Fisheries and Oceans Science | Pêches et Océans Sciences

C S A S | *S C É S*

Canadian Stock Assessment Secretariat | **Secrétariat canadien pour l'évaluation des stocks**

Proceedings Series 2000/04 | **Série des compte rendus 2000/04**

Report of the Joint Science - Fisheries Management Policy Workshop on the Precautionary Approach (DFO - Newfoundland Region)

27-28 September 1999, St. John's, Newfoundland

Edited by:

D.B. Atkinson

Department of Fisheries and Oceans
NAFC, P.O. Box 5667
St. John's, Newfoundland A1C 5X1

April 2000

Report of the Joint Science - Fisheries Management Policy Workshop on the Precautionary Approach (DFO - Newfoundland Region)

27-28 September 1999, St. John's, Newfoundland

Edited by:

D.B. Atkinson

Department of Fisheries and Oceans
NAFC, P.O. Box 5667
St. John's, Newfoundland A1C 5X1

April 2000

Abstract

The Precautionary Approach to fisheries and fisheries management has received widespread attention in recent years in response to a global quest for sustainability expressed by the UN Conference on Environment and Development of 1992. Activities in this regard related to Canadian fisheries have taken place through science participation in ICES, NAFO activities, work of the FRCC and the DFO High Priority Project on the Precautionary Approach. An important aspect of development toward a Precautionary Approach identified in all is for the necessity of open and ongoing dialogue between scientists, fisheries managers and the fishing industry. In DFO, Newfoundland Region, while dialogue takes place routinely to deal with specific issues, it has not been common for the different sectors to meet to discuss more generic issues. As a step in improving this necessary dialogue, staff from the 3 sectors met for 2 days during 27-28 September 1999 at the Airport Inn. The primary focus of the Workshop was to: “Describe and discuss the current status and future directions of the Precautionary Approach (PA) to the assessment and management of fisheries resources in the Newfoundland Region”, but discussions were wide ranging and have laid the foundation for future discussions and collaborative work.

Résumé

L’approche de précaution pour la pêche et la gestion des pêches a reçu une grande attention au cours des dernières années suite à la quête mondiale de la mise en place d’un développement durable exprimée lors de la conférence des Nations unies sur l’environnement et le développement de 1992. Des activités liées aux pêches canadiennes ont eu lieu à cet égard dans le cadre d’une participation aux travaux scientifiques du CIEM, de l’OPANO, du CCRH et du projet hautement prioritaire au MPO de l’approche de précaution. Un aspect important du travail menant à une approche de précaution qui a été identifié dans tous ces forums est la nécessité de tenir un dialogue ouvert et continu entre les scientifiques, les gestionnaires des pêches et l’industrie de la pêche. Au MPO, Région de Terre-Neuve, des dialogues ont lieu de manière courante sur des sujets précis, mais il est rare que les divers secteurs se rencontrent pour discuter de questions plus génériques. Dans le but d’améliorer ce dialogue nécessaire, des membres du personnel des trois secteurs ont tenu une rencontre du 27 au 28 spetembre 1999 au Airport Inn. L’atelier avait pour but principal de « décrirer la situation actuelle et les orientations futures de l’approche de précaution (AP) pour l’évaluation et la gestion des ressources halieutiques dans la Région de Terre-Neuve, puis d’en discuter », mais les délibérations ont eu une portée beaucoup plus grande et ont permis de jeter les bases de futures discussions et de travaux de collaboration à venir.

INTRODUCTION:

It is important that DFO scientists, managers and policy developers interact on an ongoing basis in order to provide the best possible services to their clients and the people of Canada. In Newfoundland Region, while dialogue takes place routinely to deal with specific issues, it has not been common for the different sectors to meet to discuss more generic issues.

As a step in improving this necessary dialogue, staff from the 3 sectors met for 2 days during 27-28 September 1999 at the Airport Inn. The primary focus of the Workshop was to

> "**Describe and discuss the current status and future directions of the Precautionary Approach (PA) to the assessment and management of fisheries resources in the Newfoundland Region**",

but discussions were wide ranging and laid the foundation for future discussions and collaborative work.

The Workshop was co-chaired by Bruce Atkinson (Regional Director – Science, Oceans and Environment) and Jim Baird (A/Regional Director – Fisheries Management).

The agenda is contained in Annex I, and list of participants in Annex II.

The following represents the report of this Workshop.

OPENING REMARKS:

The co-chairs welcomed participants to the workshop and indicated their pleasure that the opportunity for such a meeting existed. Thanks was expressed to Noel Cadigan and Peter Shelton for their organization of the Workshop.

It was noted that the Precautionary Approach and its application to fisheries is a significant development and one which requires ongoing close collaboration between science, management, and policy within the Department as well as clients. Involvement of our clients in the fishing industry at every step of the way in development of approaches and strategies was seen as critical, but it is also important that different sectors within the Department ensure they are 'on the same wavelength' in order to present consolidated agreed upon perspectives during external consultations. Therefore, the Workshop is both important and timely.

I was also noted that although the Workshop was focussed on the Precautionary Approach, it afforded a very useful opportunity for staff from the different sectors to interact and share views on more generic issues than the quite specific topics that have brought them together in the past. As such, it was expected, and would be welcomed, if discussions were more wide ranging that the topic of the Precautionary Approach.

It was agreed that that there was a specific objective that the Workshop could hope to accomplish. This was:

- Develop a direction for the region as we move toward implementation of the Precautionary Approach keeping in mind issues related to NAFO, ICES, the FRCC and the departmental Strategic Funding Project on the PA. This would be developed based on:
    - Generating better understandings and increased dialogue between Science and Fisheries Management pertaining to the Precautionary Approach as well as other areas of mutual interest
    - Gaining a better understanding of what the Precautionary Approach means to us as well as what it does not mean
    - Consideration of respective roles of Science and Fisheries Management in development and implementation of the Precautionary Approach

CURRENT ICES AND NAFO INTERPRETATIONS OF THE PA (ATKINSON):

Summary of Presentation

A brief history of the Precautionary Approach as well as details of interpretations by NAFO and ICES was presented. It was indicated that there is no explicit definition of the Precautionary Approach but that it is described *inter alia* in the FAO Code of conduct on Responsible Fisheries as well as the UN Agreement on the Conservation and Management of Straddling fish Stocks and Highly Migratory fish Stocks. The later has been ratified by Canada.

In summary, the Precautionary Approach requires that uncertainties should be taken into consideration, one should 'err on the side of caution,' and lack of information should not be used to justify inaction. It is important that the risk of crossing 'limit' boundaries should be kept low.

It was pointed out that while both indicate that consideration of the resources must be given, they allow for consideration of socio-economic conditions and thus allow flexibility in dealing with the issue based on human considerations. This is especially important for managers.

There is a requirement to develop biological reference points (limits and targets) for the resources based on fishing mortality as well a spawning stock biomass. But there is also a need to consider other measures that managers can employ in order to better ensure the objectives of any developed strategy are met (observers, closed areas, gear restrictions, etc.).

Information on progress to date by NAFO was described. One issue raised by Fisheries Commission of NAFO related to differences in terminology between NAFO and ICES. Some of these differences were described to participants.

The respective roles established for scientists and managers in the NAFO context were also described and it was suggested that discussion of these within the Newfoundland context would be useful.

It was also indicated that the FRCC is developing its own documentation on the Precautionary Approach and that there is a Science initiative (the High Priority Project

on the Precautionary Approach) which is looking at ways of developing the requisite reference points. The need to ensure good co-ordination between different bodies working on this topic was emphasized in order to make the eventual application work.

Discussion

Discussion following the presentation was wide ranging and included issues related specifically to the Precautionary Approach as well as many other science/management issues.

The need for continuing interaction between scientists and managers was highlighted and it was pointed out that while this happens regularly for salmonid, pelagic and shellfish issues, the existence of the FRCC and their mandate related to groundfish results in a quite different situation. For groundfish stocks, scientists and managers are less able to work together in development of strategies and approaches. Instead, science provides information to the FRCC and management is charged with implementing their recommendations when accepted by the Minister.

It was agreed that the respective roles of scientists and managers, as developed by NAFO were useful and the Workshop should review these and develop a modified list to guide activities in the Newfoundland Region. These should then be put forward as suggested guidelines nationally.

WHAT THE PA MEANS TO MANAGERS (BAIRD):

Summary of Presentation (See also ANNEX III)

Discussions on the Precautionary Approach are occurring in several fora/commissions: NAFO, NASCO, ICCAT, ICES, FRCC, etc. The scientific community conducted most of the early work on this issue. Participation by managers was slow in the beginning, but is now starting to expand. There have been joint science/management working groups at NAFO and managers and scientists at NASCO are discussing precautionary approach formulations. In Canada the FRCC has held preliminary discussions on the PA and is planning another session early in 2000 to include scientists, managers and industry stakeholders.

The key elements in the development of the Precautionary approach for practical application are: the determination of the roles of science and management, the implementation of a comprehensive suite of management measures to complement the PA framework, and a clear definition of objectives for the management of fishery resources. The development or expansion of these elements will require extensive consultation with fishing industry participants.

Issues that need to be addressed or next steps that should be taken:

- Establish the link between the development of reference points/limits/harvest control rules and comprehensive management measures.
- Implement a comprehensive consultation process to include scientists, managers and industry stakeholders to promote a broad understanding of the various elements of the PA.

- Develop mechanisms that increase industry accountability in the management of fisheries.
- It appears, that for case studies examined, biomass reference points (e.g. Blim) are quite high. This issue needs some discussion/investigation.
- Continued management participation in precautionary approach discussions at international and domestic forums.

Discussion

A wide-ranging discussion followed, with comments on the respective roles of science and management in the process. The respective roles, as defined by NAFO, were discussed and additions/changes suggested as reflected in the 'Conclusions' (section #4). Discussion also indicated the need for managers and scientists to work together to ensure that future CHP's are 'cast' in terms of the PA. It was agreed that it would be helpful to scientists if managers, prior to assessments, provided scientists with information on the management objectives for various resources as well as indicating specifics of information they may need in this regard. The issue of the FRCC being an 'intermediary' with regard to groundfish was raised as an additional challenge to scientists and managers in their attempts to work closely in service delivery.

DESCRIPTION OF NATIONAL PROJECT ON THE PA (SHELTON):

Summary of Presentation

Although international agreements give conceptual guidelines for a precautionary approach, precise operational procedures for implementation have not been defined. The National Strategic Project on the Precautionary Approach aims to develop analytical techniques necessary for applying the precautionary approach to Canadian fisheries stock assessments. This initiative is national in scope and supports a number of regional projects in each DFO Region. The principal aim of this project is to complement other initiatives (national and international) aiming at the development of a precautionary framework for fisheries management. The project also aims at improving the transfer of knowledge between key players and at providing new tools (e.g. software) to enhance our ability to evaluate reference points and management strategies that are consistent with our knowledge base. Attempts are being made to define robust ways to assess and manage fish stocks and to promote the use of frameworks that are statistically sound and reflect the state-of-the-art in population modelling. Participants have agreed to build a suite of case studies that illustrate technical applications of the precautionary approach. The project is planned to terminate at the end of year 2000.

Discussion

The meeting discussed the viability of the different case studies initially considered under the Strategic Project and the process whereby these had been reduced to essentially 1 - 3Ps cod. It was agreed that while the assessments of other stocks were not being actively considered as case studies at present, there were a number of advancements in terms of herring, capelin, shrimp, crab and flatfish assessments in the Region that should be brought to the attention of participants in the Strategic Project.

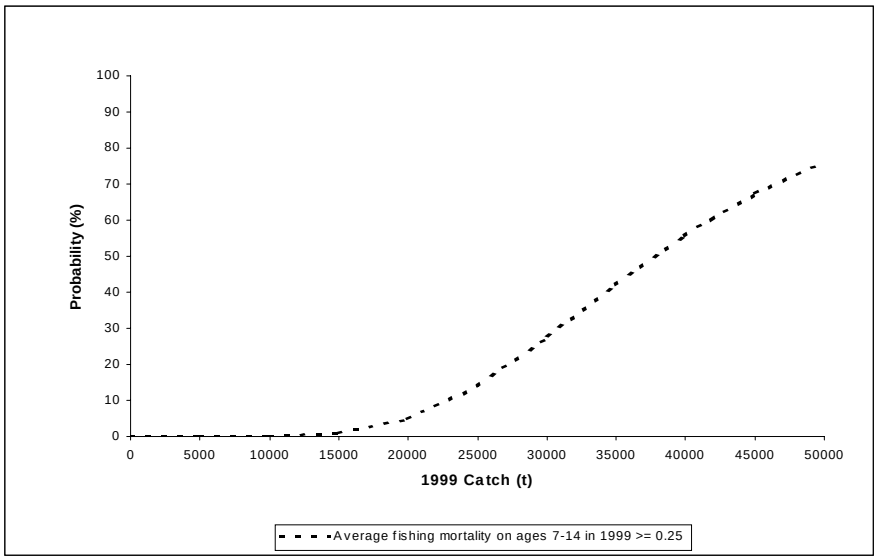
REVIEW OF RISK ANALYSIS AND EVALUATION OF OPTIONS FOR 3Ps COD (CADIGAN/STANSBURY):

Summary of Presentation

The assessment of 3Ps cod has been relatively uncertain compared to other eastern Canadian cod stocks because of complex stock dynamics in the 3Ps region. For example, the research vessel survey index for this stock has been quite variable in the 1990's.

As part of the last two assessments of 3Ps cod, one-year projections and risk analyses for a range of TAC's were considered. The projections are based on an assumed partial recruitment vector for the commercial fishery, and an assumed TAC. The deterministic projections have been presented in terms of graphs of fishing mortality and TAC, and also change in spawner biomass and TAC:

In the March 1999 assessment of this stock the risk analysis involved assessing the probability associated with fishing mortality exceeding a reference value ($F_{0.1}$):



Information on the probability of not exceeding an arbitrary spawner biomass reference point (100,000 t) was also provided.

In future assessments it is anticipated that more desirable biological and fishing mortality reference points will be considered. Some examples include F_{loss} (Fishing mortality at the lowest observed spawner stock), F_{med} (Fishing mortality from the spawner per recruit (SPR) function which corresponds to the median of the historical SPR series) and B_{loss} (spawner biomass at the lowest observed spawner stock size).

Discussion

There was little discussion of the SPA and stock projection methods, or the biological and fishing mortality reference points. In part this may have been related to unfamiliarity

with these methods. Some confusion was apparent about what exactly fishing mortality meant. A question was raised about what the appropriate level of risk is for fisheries management, and one response was that a range is required to help in decision making.

CONSERVATION HARVESTING PLAN (CHP) FOR 3Ps COD (CURRAN):

Summary of Presentation

CHP's for 3Ps cod are in place for fixed gear vessels less than 65', fixed gear vessels 65' – 100' and vessels greater than 100'. They all include regulations for mesh size with the different gears in use. They also include provisions for by-catch, small fish protocols, dockside monitoring, provision of logbook information and seasonal closures. In 3Ps, there are Individual Quotas (IQs) for vessels less than 65' in areas east of Point Crewe while the fishery west of there is competitive.

Discussion

It was noted that the current CHP's contain many of the management measures that could be included in a precautionary approach. While many of these measures have been more formalized in recent years, they have been included in management plans for many years. It was noted that there is a need for greater involvement of Science staff in the development of CHP's. Many of the measures, such as minimum fish size, are based on biological assumptions that need verification.

PA AND OTHER GROUNDFISH – STATUS AND FUTURE DIRECTION (BRODIE):

Summary of Presentation

A summary was presented based on recent work from the NAFO Scientific Council on 3 flatfish stocks: 3LNO American plaice and yellowtail, and 2+3KLMNO Greenland halibut. The focus was on definition of reference points (RP's) for American plaice, as an analytical (VPA-based) assessment existed for this stock, and considerable work had been done to estimate RP's at the NAFO SC workshop in March 1998. Based on this earlier work, a tentative value for B_{lim} of 150,000 tons was proposed. No RP's based on fishing mortality were proposed. Subsequent work was carried out in the 1999 assessment, incorporating a VPA with a change in natural mortality and updated estimates of SSB based on annual maturity ogives. Based on this updated VPA, it was not yet possible to recommend RP's, although it was apparent that the earlier value for B_{lim} of 150,000 tons was probably not appropriate, and should be re-evaluated.

For yellowtail flounder, there is no VPA-based assessment at present, given long-standing questions about the age and growth, natural mortality, and longevity of the stock. A surplus production model (ASPIC) has been used to define F-based RP's, although biomass based RP's were not proposed, due to the lack of a stock recruit relationship.

For Greenland halibut, there is also no VPA-based assessment at present, and measures of SSB from research vessel surveys are inadequate. Thus there is limited

work on which to define RP's. Some analyses exist which attempt to define RP's in terms of allowing sufficient numbers of juveniles to reach the SSB, given that much of the current fishery catches immature fish. Other methods have looked at defining RP's based on catch to survey biomass ratios as a proxy for fishing mortality

In all 3 stocks, priority will be given to using age-based methods, such as VPA, in the assessment and definition of RP's. Once VPA-based assessments and RP's are accepted, stock and catch forecasts can be presented in terms of risk management. In the absence of such age-based methods, other techniques, such as ASPIC, will be explored as assessment tools and as methods to define reference points under the precautionary approach.

Discussion

Discussion focussed on definition of reference points and their tentative nature, i.e. how it may be necessary to redefine these based on stock conditions. In this regard, the concept of different regimes for the American plaice stock was discussed, and how different the RP's were under these different regimes. Some participants questioned the use of SPA-based approaches for 3LNO A. plaice, given the uncertainties with catch and catch at age from some fleets in the 1980's, and the ongoing investigation of possible changes in natural mortality in this stock. The importance of using annual maturity data to calculate SSB was highlighted. It was noted that many methods are available for PA work using SPA-based assessments, but that fewer are available if SPA are not used as the basis of assessing the stock. Aspic shows some promise in this regard, particularly for yellowtail flounder, and it was noted that this model could be applied to other stocks to see how it compared with other techniques.

EXAMPLES OF CHP's FOR OTHER GROUNDFISH STOCKS (CURRAN):

Summary of Presentation

CHP's for other groundfish are similar in many ways to those described above for cod in 3Ps. There are different CHP's for different fleet/vessel size components with provision in these for bycatch regulation, small fish protocols, dockside monitoring requirements, observer requirements, seasonal closures as well as other measures.

Discussion

Similar issues to those raised in the cod discussion were noted. There is a requirement to have Science input into the development of management measures such as spawning closures, juvenile closures, and minimum fish sizes.

PA AND SHRIMP (PARSONS):

Summary of Presentation (see also ANNEX IV)

The 'stop light' approach has been developed as a means of clearly and concisely assessing the status of stocks for which there are not more analytical methods. The method entails the creation of a checklist of stock-specific quantitative/ qualitative indices, each of which may refer to a factor that can affect fishing success, stock

abundance or overall resource productivity, etc. Observations made from each index are interpreted and evaluated. The outlook is colour coded as follows:

- red = cause for concern
- yellow = uncertainty
- green = positive outlook.

The relative number of green, yellow and red codes are used in deciding whether/ how the Total Allowable Catch (TAC) should be adjusted from one year to the next. As well, certain indicators are considered of higher importance than others (e.g. recruitment) and implicitly given more weight in the determination of overall stock status.

Three examples illustrated how the approach could be used. The first considered the Hawke Channel – 3K (SFA 6) stock, the second considered a multi-year retrospective view of the Sept Isles stock, while the third illustrated a change in stock status over a broad geographic area (SFA2 – SFA6). In the latter case, the change in status was not necessarily due to a change in population dynamics of the animals but rather it was due to a change in data quality. As one travels north the intensity of research surveying declines.

It is important to note that this approach is evolving and that certain deficiencies exist. There must be clarification of the term “uncertainty”. There must be an explicit weighting system to address the uncertainty and the importance of the various indictors. Finally there must be agreement as to the decision making process that links the status of the resource to clearly defined management decisions and options.

In conclusion, the stop light analogy provides a visual, simple and transparent approach allowing for the inclusion and consideration of both qualitative and quantitative indicators. The observations and interpretation are non-analytical and hence are easily understood by all stakeholders, thereby providing a convenient mechanism for consensus building.

Discussion

The stoplight approach was well received as a means of assessing the status of data sparse stocks. The approach could be used in three different ways:

1) to illustrate within year stock knowledge;
2) to illustrate retrospective stock knowledge or;
3) to illustrate between stock knowledge.

It was acknowledged that the approach is accepted by industry as a clear means of reaching a decision-making consensus pertaining to relative health of a stock. The method will have to include a rating scheme because at present each of the stock descriptive categories may receive equal weightings that may not be realistic or desirable. A few relatively unimportant categories could sway recommendations. Alternately, any weightings may be only implicit. Additionally, it was pointed out that the traffic light analogy might not be appropriate because in some countries, there is a yellow traffic light prior to both red and green lights.

There is a north to south cline in levels of research survey data. The stoplight approach highlights this paucity of information but does not aid in decision making.

PA AND CRAB, SQUID (DAWE):

Summary of Presentation

Examples of the utility of the 'traffic-light' checklist to summarize stock status for data-poor stocks were provided by applying it to NAFO Div. 2J3KLNO snow crab and to NAFO SA 3-6 short-finned squid. It was noted that of these two examples squid could be considered to be particularly data-poor.

A single checklist was adequate for summarizing the relatively continuously distributed snow crab resource that is domestically managed and harvested as a unit. However, for squid, application of the checklist by management area (SA3 vs. SA 4 vs. SA 5+6) was useful for highlighting the considerable differences in fishing methods and management practices among the discrete fishery areas. Fishery practices and management measures differ between Canada and the USA, as well as within Canadian waters.

Discussion

There was discussion regarding indices that pertain to the life cycle of either species that would always remain constant and it was questioned whether it was of any value to include such indices. It was pointed out that such constants were very important in indicating the level of risk associated with managing the particular resource. For example 'female catch' for snow crab would always have a 'green light' because females are not caught by the fishery and so there are minimal concerns for this fishery regarding conservation.

In contrast, 'life cycle' for squid would always have a 'red light' because this species has an annual life cycle, indicating that the consequences of recruitment overfishing could be very serious. This comparison illustrated the value of developing some method for ranking key indicators.

CHP's FOR SHRIMP AND CRAB (ANDERSON):

Summary of Presentation

The current CHP for crab is a Multi-Year Plan, with TAC's developed in consultation with science and subject to annual adjustments. Allocations are based on Individual Quotas, and it is a limited entry fishery with temporary permits for vessels less than 35'. There are soft-shell closures (usually August), and fishing seasons vary by fleet. Mesh size in traps is regulated by condition of license and it is illegal to harvest female crab. There is mandatory Dockside Monitoring and 100% observer coverage for exploratory fisheries. Trip and weekly limits are in place and administratively managed by industry.

The CHP for shrimp is also a Multi-Year Plan with TAC's developed in consultation with science, and subject to annual adjustment. The quotas and quota sharing are based on industry consensus. It is a competitive fishery with limited entry licencing with temporary permits for the inshore fishery. There are trip limits to ensure an orderly harvest (administered by industry), and the season is determined by harvest rates. A number of other regulations include partial observer coverage on inshore vessels and 100% coverage on offshore boats, mandatory use of Nordmore Grate (license condition), mandatory completion/submission of fishing logs for vessels greater than 35',

restrictions on the amount of gear that can be fished (fixed gear) and regulated mesh size.

Discussion

Many of the management measures that would be included in a precautionary approach are included in the management plans for shrimp and crab. However, the management of these species result in a different approach than most of the traditional groundfish fisheries. The minimum size for crab results in a fishery that harvests primarily terminally moulted males. All females and a significant portion of mature males are not harvested and will contribute to recruitment. One of the major concerns raised with the harvesting of shrimp is the by-catch of groundfish species, particularly immature turbot. While measures have been implemented to minimize these concerns, additional examination of the issue involving both Science and management is required.

PA AND HERRING (WHEELER):

Summary of Presentation (See also ANNEX V)

Since 1995, harvest control rules for Newfoundland herring stocks have been based on a Stock Status Classification System that relies on stock recruitment relationships incorporating environmental effects (salinity, water temperatures). Each stock recruitment relationship is partitioned into four zones that relate exploitation rates with recruitment estimates to spawning stock biomass (SSB). In part the approach was designed to address concerns by industry that at low stock levels the fishery would be closed making it difficult to retain markets. For science the measures would reduce fishing mortalities at low stock levels, thereby reducing the risk of recruitment overfishing. A Herring Working Group representing industry, management, and science developed the Stock Classification System and recommended the harvest control rules. After the RAP the Herring Working Group meets and submits its recommendations to the Small Pelagics Advisory Committee (SPAC). Fisheries management considers the advice from SPAC in developing the herring management plan. There is flexibility within each of the zones to choose a TAC that corresponds to a fishing mortality (F) given the risk of causing the spawning biomass to decline into a lower zone. The important part of the process is that the harvest control rules were agreed to by all parties.

Discussion

- The analysis for herring spawning biomass is based on ICA, however the uncertainties in an ICA were not reported.
- The uncertainty related to the zonal boundaries is not expressed. Can simulations using various combinations of salinities and water temperatures be used express these uncertainties?
- In essence, the boundary between Zone 1 and 2 is similar to Blim but not analogous to the PA jargon. Should fishing be allowed below Blim as is the case for herring. ICES and NAFO recommend no fishing. For herring the range of F's is 0.0 to 0.05 with one option being no fishing. The payoff to science of some fishing even at low SSB is to collect data and to industry is to keep a position in the market.

- Concern was raised that the level of catch meant a 1 in 4 chance of the stock falling into the lower zone. Is this an acceptable level of risk?
- Is the Stock Classification System more about increasing yield than maximizing recruitment?
- Many considered the herring approach to be a good working example of the Precautionary Approach (before the HPPPA).

PA AND CAPELIN (NAKASHIMA):

Summary of Presentation

Should capelin be a data poor case study? The Barents Sea and Icelandic capelin fisheries have allowed fishing above a minimum spawning biomass of 500,000 t and 400,000 t respectively. Under the ICES Precautionary Approach, the Barents Sea has B_{lim} =200,000 t and B_{buf}=500,000 t and Iceland has a B_{lim}=400,000 t. Both set preliminary TAC's and conduct a mid-season review to adjust the final TAC.

In the northwest Atlantic since 1979 NAFO recommended no more than 10% of the spawning stock biomass (SSB) should be harvested as a conservation measure. This 10% rule is still in effect although no absolute SSB has been estimated since 1991. Instead stock status has been assessed using relative biomass estimates and relative yearclass strengths. In 1999, only relative yearclass strengths based on a multiplicative analysis incorporating several indices were available. While not part of the Precautionary Approach as outlined earlier, fishing mortality is negligible compared to natural mortality from predation and spawning, landings are similar to historical estimates, landings are related to the market, and recruitment is significantly correlated to environmental influences. Without annual SSB's or a reasonable stock recruitment relationship, it is difficult to apply the algorithms and standards of the HPPPA to capelin. Precautionary approach should consider role as the principal forage fish in the ecosystem and problems with bycatches of cod and salmon in the capelin fishery.

Discussion

- capelin considered data poor because no absolute biomass estimates since 1991
- not certain low TAC is precautionary because SSB is unknown
- absolute biomass estimates and precautionary approach necessary when considering multispecies approaches

CHP's FOR HERRING AND CAPELIN (CURRAN):

Summary of Presentation

CHP's for herring are the same as for groundfish, that is seasons, quotas, minimum size, fishing gear restrictions, dock side monitoring for mobile gears and fixed gear vessels over 35 foot, ship patrols, and inspections. Minimum size for herring is biologically based.

CHP's for capelin used size of females for a few years but no longer. A monitoring scheme (for size, female percent, redfeed, percent roe) based on market requirements

applied to open some areas. Dockside monitoring came into effect in 1999 for the mobile fleet and large vessels used in the fixed gear fishery. The fishery can be closed if dumping is high.

General Discussion

Herring

- herring Stock Classification Scheme comparable to NAFO proposal for precautionary approach
- B_{lim} buffer only on biomass and does not include environment
- retrospective analysis needed to see if buffer is sufficient
- some stocks have collapsed without fishing which may indicate that buffer not important

Capelin

- not taking into account the risk of being wrong. For capelin, the impact may be high because its role in the food web is not fully understood
- fishing mortality occurs after predation mortality
- fishing mortality on bycatch species in capelin gear may be more important than on capelin itself

PA AND SALMONIDS – STATUS AND FUTURE DIRECTION (PORTER / DEMPSON / O'CONNELL):

Summary of Presentations (see also ANNEX VI)

A. Newfoundland

There has been a long history of applying a precautionary approach to the management of Atlantic salmon stocks in the Newfoundland Region. In the context of reference points, salmon management has been based on achieving a 'target' egg deposition of 2.4 eggs/m^2 of fluvial habitat. Application of this value to deriving spawning requirements for Salmon Fishing Areas (SFAs) in Newfoundland and Labrador began in 1978 and extended to the provision of biological advice for individual rivers by 1980. In 1991, CAFSAC formally defined 'conservation' for Atlantic salmon and provided an operational translation by accepting the current "target egg deposition rate" of 2.4 eggs/m^2 with the addition for insular Newfoundland of 368 eggs/hectare of lacustrine habitat as a "biological reference level". Subsequent discussions clarified that the original intent of the CAFSAC definition of conservation was as a 'threshold'; that is, a level below which allowing the escapement to fall could incur irreversible damage to the population. This is consistent with the 'limit reference point' concept of the 'precautionary approach'. Science has continued to advise that there should be no harvests on salmon stocks that are below their conservation requirements. In a few instances, management targets, that are higher than conservation requirements, have also been established for individual rivers.

Currently there are 177 scheduled Atlantic salmon rivers in Newfoundland (N=158) and Labrador (N=19). Conservation spawning requirements (*limit reference points*) have

now been established for 50 rivers in Newfoundland (31.6%) but only three (15.8%) in Labrador. In 1997, 26 rivers were assessed relative to conservation spawning requirements while 20 stocks were evaluated in 1998. Conservation egg requirements and requirements in terms of numbers of small and large Atlantic salmon by Salmon Fishing Areas (SFAs), have recently been summarized for all of Canada.

In addition to identifying spawning requirements, both conservation and environmental protocols have been applied in determining whether salmon rivers would be open or closed to angling based on anticipated spawning escapements or actual environmental conditions prevailing during the salmon angling season. Protocols are often addressed or implemented relative to pre-season and in-season assessments of salmon stock status.

In the absence of pre-season forecasts, in-season evaluations are precautionary in those cases where stocks are at low levels and there is uncertainty about either continuing, or implementing a fishery.

In the absence of additional information, current conservation spawning requirements will continue to be used as '*limit reference points*' or '*thresholds*' below which there should be no fishing mortality. Mapping habitat characteristics of other watersheds will increase the number of rivers for which conservation requirements are available. Management spawning 'targets', which are higher than conservation '*thresholds*', should also be identified for other rivers taking into consideration the uncertainties of achieving these designated levels. In addition, existing conservation spawning requirements, or management '*targets*' will continue to be examined and evaluated with attempts made for further refinements, but this can only be accomplished with the continuance of geographically distributed smolt and adult salmon monitoring facilities. Ideally, river-specific stock-recruitment relationships should be developed, but the absence of sufficient time series of information from individual stocks precludes progress in this area.

B. NASCO (North Atlantic Salmon Council)

NASCO and its Contracting Parties, in 1998, agreed to adopt and apply a "Precautionary Approach" to the conservation, management and exploitation of Atlantic salmon. This "Precautionary Approach" is consistent with the "Precautionary Approach" put forth in the UN *Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks*.

The "Precautionary Approach" requires:

- avoidance of changes that are potentially irreversible;
- identify and take measures to avoid undesirable outcomes;
- initiate corrective measures without delay;
- give priority to conserving the productive capacity of the resource use where the likely impact of the resource is uncertain; and,
- appropriate placement of the burden of proof.

The initial application will be: 1) management of North Atlantic salmon fisheries; 2) formulation of management advice and associated scientific research; and 3)

introductions and transfers, including aquaculture impacts and possible use of transgenic salmon.

Application of the Precautionary Approach to salmon fishery management is an integrated process, which requires at least the following:

- that stocks be maintained above the conservation limits by the use of management targets;
- that conservation limits and management targets be set for each river and combined as appropriate for the management of different stock groupings;
- the prior identification of undesirable outcomes;
- that account be taken at each stage of the risks of not achieving the fisheries management objectives by considering;
- the formulation of pre-agreed management actions in the form of procedures to be applied over a range of stock conditions;
- assessment of the effectiveness of management actions;
- that stock rebuilding programmes be developed for stocks that are below their conservation limits.

NASCO has developed elements for inclusion in management procedures and the scientific advice required.

NASCO is currently in the initial stage of implementation of the Precautionary Approach. A Standing Committee was formed to co-ordinate the implementation.

Discussion

A. Newfoundland

Questions associated with the precautionary approach as applied to Atlantic salmon centred around the application of current conservation requirement of 2.4 eggs/m^2 as follows: a) how does the application of 2.4 eggs/m^2 relate to preventing irreversible effects on the salmon stock? b) how does the use of 2.4 eggs/m^2 relate to carrying capacity? and c) are there any estimates of illegal catches built into the process of assessing conservation requirements for salmon?

a) It was pointed out that we cannot currently assess the risk to the long-term viability of the stock by allowing spawning requirements to fall below current conservation requirements. However, consistent with the CAFSAC definition of conservation, it is believed that the further the escapement is below conservation and the longer the situation prevails, the greater the possibility of doing long term harm to the stock. One only has to examine the current state of the salmon resource eight years into a moratorium to appreciate the importance of maintaining spawning escapements during a prolonged period of low marine survival.

b) Conservation spawning requirements are not directly linked with the carrying capacity of individual systems. For some rivers, current requirements may be quite appropriate for the system. For others, it could be higher than that normally associated with a '*threshold*' level of escapement while for other rivers, the conservation requirements may indeed be too low. Only through the continuance of long term monitoring facilities and subsequent derivation of river-specific stock-

recruitment relationships will the present conservation requirements be able to be associated with capacity and dynamics of individual river systems.

c) Current conservation requirements incorporate an inflationary component to account for in-stream adult salmon losses (i.e. poaching and disease). This, however, only applies to the fluvial part of the conservation requirement. No adjustments or consideration is given for salmon losses in the marine environment.

B. NASCO

Question: The derivation of the quota at West Greenland uses a 50% probability that the conservation requirements will be achieved or exceeded. Is this risk neutral probability considered Precautionary by NASCO?

Response: No the 50% probability was agreed to by the Parties several years ago before the concept of Precautionary Approach was discussed. Also, at that time the amount of uncertainty surrounding the forecast model and the derivation of conservation limits were not fully understood; so the social and economic implications of using a higher probability was given greater consideration. The management model is now under consideration with greater consideration to a Precautionary Approach.

CHP's AND SALMONIDS (CURRAN):

Summary of Presentation

There are no CHP's for salmon in the context they are used for commercial fisheries. Instead there is an Integrated Management Plan for the recreational fisheries in insular Newfoundland and Labrador.

The recreational fishery in insular Newfoundland is currently under a three year Integrated salmon management plan (1999 – 2001). This plan includes the following:

- A river classification system by SFA based on the health of individual stocks.
- Environmental Protocols based on water temperature.

The current Integrated Salmon Management Plan for Labrador is still based on bag limits, seasons, etc. The only distinct difference from Insular Newfoundland is the allowance of retention of a large fish greater than 63 cm. DFO Science did not have the required information to apply the river classification system for rivers north of Cape Charles, however the classification system does apply to Labrador Straits rivers.

The other significant element of the Labrador Salmon Fishery is the negotiations and introduction of a salmon food fishery for the LIA and the Innu Nation.

Discussion

While there are no formal CHP's for salmonids, the management approach in the multi-year plan include many elements of a precautionary approach. The river classification system allows a flexible approach, taking into account concerns with respect to individual rivers. The environmental protocols provide for the protection of salmon while they are vulnerable.

PA AND MARINE MAMMALS (STENSON):

Summary of Presentation (see also ANNEX VII)

Although the Precautionary Approach has not been formally applied to marine mammals in Atlantic Canada many of the approaches taken are directed towards making precautionary decisions and the National Marine Mammal Peer Review Committee is tasked with the same questions as any other stock. The Precautionary Approach is also the basis of marine mammal assessments in a number of other areas (e.g., the Revised Management Plan of the International Whaling Commission and 'Potential Biological Removals' as a critical limit under the US Marine Mammal Protection Act).

Although over 30 species of marine mammals occur in Newfoundland, only two, harp and hooded seals, are assessed on a regular basis in this Region. Assessments of both species are based upon population models that incorporate periodic (preferably 4-5 yr. intervals) independent estimates of pup production with annual data on reproductive rates and catches.

In addition to estimating total abundance, the models are used to provide a Biological Reference Point for managers. The current biological reference point is referred to as the "Replacement Yield" and is defined as the level of harvest that can be taken such that the total population next year equals this years population. The level is dependent upon the age structure of the harvest and requires us to make assumptions about future reproductive rates (usually assumed to remain constant). A range of replacement yields is usually presented based upon different assumptions of the age of catch and mortality rates.

Other reference points have been used in the past including Maximum Sustainable Yield and a projection of long term sustainable yields at a given population level. However these require extensive assumptions about future reproductive rates and age structure of the catches. Given the significant changes in reproductive rates observed in many seals and the volatile nature of the sealing industry, long-term projections are considered too uncertain to be of any value.

Discussion

The questions of a target population were raised during the discussion and how this relates to the current replacement yield. It was indicated that the concept of a target population is one that must be explored but that with our current knowledge it is mainly a management question. Once the target population is decided upon, science can provide information on the level of catches needed to reach that population. It was also pointed out that political agendas rather than biology drive many of the questions related to seals.

HP FOR HARP SEALS (CURRAN):

Summary of Presentation

The Atlantic Seal Management Plan has the following Management Objectives:

1. Conservation/Sustainability/ Human Harvesting Practices

- Long-term Sustainable use for commercial, personal use and subsistence
- A market-driven Commercial harvest within Conservation Parameters
- Full Use of each animal harvested(DFO encourages the fullest possible use of all animals
- Humane Harvesting Practices, regulatory requirements are that a seal must be killed quickly, licensing policy will ensure that new sealers go through a training period under the direction of a Professional sealer

2. International Considerations

- This will include discussions with Greenland in relation to their reported harvest from the same seal herds
- trade/trade barriers still exist especially in the US. The Asian market appears to opening even though their currency is causing some problems
- Animal rights campaigns are always evident as they continue with their opposition to the seal harvest

3. Domestic Considerations

- Equitable Allocation ensures a share of the TAC based on traditional allocations
- Good sealing practices are encouraged to produce top dollar for all seal products

Many of the harvest issues related to seals are under the sealing regulations that are being re-written.

Discussion

Given that assessments are carried out every 4-5 years and there are plans for a multi-year management plan, a question was raised about the appropriateness of using a short-term biological reference point such as replacement yield. Trial runs have indicated that the population models can make reasonable predictions for short periods and that changes tend to occur slowly in mammal populations. However, long term predictions tend to be unreliable. Also, since the seal hunt is focussed towards young animals, the impact of a given level of hunt is not obvious in the pup production until these year classes mature. Therefore, replacement yields are unlikely to change significantly over short periods unless there are significant changes in reproductive rates or the harvest. Interim assessments could be undertaken if such changes occur.

OPEN DISCUSSIONS:

It was emphasized that one of the most critical pieces of information required by scientists is reliable catch data. While scientists may be able to develop biological reference points in relation to the Precautionary Approach, and managers may be able to implement a number of measures to enhance possibilities of achievement, having

fundamental catch information as well as information on its accuracy is of prime importance.

Participants agreed that while it may not be possible to get completely accurate catch information, it is possible to gain some understanding of the degree of uncertainty associated with catch data which could then be built into scientific analyses of risk and then be useful to managers.

There were a number of other areas where there are important links between scientific analyses and management. One example raised was that of the impacts of resource allocations (areas, gears, etc.) on scientific prediction and risk analysis. These all pointed to continuing dialogue and consultation between the two groups.

Discussion returned, on many occasions, to the interactions between scientists and managers. It was emphasized repeatedly that ongoing interaction is essential and in the region is working well for non-groundfish species. Frustration was expressed by both groups regarding the role of the FRCC in the management process in this respect in that their role is such that it 'breaks' the important links and interactions. Both groups are tasked with 'serving' rather than being empowered to work together in the development of meaningful approaches and strategies to ensure resource sustainability.

Participants spent some time reviewing the summary of respective roles of scientists and managers related to the Precautionary Approach. To date, although Canadian scientists and managers have endorsed the role definitions as spelled out by NAFO (see Annex III), there has been no discussion, at least in Newfoundland, of these. The Workshop concluded that the NAFO list represented a reasonable starting framework for defining respective roles but for our purposes should be modified somewhat. After discussion, it was agreed that with changes, the definition of respective roles should be adopted by the region as a working model for scientists and managers.

General discussion of how the PA may deal with multi-species issues also took place. Some actions that may appear precautionary under a single species approach may not be when considered in a multispecies model. To date, there has been no real discussion on how to incorporate multispecies, or ecosystem approaches into the PA or who is responsible for initiating the discussion. These issues must be considered and the single species PA approach re-evaluated.

CONCLUSIONS:

1. There needs to be close involvement of industry in the process of moving toward implementation of the Precautionary Approach so as to ensure 'buy-in'.

   ACTION: Ensure industry in brought into all regional discussions on PA as well as including them in other discussions on the PA.

2. In order to bring industry 'on side' regarding the Precautionary Approach, it is essential that scientists and managers ensure ongoing dialogue so as to be able to present an agreed and united position.

   ACTION: Atkinson/Baird to ensure common perspectives presented during January FRCC Workshop on the PA.

3. Science and Fisheries Management should review text of future CHP's to ensure that clear links are made with the Precautionary Approach.

   ACTION: In future, Fisheries Management will ensure CHP's are available for Science to review during their RAP meetings with specific remits from managers to science requesting feedback (it was noted that this would apply primarily to non-groundfish stocks but that it could also be implemented for groundfish recognizing that CHP's for these species often reflected FRCC recommendations).

4. Within Newfoundland Region, the respective working roles of scientists and managers in the context of the Precautionary Approach will be as follows:

Science	Management
1. Determine stock status. 2. Classify stock status with respect to biomass/fishing mortality zones. 3. Calculate limit reference points and security margins. 4. Describe and characterize uncertainty associated with current and projected stock status with respect to reference points. 5. Conduct risk assessments. 6. Evaluate and make recommendations regarding comprehensive management measures that may enhance probabilities of avoiding limit reference points.	1. Specify management objectives (biological as well as socio-economic), select target reference points, and confirm limit reference points as recommended by science. 2. Specify management strategies (courses of actions) for biomass/fishing mortality zones. 3. Implement other management measures to enhance probabilities of achieving resource objectives. 4. Develop comprehensive management plans that explicitly take the Precautionary Approach into consideration. 5. Specify time horizons for stock rebuilding and for fishing mortality adjustments to ensure stock recovery and/or avoid collapse. 6. Specify acceptable levels of risk to be used in evaluating possible consequences of management actions.

5. Newfoundland Region should promote discussion of the above guidelines within the Department beyond the region with the objective of establishing an agreed set of respective responsibilities nationally. This will require discussion with, and input from the FRCC.

   ACTION: Shelton/Cadigan to promote consideration of the 'list' during the HPPPA Workshop in November; Atkinson/Baird to promote consideration of the 'list' during FRCC Workshop in January.

6. A working group consisting of staff from Science, Fisheries Management and Policy be struck to address the issue of determining accuracy and precision of catch data.

   ACTION: Atkinson/Baird/Collins to develop Terms of Reference and establish WG membership.

7. Continuing dialogue between scientists, managers and policy makes is critical to ensure continued understandings and forming bonds to enable collective horizontal approaches to dealing with issues of mutual relevance and importance.

   ACTION: Atkinson/Baird/Collins to ensure and promote ongoing dialogue and ensure that staff get together formally at least once each year for discussions of mutual interest.

8. There is a need for more consideration of how to move forward with the Precautionary Approach as related to stocks for which there are not analytical assessments. These ‘data poor’ stocks are numerous in our area and represent a particular challenge.

   ACTION: Scientists to continue to examine ways of dealing with these ‘data poor’ resources drawing on information based on developments in other jurisdictions, information from managers and input from industry.

9. There needs to be consideration of how, in terms of the Precautionary Approach, ‘multi-species’ and ‘ecosystem’ considerations may impact the various reference points and management strategies.

   ACTION: Scientists and managers in Newfoundland Region and elsewhere in Canada need to keep in mind that the more holistic approaches may impact on criteria consistent with, and implementation of the PA. Everyone needs to keep abreast of national and international developments in this regard.

ANNEX I

Joint Science - Fisheries Management – Policy Workshop
on the Precautionary Approach

Newfoundland Region

Airport Inn
St. John's, Newfoundland
September 27-28, 1999

Agenda

Purpose

To describe and discuss the current status and future directions of the Precautionary Approach (PA) to the assessment and management of fisheries resources in the Newfoundland Region.

Co-Chairs: Bruce Atkinson and Jim Baird

Tuesday, Sept. 28:

0900-0925: Current ICES and NAFO interpretations of the PA – Bruce Atkinson.

0925-0950: What the PA means to managers – Jim Baird.

0950-1000: Brief description of the national High Priority Project on the PA – Peter Shelton.

1000-1015: Discussion – what can we achieve in the next two days?

1015-1045: BREAK

1045-1110: Review of the risk analysis and evaluation of TAC options carried out in the March 1999 3Ps cod assessment – Noel Cadigan and Don Stansbury.

1110-1135: Conservation Harvesting Plan (CHP) for 3Ps cod.

1135-1200: Discussion.

1200-1300: LUNCH

1300-1325: PA and other groundfish - status and future direction - Bill Brodie.

1325-1350: Examples of CHP's for other groundfish stocks.

1350-1415: Discussion.

1415-1445: BREAK

1445-1500: PA and shrimp – Don Parsons.

1500–1515: PA and crab – Earl Dawe.

1515-1535: CHP's for shrimp and crab.

1535-1600: Discussion.

Wednesday, Sept. 29:

0900-0915: PA and herring – John Wheeler.

0915-0930: PA and capelin – Brian Nakashima.

0930-0950: CHP's for herring and capelin.

0950-1015: Discussion.

1015-1045: BREAK

1045-1110: PA and salmonids - status and future direction - Rex Porter.

1110-1135: CHP's and salmonids.

1135-1200: Discussion.

1200-1300: LUNCH

1300-1325: PA and marine mammals – Garry Stenson.

1325-1350: CHP for harp seals.

1350-1415: Discussion.

1315-1345: BREAK

1345-1600: Open discussion about short, medium and long term directions and requirements for implementing a Precautionary Approach to marine resources in the Newfoundland Region.

ANNEX II

Joint Science - Fisheries Management – Policy Workshop
on the Precautionary Approach

Newfoundland Region

Airport Inn
St. John's, Newfoundland
September 27-28, 1999

List of Attendees

NAME	BRANCH/DIV	PHONE #
Bruce Atkinson	Science	2027
Jim Baird	Fisheries Management	
Becky Sjare	Science (Mar. Mammals)	4049
Paul Cahill	Policy and Economics	6931
Kevin Anderson	Fisheries Management	4653
Brian Nakashima	Science (Pelagics)	4925
John Wheeler	Science (Pelagics)	2005
Geoff Evans	Science (Pelagics)	2090
Morley Knight	Fisheries Management	4010
Roy Russell	Fisheries Management	4497
Jerry Ennis	Science (Shellfish)	2094
Gary Brocklehurst	Fisheries Management	2320
Gerry Brothers	Fisheries Management	4438
Steve Walsh	Science (FFDWS)	5478
Joanne Morgan	Science (FFDWS)	2261
Earl Dawe	Science (Shellfish)	2076
George Lilly	Science (Gadoids)	0568
Don Stansbury	Science (Gadoids)	0559
Peter Shelton	Science (Gadoids)	2341
Brian Dempson	Science (Salmonids)	4475
Mike O'Connell	Science (Salmonids)	2866
Rex Porter	Science (Salmonids)	4409
Frank Corbett	Policy and Economics	6935
Garry Stenson	Science (Mar. Mammals)	5598
Brian Healey	Science (Mar. Mammals)	5693
Don Power	Science (FFDWS)	4935
Dave Orr	Science (Shellfish)	7343
Ray Bowering	Science (FFDWS)	2054
Bill Brodie	Science (FFDWS)	3288
Noel Cadigan	Science (Gadoids)	5028
Eugene Murphy	Science (Gadoids)	5479
Don Parsons	Science (Shellfish)	2093
John Collins	Policy and Economics	4446
Ken Carew	Policy and Economics	6934

ANNEX III

PRECAUTIONARY APPROACH
A MANAGEMENT PERSPECTIVE

Jim Baird

INTRODUCTION

Discussions on the Precautionary Approach are occurring in several fora/commissions: NAFO, NASCO, ICCAT, ICES, FRCC, etc. Most of the early work on this issue was conducted by the scientific community. Participation by managers was slow in the beginning, but is now starting to expand. There have been joint science/management working groups at NAFO and precautionary approach formulations are being discussed by managers and scientists at NASCO and ICCAT. In Canada the FRCC have held preliminary discussions on the PA and are planning another session early in 2000 to include scientists, managers and industry stakeholders.

ROLES OF SCIENCE AND MANAGEMENT

One of the issues that requires some discussion are the roles of scientists and managers in the implementation of precautionary management (or any management for that matter!). During a 1998 meeting of NAFO scientists and managers, the following list was developed:

Science	Management
1. Determine stock status	1. Specify management objectives, select target reference points, and set limit reference points.
2. Classify stock status with respect to biomass/fishing mortality zones.	2. Specify management strategies (courses of actions) for biomass/fishing mortality zones.
3. Calculate limit reference points and security margins	3. Specify time horizons for stock rebuilding and for fishing mortality adjustments to ensure stock recovery and/or avoid collapse.
4. Describe and characterize uncertainty associated with current and projected stock status with respect to reference points	4. Specify acceptable levels of risk to be used in evaluating possible consequences of management actions.
5. Conduct risk assessments	

This list was developed with the management of NAFO stocks in mind (shrimp, capelin, squid and a variety of groundfish stocks). However these roles and responsibilities could have a wide application for most stocks that are managed domestically. There may be some difficulty in resolving some of these issues listed above for stocks that are data poor, however there are alternate, more subjective approaches that can be applied in these cases (e.g. stop light approach).

There is one element that should be added to this list on the management side. "Develop implementation strategies (a list of comprehensive management measures) that are applicable to meet science and management requirements." The inclusion of this responsibility for managers would lead to what we would characterize as a comprehensive precautionary approach.

We also need to emphasize that the roles and responsibilities listed for managers can't be determined in isolation from industry. A broad consultation with industry stakeholders is required to achieve consensus on most of these issues. Currently, management objectives and conservation harvesting plans are developed through this type of consultation.

OTHER MANAGEMENT MEASURES - COMPREHENSIVE PA

It is clear that for stocks that are at low levels any fishing activity contemplated should employ a cautious approach. In addition, fishing should only be permitted if comprehensive suites of management measures are developed to assist in the application of the PA and to ensure that conservation is not compromised. A potential inventory of management measures that could be included is as follows:

- TAC/Moratorium
- Limited entry licensing
- Vessel replacement restrictions
- Effort control
- By-catch protection provisions
- Minimum fish size
- In season management for by-catch and small fish (protocols)
- Spawning closures
- Juvenile closures
- By-catch closures
- Fishing gear restrictions (minimum mesh size/use of separator grids)
- Observer deployments
- Dockside monitoring
- Vessel monitoring systems
- Air patrols
- Ship patrols
- On-board inspections

The types of measures described above are regularly implemented for domestic fishing activity in Canada and are included in Conservation Harvesting Plans (CHP's) for specific fisheries. Not all measures apply to each fishery, but a comprehensive suite of measures (subset of the above) are applicable to every fishery.

The implementation of these and/or similar measures are not new to fisheries management in Canada. Management plans that contain some of these measures date back several years. More comprehensive CHP's began to be developed in the early 1990's - mainly as a measure to protect groundfish stocks that were under moratoria**.**

MANAGEMENT OBJECTIVES

One of the key responsibilities of fisheries managers is the specification of management objectives. These are developed in consultation with industry and are included in all Fisheries Management Plans. One of the basic objectives included in most plans has been something like:

- To ensure conservation and protection of stocks through the application of sound management practices.

More recently the Department has considered that we are conserving these resources for a specific reason - to provide commercial sustainability to fish harvesters. As a result the basic management objective of conservation has been linked to sustainable fishing (resource utilization to achieve viability of fishing enterprises over the long term).

In many cases there are also a variety of additional management objectives that include:

- To ensure that reliable and adequate information is collected for management and science.
- To promote efficient and orderly harvesting practices.
- Aboriginal considerations for food, social and ceremonial purposes.
- Recreational or international considerations.
- To minimize by-catch of incidental species.

For the most part the types of objectives described above are broad in scope making it difficult to develop performance measurements. In many cases specific strategies are identified that promote achieving specific objectives: ensuring the quotas are not exceeded, requirement for observers or dockside monitors, restrictions on gear, etc.

In other cases management objectives are quite specific:

- To double egg production by 2003.
- Maintain moratoria for specific stocks.

NEXT STEPS/ISSUES

Issues that need to be addressed or next steps that should be taken:

- Establish the link between the development of reference points/limits/harvest control rules and comprehensive management measures.
- Implement a comprehensive consultation process to include scientists, managers and industry stakeholders to promote a broad understanding of the various elements of the PA. It appears that industry stakeholders are familiar with the term "precautionary approach", but they have very little understanding of the specific elements.
- Develop mechanisms that increase industry accountability in the management of fisheries. This could be accomplished in part by including industry in specifying the various decision elements of the PA (management objectives, target/limit reference points, management strategies, time horizons for rebuilding, acceptable levels of risk, etc).
- It appears, that for case studies examined, biomass reference points (e.g. B_{lim}) are quite high. For example the B_{lim} for Yellowtail appears to just have been

reached while all stock indicators suggest that this stock is at or near an all-time high. This issue needs some discussion/investigation.

- Continued management participation in precautionary approach discussions at international and domestic forums. Newfoundland Regional fisheries managers are participating at NAFO, NASCO and FRCC – NHQ managers are participating at ICCAT. (Resolution to Guide Implementation of the PA with NAFO – attached).

ANNEX V

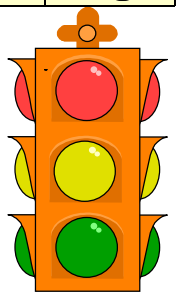
Stop-light Approach pertaining to shrimp:

	EVALUATION			
INDEX	Hawke+3K	Hope+Cart	Div. 2G	Div. 0B
FISHERY DATA				
CPUE - KG/HR	●	●	●	●
Spatial pattern	●	●	●	●
Temporal pattern	●	●	○	○
Male abundance	●	●	●	●
Female abundance	●	●	●	●
Sex inversion	●	●	●	●
RESEARCH DATA				
Biomass/abundance index	●	●	●	○
Spatial pattern	●	●	●	○
Recruitment (male age structure)	●	●	●	○
Spawning stock (females)	●	●	●	○
ANCILLARY				
Predation	●	●	○	○
Environment	●	●	○	○
Industry perspectives	●	●	●	●
ASSESSMENT				
Exploitation rate	●	●	●	●
Stock Status 1999	●	●	●	●
Future Prospects 2000+	●	●	●	●

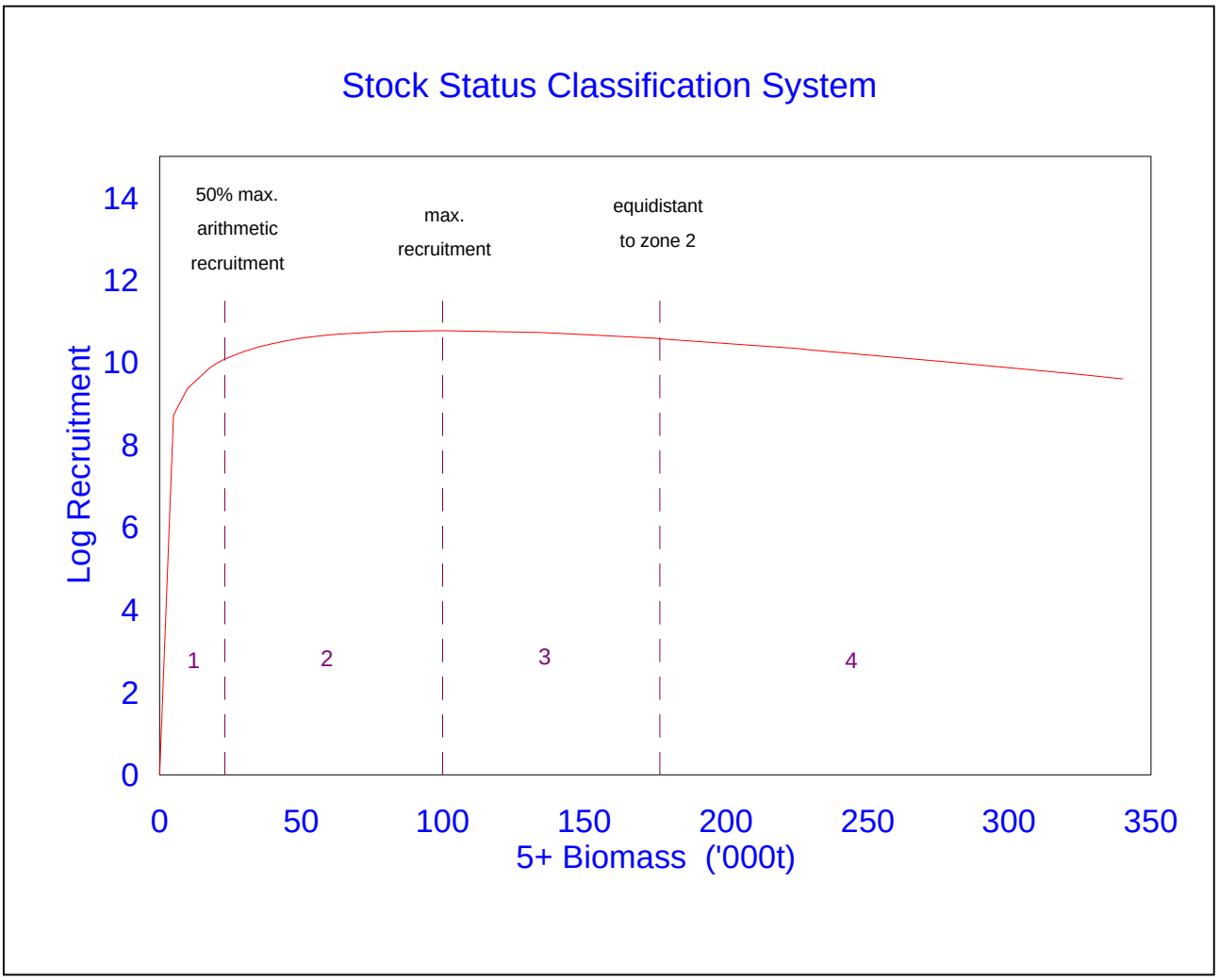
Concerns regarding current status and/or future prospects

Uncertainty regarding the impact

Positive evaluation



ANNEX V



Herring Stock Status Classification System

Zone	Stock Status	F	Type of Fishery
1	Very Poor	0.00 - 0.05	Scientific
2	Poor to Moderate	0.05 - 0.10	Restricted
3	Moderate to Good	0.10 - 0.20	Commercial
4	Good to Very Good	>=0.20	Accelerated

ANNEX VI

Status of the 'precautionary approach' applied to Atlantic salmon in Newfoundland and Labrador

J. B. Dempson, M. F. O'Connell, and T. R. Porter

'Precautionary approach' and stock-specific reference points

In contrast with other marine fish species, derivation of '*limit reference points*' for Atlantic salmon is not associated with fishing mortality rates or specific harvest levels. Rather, management of Atlantic salmon stocks in eastern Canada, in the context of reference points, has been based on achieving a 'target' egg deposition of 2.4 eggs/m^2 of fluvial habitat. This value originated from the work of Elson (1957) as the egg deposition required to maximize smolt production and later became accepted as a 'target' egg deposition rate. The concept of achieving a minimum 'target' number of required spawners as a basis for Atlantic salmon management advice was formalized through CAFSAC in 1977 for several rivers in the Maritimes (Appendix 2 - CAFSAC Advisory Document 77/2).

The applicability of using a 'target' egg deposition for a reference point was reviewed in a CAFSAC workshop in 1980. A report from the workshop concluded that "… *the existing database is not a sufficient basis for detailed and accurate advice on management measures to optimise production on a river-by-river basis. However, a point of reference is offered for management of stocks until target spawning escapements can be accurately set and the impact of regulatory measures can be better estimated. Achieving potential egg depositions of 200 per 100 sq. metres of salmon rearing habitat or, where possible, at spawning levels associated historically with high levels of recruitment is adequate to conserve stocks and to retain future options*".

Numerical reference points (i.e. spawning requirements) for Salmon Fishing Areas in Newfoundland and Labrador were first developed in 1978 for the Atlantic Salmon Task Force Review with the corresponding area values included in CAFSAC Advisory Document 81/2. The provision of advice based on the spawning requirements of individual Newfoundland rivers began in 1980 for rivers on the southwest coast (CAFSAC Advisory Document 80/4) and was further highlighted in 1983 and 1984 (CAFSAC Advisory Documents 83/7, 84/2). However, the fisheries management requirement for annual stock assessment advice, based on a 'target' spawning level for an individual river began in 1986 for Conne River expanding to eight rivers by 1992 (CAFSAC Advisory Document 92/3).

Conservation

In 1991, CAFSAC formally defined '*conservation*' for Atlantic salmon following court decisions (Sparrow decision) that native food fisheries have first right of access to natural renewable harvestable resources, once conservation was assured (CAFSAC Advisory Document 91/15). CAFSAC also provided an operational translation of

conservation by accepting the current "*target egg deposition rate*" of 2.4 eggs/m^2 with the addition for insular Newfoundland of 368 eggs/hectare of lacustrine habitat as a "*biological reference level*". This reference level also incorporated an inflationary component intended to account for in-stream adult salmon losses (i.e. poaching and disease) following their enumeration in a river, as well as for disproportionate adult exploitation and unequal rate of recruitment of the multiple stocks that could comprise a river stock complex. The methodology, derivation of associated parameter values, limitations and research needs identified for determining conservation requirements for the Newfoundland Region are summarized in O'Connell and Dempson (1995).

Targets or thresholds?

Owing to perceived confusion over whether the operational translation of 'conservation' was intended as a '*threshold*' or as a '*target*', a workshop was held in March 1996 to review conservation principles for Atlantic salmon in Eastern Canada (Chaput 1997). At that time 'conservation' was being interpreted and applied differently among various regions of eastern Canada. The consensus of the workshop was that, contrary to the different interpretations as to what 'conservation' meant, the original intent of the CAFSAC definition was as a '*threshold*'; that is, a level below which allowing the escapement to fall could incur irreversible damage to the population. This would be consistent with the '*limit reference point'* concept of the 'precautionary approach'. In contrast, a '*target*' was a point to be achieved, and should be an objective of fisheries management and thus becomes a reference level for managing people. Science has continued to advise that there should be no harvests on stocks that are below the conservation requirement.

Current status

There are currently 177 scheduled Atlantic salmon rivers in Newfoundland (N=158) and Labrador (N=19). Conservation spawning requirements (*limit reference points*) have now been established for 50 rivers in Newfoundland (31.6%) but only three (15.8%) in Labrador. Note that conservation requirements have also been identified for some non-scheduled salmon rivers (e.g. Little River, SFA 11), while many other Labrador rivers remain unscheduled. While the number of rivers for which conservation requirements have been determined is relatively few, conservation egg requirements and requirements in terms of numbers of small and large Atlantic salmon by Salmon Fishing Areas (SFAs), with the corresponding methodology used to derive these data, have recently been summarized for all of Canada (O'Connell et al. 1997). Where appropriate habitat information was not available, the requirements were based on drainage area or as a proportion of estimates of previous total production.

In 1997, 26 rivers were assessed relative to conservation spawning requirements.

while 20 stocks were evaluated in 1998 (none in Labrador). Of these 20 stocks, only 8 have time series of $\geq$ 15 years, or approximately three generations.

Science advice and management protocols

In recent years, various management strategies or protocols were used to determine whether salmon rivers would be open or closed to angling based on anticipated spawning escapements (Porter 1997). Protocols respecting conservation concerns were

related either to retention fisheries, hook-and-release fisheries, or outright river closures. These measures were developed in response to a request from Management for Science to provide options that would allow some rivers currently below conservation requirements to remain open but also incorporate a stock rebuilding strategy (Chaput 1997). Thus, contrary to the concept of a consistent 'precautionary approach', in some cases protocols allowed for retention or hook-and-release fisheries when spawning stocks were below established conservation requirements. These protocols were implemented using results of pre-season and in-season assessments of stock status.

In-season assessments began around 1994. In the absence of pre-season forecasts, in-season evaluations are precautionary in those cases where stocks are at low levels and there is uncertainty about either continuing, or implementing a fishery.

In addition to conservation protocols, there were also protocols related to environmental considerations (i.e. warm water temperatures and low water levels) as to when rivers should be closed. This is because of real or perceived concerns that salmon are susceptible to added physiological stress associated with these environmental conditions such that they are unable to cope with agitation, injury and exhaustion from hook-and-release fisheries which could trigger and accelerate the onset of disease (Chaput 1997). The closure of rivers to hook-and-release fisheries when water temperatures reached 18 °C, and to retention fisheries when water temperatures reached 22 °C, were based on recommendations from Science.

Following a substantive decline in Atlantic salmon returns to most rivers in Newfoundland in 1997, Science advised a precautionary approach to the management of stocks in 1998. This was because of the uncertainty associated with pre-season forecasts of subsequent salmon abundance. Under certain conditions the level of exploitation should be decreased thereby reducing the risk of not achieving conservation requirements (DFO Science 1998). In the absence of pre-season quantitative forecasts, Fisheries Management did take a precautionary approach by reducing the seasonal retention limit in the recreational fishery by 75% from 4 fish to 1, pending an in-season review of the status of stocks.

Management targets and river classification

Management 'targets' have been set on several rivers in past years (e.g. Torrent, Exploits, Conne). However, in 1999, Conne River was the only stock for which a separate management target that is higher than the conservation spawning requirement was maintained. In all other cases, previous 'targets' or river-specific quotas were replaced with the introduction of the river classification system. The latter provides for different retention levels based upon the actual or perceived 'health' of individual stocks. Retention levels associated with the river classification system were assigned either according to the degree to which conservation spawning requirements were met on average during the commercial salmon fishery moratorium years, 1992-96, or, in the absence of information related to conservation requirements, historical angling data were used. In addition, qualitative factors such as the degree of remoteness, level of angling effort, proximity to highly populated areas, size of river, and overall perception of stock status based upon observations from local anglers and DFO field staff were integrated into the categorization process. As stated in the 'Integrated Management

Plan' for Atlantic salmon (DFO 1999), "*In the absence of adequate information consideration is given to the precautionary approach of minimal retention or hook and release only*".

Future direction

In the absence of additional information, current conservation spawning requirements of individual rivers will continue to be used as '*limit reference points*' or '*thresholds*' below which there should be no fishing mortality. Mapping of habitat characteristics of other watersheds will increase the number of rivers for which conservation requirements are available. Management spawning 'targets', which are higher than conservation '*thresholds*', should also be identified for other rivers taking into consideration the uncertainties of achieving these designated levels. In addition, existing conservation spawning requirements, or management '*targets*' will continue to be examined and evaluated with attempts made for further refinements (e.g. Prevost and Chaput 1996), but this can only be accomplished with the continuance of geographically distributed smolt and adult salmon monitoring facilities. Ideally, river-specific stock-recruitment relationships should be developed, but the absence of sufficient time series of information from individual stocks precludes progress in this area. Modelling the dynamics of egg-to-smolt production when different habitat attributes and biological characteristics of recruiting adults are incorporated, is an alternative approach to defining conservation spawning requirements (Chaput et al. 1998). However, the latter is still dependent upon a composite of information obtained across various stocks.

References

CAFSAC. 1977. Report to management in anadromous and pelagic stocks: Appendix 2 – Anadromous, Catadromous and Freshwater Subcommittee - New Brunswick salmon assessment, stock forecasts for the 1977-1980 period. Canadian Atlantic Fisheries Scientific Advisory Committee Advisory Document 77/2. 4 p.

CAFSAC. 1980. Assessment of anadromous fish stocks. Canadian Atlantic Fisheries Scientific Advisory Committee Advisory Document 80/4. 3 p.

CAFSAC. 1981. Assessment of anadromous fish stocks. Canadian Atlantic Fisheries Scientific Advisory Committee Advisory Document 81/2. 8 p.

CAFSAC. 1983. The status of Atlantic salmon stocks on the west coast of Newfoundland and advice for their management in 1983 and 1984. Canadian Atlantic Fisheries Scientific Advisory Committee Advisory Document 83/7. 5 p.

CAFSAC. 1984. The status of Atlantic salmon stocks on the western coast of Newfoundland and advice for their management in 1984. Canadian Atlantic Fisheries Scientific Advisory Committee Advisory Document 84/2. 4 p.

CAFSAC. 1991. Definition of conservation for Atlantic salmon. Canadian Atlantic Fisheries Scientific Advisory Committee Advisory Document 91/15. 4 p.

CAFSAC. 1992. Status of Atlantic salmon stocks in 1991. Canadian Atlantic Fisheries Scientific Advisory Committee Advisory Document 92/3. 26 p.

Chaput, G. J. [ed.]. 1997. Proceedings of a workshop to review conservation principles for Atlantic salmon in eastern Canada. Canadian Stock Assessment Proceedings Series 97/15. 33 p.

Chaput, G. , J. Allard, J. B. Dempson, C. C. Mullins, and M. F. O'Connell. 1998. River-specific target spawning requirements for Atlantic salmon (*Salmo salar*) based on a generalized smolt production model. Canadian Journal of Fisheries and Aquatic Sciences, 55: 246-261.

Department of Fisheries and Oceans. 1999. Integrated management plan, Newfoundland and Labrador – Atlantic salmon 1999-2001.

Department of Fisheries and Oceans – Science. 1998, Atlantic salmon – Newfoundland and Labrador, Salmon Fishing Areas 1-14B. Stock Status Report D2-01. 8 p.

Elson, P. F. 1957. Number of spawners needed to maintain stocks. Canadian Fish Culturist, 21: 19-23.

May, A. W. 1993. A review of management and allocation of the Atlantic salmon resource in Atlantic Canada, p. 220-232. *In*, D. Mills [ed.], Salmon in the sea and new enhancement strategies. Fishing News Books, Oxford, London.

O'Connell, M. F., and J. B. Dempson. 1995. Target spawning requirements for Atlantic salmon, *Salmo salar* L., in Newfoundland rivers. Fisheries Management and Ecology, 2: 161-170.

O'Connell, M. F., D. G. Reddin, P. G. Amiro, F. Caron, T. L. Marshall, G. Chaput, C. C. Mullins, A. Locke, S. F. O'Neil, and D. K. Cairns. 1997. Estimates of conservation spawner requirements for Atlantic salmon (*Salmo salar* L.) for Canada. Department of Fisheries and Oceans Canadian Stock Assessment Secretariat Research Document 97/100. 58 p.

Porter, T. R. 1997. Protocols used in Newfoundland for determining if a river will be closed for salmon angling, p. 21-23. *In*, G. J. Chaput [ed.], Proceedings of a workshop to review conservation principles for Atlantic salmon in eastern Canada. Canadian Stock Assessment Proceedings Series 97/15. 33 p.

Prevost, E., and G. Chaput [eds.]. 1996. Atlantic salmon spawning target workshop: determination, precision, transportability and risk. Unpublished report from a workshop held in June 1996, Pont-Scorff, Brittany, France.

NORTH ATLANTIC SALMON CONSERVATION ORGANISATION (NASCO)

PRECAUTIONARY APPROACH

NASCO and its Contracting Parties agreed, at its annual meeting in 1998, to adopt and apply a "Precautionary Approach" to the conservation, management and exploitation of Atlantic salmon in order to protect the resource and preserve the environment in which it lives. The "Precautionary" Approach adopted by NASCO is consistent with the "Precautionary Approach" put forth in the UN *Agreement on Straddling Fish Stocks and*

Highly Migratory Fish Stocks. Accordingly NASCO and its Contracting Parties agreed to be more cautious when scientific information is uncertain, unreliable, or inadequate. The absence of adequate scientific information should not be a reason for postponing or failing to take conservation and management measures.

Canada is not bound to conform to the "Precautionary Approach", however, since Canada agreed to adopt the Agreement, it is obligated to apply the "Precautionary" principles to the extent possible. This Agreement provides some consistency among Contracting Parties in the application of management measures. NASCO is presently developing an action plan for application of a "Precautionary Approach".

The "Precautionary Approach" requires:

- avoidance of changes that are potentially irreversible;
- identify and take measures to avoid undesirable outcomes;
- initiate corrective measures without delay;
- give priority to conserving the productive capacity of the resource use where the likely impact of the resource is uncertain; and,
- appropriate placement of the burden of proof.

The "Precautionary Approach" will be applied by NASCO and its Contracting Parties to the entire range of a country's salmon conservation and management activities. The initial application will be to:

- management of North Atlantic salmon fisheries;
- formulation of management advice and associated scientific research; and
- introductions and transfers, including aquaculture impacts and possible use of transgenic salmon.

Management of North Atlantic Fisheries

Application of the Precautionary Approach to salmon fishery management is an integrated process, which requires at least the following:

- that stocks be maintained above the conservation limits by the use of management targets;
- that conservation limits and management targets be set for each river and combined as appropriate for the management of different stock groupings defined by managers;
- the prior identification of undesirable outcomes including the failure to achieve conservation limits (biological factors) and instability in the catches (socio-economic factors);
- that account be taken at each stage of the risks of not achieving the fisheries management objectives by considering uncertainty in the current state of the stocks, in biological reference points and fishery management capabilities;
- the formulation of pre-agreed management actions in the form of procedures to be applied over a range of stock conditions;
- assessment of the effectiveness of management actions in all salmon fisheries;
- that stock rebuilding programmes (including, as appropriate, habitat improvement, stock enhancement and fishery management actions) be developed for stocks that are below their conservation limits.

The management procedures for all salmon fisheries could include the following elements:

- definition of target spawning stock levels in the relevant rivers;
- definition of pre-fishery abundance of individual salmon stocks or groups of stocks occurring in the relevant fishery;
- utilisation only of the surplus according to a) and b) above;
- socio-economic factors.

The Formulation of Management Advice and Associated Research

ICES or other scientific advisors should be requested, inter alia, to:

- provide stock conservation limits and management targets for all river stocks;
- advise on the risks of not achieving the objectives of NASCO or its Contracting Parties by considering uncertainty in the current state of the stocks, in biological reference points related to specific management objectives and in fishery management capabilities;
- provide catch options or alternative management advice with associated risk assessments for the fisheries regulated by NASCO and homewater fisheries for all salmon stocks;
- advise, in the light of current conditions in the freshwater and marine environment, on stock rebuilding programmes including, where appropriate, habitat improvement, stock enhancement, disease prevention and fishery management actions;
- identify the monitoring and data collection required to better achieve the objectives of NASCO and its Contracting Parties;
- advise on the impacts on salmon stocks of existing and new fisheries for other species, and of salmon fisheries on non-target species.

NASCO is currently in the initial stage of an evolving process for implementation of the Precautionary Approach. A Standing Committee was formed to co-ordinate the implementation. The Committee will be meeting this winter and reporting back to NASCO in June 2000.

ANNEX VII

The Precautionary Approach: Incorporating Uncertainty in the Assessment of Marine Mammals

Garry Stenson

Although the Precautionary Approach has not been formally applied to marine mammals in Atlantic Canada many of the approaches taken are directed towards making precautionary decisions. The role of Science is to determine the status of stocks in various areas and determine the uncertainty associated with these assessments. Also, scientists are asked to carry out a risk assessment of various management options. With the exception of defining a suite of biological reference points such as B_{lim}, or F_{buff}, the National Marine Mammal Peer Review Committee is tasked with the same questions as any other stock.

The Precautionary Approach is also the basis of marine mammal assessments in a number of other areas. For example, the Revised Management Plan of the International Whaling Commission and the concept of 'Potential Biological Removals' as a critical limit under the US Marine Mammal Protection Act are designed to meet much of the same objectives as the precautionary approach.

Although over 30 species of marine mammals occur in Newfoundland, only two, harp and hooded seals, are assessed on a regular basis in this Region. Generally, less is known about hooded seals than harp seals and as a result, assessment methods are slightly different. However, assessments of both species are based upon population models that incorporate periodic (preferably 4-5 yr. intervals) independent estimates of pup production with annual data on reproductive rates and catches. In addition to estimating total abundance, the models are used to provide a Biological Reference Point for managers to consider when setting the total allowable catch (TAC). Both harp and hooded seals in this region are part of populations that inhabit the entire Northwest Atlantic. Each population has several whelping areas that must be assessed concurrently.

The current biological reference point is referred to as the "Replacement Yield" and has been calculated since the late 1970s/early 1980s. It is defined as the level of harvest that can be taken such that the total population next year equals this year's population. The level is dependent upon the age structure of the harvest and requires us to make assumptions about future reproductive rates (usually assumed to remain constant). A range of replacement yields is usually presented based upon different assumptions of the age of catch and mortality rates.

Other reference points have been used in the past including Maximum Sustainable Yield and a projection of long term sustainable yields at a given population level. However these require extensive assumptions about future reproductive rates and age structure of the catches. Given the significant changes in reproductive rates of many seals (including harps) observed over time and the volatile nature of the sealing industry (both in terms of total numbers and age classes preferred), long term projections are considered too uncertain to be of any value.

Hooded Seals

The NW Atlantic population of hooded seals whelp in 3 locations; a small group whelps in the southern Gulf of St. Lawrence, a slightly larger group in Davis Strait and the largest off southern Labrador/northeast Newfoundland (referred to as the Front). This population is hunted in Newfoundland and off Greenland.

There are limited data on reproductive rates and pup production of Northwest Atlantic hooded seals. Pup production in the Davis Strait and off Newfoundland was first estimated using aerial surveys in 1984. In 1990, pup production was estimated off Newfoundland and in the Gulf. The population was last assessed in 1995 (Anon. 1995), based on pup production estimates from the early 1990s. The relationship between the 3 whelping areas is unknown and given the possibility of transfer between them, the Joint ICES/NAFO Working Group on Harp and Hooded Seals concluded that total population in 1984 (Davis Strait and Front) and 1990 (Front and Gulf) was in the range of 84,000.

Due to the absence of a series of pup production estimates and the lack of independent estimates of age structure, there are no estimates of natural mortality (m) for hooded seals. However, based on catch models from the early 1970s and information on other seals with similar life histories, it was estimated that m was in the order of 0.10 (range 0.07 - 0.13; Myers and Stenson 1996). With limited information on the age of catches, reproductive rates and pup production, total population and replacement yields were estimated using a simple Leslie-matrix type model. A range of Replacement Yield values were provided assuming different levels of m and the age structure of the harvest. Estimates were also presented for two model formulations that assume different levels of pup mortality ($m_0=m_{1+}$ and $m_0=3m_{1+}$). These estimates provide the managers with a range of options that can be used to qualitatively indicate the uncertainty associated with a given level of harvest.

Harp Seals

Much of the effort to assess population size and uncertainty has been directed toward harp seals, as there are more data available. Also, they are the most abundant marine mammal in the Northwest Atlantic and the primary species taken in the seal hunt. There are two major whelping locations for harp seals in the Northwest Atlantic, the Gulf of St. Lawrence and off the coast of southern Labrador/northeast Newfoundland (Front). Whelping also occurs in the northern Gulf although the numbers that occur there vary significantly among years. Seals from the different areas appear to form a single population.

A number of pup production estimates are available for harp seals. In the late 1970s, early 1980s four estimates were obtained using mark/recapture methods. In 1990 and 1994, pup production was estimated using aerial surveys (Stenson et al. 1996). Another aerial survey was conducted this past March but the results will not be available until early next year. Age specific reproductive rates and catch data for both the Canadian and, to a lesser extent Greenland, hunts are available on an annual basis since the mid 1950s. The landed catches are corrected for animals that are killed but not landed (referred to as struck and lost). These data are incorporated into an age-specific population model that allows us to estimate trends in pup production, and total

population (Stenson et al. 1999). Natural mortality (m) is one of the parameters estimated by the model. The last formal assessment of this population was carried out in 1995 (Anon. 1995) but due to new information on the level of Greenland catches and questions about the level of animals struck but lost, the population trajectories were updated in February, 1999 (Stenson et al. 1999). We are currently re-examining the model and all of the inputs in order to reassess the population once the 1999 pup production estimate is available.

Three sources of data are incorporated into the population model; catches, reproductive rates and pup production. The most recent estimates of the harp seal population trajectories estimated the uncertainty associated with the population estimates by resampling the pup production estimates from within their variance. This provides a range of population estimates and associated replacement yields. However, the total catches, their age structure and the reproductive rates were assumed to be known without error and therefore, the total uncertainty is underestimated.

We are now in the process of incorporating the uncertainty associated with reproductive rates and the catch at age data into the model. We anticipate having this completed for use in the next assessment. Warren et al. (1997) completed a preliminary study of the impact of including the uncertainty associated with reproductive rates into the model. They found that the uncertainty associated with the reproductive estimates increased the variance in the estimates of total abundance only slightly when compared to that observed using uncertainty in the pup production estimates only.

Our future goal is to construct a risk assessment where uncertainty in the total removals, age structure of the catches and future reproductive rates are incorporated into the replacement yield estimates in order to provide a probability of a given catch level exceeding the biological reference point.

References

Anonymous. 1995. Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals. NAFO SCS Doc. 95/16. Serial No. N2569. 40p.

Myers, R. A. and G. B. Stenson. 1996. Replacement yield of hooded seals in the northwest Atlantic. NAFO Sci. Coun. Stud. 26:121-122 (NAFO SCR Doc. 95/40, Serial No. N2549)

Stenson, G. B., M. O. Hammill, M. C. S. Kingsley, B. Sjare, W. G. Warren and R. A. Myers. 1996. 1994 Pup production of northwest Atlantic harp seals, *Phoca groenlandica*. NAFO Sci. Coun. Stud. 26:47-62 (NAFO SCR Doc. 95/17, Serial No. N2524)

Stenson, G. B., B. Healey, P. A. Shelton and B. Sjare. 1999. Recent trends in the population of northwest Atlantic harp seals, *Phoca groenlandica*. NAFO SCR Doc 99/26. Serial No. N4082. 18p.

Warren, W.G., Shelton, P.A. and G. B. Stenson. 1995. Quantifying some of the major sources of uncertainty associated with estimates of harp seal prey consumption. Part I: Uncertainty in estimates of harp seal population size. NAFO SCR Doc. 95/94, Serial No. N2616. 11p.