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Proceedings of the Newfoundland Regional Advisory Process for Div. 2J3KL Cod

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Abstract

The annual regional assessment of Div. 2J+3KL (northern) cod was held in St. John's at the Airport Plaza Hotel from March 12-14, and March 19-23, 2001. These proceedings contain a summary of the presentations and discussions of that assessment meeting. They also include as an Appendix the report of the external reviewer, Dr. C. Darby. An important issue at this meeting was the stock structure of northern cod and implications for management and recovery. Given the uncertainties regarding stock structure and possible colonization one can not ignore the hypothesis that the subcomponents of Div. 2J+3KL are not functionally isolated. There are likely to be a variety of subcomponents which may vary in their amount of isolation. With this in mind the meeting decided that the assessment should be conducted under two scenarios: a) that the inshore constitutes a separate inshore subpopulation that is functionally separate from the offshore; and b) that inshore and offshore fish together constitute a single functional population.

Résumé

L'évaluation régionale annuelle du stock de morues du Nord des divisions 2J+3KL s'est tenue du 12 au 14 mars et du 19 au 23 mars 2001, à l'hôtel Airport Plaza de St. John's. Le présent compte rendu contient un sommaire des présentations et des discussions de la réunion. Il comprend aussi en annexe le rapport de C. Darby, l'évaluateur indépendant. La structure du stock de morues du Nord et son incidence sur la gestion et le rétablissement ont occupé une place importante dans la rencontre. Compte tenu des incertitudes associées à la structure du stock et à sa colonisation possible, on ne saurait négliger l'hypothèse que les sous-éléments des divisions 2J+3KL ne sont pas fonctionnellement isolés. Il est probable qu'il y ait divers sous-éléments qui peuvent varier selon leur degré d'isolement. Dans ce contexte, les participants ont convenu de mener l'évaluation en tenant compte de deux scénarios : a) que les morues de la zone côtière constituent une sous-population indépendante, fonctionnellement séparée de celles de la zone hauturière; et b) que les morues côtières et hauturières, à toutes fins pratiques, constituent une seule et même population.

Introduction

The annual regional assessment of Div. 2J+3KL (northern) cod was held in St. John's at the Airport Plaza Hotel from March 12-14, and March 19-23, 2001. There was participation from the Department of Fisheries and Oceans, the fishing industry, Memorial University of Newfoundland, and the Fisheries Resource Conservation Council. Dr. Chris Darby of the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) in the UK, attended as an invited external reviewer. The assessment of Div. 3LNO haddock was originally scheduled for this meeting but was postponed until October.

The meeting was divided into 3 sessions. In the first session all of the background information on which the assessment would be based was presented. This included information such as the research vessel survey results and results of the sentinel survey and the fishery. During this part of the meeting there was also a discussion of the proposed analytical methods and any changes that the meeting suggested for these. The second session of the meeting focussed on a discussion of different models of stock structure and their implications for rebuilding of the stock. Finally, the last session of the meeting presented and discussed the results of the analyses agreed upon earlier in the meeting. During this part of the meeting the SSR was also written.

These proceedings present summaries of the working papers presented at the meeting as well as summaries of the discussions.

SESSION 1: DATA AND PROPOSED ANALYSES

WP 1: Physical oceanographic conditions on the Newfoundland and Labrador shelves during 2000

E. Colbourne

Annual air temperatures throughout much of the Newfoundland and Labrador Region were above normal during 2000. Annual mean air temperatures at Cartwright for example, on the southern Labrador Shelf cooled slightly from the record high set in 1999, but were still above their long-term means by over 1^{o}C. Air temperatures at Goose Bay were above normal for 10 out of 12 months and at St. John's they were above normal for 11 out of 12 months. The North Atlantic Oscillation (NAO) index for 2000 was similar to the 1999 value, which was well above normal, reversing the trend of below normal and near normal values of the previous three years. The index during 1999 and 2000 was similar to levels obtained during the cold early 1990s, however the colder-than-normal environmental conditions usually associated with a high NAO index did not influence the northwestern side of the Atlantic during the past two years. This was due to an eastward shift in the anomalous air pressure fields resulting in milder-than-normal conditions in the region. Sea ice on the southern Labrador and Newfoundland shelves generally appeared on schedule during 2000 but left early, resulting in a shorter duration of ice than usual. The total ice coverage in these areas during 2000 was lower than average but increased slightly over conditions in 1999 during both winter and spring.

The annual water column integrated temperature at Station 27 for 2000 cooled slightly compared to 1999 but remained above the long-term mean. Surface temperatures were above normal for 9 out of 12 months with anomalies reaching a maximum of near 1.5^{o}C during August. The June, July and December values were about normal. Bottom temperatures at Station 27 were above normal (by >0.5^{o}C) during the first 6 months of the year and about normal during the remainder. Salinities at Station 27 were below normal during winter and spring and above normal during the remainder of the year. The vertically integrated salinity for the summer months was about normal. Similar trends in temperatures and salinity were observed on the Flemish Cap and on Hamilton Bank during 2000. Temperatures at 10-m depth in the inshore regions along the east coast of Newfoundland during 2000 were above normal by up to 3^{o}C during the summer months.

The cross-sectional area of sub-zero ^{o}C (CIL) water on the Newfoundland and Labrador Shelves during the summer of 2000 increased over 1999 values. The CIL areas ranged from below normal on the Grand Band (Flemish Cap transect), near normal on the east coast (Bonavista transect) and slightly above normal off southern Labrador (Seal Island Transect). The total volume of sub-zero ^{o}C water on the shelf during the fall increased compared to 1999 but amounts were still below that observed during cold years. Minimum CIL core temperatures during the summer of 2000 were also slightly cooler than 1999 values but about normal.

Bottom temperatures on the Grand Banks during the spring of 2000 ranged from 0.5°C above normal in 3L and up to 2°C above normal in 3O. During the fall they decreased to mostly below normal values except in regions of northern 3L. Fall bottom temperatures in Divs. 2J and 3K were above normal in most areas, however, the mean bottom temperature in all regions decreased from 1999 values. Correspondingly, the area of the bottom in all areas covered by water in the lower end of the temperature range (<1°C) increased slightly over 1999 values while the area of warmer water decreased. The largest increase in the area of sub-zero °C water occurred over the Grand Banks during both summer and fall with still no sub-zero °C water in 2J during the fall of 2000.

In general, the below normal trends in temperature and salinity, established in the late 1980s reached a peak in 1991. This cold trend continued into 1993 but started to moderate during 1994 and 1995. During 1996 temperature conditions were above normal over most regions, however, summer salinity values continue to be slightly below the long-term normal. During 1997 to 1999 ocean temperatures continued above normal over most areas with 1999 one of the warmest years in the past couple of decades. In general, during 2000 ocean temperatures were cooler than 1999 values, but remained above normal over most areas continuing the warm trend established in 1996. Salinities during 2000 were similar to 1999 values, generally fresher than normal throughout most regions, which is a continuation of the trend observed during most of the 1990s.

Discussion – D. Maddock Parsons

The ‘normal’ is defined as the average of conditions from 1961-1990. Next year the ‘normal’ reference time will change to 1971-2000. This will change how the cold temperatures in the 1990’s relate to ‘normal’ since they will now be included in the calculation of the average. This will have to be kept in mind in future discussions. One possibility would be to compare things to both the old and new ‘normal’.

There appear to be trends in the temperature data which are decadal in nature. At the moment there is only a lag 1 autocorrelation but if decadal patterns repeat then the predictive ability may be improved. If these patterns hold then one would expect a decrease in temperatures in coming years.

Nearshore temperature conditions were not necessarily the same as those offshore. For instance inshore 3K appeared to be very cold while the offshore in 3K was above normal. These inshore data are based on thermographic records in a few areas. There are temperature data collected in the sentinel program but the headers are frequently incorrectly entered and this makes the processing of the data very slow. At this time only the 1999 data are available.

WP 2: Sentinel surveys 1995-2000: catch per unit effort in NAFO Divisions 2J3KL

D. Maddock Parsons, R. Stead and D. Stansbury

Sentinel enterprises continued to provide catch rate and biological information on inshore cod resources in 2J3KL for 2000. Data were presented as weekly average catch rates and annual relative length frequencies: number of fish at length divided by amount of gear for each set and averaged by year and gear type, grouped by division. With few exceptions, average catch rates were lower in 2000 than in 1999 in all gears fished. Catches in 2J have remained very low since 1995 with only the 3 ¼” gill net showing catches comparable to other areas. 3K catches from gill net, line trawl and hand line have declined in 2000. Line trawl catches in 3L for 2000 are similar to 1999 results, but gill net catches are down for 5 ½” mesh. The small mesh gear in 3L shows an increased catch of small fish compared to 1999.

Discussion – J. Brattey

There has been a reduction in the amount of linetrawl fished in the sentinel program. This may be because this gear doesn’t mix well with a commercial fishery comprised mainly of gillnets. As a result the amount of effort for this gear within the sentinel program has become quite low and this may affect the reliability of the catch rates for linetrawls.

The sentinel catch rates may be affected in some cases by the timing of the arrival of fish. If they move into an area after the sentinel program is finished for the year then the catch rate may be artificially low.

WP 3: Description of the 2000 fishery for 2J3KL cod

L. Yetman

The TAC for the 2000-01 fishery was 7000 t. The fishery was managed on the basis of individual quotas, IQ’s, with each eligible fisher having an IQ of 8400 lbs round weight. Fishing was restricted to a maximum of 6 gillnets with 5 ½ - 6 ½ inch mesh <u>or</u> 2000 hooks. The use of cod traps was not permitted except by fishers involved in cod growout. To protect any recruitment in the offshore fishing was not permitted outside 12 miles. Provision for Observer coverage and 100% Dockside Monitoring was required There were two open periods, June 26 – July 29 and September 11 - November 30

Participation

DFO restricted access to 2J3KL cod by shrimp vessels in 1999 and 2000. 286 vessels licensed to participate in the shrimp fishery were not eligible for cod.

Core, Level 1 and Level 2 professional fishers holding groundfish licenses and a small number of apprentice fishers were permitted to participate in the fishery.

2J3KL GROUNDFISH LICENCE HOLDERS JULY 2000					
NAFO	CORE	LEVEL 2	LEVEL 1	APPRENTICE	TOTAL
2J	168	27	4	7	206
3K	995	269	20	19	1,303
3L	1,231	202	17	10	1,460
Total	2,394	498	41	36	2,969

Total number of fishers eligible to Participate = 2683

Total number of fishers who Participated = 2007

A Total catch of 4648t representing 66% of TAC was harvested. Approximately 95% of commercial catch was taken by Gillnet. As expected fishers experienced good catches in Trinity and Bonavista Bays accounting for approximately 52% of the catch. With the exception of the Area around Fogo few fishers in other areas were successful in taking their IQ.

Cod Landings (mt) by Geographic Area and Fleet Sector

LANDINGS (T) BY AREA BY VESSEL SIZE			
AREA	< 35’	35-64’	TOTAL (MT)
Labrador	11		11
White Bay	90	6	96
Notre Dame Bay	1,168	61	1,229
Bonavista Bay	1,171	104	1,275
Trinity Bay	944	178	1,122
Conception Bay	344	28	372
Southern Shore	350	33	383
St. Mary’s Bay	114	32	146
Other	14		14
Total	4,206	442	4,648

Catch Range by Number of Fishers

CATCH RANGE	Number of Fishers
< 1000 LBS	355
1000 - 2999 LBS	336
3000 - 4999 LBS	261
5000 + LBS	1055
Total	2007

A number of issues were identified as problems following the fishery:

- Seals and their impact on stock rebuilding.
- Dockside Monitoring not available at all times/areas in Labrador resulting in difficulty with reporting.
- Requirement to remove nets from the water considered to be a serious safety issue by fishers.
- Low TAC and subsequent low IQ's limited participation in other groundfish fisheries since once the IQ was taken then all other groundfish fisheries were closed to the fisherman. This may lead to discarding.

Management Measures

Fishers with a homeport in Bonavista Bay or Trinity Bay (Cape Freels to Grates Point) were only permitted to fish north of a line drawn due east from Grates Point at 48 degrees 10'N.

Fishers with a homeport in Conception Bay, Southern Shore or St. Mary's Bay (Grates Point to Cape St. Mary's) were only permitted to fish south of a line drawn due east of Grates Point at 48 degrees 10'N.

Fishers with a homeport in Daniel's Cove or Old Perlican in Trinity Bay, were also permitted to fish that portion of Western Conception Bay situated between Grates Point and Bay-de-Verde.

Fishers with a homeport in Grates Cove, Red Head Cove or Bay de Verde in Conception Bay, were also permitted to fish that portion of Eastern Trinity Bay situated between Old Perlican and Grates Point.

No fishing outside 12 mile limit

Smith Sound restricted to resident fishers

Maximum 6 nets or 2000 hooks

Mesh size: Min 5 ½ , Max 6 ½ inch mesh

Remove gillnets from water 6 pm Saturday to 6 am Monday.

Once IQ harvested all other groundfish closed to harvester**.**

Recreational Cod Fishery

Season August 25-27,
September 02-04,
September23-24

Participation/Catch

An average of 24,000 people, island wide took part in the fishery each weekend, compared to a weekend average of 10,000 in 1999. Total catch for 2000 was 872 tons. The total catch for 1999 was estimated at 400 tons.

The ability of people to catch the daily ten-fish limit varied by day as well as by area. During the first weekend a significant number reached the daily limit, except for the first day of fishing.

On the second weekend success was limited due to two days of bad weather. On the third day approximately half the fishers reached the daily limit.

Fish size throughout the province was primarily small, ranging in size from 1 – 3 pounds. In isolated locations fish were somewhat larger, 3 – 8 pounds.

Three Weekend Totals

Area	**Total Activity Observed/estimated**		**Checks Conducted**		**Estimate of Fish Per person**		**Total Catch Observed/ Estimated Round mts.**
	Vessels	**Fishers Per Boat**	**At Sea**	**Port**	**Average # Per person**	**Avg Weight Per fish**	
2J+3K	5,043	3.5	1,072	169	4	2.5	80mts
3L	9,621	4	506	628	6	4	418mts
3PSN	6,181	3	1,214	622	6	5	251mts
4R	3,756	3	1,178	425	6	4	123mts
All	24,601	3	3,970	1,844	5.5	4	872mts

Discussion – J. Morgan

The 4650 t caught does not include the food fishery or sentinel catch.

It is possible that because of the summer closure the 4650 t is not a reflection of the abundance of the fish in the population.

There was movement of people, but within the restrictions set in the management plan, to different areas to catch fish. Bigger boats moved in to Smith Sound in the fall. There was also movement of southern shore fishers to St. Mary's Bay.

The restriction on movement of fishers from southern 3L into Trinity Bay is probably one of the reasons the quota was not taken.

WP 4: An age disaggregated index from the sentinel program for cod in NAFO Divisions 2J3KL

D. E. Stansbury, D. Maddock Parsons and P. A. Shelton

An age disaggregated index of abundance was derived from both the gillnet and linetrawl sectors of the sentinel survey in NAFO Divisions 2J3KL. A generalized linear model was applied to the catch and effort data at age for each gear and survey method with an assumed Poisson distribution for catches.

Discussion – P. Shelton

The model does not include fish older than age 10 as they do not appear much in the data. Also there are various vetting criteria in order to attempt to reduce the effect of gear not being fished in a standardized way. This results in the removal of as much as 40% of the data.

There was also some concern about residual patterns. It was decided that the model should be rerun using a negative binomial distribution of the data and that for both distribution types there should be plots of residuals (raw, deviance, chisquare) by different category (e.g. community) to further explore model fit. Particular attention should be paid to possible age*community interactions.

WP 5: 2J3KL fish harvester committee questionnaire (2000)

H. Jarvis and R. Stead

The Fish Harvester Committee at each Sentinel site (55) in 2J3KL was asked to participate in the completion of the questionnaire. All committees participated and a total of 258 Fish Harvesters had input.

With the exception of parts of Bonavista – Trinity – and St. Mary's Bays, commercial catch rates during 2000 were average to low and were about the same as or lower than those of 1999. Cod abundance is lowest in the North with the areas of highest abundance being Bonavista Bay, Trinity Bay and St. Mary's Bay. Sounder recordings of cod (overall) were about the same as or less than those of 1999. The presence of baitfish varied greatly by area. Cod condition and signs of recruitment (overall) were good.

Fish Harvester Committees suggested that warm water, bad weather and the 2000 Conservation Harvesting Plan contributed negatively towards overall catch rate results.

Discussion – R. Stead

The responses by a community to the questionnaire are the consensus of the committee.

Catch rates were reported to be lower in 2000 and this may be at least partly the result of an industry imposed closure in August, a time when many fishers expected fish to be plentiful in their area.

A useful addition to the questionnaire would be questions that attempted to determine if there were changes in the distribution of fish from year to year. In particular questions about the seaward distribution of the fish may be able to help determine if changes in local density are related to abundance or perhaps to a wider distribution of the same number of fish.

WP 6: The Petty Harbour fishery

T. Best

A history of the Petty Harbour cod fishery was presented as well as views on factors which have contributed to the current status of northern cod. In the view of the participants in the Petty Harbour sentinel program a number of factors led to the northern cod moratorium. These were: 1) the introduction of the offshore dragger fleet; 2) the fishery policy and harvesting technology introduced as a result of recommendations by the Kirby Task Force; 3) measures that allowed the processing of small skin-on cod products; 4) development of a fleet of inshore draggers and mobile gill-netters.

In the opinion of the participants there are a number of factors which have prevented recovery. Some of these are: 1) allocation of quotas; 2) predation by seals and competition from whales; 3) cod by-catch policy which allows fish harvesters to land and sell cod by-catch; 4) allowing fishing beyond traditional adjacent fishing areas.

A number of management measures which, in the opinion of participants, would support the recovery of northern cod were also suggested.

Discussion – J. Morgan

The role of science is not so much concerned with advising on how, where or at what age fish are caught but on the impact of removals on the population.

There are issues in the management of the fishery that may affect the interpretation of data for example an increase in effort producing the same catch. Gear competition/interference for the sentinel fishery when a commercial fishery is in progress may affect catch rate.

Petty Harbour sentinel fishery participants would suggest a management regime that restricts people to even smaller areas than the current management plan.

WP 7: Quality of Newfoundland region cod age determination.

H. F. Hicks, G. Cossitt and C. Hiscock

An outline of methods used to assess precision of aging and records of precision from1978 to 2000 were presented. The result of a validation exercise involving early otolith collections (from 1978 to 1982) read by the 1998 ageing workgroup was documented. The aim of this exercise was to keep individuals interpreting ages of cod otolith samples in the Newfoundland Region at an 80% or greater agreement level with modal ages. The current ageing workgroup is maintaining a good standard. Consistent ageing and monitoring of this ageing is ongoing. Informal exchange of difficult otoliths continues at all times and as time permits more extensive monitoring of ageing involving other cod ageing groups will occur.

Discussion – D. Stansbury

Otolith reading is the internationally accepted method of ageing cod. There have been some attempts at otolith exchanges with other labs to do more work on assessing the accuracy of ageing in this region but there have been no exchanges to date. It may be useful to attempt exchanges with European countries where cod ageing is also being done. The work that they are doing on ageing should also be reviewed to see if there is anything helpful for the program here.

WP 8: Stock structure and movements of Atlantic cod (*Gadus morhua*) in NAFO Divs. 2J+3KL based on tagging experiments conducted during 1999-2000

J. Brattey, D. Porter and C. George

A large-scale tagging study of adult (>45 cm) Atlantic cod (*Gadus morhua*) in Divs. 2J+3KL, initiated in spring 1999, was continued. During 2000 a total 3,417 cod were tagged with single, double, or high-reward t-bar anchor tags and released at various inshore locations off the east and northeast coasts of insular Newfoundland and southern Labrador. A total of 205 tagged cod (5.9%) were reported as recaptured from 3KL during 2000 from recreational, sentinel, directed commercial and by-catch fisheries. There were no recaptures from cod tagged in 2J. The results from 2000 are consistent with other post-moratorium northern cod tagging studies and indicate that the inshore of 3KL is inhabited by (1) a northern resident coastal group of cod that occupies an area from western Trinity Bay northward through Bonavista Bay, the Fogo-Twillingate area, to western Notre Dame Bay, and (2) a migrant group from inshore and offshore areas of 3Ps that moves into southern 3L and more rarely northern 3L and 3K during late spring and summer and returns to 3Ps during fall. The contribution of offshore northern cod to the inshore fishery in 3KL during 2000 remains unknown.

Discussion – C. Darby

There were fewer fish tagged in Div. 3KL in 2000 because it proved difficult to find bodies of fish to tag. Many of the fish caught on the eastern Avalon seem to come from Subdiv. 3Ps since most of the tags returned from the fishery in that area had been tagged in Subdiv. 3Ps. There have been no tags recovered offshore but there is very little cod catch in the offshore of Div. 2J3KL.

Since most of the fishery is conducted with gillnets and this gear is fairly size selective then tagged fish that are above or below this size range may not be subject to much fishing pressure. The return rates for fish may be affected as they grow beyond the size range of this gear.

WP 9: Sentinel surveys 1995-2000: catch per unit effort summarized by commercial logbook area

D. Maddock Parsons and R. Stead

For information purposes only. Not presented or discussed.

WP 10: Cod in NAFO Divisions 2J+3KL; catches and bottom-trawl surveys. Part 1. Bottom-trawl surveys: abundance/biomass and distribution

G. R. Lilly, P. A. Shelton, J. Brattey, N. G. Cadigan, E. F. Murphy and D. E. Stansbury

Autumn surveys

Abundance/biomass: Research vessel surveys have been conducted by Canada during the autumn in Divisions 2J, 3K and 3L since 1977, 1978 and 1981 respectively. The survey stratification scheme is based on depth intervals intersected by lines of latitude and longitude. The survey in 2000 was similar to those conducted during the previous 5 years, with the exception that the inshore strata in 3K and 3L, which were not fished in 1999, were fished once again in 2000. A few strata in both 3K and 3L were either not fished or received only 1 set.

Because there have been changes over time in the depths fished, annual variability in the abundance and biomass of cod has been monitored for those strata that have been fished most consistently since the start of the surveys. These "index" strata are those in the depth range 100-500 m in Divisions 2J and 3K and 55-366 m (30-200 fathoms) in Division 3L. The inshore strata fished in 1996-1998 and 2000 are not included in the index.

Changes in abundance and biomass in the offshore index strata were presented by Division for the years 1983-2000. Values for 1983-1994 are based on Engel trawl catches converted to Campelen equivalents and values in 1995-2000 are based on actual Campelen catches. The patterns in abundance and biomass differ in detail, reflecting changes in the relative abundance of small and large fish. Of note are the positive anomaly in 2J and 3K in 1986, the very large increase in 3K in 1989 and the rapid decline during the early 1990s. Abundance and biomass have remained at extremely low levels in all Divisions since 1993.

Abundance in offshore index strata declined from 1995 to 1997 and increased from 1998 to 2000, with the largest increase occurring in 1998-1999. Biomass in offshore index strata increased from 1995 to 1997, remained unchanged in 1998, increased substantially in 1999 and increased a little in 2000. The biomass in offshore index strata in 2000 was about 30,000 t, which is about 2.5% of the average biomass of 1,200,000 t (in Campelen equivalents) in the period 1983-1988 (excluding the high value in 1986).

Abundance and biomass estimates were also presented for the new inshore strata in 1996-1998 and 2000.

Distribution: Commencing in 1989 the fish in Divisions 2J and 3K became increasingly concentrated toward the edge of the bank. By 1991, concentrations on Hamilton Bank and the plateau of Grand Bank disappeared, leaving fish in inner Hawke Saddle and in the saddles between Belle Isle Bank and Funk Island Bank and between Funk Island

Bank and Grand Bank. In 1992, only the concentration between Funk Island Bank and Grand Bank remained. This concentration was smaller in 1993 and disappeared in 1994. During 1995-2000 catches were very small. On the southern Labrador Shelf and the Northeast Newfoundland Shelf the larger catches were broadly spread, with a tendency toward occurring off the banks. In Division 3L, catches tended to be small in 1995-1998, but somewhat larger and more broadly distributed in 1999 and 2000.

Previous work on the distribution of juvenile cod in Divisions 2J3KL has revealed that individuals of ages 0 and 1 were found mainly in shallow waters near the coast off southern Labrador and northeastern Newfoundland and on the northern Grand Bank, that individuals of ages 3 and 4 were mainly in those offshore areas occupied by older cod, and that individuals of age 2 were intermediate in distribution. Catches from autumn surveys in 1995-1998 have revealed a similar pattern, with the notable exception that the 1994 year-class, which has been the strongest year-class appearing in the surveys since at least the early 1990s, was already well onto the shelf by age 1. More recent year-classes have been extremely weak in Division 2J, but have been somewhat more abundant adjacent to the coast in Divisions 3K and 3L.

Catch-at-age: The divisional mean number of cod caught at age per tow in offshore index strata during autumn surveys from 1983 to 1994 have been converted to Campelen equivalents and were presented along with the actual Campelen data from 1995-2000 for Divisions 2J, 3K and 3L separately and for all three Divisions combined. Mean catch per tow has continued to be very low for each age in each Division during the past few years when compared with many years in the 1980s and early 1990s. An increase in the abundance index from 1998 to 1999 occurred in 3K and 3L but not in 2J. The index was higher in all Divisions in 2000 compared with 1999, but was still far below levels seen prior to 1993.

The overall 2J3KL catch at age 1 in 2000 was similar to that in 1995, indicating that the 1999 year-class may be comparable to the 1994 year-class, which has been recognized as the strongest in the offshore since the early 1990s. The 1994 year-class was well represented in 2J and 3K, but not in 3L, whereas the 1999 year-class was weaker in 2J, of comparable strength in 3K, and stronger in 3L.

The mean catch at age per tow was presented for the inshore strata of 3K and 3L separately.

Spring surveys

Distribution: During the second half of the 1980s the spring distribution in Division 3L was similar to that observed during the autumn, in that the highest densities were generally on the plateau of the bank and along the northern and northeastern slopes of the bank. Catches declined during the early 1990s, and by 1995 very few cod were caught. Catch rates increased with the introduction of the Campelen trawl in 1996, but have remained far below the levels in the 1980s. In 1999 there was a hint, for the first time in many years, of a continuous distribution of cod from the southwestern part of 3O across the 3L/3NO boundary into the area of the Virgin Rocks. In 2000 cod were caught from the southernmost part of the Northeast Newfoundland Shelf in northern 3L along the northeastern slope of Grand Bank and on the Nose of the Bank. Small catches were also taken on the plateau of Grand Bank and in the Avalon Channel.

Catch-at-age: The mean number of cod caught at age per tow in index strata during 3L spring surveys from 1985 to 1995 have been converted to Campelen equivalents and were presented along with the actual Campelen data from 1996-2000. Mean catch per tow declined precipitously in the early 1990s. There were increases in both 1999 and 2000, but values continue to be well below levels obtained prior to 1993.

Part of the increase in total catch per tow in 1999 and 2000 was due to the strength of the 1998 and 1999 year-classes, both of which were stronger at age 1 than the preceding 3 year-classes. In addition, catch per tow increased from 1999 to 2000 for each of the 1996 to 1998 year-classes, indicating either a year effect in the survey or immigration into the 3L survey area. On the other hand, catch per tow of fish older than age 6 declined from 1999 to 2000.

Tobins Point and Nose of Grand Bank

There are indications from several sources of a recent build-up of cod in Division 3L, particularly in the Tobins Point area, which is toward the shelf break near the 3K/3L boundary. Plots of the distribution of cod during spring and autumn bottom-trawl surveys in southeastern 3K and eastern 3L in 1995-2000 reveal spotty catches throughout the period, and an increase starting at least as early as autumn 1999.

Discussion – P. Winger

The survey gear used in the DFO autumn and spring surveys changed in the fall of 1995. Extensive comparative fishing was conducted in order to convert the data collected with the previous fishing gear to 'Campelen equivalents'. These fishing trials were conducted during a period of low abundance, especially of large fish. Low sample size for the large fish has produced greater uncertainty about the conversion for large fish.

The slight increasing trend in biomass in the autumn survey could be recruitment or perhaps immigration.

WP 11: Cod in NAFO Divisions 2J+3KL; catches and bottom-trawl surveys. Part 2. Bottom-trawl surveys; size-at-age, condition and maturity

G. R. Lilly, P. A. Shelton, J. Brattey, N. G. Cadigan, E. F. Murphy and D. E. Stansbury

Size-at-age

The lengths-at-age and weights-at-age of cod sampled during the autumn surveys confirm the general pattern of a decline in the 1980s and early 1990s as observed in commercial weights-at-age. The research survey data illustrate that the changes varied with Division; there was a strong decline in Division 2J, a lesser decline in Division 3K, and little or no decline in Division 3L. Superimposed on the long-term decline are periods of relatively quicker or slower growth associated with changes in water temperature. The trend toward low mean lengths-at-age and weights-at-age in the early 1990s appears to have been reversed during the latter half of the 1990s. However, size-at-age declined again at some ages, particularly in 3L, from 1999 to 2000. Sample sizes at ages greater than age 4 have been very small since about 1992-1994, so the accuracy of these estimates is likely to be poor.

Condition

Condition was expressed as W/L^3, where W is either the gutted weight of the fish or the liver weight, and L is the length. Arithmetic means by Division, year and age were presented for gutted condition and liver index.

In Division 2J, both gutted condition and liver index declined in the early 1990s. During the second half of the 1990s gutted condition returned to approximately normal, whereas the liver index improved but did not fully recover. There is evidence of a decline in condition, particularly in the liver index, in 2000.

In Division 3K, gutted condition declined during the early 1990s and improved during the latter half of the 1990s. Liver index changed little during the 1990s. As in Division 2J, there is evidence of a decline in condition, particularly in the liver index, in 2000.

In Division 3L, gutted condition has remained relatively unchanged over time whereas liver index increased considerably in the early 1990s and has since declined to an intermediate level.

The cause of the decline in condition in 2J and 3K in 2000 has not yet been examined. Historic trends in condition indices are complex and poorly understood.

Maturity

Proportions mature at age were calculated for female and male cod in divisions 2J3KL combined from 1982 to 2001 based on sampling conducted during autumn bottom-trawl surveys in 1981 to 2000. These proportions were used in a probit model fitted with a logit-link function to provide estimates for A50. In the early portion of the time series from 1972 until the mid to late 1980s the A50's were higher and fluctuated irregularly between 5.8 and 6.2 for females and 4.8 to 5.3 for males. From the mid to late 1980s until the mid-1990s the A50's declined in both sexes. The A50's for females varied considerably in the past decade.

Age at 50% maturity was also calculated for females by year-class. A decline in 50% maturity occurred between the year-classes of the mid-1980s and those of the late 1980s. Year-classes born in the 1990s tended to mature about one year earlier than those born prior to the mid-1980s.

Discussion – J. Morgan

There have been quite dramatic changes in length at age over the time period and these could affect catchability of the survey gear. However, a bigger effect has probably been the change in survey gears. Length-based conversions of the Engel survey series of mean numbers per tow have been done. Estimates of length, weight and maturity at age have not been recalculated using the converted length frequencies.

There isn't a long enough time series of information to determine whether there have been similar trends in length at age and weight at age in the inshore as in the offshore. Fishermen in the inshore are reporting that the fish they saw in 2000 were in good condition.

The method of calculating maturities by cohort does not produce estimates for all ages in the current year. A method is being developed for producing these estimates.

There have been similar declines in maturity at length as there has been in maturity at age.

The fecundity of fish may be affected when they are in low condition but there is little information to produce any time series. There is however a lot of information on liver index and this may be related to potential fecundity. It would be useful to examine what fecundity data there are for a relationship with liver index.

WP 12: Scientific publications discussing northern (2J+3KL) cod

G. R. Lilly

For information purposes only. Not presented or discussed.

WP 13: Relative strength of the 1999 and 2000 year-classes, from nearshore surveys of demersal age 0 & 1 Atlantic cod in 3KL and Newman Sound, Bonavista Bay

R. S. Gregory, B. J. Laurel, D. W. Ings and D. C. Schneider

From 1959 to 1964 and 1992 to 1997 (i.e., 1990s), demersal age 0 Atlantic cod (*Gadus morhua*) in the nearshore (<10 m deep) were surveyed by seine from St. Mary's Bay to Notre Dame Bay, Newfoundland during the Fleming survey, conducted annually in September and October. In the absence of a coastwide Fleming survey in 1998-2000, we conducted a qualitative assessment of the strength of the 1997-2000 year-classes. Our assessment was based on abundance of demersal age 0 and age 1 Atlantic cod sampled at 6 - 13 nearshore sites in Newman Sound, Bonavista Bay in five summer-autumn periods during 1995-2000. Sampling techniques and collection dates for the Fleming survey and Newman Sound study were similar. Therefore, cod abundances in the two studies were comparable, albeit at different geographic scales. Abundance trends of age 0 and 1 cod covaried between the studies in 1995 and 1996, when both were conducted concurrently, suggesting that abundances of juvenile cod in Newman Sound mirrored those observed in the spatially broader Fleming survey. In 1997, age 0 abundance in the Fleming survey was the highest observed in the 1990s, leading to the prediction that age 1 cod would be high the following year. High age 1 abundance in 1998 compared to 1995 and 1996 in Newman Sound supported this prediction. Compared with the historical low in 1996 observed in both studies, age 0 abundance was 10 times higher in 1998 and 40 times higher in 1999. These results suggest that the 1997, 1998, and 1999 year classes should be strong compared to those in 1995 and 1996.

Analysis of length frequency data collected from July to November in Newman Sound indicated that age 0 Atlantic cod settled in the nearshore in two distinct recruitment pulses in "good years" - i.e., 1998 and 1999 - the first pulse arriving in early August, the second in late September. In "bad years" - i.e., 1995 and 1996 - only the second of these pulses was evident. The length frequency data also suggest that the pulse structure may remain intact through the first winter and appears to be detectable in age 1 cod the subsequent year. In 2000, we predicted that the 1999 year class of Atlantic cod will prove to be the strongest since the 1992 moratorium. Catches of the 1999 year class in 2000 as age 1 fish, support this prediction. Age 1 Atlantic cod in Newman Sound in 2000 were the highest we have ever recorded at these sites. In contrast to 1997-1999, we anticipate that the 2000 year class will be weak, based on nearshore densities of age 0 Atlantic cod in Newman Sound. Densities of age 0 Atlantic cod were consistently low throughout much of the season, and were comparable to 1996, the poorest year class on record in three independent surveys of age 0 abundance off the northeast Newfoundland coast.

Discussion – G. Rose

The beach seine is very efficient for age 0's but less so for age 1. This may mean that age 0 data would be a better index of recruitment.

There is some question of how representative the Newman Sound area could be of recruitment in the entire Div. 2J3KL area. In years when surveys were done on a much wider geographic scale, the index in this area seemed to track the overall index.

There may be saturation of available habitat in the nearshore which would limit the usefulness of an index derived in this area. The catch rates in the 1960's when recruitment was thought to be high were not much different from those of the early 1990's when recruitment was thought to be very low.

Discussion of method to produce a recruitment index

The model used last year was described. There was some concern over the inclusion of such a wide variety of indices, many of which had not been examined on their own in any detail. It was decided to attempt to derive a recruitment index from catch rates series of juvenile (ages 0-3) cod from various studies, as was done the previous year. It was also decided to include the beach seine series from Newman Sound, Bonavista Bay and to include data from the spring 3L research vessel series. The various series start as early as 1991 and have continued anywhere from 4 to 6 years. Six of the twelve series used in the analysis are still ongoing.

To evaluate the validity of the model it was decided to plot residuals for each index across years. Also a 'leave one out' approach would be used where indices would be dropped to test the sensitivity of the analysis to specific indices.

WP 14: A charmingly simple migration model

J. Pope

A model of tag recaptures based upon a simple model of migration and harvest was proposed at the 1999 assessment of northern cod and a pragmatic spreadsheet minimization was used to provide harvest rate and proportionate occurrence estimates from available tag return data. This year it was possible to describe the solution in more formal matrix algebra terms and this allows insight into the solution.

While this model ignores many practical problems, such as fish size and gear selection, the simplicity of the model allows insights into the estimation process which may illuminate problems in more detailed estimation approaches and provides simple estimates of harvest rates which can be used to judge if more detailed models are broadly on track.

Discussion – P. Shelton

This model is much simpler than a fully parameterized model accounting for growth and truly accounting for migration. However this may be a simpler model to think about and hence make the more complicated model easier to understand.

The level of tagging in 2000 is a problem but was unavoidable as there were few large aggregations of fish located to tag in Div. 3K.

There is some indication of a high return rate in the first year which then tails off faster than you would expect in the next year. This may be because of high mortality or because the fish are going somewhere where they are not caught. It is probably not going to be possible to separate the two.

It was decided that this model should be updated using the most recent data.

WP 15: Some preliminary analysis of tagging data

N. G. Cadigan

The basic model described was similar to that used to analyse the returns from cod tagging experiments in 3Ps and 3KL in the 2000 northern cod RAP. The model was modified in two aspects. The first modification was that, although the model did not explicitly allow for migrations of tagged fish out of "exploitation regions", the size of the tagged population available to the fishery was adjusted by all previous fishing mortality in all exploitation regions. In the 2000 RAP the size of the tagged population available to the fishery was adjusted for only that fishing mortality that occurred in the region of release. The current model essentially allows for migration of only those tagged fish that are captured outside of the release region, which is a "minimal migration model". The second modification was that some limited smoothing was used when estimating the weekly exploitation rates. This involved local kernel estimation using essentially a five-week smoothing neighbourhood.

Discussion – P. Shelton

There was a significant decrease in reporting rate in 3L north in 2000. It is not known why this would be the case but it may be related to catch levels or it could be an artefact.

There was considerable concern that the selectivity patterns estimated for the various gear types are domed. This may be a result of the functional form chosen for the estimation. This domed selectivity can result in large estimates of population size for large fish.

It was decided to update the model as described with the current data. Also it was suggested that other means of estimating selectivity be examined.

WP 16: Smoothing length frequency data via kernel density estimation

B. P. Healey and N. G. Cadigan

Kernel smoothing was applied to fill 'gaps' in the length frequency sampling, to smooth both time and length variations in sampling. By predicting weekly sample proportions, we can make direct inferences on how the fishery was prosecuted when no length sampling data are available to indicate the true fishery dynamics. When coupled with catches and tagging data, predicted length frequencies enable the estimation of weekly exploitation rates. Kernel density estimation allows prediction of a sample proportion for each length class for each week in 1998-2000, for all gear types and regions which have sampled length frequencies.

Discussion – J. Morgan

There were patterns at the boundaries which do not appear to be reasonable. This may be because at these points the 2D smoother only has data on one axis to use. This could also be the result of data with 2 modes in the length frequencies (e.g. gillnets of 2 different mesh sizes).

The time band used (week) may be too small given the amount of sampling and this should be investigated.

The residuals were small but there were patterns. The patterns may be a result of boundary effects.

WP 17: Status of the Smith Sound cod January 2001.

G. A. Rose

A dense and relatively large spawning aggregation of cod was first observed in Smith Sound, Trinity Bay in the spring of 1995. Since that time several acoustic surveys have been attempted. In the present report a survey method was developed that can be completed in 12 hours (including data collection and analyses) and that requires minimal fishing. Surveys conducted in April 2000 and January 2001 were described in detail.

April 2000 indicated a biomass of 21-38 Kt. (4 surveys). January 2001 indicated a biomass of 24-37 Kt (4 surveys). These results are compared with earlier surveys and more complex analytical methods. There was no significant difference in the biomass indicated using the different methods (1999 and 2000 surveys analyzed 2 ways). Comparisons of survey results back to 1995 suggest that variable fish distributions make attempts to develop a biomass index from surveys from June to December problematic. However, the January surveys show promise. Overall, accounting for seasonal differences, it appears that the biomass remained relatively stable from 1995-1998, but since then has increased, largely as a consequence of self-recruitment of the 1995, 1996, and 1997 year classes. The 1990 and 1992 year classes are still present in relatively large numbers.

Discussion – W. Brodie

It was suggested that similar densities of cod were not present in Smith Sound prior to 1995, based on observations of fishers and researchers. However, some fishers thought that cod increased in this area earlier than 1995, most likely after 1989. There were no surveys in this area prior to 1995. However, there was research on spawning of cod prior to 1995 and many passes over the Sound had been made by experienced observers using the Simrad echosounder on the Shamook (the same sounder by which the so-called "discovery" was made in April 1995. Prior to the discovery no large aggregations of cod had been observed.

There was considerable discussion on the origin of the fish in Smith Sound. It was proposed that the year classes present in the current population may have been spawned by the Smith Sound fish (self-recruitment) and that it was possible (although certainly not proven) that a portion of the original spawning stock may have come from 3Ps. This hypothesis was not consistent with other information, such as sentinel data on the strength of the 1990 and 92 year classes, and that there were other explanations for the origin of the Smith Sound fish. As well, tagging indicates that there is little or no mixing of adult fish from Placentia Bay and Smith Sound. This is an important issue related to possible recolonization and capacity of fish to repopulate areas in 3K and north. The reasons for the increase in abundance of cod in Smith Sound, along with the origin of these fish, remain as open questions.

WP 18: What is the spatial ontogeny of groups known to be spawning in Trinity Bay, Hawke Channel, and Bonavista Corridor/Tobin's point?

G. A. Rose

There are several conceptual models of fish distribution and ontogeny of movement patterns for 2J3KL cod (back to Templeman and Lear). The most accepted model assumes that there are coastal spawning groups that self recruit, and potentially much larger shelf groups whose juveniles are concentrated in the coastal region until age 2 or thereabouts then migrate seaward at age 3-4 and adapt to the migratory life history of their parent population (or the closest population). Recent observations both in the coastal and shelf regions raise many questions about this model and others. Known spawning groups of cod in Trinity Bay, the Bonavista corridor and Hawke Channel show different characteristics in the 1990s. The Trinity Bay group has grown and appears to be self recruiting with biomass in January 2001 approximately 30,000 t. The Hawke group has declined since 1994 to levels of approximately 5,000 t. Older fish (5+) are suffering high mortality or outmigration but age 2-3 cod "appear" suddenly here between January and June. Condition has declined since 1999. Age at maturity is very low (ca. 4 for females). A similar but less observed situation appears to be occurring the Bonavista corridor, where biomass has increased in the past 2 years (June 2000 estimate of 10,000 t). Again, cod are first observed at ages 2 or 3 and there origin is unknown. A genetic-ecological study is underway to try to determine the origin of these fish and their ontogeny.

Discussion – W. Brodie

The author noted that these were his "musings" on small spawning aggregations of cod in Trinity Bay, Hawke Channel, and Bonavista Corridor/Tobin's Point. At present, it is impossible to understand the comings and goings of these groups of fish based on the available data and limited number of observations. The importance of determining the origins of the fish in the coastal and shelf regions was stressed.

It was noted that the presence of fish in the Bonavista Corridor in 2000 was consistent with observations of by-catch in the turbot fishery. The origin of these fish is uncertain and further genetics studies are planned. Further studies of the Bonavista Corridor and the other areas are also planned in the next 4 years.

WP 19: Performance of the Campelen 1800 shrimp trawl during the annual bottom trawl surveys of 2J+3KLMNO, 3Ps and 3LNO, 1995-2000

B. R. McCallum and S. J. Walsh

In 1995, the Northwest Atlantic Fisheries Centre adopted the Campelen 1800 shrimp trawl as it's standard bottom trawl gear to replace the Engel 145 High-Lift otter trawl used onboard the research vessels Wilfred Templeman and Teleost. Trawl performance data are recorded for all fishing sets during each survey using SCANMAR acoustic trawl instrumentation. This paper presents an analysis of the performance of the Campelen 1800 during the 1995 to 2000 annual fall surveys of NAFO divisions 2J+3KLMNO and the 1996 to 2000 spring surveys of 3PS and 3LNO. There was a statistical difference in trawl geometry between research vessels and between surveys conducted with the same research vessel in different years. Trawl geometry i.e., wing spread, door spread and vertical opening is more variable on the Wilfred Templeman than on the Teleost even when standardized for maximum depth fished. However, some of this variability may be due to the fact that the Templeman fishes more in shallow waters than the Teleost. The doorspread of the Teleost is significantly wider than that of the Wilfred Templeman and the impact on herding and catchability of groundfish can only be speculated. Analysis of tow duration between both vessels has shown that the Templeman has a higher proportion of tows longer than the standardized 15 minutes. Some of this variability may be due to the Wilfred Templeman's inability to maintain vessel speed during haul-back resulting in longer on-bottom times. The standard practice is to adjust catches based on the ratio of actual tow duration/standardized tow duration, assuming that the trawl is moving and therefore fishing over the entire tow period. Inconsistencies in vessel speed during haul-back will impact calculations of swept area and abundance indices. Differences in survey gear performance between the two research vessels may be due to differences in horsepower, displacement and the trawl winches, and depth fished.

Discussion – D. Parmiter

The Teleost is a more powerful vessel in comparison to the Templeman. Door spreads and wing spreads were generally greater on Teleost than on Templeman. Gear performance was less variable on Teleost. Tow duration is longer on Templeman. There was considerable discussion on whether a correction should be made to adjust for these differences, i.e. a set by set standardisation to correct for these variations.

Many of the sets on the Templeman are consistently going over time (greater than 15 min.). This isn't the case with the Teleost. This is not the result of operator/crew error. Speed should be incorporated into the tow plot otherwise, the tendency would be to over estimate the area swept. This problem should be accounted for but only affects a low proportion of the total number of sets on the Templeman

It was recommended that a power lift –off should be emphasised for future surveys.

WP 20: Catch and catch at age

E. F. Murphy

Nominal catch. The commercial fishery on 2J+3KL cod was closed in July 1992. Reported catches in 1993-1998 came from bycatch and sentinel surveys (1995-1998) and estimates of catches during food fisheries (1994, 1996, 1998). The reported catch of about 4,500 t in 1998 came mainly (68%) from an inshore index fishery.

In 1999 the commercial fishery was re-opened with a TAC of 9,000 t in the inshore for vessels under 65 feet. Reported landings were approximately 8,000 t from the commercial fishery and 200 t from the sentinel survey, which together with the estimate of 235 t for the food/recreational fishery totalled approximately 8,500 t.
In 2000 a TAC of 7,000 t was established for an index fishery and sentinel surveys in the inshore for vessels under 65 feet. Reported landings were approximately 4,700 t from the

commercial fishery and 200 t from the sentinel surveys, which together with the estimate of 500 t for the food/recreational fishery totalled approximately 5,400 t. Landings increased from 2J (< 1% by weight) to 3K (27%) to 3L (73%). In 1999 landings in 3K had been 43% of the total.

When all sources of landings (index, sentinel and food/recreational) were combined, gillnets contributed 76% by weight, linetrawls 4% and handlines 18%. There was also a small catch from traps deployed in the sentinel surveys and a very small by-catch in the yellowtail fishery by large otter trawlers on Grand Bank (3L).

Catch-at-age

The total catch-at-age in 2000 comprised a range of ages, with ages 3 to 10 each contributing at least 5% by number and ages 5 and 6 most prominent. The 1992 year-class was considerably less prominent than it had been in 1999. The total catch at age in 2000 strongly reflects the selectivity of the gillnets, which tend to select ages 6 and 7 but caught roughly equal numbers of ages 5 to 8 in 2000. Hook and line gears caught cod of a wide range in age, with ages 3-5 most prominent in linetrawls and ages 4-5 most prominent in handlines. The trap catch was dominated by age 4 and the otter trawl by-catch by ages 3-4. The small size of cod in the otter trawl by-catch presumably results from the use of restrictor grates in the yellowtail fishery. Only 2% (by number) of the total catch in 2000 was older than age 10.

Discussion – J. Morgan

There was a slight shift in catch-at-age in 2000 to mostly age 6 while in 1999 the predominant age was age 7. The presence of the 1989 and 1990 year classes can still be seen in the fishery at ages 10 and 11, although at reduced levels.

Discussion of method to analyse commercial logbooks

The methods used in the last assessment to analyse catch and effort data from logbook were described. It was decided to follow these methods examining plots of mean and median catch rate and standardising the data using a generalised linear model. This was essentially the same model as the sentinel age disaggregated analyses without the age term: [log(u)=log(E)+month(site)+year]. Various residual plots would also be produced. It was decided that different gears should be analysed separately since the selectivities are very different.

WP 21: Consumption of Atlantic cod (*Gadus morhua*), capelin (*Mallotus villosus*) and arctic cod (*Boreogadus saida*) by harp seals (*Pagophilus groenlandicus*) in NAFO Divisions 2J3KL

G. B. Stenson and E. Perry

Consumption of prey by harp seals in NAFO divisions 2J3KL was estimated by synthesizing and integrating information on individual energy requirements, population size, distribution, and diet composition. Diets were estimated using reconstructed stomach contents collected between 1982 and 1986 to 1998, inclusive. Uncertainty in the estimates of numbers at age, diets, residency in 2J3KL and the proportion of seals in nearshore areas, was incorporated into the consumption estimates. Based on their average diet, Harp seals consumed an estimated 893,000 (682,000-1,100,000) tonnes of capelin, 185,000 (58,000-457,000) tonnes of arctic cod and 37,000 (14,000-62,000) tonnes of Atlantic cod in 2000. The proportion of cod in nearshore diets varied among years and seasons with a significant increase in cod present in the winter 1998 diet. Generally low levels of cod were present in offshore winter diets while no cod were present in the summer. Examination of the proportion of nearshore seal stomachs containing cod (prevalence), mean weights of Atlantic cod, Arctic cod and capelin in the stomach, and mean lengths of cod consumed, indicated that during the winter of 1998, the prevalence of Atlantic cod in harp seals was higher than average but not the highest documented. However, the mean weight of cod in stomachs and the length of cod consumed were greater than previously seen.

These estimates of consumption by harp seals were based upon a model very similar to that used previously. However, some changes have been made to improve the estimates. The equations used to estimate the lengths of Atlantic cod, American plaice, pleuronectidae and squid from hard parts were changed to reflect additional data and/or local equations that are more appropriate for the area. The previous estimate incorporated a 10% ‘correction factor’ for unidentified prey to account for biases associated with using hard parts to identify prey. Because the degree of potential bias associated with the consumption of soft bodied prey, the digestion of small otoliths, and belly biting could not be estimated, this correction factor was removed. The largest single change in the estimates was due to the removal of some offshore samples that were obtained from the vicinity of research vessels conducting surveys for cod. Comparing the species composition and size of prey found in the stomachs of seals obtained shortly after trawling occurred to the catches suggests that some of the seals may have been feeding on discards from the vessels. Therefore, all seals (n=11) collected in the vicinity of the trawler within 5 hours of fishing were removed. This is consistent with the removal of potentially biased samples from other sources and samples collected around trawlers in other studies (e.g. South African fur seals). As a result, the proportion of cod in the offshore diet was reduced.

Improvements in estimates of consumption can be achieved by further diet sampling in offshore areas and increased information on residency of seals of all ages in the area.

However, estimates will likely remain quite variable owing to the strong temporal and spatial changes in diet composition.

Discussion – D. Maddock Parsons

The problem of using only the hard bits in the stomach to reconstruct the diet is that certain fish are underestimated in the diet because of rapid digestion, for example, smaller fish species and invertebrates. For lumpfish, where it has been observed that only the roe is taken, underestimation is certainly a problem.

The prevalence of arctic cod in the diet appears high. Does this mean that there were more arctic cod inshore in the wintertime?

Seals will eat what prey types are available in an area and this raises the concern of large numbers of seals moving into Smiths Sound and consuming the cod there. However, there aren't millions of seals in Smiths Sound. There are observers in the area and samples of seal stomachs are being taken from that area. It is known that seals are feeding on cod concentrations inshore, but not in huge aggregations of seals. With respect to feeding after breeding, the males are not observed to feed until after the moult in mid-May, and the females feed for a short period before they moult and start to feed again after the moult.

The question of belly feeding on cod by seals was raised, and that the samples don't account for this. It was pointed out that of samples that were taken from animals observed to have been taking the bellies from cod also showed otoliths and hard parts, so cod was considered part of the diet in these samples. The question becomes is the proportion that you apply to the whole stock appropriate? Given that other components of the diet may be underestimated, it's unsure how much this belly feeding affects the proportion of cod in the diet as a whole.

It was pointed out that in instances where belly feeding is occurring, otoliths from fish up to 50 cm or so have been found, but the observations of this feeding mechanism suggests much larger fish (60-100 cm) are being subjected to mortality, and not being accounted for in the diet. The effects of this problem on the estimation of total consumption are uncertain. It would depend on the relative occurrence of belly biting versus the sampling bias. These large fish are not represented in the estimates of consumption at age. It was mentioned that these local events might be very important to the area in question. The point is that the weight of cod killed by seals is much higher than the weight consumed.

The main difference in calculation of these estimates was explained by the exclusion of some of the offshore diet from the estimates, due to suspicions of bias. The proportion of seal stomachs sampled in different areas has remained reasonably consistent in the last 3-4 years. There has been a difference in the size of cod eaten, they are larger fish and the proportion of stomachs with cod in them is higher.

With respect to the belly biting strategy, it seems that there were more incidents reported and seen in the media last year. Is this strategy being observed and reported this year? According to fishermen present in the meeting, evidence of this was seen, by sea urchin divers, for example, but reports probably were less because people feel it isn't worth the bother. There are observers and seal collectors in many areas and they aren't reporting any significant episodes this year.

It was decided to explore the sampling in 1998 to try to determine if the increase in cod consumption is a result of the seals or sampling (e.g. sample size by area, time). In addition it was decided to examine the prevalence of cod, capelin and arctic cod in 1998 relative to other years as well as the average weight of food in the stomachs over time.

Discussion of estimation of numbers of cod consumed at age

The model used in previous years was described. This model uses otoliths found in seal stomachs and total consumption estimates calculated from the seal consumption model. It was decided to apply the same approach as in 1999 using seal consumption estimates from1986-1998 and age-length keys from the research vessel surveys.

WP 22: Whole stock perspective: precautionary approach and risk of extinction

P. A. Shelton

The approach taken in the last assessment was reviewed and an alternative whole stock perspective was suggested. Under the whole stock perspective a B_{lim} would be determined below which there would, in keeping with a precautionary approach, be no directed fishing. Under the alternative of a functionally separate inshore stock component, the approach might be to apply a harvest rate of 10% (assuming this stock component is above B_{lim}). This is essentially the approach taken in the inshore over the last three years.

In addition to the whole stock perspective, "species at risk" aspects were considered. This requires a definition of the entity of concern. Concepts such as the distinct population segment, evolutionary significant unit or significant population unit were described. These terms define a population or group of populations that is substantially reproductively isolated from other conspecific units and represents an important evolutionary component of the species. Under COSEWIC cod in the Northwest Atlantic is considered to be of "special concern". Under the IUCN classification, northern cod could be considered to be "critically endangered" because of a more than 80% decline over 10 years or 3 generations. This does not seem appropriate for a population that continues to number in the millions. The appropriate criteria for classifying the risk status for the northern cod stock was discussed, in the context of the declines that have occurred in other cod stocks. In addition, a simulation study was carried out to investigate the amount of variability in spawner stock biomass that could be expected to occur in the absence of fishing. Natural variability in unfished populations can quite commonly lead to declines above 20% (vulnerable). In order to model extinction probabilities for stocks at low abundance, population viability analysis (PVA) and metapopulation analysis approaches were considered. A metapopulation is a set of local populations or subpopulations within some larger area (usually the population's range) where movement from one subpopulation to another subpopulation is possible. Subpopulations may not be genetically distinct although such differentiation is suggestive of the existence of metapopulation structure with low level of exchange.

Discussion – B. Healey and J. Morgan

There does not as of yet appear to be a generally accepted measure of 'risk of extinction' for marine fish species nor an accepted unit over which to assess this (i.e. species vs. populations vs. subcomponents). There has never been a documented case of an extinction of a marine fish species.

Measuring collapse as the largest decline in SSB over a 15 year period and recovery in relation to this decline does not appear to be useful. The largest decline is likely to occur when the population is just beginning to be fished (a time when you would expect there to be a decline in SSB) or at a time when the SSB is unsustainably high (e.g. during the gadoid outburst in the North Sea).

A whole stock perspective is an approach that should be considered but there are many questions as to how one should address this for northern cod. There is no single index that covers the entire stock area and it is thought that there have been changes in the proportion of the stock that is found within the area of the fall survey.

SESSION 2: SPECIES AT RISK AND STOCK STRUCTURE DISCUSSION

An afternoon session was devoted to a discussion of species at risk and the stock structure of Div. 2J+3KL cod and possible implications of stock structure for recovery of the stock. There were 3 presentations around which the discussion was structured. Dr. Richard Haedrich of Memorial University gave a presentation on COSEWIC, Dr. George Lilly of DFO gave a presentation on what work has been done on stock structure and Dr. Steve Carr of Memorial University gave a presentation on the use of mitochondrial DNA for determining stock structure and his views on the drawbacks of microsatellite DNA techniques.

COSEWIC

Dr. Haedrich gave an overview of the structure and function of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Few of the criteria applied by COSEWIC are relevant to marine fishes because they are generally much more widespread and abundant than other species. The criteria related to the percentage decline in the population are the ones that are used in assessing species status for fishes. The IUCN (The World Conservation Union) uses different criteria depending on the amount of information available on a species. If only data on the percentage decline is available then that is what is used. However, if there is information on things such as area of distribution or the number of mature individuals then these are used. To date there is no known record of a marine fish species becoming extinct.

Within COSEWIC there has been a move to examining units smaller than the species level. However, there are presently no criteria as to what is the appropriate subunit level to be examining for a marine fish species. For example, should the committee be concerned with all cod in Atlantic Canada or cod in a small bay. This question has not yet been answered and it may depend on the amount of genetic isolation of the subunits and the potential for mixing between them.

Previous Studies

Dr. Lilly gave a brief overview of some of the studies done which indicate that there may be substock structure within the overall Div. 2J+3KL population. These included studies on meristics, morphometrics, spawning time, length-at-age, tagging, and microsatellite DNA studies. There is certainly at least a geographic cline in many biological characteristics. As well, the microsatellite work has indicated that there are several offshore subcomponents and that the offshore fish are quite distinct from those in the inshore. Studies have also shown that there is a lot of movement between areas (for example the inshore feeding migration of offshore fish) and so this raises the possibility of mixing between the subcomponents.

Mitochondrial DNA

Dr. Carr gave an overview of of a new technique he plans to use to determine if groups of animals are genetically distinct populations. The technique involves examining sequence variation in the entire mitochondrial DNA. This technique will be applied to northern cod in the near future. Previous studies that he has been involved in examined a small portion of the mitochondrial DNA and found that the genetic differences among populations of cod in the Northwest Atlantic were extremely small and not consistent with stock differentiation. The microsatellite technique has found significant differences between sampled groups, but it should be borne in mind that identification of *statistically significant differences between sample means* is not equivalent to establishing that the geographic stock components from which the samples are drawn are distinguishable, and that even if stock components are *distinguishable*, they are not be *distinct* if there is substantial over lap in genetic composition.

General Discussion of Stock Structure and Implications for Recovery

There appears to be no agreement among geneticists as to the existence of genetically distinct populations within the Div. 2J+3KL stock area. There is evidence of at least clines in biological characteristics and there is some evidence of site fidelity. This evidence supports the possibility of distinct populations. However, given the migrations of cod and the extensive drift of eggs and larvae, there would be ample opportunity for gene flow.

If there are distinct populations then the question becomes one of colonization. We do not know the probability of fish from one population moving into another area and taking up residence. Nor do we know the time scale over which such an event would occur.

Given the uncertainties regarding stock structure and possible colonization one can not ignore the hypothesis that the subcomponents of Div. 2J+3KL are not functionally isolated. There are likely to be a variety of subcomponents which may vary in their amount of isolation. With this in mind the meeting decided that the assessment should be conducted under two scenarios: a) that the inshore constitutes a separate inshore subpopulation that is functionally separate from the offshore; and b) that inshore and offshore fish together constitute a single functional population.

SESSION 3: RESULTS OF ANALYSES

An age disaggregated index from the sentinel program

The analysis was repeated assuming a negative binomal error. Conclusions were the same regardless of the error structure. Standardized deviance residuals by age for each area by year were presented. Plots of other types of residuals were also available to the meeting. Plots of data were by bay not by site since there are 60 sites. There is some indication of a bay*year interaction in the catch rate. This may indicate that a ‘sentinel index’ based on all areas may not give a good index for a stock that is highly restricted in distribution. This is not sufficient at this point to cast doubt on the analysis but should be monitored in the future. There does not appear to be any consistent pattern in the residuals by age and site indicating that there is no age*community interaction.

Conclusion: Through the use of different gears which have very specific selectivities, it is possible to track year-classes through the six years that the sentinel program has been operational. Gillnet catch rates increased from 1995 to 1998 but declined from 1998 to

1999 and decreased further in 2000. Linetrawl catch rates showed relatively little change from 1995 to 1996, increased in 1997, and declined again in 1998,1999 and 2000. The catch rates at age indicated that the 1990 and 1992 year-classes were relatively strong and that all subsequent year-classes are weaker.

Consumption by seals

There was a large increase in winter inshore in the amount of cod in seal stomachs. The sampling was explored to determine if this was a function of seals or sampling.

The number of seals sampled in 1998 was comparable to previous years in both summer and winter. The average weight in seal stomachs of cod, arctic cod and capelin was highly variable in summer but was not different in 1998 than other years. In the winter of 1998 there was a large increase in weight of cod in stomachs, arctic cod was a bit down but capelin was similar. There appears to be somewhat of a declining trend in the weight of arctic cod in seal stomachs.

Sample size was broken down by fishery unit area. There was an increase in percent of stomachs with cod in 1998 when broken down this way as well, especially in units 338 (Bonavista Bay) and 340 (Notre Dame Bay). The size of cod in stomachs also increased in 1998. There was some correspondence between areas with increased size and percentage of cod in stomachs and areas where there were reports of seals eating cod in the inshore. 1998 was the first year of increased reports of this behaviour. Reports continued in 1999 and 2000 and it will be interesting to see if the increased amount of cod in seal stomachs will again be found when stomachs collected in 1999 and 2000 are examined.

The size of cod being eaten by seals is larger and this translates into increased weight of cod in the stomachs. It is hard to determine if changes in the consumption estimates are the result of a change in abundance of other prey or a change in abundance of cod. The percent of energy from cod in nearshore in winter does not show an increasing trend from 1994 onwards as shown by estimates of weight in seal stomachs, but the 1998 estimate is very large.

Conclusion: the increase in cod in seal diet in the inshore in winter 1998 does not appear to be a function of sampling variability. There is some correspondence between areas with increased size and percentage of cod in stomachs and areas where there were reports of seals eating cod in the inshore. When harp seals find cod they are eating larger cod. The impact of seals feeding on cod may be difficult to quantify (e.g. belly biting) but this may be locally important especially in nearshore areas. Predation by harp seals is estimated to be 37,000 t and may be preventing the recovery of the cod stock

Numbers consumed by harp seals

The maximum size of cod found in seal stomachs in any year was 52 cm. In the last three years the sample size in the second half of the year was very small so the length frequency of the first half of the year was added to that from the second half. Nearshore and offshore samples were combined for producing the length frequencies. A spring age length key combined over 1996-1997 and a fall key combined over 1995-1997 were used. The spring age length key was used for Jan-June and fall for July-Dec. The number of fish consumed Jan-June has declined in recent years even though consumption has increased because the mean weight of fish consumed has also gone up. There appears to be no trend in July-Dec. The estimate of consumption for 1998 is 86,000,000 fish compared to a peak in 1989 of 1.4 billion fish. Ages 6 and 7 appeared in the data in recent years. There has been a change in the length frequency data from the seal stomachs compared to earlier analyses. The reason for this is unclear. The current analysis does not show any year classes tracking through.

There are a large number of zeros in the data in the 2nd half of the year. The length frequencies come mainly from the nearshore because that is where most of the sampling of seal stomachs comes from. Yet in the second half of year (mainly 4th quarter) a lot of the consumption is coming from the offshore. Therefore the nearshore length frequencies may not be representative of this consumption.

Conclusion: From 1986 to 1996 cod age 0 and 1 were the predominant age groups found in harp seal stomachs. In 1997 and 1998 older fish (ages 3-5) were the dominant age groups and fish as old as age 7 have been found more frequently than in previous years. With this shift to older, larger cod the total number of fish consumed has decreased in recent years while the estimates of total biomass consumed have been relatively constant. Seals are now consuming fish that are mature as well as juveniles so they will have a direct impact on the SSB. It is not possible to determine how much of an impact they are having since there is currently no way to relate population size (absolute number of cod) and numbers removed by seals.

The marine mammals section should determine why there has been a change in this data set in the estimated length frequency of cod consumed compared to previous data sets.

Recruitment Index

An analysis to test the sensitivity of the model to leaving each of the catch rate series being left out one at a time was conducted. Overall time trends in year-class strength were consistent except for the estimate of the 2000 year-class when the Newman Sound Beach Seine was deleted. However, this change was well within the error bounds of the estimate using all catch rate series.

The recruitment data from inshore and offshore were treated together because the inshore appears to be an important nursery area for cod spawning in both the inshore and the offshore. These data were combined to produce a single index of relative year-class strength. When only inshore or only offshore data were used the patterns were similar to the combined run, although there were some slight changes in relative year class strength, particularly with respect to the 1994 year class.

Plots of each index at age by year class for each index used were presented. There was some inconsistency within indices across age as to year class strength. Residuals were presented by year class and by index/age combination. Residual plots for each index/age combination by year class were also presented. No patterns emerged that would suggest the model should be abandonded. Since there is a parameter for each survey age combination this should deal with different ages coming in and out of a survey.

Conclusion: The overall pattern of year class strength is fairly robust to which indices are included.

The index declined from 1989 to 1991, increased to 1994, and declined to 1996. The 1998 to 2000 year classes are higher than earlier year-classes in the time series. The ultimate strength of the 1998 to 2000 year-classes is yet to be determined. Their present strength is known only imprecisely. The strength of all of these year classes is much lower than the strength of those that occurred during the 1980s. The 1992 year class does not appear to be strong in this index although it does appear to be one of the stronger year classes in the fishery in recent years.

In the future the individual indices should be looked at in more detail to try to learn more about what each is indicating about year class strength. Also a random number series should be included as a dummy index to investigate the weighting of the indices.

CPUE from commercial logbooks for the less than 35 ft sector

Plots of median catch rate by area for gillnet were presented. This constitutes the bulk of the data. Catch rates in 2000 are less than 1999, which are less than 1998. Plots of CPUE from 1998 through 2000 by area with the x-axis divided into weekly increments were also shown. Most of these plots showed a continuous downward trend. When calculated by division, both Div. 3K and 3L (2J was not computed because of lack of data) showed a substantial decline in gillnet catch rates over 1998-2000. The line trawl data was less consistent but there was also a very small sample size in comparison with the gillnet data.

Catch and effort data from logbooks maintained by the <35 foot sector fishing gillnets were standardized by using a generalized linear model to remove spatial (bay) and seasonal (month) effects to produce annual estimates of average catch rates for 3KL.

Gillnet catch rates declined from 1998 to1999 to 2000. Data were insufficient to fit the same model for linetrawl.

Conclusion: Mean gillnet catch rates show a continuous decline over time with perhaps the exception of couple of areas. The standardized CPUE also shows a decrease from 1998 to 1999 to 2000. Linetrawl showed a declining trend in 3K and an increase in 3L but the amount of data is much less than gillnets. These decreases could indicate a decline in population abundance. However, the fishery plan (closure in August in 1999 and 2000), plus bad weather in 2000 may have affected the catch rate. Also if a year class was moving out of the selectivity of gillnets this could cause a decline.

In the future a mixed model should be tried with random effects for site nested within month since there may be some areas that are fished in different months each year and these would be adding nothing to the model as it is now.

Bycatch and discards

Analyses of data from observers were presented. There was a substantial increase in 1999 and 2000 in bycatch and discard (up to 39 t from around 2 or 3 t). Bycatch and discards came predominantly from gillnets, shrimp trawls and some ottertrawl. The increase in 1999 and 2000 occurred in Div. 3K and 3L but not 2J. Bycatch in 1997, 1998 and 2000 was split between inshore and offshore but in 1999 it came almost entirely from inshore.

Discarding in the cod directed fishery in 2000 was estimated to be 71 t based on observed sets. However, this may be a biased estimate. The quantity of discarding in the shrimp fishery appears to be small in both the large vessel and small vessel fleets. There were reports of discarding of cod in the Greenland halibut gillnet fishery, but the quantity of discarded cod was small in the relatively few sets seen by observers.

Conclusion: although there was an increase in bycatch and discards in 1999 and 2000 the amount of cod removed appears to be relatively small. However deployment of observers on small vessels is a problem. Coverage is low and the method of deployment has not been designed to give unbiased coverage.

The estimates of catch, particularly bycatch in the offshore, were not up to date for this meeting. There were no data from EU observers or from Canadian surveillance.

Estimates of total mortality (Z) from surveys

Age by age estimates of Z from the fall survey were presented. There was an increase in Z across the late 80's early 90's up to 1992 and then a decrease following the imposition of the moratorium. However estimates have not decreased to 0.2, the assumed level of natural mortality. Z's have come down to near their pre moratorium level but not as much as you would expect under no directed fishing in the offshore. There is no evidence that estimates have been decreasing in recent years.

Results of a multiplicative model on ages 3 to 7 over 4 year time periods were also presented. The Z's in recent years in this analysis are below 0.2. There are a few estimates of Z at ages 6 and 7 which are quite low and these make the slopes less than 0.2.

Conclusion: Total mortality remains very high despite the low level of fishing.

Whole stock analyses

A number of formulations of VPA in the ADAPTive framework were attempted. One run was presented in some detail and included RV fall offshore, RV fall inshore, RV spring, sentinel gillnet, and sentinel linetrawl as calibration indices. The VPA was run over ages 3 to 20, with number at age 20 set to 0 for years 1991-1999 and estimated in 2000. The F constraint on age 20 in other years was the average of 17-19. There is a lack of confidence in current biomass estimates because F in recent years is so low. With low catch estimates of Q and M determine population size.

In 1999 it was stated that VPA was not done since the offshore survey did not contain the ages and quantities of fish that are inshore, but now there are additional indices which are in the inshore (fall RV inshore and 2 sentinel indices, linetrawl and gillnet). In 1999 there was also a problem since the discrepancy between the catch and survey in early 1990's could not be explained. The VPA examined here estimates the magnitude of that discrepancy.

An SPA using XSA and including sentinel (linetrawl, GN 3/14, GN 51/2 fixed and experimental), fall RV inshore and offshore, and RV spring as calibration indices was presented. The RV series were split into two, pre and post 1995. Plots of Q residuals by age were examined. Inshore fall RV showed a large trend in residuals. Gillnet sentinel showed little pattern in the residuals. Linetrawl showed increasing catchability but there has been a decrease in number of linetrawl sites. Offshore fall and spring RV both showed no pattern from 1995 on. Both spring and fall RV pre 1995 are u shaped (this could be the result of 'missing fish' as this analysis did not estimate that).

Catchabilities were lower for the Campelen portion of the series for older ages but not for the earlier portion of the series. This could mean that the Campelen is not as good at catching older fish or that the fish are not available.

Estimates of F were quite sensitive to how the model was set up. Levels of F are so low that the VPA is not going to converge. The VPA is, therefore, very dependent on formulation.

A Schaeffer Production model with dynamic fit was also attempted. This model included seal consumption, catch, and 4+ biomass from VPA up to 1990. It was found that very small changes in *r* cause large changes in predicted biomass in recent years. Carrying capacity and *r* are highly correlated. This was a useful exploration but can not be used at this stage.

It was decided that an illustrative VPA would be worth pursuing and one with the following structure was attempted. The indices were fall RV ages 2-11, ages greater than 5 omitted after 1995; sentinel gillnet 51/2 fixed sites ages 4-10; catch at age 1962-2000 ages 2-20, omitting ages 3-10 for 91-93. N=0 ages 20 1991-2000 and ages > 14 in 2000. F on age 20 in 1963-90 set to be the average of 17-19. The results showed some pattern in the residuals across time. For example, age 3 residuals were all above the line after 1994 and age 5 all below the line for fall RV. There was also some problem with the residuals for gillnet which showed a decline over time. Age 2 in the converted Engel data was used and this has not been done with other cod stocks since catchability is not thought to be good at that age. Catch at age data for last 5 years is mainly from inshore, this probably means that we are only getting a reflection of one part of the stock.

Conclusion: any whole stock model assumes that the proportion of the population in the survey area is the same over time. This can not be addressed by a change in catchability in the model at this time. This may be at least partly compensated for by the introduction of the inshore gillnet index. However, this series may not be reflective of changes in the whole stock, and the gillnet catch rate is not going to be able to increase to a much higher level given that the gear will saturate. The lack of an index that reflects a consistent proportion of the stock means that a whole stock VPA is not valid at this time.

It would be better to have a VPA for inshore and one for offshore and such analyses should be explored further when there are more years with sentinel indices. Also, one could combine the tagging and do a forward VPA using an age structured production type approach.

Tagging

Analyses of 'raw' return rates

Of the 2553 fish tagged in 3K and 3L in the early part of year 2000, 6.3% have been recovered suggesting a harvest rate for the tagged population of at least this amount.

Tag releases were adjusted for tag loss and M. Recaptures were adjusted for reporting rate. For the 1999 releases recaptured during 1999, the exploitation rate in 3K was quite high. It was about 15% in 3La and lower in 3Lb. Exploitation of fish released in 2000 and recaptured in 2000 tended to be similar in 3LA and 3LB as for the 1999 releases recaptured in 1999. The 3K returns in 2000 were lower but they were not released until August in that year so they were only exposed to part of the fishery. For the 1999 releases recaptured in 2000 exploitation was lower for 3K than for those recaptured in 1999.

Conclusion: based on the unmodeled tag return rates the exploitation rate in 2000 was 10.3% for fish tagged in 3K, 10.7% in northern 3L (Trinity and Bonavista Bays), and 22% in southern 3L.

A charmingly simple migration model

The model was run using the following assumptions: 13% initial tag mortality, tag loss was exponential with loss rate of 0.2 in first year and then no further loss, M=0.2, reporting rate was assumed to be 65%, tag loss for double tagged fish assumed to be $1-(0.2)^2$. Only fish tagged before a fishery began in a given year were included. For Placentia Bay and 3L south this was taken as week 21, 3L north and 3K are week 25.

There are circumstances where the model may have problems estimating migration and harvest due to either singularity in the tag returns per tags in the sea matrix or areas of low harvest. After suitable amalgamations and exclusions the method gives coherent results.

Harvest Rate Based upon Diagonal terms only
Highlighted values estimates based upon the earlier years result

Recaptured in		Tagged in				
	H	1997	1998	1999	2000	Average
1997	3K In					
	3L In N	0.005				0.005
	3Ps PB	0.170				0.170
1998	3K In	0.153	0.307			0.230
	3L In N	0.061	0.064			0.062
	3Ps PB	0.142	0.134			0.138
1999	3K In	0.050	0.186	0.630		0.289
	3L In N	0.115	0.121	0.117		0.118
	3Ps PB	0.250	0.355	0.302		0.303
2000	3K In	0.032	0.141	0.148	0.156	0.119
	3L In N	0.065	0.069	0.084	0.101	0.080
	3Ps PB	0.196	0.346	0.372	0.186	0.275

These can be used to give approximate estimates of biomass.

Tag recaptured	Area H	Catch	Average F all years	Biomass	Average F last 2 years	Biomass
1998	3K In	2119	0.230	9214	0.226	9368
	3L In N	1762	0.062	28207	0.061	28905
Total				37421		38274
1999	3K In	3716	0.289	12865	0.403	9211
	3L In N	3256	0.118	27633	0.116	28024
Total				40498		37234
2000	3K In	1459	0.119	12257	0.148	9849
	3L In N	2850	0.080	35769	0.090	31545
				48026		41394

Conclusion: the estimated biomass in Northern 3L and in 3K from 1998 to 2000 has been in the order of 40,000 t. The majority of this estimated biomass (about 30,000 t) was in Bonavista Bay and Trinity Bay.

The data used did not include any returns of double tagged fish where only one tag was returned. To account for this the assumption of tag loss on double tagged fish was increased. The actual number of tags that were missed was small.

This model takes harvest rate as calculated by number and applies it to catch in weight to provide an estimate of biomass.

Since these estimates are provided without error it is difficult to determine at this stage how well the model fits the data.

Various extensions to the model might be considered for future years. The inclusion of size selection seems important and might initially be addressed by fitting the existing model separately to broad size groups of tagged fish and/or tag returns or by using all tagged and recapture sizes and interpreting these with an overall all gears selection curve. Consideration of how to optimally fit a common migration model to the separate years data might also indicate ways to handle missing data.

A more detailed tagging model

The model was run two times. The first run used annual estimates of reporting rates for all regions. The second run used annual estimates of reporting rates for the northern part of 3L, and annually constant estimates for the other regions.

There was little reason to prefer either run (and little difference in the results) so, since the second run was more similar to the formulation used in the last assessment of this stock, it was decided that this would be the analysis to report.

Several functional forms for the estimation of selectivity were explored and all produced some dome in the estimates. Thus the dome appears to be inherent in the data rather than the result of the functional form fit.

The model only supplies under-estimates of exploitation rates because the model does not fully account for movement of tagged fish out of the exploitation region. The estimates of total exploitation in 2000 were 3.4% and 8% for 3K and northern 3L. Estimates for southern 3L were considered too unreliable because of substantial mixing between cod in this region and cod in 3Ps. Total exploitation was taken to be total catch weight for fish of lengths 40 cm and greater, divided by average weekly estimated population biomass for the same range of lengths. The average is based on weeks with at least 50 tonnes of fish landed by the commercial fishery.

Conclusion: Year 2000 average weekly biomass in 3K inshore (3K_IN) is 42 000 tonnes and in 3L inshore north (3L_INN) is 35 000 tonnes. For 3L_INN the results are broadly similar to those coming from the more simple model but the estimate for 3K_IN is higher from this model.

Appendix I External Reviewer's Report

by

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The annual regional assessment of Div. 2J+3KL (northern) cod, was held in St. John's at the Airport Plaza Hotel from March 12-14, and March 19-23, 2001. The meeting was open, and was attended by representatives of the fishing industry, scientists from DFO, the Memorial University of Newfoundland and the United Kingdom and representatives from the FRCC. This review examines the organisation of the meeting and some of the details of the assessment process, based on observations made before and during the meeting. The observations made in the review are derived from a personal view of the meetings and are based on a relatively limited experience of the biology and fishery for cod in the 2J3KL region. Therefore, the report may include rookie comments on subjects that are common knowledge to experienced members.

Format and conduct of the meeting.

The assessment meeting was scheduled in two main sessions. The first presented the background information and available assessment data, a discussion of potential model structures for estimating the dynamics of the stock, and an examination of the implications for rebuilding the biomass. The second session considered the implications of genetic studies that examined the sub-stock structure of the cod population, the results of the agreed analyses and the writing of the Stock Status Report.

Representatives attended the open meeting from a majority of the interested parties, including representatives of the fishing industry, scientists from DFO and the decision-makers (FRCC). This format may have its problems if dominated by one side, but in my opinion it is far superior to that adopted by ICES at which the science is examined in isolation and in general is not presented to the industry until the “scientific opinion” has been constructed.

A major advantage of the format and length of time allocated to the meeting is that all of the views of the meeting participants can be debated. This can sometimes lead to meetings losing their way and a strong chair is required to navigate a successful transit. Joanne Morgan chaired each of the sessions very professionally. It was not an easy task given the diverse nature of the subjects presented and the interests of the parties present.

Comments:

Apart from references made to the previous years SSR, I was not aware of any action points resulting from the conclusions reached at previous meetings. Areas of study that could lead to an improved assessment of the status of the stock were discussed but not specifically identified or recommendations made for the future work. How is the linkage between meetings maintained?

Background information.

The series of presentations by Eugene Colebourne, George Lilly, Gary Stenson and co-workers on the subjects of the environment and the major cod predators (man and seals) were extremely useful. This was especially the case for new members of the meeting, such as myself, as well as providing a useful aide memoire of the situation and a basis for discussion.

I was very surprised and disappointed that the biological reviews only covered the trophic levels above cod. There was no information on species at the equivalent trophic level or those below, on which cod is dependent for food.

It was my impression from the paper on the environment, that conditions on the shelf are close to their historic norm and yet there has been no sign of a recovery in cod recruitment. Have any other species begun to recover? It would be expected that, after such a severe perturbation of an environment, short-lived r selected species would be the first to show signs of a recovery and therefore provide pointers as to the potential future of the cod stock.

Capelin, the preferred prey species of the cod, was barely mentioned in the review. During discussion it was revealed that there is very little information on the current status of the capelin stock and that which is available has conflicting signals. Moreover it was pointed out that information on the feeding habits of the cod, from stomach sampling, is no longer being collected. Frankly, I found this astonishing. I realise that regular stomach sampling on an annual basis is expensive and a luxury in the majority of ecosystems, where there is a relatively stable trophic structure and environmental effects are usually relatively unimportant. However, in the 2J3KL situation where huge perturbations have taken place, any understanding of the system must be based on as complete knowledge of the biology of the target species as possible. If the cod stock does recover will we be able to say why it recovered, or why growth was suppressed in the offshore and mortality is high in the absence of fishing? If fish move away from the inshore nursery area only to starve in the offshore is production being wasted?

Comments:

I was surprised that feeding and the state of the prey stocks is given such a low priority in the RAP. This was in part due to a lack of available information.

Can we fully understand the changes taking place in the cod stock in the absence of fishing without a study of its prey? Or, does the lack of information reflect something of which I am not aware; such as, prey availability is not considered important in the current dynamics of the system?

If the information were available, I would suggest that the RAP include an annual presentation of the status of the competitors and prey species of the cod. It may be common knowledge to the regular participants, but it is advantageous to regularly review the multispecies information available.

In my opinion the decision to stop the cod stomach-sampling program should be reviewed. If expensive on an annual basis and given the rapid rates of change in the regional ecosystem, a biennial program could provide indications of trends in changes in state.

Surely the RAP meetings are where we should be identifying and requesting information from other people and if they cannot provide it, asking for a review of research priorities. Is there a formal mechanism for initiatives from the RAP filtering into research priorities or is it the left to the participants. ICES working Groups make specific recommendations from each report, which are then reviewed by a parent committee for action.

The assessment data

Time-series of data on landings, catches at age, survey indices, distribution patterns and biological parameters were presented. Also presented were the results of tagging studies on cod, trends in catch rates from the Sentinel fishery and the log book scheme, and spatial and temporal trends in recruitment indices. Each of the presentations was detailed and clear.

Total catch and catch numbers at age data sets

The TAC was 7,000 t but only 5,400 t was taken. This must be examined very closely, by region, as it could be perceived as indicating that the fish are not there. There were gear, area and time restrictions imposed on the fishery in 2000 and to some extent they are known to have handicapped the fishers ability to take the catch. Did the restrictions result in the incomplete uptake or was it because the fish were not available? I cannot emphasise sufficiently the importance of this question. The tagging paper presented by Brattey, Porter and George also notes that in spite of a considerable increase in searching effort the number of cod tagged was substantially smaller as no aggregations of cod could be located in 3K and 3Lf and 3Lj.

A paper was presented on the ageing of the cod taken in samples. The age reading methodology is reviewed periodically with the use of reference sets of otoliths, otolith photographs. The review process shows that readers are in good agreement with the mode of the distribution; however, modes can be biased. The review process is important and should be encouraged. The regular inclusion of outside readers with experience of cod ageing in other areas should be considered as a method for cross-validating the results.

If achievable the errors associated with the ageing and the procedures for sampling the catches at the ports of landing should be used to provide coefficients of variation on both the total landings and the numbers at age.

The Sentinel survey data set

The Sentinel data set summary tables show that the amount of effort directed towards line trawls is decreasing. Line trawl is the only commercial gear type, currently in use, that will take large fish and subsequently provide indices of abundance at the oldest ages in the population. If the decreasing trend continues, it will be almost impossible to track the progress of year classes that have escaped the selection range of the gill nets. Associated with the loss of information, there will be deterioration in the quality of model estimates of abundance and SSB at the oldest ages.

A generalised linear model was fitted to 60% of the data and used to condense the spatial and temporal effects into a single series for use in assessment models. Although, due to the short time series, the model is at an early stage of development, the results allow year classes to be tracked through the age structure. There was relatively strong correlation of the survey the abundance at age index with the population structure estimated by the exploratory ADAPT type VPA presented at the meeting. This indicates that the survey is apparently doing that which we are asking of it and that, even at this early stage this is proving to be valuable data. We should still be cautious in utilising the results of the analyses as there has been very little contrast in the abundance of the year classes passing through the fishery during the period in which the survey has been conducted and our ability to predict large year classes is unknown.

The analyses of the survey series should be continued in order to stabilise the model structure and diagnostic output for use at subsequent meetings. The work should include a sensitivity analysis to examine the influence of individual or groups of sites. Analysis of the 40% of the sentinel data set that is gated out prior to fitting the model should be performed to isolate the reason for the high rejection rate. Is the high rejection rate due to factors that could be reduced by feedback to the participants, perhaps through a newsletter, or should we expect this rate every year due to factors beyond our control?

Has the scope for a subsidised offshore sentinel survey series been considered? Even if nothing is caught it is a result.

Recruitment surveys

Several series of survey information are available comprising a diverse array of gear types and time series. These were brought together using a generalised linear model to produce a single time series of estimates. Due to the incomplete nature of the time series available for each component this is a complex modelling exercise.

The progress in the development of the model, made at the meeting was significant, and should be continued. A full analysis of the sensitivity of the model results to the inclusion of the individual or groups of data sets and bootstrapping of model to estimate coefficients of variation would aid decisions as to the quality of the model predictions.

Research surveys

The documentation and presentations describing the research survey time series clearly show the value of the series to the assessment process and our understanding of the current regional stock status. The content and detail of the reports is far superior to any of the analyses that I have seen presented for ICES assessments.

The recent addition of the inshore stations has added to the information arising from the surveys and with time should prove a useful adjunct to the inshore recruitment series. It is disappointing that the 1999 survey omitted the inshore stations. Given the importance of predicting catches to the inshore fishery any opportunity to expand the series in the inshore should be taken.
The conversion of the Engels data to Campelen equivalents was heavily discussed at the meeting. There appears to be a step in the catchability at age with a transition occurring around the year of conversion. Analyses of variance with a gear effect included showed a better fit to the CPUE data than without the effect. This suggests that the conversion may

not be sufficient. Could the comparative tow conversion experiment be repeated? Once the Campelen data series has sufficient years of data to stand alone, it may be better to treat the series separately in modelling exercises.

Recent studies within ICES and NAFO are revealing the importance of maternal condition to viable egg production and the strength of subsequent recruitment to the stock. An essential piece of information in the reconstruction of the historic time series of the viability of the stock is a liver index. This information has been collected regularly on the survey and should be maintained as a priority.

Acoustic surveys

The acoustic surveys carried out by the Memorial University of Newfoundland in Smith Sound and offshore suffer from the complexity introduced by variation in the timing of the migration of the cod and difficulties in measuring the absolute density and abundance of fish. However, they are providing informative data on this remnant of the cod population with regard to current behaviour patterns, age structure and condition.

The age structure of the catches is given in the tables. I would have liked to see comparisons of the age distribution and mortality estimates from catch curve analysis compared with those of the DFO offshore survey. As discussed at the meeting an understanding of the ontogeny of these fish should have a high priority.

Are the fish George Rose is finding in his directed surveys suitable for tagging? Has the possibility of using data storage tags been explored?

Tagging studies

Two tagging models were constructed at the RAP. Both were used to provide information on the estimated level of fishing mortality and stock abundance in the absence of a VPA type model. The tagging studies are an essential part of the information required to understand the complex nature of the movement of fish around the coast, the mixing of the sub-stocks and the levels of exploitation.

Tagging experiments can be an expensive luxury where stocks are in a relatively healthy state and information on dynamics is provided by other sources. In the 2J3KL situation where the stock has been reduced to pockets of remnant sub stocks, the value of tagging information has been increased exponentially. Given the current importance of the results to assessment process I would recommend that two points should be considered:

Firstly, the tagging studies were initiated to provide information on movements and exploitation rates inshore. The data are currently being used in models, developed further at the meeting, which are highlighting possible deficiencies in the experimental design if the data are used to estimate exploitation within and migration between regions simultaneously. For instance the results of the model fitted by Pope showed that in order to achieve a solution he had to combine the returns from 3L Inshore-South and in

Placentia Bay. Before next years tagging begins, I would suggest that the experimental design be reviewed by the modellers and tagging co-ordinators.

Secondly, within DFO the gadoids team appears to be fully committed to their current researches. The analysis and construction of the tagging mortality and migration models is a relatively new area that should be given a high priority and developed as soon as practically possible. One way of achieving this would be to appoint a short-term research position dedicated to the development of a suitable model for the 2J3KL stock dynamics. This would also help with a concern that it was my impression that the expertise required for the extraction of the tagging data and its analysis is concentrated in two DFO staff. If they were not available to carry out the analysis would the meeting be able to proceed.

Modelling of the population dynamics

VPA models used for rebuilding stock structure are based on a dynamic pool assumption, that catches are removed and CPUE calibration series are sampled from the whole stock distribution. Whilst the 2J3KL population was abundant and the catches were predominantly from the offshore, the area covered by the survey, the VPA assessment was coherent. Now that the remaining stock is distributed inshore with the catches being taken in that area, the suitability of calibration using the offshore survey has rightly been questioned. Changes in the distribution of the fish relative to the distribution of survey effort can violate the assumption of constant catchability.

As the inshore survey stations develop into a full time series, the survey indices derived from them and the sentinel catch rate series should allow an inshore VPA type assessment for comparison with the tagging results. A suggested approach would be to ignore the historic catch data and construct an inshore assessment using the most recent data in isolation.

Stock structure

I have no experience of genetic analysis and so I leave this for the appropriate protagonists to fight out. I can only refer to my experience of an ICES stock in which I was directly involved in the scientific advice and a similar situation occurred.

The North East Atlantic mackerel stock has been shown to be genetically isolated into three main sub-components. The fish are exploited mainly in their over-wintering area to the north of Scotland. Tagging studies have shown that the catches taken in that region are composed of fish from all three components. Given that it would take a substantial effort and cost to separate the catches into sub-stocks we can only manage as a single unit.

There may be genetically different cod stock units in 2J3KL but it will be our ability to separate the catches accurately into stock units that will determine our success at management.

If a two stock approach is followed the tagging studies will become even more important.

The organisation of the stock assessment process

In general the DFO assessment team was well prepared. Finished presentations were detailed and clear, and were understandable to all attending the meeting. Work requested by the meeting was carried out efficiently although this meant DFO staff working late into the evenings in order to have results ready for the following morning. The discussions at the meeting were relevant to the topics and showed that the DFO team and invited participants had a well-balanced comprehension of the subject. The DFO team worked well together and individually, they answered questions and accepted suggestions in a professional manner. Their knowledge of the subject was continually tested in front of the end users and was not found lacking. I very much doubt whether the same would be said of many of the ICES working groups that I attend.

I was also impressed by the quality of the papers presented by the industry representatives. I thought that they made a valuable contribution in providing the fishers perspective of the past year. The involvement of the fishing industry in the collection and interpretation of data is a major strength of the RAP process that is missing from ICES and the majority of NAFO assessments. If it has not been carried out already, it would be appropriate in some way, to convey to the industry the valuable contribution that such papers can make in providing information to the meetings. It may encourage further constructive contributions.

One area in which I think the introductory sessions could have been improved was the level at which some of the preliminary research was presented. New data sets were available prior to the start of the meeting and yet some of the presentations described only structure of the model that had been used in the previous year. A common theme appeared to be “This was the model we applied last year is this acceptable before we fit it to the new data time series”. In one case the results from a relatively simple model that had been applied in the previous year were not available until late into the second week.

During assessment meetings there is often inadequate time available for carrying out, interpreting and presenting the different model runs. Working to short deadlines increases the potential for making undetected mistakes. It would be a valuable time saver if any model that had been accepted by the previous meeting was applied to the new data sets as a “default option” and a paper presented on the results at the first stage meeting. It would allow the presenters to isolate obvious errors and examine the influence of outliers on the results in the “relaxed atmosphere at DFO” rather than under the pressure of thinking on their feet in the meeting. This approach would allow discussion centred on any problems in the new data and the relevance of the model as soon as the first presentation is made, rather than three days into the meeting or during the second meeting.

Such an approach would avoid the perception that I detected from several fishermen that only a limited amount of new work had been carried out during the previous year, subsequent to the last meeting. There is a balance that has to be achieved between models that are fitted “behind closed doors” with formal presentations of the results and an open meeting in which even the exploratory runs used for model building are shown at each stage of the process. With the former approach there may be allegations of hidden results, in the latter calculations can be rushed and most of the discussion goes over the heads of the non-modellers, sometimes giving the impression that we do not know what we are doing. I had the impression from the floor of the meeting room that this year we fell in to the second trap too often.

Comments:

What is the time span between the previous RAP meeting and the 2J3KL meeting? Is the data for the assessment processed with a sufficient time period for the preliminary or new analyses to be completed? At ICES the majority of assessment meetings take place during the latter half of the year and in my experience this usually allows one month for analysis prior to the final assessment meeting and report writing.

Is there a leaflet/newsletter that returns information to the sentinel fishermen to show where and how the information is being used (not the SSR which is too formal), this would be one way of providing feedback and encouraging compliance with the experimental design?

Appendix II List of Participants

Name	Affiliation
Tom Best	Petty Harbour, Sentinel
John Brattey	DFO Science, Oceans and Environment
Bill Brodie	DFO Science, Oceans and Environment
Rodney Budden	Fisherman, Seldom
Noel Cadigan	DFO Science, Oceans and Environment
Steven Carr	MUN
Eugene Colbourne	DFO Science, Oceans and Environment
Cyril Dalley	FFAW, Sentinel
Chris Darby	CEFAS Lowestoft
Tom Dooley	NF Dept. of Fisheries and Agriculture
Dave Downton	DFO Science, Oceans and Environment
Gus Etchegary	
Roy Freake	Fogo Island Co-op
Bob Gregory	DFO Science, Oceans and Environment
Richard Haedrich	MUN
Brian Healey	DFO Science, Oceans and Environment
Harry Hicks	DFO Science, Oceans and Environment
Catherine Hood	DFO Science, Oceans and Environment
Dennis Ivany	Fisherman, Smith Sound, Sentinel
Harvey Jarvis	FFAW
Yan Jiao	MUN
Len Knight	DFO Resource Management
Ben Laurel	MUN
George Lilly	DFO Science, Oceans and Environment
Dawn Maddock Parsons	DFO Science, Oceans and Environment
Joanne Morgan	DFO Science, Oceans and Environment
Eugene Murphy	DFO Science, Oceans and Environment
Dale Parmiter	DFO Science, Oceans and Environment
Beth Perry	DFO Science, Oceans and Environment
John Pope	FRCC
Don Power	DFO Science, Oceans and Environment
V. Puvanendran	OSC
George Rose	FRCC – MUN
Sandy Sandeman	
Joseph Sesk	Fisherman, Aquaforte
Max Sexton	Fisherman
Peter Shelton	DFO Science, Oceans and Environment
Leonard Stack	Petty Harbour, Sentinel
Don Stansbury	DFO Science, Oceans and Environment
Rick Stead	DFO Science, Oceans and Environment
Garry Stenson	DFO Science, Oceans and Environment
Joe Tillman	DFO Science, Oceans and Environment

David Vardy	Seal Panel
Steve Walsh	DFO Science, Oceans and Environment
Paul Winger	MUN
Joe Wroblewski	MUN
Larry Yetman	DFO Resource Management

Appendix III List of Working Papers

No.	Title	Status*
1	Physical oceanographic conditions on the Newfoundland and Labrador shelvesduring 2000. E. Colbourne	P
2	Sentinel surveys 1995-2000: catch per unit effort in NAFO Divisions 2J3KL. D. Maddock Parsons, R. Stead and D. Stansbury	P
3	Description of the 2000 fishery for 2J3KL cod. L. Yetman	P
4	An age disaggregated index from the sentinel program for cod in NAFO Divisions 2J3KL.D. E. Stansbury, D. Maddock Parsons and P. A. Shelton	P
5	2J3KL fish harvester committee questionnaire (2000). H. Jarvis and R. Stead	P
6	The Petty Harbour fishery. T. Best	P
7	Quality of Newfoundland region cod age determination. H.F. Hicks, G. Cossitt and C. Hiscock	P
8	Stock structure and movements of Atlantic cod (*Gadus morhua*) in NAFO Divs. 2J+3KL based on tagging experiments conducted during 1999-2000. J. Brattey, D. Porter and C. George	P
9	Sentinel surveys 1995-2000: catch per unit effort summarized by commercial logbook area. D. Maddock Parsons and R. Stead	I
10	Cod in NAFO Divisions 2J+3KL; catches and bottom-trawl surveys. Part 1. Bottom-trawl surveys: abundance/biomass and distribution. G. R. Lilly, P. A. Shelton, J. Brattey, N. G. Cadigan, E. F. Murphy and D. E. Stansbury	P
11	Cod in NAFO Divisions 2J+3KL; catches and bottom-trawl surveys. Part 2. Bottom-trawl surveys; size-at-age, condition and maturity. G. R. Lilly, P. A. Shelton, J. Brattey, N. G. Cadigan, E. F. Murphy and D. E. Stansbury	P
12	Scientific publications discussing northern (2J+3KL) cod. G. R. Lilly	I
13	Relative strength of the 1999 and 2000 year-classes, from nearshore	P

	surveys of demersal age 0 & 1 Atlantic cod in 3KL and Newman Sound, Bonavista Bay. R. S. Gregory, B. J. Laurel, D. W. Ings and D. C. Schneider		
14	A charmingly simple migration model.	J. Pope	P
15	Some preliminary analysis of tagging data.	N. G. Cadigan	P
16	Smoothing length frequency data via kernel density estimation. B. P. Healey and N. G. Cadigan		P
17	Status of the Smith Sound cod January 2001.	G. A. Rose	P
18	What is the spatial ontogeny of groups known to be spawning in Trinity Bay, Hawke Channel, and Bonavista Corridor/Tobin's point? G. A. Rose		P
19	Performance of the Campelen 1800 shrimp trawl during the annual bottom trawl surveys of 2J+3KLMNO, 3Ps and 3LNO, 1995-2000. B. R. McCallum and S. J. Walsh		P
20	Catch and catch at age.	E. F. Murphy	P
21	Consumption of Atlantic cod (*Gadus morhua*), capelin (*Mallotus villosus*) and arctic cod (*Boreogadus saida*) by harp seals (*Pagophilus groenlandicus*) in NAFO Divisions 2J3KL. G. B. Stenson and E. Perry		P
22	Whole stock perspective: precautionary approach and risk of extinction. P. A. Shelton		P

*P = presented to the meeting
I = for information only