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Proceedings of the Newfoundland Regional Groundfish Stock Assessment Review, April, May, September 1995

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PROCEEDINGS OF THE NEWFOUNDLAND REGIONAL GROUNDFISH STOCK ASSESSMENT REVIEW, APRIL, MAY, SEPTEMBER 1995

by

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ABSTRACT

Shelton, P.A. (Editor). 1996. Proceedings of the Newfoundland Regional Groundfish Stock Assessment Review, April, May, September 1995. Can. Manuscr. Rep. Fish. Aquat. Sci. 2343: vi + 60 p.

The second Regional Groundfish Assessment Review for Newfoundland was held in St. John's on 24-28 April, 5, 11, 25, 26, 29, 30 May and 22 September 1995. Overviews of the physical environment and pelagic, invertebrate and marine mammal stocks were tabled. The technical basis for a full assessment of the Divs. 2J3KL cod stock was reviewed. The technical basis for stock assessment updates for SA2+3K redfish and Amercian plaice, Divs. 2J3KL witch flounder, Divs. 3NO haddock, Subdiv. 3Ps cod, American plaice, witch flounder, haddock and pollock were reviewed. Preliminary assessments for Divs. 3LNOPs skates and lumpfish were also reviewed. This report provides a record of the proceedings of the Review and recommendations for future work related to the assessment of these stocks. Titles of 50 working papers tabled at the Review are listed and summaries of these papers with a brief record of any ensuing discussion are provided.

RÉSUMÉ

Shelton, P.A. (rédacteur). 1996. Proceedings of the Newfoundland Region Groundfish Stock Assessment Review, April, May, September 1995. Rapp. manuscr. can. sci. halieut. aquat. 2343: vi + 60 p.

Le deuxième examen régional de l'évaluation des stocks de poisson de fond de Terre-Neuve a eu lieu à St. John's du 24 au 28 avril, les 5, 11, 25, 26, 29 et 30 mai ainsi que le 22 septembre 1995. On y a brossé un tableau du milieu physique et des stocks de poissons pélagiques, d'invertébrés et de mammifères marins. On y a également examiné le fondement technique d'une évaluation complète du stock de morue des divisions 2J3KL, et de mises à jour des évaluations des stocks de sébaste et de plie canadienne de SA2 + 3K, de plie grise des divisions 2J3KL, d'aiglefin des divisions 3NO ainsi que de morue, de plie canadienne, de plie grise, d'aiglefin et de goberge de la subdivision 3Ps. Les évaluations préliminaires du stock de raie et de lompe des divisions 3LNOPs ont aussi été passées en revue. Le présent rapport rend compte des résultats de cet examen et comporte des recommandations pour les travaux futurs associés à la gestion des stocks considérés. Il contient une liste et des résumés des 50 documents de travail présentés, ainsi qu'un bref compte rendu des discussions auxquelles ils ont donné lieu.

1. Introduction to the 1995 review - P. Shelton

The Review convened from 24 - 28 April, 5 May and 11 May to examine the technical basis for the assessments of the SA2+3K redfish, SA2+3K American plaice, 2J3KL witch flounder, 3NO haddock, 2J3KL cod and 3LNOPs skates. The Review reconvened on 25, 26 29 and 30 May to examine the technical basis for the 3Ps cod, 3Ps American plaice, 3Ps witch flounder, 3Ps haddock, 3Ps pollock and 3LNOPs lumpfish, and again on 22 September to review the Unit 2 and 3O redfish assessments. In the case of the 2J3KL cod stock the assessment was considered to be full and comprehensive, whereas for all but two of the remaining stocks the assessments were considered to be updates of the previous assessments incorporating the limited amount of recent data. For skates and lumpfish, the assessments were considered preliminary as this is the first time the status of these stocks have been considered in any detail.

A total of 43 people participated in the review, including researchers from Memorial University, the Provincial Department of Fisheries, Food and Agriculture, the Fisheries Resource Conservation Council, the fishing industry and Dalhousie University. An attempt to broaden the Review further by obtaining the participation of stock assessment specialists from Woods Hole, St Andrews and Ottawa were unsuccessful due to scheduling conflicts of invited persons.

A total of 50 working papers were tabled at the meeting. Each working paper was presented orally and was followed by the opportunity for open discussion. In all cases where a discussion of the paper occurred, this was recorded by an appointed rapporteur. Several working papers addressing the 2J3KL cod stock were tabled and these were synthesised into a single document by a team of scientists led by the lead researcher for this stock. This synthesis was facilitated by several meetings of the team, both before and during the Review. Stock status reports for each stock, prepared by the lead researcher, were reviewed and adopted in the meeting. All working papers from which information was incorporated in the stock status reports were requested to be upgraded into Research Documents.

This Proceedings contains brief summaries of each working paper and major points raised in the ensuing discussion. In addition a list of research recommendations are provided regarding assessment-related topics that require further attention. The main purpose of the proceedings is to provide a record for participants in the meeting and a basis for the subsequent meeting. The actual assessments appear in the DFO Atlantic Fisheries Stock Status Report series and the technical basis for the assessments appear in the DFO Atlantic Fisheries Research Document series, both of which are available to the general public on request. The research recommendations at the end of the report are for the attention of the Regional Director, Science Branch and are considered an important part of the processs that guides research planning in the Region.

The Stock Status Reports produced by this Review are provided to the Fisheries Resource Conservation Council (FRCC) which is mandated by the Minister of Fisheries and Oceans to review these assessments together with other relevant information and recommend to the Minister total allowable catches (TACs) and other conservation measures. Following the Minister's decisions regarding these recommendations, Fisheries Management Branch meets with the stakeholders to develop Management Plans and Conservation Harvesting Plans for the relevant stocks in keeping with the decisions that have been made.

In a departure from the previous two years it was decided that in 1995 Science Branch rather than FRCC would release the Stock Status reports in a public forum. Consequently, there is now a

more direct link between Science and the public with respect to the assessment results. The process by which Management and Conservation Harvesting Plans are developed remains somewhat obscure and attempts to get Fisheries Management Branch to participate in the Regional Groundfish Stock Assessment Review have not been successful thus far, partly due to the many other demands made of this Branch by the Department. Ideally, the assessment for each stock should commence with a review of the Fisheries Management Plan (or Conservation Harvesting Plan) for the previous year, how this addresses the management objectives for the stock, how this was derived from the scientific assessment, how it was implemented and how successful it was in achieving the objectives.

Although the 1995 Review had to deal with a large number of stocks under quite severe time constraints, most working papers were given a high level of peer review. Considerable effort was devoted to drawing together the available information into a comprehensive report on the status of each stock. In future the process may benifit by deciding ahead of time which issues or stocks are of greatest importance and by devoting the major portion of the time at the meeting to these. Stocks for which assessment updates are required but for which there is only a limited amount of new information could be handled largely within Groundfish Division although the Stock Status Reports should still be presented for discussion and possible modification at the Review.

All working papers which are drawn upon in the compilation of the stock status reports are required to be revised and submitted as Research Documents. Other working papers which may present preliminary interpretations of data or suggest hypotheses, theories or ideas are not necessarily upgraded into Research Documents. The Region should give consideration to archiving all working papers for a period of time as they may provide a useful source of information for researchers working on groundfish species.

Uncertainties associated with the asessments are often documented in the body of working papers, research documents and stock status reports. However, uncertainties do not always appear to be effectively communicated to the resource managers. Consideration should be given to a more explicit treatment in future, perphaps through the creation of a separate section entitled "Major sources of uncertainty". It would be logical to have a link between this section and the Research Recommendations since research should focus on eliminating or at least reducing the main sources of uncertainty in assessments. Focussing on uncertainties would require a more thorough treatment of the confidence intervals around estimates. Suitable methods for quantifying uncertainties should be developed. These need to be translated into computer code that can be routinely applied in future stock assessments. In this regard, the highest priority should be given to developing a method for estimating confidence intervals for the groundfish RV bottom trawl biomass estimates (see discussion following WP#17 and WP#39, and Research Recommendation # 2).

All the participants in the 1995 Review are to be thanked for their efforts in ensuring that the highest level of Review possible was achieved. In all but a few cases the Review was conducted with a high degree of collegiality despite the different scientific backgrounds and affiliations of the participants, and the importance of the topics being discussed. This bodes well for future groundfish stock assessments in this Region.

2. Fisheries Resource Conservation Council - perceptions and expectations - H. Clarke (note this section reports on some views expressed by the Chair of the FRCC as well as comments and points raised by others in the meeting)

The FRCC is charged with determining DFO research priorities as they relate to the assessments and is one of the main users of the scientific results from the assessments. The FRCC is also a conduit for information from stake-holders in the fishery. It is therefore important to consider the perceptions and expectations of the FRCC with respect to the stock assessments. The Chair of the FRCC, Herb Clark, provided the Review with an overview.

The FRCC fosters an interdisciplinary approach to stock assessments in which information from the various scientific disciplines, including environmental and ecosystem information, are combined with information from fishers. It is the view of the Chair of FRCC that the assessment of Newfoundland stocks should move further in this direction.

The Stock Status Reports are important documents for communicating with the stake-holders. In contrast to last year when these reports were released by the FRCC, this year it will be the responsibility of the Department to release the reports and to hold subsequent consultations with stake-holders. After this the FRCC will hold their own formal consultations with the stake-holders (September) and the provide a final report to the Minister (mid to late October).

Although the new proposed format for the Stock Status Reports will meet most of the requirements of the FRCC, some members of the FRCC as well as some of the stake-holders may want access to the more detailed technical documents supporting the assessments. This information must be availably in an easily accessible form at the time of release of the Stock Status Reports.

It is the experience of the FRCC that at present the main concerns of people involved in the fishery is not the status of the depleted groundfish stocks but questions such the effect of predator-prey relationships, particularly seal consumption and the effect of capelin on predator species. The FRCC believes that it is important for the the different disciplines to talk about these problems in the same room to give a better chance of not missing the signals. For example, information on seals should be looked at when carrying out the groundfish assessments.

Glenn Blackwood, member of the FRCC, expressed the opinion that scientists are meant to provide the information that leads to the protection of the stocks, whereas at present much effort is still going into documenting the declines. In the past decision makers followed scientific advice when it suited them but then became very critical of the advice when the "wheels fell off". In the present process, the FRCC takes some of the "heat" off the scientists so that science can objectively provide advice to FRCC. Blackwood feels that it is important to realise that decision making is becoming more broad based and that consequently the results of the scientific assessments must become more readily available to the people that are involved. He believes that there is a need for fisheries science to become more closely tied to what is happening in society and the industry. Questions such as "Why do we spend all the money doing cod research and not grenadier research" must be asked. Although the FRCC has not received much positive feedback regarding fisheries science, there is widespread acceptance that conservation policies must be scientifically based.

The question was raised whether there would now be such a focus on the so-called "ecosystem approach" to fisheries assessments if the F0.1 approach had been successfully applied. The F0.1 approach aimed at limiting the "predation" by one of the main "predators" in the system, humans. The FRCC agrees that the control of human predation is a integral part of the ecosystem approach.

However, the FRCC has come to the conclusion that an F0.1 strategy by itself is not adequate. A broader approach incorporating understanding of the ecological interactions in the fishery is required because very few of the things that are done to one stock do not have implications with respect to other stocks. The whole system needs to be looked at when making management decisions.

The FRCC is concerned about the redirection of effort to previously underutilized species for which scientific stock assessments have not yet been carried out. The question was raised as to whether exploitation should have commenced without first carrying out a scientific assessment of the level of exploitation these stocks can withstand. Because of the limited and decreasing human resources within Science Branch, providing assessments of stocks such as lumpfish, thorny skate and monkfish will require attention to be diverted from the traditional gadoid and flatfish stocks. However, both the FRCC and the ADM Science require that as a minimum, stock status updates be completed for each of the traditional stocks each year, with full assessments at regular intervals. To divert attention to those stocks currently supporting the bulk of the fishing effort would require a substantial change in Science Branch priorities.

The problem also exists that for some of these stocks the basic data on stock structure and biology required to carry out a scientific assessment does not exist. For example, research on lumpfish was terminated by Science Branch in the Newfoundland Region a number of years ago because it was deemed low priority by science managers. It was noted that the last review of the lumpfish stock by CAFSAC in 1992 provided no scientific basis for the subsequent increase in the quota. Similarly, the management plans for many of the other previously underutilized species do not have a scientific basis. The suggestion was made that science should be built into Management Plans before the harvesting commences and that there should be no harvest without a scientifically based Management Plan. The question of redirecting scientific research related to stock assessments from traditional, but now depleted, groundfish species to other species which are now being quite heavily fished, in the absence of any scientific assessment of yield, is of concern to both the FRCC and scientists in the Newfoundland Region.

With regard to criteria for reopening closed fisheries, the FRCC has recently gone through the "ground-truthing" of a process designed to establish conservation criteria for reopening fisheries. It is likely that implementation of some of these criteria will require additional scientific research. The development of the criteria is an important next step in the FRCC's activities.

Comments by H. Clarke following the meeting

First of all you are to be commended because the process seems to be so tremendously difficult to try to bring things together. My suggestions are:

(i) The meeting should be attended by managers and regularly by the various scientific disciplines.

(ii) Put more effort in trying to arrive at a consensus at the meeting for two reasons. The first would be for the report itself but, more importantly, a meeting of minds would help determining work priorities for the next number of months.

(iii) I am concerned about capelin. In other cases where we have seen mixed or unusual signals it has never worked out positively. Rather, in the event, it generally turns out for the worst. For capelin we have two conflicting indices, a wide range of biomass estimates, spawning and migration patterns have changed, the fish are growing more slowly etc. It seems to me that the groundfish people should have more to say about this.

(iv) Estimates of natural mortality? (where are they?)

(v) I agree you should make some statement on skate, monkfish, lump-fish etc.

(vi) Regarding the point brought up by G. Evans (changing the format of the Review to be more problem orientated) wouldn't it be appropriate before the meeting is over to outline what we don't know (or what should be priority work activities) as well as what we do know?

3. Status of the capelin stock in SA2 +Div. 3KL (WP#1) - J. Carscadden

Summary

Catch Trends SA2 + Div. 3K

The 1994 preliminary inshore catch was 67 t, well below the 1993 catch of 13,000 t and the 1994 TAC. The 1994 fishery did not open because the capelin were too small to meet the market size criteria of 50 count/kg, defined in the Management Plan. In 1994, capelin continued a trend that began in 1991 of spawning late although the 1994 spawning was somewhat earlier than in 1993.

Div. 3L

The 1994 preliminary catch of 871 t was well below the 1993 catch and the 1994 TAC. Most (82%) of the catch came from the Southern Shore, an area that usually accounts for only a small proportion of the 3L catch (no more than 7% between 1990-93). The low catches in 1994 occurred because capelin did not exceed the size criteria necessary to open the fishery.

Stock Status in 1994

Stock status has been difficult to determine in recent years because of the divergence between inshore indices and the offshore acoustic surveys. This continued to be the situation in 1994 with the added uncertainty regarding the appropriate interpretation of the 1994 inshore indices. Egg deposition in 1994 varied from low to average on monitored beaches. Although the aerial survey index for 1994 was high, it was largely a result of the presence of large schools only in Trinity Bay and not in Conception Bay. Capelin arrived late inshore again in 1994 and the fishery opened only sporadically because the management criteria related to size were not met.

The 1991 and 1990 year-classes contributed (about 80% combined) to the spawning population in 1994. These year-classes were estimated to be average and strong, respectively, in the multiplicative analysis suggesting a higher than average spawning stock abundance in 1994.

The results of the multiplicative model formulations rely in some cases on indices which have not been collected specifically to monitor capelin abundance nor have they been validated as reliable indicators of capelin abundance. In addition, the formulation of the multiplicative model combining different kinds of indices is not known to have been attempted in other fish stock assessments.

Prognosis for 1995

The 1994 acoustic survey estimate was again low, even though this was the second year of such an extensive synoptic survey. These acoustic surveys have been designed to provide a recruitment index and therefore, were expected to provide a basis for prediction of the spawning biomass inshore the following year. In recent years, these expectations have not been met. Consistently low biomasses have been estimated offshore but there have been no decreases in catch rates or

aerial survey indices inshore of the magnitude that would be expected from the low acoustic indices. Thus, similar to last year, the acoustic survey is not being relied upon although there continued to be concern about the trends in this survey. The reasons for these low biomass estimates in the acoustic survey as well as the concerns regarding the indices and the multiplicative model noted above require further research. Despite the concerns about the indices and the model, the Committee noted that the projected biomass in 1995 would support a catch of 33,000 t as outlined in the Management Plan without exceeding the conservation level of 10% of the spawning stock biomass.

Capelin captured in the 1994 acoustic survey were relatively small and based on historical trends in sizes in the acoustic survey and sizes inshore the following year, capelin in the 1995 spawning stock likely will be small. Even if spring water temperatures were average or above normal, growth would have to be exceptional for capelin to reach sizes attained in the late 1980s. The overall average size in the spawning stock will be dependent on the relative proportions of the year-classes present. Since the 1992 year-class is expected to be stronger than the 1991 and the latter should already be reduced by spawning mortality, the 1992 year-class would be expected to dominate. This will likely contribute to an overall smaller mean size. Although the abundance of the 1993 year-class could not be quantified, it dominated in some surveys and appeared widespread in the offshore. If it is a strong year-class, it could also appear in the 1995 spawning population and contribute to a small overall mean size.

4. An update on the status of invertebrate stocks off Newfoundland (WP#2) - M.J. Morgan

Summary

The regional assessments of invertebrate species met on a number of occasions between February 27 and Mar 31, 1995. Three species, comprising a variety of stocks, were assessed. Most of the work presented was by D. Parsons, E. Dawe, D. Taylor, S. Naidu and their coworkers. It is their work that is summarized here and not the work of the author of this working paper. The information is taken directly from their working papers and SSRs.

Northern Shrimp (Pandalus borealis)

Shrimp are assessed as four "stocks", 0B, 2G, Hopedale and Cartwright Channels, and Hawke Channel and 3K.

In 0B the status of the resource remains uncertain. The CPUE and biological sampling are not considered reliable indices of stock conditions. The declines in catch and catch rates are considered to be more likely a reflection of the difficulty in locating high concentrations of shrimp than they are indicators of a decreasing resource. Fishermen have reported that concentrations of shrimp in this area are short lived and not persistent as they are in the more southern areas.

In 2G CPUEs continue to be high with the daily production often being achieved in only a few hours fishing. The catch is mainly composed of large, female shrimp, indicating a healthy spawning stock and little impact of the fishery on the resource to date.

In Hopedale and Cartwright Channels the resource remains healthy with CPUE remaining stable from the mid to late 1980s, with some increase in recent years. No declining trend in the

proportions or catch rates of female shrimp has been seen since 1986 and prospects for recruitment to the female component in the near future are favourable. Preliminary data from the fishery for 1995 (from January to early March) indicates that catch rates are still high.

In Hawke Channel and 3K the resource appears to be healthy and catch rate data suggest that abundance has increased in recent years. The proportion of female shrimp in the catches remains high and there are no signs of weak recruitment. The fishery has moved to new areas recently, but catch rates in more traditional areas remain high. Preliminary data for 1995 indicate that catch rates are higher in Jan-March this year than they were in 1994.

Although there is no biomass index for shrimp, the fishery data, both in terms of CPUE and proportion of female shrimp in the catch, would indicate that the resource remains healthy throughout the area. Changes in the distribution of the fleet indicate that shrimp are widespread, as well as abundant.

Snow Crab (Chionoecetes opilio)

Landings of snow crab have been increasing in Newfoundland and Labrador since 1989 or 1990. In 1994, they reached and all time high of 27,844 t. The fishery in 1994 was widely distributed indicating that crab are found throughout the area. Commercial CPUE in the three areas where there is research vessel survey information, continued to be high in 1994 and the catch per survey trap of legal sized crab remained high. However, the trend of decreasing catch of prerecruits in the surveys continued. The survey and fishery data indicate that biomass continues to be high. However, if the declines in prerecruit abundance observed in the 3L research survey areas are indicative of trends for the whole Newfoundland region, there will be a reduction in biomass as the large stock of commercial sized crab is depleted.

Iceland Scallop (Chalmys islandica)

Iceland scallops on the Grand Banks occur in only a few known areas of concentration. Based on fishing patterns and exploratory surveys it is unlikely that unknown massive beds are present. There have been two surveys in 3N, one in 1989 and one in 1994. Mean research vessel catch rates were 50% lower in 1994 than they were in 1989 (17.3 vs. 35.2 kg/tow mile). CPUEs declined over the season for vessels fishing in 3N. These data both indicate that the beds of scallops in 3N may be being depleted.

From the RV survey it was possible to estimate a biomass for 3N and 3L. The biomass for 1994 for 3N was estimated to be 28,800 t (range 19,600 to 38,000 t) and in 3L it was estimated to be 9,500 t (range 4,000 to 15,000 t).

5. Oceanographic conditions and climate change in the Newfoundland Region during 1994 (WP#3) - E. Colbourne

Summary

Oceanographic data from the Grand Bank, northeast Newfoundland Shelf, St. Pierre Bank and the southern Labrador shelf during 1994 are compared to historical data from the area. The cold air temperatures experienced in Atlantic Canada during the winter of 1994 had moderated to near normal conditions by the spring of 1994 and to above normal values by the summer. As a result

the anomalously cold water temperatures experienced in recent years along the east coast of Newfoundland had moderated in the upper water column (0-30 m depth) and by July surface layer temperatures were up to 2.0 °C above normal at Station 27. Temperatures remained below normal however in deeper water (100-176 m) until the fall, when they returned to near normal values. The Bonavista cold-intermediate-layer (CIL) was slightly above normal in area (7 %) but much less than the past four years (up to 68 % in 1991). Comparisons of historical temperature data from NAFO Subdivisions 3Pn and 3Ps to data collected during April of 1994 indicate that the anomalous cold period that began in the mid 1980s has moderated somewhat but is continuing into 1994 near the bottom over St. Pierre Bank. In addition, large areas with below normal temperatures exist, particularly on the eastern portions of St. Pierre Bank, Placentia Bay and on the continental slope areas.

In the last three decades the oceanographic, meteorological, and ice conditions of the Northwest Atlantic have been dominated by three anomalous periods: early 1970s, mid 1980s and the early 1990s. During these periods stronger than normal northwesterly winds during the winter months were mainly responsible for colder than normal air temperatures over the Northwest Atlantic resulting in increased ice cover and eventually colder and fresher than normal oceanographic conditions over most of the continental shelf in Atlantic Canada.

Time series of temperatures at Station 27 show below normal values during the winter of 1994 over all depth ranges. By the summer however temperatures had increased to about 2.0 °C above normal in the upper water column and to near normal values in deeper water by the fall. Salinities were near normal in the upper water column during the first half of 1994, slightly below normal in deeper water and significantly below normal during the summer in the upper water column. Time series of temperature anomalies in the 3Ps area show the cold period which started around 1984, continued to the early 1990s with temperatures up to 1.0 °C below average over all depths and up to 2.0 °C below the warmer temperatures of the late 1970s and early 1980s in the surface layers.

The summer area of the CIL across the northeast Newfoundland shelf has returned to near normal at Bonavista but remained above normal on Hamilton Bank and slightly above normal on the Grand Bank. During the fall the CIL increased from 22 km^2 in 1991, 30 km^2 in 1993 and 26 km^2 in 1994 compared to the 1980-1994 average of 24 km^2. In area 2J across Hamilton Bank the fall

CIL area had decreased from 27 km^2 in 1992, 16 km^2 in 1993 and to 14 km^2 in 1994. Comparison of data collected along the Bonavista transect during 1994 with all available historical data on the Newfoundland shows near normal values with no evidence of oxygen depletion anywhere over the water column.

Surface temperatures during 1994 ranged from above normal in southern regions of Division 3L to below normal in Division 2J. Large areas of the continental shelf, particularly the Grand Bank, saw a continuation of the below normal bottom temperatures (up to 0.5 °C below average) experienced during 1991-1993.

The below normal air temperatures and above normal ice coverage since the late 1980s have contributed to a lower than normal heat content on the eastern Canadian continental shelf areas. The analysis presented here shows conditions returning to more normal values however widespread negative temperature anomalies still exist over much of the water column particularly in deep water.

6. A model of harp seal predation in waters near Newfoundland and Labrador (WP#4) - G.B. Stenson and J.W. Lawson

Summary

Current estimates of harp seal abundance indicate that the total population size in eastern Canada in 1994 was approximately 4.8 million (95% C.I. of 4.1-5.0 million) animals. To estimate consumption of major fish prey by harp seals off the coast of Newfoundland and in the Gulf of St. Lawrence, a model incorporating age-specific estimates of energy requirements, population size, seasonal distribution and diets was constructed. Total prey consumption increased from 3.6 million to 6.9 million t between 1981 and 1994. The proportion of prey obtained in the Arctic and Newfoundland areas were similar (46% and 40% respectively), while 14% were consumed in the Gulf. The major prey off Newfoundland was Arctic cod and capelin. Based on average diet, harp seals consumed an estimated 1.2 million t (95% C.I. of 735,000 to 1.7 million) of Arctic cod and 620,000 t (95% C.I. of 288,000 to 1.0 million) of capelin in 1994. An estimated 88,000 t (95% C.I. of 46,000-140,000) of Atlantic cod were also consumed. Incorporating seasonal, geographic and annual variation in the diet provide additional information on trends in consumption. The basic assumptions of the model were varied to assess its sensitivity. Changes in the energetic costs of activity and growth as well as abundance, residency period, or the proportion of energy obtained from offshore areas can affect estimates of total consumption significantly.

7. Distribution and abundance of Arctic cod (*Boreogadus saida*) off southern Labrador and eastern Newfoundland (WP#5) - G.R. Lilly

Summary

Arctic cod (*Boreogadus saida*) is the major trophic link between zooplankton and piscivores in the Arctic Ocean. In the northwest Atlantic, where it extends southward to Grand Bank, it is eaten by Atlantic cod, Greenland halibut, seabirds and seals, particularly harp seals. Because it is not fished commercially in this area, there have been no attempts to estimate its total biomass. However, insight into trends in its status may be derived from the bycatches in trawl surveys conducted in Divisions 2J+3KL during the autumn (Lilly et al. 1994). Catches tend to be small, and the minimum trawlable number and biomass are assumed to underestimate the true values considerably. The biomass was relatively low in 1978-1984 but generally higher and more variable in 1985-1994. Peak years were 1985, 1989, 1993 and 1994. In some years (e.g. 1981, 1985) most of the biomass was found in Division 2J, whereas in other years (e.g.. 1988, 1989, 1994) most was in Division 3K. The biomass in Division 3L was relatively low in 1981-1991, but increased in 1992 and 1993 before declining again in 1994.

The distribution of Arctic cod has changed. In years prior to 1991, most Arctic cod were caught on Hamilton Bank and the coastal shelf off southern Labrador and northeastern Newfoundland (Lilly et al. 1994). In 1991-1994, the distribution expanded further to the east, with larger and more frequent catches occurring on southeastern Hamilton Bank, Belle Isle Bank, northeastern Funk Island Bank, and the northern and northeastern slopes of Grand Bank.

Reference

Lilly, G.R., H. Hop, D.E. Stansbury, and C.A. Bishop. 1994. Distribution and abundance of polar cod (*Boreogadus saida*) off southern Labrador and eastern Newfoundland. ICES C.M. 1994/O:6.

Discussion - P. Shelton (Rapporteur)

It was considered that the new Campelen trawl to be used in groundfish surveys will have a greater catchability for Arctic cod than the gear previously used.

Data on the abundance and distribution of Arctic cod from north of 2J (up to Cape Chidley) would be very informative. Greenland halibut and Arctic cod occupy much of the same area and the question was raised as to whether there is any synchrony in the two stocks. Greenland halibut spawn in the high arctic. It is not clear exactly where Arctic cod spawn but most of the large fish are in the north. However, many of the fish sampled in the south have well developed gonads.

The question was raised as to whether the apparent increase in Arctic cod could be a result of fish moving south into the survey area. In recent years there has been no sampling on Saglek Bank where Arctic cod were found to be abundant in 1978, 1979 and 1981, so it is not known if these fish still occur there or have shifted southward. Recently there has been evidence of a series of strong year classes in the length frequency data for 2J3KL.

It was clarified that no age determination of Arctic cod by otolith reading has taken place for many years and that age classes are inferred from length data at present.

The suggestion was made that trawl surveys should periodically extend north of 2J to monitor the abundance of stocks in this area.

8. Stock status update of witch flounder in NAFO Div. 2J and 3KL (WP#6) - W.R. Bowering

Summary

Description of the fishery

The commercial fishery began for witch in 2J and 3KL in the early 1960s and increased steadily from about 1,000 t in 1963 to a peak of over 24,000 t in 1973. Catches declined rapidly to 2,800 t by 1980 and subsequently fluctuated between 3,000 and 4,500 t to 1991. The catch in 1992 declined to 2,300 t, the lowest since 1964, and further declined to 342 t in 1993 and just 12 t were reported in 1994.

Commercial fishery data

No new data were available from the commercial fishery for 1994 partially due to very low catches in these years.

Research vessel survey data

Stratified–random research vessel surveys have been conducted in the fall in 2J, 3K and 3L since 1977, 1978 and 1981 respectively. For 2J, biomass estimates ranged from as high as 4,100 t in 1986 to a low of less than 160 t in 1994. In 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 just over 340 t in 1994 the lowest in the time series. For 3L, biomass estimates varied generally between 6,000 and 7,000 t from 1981–88 but declined rapidly since then to a low of just under 1,500 t in 1992 and less than 400 t by 1993 and 1994. For the three divisions combined there has been a very steady and rather systematic decline from about 1984 through 1994 with the estimate of 900 t in 1994 the lowest in the time series.

Estimates of biomass by depth indicate that for all Divisions in the earlier years the biomass is distributed in depths generally less than 500 m. Since 1989 most witch flounder is found in depths greater than 500 m although the overall biomass in all depths and areas is now extremely low.

Prognosis

This stock has been reduced to levels far below anything observed in the past. It is also apparent that during the 1980s, the magnitude of the declines in biomass observed in the surveys cannot be fully explained by the removals of the commercial fishery as the commercial catch over trawlable biomass ratios are generally quite low during most of the period. On the other hand, having observed the shrinking area of distribution in recent years (as presented in the previous assessment) coupled with the fact that fishing was most intense in this area upon prespawning aggregations it is probable that recent catches may have accelerated the decline over the last few of years. This is suggested by the much increased ratios in 1991 and 1992. 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, at least to some degree. Nevertheless, fishing took place in a very restricted area in 1993 and was a failure as indicated by poor catch levels in comparison to the TAC. In 1994, no concentrations could be found by commercial vessels to support a viable fishery, therefore, virtually no fishery was conducted. It is difficult not to accept that this stock is at a dangerously low level and exploitation in its present state continues to be unjustifiable from a conservation point of view.

Discussion - P. Shelton (Rapporteur)

A detailed assessment of this stock was last carried out in 1993. There has been no change in perception regarding the status of the stock since then. Age determination for this stock is behind schedule as a result of reductions in personnel. Consequently the age composition of the last survey estimate is currently unknown. Criteria for eventual reopening this fishery are likely to include those based on a rebuilding of the age composition of the stock. Steps should be taken to avoid any further accumulation of a back-log of age material.

It is recommended that peer review of this stock take place again in 3 years time (1998), unless there is a substantial improvement in stock status or new scientific analyses regarding stock status are undertaken before then.

9. An update of the status of the stock of American plaice in Subarea 2 + Div. 3K (WP#7) - W. Brodie, J. Morgan and W.R. Bowering

Summary

Description of the fishery

Catches exceeded 2,000 t on only 2 occasions after 1981, and from 1992 to 1994 averaged less than 100 t per year. These are by far the lowest in the time series, due to the moratorium on the northern cod fishery, and a sharp reduction in the TAC for 1994 (500 t by-catch only).

Commercial fishery data

No new data were available from the commercial fishery for 1993 or 1994, due mainly to the very low catches in these years.

Research vessel survey data

Stratified random surveys have been conducted in 2G, 2H, 2J, and 3K since the late 1970s, although not annually in 2GH. In 2GH, there was a substantial drop in biomass from the late 70s/early 80s to the late 80s/early 90s. In 2J, where survey coverage has been virtually complete since 1981, the trawlable biomass index declined drastically from estimates of about 90,000 t in 1982-83 to around 2,000 t in each year from 1992-1994. 3K shows a similar pattern, with the trawlable biomass index declining from a range of 25,000 to 40,000 t between 1979 and 1987 to a level around 3,000 t in the 3 most recent surveys. The 1994 values are the lowest on record in both 2J and 3K.

Virtually all cohorts declined at very high rates from 1990 to 1993, and current estimates of spawning stock (RV survey ages 9+) are in the range of 1 to 3% of peak values. There has also been decreased recruitment in recent years, although the decline is not as severe as the overall decline in stock abundance. Age specific data from the 1994 survey are not available at this time.

Shifts in the depth distribution of the biomass to deeper water occurred during 1986-89 in both divisions, and were followed by rapid declines to very low levels. In 2J, concentrations of plaice on Hamilton Bank and in the southwestern portion of 2J, present in most surveys up to 1988, disappeared in subsequent surveys. Similar patterns were observed in 3K, with plaice becoming less abundant in the shallower areas in the western part of the division since the late 1980s.

Prognosis

It is evident from the RV survey data that this stock has declined to an extremely low level in recent years. With the stock size estimated from surveys in the early to mid 1980s, and the relatively low catches in the commercial fishery since then, it was concluded that fishing mortality alone cannot explain the magnitude of the declines in stock size which have occurred. Using catch/RV biomass as a proxy for exploitation rate showed that during the period of greatest decline (1982/83 to 1987), this ratio did not exceed 5% in any year, and was below 2% in each year from 1982-85. In fact, the ratio never exceeded 9% and was less than 5% in 13 of the 17 years in the series.

At present there is no explanation for the decline in this stock, or why it has remained at such a low level with virtually no fishery in the past 3 years. Factors such as affects of anomalously low water temperatures since the mid 1980s, seal predation, dumping/discarding/misreporting, and migration

have all been speculated, but none has been shown to have caused the decline.

Given the current stock size estimates from surveys, there can be no hope for recovery in the short or medium term. Even with negligible catches, the stock size remained at extremely low levels in 1992-94. The prospects for rebuilding in the longer term are unknown, although a recovery of the fishery is unlikely before at least 10 years, given the age and maturity structure of the population. It was concluded that any fishery on this stock in 1996 would be detrimental to its recovery.

Discussion - P. Shelton (Rapporteur)

A detailed assessment of this stock was last carried out in 1993. There is no directed catch and the bycatch is limited to 500 t. The biomass is clearly at a very low level. Estimation of mature biomass from maturity data could be carried out but would not change the perception regarding the status of this stock. The stock in 2GH has also declined.

The similarity in spatial patterns of cod and American plaice, viz.- moving into deeper water at the same time, particularly in 2J, was noted. There is, however, no evidence that American plaice shifted southwards, in contrast to the southerly shift suggested by some for cod.

It was suggested that peer review of this stock take place again in 3 years time (1998), unless there is a substantial improvement in stock status or new scientific analyses regarding stock status are undertaken before then.

10. An update of the haddock stock status in NAFO Div. 3NO (WP#8) - E.F. Murphy and C.A. Bishop

Summary

The Fishery in the 1948 to 1962 period gave average annual catches of 62,000 t. These catches were supported by several strong year classes. Catches declined significantly through the 1960s and reached a low of 128 t in 1981. Year classes of the early 1980s were relatively strong and catches increased to a high of 8,200 t in 1988. The 1994 reported catch for Haddock was only 8 t.

Stratified random surveys have been conducted in 3NO since the early 1970s . Abundance and Biomass estimates from the surveys for haddock were low during the 1970s peaked in the early 1980s and have since declined to low levels. Survey abundance at age for stock shows recent year classes are weak.

Advice from reviews of this stock by CAFSAC in the late 1980s and early 1990s was that there be no directed fishery so that yield could be enhanced and incoming good year classes be given a chance to contribute to the spawning stock. However TACs were set between 4,100 and 10,000 t during 1987-1992. Survey data suggests that the large catches of this period substantially reduced numbers before they reached spawning age (50% maturity at about age 5).

The 1994 Stock Status Report suggested a TAC of 500 t would approximate the average during periods when recruitment was low. It was also suggested that should another good year class occur, it should be protected so it could reach spawning age. The FRCC in it's 1994 Report reiterated this advice and suggested that haddock bycatch in other fisheries be limited to 100 t.

The results from the 1994 survey indicate that the stock remains low with weak year classes. Consequently there is no reason to change the most recent advice.

11. An update of the redfish stock status in Subarea 2 + Div. 3K (WP#9) - D. Power

Summary

Description of the fishery

The highest catch taken from this stock was 187,000 t in 1959. Between 1961 and 1979 catches averaged about 30,000 t, ranging between 17,500 t and 56,000 t. From 1980-83 catches averaged 16,000 t, increased to about 27,000 t from 1984-1986 in response to improved markets and declined thereafter. There has not been a persistent directed effort on this stock since 1990 when 2,400 t were landed. Landings declined to 280 t in 1991, and have been less than 15 t in each year from 1992-1994. In addition, redfish discards from shrimp fisheries in the area amounted to 386 t, 185 t and 110 t in 1992, 1993 and 1994 respectively. Canada has accounted for most of the landings since the implementation of the 200-mile economic zone in 1977. The steady reduction since 1986 was due primarily to a major redirection of effort to other redfish fisheries. In addition there was no effort by foreign countries (Russia and Japan) fishing Canadian quotas since 1987.

In the 1980s, most of the landings were taken from 3K. This was primarily due to the prevalence of external parasites in 2J (see below). Throughout the existence of this fishery, the predominant fishing gear has been the bottom otter trawl.

The fishery has been under TAC regulation since 1974 when 30,000 t was implemented. The TAC was increased to 35,000 t in 1980, decreased to 20,000 t in 1991 and further reduced to 1,000 t in 1994. For 1995, 200 t has been set aside for test fisheries.

Industry Experience

A number of reasons have been cited for the substantial reduction in landings since 1986 according to Canadian companies which had a directed fishery for this stock. First there was the continuous complaint of parasite infestation (*Sphyrion lumpi*, an external copepod which attaches itself to the flesh), particularly in 2J. In addition there is a bacterial infection of the skin which also renders them undesirable for the prime market. Secondly, according to veteran trawler captains of this fishery, concentrations of fish had diminished on their traditional fishing grounds. Finally the major Canadian stakeholder, National Sea Products, had diverted effort to other fisheries. In early 1995, National Sea Products conducted a short experimental fishery in 3K on traditional redfish grounds. Although only a few sets were conducted the results were very poor and the area steamed over was considered a desert in terms of viable concentrations of redfish.

Commercial fishery data

There has been very limited data available since 1990 when this fishery virtually became a by-catch fishery. In the mid-1980s prior to the decline in catches the bulk of the fishery consisted of fish in the 28-40 cm range which correspond to ages from 10-20 years.

Research survey data

Stratified random groundfish surveys have been conducted in the fall in 2J and 3K since 1977. These surveys generally cover strata to depths of 1000m. The stratification scheme was redesigned for the 1993 survey to redefine stratum boundaries based on more recent information on depth soundings. Although it is difficult to compare the results of certain strata to those previous to 1993, in general the total area of revised stratification is only slightly different from the previous scheme used from 1977-1992.

The derived indices of stock size suggest the population in 2J and 3K were at historically low levels in 1994. Although there have been rather large fluctuations between some years in both series, there has been a general decline in the 2J biomass index from about an average of 200,000 t (1978-1981) to an average of 1,600 t (1992-1994). The 3K biomass index suggests an even larger reduction from an average of 316,000 t (1978-1981) to an average of 1,000 t (1992-1994). Average catch per tow was less than 2.2 kg in 2J and less than 0.5 kg in 3K since 1992 compared to an average of 182 kg and 150 kg respectively from 1978-1981 surveys. Length distributions in terms of mean number per tow at length indicate (i) that the stock is at a very low level and (ii) recruitment has been poor since the year classes of the early 1970s.

Stratified random groundfish surveys have been conducted occasionally in 2G and 2H from 1978-1991. The information from these surveys suggest that the density and trawlable biomass estimates of redfish in these areas was relatively low when compared to surveys in 2J and 3K conducted in equivalent years (Power and Atkinson 1990).

Greenland halibut surveys have also been conducted in 3K in 1991, 1994 and 1995 from which redfish information was collected. The 1991 survey was a line transect survey conducted in September and the 1994 survey a stratified random design conducted in February-March. Both surveys covered depths from 750 m - 1500 m. The 1995 survey, conducted in March-April was also stratified random but had more extensive coverage from 500 m - 1500 m. Trawlable biomass was estimated about 4000 t in the 1991 survey, primarily due to one large set and there was no catch taken in the 1994 survey (Morgan et al. 1994). The trawlable biomass from the 1995 survey was about 1700 t.

It had been suggested previously that the timing and coverage of the surveys may not be optimum to fully understand the dynamics of the stock because distribution plots of the 2J3K survey catches indicated that in some years large concentrations of fish were at the border of the surveyed area (Power and Atkinson 1990). The data from the Greenland Halibut surveys suggest there was no large abundance of redfish missed in the 1991, 1993 and 1994 fall surveys of 3K.

Mortality Rates

An approximation to an exploitation rate by calculating ratios of catch to trawlable biomass estimated from the fall surveys to 2J3K suggest that exploitation on this stock has been above 12% only in 1985 (18%) and 1986 (18%) and has generally been below 6%, which for redfish is considered to be below the $F_{0.1}$ level (F=0.12 or 11%) based on yield per recruit calculations from neighbouring 3LN (ANON 1989).

Summary and prognosis

It is not possible to provide an estimate of the absolute size of this stock. The estimates of trawlable biomass from surveys in 2J and 3K combined indicate the population has declined from an average of 516,000 t from 1978-1981 to an average of 2,600 t from 1992-1994. The exploitation rate generated from the catches over this time period is not sufficient enough to totally account for the decline in the biomass since the late 1970s.

There is a strong concern regarding the current state of this stock and an even stronger concern about the future because of poor recruitment since the year classes of the early 1970s. From a conservation point of view, exploitation of this stock is unjustifiable. There has been nothing to indicate that the status of this stock will change in a positive way in the foreseeable future. Any good recruitment coming into this stock will need at least 10 years before it will start contributing to a fishery because of the relatively slow growth rate of redfish. If this stock were to experience good recruitment in the near future, it would still take about 10 years for this to start contributing to a fishery because of the relatively slow growth rate of redfish. It is therefore unlikely that this resource can sustain a directed fishery in the foreseeable future given the perceived current state of the stock.

References

Anon 1989. NAFO Sci. Coun. Rep., Northwest Atlantic Fisheries Organization, Dartmouth Canada 69p.

Power, D. and D. B. Atkinson 1990. Redfish in NAFO Subarea 2 and Division 3K. CAFSAC Res. Doc. 90/59. 77p.

Morgan, M. J., W. R. Bowering and W. B. Brodie 1994. A comparison of results from Canadian Deepwater Surveys in 1991 and 1994, with emphasis on Greenland Halibut. NAFO SCR Doc. 94/53 Ser. No. N2424. 18p.

12. An overview of thorny skate (WP#10) - B. Atkinson

Summary

Because of declines in "traditional" groundfish resources, interest in fisheries for other, previously underutilized species, has increased. One of these is skates. Test fisheries began in 1993 and were continued during 1994. Because of developing markets, fisheries have developed, and the first management plan was put in place for 1995, albeit based on very limited scientific information. The current management units are 3LNO combined, and 3Ps. Preliminary analyses of research survey data suggest different trends in biomass over time in the 4 areas: dramatic and continuous declines from 1984 to 1994 in 3LN, stability in 3O and recent declines in 3Ps. Data also suggest differences in size at maturity between 3LN and 3OPs. These data, when taken together, suggest that more appropriate management units might be 3LN, 3O, and 3Ps. Also, because skates appear to be sedentary, it is suggested that fishing effort be spread out rather than being concentrated in any one portion of these divisions.

13. Level of discarding of commercial groundfish species in the northern shrimp fisheries in 1992-1994 (WP#11) - D. Kulka

Summary

A fishery for shrimp (*Pandalus borealis* and *P. montagui*) has existed since the late 1970s. Shrimp grounds cover a large area from Lat. 70° N in Davis Strait, south along the Labrador Shelf to the Funk Island Deep. These grounds overlap extensively with various groundfish species throughout the entire range. Concerns have frequently been expressed about the level of bycatch of groundfish species, particularly cod in the catches of shrimp. Because of the use of small mesh gear, this bycatch is often comprised of small fish. In general, bycatch both in terms of weight and as a proportion of the shrimp catch have declined over the 1992-1994 period. The introduction of mandatory use of the grate in 1994 coupled with a decline in abundance of the stocks caused the reductions. Redfish still remains a significant problem in the north where the grate is not an effective excluder of small (mainly 10 to 20 cm) fish.

Discussion - P. Shelton (Rapporteur)

The introduction of the grate (mandatory in 1993) in the shrimp gear has clearly resulted in a substantial decrease since 1991 in the bycatch of cod, redfish, Greenland halibut and American plaice. While this is advantageous with respect to the potential bycatch problem in this fishery, it reduced the value of the bycatch as an index of the status of the bycatch stocks. There is now 100% observer coverage of the shrimp fishery so that unrecorded bycatches are unlikely.

14. Genetic differentiation between inshore and offshore Atlantic cod (*Gadus morhua* L.) off Newfoundland: Microsatellite DNA variation and antifreeze protein level (WP#12) - D.E. Ruzzante, C.T. Taggart, D. Cook and S.V. Goddard

Summary

Microsatellite DNA and antifreeze protein levels provide evidence that cod populations overwintering in inshore Newfoundland are genetically distinguishable from cod overwintering offshore along the shelf-break of the Grand Bank. Variation in 5 loci were compared in samples collected at various times over a period of three years from 5 inshore locations in and around Trinity Bay, Newfoundland and from an offshore region on the northern Grand Bank (North Cape). Allele sharing distances between inshore and offshore cod are significant when the comparison involves all inshore cod as well as when it is restricted to individuals which (on the basis of their blood plasma thermal hysteresis, a measure of antifreeze content) were presumed to have over-wintered inshore. Distances are not significant for the comparison involving inshore cod with near- zero thermal hysteresis and offshore cod. The genetic distance between a group of inshore cod collected while spawning and offshore cod is relatively high and significant. Sub-population structure (Rst) is detected when offshore cod are compared to inshore cod with high antifreeze level but not when compared to inshore cod with low antifreeze level and is consistent with the hypothesis that cod overwintering inshore constitute a population that is genetically distinct from the offshore cod population(s). The results suggest that inshore and offshore cod remain genetically distinct despite the fact that individuals from both populations intermingle during most of summer and fall as a result of the inshore feeding migration by offshore individuals. Our

study achieves a population description at a finer geographical scale than has been done before in this species.

Discussion - D. Schneider (Rapporteur)

The background for this paper is that up until now, large scale stocks (e. g. Greenland versus Grand Banks) can be differentiated by DNA analysis, but smaller scale sub-stocks cannot. A more sensitive analysis was undertaken by focussing on fish with known history (high or low antifreeze levels for inshore-offshore comparisons, spawning only for north-south comparisons).

The inshore-offshore differentiation is consistent with several sources of evidence: with Templeman's work (morphometrics), with observation by inshore fishermen of spring (handline) and summer (trap) fish. The principal implication of the study is that substocks exist and that these may be depleted differentially. This suggests the need for smaller scale management than the present where, for example, 2J3KL cod is considered one stock.

15. Genetic variation among NW Atlantic cod and northern cod (*Gadus morhua* L.) populations based on nuclear DNA microsatellite analysis (WP#13) - P. Bentzen, D.E. Ruzzante, C.T. Taggart and D. Cook

Summary

Microsatellite DNA variation provides evidence of subpopulation structure among cod (*Gadus morhua*) aggregations from different regions within the northern cod complex, as well as among Northern, Flemish Cap, Scotian Shelf, and Barents Sea cod populations. Analyses based on Rst and Fst estimates indicate some degree of genetic differentiation between sample populations from the northern and southern parts of northern cod complex (2J3K and 3L). Highly significant differences exist between northern cod and Scotian Shelf cod. Analysis based on Rogers' and allele sharing distances support these conclusions. In a preliminary analysis sample populations collected in the North Cape region in Winter 1992, 1993 and in June 1994 were compared and no genetic differences among these populations were found using Rst, Fst or any of the other measures of genetic distance. Northern cod samples collected in 1994 from the Hawk Channel, St. Anthony Basin, Notre Dame Channel and the North Cape were also compared. There were no detectable differences among these sample populations using Rst, Fst or Rogers genetic distance. However, the allele sharing method showed significant differences between the St. Anthony Basin and the Notre Dame Channel samples and between the St. Anthony basin and Hawk Channel sample populations.

Discussion -D. Schneider (Rapporteur)

The north-south difference in genetic structure was not detectable with Wright's F- statistic, but was with Rst, another measure of genetic structure. It was not detectable in 1994, only in 1992 and 1993. These conclusions apply to the samples (inshore from Trinity Bay only). A wider spatial range of samples is needed to extrapolate to the entire 2J3KL stock. However, it was considered that the analysis of present data should be completed before more sampling is undertaken. The reason why a north-south difference was not detected in 1994 was discussed. Explanations include (i) different time of sampling (1994 sampled in the near shore in June and

1992 and 1993 sampled more offshore and in January); (ii) a shift of fish from north to the south in 1994, and (iii) a greater degree of mixing in June 1994.

16. Why do fish stocks collapse? The example of cod in Atlantic Canada (WP#14) - R.A. Myers, J.A. Hutchings and N.J. Barrowman

Summary

In 1993, six Canadian populations of Atlantic cod had collapsed to the point where a moratorium was declared on fishing. The hypothesis that these collapses were caused by poor recruitment of cod to the fishery, i.e., high juvenile mortality was tested. The recruitment levels of those fish that would have comprised the bulk of the reproductive biomass at the time of the collapses was compared with long-term average recruitment levels for each stock. The hypothesis that recruitment prior to the collapse was anomalously low can be rejected for five of the six stocks; for the sixth, the southern Grand Bank cod, poor recruitment in the mid 1980s can be attributed to directed fishing mortality on 2- and 3-yr-old cod outside Canada's 200 mile jurisdictional limit.

There are considerable differences in the abundance trends as determined by research surveys and by Virtual Populations Analysis (VPA) for each stock. VPA-based abundances consistently depict lower recruitment levels than do survey-based estimates in recent years. More important is the observation that from the early 1980s, the VPA-based trend shows a decline where none is apparent in the survey-based trend.

The hypothesis is that the discarding of young fish increased with increased fishing mortality was tested. This can explain the significant differences that exist between survey and VPA indices of abundance. In each of the six stocks, high juvenile mortality was associated with high adult mortality, which is consistent with the hypothesis of discarding.

It was concluded that the collapse of cod off eastern Canada cannot be attributed to poor recruitment, that age-specific abundance trends estimated from research surveys and VPA should be compared for all stocks where such data exist, and that high priority should be given to the measurement of discarding levels and the extent to which catch misreporting is related to changes in fishing mortality.

Discussion - P. Pepin (Rapporteur)

It was contended that there was no evidence of collapse in the six cod stocks due to unusually low recruitment (based on RV data). The conclusion was drawn that discards were a major factor in the collapses. Participants considered that this conclusion represented a hypothesis and that data needed to be presented that show that discards were substantial.

Changes in fishing pattern by smaller boats (gill netters, long liners, draggers) may have contributed to bycatch. It was suggested that larger offshore vessels were not a major contributor to discarding. The spatial component of changes in abundance in relation to changes in pattern of fishing effort need to be resolved. There was some suggestion that the scientific data may differ from "traditional" knowledge. For comparisions to be made, traditional knowledge needs to be analyzed in quantitative manner.

17. The collapse of cod in Eastern Canada: the evidence from tagging data (WP#15)- R.A. Myers, N.J. Barrowman and J.M. Hoenig

Summary

The history of exploitation of three cod populations in Eastern Canada since 1954 was estimated from tag return data from 122 tagging experiments. It was found the there were very high rates of exploitation in the late 1980s and early 1990s; this is consistent with the hypothesis that these populations collapsed because of overfishing. The estimates are made with a new method that incorporates the data in the year of tagging which are often ignored. Results show that fishing did not occur uniformly throughout the populations in the 2J3KL regions; fishing mortality was higher in the more northern part of the management area in the late 1980s. In particular, the 3K estimates are higher than the 3L estimates. This is consistent with the observation that the fish disappeared from this region first. Estimates of higher fishing mortality north of the Grand Banks (3K) than on the northern Grand Banks (3L) in the late 1980s suggest the reduction of fish in 3K was caused by overfishing.

Thus, the results are not consistent with the hypothesis that the fish moved south in the late 1980s from the northern regions because if they had, then the fishing mortality on those fish would have been similar to those tagged in 3L. A further check on the hypothesis that cod moved south more than usual during the late 1980s and early 1990s is to examine the proportion of recoveries from cod tagged in 3K that were recovered on offshore banks to the south of the region. There were 9 tagging experiments between 1985 and 1989; a median of 3.9% of the recoveries occurred on offshore banks south of 3K (the range was 0.8% to 11. 9%). The median percentage of cod tagged in 3K between 1979 and 1984 that were recovered to the south was greater, i.e. a median of 6.9%. It was concluded that the tagging data provided no support for the southward migration hypothesis, but is consistent with the hypothesis that the cod north of 3L were eliminated by overfishing.

Discussion - G. Rose (Rapporteur)

The data that were presented are consistent with increasing F in early 1990s. However, the analyses are less revealing about potential changes in M. The interpretation regarding migration was not considered convincing by some participants.

Nominal effort data shows that 2/3 of offshore effort was in 3L - this contradicts what the tagging data says. There are some apparent contradictions between the interpretation of the tagging data and the activity of the fishery that have to be looked at more carefully.

There are mortality estimates made by Pinhorn for a period for which there are gaps in the tagging data - these estimates should be looked at and compared with those from the earlier and later tagging data.

Care should be taken in the extrapolation of results from tagging experiments in Trinity Bay to larger areas because of the indication of a resident population of cod in Trinity Bay.

The purported test of the hypothesis that cod moved southward after 1989 was considered to be

weak by some participants. The spatial interpretations of the data were questioned. The classification of 3K as the northern area was considered inappropriate by some - it is the intermediate area, 2J is the northern area. The difference in latitudes between tagging sites deemed to be from different N-S areas is trivial and of no biological significance. Hence, no difference in spatial returns should be expected (as reported in the working paper). The temporal interpretations were also questioned. For example, the temporal split in the data to compare *F*s among so-called regions is inappropriate - movement was purported to start in 1989 - but the comparisons here are drawn essentially from data up to 1990 - there are no returns from 3K after 1990.

The question was asked in what way the interpretation from the tagging data was inconsistent with the hypothesis that natural mortality was increasing over the same time period.

It has been suggested that dumping and discarding increased at the same time as fishing mortality increased - the effect that this may have on the estimation of fishing mortality from tagging data should be considered. Fishing moralities estimated from both tagging and ADAPT should be plotted for a period when discarding was thought to have occurred to see if there are differences in mortality from the two approaches that are consistent with the discarding/dumping hypothesis.

The suggestion that fishing mortality was high enough to cause the collapse in the north but not high enough to cause the collapse in 3L was considered by some participants to be inconsistent with the spatial distribution of fishing effort over the time period. In defence the authors argued that it is well known that most of the fish caught off the Avalon Peninsula originated from offshore in 3K and not from offshore in 3L (note however WP#33 which shows that this is not so).

18. Inshore exploitation of Newfoundland cod since 1948 as estimated from mark-recapture data (WP#16) - R.A. Myers and N.J. Barrowman

Summary

Tagging studies were used to estimate fishing mortality (*F*) of inshore populations of Atlantic cod around Newfoundland. New methods have been developed for this analysis that allow fishing mortalities and reporting rates to be estimated for different sectors of a fishery, e.g. inshore fixed gear and offshore trawlers. It was found that the fishing mortalities have been very high on the inshore components of the cod stocks since 1948, when the estimated fishing mortality was greater than 0.5. Since then the fishing mortality has increased, and in recent years *F* has been greater than one. There is a critical need to define inshore stocks and to institute conservation measures specific to inshore populations.

Discussion - B. Davis (Rapporteur)

The question was asked whether there was any evidence from the sixties data for an increase in mortality rate when gill nets were introduced. In response Myers stated that gill net mortality was higher inshore than offshore when they were introduced. The effort was sufficient to wipe out the whole stock.

Several questions were asked related to clarifying the method whereby fishing mortality from the different sources could be distinguished and the assumptions that had to be made to do so.

The Review noted that, while the working paper stressed that there was "a critical need to define inshore stocks and to institute conservation measures specific to inshore populations", there are efforts underway to define inshore stocks through sentinel fishery activities in NAFO Subdivision 3Ps, 3Pn4R, genetic research for the purpose of stock identification being conducted jointly by DFO in Newfoundland Region and Dalhousie University, Memorial University of Newfoundland research in Trinity Bay and expected sentinel fishery activity in other areas of NAFO Division 2J3KL.

19. An update of the stock status of Div. 2J3KL cod (WP#17) - C.A. Bishop, D. Stansbury and E. Murphy

Summary

Nominal Catch

The commercial fishery on this stock was closed in mid-1992 with only food and subsistence fisheries permitted in 1993 and 1994. This fishery was closed at the end of 1993 but was re-opened on a limited basis (10 fishing days) in 1994, during August and September. The fishery was closed again after 8 fishing days had been completed because catches were low and mostly small cod were being caught. About 1,300 t were caught by handline and jigger during the course of the fishery, mainly from 3L. A small amount was also obtained as by-catch in other fisheries.

The foreign catch in 1994 (outside the 200 mile limit on the nose of the Grand Bank) was estimated by Canadian Surveillance at about 50 t.

Catch-and weight-at-age

Catch and average-length-at age from the Canadian fishery were estimated from a total of 16,458 measured and 756 aged fish. Catches were mainly from ages 4 and 5 with age 5 predominating .

Average weights-at-age increased from the early 1970s to the early 1980s and then declined. The 1994 data suggest that average weights have increased for the dominant age group (4-6).

Research vessel survey data

Research vessel surveys have been conducted by Canada during autumn in 2J, 3K, and 3L since 1977, 1978 and 1981 respectively. Spring surveys have also been conducted in 3L for the years 1971-82 and 1985-94.

The 1994 surveys in 2J and 3K used the revised stratification schemes (Bishop,1994) which were first used in the 1993 survey. The survey was similar to those previously conducted with regard to timing, area covered and total number of sets. Set positions were selected in a similar manner to that of recent years (Gagnon, 1991).

Autumn survey estimates of biomass and abundance have shown severe declines in recent years. The 1994 values were even lower than the previously recorded lows from the 1993 surveys. Estimates from spring surveys in 3L have also declined substantially in recent years with the 1993 and 1994 being at similar but very low values.

Mean numbers per tow at age indices by division and stock area also demonstrate the severe decline in recent years as well as the virtual absence of cod older than age 7. Survey average lengths and weights at age for the dominant ages generally declined for most years from the late 1970s and early 80s to 1992. The declines were more pronounced in 2J than 3K and 3L. Although these may not be well estimated for 1993 and 1994, because of smaller sample sizes, there appear to be increases in 1993-94.

Condition Factors

A declining trend in cod condition factors (gutted weight/length^3), observed in 2J from 1989 to 1992 appears reversed in 1993-94. However the latter is based on smaller sample sizes. A similar pattern was observed for 3K although less pronounced and no trend was apparent for 3L.

Comments

The research vessel survey data would suggest that even in the absence of commercial fisheries since mid-1992 the 2J3KL cod stock has continued to decline and is currently at an extremely low level. While these surveys do not cover the inshore bays, the results for the 1994 food and subsistence fishery did not suggest that cod were particularly abundant in these areas.

The autumn bottom trawl surveys have not been considered adequate indicators of abundance for cod aged 0-2 because of the selection characteristics of the survey trawl. However large year-classes are usually present in some, albeit variable strengths, by age two. The very low 1994 survey abundances at age suggests that all recent year-classes are weak.

The most recent analytical assessment of this stock (1994) was unable to adequately determine the absolute stock size. Results from ADAPT were considered too imprecise and did not adequately represent the stock abundance. Residual patterns showed strong year effects reflecting the large interannual variation in the research vessel index. It was considered possible to describe only general trends from the analysis which suggested high total mortalities although catches were low.

This situation once again appears to be the case when the 1994 data are considered, particularly with respect to the very low survey abundance estimate. An analysis of available data in an analytical model (ADAPT) was not considered at this time as difficulties previously experienced in the determination of absolute stock biomass would remain. If the most recent survey is considered to provide an adequate estimate of stock status then such analyses might be academic.

References

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Discussion - G. Lilly (Rapporteur)

An analytical assessment was not presented. The meeting was advised that an initial attempt at using the ADAPT formulation revealed too many problems. As had been observed last year, there were strong year effects in the residuals, indicating serious violations of the basic assumptions of

the model.

The impression from the autumn survey in 2J3KL and the spring survey in 3L is that the stock size is extremely low. The biomass estimate from the autumn survey in 1994 is lower than the 1993 estimate, and continues the decline seen through the 1990s. It is important to determine if the stock has indeed continued to decline, or if we can only say that the biomass is very low, and that at such low levels we are unable to detect trend.

It was noted that there was no indication of even moderately large year-classes in the autumn survey. The Engels trawl is not efficient at catching small cod, but in the past good year-classes were obvious by age 2.

It was recommended that error bars be shown in the plots of trends in numbers and biomass over time to provide a relative index of uncertainty. There was agreement that the uncertainty needs to be estimated properly, but that an appropriate statistical method for calculating confidence intervals was not yet available. A recommendation was made for the development of a statistical procedure for calculating confidence intervals for the stratified-random surveys. It was suggested that a method could be developed relatively easily using a boot-strap technique.

There was a suggestion that the area inside the 12-mile limit be surveyed during the standard assessment surveys. It was further suggested that, if it were not possible to add more time to the survey, then some effort should be re-allocated from the offshore, possibly by reducing the number of offshore strata. In response, it was noted that (i) these are multispecies surveys, so the design should not be modified for cod to the detriment of the information provided for other species, (ii) there is a need to continue monitoring the offshore at an adequate level, (iii) much of the area inside the 12-mile limit is too rough to be trawled, (iv) in some seasons and areas there will be conflicts with fixed gear, and (v) there had been extra sets made in the bays during one of the autumn surveys a few years ago, and very few cod had been found. It was further noted that considerable effort is being directed toward modifying the surveys. Changes already adopted or being considered include (i) replacement of the Engels trawl with a Campelen trawl with rock-hopper foot gear, (ii) a new survey design, possibly to include incorporation of acoustics, and (iii) incorporation of some inshore areas to enhance the capture of small cod.

With respect to learning more about the distribution and abundance of cod in the inshore areas, it was noted that there is a proposal for a sentinel fishery in 2J, 3K and 3L to start in 1995. This fishery may start too late in 1995 for traps to be deployed.

It was brought to the attention of the meeting that a dense aggregation of large cod had recently (late April 1995) been found in Smith Sound in Trinity Bay. While such aggregations were of considerable interest, the general feeling was that one must recognize that the sounds near Random Island may be unusual habitats and not typical of the inshore area. One must be careful in extrapolating from such small areas.

There was a suggestion that additional surveys be conducted at times other than the autumn, in hopes of obtaining a better fix on changes in abundance. It was noted that there was already a spring survey in 3L. Surveys were impractical during the winter because of extensive ice cover, and the summer has been avoided because an unquantified and possibly variable portion of the cod stock has traditionally migrated inshore. It was also stated that additional surveys may not be possible given the present financial restraint.

It was asked whether there has been a decision on criteria for re-opening the fishery. It was noted

that no decisions have been made, but this was an active area of research. It was further noted that the general scheme being considered may not be adequate or sufficient if there prove to be inshore components to the northern cod stock complex. A scheme with smaller scale management units might have to be adopted if the stock structure proves to be complex and some components rebuild faster than others.

There was a request that the Gini index be calculated for 1994, to aid in interpretation of the relationship between stock size and the degree of aggregation. This information was presented in WP#38.

There was an offer to calculate the ratio of commercial catch to biomass from the bottom trawl survey, to provide a rough index of exploitation. This was presented in WP#36.

There was a request that the liver index be presented for 1993 and 1994. The liver index may be more sensitive to low feeding level than the somatic condition index. This information could not be provided before the end of the meeting.

20. Summary of the food fishery for cod in NAFO Divisions 2J, 3K, 3L and 3Ps in 1993 and 1994 (WP#18)- D.W. Kulka, R. Stead, D. Lane and L. Russell

Summary

Food Fishery in 1993 and 1994

Recreational handlining (later referred to as the food fishery) was permitted in 1993 and 1994 in 2J, 3K, 3L and 3Ps. No restrictions were placed on season or quantity of fish that could be taken in 1993. Estimates of hook and line catches by Statistics Branch. for the year was 4,838 t in 2J, 3K, 3L and 3Ps. In 1994, the food fishery was restricted to five Friday/Saturday periods in August and September. Both the landings and the estimates from this study suggest a catch between 1,000 and 1,500 t for 1994.

In both years, size of fish was similar within bays over time. However, differences in average size was observed among bays. Only Notre Dame Bay, Trinity Bay and Southern Shore were sampled in 1993 and detailed comparisons were possible only for 1994. Fish were smaller on average to the north (as far south as Conception Bay), averaging between 42 and 46 cm, mainly 4 to 6 year olds. For the Southern Shore and south (and including Trinity Bay), the fish averaged between 50 and 54 cm. Size range also increased from north to south, such that very large fish were taken only in St. Mary's Bay (St. Shott's), Placentia Bay and Fortune Bay. It was generally noted that the fish in 1994 were of average condition as opposed to the "slinks" (thin fish) noted in certain areas in 1993.

General patterns of catch rates (1994) were similar for the four weekly periods and showed no trend among bays. Catches ranged between 1.5 and 2.5 fish per hour. The best catch rates came from Bonavista Bay and Placentia Bay, and were poorest in Conception Bay especially on the south side of the bay. This confirmed anecdotal reports of low catch rates from that area.

Discussion - J. Morgan (Rapporteur)

The food fishery in 1994 was sampled extensively but there were some differences from area to area, mainly as a result of logistics. The data provided the only "commercial" age sample available. However, there is no time series of CPUE, so the information can not be used as an index of stock status. Some anecdotal reports from the fishery were not born out by the data. For example, there were reports that catch rates were lower in the north but this was not the case.

There is no food fishery planned for 1995. A sentinel fishery will provide some of the information that would come from sampling a food fishery. However, the cost will be higher and the samples may be less random. The catch from the sentinel fishery should be much less than from the food fishery and given the apparently very low stock levels caution is advisable.

21. Nearshore distributions and abundance of juvenile Atlantic cod (*Gadus morhua*) at two sites in coastal waters of Newfoundland (WP#19) - J. Anderson and E. Dalley

Summary

Results from this study demonstrate that 0-group and 1-group juvenile cod remained relatively abundant out to depths of 40 m, which occurred approximately 2-3 km from shore. The higher abundances of 2-group and 3-group cod observed at deeper depths at the Bellevue Site, and the virtual absence of these older cod at the Kelligrews Site, suggests there is a definite spatial separation among younger (0-group and 1-group) and older (2-group and 3-group) juvenile cod within relatively small spatial scales. At the Bellevue Site this cross-shore separation occurred within a 7 km range.

The shallowest tow location at the Bellevue Site was 8 m depth and approximately 700 m from the beach. At the Kelligrews Site the shallowest depth sampled was 20 m although this occurred within 1,000 m from the shore. While higher abundances may have occurred shoreward of these trawl locations, it is clear that 0-group cod were abundant at deeper depths away from shore. These observations suggest that cod sampled by beach seines in the very nearshore probably represent the edge of a much greater distribution which extends into deeper water.

It is noteworthy that the mean abundance of 0-group cod sampled at the shallowest location at the Kelligrews Site was approximately 30 cod/tow, whereas at the shallow locations at the Bellevue Site highest mean abundances ranged around 4 cod/tow. This significant difference suggests that the abundance distribution of 0-group cod may be more dependent on different bottom habitats than simply water depth and distance from shore. This observation is supported by the abundance distribution of 1-group cod at the Bellevue Site, which oscillated between high and low moving away from shore into deeper depths.

Discussion - E. Murphy (Rapporteur)

Discussion on this paper was focused on the issue of significant differences in catches made during the day and night. Patches of 1 and 2 year old cod were observed while calibrating acoustic equipment at Bay Bulls. During the day these fish were up in the water column and this may explain the low catches in tows during the day.

Questions were also raised as to the presence of larger cod in the survey area. It was felt that if the bottom type at Bellevue or Kelligrews was cobble then the juvenile cod may have been avoiding the trawl by hiding amongst it. It was pointed out that during demersal juvenile trips large catches of small cod are often associated with catches of seaweed.

22. Distribution and recruitment of demersal juvenile cod (0, 1, and 2 group) in the Coastal Zone, NAFO Divisions 3K and 3L (WP#20) - D.C. Schneider, D.A. Methven and D. Ings

Summary

Research carried out under the Northern Cod Science Program (Methven, unpublished) showed that 0-group and 1-group cod currently (1992 onward) concentrate in coastal areas, with highest densities at depths of 4-7 m. Lower densities occurred at greater depths. 0-group cod are also concentrated in time, arriving in coastal nursery areas as distinct and predictable pulses in April-June, mid-August, mid-October, and possibly late December- January. Surveys were made during the October recruitment pulse at depths with maximum density by setting seines at 10-20 metres then hauling them shoreward. Data from the 1959- 1964 and 1992-1994 coastal surveys were used to investigate whether a recruitment signal could be detected. A recruitment signal from one year to the next, on a ratio scale, was detectable when two successive years were used. It was of interest to investigate whether the sensitivity of the analysis could be increased by restricting the analysis to frequently visited sites, thus reducing effects of spatial variability. Re-analysis of the data collected by Alistair Fleming showed that a recruitment signal was more readily detected with a small number of consistently positioned hauls than with a larger number of hauls that varied in location. Based on these sites, the density of LG0, LG1, and LG2 fish per seine haul in 1994 was greater than in 1992 and 1993. The changes in catch per unit area (ca. 16 m by 50 m) observed from 1992-1994 in the coastal zone were similar to changes in catch per unit effort from surveys covering all of the shelf area in 3K and 3L. The predicted density of LG1 cod for 1995 is 1.5 times that of 1994. The predicted density of LG2 cod for 1995 is 1.6 times that of 1994. The recruitment signal from coastal juveniles did not carry through to the entire stock in the 1960s, a situation that cannot be extrapolated to currently low stock conditions. The 1992 and 1993 year classes at ages 0 and 1 were confined almost entirely to coastal waters (Dalley and Anderson, NCSP symposium). Coastal nursery areas are at present the only known source of demersal stage recruits to adult cod stocks. Because 0-group juveniles are now confined to coastal habitats, we expect that the recruitment signal currently evident in the coastal surveys will carry over to the entire stock, regardless of whether this signal carried through to the stock in the past.

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Discussion - K. Smedbol (Rapporteur)

The main discussion of the paper centred upon the comparison of absolute abundances between the Fleming surveys in the late 1950s and early 1960s to the Schneider-Methven surveys in the 1990s. It was suggested that the relative stability of the means and variances of abundances was indicative of a saturated habitat, leading to the conclusion that juvenile abundance calculated from beach seining may be an insensitive index of recruitment. However, as outlined in WP#35 and 36, the average abundance was found to be significantly different between the early and recent surveys.

Also of concern was the possible influence of the exceptionally large catches of the 1959 sampling year may have made on the above comparison. It was noted, however, that this year-class continued to show relatively high numbers in subsequent years (as 1 and 2 groups). Also, the use of a non-normal error structure (gamma distribution) in the analysis would serve to lessen the weight of large abundance values.

The question was raised of whether the sampling sites represent good habitat. It was determined that the habitat quality would not affect the predictive power of the model derived, since any quality effects would be constant throughout the survey. It was necessary to aggregate the data to a larger scale (bay) to overcome noise around the recruitment signal.

23. Did the feeding level of the cod off southern Labrador and eastern Newfoundland decline in the 1990s? (WP#21) - G.R. Lilly.

Summary

Capelin has been the major prey of cod on the continental shelf off southern Labrador and eastern Newfoundland (2J, 3K, and 3L) during the autumn of most years since 1978. Since the early 1990s the capelin in 2J3K have shifted their late autumn distribution from the north and west of the area to the south and east (Lilly 1994). The few cod remaining in 2J at the time of the surveys in 1991 and 1992 had little or no capelin in their stomachs, resulting in a substantial decline in the average quantity of food in the stomachs (Taggart et al. 1994). In contrast, cod in 3K and 3L did not experience a sharp decline in stomach fullness.

In 1993, the geographic patterns in cod catch and feeding by cod on capelin were similar to patterns seen in 1992 (Lilly 1994), and the average quantity of food in the stomachs of cod caught

in each division also was similar to that found in 1992. In 1994, no capelin were found in stomachs of cod from 2J and the quantity of capelin in stomachs of cod in 3K declined considerably below levels in recent years. Little change was observed in 3L.

The average fullness indices by Division must be considered preliminary, because there has not yet been an adjustment for the observation that individual fish taken from large catches tend to have less food in their stomachs than individuals taken from small catches. There is also a concern about declining sample size. The number of stomachs examined in 1994 was very small.

References

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Discussion - C. Taggart (Rapporteur)

Consideration was given to the inferences that could be drawn from this study concerning capelin other than the implications regarding the movement distribution of capelin. It was suggested by the author that the focus of the work was on cod and what cod do and have done with respect to feeding on capelin among the 2J3KL regions. It was noted that some better statistical techniques for analysis of the apparent changes is feeding among the regions would be necessary to draw firm conclusions and it would be difficult due to the influences of interaction in the migration of cod and capelin. Capelin become important in the diet of cod when cod reach 35 cm, corresponding to ages 3-4 depending on region as growth rates vary among regions.

24. Is the first overwintering period a time of strong environmental selection for the more cold-tolerant Atlantic cod (*Gadus morhua*) within a year class? (WP#22) - S.V. Goddard, M.H. Kao and G.L. Fletcher

Summary

Atlantic cod produce antifreeze proteins in winter as a protection against low temperature damage. Under the same environmental conditions, 1+ cod produce higher mean levels of antifreeze than 0+ cod. This may be because the first winter, spent inshore in nursery areas, is a time of natural selection for more cold-tolerant individuals, or there is an increase in the ability to produce antifreeze between the first and second winters of life, possibly triggered by spending the first winter in very cold coastal Newfoundland waters. The working paper concludes that it is the latter explanation is the correct one.

Discussion - J. Morgan (Rapporteur)

There appears to be no selection on 0-group cod for individuals with high antifreeze protein levels, yet the increase in antifreeze production by 1 year olds remains. There appears to be fairly high overlap in habitat between the two age groups, which would indicate that 1 year olds do not occupy a habitat that requires more antifreeze. It is possible that exposure to their first winter "primes" the production of antifreeze, resulting in higher levels the next year.

25. Notes on shoal densities and movements of cod on the northeast Newfoundland shelf, 1983-1993 (WP#23) - G.A. Rose

Summary

Several lines of evidence from DFO surveys and the commercial fisheries suggest that northern cod shifted seaward and southward from 2J to 3Kand 3L after 1989, and may have become compacted in the southern range near the 3K-3L border. Acoustic and tagging data from the springs of 1983-1993 were examined to explore this hypothesis. Mean annual catch rates from tagging sets ranged from 200-1000 kg and did not differ from 1983 to 1989. However, in 1990, mean catch rates quadrupled and remained significantly above historic averages through 1991 and 1992. In 1993 sets made in a similar fashion (although not for tagging) had the lowest catch rates of the series. In 1994 even lower catch rates were experienced in this region. Numbers of cod caught showed a similar trend, but remained relatively higher in 1991 and 1992 as a consequence of the smaller size of the fish.

Mean acoustic densities showed a similar pattern to the catch rates of the tagging sets with respect to the increases after 1989, but the magnitude of the increase was even greater (an order of magnitude). Also, densities were higher from 1983-1985 than during the years 1986-1989.

These data support the compaction hypothesis. The effects of such compaction on vulnerability to the fisheries (q and F) is under study. A similar but less intense compaction appears to have taken place from 1983-1985. A central question is what happened to the fish present at high densities in 1992 (after imposition of the moratorium)? They were virtually all gone from the Bonavista area in 1993. In the spring and fall of 1992 most all fish located by DFO surveys were at the offshore margins of the Bonavista corridor (3K-3L border). In the winter of 1993 a concentration of cod (abundance not known) was located outside the 200 mile limit on the western edge of the Sackville Spur. In the spring of 1993 a dense aggregation of mostly adult cod (acoustic estimate 20,000 t) was located about 25 n. miles from the winter location and 20 n. miles outside the 200 mile limit. By 1994, the spring survey found no adult cod and few juveniles outside the 200 mile limit. These data provide evidence, albeit circumstantial, that the southeastward movement of cod first evident in 1989 stalled in the Bonavista area from 1990-1992, then continued along the north Cape of the Grand Bank in late 1992. Whatever their fate these fish could not be located in 1994 in this area. It is also possible that some of the fish last encountered migrating shoreward in 1992 stayed inshore and did not return on the typical offshore migration in the fall of 1992.

Discussion - E. Dalley (Rapporteur)

In support of the 'compaction hypothesis' it was pointed out that the shifts in distribution described in the working paper are supported by the commercial catch data. However, there are differences

with respect to patterns observed in the survey data. Caution was expressed regarding interpretations about cod distribution and catch rates from sets made for tagging purposes because of the specific objectives of these trips. For example, scientists may have preferred to set on small concentrations to get healthier fish for tagging. The suggestion was made that these data be spatially integrated if possible and compared in a summary table with the groundfish bottom trawl survey data.

26. An acoustic survey of cod in parts of NAFO Divisions 2J3KL in June 1994 (WP#24) - G.A. Rose

Summary

An acoustic survey approach was used to search for and map distributions and abundance of cod in selected areas of 2J, 3K, and 3L during June 1994 (areas based on temperature and salinity distribution relationships established in previous years). The objective was to study population structure by locating aggregations of juvenile and adult cod from the Grand Banks to Hamilton Bank, to map their distribution and abundance, and to take common samples to test differences in size, age, meristics, genetics, growth, and physiological characteristics (under the IFRP research program).

A total of approximately 3,000 n. miles of transects were run from Latitude 46° N to 54° N using scientific echosounders (38 kHz). Six areas were searched using systematic grids: (i) Nose and North Cape of Grand Bank (E 3L); (ii) Western edge of Flemish Cap; (iii) Bonavista Basin (3KL border); (iv) Notre Dame Channel (SW 3K); (v) St. Anthony Basin (N 3K); and (vi) Hawke Channel (S 2J). All acoustic interpretations were supported by trawl sampling. Integration scaling was based on a TS model. A total of 38 fishing sets were made as directed by the acoustic record with the Campelen 1800 ground trawl and Diamond IX mid-water trawl.

Results were as follows:

(i) no cod were located on the Nose of the Grand Bank or on the western Flemish Cap;

(ii) a low density concentration of primarily juvenile and some adult fish (ca. 3,000 t) was located along the north Cape of the Grand Bank in a narrow band along 90 n. miles at depths between 400 and 500 m (water temperatures 2.5-3.8 °C). Hereafter called Block 4.

(iii) no cod were located in the Bonavista Basin;

(iv) a low density concentration of juvenile cod was located in the Notre Dame Channel at depths between 400 and 450 m (ca. 2,000 t) (water temperatures 2.5-3.5 °C). Hereafter called Block 3.

(v) a small and low density concentration of juvenile cod was located in the St. Anthony Basin at depths between 400 and 500 m (ca. 1000 t) (water temperatures 2.5-3.5 °C). Hereafter called Block 2.

(vi) a large but low density aggregation of juvenile and adult cod (ca. 10,000 t) was located in the Hawke Channel at depths ranging from 380-525 m (2-3 °C). Hereafter called Block 1.

Cod catches were very low and ranged from 0 to 300 fish per half hour tow. No high density

aggregations of adults were located(the first such instance since 1990). Most of the higher catches were in Block 1, as were most larger and older fish. For example, in Blocks 2,3,and 4 <15% of fish were >4 years of age. In contrast, in Block 1 almost 50% were >4 years of age.

Overall abundance levels were the lowest encountered since 1990 when this research began. Using a strip survey approach and the assumption that densities measured represent those on average in a 10 n. mile swath centred on the transect, the mean estimate of the number of cod observed was 40 million and the biomass 16K t.

The age structure of the stock has been severely truncated since 1990 and 1991. In 1993, the southerly Block 4 held the most adult fish encountered (mostly outside the 200 mile limit) and fish ages >5 years were common. By 1994, almost all fish encountered were of ages 3 and 4. What happened to the fish present in 1993? They must have either moved from the area or died of natural or fishery-related causes (the majority of these fish were beyond the 200 mile limit).

Another question is the origin of northerly block 1 fish. 1994 was the only year this spring work has been done off Labrador and the fall trawl survey has detected almost no cod in this region in the past few year (1994 estimate of <1 t). One possibility is that the Block 1 fish came from the south and represent part of the fish surveyed in the southern blocks in 1993 but absent in 1994. Consistent with this idea, southern fish age structures are inconsistent from 1993 to 1994, but the southern ages predict the northern age structures quite well in 1994.

Discussion - E. Dalley (Rapporteur)

It was noted that the observation of older fish being north may be consistent with observations from the pelagic 0–group survey in 1994 which indicated a more northern distribution than 1992–3. However, it was also noted that there were no acoustic observations in 2J in previous years for comparison.

It was suggested that other information may be available to substantiate observations of cod concentrations during the period. There were some FPI trawlers 3–4 weeks after the survey in the area on their way north to fish for shrimp, but it is unknown what they observed.

The question was asked whether Arctic cod or capelin acoustic signatures are different from that of cod. In reply it was stated that the signal looks different and that the acoustic observations were groundtruthed with fishing sets.

More details were requested on the way in which the condition factors were calculated. It was noted that the fish in 2J which had a higher condition factor were almost exclusively feeding on shrimp.

There was a discussion on evaluation of biomass from the 1994 survey and comparison with other years in terms of block size, shoal size, density and criteria used to define edge of shoals. The author expressed reluctance to produce biomass estimates because they were open to so much objection, but noted that no matter which way you cut it the estimate for 1994 was orders of magnitude less than 1993.

The question was asked whether differences noted in density could reflect differences in concentration on the bottom. This was acknowledged, although in the Hawke Channel area observations were made on fish off the bottom.

It was noted that in earlier years of the June acoustic work there was a perception of large discrepancies between it and the fall groundfish bottom trawl survey. This "perception of discrepancy" does not exist for the most recent survey. It was also questioned if distance off bottom was considered. It was, but densities were relatively low off bottom, and were comprised mostly of juvenile fish. It was acknowledged that the present design for the summer surveys may target juvenile areas as opposed to that occupied historically by larger fish on the Hamilton Bank.

27. Alternative models of maturity at age applied to cod in NAFO Divisions 2J3KL (WP#25) - M.J. Morgan and P.A. Shelton

Summary

This paper examined five models of time series of maturity at age. The models were constant maturity at age, a year effect, a cohort effect, a year*age interaction and a cohort*age interaction. Each model contained a season effect and was applied to data for female cod in 2J3KL from 1971 to 1993. The residuals of all models had similar patterns but were much larger for the constant maturity at age model than for the others. The estimates of maturity at age over the time series were very similar for the year effect, cohort effect, year*age interaction and cohort*age interaction. The best model to use will probably depend on the objectives of the study. The year effect model was chosen and applied to the data for female and male maturity at age and size from 1971 to fall 1994. Both males and females show increasing proportions mature at age and size since about 1991. The age and size at 50% maturity for both sexes are currently the lowest in the time series. The current estimate of age at 50% maturity for females is 4.9 and for males 3.6 years. The current estimate for length at 50% maturity is 42.5 cm for females and 33.4 cm for males.

Discussion - G. Mertz (Rapporteur)

It was remarked that the excess depletion of the 2J fish could bias the results, since age at maturity varies with latitude. In response it was pointed out that the same trends were evident in all divisions when disaggregated analyses were carried out.

The Chair of the FRCC pointed out that fishers are concerned that earlier age at maturity for many stocks may be indicative of stress on the fish. In response, the example of North Sea plaice was cited, for which it has been surmised that earlier maturity stems from faster growth engendered by weaker density dependence at the prevailing low stock sizes. Alternatively, life history theory predicts that high adult mortality will favour earlier maturity. A number of scientists remarked on the possibility that cropping of the older fish through size selective fishing mortality was creating the appearance of earlier maturity in the northern cod stock. It was proposed that a simulation study be performed to examine this.

Concern was expressed that the earlier maturity of northern cod may persist despite reduced fishing pressure, and that this might lead to a reduction of egg quality and poorer recruitment. However it was noted that an eventual return to the historical norm is a reasonable expectation, although the duration required is not known.

28. Analysis of replacement in eight Northwest Atlantic cod stocks (WP#26) - P.A. Shelton

Summary

The relationship between ADAPT estimates of recruitment and the amount required for replacement was been examined for three of the northwest Atlantic cod stocks in previous studies by the author and co-workers. In this paper these studies are extended to eight stocks. Comparison among stocks shows that in six cases recruitment fell below replacement and remained below at approximately the same time (early 1980s). In five of the stocks recruitment fell to a level close to or below replacement calculated at zero fishing mortality. With the exception of the southernmost two stocks, all stocks showed generally increasing replacement per spawner from 1980 throughout the remainder of the 1980s as a result of decreasing weights-at-age. In several of the stocks there is a levelling off or dip in the replacement per spawner in the early 1990s as a result of a slight increase in the weights-at-age (and in 2J3KL and 3NO, proportion mature-at-age). The effect of changes in weights-at-age can most easily recognized in plots of spawner biomass per recruit (SPR). SPR peaks around 1980 is a factor of about 2 or 3 higher than the subsequent trough in the 2J3KL, 3Pn4RS, 4TVn and 4VsW stocks.

The conclusion is drawn that, within the context of the ADAPT assessment results, deceases in recruitment and growth occurring in at least four of the eight stocks over the 1980s played a major role in the decline of these stocks. It is suggested that these changes are not a direct consequence of fishing mortality in the context of the ADAPT recreation of the population dynamics of these stocks.

Discussion - B. Atkinson (Rapporteur)

It was suggested that the working paper completely disregards the recent findings that there has been an increase in discarding and dumping concomitant with the increase in fishing mortality that invalidates any interpretations of recruitment from ADAPT estimates for many of these stocks. It was noted, however, that the plots of replacement per spawner biomass and spawner biomass per recruit do not depend on ADAPT estimates, but only on weight at age, maturity at age and natural mortality. It was argued that it can be demonstrated that the decline in weights at age is a consequence of increasing fishing mortality rather than a decrease in growth rate as a result of environmental changes such as temperature.

29. Initial simulation trials for achieving conservation and sustainable use objectives for the northern cod stock (WP#27) - P.A. Shelton

Summary

Conservation and sustainable utilization are two sides of the same problem, but reflect different emphases, and may require different measures of performance. If thresholds relating to conservation and targets relating to sustainable utilization can be defined, then alternative comprise management solutions (some probability of falling below threshold allowed in order to attain target a reasonable proportion of the time) can be evaluated. Although quantifiable management objectives from which targets and thresholds can be developed are not yet available to fisheries scientists for the 2J3KL cod stock, a variety of alternative assessment/management procedures can

be evaluated across a variety of performance statistics that potentially relate to the objectives, by carrying out simulation trials.

Preliminary simulation trials involving resampling of biological data without measurement error on stock size are reported. These trials include procedures based on constant fishing mortality, as well as procedures incorporating thresholds. It is suggested that the advantages of procedures incorporating thresholds over constant fishing mortality procedures may not be apparent once measurement error is accounted for.

Discussion - B. Atkinson (Rapporteur)

Interest was expressed in the results and further work in this direction is obviously required, however, caution must be exercised in estimates of future stock size based on resampling past values of recruitment given that the spawner stock is now at unprecedented low levels.

30. Objectives of Canada's surveillance and enforcement program in the NAFO regulatory area (WP#28) - Ben Whelan

Summary

A substantial data base (SEAFIN) of 8,000 log books containing 20,000 records by nation, division and species are maintained by Surveillance in the Newfoundland Region. Observers obtain daily catch rate per species from logbooks. For periods not covered by observers sighting information from aircraft over-flights are used to estimate fishing days by vessel.

In the last few years Canada and the EU combined have inspected close to 70% of all effort. Approximately 240 vessels fish in the NAFO regulatory area during the year with an average of 100 days per vessel. Vessels change position once every 14 days depending on the catch rates. Air surveillance is carried out every day if not twice every day so that vessels are sighted every 3 or 4 days. The change in position of vessels is tracked on a daily basis. Between 80-90% of vessels are inspected at least once during the year. A model is used to estimate annual catch from the surveillance data. Over the last few years the estimate for foreign vessels is about 250,000 t of various groundfish species caught annually. The reliability of the model estimates is directly related to the amount of verified logbook data obtained from the vessel and the number of flights between inspections. Based on historic data it is evident that there is a minimum amount of information required to verify catches. If less than 30% of the catch is inspected then model is not as reliable. The inspection level has been at 50% to 60% in most years. Further, at least one aerial sighting every 7 day period is required. Recent intensification of efforts by Surveillance as a consequence of the "turbot war" has resulted in 3 to 4 flights a day so that each vessel is sighted once a day. Given remaining uncertainties, model estimates of foreign catch are acknowledged to be under-estimates rather than over-estimates. The estimate of the foreign catch of northern cod within the 2J3KL area in 1994 is only 50 t.

Discussion - P. Shelton (Rapporteur)

The problem of misreporting was discussed. This will effect the accuracy of the model estimates. Surveillance has procedures for estimating the amount of misreporting that is taking place on a

monthly basis, so this is partly corrected for in the estimates.

The question was raised regarding undetected fishing at night. This is not considered to be a problem because there are regular night-time surveillance flights.

The suggestion was made that product logs may provide useful information on foreign landings. Surveillance gets quarterly reports from the EU which includes production figures and this is taken into account in adjusting the on-board estimates.

31. The population growth rate of Atlantic cod (*Gadus morhua*) at low abundance (WP#29) - R.A. Myers, G Mertz and P.S. Fowlow

Summary

The population to population variability of intrinsic rate of natural increase, *r*, was examined for Atlantic cod. The intrinsic rate of increase is positively related to temperature, contrary to the expectation that *r* might decrease as the high and low temperature limits of habitability for cod are approached. For the parameter regime considered, *r* has a simple dependence on age at maturity and the number of replacements each spawner can produce at low population densities. It is shown that number of replacements each spawner can produce at low population densities is not temperature dependent, and thus the covariation of *r* and temperature arises from the influence of temperature on age at maturity. It was demonstrated that the estimates of the intrinsic rate of increase are robust and thus may be of use in estimating the recovery time of depleted stocks.

The most important practical implications of this paper is that it is almost impossible to eliminate a cod populations without high mortality on the juveniles.

Discussion - D. Stansbury (Rapporteur)

It was pointed out that the consumption by seals is between 70 - 80,000 t for age 1 and 2 cod and discards are relatively insignificant in comparison to this. It was suggested that it is important to analyse what actual discard data are available. For example, good information is available on discards in the Davis Strait shrimp fishery. Also there are data on the 3M shrimp fishery which has a problem with 1-3 year old redfish.

To emphasise the importance of by-catch and discarding, it was pointed out that the Kattegat cod crashed not because of a cod fishery but because of high mortality on 1 and 2 year old cod as a by-catch in the Nephrops fishery.

32. Distribution and abundance of demersal juvenile cod (*Gadus morhua*) in inshore and offshore areas of northeast Newfoundland, the northeast Newfoundland shelf and the northern Grand Bank in the early 1990s (WP#30) - E.L. Dalley and J.T. Anderson.

Summary

Surveys were carried out using the Campelen 1800 survey trawl during December 1992, December 1993 – January 1994, and December 1994 – January 1995 to examine inshore and offshore distribution and abundance of demersal juvenile cod in 3KL. Juveniles (all sizes combined <391 mm.) were found to be widely distributed in inshore and offshore areas. Length groups were used to approximate age groups such that age 0 < 116 mm., age 1 = 116 – 195 mm., age 2 = 196 – 290 mm., and age 3 > 290 mm. There was an ontogenetic pattern in distribution whereby age 0 fish were restricted to the inshore, age 1 fish extended further onto shelf areas, and larger juveniles were widely distributed on the shelf. Relatively high catch rates of age 1, 2, and 3 were maintained in the inshore, particularly Trinity and Conception Bays, even though distribution of these age groups extended further onto the shelf. There was a significant negative correlation between catch rate of age 0s and 1s and mean depth of tow, and a significant positive correlation between age 3s and temperature in all three years. Distribution of age 0 juveniles appears more restricted than historic distributions when they were also found, albeit in relatively low numbers, in offshore portions of the survey area. Distribution of older juveniles was similar to that observed historically.

Ranking of mean catch rates of age groups over the three years indicates that 1991 has been the weakest year–class since 1989 and that there has been an increase in spawning success each year since 1991. The 1994 year class has been measured only as age 0s, and although increased catch rate was not pervasive throughout the survey area overall catch rate increased nearly 7x and was statistically higher (P=0.02) than that of 1992. The 1994 year class was ~3x that of 1993 measured as age 0s (not statistically different). Other statistical differences include: the 89 YC > 90 YC (P=0.05) and the 91 YC (P=0.0002) measured as age 3s. Measured as age 2s in the inshore, 90 YC > 91 YC (P=0.006) and 92 YC >91 YC (P=0.04). The 90 YC > 91 YC (P=0.003) measured as age 3s in the offshore.

Discussion - W. Brodie (Rapporteur)

A useful approach to analyzing data from the juvenile cod trawl surveys may be to stratify the cod catches by depth and temperature, allowing estimates of abundance to be obtained by areal expansion (contouring, STRAP, etc.). It was noted that the line transect design precluded the use of STRAP with the current data, but that the stratification approach was worth investigating. Estimates from these analyses could then be compared against the estimates of seal predation on juvenile cod.

33. Catch rates of juvenile cod (*Gadus morhua*) from Japanese pelagic traps at inshore northeast Newfoundland sites 1992-1994 (WP#31) - E.L. Dalley, E.G. Dawe and D.E. Stansbury

Summary

During 1992–94 small meshed Japanese pelagic traps were fished from ~ May 15 to early November to examine catch rates of juvenile Atlantic cod at inshore locations along Newfoundland's Northeast coast. In 1992–93 sites were maintained in (i)Holyrood, Conception Bay (3L), (ii) Bellevue, Trinity Bay (3L), (iii) Herring Neck, Notre Dame Bay (3K), and (iv) St. Lunaire near the northern tip of insular Newfoundland (3K). In 1994 the project was reduced to two sites, one in 3K (Herring Neck) and one in 3L (Holyrood). Daily catch rates varied considerably at all sites in all years and peaks in abundance were sometimes associated with sharp drops in temperature and often occurred synchronously between sites. Monthly means indicated a single peak in catch rate at Holyrood and Bellevue, the two most southerly sites, in July–August and two peaks at Herring Neck in 1992 and 1993. At St. Lunaire catch rates were relatively low in 1992 and substantially higher in 1993 as a result of relatively high catch rates early in the season.

By the end of the sampling period catch rates were low at all sites. Highest mean catch rates of all sites were recorded in Bellevue in both 1992 and 1993. Overall mean catch rate (4 sites combined) was 20% higher in 1993 than 1992, largely as a result of increased catch rate at St. Lunaire. Mean catch of the two sites sampled in 1994 indicated a trend of decreasing catch rate at the site in 3K and an increasing one at the site in 3L from 1992–94, consistent with a southerly shift in the juvenile population as observed in the adults.

Age frequency distributions (all months combined) from the four sites in 1992 and 1993 indicated a decrease in the proportion of younger fish (age 1 and 2) and an increase in the proportion of older fish (age 3 and 4) from south to north. This supports a longshore northerly migration of juveniles as they become older. Age frequencies by month, and length frequency distributions plotted weekly and standardized by weekly catch rate indicate high variability in population structure as the season (May/June to November) progressed, supportive of a highly mobile coastal population of juveniles.

34. Dynamics of spawning and survival of northern cod (NAFO 2J3KL as measured by pelagic juvenile cod surveys during the period of stock collapse, 1991-1994 (WP#32) - J.T. Anderson and E.L. Dalley.

Summary

Pelagic juvenile cod measured by trawl surveys in the late summer and early fall demonstrated significant variations in geographical distributions, abundance, spawning period and growth from 1991-1994. In general, there was an expanding distribution during these four years. In 1991 cod were located at only a few locations within the inshore areas whereas in 1992-1994 cod were observed abundantly throughout the inshore areas. Sampling effort offshore varied among years making direct comparisons among years difficult. Generally, few cod occurred in the offshore areas sampled over the southern Northeast Newfoundland Shelf and northern Grand Bank in 1991-1993. In 1994 cod were observed abundantly offshore on the Northeast Newfoundland Shelf. Very few cod were observed on the northern Grand Bank in 1994 whereas a distinct

concentration was observed over the southern Grand Bank. Year-class strength in 1991 appeared to be very low while in 1994 it appeared to be relatively large. Mean cod abundances (10,000m^{-3}) were significantly greater ($P<0.01$) in 1994 in both inshore and offshore areas compared to the earlier years. Mean abundance in 1992 was significantly greater inshore than 1993 ($P<0.01$), whereas offshore there was no significant difference. Overall, year–class strength is estimated to be 1991 < 1993 <= 1992 < 1994. Successful spawning (eggs and larvae that survived to become pelagic juveniles) occurred relatively late in 1992 and 1993, with hatching occurring primarily in July and August. In 1994 spawning occurred much earlier with hatching occurring primarily in June. There was no late spawning in 1994, as there was in 1992 and 1993. The earlier spawning can be qualitatively linked to less severe ice conditions and warmer water temperatures in 1994. Growth rates were statistically greater in 1992 and 1993 (0.65 mm d^{-1}) than in 1994 (0.48 mm d^{-1}) ($P<0.015$).

Discussion - S. Goddard (Rapporteur)

Results of the surveys from 1991-1994 suggested that while the pelagic juveniles sampled in 1992 and 1993 appear to have hatched predominantly in July and August, hatching in 1994 occurred significantly earlier - from mid-May to July 1st. Thus, in 1994 there must have been successful spawning earlier in the year throughout the range (inshore and offshore). It was suggested that this could have been due to the early retreat of ice cover in 1994. Since the area under investigation was free of ice some time in April allowing earlier warming of the surface waters than in previous more icy years, this could have had an effect on the timing of spawning. It was noted that the suggested April spawning in 1994 was consistent with historical spawning times for the Hamilton, Belle Isle and Funk Island Banks. 1989 was described as a good year and it was noted that the data presented for 1994 were quite consistent with findings for 1989. It was agreed that both these years (1989 and 1994) could be better described as approaching the long term mean rather than particularly good years.

By comparison with the previous years under discussion, the 1994 sampling showed higher numbers of pelagic juveniles, larger at the time of sampling and widely distributed throughout the sampling range - all suggestive of good year-class strength. However, it was pointed out that in the survey for demersal juveniles carried out in December 1994 - Jan 1995, all 0 group fish were found inshore. This was true even though the demersal survey was carried out over areas of high pelagic abundance offshore. Several suggestions were made that might explain the lack of 0-group cod offshore. Due to the timing of the surveys, the offshore pelagics might have drifted elsewhere, or actively migrated inshore. Offshore, they might still be up in the water column and therefore not caught at the time of the demersal survey. Alternatively, they might have been eaten by predators, however there was no evidence from stomach contents to suggest this, and also the time frame was considered rather short for this to be the case. They might be settling in very deep unsurveyed waters offshore. The pelagic juveniles were found over a range of depths including depths > 200 - 400m, while demersal 0-group cod are usually only found in waters less than 200m in depth. The survey gear is not capable of surveying at great depths, and could be missing the demersal 0-group juveniles. However, it was thought highly unlikely that the pelagics had all settled in very deep waters.

It was concluded that the explanation for the missing 0-group cod cannot yet be provided, but that surveys in 1995 will show whether the 0-group were actually offshore but were somehow missed by the demersal survey, or if the inshore sites are the true, prime nursery grounds and that all successful 0-group cod either drift or actively move to these inshore sites as soon as they are able.

Finally, it was agreed that results from three surveys - beach seine (Fleming type,WP#20), pelagic and demersal surveys - all gave similar results of year class strength for years sampled in the 1990s, and that a table could be drawn up to facilitate comparisons between these three surveys.

35. Tagging recapture of cod by tagging area and NAFO Division (WP#33) - C.A. Bishop

Summary

A summary of cod tagging and general recovery locations (by division) was presented for tagging experiments in 2K3KL and 3Ps over the period 1978-90. The main focus pertained to return data for cod tagged in northern 3L. Recapture data indicated that the majority were recorded in 3L (see discussion following WP#15).

36. Exploitation rate for northern cod from catch over RV biomass ratios (WP#34) - W. Brodie

Summary

An examination of reported catch from the commercial fishery in year n dividedby the trawlable biomass estimate from the fall RV survey in 2J3KL in year n-1 showed a continuous decline in this ratio since 1988. This is not consistent with the hypothesis that fishing mortality increased substantially in the late 1980s and early 1990s.

37. Multiplicative model of beach seine data (WP#35); Analysis of the contrast between years in the beach seine data on prerecruits (WP#36) - R.A. Myers

Summary

A multiplicative analysis of the Fleming survey data for ages 1, 2 and 3 from WP#20 was carried out. The cohort effect was very significant no matter how the analysis was carried out. This indicates that the survey can be used to reliably detect relative strengths of cohorts at least in the inshore. The estimated estimation error variance was similar to that of the fall research surveys for younger ages. There were significant differences between cohort strength between the 60s and 90s if this factor was included. This analysis did not include the estimate of difference in catchability from the 60s to the 90s (the 90s surveys are considered to be more efficient by a factor of 1.67); if this is done the difference between the 60s and 90s is much greater. These results were repeated using a gamma error distribution instead of the usually lognormal. The results were similar in both cases.

38. Size and age of juvenile cod caught as bycatch in capelin traps in 1994 (WP#37) - E.L. Dalley, J.T.Anderson and B.S.Nakashima

Summary

At last year's regional groundfish assessment review data were presented data demonstrating a statistical relationship of cod by–catches in the capelin trap fishery for the period 1981–93 and mean cod recruitment as estimated by the 1993 ADAPT. It has been shown that in earlier years the majority of this cod by–catch consisted of age 2 and 3 cod. It was noted at the meeting that cod by–catch is noisy with gaps in the years of coverage because of closures in the fishery. There has not been systematic sampling of the by–catch in recent years and it was recommended that consideration be given to using cod by–catch as an additional source of samples. The size and age of juvenile cod samples collected in capelin traps in 1994 are reported here. Unfortunately, the capelin fishery was sporadic and of short duration in 1994, precluding an estimate of total by–catch. The small number of samples (5) collected indicate that age structure of all sites combined was dominated by age 3 and 4 year old fish, differing from the historical samples which were dominated by 2s and 3s. Age structure varied from site to site.

Discussion - W. Brodie (Rapporteur)

It was noted that the catch of juvenile cod in inshore capelin traps consisted mainly of age 3 fish, while the results from the inshore juvenile cod trawl survey showed that cod age 1 predominated. Two possible reasons were that the survey was earlier in the year than the capelin fishery, and that the survey used lined trawl gear while the data from the capelin fishery were from traps.

It was thought it would be useful to tabulate the results of juvenile cod abundance in Japanese pelagic traps by length group rather than by age, to make these data comparable with other studies. It was noted that these results cover a longer period within a year than most other studies, meaning that there would likely be a larger range in the mean lengths at age.

Although the traps were hauled every day, weather permitting, it was thought that some data may indicate that predation was occurring in the traps.

39. Changes in concentration of 2J3KL cod from 1981 to 1994 (WP#38) - R.A. Myers and N.J. Barrowman

Summary

The degree of concentration of cod in 2J3KL fall surveys were calculated by using a standard method used in econometrics to study the distribution of income among individuals. As the distribution of fish becomes more unequal, i.e. more concentrated, the Lorenz curve bends downwards and to the right within the unit square. Twice the area between the identity function and the Lorenz curve is known as the Gini index, and is the most commonly accepted measure of concentration. The increase in concentration of cod from 1981 to 1992 in the research surveys is clear from the Lorenz curves and the Gini index. The concentration reached a maximum in 1992. Since 1992, the concentration has decreased to levels common in the early 1980s.

40. Status of the cod stock in NAFO Subdivision 3Ps (WP#39) - C.A. Bishop, E.F. Murphy and D.E. Stansbury

Catches averaged slightly over 30,000 t from 1977 to the mid 1980s when there was an increase to about 57,000 t in 1986 and 1987. Since that time there has been a decline in catches to about 32,000 t in 1992 and a further decline to only 15,000 t in 1993, the lowest level in the time series. The fishery was put under moratorium in August 1993. The research vessel data suggest population numbers and biomass have been declining since the late 1980s. This is consistent with declining length at age, increased total mortality from catch curve analysis and a loss of older age groups. Research survey biomass was low in 1994 but increased substantially in 1995. However, this was based on the results from one survey tow and the estimate consequently had a large standard error. The stock is considered to be very likely close in size to that estimated in 1994. There are no indications of good recruitment after the relatively strong year class of 1989. The reliability of the surveys as indicators of stock abundance in 3Ps has been questioned. In particular there are possible problems with stock structure identification and stock overlap with adjoining divisions. In response, research survey coverage in recent years has been increased and the timing of the survey changed.

Summary - S. Walsh (Rapporteur)

It was noted that the by-catch of cod in several other groundfish fisheries in the area was high in 1994/95, which subsequently lead to closures. Information from fishers indicate that high amounts of cod were being found in lobster pots and herring nets. This information, along with the high survey estimate for 1995 may be signs of improvement. However, 91% of the 1995 survey estimate was generated by one set in stratum 318 - the largest RV catch ever taken in 3Ps. This could be interpreted as a danger sign if it implies that the remaining fish are concentrated into small pockets.

Discussion of the working paper centred on the best way of presenting survey data in assessments. It was noted that confidence limits need to be estimated and a suitable method should be developed to do so. It was agreed that there was no statistical justification for eliminating the high value from stratum 318 in the April 1995 survey. In the absence of a method for estimating confidence intervals, it was decided that standard errors should be plotted as a relative index of uncertainty with a footnote to stress that these could not be interpreted in terms of confidence intervals.

It was noted that the large set in stratum 318 occurred in the Halibut Channel. This is a very dynamic area with survey temperatures ranging from 1° to 6°C. The occurrence of the aggregation may have been influenced by temperature conditions in the area. Comparative fishing during the winter months of 1995 did not yield any substantial catches in this area, however the commercial fishery has historically had good catch rates in the vicinity.

41. An update of stock status of 3Ps haddock (WP#40) - E. F. Murphy and C.A. Bishop

Summary

This stock was last reviewed in 1992. The working paper provides an update of data available on the commercial catch and research survey since 1991. Catches peaked at 7,500 t in 1985, mainly

as a result of increased catches by France. Catches have declined since 1985 and have been less than 500 t since 1992.

Research surveys have been conducted by Canada in 3Ps since 1972 using the stratified-random design. Biomass and abundance estimates were highest in 1985 and have since declined. Biomass in recent years has been found mainly in strata with depths of 100-200 fathom.

Haddock in Newfoundland waters is at the northern end of their range. Survival of year classes is at best, marginal. However, recent history has shown that occasionally the correct conditions prevail and year class survival is extremely good. This situation occurred in with the 1950 and 1956 year classes and in 3Ps with the 1959 year class. In both areas these strong year classes sustained substantial fisheries for a number of years. In reviews of this stock during the late 1980s and early 1990s CAFSAC advised that there be no directed fishery on this stock. It was felt that yield could be enhanced from incoming year classes and these year classes should also be allowed to contribute to the spawning stock. This advice was not headed and in the late 1980s and early 1990s the TAC climbed from the initial 150 t in 1987 to 3,200 t for 1989-92. Biomass and abundance estimates presented for this stock in the 1992 assessment showed values similar to the 1970s. The advice in 1992 was for no directed fishery. A bycatch TAC of 500 t was established for 1993 and 1994. The FRCC 1994 Report advised a 100 t bycatch TAC for 1995. No data were presented in the working paper to suggest that this advice should be revised upward.

Discussion - M.J. Morgan (Rapporteur)

As fisheries reopen in 3Ps, particularly the cod fishery, it will probably be necessary to take measures to allow the haddock stock to rebuild, since haddock might be taken as by-catch in other fisheries. In the past, good year classes have usually been fished out before they reach maturity. One possibility to protect haddock would be to close areas of juvenile abundance. The research vessel bottom trawl data base should be examined to determine if there is spatial separation of age classes so that "nursery" areas could be identified. The use of the Campellen trawl will allow better definition of any juvenile areas since it catches young fish more efficiently than the Engels gear. Also, there are fishing methods which allow the capture of cod with little haddock by catch. Research towards the development of a plan to allow the stock to grow in the face of other fisheries should be conducted before good recruitment is detected in the surveys.

42. An update of stock status of 3Ps pollock (WP#41) - E.F. Murphy and C.A. Bishop

Summary

Pollock landings in 3Ps averaged 420 t from 1967 to 1982, increased to a high of 7,554 t in 1986 and subsequently declined to 1,305 t in 1991. The Canadian catch in 1992 was only 473 t and the TAC of 600 t recommended by CAFSAC for 1993 was reduced to 1 t for 1995. Catches in recent years have been mainly by Canada and France.

Research vessel surveys have been conducted in 3Ps using the stratified random design since 1972. These surveys have been conducted mainly in the February to March period and are used in assessing several groundfish species. In 1993 the survey period was shifted to April to lessen the impact on the result of cod migrating from the Gulf of St Lawrence. Biomass estimates from the

surveys were low in the 1970s (<1000 t) increased to a high of 7,877 t in 1987 and have since declined to 1970s levels. Survey catches for most of the time period have been highest from strata surrounding the Burgeo Bank and to a lesser degree those on the slopes of St Pierre Bank. In recent surveys catches seem to be confined to the strata along the slope.

Discussion - R. Bowering (Rapporteur)

A history of TAC development was discussed. It was indicated that occasionally small pulses of recruitment in the area attracted the interest of some fishers even though a fishery for pollock in the Newfoundland area is not routine. In order to maintain control for regulation purposes a catch or by-catch level is introduced at a level determined either scientifically (if possible) or by other means such as preemptive quotas. It was agreed that the fishery for pollock will likely continue to be opportunistic. It was considered that comprehensive advice on this stock is unlikely in the foreseeable future but monitoring of the stock should continue. An annual review is probably unnecessary and this stock should be reviewed cyclically, i.e. about every three years.

43. Assessment of the American plaice stock in NAFO Subdiv. 3Ps (WP#42) - M.J. Morgan, W.B. Brodie and G.T. Evans

Summary

Recent research vessel surveys have shown the stock size of American plaice in 3Ps to be at its lowest observed level. The stock is currently only 10% of the average levels observed in the mid 1980s. Although catches may have added to the decline of this stock in recent years, the large decline observed in the late 1980s occurred when catches were low. The ratio of catch to trawlable biomass from surveys for the period 1983-93 show that for the period 1983-89 the "exploitation rate" was less than 10% although the stock size declined substantially during this time. Thus it appears that commercial catches were unlikely to have been the major cause of the decline, although in the early 1990s the the catch to biomass ratio increased and this may have accelerated the further decline in stock size. Groundfish bottom trawl surveys have tracked the decline in the abundance of this stock in recent years. The two 1993 surveys are the lowest in the 18 point series. The abundance of all age groups has declined and there has been a decrease in recruitment. French RV surveys in 3Ps also show a decline in abundance through 1992 after which the surveys ceased.

Based on a recommendation by the FRCC the fishery was closed in September 1993 for the remainder of that year. The TAC for 1994 was set at 500 t to allow a by-catch in other fisheries. Total catch in 1994 was 117 t, of which 56% was taken by otter trawl. There is a 100 t by-catch quota for 1995. The outlook for this stock is very pessimistic, given the current low stock size and the lack of recruitment indicated by the surveys. In the short to medium term there is no prospect of the stock rebuilding.

Discussion - C.Bishop

It was noted that the effort data presented showed an increase after 1983, however data available since 1974 indicate that effort was higher in the 1970s when landings were higher. It was suggested that the Spanish fishery for cod prior to 1977 would have discarded American plaice and

that reported catches for this period may therefore be underestimates. Prior to 1973 catches were recorded as unspecified flounder and separated to species based on ratios. Effort was no doubt high in the earlier years.

It was noted that there are no catch rate data for recent years as catches were low or non-existent. Catch rates were highest in the 1980s.

It was suggested that because of the poor selection properties of the survey trawl, comparisons of annual length frequencies may not be the most appropriate method for determining incoming recruitment. However, survey vessels and gear have been consistent since 1983 and there have been substantially lower numbers of young fish over this period.

A new method of sequential population analysis using catch and survey data to 1993 indicated that in recent years, year classes recruiting at age 6 have been relatively low. Some advantages of this "2-phased VPA" method over currently used models (ADAPT, Laurec/Shepherd,etc.) were explained. These included the provision of a clearer picture as to the sources of variability of estimates, less "masking" of the influence of weighting factors, separate treatment of each year class, and more flexibility in looking at different sorts of uncertainty. The method was considered a valuable tool for looking at the retrospective problem.

44. Witch flounder in Subdivision 3Ps: A stock status update (WP#43) - W.R. Bowering

Summary

Catches from this stock have been generally about 1,000 t annually since 1989 with the exception of 1994 which was about 400 t. The reduced catch is largely a result of by-catch constraints of cod and American plaice whose fisheries in are under moratoria. Survey biomass indices since 1976 have generally ranged between 2,000 and 6,000 t with the recent estimates stable at the low end of the range. The maximum age observed in this stock since the early 1970s has been reduced from 22 years old in 1976 to 14 years by 1980 and the overall age structure has been stable since that time.

Data from surveys and recent observations from the commercial fishing industry indicate that the witch flounder in 3Ps are found in deeper water than in past years. Stratified-random bottom trawl surveys have been conducted in the 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 550 m. Biomass estimates have been highly variable over the past 15 years and it has been suggested that this is because the main depths where witch flounder are located are not surveyed by the research vessels. An examination of survey indices by depth zone indicates that during the late 1970s and early 1980s there were considerable levels of the biomass in depths less than 183 m whereas during the 1990s there were none. While two surveys in 1993 and the surveys in 1994 and 1995 were within the range of past biomass estimates, albeit at the low end of the range, it is known that a quite successful fishery occurred in deep water beyond the survey area in 1993 and may have also occured in 1994 if it were not for by-catch constraints. Although this supports the contention that fish have moved to deeper water, the fishery usually concentrates within a relatively small area on a spawning concentration of fairly high density which may not be an indicator of a high level of biomass.

Discussion - P. Shelton (Rapporteur)

It was noted that this is one of the few fisheries that is still open although bycatches of American plaice and cod have hampered the fishery and resulted in a low catch in 1994. The Flatfish and

Deepwater Species Section lacks resources to keep up with the age reading for this stock. This was considered unfortunate given the substantial reduction in the number of age groups that were present earlier in the history of the fishery. It was suggested that maturities at age should be examined for this stock, but this would first require the age readings to be brought up to date.

45. An update of stock status of 3KLP lumpfish (WP#44) - D.E. Stansbury, E.F. Murphy and C.A. Bishop

Summary

Lumpfish are primarily a bottom dwelling species but have been reported to be semi-pelagic during early life. Spawning takes place during the spring in Newfoundland waters and continues into the summer. The preferred spawning grounds are shallow water rocky shores with abundant seaweed growth. The fishery on this species is primarily based on roe and is prosecuted by vessels less than 65 ft in Newfoundland bays. The lumpfish roe fishery in 3KLP has been approximately 500 t from 1977 to 1984. Landings reached a high of 3,000 t in 1987 and dropped to an average of 2,000 t from 1988 to 1994.

The fall research surveys in the offshore areas of 3K resulted in biomass estimates of less than 1,000 t in the early 1980s, increased to 8,000 t in 1988 and then decreased to 1,600 t in the 1990s. 3L biomass estimates were low in the early 1980s with a slight increase in the mid 1980s and then declined to the lowest level in the time series in 1988 and 1989. Estimates for the 1990s appear to be stable but have a large standard error. 3Ps biomass estimates were an order of magnitude higher than 3K and 3L with most of the biomass in depths of 51 to 100 fathoms.

The stock structure of this species in Newfoundland waters is not known. Lumpfish are thought to migrate inshore in the spring and early summer to spawn in shallower coastal waters and to return to deeper waters offshore in late summer and early fall. Small female lumpfish (<25 cm) have not been caught by the survey trawl and it is thought that adults remain pelagic until the winter preceding spring spawning.

With survey estimates from 3Ps declining and landings with similar or higher effort in 3K also declining, it is very likely that this species is being over-exploited in Newfoundland waters.

46. An analysis of lumpfish from data on individual fishermen (WP#45) - R.A. Myers, B. Sjare and R.B. Luscombe

Estimates of the catch per unit effort of lumpfish from 1989 to 1994 were obtained from the daily catch records of 9 fisherman. These data were extracted from the data provided by a group of index fishers who are monitored for seal bycatch data. Data were extracted for the 9 longest, consistent time series in the record. Each fisher records the number of nets in the water, the

number of nets hauled and the weight of lumpfish roe caught. Two methods were used to estimate catch rates. First, the mean catch per haul each day the fishery took place during May and June was estimated. Then the median of these values for each year was used as an index of stock abundance. Approximate confidence limits were calculated for the median. As an alternative, the mean catch per net per day was estimated. To calculate the mean catch per net day for a given year the total number of net days and the total catch of lumpfish roe was calculated for the year. The total number of net days for the year was calculated by summing the number of nets in the water for each day over all the days of the year. The total catch for the year was computed and the mean catch per net day obtained by dividing the total catch by the total number of net days. A potential source of error is the inclusion of days that the net was not checked in the calculation (e.g. stormy periods).

The results suggest that CPUE is declining in all regions with the decline most pronounced along the north coast of Newfoundland, where the CPUE has dropped by almost an order of magnitude. The declines are less along the southwest coast but are still large. Low CPUEs in 1990 appear to be caused by very stormy conditions and pack ice.

Discussion WP#44 and WP#45 - B. Davis (Rapporteur)

It was noted that the Gadoids Section used to have a lumpfish research project and that assessments were carried out but that the work was discontinued due to limited resources.

The catch rate information is for large mature females. The question was asked whether it was possible to extrapolate this to the entire stock based on this information alone or whether frequency information was required to determine what portion of the catch is of no commercial value, (i.e.males and immature females).

The question was asked whether there was an increase in seal by-catch which may have had an impact on gear performance. There has been more damage by seals since 1991 but information from damaged nets was excluded from the analysis.

It was noted that there had been a big increase in fishing effort directed at lumpfish since 1992 as a consequence of the moratorium on cod. It was suggested that few immature females get caught in the nets and that most males are released alive. Discards appear to have high survivability.

A research recommendation was made to examine the stock structure of lumpfish.

It was noted that mesh size restrictions is not an effective measure in this fishery and that limited entry was probably the more appropriate approach.

47. Preliminary report on acoustic survey of inner Placentia Bay, February 1995 (WP#46) - G.A. Rose

Summary

A pilot acoustic survey of the inner portion of Placentia Bay was conducted during 23 January and 23 February 1995. The purposes of the survey were to investigate (i) the use of small fishing vessels as acoustic platforms for prototype digital acoustic systems, (ii) the performance of

prototype digital systems in this environment, and (iii) the feasibility of inshore winter acoustic surveys on the south coast as a cooperative venture with fishermen. The survey was conducted from a chartered vessel, the Lady Kenda and equipped with dual frequency digital DT4000 echosounders and a dual beam 120 kHz analogue echosounder. The digital echosounders were run over all survey lines whereas the dual beam system was employed only to test TS predictions from the digital single beam convolution method. Fishing was conducted from the Lady Kenda with baited lines and gillnets. This proved very difficult as cod were identified on the sounder at depths >300m. Catches were low but corresponded well with the sounder interpretations. Low acoustic densities and catches in areas where fishermen expected fish to be abundant led to discussions about methods. Sentinel fishermen from the area were allowed to fish both along transects and at sites they selected as traditional grounds and which were surveyed acoustically before and after the fishing. In all cases only very low densities of cod were recorded acoustically at these sites and fisher's catches were also low.

The difficulty of properly sampling the several types of acoustic signals identified during the survey (e.g. capelin, herring, small cod, large cod) from the Lady Kenda, or with the assistance of the sentinel fishermen, led to the use of the Shamook and the bottom trawl. Six sets were done at selected sites to help verify acoustic signals and the interpretation of catches from other gear. Cod were caught in all sets targeting cod areas. The quantitative analysis of the acoustic data has not yet been completed. However, it was established that small fishing vessels can be used successfully as acoustic platforms for portable digital sounders for inshore surveys, but their rigging must be carefully scrutinized. The prototype digital equipment performed well. The chief difficulty with conducting an abundance survey in this area at this time of year is biological not technical. Fish migration patterns are not sufficiently understood to consistently place a short observation window on Placentia Bay and hope to develop an unbiased index. The fact that this survey did not detect large numbers of cod does not mean that large numbers did not migrate through Placentia Bay, only that such a phenomenon did not occur during the course of this study. The first step toward improving the likelihood of developing more reliable survey strategy is to gain a better understanding of the migration routes and timing. In this regard local knowledge proved to be a great help. Although there was often disagreement between scientific staff and fishers, the open and mostly good natured dialogue was very helpful to the survey.

Discussion - D. Power (Rapporteur)

The main objective of the research in the Placentia Bay area was to determine the relationship and size of cod in the Bay to the main body of fish encountered in the 3Ps area in the offshore surveys. It was pointed out that much was accomplished in solving the technical problems of conducting an acoustic survey in the area. The results suggest the existence of "resident fish" but the timing of this survey (February) was not appropriate relative to when there is the greatest abundance of fish in the bay (November-December). The perceived migration route of cod in and around the bay and the relationship between cod in Placentia Bay and offshore areas needs to be resolved.

48. Preliminary results from the inshore sentinel survey for cod in NAFO Subdivision 3Ps (WP#47) - M.B. Davis

Summary

A sentinel fishery in 3Ps was announced in October 1994. The survey is an extension of the index

fishers project of the Northern Cod Science Programme with modifications to allow for activities achievable only under a moratorium. The objectives are: (i) to describe the temporal and spatial distribution of cod in the inshore area over a number of years through, for example, the use of catch rate information, tagging studies, by-catch information and fisher's observations; (ii) to develop reliable catch rate series for use in resource assessments; (iii) to gather length, sex and maturity data and otoliths for use in resource assessments; (iv) to establish a long-term physical oceanographic and environmental monitoring program of the inshore area of 3Ps; (v) to provide a source of biological material for other researchers, e.g. tissue for genetic, physiological and toxicological analyses, cod stomachs for feeding studies and by-catch information; (vi) to incorporate the knowledge of inshore fishers into the process of resource assessment.

Catch rate information was provided for each of twelve sites. Analysis of frozen samples, age and length frequencies and the oceanographic information is not yet completed. The catch rate pattern for the sites is similar to a description of the fishery provided by fishers during an interview survey in 1994. Areas west of the Burin Peninsula which traditionally have a winter hook and line fishery clearly had the best catch rates of the sites surveyed. In contrast, the increase in catch rates in Placentia Bay is consistent with the development of an early spring fishery. There has never been a large scale winter fishery in most parts of Placentia Bay with the exception of the very north end around North Harbour. Fishers describe the condition of fish as improved since the moratorium. The research vessel survey conducted in 3Ps in April 1995 did not catch any fish in the strata in Placentia Bay. However, catch rates in the sentinel fishery in the unsurveyed portions of the bay were increasing around the time of the survey. The biological significance of this requires further exploration.

Since this is the first year of the sentinel survey, there is no time series of data with which to compare. However, there is a useful reference available. Observations from fishers suggest that in all areas, catch rates are as good or better than they were prior to the closure of the fishery in 1993. Fishers have regularly commented that the research vessel surveys conducted by DFO do not cover all of the areas which contain fish and are conducted at the "wrong" time of the year. Comparison of catch rates from the RV and sentinel surveys suggest that simultaneous sampling is desirable since the sentinel survey found fish adjacent to RV surveyed areas which were empty. Quantitative methods for incorporating sentinel survey data into analytical assessments require further development.

Discussion - P. Shelton (Rapporteur)

The basis for the conclusion by the participants in the Sentinel Fishery that the catch rates were as good or better than those experienced prior to the moratorium was discussed. It is difficult, if not impossible to infer historic catch rates for the smaller vessels for which only purchase slip records are available. Quantitative comparison is therefore difficult. Also there are differences in the way the Sentinel Fishery is pursued compared to the regular fishery. For example, in the Sentinel Fishery the gillnet soak time is about an hour compared to overnight in the regular fishery although the longline soak time is the same. It was also pointed out that the catch rates may be maintained by the small number of participants in the sentinel fishery, but that the catch rates may not be nearly as high if there were a larger fishery.

The problem of having different kinds of gear (e.g. gillnets and longlines) involved in the Sentinel Fishery and of using different sampling protocols (e.g. exploratory and fixed) was raised. In order to see the signal in the data it is important to try and control as much of the variability as possible. It would have been better to have chosen one gear and a single sampling protocol. If

two gears are to be used then the gear should be paired so that relative effects can be determined. The use of fixed sites would facilitate the interpretation of any catch rate data. Any time spent searching would only confound the interpretation. If there is to be an exploratory or searching component to the Sentinel Fishery, then the objectives need to be carefully spelled out and this time series should be kept separate from the fixed site/single gear time series which may provide a useful index.

49. What can we learn about lumpfish mortality from sex ratio data? (WP#48) - J.M. Hoenig

Summary

Under certain assumptions, the ratio of females to males in the virgin population (i.e. before exploitation begins) can be used to estimate the ratio of mortality rates of males to females (i.e. Z_m/Z_f). Changes in sex ratio over time for a cohort of animals can provide an estimate of the difference in mortality rates. Thus, if one compares the sex ratio in a survey at time i with the sex ratio of the same cohorts at time i+1 one can estimate $Z_m - Z_f$. This latter approach is appealing because only minimal assumptions are made about catchabilities - the ratio of catchabilities of females:males remains constant over time but the catchabilities are not assumed equal or constant over time. However, it is necessary to remove the recruitment from the survey results at time i+1 to get unbiased estimates. The lumpfish sex ratio in 3Ps groundfish surveys has always been heavily skewed towards females suggesting that females have a lower mortality rate than males if the survey estimates of sex ratio are unbiased. When the change in sex ratio over pairs of years is compared for the years from 1979 to 1994, without correcting for recruitment in the second year, the median estimate that the survival of females is 1.11 times the annual survival rate of the males, i.e. slightly higher. If recruits could be identified in the trawl data and removed from consideration, one might get some useful information on relative mortality rates and on changes in mortality rates of females over time.

50. Synthesis of information on cod in Divs. 2J3KL - C.A Bishop, J.T. Anderson, E. Colbourne, G.R. Lilly, R.A. Myers, G.A. Rose, D.E. Schneider and D.E. Stansbury

Summary

The 2J3KL cod stock remains at a very low level, probably in the order of 1% of that in the early 1980s. The stock consists mainly of young fish with virtually none older than age 7. The stock size has continued to decrease since the introduction of the moratorium even though catches have been much reduced. The majority of the catch since the moratorium has come from inshore areas where it has been shown that separate stock components are likely to exist, mainly in the deep water bays.

The reasons for the drastic decline in this stock remain unresolved. Hypotheses suggest a variety of potential causes, such as, adverse environmental conditions, underestimation of fishing mortality, and increased predation. Although water temperatures were anomalously low during the early 1990s, there are indications of a return to more normal conditions in 1994. Analysis of

tagging concluded, as did previous results from VPA analysis, that fishing mortality in the late 1980s and early 1990s was high, assuming a constant rate of natural mortality. Since the moratorium, fishing mortality would have been reduced in the offshore areas as catches were very small. By-catch mortality of cod in the northern shrimp fishery declined from 1992-94 with the introduction of the Nordmore grate. Harp seal numbers have increased substantially since the early 1980s and their consumption of juvenile cod as well as other fish species has increased.

Since 1990-91 cod have shown an increasing proportion mature at younger ages with the proportion for 1994 being the highest in the time series. This may be a response to population declines. Estimates of the abundance of pre-recruits (ages 0-2) have been obtained in recent years using a variety of indices. The abundance in 1994 at age 0 is estimated to have been greater than in 1992 and 1993.

51. The status of redfish in Div. 3O (WP#49) - D. Power, D.B. Atkinson, J. Morgan and W.R. Bowering

Summary

The first quota was put in place for 3O redfish in 1974 at 16,000 t. Russia predominated in this fishery up until 1993 and took about 50% of the non-Canadian TAC. Russia had a very limited fishery in 1994 and Cuba did not participate at all. Portugal, which began fishing in the area in 1992, took 2,900 t and Canada took 1,600 t in 1994. The predominant means of capture up until the early 1980s was the bottom trawl but since 1984 there has been an increase in the use of midwater trawls. The standardized catch rate (all countries) increased in 1979 and subsequently declined through 1993. A preliminary analysis of the Canadian catch rate data only (inside the 200 mile limit) does not show the same trend as the overall catch rate and further investigations are necessary. RV surveys in the spring and fall since 1991 (up to 730 m) show different trends. The spring survey showed a steady increase from 7,000 t in 1991 to 84,000 t in 1995, whereas the fall survey ranged from 16,000 t to 28,000 t with no trend. The differences may be related to changes in availability within the Division. A multiplicative analysis of the catch rate at age for the period 1987 to 1990 indicates a fishing mortality of about 0.16 compared to an $F_{0.1}$ level of 0.12. The average catch over this period was about 15,000 t.

There is considerable uncertainty regarding the current size of the stock and the level of fishing mortality being applied. There is an indication that fishing mortality was slightly above $F_{0.1}$ over the late 1980s - early 1990s. Based on the research vessel data the stock appears to be mostly comprised of young immature fish, although significant amounts of larger fish have been found in the past in the deeper areas of the division. Given that generally the shallower the depth fished the smaller the size composition, fishing mortality applied in the shallower depths will lead to a higher mortality on immature females than if it were applied further offshore.

Discussion - M.J. Morgan (Rapporteur)

The multiplicative model for catch and effort indicated a decline in commercial catch rates since the early 1980s. It was noted that 1994 had not been included in the model because only limited data were available and an initial run had revealed a large increase in 1994 over 1993. Additional study was required.

It appears that the catch rate index for 1991 is considerably lower in the present analysis than in the analysis illustrated in DFO Atlantic Fisheries Stock Status Report 95/4E. The cause of this difference was not immediately apparent.

It was noted that there had been a substantial change in participation by countries in the 3O fishery. In particular, there had been a large reduction in catch by Portugal and a great decline in catch by Russia, which had dominated the fishery for many years. The influence of these changes on catch rate indices had not been investigated.

It was also noted that much of the effort by non-Canadian fleets occurred within the small area of 3O outside Canada's 200 mile limit. The influence of this on catch rates is not known.

The survey results are difficult to interpret. First, the biomass estimates from the spring series have increased substantially since 1992 whereas the estimates from the fall series have been stable. It was noted that the increase in the spring series may reflect recruitment of a year-class from the late 1980s. This year-class was tracked in both spring and fall surveys. A satisfactory explanation for the difference in biomass estimates has not been proposed. Second, the surveys find very few fish longer than 25 cm. This problem has long been recognised and fish in 3O either cease growing at about 25 cm, become inaccessible to the surveys, or migrate from the area. This problem has not been resolved.

It is difficult to compare changes in biomass estimates from surveys to changes in commercial catch rates. The surveys catch relatively few fish longer than 25 cm. It is understood that the Canadian commercial fishery also has difficulty finding large fish in 3O. Nevertheless, most length frequencies from the commercial fisheries in 1994 reveal a high proportion of larger fish. The surveys provide no information on that component of the population which dominates catches by the fishery.

It was concluded that it is not possible to estimate the size of the stock from the available data.

52. The status of redfish in Unit 2 (Laurentian Channel Management Unit) (WP#50) - D. Power, D.B. Atkinson, W.R. Bowering and J. Morgan

Summary

Unit 2 redfish represents a relatively new management unit. Redfish in this area (3Ps4Vs, 3Pn4Vn-June to December, 4Wfgj) were previously managed separately as a 3P stock and part of a 4VWX stock. In 1991, based on a detailed examination of available data, it was proposed to realign the management units to better represent what was known about the resource in these areas. The new management units were put in place beginning in 1993 and the quota in that year was set at 28,000 t. This was reduced to 25,000 t in 1994 and to 14,000 t in 1995. Annual catches have ranged between 8,100 t in 1984 to 58,000 t in 1971. Since the declaration of the 200 mile limit in 1977 catches have been primarily by Canadian fleets with Maritime fleets accounting for the majority of the landings from 4Vs and 4Vn while Newfoundland fleets concentrate on 3Ps and 3Pn.

The standardized catch rate series for this stock shows a rapid increase from 1988 to 1990 followed by an abrupt decline with the 1994 value the lowest on record. The increase can be

partly attributed to the recruitment into the fishery of the relatively strong year-class of the early 1980s but may also be a result of technological changes. RV surveys have been conducted in 3Ps in the February-April period since 1973. The surveys do not cover the entire stock area and may not accurately reflect changes in stock size. Surveys conducted in the summer of 1994 and 1995 are considered to be more representative and gave estimates of minimum trawlable biomass of 240,000 and 210,000 t respectively.

Because of the limited database, it is not possible to provide an estimate of the size of this stock or to estimate fishing mortality rates equivalent to the past catches. Examination of the ratio of catch to the exploitable biomass suggest that the current TAC of 14,000 t would generate an exploitation rate of between 13% and 24% compared to an $F_{0.1}$ value of about 11%. Overall, this stock is probably lower than it has been in recent years. Catch rates have declined steadily since 1990. Current catches are composed primarily of the early 1980s year classes which have already been fished for about 6 years. The fishery is unlikely to improve until the 1988 year class enters the fishery in about 1997 or 1998.

Discussion - G. Lilly (Rapporteur)

Commercial fishery data forms an important part of this assessment. In the multiplicative catch rate model, percentage of redfish in the catch is included as a factor. Catches with a higher percentage of redfish have higher CPUE but each category of percentage redfish included in the model shows the same trends over time. A variety of analyses of catch rate all showed a large increase in 1989 and 1990 with a steep decline since then. It was thought that the large increase in catch rate was the result of the introduction of the Turbo midwater trawl in 1989 or the entery of a large year-class into the fishery. When only bottom trawl data were analysed the large increase remained. This would indicate that the large increase in catch rate in those years was not solely a result of new technology.

The results of two survey series were available, the 3Ps groundfish series from 1973 to 1995 and summer redfish surveys in 1994 and 1995. The summer surveys should prove to be more representative of the Unit 2 stock size as the entire stock area is covered and the timing is such that there should be less mixing with Unit 1 fish during the survey. Both survey series indicate that the 1988 year class is the next strong year class. However, there are indications that this year class is mainly *S.f asciatus*. The fishery now mainly focuses on *S. mantella* which is found in deeper waters.

The management objective for this stock is not clear. Currently the catch/biomass ratio is about 7% (including all of the minimum trawlable biomass, not just the exploitable portion). Given that this species exhibits pulses of recruitment a consistent exploitation rate strategy may not be appropriate.

After evaluating the data presented the committee agreed on a number of conclusions: (i) the 3Ps winter/spring survey series has limited value in assessing the current overall Unit 2 stock size because of limited coverage and timing; (ii) commercial catch rates have been declining since the early 1990s and this decline continued in 1994 , with the 1994 point being at or near the lowest observed; (iii) the next anticipated pulse of recruitment (based on survey length frequencies and aging) will not enter the fishery before about 1998; (iv) the 1994 and 1995 summer surveys are better timed and have more complete coverage than the 3Ps series and so are considered to be more representative of Unit 2 relative stock size; (v) the summer surveys show stock size to be stable between 1994 and 1995; (vi) based on the above, it is anticipated that catch rates will not improve in the immediate future.

53. Research Recommendations

1. Reduction in personnel due to funding restraint has placed a strain on the assessment groups. There is a growing backlog of unread age material for several groundfish stocks. Steps should be taken to avoid this.

2. RV estimates of minimum trawlable biomass are routinely presented in assessments, however, the associated uncertainty is not communicated in a standard way easily interpretable to clients. The standard error provides only an index of the uncertainty and cannot be used to obtain confidence limits or in simulations comparing the robustness of alternative management strategies to the uncertainty in stock size. A suitable method for providing 95% confidence intervals should be developed for routine application for all groundfish stocks as a matter of priority.

3. Changes in lengths, weights and proportions mature at age have been observed concomitant with stock declines in several groundfish species. Both the environment and fishing have been suggested as possible causes. The potential for fishing mortality alone to cause the observed changes should be examined by conducting appropriate simulation experiments.

4. With the decline in abundance of traditionally exploited groundfish stocks, some effort has been redirected to stocks that have not been traditionally exploited to any great extent. Some these stocks are being over-exploited (e.g. skate in 3LN) Assessments for these groundfish stocks should be given urgent attention.

5. Synchronous changes in several groundfish stocks off Labrador and eastern Newfoundland have been observed. Some of these stocks experienced increasing exploitation at roughly the same time whereas others have only ever been lightly exploited. The extent to which this synchrony could have resulted from environmental causes should be examined.

6. Current assessments of groundfish stocks do not benefit significantly from the substantial amount of oceanographic research being conducted by the Newfoundland Region. Relationships between recruitment in northern cod and oceanographic factors have not held up. Relationships between temperature and growth need to be updated. Attention should be given to what further extent oceanographic research can be used to reduce the uncertainty in groundfish assessments.

7. Despite the moratorium there is evidence that northern cod and possibly other groundfish stocks may have continued to decline. The ability of the RV surveys to detect changes at low population size should be determined and possible causative factors should be sought if these declines are real.

8. Changes in several biological relationships in cod have been observed in recent years (e.g. growth, condition, liver index, maturity). This may represent real changes in time or shifts in the seasonal cycle relative to an annual survey conducted at a fixed time. The extent to which such "aliasing" could be occurring should be determined.

9. The apparent recruitment of northern cod as 3-year-olds declined with the decrease in the spawner stock biomass. It is possible that this represented an increase in prerecruit mortality caused by increased discarding rather than a change in the production of eggs or survival of eggs, larvae and juveniles due to non-anthropogenic causes. Analysis should be carried out to determine whether or not recruitment of northern cod declined significantly independently of discarding over the period of increasing exploitation in the 1980s, accelerating the collapse of the stock.

10. It has been suggested that catch rate indices for cod can be derived for traps, gillnets and

longlines and that these indices could have provided useful warnings of the decline in the northern cod stock independent of the RV survey and offshore catch rates prior to 1988. This source of information should be critically re-examined to determine whether the interpretation is valid and to decide on the potential of such indices in future assessments once the fishery is reopened.

11. There are interesting indications of genetic material from specific geographic locations that that there are resident inshore stocks of cod in bays. A full synthesis of all genetic results as well as other evidence of stock discrimination for northern cod such as tagging data and parasite incidence data should be carried out and a comprehensive interpretation of stock structure attempted.

12. There are several potentially useful indices of northern cod year-class strength. The precision of these different indicators needs to be determined and methodology considered for combining them into a single composite index of year-class strength.

13. A "sentinel fishery" for cod in 3Ps is underway and plans are being developed for one in 2J3KL. Sentinel fisheries may have the potential to provide an index of stock abundance as well as information on spatial and temporal patterns of abundance, provided they have been well designed with these objectives in mind. Improvements in the statistical design of the 3Ps survey based on the initial implementation and alternative designs for the 2J3KL sentinel fishery should be given priority attention.

14. There is a tendency to limit research in the Newfoundland Region to the northern 2J boundary. The abundance and distribution of groundfish in 2GH as well as physical and biological conditions in this region could have very important implications for 2J3KL. Regular comprehensive multidisciplinary surveys of this region are advised and plans should be developed to implement such a program.

15. The shrimp fishery pursued in the north of the region is a potentially important source of mortality on prerecruit groundfish species. Devices developed to reduce this mortality may be only partially effective and the available data should be fully analysed to estimate the potential impact.

16. It has been hypothesised that discarding of small groundfish, particularly northern cod, could have been a widespread practice that had an important impact on these populations. The available discarding data should be thoroughly analysed in order to test this hypothesis.

17. Multiplicative models of RV numbers at age can provide a useful index of total mortality. Such analyses should be routinely conducted as part of the assessment for all groundfish stocks (dependent on Recommendation #1 above).

18. In order to enhance the possibility of larger groundfish stock sizes in the future, it would be necessary to protect incoming recruitment from fishing until fish reach maturity and can spawn. It is recommended that the historical data base on geographic distribution by age should be examined to determine the location of young immature fish, and to determine areas of distribution for different year classes. These areas should be compared with known areas of distribution of the various groundfish fisheries in order to determine the possibility and practicality of closed areas as a conservation measure.

19. The potential for modifications of the fishing gear in fisheries directed at cod and flatfish in order to reduced the haddock bycatch should be examined.

20. Stock structure information relative to common lumpfish in Newfoundland waters is lacking but necessary. Continuation of tagging studies commenced in the late 1980s, analysis of research survey data, as well as meristics are areas which should be investigated.

21. Lumpfish catch rate information should continue to be collected in a manner similar to that being obtained in a current seal by-catch study. A full analysis of all existing data from this source should be carried out.

22. Age composition data for lumpfish would be extremely helpful in interpreting survey and catch data. Age determination studies should be initiated.

23. The present lumpfish fishery results in the mortality of the female for the removal of the roe. Methodologies for roe removal without female mortality should be investigated.

24. Lumpfish spatial patterns of abundance by size, age and maturity should be examined in order to interpret the survey and commercial catch rate data, and to explore the potential effects of closed areas.

25. Although Canadian catches of redfish in 3O have not been large, they have increased in recent years while catches from other countries have declined, so that the proportion of the total catch taken by Canada has increased. The catch rate series should be examined more carefully to determine the influence of an increasing contribution by the Canadian fleet. In addition, the size composition of Canadian catches in the past should be examined to determine if catch rates in earlier years were based on small or large fish.

26. A geographical analysis of catch and effort for redfish by Canadian and foreign fleets should be conducted. Information sought includes the size of the area being exploited by each country and the locations of catches of large (>25 cm) fish.

27. A thorough analysis of redfish catch rate time series on a set by set basis should be undertaken with cooperation from fishers where possible.

28. Redfish biomass at length should be calculated in the absence of biomass at age.

29. Information from the summer surveys in 3Ps (abundance, distribution, length frequencies) should be provided for the two redfish species separately.

54. List of working papers tabled

WP#1 Status of the capelin stock in SA2 +Div. 3KL - J. Carscadden.

WP#2 An update on the status of invertebrate stocks off Newfoundland - M.J. Morgan.

WP#3 Oceanographic conditions and climate change in the Newfoundland Region during 1994 - E. Colbourne.

WP#4 A model of harp seal predation in waters near Newfoundland and Labrador - G.B. Stenson and J.W. Lawson.

WP#5 Distribution and abundance of Arctic cod (*Boreogadus saida*) off southern Labrador and eastern Newfoundland - G.R. Lilly.

WP#6 Stock status update of witch flounder in NAFO Div. 2J and 3KL - W.R. Bowering.

WP#7 An update of the status of the stock of American plaice in Subarea 2 + Div. 3K - W. Brodie, J. Morgan and W.R. Bowering.

WP#8 An update of the haddock stock status in NAFO Div. 3NO - E.F. Murphy and C.A. Bishop.

WP#9 Redfish in SA2 and Div. 3K - D. Power.

WP#10 Skates - overview - B. Atkinson.

WP#11 Bycatch of cod in the shrimp fishery - D. Kulka.

WP#12 Genetic differentiation between inshore and offshore Atlantic cod (*Gadus morhua* L.) off Newfoundland: Microsatellite DNA variation and antifreeze protein level - D.E. Ruzzante, C.T. Taggart, D. Cook and S.V. Goddard.

WP#13 Genetic variation among NW Atlantic cod and northern cod (*Gadus morhua* L.) populations based on nuclear DNA microsatellite analysis - P. Bentzen, D.E. Ruzzante, C.T. Taggart and D. Cook.

WP#14 Why do fish stocks collapse? The example of cod in Atlantic Canada - R.A. Myers, J.A. Hutchings and N.J. Barrowman.

WP#15 The collapse of cod in Eastern Canada: the evidence from tagging data - R.A. Myers, N.J. Barrowman and J.M. Hoenig.

WP#16 Inshore exploitation of Newfoundland cod since 1948 as estimated from mark-recapture data - R.A. Myers and N.J. Barrowman.

WP#17 An update of the stock status of Div. 2J3KL cod - C.A. Bishop, D. Stansbury and E. Murphy.

WP#18 Summary of the food fishery for cod in NAFO Divisions 2J, 3K, 3L and 3Ps in 1993 and 1994 - D.W. Kulka, R. Stead, D. Lane and L. Russell.

WP#19 Nearshore distribution and abundance of juvenile Atlantic cod (*Gadus morhua*) at two sites in coastal waters of Newfoundland - J. Anderson and E. Dalley.

WP#20 Distribution and recruitment of demersal juvenile cod (0, 1, and 2 group) i the Coastal Zone, NAFO Divisions 3K and 3L - D.C. Schneider, D.A. Methven and D. Ings.

WP#21 Did the feeding level of the cod off southern Labrador and eastern Newfoundland decline in the 1990s? - G.R. Lilly.

WP#22 Is the first overwintering period a time of strong environmental selection for the more cold-tolerant Atlantic cod (*Gadus morhua*) within a year class? - S.V. Goddard, M.H.

Kao and G.L. Fletcher.

WP#23 Notes on shoal densities and movements of cod on the northeast Newfoundland shelf, 1983-1993 - G.A. Rose.

WP#24 An acoustic survey of cod in parts of NAFO Divisions 2J3KL in June 1994 - G.A. Rose.

WP#25 Alternative models of maturity at age applied to cod in NAFO Divisions 2J3KL - M.J. Morgan and P.A. Shelton.

WP#26 Analysis of replacement in eight Northwest Atlantic cod stocks - P.A. Shelton.

WP#27 Initial simulation trials for achieving conservation and sustainable use objectives for the northern cod stock - P.A. Shelton.

WP#28 Objectives of Canada's surveillance and enforcement program in the NAFO Regulatory area - B. Whelan.

WP#29 The population growth rate of Atlantic cod (*Gadus morhua*) at low abundance - R.A. Myers, G. Mertz and P.S. Fowlow.

WP#30 Distribution and abundance of demersal juvenile cod (*Gadus morhua*) in inshore and offshore areas of northeast Newfoundland, the northeast Newfoundland shelf and the northern Grand Banks - E.L. Dalley and J.T. Anderson

WP#31 Catch rates of juvenile cod (Gadus morhua) from Japanese pelagic traps at inshore northeast Newfoundland sites, 1992-1994 - E.L. Dalley, E.G. Dawe and D.E. Stansbury.

WP#32 Dynamics of spawning and survival of northern cod (NAFO 2J3KL) as measured by pelagic juvenile cod surveys during the period of stock collapse, 1991-1994 - J.T. Anderson and E.L. Dalley.

WP#33 Offshore tagging recapture of cod by tagging area and NAFO Division - C.A. Bishop.

WP#34 Exploitation rate for northern cod from catch over RV biomass ratios - W. Brodie.

WP#35 Multiplicative model of beach seine data - R.A. Myers.

WP#36 Analysis of the contrast between years in the beach seine data on prerecruits - R.A. Myers.

WP#37 Size and age of juvenile cod caught as by-catch in capelin traps in 1994 - E.L. Dalley, J.T. Anderson and B. Nakashima.

WP#38 Changes in the concentration of 2J3KL cod from 1981 to 1994 - R.A. Myers and N.J. Barrowman.

WP#39 Status of the cod stock in NAFO Subdivision 3Ps - C.A. Bishop, E.F. Murphy and D.E. Stansbury.

WP#40 An update of stock status of 3Ps haddock - E. F. Murphy and C.A. Bishop.

WP#41 An update of stock status of 3Ps pollock - E.F. Murphy and C.A. Bishop.

WP#42 Assessment of the American plaice stock in NAFO Subdiv. 3Ps - M.J. Morgan, W.B. Brodie and G.T. Evans.

WP#43 Witch flounder in Subdivision 3Ps: A stock status update - W.R. Bowering.

WP#44 An update of stock status of 3KLP lumpfish - D.E. Stansbury, E.F. Murphy and C.A. Bishop.

WP#45 An analysis of lumpfish from data on individual fishermen - R.A. Myers, B. Sjare and R.B. Luscombe.

WP#46 Preliminary report on acoustic survey of inner Placentia Bay, Feb. 1995 - G.A. Rose.

WP#47 Preliminary results from the inshore sentinel survey for cod in NAFO Subdivision 3Ps - M.B. Davis.

WP#48 What can we learn about lumpfish mortality from sex ratio data? - J.M. Hoenig.

WP#49 The status of redfish Div. 3O - D. Power, D.B. Atkinson, J. Morgan and W.R. Bowering.

WP#50 The status of redfish in Unit 2 (Laurentian Channel Management Unit) - D. Power, D.B. Atkinson, W.R. Bowering and J. Morgan.

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