Fisheries and Oceans Canada / Pêches et Océans Canada
Science / Sciences

C S A S / S C C S
Canadian Science Advisory Secretariat / Secrétariat canadien de consultation scientifique

Proceedings Series 2002/007 / Série des compte rendus 2002/007

Proceedings of the National Science Review Meeting on Species at Risk Issues, March 18-22, 2002, Halifax, Nova Scotia

Compte rendu de la réunion de la revue national des sciences au sujet des espèces en péril, le18-22 mars, 2002, Halifax, Nova Scotia

Howard Powles – Chairperson / président

Fisheries and Oceans Canada / Pêches et Océans Canada
200 Kent St. / 200 rue Kent
Ottawa, Ontario
K1A-0E6

July 2002 / juillet 2002

ISSN 1701-1280
www.dfo-mpo.gc.ca/csas/
Canada

Proceedings of the National Science Review Meeting on Species at Risk Issues, March 18-22, 2002, Halifax, Nova Scotia

Compte rendu de la réunion de la revue national des sciences au sujet des espèces en péril, le18-22, 2002, Halifax, Nova Scotia

Howard Powles – Chairperson / président

Fisheries and Oceans Canada / Pêches et Océans Canada
200 Kent St. / 200 rue Kent
Ottawa, Ontario
K1A-0E6

July 2002 / juillet 2002

Table of Contents

SUMMARY

The first DFO National Advisory Process meeting to discuss science issues related to the assessment, protection and recovery of marine fish species at risk was held in Halifax, Nova Scotia, March 18-22, 2002. DFO information on upcoming marine fish species to be assessed by COSEWIC (Committee on Status of Endangered Wildlife in Canada) was reviewed at the meeting and the assessment and advisory implications of incidental harm permits which can be issued under the proposed Species at Risk Act (SARA) were considered. Participants included DFO scientists, university scientists, authors of COSEWIC Status Reports, COSEWIC members, and a scientist from the US National Marine Fisheries Service. Each DFO Atlantic Region presented information for review on Atlantic cod (*Gadus morhua*) stocks in their region relating to the terms of reference of the meeting (population structure, abundance, distribution and trends). Working papers were also reviewed on barndoor skate (*Raja laevis*) (information from commercial fisheries and from surveys), bocaccio (*Sebastes paucipinnis*) and cusk (*Brosme brosme*). The identification of evolutionarily significant units was discussed using Atlantic cod as a model, and a table of observations supporting mixing and the separation of cod stocks is presented for consideration in future discussions on this issue. An overall summary on the status of Atlantic cod based on the information presented at the meeting is also included in these proceedings. Information and analytical requirements to support incidental harm permits, which can be issued under certain conditions under the terms of SARA, were discussed and recommendations for possible actions have been documented. Requirements for the content of the Research Documents that result from the meeting were documented.

SOMMAIRE

La première réunion de consultation nationale du MPO, portant sur des questions scientifiques liées à l'évaluation, à la protection et au rétablissement des espèces de poisson marin en péril, s'est déroulée du 18 au 22 mars 2002 à Halifax, en Nouvelle-Écosse. Les participants ont examiné l'information du MPO sur les espèces de poisson marin que doit évaluer prochainement le COSEPAC (Comité sur la situation des espèces en péril au Canada), ainsi que les conséquences en matière d'évaluation et de consultation des permis autorisant les dommages dûs à des activités qui touchent l'espèce de façon incidente qui sont prévus dans le projet de Loi sur les espèces en péril (LEP). Étaient présents à la réunion des scientifiques du MPO et d'universités, les auteurs de rapports de situation du COSEPAC, des membres du COSEPAC et un scientifique du National Marine Fisheries Service des États-Unis. Chaque bureau régional de l'Atlantique du MPO a présenté de l'information pour l'examen des stocks de morue (*Gadus morhua*) conformément aux paramètres de la réunion (structure, abondance, distribution et tendances des populations). Les participants ont examiné des documents de travail sur la grande raie (*Raja laevis*) (information issue de pêches commerciales et de relevés), le bocaccio (*Sebastes paucipinnis*) et le brosme (*Brosme brosme*). Ils ont aussi discuté de la détermination d'unités évolutionnaires significatives en utilisant la morue comme modèle. A ensuite été présenté un tableau d'observations appuyant le mélange et la séparation des stocks de morue en vue de futures discussions sur le sujet. Est joint au présent résumé un aperçu général de la situation des stocks de morue fondé sur l'information transmise à la réunion. Par ailleurs, les participants se sont penchés sur les besoins en matière d'information et d'analyse concernant les permis autorisant les dommages incidents, qui peuvent être délivrés dans certaines circonstances aux termes de la LEP, et les mesures possibles recommandées ont été recensées.Les renseignements à incorporer aux documents de recherche découlant de la réunion ont été identifiés.

INTRODUCTION AND TERMS OF REFERENCE

Terms of reference for the meeting are in Appendix 1. Under the proposed Species at Risk Act (SARA), assessment of species status and designation of risk categories are the responsibility of the Committee on Status of Endangered Wildlife in Canada (COSEWIC). The Department of Fisheries and Oceans holds information and expertise which will be essential to COSEWIC in assessing status and extinction risk for aquatic species.

One objective of this meeting was to review DFO information holdings on several marine species with the intent of providing this information to COSEWIC.

Working papers summarizing the information held by DFO on the following species were reviewed:

- Atlantic cod (*Gadus morhua*)
- cusk (*Brosme brosme*)
- barndoor skate (*Raja laevis*)
- bocaccio (*Sebastes paucispinis*)

The type of information reviewed for each species included (where available):

- distribution
- abundance
- relevant life history characteristics such as growth parameters, age (and/or length) at maturity, maximum age (or length), fecundity, production of young per year, duration of planktonic larval life and specialised habitat requirements

Another objective of the meeting was to give general consideration to analytical approaches and data requirements for providing scientific advice on incidental harm permits as provided for in the Species at Risk Act (SARA).

A third objective of the meeting was to assess how well this process worked, so that in future DFO can provide relevant information most efficiently and effectively for species at risk assessments.

These proceedings document the discussion and conclusions resulting from this national review meeting to consider certain questions related to species at risk protection and recovery.

Unlike typical scientific advisory process meetings, scientific advice was not provided. Research Documents summarising the available information on the above species will be produced from this meeting, in addition to the summary of discussions in this Proceedings.

INCIDENTAL HARM PERMITS

Working Paper SARA NAP 02/02

Incidental Harm Permits: Assessment and Advisory Implications

Author: H. Powles

Presentation Summary

Under SARA, once a species is placed on the legal protection list it becomes illegal to kill or harm the species or harm its residence. SARA provides that a competent Minister may issue a permit to allow for incidental harm to a listed species, such as in the case of fisheries bycatch. Before a permit can be issued the Minister must show that alternative measures have been taken to reduce the impact to the species, and must show that any incidental harm allowed will not jeapardize survival or recovery of the species. IHPs may be required upon proclamation of SARA for species legally listed at that time.

It needs to be determined who will issue IHPs and the assessment and review approach for supporting an IHP needs to be outlined. Species for which IHPs may be necessary upon proclamation of SARA due to potential effects from fisheries bycatch are: Leatherback turtles, Spotted and Northern Wolffish and Inner Bay of Fundy Salmon. Northern abalone, Sea otter and Atlantic Whitefish are listed under SARA Schedule 1, however, incidental harm does not appear to be a major issue. Upcoming assessments of species that may be listed and may be subject to incidental harm are Interior Fraser Coho Salmon, Right Whale, Eulachon and Harbour Porpoise. The protocol for assessing permits for freshwater species has not yet been determined.

Possible analytical approaches to incidental harm permits include: temporal and spatial restrictions, modifications to fishing activities and/or determining an 'allowable' incidental harm quota. The US Endangered Species Act (ESA) employs a mortality limit called the Potential Biological Removal (PBR) for marine mammal populations under legislation. This limit is calculated using the minimum population estimate of the stock, an estimated productivity rate and a recovery factor. Further discussion on whether this is an appropriate method for Canadian populations of species at risk is needed. The use of some fraction of natural mortality as a permissable mortality level is a possible alternative approach. In many cases information available to assess mortality from incidental harm will be limited and management for incidental harm of species at risk will have to be in line with the precautionary approach.

Discussion

IHP process:

Justification for an IHP is needed at the time of legal listing under SARA, so it will be necessary to anticipate listings by working in parallel with the COSEWIC and legal listing processes. Persons clearly identified as likely to encounter and incidentally kill the listed species, and thus at risk of prosecution (e.g. fishers) would be issued a permit. Regarding IHP requirements for recreational fisheries with a large potential impact but where the impact of an individual fisherman would be very small, it was presumed that individual recreational fishers would require an IHP to avoid being prosecuted. IHPs would become part of the commercial or recreational fishing licence.

Although traditional approaches may be adequate to estimate the likely impact of *direct* by-catch mortality, it may be much more difficult to estimate or reach consensus on the likely impact of other indirect sources of anthropogenic mortality such as ship strikes or habitat loss. However these are unlikely to be IHP issues since individuals would typically not be subject to prosecution for such harm, and these issues should be addressed more comprehensively by a recovery team after listing. The recovery team would be expected to review the basis for any IHPs, consider other impacts such as threats to critical habitat, and investigate other approaches to reducing harmful impacts.

It was suggested that the evaluation of conditions for an IHP would also include an estimate of the socio-economic cost of listing the species. It might be beneficial for DFO to do these assessments within the RENEW framework rather than in DFO's advisory process, thereby sharing the burden of responsibility. To this end, it might be advantageous to create another committee, similar to COSEWIC, to deal with IHP issues and other scientific issues related to recovery planning under the RENEW umbrella. While potentially a useful approach, in practice this might be slow to put into practice given the many issues facing RENEW. If scientific advice cannot be provided rapidly on IHPs, fisheries might have to be closed without adequate analytical background and this might be unacceptable to the public.

The utility of prohibitions on by-catch was questioned in that they may provide an incentive for dumping and a loss of information about impacts without ameliorating those impacts. An alternative approach would be to consider complete closures of large refuge areas rather than to attempt to reduce mortality to an arbitrary and perhaps insufficient degree everywhere. Development of institutional mechanisms to achieve ecosystem objectives such as reducing mortality of species at risk to acceptable levels will be encouraged under Objectives-Based Fisheries Management and Integrated Oceans Management initiatives currently being undertaken by DFO.

IHP assessment issues:
A fundamental question remains unresolved: what reduction in probability of extirpation would be acceptable to warrant an IHP under the Precautionary Approach, and is this the same for all species and contexts? This may not be a *scientific* question, even if science could estimate with rigour the reduction in viability expected for various levels of by-catch. In practice, these calculations will be difficult. "Arbitrary" approaches like PBR and MPBR proposed in the working paper give an appearance of being scientific, by attempting to circumvent the issue of trade-offs. It may be better to address the trade-offs explicitly by presenting options and their likely consequences, then allowing the public to decide what level of sacrifice is warranted. Population viability analysis is feasible, and by making assumptions explicit, this approach might be more convincing than the PBR method. Ultimately, however, such projections need to be tested against empirical indices such as the IUCN criteria.

The issue is similar to the discussion at the December 2001 workshop on the Precautionary Approach (Rice and Rivard eds. 2002), where there were several unresolved points of view regarding conservation limit reference points, which are also "arbitrary" limits analogous to PBR. Many felt that these heuristic reference points were useful, but only as a proxy for more rigorous probabilistic models. There was a lack of consensus at that meeting on whether conservation limits should be established on scientific considerations alone, or whether scientific analyses should show options and consequences allowing for decisions on limits to made by wider society.

Concern was raised that the PBR method may not translate well from mammals to fish and that it should be tested in simulations. It was also noted that natural mortality M and the related parameter, longevity, are both so difficult to estimate that they might be unverifiable concepts. An implicit assumption in the proposed MPBR method is that viability is ensured if $F<M$, a concept advanced to cope with uncertainty and/or lack of data in exploiting healthy populations. Thus, the method is more suitable to equilibrium conditions (i.e., stable abundance) and likely not appropriate for populations that are declining or already at low abundance. To provide a conservative estimate of PBR, M should be that for the unexploited population.

Catch is typically known even where the minimum estimate of population size N_{min} and M are unknown so it might be easier and more useful to express IHP limits as a required percentage reduction in by-catch mortality. Such a pragmatic approach might limit expectations that would lead to an impossible workload. However, the adequacy of simple, pragmatic methods should be confirmed in case studies with simulations. Purely pragmatic approaches not based on agreed standards may not be acceptable.

Conclusions and Recommendations
The meeting made the following recommendations:

- Revise this working paper following the comments in the meeting and include as an Annex in the Proceedings of this meeting
- Pursue broader policy options for setting trade-offs in recovery strategies; explore possibility of using RENEW as umbrella organization for incidental harm permit analyses to achieve better consistency across taxa
- Conduct simulations with explicit assumptions and develop case studies for review at the next SARA NAP meeting.
  - several participants indicated their potential interest but also indicated that existing workloads would compromise taking on much additional work. Participants agreed to further discuss how analyses would be organised for presentation at the fall meeting.
  - it was proposed that a schedule for reviewing case studies be developed by DC3 or another SAR committee that has a representative from each region.
- Alternatively, develop case studies for discussion and reporting at a separate SAR workshop

BOCACCIO

Working Paper SARA NAP 02/01

Status Report on Bocaccio Sebastes paucispinis Ayres, 1854 From B.C. waters

Authors: R.D. Stanley, K. Rutherford and N. Olsen

Presentation Summary
Bocaccio is one of over 35 species of rockfish found in marine waters of British Columbia (B.C.). It is distinguished from other rockfish (*Sebastes* spp.) by its large jaw. It ranges in colour from olive orange to burnt orange or brown on the back becoming pink to red on the underside. Other common names for bocaccio include rock salmon, salmon rockfish, Pacific red snapper, Pacific snapper, and Oregon snapper.

Bocaccio are found in coastal waters of the eastern Pacific Ocean from the Gulf of Alaska to Baja California, Mexico. Most B.C. catches come from the outer Pacific coast near the edge of the continental shelf, with the largest catches coming from the northwest end of Vancouver Island and from Queen Charlotte Sound. They are occasionally reported from some inlets and the Strait of Georgia.

In California, larval bocaccio have been caught up to 480 km from the coast. Young of the year reside near the surface for a few months then settle in nearshore areas where they form schools over bottom depths of 30-120 m. Adult bocaccio can be semi-pelagic and are found over a variety of bottom types, between bottom depths of 60-200m. In B.C. they are caught with several other groundfish species including Pacific ocean perch, yellowtail rockfish, and canary rockfish.

Biological research on bocaccio in B.C. waters has been limited. Most of the available biological information comes from studies done in California. Bocaccio are live-bearers like all members of their genus. Fecundity ranges from 20,000-2,300,000 eggs and increases with the size of the female. Copulation occurs in early fall but fertilization is delayed. Fertilized eggs are retained in the body of the female through hatching and much of larval development. Embryonic development takes about one month and, in B.C. waters, young are released in the winter. Settlement to the littoral and demersal habitat extends from late spring through the summer. Larvae are approximately 4-5 mm at release and then metamorphose into pelagic juveniles over several months. Bocaccio are thought to mature at 4 to 5 years of age and can reach a weight of almost 9 kg and a length of over 90 cm. Females tend to be larger than males. Maximum age is unknown but radiometric dating of the ear-bones has indicated a maximum of 40 years.

Juvenile bocaccio feed on larvae, euphausiids, young rockfish, surfperch, mackerel and various small inshore fishes. Adult bocaccio prey on other rockfish, sablefish, anchovies, lanternfish and squids. The main predators of juvenile bocaccio in California are sea birds and the main predators of adults are marine mammals. Bocaccio are host to a number of parasites including a parasitic copepod that occurs in the muscle tissue and has given bocaccio a market reputation for "worminess". Bocaccio may also be the only host for one species of tapeworm.

Bocaccio is a relatively uncommon species in BC waters although its abundance is not known in detail. Its low commercial importance has resulted in no directed research, and the low catches of bocaccio in the fisheries limit the utility of fishery-dependent data for tracking abundance. Catches do indicate that the population is present in all coastal waters at the edge of the continental shelf. The distribution in inshore waters is unknown. However, bocaccio continue to be reported from several inlets as well as the Strait of Georgia. The abundance trend is unknown for the outer north coast where bocaccio have never been caught in large numbers, but appears stable for the central coast. It has possibly declined off the West coast of Vancouver Island over the last two decades but it appears stable over the last five years.

Current commercial catches of bocaccio in B.C. are low. Sport and First Nations catches are probably negligible. The commercial harvests in the Strait of Georgia are also negligible, if not zero.

The population of bocaccio in B.C. is probably continuous with populations in Washington State. Therefore, harvests in waters off Washington likely have an impact on the regional population of bocaccio in B.C. However, U.S. landings are now negligible due to restrictive trip limits.

There are no means for ascertaining the impact of the two parasites on bocaccio abundance and distribution over time. Nor is there information on how other types of environmental change may influence bocaccio populations.

We know of no special economic, cultural or ecosystem significance of bocaccio. It may be the unique host for one species of tapeworm, however, the presence of this tape worm in B.C. waters has not yet been documented.

Discussion on the Terms of Reference

Population Structure

Evidence for Mixing

Larvae are planktonic and may disperse from spawning areas, but the degree of dispersion is unknown. Limited tagging shows juvenile movements of 1-150 km. No obvious evidence of discontinuities in Canadian distribution was presented.

Evidence for Separation

Adults have been shown in tagging studies to exhibit limited movements.

Conclusion

In conclusion, it was decided that there was no evidence to treat bocaccio as more than a single ESU in Canadian waters. Some concern has been expressed concerning the population status of individuals in the area of the Strait of Georgia, but it was decided that the data were inadequate to justify considering this area separately. To place the consideration of populations in Canada in context, the US has designated two ESUs in US waters, a northern and southern ESU, based on genetics. This designation is consistent with a spatial discontinuity in catch.

Abundance trends

Catch Data

All series shown in the working paper were mature individuals.

The meeting accepted the authors' recommendation that little or no credence be given to the catch and CPUE data prior to the implementation of dockside monitoring and 100% observer coverage in the mid-1990's, and accordingly considered these series accurate only in the last 5 years of the series (1996-2001). In addition the meeting suggested that the document emphasize the risk in assuming comparability in fishing effort over time. However, the meeting noted the congruence between the high relative landings of the earlier period and the indications of population decline in the southern region and therefore found it unfortunate that there was not a more rigorous basis for rejecting these earlier data. Trends were greatly affected by spatial/depth range covered by the fishery.

It was decided that there was no evidence for overall change in CPUE over past 5 years, in particular no consistent negative trend overall. However, one of the 3 CPUE indices in the northern area has shown a decline during this period.

Survey trends

a) Southern area (US triennial survey off southwest Vancouver Island, near US)
Survey catch rate has exhibited a large decline over the period available. This decline reaches approximately 99.7% when extrapolated back to 3 generations. Regression analysis provided an estimate of a 20% drop per year during the survey series. The degree of decline is similar to what has been observed in the US (1% left). There has been no sign of a rebound, given the variance around last 3 points in the series.

b) Ocean perch survey
This survey occurs at the deep end (150-350 m) of the estimated depth range of bocaccio. No trend was evident in the series. The authors will investigate the possibility of a change in survey design.

c) Hecate Strait assemblage survey
This survey exhibited high catches early in the series and relatively very low catches late in the series. The survey occurs mainly over habitat not favoured by rockfish species. Overall, the catches and catch rates were very low. The authors considered this survey useful mainly as an index of presence/absence. So few individuals were caught that this survey may not serve reliably as an index of abundance. The authors were asked to add total numbers to the table of this series.

Overall trends

Regressions through all series would exhibit negative slopes. There was some evidence for a leveling off of decline in recent years.

The meeting found more source for concern in the fishery-independent surveys than was reflected in the report. In particular, the meeting suggested that the US triennial survey off southwestern Vancouver Island provided a credible basis for inferring that the population in the covered area had declined by 1-2 orders of magnitude. This conclusion was supported by the strong evidence that was cited for a similar decline in adjacent US waters and the results of the shrimp survey. Furthermore, while the meeting agreed that data were too limited from the remaining regions to form strong conclusions, some of the provided indices had declined (for example, some subsets of the ocean perch survey) and there was little evidence to counter a general perception that the population might have declined throughout Canadian waters. The meeting also commented that a low catch frequency for a species in a survey does not necessarily invalidate its use as an index for that species. Finally, the meeting commented that a review of these indices would be significantly aided by including a presentation of point estimates of the variance.

Number of Mature Individuals
No reason to conclude that population abundance < 10 000 mature individuals.

Distribution
Mid-water trawls
This series did not display any trend in spatial distribution. The senior author noted that data for 2001 in the working paper represented the January-June period. The senior author also emphasised that the distribution of midwater trawl effort was spotty along the coast, and the figure was only presented to look for gross changes in the general distribution.

Threats

1. Fishing: true removals, as evidenced by the period of 1996-2001 where observer coverage was 100%, were likely in the range of 200-300 tonnes per year. Catches in areas 3c, 3d were relatively very low. Whether these catch levels were sufficient to have caused the decline is unknown, since a suitable estimate of total abundance does not exist.
2. Natural mortality: diseases, parasites
   No evidence of increases in natural mortality was presented.
3. Recruitment failure (excluding recruitment overfishing)
   Recruitment failure is considered to have been a major factor in the decline of boccacio in US waters. There is discussion in the US about whether recruitment failure would be primarily due to recruitment overfishing, changes in environmental conditions, or some combination of both.

Conclusions and Recommendations
A major point of discussion concerned the spatial distribution and occupancy of possible habitat. Of concern was the degree to which commercial catch, with its concomitant spatial limitations, map the distribution.

It was recommended that confidence limits be applied to the point estimates presented in the graphs of survey indices in order to aid in interpretation of trends.

The meeting concluded that the authors had presented a very good summary of available information. Information on bocaccio is sparse as this species is not targeted by commercial fisheries and is relatively uncommon compared to other rockfish species targeted by fisheries. Fishery data were considered unreliable prior to about 1996 because of the lack of independent verification in previous years. Survey data were best off southwest Vancouver Island. The status report shows both the potential and the difficulties of using available information to assess status of uncommon or non-commercial species.

ATLANTIC COD

Working Paper SARA NAP 02/03

Authors: by K. Smedbol, P. Shelton, D. Swain, A. Fréchet & G. Chouinard

COD POPULATION STRUCTURE – EVOLUTIONARILY SIGNFICANT UNITS

Presentation Summary

The debate over what should constitute an ESU is roughly divided into two approaches for evaluation, (1) multi-metric procedures that weigh adaptation and evolutionary legacy, and (2) phylogeographic or phylogenetic techniques that set rigid criteria. However, both of these definitions of ESUs explicitly incorporate population and management structure at finer scales within ESUs. Differences among putative ESUs are considered to be of evolutionary significance, whereas the separation among population units within an ESU is not of evolutionary significance. Thus the case can be argued that the stock concept (as currently defined) incorporates population structure of a finer scale than that embodied by an ESU.

The number and location of fish stocks was a consideration in the construction of Canadian fisheries management units. Generally, the boundaries of management divisions have been arranged to encompass unit stocks. One can conclude, therefore, that if fish stocks within Canadian waters have been identified correctly, Canadian fishery management units are already defined on a finer scale than potential ESUs. Therefore, under the Terms of Reference, population structure *within* current assessment and management units should be reviewed. Only if this review provides evidence of *evolutionarily* important differences *within* stock boundaries should current stock designations be dropped. However, detectable stock differentiation may not be of evolutionary significance. The review may provide evidence of population structure at this finer scale within current management units that is not currently incorporated into management planning. Such evidence should lead to a re-evaluation of the current management units encompassing the population components in question.

Discussion

The question of relevance is ‘what units below the species level are appropriate for designation under species at risk criteria?’ The terms of reference for this meeting refer to ‘evolutionarily significant units’ (ESU)(sensu Waples) which was seen as a proxy for the general question.

Major considerations regarding population designation following the ESU protocol specified for this meeting include:

a) Is the unit distinct, demonstrably separate, reproductively isolated?
b) Does unit occupy a distinct/unique habitat? Is population uniquely adapted to its particular environment?

c) Does the unit represent (would loss of the unit result in loss of) a significant part of the genetic legacy of the population?

There was discussion of the degree of differentiation shown by the most recent genetic papers on cod (genetic differentiation vs genetic distinctiveness) and the variety of observations (tagging, biological characteristics, etc) that indicate the existence of cod components.

Members of the cod working paper team proposed that the current set of management units was at, or below the scale of the ESU under common current definitions. Information was, therefore, summarized on the basis of current management units but with note of additional structure within each unit where it has been observed. Information on population structure within management units discussed at the meeting is found in the sections on specific management units.

The meeting concluded that there is a hierarchy of structure in time and space. The bottom line is preservation of 'genetic legacy', and at present there is no standard approach to the evaluation or designation of units in this regard.

Overall there is abundant evidence for population structuring of cod within Atlantic Canada and within management units as currently defined, and conservation of this diversity of units was considered important in order to maintain productivity and reproductive potential. Overall there was considered to be little evidence available to the meeting for distinctness and uniqueness at the level required to define ESU's within Atlantic Canada, ie units the loss of which would represent an irreplaceable loss to the evolutionary legacy of cod.

However the meeting was only able to review information available through participants and publications and did not have access to comprehensive information on this topic – indeed a multi-day symposium would be required to comprehensively review and synthesise the available information on cod population structuring and ESU's. The meeting noted that not all the studies necessary to define ESU's had been done. In particular studies of adaptive genetic variation have not been conducted. There was lack of consensus among meeting participants which reflects a lack of consensus among specialists on this issue about whether neutral genetic markers are appropriate proxies for adaptive variation. In addition there are no agreed thresholds for degree of separation in genetic markers that would allow for establishment of ESUs.

There is a need for development of a Canadian policy/approach to the designation of significant units under the new Species at Risk Act. A discussion paper on this is being developed by federal Departments involved in species at risk initiatives, and a workshop on 'Distinct populations in aquatic endangered species' is being planned for late 2002/early 2003.

There is a wealth of information of relevance to stock structure of cod. While it was not the intent/mandate of the meeting to undertake a thorough compilation or review of that information, some relevant observations representing evidence for separation of units and for mixing of units.

Table of Observations Potentially Useful in Considering Cod Populations and ESU's in Atlantic Canada

Observations on separation of units	Observations on mixing of units
Genetic information *Allele frequency, mitochondrial DNA* ▪ Inshore and offshore components in 2J3KL can be distinguished based on frequency of alleles (Beacham et al 1999, 2000, 2001; Ruzzante et al 1996, 1997, 1998, 2000) ▪ There are no agreed thresholds so overlap in alleles does not mean lack of ESU's ▪ Neutral genetic markers may not be good proxies for adaptive variation	▪ Although units are statistically distinguishable for inshore vs offshore cod in 2J3KL, there is considerable overlap in alleles ▪ Similar inshore-offshore differences not found in other areas (3Ps)
Unique alleles, microsatellite DNA	▪ Based on genetic information, unique units cannot be identified among Atlantic cod in Atlantic Canada except for Flemish Cap and Gilbert's Bay which have "private alleles" and are very distinctive (Carr pers comm)
Potential for recolonisation ▪ Rebuilding of offshore 2J3KL component(s) unlikely to come from inshore component(s) because of genetic differences (Beacham et al. 1999, 2000, 2001; Ruzzante et al. 1996, 1997, 1998, 2000)	▪ Expansion of range commonly seen in marine populations at high abundance
Tagging and migration ▪ Templeman (1962, 1974, 1979, 1981) long-term studies show presence of persistent migration pathways and spawning aggregations ▪ Recent tagging in 2J3KL and 3Ps shows high degree of site fidelity (Brattey 1996, 1999, 2000; Brattey et al 2001); also in 4RS3Pn (Bérubé and Fréchet, 2002)	▪ Cod from different spawning areas mix in non-spawning periods and/or areas and this may provide opportunity for straying, (adolescent animals may follow adults from "wrong" population) (eg 3Pn/3Ps)

Observations on separation of units	Observations on mixing of units
Meristics, morphometrics, parasites ▪ Templeman (1962) – long-term studies show presence of persistent components on the basis of vertebral counts (within most management units, between management units) ▪ There is a genetic component to vertebral number in species studied (eg. the genus *Menidia*) ▪ Templeman (1962, 1974, 1979, 1981) also showed differences in parasite loads between areas	• Templeman (1962, 1974, 1979, 1981) referred to "stock complexes" suggesting some degree of exchange between components • Vertebral numbers may be affected by environmental conditions where larvae develop
Life history characteristics ▪ a number of differences in length at age between areas in Atlantic Canada were noted at the meeting (eg 4Vs vs 4W; Bay of Fundy vs southern Nova Scotia) ▪ spring and fall spawning components exist within some areas (eg 4VsW, 4X) Frank et al. (1994) 4VsW; Clark and Paul (1999) 4X ▪ Otolith elemental composition shows differences among areas/putative populations (Campana et al. 1999) ▪ Differences in growth and survival between populations when reared in common lab environments (Puvanendran and Brown, 1998; Purchase and Brown, 2000)	• length at age, age at maturity have shown plasticity over past decades in many areas
Distribution • There are discontinuities in distribution and movements: for example there is little exchange between northern and southern sides of the the Laurentian Channel, and there is a discontinuity in distribution between the Bay of Fundy and southern Nova Scotia • Flemish Cap and Gilbert Bay which are distinct based on microsatellite DNA are geographically separate from other cod stocks	• Discontinuity Bay of Fundy/southern NS not "absolute", ie., there are fish throughout the area but centres of abundance are separate

Observations on separation of units	Observations on mixing of units
Early life history information ▪ Cod have complex spawning behaviour (Hutchings et al, 1999; Brawn, 1961; Morgan and Trippel, 1996) which might contribute to population structuring	▪ Eggs are planktonic (days) and larvae are planktonic (weeks), leading to the potential for exchange between areas with drift in currents

NEWFOUNDLAND STOCKS (2GH, 2J3KL, 3Ps, 3NO)

Author: P. Shelton

Presentation Summary

Four Newfoundland cod stocks were reviewed in the context of species at risk: 2GH, 2J3KL, 3NO and 3Ps.

2GH cod is part of Templeman's Labrador-Newfoundland stock. It has been managed under a separate TAC since 1974. It collapsed in the late 1960s and early 1970s as a consequence of foreign overfishing. It retained the ability to produce significant yearclasses into the early 1980s, but the consequences were short lived in the face of increasing Canadian effort, and by 1987 survey biomass had reached an extremely low level. The stock has been under a moratorium on directed fishing from 1986 to present. Canadian bycatch in the shrimp and turbot fisheries and harp seal predation are potential causes for the lack of recovery.

2J3KL cod comprises the major portion of Templeman's Labrador-Newfoundland stock. It collapsed as a consequence of foreign overfishing and reached a very low level by the time of extension of jurisdiction in 1977. There was a limited recovery though the early 1980s but this was short lived and by the late 1980s the stock was collapsing for a second time through unsustainable exploitation by the Canadian fishery. A moratorium was put in place in place on 2 July 1992 but the stock continued to decline until 1994. The commercial fishery reopened in the inshore in 1998 when the moratorium was imposed. The population has remained below moratorium levels with no evidence of recovery. The recent fishery has been based mainly on fish thought to overwinter in Smith Sound and on seasonal migrants out of 3Ps. Tagging estimates for the 3K and northern 3L for year 2000 are about 40,000 t, while acoustic estimates for the Smith Sound aggregation are about 20,000 t. The most recent assessment suggests that the current fishery on the remnant of northern cod may not be sustainable. In addition, harp seals may be contributing to lack of recovery but adequate seal diet data for the offshore are lacking.

3NO cod comprises Templeman's (1962) southern Grand Bank stock. The stock went through a first collapse during the late 1960s and early to mid 1970s reaching the lowest level in 1977. Following extension of jurisdiction there was a rapid recovery in the early 1980s but the stock collapsed a second time in the late 1980s as a consequence of unsustainable fishing mortality by both the Canadian and the foreign trawler fleet. There has been no recovery and the stock remains at a very low level. Bycatch fishing mortality levels are increasing and could be contributing to a lack of recovery. A few large fish remain, mainly in deep water.

3Ps cod was recognized by Templeman to be a complicated complex of several stock components. The stock declined during the late 1980s as a consequence of unsustainable fishing mortality by Canada and France. The Canadian offshore trawler fishery has never been very large on this stock. A moratorium was in place from September 1993 to 1996 and the stock recovered rapidly over this period. The fishery reopened in 1997 and TAC's have been set based on scientific advice at levels between 10,000 and 30,000 tonnes in subsequent years.

Discussion on the Terms of Reference

2GH

Responses to questions about the early period of catch history (1950's and 1960's) suggested that there was evidence that biomass present in the 60's was fished out. Earliest catch data point from Portuguese fishery in 1953 was questioned since it is much higher than estimates in years immediately after it. The author has confirmed the 1953 value exists in catch statistics, although there is some doubt about whether it accurately reflects removals.

The most likely explanation of the patterns of catch is one of recruitment over-fishing followed possibly by some environmental factor.

It was noted that the collapse through the 1970's and 1980's pre-ceded the period of cold water regime in the late 1980's and early 1990's. Comments suggesting that the history is similar to that of W Greenland, which is interpreted as being environmentally driven, were questioned and the authors were urged to include references to this work if this would help in the interpretation of patterns of abundance in this stock.

The authors were questioned about the role of bycatch since the moratorium. Shrimp fisheries are intensive and there is bycatch although little is reported. However, industry has adopted the Nordmore grate to reduce fish bycatch, and there is good observer coverage in this fishery. There are no indications that bycatch has played or is playing a significant role in preventing recovery.

2J3KL

Population structure

Templeman (1962) concluded that Northern Cod was an aggregation of populations that could be treated as a single stock. Recent studies using molecular genetics do not provide much insight into the stock structure beyond that of Templeman. It was pointed out that Templeman's much earlier stock typology based on vertebral counts and other life history characteristics has for the most part been consistent with tagging and microsatellite DNA genetics.

There are very different conclusions about the differences between inshore and offshore groups based on microsatellite DNA (µsatDNA) and mitochondrial DNA (mtDNA). The µsatDNA analysis shows persistent differences between the groups that are dependent on geographic separation. It was suggested that the hypothesis of separation by distance is driven by the distinctiveness of the Flemish Cap. No differences are seen in mtDNA.

A considerable discussion arrived at the conclusion that µsatDNA allowed the inshore and offshore groups to be distinguished but the very low F_{ST} (<~ 0.02) values suggested that there has been considerable gene flow between the two groups. Other evidence from tagging studies do not support the µsatDNA study conclusion of distinct inshore and offshore populations and suggests that the straying rate appears to be quite high with values >2% mentioned. The debate between the two competing models (highly structured stock structure vs. significant gene flow) is unresolved.

The question of whether inshore and offshore fish are distinct is important to fisheries management. If the two groups were distinct then it would be less likely that recovery in the offshore stocks could be driven by recovery in the inshore stocks.

For the 2001 assessment two assumptions of stock structure were made. Under the assumption that there is one stock, no directed fishery would be consistent with current stock status under a precautionary approach. Under the assumption that there are two stocks (inshore and offshore) the conclusion is that the inshore stock may not be sustaining current fishing levels.

Gilbert Bay is an unusual component in genetics (both approaches), morphology, color and other aspects of life history and ecology and represents a distinct but far from unique environment. There have been no genetic surveys in similar habitats elsewhere.

There is one other confirmed distinctive (genetics-both approaches, morphology, life history) population within this stock aggregate (Flemish Cap) and one other possibly distinctive population (Virgin rocks), which was “wiped out” in a late 80's gillnet fishery.

Abundance

Resumption of fishery in 1998 coincided with resumption of decline in SSB. There is uncertainty about the true catch but the belief is that 20%+ of SSB is currently being harvested. The suspected level of harvest is higher because of unreported catches and discarding. The authors noted that some tagging studies are estimating exploitation rates in some areas as high as 30%.

Authors agreed to put a table of the recent fisheries management actions (quotas openings and estimates of catch) into the summary document.
The catch history was characterized as follows: continuous and slowly increasing catch from 1850 to 1960, rapid expansion of foreign fleet in early 1970's resulting in collapse due to recruitment overfishing, small recovery in the 1980's followed by collapse in early 1990's to low point in 1994.

There was a change in trawl survey gear in 1995 fall/1996 spring, moving to a gear that could fish in areas that were not fished previously and which takes a higher proportion of smaller fish than the previous year. This change confounds abundance estimates to some extent and severely confounds the presence/absence indices of distribution that were presented.

Evidence in the form of the "missing fish model" (Shelton and Lilly 2000) was presented, capturing the observation that adults (large or older fish) from two year classes (1986, 1987) disappeared more rapidly than could easily be explained. Of the three explanations that were offered – catchability, natural mortality and fishing mortality - the authors lean toward fishing mortality.

Difficulties in applying COSEWIC status criteria based on the rate of decline were discussed. These difficulties stem from the large and auto-correlated variation in abundance. These difficulties were cited by all of the authors. The difficulties mainly relate to selecting the appropriate time period in a population where there are fluctuations in abundance. This may stem from a lack of understanding of how COSEWIC uses these status indicators. However, discounting time trends requires examination of the probable causes of the variability and determination of whether there are continuing or new threats.

Distribution
Habitat usage (habitat area occupied by 95% of the fish) declined from ~50% to ~30-35% and has shown limited recovery from the minimum. The Design-Weighted Area of Occupancy (DWAO) index based on presence or absence shows recovery after 1995 but this may be an artifact of a gear change that allowed fishing in areas that were excluded to previous gear. This gear change may also affect the abundance surveys as well since it represents more of an effect than a simple change in efficiency.

Threats
Threats include poor monitoring of commercial landings, the pilot recreational fishery, bycatch in shrimp and turbot (and other) fisheries; predation by seals; possible Allee effects or depensation mortality; poor recruitment and high total natural mortality. Seal predation was suggested as a likely factor delaying recovery in the report of the Seal Panel (Eminent Seal Panel. 2001).

3NO
This stock is currently under moratorium on directed fishing, with reference points

endorsed by NAFO Scientific Council and is expected to remain under moratorium for the immediate future.

Population structure
This is Templeman's "Southern Grand Banks" stock. Based on µsatDNA it can be distinguished from surrounding stocks consistently over time, but mtDNA shows no differences from surrounding stocks except for Flemish Cap (3M). The "migratory component" referred to in the Working Paper was clarified as the component migrating seasonally to inshore southern 3L.

Abundance
The temporal pattern in catch resembles that of northern cod but the changes in abundance are smaller.

Bycatch mortality (in for example fisheries for redfish; turbot, skate, monkfish) may have risen beyond what would be considered an advisable (or sustainable) level for a directed fishery. There is some limited observer data available indicating that some foreign vessels are not accurately reporting bycatch in this area. Agreed bycatch estimates are not currently available to analyze and accordingly the NAFO directive to minimize bycatch cannot be validated or enforced.

The suggestion that there is a stock-recruitment relationship with two regimes and a boundary of high/low recruitment at 60kt SB was questioned. An alternative interpretation was presented in which high levels of auto-correlation are evidence of a temporal change in productivity that would be best expressed as a change in the recruitment rate. There are also indications that productivity is worsening. The authors asserted that changes in recruitment can be at least partially explained by loss of large old fish with higher effective fecundities. The search for environmental correlates of recruitment changes has been largely unsuccessful. The only environmental correlation discovered seems to be a positive relationship between temperature and growth in northern cod.

There was an extensive discussion about the difficulties of selecting an appropriate period over which to estimate rates of decline. This discussion was repeated during later presentations (also see discussion for 2J3KL above).

A paradox in this cod stock (and in others) is that age of maturity, growth rate & abundance have all decreased simultaneously which is not what one would expect based on simple density dependence. One suggestion is that this pattern of change in life-history characteristics could be the result of a size-selective process (fishing) in the past favoring slow growing fish that mature early at small size.

There was considerable discussion regarding the inclusion of projections of future stock status. The projections presented in the Working Paper were developed at the request of NAFO and have been peer reviewed. Consensus was that the Research Document should refer to the projections. The projections indicate that under a “low” recruitment regime no recovery is likely above a fishing mortality *F*=0.04 - *F* is suspected to be considerably greater.

Requests that some indication of model uncertainty associated with survey biomass estimates be included were acknowledged, although there was general recognition that there are many sources of uncertainty in these estimates and that many of these will remain unquantified.

Although declines in biomass had stopped following the moratorium, fishing mortality due to increased levels of bycatch increased sharply in 1999. In 2000 F was estimated to be 0.6. With that level of F and current levels of recruitment the stock is unlikely to recover, and is more likely to decline further.

There was some discussion about possible ecosystem changes that have resulted from decreased abundance of cod but the general conclusion was that these kinds of effects cannot be documented and their effects on recovery prospects are unknown. There was also some discussion about possible effects of fishing on bottom habitat and consequences to recruitment. The possibility of such effects cannot be ruled out.

Distribution
There were indications of significant habitat contractions through the mid-1990’s. Graphs of habitat occupancy will be provided with units of km^2. A line indicating the change in gear type in the 1996 survey will be added to the DWAO plot.

3Ps
Population structure
Templeman identified 5 stock components including a northern Gulf stock component within this stock area. Tagging studies have confirmed that there are 3 migration patterns including the classic seasonal migration of offshore fish to inshore, migration out of Placentia Bay around the Avalon Peninsula, and migration of northern Gulf cod into the western portion of the area. Although no clear overall conclusions are possible concerning population structure beyond what is noted above, there do appear to be persistent differences in migratory patterns and morphology that are consistent with some underlying population structure.

Abundance
There are a variety of research vessel series including a French research cruise series. Catch data statistics from this area are thought to be unreliable because of monitoring problems so severe that actual catch may be up to three times that which is reported.

During the last assessment, Sequential Population Analysis (SPA) was used to evaluate 5 different model formulations of which none was preferred. Accordingly the best estimate of abundance trends comes from the 5 SPA models. The authors noted that there appeared to be less recruitment overfishing in this area, and that there are possibly fewer seals, than in other areas. Also, bycatch in offshore trawl fisheries is not considered to be a major problem – the Canadian fishery never had a strong offshore trawl component in this stock area. There are however some concerns about excessive exploitation on the Placentia Bay component.

The long-term declines in recruitment have apparently reversed but there is considerable uncertainty over the size of recent year classes. Although the 1-year projection showed low probability of spawning stock biomass decreasing at current total allowable catch levels, there was consensus in the meeting that in the longer term decreases or increases appeared to be equally likely.

Threats

The most significant threat identified is the unknown extent of unmonitored removals by the inshore commercial fishery. Seals in particular areas and bycatch were also mentioned but no specifics were presented.

Conclusions and Recommendations – Newfoundland Cod

Some concerns were expressed in the meeting that conclusions about bycatch being a relatively unimportant issue for 3Ps cod were possibly overstated; the authors will examine this issue more closely and revise the Working Paper if necessary. The authors will also modify the figure of the DWAO index to indicate the year of survey gear change. The absolute biomass estimate from tagging is not reliable for offshore component. Indications of the range in biomass estimates from SPA will be included in the Working Paper.

NORTHERN GULF OF ST. LAWRENCE STOCK (3Pn, 4RS)

Author: A. Fréchet

Presentation Summary

There was a moratorium on fishing this cod stock from 1994 to 1996 that was justified by very few mature fish present and low recruitment. Since 1997 there has been a limited fishery ranging from 3 000 t to 7 500 t but according to the most recent assessment these small catches are still high in relation to the available biomass. The most recent fishing mortality estimate is about 0.5. This limits rebuilding of the stock.

The most recent assessment of this cod stock shows that the abundance of spawning cod declined from 311 million in 1982 to 23 million in 1994. It increased to 43 million in 2002, with a 10% decline between 2000 and 2001. The spatial analysis has limited value for this stock since the data are available only for the last 11 years, while the maximum abundance for this cod stock was observed 19 years ago. The use of an earlier time series of winter surveys (1978-1994) has limited value as well because of poor spatial coverage of the stock area.

General Discussion
In discussion the following points were raised :

- results presented are from latest stock assessment completed February 2002
- why is biomass rather than population fecundity presented on X-axis of stock-recruitment graph ? The author responded that the analysis has been done with population fecundity and egg production and same pattern is shown.
- there appears to be a «break » point in the stock-recruitment graph at 200 thousand tons of spawning biomass.
- the graph of F (fishing mortality) against spawning biomass for the years in the time series is very useful and should be presented for the other management units.
- how has size composition changed in this unit ? The author responded that the change has been similar to most other units and there are very few large fish recently.

Discussion on the Terms of Reference
Population structure
Tagging in this area shows considerable mixing. Fish tagged in 3Pn/4RS move into western 3Ps in winter. Some fish tagged on Burgeo Bank (western 3Ps) move into the Gulf of St. Lawrence. However in general tagging on spawning groups shows no significant mixing between spawning groups from year to year.

No genetic work has been done on structure within the unit, but comparisons between northern and southern Gulf have shown no genetic differences, despite the existence of striking differences in vertebral numbers and size at age and the results of tagging work which has shown essentially no interchange of tagged fish between northern and southern Gulf.

Information on stock structure available up to the late 1990's is summarised in a workshop document : Workshop on 4RS3Pn components (Chouinard ed 2000).

Abundance
For estimating generation time, age at 50% maturity is at age 3.5 years in recent years but was 5 years historically.

The meeting agreed that survey results from the *Gadus* surveys (1978 to 1994) should be included to provide information on these earlier years.

The sequential population abundance (SPA) series 1974-2001 is the best overall index of abundance but should be presented as numbers of mature fish rather than biomass of mature fish. This is also the best information for estimating current total numbers in the population.

Regarding whether declines have ceased and whether they are reversible, the meeting noted that total abundance increased from a minimum, very low level reached in 1994 following moratorium on fishing, suggesting that increase from current low levels is possible (although mature biomass decreased 13% between 2000 and 2001). The long-term decline should be reversible if adequate spawning biomass is maintained and environmental conditions become favorable for recruitment.

Threats

Current threats include:

- fishing at levels above previously accepted targets. F0.1 is about 0.2; F has rarely been below 0.4 and has recently increased from very low during the moratorium to about 0.5. At this level of F short-term projections indicate a further decline in mature biomass.
- estimated seal consumption is large relative to estimated biomass (Maclaren et al. 2001)
- inadequate information on removals resulting on incomplete reporting of fishery removals and the problem of mixing with 3Ps, which hinders ability to assess status accurately

Bycatch is not as much a threat as in stocks with large foreign fisheries.

Conclusions and Recommendations – Northern Gulf Cod

The most recent Research Document with detailed assessment results is 1998 (from 1997 assessment). COSEWIC should refer to this and to subsequent annual Stock Status Reports, and contact A. Fréchet for additional information. A Research Document on most recent assessment should be available by May 2002.

Publication on lessons from a declining cod stock by Fréchet provides further information on this stock which may be of interest to COSEWIC (Fréchet, 1991)

SOUTHERN GULF OF ST. LAWRENCE STOCK (4T, 4Vn(November-April))

Authors: G. A. Chouinard and D. P. Swain

Presentation Summary

Southern Gulf of St. Lawrence cod migrate between overwintering grounds in the Sydney Bight area and spawning and feeding grounds in the southern Gulf. During the winter in 4Vn, they mix with the resident 4Vn cod stock. Virtually no mixing occurs with the northern Gulf and southern Newfoundland stocks overwintering on the north side of the Laurentian Channel and tagging studies indicate that little mixing occurs between southern Gulf cod and neighbouring stocks during the spring spawning season and summer feeding season. Southern Gulf cod differ from neighbouring stocks in a number of adaptive phenotypic traits (e.g., vertebral number and size-at-age). Early workers suggested that there may be western and eastern stock components in the southern Gulf, but there is no strong evidence to support this view in recent times. Vertebral number and size-at-age do not differ between western and eastern regions of the southern Gulf.

The spawning stock declined from the early 1950s to the mid 1970s, probably as a result of high fishing mortality. The stock recovered very rapidly in the late 1970s and early 1980s. This recovery resulted from unusually high productivity during this period. The rate of recruitment (recruits per unit of spawning stock biomass) during this period was exceptionally high. Recruitment rate in this stock appears to be inversely related to the biomass of pelagic fishes (herring and mackerel), possible predators and competitors of early life history stages of cod. The high recruitment rate during this period can be accounted for by the collapse of pelagic fish stocks at this time and compensatory effects at low SSB. Spawning stock abundance increased in the 1980s to levels that were much higher than the previous peak in the early 1950s. These levels may have been unusually high, and were reflected by density-dependent declines in growth and density-dependent changes in distribution. Changes in size-selective mortality also appeared to be a major cause of a sharp decline in size-at-age observed in the late 1970s and early 1980s. Fishing mortality rose sharply in the late 1980s and early 1990s, and the spawning stock declined rapidly during this period. This decline ceased with the closure of the fishery in September 1993. The spawning stock has remained stable at a level near 90 million spawners (77,800 t) since then. While fishing mortality is thought to be the main cause of the recent decline in the stock, a decrease in productivity from the very high levels in the late 1970s contributed to the decline. Lack of recovery is attributed to high natural mortality of adults, estimated to be about twice the level usually assumed for cod. The fishery for this stock re-opened in 1999, with a Total Allowable Catch of 6000 t (compared to levels near 60,000 t in the 1980s).

Mean age of spawners has varied between 4.7 and 6.6 yr, and is currently high in this range (6.5 yr). This suggests a 3-generation time based on 50% maturity between 15 and 20 yr. An estimate of generation time in an unfished state is 9.5 yr (based on age of 50% maturity + 1/*M*), yielding 30-yr for the 3-generation time. Because there have been both rapid increases and rapid declines in abundance over the past 25 yr, estimates of the rate of decline depend strongly on the generation time used. Using both SPA (Sequential Population Analysis) and research survey estimates of abundance, percent declines range from 70-85% over the past 15-20 yr. Over the past 30 yr, the SPA abundance estimates indicate a 34% decline while the survey estimates yield a 27% increase.

Area of occupancy is currently estimated to be near 55,000 km^2, down from 65,000 km^2 in the 1980s. A sharp and steady contraction in geographic range has occurred since the late 1980s based on data from the September research survey. Geographic distribution in September is currently the most concentrated observed in the 31-yr time series. Geographic range continued to steadily decline in recent years even though abundance has changed little since 1993.

General Discussion

Appropriate time scale and decline rates were discussed. Variation of the time period (based on assumed generation time) over which decline rate was calculated gave very different results. Therefore, decisions as to which time scale (generation time) or number of generations to use will greatly influence the estimated rate of decline. Rate of decline of SSB for 15, 17, 20, and 30 years was given in the Working Paper.

Eastward shift in cod biomass (age 5+) during the early to mid-1990s was apparent. Possibly this is due to differential exploitation of stock components, to changing migration patterns of the stock or to the effects of cold bottom temperatures in the western part of the area during the 1990's. Similar shifts occurred for other groundfish species.

Method of estimation of total mortality (Z) is different for the different cod stocks in Working Papers presented at the meeting. For cod, a similar Z methodology was used for all stocks at a 2000 Fisheries Oceanography Committee workshop on the cod recruitment dilemma (Swain and Castonguay, 2000). The meeting concluded that Z estimates (M for areas under moratorium) should be presented for all stocks for comparative purposes.

Current spawner biomass is about 85,000 t. Across the species range for cod in the NW Atlantic, southern Gulf cod is at the centre. In addition, relative to other cod stocks it has the highest density (upwards of 50 fish per tow at low abundance levels).

High herring and mackerel abundance has been negatively correlated with cod recruitment over the past 40 years (Swain and Sinclair 2000).

Discussion on the Terms of Reference

Population structure

Templeman suggested there were several stock components in the southern Gulf. Recent work on vertebral counts and size at age show no differences between eastern and western regions of the southern Gulf. Vertebral numbers and size at age indicate that there is fine scale structure on the Magdalen Shallows during the summer feeding season.

Ruzzante et al. (1996, 1997, 1998, 1999, 2000) have completed genetic studies that showed no differences between northern and southern Gulf cod. However, tagging studies show very little exchange between north and south and there are significant differences in vertebral counts and length at age.

Some criticism was expressed that the southern Gulf survey does not cover the entire 4T area – there is no sampling north of the Gaspé peninsula, in the St. Lawrence estuary and in deep waters in the Laurentian Channel. However, it is clear that vast majority of the stock is contained within the existing survey area.

Abundance

Abundance trends/declines were well summarised in the working paper.

Regarding whether the declines have ceased and are reversible, it was noted that the stock has been at a stable low level since closure of the fishery. No evidence of significant increase in abundance exists at this time. Natural mortality of adults has been high but we do not know why this is the case, so we cannot pin down the threatening process or processes acting on the stock. Current fishing mortality is adding a further pressure and may be hindering recovery.

Conclusions and Recommendations – Southern Gulf Cod
The meeting requested that confidence intervals on the recent population estimates be provided and that a recruitment (R) vs spawning stock biomass (SSB) plot connecting years (phase plot) be provided along with R/SSB time trends.

SCOTIAN SHELF AND GEORGES BANK COD STOCKS (4Vn (May-October), 4Vs, 4W, 4X, 5Zej and 5Zem)

Author: K. Smedbol

Presentation Summary
In the Eastern Scotian Shelf cod are considered a stock complex. No information was presented to suggest the existence of an ESU within the unit area. This stock has experienced an estimated decline of 85-90% over the presented time period. Current estimated abundance is among the lowest recorded. Indices of geographic distribution reveal a decrease in the area of occupancy, and an increase in concentration of the remaining population over the course of the time series. There is no evidence of a recovery from minimum abundance.

Cod in the region of the Southwestern Scotian Shelf and Bay of Fundy are considered a stock complex. No information was presented to suggest the existence of an ESU within the unit area. This stock has experienced an estimated decline of 30-40 % over the period of 1983-2001. The abundance trends provide some evidence for a halt in abundance decline during the most recent years. The fishery in this unit area has never been placed under moratorium. Indices of geographic distribution suggest a slight decrease in the area of occupancy, and an increase in concentration of the remaining population over the course of the time series. The Gini index reveals no trend.

Following the 1985 World Court decision regarding delineation of the maritime international boundary in the Georges Bank area, fisheries by Canada and the USA were constrained to their respective sides of the boundary. However, the fisheries management unit for cod in the Georges Bank area remained as the entire NAFO Division 5Ze (Georges bank including both Canadian and US fishing areas) and stock evaluations are undertaken for this area. No information was presented to suggest the existence of an ESU within the unit area. This stock has experienced an estimated decline of 30-40 % over the period of 1983-2001. Abundance estimates indicate a precipitous decline in the mid-1990’s followed by a gradual increase in abundance in the last few years. The stock remains at a low level of abundance. Indices of geographic distribution suggest a slight decrease in the area of occupancy, and an increase in concentration of the remaining population over the course of the time series.

General Discussion

Scotian Shelf cod stocks

Limited information presented on the cod stock resident in Div. 4Vn or Sydney Bight indicated that it was at a very low level and showing little sign of recovery. This stock is currently under moratorium. A recent assessment of this stock was conducted in fall 2001 and a Research Document has recently become available (Mohn et al. 2001).

The most recent assessment of the 4VsW (eastern Scotian Shelf) stock was conducted in 1997/1998 and a new assessment will be required to update the recent stock dynamics. The 1997 assessment showed extremely low abundance. Survey information tabled at this meeting shows no recent increase in abundance. The 1997 assessment incorporated grey seal predation information as this is considered a potentially significant factor for this stock. Grey seal abundance has continued to increase in recent years. It is generally believed that this stock is one of those which has declined most and there have been no requests from industry to reopen the fishery. Citing Frank et al. (1994) the 1997 assessment suggested that a large spawning component (spring spawners offshore to the west of Sable Island) had been lost. Further work on this stock has been done by Fu et al. (2001).

Div. 4X cod was reviewed using quantitative information from recent assessments. There is a general lack of historical maturity information because of the timing of the survey and lack of special sampling from the commercial fishery for such purposes. Recent sampling of the fishery suggests that age at 50% maturity is 2.5 y and full maturity is reached at age 4. It was noted that fisheries on this stock were never closed and that fishing mortality has been reduced to the F0.1 level recently.

The question of oil and gas development was raised in relation to possible impact in and around Browns Bank. It was pointed out that most of the exploration/production activities occur on the eastern Scotian Shelf. The meeting reached no conclusion on this issue.

Georges Bank cod

This is a transboundary stock that is assessed jointly by the US and Canada. It appears as though it is one contiguous stock distributed across the entire bank with notable concentrations within the Canadian zone.

Recent year-classes have tended be under-estimated and upward revisions have been made.

The meeting concluded that historical and contemporary distribution patterns should be included in the Working Paper.

ATLANTIC COD NOTES TO AUTHORS

To ensure that comprehensive information is provided to COSEWIC for assessing status of Atlantic cod, the following are to be included in the cod Research Document to be produced from this meeting, for each management unit :

- a description of available information on population structure within the unit
- two abundance time series : (1) survey and (2) sequential population analysis (SPA) or equivalent model estimate. Abundance should be expressed as numbers of mature individuals and on log scale. Assumptions underlying the methods should be described – a general description which would be applicable to all management units and specific details on caveats or assumptions for each management unit.
- Information for estimation of generation time: age at 50% maturity and « background » natural mortality from an unexploited population (which allows calculation of an estimate of generation time which was considered potentially appropriate, A + 1/M, where A = age at 50% maturity and M = natural mortality).
- mean age of spawners represents another possible estimate of generation time and this should be provided for recent and historical periods if possible.
- graphs of fishing mortality vs biomass over the time series available with years identifiable (F shown on the Y axis); of stock vs recruitment; of recruitment rate over time
- graphs of the three spatial indices: DWAO, D95, Gini
- one or more maps of distribution from survey information during recent period (low abundance) and one or more during periods when abundance was high should either be included or citations to maps in available publications or Research Documents provided
- estimate of number of mature fish from most recent SPA estimate with confidence intervals; use survey estimate with appropriate caveats if SPA not available
- description of principal threats
- text on whether reasons for decline are understood, whether decline has ceased and is reversible
- projections of future status in available documents are not necessary in the Research Document but should be cited where available in published material

COD – OVERALL SUMMARY AND CONCLUSIONS

The following conclusions on overall status of cod in Atlantic Canada were drawn :

- cod still occurs throughout the parts of its historic range examined at the meeting, ie from northern Labrador to the northeast part of George's Bank.
- populations declined across Atlantic Canada in the late 1980's and early 1990's, rapidly in most management units
- abundance is now a very small fraction (ca. 1%) of that prevailing during historical high abundance periods in large parts of the range, notably the

continental shelf off Labrador and eastern Newfoundland (2GH, 2J3KL, 3NO) and the eastern Scotian Shelf (4VsW). In these areas most remaining individuals are concentrated in small aggregations in restricted parts of the former range.

- populations with distribution and migration patterns generally similar to those prior to the declines exist in the remainder of the range although their abundance is generally much lower than historically. Some of these populations have shown the capacity to increase in abundance following imposition of fishery closures (4RS3Pn, 3Ps).
- in all areas except 3NO and 3Ps large old fish are essentially absent from populations.
- in some of the areas where populations persist, unexplained increases in mortality are estimated and area of distribution has declined.
- fishing mortality, which has often been above levels once considered appropriate (F0.1 was a formal reference level in the the 1980's and is generally around 0.2 or above throughout the area at the present time), was identified as a major current threat. The reasons for the occurrence of fishing above reference levels vary between management units and may include :
  - uncontrolled bycatch by foreign or domestic vessels
  - recreational fishing which is not subject to quota control
  - unreported catch
  - unaccounted fishing mortality (drop-off mortality, post-selection mortality, ghost fishing)
  - (some of these could contribute in assessments to unexplained increases in mortality)
- seal predation was identified as a factor which could potentially contribute to increased mortality and thus impede recovery in some areas (2GH, 2J3KL, 4RS3Pn, 4T, 4VsW). Recent information on this can be found in the Report of the Eminent Panel on Seals (Eminent Panel on Seal Management. 2001). Although not mentioned by the Panel, the most recent analyses suggest that the impact of seal predation in 4T may be greater than previously thought.
- high pelagic biomass is correlated with low recruitment in the southern Gulf of St. Lawrence over the past 40 years, suggesting the possibility of predation by pelagic species (herring, mackerel and others) on cod eggs and larvae.
- trawl damage to bottom habitat and effects of seismic exploration on early life history stages were raised as potential threats, although the meeting could not come to any conclusion on the importance of these. Information on the former can be found in the report of the ICES Working Group on Ecosystem Effects of Fishing Activities (ICES, 2000). No information on the latter was available to the meeting.
- although a shift in environmental conditions in the late 1980's/early 1990's which might contribute to reduced productivity of stocks was raised as a possible factor contributing to decline and lack of recovery, the meeting did not have access to analyses which would support this hypothesis. It was noted that cold water conditions prevailed during the early to mid 1990's in much of the region (particularly in the more northerly areas) and that changes in

distribution and abundance of prey species such as capelin, sand lance and Arctic cod had occurred concurrently. It was noted that there had been large changes in distribution and abundance of both fished and unfished species off Newfoundland at the time cold conditions occurred (Gomes et al. 1995; Bowering et al. 1997; Morgan et al. 2002; Swain and Castonguay, 2000).

BARNDOOR SKATE

RESEARCH VESSEL AND INDUSTRY SURVEY DATA FOR BARNDOOR SKATE

Working Paper SARA NAP 02/05

Distribution and abundance of barndoor skate Leucoraja laevis in the Canadian Atlantic based upon research vessel surveys and industry/science surveys

Authors: J.E. Simon, K.T. Frank and D.W. Kulka.

Presentation Summary

A comprehensive examination of all DFO research vessel (RV) and industry/science surveys that might provide information on the occurrence of barndoor skate in the broad geographic area between Georges Bank and northern Labrador was undertaken. The data were derived from three principal sources: i) seasonal research vessel surveys conducted by DFO using standard sampling protocols, ii) non-standard research vessel surveys that preceded the standardized surveys conducted prior to 1970, and iii) industry/science surveys that began in the mid-1990s using either fixed or mobile gear. Generally, the data are composed of number or weight caught, latitude and longitude, depth of capture, time of day, and gear type. More detailed information such as individual length, weight, and sex are available from a subset of the surveys. The data were tabulated and portrayed geographically to show the distribution and abundance patterns of the species.

An examination of 80,427 RV and industry/science survey sets revealed a frequency of occurrence of barndoor skate equal to 1.3%. Barndoor skates were relatively more common in the 1950s and 1960s in comparison to later decades. They were sporadically encountered throughout the 1970s, nearly absent during the 1980s, but have increased in abundance since the mid-1990s throughout the central/western Scotian Shelf/Gulf of Maine area. There appear to be some persistent areas of concentration, i.e. those associated with Georges Bank/Fundian Channel region, in the vicinity of Browns Bank, the central and slope waters of the Scotian Shelf and possibly the Laurentian Channel region. Concentrations that were evident early in data series but are not evident now include the eastern Scotian Shelf, Div. 3Ps and the southwestern slope waters of the Grand Banks. Length at first and 50% maturity is in excess of 105 cm and 110 cm respectively for both male and female barndoor skate. Length composition of barndoor skate from both RV and industry/science surveys show a wide range of sizes, indicative of both juvenile and adult fish. RV surveys appear to capture mainly juveniles.

Discussion on the Terms of Reference

Abundance

Overall this has been a relatively uncommon species in surveys, occurring in approximately 1,000 of the 80,000 survey sets examined. Status in adjacent areas in the US has recently been examined (Sosebee and Terceiro 2000). The species was more common in the 1950's and 1960's, essentially disappeared from surveys in the 1970's and 1980's, and is increasing (mainly in the southern part of the area) in the 1990's; new surveys in deeper areas have also picked them up in the 1990's. Some concentrations found in earlier years are no longer present, eg 4Vs, 3Ps, and southern 3NO.

Trawl survey indices reflect change in abundance over the survey area, which is not necessarily the entire distribution of barndoor skate. Surveys were designed for other species with very different distributions. Commercial data indicate that surveys cover only a part of the population. Thus, survey indices could reflect changes in abundance or distributional changes.

In 4X the Canadian survey index has been increasing since the mid-1990's and in 5Z there has been an apparent small decline (possibly due to measurement error). Fish are smaller in 5Z which could be due to new recruitment or to differences in distribution. The US survey shows an increase on George's bank beginning in 1990. Small fish are taken there, as in Canadian waters.

The very few barndoor skate that were ever found in the Gulf of St. Lawrence were all in the Laurentian Channel.

Line surveys in the 1950's and 1960's in 3NOP, directed for haddock, caught barndoor skate mainly on the Scotian Shelf edge, Laurentian Channel and along the southwest slope of the Grand Banks.

Monkfish industry surveys (1995-1999) commonly took barndoor on the Scotian Shelf and Georges Bank with an increase in weight per tow over the period surveyed.

ITQ survey (longline, edge of the Scotian Shelf) shows an increase from 1996-2000, slightly lower in 2001.

Sentinel surveys (1995-2001) took barndoor skate on the south-western part of the survey on Emerald Bank and in Emerald Basin (4VsW).

The meeting noted that identification of barndoor skate is straightforward and misidentification is unlikely to be an issue.

The longline surveys generally showed good catches and catchability may be higher for longlines. A study (Edwards, 1968) using cameras on towed gear suggested that barndoor skate were adept at avoiding capture by trawls. Although this study is not necessarily definitive it appears reasonable that large animals such as this (like Atlantic halibut which also is taken more often in longlines than trawls) could avoid capture in trawls.

The species has no commercial value and is generally released on capture. There is no current information on vigour upon release but this could be obtained.

Larger fish were caught in the past off Newfoundland than more recently. This may be a depth or gear effect, it has changed with time. Analyses of length-frequencies over the period of trawl surveys have been done and are available; these indicate a decline in mean length from the 1950's to most recent times. In the USA abundance of smallest and largest animals declined in the 1970's and 1980's but recently all sizes are being taken.

Life History Characteristics

It was noted that there is little information on life history parameters. Some information on growth in captivity is available and any references on this should be cited if possible, recognising that biological traits may be different in rearing conditions than in the wild. Size at maturity is around 115 cm from Canadian and US data; males may mature slightly smaller than females.

COMMERCIAL FISHERIES BYCATCH OF BARNDOOR SKATE

Working Paper SARA NAP 02/06

Barndoor skate in the Northwest Atlantic off Canada: Distribution in relation to temperature and depth based on commercial fisheries data.

Authors: D.W. Kulka, K. Frank and J. Simon

Presentation Summary

Between 1980 and 2001, rate of occurrence of barndoor skate in commercial sets was 1 set in 200 over all areas and depths. They were recorded in 7 commercial gears, primarily in otter trawls and longlines. Bycatch in the commercial fisheries shows that the distribution of barndoor skate extends much further north than indicated by survey data, present along the shelf edge as far north as 62^0 Lat. Spatial differences in percent occurrence suggested that barndoor skate were more common in certain areas, namely the outer edge of the western Scotian shelf, the outer Laurentian Channel, the southeast Shoal and parts of shelf edge to the north. Catch rates (based on weight) yielded a similar result.

Percent of survey sets containing barndoor skates was 0.03% compared to 0.68% in commercial otter trawls for the same time period and area. A much larger pool of data (950,000 commercial vs. 60,000 survey sets), a greater proportion of deeper sets (where most of the records occurred north of the Scotian Shelf) and perhaps higher catchability of barndoor skates in larger commercial gears would explain why barndoor skate may be far more common in commercial than in survey sets.

Barndoor skate are widely distributed in terms of depth across their entire range although their depth distribution varied among areas. Most (99%) of the southern (Scotian Shelf) fishing effort occurred at < 450 m but the greatest rate of catch occurred between 500-850 m. A truncated distribution and a few deep sets indicates that a significant proportion of barndoor skate were distributed deeper than 850 m. Survey data, restricted to < 400 m in this area do not cover the depth ranges where commercial catch rates were highest. Thus the surveys may not overlap the main body of the distribution of barndoor skate. Changes in estimates of abundance based on survey data may not reflect changes in the population. In the northern area, % of sets with barndoor is low at depths < 650 m, increasing out to depths of 1450 m. There as well, the surveys did not extend over the entire depth range of the barndoor skate. In terms of bottom temperature, very few were taken where temperature was < 1.5^0C even though substantial proportion of the fishing effort was associated with the colder bottom waters. To the north, barndoor skate were associated mainly with temperatures of $2\text{-}4.5^0$ C, to the south, $4\text{-}9^0$ C.

General Discussion

The species was taken in 4700 commercial sets of 951,000 examined from the Scotian Shelf to Davis Strait between 1980 and 2001. Surveys did not take barndoor skate north of the Grand Banks. It is more often taken at depths where there were few survey sets.

Offshore fishing effort was substantially reduced in the early 1990's with the closure of grenadier, cod and flatfish fisheries, and reduction in the redfish fishery. This along with introduction of an excluding device (Nordmore grate) in the shrimp fisheries (now the dominant offshore fishery) has contributed to an observed reduction in catches of barndoor skate on the Grand Banks and areas north. The Greenland halibut fishery continues to capture barndoor skate but effort associated with this fishery is relatively small compared to earlier total groundfish effort.

Considering the presentation on catch per unit effort (CPUE) in different gears it was questioned whether one can compare CPUE for different gears. This can be difficult but scaled CPUE's can be taken to reflect local density. For such uncommon species that occur only occasionally in sets, usually as single specimens, percent occurrence may provide a better estimate of relative abundance than CPUE.

While it was noted that information from commercial fisheries 1980-2000 showed reasonably large numbers of barndoor skate in deep areas on the edge of the Grand Banks and Labrador Shelf, the question was raised as to the trend during this period. Deriving reliable trends in abundance from the commercial data may be difficult due to radical inter-annual changes in the fisheries (species, depths, areas, gears and gear modifications, fishing practises, countries, levels of observer coverage) which confound observed changes in barndoor catches. Data will be examined to see if a trend can be derived, possibly using GLM or similar model. This might be based on presence/absence information.

A description of fishing intensity by the various fleets over time should be included in the Research Document both as a description of current threats and to help interpret the data for this 20-year period.

Using longterm annual mean temperature data, barndoor skate are rarely observed at temperatures less than 3 C, both in US waters and off Canada. In the temperature preference analysis, all gears are used, scaled for CPUE. Preferences (temperature and depth) might be affected if these are depleted populations. Changes in distribution coupled with incomplete coverage of the extent of the population by commercial activities as well as surveys may distort the overall picture. The paper on surveys (Simon et al.) provides a comprehensive distribution map based on all surveys; (the ECNASAP database).

Discussion on the Terms of Reference

Population structure

No genetics or tagging information is available and little information exists on life history. Early life history is typical of skates – production of few egg cases which are benthic (low dispersal in early life history could lead to local population structuring), juveniles are not planktonic (born at about16 cm). Distributed mainly along the shelf edge, no distributional discontinuities were noted. There is no information on movements of migration of the adults.

Abundance

More work is needed on observer data from commercial fisheries from 1980-2001 to see if a trend can be derived, (see notes above); this information would assist the COSEWIC Status Report author and is required to meet the Terms of Reference. This should be done for the entire Canadian zone.

Where possible the analysis should emphasize whether mature or immature individuals are concerned.

Survey information in the Davis Strait from the recent 3-year turbot survey was analysed subsequent to the meeting and showed no barndoor skates in this area.

There has been a recent increase in abundance from survey data in the southern part of the area.

Could the observed declines in survey abundance over the past 50 years be due to a change in distribution? The surveys do not cover deep waters (where commercial data indicate that barndoor skate occur). Based on surveys < 450 m on the Scotian Shelf, they have disappeared for a while but are reappearing in the mid-1990's (see figures in Working Paper). Barndoor skate occur up to 1200 m off the Scotian Shelf and up to 1700 m in areas further north (as deep as the commercial fisheries occurred). In the USA egg cases have been found in deeper waters than covered by surveys.

Wherever possible confidence intervals on abundance estimates should be provided.

The observed decline has ceased in the southern part of the area (4X and south) where barndoor survey indices are increasing based on surveys and commercial fishery bycatch. The increase is mainly in immature fish. North of this the picture is less clear with increases in some commercial indices on the Scotian Shelf but not in all. There has been no increase in survey indices on the Grand Banks and north despite the presence of numbers of skate in commercial fisheries in waters deeper than covered by surveys.

Number of Mature Individuals
Absolute abundance of mature individuals was not presented; it could be estimated using many assumptions (catchability etc) at least over parts of the area, using information presented in the Working Papers. Surveys appear to take a relatively lower proportion of mature individuals than commercial fisheries.

Distribution
Comprehensive information on changes in distribution is not available due to surveys covering part of the range but barndoor skate were greatly reduced in abundance over the areas covered by surveys from the 1970's until recently when increase in southern areas is noted.

Threats
The primary threat is fishery bycatch; impact of this would depend on condition when released and resulting survival.

Life History Characteristics
Fecundity is being studied in the USA and is expected to be low. An analogy with similar skate species would give clutch sizes in the range of 20-80 per year with 40 as a rough average (see eg Frisk et al 2001 but note that information from such analogies often does not correspond to observations once these are made).

Age at maturity is unknown but could be around 8 to 11 years based on length at maturity of 115 cm and scarce information on growth, and by analogy with other skates.

CUSK

Working Paper SARA-NAP-02-03

Evaluation of Cusk (Brosme brosme) in Canadian waters.

Authors: L.E. Harris and P.A. Comeau

Presentation Summary
Cusk are distributed from Cape Cod to Labrador but are concentrated mostly in the Gulf of Maine and the Western Scotian Shelf. There is little known of cusk life history or genetics making it impossible to identify separate evolutionarily significant units in the Northwest Atlantic. Catches in the summer Research Vessel (RV) survey decreased from levels observed in the mid-1970s with a dramatic decline in 1992. Survey catches have been low but stable since 1993. There was also a concomitant decline in CPUE in the 4X longline groundfish fishery but of a lesser magnitude. There was no large increase in landings before the decline to indicate overfishing. However, there has been a decrease in the average size of individual fish in the summer RV survey, which is consistent with overfishing in a size-selective fishery. There was no evidence of changes in cusk distribution with respect to temperature or season.

The distribution of cusk caught in the summer RV survey area has contracted and is now highly concentrated in the Gulf of Maine. However the halibut survey and commercial landings data suggest that cusk are still widely distributed and common along the Shelf edge and on the Western portion of the Scotian Shelf. The total number of mature individuals estimated from the summer RV survey is 270 000. This number is considered conservative because the RV survey only samples part of cusk's distribution. Catchability to the survey gear is also considered low as cusk are crevice dwellers and rocky bottoms are not often surveyed due to a risk of damaging gear. In addition, over 1000 tonnes are landed annually (representing 500 000 fish for an average fish weight of 2 kg) suggesting that the RV survey underestimates abundance.

General Discussion
The meeting noted that the species is distributed from Cape Cod to Labrador in

the western Atlantic, with highest densities in Gulf of Maine and western Scotian Shelf. There is no directed fishery in Canada but cusk can be landed if caught incidentally in another fishery such as cod or haddock. Spawning is from May to August and eggs and larvae are planktonic.

Varied information is available including long commercial fishery and survey series and shorter industry survey series, but trends are quite consistent. Research vessel survey shows a decline on the Scotia Shelf/ Gulf of Maine beginning in the middle 1970's with abrupt decline around 1992/3 and no apparent further decline or recovery. The general pattern is repeated in the 4X commercial longline fishery index where the extent of the decline in the early 1990's was smaller although still substantial (2-3X). The longline industry surveys are a shorter time series (1995 and later) and do not show a decline.

There was discussion of the availability of longline commercial fishery data before 1988. Some extension of the time series may be possible but such inclusion would be heavily qualified. In particular data on catch composition from individual vessels in tonnage class 1 (smallest class) were not collected but in recent years catch from these vessels is the largest component. Commercial landings of cusk prior to late 1980's would have been included in the "shack" and "unidentified groundfish" fisheries. These groups included pollock and white hake since they were the same price and were often landed together. The recorded changes in catch may be misleading in this early period and the relative magnitude of the increases in landings seen in the late 1980's may have been underestimated.

Along with the decline in catch in the groundfish research survey, there was a decrease in mean size (from 3 kg to 1.5 kg between 1970 and 2000 survey catches), which is consistent with excessive fishing in a size-selective fishery.

There were no indications of changed depth or spatial distributions or changed thermal preferences that might have resulted in changed catchability. The committee concurred with the authors that the declines in abundance were likely real, but may be overestimated. The apparent collapse may have been exaggerated in the RV survey because only part of the distribution was sampled and a decline was seen in the longline catch data but it was not nearly so drastic.

Despite rarity in survey catches over much of the Gulf of Maine/Scotian Shelf area surveyed recently, the species is found here in longline sets.
Catchability in longlines is likely higher than in trawls because of attraction to bait and it was suggested that longlines could continue to catch the species in quite low densities. Although some information is available for deep water surveys, rocky bottom is avoided and, therefore, cusk habitat is not well sampled.

Various hypotheses for the observed patterns were discussed: a possibility of decline in a "fringe" habitat but continued persistence in deeper or rockier preferred habitats, decline in the preferred habitat, or a the possiblity of a shift in distribution. Information available was inadequate to choose between hypotheses. There were no indications of changed depth or spatial distributions or changed thermal preferences that might have resulted in changed catchability. The committee concurred with the authors that the declines in abundance were likely real, but may be overestimated.

The Working Paper documented a substantial decrease in the area where 75% of the catch occurred, between 1970 and 1990, as well as an increase in proportion of zero sets within two depth strata in the bottom-trawl research survey. However, industry long-line surveys indicate that cusk are still found throughout their known habitat and can be caught in significant numbers in some locations (ie. along the edge of the Scotian shelf and in SW Nova Scotia). These and the catch data suggest that fishing pressure has reduced cusk abundance throughout the habitat they utilize but that the declines have been more pronounced in the more open areas that can be trawled and that are fished by the research surveys. A somewhat similar pattern was observed in barndoor skate.

The authors were requested to add details on how CPUE changed within depth strata in the commercial longline and RV survey series, in order to explore preferred depth, and to add estimates of sample variance to the time series of catch where possible.

Discussion on Terms of Reference

Population structure

There is no genetic information and very little life-history information so there is no information upon which to further determine population structure within Canada. The authors presented an interesting analysis of the temporal patterns in egg and larval abundance. There is no indication of recruitment pulses, which might have suggested some local population structure. The adults are adapted for sedentary life and eggs and larvae are planktonic. The meeting concluded that there is no information to suggest multiple ESUs within Canada.

Abundance

Overall there was a marked decline in the early 1990's in all indices, but industry surveys and longline fishery (short time series) show the species still widely occurring and relatively abundant at the edge of the Scotian Shelf (where there is substantially more effort along the edge of the shelf by commercial surveys relative to RV surveys). There has been a decline in mean size and proportion of mature individuals (90% to 50% 1970-2001) in surveys. The abundance picture in the US is similar ie. a recent decline in trawl surveys with no rebound.

Area occupied by 75% of individuals has declined in recent years from survey information but the species is still widespread in longline catches. (Note: when catch is < 1/tow, any decline in catch results in a decline in area occupied. This is not measuring a different parameter of stock health than total catch).
Absolute abundance of mature individuals (those greater than 50 cm) was

estimated at 270,000 from survey results.
Regarding whether the decline had ceased, there has been no significant increase in abundance following the abrupt decline in the early 1990's.

Threats
The committee concluded that the primary threat to cusk was from fishing. Habitat damage was a possibility but the likely habitat preferences of this fish (deep and rough bottom) would make it unlikely that this core habitat would be at risk from trawlers, which would tend to avoid these areas.

Life History Characteristics
Size at 50% maturity is 44 cm for males (age 5 years) and 51 cm for females (7 years). Fecundity at 80 cm (about 10 yrs old) is 700 thousand to 2.6 million. Maximum age was estimated at 14 years in the 1960's and maximum length in survey catches is 108 cm. Natural mortality may be around 0.3 and generation time calculated using age at 50% maturity plus 1/M would thus be (7+3) = 10 years.

References

Beacham, T.D., Brattey, J., Miller, K.M., Le, K.D., and Withler, R.E. 1999. Population structure of Atlantic cod (Gadus morhua) in the Newfoundland and Labrador area based on microsatellite variation. DFO Can. Stock Assess. Sec. Res. Doc. 99/35. 32 p.

Beacham, T.D., Brattey, J., Miller, K.M., Le, K.D., Schulze, A.D., and Withler, R.E. 2000. Population structure of Atlantic cod (Gadus morhua) in the Newfoundland and Labrador area determined from genetic variation. DFO Can. Stock Assess. Sec. Res. Doc. 2000/099.

Beacham, T.D., Brattey, J., Miller, K.M., Le, K.D., and Withler, R.E. 2001. Stock structure of Atlantic cod (Gadus morhua) off Newfoundland and Labrador determined from genetic variation. ICES CM 2001/L:17.

Bérubé, M. and A. Fréchet. 2002. Sommaire du programme de marquage des pêches sentinelles du nord du Golfe avec une emphase sur les recaptures provenant des unités de gestion voisines. DFO Research Document 2001/002

Bowering, W.R., M.J. Morgan and W.B. Brodie. 1997. Changes in the population of American plaice (Hippoglossoides platessoides) off Labrador and northeastern Newfoundland: a collapsing stock with low exploitation. Fish. Res. 30: 199-216.

Brattey, J. 1996. Overview of Atlantic cod (Gadus morhus) stock structure in NAFO Subdivision 3Ps. DFO Can. Stock Assess. Sec. Res. Doc. 96/93, 19p.

Brattey, 1999. Stock structure and seasonal migration patterns of Atlantic cod (Gadus morhua) based on inshore tagging experiments in Divs. 3KL during 1995-97. DFO Can. Stock. Assess. Sec. Res. Doc. 99/103.

Brattey, J. 2000. Stock structure and seasonal movements of Atlantic cod (Gadus morhua) in NAFO Divs. 3KL inferred from recent tagging experiments. DFO Can. Stock. Assess. Sec. Res. Doc. 2000/084.

Brattey, J., Porter, D., and George, C. 2001. Stock structure, movements, and exploitation of Atlantic cod (Gadus morhua) in NAFO Divs. 2J+3KL based on tagging experiments conducted during 1999-2000. DFO Can. Stock Assess. Sec. Res. Doc. 2001/072.

Brawn, V.M. 1961. Reproductive behaviour of the cod (*Gadus callarias* L.). Behaviour 18: 177-197.

Campana, S.E., Chouinard, G.A., Hanson, J.M., and Fréchet, A. 1999. Mixing and migration of overwintering Atlantic cod (*Gadus morhua*) stocks near the mouth of the Gulf of St. LawrenceCan. J. Fish. Aquat. Sci. 56: 1873 - 1881.

Chouinard, G. A. (ed.). 2000. Report of the Cod Mixing Workshop, 16-17 October 2000,St. John's, Nfld. CSAS Proc. Series 2000/27, 18 p.

Clark, D. S., and Paul, S. D. 1999. Assessment of cod in Division 4X. CSAS Res. Doc. 99/159.

Edwards R.L.(1968) Fishery resources of the North Atlantic area, pp. 52-60. In D.W. Gilbert(ed.) The Future of the Fishing Industry of the United States. Univ. Wash. Publ. Fish. N.S. 4.

Eminent Panel on Seal Management. 2001. Report of the Eminent Panel on Seal Management. Prepared for Fisheries and Oceans Canada. 145 pp.

Frank, K.T., Drinkwater, K.F. and Page, F.H. 1994. Possible causes of recent trends and fluctuations in Scotian Shelf/Gulf of Maine cod stocks. ICES Mar. Sci. Symp.198: 110-120.

Fu, C., Mohn, R.K., and Fanning, L.P. 2001. Why the Atlantic cod (*Gadus morhua*) stock off eastern Nova Scotia has not recovered. Can. J. Fish. Aquat. Sci. 58: 1613-1623.

Fréchet , A. 1991. A declining cod stock in the Gulf of St. Lawrence: How can we learn from the past? NAFO Sci. Coun. Studies. 16: 95-102.

Frisk, M. G., T. J. Miller and M. J. Fogarty. 2001. Estimate and analysis of biological parameters in elasmobranch fises: a comparative life history study. Can. J. Fish. Aquat. Sci. 58: 969-981.

Gomes, M.C., R.L. Haedrich, and M.G. Villagarcia. l995. Spatial and temporal changes in the groundfish assemblages on the northeast Newfoundland/Labrador Shelf, northwest Atlantic, 1978-91. Fisheries Oceanography. 4: 85-l0l.

Hutchings, J.A., Bishop, T.D., and McGregor-Shaw, C.R. 1999. Spawning behaviour of Atlantic cod, *Gadus morhua*: evidence of mate competition and mate choice in a broadcast spawner. Can. J. Fish. Aquat. Sci. 56: 97-104.

ICES 2000. Report of the Working Group on Ecosystem Effects of Fishing. ICES CCCM 2000/ACME:02. 93 pp.

Mohn, R.K., D. Beanlands, G.A.P. Black and T. Lambert. 2001. Assessment of the Staus of 4Vn Cod (May to October): 2000. DFO Canadian Science Advisory Secretariat Research Document 2001/105
Morgan, M.J., W.B. Brodie, and D.W. Kulka. 2002. Was over exploitation the cause of the decline of the American plaice stock off Labrador and northeast Newfoundland? Fish. Res. 57: 39-49.

Morgan, M. J. and E. A. Trippel. 1996. Skewed sex ratios in spawning shoals of Atlantic cod (Gadus morhua). ICES J. mar. Sci. 53: 820-826.

Purchase, C. F., and Brown, J. A. 2000. Interpopulation differences in growth rates and food conversion efficiencies of young Grand Banks and Gulf of Maine Atlantic cod (*Gadus morhua*). Can. J. Fish. Aquat. Sci. 57: 2223-2229.

Puvanendran, V., and Brown, J. A. 1998. Effect of light intensity on the foraging and growth of Atlantic cod larvae: interpopulational differences? Mar. Ecol. Progr. Ser. 167: 207-214.

Rice, J. and D. Rivard 2002. Proceedings of the DFO Workshop on implementing the precautionary approach in assessments and advice. Canadian Scientific Advisory Secretariat Proceedings Series 2002/009: 99 pp.

Ruzzante, D.E., Taggart, C.T., Cook, D., and Goddard, S. 1996. Genetic differentiation between inshore and offshore Atlantic cod (Gadus morhua) off Newfoundland: microsatellite DNA variation and antifreeze level. Can. J. Fish. Aquat. Sci. 53: 634-645.

Ruzzante, D.E., Taggart, C.T., Cook, D., and Goddard, S.V. 1997. Genetic differentiation between inshore and offshore Atlantic cod (Gadus morhua) off Newfoundland: a test and evidence of temporal stability. Can. J. Fish. Aquat. Sci. 54: 2700-2708.

Ruzzante, D.E., Taggart, C.T., and Cook, D. 1998. A nuclear DNA basis for shelf- and bank-scale population structure in northwest Atlantic cod (Gadus morhua): Labrador to Georges Bank. Molecular Ecology 7: 1663-1680.

Ruzzante, D.E., Taggart, C.T., and Cook, D. 1999. A review of the evidence for genetic structure of cod (Gadus morhua) populations in the NW Atlantic and population affinities of larval cod off Newfoundland and the Gulf of St. Lawrence. Fisheries Research 43: 79-97.

Ruzzante, D.E., Wroblewski, J.S., Taggart, C.T., Smedbol, R.K., Cook, D., and Goddard, S.V. 2000. Bay-scale population structure in coastal Atlantic cod in Labrador and Newfoundland, Canada. J. Fish Biol. 56: 431-447.

Shelton, P.A. and Lilly, G.R. 2000. Interpreting the collapse of the northern cod stock from survey and catch data. Can. J. Fish. Aquat. Sci. 57:2230-2239.

Smedbol, R. K. and R. Stephenson. 2001. The importance of managing within-species diversity in cod and herring fisheries in the north-western Atlantic. J. Fish. Biol. 59 (Suppl. 1): 109-128

Sosebee, K. and M. Terceiro. 2000. Assessment of the United States northeast region skate complex for 2000. NAFO Sci. Counc. SCR DOC 00/15: 74 pp.

Swain, D. P. and M. Castonguay eds. 2000. Final Report of the 2000 Annual Meeting of the Fisheries Oceanography Committee including the Report of the Workshop on the Cod Recruitment Dilemma. CSAS Proceedings Series 2000/17

Swain, D.P., and Sinclair, A. F. 2000. Pelagic fishes and the cod recruitment dilemma in the Northwest Atlantic. Can. J. Fish. Aquat. Sci. 57: 1321-1325.

Templeman, W. 1962. Divisions of cod stocks in the Northwest Atlantic. ICNAF Redbook, Part III:79-123.

Templeman, W. 1974. Migration and intermingling of Atlantic cod (Gadus morhua) stocks of the Newfoundland area. J. Fish. Res.Board. Can. 31:1073-1092.

Templeman, W. 1979. Migration and intermingling of stocks of Atlantic cod Gadus morhua, of the Newfoundland and adjacent areas from tagging in 1962-66. ICNAF Res. Bull. 14:5-50.

Templeman, W. 1981. Vertebral numbers in Atlantic cod, Gadus morhua, of the newfoundland and adjacent areas, 1947-71, and their use for delineating cod stocks. J. Northw. Atl. Fish. Sci. 2:21-45.

Appendix 1. Terms of Reference for the National Science Review Meeting in Halifax, Nova Scotia, March 18-22, 2002

A. Background

The federal government is committed to delivering certain activities for protection and recovery of species at risk, based on the Federal Strategy on Species at Risk (2000). Government intentions are further detailed in the Species at Risk Act (SARA) currently under consideration in Parliament. Activities under these initiatives relate to species assessment, protection and recovery. The Minister of Fisheries and Oceans is identified as the Minister responsible for aquatic species at risk under these initiatives.

The various activities envisaged must be based on sound scientific knowledge of species at risk or potentially at risk and the threats facing them. The Department of Fisheries and Oceans intends to support species at risk protection and recovery activities by contributing to or providing scientific information, assessments and advice.

Certain of these activities are not the responsibility of DFO. Assessment of species status and designation of risk categories is the responsibility of the Committee on Status of Endangered Wildlife in Canada (COSEWIC). DFO holds information and expertise on aquatic species which should be put at the disposition of COSEWIC so that its assessments can be based on the best information available. DFO has recently developed a process under which its own science review processes can support the COSEWIC process; the intent is that, once it is known that COSEWIC will assess a species, DFO will review its information holdings on the species through a formal review meeting, and provide the available information to COSEWIC.

In other cases where the Minister of Fisheries and Oceans must make certain determinations, DFO will provide the Minister with scientific advice to support these determinations. This is the case for « incidental harm permits », a provision in the Act whereby a responsible Minister can issue a permit allowing for incidental harm to a species, subject to certain conditions, as long as that incidental harm does not jeopardise the survival and recovery of the species.

The first national review meeting to consider certain questions related to species at risk protection and recovery will be held March 18-22, 2002, in Halifax, NS.

B. General objectives

A DFO National Advisory Process (NAP) meeting will be held to review information relevant to protection and recovery of marine species at risk in Canada. The meeting has two general objectives :

1. To review information held by DFO which could be used by the Committee on Status of Endangered Wildlife in Canada (COSEWIC) in assessing status and extinction risk of several marine fish species, including :

Atlantic cod (*Gadus morhua*)
cusk (*Brosme brosme*)
barndoor skate (*Raja laevis*)
bocaccio (*Sebastes paucispinis*)

Although this meeting is being organised under the auspices of the Canadian Science Advisory Secretariat (CSAS) in the series of NAP meetings, it differs from typical science advisory meetings in that no scientific advice will be produced (typically such meetings are organised with the objective of providing scientific advice on a given topic or remit) and non-DFO information will not be considered (typically DFO science advisory meetings consider all available information on the question at hand, whether held by DFO or by other organisations). The intent of this part of the meeting is simply to review and provide information from DFO to COSEWIC.

2. To give general consideration to analytical approaches and data requirements for providing scientific advice on incidental harm permits as provided for in the Species at Risk Act (SARA) currently before Parliament.

3. To develop experience for use in organising future such meetings, since this is the first of what is anticipated to be a series of review meetings on species at risk issues.

C. Specific objectives

1. Species information
The purpose of the first part of the meeting is to ensure that information on these species held by DFO is made available to COSEWIC (including the authors of status reports on these species and the Chairs of the COSEWIC Marine Fish Species Specialist Group) so that status assessments based on the best available information can be conducted.

The meeting will review information on distribution, abundance and life history characteristics of these species which could be used by COSEWIC to determine, following its assessment guidelines and criteria, whether a risk category is justified. Discussion on each species will begin with a consideration of the available information on population differentiation, which could support a COSEWIC determination of which populations would be suitable for assessment.

Documentation produced by this part of the meeting will include Research Documents summarising the available information on these species and Proceedings documenting discussions at the meeting.

A detailed description of the information to be produced for each species follows. In addition, information on life history and ecological characteristics will be reviewed for each species to allow a general assessment of the resilience or general vulnerability of the species. The following information will be reviewed to the extent that it is available:

- growth parameters : age (and/or length) at maturity, maximum age (or length), growth parameters
- fecundity, production of young per year
- early life history pattern, duration of planktonic larval life
- specialised niche or habitat requirements

Atlantic Cod

1. Review the population structure of Atlantic cod in Canada in the context of "evolutionarily significant units" (*sensu* Waples 1995: Evolutionarily significant units and the conservation of biological diversity under the endangered species act. pp 8-27 in Nielsen, J. L., Ed. Evolution and the aquatic ecosystem: defining unique units in population conservation. Symposium 17, Am. Fish. Soc., Bethesda, Md.) Consider *inter alia* existing stock definitions, the results of the Workshop on Cod Stock Components (1997), and any relevant publications since that workshop. Provide conclusions regarding the degree to which population units at and below the scale of stocks (as used in current management) are evolutionarily independent and the scientific evidence for those conclusions. (
2. By stock, for Atlantic cod in Canada as a whole, and for ESUs identified in 1 (if on a scale finer than stocks), and using information in the most recent assessments (COSEWIC Criterion: <u>Declining Total Population</u>):
   a. Summarize overall trends in population size (both number of mature individuals and total numbers in the population) over as long a period as possible, and in particular for the past three generations (taken as mean age of spawners);
   b. Where declines have occurred over the past three generations, summarize the degree to which the causes of the declines are understood, and the evidence that the declines are a result of natural variability, habitat loss, fishing, or other human activity;
   c. Where declines have occurred over the past three generations, summarize the evidence that the declines have ceased, are reversible, and likely time scales for reversibility.
3. By stock, for Atlantic cod in Canada as a whole, and for ESUs identified in 1 (if on a scale finer than stocks) (COSEWIC Criterion: <u>Small Distribution and Decline or</u> <u>Fluctuation</u>) :
   a. Summarize current area of occupancy (in km^2)
   b. Summarize changes in area of occupancy over as long a time as possible, and in particular, over the past three generations.

c. Summarize any evidence that there have been changes in the degree of fragmentation of the overall population, or a reduction in the number of meta-population units.

4. By stock, for Atlantic cod in Canada as a whole, and for ESUs identified in 1 (if on a scale finer than stocks), and using information in the most recent assessments (COSEWIC criteria Small Total Population Size and Decline and Very Small and Restricted):
   a. Tabulate the best scientific estimates of the number of mature individuals
   b. If there are likely to be fewer than 10,000 mature individuals, summarize trends in numbers of mature individuals over the past 10 years or three generations, and, to the extend possible, causes for the trends.

Barndoor Skate

5. Review the evidence, if any, that there are separate evolutionarily significant units for Barndoor Skate within Atlantic Canada, smaller than the range of the species.
6. For Barndoor Skate in Canada as a whole, and for ESUs identified in 5 (if any):
   a. Summarize overall trends in population size (abundance) over as long a period as possible, and in particular for the past 10 years or three generations (whichever is longer);
   b. Where declines have occurred over the past 10 years or three generations, summarize the degree to which the causes of the declines are understood, and the evidence that the declines are a result of natural variability, habitat loss, bycatch from fishing, or other human activity;
   c. Where declines have occurred, particularly over the past 10 years or three generations, summarize the evidence that the declines have ceased, are reversible, and likely time scales for reversibility.
7. For Barndoor Skate in Canada as a whole, and for ESUs identified in 5 (if any):
   a. Summarize current area of occupancy (in km^2)
   b. Summarize changes in area of occupancy over as long a time as possible, and in particular, over the past 10 years or three generations.
   c. Summarize any evidence that there have been changes in the degree of fragmentation of the overall population, or a reduction in the number of meta-population units.
8. For Barndoor Skate in Canada as a whole, and for ESUs identified in 5 (if any):
   a. Tabulate the best scientific estimates of the number of mature individuals
   b. If there are likely to be fewer than 10,000 mature individuals, summarize trends in numbers of mature individuals over the past 10 years, and, to the extend possible, causes for the trends.
   c. If there are estimated to be fewer than 1,000 mature individuals, summarize available information on the degree to which these individuals may be densely aggregated for at least part of the year, and if aggregated, the possible threats to those aggregations.

Cusk

9. Review the evidence, if any, that there are separate evolutionarily significant units for Cusk within Atlantic Canada, smaller than the range of the species.
10. For Cusk in Canada as a whole, and for ESUs identified in 9 (if any):
    a. Summarize overall trends in population size (abundance) over as long a period as possible, and in particular for the past 10 years or three generations (whichever is longer);
    b. Where declines have occurred over the past 10 years or three generations, summarize the degree to which the causes of the declines are understood, and the evidence that the declines are a result of natural variability, habitat loss, bycatch from fishing, or other human activity;
    c. Where declines have occurred, particularly over the past 10 years or three generations, summarize the evidence that the declines have ceased, are reversible, and likely time scales for reversibility.
11. For Cusk in Canada as a whole, and for ESUs identified in 9 (if any):
    a. Summarize current area of occupancy (in km^2)
    b. Summarize changes in area of occupancy over as long a time as possible, and in particular, over the past 10 years or three generations.
    c. Summarize any evidence that there have been changes in the degree of fragmentation of the overall population, or a reduction in the number of meta-population units.
12. For Cusk in Canada as a whole, and for ESUs identified in 9 (if any):
    a. Tabulate the best scientific estimates of the number of mature individuals
    b. If there are likely to be fewer than 10,000 mature individuals, summarize trends in numbers of mature individuals over the past 10 years or three generations, and, to the extend possible, causes for the trends.
    c. If there are estimated to be fewer than 1,000 mature individuals, summarize available information on the degree to which these individuals may be densely aggregated for at least part of the year, and if aggregated, the possible threats to those aggregations.

Bocaccio

13. Review the evidence, if any, that there are separate evolutionarily significant units for Bocaccio within Pacific Canada.
14. For Bocaccio in Canada as a whole, and for ESUs identified in 13 (if any):
    a. Summarize overall trends in population size (abundance) over as long a period as possible, and in particular for the past 10 years or three generations, whichever is longer (up to 100 years);
    b. Where declines have occurred over the past 10 years or three generations, summarize the degree to which the causes of the declines are understood, and the evidence that the declines are a result of natural variability, habitat loss, bycatch from fishing, or other human activity;

c. Where declines have occurred, particularly over the past 10 years or three generations, summarize the evidence that the declines have ceased, are reversible, and likely time scales for reversibility.

15. For Bocaccio in Canada as a whole, and for ESUs identified in 13 (if any):
    a. Summarize current area of occupancy (in km^2)
    b. Summarize changes in area of occupancy over as long a time as possible, and in particular, over the past 10 years or three generations.
    c. Summarize any evidence that there have been changes in the degree of fragmentation of the overall population, or a reduction in the number of meta-population units.
16. For Bocaccio in Canada as a whole, and for ESUs identified in 13 (if any):
    a. Tabulate the best scientific estimates of the number of mature individuals
    b. If there are likely to be fewer than 10,000 mature individuals, summarize trends in numbers of mature individuals over the past 10 years or three generations, and, to the extend possible, causes for the trends.
    c. If there are estimated to be fewer than 1,000 mature individuals, summarize available information on the degree to which these individuals may be densely aggregated for at least part of the year, and if aggregated, the possible threats to those aggregations.

For All Species:

17. As time allows, review status and trends in other indicators of the status of each of the species that would be relevant to evaluating the risk of extinction of the species, the likelihood of imminent or continuing decline in the abundance or distribution of the species, or otherwise be of value in preparation of COSEWIC Status Reports.

2. Incidental harm permits

Under SARA, once a species is placed on the legal list it becomes illegal to kill or harm the species or its residence. SARA allows that a competent Minister may make an agreement or issue a permit to allow for "incidental harm" to a listed species. If such a permit were not issued, and a person was found to have caused harm to the species, the person would be subject to prosecution. Fisheries bycatch is a potential source of "incidental harm".

Before the competent Minister can issue such a permit, he must show the following –

(*a*) all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best alternative has been adopted; in the case of bycatch this would imply considering alternative possible gear types or management approaches.

(*b*) all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals; for fisheries this might imply such things are areal or seasonal restrictions.

(*c*) the activity will not jeopardize the survival or recovery of the species.

The meeting will consider what analytical techniques could be used, and what data would be required, to conduct assessments of allowable mortality for species at risk, such that permits could be issued to allow « incidental harm ».

Various analytical techniques are available for conducting such analyses, such as the « potential biological removal » protocol used under the US Endangered Species Act and elsewhere for determining allowable mortality for marine mammals. The meeting will provide recommendations on analytical techniques, data requirements, timing of analyses, and process for conducting IHP assessments, such that these assessments can be conducted in the near future.

D. Documentation

The meeting will produce the following documentation :

1. One Research Document for each of the four species to be considered, summarising the overall status of the species and the data and information held by DFO which could be used by COSEWIC in making status designations. These Research Documents will cover the information called for in the Terms of Reference above.
2. Proceedings summarising the decisions, recommendations, and major points of discussion at the meeting, including a reflection of the diversity of opinion present in the discussions.
3. Documentation of the incidental harm permit issue will be determined at the meeting; a specific Research Document may be produced if available information merits this, or discussions may simply be summarised in the Proceedings.

Appendix 2. List of Presentations the National Science Review Meeting in Halifax, Nova Scotia, March 18-22, 2002

1. Status of Bocaccio: Working Paper SARA NAP 02/01; CSAS Research Document 2001/148
   Status Report on Bocaccio *Sebastes paucispinis* from B.C. waters
   Authors: R.D. Stanley, K. Rutherford and N. Olsen

2. Incidental Harm Permits: Working Paper SARA NAP 02/02
   Incidental Harm Permits: Assessment and Advisory Implications
   Author: H. Powles

3. Atlantic Cod Population Structure - Evolutionarily Significant Units; CSAS Research Document 2002/082
   Working Paper SARA NAP 02/03 (Introduction)
   A discussion of appropriately scaled management units for conservation of marine populations
   Author: K. Smedbol

4. Atlantic Cod - Newfoundland Stocks; CSAS Research Document 2002/082
   Working Paper SARA NAP 02/03 (Newfoundland)
   Evaluation of four Newfoundland cod stocks in the context of species at risk
   Author: P. Shelton

5. Atlantic Cod - Northern Gulf of St. Lawrence Stocks; CSAS Research Document 2002/082
   Working Paper SARA NAP 02/03 (Northern Gulf of St. Lawrence)
   Evaluation of Northern Gulf of St. Lawrence cod stocks in the context of species at risk
   Author: A. Fréchet

6. Atlantic Cod - Southern Gulf of St. Lawrence Stocks; CSAS Research Document 2002/082
   Working Paper SARA NAP 02/03 (Southern Gulf of St. Lawrence)
   Evaluation of Southern Gulf of St. Lawrence cod stocks in the context of species at risk
   Authors: G.A. Chouinard and D.P. Swain

7. Atlantic Cod - Scotian Shelf Stocks; CSAS Research Document 2002/082
   Working Paper SARA NAP 02/03 (Scotian Shelf)
   Summary of the status of Cod stocks in Maritimes region: Eastern Scotian Shelf (4VsW), Southwestern Scotian Shelf/Bay of Fundy (4X/5Y), and Georges Bank (5Zej and 5Zem)
   Author: K. Smedbol

8. Barndoor Skate – Survey Information; CSAS Research Document 2002/070
   Working Paper SARA NAP 02/05
   Distribution and abundance of barndoor skate *Leucoraja laevis* in the Canadian Atlantic based upon research vessel surveys and industry/science surveys
   Authors: J.E. Simon, K.T. Frank and D.W. Kulka.

9. Barndoor Skate – Commercial Fishery Information; CSAS Research Document 2002/073
   Working Paper SARA NAP 02/06
   Barndoor skate in the Northwest Atlantic off Canada: Distribution in relation to temperature and depth based on commercial fisheries data.
   Authors: D.W. Kulka, K. Frank and J. Simon

10. Cusk: Working Paper SARA NAP 02/07
    Evaluation of Cusk (*Brosme brosme*) in Canadian waters.
    Authors: L.E. Harris and P.A. Comeau

Appendix 3. Incidental Harm Permits: Assessment and Advisory Implications
by Howard Powles

Introduction and Problématique

Under the proposed Species at Risk Act[1] (SARA), once a species is placed on the legal protection list in the “endangered” (EN) or “threatened” (TH) categories, it becomes illegal to kill or harm the species or its harm its residence. SARA provides that a competent Minister may make an agreement or issue a permit to allow for “incidental harm” to a listed EN or TH species. If such a permit were not issued, and a person was found to have caused harm to the species, the person would be subject to prosecution. SARA includes provisions for similar permits for incidental harm to critical habitat identified in a recovery strategy or action plan; this paper does not cover this although some of the issues would be quite similar.

Fisheries bycatch is a potential source of “incidental harm”.

Under SARA, before the competent Minister could issue an incidental harm permit, he would have to show that:

(*a*) all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best alternative has been adopted (in the case of bycatch this would imply considering alternative possible gear types or management approaches).

(*b*) all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals (for fisheries this might imply such things are areal or seasonal restrictions).

(*c*) the activity will not jeopardize the survival or recovery of the species (for fisheries this would imply an analysis of the bycatch mortality, taking into account any restrictions under a and b, in relation to an allowable level which would not increase risk of extinction unacceptably).

The reasons for issuing such a permit would have to be publicised in the Public Registry established under SARA.

If these tests were passed, an incidental harm permit (IHP) issued to a fisherman for a given EN or TH species would exempt the fisherman from prosecution if he inadvertently harmed or killed the listed species for which the permit was given. IHPs would only be issued to individuals who had some probability of being identified as causing direct mortality; allowable levels of general “harm” to a species (for example shipping effects on whales or general degradation of habitat) would be covered under the provisions of recovery strategies.

IHPs including the supporting rationale would have to be ready at the time the species was added to the legal list (notionally, some months after the time of

---

[1] all references to SARA in this paper are based on text under debate in the House of Commons at time of writing, May 2002. Wording is available on the Parliamentary web site, www.parl.gc.ca

COSEWIC designation)(Figure 1). For species included on the legal list as part of the initial Schedule 1 upon proclamation of SARA, IHPs would be required upon proclamation of SARA.

It is important to note that IHPs are a “first, immediate” word on permissible incidental mortality; incidental mortality can be examined in more detail by the recovery team developing the recovery strategy (Figure 1) and measures for restricting or permitting incidental harm can be written into recovery strategies and action plans as these are developed.

It is important to note that IHPs are to be seen as an exception. The basic principle is that risk of extinction should not be increased by human activity.

Assessment issues
A number of issues arise regarding implementation of these provisions of SARA:
1. Who triggers consideration of an IHP ?
2. Who triggers the assessment (tests) to support an IHP ?
3. Should assessment of social and economic impacts of measures be combined with the biological assessment or done separately ?
4. What are the appropriate analytical tools ? especially for estimating permissible levels of harm which will not jeopardise survival or recovery.
5. What is the appropriate forum for the science work on IHPs ? RAP, NAP, etc.

Species for which incidental harm is a threat
Several marine species for which fishery bycatch is a threat will be put on the legal protection list when SARA comes into force (Schedule 1 species):

Leatherback turtles (COSEWIC EN) – Atlantic longline fishery plus occasional entanglement in other fisheries; possible (but very rare) entanglement in Pacific fisheries
Spotted and Northern wolffish (COSEWIC TH) – groundfish, shrimp and snow crab fisheries on the Grand Banks and elsewhere
Inner Bay of Fundy salmon (COSEWIC EN) – incidental catch does not appear to be a major threat but could occur occasionally in Bay of Fundy net or weir fisheries
Northern abalone (TH), sea otter (EN), Atlantic whitefish (EN) – will be on Schedule 1 but incidental harm does not appear to be a significant issue.

Other species will probably come onto the protection list later via COSEWIC assessment/reassessments and legal listing, for example:

Interior Fraser coho salmon – bycatch in other salmon fisheries
Right whale – occasional entanglement

Yet others are candidates for assessment and might be listed if found to be EN or TH by COSEWIC:

Eulachon – Pacific shrimp fisheries
Harbour porpoise – gillnet and other coastal fisheries throughout Atlantic Canada

A number of freshwater species will be listed, some of which may be subject to incidental harm from fishery bycatch. The protocol for conducting assessments and issuing permits for such species has not been worked out; close cooperation with provinces would be necessary.

Possible analytical approaches
The basic question is: what level of mortality ("harm") can be tolerated without increasing the risk of extinction unacceptably. A wide range of analytical approaches could be considered to address this and related questions. Approaches will vary with species, given differences in life-history and ecological characteristics, and with the state of knowledge of the species and its dynamics. Analyses will have to be done with the precautionary approach in mind, such that management response can be commensurate with degree of risk and can account for uncertainty (Rice and Rivard eds. 2001).

Analyses may include "arbitrary" approaches giving a single value for allowable mortality (such as the PBR outlined below, which has gained a degree of acceptance in the USA). More analytical approaches outlining the consequences of a range of incidental harm impacts, to allow for decision-making, could also be considered. Population viability analysis techniques are relatively well developed for very small populations of long-lived species but are little developed for larger more widespread populations such as many marine fish. Approaches to outline consequences of various levels of additional mortality are well developed but require much information on the population.

Notes on some possible approaches follow.

Temporal restrictions.
Temporal restrictions on the activity might reduce the risk of extinction from incidental harm to the extent that an IHP could be issued. This would require knowledge of temporal pattern in the listed species in relation to temporal patterns in the activity causing incidental harm. Consideration of social and economic impacts of potential restrictions may be required as well as benefits to the species.

Spatial restrictions.
Incidental harm may be minimised or eliminated through spatial restrictions on the activity causing incidental harm. Analysis of spatial patterns of the species in relation to the activity would be required and social and economic impacts as well as biological benefits may need to be considered.

Assessing allowable harm.
Ultimately an assessment of the mortality caused by incidental harm in relation to some "allowable" level which would not prejudice survival or recovery of the

species will be required. Ideally the analyses would be similar to those required to establish allowable harvests in fisheries science, but in reality would be complicated by several factors:

- for many species the information available will not be adequate to construct detailed population models
- many species will be at very low abundances and behaviour of aquatic populations at low abundance is not well known. There is debate in the literature on whether such populations show compensatory or depensatory responses (see eg Rose et al. 2001).
- for species which are at risk of biological extinction, management will have to be in line with the precautionary approach (under which strong management measures are required when the consequences of management failure are irreversible, and under which scientific uncertainty should be considered in establishing management measures). Assessments will have to describe and where possible quantify uncertainty and offer options for cautious management such as to avoid irreversible harm.

Potential biological removal (PBR)

A mortality limit which takes into account uncertainty in available information is used in the USA to establish allowable mortality for marine mammal populations under the US Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) (Wade 1998). The PBR is based on definitions written into the MMPA and is calculated as follows:

$$PBR = (N_{MIN})\,(1/2\ R_{MAX})\ (F_R)$$

Where

N_{MIN} = the minimum population estimate of the stock, based on the best available scientific information and providing a reasonable assurance that the stock size is greater than or equal to the estimate. Wade (1998) suggests that the 20th percentile of the abundance estimate.

R_{MAX} = the theoretical or estimated net procudtivity rate of the stock at a small population size

F_R = a recovery factor between 0.1 (for highly endangered stocks) and 1 (for stocks at relatively high abundance).

The PBR protocol is an accepted protocol for establishing “allowable harm” (termed “take”) under the US ESA. It is explicitly precautionary through the use of a lower percentile than the 50th for population estimates, through the use of ½ R rather than R, and through the use of the “recovery factor”. Further discussion of its application to Canadian populations under the Species at Risk Act is needed.

The PBR protocol has been used to estimate allowable harvest levels for the Hudson Bay-Foxe Basin bowhead stock which is subject to subsistence harvests by Inuit (DFO 1999). The allowable take for 24 cetacean and pinniped species in the USA has been determined by the PBR protocol (Waring et al.

2000). For example the PBR for north Atlantic right whales was determined to be 0 because the population has been declining in recent years; for Gulf of Maine humpback whales the PBR is determined to be 33 whales, based on a 20th percentile abundance estimate of 10,019, a maximum productivity rate of 0.065, and a recovery factor of 0.1 since the species is listed as endangered (Waring et al. 2000, page 16).

One question for consideration is whether this protocol might be applied to other groups than marine mammals, for example marine or anadromous fish. Although abundance estimates are often available or could be developed for such species, there is uncertainty about values of rate of increase (R) for such species, particularly in relation to stock size. Although computational methods and approximations for R exist (eg Jennings et al. 1998; Myers et al. 1997) there is not wide acceptance of the results (Musick 1999) and there is uncertainty about whether R varies with abundance at low population levels (depensation – Rose et al. 2001).

Some fraction of natural mortality

A protocol similar to the PBR but based on applying some fraction of natural mortality (M) to an estimate of stock size can be envisaged. The basis for this approach is the "rule of thumb" that fishing mortality at or below the value of natural mortality would be a relatively safe level. M for a fish population is notoriously difficult to estimate at any given time, as it varies with changes in ecosystem conditions, but a long-term "background" level of M can be estimated from life history and environmental parameters (Hoenig 1983; Pauly 1979). A protocol similar to the PBR (call it the MPBR for now) would be:

$$MPBR = (N_{MIN})\,(M)\,(F_R)$$

where the minimum population estimate and the recovery factor are as above and M is the estimate of "background" natural mortality from life span or other information. If desired, a fraction of M (eg ½) could be used to further explicitly introduce precautionarity into the protocol.

As with the PBR the MPBR could be made explicitly precautionary by choosing a low percentile of the abundance estimate, a fraction of M, and an appropriate recovery factor based on the level of risk of extinction of the population. As with the PBR this protocol is based on the assumption that the population is increasing from a low level toward carrying capacity; in situations where this was demonstrably not the case a PBR of 0 could be considered.

Hoenig (1983) provides estimates of M ranging between about 1 for species with life spans of 3-5 years, to 0.05 for species with life spans 50-100 years.

Information requirements for IHPs
An initial assessment of the information which will be required to support IHPs is in Annex 1.

Conclusions
Much needs to be done to develop analytical approaches for assessment of allowable incidental harm. Simulation studies and pilot studies on species which will be listed early in the SARA process are likely to be productive approaches to improving our analytical capacity.

Further work on process for issuing IHPs is also necessary and will be conducted with DFO Fisheries Management staff.

Literature cited

DFO 1999. Hudson Bay-Foxe Basin Bowhead Whales. DFO Science Stock Status Report E5-52: 8 pp.

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 81: 898-903.

Jennings, S., J. D. Reynolds and S. C. Mills. 1998. Life history correlates of responses to fisheries exploitation. Proc. R. Soc. London B 265: 333-339.

Musick, J. A. 1999. Criteria to define extinction risk in marine fishes. Fisheries 24(12): 6-14.

Myers, R. A., G. Mertz and P. S. Fowlow. 1997. Maximum population growth rates and recovery times for Atlantic cod, *Gadus morhua*. Fish. Bull. 95: 762-772.

Pauly, D. 1979. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer 39: 175-192.

Rice, J. and D. Rivard 2002. Proceedings of the DFO Workshop on implementing the precautionary approach in assessments and advice. Canadian Scientific Advisory Secretariat Proceedings Series 2002/009: 99 pp.

Rose, K. A., J. H. Cowan Jr., K. O. Winemiller, R. A. Myers and Ray Hilborn. 2001. Compensatory density dependence in fish populations: importance, controversy, understanding and prognosis. Fish and Fisheries. 2: 293-327.

Wade, P. R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Marine Mammal Science 14: 1-37.

Waring, G. T. and 14 co-authors and co-editors. 2000. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2000. NOAA Tech. Memorandum NMFS-NE-162: 309 pp. (www.nefsc.nmfs.gov/psb/sar2000.pdf)

Annex 1.

Contents of an Incidental Harm Permit Assessment

Introduction
- why this assessment is being done

Description of the species
- biology (life history) and trends in LH characteristics
- distribution and trends
- abundance and trends
- can "residence" be identified

Description of the threat(s) from incidental harm
- distribution and intensity of incidental harm (eg bycatch) to species and residence (if identified)
- available data and information on magnitude of incidental harm (eg mortality estimates)

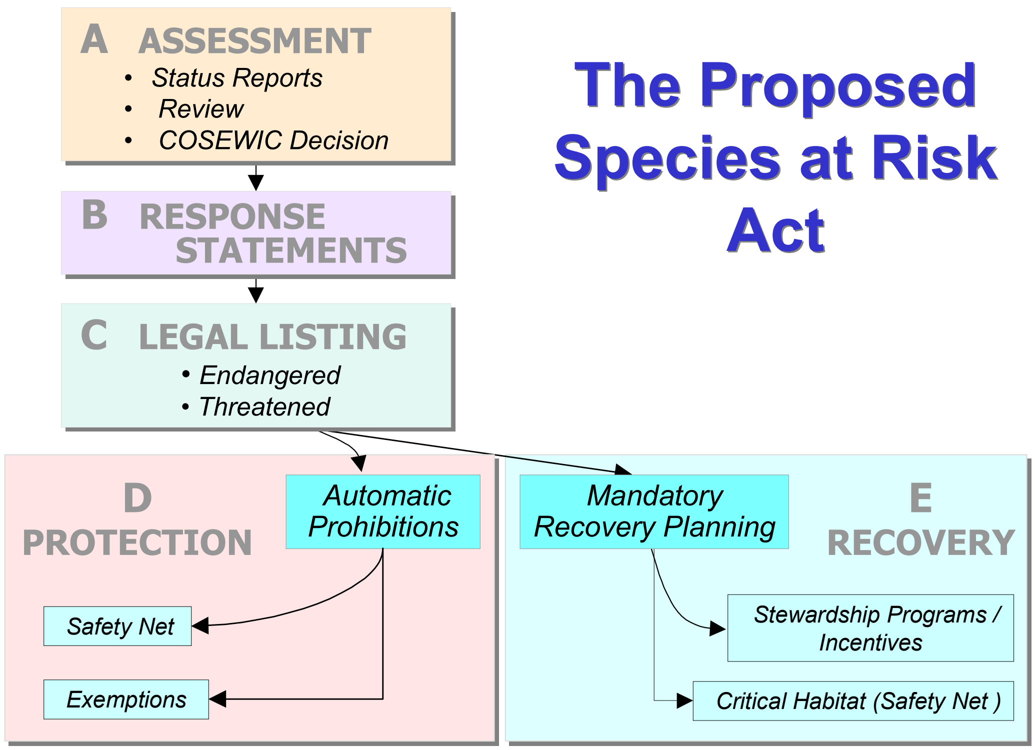
Alternative measures
- the following alternative measures were considered (or: none were considered because....)
- closing or restricting the activity

Mitigating measures
- the following mitigating measures were considered (or: none.....)
- spatial or temporal restrictions on the activity (eg closed areas or seasons)
- modifications to the activity (eg fishing gear modifications)
- management of incidental harm by quota (eg quota on allowable bycatch after which the fishery is closed)

Incidental harm in relation to survival or recovery of the species
- analyses of mortality from incidental harm relative to a level which would ensure survival or recovery
- same analyses incorporating any alternative or mitigating measures from above

Conclusions
- overall summary of conclusions
- permitting incidental harm under the following conditions would not jeopardise survival/recovery of the species
    - mitigating measures
    - restrictions
    - etc
- OR incidental harm cannot be adequately mitigated and closure is necessary

Figure 1. Implementation of activities under the proposed Species at Risk Act (SARA).



Appendix 4. List of Participants at the National Science Review Meeting in Halifax, Nova Scotia, March 18-22, 2002

Julia Baum - Dalhousie University
Paul Bentzen - Dalhousie University
Ruben Boles – Environment Canada – COSEWIC[#] Secretariat
Steve Carr - Memorial University/ COSEWIC[#] member
Ghislain Chouinard - DFO* - Gulf
Don Clark - DFO* - Maritimes
Scott Douglas - DFO* - Maritimes
Ken Frank - DFO* - Maritimes
Alain Fréchet - DFO* - Quebec
Mart Gross - University of Toronto – COSEWIC[#] Marine Fish Specialist Group
Lei Harris - DFO* - Maritimes
Blair Holtby - DFO* - Pacific
Catherine Hood - DFO* - Newfoundland
Colleen Hyslop – Environment Canada – COSEWIC[#] Secretariat
Dave Kulka - DFO* - Newfoundland
Pierre Mallet - DFO* - Gulf
David Methven - Memorial University
Ransom Myers - Dalhousie University
Bob O'Boyle - DFO* - Maritimes
Julie Perrault - DFO* - Headquarters
Howard Powles - DFO* – Headquarters (Chair)
Peter Shelton - DFO* - Newfoundland
Jim Simon - DFO* - Maritimes
Patrice Simon - DFO* - Headquarters
Kent Smedbol - DFO* - Maritimes
Kathy Sosebee – United States National Marine Fisheries Science - Woods Hole
Rick Stanley - DFO* - Pacific
Rob Stephenson - DFO* - Maritimes
Doug Swain – DFO* - Gulf
Chris Wood – DFO* - Pacific

*DFO = Department of Fisheries and Oceans
#COSEWIC = Committee on the Status of Endangered Wildlife in Canada