been put forward to explain the dramatic decline in 2J3KL cod. Many have variously blamed the decline on the Canadian offshore trawler fleet (destroying habitat, interrupting spawning, excessive dumping and discarding), the foreign fishery outside 200 miles, gillnets, cod traps, seals and the environment. It is currently believed that all of these may have contributed, in part, to the decline. It is not possible, however, to determine the relative importance of each factor. It is also not clear when the decline took place. Evidence from various surveys and fisheries may indicate that the decline occurred during the first half of 1991, but the earlier decline in biomass in the more northern areas, in 2 J and perhaps in 2GH may suggest that events began as early as the late 1980s. On the Grand Banks (Div. 3 NO ), the decline in recent years is thought to be due to a combination of factors. There were a number of years of poor year-classes during the mid-1980s. Beginning around 1986, total catches far exceeded TACs due to foreign catches outside 200 miles on the "tail" of the Grand Banks. The problem of overfishing is exacerbated by the fact that these foreign fisheries are taking very high numbers of small fish probably as a result of the use of undersized mesh in cod ends. In Subdiv. 3Ps, survey estimates fluctuated considerably between years but gradually increased until about 1988 ( $85,000 \mathrm{t}$ ) before declining somewhat. The 1992 survey results suggested a decline to only 16,000 t and the 1993 results were $12,000 \mathrm{t}$ and $7,800 \mathrm{t}$ from the February and April surveys respectively. With settlement of the boundary dispute, French catches dropped from about 16,000 t in 1991 to only 7,000 in 1992. There has been no French catch to date in 1993. This stock is considered to be at a low level, primarily due to high fishing mortalities in recent years.

Of the flatfish stocks, American plaice on the Grand Banks (Div. 3LNO) is historically the most important. The 1992 biomass estimate from surveys is the lowest in the series. As with cod on the Grand Banks, foreign catches outside 200 miles have been greater than their allocations since 1986, and they have caught smaller fish than taken in the Canadian fishery. This has resulted in exploitation rates exceeding reference levels. There are however, indications that the declines in biomass in Div. 3L are greater than can be explained by the fishery alone. It is unknown if this is related to factors contributing to the decline in 2 J 3 KL cod or not. American plaice fisheries also take place in SA2+Div. 3K, and Subdiv. 3Ps. Research vessel survey results indicate that through the 1980 s , the greatest proportion of biomass was in Div. 2 J where it peaked in 1983 then gradually declined thereafter. In Div. 3K, biomass was stable until about 1987 then declined. Estimates in the 1990s from both divisions continued to decline, and the 1991 and 1992 estimates were only 12,800 t and 5,500 t respectively. The observed declines cannot be attributed to fishing mortality alone. Similar to 2 J 3 KL cod, non-fishery related factors are probably contributing to the observed declines, although these cannot be quantified at present. In Subdiv. 3Ps, survey estimates of trawlable biomass fluctuated through the 1980s but there has been a gradual and systematic decline since about 1989, and the two estimates from the 1993 surveys are the lowest observed. Although fishing mortality has
probably been above $F_{0.1}$ in recent years, it is not believed that catches in the range of $2,500-5,000$ t could be fully responsible for declines of about $90 \%$ (from surveys) since 1986-1988. As with other American plaice stocks around Newfoundland, it appears that non-fishery related factors may be contributing to the observed declines.

The only significant fishery for yellowtail flounder is on the Grand Banks (Div. 3LNO). After remaining stable through most of the 1980s, biomass as estimated from Canadian surveys, steadily declined and in 1992 was only about one third that estimated from the 1985 and 1986 surveys. Until fishing effort is curtailed, it is not expected that this resource will increase significantly.

Witch flounder fisheries take place in Div. 2J3KL, Div. 3NO and Subdiv. 3Ps. Biomass estimates from surveys peaked in Div. 2J in 1986 but declined during the more recent period. In Div. 3K, estimates were stable through the early 1980s (about 30,000t) but declined subsequently. The total estimated biomass in these two divisions in 1992 was only 1435t. In Div. 3L, estimates were between 6,000-7,000t until 1988 but declined to only 1,500t in 1992. In 1992, the stock was at the lowest level ever observed. As with other stocks in the area, current fishing effort cannot account for the observed declines in biomass. On the Grand Banks (Div. 3NO) survey estimates of biomass show considerable fluctuation over the time series, but are generally lower now than in the mid-1980s. Whether this indicates a decline in stock size, or a movement of the fish to deeper water outside the survey area is unclear. Biomass estimates from surveys in Subdiv. 3Ps have fluctuated substantially between years, but there does not appear to be any long term trend in the estimates. The fluctuations may be the result of some portion of the stock being distributed in deeper water outside the survey area. Possible impacts of the fishery cannot be determined.

It is currently believed that Greenland halibut in the northwest Atlantic (with the exception of those in the Gulf of St. Lawrence) constitute one stock extending from Davis Strait (SAO+1) to around the Grand Banks (SA3). Results of surveys to Div. 2GH in the late 1980s indicated that the biomass had decreased by about $50 \%$. The biomass in Div. 2 J 3 K also declined by about $50 \%$ between 1987 and 1990. The TAC was therefore lowered to 50,000 in 1990. The estimate from the 1991 survey was only 55,000 t. The observed declines in Greenland halibut in the northern areas cannot be explained by the fisheries. It is possible that the fish have redistributed to deeper water, and they may have moved further south and outside 200 miles where they have become available to the foreign fleets. At present there are no data to suggest that this foreign fishery is being prosecuted on a separate stock, and the high catches of recent years from this fishery are cause for concern.

There are four stocks of redfish in the Newfoundland area; SA2+3K, Div. 3LN, Div. 30 and the newly defined Laurentian Channel stock. In SA2+3K, survey estimates of biomass reflect a decline in the size of the stock. Estimated biomass declined from over 100,000t in the early 1980s to only about 2,000t in 1992 in Div. 2J. In Div. 3K, the decline over the same period was from over 200,000t to only 1135 t in 1992. There can be no optimistic outlook for this resource until about 9-10 years after good recruitment occurs. In Div. 3LN, much of the resource is distributed outside the 200 mile limit in both 3L and 3N. There are indications that the foreign fishery continues to be excessive, and concern exists that this stock will be rapidly depleted in a short time. Because of rough bottom in much of Div. 30 where redfish could be caught, it is difficult to carry out trawling and the fleets are restricted to shallower water where smaller fish reside. These fish are unsuitable to the Canadian processors although acceptable to the foreign fleets which fish in the area outside 200 miles. Little is known about the status of this resource. The Laurentian Channel redfish stock was recently defined based on evaluation of available data from the fisheries and research in the area. Estimates of biomass in Div. 3P have fluctuated considerably over the period of surveys, but there are no long term trends in the data. There is no evidence to suggest that fishing pressure is excessive on this stock, and the size of the resource should fluctuate in the future with recruitment levels. Because new recruitment will not reach the fishery until 1997-1998, biomass and catch rates are expected to decline until then.

In the Newfoundland area, groundfish stocks can be divided into two general groups. In the areas south of Div. 3L, they appear to be primarily responding to fishing pressure. With the possible exception of Subdiv. 3Ps American plaice, all declines can be linked to excessive fishing; either Canadian or foreign. The status of the various resources is only changing in parallel for those stocks subjected to this pressure. Trends in other stocks appear to be independent. Of particular concern is the effort being exerted outside 200 miles on the various Grand Bank stocks. All of these are important to Canadian interests, and the current moratorium on 2 J 3 KL cod magnifies this importance. The outlook for these stocks cannot be improved unless the excessive fishing pressure is curtailed.

In the more northern areas (Div. 3L and north), the situation is less clear. While it can be argued that fisheries have affected the resources in these areas, they alone cannot account for the observed declines that are occurring across all groundfish species. For some of these species (for example, cod) the decline may have been abrupt, but there are indications of changes taking place earlier. For example, the reduction in biomass appears to have progressed from Div. 2J (and possibly 2GH), to Div. 3K to Div. 3L. Condition factors of cod began declining in 1990. For other species, the declines seem to have been progressive through the 1980s. Survey and fishery data also indicate that many of the species are now distributed further offshore and in deeper water than previously. The reasons for this are unknown. Although the 1981 year-class of redfish was relatively strong throughout all the rest of the northwest Atlantic, this was not the case in Div. 2J3K and northern 3L.

During the 1990s, sudden declines were also observed in the capelin biomass. Offshore acoustic surveys consistently failed to detect large concentrations beginning in 1990 although information from the inshore fishery suggests that the decline in biomass may not have been as precipitous as suggested by the offshore data. The abundance of harp seals has increased, but as is noted elsewhere in this report, no clear assessment of the harp seal's impact on cod can be made at this time although it can be hypothesized that increasing harp seal abundance will have an increasing impact.

All of these observations are coincidental with a gradual cooling trend in the area through the 1980s. In 1991, the ice cover was the greatest observed in 40 years, and the cold intermediate layer (CIL) was more extensive than had been observed previously. The impact of these changes on the biota of the area is unclear, and especially uncertain are the possible impacts on species interactions (both plant and animal).

For these northern resources, it is unclear if decreased or complete cessation of fishing will result in improvements in stock status. No meaningful predictions concerning the future of these resources can be made until the processes at work are better understood.

### 8.3. Overview of Commercially Exploited Groundfish in the Gulf of St. Lawrence <br> D. Gascon

The Gulf of Saint Lawrence groundfish fishery is dominated by three species: cod north and south of the Laurentian Channel (stocks of 3Pn4RS and 4TVn [Jan.-Apr.]), redfish in the deep waters of the Laurentian Channel, and to a lesser extent, American plaice in the southern Gulf. There are smaller localized directed fisheries for Greenland halibut in the St. Lawrence estuary and western Gulf, witch along the southwest coast of Newfoundland and 4T, white hake in Northumberland Strait, and winter flounder in inshore areas. Both cod and redfish are migratory and sustain winter fisheries in the Cabot Strait area and summer fisheries within the Gulf of St. Lawrence.

The water temperature in the Gulf of St. Lawrence was substantially cooler from 1990 to 1992 than in the mid-1980s. Bottom temperature in the southern Gulf in September were warmer in the 1970s and have been cold since the early 1980s. Since 1990, cold waters coming through the Strait of Belle-Isle have occupied increasingly large areas in inshore zones of the northern Gulf. The deep Atlantic waters moving through Cabot Strait were colder (reduction from about $6^{\circ}$ to $4^{\circ} \mathrm{C}$ ) bringing about a cooling of the deep
waters in the Gulf. Ice coverage in recent years has been much more extensive than normal. This has considerably delayed the spring fisheries for cod, both in the northern and southern Gulf.

The two cod stocks in the Gulf have fluctuated in harmony with the other "Northern stocks" (i.e. northern cod, Saint-Pierre Bank cod, and eastern Scotian Shelf cod). After a period of high abundance in the 1960s, the two stocks declined to very low levels in the mid-1970s, increased to very high level of abundance in the mid-1980s, to decline very sharply since then to the lowest levels on record. The exploitation rate on these stocks increased gradually throughout the 1980s, and has increased abruptly in the 1990s. In recent years, with the decrease in growth rate and lower abundance of larger cod, the fishery has been characterized by large catches and discards of small fish (less than 41 cm ). Recruitment for the two stocks has been well below average since the mid-1980s, despite high levels of spawning biomass at that time. This means that fewer recruits are produced per unit of spawning biomass. The low recruitment, combined with slower growth has contributed to the decline in the biomass of cod in the Gulf of St. Lawrence.

The redfish "stock" was recently redefined to take into consideration the migration into the Cabot Strait area in the winter. Two species comprise the stock, but the dynamics of these two species are not well understood. Gulf redfish seems closely related to Laurentian Channel redfish (3P4V), The history of the stock, and hence of the fishery, is dominated by the appearance of very large, sporadic year-classes (late 1950s, early 1970s, 1982, and now 1988. The catches of redfish have a tendency to fluctuate as these strong year-classes move through the population. The large 1982 year-class is now fully recruited to the fishery and it has allowed catches and catch rates to be very high since 1990. The next visible year-class will recruit to the fishery in 1997-1998, but as this year-class recruits, the species composition of redfish in the Gulf should shift from Sebastes mentella to S. fasciatus.

The flatfish stocks, with the exception of Greenland halibut, do not seem to show these large fluctuations. After a period a relatively high abundance in the 1960s and early 1970s, the exploited flatfish stocks declined to somewhat lower levels in the recent past but have remained relatively stable since then. The fishery for Greenland halibut was characterized by large fluctuations ( 5 fold differences between the lows and the high over 5 years), a consequence of highly irregular recruitment and very high exploitation that does not allow the persistence of the incoming year-class in the population.

American plaice abundance varies on a much longer time scale, and for a time, appeared to be inversely related to cod abundance. American plaice abundance is now lower than average and this fishery is plagued with a major discarding problem.

### 8.4. Overview of Commercially Exploited Groundfish on the Scotian Shelf and on Georges Bank R. O'Boyle

The Scotian Shelf and Georges Bank groundfish fisheries are dominated by cod, haddock and pollock. In addition, important fisheries for flatfish, (plaice, yellowtail, witch and winter flounder), Atlantic halibut, redfish and silver hake are conducted in the Region (the silver hake fishery is mostly by foreign vessels). The area can be considered as two major ecosystems, the eastern Scotian Shelf and the southwest Scotian Shelf/Georges Bank area.

Since 1970, groundfish stock abundance in these two ecosystems has increased to a peak in the mid1980s and thereafter declined to the current historical low levels. These changes have been particularly pronounced on the eastern Scotian Shelf. This year's assessment of the 4 VsW cod resource is considerably more pessimistic than last year's, with downward adjustment of the 1985-90 year-classes and estimation of the highest fishing mortalities recorded. The mature biomass which was high in 1985, by 1992 had declined to the lowest levels observed. The status of this resource is precarious and there are concerns about its long term viability if fishing mortality is not reduced.

The analysis of the Sydney Bight cod ( 4 Vn May to December) resource focused on confirming that fish present in the area during December were of 4 T origin. The definition of the management unit should be adjusted accordingly.

Present estimates of eastern Scotian Shelf haddock (4TVW) spawning biomass are lower than last year with concomitantly lower probability of average or better recruitment. The population size structure has narrowed to the point where a single year-class, the 1988 year-class, dominates the population. Fishing morality rates on the fully exploited size ranges are presently very high and, if continued, will slow or prevent the rebuilding of spawning biomass. Year-classes after 1988 have been below average.

Flatish resources (plaice, yellowtail and witch) while under quota management, have been under increasing pressure since the introduction of individual quotas in 1991. In 4VW, yellowtail and plaice abundance are either relatively stable or increasing while that for witch is decreasing. Atlantic halibut abundance of older fish has fallen steadily since 1988.

It is evident that for most of the eastern Shelf resources, recruitment has declined since the mid-1980s. While a reduction in spawner biomass may be partially the cause, the low survivorship of ages 1-3 cod in 4VsW since 1985 indicates that other factors are involved. Ocean climate changes may be implicated. There is considerable evidence to show that the oceanographic regime on the Shelf has changed in recent years. During 1992, sea surface temperatures were generally below normal throughout most of the year. An analysis of near-bottom temperatures suggests that the region is in a period of ocean cooling with particularly cold conditions in 4 V . In this area, summer bottom temperatures have declined steadily since 1978 to reach an all time low in 1992. These climate changes have been accompanied by an increase in the abundance of capelin, a cold water species. Grey seal abundance has also increased markedly since the 1960s due to sustained high pup production. While this increase has likely had some impact on eastern Shelf populations, the extent of this cannot be determined. Suspected high discard rates in the fishery may also have decreased survivorship of ages 1-3 cod.

The cod and haddock on the southern Scotian Shelf and on Georges Banks grow faster and recruit to the fishery at an earlier age than those on the eastern Scotian Shelf. Since the early 1970s, high exploitation rates mean that fish are harvested at a young age. This makes these fisheries extremely dependent on incoming recruitment. As a result, landings have fluctuated greatly with changes in recruitment. Specifically, the 4 X cod and haddock fisheries are presently dependent on only 1 or 2 year-classes, with biomass either declining or expected to decline due to recent poor recruitment and high exploitation rates. Misreporting of catches by management unit (e.g. $5 Z$ haddock catches reported as 4 X haddock) continues to occur, though apparently to a lesser degree than in the 1980s.

The only positive sign is an indication, based on Georges Bank cod, of an above-average 1990 year-class. The Georges Bank cod and haddock stocks are severely depleted as excess fishing capacity has been channelled to those stocks when individual quotas were introduced on the Scotian Shelf in 1991. The transboundary nature of these resources has complicated management. A study of migration patterns suggests that for haddock in particular, but also for cod there would be benefits to Canada if it were to unilaterally adopt conservation measures. However, considering the presently very low stock sizes, stock rebuilding would require joint management.

The Scotian Shelf pollock has been declining as the year-classes which followed the exceptional 1979 yearclass have been moderate at best. Exploitation for this species is also very high and a continued decline is forecast until better recruitment occurs.

Flatfish resources (plaice, yellowtail and witch) in 4 X while under quota management have also been under increased fishing pressure since the introduction of individual quotas on the Scotian Shelf in 1991. Survey estimates indicate that witch flounder abundance is decreasing while for plaice and yellowtail, abundance is either stable or increasing slightly.

Winter flounder are currently outside the quota management system although landings in 4 X are higher than for other flatish species. Survey catch rates have increased since 1988, however being in part a coastal species, the survey only covers the offshore portion of this resource. Industry comments suggest that catch rates are declining in inshore areas. If individual quotas are introduced for flatish, winter flounder should be included under quota management to prevent a shift of effort to non quota species or to misreport quota species. Overall the status of flatiish stocks on the Scotian Shelf cannot be assessed with present information because landings are not reported by species.

Contrary to the situation on the eastern Scotian Shelf, while recent recruitment on the southern Shelf has been low, this does not appear to be as a result of low survivorship of young fish. Sea surface and near bottom temperatures on the southern Scotian Shelf and Georges Bank were generally below normal throughout most of 1992. Also, in 1992 normal low spring salinities extended deeper into the water column and persisted longer than usual. It is not possible to relate these changes to the declines in abundance.

Overall, except for stocks such as 4 X haddock, 4VW plaice and yellowtail and 4 X winter flounder, all groundfish resources have declined in abundance since 1988, in some cases to historical low levels. These declines are due to a combination of recent low recruitment and high exploitation rates. Examination of stock/recruitment relationships indicates that juvenile survivorship in a number of stocks has declined in recent years, with fewer recruits being produced per unit of spawning biomass. Some of this may be due to seal predation or discarding by the commercial fishery. However, the dramatic changes in the ocean climate likely also play a large role.

## 9. Summary Sheets

### 9.1 COD in 2J, 3K and 3L SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de reférence '000t | 266 | 266 | 293 | N/A | N/A | $\begin{gathered} 100- \\ 215 \end{gathered}$ |  | $\underline{2}$ |  |  |  |
| TAC - TPA '000t | 266 | 256 | 266 | 235 | 199 | 190 | 120 |  |  |  |  |
| Rep.catches-Prises décl. '000t | 252 | 235 | 269 | 253 | $219^{3}$ | $171^{3}$ | $44^{3}$ |  | 49 | 278 | 810 |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. Sp.biomass-Biomasse Rep. Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour 1962-1992 <br> ${ }^{2}$ June 1992-lowest possib <br> ${ }^{3}$ Preliminary statistics/Stati | 1992, <br> provi | bas res | ssible. |  |  |  |  |  |  |  |  |

Forecast for 1994: Continuing fisheries (the Canadian recreational fishery and foreign catches outside the $\mathbf{2 0 0}$ mile limit) may be factors in retarding the recovery of the stock.

Catches: A moratorium was imposed on the Canadian fishery in July 1992. Canadian fishing in this area was severely curtailed with about 29,000 t taken in 1992. However, 14,300 t of cod were also caught outside of the Canadian Economic Zone in Division 3L during the first half of the year by non-Canadian vessels.

Data and Assessment. The principal index of abundance is an autumn research vessel survey series. From 1978 to 1990, the catch per tow has averaged about 50 fish with the 1990 catch per tow equal to the average. The catch per tow decreased to 33 fish in 1991. The decline was more pronounced for fish age 6 and older. Despite the severe reduction in fishing activity as a result of the moratorium, the catch per tow decreased further during the 1992 autumn survey to 9 fish per tow.

Fishing Mortality. Total mortality is estimated to be very high, above 1 in 1991 which means that more than $60 \%$ of the fish are dying each year. Under the normal assumption of constant natural mortality ( $M=0.2$ ), this would imply very high fishing mortality. However, fishing activity has not increased in the Canadian Zone so as to explain such an increase in total mortality. The fishing mortality, however, may have increased because the fish could be substantially more catchable, perhaps because of climatic conditions. Another possible explanation is that natural mortality may have increased as a result of harsh climatic conditions, poor feeding, predation by seals or competition with them, or migration out of the area.

Pecruitment The 1986 and 1987 year-classes are still dominating the stock despite their being less abundant than the average for corresponding age. Based on relationships between recruitment success and hydrographic variables, it is likely that the 1988 to 1991 and probably 1992 year-classes will be weak.

State of the Stock. The stock is in a very depressed state, probably the lowest abundance in the $20^{\text {th }}$ century.
Environmental Factors: Climatic and hydrographic conditions in 1991-1992 off the Newfoundland shelf have been among the worst recorded for ice coverage, duration of ice, extent of the cold intermediate layer of water less than $\delta^{\circ} \mathrm{C}$.

Multispecies Considerations: Capelin abundance as estimated from acoustic surveys have been very low since 1990 in these areas and the biomass of several other groundfish stocks, some very lightly exploited have also decreased markedly during the 1980s. Following the cessation of the large vessel hunt for harp seals in 1983, the abundance of the seal herd is estimated to have increased to about 3 million seals in 1990. However, the increase is likely to have continued.

Long-term Prospects: Catches since 1960 have averaged about 350,000 t during a period of relatively high exploitation rates. Before the expansion of the fishery in the 1960 s, catches have generally been in the 200,000 to 300,000 range. Given the current state of the stock, and considering that fish are normally becoming mature at about age 7 , recovery of the spawning stock biomass is unlikely before the year 2000 at the earliest.

### 9.2. COD in 3Ps

## SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t | 26-61 | 26-58 | 37 | 20.5 | N/A | 2-44.5 | $\begin{array}{r} 39- \\ 44.5 \end{array}$ | 20 |  |  |  |
| TAC - TPA '000t | $60.6^{3}$ | $60.6{ }^{3}$ | $60.6{ }^{3}$ | $50^{3}$ | $45^{3}$ | $44^{3}$ | $44^{3}$ | 20 |  |  |  |
| Rep.catches-Prises décl. '000t | 57 | 57 | 43 | 39.5 | $41^{2}$ | $43^{2}$ | $31.5^{2}$ |  | 27 | 49 | 84 |
| Unreported catches <br> Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. ${ }^{4}$ ('O00t) | 200 | 168 | 144 | 141 | 139 | 111 | 81 |  | 80 | 168 | 293 |
| Sp.biomass-Biomasse Rep. ${ }^{4}$ ('O00t) | 60 | 57 | 49 | 43 | 36 | 28 | 24 |  | 18 | 58 | 123 |
| Mean - F - Moyen ( $6+)^{4}$ | . 55 | . 66 | . 59 | . 46 | . 58 | . 70 | . 70 |  | . 33 | . 54 | 1.16 |
| ${ }^{1}$ For/Pour 1959-1992 <br> ${ }^{2}$ Preliminary statistics/Statistiques provisoires <br> ${ }^{3}$ This is the effective TAC which was obtained by combining the Canadian quota and the French quota of the TAC set by each party/TPA "defacto" obtenu en additionant les quotas établis par le Canada et la France <br> ${ }^{4}$ Not calibrated, for illustrative purposes/Non ajusté, pour illustration |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: No quantitative forecast was made. Fishing mortality, and therefore fishing effort, would have to be decreased by a factor of about 3 to correspond to $\mathrm{F}_{0.1}$.

Catches: 1992 catches were 32,000 t, markedly lower than those during 1991. The decrease was partly due to the settlement of the boundary dispute because France did not fish after July 1992.

Data and Assessment: Canada conducted two surveys in 1993 (February and April) to ensure that the timing of the cod migration would not impact on the estimate of biomass. Results from the two surveys confirmed the low estimate from the 1992 survey. France discontinued their surveys after 1992. Based on multiplicative analyses of catch-at-age from research surveys and the commercial fishery and on average fishing mortalities from preliminary SPA, It was concluded that fishing mortality in recent years has probably been in the range of 0.5 to 0.9. An illustrative SPA using $\mathrm{F}=0.70$ was conducted to demonstrate stock size trends.

Fishing Mortality: Results from the illustrative SPA indicate that fully recruited fishing mortalities have been greater than twice $F_{0.1}$ since the extension of jurisdiction, and have been gradually increasing since that time. Coincidentally, there has been a gradual decline in stock size through the second half of the 1980 s.

Recruitment: The 1993 survey results indicated that the 1987 and 1989 year-classes are relatively strong.
State of the Stock: The stock abundance is at about its lowest since 1978.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects: There has been a gradual decline in stock size through the second half of the 1980s. Some decrease in the rate of decline can be expected because of recruitment of the relatively strong 1987 and 1989 year-classes. However, unless there is a considerable reduction of fishing effort, longer term increases in stock size cannot be anticipated at this time.

### 9.3. COD in 3Pn and 4RS SUMMARY

| Year - Annee | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t | 83 | $80.3^{2}$ | $73.9{ }^{2}$ | 72 | 56 | 35 | 24-35 | 35 |  |  |  |
| TAC - TPA '000t | 92.1 | 80.3 | 73.9 | 76.5 | 58 | 35 | 35 | 31 |  |  |  |
| Rep.catches-Prises déc. '000t | 83 | 67 | 48 | 47 | $40^{3}$ | $32^{3}$ | $29^{3}$ |  | 29 | 79 | 106 |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. '000t | 303 | 210 | 168 | 162 | 211 | 188 | 172 | 193 | 162 | 303 | 444 |
| Sp.biomass-Biomasse Rep. '000t | 111 | 87 | 59 | 62 | 47 | 34 | 29 | 46 | 29 | 99 | 182 |
| Mean - F - Moyen (7-9) | 0.69 | 0.86 | 0.53 | 0.69 | 0.69 | 0.57 | 0.51 |  | 0.36 | 0.51 | 0.86 |
| ${ }^{1}$ For/Pour 1974-1992 <br> 2 50\% rule / Règle du 50\% <br> 3 Preliminary statistiques/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Fishing at $F_{0.1}=0.20$ in 1994 will yield catches of about 20,000 . The total biomass would increase to 210,000 and the spawning biomass to 81,000 t in 1994.

Catches: Peaked at 106,000t in 1983 and have steadily declined to an historic low of 29,000 in 1992. Catches since 1987 have been lower than the average for the period 1964-1992 which equals 75,000 .

Data and Assessment Commercial catch rates are not considered reliable indices of abundance because of contradictory trends between fleets (work to investigate this question is ongoing). Therefore the assessment is calibrated with the results of a research survey conducted in January. The results for 1993 are the second lowest in the time series. The assessment was calibrated using ADAPT in a manner very similar to last year.

Fishing Mortality. Is estimated to have been about $\mathrm{F}=0.50$ on fully recruited ages, substantially above the target of $\mathrm{F}_{0.1}=0.2$.
Pecruitment The 1971 to 1983 year-classes ranged from 61 million to 196 million. Since then, with the exception of the 1987 year-class at 140 million, year-classes have ranged between 43 million and 90 million, considerably less than during the previous decade. The 1988 and 1989 year-classes are estimated to be weak although the information on their abundance is not precise.

State of the Stock. This cod stock is at a very low level, probably the lowest in the last 20 years.
Environmental Factors: The distribution of cod (based on the research survey data) moved to considerably greater depths, from 150 m in 1978 to 250m in the early 1980s, and over 450m from 1991 to 1993. Bottom water temperatures have been lower than average in 1991 and 1992.

Multispecies Considerations: Shrimp, snow crab, lobster, herring and mackerel abundance are generally high in this area. Grey seal abundance in the Gulf of St. Lawrence is increasing albeit at a rate slower than on Sable Island. A component of the harp seal herd breeds in the Gulf of St. Lawrence.

Long-berm Prospects: Under conditions of average productivity, cod in this area should yield in the order of 80,000 per year. Biomass is expected to increase in the near future as a result of the average 1986 and 1987 year-classes. However considering the current low abundance and weak incoming recruitment, sustained stock rebuilding is likely to be slow.

Special Comment This assessment is currently entirely dependent on the research vessel survey conducted in January which could cease to be conducted after 1994. However this may be counteracted by the addition of new indices of abundance. The index fishers program started in 1990, the summer survey, and the new commercial catch rate series based on individual vessels may show some promising avenues.

### 9.4. COD in 4T and 4Vn (Jan.-Apr.) <br> SUMMARY

| Year - Annee | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference Level - Niveau de reférence '000t | 60 | 24 | 49 | 55 | 53 | 48-53 | 43 | 13-15 |  |  |  |
| TAC - TPA '000t | 60 | 45 | 54 | 54 | 53 | 48 | 43 | 13 |  |  |  |
| Rep.catches-Prises decl. '000t | 67.2 | 53.2 | 54.6 | 55.4 | $54.5^{2}$ | $47.4^{2}$ | $38.7{ }^{2}$ |  | 22.2 | 56 | 104.5 |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. '000t |  |  |  |  |  | 3.0 | 2.6 |  |  |  |  |
| Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. '000t | 324 | 279 | 213 | 196 | 184 | 153 | 119 | 102 | 102 | 279 | 491 |
| Sp.biomass-Biomasse Rep. '000t | 249 | 219 | 181 | 154 | 121 | 103 | 83 | 63 | 63 | 189 | 427 |
| Mean - F - Moyen ( $7+$ ) | . 66 | . 48 | . 61 | . 84 | . 97 | . 95 | . 87 |  | . 28 | . 54 | 1.39 |

${ }^{1}$ For/Pour 1950-1992
${ }^{2}$ Preliminary statistics/Statistiques provisoires
Forecast for 1994: Fishing at $\mathrm{F}_{0.1}=0.20$ in 1994 will yield catches of about 8,000 . Both the total biomass and the spawning biomass would remain stable, close to the lowest values observed.

Catches: Catches from 1950 to 1992 have averaged 56,000 . The 1992 catches of $38,666 t(4,358 t$ of which were taken outside of the stock area, primarily in unit area 4Vsb) were lower than the TAC because fixed gear did not catch their allocation. The average size in the catch is small and very few fish greater than 50 cm (about 20 inches) have been caught in recent years. Persistent ice during the spring of 1992 delayed the fishery until mid-May in 4T.

Data and Assessment The average catch per tow during the September 1992 survey was the second lowest since 1971 when the surveys started. The 1992 survey was done using a different vessel and results were adjusted to take into account changes in vessel fishing power. The commercial catch rates for otter trawlers increased slightly in 1992. The assessment was made using Sequential Population Analyses calibrated with ADAPT as in previous years, but also using the Laurec/Shepherd hybrid and the Extended Survivor methodology (XSA).

Fishing Mortality. Fishing mortality varies depending on the assessment method used, but it is likely high, quite substantially above the target of $F_{0.1}=0.2$.

Recruitment All indices and all assessment methods used indicate that recruitment since the 1982 year-class has been below average. The 19881990 year-classes appear to be particularly weak, much lower than the previous smallest year-class.

State of the Strock: This stock is currently at its lowest observed level in recent history since about 1950. Weights-at-age remain below average and there are no signs of improving recruitment.

Environmental Factors: The average temperature in which cod are found during the research survey is considerably lower during the 1980 s than during the 1970s. The period of low temperature also corresponds to the period during which average weights have been lower.

Multispecies Considerations: Snow crab, lobster, herring and mackerel have been and are probably still relatively abundant in this area.
Long-term Prospects: Given average conditions for recruitment and weights-at-age, this resource could produce in the order of 50,000 in the long term. Cod are first recruited to this fishery at age 3, but they make their greatest contribution to the stock at age 5 to age 7 . Considering that the 1989 and 1990 year-classes appear to be weak, spawning stock biomass is not expected to recover by any significant amount until recruitment improves and the fish become mature. Recovery after 1995 is dependent on future recruitment on which there is at present no information.

### 9.5. COD in 4Vs and in 4W SUMMARY

| Year - Annoe | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t | 36 | 40 | 32 | 33.2 | 35 | 21-35 | 35.2 | 11 |  |  |  |
| TAC - TPA '000t | 48 | 44 | 38 | 35.2 | 35.2 | 35.2 | 35.2 | 11 |  |  |  |
| Rep.catches-Prises décl. '000t | 52 | 46 | 38 | 37 | $30^{2,4}$ | $24^{2,4}$ | $25^{2,4}$ |  | 10 | 52 | 80 |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. '000t | 3 | 3 | 3 | 3 | 3 | 3 | 3 |  |  |  |  |
| Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. '000t | 175 | 136 | 110 | 101 | 86 | 67 | 50 | 37 | 37 | 151 | 243 |
| Sp.biomass-Biomasse Rep. '000t | 100 | 84 | 71 | 52 | 33 | 19 | 18 | 14 | 10 | 59 | 102 |
| Mean - F - Moyen (7-9) | 0.44 | 0.53 | 0.66 | 0.55 | 1.31 | 0.73 | 1.56 |  | 0.22 | 0.46 | 1.56 |

${ }_{2}^{1}$ Catches/Prises: 1958-1992; Biom. \& F; 1970-1992
${ }^{2}$ Adjusted for 4T / Ajusté pour 4T
${ }_{4}^{3}$ Discards reported to have been high but not quantified/Rejets ont été eleves mais non quantifiés
${ }^{4}$ Preliminary statistics/Statistiques provisoires
Forecast for 1994: $\mathrm{F}_{0.1}$ catches in 1994 are in the order $2,500 \mathrm{t}$.
Catches: Discards are reported to have been high in some years, but they have not been quantified. Reported catches have been maintained close to the TAC partially because of the harvest of $4 \mathrm{~T}-4 \mathrm{Vn} \operatorname{cod}$ in 4 Vsb in the winter. Historically, longlines have taken larger fish than mobile gear. In 1992, however the size composition for both gear was very similar with very few fish larger than 70 cm and most of the catch in the 45 to 60 cm range. After the mobile gear closure in 4 W to protect juvenile haddock came into effect, there has been a marked increase in longline catches of cod in the closed area.

Data and Assessment: The sequential population analysis was calibrated with the results of a spring survey (1979-1992) and a summer survey (1970-1992). The spring 1992 survey was the lowest ever with less than 200 fish taken during the entire survey. The July 1992 survey was higher than the 1991 value, but still low. The 1993 spring survey was similar to the July 1992 summer value but was not used in the calibration.

Fishing Mortality. Total mortality is estimated to have increased substantially over the 1980 s and was above 1.0 in 1992, implying that more than $60 \%$ of the population is dying each year. With a constant natural mortality rate of $M=0.20$, this would mean that fishing mortality is substantially above the $F_{0.1}=0.20$ target. A shrinking of the distribution may have increased catchability and fishing mortality per unit of fishing effort.

Recruitment Has been substantially below average since 1984. The 1988 to 1991 year-classes, according to preliminary estimates are small.
State of the Stock. The spawning stock biomass and fishable biomass are at the lowest levels seen since 1970. However, small fish are still seen in the surveys. If the 1993 TAC of 11,000 is taken the spawning stock biomass will continue to decline. At such low biomasses and given the recent poor survivorship of juveniles, any recovery will be slow.

Environmental Factors: Bottom water temperatures have decreased markedly since the early 1980s, particularly in 4 V , somewhat in parallel with decrease in recruitment, although no causes effect has been demonstrated.

Multispecies Considerations: Grey seal population abundance has increased steadily since the early 1960s and pup production has been increasing since the early 1960s at about $12 \%$ per year. Although it is not presently possible to quantify the effects of grey seals on cod, they are certain to exist either directly by predation or indirectly by competition. Grey seal stomach analysis from this and other areas show that cod can be an important food item, with the largest proportion in the stomach being less than 30 cm .

Long-term Prospects: Cod in this area are first caught at about age 3, but they do not become mature until about age 6. This means that even if the 1992 year-class were to be strong, it would not result in a spawning stock increase until 1998. Stock rebuilding will therefore be slow.

### 9.6. COD in 4 X

## SUMMARY

Figs. 1.6a-1.6g

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t |  | 13 | 9 | 12.5 | 12 | 20 | 20 | 26 |  |  |  |
| TAC - TPA '000t | 20 | 17.5 | 14 | 12.5 | 22 | 26 | 26 | 26 |  |  |  |
| Rep.catches-Prises décl. '000t | 20 | 19 | 20 | 20 | $24^{2}$ | $28^{2}$ | $26^{2}$ |  | 12.2 | 21.2 | 35.5 |
| Unreported catches Prises non-déclarées <br> Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. '000t | 58 | 65 | 77 | 80 | 87 | 83 | 74 | 68 | 58 | 80 | 113 |
| Sp.biomass-Biomasse Rep. '000t | 46 | 42 | 53 | 58 | 75 | 68 | 56 | 50 | 42 | 62 | 95 |
| Mean - F - Moyen (4-6) | 0.55 | 0.49 | 0.58 | 0.40 | 0.45 | 0.48 | 0.60 |  | 0.27 | 0.45 | 0.76 |
| ${ }_{1}{ }^{1}$ For/Pour 1948-1992. <br> ${ }^{2}$ Preliminary statistics/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: If the TAC of 26,000 in 1993 is taken, $\mathrm{F}_{0.1}$ catches in 1994 would be about $7,000 \mathrm{t}$.
Catches: Catches have been irregularly cyclical since 1960 with peaks in 1968, 1982 and 1991. They have averaged about 20,000 t over this period.

Data and Assessment: The assessment was done using sequential population analyses calibrated with ADAPT using the results of a July research vessel survey. The 1992 survey biomass was $10 \%$ lower than in 1991.

Fishing Mortality: F has been consistently above twice $\mathrm{F}_{0.1}$ and has been increasing since 1989.
Recruitment: The strong 1985 and 1987 year-classes have made most of their contribution to catches. Other year-classes during the 1980s were generally below average. Incoming year-classes were assumed to be average.

State of the Stock: This stock is rapidly declining from very high abundance in 1990. Although stock biomass shows distinct irregular cycles, there is a general downward trend.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects: Catches since 1948 have averaged about 20,000t, but the average for 1960 to 1992 was higher. Decreasing maxima in biomasses may be indicative of decreasing productivity, perhaps because of continued high exploitation. Yield has been foregone due to high fishing mortalities which do not permit the growth potential to be realized. The fluctuations in biomass and catch could be dampened by reducing exploitation rates and allowing each year-class to contribute to the fishery for a greater duration. This would make the fishery less susceptible to recruitment variations.

### 9.7. COD in 5 Z and in 5 Zm SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t | 11 | 12.5 | 9.9 | 8 | 8 | 11-22 | 15-22 | 14 |  |  |  |
| TAC - TPA '000t | $11^{2}$ | $12.5{ }^{2}$ | $12.5{ }^{2}$ | $8{ }^{2}$ | - | $15^{3}$ | $15^{3}$ | $15^{3}$ |  |  |  |
| Rep.catches-Prises décl. '000t | 14 | 17 | 21 | 14 | $21^{4}$ | $20^{4}$ | 14 |  | 12 | 17 | 26 |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. $(1+)^{\prime} 000 \mathrm{t}$ | 63 | 71 | 72 | 64 | 68 | 57 | 41 | 29 | 29 | 62 | 75 |
| Sp.biomass-Biomasse Rep. $(3+)^{\prime} 000 t$ | 40 | 37 | 54 | 48 | 58 | 39 | 25 | 25 | 25 | 43 | 58 |
| Mean - F - Moyen (3+) | . 49 | . 42 | . 50 | . 34 | . 52 | . 78 | . 86 |  | . 34 | . 48 | . 86 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{2}$ Canadian allocation / Allocation canadienne |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{3}$ Canadian quota in the new management unit / Contingent canadien pour la nouvelle unite de gestion |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: All indications are that this stock has declined substantially since 1990 and that further reductions are expected if fishing continues at the present level. Given the indications that the 1991 and 1992 year-classes are well below average abundance, a catch equal to that of 1992 could 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 1993 and 1994 fisheries. $\mathrm{F}_{0.1}$ catches in 1994 would be less than 2,000 t.

Catches: Landings in 1992 were the lowest since 1987 for the USA while Canadian landings decreased by 2,000 t compared with 1991. The 1992 landings were 16,792t, equal to the long term average of $17,000 \mathrm{t}$. Canadian landings account for about $65 \%$ of the total. Canadian landings to the end March, 1993 were about 2,000 t.

Data and Assessment: The 1993 Canadian survey shows a continuing decline and USA spring surveys also show a decline in 1992 to the lowest observed. The USA autumn survey estimate, while increasing slightly in 1992, is very low compared with other values in the series. 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 19911992.

Recruitment: Preliminary estimates of the 1991 and 1992 year-classes based on research vessel surveys appear below average.

State of the Stock: Total and spawning biomasses are the lowest observed in the time series which begins in 1978.

Environmental Factors: No abnormal water temperature conditions or long term trends have been noted on Georges Bank.

## Multispecies Considerations:

Long-term Prospects: Sustained stock rebuilding will probably 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 quickly.
9.8. HADDOCK in 4T, 4V and in 4W

SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t | 17 | $\underline{2}$ | 4.5 | 6.7 | 6 | $\underline{2}$ | $\underline{2}$ | 4-6 |  |  |  |
| TAC - TPA '000t | 17 | 3 | 3 | 6.9 | 6 | 3 | 3 | 3 |  |  |  |
| Rep.catches-Prises decl. '000t | 16.9 | 3.9 | 4.5 | 9.1 | 4 | $5.4{ }^{4}$ | $6^{4}$ |  | 1.4 | 11.7 | 56 |
| Unreported catches Prises non-déclarées <br> Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Ab. \#/t (RV/NR) ('000 t) <br> Sp.biomass-Biomasse Rep. <br> Mean - F - Moyen | 50.5 | 30.9 | 56.2 | 41.6 | 42.4 | 63 | 28.6 |  | 3 | 38 | 85 |
| ${ }^{1}$ For/Pour 1954-1992, except/sauf \#/t, 1970-1992 <br> ${ }^{2} 1987$ lowest possible, 1991-1992 by-catch only / 1987 plus bas possible, 1991-1992 captures accessoires <br> ${ }_{4}^{3}$ No TAC, by-catch only / Pas de TPA, captures accessoires seulement <br> ${ }^{4}$ Preliminary statistics/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: No quantitative catch forecast was calculated.
Catches: Landings averaged 26,500t per year from 1950 to 1969. The average was lower from 1970 to 1979 at 5,000 t. Landings ranged between 8,000 t and 20,000 from 1980 to 1987. Since 1987, landings have been coming exclusively from by-catches in other groundfish fisheries. The 1992 total was about 6,000t.

Data and Assessment: The results of both the summer and spring surveys indicate that haddock abundance is decreasing. The bulk of the stock is concentrated in Division 4W and is mainly comprised of the 1988 year-class.

Fishing Mortality: Total mortality is believed to have been high in recent years. If natural mortality is $M=0.20$, this would mean that fishing mortality is substantially above the $F_{0.1}=0.25$ target probably in the order of 1.0 .

Recruitment: There are no indications of strong year-classes after that of 1988.
State of the Stock: The stock has essentially disappeared from 4 Vn and 4 Vs . In 4 W , summer survey estimates in 1992 are lower than those for 1991.

Environmental Factors: Bottom water temperatures in large portions of the traditional stock area ( 4 V ) have been too cold for haddock in recent years. These may have either caused mortality or migration. By restricting the distribution of haddock and therefore concentrating the stock, water temperature may increase the efficiency of fishing where haddock concentrations are located.

Multispecies Considerations: Although it is not presently possible to quantify the effects of grey seals on haddock, they do not appear to be an important item in the diet of grey seals.

Long-term Prospects: Current stock sizes are much lower than those that produced average catches greater than 25,000 for the period 1950 to 1969 . It is not possible to say if and when the stock can rebuild to such levels. However it is certain that current high exploitation rates will not allow such rebuilding. Reducing exploitation on the 1988 year-class will allow for a more rapid rebuilding of spawning stock biomass and increased potential for stronger recruitment.

### 9.9. HADDOCK in $4 X$ SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t | 12 | 12.3 | 8.2 | <4.6 | 4.6 | $\underline{2}$ | $\underline{2}$ | 3 |  |  |  |
| TAC - TPA '000t | 15 | 15 | 12.4 | 4.6 | 4.6 | $\underline{2}$ | $\underline{2}$ | 6 |  |  |  |
| Rep.catches-Prises decl. '000t | 15 | 13.6 | 11 | 6.7 | $7.3{ }^{3}$ | 9.73 | $10.4{ }^{3}$ |  | 6.7 | 18.5 | 35.9 |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. <br> Sp.biomass-Biomasse Rep. (Female) '000t (RV/NR) | 17 | 12 | 9 | 10 | 15 | 16 |  |  | 9 | 17 | 31 |
| Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }_{2}^{1}$ Catches/Prises: 1948-1992; Biomass/Biomasse: 1970-1992. <br> ${ }^{2}$ By-catch / Captures accessoires <br> ${ }^{3}$ Preliminary statistics/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Catches equal to the 1993 TAC of 6,000 t will likely result in a reduction in fishing mortality. Catches of about 6,000t in 1994 would permit a greater contribution to spawning by the 1987-1988 year-classes.

Catches: Long term reported landings since 1930 have averaged about 20,000 , and exceeded 30,000 t during the 1960 s and early 1980s. Landings have been lower than average since 1984, but they have increased recently reaching 10,000 under a "by-catch" fishery.

Data and Assessment: Commercial catch rates for both longliners and draggers have increased somewhat in recent years. Survey indices of abundance have generally increased from 1989 to 1991, but the 1992 value is lower than 1991.

Fishing Mortality: Fishing mortalities for fish at length for 40,50 , and 60 cm were estimated to have been high (0.5-1.0) throughout the 1980s but have decreased to 1992 ( 0.25 to 0.50 ).

Recruitment: Has been average or smaller since 1983. The survey results suggest that the 1991 year-class may also be below average.

State of the Stock: Stock abundance is higher than the low values of the mid-1980s, but it remains below the productive levels of the 1960s and early 1980s.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects: The 1987 and 1988 year-classes were close to average, but all year-classes since are lower than average. Stock rebuilding is unlikely in the absence of large year-classes.

### 9.10. HADDOCK in 5 Zj and in 5 Zm SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t | 4.3 | $8.3^{5}$ | $8.3^{5}$ | 8.5 | $3^{5}$ | 5.4 | 5 | 3.5-4 |  |  |  |
| TAC - TPA '000t | 5.14 | $8.3{ }^{4}$ | $8.3{ }^{4}$ | $8.3{ }^{4}$ | NA/ND | 5 | $5^{2}$ | $5^{2}$ |  |  |  |
| Rep.catches-Prises décl. '000t | 5.6 | 6.1 | 5.7 | 3.8 | 4.53 | $6.4{ }^{3}$ | 5.73 |  | 2.4 | 5.9 | 25.0 |
| Unreported catches <br> Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. (000t) | 21.5 | 19.7 | 18.8 | 16.5 | 17.0 | 15.3 | 11.8 | 13.9 | 7.5 | 19.7 | 57.7 |
| Sp.biomass-Biomasse Rep. ('O00t) | 16.5 | 13.1 | 14.4 | 9.9 | 15.6 | 12.6 | 8.5 | 4.3 | 2.2 | 12.6 | 42.6 |
| Mean - F - Moyen (4+) | 0.33 | 0.43 | 0.46 | 0.32 | 0.47 | 0.6 | 1.29 |  | 0.18 | 0.38 | 1.29 |

${ }^{1}$ For/Pour 1969-1992
${ }^{2}$ Canadian quota for the current management unit/Contingent canadien pour l'unite de gestion actuelle
${ }^{3}$ Preliminary statistics/Statistiques provisoires
${ }_{5}^{4}$ Canadian allocations for the management unit used prior to 1990/Allocations canadiennes pour l'unité de gestion avant 1990
${ }^{5}$ For/Pour 5Z
${ }^{6}$ Canada only/Canada seulement
Forecast for 1994: The current Canadian allocation of 5,000 for 1993 will result in fishing mortalities greatly exceeding twice the $F_{0.1}=0.25$ value. $\mathrm{F}_{0.1}$ catches in 1994 would be about 2,000 t, but would be comprised almost entirely ( $70 \%$ ) of the incoming 1992 year-class. It is too early to reliably estimate the strength of the 1992 year-class.

Catches: The 1992 landings by Canada declined to 4,000 with a substantial shortfall in the mobile gear allocation which is an indication of low abundance. Atthough catches during January and February 1993 (when haddock are in spawning aggregations) were good, catches in June 1993 following the spawning closure period were generally poor.

Data and Assessment An assessment of yield per recruit for this transboundary resource concluded that the types of benefits expected from fishing at $\mathrm{F}_{0.1}$ (higher catch rates, higher biomasses, and larger fish sizes) could accrue to Canada from unilateral Canadian conservation actions. Yield for Canada and the Canadian $\mathrm{F}_{0.1}$ exploitation rate are not affected much by USA actions because the stock is largely distributed in Canadian waters and migration is limited.

The assessment of the status of the stock was done using sequential population analysis calibrated with ADAPT using the results from the Canadian spring survey and the USA spring and fall surveys.

Fishing Mortality. Has been higher than twice $\mathrm{F}_{0.1}$ in recent years and increased markedly in 1992 to the highest level, corresponding to a harvest rate of roughly $60 \%$ to $70 \%$.

Recruitment Recent recruitment has been poor, with occasional moderate-sized year-classes being produced. Early indications for the 1992 year-class suggest a moderate strength comparable to those of 1983, 1985, and 1987.

State of the Stock. The stock is near the historically low levels which occurred in the mid-1970s. It is a small fraction of the previous average stock sizes from 1920 to the 1960 s.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects: Rebuilding of this stock to its long term average will not be possible unless the exploitation rate is decreased substantially. In the absence of a substantial standing stock, catches will fluctuate due to their dependence on variable recrultment. Heavy harvesting of incoming year-classes as soon as they recruit to the fishery will not permit realization of their full growth potential resulting in lost yield. The stock is mostly distributed in Canadian waters with limited migration. Therefore, unilateral Canadian conservation efforts could be effective in managing a healthy stock. However, because the stock is presently severely depleted, consistent restrictive measures by both Canada and USA would enhance the chances of accelerating recovery and restoring the stock biomass.

### 9.11. POLLOCK in $4 \mathrm{~V}, 4 \mathrm{~W}, 4 \mathrm{X}$ and in 5 Zc <br> SUMMARY

| Year - Anné | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de <br> référence '000t | 43 | 30 | 42 | 42.5 | 38 | 43 | 43 | 35 |  |  |
| TAC - TPA '000t |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Fishing at $F_{0.1}$ would imply catches of about $20,000 \mathrm{t}$ in 1994.
Catches: Decreased from 39,000t in 1991 to 34,000 in 1992, continuing a generally decreasing trend since 1987. The decrease in catches is more pronounced in 4 VW than in $4 \mathrm{X}+5 \mathrm{Zc}$ and catches have become more concentrated during May-August.

Data and Assessment: The assessment is made using Sequential Population Analysis calibrated with the summer research vessel survey results. Survey population estimates have decreased substantially from the high value observed in 1990. The survey shows strong year to year variability, making it difficult to estimate abundance.

Fishing Mortality: Fishing mortality has been about $F=0.60$ on fully recruited ages, twice the $F_{0.1}=0.30$ target.
Recruitment: Recruitment has averaged 28 million since 1974. The 1989 year-class appears to be above average.
State of the Stock: Pollock abundance is currently lower than average and it is expected to continue to decrease.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects: The average productivity of pollock in this area since 1974 has been 37,000 t, with catches in the 1980s being generally higher than average as a result of the strong 1979 year-class. If fishing mortality remains high, the 1989 year-class, which may be above average, will not contribute substantially to spawning stock increases.

### 9.12. REDFISH in 4R,4S,4T,3Pn(J.-M.) and in 4 Vn (J.-M.) SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t |  |  |  |  |  |  | 67 | 00 |  |  |  |
| TAC - TPA '000t | New Management Unit / Nouvelle Unite de Gestion |  |  |  |  |  | 67 | 60 |  |  |  |
| Rep.catches-Prises décl. '000t | 36 | 43.5 | 52 | 52.5 | $60^{2}$ | $59.5{ }^{2}$ | Tr |  | 7.1 | 44 | 136 |
| Unreported catches <br> Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. | - |  |  |  |  |  |  |  |  |  |  |
| Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. Sp.biomass-Biomasse Rep. Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| $\begin{aligned} & 1 \text { For/Pour 1959-1992 } \\ & 2 \text { Preliminary statistics/Statistiques provisoires } \end{aligned}$ |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: No quantitative forecast was made. Recent catches are expected to result in rapid decline in abundance.

Catches: Catches have increased substantially in 1992, exceeding the TAC suggested for the new management unit by 10,000 t.

Data and Assessment: Commercial catch per unit of effort and research vessel surveys are used as indices of abundance. The commercial CPUE increased about $20 \%$ from 1991 to 1992. The research surveys suggest either stability or a decline in abundance.

Fishing Mortality: No quantitative estimate available.
Recruitment: The 1988 year-class still appears strong, but it may be weaker than previously estimated. It will start to contribute to the fishery in 3-4 years.

State of the Stock: The stock is still quite abundant but it is expected to continue to decrease as a result of fishing and natural mortality until the 1988 year-class reaches maturity and is recruited to the fishery.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects: Redfish stocks are noted for recruitment occurring only periodically. This leads to wide fluctuations in stock abundance. Given that the incidence of strong year-classes is infrequent and that growth rates are very low, fishing mortalities on redfish stocks must be maintained at low levels.

### 9.13. AMERICAN PLAICE in Subarea 2 and in 3 K SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 5 |  |  |  |
| TAC - TPA '000t | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 5 |  |  |  |
| Rep.catches-Prises decc. 'OOOt | 3 | 1.1 | 1 | 4.2 | $1.8{ }^{2}$ | . $5^{2}$ | . $T^{2}$ |  | . 1 | 3.6 | 12.7 |
| Unreported catches Prises non-d 6 clarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. Sp.biomass-Biomasse Rep. Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour 1963-1992 <br> ${ }^{2}$ Preliminary statistics/Statis | prov |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: No quantitative forecast is possible. However stock size is very low.
Catches: Catches in the last two years are the lowest in the time series. The low 1992 catches may be due, in part, to low fishing activity as a result of the cod moratorium.

Data and Assessment: Research vessel survey results are used as indices of abundance. They show a steep decline in biomass from the late 1980s to the present, despite low commercial catches.

Fishing Mortality: Total mortality is likely very high in order to have caused such a rapid decrease in abundance. However, reported catches cannot explain such a rapid decrease. Misreporting of catches and migration are thought to be unlikely causes.

Recruitment: Research surveys indicate a decline in recent years.
State of the Stock: This stock had declined to very low abundance by the end of 1992. The currem TAC of 5,000 is about equal to the total biomass estimate from the 1992 survey. This means that if the TAC were to be caught, it would result in very high fishing mortalities on a stock which is at an extremely low level.

Environmental Factors: Extreme oceanographic conditions may have increased natural mortality by an unknown mechanism.

## Multispecies Considerations:

Long-term Prospects: The prospects for rebuilding in the long term are unknown. There is no sign of good recruitment. Considering that plaice ages $9-12$ comprise the majority of commercial catches, a recovery of the fishery is unlikely before at least 10 years. Both the total and the spawning stock biomasses are far below any previous estimate in the 15 -year time series.

### 9.14. AMERICAN PLAICE in 3Ps SUMMARY



Forecast for 1994: In the short term, fisheries can expect a continued down-turn, with no immediate prospects for stock rebuilding.

Catches: The Canadian inshore catch in 1992 declined to the lowest value since 1985. The catch by Canadian offshore trawlers in 1992 was the lowest since 1983, at about half the 1990 and 1991 values. The total 1992 catch was $2,300 \mathrm{t}$, a $50 \%$ decrease compared with the average of the last 6 years.

Data and Assessment: The commercial catch per unit of effort decreased sharply in 1991 and 1992 to the lowest levels observed. Research surveys biomass estimates were relatively stable around 30,000 in 1986-1988, the 1989 estimate was 17,000 t and 4 of the 5 surveys since have estimated the biomass at less than 7,000 . The two surveys conducted in 1993 gave biomasses less than $5,000 \mathrm{t}$.

Fishing Mortality: Total mortality is likely very high in order to have caused such a rapid decrease in abundance. Although recent catches have likely exceeded $\mathrm{F}_{0.1}$, it is unlikely that reported catches are solely responsible for the observed decline in abundance. Misreporting of catches and migration are thought to be unlikely causes.

Recruitment: Recruitment is very low according to the surveys.
State of the Stock: Similar to other American plaice stocks in the Newfoundland and Labrador area, 3Ps plaice has declined markedly since the mid-to-late 1980s and is now below any previously observed value. The TAC of 3000 is in the range of the total biomass estimate from the 1993 survey. If caught, the TAC would result in a very high fishing mortality on a stock that is at an extremely low level.

Environmental Factors: Oceanographic conditions in 1985 may have concentrated plaice, resulting in higher catchabilities to the commercial fishery and to the surveys.

## Multispecies Considerations:

Long-term Prospects: The prospects for rebuilding in the long term are unknown. Both the total and the spawning stock biomasses are far below any previous estimate in the 15 years time series. There is no sign of good recruitment.

### 9.15. AMERICAN PLAICE in $4 T$ SUMMARY

| Year - Ann6e | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de reférence '000t | 10 | 10 | 10 | 8 | 10 | 10 | 10 | 10 |  |  |  |
| TAC - TPA '000t | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 5 |  |  |  |
| Rep.catches-Prises décl. '000t | 7.2 | 8 | 7 | 5.7 | $5.6^{2}$ | 5.2 | $5.1^{2}$ |  | 5.1 | 8.5 | 11.8 |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. |  |  |  |  |  | 3.2 | 3.3 |  |  |  |  |
| Tot. catches - Prises Tot. |  |  |  |  |  | 8.2 | 8.3 |  |  |  |  |
| Tot.biomass-Biomasse Tot. (RV/NR) '000t | 94 | 76 | 87 | 63 | 81 | 106 | 65 |  | 63 | 150 | 338 |
| Sp.biomass-Biomasse Rep. <br> Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ Catches/Prises: 1965-1992; Biom: 1970-1992. <br> ${ }^{2}$ Preliminary statistics/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Quantitative forecast is not possible, but landings are expected to remain stable or decrease.

Catches: Past total catches are not known because of substantial discarding. Landings have consistently been lower than the TAC except in 1979. Landings have decreased steadily since the mid1980s.

Data and Assessment: The results of a September groundfish survey are used as an index of abundance. They have also been used to estimate total mortality trends, biomass trends and year-class trends.

Fishing Mortality: Recent total mortality estimated from the survey is 0.54 . Assuming $M=0.20$, this implies a fishing mortality of $F=0.34$, between $F_{0.1}$ and twice $F_{0.1}$.

Recruitment: Recruitment appears to have decreased from 1972 to 1981 but has increased since, although recent estimates are not precise.

State of the Stock: The stock is currently much lower than in the mid-1970s. Recruitment appears to have been increasing since 1982.

## Environmental Factors:

Multispecies Considerations: Snow crab, lobster, herring and mackerel have been and probably still are abundant in this area.

Long-term Prospects: Yield from this plaice resource could be increased substantially if discarded plaice were not caught and were allowed to grow until they reach an appropriate commercial size.

### 9.16. AMERICAN PLAICE in 4 V and in 4 W

 SUMMARY| Year - Annee | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reforence level/Niveau de référence TAC - TPA <br> Rep.catches-Prises décl. '000t <br> Unreported catches Prises non-déclarées <br> Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  | $\mathrm{No}$ | Manag | nt Un | Nouve | . $4^{2,3}$ | stion |  |  |  |  |
| Tot.biomass-Biomasse Tot. <br> Sp.biomass-Biomasse Rep. <br> Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour <br> ${ }^{2}$ Prior to 1991, species identification is unreliable / Avant 1991, l'identification spécifique n'est pas fiable. <br> ${ }^{3}$ Preliminary statistics/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Assuming that the exploitation rate remains stable, catches are expected to also remain stable.

Catches: Landings data are not reliable because plaice are reported as unspecified flounder.
Data and Assessment: Estimates from summer and spring surveys are used as indices of abundance.

## Fishing Mortality:

Recruitment:
State of the Stock: The index of abundance from the summer research surveys has recently been increasing except in 1992. The index from the spring surveys has been declining since 1990.

Environmental Factors:

## Multispecies Considerations:

Long-term Prospects:

### 9.17. AMERICAN PLAICE in 4 X SUMMARY

| Year - Annse | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de référence TAC - TPA <br> Rep.catches-Prises décl. '000t <br> Unreported catches Prises non-déclarees <br> Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  | $\mathrm{Ne}$ | Aanag | ant Uni | Nouve | $1.0^{2,3}$ | $\frac{\text { stion }}{.4^{2,3}}$ |  |  |  |  |
| Tot.biomass-Biomasse Tot. Sp.biomass-Biomasse Rep. Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour <br> 2 Prior to 1991, species identification is unreliable / Avant 1991, l'identification spécifique n'est pas fiable. <br> ${ }^{3}$ Preliminary statistics/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Assuming that the exploitation rate remains stable, catches are also expected to remain stable.

Catches: Landings data are not reliable because plaice were reported as unspecified flounder.
Data and Assessment: Estimates from summer and spring surveys are used as indices of abundance.

## Fishing Mortality:

Recruitment:
State of the Stock: Abundance estimates from the summer surveys have increased in the last two years.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects:
9.18. Witch $2 \mathrm{~J}, 3 \mathrm{~K}$, and in 3L SUMMARY

| Year - Annéa | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de référence '000t | 8 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |  |  |  |
| TAC - TPA '000t | 8 | 6 | 5 | 5 | 4 | 4 | 4 | 4 |  |  |  |
| Rep.catches-Prises décl. '000t | 3.9 | 4.5 | 4.2 | 4.9 | $3.6{ }^{2}$ | $4^{2}$ | $2.3{ }^{2}$ |  | . 9 | 4 | 24 |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. Sp.biomass-Biomasse Rep. Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: No quantitative forecast possible.
Catches: Catches fluctuated between 3,000t and 4,500t from 1980 to 1991. Catches in 1992 decreased to 2,300 t.

Data and Assessment: Commercial catch per unit of effort fluctuated widely in the late 1980s, reaching very high values in 1986 and 1989, perhaps reflecting increased concentrations of fish rather than higher stock sizes. Biomass estimates from research surveys have decreased from about 40,000-45,000t in the early 1980s, to about 2,500 in 1992. The geographical distribution of witch in the surveys changed suddenly in 1986 after the 1985 survey. The area of distribution has gradually decreased since. The fishery in recent years has been prosecuted in depths deeper than those covered by the survey.

## Fishing Mortality:

Recruitment: The decrease in biomass from the mid-1980s implies that recruitment has been very small to non-existent during that period.

State of the Stock: The stock is presently the lowest recorded. The biomass outside of the survey area is not believed to be very high.

Environmental Factors: Harsh oceanographic conditions may have played a role in the decreased abundance of witch.

## Multispecies Considerations:

Long-term Prospects: The prospects for rebuilding in the long term are unknown. Both the total and the spawning stock biomasses are far below any previous estimate in the 15 -year time series.

### 9.19. WITCH in 3Ps

## SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de référence '000t | 3 | 3Max | 1 | 1 | 1 | 1 | 1 | 1 |  |  |  |
| TAC - TPA '000t | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 |  |  |  |
| Rep.catches-Prises décl. '000t | 1.3 | 1.3 | . 6 | . 9 | $1.0^{2}$ | $1.1^{2}$ | $1.0^{2}$ |  | . 4 | 1.0 | 4.8 |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. <br> Sp.biomass-Biomasse Rep. <br> Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour 1960-1992 <br> ${ }^{2}$ Preliminary statistics/Statis | provi |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: A quantitative forecast is not possible.
Catches: Catches have generally been about 1,000t since 1979.
Data and Assessment: Biomass has been estimated by research surveys since 1976. Biomass estimates were generally between 3,000 t and 6,000 t during the 1980 s, with no identifiable persistent trend. Estimated biomass was about 2,000t in February 1993, but the 1993 April survey estimate increased to about 3,000 t.

## Fishing Mortality:

## Recruitment:

State of the Stock: The state of the stock is uncertain. The 1993 survey estimates are within the range of variability during the last 10-15 years.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects: Long term prospects are uncertain. The 1993 fishery was considered highly successful, however, it occurred on a very densely aggregated pre-spawning concentration and may not be representative of stock abundance.

### 9.20. WITCH in 4RS

SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de référence '000t | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |  |  |  |
| TAC - TPA '000t | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |  |  |  |
| Rep.catches-Prises décl. '000t | . 7 | . 9 | 1.1 | 1.2 | . $6^{2}$ | . $5^{2}$ | . $4^{2}$ |  | . 2 | 1.5 | 5.3 |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. <br> Sp.biomass-Biomasse Rep. <br> Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour 1960 to 1992 <br> 2 Preliminary statistics/Statis | provi |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: A quantitative forecast is not possible. However, based on the results of research surveys and the commercial fishery, catches are expected to remain low, particulary in 4R.

Catches: Catches have decreased steadily for the last three years. They have been lower than 1000t every year since 1983, except in 1988-89.

Data and Assessment: Qualitative interpretation of the research survey results and of the commercial fishery.

## Fishing Mortality:

## Recruitment:

State of the Stock: The abundance of this stock is thought to be low.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects: Catches since 1960 for this stock have averaged 1,800 t. Given the current stock size and age of recruitment, stock rebuilding is expected to be slow. The definition of the stock unit will be studied to determine if catches in 4T, close to the stock unit, should be assigned to 4RS witch.
9.21. WITCH in 4 V and in 4W

## SUMMARY

| Year - Annee | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de référence |  |  |  |  |  |  |  |  |  |  |  |
| TAC - TPA | New Management Unit / Nouvelle Unité de Gestion |  |  |  |  |  |  |  |  |  |  |
| Rep.catches-Prises décl. '000t | $1.3^{3.3} \quad 1.0^{2.3}$ |  |  |  |  |  |  |  |  |  |  |
| Unreported catches Prises non-déclarees |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. <br> Sp.biomass-Biomasse Rep. <br> Mean - F-Moyen |  |  |  |  |  |  |  |  |  |  |  |
| $\begin{aligned} & 1 \text { For/Pour } \\ & 2 \text { Prior to 1991, species identification is unreliable / Avant 1991, l'identification spécifique n'est pas fiable. } \\ & 2 \\ & \\ & \hline \end{aligned}$ |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Catches are expected to decrease as a result of declining abundance.
Catches: Landings have been decreasing. The species identification is more reliable because witch command a higher price.

Data and Assessment: Estimates from a summer and a spring survey are used as indices of abundance.

## Fishing Mortality:

## Recruitment:

State of the Stock: Summer survey abundance estimates indicate stable blomasses at low values. The spring survey estimates declined from 1987 to 1990 but have remained stable since.

## Environmental Factors:

Multispecies Considerations:
Long-term Prospects:

### 9.22. WITCH in 4X SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Mod. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de référence <br> TAC - TPA <br> Rep.catches-Prises décl. '000t <br> Unreported catches Prises non-déclarées <br> Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  | $\mathrm{Ne}$ | Manag |  | Nouvel | nite de | $\frac{\text { astion }}{.6^{2,3}}$ | . $8^{2,3}$ |  |  |  |
| Tot.biomass-Biomasse Tot. <br> Sp.biomass-Biomasse Rep. <br> Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour <br> ${ }^{2}$ Prior to 1991, species identification is unreliable / Avant 1991, l'identification spécifique n'est pas fiable. <br> ${ }^{3}$ Preliminary statistics/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Catches are expected to decrease as a result of declining abundance.
Catches: Landings have been decreasing. The species identification is more reliable because witch command a higher price.

Data and Assessment: Estimates from a summer survey are used as indices of abundance.
Fishing Mortality:

## Recruitment:

State of the Stock: Increasing catches may be due to increased fishing effort as a result of the introduction of individual quotas. Estimates of abundance from the surveys have been decreasing since 1984.

## Environmental Factors:

Multispecies Considerations:
Long-term Prospects:

### 9.23. YELLOWTAIL in 4 V and 4 W SUMMARY

| Year - Ann6e | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Mod. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de référence |  |  |  |  |  |  |  |  |  |  |  |
| TAC - TPA | New Management Unit / Nouvelle Unité de Gestion |  |  |  |  |  |  |  |  |  |  |
| Rep.catches-Prises dect. '000t | $1.3^{2.3} \quad 1.4^{2,3}$ |  |  |  |  |  |  |  |  |  |  |
| Unreported catches Prises non-déclarées | . |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. <br> Sp.biomass-Biomasse Rep. <br> Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour <br> ${ }^{2}$ Prior to 1991, species identification is unreliable / Avant 1991, l'identification spécifique n'est pas fiable. <br> ${ }^{3}$ Preliminary statistics/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Landings are expected to remain stable or increase slightly.
Catches: Landings data are not reliable because of problems with species identification and reporting.
Data and Assessment: Estimates from a summer and a spring survey are used as indices of abundance.

Fishing Mortality:
Recruitment:
State of the Stock: Estimates of abundance from the summer surveys have generally been stable with perhaps an increase recently. The estimates from the spring surveys have generally decreased since 1988.

## Environmental Factors:

Multispecies Considerations:
Long-term Prospects:

### 9.24. YELLOWTAIL in $4 X$ SUMMARY



Forecast for 1994: Catches are expected to remain stable at a low level.
Catches: Landings data are not reliable because of problems with species identification and reporting.
Data and Assessment: Estimates from summer surveys are used as indices of abundance.

## Fishing Mortality:

## Recruitment:

State of the Stock: Based on the surveys, the stock appears stable at a low level, and perhaps slightly increasing.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects:

### 9.25. ATLANTIC HALIBUT in 3N, 3O, 3Ps, 4V, 4W, and in 4 X SUMMARY

Figs. 1.25a-1.25d

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de reférence '000t | - | - | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 |  |  |  |
| TAC - TPA '000t | - | - | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 |  |  |  |
| Rep.catches-Prises décl. '000t | 3.3 | 2.6 | 2.3 | 1.9 | $2 .{ }^{2}$ | 2.2 | $1.3^{2}$ |  | 1.1 | 1.9 | 4.0 |
| Unreported catches Prises non-déclarbes |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. Sp.biomass-Biomasse Rep. Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour 1961-1992. <br> ${ }^{2}$. Preliminary statistics/Statis | provi |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: The Atlantic halibut stock size appears to be decreasing and catches are expected to continue to decline.

Catches: Catches have decreased more or less steadily from a maximum of 4,000 in 1985 to 1,331 in 1992.

Data and Assessment: Landings, commercial catch rates and biomass estimates from research surveys were used as indices of abundance. The landings suggest a decreasing stock size while the commercial catch rates have decreased markedly since 1988 despite technological improvements to fishing. The biomass estimates from research surveys have increased from 1983 to 1989, but they have fluctuated since, perhaps with a downward trend.

Fishing Mortality:

## Recruitment:

State of the Stock: The stock is decreasing based on declining commercial catch rates and landings. The stock is now less abundant than when the 3,200 TAC was established.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects:

### 9.26. ATLANTIC HALIBUT in 4R, 4 S and in $4 T$ SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de référence '000t | - | - | . 3 | . 3 | . 3 | . 3 | . 3 | . 3 |  |  |  |
| TAC - TPA '000t | - | - | . 3 | . 3 | . 3 | . 3 | . 3 | . 3 |  |  |  |
| Rep.catches-Prises décl. '000t |  | . 3 | . 2 | . 3 | . $4^{2}$ | . $3^{2}$ | . $2^{2}$ |  | . 091 | . 189 | . 411 |
| Unreported catches Prises non-déclarées <br> Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. <br> Sp.biomass-Biomasse Rep. <br> Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour 1979-1992 <br> ${ }^{2}$ Preliminary statistics/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: It is not possible to make a quantitative forecast.
Catches: Catches have exceeded the TAC in 1990 and 1991. The 1992 catches are substantially lower.
Data and Assessment: Biological update based on examination of landings data and limited information on catch composition.

Fishing Mortality:

## Recruitment:

State of the Stock: Landings increased from 1979 to 1990 although there was considerable interannual variability but they have abruptly decreased since. This may indicate lower stock abundance or may be the result of lower fishing effort or lower availability of the halibut.

## Environmental Factors:

Multispecies Considerations:
Long-term Prospects:

### 9.27. GREENLAND HALBUT in $4 R$, 4 S and in $4 T$ SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. ${ }^{1}$ | Med. ${ }^{1}$ | Max. ${ }^{1}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level/Niveau de référence '000t | 5 | - | - | - | - | - | - | 4 |  |  |  |
| TAC - TPA '000t | 5 | 8.9 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 4 |  |  |  |
| Rep.catches-Prises décl. '000t | 6.5 | 11 | 8 | 5 | $2.4{ }^{2}$ | $2.3^{2}$ | $3.4{ }^{2}$ |  | . 7 | 2.3 | 11 |
| Unreported catches Prises non-déclaré |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. Sp.biomass-Biomasse Rep. Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour 1970-1992 <br> ${ }^{2}$ Preliminary statistics/Statis | prov |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Catches are expected to increase as a result of increased fishing effort and perhaps increased abundance.

Catches: Catches have fluctuated as a result of fluctuations in recruitment. Catches increased in 1992 for the first time since 1987.

Data and Assessment: Estimates from a summer research survey suggest that the biomass increased sharply from 1990 to 1991 but only slightly in 1992.

Fishing Mortality: The fishing mortality is not known precisely, but it is likely quite high.
Recruitment: It is too early to estimate recruiting year-classes with precision, but there are some positive signs from the surveys and the shrimpers that recruitment may be increasing.

State of the Stock: The stock was quite low but may be increasing.

## Environmental Factors:

## Multispecies Considerations:

Long-term Prospects: Not known. Will depend on future recruitment. However sustained rebuilding is unlikely unless exploitation rates are decreased substantially.

### 9.28. COD in 4Vn during May to December SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. | Med. ${ }^{1}$ | May. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t | 10 | 6.1 | 7.5 | 7.5 | 7.5 | 7.5-10 | decrease | 1.8 |  |  |  |
| TAC - TPA '000t | 12 | 9 | 7.5 | 7.5 | 7.5 | 10 | 10 | 1.8 |  |  |  |
| Rep.catches-Prises décl. '000t | 12 | 10.5 | 9 | 7.6 | $5.2^{2}$ | $4.6{ }^{2}$ | $4.3{ }^{2}$ |  |  |  |  |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. <br> Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. Sp.biomass-Biomasse Rep. Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: No quantitative forecast possible.
Catches: Catches have decreased rapidly in the last five years, particularly in the fixed gear sector which has been unable to catch its allocation in the past three years.

Data and Assessment: Stock mixing with neighboring stocks in this area precludes an analytical assessment. Research vessel survey biomass estimates are available since 1970. They are highly variable because of stock mixing and small sample size. Information on fishing effort is available only for a small portion of the fleets and is not considered a reliable index of stock size.

Fishing Mortality: Fishing mortality is not estimated precisely, but is likely above $F_{0.1}$.
Recruitment: The 1986 and 1987 year-classes are the only ones above average in the stock. More recent year-classes do not appear strong.

State of the Stock: The longliner catches are very poor, and a major portion of the landings are coming from migrating 4T fish. The stock abundance is very low.

Environmental Factors: Declining abundance may have been exacerbated by cooling trends experienced throughout this general area.

## Multispecies Considerations:

Long-term Prospects: Rebuilding will be slow and may require a substantial reduction in exploitation rate.

### 9.29. REDFISH IN 2+3K

SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. | Med. | Max |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence | 35 | 35 | 35 | 35 | 35 | 20 | 20 | 20 |  |  |  |
| TAC - TPA '000t | 35 | 35 | 35 | 35 | 35 | 20 | $20^{4}$ | $20^{4}$ | $20^{1}$ | $32^{1}$ | $35^{1}$ |
| Rep.catches - Prises ded. '000t | 27 | 19 | 7 | 3 | $2.4{ }^{3}$ | $0.4{ }^{3}$ | $0^{3}$ |  | $\sigma^{2}$ | $25^{2}$ | $130^{2}$ |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Sp.biomass-Biomasse Rep. |  |  |  |  |  |  |  |  |  |  |  |
| Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For 1974-1993/Pour 1974-1993 |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{2}$ For 1960-1992/Pour 1960-1992 |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{3}$ Preliminary statistics/Statistiques provisoires |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{4}$ 1991-1993 TAC - multi-year management plan/1991-1993 TPA - le plan pluri-annuel |  |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: Although there is no information to precisely estimate fishing mortality or exploitation rate generated by recent catches, it is considered that catches in the order of the present TAC ( $20,000 \mathrm{t}$ ) would be very detrimental to the population if achieved.

Catches: Catches since 1960 ranged from 9t to 130,000 t. Between 1961 and 1977, catches averaged about 28,000 t. In the early 1980s, landings ranged from 14,000 to 18,000 t and increased to between 24,000 to 29,000 from 1984 to 1986 in response to improved markets. Since 1986, landings have drastically declined annually to the record low of about $9 t$ in 1992. These reductions have come about because of persistent complaints of external parasite infestation and a diversion of effort by the principal Canadian harvester to other fisheries because of low catch rates.

Data and Assessment The information is not adequate for an analytical assessment. Standardized commercial CPUE shows high variability between some years but indicates a general decrease from 1984 to 1990. Limited fishing effort has occurred since 1990. Research vessel trawl surveys to 2 J and 3 K indicate declines in biomass in both divisions since the early 1980s. Trawlable biomass estimates since 1989 are consistently low in 2 J and 3 K and indicate that the population is at a very low level compared to estimates from the early 1980 s.

## Fishing mortality.

Pecruitment There has been no substantial recruitment since the year-classes of the early 1970 s.
State of the Stock: The stock is at a low level due to poor recruitment. The 1992 survey of Div. 2 J 3 K indicates trawlable biomass to be at an historically low level.

## Environmental Factors:

## Multi-species considerations:

Long-term Prospects: The stock will continue to decline until good recruitment takes place, and prospects for the fishery will not improve until 8-10 years after good recruitment occurs.

### 9.30. Redfish in 30 <br> SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. | Med. | Max. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence '000t | 20 | 20 | 14 | 14 | 14 | 14 | 14 | 14 |  |  |  |
| TAC - TPA '000t | 20 | 20 | 14 | 14 | 14 | $14^{4}$ | $14^{4}$ | $14^{4}$ | $14^{1}$ | $18^{1}$ | $21.9{ }^{1}$ |
| Rep. catches-Prises déc. '000t | 10 | 13 | 11 | 11 | $9^{3}$ | $7.5^{3}$ | $9.5{ }^{3}$ |  | $5^{2}$ | $13.3^{2}$ | $25^{2}$ |
| Unreported catches Prises non-déclarées est. '000t |  | 11 | 13.5 | - | 1.9 | 0.4 | 1.5 |  |  |  |  |
| Est. discards - Rejets est. |  |  |  |  |  |  |  |  |  |  |  |
| Tot. catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Sp.biomass-Biomasse Rep. |  |  |  |  |  |  |  |  |  |  |  |
| Mean F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For 1974-1993/Pour 1974-1 <br> ${ }^{2}$ For 1959-1992/Pour 1959-1 <br> ${ }^{3}$ Preliminary statistics/Statisti <br> ${ }^{4}$ 1991-1993 TAC - multi-year | provis <br> ageme | es plan/1 | 1-1993 | $A-\operatorname{le} p$ | pluri-a |  |  |  |  |  |  |

Forecast for 1994: There is no information upon which to base a forecast of this stock.
Catches: Catches since 1959 have ranged between 5,000t and 25,000t. From 1980 to 1986, an average about 11,000t was taken. In 1987, catches increased to 24,000 and remained at that level in 1988. In 1989 catches declined to 11,000 and have been at this level ever since. The increase in 1987 and 1988 was due to the activity of fleets that are not members of NAFO (primarily those of Panama). Russia and Cuba account for most of the catch. Canada has taken less than 300 t per year since 1983.

Data and Assessment The information is not adequate for an analytical assessment. Estimates of relative abundance from research vessel surveys are associated with high variability and are not considered indicative of population trends. Standardized commercial CPUE shows much interannual variability before 1982. Since 1982 there has been a general decline in this index. The year-classes of the early 1980s are dominant in the fishery.

## Fishing mortality:

Recruitment Relative length distributions indicate a pulse of recruitment that occurred in the spring 1991 survey at mode of 11-12cm corresponding to the 1988-89 year-classes. These year-classes comprised $14 \%$ of the research catch numbers in the 1992 fall survey. The magnitude of these year-classes is unknown but should start recruiting to the fishery by 1996.

State of the Stock. There is no information to determine stock size. The CPUE index is indicating a general decline since 1982 and the contribution expected from the 1988-89 year-classes is unknown. There is no information to precisely estimate fishing mortality or exploitation rate generated by catches that have been in the range of 11,000 since 1989.

## Environmental Factors:

## Multi-spécies Considerations:

Long-term Prospects: Redfish stocks are noted for recruitment occurring only periodically. This leads to wide fluctuations in stock abundance. Given that the incidence of strong year-classes is infrequent and that growth rates are very low, fishing mortalities on redfish stocks must be maintained at low levels.

### 9.31. REDFISH IN LAURENTIAN CHANNEL SUMMARY



Forecast for 1994: Catch rates will decline somewhat until recruitment of the 1984-85 year-classes enters the fishery.
Catches: Catches ranged from 8,100 (1984) to $58,000 \mathrm{t}$ (1971). Catches were in the vicinity of $20,000 \mathrm{t}$ from $1960-1968$, increased to an average of 43,000 from 1969 to 1975 then declined steadily to the lowest on record in 1984 at $8,100 t$. Since 1984, landings increased steadily to 20,000 in 1991. The 1992 catch was 17,000 t.

Data and Assessment The standardized catch rate series shows large increases in 1989 and again in 1990 followed by successive decreases in 1991 and 1992. These are considered too dynamic to reflect changes in abundance. Research vessel trawl surveys are not considered reflective of stock abundance. Production models using catch and standardized effort did not result in reliable parameter estimates.

## Fishing Mortality:

Recruitment: Length frequencies from the 1993 February research survey in Div. 3Ps show two modes, one at $14-15 \mathrm{~cm}$ which corresponds to the 1987-88 year-classes and another at $21-23 \mathrm{~cm}$ which corresponds to the $1984-85$ year-classes. Both of these yearclasses have yet to recruit to the fishery. These pulses together represented about one third of the research catch.

State of the Stock: There is no information to determine estimates of stock size in 1993. The stock appears healthy with the good yearclasses of the early 1980s well represented in the fishery. The exploitable stock should also be augmented by the year-classes of 1984-85 and $1987-88$ in the mid-1990s and again near the turn of the century. There is no information to precisely estimate fishing mortality or the exploitation rate generated by catches that have been in the vicinity of $18,000 \mathrm{t}$ for 1991 and 1992.

## Environmental Factors:

## Multi-species Considerations:

Longterm Prospects: Redfish stocks are noted for recruitment occurring only periodically. This leads to wide fluctuations in stock abundance. Given that the incidence of strong year-classes is infrequent and that growth rates are very low, fishing mortalities on redfish stocks must be maintained at low levels.

### 9.32. WHITE HAKE IN $4 T$ SUMMARY

| Year - Année | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Min. | Med. | Max. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference level - Niveau de référence | . 12 | - | 5.5 | 5.5 | N/A | N/A | N/A | 5.5 |  |  |  |
| TAC - TPA '000t | 12 | 9.4 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | $12.0{ }^{1}$ | $5.5{ }^{1}$ | 5.51 |
| Rep.catches-Prises décl. '000t | 5 | 6.4 | 3.9 | 5.3 | $4.9^{2}$ | 4. $1^{2}$ | $3.5{ }^{2}$ |  | $14.0{ }^{1}$ | $3.5{ }^{1}$ | $6.1^{1}$ |
| Unreported catches Prises non-déclarées |  |  |  |  |  |  |  |  |  |  |  |
| Est.discards - Rejets est. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.catches - Prises Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Tot.biomass-Biomasse Tot. |  |  |  |  |  |  |  |  |  |  |  |
| Sp.biomass-Biomasse Rep. |  |  |  |  |  |  |  |  |  |  |  |
| Mean - F - Moyen |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{1}$ For/Pour 1982-1992 <br> ${ }^{2}$ Preliminary statistics/Statisi | provis |  |  |  |  |  |  |  |  |  |  |

Forecast for 1994: The precautionary TAC of 5,500 appears to represent a high rate of exploitation. However, given the uncertainties about stock definition, there is no firm basis to suggest a modification of the 5,500t TAC.

Catches: Since 1970, the average annual catch of white hake has been 6,100t. During this time, catches have declined from a maximum in 1981 (14,039t) to a minimum in $1992(3,547 t)$, with the greatest decline occurring in the gillnet component. The majority of the landings $(80 \%)$ are taken in the Northumberland Strait, off the western end of P.E.I. and between P.E.I. and Cape Breton Island in July and August.

Data and Assessment An SPA assessment has not been conducted since 1989 due to the lack of a reliable index of abundance and because of concerns about stock definition within the 4T management unit.

Fishing Mortality. An analysis of estimates of instantaneous mortality rates from the 1992 research surveys, suggested that fishing mortality has probably been high (approx. 1.0) during the past several years.

Recruitment Indications from the commercial fishery and research vessel survey are that recruitment has not been above average.
State of the Stock. The research survey data indicates that recruitment has not been above average and that fishing mortality appears to be high. Fewer old white hake were caught in 1990 and 1991, making this fishery even more dependent on a few age classes than in the past. As a result, this fishery will be sensitive to annual fluctuations in recruitment. Research vessel estimates of population abundance. and biomass for 1990 and 1991 were below average for the period 1986-1991.

## Environmental Factors:

Multi-epecies Considerations: White hake are frequently caught by inshore trawlers targeting winter flounder in the Northumberland Strait.

Long-term Prospects: Catches from this resource have averaged 6,100t since 1970 but have declined to a minimum of 3,547t in 1992. Indications are that recruitment has been below average since 1990 and that fishing mortality has been high. Recovery of this resource will depend on the occurrence of favourable recruitment.

## 10. Stock Assessments

The following section contains reports on assessments of 27 groundfish stocks from the northwest Atlantic. Supporting figures are given in section 16 and the figures numbers correspond to the assessment section number. Unless otherwise stated, population numbers and biomasses from sequential population analyses (SPA) are given as beginning of year.

A prognosis summary figure is given for each stock for which an analytical assessment was performed and catch projections made. These figures give catch in year $t$ and adult biomass at the beginning of year $t+1$ as a function of fishing mortality (F) in year t . These are deterministic catch projections and in no way indicate the uncertainties associated with the specific parameters used. The figures summarize catch projections over a broad range of $F(0.0-1.0)$ and provide four points of reference; $F_{0.1}$, twice $F_{0.1}$, the current (beginning of year 1993) adult biomass (on the right axis), and the current (1992) fishing mortality (on the bottom axis).

Reading the projection figures is quite straightforward. In Fig. 10.3j, the catch at any F may be read by moving vertically from the bottom axis to the catch line (solid line) and then horizontally to the left axis (e.g. $20,000 t$ at $F_{0.1}$ ). If one wishes to determine the projected adult biomass at the beginning of 1995 that corresponds to a given $F$, one moves vertically from the bottom axis to the biomass line (dashed), then horizontally to the right axis (e.g. $87,000 t$ at $F_{0.1}$ ). To determine the $F$ in 1994 that would leave a given adult biomass at the beginning of the year 1995, one moves horizontally from the right axis to the biomass line, then vertically to the bottom axis (e.g. 0.88 to leave the current biomass). The associated 1994 catch may be read by moving vertically to the catch line, then horizontally to the left axis.

## General comments on flatfish in 4WWX

American plaice, witch and yellowtail in 4VWX have been managed as a species complex with a single flatfish TAC since the mid-1970s. CAFSAC recommended that it would be more appropriate to assess the species separately and that stocks could be separated into 4 X and 4VW. It was also noted that landings by species were required in order to assess these individual stocks. The 1992 landings of unspecified flounder was the highest in the time series. However, landings in this category have always been high preventing any analysis of commercial landings on a species basis. Before January 1991, unspecified flounder were partitioned by species according to the district in which they were landed. The unspecified category must be partitioned to species in order to provide useful information on the individual stocks.

Winter flounder is also caught on the Scotian Shelf. Because it is not under quota regulation, it is vulnerable to a shift of fishing effort or to misreporting by species as a result of changes in management practices and decreases in other groundfish. Winter flounder is currently increasing in abundance in 4 X although being a more coastal species, a portion of the fishery is outside the survey area. Because it was considered primarily a coastal species and outside the ICNAF convention area it was not considered when the other flatfish species were put under quota regulation.

### 10.1. Cod in Divisions $2 \mathrm{~J}+3 \mathrm{KL}$ (WP 120, 122) C. Bishop, C. Taggart

### 10.1.1. Introduction

Landings from 1959 to 1992 have ranged from a high of 810,000 (1968) to a low of 44,000 t in 1992 (Fig.10.1a,b)

In June 1991, CAFSAC commented on the appropriateness of the 185,000 TAC as incorporated in the longterm management plan. It was concluded that this would allow stock size to increase. The poor commercial fishery of 1991 and much lower than expected research survey results in the autumn of 1991 led to a reassessment of stock status. A preliminary assessment in January 1992 recommended limiting the catch in the first half of 1992 to half that taken in the first half of 1991; that is, in the order of 25,000 . The TAC was reduced to $\mathbf{1 2 0 , 0 0 0}$ in February.

In July 1992, CAFSAC advised that the 2J3KL stock was at an extremely low level; the 3+ blomass and the $7+$ biomass (the latter approximating the spawning stock biomass) estimates were at or near the lowest levels ever observed. The fishery was expected to be dependent on the 1986 and 1987 year-classes with the 1988 year-class being below normal and approximating the low 1983 and 1984 year-classes. Analysis indicated a $1992 \mathrm{~F}_{0.1}$ catch of between 50,000 t and $79,000 \mathrm{t}$. Reported and projected catches by mid-year would account for approximately 35,000 t. CAFSAC recommended that the catch in 1992 be restricted to the lowest possible level. Similar advice was provided after the June 1992 Scientific Council meeting of NAFO. The Canadian offshore fishery was closed in May 1992, and subsequently the entire commercial cod fishery in 2J3KL was closed with the announcement of the cod moratorium in July 1992.

### 10.1.2 Data

## Catch and average weight at age

Sampling data were available only for the Canadian commercial catches and these were used to obtain estimates of catch and average weights at age for the total catch in 1992. Ages 5 and 6 (the 1987 and 1986 year-classes) were most abundant by number in the commercial catch as was the case in 1991. Average weight at age 7 in 1992 was the second lowest since 1977 (Fig.10.1c).

Research vessel survey data
Research vessel surveys have been conducted by Canada during the autumn in divisions $2 \mathrm{~J}, 3 \mathrm{~K}$, and 3 L beginning in 1977, 1978, and 1981 respectively. Biomass and abundance estimates have indicated a declining trend since 1988, especially in Divs. 2J and 3K (Figs 10.1d,e,f). The 1992 estimates for all 3 divisions were the lowest in the time series.

In the autumn 1992 survey, over $80 \%$ of the estimated biomass was located in Div. 3L, and survey catch rates indicated the greatest concentrations of cod in the deeper strata near the shelf break (Fig.10.1g). The 1987 year-class was most abundant in divisions 2J and 3K while in Div. 3L the 1987 and 1988 year-classes dominated. No cod older than age 7 were collected in Division 2J. The autumn survey results indicate that there has been no improvement in recruitment prospects.

Survey time in 1992 was allotted for limited coverage (using the bridge sounder to detect fish, and trawling where possible) of the nearshore areas which are not normally included in the regular survey. Very few cod were encountered in the inshore areas surveyed.

## Additional surveys

Winter (February) hydroacoustic surveys offshore in 1991 to 1993 indicate substantial declines in average density, particularly in 1993. The only significant concentrations were located outside the normal survey area in waters 930m deep where the foreign fleet was fishing. The January 1993 offshore tagging initiative was unable to locate any suitable cod concentrations along the entire shelf break from Hamilton Bank (2J) to the Nose of the Bank (3L) at depths ranging from 150 m to 600 m .

### 10.1.3. Estimation of Stock Parameters

An illustrative sequential population analysis (SPA) suggested that total mortalities were high, as was the case last year. Presently, there is not sufficient information to partition total mortality into fishing and natural components. It would therefore be misleading to present the results either assuming a constant natural mortality (M) of 0.2 or with an arbitrarily increased $M$ in 1991 and 1992. There are no doubts, however, that biomass is extremely low. Based on the 1992 survey, the total biomass could be as low as 100,000150,000t.

### 10.1.4. Discussion

Possible factors effecting the abundance of cod are fishing, biological interactions, and environmental conditions.

## The fishery in 1992

The total estimated cod catch for 2 J 3 KL in 1992 was approximately 44,000 . The reported Canadian commercial catch was $23,796 t$, a commercial catch of 583 t was reported by France; the offshore foreign catch (outside 200 mile-limit on the Nose of the Grand Bank) was estimated by Surveillance Branch at $14,300 \mathrm{t}$ ( $10,750 \mathrm{t}$ of which comes from the European Economic Community (EEC); the EEC has reported $9,532 \mathrm{t}$ to NAFO as of the end of November 1992), and $5,000 \mathrm{t}$ estimated from the inshore "recreational fishery". The latter estimate is based on a combination of information supplied by DFO and the United Fish, Food, and Allied Workers Union.

No commercial catch was reported from Div. 2J. Almost all (95\%) of the Canadian catch was taken in Div. 3L over the period of January to May 1992. Approximately $30 \%$ of the total Canadian catch was taken by the recreational fishery using jiggers or baited hooks. The Canadian offshore otter trawl fishery was typified by low catch rates and catches of small fish.

A continuing fishery may retard the recovery. It was noted that the survey abundance estimates showed a greater decline in 2 J and 3 K while most of the fishery occurred in 3L. The autumn surveys were conducted in the offshore areas and do not provide the status of potential inshore stocks. The impact of recreational fisheries on these stocks is not known.

## Biological and environmental considerations

The following biological and environmental information is drawn from a meeting of Fisheries Oceanography Subcommittee (March 1993), and the Northern Cod Hypotheses Workshop (Jan. 1993) and are presented as important ancillary information to be considered in assessing the status of the 2 J 3 KL cod stock(s).

## Biological considerations

There are indications from trawl and acoustic surveys, and from the commercial fisheries that the recent decline in stock biomass was abrupt and occurred between January and June 1992. Other interpretations of the data suggested a more gradual decline that began first in the north (2J) in 1990 and propagated southward. The survey shows that changes in distribution were taking place prior to 1991 (Fig.10.1g) and the biomass of other commercial and non-commercial demersal species declined gradually during the 1980s (Fig.10.1h).

There is a significant non-linear relationship between area occupied and biomass for most species, in each division. This relationship has important assessment consequences as catchability will increase with
decreasing stock distribution, causing increased fishing mortality per unit effort. This may have happened with northern cod as the autumn 1992 survey showed a concentration of cod in the deeper portion of Div. 3L near the shelf break (Fig. 10.1g)

Declines were also observed in capelin biomass during the 1990s. Offshore acoustic surveys consistently failed to detect large concentrations beginning in the autumn of 1990, although information from inshore indices suggests that biomass has remained normal or above normal for the period. If capelin biomass has not declined, then results from recent acoustic surveys would suggest distribution or behaviourial changes.

The condition of cod according to body and liver indices in 1977-92 both indicate declining trends in 2 J and 3K from 1989 onward with the decline being most pronounced in 2J. Cod feeding data from 1978 and 1980-91 indicate that stomach fullness indices in 1991, when capelin abundance was relatively low, were not substantially lower than in 1978, 1980 and 1982.

There is considerable interannual variation in size and age of maturity, but cod were mature at a considerably smaller size in 1992. In all three divisions females mature at a later age and larger size than males. Older female cod begin annual maturation later than younger females and males are in spawning condition for a longer period than females. The reduction in the proportion of older individuals will likely reduce the duration of spawning. This may have two consequences: increased recruitment variability, and reduced probability of good recruitment. It was also determined that the number of recrults required to maintain the spawner biomass has increased steadily since 1980 as a consequence of reduced weights at age (see Section 13.3).

Inshore spawning may have provided a considerably larger contribution to recrultment in coastal regions than previously thought. Published information on spawning distributions has shown that spawning occurs on the outer edges of the offshore banks (Fitzpatrick and Miller 1989). This had been interpreted as representing the main spawning component of the stock. However, analysis of data from 1946 to 1992 indicated that spawning can occur across the entire 2 J 3 KL shelf to within 10 km of the coast in eastern Newfoundland and southeastern Labrador.

Inshore trap landings in Bonavista and Trinity bays generally start one month earlier in the inner reaches of the bays relative to the outer reaches suggesting the earlier landings may be derived from cod overwintering in the nearshore and later landings derived from offshore-to-inshore migrants. The regional timing pattern of inshore landings varies among years (relatively high landings in the north and west while poor in the south and east and vice-versa). The pivot for oscillations appears to be in the area of Baie Verte Peninsula.

Juvenile survey data from 1992 indicate that 0-group cod were restricted to the inshore bays. One and two year-old cod occurred on the shelf but were most abundant within the inshore bays. By age $3+$, cod were distributed more abundantly over the shelf and at the shelf edge, although the highest catch occurred inshore. These results indicate that inshore abundance of juvenile cod was high relative to that offshore. There were few juvenile cod observed offshore in 1992, when compared with the historical distributions of young cod in the autumn research vessel surveys (1981-82) and to pelagic 0-group cod surveyed in 1981.

## Environmental considerations

Near record low air temperatures persisted throughout 1992 in coastal regions bordering the Labrador Sea. Cold air and strong northwesterly winds during winter resulted in earlier ice formation, greater extent and later retreat than normal.

Station-27 water temperatures for 1992 were generally below normal throughout the water column. Nearbottom temperatures were slightly warmer than in 1991 but continue the pattern of below normal values as observed since 1983. Station-27 salinities were below normal through most of 1992. The summer areal extent
of the cold intermediate layer decreased relative to 1991 but was still larger than normal. The generally cold conditions observed during the 1990s are similar to those observed in the early 1970s and mid-1980s. Surface temperatures over the 2J3KL survey area were 1.0 to 2.0 degrees below the long-term average during November 1992 and 1.0 to 3.0 degrees below the 1991 values for the same period. Bottom temperatures over the 2J3KL survey area in the autumn 1992 were as much as 1.0 degree below the 19801990 average. Negative bottom temperature anomalies were mainly restricted to Div. 3L in 1991, but were distributed throughout 2J3KL in 1992. Oxygen levels in June 1992 at depths greater than 200m over a large part of the shelf in the Cape Bonavista area were below $75 \%$ saturation. Cod are believed to become stressed when the water is below $60 \%$ oxygen saturation. Oxygen minima were associated with salinities of 34.25-34.50 psu and located in the "cod migration corridor". No data are avallable for previous years.

The North Atlantic oscillation (barometric pressure difference between Azores and Iceland) has shown a positive (cold winters) trend over the last several years and the continuing poor growth and recrultment in northern cod may be associated with this trend. Predictions of recent recruitment are not high, based on a combination of spawning biomass and salinity-based models.

### 10.1.5. Prognosis

Although a moratorium was in effect during the last half of 1992, it is estimated that about 5,000 or more were taken by the "recreational" fishery. Research vessel survey biomass and abundance estimates in 1992 were the lowest observed in the time series.

Data from a 1993 winter hydroacoustic survey indicate very low densities with cod being most abundant at depths in excess of 900 m in the area of the Nose of the Bank. The foreign fleet was also observed fishing in the same area. Surveillance Branch has verified that there was cod directed effort in this area in 1993 and that the catch may have been in the order of $3,000-4,000 \mathrm{t}$.

Any recovery in 2J3KL cod depends on the appearance and survival of strong year-classes like those seen in 1986 and 1987. The population appears to have continued to decline in 1992, even in areas in which no fishing occurred. The recreational fishery is likely to be harvesting inshore populations which may be important for stock rebuilding. Growth of the offshore populations may be compromised by harvesting in offshore areas.

The significance of predation by harp seals must be viewed in the context that only 2 of 122 harp seals captured away from areas of offshore commercial fishing contained significant amounts of cod in their stomachs, while seals near fishing vessels had eaten cod predominantly less than 41 cm , some of which may have been discards. Investigations of seal diets that take into account the distribution of seals throughour the year are being developed to estimate actual volumes of dietary items.

The decline in the 2J3KL stock appears to be continuing even in areas where there was no fishing in 1992. The 1992 research vessel biomass index decreased by $70 \%$. There are a number of environmental, biological and fishery related factors that have, and are likely to continue to contribute to declines. Any recovery will depend on the appearance of and survival of strong year-classes. The 1986 and 1987 yearclasses which had previously been estimated as above average have decreased substantially in abundance and they are now below average. The 1988-1991 year-classes are all expected to be below average in abundance. Recovery of the spawning stock biomass is unlikely for several years.

10.2. Cod in Subdivision 3Ps (WP 121, 136) C. Bishop, E. Murphy, D.B. Atkinson

### 10.2.1. Description of the Fishery

Nominal catches were highest from 1959 to 1974 (average of 62,000t) and peaked at 84,000t in 1961. They then gradually declined to a low of 27,000 in 1978 (Fig. 10.2a). From 1985 to 1987, catches averaged 50,000 mainly due to increased catches by France. The 1992 catch was only about 32,000 t, reflecting a decline in French offshore and Canadian inshore catches by about 8,500t and 3,300t respectively.

Since 1976 only Canada and France have participated in the fishery. Catches by inshore gear (trap, gillnet, longline and handline) have traditionally accounted for the largest portion of the total Canadian catches and these ranged between 20,000 and 29,000 t since 1976 with a decline to 18,000 in 1992 (Fig. 10.2b). The longline fishery takes the largest portion of the total inshore catch followed by gillnet, trap and handline.

French catches since 1959 have been taken by a metropolitan France freezer fleet (METRO) and by inshore and offshore fleets based in St. Pierre and Miquelon (SPM). From 1959 to 1977, most of the SPM catch was caught by the inshore fleet, with the largest catch ( $3,800 \mathrm{t}$ ) occurring in 1961. Catches by this gear have declined to less than 500t in recent years. Offshore catches by SPM trawlers increased from about 200 t in 1975-76 to between 10,000t and 16,000t since 1985, but declined to about 8,000 in 1992. METRO catch was highest in 1986 at about 12,000 because of the diversion of fishing effort from the Gulf of St. Lawrence. Catches declined rapidly thereafter, and the fleet has not fished in Subdiv. 3Ps since 1989.

There were no catches by the French otter trawl fleet for the first quarter of 1993 because of a dispute with Canada concerning allocations in the Canadian zone.

As reported last year, in recent years an increasing portion of the winter otter trawl catch has boen taken in deeper waters. This effort was not as pronounced in the 1993 winter fishery although there were catches at depths greater than those covered in the surveys.

### 10.2.2. Data

## Catch and weight-at-age

Sampling data from the 1992 Canadian fishery were used to estimate catch-at-age and mean weight-at-age for this component. Similar data for the French catches in 1992 were provided by the IFREMER St. Pierre and Miquelon laboratory. Ages 5 and 6 (1986 and 1987 year-classes) dominated both fisheries. Weights at age show a gradual cyclic decrease (Fig. 10.2c).

## Commercial catch and effort data

During previous assessments, various problems were noted with the catch rate data. Rates from the French fleet were difficult to interpret because of possible learning over time, the considerable fluctuations in catch, and possible influences of fishing area restrictions. Catch-rate-at-age data from the Canadian fisheries indicated that there were substantial fluctuations in the age structure of the catch. These problems have not been resolved and consequently these data were not used in calibrations.

## Research vessel surveys

Stratified-random bottom trawl surveys have been conducted in Subdiv. 3Ps by Canada beginning in 1972 and France beginning in 1978. The French surveys were conducted by the research vessels Cryos (1978-91)
and Thalassa (1992). Comparable fishing data between these two vessels are not avallable and the Thalassa data were therefore not used. The French discontinued their surveys after 1992.

Biomass estimates from Canadian surveys (Fig. 10.2d) showed an increasing trend in the mid-1980s peaking at $60 \mathrm{~kg} / \mathrm{tow}$ in 1988. This was followed by a decline in 1989, slight increases in both 1990 and 1991, then a substantial decline in 1992 to about $12 \mathrm{~kg} / \mathrm{tow}$. Concern was expressed last year about these results because of evidence of fishing outside the survey area. In order to address this, two surveys were conducted by Canada in 1993, one in February and another in April. A further decline in the biomass index was observed, and the 1992-93 results are among the lowest estimates observed in the time series.

Ageing data were available from the February 1993 survey, but not the April survey. Mean number-per-tow estimates indicated that the 1987 and 1989 year-classes were most abundant.

### 10.2.3. Estimation of Stock Parameters

A number of formulations of ADAPT were tried incorporating the research vessel indices. These included using both Canadian (1978-1993) and French (1978-1991) indices, and the Canadian index alone. The assumptions of both flat topped and dome shaped partial recruitments were examined. The Laurec-Shepherd method was also carried out using the Canadian index only. Residual patterns indicated strong year effects and suggested a poor fit in all cases. In addition, the resulting age 4+ population estimate did not track the age 4+ survey estimate. Although the Canadian survey indicated a substantial decline in 1992 and 1993, the population estimates did not. It was concluded that calibrations of SPA were not possible with these indices.

Based on the above results and on multiplicative analyses of catch-at-age from research surveys and the commercial fishery it was concluded that fishing mortality in recent years has probably been in the range of 0.5 to 0.9 . An illustrative SPA using $\mathrm{F}=0.70$ was conducted to demonstrate stock size trends. With a reduction in the French fishery in 1992, some decrease in effort would be expected. Anecdotal information suggests that there was some increase in the inshore effort in recent years but the magnitude cannot be determined. Partial recrultment was assumed to be flat topped and equal to the average of the last 3 years (1990-1992).

### 10.2.4. Assessment Results

The results of the illustrative SPA suggest that the age 3+ population peaked around 1984-1985 but decreased in recent years, and may now be at or near the lowest level observed during the time series. (Fig 10.2 e ). The $7+$ biomass also decreased during this period.

Fishing mortalities on fully recruited ages ( $6+$ ) peaked (1974) just before the extension of jurisdiction then dropped rapidly to the lowest observed in 1976 (Fig. 10.2f). Since then there has been a gradual increasing trend in Fs. During the late 1980s they were well in excess of twice $\mathrm{F}_{0.1}$.

### 10.2.5. Prognosis

Last year concerns were expressed about the reliability of the survey estimates of stock size because of questions about the distribution of the fish relative to the survey coverage. Results from both surveys in 1993 support the decline observed in 1992. Possible movements of fish between 3Ps and other regions outside the stock or survey area may also confound this issue.

Results from the illustrative SPA indicate that fully recruited fishing mortalities have been greater than twice $F_{0.1}$ since the extension of jurisdiction, and have been gradually increasing since that time. There has been a gradual decline in stock size through the second half of the 1980s. Some decrease in the rate of decline can be expected because of recruitment of the relatively strong 1987 and 1989 year-classes. It is expected that the 1993 TAC of 20,000 will generate fishing mortalities greater than $F_{0.1}$. Increases in stock size cannot be anticipated at this time unless there is a considerable reduction of fishing effort and an improvement in recruitment.

### 10.2.6. Research Recommendations

It is recommended that the working group being established by the Fisheries Oceanography Subcommittee, review cod tagging data as well as examine the historical survey data (and commercial data) in detail to address the issue of cod stock mixing in the 3Pn-3Ps area.

### 10.3. Cod in Divisions 3Pn,4RS (WP 106, 130) A. Fréchet

### 10.3.1. Description of the Fishery

## Nominal catches

Landings reached a peak of 106,000 in 1983 then steadily declined to an historic low of 29,000t in 1992. Only 1,459 had been landed to the $21^{\text {st }}$ of April in 1993 compared to 6,500 (domestic) and $1,432 \mathrm{for} \mathrm{St}$. Pierre and Miquelon for the same time period in 1992 (Figs. 10.3a,b). This is due to a combination of late approval of the conservation plan (mid-February), strikes caused by mandatory gutting at sea, issues concerning dockside monitoring, prices and severe ice cover and gear conversions. Catch to date of the offshore fleet was approximately $60 \%$ of last year. The offshore harvesting plan was approved in midJanuary, a month before the ITQ fleet started fishing. Problems with enforcement have existed in this fishery in the past. Beginning in 1991, efforts were made to improve enforcement measures through increased observer coverage, monitoring of small fish and closures of areas of small fish to trawiers (Stralt of Belle Isle).

## Fish distribution

Monthly maps of catches from the mobile gear fleet indicated that northern Gulf cod moved into northern 3Ps during February and March in 1991 and 1992. This may have affected the abundance estimates derived for the northern Gulf cod stock from the winter surveys.

## Environmental conditions

Very heavy ice cover during the winter of 1992 limited the winter fishery. The spring fishery along the Quebec North Shore (4S) did not begin until July because of heavy ice.

An examination of the relationship between the 200-300 meter temperature anomaly in Cabot Strait and the depth distribution of cod during the winter survey indicated a weak negative relationship.

### 10.3.2. Data

## Catch and weights at age

The 1989 catch at age was recalculated since the NAFO statistics were published. The landings for 1989 increased by 251t (less than 1 percent). Sampling of the 1992 fishery was above previous years given the increased observer coverage aboard otter trawiers.

The sum of the 1992 catch at age numbers is the lowest since 1974 with most of the catch composed of the 1987 year-class (age 5). The percentage of fish of $6+$ was the lowest since 1974. Weights at age in 1992 are the lowest since 1974 (Fig. 10.3c.)

## Commercial catch rates

As has been the case in the last few assessments of this stock, the commercial CPUE has not been used for calibration purposes because of conflicting trends in CPUE for various fleets. Technological changes may have a significant impact on these trends. Work is ongoing to derive a new CPUE index based on individual vessels. Late arrival of the analytical ZIF this year has prevented this analysis to be done.

Research survey data.

## Winter surveys

Biomass estimates from the winter survey varied between 100,000t and 200,000t in 1978 and 1983 and increased by a factor of two in 1984 and 1986 before suddenly declining in 1987 (Fig. 10.3d). Results from the 1991 survey indicated a significant increase in abundance. The 1992 survey suggested that the biomass had remained stable, but the 1993 biomass estimate is very low (comparable to the 1987 and 1989 survey results).

The winter survey occurs at a time when fish are actively migrating and small differences in the timing of the surveys may provide a different view of the distribution of the fish. This should not affect the biomass estimates from this survey, however as noted in the past, northern Gulf cod may migrate into 3Ps in the winter. The 1993 survey covered Subdiv. 3Pn in two legs. In the first pass, the average catch was 1051 $\mathrm{kg} / \mathrm{tow}$ ( 10 sets, CV $139 \%$ ) whereas the mean was only $183 \mathrm{~kg} / \mathrm{tow}$ in the second leg ( 12 sets, CV 148\%). It is not known whether these differences are due to sampling variability or if the fish had moved to adjacent areas ( $3 \mathrm{Ps}, 4 \mathrm{Vn}$ ). During the 3 Ps survey (conducted two weeks later), $67 \%$ of the estimated cod biomass came from a single strata adjacent to Subdivision 3Pn, giving some support to the hypothesis that northern Gulf cod had moved in 3Ps. This was substantiated by monthly maps of otter trawl activity intruding into 3Ps in February and March. Examination of the age structure of the 3Ps population shows a higher proportion of age 4 fish.

It was difficult to assess at this point if significant numbers of Gulf fish had moved in 3Ps by the time of the second leg and it was decided to consider the total estimate from the survey as the population estimate for 3Pn 4RS cod in 1993. A working group of Fisheries Oceanography Subcommittee will examine the movement of cod and redfish stocks in the Cabot Strait area and may be able to shed some light on this problem in the future.

## Summer surveys

The research vessel Alfred Needler has been conducting joint shrimp/redfish surveys in divisions 4RST since 1990 using a shrimp trawl. New strata were added to the 1991 survey to estimate cod abundance in shallow
waters. Five new strata along the west coast of Newfoundland and the extension of survey coverage in the Strait of Belle-Isle accounted for half of the survey biomass in 1991 and 1992. The biomass estimate from the 1992 summer survey was down by $66 \%$ relative to the 1991 survey.

It is probable that the Gadus Atlantica winter survey which started in 1978 will be discontinued after January 1994 and the index of abundance will be based on the results of the Affred Needler summer survey. The time series of the summer survey is short, starting in 1990, and it has never covered Subdiv. 3Pn. The Affred Needler summer survey was primarily developed as a shrimp/redfish survey. A shrimp net is used, tows are of 20 minutes duration on bottom and done at a speed of 2.5 knots. A comparison of the estimated population length frequencies show general agreement between both surveys until 50 cm in length, but the Afred Needler catches fewer fish over 50 cm . The 3 year long series will be included in the next assessment of this stock along with the results of the winter survey in order to better ascertain the usefulness of this index of abundance.

With the withdrawal of the winter survey and the use of the summer survey, the quality of the assessment may be affected. However this may be counteracted by the addition of new indices of abundance. The index fisherman program started in 1990 and the new commercial catch rate series based on individual vessels may show some promising avenues.

### 10.3.3. Estimation of Stock Parameters

## Sequential population analysis

The ADAPT framework was used to calibrate the SPA for this stock with the following conditions:
Parameters estimated

- Year-class estimates $\left\{\mathrm{N}_{.1993}(\mathrm{I}=3,13)\right\}$
- Calibration constants for RV population estimates $\left\{\mathrm{K}_{( }(\mathrm{l}=3,13)\right\}$

Framework
The formulation used results of the January RV using log residuals. The structure imposed is as follows:

- Error in catch assumed negligible
- No intercept was fitted
- M=0.2
- F on age 13 set equal to arithmetic mean over ages 7-9.

Input data

- Catch at age $\left\{G_{1}(\mathrm{i}=3,13, \mathrm{t}=1974,1992)\right\}$
- R. V. population estimates $\left\{\mathrm{RV}_{\mathrm{t}, \mathrm{t}}(\mathrm{i}=3,13, \mathrm{t}=1978,1993)\right\}$ (no survey in 1982)

Objective function

- Minimise $\Sigma_{\mathrm{tt}}\left(\left(\ln R V_{\mathrm{i}, \mathrm{t}}\right)-\left(\text { Ink } N_{\mathrm{t}}\right)\right)^{2}$


## Summary

- Number of observations: 165
- Number of parameters: 22

The formulation in ADAPT was similar to that used last year. Residuals show strong yearly effects, indicative of large inter-annual variations in the RV index. Bias adjustments were applied to the 1993 estimated population numbers and resulted in a $16 \%$ reduction of $3+$ beginning of year numbers.

### 10.3.4. Assessment Results

## Population abundance

The 3+ population numbers reached an historic low of 200 million fish in 1988, increased slightly to 1990 and have remained stable (Fig.10.3e). Cvs from the ADAPT calibration for population estimates were high, hence an analysis of the retrospective pattern is recommended.

## Recruitment

As was noted in the last assessment of this resource, the 1986 and 1987 year-classes were relatively abundant (Fig. 10.3f). These are preceded and followed by very small year-classes, the 1989 year-class at age 3 in 1992 is the second lowest in the time series. The estimate of the 1990 year-class, 100 million at age 3 , is about equal to the average but is not precisely estimated. This year-class was estimated to be strong in the 1991 Affred Needler summer survey but not in the 1992 survey. The proportion of the 1994 catch from the 1990 year-class is expected to be low.

## Population biomass

The $3+$ biomass is 172,000 in January 1992 and has been stable at this level since 1987 (Fig. 10.3g). The $19927+$ biomass is the lowest since 1974 and is estimated to be 29,000t (Fig. 10.3h).

Fishing mortality
Results from the current calibration indicate consistently high fishing mortalities since 1974 between 0.36 and 0.86 (in 1987). The 1992 fishing mortality is estimated to be 0.51 (Fig. 10.3i).

### 10.3.5. Prognosis

The following parameters were used for catch projections:

| Age | January 1993 population <br> numbers (bias adjusted) | Average Weight (kg) | Partial Recrultment |
| ---: | :---: | :---: | :---: |
| 3 | 100810 | 0.463 | 0.007 |
| 4 | 39714 | 0.606 | 0.101 |
| 5 | 37368 | 0.793 | 0.332 |
| 6 | 66278 | 1.006 | 0.665 |
| 7 | 26830 | 1.290 | 1.000 |
| 8 | 4925 | 1.501 | 1.000 |
| 9 | 1983 | 1.745 | 1.000 |
| 10 | 1693 | 1.977 | 1.000 |
| 11 | 1071 | 2.274 | 1.000 |
| 12 | 155 | 2.227 | 1.000 |
| 13 | 203 | 2.922 | 1.000 |

Partial recruitment was derived from average fishing mortalities from 1990 to 1992. Weights at age were calculated as average weights at age from the commercial fishery in 1992. This was done to take into account the trend for decreased weights at age from the commercial fishery. Incoming recrultment for 1994 at age 3 was set at the geometric mean recruitment of the time series.

Assuming the 31,000 TAC for 1993 is caught, this would result in a fully recrulted fishing mortality of 0.34 in 1993. Catches at $F_{0.1}$ of 0.2 for 1994 would be $20,000 \mathrm{t}$. A summary of projected 1994 catches and the resulting 1995 adult biomasses at various levels of fishing mortality in 1994 are shown in Fig. 10.3j.

Despite aiming to achieve an exploitation rate consistent with a $\mathrm{F}_{0.1}$ strategy, the resulting fishing mortality rates have been about twice that high. Though the reasons for this are not fully understood, it may be prudent to aim for a fishing mortality lower than $F_{0.1}$ if the objective is to attain this level.

### 10.3.6. Research Recommendations

1. Pursue the analysis of vessel specific catch rates that include considerations of technological changes based on results of a survey that was conducted recently.
2. Examine the extent of the winter migration of cod into Subdiv. 3Ps according to historical surveys conducted by Quebec and Newfoundland regions as well as from Saint Pierre and Miquelon.
3. It is recommended that the 3 year long time series from the Alfred Needler be considered in the next assessment.
4. The retrospective pattern for this stock should be investigated with attempts to identify the causes.

### 10.4. Cod in $4 T-V n(J .-A).(W P ~ 92,118) ~ G . ~ C h o u i n a r d ~$

### 10.4.1 Description of the Fishery

Nominal catches in the time period beginning in 1950 have varied from 104,000t in 1956 to 22,000 in 1977 (Fig. 10.4a). Between 1980 and 1986, the catch averaged about 60,000 . Catches varied between $53,000 \mathrm{t}$ and 55,000 (including catches made in 4 Vs ) from 1987 to 1990. Catches declined to 47,000 in 1991. The nominal catch for 1992 was 38,666 (including 4,358t estimated in 4 Vs ); approximately 4,000t lower than the 1992 TAC of $43,000 \mathrm{t}$. Revised catch statistics were available and resulted in increases of about 2,000 and 4,000 for 1989 and 1991 respectively. The shortfall in catches within the stock unit was almost entirely due to the failure in the fixed gear fishery.

Landings by Canada in the 1992 4Vn (Jan.-Apr.) winter fishery were 5,084t and were mostly taken with otter trawls. The French catch was 1,610 d during the same period. The fishery in 4 T was delayed due to severe ice conditions that persisted until the second week of May. Contrary to the normal pattern, the fishery was concentrated in eastern 4T (4Tf and 4Tg) for most of the months of May and June. Landings from western 4 T (4Tn and 4To) peaked in July compared to June in previous years. The proportion of the catch in 4 T taken in the autumn (September-December) decreased from about 48\% in 1991 to $41 \%$ in 1992.

Landings by fixed gears ( $3,742 \mathrm{t}$ ) continued their decline and were the lowest in the time series beginning in 1965 (Fig. 10.4b). The fishery in 1992 was again marked by several closures for the mobile gear fleets when catches of cod less than 41 cm exceeded $15 \%$ by weight. Catches to date in 1993 amount to approximately $1,200 \mathrm{t}$. Information from observers indicates that the average mesh size used in the 4 Vn fishery increased from about 140 mm in 1992 to 155 mm in 1993.

Information received from fishers (meetings and the index fishers program) indicated that they considered that stock abundance in recent years was considerably lower than it was in the mid-1980s. They thought that cod was scarce in 1992 and the fish that were caught were small. They thought that the decline in catch rates seen in recent years was likely underestimated, given the technological advances that they have made over the last few years.

Movement of $4 \mathrm{~T}-\mathrm{Vn}$ (J.-A.) cod into 4 Vn occurs before the end of the year, around November-December, and should be considered in the management of the stock (also see section 11).

### 10.4.2 Data

## Catch and weight at age

In 1992, the catch at age was dominated by the 1987 year-class (age 5) which comprised over $31 \%$ of the numbers caught and was the highest numbers recorded since 1980. Previous estimates of the 1987 yearclass indicated that it is much less abundant than the 1980 year-class and the large numbers seen in the catch at age probably indicate that this year-class was targeted in 1992. The strong year-classes of 19791980 (age 11 and 12) which supported the fishery in the mid-1980s were not very abundant in the catches. About $75 \%$ of the numbers landed were less than 51 cm .

Average weights for younger ages (3 to 7) were similar to those in 1990 and 1991. The average weights for ages 8 to 10 were greater than in 1991 and have been increasing since 1989. Average weights for ages 11 to 14 were larger than in 1991. Despite recent increases, weights at age remain considerably lower than those observed in the 1970s (Fig. 10.4c).

## Commercial catch rates

Standardized catch rates for otter trawlers and seiners were calculated using a multiplicative model. An analysis of otter trawl catch rates was conducted on data from 1966 to 1992. To reduce the effect of increases in efficiency of the fleet and in the regulated mesh size on the index, an analysis was conducted on data from 1982 to 1992 only. Catch rate analyses of a series of vessels involved in the fishery since 1985 (otter trawl and seiners) were also conducted. The analyses generally indicated higher catch rates in the period 1986 to 1988 and a subsequent decline to 1991. Catch rates in 1992 were higher than in 1991 but still 40 to $50 \%$ lower than in 1986-1988 (Fig. 10.4d).

A catch rate at age index for otter trawlers was obtained by dividing the otter trawl catch at age by otter trawl effort derived from the standardization of catch rates for the period 1982-1992. Results indicate that the catch rates of ages 4 to 6 were the highest in the time series while those for ages 7 to 11 were amongst the lowest.

The presence of density-dependent changes in catchability, which could explain the increase catch rates on these age groups, was examined by the Statistics, Sampling and Surveys Subcommittee but results indicated that these were likely not the cause of this increase in catch rates.

## Discarding practices

Estimates of discards of cod by the mobile gear fleet in Div. 4T were obtained from the Gulf and Quebec observer programs and indicated a discard rate of $11.1 \%$ by weight in 1992. Revised estimates of the discard rate for 1991 indicate that it was 10.4\%. Discard rates in 4 Vn for 1991 and 1992, calculated from data obtained from the Scotia-Fundy International Observer Program, were 6.0 and $3.4 \%$ by weight respectively. During 1992, the percentage of cod less than 41 cm in the catches (discards and landings) was $15 \%$ by weight ( $29 \%$ by numbers).

## Research survey data

In 1992, the research vessel Alfred Needler replaced the Lady Hammond for the abundance survey. Prior to the change, a comparative fishing experiment was conducted and it was found that the Alfred Needler was more efficient than the Lady Hammond in shallow waters. The following correction was applied to the 1992 results to make them comparable with the earlier years.

$$
I_{\mathrm{gIft}}=-0.4895+0.0046 \text { depth }
$$

where $I_{n_{\text {diff }}}=$ log-transformed catch of cod by the Lady Hammond minus the log-transformed catch of cod by the Affred Needler

Mean numbers per tow (age 3 and older) are about $49 \%$ lower than observed in 1991 (Fig. 10.4e). Survey estimates have been declining since about 1986. Coefficient of variations varied between 13 and $23 \%$ for the most abundant age-groups (2-12). The 1988 and 1987 year-classes (age 4 and 5) were the most abundant in the 1992 survey, however they were the lowest observed at those ages since 1977. The abundance of age 5 and older (spawning fish) continued to decline (Fig. 10.4f). The survey indicated that abundance of recent year-classes are probably low.

The geographic distribution at age in the survey was relatively similar to previous years except for a concentration of young cod (ages 2-4) found south of the Magdalen Islands. The bathymetric distribution of young cod (ages 3 and 4) indicated that they were found in shallow waters conforming to patterns
observed during periods of low abundance. Older cod (ages 5 to $8+$ ) tended to be found in deeper waters than observed previously but well within the survey area. The average temperatures of waters occupied by cod in 1992 were among the coldest since 1971.

A survey for juvenile cod has been conducted each July-August since 1990 in area 471 which was previously identified as an area of high juvenile (ages 0-2) concentration (Chouinard et al. 1991). Estimates of recruitment derived from the juvenile survey were consistent with observations from the September survey and do not indicate strong incoming year-classes.

### 10.4.3. Estimation of Stock Parameters

## Mortality rates and recruitment from abundance indices

The two indices of abundance (otter trawl catch rate at age and the research survey mean numbers per tow at age) were analyzed using multiplicative models which account for age and year-class effects.

The slope of the descending limb of the age effects from the models were calculated as estimates of total mortality. The analyses were conducted for 5 -years moving windows and indicated increasing $Z$ (total mortality) over the last 12 years. Analyses of the research vessel and otter trawl catch rate at age were consistent and indicated that $Z$ for the last-time period averaged 0.7.

Another analysis was conducted to obtain a recruitment index. In this analysis, the mean catch per tow at age and by stratum was modelled as a function of the age, year-class, stratum, and an age*stratum interaction (Sinclair and Chouinard 1992). The year-class index derived from the analysis indicated that the 1987 year-class was about average in strength while the 1988 to 1990 year-classes were below average.

## Calibration of SPA with an integrated model (ADAPT), Laurec-Shepherd, Hybrid and XSA methods

Previous analyses presented to the Statistics, Sampling and Surveys Subcommittee have indicated changes in catchability in the research vessel survey index around 1977-1978 and increases in catchability with the commercial catch rate index in recent years. To reduce the effects of these changes in catchability on the results, only the years 1978 to 1992 were used for the research vessel index and 1982 to 1992 for the commercial catch rate index. In addition, the increasing trend in catchabilities in the commercial catch rate needed to be taken into account.

Several analyses using both indices and the various methods (see Mohn and Cook 1993 for details) were conducted, however most indicated strong retrospective patterns (with regards to sign and not magnitude) with the exception of the Hybrid method which incorporated a trend in the commercial catch rate catchabilities. Interpretation of retrospective patterns assumes that the converged portion of the SPA reflects the truth. The fishing mortality trends were consistent with effort trends derived from the standardization of catch rates. F (ages 7-12) was estimated at 0.85 in 1992. The Hybrid method results tended to have a higher year to year variance.

Analyses were conducted with each index separately. The analyses with the commercial catch rate did not indicate a large decrease in population abundance and were considered to be optimistic. A LaurecShepherd analysis, using the research vessel index, indicated a large increase in fishing mortality from 1991 to 1992 ( F (ages 7-12) increased from 1.0 to 1.4). This is due to the low survey results in 1992. These results are not consistent with the commercial effort trends from the standardization of catch rates which indicates a decrease in effort in 1992. However, this could reflect a change in catchabillty or an increase in natural mortality in 1992, in which case, the results would reflect stock abundance. Consequently, they should not be dismissed.

An analysis using ADAPT and the research vessel index with the following formulation was conducted:

## Parameters

- $\quad$ survivors at the end of 1992 for ages 3 to 10
- calibration constants for RV mean numbers/tow for ages 3 to 10

Framework

- $\quad$ F on ages 11-12 set to unweighted $F$ for ages 7 to 10
- $\quad$ F on ages 13-14 set to unweighted $F$ for ages 7 to 12
- plus group at age $14+$
- $\quad$ natural mortality $=0.2$
- log model with no intercept
- assumed no error in catch

Input data
catch at age (ages 3 to 14+) for 1971 to 1992

- RV mean numbers/tow (ages 3 to 10) for 1978 to 1992
- minimize

$$
\sum_{i, t}\left[o b s\left(\ln R V_{i, t}\right)-p r e d\left(\ln R V_{i, t}\right)\right]^{2}
$$

## Summary

number of observations $=120$
number of parameters $=16$
It indicated $F$ (ages 7-12) of about 1.0 and the trends in $F$ were consistent with effort trends. A retrospective pattern was apparent in the analysis. Population estimates were relatively similar to estimates derived from the Hybrid method.

As indicated earlier, the Hybrid (both indices) and the ADAPT (RV index) analyses gave results which were more consistent with effort trends in the commercial fishery and were considered to represent population trends in recent years. Of the analyses conducted, the Hybrid results were preferred because of the lack of a retrospective pattern. However, given the possibility that there could have been changes in catchability or increase in natural mortality in 1992; the results from the Hybrid analysis should be considered as preliminary until results from the 1993 survey are available in the autumn. If results of the 1993 survey are more consistent with the Laurec-Shepherd analysis, then the more pessimistic view of the resource would be supported.

### 10.4.4. Assessment Results

All analyses indicated that the population abundance has decreased in the recent past. While this trend is consistent with the previous assessment, the current estimate of the 1991 populabion abundance is $30 \%$ lower than that estimated last year. Contributing factors for this change in our perception include the low survey index for 1992 and revised catch statistics data for previous years.

## Recruitment

Results from the analyses suggest that recruitment in recent years has been well below average (Fig. 10.4g). The 1987 year-class is now estimated at about 63 million fish; well below the 87 million predicted from a regression of year-class estimates from a multiplicative model and age 3 SPA numbers from the Hybrid analyses. Although no estimate of the 1990 year-class can be obtained from SPA calibration, the predicted value from the multiplicative analysis indicates that it is likely in the range of recent the 1989 year-class.

The relationship between age-3 recruitment and spawning stock biomass indicated that, since the early 1980s, while biomass was relatively high, recruitment has continually declined. This indicates that survivorship during the first three years of life declined in recent years.

Ocean climate changes in the Gulf of St. Lawrence, as elsewhere in the Canadian Atlantic, have been significant since the mid-1980s. It is possible that the reduced recruitment productivity is related to these changes. The Fisheries Oceanography Subcommittee examined the relationship between 4T cod recruitment and Gulf of St. Lawrence river runoff but found no significant correlation ( ${ }^{2}<0.2$ ). Further studies are required to describe the influence of ocean climate on recruitment production.

Fishing mortality and stock abundance
The analyses indicated that $F$ (ages 7+) has nearly doubled from 1989 to 1992 (Fig. 10.4h). Fishing mortality is estimated to be in the range of 0.85 to 1.0 with $F$ increasing from the late 1980s to 1991, with a small decline in 1992, and fluctuating between 0.5 and 0.8 during the 1980s. The more pessimistic LaurecShepherd analysis indicated fishing mortality of about 1.4 in 1992.

Spawning stock biomass (ages $5+$ ) estimated from the various analyses would be at about the low levels observed in the mid-1970s (Fig. 10.4i). Population biomass and abundance has been decreasing steadlly since the mid-1980s (Fig. 10.4j,k).

### 10.4.5. Prognosis

Catch projections were conducted with the population estimates from the calibration of SPA with the Hybrid method. Weights at age were the average from 1990 to 1992. Partial recruitment was derived from fishing mortalities in the period 1989-1992; full recruitment was assumed at age 9. The recruitment of the 1989 year-class was set at 40 million; approximately the value predicted from a regression of year-class estimates from a multiplicative model and age 3 SPA numbers for 1978-1992. The 1990 and 1991 year-classes were
considered to be below average and were set at the same value. The input data are given below:

| Age | 1993 Population Numbers | Average Weight (kg) | Partial Recruitment |
| :---: | :---: | :---: | :---: |
| 3 | 40000 | 0.541 | 0.009 |
| 4 | 32371 | 0.673 | 0.082 |
| 5 | 22504 | 0.839 | 0.285 |
| 6 | 20119 | 1.015 | 0.523 |
| 7 | 12478 | 1.200 | 0.744 |
| 8 | 4265 | 1.382 | 0.867 |
| 9 | 2777 | 1.493 | 1.000 |
| 10 | 1135 | 1.620 | 1.000 |
| 11 | 397 | 1.675 | 1.000 |
| 12 | 427 | 1.832 | 1.000 |
| 13 | 258 | 2.355 | 1.000 |
| 14 | 68 | 3.885 | 1.000 |

If the 1993 TAC of 13,000 is taken, it implies a fully recruited fishing mortality of 0.38 . Results of the projections indicate that $F_{0.1}$ in 1994 would be $8,000 \mathrm{t}$. A summary of projected 1994 catches and the resulting 1995 adult biomass at various fishing mortalities in 1994 is shown in Fig. 10.41.

For comparative purposes, projections were also conducted with population estimates from the ADAPT and Laurec-Shepherd (RV) analyses. The ADAPT estimates would imply $F_{0.1}$ catches of 8,400 while the more pessimistic Laurec-Shepherd (RV) population estimates would imply 4,800t in 1994.

Given that recent year-classes appear to be weak, stock biomass is not expected to increase without improved recruitment.

### 10.4.6. Research Recommendations

1. A review of the status of the $4 \mathrm{~T}-\mathrm{Vn}(\mathrm{J} .-\mathrm{A}$.$) cod stock should be conducted during the autumn of 1993$ after the preliminary results of the research vessel survey are available.
2. An investigation of the effects of past discarding practices on the status of the resource and the assessment of the stock should be conducted.
3. The distribution of cod in the Laurentian Channel during the winter should be examined in relation to stock management units and physical oceanographic observations to determine the magnitude of stock mixing in the area in recent years.
4. Studies of stock definition related to the timing of the movement of $4 \mathrm{~T}-\mathrm{Vn}$ (J.A) cod in the Sydney Bight $(4 \mathrm{Vn})$ area should be continued.

### 10.5. Cod in Division 4VsW (WP 83, 99, 119) R. Mohn

### 10.5.1. Description of the Fishery

Catches of 4 VsW cod ranged from 40,000 t to 80,000 t in the years 1958 to 1974 and then declined rapidly to a low of 10,000 in 1977 (Fig. 10.5a). Subsequent to extension of jurisdiction the catches quickly climbed again and were at or above 50,000 from 1980 to 1986. Under quota restrictions, the TACs have been reduced and consequently the catches have declined in recent years to 29,800 in 1992, the lowest catch since 1978. Since 1977, the foreign catch has only exceeded 1,000 once and in 1992 was approximately 120 t , primarily by-catch in the silver hake fishery.

Anecdotal information suggests that there was a strong 'river' of fish from the Gulf in 1991 that contributed 8,761t to the January to April fishery in 4 Vsb. However, during the same period in 1992 the 'edge' fishery was not nearly as strong and the estimated catch of 4 TVn cod was 4358 t .

Prior to 1980, the total catch was nearly equally split between Subdiv. 4Vs and Div. 4W however, since 1980 the percentage of the catch coming from Subdiv. 4 Vs climbed from $60 \%$ to a high of $87 \%$ in 1988 . The percentage has declined for the last three years and was $70 \%$ in 1992, the lowest since 1983.

The proportion of the catch taken by each gear type is essentially unchanged from 1989 with over $70 \%$ of the catch taken by otter trawis, $25 \%$ taken by longline and handline and the remainder taken primarily by seines and gillnets. In some cases (fixed gear (FG) < 45 and fixed gear 65-100) the catches were close to the final allocations. This was not the case for FG 45-64' (caught about $1 / 3$ of their allocation ), mobile gear (MG) <65' (caught about two-thirds) and the vessels >100' which were about 1,000 thort of their final allocation ( 2,500 t short of their initial allocation). In 1992 some gear sectors were complaining about the difficulty in getting legal sized catch. Anecdotal information also reported that many tons were being discarded in order that a few might be landed.

The 1993 fishery has seen very little effort to date. The fishery has been divided into 14 management subareas in which the fishery is closed if more than $15 \%$ by number in the catch is less than legal size. With the depressed nature of the fishable biomass, this has resulted in several closures. Also, 4Vsb, an area which traditionally contributes heavily to the winter fishery, was closed until May 1 . The catch until the end of May was less than 500t compared to over 15,000 t to this date in recent years.

### 10.5.2. Data

## Catch and weight at age

The 1992 catch at age was constructed in a manner similar to previous years and sampling was adequate to estimate ages. The 1986 and 1987 year-classes at age 5 and 6 contributed $60 \%$ of the catch in numbers in 1992.

Corrections for the proportion of the catch that are slower growing fish, and presumably to a large degree from 4T, were estimated for 1986-1992. The "4T" corrected catch is used in all analyses.

The commercial mean weights at age (Fig. 10.5b) in 1992 continue the recent trend to smaller weights at age. The mean weights at age peaked in the mid-1970s and have declined since that time.

## Commercial catch rates

A standardized catch rate series was estimated using NAFO data for 1968-88 and ZIF data for 1989-92. Throughout the 1980s the C/E remained higher than the 1970s and relatively stable, with the exception of 1985-86 which were the highest observed (Fig. 10.5c). The 1992 value rose slightly from the 1991 value.

The Canadian OTB (tonnage class (TC) 4-5) catch rates from the International Observer Program (IOP) were calculated for the years 1982-1991. The observed catch has varied between $7 \%$ and $17 \%$ of the total OTB catch during 1982-89, however, in 1990 the IOP observed $34 \%$ of the OTB catch. When standardized to the same basis, the C/E based on the IOP was significantly higher than that based on the commercial statistics in 1984-89 but nearly equal in 1982, 1983 and 1990 and 1991, but lower in 1992 (Fig. 10.5d).

Catch rates from a single longliner captain, who kept detailed daily records over a number of years, were presented. The peak in the catch rate was 1985-86 which matches the pattern of the surveys.

Maps of fishing effort distribution were presented and indicate large shifts in fishing grounds. The disappearance of a spring fishery in 4 W was observed and a shift in fishing effort from Banquereau Bank to Artimon Bank. There has been a considerable reduction in the area fished in recent years. Given this observation, the catch rates estimated above would represent average local densities rather than stock abundance and as such should not be used to calibrate SPAs.

## Research vessel surveys

Two research survey abundance indices are available for this stock. A July survey had been conducted annually since 1970. Indices from this survey were low in the early 1970s, increased until 1981, were high in 1982-84 due to the strong 1980 year-class, and declined thereafter (Fig. 10.5e).

A second survey has been conducted in March from 1979 to 1993 with the exception of 1985. From time to time the estimation of abundance from the March survey was complicated by missing strata due to the presence of ice in the survey area. In 1991 and 1992 there were no missing strata although a number of strata contained only 1 set. In 1993, four new strata were added in deeper water in the Laurentian Channel. The Cvs associated with the March survey estimates are generally larger than in the July survey, probably reflecting the more aggregated distribution of fish in the winter. Trends are similar to the July survey with increasing catch in the late 1970s to early 1980s. High variation is seen in the mid-1980s and a decline thereafter. The 1992 spring survey estimate was extremely low and may be anomalous given the agreement of the July 1992 and spring 1993 at a higher level (Fig. 10.5f).

Smith et al. (1991) reported that large catches of cod in the March surveys of 4 VsW were associated with water characterized as cod intermediate layer (salinity between 32 and 33.5 psu ; temperatures less than $5^{\circ} \mathrm{C}$. They had suggested that in years in which a high proportion of the bottom water was made up of this water mass, cod would be more available to the survey trawl gear.

Further work confirmed that large catches of cod are associated with the cold intermediate layer water mass. It has also been shown that large catches of cod are more likely to occur in the survey when the distribution of this water mass is constricted and only intersects with the shallower portions of the survey areas. Over $40 \%$ of the 4 VsW survey area can be classified as shallow (less than 91 m in depth) and these depths include many of the large strata. Consequently, large catches of cod in these shallow strata will have a major influence on the estimate of the stratified mean abundance. Therefore, survey abundance indices may be confounding density changes with changes in abundance due to fluctuations in the distribution of the cold intermediate layer water mass.

The hydrographic data for 1992 showed that overall the bottom water in the March survey was colder and more saline than average, but not so much that the conditions could be considered as outliers in the 19701992 series. Bottom salinity and temperature data could not be collected for all sets containing cod due to storm conditions and therefore we do not know for certain what conditions the cod were specifically associated with in the 1992 survey. However, cod in 1992 were found deeper than usual and conditions overall indicated that the cold intermediate layer was deeper and more widely spread than usual. As a result, the low 1992 cod abundance estimate may be more indicative of low density rather than low abundance.

Previously both survey series have indicated that the 1986 and 1987 year-classes were 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, and it was $30 \%$ of the total numbers in the fifth survey (July 1989). However, recent surveys show them to be below average.

### 10.5.3. Estimation of Parameters

Last year's formulation was repeated with the input.
$G_{\text {,.t. }} i=1$ to $15 ; t=1970$ to 1992 - Full year catch at age
L.t. $_{M_{i, t},}, i=3$ to $9 ; t=1970$ to 1992 - July RV index $t=1979$ to 1992 - March RV index (excluding 1985)

All the ADAPT formulations investigated continue to show the retrospective pattern that has been of concern in this assessment for the last few years. The estimates for average F for ages 7-9 increase as additional data are added to the analysis. In last year's assessment, bootstrapping was used to remove the retrospective pattern. The mean F from the bootstrap estimates was higher than the point estimate and was stable as more data were added, removing the retrospective pattern. Because the $F$ estimate for 1992 was well above 1, an even higher value would not change the conclusions for this stock. Also, bootstrapping is very computer intensive and was not carried out in this assessment.

The diagnostic statistics from ADAPT show that the coefficient of variation on the terminal $F$ range from 42 to $57 \%$. As seen in previous years, the Cvs are higher for the March survey than the summer survey. The bias estimates for $\mathrm{F}_{1992}$ range from -9 to $-16 \%$. The qs have small $(<3 \%)$ negative biases.

### 10.5.4. Assessment Results

The SPA results indicate that the average $F(7-9)$ has increased in recent years and is well above $F_{0.1}$ and the highest seen (Fig. 10.5g). The results show that the total and adult ( $6+$ ) biomass is extremely low, below those of the mid-1970s (Fig. 10.5h,i). This year's VPA results indicate much lower recent recrultment than last year's with levels well beneath the long-term geometric mean of 61 million animals (Fig. 10.5). The results also indicate that the 1987 year-class is the strongest in recent years but still well below the geometric mean. Given that age 1 abundance has been below the mean since 1984, It was considered prudent to use a more recent period to calculate average recruitment for catch projections. The geometric mean from 1984 to 1990 is 28 million and was used for catch projections.

Figure 10.5 k shows the VPA numbers (3-8) compared to the estimates from the surveys after scaling by the estimated catchabilities. This is done to allow a direct comparison of the results. The VPA numbers show a steady decline since the early 1980s. On this scale the summer surveys show a.slow, steady decline (excepting 1990). In the last 4 years the spring survey is seen to be quite erratic.

### 10.5.5. Prognosis

The 1992 numbers are projected ahead from base run of ADAPT with a geometric mean recrultment of 28 million (geometric mean average 1984-1990) for ages 1-3. The weights are the average commercial weights (Jan. 1) for the years 1990-1992 and the selectivity is the smoothed average from the last year's assessment.

Values used in stock projections are:

| Age | $\mathrm{N}_{1993}$ | Weight | Selectivity |
| :---: | :---: | :---: | :--- |
| 1 | 28000 | .05 | .000 |
| 2 | 22900 | .33 | .000 |
| 3 | 18770 | .72 | .014 |
| 4 | 5801 | .89 | .156 |
| 5 | 7501 | 1.27 | .480 |
| 6 | 8048 | 1.39 | .740 |
| 7 | 1484 | 1.67 | .951 |
| 8 | 288 | 2.02 | 1.000 |
| 9 | 241 | 2.17 | 1.000 |
| 10 | 38 | 2.39 | 1.000 |
| 11 | 59 | 3.25 | 1.000 |
| 12 | 17 | 4.11 | 1.000 |
| 13 | 22 | 6.10 | 1.000 |
| 14 | 6 | 12.95 | 1.000 |
| 15 | 1 | 10.80 | 1.000 |

Projections with these data were done assuming a catch at the 11000 TAC for 1993 and $\mathrm{F}_{0.1}$ ( 0.22 ) for 1994 and 1995. The results are summarized below.

|  | 1993 | 1994 | 1995 |
| :--- | :--- | :--- | :--- |
|  |  |  |  |
| Yield | 11.0 | 3.0 | 4.3 |
| Biom 3+ | 36.2 | 37.7 | 47.8 |
| Biom 6+ | 14.5 | 12.0 | 13.6 |
| F 7-9 | 0.88 | 0.22 | 0.22 |

The severe depletion of the fishable biomass estimated by the above VPA is reflected by very low $F_{0.1}$ yields for 1994 and 1995. The projection for 1994 for a range of fishing mortality up to 1.0 is shown in Fig. 10.5l. The $6+$ biomass is of the same magnitude as the yield in the region of twice $F_{0.1}$ which suggests that the fishery is based largely on recruiting year-classes.

The spawning stock biomass and fishable biomass are at the lowest levels seen since 1970. However, small fish are still seen in the surveys. If the 1993 TAC of 11,000 is taken, spawning stock biomass will continue
to decline. At such low biomass and given the recent poor survivorship of juveniles, any recovery will be slow.

### 10.5.6. Discussion

Compared to last year's assessment, the current VPA indicates a much less abundant. Atthough the 1987 year-class is relatively strong compared to others in recent years, it is still below the long-term average. Similarly, the summer survey estimates that the 1987 year-class is the strongest in recent years but below the long-term average. The spring survey suggests that it is a bit stronger (as 4 year olds in 1991) and near average recruitment for neighbouring year-classes as 3 year olds.

The current size distribution seen in the 1992 summer survey when compared to the long-term average indicates a very low fishable biomass, Fig. 10.5m. Similarly, the size distribution of the 1993 spring survey shows very few animals above the legal size. The commercial size frequencies for 1991-92 show that the fish are increasingly being caught nearer the legal size and fixed gear catch is dominated by fish in the 50 cm range, except the 1991 gill net catch.

A number of factors contributed to the change in perception in this assessment compared to last year. Probably the most important is the inclusion of the 1992 survey estimates. The summer research vessel estimate is the lowest since 1978 and the spring 1992 point is the lowest on record. Minor changes were also made in re-calculating the catch at age for 1990-91. Based on a review of the hydrographic conditions during the spring survey it was not possible to exclude the 1992 point from the series. To assess the sensitivity of the SPA results to the 1992 spring survey results, these data were increased by $700 \%$ to match the 1993 spring 3+ numbers and ADAPT was re-run with the adjusted data. The original (Unadj.)and adjusted (Adj.) results are:

|  |  | F (7-9) | Biomass $6+$ <br> ('O00) |  | Recruits <br> (Mill. age 1) |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Year | Unadj. | Adj. | Unadj. | Adj. | Unadj. | Adj. |
| 1986 | .44 | .44 | 100 | 100 | 33 | 38 |
| 1987 | .53 | .53 | 84 | 85 | 43 | 56 |
| 1988 | .66 | .64 | 71 | 72 | 49 | 73 |
| 1989 | .55 | .52 | 52 | 54 | 22 | 38 |
| 1990 | 1.31 | 1.13 | 33 | 36 | 12 | 35 |
| 1991 | .73 | .53 | 19 | 24 |  |  |
| 1992 | 1.56 | .67 | 18 | 28 |  |  |

Although the differences are large they do not change the perception of a seriously depleted resource, fished more than twice $F_{0.1}$.

### 10.5.7. Discussion of Factors Contributing to Current Status

To provide a view of the future of this resource, it is first necessary to understand the processes that brought the population to its current state. A number of hypotheses can be put forth:

- catchability has increased due to reduced stock size;
- the population has experienced recrultment failure;
- production has been reduced by changes in the ecosystem which have in turn been prompted by environmental fluctuations; and
- grey seal predation on small cod has been a significant cause of reduced recruitment to the population.


## Increased catchability

The radical change in of the status of this stock over a few years is a source of concern. The system may be showing non-linear or positive feedback dynamics which could cause rapid transitions. For example, as the geographic extent of the stock decreases the same effort would produce a higher exploitation. This in turn would decrease survivorship and further reduce the stock etc. This effect has been seen for many stocks and is well documented. Similarly, as the size distribution shrinks towards the legal minimum (Fig. 10.5n), the tonnage removed would represent more animals and a higher $F$. This would decrease survivorship into larger sizes shifting the size distribution further exacerbating the problem, etc. Unfavourable environmental and/or multispecies effects could further accelerate the decline.

## Recruitment failure

During 1985-89, while spawning stock biomass was relatively high, below average strength year-classes were produced (Fig. 10.5n). This is indicative of low survivorship during the first three years of life. If these poor survival conditions persist and spawning stock biomass remains low, the chances for good recrultment will continue to be poor.

Ichthyoplankton surveys during 1979-81 observed that 4 VsW cod spawning occurred on western Sable Island Bank during spring (April-May) and autumn (Nov.-Dec.). Surveys during 1991-1992 in this area have failed to locate spawning in the spring while autumn spawning occurred as expected based on the historical data. During 1986-1992, there was no fleet activity on Middle Bank and only sporadic fishing activity on Sable Island Bank during the spring spawning period. If the fleet distribution reflects spawning concentrations, this observation suggests that the spring spawning aggregations became uninteresting to the fleet around 1985.

A number of hypotheses are being investigated to explain this apparent disappearance of spring spawning activity and perhaps explain why recent survival has declined.

## Environmental influences

There is substantial evidence to show that the oceanographic regimes on the eastern Scotian Shelf have changed since 1985. An analysis of near-bottom temperatures suggests that the region is in a period of ocean cooling, resulting in water temperatures on the northeast portion of the Scotian Shelf, particularly 4 V , being unusually cold in recent years. As well, the abundance of the cold water species, capelin, has increased in 4 VW since the mid-1980s.

A re-analysis of the relationship between age three recruitment and Gulf of St. Lawrence river runoff (RIVSUM) was conducted using the current SPA and RIVSUM information. This relationship previously provided promising evidence for a link between cod production and ocean climate. Unfortunately, RIVSUM predicted relatively stable recruitment since 1977 when in fact the latter has declined. Interestingly during the recent period, water temperatures have declined, paralleling declines in recruitment. While this may
indicate a cause and effect relationship and more analysis is required to better understand the relationship between fish production and ocean climate before management decisions can be made.

## Predation by grey seals

There are two components to the grey seal population on the east coast. One breeds on Sable Island and the other on the ice in the southern Gulf of St. Lawrence. It is the Sable Island component that could impact the 4 VsW cod population. Since 1962, grey seal pup production on Sable Island has increased at an annual rate of about $12 \%$. Age $1+$ grey seal population size of this component, based on pup production estimates, were estimated to be about 95,000-134,000 animals (see section 7.2) in 1990 . While more current estimates of population size are not yet available, it is likely that the 1993 population size is larger due to the measured trend in pup production.

To completely evaluate the impact of this population on 4 VsW cod, it is necessary to determine a seal's annual consumption, the species and size composition of the diet, the relationship of diet with prey abundance and the mortality caused by other predators.

A number of studies conducted since 1988 have determined that the diet composition and the relative importance of different prey exhibit marked seasonal and geographical variation. These studies, based on stomach samples, show that about $90 \%$ of the grey seal diet consists of fish such as herring, cod, mackerel, sand lance and silver hake, mostly in the $15-35 \mathrm{~cm}$ length range which in the case of cod are about 1-3 year old. In the summer, cod can make up $18 \%$ to $20 \%$ wet weight of the diet while in the winter, the range can be $14-40 \%$, dependent on whether feeding occurs inshore or offshore. These data are based on small sample sizes and limited geographical distribution and these may be biased by local feeding conditions. Seal faecal or scat samples collected in 1992 are currently being processed and may provide a different perspective of seal diet. To date, available data on the diet of grey seals are too preliminary to report on seasonal and geographic differences in seal diet.

There is as yet little information on the seasonal distribution of grey seals on the Scotian Shelf to determine the degree of potential interaction between seals and 4 VsW cod. Studies are currently underway to document the seasonal distribution of the seal population.

The uncertainties in diet composition, energy requirements and seal feeding behaviour preclude estimation of seal impacts on cod population at this time. It is planned to conduct an evaluation of the impact of the seal population on 4 VsW cod by the autumn of 1993.

The cod population size structure of recent surveys shows a relatively faster depletion of the resource as fish approach legal size. Seal predation is typically of fish smaller than legal size. These observations imply that overfishing is more likely to cause such a size distribution than predation by seals, at least in recent years.

It is not possible at this time to establish the relative importance of each of the four hypotheses as to the cause for reduced recruitment since 1985. A number of studies are currently underway which will provide insight on this issue.

### 10.5.8. Research Recommendations

The sensitivity of this assessment to shifts of data or model should be systematically investigated.

### 10.6. Cod in 4X (WP 82, 85, 113) S. Gavaris

### 10.6.1. Description of the Fishery

Landings of cod from Div. 4X averaged about 15,000t between 1947 and 1961. With increased exploitation on the offshore banks, landings increased to a maximum of about 35,500 in 1968. Since 1969, landings have varied between about 16,000t and 33,000t (Fig. 10.6a). Landings in 1992 were 26,000t, a 2,000t decline from 1991. Much of the increased landings between 1990 and 1992 came from grounds to the northeast of Browns Bank. Early reports from the fishery in 1993 indicate that the cod are not being found on the traditional grounds in this area. Reported landings since 1990 are considered to be more accurate due to introduction of mandatory weigh-outs.

### 10.6.2. Data

## Catch and weight at age

Catches from the commercial fishery in 1992 were well sampled for length and age composition with the 87 samples taken being suitably distributed over gear types and seasons. The 1987 (average length of 65 cm ) and the 1989 (average length of 50 cm ) year-classes were prominent in both otter trawl and longline catches. Catches of the 1985 year-class, which has contributed significantly in recent years, was greatly reduced in 1992. There were no long-term persistent trends in average weight at age but a decline was noted for ages 3 and 4 in recent years.

## Research vessel surveys

Annual stratified random surveys have been conducted during the summer since 1970. The relationship between historical population estimates and survey results are poor for ages 1 and 2. Recent results for ages 3 and older have identified the 1985 and 1987 year-classes as relatively strong. Early indications for the 1989 year-class suggest that it is below average. From 1991 to 1992, the total biomass declined by about $15 \%$ and abundance for ages $3-10$ declined by about $25 \%$ (Fig. 10.6b). The spatial distribution of cod during the 1992 survey was similar to past years. A large part of Div. 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 which occupies this area is constant from year to year. Variations in this proportion may be a contributing factor to the poor relationships between survey results and population abundance at younger ages as significant numbers of small fish are known to occur in these coastal waters.

The area swept by bottom trawls is influenced by the depth and bottom type. Information collected during the research surveys with SCANMAR equipment was analyzed and relationships between doorspread and depth/bottom type were determined. On hard bottom, door spread varied between 35 m and 75 m , increasing with depth. Although a similar pattern was indicated for soft substrate, this tendency was less pronounced and with few observations below 80 fathoms, a relationship could not be established. These results suggest that abundance from deep tows may be overestimated relative to shallow tows If cod catch is related to doorspread (Andrew et al., 1991, Godo and Engas 1989). Swept area for all tows from research surveys conducted in Div. 4X were adjusted according to the depth/substrate results. Comparison of mean numbers per tow at age between the adjusted and standard results over the 1970-92 period indicates that the effect varies with age. The adjustment is greatest for older cod, consistent with the observation that older cod are distributed in deeper water than young cod. Calibration of the sequential population analysis with the adjusted survey index did not significantly alter results. This is an indication that the depth distribution of cod in Div. 4X has not changed substantially over the time period.

## Commercial catch rates

Catch effort reports from 139 commercial vessels which currently hold ITQs and which had a history of three or more years in the fishery were analyzed. The impact of individual vessel power, area of capture and month of capture were taken into account assuming multiplicative effects. The derived annual catch rate index increased from 1987 to 1989 and subsequently declined. The associated bottom trawl effort showed a marked increase between 1990 and 1992. The catch rate trend has not been used to calibrate the sequential population analysis due to suspected misreporting and under-reporting. These results indicate that the trend is consistent with the population analysis and warrants further investigation. Specifically, the assumption of multiplicative effect without interaction, the seasonal pattern and the impact of introducing ITQs should be investigated.

### 10.6.3. Estimation of Stock Parameters

The adaptive framework was used to calibrate the sequential population analysis with the research survey results. Two model formulations were employed, an integrated index error model and the Laurec-Shepherd model. Both the integrated index error and Laurec-Shepherd formulations used the following data:

$$
\begin{aligned}
& C_{a, y}=\text { catch } \quad a=1 \text { to } 12, y=1970 \text { to } 1992 \\
& G_{a, y}=\text { Canadian summer survey } a=3 \text { to } 10, y=1970 \text { to } 1992 \text { excluding } 1971 \text { and } 1988
\end{aligned}
$$

For both models, the summer survey results were compared to average (mid-year) population abundance. Those for 1971 and 1988 were excluded based on preliminary analyses which showed very large residuals. Natural mortality was assumed constant and equal to 0.2 . Further, both models assumed that error in catch could be ignored and population numbers were computed using the common catch equation given a terminal population estimate. The fishing mortality rate on age 12 was calculated as the unweighed average for ages 5 to 7 in the same year. Error in the survey data was assumed to be independent and identically distributed for all ages after taking logarithms of the data. The Laurec-Shepherd model estimates the calibration constants using least squares and assumes that the terminal mid-year population numbers are exactly equal to the calibration constant times the terminal year survey results. The integrated index error model estimates calibration constants and terminal population numbers simultaneously using least squares.

The population biomass estimates from the two model formulations were not different for practical purposes (Figs. 10.6b). For each cohort, the terminal population abundance estimates from the integrated index error model were adjusted for bias and used to construct the history of stock status. This simple approach for bias adjustment, in the absence of an unbiased point estimator with well determined statistical properties, was considered preferable to using the biased point estimates.

Figure 10.6c shows the age 3-10 population numbers estimated with the integrated model (SPA) and the RV estimates for the same ages adjusted by the estimated catchability coefficients. The agreement between the two was good in the 1972-77 and 1986-92 periods. However, during 1978-82 the RV estimates were below the SPA estimates, giving negative residuals, and the residuals from $1983-85$ were large and positive.

### 10.6.4. Assessment Results

The analysis indicates that the 1985 and 1987 year-classes were among the strongest since 1970 (Fig. 10.6d). Excluding these, recruitment during the 1980s was generally lower than recruitment in the 1970s. The beginning of year population biomass for ages 3 and older has declined rapidly from a peak in 1990 and is approaching historically low levels (Fig. 10.6e). 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. The total fishing mortality rate for ages 4 and older (Fig. 10.6f), does not show any sustained trends but has fluctuated around 0.5 . This 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 that target.

The following table shows estimates of population abundance for the dominant age groups in the fishery at the beginning of the year in 1992 for A) last year's assessment (Campana and Hamel 1992), B) last year's assessment redone but excluding the survey estimates for 1971 and 1988 as was done in this assessment, C) this year's assessment (i.e. the inclusion of the 1992 catch at age and research survey abundance estimates) and $D$ ) this year's assessment results adjusted for bias.

| Age | A | B | C | D |
| ---: | ---: | ---: | ---: | ---: |
| 3 | 12612 | 12000 | 11085 | 9741 |
| 4 | 3905 | 4213 | 4053 | 3762 |
| 5 | 9997 | 10551 | 8828 | 8293 |
| 6 | 3837 | 3917 | 2655 | 2497 |
| 7 | 2841 | 2052 | 1791 | 1677 |
| 8 | 250 | 249 | 292 | 273 |
| 9 | 331 | 285 | 189 | 177 |

The modifications incorporated in the ADAPT formulation did not result in important changes except for the estimate of the 1985 year-class at age 7. The lower estimate from the modified formulation is more consistent with the observed catch in 1992 as the number caught of this year-class was about half of what had been forecast with the results from A). Incorporating the observed catch at age and survey abundance index for 1992 resulted in lower population estimates for the 1986-87 year-classes. This was because a) greater numbers of the 1987 year-class were caught in 1992 than had been forecast because the TAC was taken while there was a shortfall in the catch of the 1985 and older year-classes, and b) the survey abundance estimates declined more than expected. The adjustment for bias was largest for age 3 and was consistent for older ages. This adjustment was not applied in last year's assessment. It should be noted that the 1989 year-class in last year's assessment could not be estimated and was assumed equal to the mean following common practice. This year-class is now estimated to be about $80 \%$ of the average. With the reduced estimates of the 1987 and 1989 year-classes, which were to have accounted for almost $50 \%$ of the projected catch in 1993, the fishing mortality rate on fully recruited ages in 1993 will have to be substantially higher if the TAC of 26,000 is to be caught.

### 10.6.5. Prognosis

Yield projections were done using the results from the integrated model.

| Age | Population numbers <br> (thousand) | Mean Weight at age <br> (kg) | Beg. of yr. <br> Weight at age | PR Pattern |
| :---: | ---: | ---: | ---: | ---: |
| 1 | 20000 | 0.50 | 0.37 | 0.00 |
| 2 | 16000 | 0.92 | 0.68 | 0.05 |
| 3 | 12000 | 1.41 | 1.13 | 0.35 |
| 4 | 4917 | 2.06 | 1.71 | 0.75 |
| 5 | 1318 | 2.86 | 2.46 | 1.00 |
| 6 | 3788 | 3.94 | 3.33 | 1.00 |
| 7 | 1187 | 5.26 | 4.52 | 1.00 |
| 8 | 907 | 7.72 | 6.28 | 1.00 |
| 9 | 159 | 9.81 | 8.74 | 1.00 |
| 10 | 101 | 12.13 | 11.07 | 1.00 |
| 11 | 4 | 13.90 | 13.30 | 1.00 |
| 12 | 18 | 16.14 | 14.88 | 1.00 |
| 13 | 3 |  | 17.39 |  |

As with population abundance estimates, the simple adjustment for bias was considered more appropriate than using the biased point estimate, especially in view of retrospective results and the declining population biomass. Due to a lack of good abundance indices at younger ages, the incoming year-classes were assumed to be about equal to the long-term geometric mean. These year-classes account for about half of the projected yield. If the 1990-93 year-classes, which were set roughly equal to the long-term geometric mean, continue this trend of lower recruitment, the prognosis would be worse than that presented here.

If the TAC of 26,000 is taken in 1993, the resulting fully recruited fishing mortality would be about 0.8 and the beginning of year 1994 biomass for ages 3 and older would decline further to $47,000 \mathrm{t}$. The yield for 1994 at $F_{0.1}$ would be about 7,000 (Fig. 10.6g). A 1993 F of 0.5 , about the average in recent years, would give a catch of 18,000 t and a beginning of year 1994 biomass for ages 3 and older of 55,000 . The corresponding yield for 1994 at $F_{0.1}$ would be about 8,500 . These results are consistent with the prognosis given last year.

Beginning of year biomass for ages 3 and older has fluctuated between about 50,000 t and 80,000 since 1970 and it is currently at about the lowest level. Recent fishing mortality rates and those implied by the current management plan imply a loss in yield due to growth overfishing and significantly lower catch rates than would be realized at $F_{0.1}$. With adult biomass declining and no indication of good recrultment to follow. a lower fishing mortality rate would distribute the available yield over more years and maintain adult blomass at higher levels.

### 10.6.6. Research Recommendations

1. The lack of suitable indices of abundance for younger ages hinders our ability to forecast stock trajectory and associated yield. Efforts to analyze existing data in new ways and to explore alternative sources of information should continue to be pursued.
2. The accumulating SCANMAR data should be examined for other species and areas to compare results. Other factors which should be considered as influencing catchability are headline height, time on bottom, tow direction relative to current, and classification of bottom type at the scale of tow area swept. The analysis presented would be improved by classifying the substrate for tows greater than 80 fathoms and utilizing the respective relationship.
3. The assumption of proportional effects between areas, months and vessels in the catch rate analysis should be examined. The low catch rate in April-May should be investigated in relation to the spawning area closure.

### 10.7. Georges Bank Cod in Unit Areas 5Zj,m (WP 84, 96, 97) J. Hunt

### 10.7.1. Description of the Fishery

Canadian landings of cod have been dominated by otter trawlers, except in 1984 and 1989. However, in recent years the proportion of total landings taken by fixed gears (longline and gillnet) have increased and accounted for almost $50 \%$ of total landings in 1992. The below average 1989 catch by otter trawlers reflects early closure of the fishery when the combined quota for Div. $4 \mathrm{X}+5$ was exceeded.

A number of management controls have been used in this fishery including introduction of individual transferable quotas (ITQs) for $>65^{\prime}$ otter trawlers in June 1992, effort control for gillnets and removal of a 3-2-1 for haddock, cod and pollock policy used in 1992. Gear sector allocations in 1992 were based on a total of 15,000 and, with the exception of fixed gears ( $62 \%$ ), all allocations were taken or exceeded. A similar allocation plan is expected for 1993.

In 1990, a 6,000t increase over 1989 in Canadian landings was due to a return to historic catches by the otter trawlers fleet and resulted in an overall catch of 14310 t , the second highest in the time series. Canadian landings in 1991 where 13,455t but decreased to 11,712t in 1992. USA landings in 1992 were $5,080 t$ and below the average ( 6500 t ) for recent years.

The USA fishery typically is concentrated in the first half of the year while the opposite is true for the Canadian fishery. There has been some shift in the USA fishery towards the second quarter in recent years.

Total landings in unit areas 5Zj and 5Zm for 1978-92 are shown in Fig. 10.7a. Catches peaked at 26.000 o in 1982, averaged about 15,000 t between $1983-87$ and increased to 20,000 in 1988. Since 1985. Canada has taken about $65 \%$ of the total catch. Landings in 1992 were about 3,000 less than 1990 and 1991 landings.

The 1993 Canadian <65' otter trawlers fishery was opened at the beginning of January where in previous years fishing by this fleet began in June. Landings to March 31, 1993 are estimated to be close to 2.000 t with about 1,500 by otter trawlers. Length frequency samples of 1993 landings when compared with those of 1992 indicate substantial differences. In 1993 the otter trawler landings continued to be dominated (50\% in numbers) by the 1990 year-class with a mode at about 55 cm . However, a large proportion of landings were of fish $>70 \mathrm{~cm}$. This may indicate a change in availability of large fish to the otter trawler fleer during spring spawning aggregations. Anecdotal information from port technicians indicates that a substantial proportion of catches in the first quarter of 1993 were of spawning fish.

### 10.7.2. Data

## Age composition of the commercial catch

USA sampling for 1992 was not available for analysis. Canadian landings of 5 Z],m cod were estimated from landing samples and were dominated by the 1990 year-class at age two ( $44 \%$ in numbers) in 1992. Catch at age two in 1992 was the highest since 1987 when the strong 1985 year-class was entering the fishery. There appears to be no trend in size or weight at age over the 14 year time series.

## Research surveys

Vessel and gear conversion factors were used to adjust results of the USA surveys to research vessel Albatross $N$ equivalents, as was done last year. Age data were not available for the 1992 USA autumn survey and therefore catch per tow at age was estimated using an age key derived from the combined 199091 autumn surveys. Total catch per tow has been variable for each of the surveys (Fig. 10.7b). The 1991 and 1992 Canadian surveys show a marked decline from the high 1990 value and the decline continues in 1993. The 1991 USA autumn survey catch per tow is the lowest on record. A slight recovery in the autumn of 1992 still results in the second lowest estimate in the series. The 1992 USA spring is at the lowest observed value.

Distribution of catch per tow in research surveys, aggregated for 1986-92, appears to be relatively homogenous with some concentration in the northern part of the area in Canadian and USA spring surveys. Aggregation in the northern part of the area is more pronounced in the USA autumn survey. In all surveys the international boundary does not appear to provide a means of separating a Canadian or USA component. However, in the majority of cases some discontinuity associated with the 5Zj,m boundary is evident and is most pronounced in the autumn surveys.

## Commercial catch rates

A study of commercial standardized C/E for Canadian otter trawlers in 1987-92 shows that effort has increased in both 1990 and 1991 from 1989 and that catch rates have declined substantially since 1987. This is in agreement with the trend in F estimated for this stock in last year's assessment (Hunt and Buzeta 1992) but in contrast to that reported by CAFSAC (Anon. 1992a). In 1992, effort appears to have decreased but the impact of the ITQ program may be a factor.

### 10.7.3. Estimation of Stock Parameters

## Migration

Estimates of the migration rate across the international boundary were calculated for 1985-90 from research surveys. A strong and persistent pattern is evident in which movement occurs into the Canadian zone during the spring-summer period and out of the zone in the autumn-winter period. Average migration rates at age for the 1985-90 time period show some difference with age, with younger fish (<4 years) showing more movement than older fish, but annual movement for all ages combined appears to be balanced with reciprocal to/from Canadian zone exchanges. At the beginning of the spring-summer period the proportions of $5 \mathrm{Zj}, \mathrm{m}$ cod in the Canadian zone range from about 20-100 percent and the average proportion at age two is about 60 percent (ranging from $30-100 \%$ ). At the beginning of the autumn-winter period, about $69 \%$ (ranging from $50-80 \%$ ) of cod are in the Canadian zone on average.

## Stock maturity composition

Maturity composition of the annual population was estimated from Canadian spring surveys for 1986-93 and the proportion immature is strongly influenced by annual recruitment. First time spawning of 5Z,m cod occurs over a narrow length and age range and the proportion of the immature population fluctuates with the magnitude of recrultment at age two. A substantial proportion of age two fish are recrulted to the otter trawler gear and exceed the minimum legal landed size. This can result in high exploitation at this age with resulting loss of yield and spawning potential.

## Yield per recruit

A deterministic yield projection simulation which incorporated migration rates of cod in the USA and Canadian zones was examined to determine the impact of varying exploitation rates by the two fisheries on yield to the Canadian fishery. As noted above, cod exhibit considerable movement relative to the boundary and the proportion of the total stock in the Canadian zones has strong seasonal and annual variability. The average (1985-90) proportion at age two in the Canadian zone was estimated as 60 percent with $40 \%$ in the USA zone. The simulation was run with Canadian Fs ranging from 0-2 in the spring-summer period and set to $10 \%$ of the SS F in the autumn-winter (AW, quarters three and four) period. USA Fs from 0-2 in the AW period and $125 \%$ of the AW value for the SS period were used. Partial recruitment and weights at age were derived from long-term averages, were used for both Canada and USA, and the simulation used a constant recruitment of 1,000 :

| Age | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| PR | 0.4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Wt (kg) | 1.4 | 2.2 | 3.6 | 5.0 | 6.4 | 8.3 | 10.3 | 10.9 | 13.7 | 16.5 | 17.9 |

The resultant yield isopleth provides a means of assessing yield at combinations of USA and Canadian fishing mortalities. The model indicates that at low USA fishing mortalities a well defined maximum in yield occurs but the model approaches an asymptote as USA fishing mortality increases above 1.0. Canadian fishing mortality which approximates an $\mathrm{F}_{0.1}$ type strategy can be estimated for each projected USA fishing mortality. However, the annual variation in migration rates could have a substantial impact on results.

## Sequential population analysis

An illustrative ADAPT run was completed with 1992/93 survey indices and using the same formulation as in the 1992 assessment (ages 2-9 with spring and autumn USA and Canadian spring survey indices). Catch at age for the USA was not available and therefore the Canadian catch at age was prorated to the total reported landings for the USA and Canada. The relative error for population estimates are very high (46$\mathbf{8 1 \%}$ ) although the relative error for survey indices is lower (11-35\%). As was noted in last year's assessment, a strong annual pattern exists in residuals for survey indices. While the absolute values of estimates are subject to assumptions and poor precision, the relative estimates are probably indicative of population trends and confirm the substantial increase in exploitation rate and decline in abundance since 1989.

### 10.7.4 Assessment Results

Based on results of the illustrative ADAPT analysis and survey indices, the population abundance of this stock has declined in recent years and exploitation exceeds $F_{\text {max }}$. Spawning stock biomass is at a very low level. Estimates of recruitment from research surveys indicate that the 1991 and 1992 year-classes are well below average and that the 1990 year-class will account for a substantial proportion of landings in 1993. The 1991 and 1992 year-classes, will not contribute much to the 1994 biomass.

### 10.7.5. Prognosis

Exploitation rates which this stock has experienced in recent years, present low stock biomass and expected poor recruitment are cause for serious concern. There is little doubt that fishing mortalities in the 1990s are well above $F_{\text {max }}$. The fishery, in particular the mobile gear sector, is largely driven by recruitment. This can result in substantial mortality at age two and, since fish at this age are up to $50 \%$ immature, a substantial loss in spawning potential for recruiting cohorts. Indices of abundance derived from research surveys indicate a continuing decline in 1992 and are now at very low or lowest observed levels.

All indications are that this stock has declined substantially since 1990 and that further reductions are expected If fishing continues at the present level. Given the indications that the 1991 and 1992 year-classes are well below average abundance, a catch equal to the 1993 TAC could result in very high exploitation of the 1990 year-class. This year-class will have to support both the 1993 and 1994 fisheries.

### 10.7.6 Management Considerations

Management of this resource in recent years has not been based on recommended catch quotas and introduction of ITQs in 1992 and 1993 for the otter trawler fleet may have changed exploitation patterns. In 1993, the otter trawler 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 may be at its lowest level. The fishery is mostly recruitment driven and recruitment has been variable and appears to be poor for 1993 and 1994. Total catches in 1993 and 1994 of the same magnitude as taken in 1991/92 (15-20,000t) could result in fishing mortalities in excess of 1.0 and would result in a further reduction in stock biomass.

An immediate and substantial reduction in exploitation rates for both Canada and the USA is required if the decline in stock biomass is to be slowed or reversed. Distribution and migration studies suggest that the proportion of the total stock outside the Canadian zone would limit the results of unilateral management action by Canada due loss of biomass to the USA zone through migration and potential harvesting by the USA. Consistent management objectives by the USA and Canada are required for the total stock.

### 10.8. Haddock in Divisions 4TVW (WP 93/104) K. Zwanenburg

### 10.8.1. Description of the Fishery to 1992

Landings averaged 26,500t per year from 1950 to 1969, 5,000t from 1970 to 1979 and ranged between 8,000 and 20,000 t until 1987. The nominal catch totalled approximately 6,000 in 1992 (Fig. 10.8a).

## Management measures

In 1987 the combination of reduced recruitment over several successive years (1983-1985), low levels of spawning stock biomass and the concentration of the fishery on the only two remaining year-classes of any appreciable size (1981, 1982), resulted in the restriction of the fishery to a $5 \%$ by-catch. In 1988 this was increased to $15 \%$ which remained in effect through 1990 . Since then the fishery has been regulated through a combination of by-catch restrictions and trip limits. In 1992, catches were regulated through by-catch restrictions ranging from $0-30 \%$ and trip limits ranging from 680 to $2,500 \mathrm{~kg}$ per trip. The year-round nursery ground closure (mainly Emerald and Western banks) imposed in 1987 remains in effect to the present. Throughout the 1987 to 1992 period fixed gear vessels have been allowed to fish inside the closed area conducting what was essentially a directed fishery for haddock with trip limit regulation. In 1993, the closed area has been closed to all fishing.

## Distribution by area and gear types

Until 1984, most of the catch from this stock was taken from Div. 4W by large otter trawlers (TC4 and TC5) in the spring. In 1984, Div. 4 W 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 4 V s landings to the point where they represented $40-60 \%$ of total landings. Following the exclusion of mobile gear from much of Div. 4W (as a result of the imposition of the closed area) landings in 4 Vs ranged from 1,500 to 2,500 t annually, mainly due to the increased activity of the displaced mobile gear effort. Since 1990 landings in this area have declined to 780 t . Landings in 4 W have increased five-fold (from 994 to $5,164 t$ ) since 1987, mainly due to the development of the fixed gear fishery inside the closed area. Landings in Div. 4T and Subdiv. 4Vn are presently negligible.

From 1987 to 1991 the proportion of landings taken by trawlers has decreased from 60 to $35 \%$. In 1992 trawler landings represent $38 \%$ of the total. Longline landings have increased from 21 to $63 \%$ over the period 1987 to 1991. Longline landings in 1992 were the highest observed in the history of the fishery ( 3494 t ) and accounted for $58 \%$ of total landings. Seiner landings represented approximately $3 \%$ of the total landings in 1992. The most significant change in the distribution of landings from 1991 to 1992 is the increase in trawler landings during the first quarter of the year from 338 to $1,324 t$, most $(1,112 t)$ of which was taken in 4 W in areas adjacent to the closed area.

## Information from industry

Much of industries' view of the status of this resource is consistent with the groundfish surveys results. Catches of haddock in 4 T and 4 Vn are presently negligible, while catches in 4 Vs are poor and catch rates are generally low. Catches in 4W (mainly inside the closed area by fixed gear) increased from 1987 to 1991 when they were considered relatively good. Although catch rates were relatively good, the average size of fish in the catches was small due to the presence of the abundant 1988 year-class (modal length 34.5 cm in 4W in 1991). Reports from fixed gear fishers fishing inside the closed area indicate that fish there remain relatively plentiful. In 1992 large trawlers increased their fishing effort on Sable Island Bank and areas adjacent to the closed area resulting in the observed increase in trawler landings during the 1st quarter of 1992 in 4W. In general, fixed gear fishers fishing inside the closed area compared 1992 favourably with 1991 in terms of overall catches with some increase in landings reported for all quarters. Size composition of the catches in the closed area remained relatively small.

Inshore fishers in 4W indicate that 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, declines in the past 3-7 years have been relatively precipitous. In addition to this decline in landings many independent sources report a change in the 'migratory pattern' of the inshore haddock. In past years the haddock would 'come ashore' in waters westward of Country Harbour, N.S. These fish would then 'migrate' westward throughout the remainder of the summer and autumn until the fishers of the area stopped fishing when they reached Halifax Harbour and approaches. It is reported that haddock are coming onshore further westward each year, and that the numbers caught has declined substantially. All respondents indicated that these 'inshore haddock' are different from offshore haddock by virtue of colour, shape, taste, and general size composition (larger). We presently have no information by which to judge these observations. Plans for cooperative work with the inshore industry to determine the relationship between inshore and offshore haddock are being developed.

### 10.8.2. Data

## Composition of the catch

The age composition of the 1992 landings is not available. Over the past year serious concerns have been raised concerning the accuracy of the ages determined for haddock. A potentially significant bias in the ageing of haddock may have been introduced in the early 1980s. This bias, If it exists, may have resulted in over-ageing of young fish in the early 1980s and a subsequent underageing of older fish in the late 1980s and early 1990s. The full extent of the bias, if any, has not yet been determined (See Section 13.4).

Catch at length by domestic fisheries (1978-1992) were estimated using commercial groundfish samples stratified as outlined in previous documents. Catch at length for the haddock by-catch from the foreign small mesh gear fishery was estimated from International Observer Program (IOP) data. At present some discrepancies remain between the estimates of total removals at length and previous estimates of removals at age, mainly in the years 1978-1986. Although small mesh gear catches generally account for less than $10 \%$ of the total landings by weight, they are concentrated on the younger age classes, and therefore represent relatively large numbers. They also give indications of incoming recruitment.

The catch at length for 1992 shows a unimodal distribution with a mode at 44.5 cm (Fig. 10.8b), slightly smaller than the long-term average ( 46.5 cm ). Catches of small fish, 36.5 to 38.5 cm , were above the longterm mean while catches of fish $18.5-22.5 \mathrm{~cm}$ as well as fish larger than 38.5 were well below the long-term average.

## Commercial catch rates

The by-catch and trip limit regulated 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 vessel survey results

## Summer surveys

Catch rates (numbers per tow) increased from 1976 to 1982 (early 1980s year-classes) and declined from 1983 to 1987 (Fig. 10.8c). Since then, catch rates have increased somewhat due to the presence of the 1988 year-class. The 1992 estimate declined from 1991. Disaggregation of the research vessel survey series into area components shows that the population is concentrated in Div. 4 W with abundance in both 4 Vs and 4 Vn being very low.

Since the relatively large year-classes of the early 1980s, there has been no detectable recruitment to the 4 Vn portion of the population. There is no evidence of the large 1988 year-class in this area. The overall catch rate at length in 4 Vn is well below the long-term mean.

Catch rates in Subdiv. 4Vs were well below the long-term average in 1992. In 1992 there were no fish smaller than 32.5 cm and catch rates at all lengths were of the same magnitude as had been observed in 1970-76, prior to the extension of jurisdiction.

Bottom temperature in 4 V in July have shown a notable decline since 1984. Average bottom temperatures in 4 V over the past four years have been below 2.5 C . Since haddock have been shown to avoid waters below 4 C , the amount of suitable bottom area available for haddock in 4 V has probably declined in
conjunction with this cooling trend. This may have caused haddock to move out of the area or caused them to concentrate in areas of sultable habitat making them more vulnerable to the fishery.

Division 4W has traditionally been the centre of distribution of this resource as evidenced by the significantly higher average catch rates observed there than in other parts of the stock area. Analysis of the catch at length for 4 W indicates modes at $8.5,20.5$, and 32.5 cm (Fig. 10.8d) which probably represents ages 0,1 and 2. In 1992, the 1988 year-class continues to be estimated well above the long-term average. It is notable that this is only the case for 4 W , the 1988 year-class has been entirely absent from Subdlv. 4 Vn and appears to have all but disappeared from Subdiv. 4Vs. The 1992 catch rates at length show a narrower distribution than the long-term mean, and save for the presence of the 1988 year-class, resembles the catch at length distribution of the 1970-1976 period prior to the extension of jurisdiction.

Although the stratified mean bottom temperature estimates in 4 W declined since 1984 similar to that observed in 4 Vs , the average July temperature has remained above $5^{\circ} \mathrm{C}$. These temperatures are likely to be less limiting to haddock than the very low temperatures observed in 4Vs.

Previous age-based analysis of the summer survey data indicated a decline in the maximum age of the fish caught in the survey since the early 1980s with the oldest fish in the survey since 1989 being 7 years old. The catch at length data show a decline in the catch rates of fish in the larger size classes.

## Spring surveys

Spring surveys have been conducted on the eastern Scotian Shelf during March of each year since 1979, with the exception of 1980 and 1985. Catch rates increased from 1979 to 1983 and declined thereafter to a low in 1992 (Fig. 10.8e). The results of the 1993 survey may indicate some increase over 1992 but it is difficult to judge whether or not this is significant. Survey catch rates in Subdiv. 4Vs increased from 1979 through 1987 and have been low since. In Div. 4W survey catch rates peaked in 1983 and have declined since.

The long-term mean spring survey catch rates at length in Div. 4 W shows modes at 14.5, 26.5, and 40.5 cm (Fig 10.8f). The 1992 results show the 1988 year-class at a modal length of $36.5-38.5 \mathrm{~cm}$, these fish had a modal length of 36.5 cm in the July survey indicating either little growth over the year or high mortality for those fish growing fast enough to reach fishable sizes. The 1992 results also show the presence of a somewhat above average catch at 18.5 cm . this could either represent a fast growing 1992 year-class at age 1 or a slow growing 1991 year-class at age 2.

### 10.8.3. Estimation of Stock Parameters and Assessment Results

## Fishing mortality and stock abundance

An analysis of covariance of the ratios of catch and survey population at length (See Section 13.5) indicate that fishing mortalities of larger fish ( $46.5-60.5 \mathrm{~cm}$ ) have increased significantly over the past 4 years. Assuming survey catchability is approximately equal to 1.0 this implies present fishing mortallites in the order of 1.0. This is probably due to a combination of low abundance and the displacement of fishing effort out of the closed area where larger fish are relatively less abundant. Fishing mortality on the smaller length group ( 40.5 cm ) has not shown this increase.

Estimates of the relative proportions of the 1970 through 1988 cohorts removed through age 3 indicates three distinct periods. The highest proportions removed were from 1970 to 1976, prior to the extension of jurisdiction and during the period when small mesh gear fisheries were present on the Scotian Shelf. The proportions were lower following the exclusion of the small mesh gear fisheries from 1977 to 1986. The
proportions decreased again following the exclusion of mobile gear from the now closed area in 1987. However it may have resulted in increased exploitation of larger fish in other areas. The connection between establishment of the closed area in 1987 and subsequent increases in haddock abundance cannot be proven; however, the closed area has resulted in a reduction in the average rate of exploitation of fish under age 3 (assuming the previously estimated age structure).

The results of both the summer and spring surveys indicate that haddock is concentrated in Div. 4 W and is mainly comprised of a single (1988) year-class, and fishing mortalities on the exploited portions of the population are very high.

## Recruitment

Since the 1988 year-class, no large year-classes have been detected by either the summer or spring surveys. The 1992 summer survey did not catch any fish at or around 8.5 cm (age 0 ) and the catch of fish at 20.5 cm (age 1) was well below average. The 1992 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 large in subsequent surveys.

## Spawning Stock Biomass

At low stock biomass the probability of producing an above average year-class appears to be low relative to that at higher spawning stock biomass (Fig. 10.8 g ). However high spawning biomass will not necessarily result in large year-classes if juvenile survival is low (Fig. 10.8h). The female spawning stock biomass decreased since 1981 and dropped to about $4,000-8,000$ in 1992 as estimated from survey catch rates at length converted to weight and assuming knife-edged maturity at 42.5 or 46.5 cm (Fig. 10.8h). This estimate is at about the level that was observed in the late 1970s. If the 1988 year-class remains relatively abundant as the bulk of its members mature, spawning stock biomass will increase. The contribution of the 1988 year-class to spawning stock biomass will be enhanced by reduced exploitation.

### 10.8.4. Prognosis

There are a number of indicators which would lead to the conclusion that this stock has been heavily exploited, that environmental conditions over a larger portion of the stocks range have been unfavourable, and that year-class strength since the 1988 year-class have been below average. Continued fishing at currently estimated rates of fishing mortality will greatly reduce the potential contribution of the 1988 yearclass to the presently low level of spawning stock biomass.

### 10.9. Haddock in Division 4X (WP 105, 136) P. Hurley

### 10.9.1. Description of the Fishery

## Nominal Catches

The long-term (1930-88) reported annual landings of 4 X haddock have averaged about 20,000t. Landings peaked above 30,000 during the mid to late 1960s and again during the 1980s (Fig. 10.9a). Catches were lower than TACs set during 1982-84 and again in 1987-88. Total catch has been below the long-term average since 1984. Catches reached a low of $6,700 \mathrm{t}$ in 1989 when it was recommended that the fishery be maintained at the lowest possible level and the mobile gear fishery was closed mid-season. Catches have increased since 1989 under a management plan that called for a by-catch fishery only. Total 4 X
haddock landings for 1992 were $10,351 \mathrm{t}$. While this fishery has been dominated by the mobile gear historically, the proportion of the landings taken by the fixed gear has increased since 1989 (Fig. 10.9b).

## Allocations and management actions

Even though the management plan called for a by-catch fishery only, individual transferable quotas (ITQs) were introduced into the mobile gear fleet $<65 \mathrm{ft}$ in 1991. The fishing strategy of this gear sector changed substantially under ITQ management. Vessels with small ITQs for haddock avoided catching haddock while many other ITQ vessels chose to hold their 4X haddock ITQs until later in the year and directed for other species (flatfish, silver hake, shrimp) or fished other areas ( 5 Z ). ITQs were implemented for $5 Z$ for the mobile gear fleet <65 ft in 1992 and this further altered fishing strategies for this gear sector. Transfer of 4X haddock quota between vessels resulted in the amalgamation of quota in 1992. Landings of 4X haddock by the ITQ fleet totalled $2,776 \mathrm{t}$, a decrease of $28 \%$ from last year. The mobile gear generalist fleet was regulated by trip limits throughout the season in 1992 and landed 494t. Mobile gear >65 ft landed 419t of 4X haddock.

Minimum otter trawl mesh size was increased in 1991 from 130 mm diamond mesh to 155 mm diamond or 140 mm square mesh. This was reduced to 145 mm diamond or 130 mm square mesh in mid-season. Reports from fishers indicate that this new measure has been effective in reducing the capture of fish less than 43 cm .

The fixed gear fleets $<45 \mathrm{ft}$ and $45-65 \mathrm{ft}$ fished on trip limits of $6,800 \mathrm{~kg}$ of 4 X haddock until March 11992 when they were placed on trip limits of $1,500 \mathrm{~kg}$ of haddock. Longline landings totalled $6,468 \mathrm{t}$, an increase of $26 \%$ over last year. Gillnet landings totalled 251 t .

## Anecdotal information from the fishery

Industry representatives have indicated that substantial misreporting occurred during 1985-88, was low in 1989, and has increased slightly since. Misreporting was likely less than $10 \%$ in 1992. Reports suggest that a portion of the increase in longline landings may be a result of transshipping from mobile gear vessels; however the extent of this is unknown.

Anecdotal information suggests that haddock abundance has increased in the last 2-3 years. Longliners report catch rates have increased substantially over the period.

### 10.9.2. Data

## Size composition of the catch

Age reading of 4 X haddock otolths was suspended in 1992 when it was determined that the extant ageing protocol had resulted in a bias in haddock ages in recent years. A workshop was held to review procedures used in age reading and new criteria were defined for reading 4 X haddock otoliths. This matter is still unresolved and therefore age data are not presently available for commercial samples collected in 1992. Consequently, commercial sampling data were used to reconstruct a catch at length for the period 1978-92. The same grouping of commercial samples used to reconstruct the catch at age was used to reconstruct the catch at length.

The length composition of the commercial catch remained consistent during 1978-92. The catch at length was typically unimodal. Mean length ranged between 49 and 53 cm while modal length ranged from 47 to 57 cm . Mean and modal length have been relatively stable 1988-92, being 52 and 51 cm respectively (except modal length 55 cm in 1991). Eighty percent of the catch was between 44 and 60 cm . The
proportion of the catch $<44 \mathrm{~cm}$ reached $20 \%$ during 1983-86 and in 1990. The latter is likely a result of recruitment of the average 1987 and 1988 year-classes subsequent to the small 1985 and 1986 year-classes. Comparison of the 1991 and 1992 catch at length showed a shift to smaller fish in 1992 and an increase in the proportion $44-54 \mathrm{~cm}$, the 1987 and 1988 year-classes (Fig. 10.9c).

There is no evidence in the catch at length of a reduction in length range comparable to the reduction in age range observed in the catch at age since the mid 1980s, further evidence that the ageing protocol had produced a bias in ages.

## Commercial catch rates

Otter trawl catch rates have not been considered a reliable index of haddock abundance in 4 X due to the high and variable levels of misreporting, particularly in the mid 1980s, and because of the extent of management changes in the recent period. However, in recent years at least, the longline fleet has fished relatively unrestricted during January and February prior to the March 1 closure of Browns Bank. Catch rates of tonnage class 1-3 longline vessels fishing 4Xmnop in January and February were examined and showed a $25 \%$ increase from a low in 1989 to 1992 (Fig. 10.9d). This increase is consistent with anecdotal reports from the longline fleet but is of a lower magnitude than is often stated. Tonnage class $1-3$ stern trawl catch rates in the same area and period were examined for comparison and showed a doubling of catch rate between 1990 and 1991 and a further increase in 1992 (Fig. 10.9d). The magnitude of this increase may be more reflective of changes in fishing strategy related to the implementation of ITQs than of stock abundance.

Research vessel surveys
Although ageing data were available for the 1992 summer research vessel survey, these were not used due to the bias in older ages in recent years. However, ages 1-2 which are felt to be relatively free of bias, were considered for recruitment indices. Research vessel catch rates at length were calculated for the survey series 1970-92.

Research vessel catch rates were low during the 1970s and high during the early to mid 1980s (Fig. 10.9e). Catch rates declined sharply during 1985-87 to near record low levels and then increased to 1991, but were still below the long-term mean. The 1992 research vessel catch rate is half that of 1991. Disaggregation of the research vessel series into categories less than and greater than 43 cm shows the contribution of the 1987 and 1988 year-classes in 1988-90<43 cm category and then a subsequent decline. Catch rates of the $>43 \mathrm{~cm}$ category increase abruptly in 1990-91 but then fall off in 1992, suggesting a year effect.

There is no indication of a reduction in length range in the survey comparable to the reduction in age range observed in recent years, further evidence of a bias in the aged data.

Modes in the long-term research vessel mean catch at length corresponding to ages 1-5 were clear. Comparison of catch at length for the most recent surveys with the long-term mean indicates that the 1987 and 1988 year-classes are average in strength, the 1989 year-class is very weak and the 1990 and 1991 year-classes are below average (Fig.10.9f).

### 10.9.3. Estimation of Parameters and Assessment Results

## Recruitment

A recruitment index calculated from mean numbers at ages 1 and 2 of a year-class in the research vessel survey indicates that recruitment has been average or below average since 1983 (Fig. 10.9g). The 1985 and 1986 year-classes were well below average while the 1989 year-class was close to the 1970 year-class, the smallest in the series. The 1990 year-class was half the long-term mean. Mean numbers at age 1 in the 1992 survey suggest the 1991 year-class may also be below average. This is consistent with an analysis of survey catch rate at length showing the relative strengths of these year-classes at modal lengths corresponding to fish aged 1 and 2.

Length frequencies of the haddock by-catch from the foreign small mesh gear fishery in 4 X have been reflective of incoming year-class strength. Low numbers of haddock in the $18-24 \mathrm{~cm}$ size range in the bycatch in 1992 suggest that the 1991 year-class is small.

## Spawning stock biomass

Research surveys have provided relative estimates of population size for this stock since 1970. Estimates of research vessel catchability are needed to convert these relative estimates into absolute estimates, and these catchability estimates may be obtained from SPA calibrations. While SPA is not currently possible, a rough estimate of research vessel catchability was obtained from the last SPA-based assessment of this resource (O'Boyle et. al. 1989). This indicated that, for the mature portion of the population, the population estimates obtained from the research vessel surveys were approximately equal to those from the SPA, thus indicating an research vessel catchability of 1 . This catchability estimate was used in the discussion that follows.

An estimate of female spawning stock biomass was calculated from the research vessel survey mean numbers at length using a maturity at length ogive and a length-weight relationship. The resulting estimate suggests that female spawning stock biomass was below average during the eally 1970s, peaked in the late 1970s and early 1980s at about 30,000t, declined to average levels in the mid-1980s and fell to a minimum of about 9,000t in 1987-89 (Fig. 10.9h). With the appearance of the average sized 1987 and 1988 yearclasses, female spawning stock biomass has since increased and is about 15,000 . However female spawning stock biomass is still below the 1970-92 average of 19,000t calculated from the research vessel series and well below the 1962-88 average of 25,000t derived from the most recent SPA population numbers.

A nonparametric analysis of the effect of spawning stock biomass on the recruitment index was carried out. Results showed an increasing probability of low recruitment as spawning stock biomass decreases. The probability that this effect is due to chance alone was estimated to be 0.4 using an approximate randomization test. Although this is not strong evidence, it would be prudent to take the increased probability of low recruitment at the current low biomass into account.

## Fishing mortality

Total mortalities calculated from the research vessel survey were used to provide information on fishing mortalities (assuming $\mathrm{M}=0.2$ ) in the last assessment. Given that these relied upon ageing data and the bias found in the ageing data in the recent period, a sensitivity analysis was conducted to investigate the impact of this bias. The analysis indicated that the bias in the ageing data would result in an over-estimation of mortalities; total mortalities would still be in excess of 1 during 1985-89 but may have decreased to 0.8 in 1989-91.

Estimates of mean fishing mortallities for mature fish were obtained from the ratio of mature population numbers calculated from the research vessel survey, to the mature portion of the catch, calculated in the same manner from the catch at length. This analysis indicated fishing mortality was high throughout the 1980s. A decrease between 1983-87 likely reflects the misreporting that occurred during that period. Fishing mortality decreased from 1987-91 and then increased slightly in 1992.

An analysis of covariance of the In ratio of catch at length to research vessel population estimates at length (see section 13.5) showed the same general trends. Fishing mortalities for lengths 40,50 and 60 cm decreased from high levels (0.5-1.0) in 1987 to 1991 and increased slightly in 1992 (0.25-0.5).

The reason for this apparent decline in fishing mortality from 1989-91 in unclear. Calculation of total effort for the stern trawler and longline fleets from total catch and catch rates indicates that the stern trawler effort decreased 80\% from 1986-92; however longline effort decreased by 40\% 1986-89 but then doubled by 1992. The continued decline in fishing mortality in 1990-91 may be a result of recruitment of the 1987 and 1988 year-classes to the longline gear or to the research vessel survey. These recent trends in fishing mortality are influenced by the assumptions on survey catchability mentioned earlier. With recrultment of the 1987 and 1988 year-classes, the long-term catchability estimates may be conservative and thus the decline in fishing mortality will be over-estimated. The extent of this over-estimation cannot be determined.

### 10.9.4. Prognosis

This remains a recruitment fishery. The recruitment index from the research vessel survey was below average in 1985-86, average in 1987-88, and has been below average since. The 1989 year-class appears particularly low. Spawning stock biomass reached a minimum in 1988-89 and has increased since but is still well below the long-term mean.

The 1992 catch was dominated by the 1987 and 1988 year-classes and these year-classes will likely continue to make up the majority of the catch in the next two to three years. Catches will decline thereafter unless strong recruitment occurs.

The present TAC of $6,000 \mathrm{t}$ for 1993 is likely to result in a reduction in fishing mortality. With uncertainty about subsequent recruitment, a reduction in exploitation will extend the period that the 1987 and 1988 yearclasses will contribute to the fisheries and will maintain spawning stock biomass.

### 10.9.5. Research Recommendations

1. The problems identified with the age determination of 4 X haddock should be resolved and the catch at age corrected appropriately.
2. Given the uncertainties associated with the age data, alternative assessment techniques such as general production models and length based SPA techniques should be explored.
3. The magnitude of misreporting that occurred during the 1980 s should be determined and the catch at age corrected appropriately. This should also be explored using sensitivity analysis.

### 10.10. Haddock in 5Zjm (WP 80, 84) S. Gavaris

### 10.10.1. Introduction

The International Court of Justice decision in 1984 established the maritime boundary between Canada and the USA on Georges Bank. A subsequent evaluation of accumulated evidence on stock structure and consideration of practical matters relating to statistics led to the definition of an eastern Georges Bank management unit.

Recognizing that Canadian landings generally accounted for over $2 / 3$ of the total from this unit and in view of the observation that most of the stock was distributed in Canadian jurisdiction, CAFSAC provided recommendations on catches for Canada which were consistent with Canadian management strategies and targets for other stocks (i.e. at the $\mathrm{F}_{0.1}$ target exploitation rate). The 1992 stock assessment (Anon. 1992a) resulted in a significant reduction in advised catch to below 2,500 . Concern was expressed by the fishing industry that a reduced TAC would not result in subsequent yield benefits to the Canadian fishery because of the transboundary nature of this resource. The CAFSAC advice was not followed and the Canadian TAC was kept at 5000 t .

### 10.10.2. Description of the Fishery

The haddock on Georges Bank have supported a commercial fishery since the early 1920s. Record landings were reported in the mid-1960s, reaching about 60,000 t for eastern Georges Bank, (unit areas 5 Z ] and 5 Zm ). Since 1969, landings ranged between about 2,500 t and 25,000 ( $F$ ig. 10.10a) and in recent years have fluctuated around 5,000 . In 1992, Canadian landings were 4,000t, a 1,000 t shortfall as the mobile gear was unable to catch their allocation. USA landings in 1992 increased to 1,700t. Due to the introduction of ITQs, the Canadian mobile fleet fished during January and February in 1993, unlike recent years. Haddock are in pre-spawning and spawning aggregations during these months, which accounted for the reported high catch rates.

### 10.10.3. Data

Research vessel surveys
The trends in abundance derived from the research surveys (Fig. 10.10b) indicate a decline in the adult ages ( 3 to 8 ) over the last 3 years to about the lowest levels observed. The recruitment trend (ages 1 and 2) shows the strong 1975 and 1978 year-classes and the moderate 1983, 1985 and 1987 year-classes. Subsequent incoming year-classes do not appear strong.

Analysis of the most recent surveys (Canada and USA, March 1993) would provide additional estimates of the abundance of the 1992 year-class. Although inclusion of these results would not alter the view of the depressed status of the resource, it would improve the forecast of future prospects. These analyses will be provided as soon as they become available.

## Commercial catch rates

Catch effort records from 51 bottom trawlers (less than 65 ft ) which had ITQs for Georges Bank and a history of three or more years activity since 1987 were analyzed. The impact of individual vessel, area of capture and month of capture were accounted for by assuming multiplicative effects. The resulting catch rate index increased to 1989, declined sharply in 1990 and remained low (Fig. 10.10c). The associated
trawler effort was substantially higher during 1990-92 than in 1987-89 with the peak occurring in 1991. Although there are uncertainties regarding the effects of misreporting, trip limits and the introduction of ITQs, the general pattern is in agreement with the increasing trend in fishing mortality reported in last year's assessment (Gavaris and Van Eeckhaute 1992).

### 10.10.4. Estimation of stock parameters

## Yield per Recruit

Given the recent Canadian management decision to maintain their allocation at 5,000 tor 1993, an update of the stock assessment and commensurate catch advice is not sufficient. The implications of unilaterally restricting catches by Canada need to be quantified and evaluated with respect to a harvest strategy for this transboundary resource. Yield per recruit projections were conducted to investigate the effect of various exploitation rates by Canada and the USA on yield to the Canadian fishery using available information on distribution and seasonal migration between the two jurisdictions.

Information on distribution and migration of haddock on Georges Bank was obtained from analysis of the spring (March) and autumn (October) surveys conducted by USA and the spring (March) surveys conducted by Canada. These results suggested that the migration was a seasonal behaviour pattern with haddock moving to the northeast and to deeper water through the spring and summer (April-September) and returning to the bank in the autumn and winter (October-March). The movement did not appear to be related to relative densities or abundance.

Based on these observations, it was concluded that a fraction of haddock migrated between Canadian and USA territory, as opposed to all haddock circulating over the Bank making them susceptible to each of the fisheries at some time during the year. Further, the continued occurrence of haddock in USA territory, despite high exploitation, suggests mixing and redistribution. Thus it was assumed that spatial fidelity, at the scale being studied, was not a significant factor.

The net migration is toward the USA side during autumn-winter and toward the Canadian side during springsummer. The rate of movement between the two sides balances out on average, and there is no net annual migration. About $15 \%$ of the total adult population (ages 2 and older) shifts back and forth across the Canada-USA boundary during this seasonal migration. About $80 \%$ of the age 2 population is found in the Canadian territory at the beginning of the spring-summer period.

The Canadian fleet fished at much higher rates during the spring-summer period than during the autumnwinter period. A less pronounced, but similar pattern was observed for the USA. The projections reflected this feature with instantaneous fishing mortality rates for Canada during the autumn-winter period being set to $20 \%$ of the spring-summer values. For the USA, the autumn-winter values were set to $25 \%$ of those used during the spring-summer period.

Yield per recruit was calculated assuming a distribution pattern and migration rates observed during the late 1980s (described above). Projections began at the beginning of the spring-summer period with $80 \%$ of the age 2 haddock in the Canadian territory. In the simulations, virtually all fish of all ages migrated to the Canadian territory by the end of the spring-summer period. During the subsequent autumn-winter period, approximately $15 \%$ migrated to the USA territory. Yield per recruit to the Canadian fishery was calculated as a function of a range of Canadian ( $0-1.0$ ) and USA ( $0-2.0$ ) spring-summer instantaneous fishing mortality rates. It should be noted that these fishing mortalities apply only to the 6 -month spring-summer period. The F for the remaining part of the year is $20 \%$ and $25 \%$ of the spring-summer values for Canada and the USA respectively. The annual $F$ by each fleet would be approximately the average of the $F$ for the two periods.

Two other analyses were conducted. One assumed that no haddock returned to Canada after migrating to USA territory. The other assumed that only $60 \%$ of the age 2 haddock were in Canadian territory at the beginning of the spring-summer period and migration to USA was $50 \%$ greater than that used above while migration to Canada remained unchanged. These scenarios represent extreme conditions which establish bounds for "worst case" situations.

The average weight at age and partial recruitment to the fishery used previously for a yield per recrult analysis were used for both countries' fisheries here:

| Age | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| PR | 0.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Wt(kg) | .95 | 1.34 | 1.9 | 2.3 | 2.75 | 3.15 | 3.6 | 3.8 | 3.9 | 4 | 4.1 | 4.2 | 4.3 |

### 10.10.5. Assessment Results

The abundance trends from surveys support the perception from last year's assessment that the stock is in a depleted state and continuing to decline. It was reported last year that the adult blomass had declined to about 10,000t (Fig. 10.10d), near the lowest observed, and was forecast to decline further even under reduced exploitation. The indication of increased trawler effort from the analysis of commercial catch rates agrees with the trend in fishing mortality which was estimated to have reached about 0.8 , well above the $F_{0.1}$ (=0.25) level.

The results from the transboundary yield projection model are summarized in Fig. 10.10e. Note that although the USA only harvests in the range of 0 to $10 \%$ of the total population, their fishing mortality rate on that portion of the population available to them is extremely high with Fs exceeding 1.0. The yield to the Canadian fishery showed a modest decrease as the USA F increased. This relative insensitivity of the yield surface to USA fishing mortality is a reflection of the low proportion of haddock occurring in USA territory. There was not a well defined maximum yield per recruit (Fmax) as a function of the Canadian $F$ largely due to slow growth of haddock after they have attained a size of about 50 cm .

Using an heuristic approach, an equivalent harvest strategy approximating the Canadian $\mathrm{F}_{0.1}$ level, conditional on each USA exploitation rate, was considered to be that rate which achieves $85 \%$ of the asymptotic yield (taken as Canadian spring-summer $F=1.0$ ). Over the range of $F$ used for the USA springsummer fishery ( $0-2.5$ ), the Canadian spring-summer F that would give $85 \%$ of the asymptotic yield increased from 0.37 to 0.49 .

If the extreme assumption is made that none of the haddock migrating to the USA side return, then the corresponding Canadian F which achieved $85 \%$ of asymptotic yield was closer to 0.60 . The yield curve for this scenario does not reach an asymptote as quickly.

The second "worst case" scenario used a value for the proportion of the stock on the Canadian side at about the lowest observed and assumed the emigration from the Canadian side was as great as about the highest values observed. The results indicated a substantial reduction in Canadian yield. For similar Canadian and USA exploitation rates, the Canadian yield was generally less than half that obtained in the original projections. The yield continued to increase even at very high Canadian exploitation rates, precluding computation of any meaningful reference level.

### 10.10.6. Prognosis

If Canada and the USA adopted a consistent $\mathrm{F}_{0.1}$ harvest strategy for the entire stock, the annual combined Canadian/USA exploitation rate would be about 14\%. The results from the transboundary yield projections

Indicate that in the absence of a consistent management strategy and under average conditions observed during the late 1980s, the kinds of benefits associated with an $\mathrm{F}_{0.1}$ strategy can be approximately achieved by the Canadian fishery if their exploitation rate is maintained below 17\%. This exploitation is in addition to any exerted by the USA. The combined exploitation by the two countries will be higher than that associated with a consistent harvest strategy, reflecting the competitive environment.

If none of the haddock migrating to the USA return to Canada, then a higher fishing mortality rate by Canada is indicated. If the distribution of haddock changes, approaching the $60 \%$ to $40 \%$ split used in the "worst case" and migration from Canada is greater than migration to Canada, the results suggest that unilateral actions by Canada are unlikely to be effective for conservation or for management to optimize yield and catch rates. Under these circumstances, the competitiveness between the Canadian and USA fisheries to "get the fish first" becomes severe and results in very high exploitation rates.

The analysis suggests that unilateral management actions by Canada can be used to effect an $F_{0.1}$ type harvest strategy for eastern Georges Bank haddock. It should be noted that although standard $F_{0.1}$ exploitation rates are considered safe with respect to recruitment overfishing, a conditional rate would be higher and may not share this property. The results of these analyses are based on population distribution and migration patterns which have been recently observed. With increased haddock abundance, these characteristics may change necessitating a subsequent review.

Yield per recruit considerations provide useful reference points for healthy stocks. Considering the severely depleted state of this resource and the poor recent recruitment, consistent restrictive measures by both countries are needed to achieve recovery.

### 10.10.7. Research recommendations

1. The proportionality between month, area and vessel effects assumed in the catch rate analysis should be examined.
2. The projected yield simulations should be repeated using stochastic recruitment. The Canadian and total yield surfaces from these analyses should be investigated as well as the yield per unit fishing mortality and the average size of fish in the catch. Exact $F_{0.1}$ exploitation rates could be computed for comparison.
3. It was suggested that this work could be presented to the ICES Working Group on long- term management considerations which is considering spatially structured models.

### 10.11. Pollock in $4 \mathrm{VWX}+5 \mathrm{Zc}$ (WP 112) E. Trippel

### 10.11.1. Description of the Fishery

Since 1974, pollock catches have ranged between 25,000t and 46,000t with an average of 36,420 (Fig. 10.11a). Landings and TACs have been relatively stable for the 1985-1989 period due to good recrultment in the early 1980s. Shortfalls in the Canadian nominal catches for 1990, 1991 and 1992 were 6,800, 5,200 and 11,800 t, respectively under the TAC of 43,000 t. Both mobile and fixed gear fleets were below their allocations. The fishery in 4 VW is dominated by large offshore vessels greater than 100 ft using mobile gear, whereas the fishery in 4 X and 5 Zc is dominated by inshore vessels less than 65 ft using mobile and fixed gear. Catches of pollock have remained stable in 4 X 5 Zc since 1974, whereas in 4 VW catches doubled from 1974-1980, remained relatively stable to 1989 and since then have declined. The foreign catch of 2,000 in 1992 was caught mainly by Cuban and Russian vessels as by-catch in the silver hake fishery.

### 10.11.2. Data

## Catch and weight at age

As in most years, only four or fewer year-classes contributed significantly to the annual landings. The catches of fish aged 2 and 3 in 1992 were the highest observed since the early 1980s. At ages 2 and 3 years, the 1989 year-class ranked 2nd and 3rd highest in the commercial catch at age data base. The foreign small mesh gear catch at age contributed $97 \%$ of age 2 fish and $44 \%$ of age 3 fish to the total catch at age. The catches of fish age 6 and older are down substantially from the mid-1980s.

## Commercial catch rates

A multiplicative model was used to standardize catch rates by NAFO division, tonnage class, month and year (1987-1992). Data used in the analysis were aggregated to the trip level which was confined to vessels in which pollock comprised $>50 \%$ of the catch. Results indicated a steady decline in catch rate since 1989 (Fig 10.11b).

## Research vessel survey data

The research surveys indicated an increase in the age 4-10 abundance in the early 1980s with subsequent estimates being highly variable (Fig. 10.11c). In general, the survey exhibited strong year effects making it difficult to estimate year-class strengths. The 1992 survey age 4-10 estimate was the lowest since 1984. The 1989 year-class was the 4th and 5th highest in the two years it was present in the $\mathbf{2 2}$ year survey series.

### 10.11.3. Estimation of parameters

The accepted ADAPT formulation estimated seven parameters (age 8 population numbers (CV=34\%) and survey K 's ages 4-9 ( $\mathrm{CV}<16 \%$ )).

Several other ADAPT formulations were investigated but were not accepted. ADAPT formulations in which several age classes were estimated resulted in high coefficient of variations ( $60-80 \%$ ) on parameter estimates. Moreover, estimates of age-specific fishing mortality varied widely in these formulations. The accepted formulation in which one age was estimated added more structure and made use of partial recruitment values and catch data to estimate other ages.

## Fishing mortality

Fishing mortalities of fully recruited age groups (mean of ages 7-9) for this stock ranged from 0.25-0.87 between 1974-1992 (Fig. 10.11d). In 1992, fully recruited fishing mortality ( 0.55 ) was nearly twice the $\mathrm{F}_{0.1}$ target level.

## Recruitment

The 1979 ( 76 million) year-class at age 2 is the largest observed in the 1974-1992 period (Fig 10.11e). The 1980-1985 year-classes are all near the long-term geometric mean of 28 million. Using ADAPT, the 1989 year-class was estimated to be close to the historical high of 76 million. There are only two estimates of this year-class and it was considered prudent to record its size as the geometric mean. Additional information on the strength of this year-class from the 1993 commercial fishery and research survey will be available in the autumn of 1993.

## Stock size

Stock biomass (age 2+) and spawning stock biomass (age 4+) were low in the early 1970s, peaked during the mid-1980s and have declined since (Fib 10.11f,g). The abundance of age $7+$ fish has declined in recent years.

### 10.11.4. Prognosis

Catch projections were made for 1994 using the following data:

| Age | Weight (kg) |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | 1993 beginning year bias corrected pop. numbers ('000) | Mean of year | Beginning of Year | Partial Recruitment |
| 2 | $28000{ }^{\circ}$ | 0.325 | 0.530 | 0.004 |
| 3 | 13024 | 0.758 | 1.140 | 0.065 |
| 4 | 16677 | 1.406 | 1.800 | 0.345 |
| 5 | 21277 | 2.102 | 2.460 | 0.652 |
| 6 | 6836 | 2.723 | 3.080 | 0.915 |
| 7 | 2334 | 3.274 | 3.670 | 1.000 |
| 8 | 1322 | 3.830 | 4.080 | 1.000 |
| 9 | 563 | 4.410 | 4.850 | 1.000 |
| 10 | 282 | 5.010 | 5.170 | 1.000 |
| 11 | 215 | 5.320 | 6.190 | 1.000 |
| 12 | 102 | 6.500 |  | 1.000 |

${ }^{\text {a }}$ 1989-1992 average
b 1988-1991 average
${ }^{\text {c }}$ GM recruitment (1974-1992) is 28 million
The projected catches in 1994 and the resulting beginning of the year 1995 adult biomass at various fishing mortalities in 1994, are shown in Fig 10.11h.

The 1993 TAC of 35,000 implies a fishing mortality of 0.55 . The projected catch at $F_{0.1}$ in 1994 is highly dependent on the estimated size of the 1989 year-class. Assuming that it will be equal to the geometric mean recruitment, the projected catch at $F_{0.1}$ is 20,000 . However, the projected catch would be substantially higher if the year-class approaches the size estimated with the SPA. It will be possible to provide a more firm estimate of the size of this year-class in the autumn of 1993 using information from the 1993 commercial fishery and research survey.

### 10.11.5. Research Recommendations

1. Conduct a retrospective analysis.
2. Continue to examine the commercial catch rates for possible indices of abundance. Conduct future analyses using multiplicative models specific to each NAFO subdivision.
3. Explore the use of the spring research vessel survey time series as a possible index of abundance of small fish.
10.12. Redfish in the Gulf of St. Lewrence (4RST, 3Pn (Jan.-May) and 4Vn (Jan.-May) (WP 109) B. Morin

### 10.12.1. Description of the Fishery

The landings for the Gulf of St. Lawrence redfish fishery increased steadily during the 1960s to reach a maximum of 130,000t in 1973 (Fig 10.12a). Thereafter, landings declined sharply to a low of 15,000t in 1978 and have steadily increased to reach $77,400 \mathrm{t}$ in 1992 . The high catch of 1992 is mainly due to higher catches in 3Pn and 4Vn. During the last ten years, winter (January to April) catches have increased from 3\% to 47\% of total landings. Catches from midwater trawls represented 71\% of the total landings. Bottom trawis were mostly used in summer as in previous years.

TACs for the 4RST stock were introduced in 1976, but except for 1976 and 1981, landings in 4RST have been below the TACs. The TAC recommended for the new management unit (4RST+3Pn [Jan-May] + 4Vn [Jan-May]) in 1992 was 67,000t. However, the new unit was not implemented in the 1992 groundfish management plan. Instead, a provisional measure was put in place which allowed the Gulf based vessels to catch 15\% of their 4RST allocation in 3Pn and no catch limits were imposed for January-May in 3Pn-4Vn for those vessels operating under the 3P or 4VWX management unit allocations. As a result, the 1992 nominal catch of Gulf redfish was 77,400 t. The 1993 TAC of 60,000 was set for the new management unit.

### 10.12.2. Data

## Commercial sampling

Commercial length frequencies from port and sea sampling were obtained for all divisions but 4R was more covered. The length frequencies were combined by quarter, gear, region and weighted by the corresponding landings to obtain catch at length for the period 1981 to 1992. In 1992, for both midwater (OTM) and bottom (OTB) trawls, the largest proportion of the catch was composed of 29-31 cm long fish (predominantly 1981 year-class). A smaller mode at about 35-37 cm (early 1970s year-classes) is also observed, principally in the first quarter for OTB and for the first and second quarters for OTM.

A limited monitoring of the species composition in the commercial catch was done in 1991-92 using liver malate dehydrogenase (MDH) allelic frequencies which showed that $80 \%$ of the catch was composed of $S$. mentella.

## Commercial catch rates

Catch and effort data for the new management unit were extracted from ICNAF/NAFO Bulletins for the 1959-89 period and were combined with the provisional data for 1990-92. A multiplicative model was used to obtain a standardized catch rate series.

Midwater trawi data for the 1972-74 period and the Engel high lift trawl data for 1974 were removed as in previous analyses. The catch rate series shows three distinct peaks and the last one in 1990 was the highest (Fig. 10.12b). The high catch rates since 1988 were suspected to be due to the introduction of the Shilikov-Turbo midwater trawis in 1988 and the recruitment of the 1981 year-class. To investigate the effect of midwater trawls, a second standardization was performed using only bottom trawls for the months of May to October. Redfish are then within the Gulf and are thought to found closer to the bottom. This catch rate
series also showed three peaks but the last one was of the same magnitude as the previous two (Fig 10.12c). The catch rates in 1990 appeared to be anomalously high and may be the result of higher catchability of redfish in that year. Catch rates increased slightly in 1992. During the period covered by this time series, there were numerous changes in the fishing fleet which could have affected its fishing power. The standardized time series cannot account for these incremental changes in gear technology, but it should reflect the short term variations of stock biomass.

## Research survey data

Surveys for redfish have been conducted since 1984, but the estimates obtained before 1990 are not comparable to the later ones because of a change of vessels and gear in 1990 (Lady Hammond to Affred Needler; western IIA trawl to shrimp trawl).

The length frequencies from the 1992 research survey showed two important modes. The first mode at 29-31 cm corresponded to the strong 1981 year-class which dominated the commercial catches. The abundance estimates of these fishable-sized redfish ( $\mathbf{> 2 5} \mathbf{~ c m}$ ) decreased from about 800 million in 1990 to about 350 million in 1991 and subsequently increased to 400 million in 1992. The second mode at 12-14 cm (the 1988 year-class) appeared to be a good year-class. The abundance of the pre-recrulted size redfish ( $<\mathbf{2 5 c m}$ ) remained stable between 1990 and 1991 at 1,400 million and decreased to 400 million in 1992. Overall biomass estimates decreased by 45\% between 1990 and 1991 (Fig 10.12d). The 1992 biomass estimate decreased by $20 \%$ in 1992, mostly due to drops in divisions 4R and 4T.

Additional information on species composition of redfish in the Gulf was presented. A length based analysis of genetic variation patterns of MDH showed that the 1985 and the 1988 year-classes are composed almost entirely of S.fasciatus, both inside and outside the Gulf of St. Lawrence (Divs. 3P and 4V) whereas S. mentella was low in abundance and restricted to the area west of Anticosti. This observation implies that the fishery will become dominated by S. fasciatus from 1997 onward, but at this time, the consequences of this species shift are unknown.

Results from the winter groundfish survey in the Gulf of St. Lawrence indicated high concentrations in the Cabot Strait area with low catches elsewhere.

### 10.12.3. Estimation of Stock Parameters

## Estimation of the growth parameters and yield by recruit

Preliminary analyses were conducted to investigate the use of length-based methods for this stock. Analyses were performed on the catch at length data to estimate the von Bertalanffy growth parameters using a nonlinear least squares procedure provided in Sparre (1987). The growth parameters estimates were: $L_{\infty}=38.88$ $\mathrm{cm}, \mathrm{K}=0.129 / \mathrm{yr}$ and $\mathrm{t}_{\mathrm{t}}=-0.354 \mathrm{yr}$. These estimates have to be considered dynamic since the addition of a new year of catch at length data may change them. The growth parameters were used to estimate $F_{0,1}$ by Beverton and Holt yield per recruit analysis with a knife-edge recruitment at age 7 . If the natural mortality $(M)$ is assumed to be $0.1, F_{0.1}$ was estimated at 0.1 . These analyses will be pursued in the future.

### 10.12.4. Prognosis

The 1981 year-class is fully recruited to the fishery and will be the main component of the landings for the next $3-4$ years before the 1988 year-class becomes fully recruited. If the catch is kept constant ( 60,000 t) during that period, the exploitation rate will increase as the biomass decreases. Catch rates should also decrease during that time. Catch rates have decreased by a factor of two between 1980 and 1988 as the
year-classes from the early 1970 s moved through the fishery (average catch of 30,000 d during that period). Recent catches have been much higher and the population biomass is expected to decline faster at this level of exploitation if the size of the current year-class is of the same order of magnitude as that of the early 1970s.

### 10.12.5. Research recommendations

1. Investigate changes in the distribution of the recrulted and recrulting year-classes of the Gulf redfish and investigate how this may be related to CPUE. Spatial analysis of CPUE data is recommended.
2. Investigate the use of age/length based assessment methods for redfish.

### 10.13. American Plaice in Subarea 2 + Division 3K (WP 123) W. Brodie

### 10.13.1. Description of the Fishery

Catches increased steadily throughout the 1960s, peaking at 12,686t in 1970 (Fig.10.13a). After the declaration of the 200 mile limit in 1977, foreign catches were greatly reduced, with the total catch from the stock exceeding 2,000t on only 2 occasions after 1981. Catches in the last 2 years are the lowest in the time series, with 1992 being due, in part, to the moratorium on the northern cod fishery. In recent years, most of the catch has come from Div. 3K, with the exception of 1989 and 1990 when a directed fishery occurred in the autumn in Div. 2J. In most years, the inshore catch ranged between 500 and 2,000t, while the offshore catch has fluctuated more widely (Fig. 10.13b). By-catch from the shrimp fisheries in SA2 + Div. 3K averaged about 120t per year since 1980 and was mostly discarded.

### 10.13.2. Data

## Catch/effort

CPUE data are available from Canadian offshore otter trawlers for the period 1976-92. However, in only 2 of the past 11 years has the main species plaice catch exceeded 500 t, and in many years it was negligible. Therefore, these data cannot be used as an index of abundance for this stock and by-catch rates are not considered to be representative of stock abundance.

## Catch at age and mean weights at age

Catch at age data for this stock are available for the period 1984-90, based on samples from the Canadian fisheries. For many years prior to 1984, and for 1991 and 1992, sampling data are elther non-existent or inadequate to calculate catch at age. In most years, ages 9-12 comprise the bulk of the commercial fishery, and there was a declining trend in the catch numbers of older individuals up to 1990. As well, the mean weights at age increased at all ages in both 1989 and 1990.

## Research vessel surveys

Stratified random surveys have been conducted in Div. 2G, 2H, 2J, and 3K since the late 1970s, although not annually in Div. 2GH. The biomass index in Div. 2G was relatively low in all surveys, although coverage was poor in most years except 1987 and 1988. In both Div. 2G and 2H, the biomass declined substantally from the late 1970s to the late 1980s during which time commercial catches were negligible.

In Div. 2J, where survey coverage has been virtually complete since 1981, the biomass index has declined drastically from estimates of about 90,000 in 1982-83 to only 6,500 and 2,400t in 1991 and 1992 respectively (Fig.10.13c). Commercial catches in Div. 2J averaged only 540t since 1983. Div. 3K shows a simllar pattern, with the biomass declining from a range of 25,000 to 40,000 between 1979 and 1987 to only 6,300 and $3,100 t$ in the 2 most recent surveys (Fig.10.13d). Commercial catches in Div. 3K averaged only 960 t since 1983. Shifts in the depth distribution of the biomass to deeper water occurred during 1986-89 in both divisions followed by rapid declines to very low levels.

There has been a gradual reduction in the numbers of older fish caught in the surveys, consistent with the commercial fishery data. Virtually all cohorts declined at very high rates from 1990 to 1992. There has also been decreased recruitment in recent years.

### 10.13.3. Prognosis

It is clear from the research vessel survey data that this stock had declined to an extremely low level by the end of 1992. Catches in the commercial fishery, even before the moratorium on northern cod in 1992, had been decreasing and the catch in 1991 of 500 t was the lowest in about 30 years. Given the stock size estimated from surveys in the early to mid-1980s, and the relatively low catches in the commercial fishery since then, it is evident that fishing mortality cannot explain the magnitude of the declines in stock size which have occurred. One possible explanation is increased natural mortality since the mid-1980s, corresponding with periods of extremely low water temperatures in the 2J3K area. However, there are no known mechanisms to relate such an increase in natural mortality with these conditions, elther directly or indirectly.

Given the current stock size estimates from surveys, there can be no optimism in the short or medium term. Even with negligible catches, the stock size continued its sharp decline from 1991 to 1992. The prospects for rebuilding in the longer term are unknown, as little is known about stock-recruitment relationships, and both the total stock size and spawning stock biomass are now far below anything seen in the 15 year time series of research vessel survey estimates. There will likely be a much-reduced fishery, If any at all, on this stock for the next several years. The current TAC of 5,000 is clearly too high, given that the biomass estimate in Div. 2J3K from surveys in 1992 is at approximately the same level. If the current TAC is taken, fishing mortality would be very high on a stock which is already at an extremely low level.

### 10.14. American Plaice in Subdivision 3Ps (WP 125) W. Brodie

### 10.14.1. Description of the Fishery

Catches from this stock were highest from 1968 to 1973, exceeding 12,000t on three occasions in this period (Fig.10.14a). Catches by foreign vessels peaked at about 8,800 t in 1968, due mainly to the USSR catch, and have not exceeded 800 since 1973. Catches by France ranged from 540 to 770 t from $1986-90$, but declined to only 26 in 1992.

The Canadian inshore catch in 1992 declined to the lowest level since 1985. The catch by Canadian offshore trawlers in 1992 was the lowest since 1983, and was about half the level of 1990 and 1991 (Fig. 10.14b). This fishery has a substantial main species plaice component and has often boen prosecuted in the first quarter. Overall, the catch in 1992 was 2300 t, the lowest since 1983, and a decrease of $50 \%$ from the average of the past 6 years.

### 10.14.2. Data

## Catch at age and mean weights at age

The catch at age and mean weights at age for this stock are based on sampling from the Canadian fishery, as no sampling data were available for the French catches. In 1991 and 1992 the catch was comprised mainly of fish aged 8-12, similar to most years. The mean weights at age in 1991 and 1992 were similar to recent values (Fig. 10.14c).

## Catch effort data

A multiplicative analysis of commercial catch rates of American plaice for the Canadian offshore trawler fleet in Subdiv. 3Ps from 1974 to 1992 was conducted. The CPUE series shows relative stabillty from 1974 to 1980, an increase from 1980 to 1983, followed by very large increases in 1984 and 1985 (Fig.10.14d). The index was relatively stable from 1987 to 1990, at about the same level observed in 1981-83, then declined sharply to the lowest observed levels in 1991 and 1992. The magnitude of the increase from 1983-1985, and the subsequent $40 \%$ decline to 1986, as well as anomalous distributions of plaice in the Canadian and French surveys in 1985, suggest that the 1985 and possibly the 1984 C/E points are outliers.

## Research vessel survey data

Stratified-random surveys have been conducted by Canada in Subdiv. 3Ps in each year from 1972 to 1993, although survey coverage was poor in many years prior to 1979. The abundance index (Fig.10.14e) was relatively stable from 1986 to 1988, (biomass around $30,000 \mathrm{t}$ ), the value from the 1989 survey was substantially lower at a biomass of 17,000 t, and 4 of the 5 surveys since then have produced blomass estimates less than 7,000t. The 2 surveys completed in 1993 (February and April) gave biomass estimates of 2,400 and 4,600 . Most of the American plaice in recent surveys were in deeper areas than usual but little of the biomass was found beyond 366 m . The abundance of all age groups has declined and there has been a decrease in recruitment.

Data from the French research vessel surveys in 3Ps also show a decline in abundance (Fig.10.14f). Both French and Canadian surveys show a peak abundance in the early 1980s, followed by a decline, with recent values in both series being well below historic lows. Age-by-age estimates are not yet available from the French surveys.

### 10.14.3. Estimation of Stock Parameters

Sequential population analysis was attempted in the 1989 and 1991 assessments of this stock using various formulations of the adaptive framework with research vessel survey data and $\mathrm{C} / \mathrm{E}$ at age. The results were not acceptable as the basis for the assessment, due to strong year effects in the residuals and a u-shaped pattern in the slopes of the age by age relationships. Given these concerns, along with the severe decines in the recent survey indices, it was concluded that further attempts at SPA would not be useful at this time.

In the 1991 assessment, it was felt that there was some useful information available from the converged part of the SPA. That assessment indicated that the stock was at a relatively low level and that there had likely been an increase in F in recent years. Although it was not possible to quantify this increase, a mean catch of about 3,750 t from 1974-84 produced a mean $F$ above $F_{0.1}$, and catches from 1985 to 1990 averaged about 4650 . Given the further decline in stock biomass evident from the research vessel surveys, along with the catches reported in 1991 and 1992, F is likely to have increased in the recent past.

### 10.14.4. Prognosis

Similar to other stocks of American plaice in the Newfoundland \& Labrador area, 3Ps plaice abundance has declined markedly since the mid to late 1980s and is now at a level well below any observed previously. This is confirmed by all 3 indices (Canadian \& French research vessel surveys, and Canadian OT C/E) and by declines in the fishery. Although it has not been possible to quantify fishing mortality precisely, recent assessments suggest that catches have exceeded $F_{0.1}$ levels. It is questionable, however, If catches in the range of 2,500 to $\mathbf{5 , 0 0 0}$ could be solely responsible for declines in abundance of $90 \%$ from 1986-88 to the present, considering the historical catch, recruitment, and biomass levels. Regardless, the outlook is very pessimistic, given the current low stock size, spawning stock biomass, and the lack of recrultment indicated by the surveys.

In the short term, fisheries can expect a continued down-turn, with no immediate prospects for stock rebuilding. The current TAC of 3,000 is clearly too high, as this is in the range of the biomass estimates obtained in the 1993 surveys. If the current TAC is caught, fishing mortality could be very high on a stock which is already at an extremely low level.

### 10.15. American Plaice in Division 4T (WP 114) R. Morin

### 10.15.1. Description of the Fishery

Since 1965, nominal landings of plaice in 4T averaged 8,275t annually, with a maximum of 11,780t in 1966 and a minimum of 5,140 t in 1992 (Fig. 10.15a). An annual TAC of 10,000t was applied from 1977 to 1992; landings exceeded that level only once, in 1979. A reduction in the TAC for cod (the main by-catch species in the fishery) made it possible to reduce the plaice TAC to 5,000t in 1993.

Longlines, otter trawls and seiners have been the main components of the 4T plaice fishery since the late 1940s. Scottish seines and gillnets have gained importance since 1965. Scottish seines currently dominate the fishery, contributing to over $50 \%$ of plaice landings since 1991. Mobile gear less than 45 ft was the most active component of the fleet in 1992, landing approximately $50 \%$ of total 4 T plaice landings. Between $40-$ $60 \%$ of all plaice caught are discarded and thus are not included in reported landings.

### 10.15.2. Data

## Catch and weight at age

Age-length keys were developed for commercial catches in semi-annual periods, by sex and gear type. The landed catch at age for 1992 was based on 60 samples of the commercial catch, representing approximately 13,000 measured and 1,600 aged plaice. Landings at age comprised mainly plaice greater than 7 years of age. Total catch at age is difficult to estimate due to the high discarding of commercially undersized plaice in the 4T fishery. Estimates of discarded plaice, based on the Gulf Observer Program, indicated that 38\% and $39 \%$ of the plaice catches, by weight, were discarded in 1991 and 1992, respectively.

## Research survey data

The mean numbers per tow in RV-survey data indicated that stock abundance was low in the early 1970s, peaked in 1977 at 1,046 plaice per tow and declined to fewer than 215 plaice per tow in 1987 and 1989 (Fig. 10.15b). The abundance index has fluctuated at low levels of 201 to 379 plaice per tow since 1982.

### 10.15.3. Estimation of Stock Parameters

## Fishing mortality and stock abundance

A multiplicative analysis of research vessel catch at age indicated that total mortality for age classes 7-19 was 0.54 over the period of 1987-1992. Fishing mortality is estimated at 0.34 , assuming a rate of natural mortality of 0.20 . This analysis also suggested a long-term pattern in recrultment, with year-class size increasing from 1961 to 1972, then declining until 1981. The 1982 year-class, which dominated landings in recent years, was of average, or below-average, strength. This pattern is supported by estimates of minimum fishable biomass from research vessel surveys (age 10+ plaice) which declined from over 21,800t in 1991 to $\mathbf{1 2 , 6 0 0 t}$ in 1992.

### 10.15.4. Prognosis

Stock abundance has declined since the late 1970s and has fluctuated at low levels since 1982. The 1992 research vessel survey indicated a decline in fishable biomass from 1991. The current explotitation rate for the stock appears to be between $F_{0.1}$ and twice $F_{0.1}$. Research vessel survey data suggest improving recruitment composed of year-classes of the late 1980s.

A high level of discarding persists in this fishery. It is likely that substantial improvement in yield would result from eliminating the capture of commercially-undersized plaice.

### 10.16. American Plaice in Division 4VW (WP 100) C. Annand

### 10.16.1. Description of the Fishery

Because of the method of apportioning catch prior to 1991 and the amount of unspecified flounder currently being reported, landings of individual species are considered inaccurate and should be treated with caution (Fig. 10.16a). Flatish may come under the ITQ program in 1993. Currently they are being fished under interim quotas by mobile gear <65' until ITQs are established.

### 10.16.2. Data

Research survey data
The summer survey stratified mean numbers per tow for 4VW plaice were relatively stable through the early 1980s then declined to a series low in 1988 (Fig. 10.16b). Since then, abundance increased but declined in 1992.

The spring 4VW survey (1986-1993) mean numbers per tow for American plaice have declined since 1990 (Fig. 10.16c). The magnitude of the numbers per tow is lower in the spring survey by about half. 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.

Length frequencies from the surveys indicated that American plaice females larger than 60 cm appear less frequently in the catch since the late 1980s.

### 10.16.3. Prognosis

The absence of catch data makes it impossible to estimate exploitation rates on this resource. Overall flattish landings are relatively stable, however industry indicated that mobile gear have increased their effort on flatish stocks in general, with the introduction of ITQs for cod, haddock and pollock and the decline in other resources.

Summer survey abundance has been generally stable yet spring surveys indicate a decilning trend since 1989. It is unclear why the surveys support opposing views of the resource. Abundance appears to be relatively stable and should remain so unless exploitation is increased.

### 10.17. American Plaice in Division $4 X$ (WP 100) C. Annand

### 10.17.1. Description of the Fishery

Because of the method of apportioning catch prior to 1991 and the amount of unspecified flounder currently being reported, landings of individual species are considered inaccurate and should be treated with caution (Fig. 10.17a). Flatiish may come under the ITQ program in 1993. Currently they are being fished under interim quotas by mobile gear <65' until ITQs are established.

### 10.17.2. Data

## Research survey data

The summer survey stratified mean numbers per tow for 4X American plaice were low, increasing to 1982 and have been relatively stable since (Fig. 10.17b).

Length frequencies from the surveys indicated that American plaice females larger than $\mathbf{6 0 \mathrm { cm }}$ appear less frequently in the catch since the late 1980s.

### 10.17.3. Prognosis

The absence of catch data makes it impossible to estimate exploitation rates on this resource. Overall flatfish landings are relatively stable, however industry indicated that mobile gear have increased their effort on flatfish stocks in general, with the introduction of ITQs for cod, haddock and pollock and the decline in other resources.

Summer survey abundance has been low but generally stable, under current exploitation levels biomass should remain stable.

### 10.18. Witch Flounder in Divisions 2J3KL (WP 124) W.R. Bowering

### 10.18.1 Description of the Fishery

The commercial fishery began for witch in this area in the early 1960s and increased steadily from about 1,000 in 1963 to a peak of over 24,000 in 1973 (Fig. 10.18a). Catches declined rapidly to 2,800 by 1980
and subsequently fluctuated between 3,000 and 4,500 to 1991. The catch in 1992 was just 2,300t, the lowest since 1964. Up untll the late 1980s the fishery was prosecuted by Poland, USSR and Canada primarlly on Div. 3K. In recent years the fishery has been mainly Canadian although significant catches are now taken by EEC (Portugal) in the NAFO Regulatory area of Div. 3L

Since 1988, the offshore Canadian fishery has been particularly successful on prespawning concentrations in the deep slopes of Div. 3K especially in depths beyond 700 meters. Between 1988 and 1993, however the area fished has become smaller and substantially deeper. Based upon information from the fishing industry, the fishery in the winter of 1993 was very poor with the best catch rates occurring in depths greater than 1400 meters. As the season progressed, catch rates quickly declined until they became too low for economic viabillity and the fishery was curtailed. Considering usual harvesting strategies, it is likely that the nominal catch in 1993 will be the lowest since the fishery began.

### 10.18.2. Data

## Catch and effort

While there are little directed effort data, a multiplicative analysis was conducted on information avallable since 1973 where directed catch was assumed to be a catch comprised of main species witch fiounder. Trends in catch rates are very difficult to interpret with any degree of confidence particularly in the late 1980s where catch rates fluctuated widely (Fig. 10.18b). It is considered that the high points may be more a reflection of fish concentrating in deep areas at high density levels. It is also hypothesized that declines in recent years may be a reflection of reduced biomass especially when it is known that the spatial distribution of the effort has been systematically reducing over time.

## Catch at age

Catch at age data indicate that there has been a reduction in the number of age groups comprising the population with a maximum age of 17 in 1981 and 14 since about 1986. In the early to mid-1970s, there were fish in the population up to age 26 years old. Nevertheless, the age structure has been fairly stable since about 1985. While no stock recruitment relationship for this stock has ever been investigated, fewer older fish (>14 years old) seen in recent catches reflects a loss of spawning stock biomass.

## Biological surveys

Stratified-random research vessel surveys have been conducted in the autumn in Div. $2 \mathrm{~J}, 3 \mathrm{~K}$ and 3 L since 1977, 1978 and 1981 respectively. For Div. 2J, biomass estimates ranged from as high as 4,100 in 1986 to a low of just over 500 t in 1992 (Fig. 10.18c). In Div. 3K, during 1979-85, there was a period of relative stability where most annual biomass estimates were over 30,000 t. Since that time estimates have declined considerably to 935 in 1992 the lowest in the time series. For Div. 3L, biomass estimates varied generally between 6,000 and 7,000t from 1981-88 but declined rapidly since then to a low of just under 1,500t in 1992. For the three divisions combined there has been a very steady and systematic decline from about 1984 through 1992 with the estimate of about 3,000 in 1992 not only the lowest in the time series but now lower than the existing TAC of 4,000 .

Estimates of biomass by depth indicated that for all divisions, in the earlier years, the biomass is distributed in depths generally less than 500 meters. For more recent times, particularly in the 1990s, most witch flounder are found in depths greater than 500 meters. Based upon these observations, and the knowledge that the commercial fishery operates in much deeper zones, it is also evident that the depth constraints of the survey design are restrictive (maximum depth of about 1000 meters) in measuring the complete blomass
of this species more particularly in recent years. Nevertheless, a deepwater survey conducted during the summer of 1991 in divisions 3K and 3L to depths of 1500 meters did not encounter any witch flounder.

Catch at age data from the surveys show there were evidently older fish in the populations in the earlier period, with a broader age range, although it was not as apparent as in the commercial catch at age data. Age structure has been much more stable during the last 10 years although the actual abundance at age has been declining rapidly in the recent period.

## Distribution

Spatial distribution was examined from autumn survey data collected from 1978-92. From the period 197885, the pattern of distribution was fairly consistent with the dominant division being Div. 3K. The distribution in those years is also consistent with distribution patterns during the 1950s and 1960s. Between 1985 and 1986, however, there was a substantial change in the pattern culminated by a considerable reduction in biomass. Witch flounder, usually found in high abundance in the deep channels on the western side of Funk Island Bank, virtually disappeared. Throughout the late 1980s, the area of distribution continued to shrink towards the southeast portion of Div. 3K and by 1990 it became clear that the only fish apparent in the survey area were concentrated along the very deep slope area. By 1992, virtually the only witch flounder caught were located in the deep slope area of the Sackville Spur ("Nose" of the Grand Bank) outside the Canadian 200-mile zone.

### 10.18.3. Prognosis

It is clear that this stock has been reduced to levels far below anything observed in the past. It would also seem that during the 1980s, declines in biomass observed in the surveys cannot be fully explained by the removals of the commercial fishery. On the other hand, having observed the shrinking area of distribution in recent years, coupled with the fact that fishing was most intense in this area during prespawning aggregations, it is probable that recent catches may have accelerated the decline over the last couple of years. It may be argued that because the fishery has recently been prosecuted well beyond depths occupied by the surveys, biomass estimates may be biased downwards. Nevertheless, since fishing has taken place in a very restricted area and in 1993 was a virtual failure due to poor catch levels, it is difficult not to accept that this stock is at a dangerously low level. Clearly the present TAC on this stock is too high and if taken would result in very high fishing mortality.

### 10.19. Witch Flounder in Subdivision 3Ps (WP 126) W.R. Bowering

### 10.19.1 Description of the Fishery

The catches of witch flounder in NAFO Subdiv. 3Ps were about 1,000t annually during the 1960 s (Fig. 10.19a). Catches increased to over 4,000t in 1967-69, then declined slowly to former levels in the late 1970 s . During the last 10 years, catches have ranged from as low as 300t in 1983 to as high as 1,300 in 1986. However, since 1989 the average catch has been about equal to the TAC of 1,000 . During the 1980s the catch was primarily a by-catch of other groundfish fisheries, however, in recent years with the severe declines in major groundfish resources (flatiish species in particular) certain sectors of the fishing industry depend more on this stock.

Catches from this stock have been taken mainly by Canadian trawlers fishing offshore on St. Pierre Bank while there are some catches taken by small Scottish seiners and gillnetters fishing in Fortune Bay off the south coast of Newfoundland. Fishers from St. Pierre and Miquelon also catch small amounts of witch flounder.

### 10.19.2. Data

## Abundance indices

Stratified-random research vessel surveys have been conducted by Canada in winter on St. Pierre Bank since the early 1970s, however, only since about 1976 has coverage been relatively complete at least to a depth of 300 fathoms. Biomass estimates have been highly variable over the past 15 years, fluctuating between 2000 and 6,000t and showing little in the way of trends (Fig. 10.19b). An examination of survey indices by depth zone indicates that during the late 1970s and early 1980s there were considerable levels of the existing biomass in depths less than 183 meters whereas during the 1990s there were none. It has been suggested in the past that this was because the main depths where witch flounder were located were not surveyed by the research vessels. While two recent surveys in 1993 are within the range of past biomass estimates, it is known that a quite successful fishery occurred in deep water beyond the survey area which would lend support to this hypothesis. On the other hand, the fishery concentrates within a relatively small area on a prespawning concentration of high density but this may not be an indicator of a high level of biomass.

## Catch at age

Abundance estimates at age from research vessel surveys show that in the mid-1970s, ages ranged as high as 22 years, however, this was reduced to a maximum of 14 years by 1980. The age structure has remained relatively stable since that time to the present although the abundance indices have shown considerable variation on an annual basis as indicated earlier.

### 10.19.3. Prognosis

Given the high annual variability of the survey biomass indices, it is not possible to provide a precise estimate of stock size. Considering that the 1993 survey estimates are within the range of variation, coupled with the success of the 1993 winter fishery, largely outside the survey area, there may not be need for alarm at current catch levels. However, good catch rates are not necessarily an indication of the well-being of the resource when commercial fishing concentrates on high-density prespawning aggregations, especially if it occurs in a fairly localized area.

### 10.20. Witch Flounder in Divisions $4 R$ and $4 S$ (WP 115) R. Morin

### 10.20.1 Description of the Fishery

Annual witch landings in 4RS have declined from a maximum of 5,341 t in 1976 to landings since 1981 that vary between 188t and 1,219t (Fig. 10.20a). In 1992, witch landings totalled 376t, the second lowest value in the time series. A mixed otter trawl-Scottish seine fishery has exploited witch in Div. 4R for at least three decades. Since the late 1970s, seiners have caught an increasing proportion of the witch in 4R (86\% of 4R witch landings in 1992). Gulf landings of witch were dominated by the 4R fishery through most of the 1960s and 1970s. Since 1984, the 4 T fishery contributes most of the Gulf landings of witch flounder (601t in 1992), although 4T is not recognized as part of this stock area.

A TAC of 3,500 was established in 1977 based on average catches. The TAC was increased to 5,000 in 1979 to remove an aged component of the population that was in "jellied" condition. Landings never attained the 5,000 level. The TAC was reduced to $3,500 \mathrm{t}$ in 1982 and has remained at that level since then.

### 10.20.2. Data

## Research vessel survey data

Mean numbers of witch per tow in summer and winter research vessel surveys since 1983 suggest decining abundance in Div. 4R (Fig. 10.20b). Estimates of minimum stock biomass in 4R since 1984, based on summer surveys, have ranged from 1,629 in 1985 to 225 tin 1992. Summer surveys in $4 S$ indicate declining mean numbers of witch per tow since 1986 (Fig. 10.20c). Minimum stock biomass in $4 S$ declined from 23,779 in 1986 to 351t in 1992. Abundance indices, based on winter surveys in 4S, varied widely over time and do not show a clear trend; however, strata coverage was frequently limited during winter surveys, contributing to the variability in average catch.

### 10.20.3. Prognosis

The abundance of witch in 4RS appears to be declining. The current TAC is high in relation to catches since 1981. As has been noted previously, it is likely that the current stock unit definition is inappropriate.

### 10.20.4 Research Recommendation

A significant catch of witch flounder is made in 4T, close to the 4RS boundary, and doubt on stock unit definition has been expressed. A thorough investigation of the distribution of witch from survey data and commercial catches should be made to clarify this situation.

### 10.21. Witch Flounder in 4VW (WP 100) C. Annand

### 10.21.1. Description of the Fishery

Landings data for witch flounder are considered the most reliable of all the flatfish species on the Scotian Shelf. Only witch flounder command a higher price and therefore are usually identified on the purchase slip. With the introduction of the 200 mile limit, landings in 4 W have decreased dramatically, coincident with the removal of the Soviet fleet from the Canadian zone (Fig. 10.21a). Since then, landings have been variable, between 2,103t and 904t , with a declining trend since 1987 to a low of 1,023 in 1992. Witch flounder are fished throughout the year with the highest catches in spring and summer. Seines are the main gear sector. Flatiish may come under the ITQ program in 1993. Currently they are being fish under interim quotas by the <65' mobile gear fleet until ITQs are established.

### 10.21.2. Data

## Research survey data

The summer survey stratified mean numbers per tow for 4 VW witch flounder were low but relatively stable over the entire time series (1970-1992) (Fig. 10.21b). The 4VW spring survey abundance (1986-1993) declined.from 1987 to a low level in 1990 and remained stable to 1993 (Fig. 10.21c). 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.

Length frequencies from the surveys show no substantial changes in size composition over the time series.

### 10.21.3. Prognosis

The catch data for witch flounder is the most reliable for flatfish on the Scotian Sheff, although small quantities may still have been reported as unspecified flounder. Landings have decreased in recent years with the 1992 landing the lowest since the early 1980s. Overall flatfish landings are relatively stable, however industry has indicated that mobile gear have increased their effort on flatiish stocks in general, with the introduction of ITQs for cod, haddock and pollock and the decline in other resources.

In general, both survey indices have stayed at a low level over the past three to four years. During the same period, catches have remained relatively stable in 1990 and 1991, declining somewhat in 1992. The biomass appears to be stable at very low levels despite some decline in the catches.

### 10.22. Witch Flounder in Division 4X (WP 100) C. Annand

### 10.22.1. Description of the Fishery

Landings data for witch flounder are considered the most reliable of all the flatfish species on the Scotian Shelf. Only witch flounder command a higher price and are therefore usually identified on the purchase slip. Landings have increased gradually since the late 1970s with the 1992 landings of 824t the highest since 1971 (Fig. 10.22a). The majority of the landings were taken by small trawlers fishing in the winter and spring. Despite the increased landings, anecdotal information from industry has suggested that witch flounder are not as abundant as in previous years and that they appear to have shifted their distribution to somewhat deeper water. Flatfish may be scheduled to come under the ITQ program in 1993. Currently they are being fished under interim quotas by mobile gear <65' until ITQs are established.

### 10.22.2. Data

## Research survey data

The summer survey stratified mean numbers per tow for 4 X witch flounder were highly variable in the 1970 s. Since the early 1980s the survey has shown a declining trend to the present, with the 1992 point the lowest in the time series (1970-1992) (Fig. 10.22b).

Length frequencies from the surveys indicated no significant changes in size composition over the time series.

### 10.22.3. Prognosis

The catch data for witch flounder is the most reliable for flatfish on the Scotian Shelf although may still have been reported as unspecified flounder. Landings appeared to be stable through most of the 1980s with the 1992 catch the highest in the time series. Industry information indicates that effort may have increased on flatfish stocks in general, and witch in particular due to higher price, with the introduction of ITQs for cod, haddock and pollock and the decline in other resources.

Survey abundance has declined since the early 1980s. Over the same period landings have been relatively stable. Consistent with declining catch rates in the face of stable or increasing landings, it is anticipated that exploitation will go up on this resource.

### 10.23. Yellowtail Flounder in Division 4VW (WP 100) C. Annand

### 10.23.1. Description of the Fishery

Because of the method of apportioning catch prior to 1991 and the amount of unspecified flounder currently being reported, landings of individual species are considered inaccurate and should be treated with caution (Fig. 10.16a). Fatfish may come under the ITQ program in 1993. Currently they are being fished under interim quotas by mobile gear <65' until ITQs are established.

### 10.23.2. Data

## Research survey data

The summer survey stratified mean numbers per tow for 4VW yellowtall flounder declined in the late 1970s remaining stable through the 1980s and have shown an increasing trend since (Fig. 10.23a). The 4VW spring survey abundance (1986-1993) decreased between 1988 and 1992 (Fig. 10.23b). However, the 1992 point may be anomalously low with yellowtail being caught in very deep water. 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. Survey distribution maps, aggregated over five and three year periods, do suggest a possible change in distribution between 4 V and 4 W . However, distribution will have to be looked at on a yearly basis and by depth.

Length frequencies from the surveys show no substantial changes in size composition over the time series.

### 10.23.3. Prognosis

The absence of reliable catch data for yellowtail flounder makes it difficult to comment on the exploitation of this resource. Overall, flatfish landings are relatively stable, however industry has indicated that mobile gear have increased their effort on flatfish stocks in general, with the introduction of ITQs for cod, haddock and pollock and the decline in other resources.

Although spring and summer surveys indicate differing trends which we have some trouble reconciling, the biomass from the summer survey appears relatively stable in recent years. Until we can reconcile the differing trends in the surveys, it is difficult to comment on the stock status.

### 10.24. Yellowtail in 4 X (WP 100) C. Annand

### 10.24.1. Description of the Fishery

Because of the method of apportioning catch prior to 1991 and the amount of unspecified flounder currently being reported, landings of individual species are considered inaccurate and should be treated with caution (Fig. 10.17a). Flatiish may come under the ITQ program in 1993. Currently they are being fished under interim quotas by mobile gear <65' until ITQs are established.

### 10.24.2. Data

## Research survey data

The summer survey stratified mean numbers per tow for 4 X yellowtall flounder has been very low over the entire series but indicate an increasing trend since the late 1980s (Fig. 10.24a). Survey distribution maps aggregated over five and three year periods show that most of the yellowtall abundance in 4 X is located in the Browns Bank area with smaller concentrations in the Bay of Fundy. In recent years, abundance appears to be increasing in the Browns Bank area.

Length frequencies from the surveys show no substantial changes in size composition over the time series.

### 10.24.3. Prognosis

The absence of reliable catch data for yellowtail flounder makes it difficult to comment on the exploitation of this resource. Overall flatfish landings are relatively stable, however industry has indicated that mobile gear have increased their effort on flatfish stocks in general, with the introduction of ITQs for cod, haddock and pollock and the decline in other resources.

Summer survey stratified mean numbers per tow have generally increased in recent years however more so in the Browns Bank area than the Bay of Fundy. Based on the survey abundance, It would appear that the 4 X yellowtail flounder stock is small but increasing somewhat.

### 10.25. Halibut in Divisions 4VWX and 3NOPs (WP 101) C. Annand

### 10.25.1. Description of the Fishery

Based largely on tagging results, which reflected the extensive movement of Atlantic halibut throughout most of the Canadian north Atlantic, the management unit was changed in 1988 to encompass the Scotian Shelf (4VWX) and the southern Grand Banks (3NOPs). At that time, a precautionary TAC of 3,200t was put in place based largely on recent catch levels.

Since 1961, total halibut landings have ranged between a low of 1,059 in 1976 to a high of $4,031 \mathrm{t}$ in 1985 (Fig. 10.25a). Canadian nominal landings have declined from $3,531 \mathrm{t}$ in 1985 to $1,269 t$ in 1992. The TAC has never been reached and the shortfall in the 1992 allocations amounted to, 1,931 . Foreign landings in the 3NOPs area have increased in recent years but the data are generally considered unreliable. Fixed gear caught less than $50 \%$ of their allocation while the mobile gear fleet generally took less than $20 \%$ of their allocation. The less than 65' ITQ fleet was the only gear sector to exceed their allocation (Fig. 10.25b).

Small vessels ( TC 1-3 )using longlines are the dominant fleet in the Scotian Shelf fishery accounting for well over $70 \%$ of the landings while both large (TC 4+) and small (TC 1-3) longliners account for most of the landings in 3NOPs. Longliners are the only gear type vessels to direct for halibut with the moblle 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 81 cm was introduced in 1988 although not enforced untll 1990. Anecdotal information indicates that landing of small halibut was still prevalent, especially for mobile gear fisheries. New management initiatives for 1993 included the introduction of mandatory landings, thus eliminating the
minimum size regulation. As a result, landings of small halibut by all gears sectors has risen considerably.

### 10.25.2. Data

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 and a general increase since (Fig. 10.25c). Spring and autumn surveys (1978-1984) in 4VWX show a declining trend while the spring 4VsW survey is variable with no halibut caught in 1990. Examination of the abundance in the strata associated with the 4W haddock closure (1986) gave no clear indication of a significant increase in that area between 1986 and 1992. The research gear does not appear to sample the older larger halibut which predominate the catch by the commercial longline fishery. Since the survey catches a different size distribution of fish (generally smaller) the increase in abundance may be an indicator of potential improved recrultment to the commercial fishery. The 3NOPs fishery may also be dependent on the Scotian Shelf recruitment as areas on the shelf, notably Browns Bank (4X) and the Gully (4W) are considered important rearing grounds for immature halibut.

Survey results were not available for the southern Grand Banks.

## Commercial catch rates

Catch rates were calculated for longliners directing for halibut for both the Scotian Shelf and the southern Grand Banks fishery. For the Scotian Shelf, catch rates increased from 1978 through 1980 coincident with increased landings (Fig. 10.25d). In 1981, the CPUE began to fall and have generally declined since, despite the introduction of the more efficient circle hook. Catch rates on the southern Grand Banks between 19851992 indicate an increase to 1988 followed by a decline to 1992.

Anecdotal information from industry indicated no real change in the halibut fishery that would account for the decline. It was suggested that some effort may have been redirected into the swordfish fishery and that effort fluctuates with the available cod quota. It was also indicated by some industry representatives that the introduction of the minimum size regulation did not affect catch rates.

### 10.25.3. Prognosis

Canadian catches in 1992 are the lowest since 1978 for the Scotian Shelf and the lowest since 1985 for the southem Grand Banks. Commercial catch rates have been declining over time despite an improvement in technology and show no signs of increasing. Increased effort may be directed toward the hallbut fishery in the future in view of the declining cod quotas.

The precautionary TAC set in 1988 was largely a reflection of catch levels at that time. Since that time, catches have been lower for all gear sectors except the 80 ITQ by-catch fishery in 4 X .

Overall the decrease in landings, coupled with the declining commercial catch rates would suggest that the Atlantic halibut stock size is decreasing to a lower level and that the current TAC is too high. The stock appears to be at a much lower level than when the 3,200 TAC was set.

### 10.26. Atlantic Halibut in Divisions 4RST (WP 79) A. Fréchet

### 10.26.1. Description of the Fishery

Since the implementation of a precautionary TAC of 300 in 1988, only the landings of 1990 and 1991 exceeded the TAC (Fig. 10.26a). Most of the landings of Atlantic halibut in 4RST were caught by the Quebec fleet in 4 S . The largest part of the landings occur between May and October. Most of the recent landings are made by the longline fleet, while bottom trawls were, up to the 1990s, the most important gear sector in this fishery.

### 10.26.2. Data

## Catch and weights at age

Although there was a regulated minimum landed size of 81 cm for halibut, some fish as small as 25 cm were landed in 1992. However, most of the landings were between 80 and 200 cm . The main age-groups in the fishery are between 9 and 12 for males, and between 9 and 14 for females.

In order to obtain information on this stock, it would be useful to develop an index fishers program based on fishers that are involved in a directed fishery.

Research vessel surveys
The spatial distribution of Atlantic halibut in summer is found mostly on the edge of the 183 m ( 100 ff ) isobath. In winter, the fish are concentrated in deeper waters in the Esquiman and Laurentian channels. These surveys catch so few Atlantic halibut that they preclude calculating any biomass estimate.

### 10.26.3. Prognosis

Given the limited information on this stock, it is not possible to make a quantitative assessment of the resource.

### 10.27. Greenland Halibut in 4RST (WP 110) B. Morin

### 10.27.1. Description of the Fishery

Greenland halibut was predominantly taken as by-catch until the mid-1970s when a directed otter-trawl and gillnet fishery was developed. Since then, the catch has come primarily from Quebec-based gillnetters. The catch series shows two peaks: one in 1979 (8,791t) and the other in 1987 (11,069t) (Fig. 10.27a). Since 1988, landings have dropped to a low of 2,293t in 1991 but have increased to $3,423 t$ in 1992. In the mid 1970s, catches were highest in NAFO Div. 4R, but since the beginning of the 1980s, landings were mainly in 4S and 4T. TACs for this stock were introduced in 1982 on a precautionary basis and were reduced to 4,000t for 1993.

### 10.27.2. Data

## Commercial sampling

Commercial length frequencies indicated that the majority of the catch in 1992 was composed of fish in the $41-45 \mathrm{~cm}$ range for the gillnet fishery. The shrimp fishery, which accounts for $26 \%$ of the landings in 1992, caught smaller fish ( $33-37 \mathrm{~cm}$ ).

Catch at age was estimated for the 1986 to 1991 period and added to the historical series that began in 1980. In 1992, the 1985 and 1986 year-classes represented 34 and $36 \%$ of the catch. Since 1987, weights at age have decreased.

## Commercial catch rates

Catch and effort data on the bottom trawl and shrimp fisheries for Quebec based vessels were avallable for the 1976-91 period. This series was standardized with a multiplicative model. Although the CPUE index seems to reflect the abundant year-classes, it was not considered to be an adequate index of abundance of the exploitable stock biomass. It is primarily based on by-catch in the shrimp fishery which uses a gear with a very different selectivity than the gillnets which constitute the main gear in the fishery.

## Index fishers

The index fishers program for Greenland halibut in the Quebec Region was initiated in 1991. Catch rates were twice as high in 1992 than in 1991. However, there was a change in the distribution of the fishery in 1992, with index fishers operating in the St. Lawrence estuary where catch rates were higher.

## Research survey data

Summer biomass indices have declined since 1987 (Fig. 10.27b). Estimates from the 1980s are not comparable to those of 1990-1992 due to a change in vessels and gear in 1990 (Lady Hammond to Alfred Needler; western trawl to shrimp trawls). The biomass estimates of 1991 and 1992 were higher than the estimate from 1990 (Fig. 10.27c). The highest catches and abundance by size were found in the western part of the Gulf and in the Estuary of the St. Lawrence River.

In winter, the highest catches were found at the limit of Div. 4R and Subdiv. 3Pn. This concentration of fish extended continuously into Subdiv. 3Pn. It is recommended that the winter distribution of Greenland halibut in the Cabot Strait area be investigated in relation to the existing stock boundary.

Length frequencies from research vessel surveys showed that the sizes of larger fish were similar in summer and winter for the 1986-1989 period. Length frequencies of the A. Needler showed the presence of an important mode (the 1988 year-class) that can be followed from 1990 to 1992. However, it is not possible to evaluate its strength at present.

### 10.27.3. Estimation of stock parameters

The absence of any reliable abundance index precludes an analytical assessment of this stock.

### 10.27.4 Prognosis

The abundance indices for the Greenland halibut in 4RST indicate that the stock blomass was at a low level in 1990 and 1991. Catches were higher in 1992, due to an increase of effort in the gllinet fishery, but they may also indicate an increase of stock size as showed by slight increases in research vessel survey biomass. However, the exploitation rate seems to remain high. A large proportion of the effort is concentrated in the Estuary of the Gulf of St. Lawrence. The research surveys show that the 1988 year-class is relatively strong. However, at this point, it is impossible to assess its absolute size and how it compares to the strong 1980-1981 year-classes, that sustained the fishery in 1986-1987, until it contributes in a significant way to the commercial fishery.

## 11. Timing of the Winter Migration of 4 T Cod into 4 Vn (WP 93) T. Lambert

In recent years with the decline of the resident cod stock, cod of 4T origin have formed an increasing proportion of landings in the 4 Vn May to December fishery. This is most evident in the last two months of the year. Evidence from the analyses of: 1) the biological characteristics of cod caught in late autumn, 2) tagging data, and 3) the movements of the commercial fishing fleet, indicate that December would be better included in the $4 \mathrm{TVn}(\mathrm{J}-\mathrm{A})$ management unit than that of 4 Vn .

Comparisons of length frequencies at age of cod taken in different seasons reveal the presence of 4T cod in 4 Vn in other than the winter period, Jan.-April. Gulf (4T) cod are smaller at age than cod on the Scotian Shelf but many cod landed in the October-December period in 4Vn were indistinguishable from Gulf cod.

Tag return information from the early 1980s, indicates the beginning of a migration out of the Gulf in November which is largely completed by the middle of December. Tagging data suggested the existence of two groups of cod in the southem Gulf. It appears that an eastern group (eastern PEI - western Cape Breton area) exits the Gulf about two weeks prior to a western group (Gaspe-Chaleur area).

The fishing fleet is capable of rapidly locating and following aggregations of cod, thus fleet movement can be considered a proxy for movement of aggregations of migrating cod. An analysis of the distribution of mobile gear catches in 1991-92 suggests that Gulf cod begin their overwintering migration to 4 Vn in November.

On the basis of the above information, landings of cod in 4 Vn during December should be attributed to the 4TVn management unit.

The timing of the movement of 4TVn cod into Sydney Bight is likely to vary from year to year and inclusion of December in the 4 TVn stock unit may not prevent the catch of this cod stock outside of the management unit in all years. The location of catches in 4T should be monitored on a continuous basis during the autumn so that management action can be taken if it appears that the migration into 4 Vn is earlier than normal.

Based on tagging information, some cod of eastern Gulf origin (4Tq) were found in 4 Vn during the summer and early autumn, however, at much lower densities than during the winter period. Notwithstanding this, it does not seem reasonable to transfer all 4 Vn catch into the 4 TVn management unit. As noted previously the biological characteristics of cod taken in 4 Vn throughout the summer and early autumn are distinct from those of cod of Gulf origin. Furthermore, ichthyoplankton sampling has confirmed the presence of a resident cod population in 4Vn. Although presently at a very depressed level, this stock could probably be rebult with decreased exploitation.

It is recommended that the Working Group on Oceanographic Effects on Stock Migration and Mbxing presently being established by the Fisheries Oceanography Subcommittee consider, in its deliberations, the issue of movement of cod stocks within the $4 \mathrm{Vn}-4 \mathrm{Vs}$ subdivisions.

The relationship between cod in the $4 \mathrm{Vn}(\mathrm{M}-\mathrm{D})$ and 4 VsW management unlts requires further clarification.

## 12. By-catch of Finfish in the Northern Shrimp Fisheries (WP 128) <br> D. Kulka

With many fish stocks in a depressed state, attention has been focused on the northern shrimp fisheries as a cause of mortality for young fish. A comprehensive overview of by-catch levels and fish sizes for 19801991 was carried out using data collected by Canadian Fisheries Observers. Seventy percent of all shrimpdirected sets were observed during the period of study and estimates of weight were obtained for all species caught. The amounts of non-shrimp species were adjusted to the landings and monthly removals of each was estimated. Starting in 1987, information on length was collected for the dominant by-catch species.

The study, when completed, will address the following questions raised by the Regional Director-General of the Newfoundland Region.

1) What are the size and age composition of by-catch groundfish species, and times and areas when by-catches are highest?
2) What are the numbers of by-catch fish at length and age?

Responses to \# 1 and 2 for the completed portion of the analysis are:
Redfish was the main by-catch species with seventy five percent taken in the Davis Strall fisheries (Table

1) Greenland halibut were taken in lesser amounts primarily from Hopedale (Div. 2H) and Funk Island Deep (Div. 3K). Cod removals were generally low except for 1988 where 1,570 were taken, mainly from Hawke Channel (2J). Most cod taken from 2J3KL in 1992 were ages 2 and 3 (preliminary data). Removals of American plaice averaged about 120 annually.

Table 1. Summary by-catch statistics for the northern shrimp fisheries.

|  | Average <br> Annual <br> Catch (t) | 1991 <br> Catch (t) | Dominant <br> Ages | Dominant <br> Sizes (cm) | Catch <br> at <br> Depth* | Main <br> Areas <br> Caught |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Redfish | 1050 | 1995 | $1-6$ | $5-19$ | nt | Davis Stralt |
| GL Halibut | 550 | 1287 | $2-5$ | $10-48$ | $>$ | Hopedale, Funk Is |
| Cod | 365 | 644 | $2-5$ | $13-50$ | nt | Funk Is, Hawke |
| A. Plaice | 120 | 223 | $6-10$ | $17-45$ | $<$ | Funk Is, St. Arthony |

*nt refers to no trend, > indicates that catches increase with depth, < indicates that catches decrease with depth.
3) What are the potential long-term benefits to the groundfish stocks if these young fish were left in the water?

Numbers at length and age adjusted to landings by month and year for 1987 to 1991 wlll be provided to the assessment biologists. Until detailed analyses of numbers at age are completed, the potential longterm benefits of leaving the small fish in the water cannot be specified.
4) Do redfish from Davis Stralt grow to commercial size and migrate south into Canadian fisheries waters?

There is no conclusive evidence to show that redfish taken in the Davis Stralt migrate south into Canadian waters. An hypothesis considered by the ICES Study Group on Redfish is that larvae from spawning of an oceanic stock that takes place to the south and southeast of Greenland, may drift by the offshore current northward to the West Greenland coast and by similar processes drift across the Davis Stralt to areas off Labrador and north (Anon 1990). Juvenile Sebastes mentella observed here are considered to be part of this oceanic stock.

Various trawl surveys in the West Greenland area (Subarea 1) show a north to south increase in the proportion of larger fish (eg. Cornus, 1992) and this was observed for redfish by-catch in the northern shrimp fisheries from Davis Strait south to 3 K . Based on such observations, there is a postulated slow southward migration from what is considered to be a nursery area encompassing the Davis Strait to the spawning area when mature. In support of this hypothesis there have been no direct observations of spawning redfish in the West Greenland area.

## 13. Other Business

This section reports on general issues related to groundfish stock assessments that were presented at this meeting.

### 13.1. Comparative Visual and Histological Observations on Maturity staging of Georges Bank Cod (WP 102) C. Annand

A paper was presented which examined the accuracy of at-sea maturity stage determinations by comparing it with histological analyses. Gonad samples ( 87 ovaries) were collected during the 1992 spring survey on Georges Bank. As well, the observed proportion mature at length and age was calculated for both methods and the relationship between the proportion mature at length (or age) was modelled using logistic regression. The inaccuracies found in the visual determination of maturity stages were numerous enough to affect the overall estimation of the proportion of the fish that were mature. The model estimated the length and age at $50 \%$ maturity to be 39 cm and less than 2 years for the visual data (at sea) and 51-52 cm and between $2-3$ years for the histological data.

The differences in classification of maturity stages could affect estimates of spawning stock biomass. At present, for most stocks, spawning biomasses are estimated as an aggregate of adult age groups. For $5 Z$ cod, these include age $3+$ which corresponds roughly with the histological determinations. It was recommended that age and size at maturity data be reviewed using histological analysis as well as at sea observations. Training should be initiated where large deviations are noted. Given the difficulties in identifying the various maturity stages, procedures should be reviewed to improve the situation. Reducing the number of stages could be considered. This would not likely affect data quality and may improve maturity stage determinations.

As well, a zonal maturity working group has been established which, under its terms of reference will be reviewing procedures and methods used in determination of maturity data from at sea observations and providing updates to historic maturity ogives based on developed methodologies.

### 13.2. Nonparametric Stock-recruit Analysis and Replacement Recruitment (WP 122) P. Shelton

Nonparametric analyses of the effect of spawner stock size on recruitment in data for 2 J 3 KL cod and 4 X haddock were carried out. An approximate randomization test indicated that, while there was evidence of a weak effect in the 4 X haddock data, no effect could be detected in the 2 J 3 KL cod data.

Replacement in spawner biomass per recruit analysis is generally calculated from average weights at age, partial recruitments and maturity ogives (Mace and Sissenwine, in press). This can be referred to as "average replacement recruitment". In contrast, "annual replacement recruitment" uses annual values of weights, maturities and partial recrultment at age. Both methods attempt to simplify a complete Leslie model to provide a useful reference to indicate whether population size is likely to grow or decline at different levels of fishing mortality.

A comparison of the two methods was carried out on data for the 2 33 KL cod stock for the period 1973-88. Average replacement recrultment calculated using average weights, maturities and fishing mortalities at age for the period 1984-88 was found to be equal to replacement at Fmed, a commonly used estimator of Frep. This would indicate that fishing mortality had not been excessive. However, because of trends in weights and maturities at age, annual replacement recruitment per spawner has increased steadily since 1980, indicating that it has become progressively harder to meet replacement at the prevailing levels of fishing mortality. If current weights and maturities at age persist, recruitment per spawner required to meet replacement will continue to be higher than it was in the 1970s.

Where a spawner biomass effect on recruitment can be demonstrated, the nonparametric approach can be combined with the annual replacement recrultment approach to calculate the probability of obtaining replacement at current spawner biomass under different levels of fishing mortality using the most recent values of weights and maturities at age.

### 13.3. The Estimation of Ageing Error Probabilities (WP 108) P. Gagnon

For fish stocks that exhiblt strong recruitment variability, random ageing errors can attribute a certain proportion of large cohorts to neighbouring small cohorts. The immediate effect of ageing errors is thus to diminish the measured contrast between the cohorts both in the catch at age data and in the indices of abundance. Simulation studies (Rivard, 1989; Bradford 1991) indicate that age reading errors can lead to overestimated terminal year population sizes and underestimated fishing mortalities as well as blased recruitment estimates in sequential population analysis.

A new method, similar to recently developed methods (Richards et al. 1992) for estimating the age reading error rates from repeated readings data, was presented. This maximum likelihood method does not require any "modal" assumption and is more sultable for length stratified age sampling. It assumes that age reading errors are independent and identically distributed, therefore the data must come from readers that have resolved any systematic differences in their ageing methods or from independent repeated readings. These error rate estimates can be used to remove the effect of age reading errors from age-length keys or population age distributions (Richards et al. 1992). Separate error rates should be estimated for older fishes since it is well recognized that ageing older fish is more difficult than ageing young fish.

The potential effects of ageing errors on the assessment of particular stocks should be investigated. The estimation of age reading error probabilities would involve the repeated ageing of about 200 hard parts for each category of ageing difficulty defined for the stock.

### 13.4. Haddock Ageing Inconsistencies (WP 129) J. Hunt

The committee reviewed a draft report of a 4 X haddock ageing workshop held in February 1993. The report concludes that a bias exists in haddock ageing for the 1983-present time series and that the bias resulted in under-estimates of older fish in the population. Of more concern is the fact that the bias appears to have a trend over time which makes it more difficult to assess and correct the error.

The objective of the workshop was to develop recommendations for interpretations of haddock otoliths which would result in consistent and precise estimates of age and to assess the extent of blas which might exist in historical data. Workshop participants included experienced Canadian and USA haddock age readers and new readers. A sample of otoliths was read prior to the workshop and formed the basis for determining the initial inter-reader agreement and was used for discussion during the meating.

Prior to the workshop, comparison ageing of samples by the present age reader and a USA reader indicated a considerable bias with the Canadian reader tending to under estimate the age of larger fish. As well, during the course of training new readers, it became apparent that the ageing protocol used in the past was too subjective and difficult to define or implement.

The workshop made several recommendations for improving and documenting the procedures to be used for haddock ageing. Specifically, participants defined a preferred axis on the otolith for estimating age and confirmed the need to assess and monitor the precision of ageing with replicate reading and inter-reader comparisons. Post-workshop ageing of a sample following guidelines adopted by the participants indicates significant improvement in the inter-reader agreement.

The committee concludes that the uncertainty of historic (post 1985) haddock ageing precludes use of the data until evaluation and, if required, correction has been completed. Initial results of the workshop and implications of the proposed protocol suggest that the age structure of 4 X haddock may be substantially older than has been estimated in the past. Any changes in protocol and revision of data need to be carefully documented and reported in subsequent analyses.

The committee also notes that there is a need to report measures used to assess ageing precision for other stocks and that this should be part of the routine data presented for each stock.

### 13.5 Can We Estimate F From Length Frequency Data? (WP 137) A. Sinclair

A method for using length frequency data from the commercial fishery and research surveys to estimate relative and absolute fishing mortalities was presented. The basic idea is similar to what has been done in the past with catch-at-age data where the ratios of commercial catch at age divided by research vessel catch at age have been used to estimate partial recruitment at age. If age composition data are not available or If one is interested in exploitation patterns at length, the ratios of catch at length to research vessel numbers at length may also be used to estimate partial recruitment at length. Temporal change in these ratios would indicate relative changes in fishing mortality at length. If the catchability of the research vessel survey was known, then the ratios could be used to estimate fishing mortality.

An example was presented using data from the 4TVW and $4 X$ haddock stocks. The research vessel frequencies were expressed as population at length and the research vessel catchabilities were assumed
to be 1 in both cases. This is supported by SPA calibrations performed in the past, however, if this catchability is overestimated then the estimated fishing mortalities will also be overestimated. The research vessel surveys for these stocks are conducted in July and for the purposes of this paper they are taken to represent mid-year estimates of population size. The ratio of catch at length ( $C_{D}$ ) to the research vessel estimate $\left(A_{1}\right)$ were used as a direct estimate of $F$.

The $\ln \left(F_{\mathcal{W}}\right)$ was cast as a quadratic function of length, and the annual curves were estimated using an analysis of covariance described below.

$$
\begin{aligned}
& \text { In }\left(F_{1}\right)=B_{0}+B_{1} L+B_{2} L^{2}+B_{3} Y+B_{4} L Y+B_{5} L^{2} Y+e \\
& \text { where } L=\text { length } \\
& Y=\text { matrix of } 0 \text { and } 1 \text { indicating the years } \\
& \text { the coefficients } B_{3} B_{4} B_{5} \text { are vectors. }
\end{aligned}
$$

The results of these examples are reported in section 10 of this report.
It was suggested that this method be pursued further with another case study for which catch at age data are used in a calibrated SPA, and the estimates of $F$ at length should be compared to those at age. A more thorough presentation to the SSS Subcommittee is suggested.

## 14. Acknowledgements

We would like to thank D. Geddes and T. Dugas for their help in reviewing the report for consistency, grammar and spelling as well as their support during the meeting. Stock assessments are heavily dependent on time series of catch, effort, research survey and commercial sampling data which have been collected, edited and maintained by numerous support staff in each of DFO's Atlantic labortories. We gratefully acknowledge the dedicated work of all those involved.

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16. Figures.

Fip. 7.4a




Fis. 7.4 d


Fig. 7.4e


## Cod in 2J-3KL

Fig. 10.1a.
Total catches (t) and TACs ( $t$ )


Fig. 10.1b. Inshore and Offshore Canadian Catches (t)


Cod in 2J-3KL
Fig. 10.1c.
Mean Weight (kg)
at age 7


Fig. 10.1 d .
RV Abundance - 2J ( ${ }^{\prime} 000$ )


RV Biomass - 2 J ( t )


## Cod in 2J-3KL

Fig. 10.1e. $\quad$ RV Abundance - 3K ( ${ }^{1} 000$ )


RV Biomass - 3 K ( t )


Abundance Indices
Fig. 10.1f. RV Abundance - 3L ('000)


RV Biomass - 3L ( t )



Figure 10.1g. Cod Distribution 1989-1992 from Autumn 2J3KL RV Surveys, Numbers per Tow.



Division 3K


Division 3L


## Cod in 3Fs

Fig. 10.2a.
Total auches (t) and TACs ( $t$ )


Fig. 10.2b.
mehore and Offshore Canadion Catches ( $t$ )

$\cos$ in $3 F s$
SPA
Rog 1020
Mean Weight (kg)
at ape 7



Fig 1020. Total Abundance (million) 3+


Cod in 3Ps
SPA
Fgo 102.
Annual fishing mortality rates. $6+$


## Cod in 3Pn-4RS

Fig. 10.3a. Total catches ( t ) and TACs ( t ).


Fig. 10.3b . Fixed and Mobile Sectors: Canadian Catches ( t ).


Fig. 103c. Mean Weight (kg).
at age 7


Fig 10sd RV Biomass ( $t$ ) - winter.


Cod in 3Pn-4RS
ADAPT
Fg. 10.30. Total Abundance (million). 3+


Rig 103. Recruitment (milion).
Age 3


Fig 103g Total Biomass (thousand tonnes).


Fog 10.3h. Adult Biomass (thousand tonnes). $7+$

$\operatorname{cod}$ in 3Pn-4RS
ADAPT
Fig vast. Fishing mortality rates.
(7-9)


Fig. 10.3. Cod - Morve: 3Pn-4RS
Projections


## Cod in $4 T-\mathrm{Vn}$ (J.A. $)$

Fig. 10.4a Total catehes (t) and TACs ( t ).


Fig. 10.4b. Inshore and Offshore Canadian Catches (t)


Cod in 4T-Vn (J.-A.)
Abundance Indices
Fig. 10.4c.


Fig. 10.4d.
OT CPUE (thour)


Cod in 4T-Vn (J.A.)
Abundance Indices
Fig. 10.4e.
RV (Nbfow) - fall


Fig. 10.4f.
RV (Nb/tow) - fall
6


Fig. 10.4g.


Cod in 4T-Vn (J.A.)
Hybrid
Fig. 10.4h.
Fishing mortality rates.
7+


Fig. 10.4l.
Adult Biomass (thousand t)
64


## Cod in 4T-Vn (J.A.)

Hybrid
Flg. 10.4
Total Biomass (thousand t) 34


## Cod in 4T-Vn (J.-A.)

Hybrid
Fig. 10.4k. Total Abundance (million) 3+


Fig. 10.41. Cod in $4 T-A V n(J . A$.$) \quad Projections$

$C / P=$ Ref. $=$ B 1995 Act. $=$

Catch - Prises
Reference-Référence
Adult biomass at beginning of 1995 - Biomasee adulte au début de 1995
Actual - Actuel

Cod in 4VsW
Fig. 10.5a.
Total catches (t) and TACs (t)


Fig. 10.5b.
Mean Weight (kg)
at age 7


## Cod in 4 VsW

## Abundance Indices

Fig. 10.6c.
CPUE (Uhour) - ZIF All ages


Fig．10．5d．
CPUE（thour）－IOP
All ages


## Cod in 4VsW

Abundance Indices
Fig．10．5e．RV（\＃世木几 July


Fig．10．5f．$\quad$ RV（\＃How）Spring $\quad 3+$


Fig. 10.5g.
Fishing mortality rates.
7 to 9


| Cod in 4VsW | ADAPT |
| :--- | :--- | :--- |
| Fig. 10.5h. | Total Biomass (thousand 4 t |



Flg. 10.5I. Adult Biomass (thousand i) 6+


Flo. 10.5).
Recruitment (million)
Age 1


Fig. 10.5k. 4VsW cod numbers 3-8 from SPA surveys.


Fig. 10.5I. Cod - Morue: 4VsW
Projections


| C/P $=$ | Catch - Prises |
| :--- | :--- |
| Ref. $=$ | Reference - Référence |
| B 1995 = $\quad$ | Adult biomass at beginring of 1995 |
|  | Biomasse adulte au dSbut de 1995 |
| Act. $=$ | Actual - Actuel |

Fig. 10.5 m . Long-term average vs. recent alze frequencles from summer surveys.


Fig. 10.5n. Cod in 4VsW - recrultment and adult blomass.


Labels identify year-class.
$\operatorname{cod}$ in $4 x$
Fig. 10.6a. Total catches (t) and TACs (t)


Rgㅛㅇ 1006.
APA and RV (K adusted) numbors (million)


Fig. 10.6c.
Cod in $4 x$
Total Blomass (thousand ionnes) 1 +


Fig. 10.ed.
Recruitment (million)
Age 1


Fig. 10.6.
Total Blomase (thousand sonnes)




Fig. 10.6 .
Annual exploltation rates.
(4-6)


Fig. 10.6g.
Cod in $4 x$
Projectlons


## Cod in EZj,m

Fig. 10.7a. Total eatches ( t ) and TACs ( t )


Cod in 5zi,m
Fig. 10.7b. Research vessel indices.
U.S.A. spring (nb/tow) 1+




Haddock in 4TVW
Fig. 10.8a. Total catches ( $t$ ) and TACS ( $t$ )



Fig. 10.8b. 4TVW haddock. Catch at length (In 000's of fish) for the domestic and forelgn small mesh fisheries on 4TVW haddock for the perlods 1978-1991, and 1992.


Fig. 10.8c. TTVW haddock. Summer research vessel catch rates for 4TVW haddock 1970-1992.


Fig. 10.ed. $4 W$ haddock. Mean eatch rates at length from summer surveys in Subolvielon 4W for the years 1970-1991 (bars) and 1992 (IIne).


4Vs $\square$ 4W 鷕 4VW
Fig. 10.8. 4WW haddock. Catch rates from spring surveys (March) in 4 WW for the perlod 1979 to 1993.


Fig. 10.ef. UW haodock. Catch rates at length from spring surveys conducted in Divielon AW for the perlod 1979-1992 (bars) and 1993 (lines).


Fig. 10.8g. 4 TVW haddock. Relattonehip betwoen recrultment and spawning stock blomass.


Flg. 10.\%h. Summer survey estimates of mature fermale haddock blomass in AVW from 1970-1992 assuming knife-edged maturation at elther 43 cm or 46 cm .

Flg. 10.8a. Total eatches (i) and TACs (i).


Fig. 10.9b. Fixed and Mobile Canadian Catches ( t ).



$$
\rightarrow-1991 \rightarrow 1992
$$

Fig rose. ©x haddock. Catch at length in 1991 and 1992

Fig. 10.9d. CPUE.
U4000 hooks


Haddock in $4 X$
Abundance Indices
Fig. 10.9e.
RV (kghow)
$<43 \mathrm{~cm}$

$>43 \mathrm{~cm}$


Total


 catch at length for 1970-1991.

Fig. 10.9g. RV (recruitment index).


$\square$

Fig. 10.9 h . 4x haddock. Trends in spawing stock blomass for 1962-88 (from OrBoyle of al 1899) and 1970-92 epawning stock blomass (3 year mean) calculated from research vossel mean numbers at length.

## Haddock in SZj,m

Fig. 10.10a.
Total catches (t) and TACs (t)


Fig. 10.10b
Abundance Indices
Haddock in 5Zj,m
RV (\#) Ages 3-8


RV (\#) Ages 1-2


## Maddock in BZj ,m

Fig. 10.10c CPUE and Efiont


Haddock in 5Z],m
Fig. 10.10d.
Biomass 3+(000t)



Fig. 10.10e. Yield to the Canadian fishery per thousand recrults. Exploitation expressed as instantaneous fishing mortally rate relative to population abundance in each respective territory.

## Pollock in $4 \mathrm{VWX}+5$

Fig. 10.11a. Total catches ( t ) and TACs ( t )


Pollock in $4 \mathrm{VWX}+5$
Abundance Indices
Fig. 10.11b.
TC-2 in $4 \times$ (ZIF)
All ages


Fig. 10.11c.
RY (虽How) - July
4-10


## Pollock in $4 \mathrm{VWX}+5$

ADAPT
Fig. 10.11d.
Anmal Fishing mortality.
7.9


Fig. 10.11e.
Recruitmert (million)
Age 2


Fig 10.11t.


Flg. 10.11g. Spawning Biomass (thowsend t) 4+


Flg 10.11h.
Pollock in $4 \mathrm{VWX}+52 \mathrm{E}$
Projections

$C / P=\quad$ Catch - Prises
Ref. $=$ Reference $\cdot$ Référence
B 1995 = Aduh biomass at beginning of 1995 - Biomasse adutte au début de 1995
Act. $\quad$ Actual-Actuel

F1092 $=$
0.53

Gulf Redfish
Fig. 10.12a. Total catches ( t ) and TACs ( t )


Note: TACs given for 1976-1992 are for the former management unit (4RST).

Fig. 10.126. CPUE (Hhr) OTB+OTM


Flg. 10.12c.
CPUE (th) - OTB(May-Oct.)


Fig. 10.12d Recearch veaed summer blomass (4).
Al ages


## Plaice in $2+3 K$

Fig. 10.13a. Total catches (t) and TACs ( t )


Fig. 10.13b. Inshore and Ofishore Canadian Catches (t)


## Plaice in 2+3K

Abundance Indices

Fig. 10.13c.
RV in 2 J (解解) 1+


Fig. 10.13d.


American Plaice in 3Ps
Fig. 10.14a. Total catches (t) and TACs (t)


Fig. 10.14b. Fixed and Mobile Canadian Catches (i)


Fig. 10.14c.
Mean Weight (kg)


Fig. 10.14d. CPUE (units) All ages


American Plaice in 3Ps
Abundance Indices
Fig. 10.14e. GAN RV (Mean 常 per tow)


Fig. 10.14f.
FRENCH RV (mean : per tow)
1+


## American Plaice in 4T

Fig. 10.15a. Total catches ( t ) and TACs ( t )


American Plaice in 4T Abundance Indices

Pg 10.1Eb
RV (勒tow) - Fall 1+


## American Plaice in 4VW

Fig. 10.16a. Total catches (t) In 4VW


Fig. 10.16b
Summer RV Mean \# per tow
All ages


Fig. 10.16 c .
Spring RV Mean \# per tow
All ages


## American plaice in 4 X

Fig. 10.17a. Total catches ( $\ell$ )


## Amerlean plaloe 4x

Fig. 10.17b.
Surnmer RV Mean per tow Al ages


Witch 2J3KL
Fig. 10.18a. Total catches ( t ) and TACs ( t ).


Pig. 10.18.
CPUE (t/hour)
All ages


Fog 10.18c
RV Min. Biomass ( t )


Witch in 3Ps
Fig. 10.19a. Total catches ( t ) and TACs ( t ).


Fig. 10.19b. RV Min. Biomass (t).
All ages


## Writch in $4 R S$

Fig. 10.20a. Total catches ( t ) and TACs ( t )


Witch in 4RS
Abundance Indices
Fig. 10.20b.
RV (*How) in $4 R$
All ages


## Witch in 4UW

Fig. 10.21a. Total catches ( $t$ ) in 4 VW .


Fig. 10.21b.
Summer RV Mean \# per tow
All ages


Fig. 10.21c.


Witch in 4 X
Fig. 10.22a. Total catches ( t )


Fig. 10.22 b .
Summer RV Mean \# per tow
All ages


## Yewoutals fiounder In 4VW

Flg. 10.23a.
8ummer RV Mean \# per tow
All ages


Fig. 1023b
Spring RV Mean \# per tow
All ages


Pig 10.242.
Summer RV Mean 眷 per tow
All ages


Fig. 10.25a
Atlantic Halibut in 3NOPsAMWX
Total catches (t) and TACs ( t )


Fig. 10.25b.
Fixed and Mobile Canadian Catches (t)


## Adantic Malibut in 3NOPsAUWX

Fg. 1025 c .
RV - 4VWX summer (*)
All ages


Fig. 10.25d.
LL CPUE (t1000 hooks)


Fig. 10.262
Adlantic Halibut in 4RST
Total catches (t) and TACs ( t )


Fig. 10.27a. Total catches ( t ) and TACS ( t )


Greenland Halibut in 4RST
Fig. 10.27b. L Hammond blomase eetimate (i).


Fgg 10.27a. A Meedier blomaes cettinate (i).
All ages


Name
Anderson, J.
Annand, C.
Atkinson, B.
Beckett, J.
Bishop, C.
Bowering, W.R.
Brodie, W.B.
Chadwick, M.
Chouinard, G.
Clarke, H .
Coady, L.
Davis, B.
Evans, G.
Fréchet, A.
Gagnon, P.
Gascon, D.
Gavaris, S .
Hanson, M.
Hayes, D.
Hunt, J.J.
Hurley, P.
Kulka, D.
Lambert, T.
Lawson, J.
Lilly, G.
Maguire, J.-J.
Mohn, R.
Morgan, J.
Morin, B.
Morin, $\mathbf{R}$.
Murphy, E.
Myers, R.A.
Nielsen, G.
O'Boyle, R.
Power, D.
Rivard, D.
Shelton, P.
Sinclair, M.
Sinclair, A. Chairperson
Stenson, G.
Taggart, C.
Trippel, E.
Zwanenburg, K.

| Affiliation | Attendance |
| :--- | :--- |
|  |  |
| DFO, St. John's, NFLD | Partial |
| DFO, Dartmouth, N.S. | Full |
| DFO, St. John's, NFLD | Full |
| DFO, Ottawa, Ont | Final revision |
| DFO, St. John's, NFLD | Partial |
| DFO, St. John', NFLD | Full |
| DFO, St. John's, NFLD | Full |
| DFO, Moncton, N.B. | Final revision |
| DFO, Moncton, N.B. | Full |
| FRCC, Ottawa, Ont. | Observer |
| DFO, St. John's, NFLD | Final revision |
| DFO, St. John's, NFLD | Partial |
| DFO, St. John's, NFLD | Partial |
| DFO, Mont--oli, Qc | Full |
| DFO, Mont-Joli, Qc | Full |
| DFO, Mont-Joli, Qc | Full |
| DFO, St. Andrews, N.B. | Full |
| DFO, Moncton, N.B. | Partial |
| NMFS, Woods Hole, | Full |
| MA, USA | Full |
| DFO, St. Andrews, N.B. | Partial |
| DFO, Dartmouth, N.S. | Full |
| DFO, St. John's, NFLD | Partial |
| DFO, Dartmouth, N.S. | Full |
| DFO, St. John's, NFLD | Full |
| DFO, St.John's, NFLD | Full |
| DFO, Quebec, Qc | Partial |
| DFO, Dartmouth, N.S. | Full |
| DFO, St. John's, NFLD | Partial |
| DFO, Mont-Joli, Qc | Partial |
| DFO, Moncton, N.B. | Full |
| DFO, St. John's, NFLD | Puall |
| DFO, St. John's, NFLD | Full |
| DFO, Moncton, N.B. | Full |
| DFO, Dartmouth, N.S. | Full revision |
| DFO, St. John's, NFLD | Partial |
| DFO, Ottawa, Ont | Full |
| DFO, St. John's, NFLD |  |
| DFO, Dartmouth, N.S. | DFO, Moncton, N.B. |
| DFO, St. John's, NFLD | Fill |
| DFO, St. John's, NFLD | DFO, St. Andrews, N.B. |

## Attendance

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18. Annex 2

|  | Abbreviations |
| :---: | :---: |
| ADAPT | The adaptive framework for SPA calibration |
| BIO | - Bedford Institute of Oceanography |
| C/E - CPUE | - Catch per unit of effort |
| CIL | - Cold intermediate layer |
| 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) |
| $\mathrm{F}_{0.1}$ | - 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 $1 / 10$ th that of a unit of effort on the virgin stock (dynamic pool model) |
| FAO | - Food and Agriculture Organization |
| FG | - Fixed gear |
| $F_{\text {max }}$ | - 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 |


| 19. Annex 3. Working Papers |  |  |  |
| :---: | :---: | :---: | :---: |
| These papers were tabled for the purpose of this meeting only and are not citable. Details on the contents of the papers may only be obtained from the authors. |  |  |  |
| Number | Title | Author | Keyword |
| 93/79 | Atlantic halibut in 4RST | D. Archambault <br> A. Fréchet <br> C. Levesque | halibut |
| 93/80 | Yield projections for the transboundary haddock resource on eastern Georges Bank | S. Gavaris <br> L <br> VanEeckhaute | haddock |
| 93/82 | Assessment of the southwest Scotian Shelf and Bay of Fundy cod | S. Gavaris | cod |
| 93/83 | Assessment of 4VsW cod in 1992 | B. Mohn | cod |
| 93/84 | A commercial landing based estimate of cod and haddock abundance on Georges Bank | A.R. Hanke | cod |
| 93/85 | A commercial landings based estimate of cod abundance in NAFO Div. 4X | A.R. Hanke | cod |
| 93/92 | Assessment of the southern Gulf of St. Lawrence cod stock in 1993 | A. Sinclair <br> M. Hanson <br> T. Hurlbut <br> D. Swain <br> R. Morin <br> G. Nielsen <br> G. Chouinard | cod |
| 93/93 | Timing of 4T cod migration | T. Lambert | cod |
| 93/96 | Biological update of Georges Bank cod in unit areas 5Zjm for 1978-92 | J. Hunt | cod |
| 93/97 | Maturation rates, distribution and maturity composition of Georges Bank cod in unit areas 5Zjm | J. Hunt M. Buzeta | cod |


| Number | Title | Author | Keyword |
| :---: | :---: | :---: | :---: |
| 93/98 | Assessment of pollock in divisions 4VWX and Subdivision 5Zc for 1992 | E.A. Trippel <br> L. Brown | pollock |
| 93/99 | Relationships between 4 VsW cod survey indices and hyrdrographic variables | S. Smith <br> F. Page | cod |
| 93/100 | An update of the status of 4VWX flatfish stocks | C. Annand <br> D. Beanlands | flatfish |
| 93/101 | A review of the status of the 4VWX, 3NOPs halibut stocks | C. Annand <br> D. Beanlands | halibut |
| 93/1102 | Comparative visual and histological observations on maturity staging of Georges Bank cod | C. Annand | cod |
| 93/104 | Eastern Scotian Shelf haddock | K. Zwanenburg et al. | haddock |
| 93/105 | 4X haddock assessment | P. Hurley <br> J. Simon <br> P. Comeau | haddock |
| 93/106 | Cod in Division 3Pn4RS | A. Fréchet <br> Y. Gagnon | cod |
| 93/108 | The estimation of ageing error probabilities | P. Gagnon | ageing |
| 93/109 | Stock status of redfish in the Gulf of St. Lawrence | B. Morin <br> B. Bernier <br> J.M. Sevigny | redfish |
| 93/110 | Stock status of Greenland halibut in Gulf of St. Lawrence | B. Morin <br> B. Bernier | halibut |
| 93/111 | Grey seal status | W. Stobo | seal |
| 93/112 | A commercial landings based estimate of pollock abundance on the Scotian Shelf | A.R. Hanke | pollock |


| Number | Title | Author | Keyword |
| :---: | :---: | :---: | :---: |
| 93/113 | Influence of depth dependent gear - spheral variability on population estimate on $4 X$ cod | D. Clark | cod |
| 93/114 | Status of Americian plaice in NAFO Division 4T | R. Morin | plaice |
| 93/115 | Status of witch flounder NAFO Division 4RS | R. Morin | flounder |
| 93/116 | Diet of harp seals in 2J3KL: Preliminary analysis 1991-93 | J.W. Lawson G.B. Stenson D. McKinnon | seals |
| 93/117 | Distribution of harp and hooded seals in offshore waters of Newfoundiand | G.B. Stenson <br> D.J. Kavnaugh | seals |
| 93/118 | Changes in mesh size for the 4 Vn winter (Jan.-Apr.) cod fishery - 1979 to 1983 | M.A. Showell | cod |
| 93/119 | 4 VsW cod: A summary of multidisciplinary studies on population dynamics | Staff MFD, Dartmouth, N.S. | cod |
| 93/120 | Assessment of cod in 2J3KL | C. Bishop <br> B. Davis <br> E. Murphy | cod |
| 93/121 | Assessment of cod in Subdivision 3Ps | C. Bishop <br> B. Davis <br> E. Murphy | cod |
| 93/122 | Assessing the risk of failing to achieve replacement recruitment | P.A. Shelton M.J. Morgan | recruitment |
| 93/123 | An assessment of 2+3K American plaice stock | W. Brodie <br> R. Bowering <br> D. Power | plaice |


| Number | Title | Author | Keyword |
| :---: | :---: | :---: | :---: |
| 93/124 | An assessment of 2 J 3 KL witch | R. Bowering W. Brodie D. Power | witch |
| 93/125 | An assessment of 3Ps plaice | W. Brodie R. Bowering D. Power | plaice |
| 93/126 | An assessment of 3Ps witch | W. Brodie <br> R. Bowering <br> D. Power | witch |
| 93/127 | Trends in fish biomass on the Scotian Shelf 1970-1992 | J. Simon <br> K. Zwanenburg <br> K. Frank <br> P. Comeau <br> D. Beanlands | fish biomass |
| 93/128 | Finfish by-catch in the northern offshore shrimp fishery | D.W. Kulka <br> D.G. Parsons | finfish by-catch |
| 93/129 | Haddock ageing workshop summary report | J. Hunt (Ed.) | haddock |
| 93/130 | Cod catch distribution in 3P4RSTV in 1991-92 | A. Sinclair | cod |
| 93/131 | Biomass trends of selected species from groundfish surveys conducted in the southern Gulf of St. Lawrence | G.A. Chouinard G.A. Nielsen | groundfish |
| 93/136 | Multiplicative analysis of 3Ps cod commercial and RV catch-at-age | A. Sinclair | cod |
| 93/137 | Can we estimate F from length frequency data? | A. Sinclair <br> K. Zwanenburg <br> P. Hurley | fishing mortality |

## 20. Annex 4 - Additonal information on Georges Bank cod and haddock

A teleconference was held on June 29, 1993 to review the status of the transboundary Georges Bank cod and haddock resources.

## A4.1 Georges Bank Cod in Unit Areas 5Zj,m (WP 84 + revision, 96, 97) J. Hunt

## A4.1.1 Description of the Fishery (see Section 10.7.1, Fig. 10.7a)

In 1990, a 6000t increase over 1989 in Canadian landings was due to a return to historic catches by the OTB fleet and resulted in an overall catch of $14,310 t$, the second highest in the time series. Canadian landings in 1991 where 13,455t but decreased to 11,712t in 1992. USA landings in 1992 were 5080t and below the average ( $6,500 t$ ) for recent years.

## A4.1.2 Data (see Section 10.7.2)

## Age Composition of the Commercial Catch

Canadian and USA landings of $5 \mathrm{Zj}, \mathrm{m}$ cod were dominated by the 1990 year-class at age two ( $44 \%$ in numbers) in 1992. Catch at age two in 1992 was the highest since 1987 when the strong 1985 year-class was entering the fishery. There appears to be no trend in size or weight at age over the 14 year time series, although both size and numbers age one were higher than average in 1992.

## Research surveys (Figure 10.7b)

Conversion factors were used to adjust results of the USA surveys for vessel and gear changes, as was done last year. Total catch per tow has been variable for each of the surveys. The 1991 and 1992 Canadian surveys show a marked decline from the high 1990 value and the decline continues in 1993. The 1991 USA autumn survey catch per tow is the lowest on record. A slight recovery in the autumn of 1992 still results in the second lowest estimate in the series. The 1992 USA spring survey is at the lowest observed value.

## A4.1.3 Estimation of Stock Parameters (see Section 10.7.3)

## Sequential Population Analysis

An ADAPT run with 1978-93 survey indices using the same formulation as in the 1992 assessment (ages 2-9 with spring and autumn USA surveys and Canadian spring survey indices; RV catchability assumed constant for ages 4+) was completed. The relative error for population estimates are high ( $46-67 \%$ ) although the relative error for survey catchability is lower (11-35\%). As was noted in last year's assessment, a strong annual pattern exists in residuals for survey indices. While the absolute values of estimates are not precise, the relative estimates are probably indicative of population trends and confirm the substantial increase in exploitation rate and decline in abundance since 1989.

## A4.1.4 Assessment Results (Fig. A4.1)

Based on results of the ADAPT analysis and survey indices, the population abundance of this stock has declined in recent years and exploitation rates since 1978 have generally exceeded $F_{\text {max. }}$. Fishing mortality at ages $3+$ is estimated to be 0.86 in 1992. Spawning stock biomass (3+) at the beginning of 1993 is about 25,000t, the lowest observed. Estimates of recruitment from research surveys indicate that the 1991 and 1992 year-classes are below average and that the 1990 year-class will account for a substantial proportion
of landings in 1993. Both the 1991 and 1992 year-classes, which appear to be well below average in research surveys and as estimated from ADAPT, will not contribute much to the 1994 biomass.

## A4.1.5 Prognosis

The high exploitation rates in recent years, present low stock biomass, and expected poor recruitment are cause for serious concern. There is little doubt that fishing mortalities in the 1990s are well above $F_{\text {max }}$. The fishery is driven by recruitment and this can result in substantial mortality at age two. Since fish at this age are up to $50 \%$ immature, a substantial loss in spawning potential for recruiting cohorts can occur. Indices of abundance derived from research surveys indicate a further decline in 1992 and are now at the lowest observed or close to it. The estimate for the 1992 year-class at age one in 1993 was not statistically significant but survey results indicate very low abundance and therefore this year-class was set to the lowest observed at age one $(2,400,000)$.

All indications are that this stock has declined substantially since 1990 and that further reductions in stock biomass can be expected if fishing pressure is allowed to continue at its present level. In the absence of recruitment, some measures to reduce harvesting of the stock, and in particular the 1990 year-class, are required.

Catch projections for 1993 were completed with the following input parameters:

| Age | 1993 Population <br> Numbers (thousands) | Weight (kg) | Partial Recruitment |
| :--- | :---: | :---: | :---: |
| 1 | $2400^{2}$ | 0.696 | 0.004 |
| 2 | 1741 | 1.391 | 0.32 |
| 3 | 5444 | 2.249 | 1.00 |
| 4 | 878 | 3.579 | 1.00 |
| 5 | 157 | 5.012 | 1.00 |
| 6 | 297 | 6.448 | 1.00 |
| 7 | 127 | 8.333 | 1.00 |
| 8 | 294 | 10.34 | 1.00 |
| 9 | 48 | 10.95 | 1.00 |
| $10+$ | 20 | 15.00 | 1.00 |
| Adjusted for bias |  |  |  |
| ${ }^{2}$ Assumed equal the lowest observed |  |  |  |

Two options were considered for 1993 - a catch equal the Canadian quota plus expected USA catches and a combined USA and Canadian catch at $F_{0.1}$ and for 1994 catches at $F_{0.1}$. Results are shown below:


## A4.2 Georges Bank Haddock in Unit Areas 5Zjm S. Gavaris

## A4.2.1 Description of the Fishery (see Sections 10.10.1 and 10.10.2)

## A4.2.2 Data (also see Section 10.10.3)

The 1992 commercial catch was well sampled for length and age composition with 34 samples taken from the Canadian fishery and 23 samples taken from the USA fishery. Both fisheries were largely supported by the 1985 (average length of 66 cm ) and 1987 (average length of 58 cm ) year-classes which comprised over $70 \%$ of the landed weight. There were no persistent long term trends in weight at age.

Annual stratified random surveys have been conducted by the USA in the spring since 1968 and in the autumn since 1963 and by Canada in the spring since 1986. The trends indicate a decline in adult abundance to about the lowest levels observed. The abundance of ages 3 to 8 from the Canadian spring survey and the USA autumn survey declined by about $70 \%$ and $40 \%$ respectively between the beginning of 1992 and 1993. The USA spring survey results for 1993 were not available. Survey recruitment results (ages 1 and 2) identified the strong 1975 and 1978 year-classes and the moderate 1983, 1985, and 1987 year-classes. Recent recruitment has been poor but early indications suggest that the 1992 year-class may be comparable in strength to those of 1983, 1985 and 1987.

## A4.2.3 Estimation of Stock Parameters

## Yield per Recruit (see Section 10.10.4) - Sequential Population Analysis

The adaptive framework (ADAPT) was used to calibrate the sequential population analysis with the research survey results. The model formulation employed assumed that the error in the catch at age was negligible compared to the error in the survey abundance indices which was assumed to be independent and identically distributed after taking natural logarithms of the values. All available data since 1968 were used except when the indices were 0 (logarithm not defined) or when discarding was high and survey independent estimates of the catch were not available. The spring survey results were compared to beginning of year population abundance in the same year while the autumn survey results were compared to beginning of year population abundance in the following year for the respective cohort. 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 .

Comparison of the estimated population numbers (ages 3 to 8 ) with the RV estimates for the same ages adjusted by the estimated catchability (Fig A4.2a) shows that residuals are large but do not appear to indicate lack of fit. Consequently, the estimated population abundance has large variance and this in conjunction with the non-linearity results in bias.

## A4.2.4 Assessment Results (also see Section 10.10.5)

For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias and used to construct the history of stock status. This simple 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.

The analysis indicates that the 1975 and 1978 year-classes were strong. Since the moderate sized yearclasses of 1983, 1985 and 1987, recruitment has been poor but early indications for the 1992 year-class suggest that it may be of moderate strength (Fig. A4.2b). It is too early to estimate the strength of the 1992 year-class reliably. Adult biomass (ages 3+) declined rapidly since 1990 as the 1985 and 1987 year-classes were fished down and is now below 5,000t, near the historic low observed during the early 1970 s
(Fig. A4.2c). The fishing mortality rate for ages $4+$ in 1992 was the highest observed, corresponding to harvesting of roughly $60 \%$ to $70 \%$ of the population, primarily the 1985 and 1987 year-classes (Fig. A4.2d). The previous occasion when the fishing mortality exceeded 0.5 was during the early 1970 s when abundance was at its lowest.

## A4.2.5 Prognosis (also see Section 10.10.6)

Yield projections were done using 1993 beginning of year population numbers as estimated from ADAPT.

| Age | 1993 <br> Population numbers <br> (thousands) | Weight(kg) <br> Beg. of year |  | Partial <br> Recruitment |
| :--- | :---: | :---: | :---: | :---: |
| 1 | 15360 | 0.59 | 0.43 | 0.0 |
| 2 | 3604 | 1.12 | 0.82 | 0.5 |
| 3 | 1242 | 1.43 | 1.21 | 1.0 |
| 4 | 729 | 1.75 | 1.55 | 1.0 |
| 5 | 17 | 2.13 | 1.95 | 1.0 |
| 6 | 590 | 2.53 | 2.33 | 1.0 |
| 7 | 4 | 2.90 | 2.72 | 1.0 |
| 8 | 74 | 3.13 | 3.02 | 1.0 |
| 9 | 6 | 3.50 | 3.25 | 1.0 |
| 10 | 0 |  | 3.60 |  |

As with the population abundance estimates, the simple 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 1993 would be 5,000t. A catch of this magnitude would generate exploitation rates comparable to or exceeding those observed in 1992. If the 1992 year-class proves to be as abundant as those of 1983, 1985, and 1987, the adult biomass will increase to about 10,000 tat the beginning of 1995 (Fig. A4.2e). The projected yield at $F_{0.1}$ in 1994 would be about 2,000 t with the 1992 year-class accounting for about $75 \%$ of the landed weight. High exploitation has resulted in a greatly reduced biomass and future catches will fluctuate in response to variable recruitment. If these rates of exploitation are maintained, potential yield will be lost as fish are harvested before their growth potential is realized and there is an increased chance that undersized fish will be caught and may be discarded.NameAnnand, C.Bishop, C.Buzeta, M.Chouinard, G.
Gavaris, S.
Hanson, M.
Hunt, J.J.
Hurlbut, T.
Hurley, P.
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DFO, St. Andrews, N.B.
DFO, St. Andrews, N.B.



Fig. A4.2a . Haddock in 5Zjm
SPA and RV (k adjusted) numbers (million)





Fig. A4.2b Recruitment for haddock (age 1) in unit areas $5 Z \mathrm{j}$ and 5 Zm ..


Fig. A4.2c Biomass (3+) for haddock in unit areas 5 Zj and 5 Zm .


Fig. A4.2d Fishing mortality (4+) for haddock in unit areas $5 Z \mathrm{j}$ and 5 Zm .


Fig. A4.2e Projected 5Zj,m haddock yield for 1994 and beginning of year biomass in 1995.

