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National Workshop on Reference Points for Gadoids

Ottawa, November 5-8, 2002

Denis Rivard and Jake Rice, Chairpersons

Fisheries and Oceans Canada
200 Kent Street
Ottawa, Ontario
K1A 0E6

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Cette publication est aussi disponible en français

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Abstract

This was a National workshop organised jointly by the Science and Fisheries Management sectors of the Department of Fisheries and Oceans. There were about 35 participants from across the country, including four from the Fisheries Resource Conservation Council (FRCC).

The group examined three aspects related to the Precautionary Approach (PA): 1) definition of limit reference points; 2) guidelines for consideration of uncertainties in a risk management context; and 3) harvest strategies that are consistent with a precautionary approach.

Deliberations gave most attention to three cod stocks, namely northern cod, as well as cod in the northern and southern Gulf of St. Lawrence. Serious harm was defined as impaired stock productivity as exemplified by recruitment overfishing. Five methods were used to estimate the spawning stock biomass (SSB) associated with decreased recruitment.

Limit reference points were developed for two Gulf stocks, and a benchmark for interim consideration was established for the third. Estimates from the methods converged around a spawning stock biomass of 80,000 t for Southern Gulf cod. Results of these methods were more dispersed for Northern Gulf cod. and a provisional limit was adopted at 200,000 t for the stock spawning biomass. It was recognized that Observations were limited in the 100,000-200,000t range and that we are unlikely to be able to refine that estimate until more observations are obtained well within this range. Current information indicates that the biomass conservation limit is certainly higher than 100,000 t but allow the possibility that it might be lower than 200,000 t. Once the SSB has rebuilt well into the range of 100,000-200,000 t, and productivity of the stock at those biomasses has been estimated, further analyses could shed light on whether the stock has moved out of the range of impaired productivity before SSB has reached 200,000 t. Northern cod estimates were variable and a benchmark of 150,000 t was established with the understanding that the conservation limit (which is definitely believed to be much higher) would be calculated when the SSB reaches 150,000 t. The current spawning biomass for Northern Gulf and Northern cod is well below the provisional limit reference, and Southern Gulf cod is in the immediate vicinity of the value.

Concerning uncertainties and risk, it was agreed that current stock status will be evaluated in relation to the limits in the context of risk. In particular, it was agreed that the above-mentioned limits should be avoided with a high probability (e.g. 95% or more). Wherever possible, Stock Status Reports will provide an evaluation of the probability of the spawning biomass having reached the limit, or being below it.

As with northern Gulf cod, though observations are limited for northern cod in a wide range of biomasses (in this case between 150,000 t and 800,000 t), periodic re-analyses of stock-recruit data will be increasingly informative of how much larger than 150,000 the appropriate conservation limit really is for this stock. It was also agreed that the SSB would have to be distributed among the traditional spawning banks of the northeast Newfoundland Shelf and that failure of spawning to occur in the historic main spawning areas would also be considered evidence of impaired productivity.

As the conservation limit is approached, arresting the decline and rebuilding the spawning biomass will increasingly become a key consideration for management. Similarly, if a stock is below the limit, rebuilding the spawning biomass will be the primary consideration for management. Harvesting of the stock under such circumstances would be considered harm to the resource.

Regarding the establishment of harvesting strategies that take into consideration the precautionary approach, it was agreed that such strategies will involve a progressive stepping

down of the fisheries if the stock moves into less productive territory. Management benchmarks for this purpose should be established based on stock productivity characteristics.

It was recognized that, for a stock in decline, management action should start when the probability of reaching the limit reference point is still quite low, and that the fishing mortality should already be low as the biomass approaches the limit.

As more data are accumulated on the stocks, the limits will be reviewed periodically. It is suggested that limits should be evaluated at five-year intervals.

Introduction

A national workshop was held in Ottawa, on November 5-8 2002, to set reference points for cod and cod-like species. It was a joint workshop with Fisheries Management and Science, involving about 35 participants from across the country as well as four invited members of the Fisheries Resource Conservation Council.

The agenda focussed on three tasks: 1) defining and establishing limit reference points; 2) proposing guidelines for consideration of uncertainties in a risk management context; 3) discussing harvest strategies that are consistent with a precautionary approach. To focus preparatory work and discussion, and to make progress in a concrete manner, five stocks were put on the agenda: 1) northern cod, 2) cod in the northern Gulf of St. Lawrence, 3) cod in the southern Gulf of St Lawrence, 4) Pacific cod and 5) Pacific hake.

After examining the data sets, the Atlantic cod stocks were selected for limit point development. The assessments of Pacific cod were complicated by the use of a stock-recruit relationship for population reconstructions, and the recruitment dynamics of Pacific Hake are highly uncertain being characterized by a few pulses of occasional very strong year-classes surrounded by periods of low recruitment. Hence it was agreed to develop and test a template using the first three stocks, which were considered better cases from which to develop general approaches to setting reference points.

The Federal Framework for the Precautionary Approach (PA) was developed by the Privy Council Office (PCO) to ensure that precaution would be applied consistently across disciplines (e.g. Health, Natural Resources) in the government. The Precautionary Approach is a special case of risk management to be invoked in cases where three preconditions apply:

1) A decision or action is required
2) There is a risk of serious or irreversible harm
3) There is high scientific uncertainty

In a fisheries context, precaution is usually invoked because of threat of serious harm rather than demonstrated risk of irreversibility, and risk of harm is usually measured in terms of overfishing, i.e. high fishing mortality, and its effects on the spawning biomass of the target species. However, harm can also be to other properties of target species, e.g. localized depletion of components, as well as to ecosystem components, although the Workshop only had time to address biomass and exploitation rate of the target species.

Impaired productivity has been proposed as a sufficient definition of serious harm. This allows conservation limits to be chosen directly in relation to the risk of impaired productivity. In fish populations, impaired productivity is linked to the ability of a stock to reproduce itself. Impaired productivity may be due to reduced body growth, altered maturity schedule, increased natural mortality or low recruitment. With respect to conservation limits, first attention has been given to the recruitment process. In this case, impaired productivity results from depletion of the spawning biomass to a level so low that the probability that the stock will produce good recruitment is diminished, or the probability of poor recruitment is increased. Either of those situations can be considered compelling evidence of serious harm. Decision rules should incorporate limit reference points and they should identify the associated actions when these are approached or passed. Society chooses the level of risk that is tolerable and risk should be quantified using 'best practices' of science. The burden of proof may be assigned and will be evaluated on a case specific basis. In the Fisheries and Oceans context, the burden of proof of harm may be assigned to Science due to DFO having the knowledge base to assess harm. The conservation limits also are to be chosen by technical experts based on the best science available. In both cases the initiatives are led by technical experts in science and management of DFO, but should be inclusive of knowledge complementary to that provided by DFO experts.

Limit reference points are often set in terms of fishing mortality (F) and stock spawning biomass (SSB), and the workshop focused on methods using these metrics. The limit reference points define zones in relation to F and SSB. Decision rules specify the nature of the management action that is appropriate in each zone. Limit reference points for F used in the decision rules tend to be defined on the basis of not exceeding exploitation rates associated with maximum sustainable yield. Accordingly, the workshop focused on conservation limit reference points for SSB.

Reference points are specific to the particular productivity regime. While it is especially important to evaluate the limit reference point for F with respect to the prevailing productivity regime to ensure that the exploitation rate is commensurate with production, consideration of regime implications for SSB reference points takes a different tack. The SSB conservation limit for a low productivity regime is likely to be lower than that for a high productivity regime. If the SSB reference point is adjusted downward and the biomass is allowed to decline to these lower levels, it may result in an inability for the stock to subsequently rebuild even if productivity improves. Even if the relationship were the opposite, i.e the proper biomass limit for a low productivity regime was higher than in a high productivity regime, rebuilding from the lower reference point, once reached, would still be difficult and leave the stock in a state of impaired productivity for a number of years. In any case, developing regime-specific reference points would require reliable information on both what regimes prevailed both over the full historic time series and what regimes will be occurring in each year that advice is to be provided in future, using the regime-specific reference points. Such information is not available at present, nor is it expected in the medium term. Therefore we simply used all the stock and recruit data available when estimating the reference points, with the results being a robust estimator of overall biomass below which productivity is impaired, irrespective of environmental regime.

SSB Limit reference points

The basic ingredients for developing conservation limits include a biological statement of what characterizes the boundary, and a computational method for making the statement operational. A diversity of techniques has been employed to identify possible limit reference points. Each of these techniques may have some utility and each can be criticized in at least some types of applications. Due to the nature of the data and different assumptions made by various analytical approaches, there can be substantial differences in results between different techniques. In each application, experience, judgement and knowledge of stock specific circumstances are important considerations in setting the technical basis for the determination of reference points.

The working group considered three biological statements that characterize the boundary, one associated with historical biomass from which recovery was observed and two associated with identifying a biomass below which recruitment is likely to be poor:

1. The $B_{recover}$ limit is the point below which either SSB is not expected to commence recovery quickly when fishing mortality is removed, or stock dynamics are unknown. At $B_{recover}$, SSB will produce a recovery if conditions are average or favorable. However, there is no guarantee that, if SSB is around $B_{recover}$, stock rebuilding will occur during an unfavorable productivity regime.

2. The $Sb_{50/90}$ limit is the point below which the population is unlikely to produce average recruitment under good early life-history stage survival conditions.

3. The SR_{50} limit is the SSB where the population fails, on average, to produce half of the maximum possible.

For the gadoid stocks under review, five computational methods were retained for defining limit reference points in terms of spawning stock biomass, one for each of statements 1) and 2) above and three for statement 3) corresponding to three approaches for determining the stock-recruitment relationship:

1) $B_{recover}$: the lowest historical biomass level from which the stock has recovered readily.
2) $Sb_{50/90}$: the SSB corresponding to the intersection of the 50th percentile of the recruitment observations and the replacement line for which 10% of the S-R points are above the line.
3) BH_{50}: the SSB at which expected average recruitment is one half of the maximum recruitment predicted by assuming an underlying Beverton-Holt stock-recruit relationship (i.e, the recruitment that is 50% of the value at the asymptote).
4) RK_{50}: the lower SSB at which expected average recruitment is one half of the maximum recruitment predicted by assuming an underlying Ricker-type stock-recruit relationship. (i.e, the recruitment that is 50% of the value at the peak of the dome)
5) NP_{50}: estimate of the lowest SSB where the expected median recruitment is one half of the maximum recruitment calculated by a non-parametric analysis. (i.e, the recruitment that is 50% of the largest median recruitment achievable at any SSB within the range of historic observations)

Once the individual B_{lim} candidates have been checked, a comparison among those which were retained could provide insights into the certainty of advice. If they cluster into one region, some feeling of confidence would result. If they clustered into two groups, secondary arguments would have to be invoked for picking the preferred cluster. If the values for B_{lim} were scattered over a wide range (relative to the individual uncertainties), the data seem uninformative about the degree of dependency of recruitment on SSB. More analyses or simulations might shed some light on the relationships, but it is likely that more data are needed on the productivity of the stock over a wide range of spawning biomasses and environmental conditions. Under such cases, risk management practices would argue for keeping the SSB above all the plausible candidate B_{lim}, until such time as better estimates of B_{lim} are possible.

When these methods were applied to the three stocks the values obtained for the limit-SSB were relatively consistent for cod in the southern Gulf (Figure 1) but a wide range was observed for cod in the northern Gulf (Figure 2) and northern cod (Figure 3). For northern Gulf cod and northern cod, the SR_{50} reference point was very sensitive to the computational method used for the stock-recruitment relation, making these results suspect. Further, for northern cod, the results seem to be very influenced by the exceptionally high recruitment in the earliest years.

We have goodness of fit criteria and residual analysis for the stock-recruit functions and smoothers. In the cases reviewed, the limits based on BH_{50} and RK_{50} were not always robust to data uncertainty. A cursory inspection of the fits suggest that some fits of the underlying s-r functions to the stock and recruit observations were not statistically significant. It was suggested that re-sampling either the stock-recruit data or the residuals from the fit to the data could get probability distributions for the parameters of the s-r curves. The non-parametric index, NP_{50}, could be treated in a similar manner. The Serebreyakov's method is robust to model uncertainty (because it does not require a model to be fitted) and it scaled well across the three stocks considered, in the sense that it gave reasonable estimates relative to historical SSB and productivity levels. Non-stationarity in the S-R data due to environmental regimes would present problems for all methods, for example if all the points above the recovery 90% line were from a previous regime.

The best estimate of the limit reference point for cod in the southern Gulf was a stock spawning biomass of 80,000 t. For cod in the northern Gulf, the conservation limit was estimated at 200,000 t. However it was recognized that there were few data on the recruitments expected in the 100,000-200,000 t range of SSB, because the stock passed very quickly through this range. Therefore the 200,000 t is not a definitive estimate, and may require a downward revision when more data are available. However, until the stock is well within the range of 100,000 to 200,000 t, it is unlikely to be possible to define the value more precisely. For northern cod, it has not been possible to identify precisely a limit for the stock spawning biomass, in part because the BH_{50} and the RK_{50} have their peaks poorly defined by the historic stock-recruit data. However, it was agreed that the conservation limit must be a value greater than 300,000 t. When the stock spawning biomass approaches 150,000 t, we can then review the data and attempt to see if they have become more informative about the appropriate conservation limit (using all knowledge accumulated to date).

Recovery time

"Recovery time" was not retained as a primary measure of serious harm because it is strongly affected by variation in overall productivity and the definition of the recovered state. Nonetheless, evaluation of recovery time was considered as a way to cross-validate the results obtained from the five other methods identified. In that context, an interval of two generations was identified as a reasonable time frame for recovery, with a positive population response following closely in time after implementation of remedial actions (TAC reductions, spatial management, etc.). The recovery rates were determined using stock projections which, given the context of conservation limits, logically had to incorporate a stock recruit relationship.

Three estimates of recovery time were presented using different models, all using non-parametric stock-recruit relationships. These can tend to be compensatory at low biomass, as the fall to the origin is not included in such models. In one simulation of northern Gulf cod, the recovery was trapped in a low-productivity (recruitment) regime.

Uncertainty and risk evaluation

"Risk evaluations" and "buffers" are ways to take into account the uncertainties inherent in stock assessments and management systems, an essential element of good risk management and a key aspect of the Precautionary Approach. Buffers serve the function of ensuring that conservation measures begin to be implemented before the limit is breached. The performance of alternative management actions is evaluated by comparing the resulting state of the resource against the reference point. Therefore uncertainty in both the estimate of the resource state and the estimate of the reference point are pertinent.

As evidenced by the approach used here to estimate B_{lim}, the determination of reference points typically involves comparison of results from competing models, knowledge of stock specific circumstances, and judgment. Further, the models describing productivity dynamics often do not convincingly explain the variation in the observations, hence the requirement to consider several competing models. In such a situation, the prevailing uncertainty is that associated with judgment of the model inadequacies and the estimation of uncertainty from any specific model is not particularly useful. Instead, the estimation uncertainty is fully expressed in the risk management uses of the reference points, once they have been selected. Accordingly, the reference points are taken as prescribed constants based on consideration and judgment of a range of competing techniques.

Periodic assessments will typically serve to identify the current state of a stock in relation to the reference points, and can do so in a probabilistic or risk-based manner. Usually the uncertainties captured in such assessments are estimation uncertainties and random data errors, but not uncertainty due to model mis-specification or due to systematic data inaccuracies. Depending on the time frame in which risk is estimated, it may or may not include uncertainties in future states of nature, e.g. recruitment, body growth. Experience and simulation studies have shown that the uncertainty for longer term projections has generally been underestimated.

Explicit risk evaluations are already provided for many stocks. Often, risks can be expressed in terms of probability of the spawning biomass falling below a prescribed value or declining further, for various assumed catches. When risk evaluations are available, the "buffer" effect can be achieved directly by risk averse management relative to the conservation limit rather than actually constructing explicit buffers. There is currently no policy on the degree of risk aversion to be exercised in DFO, but practice elsewhere uses 5% or 10% tolerances.

Although statistical estimation of uncertainty is an important tool, all of the sources of uncertainty cannot be quantified. This caveat should be kept in mind when considering results, and it implies that real-world risks associated with management choices can only be larger than the risks produced by quantitative analyses. To the extent possible, the method used to calculate the estimation uncertainty should make few assumptions about specific error distributions or be robust to such specification.

Harvest strategies

Harvest strategies must be designed to ensure that the risk of a stock reaching a conservation limit is managed, and kept very low. In other words, SSB conservation limits must be avoided with high probability. Harvest strategies also aim to conserve resource productivity by keeping F at moderate levels. As limited amounts of fish are available to be harvested, it is imperative that clearly defined harvest levels and the control rules which guide decisions be established. If this is achieved, and the rules are implemented effectively, then there is correspondingly a high probability that the stock will increase away from the conservation limit.

In arriving at decision rules, social and economic aspects may have to be considered in addition to the conservation concerns. The significant factors that impact on management actions and/or harvest control are:

- the state and productivity of the stock
- the relative capacity of the fleet
- the economic structure of the fleet (e.g. debt load, structural incentives such as E.I. eligibility, cost/earnings analysis)
- the relationship between numbers of boats/fishermen/landing sites and the amount of verification (e.g. fishery officers and equipment, DMP, observers)
- the costs of fisheries management and verification relative to the landed value
- the management conduct of the fishery (e.g. ITQ vs IQ vs competitive)
- the conservation ethic of the fleet
- the amounts of fish needed to satisfy by-catch requirements in other fisheries
- the amounts of fish needed to satisfy aboriginal rights and/or requirements (food fisheries, commercial access)
- the amounts of fish needed to meet scientific monitoring needs.

A conceptual approach, emerging from Fisheries Management, is that the characteristics of the fleets lend themselves better to a stepped reduction of fishery quotas as the conservation limit is approached, than to a constant or linear reduction.

Fisheries Management Benchmarks

From an access perspective, it is useful to define fisheries management benchmark zones for specific fisheries which would allow clear rules to be developed to guide decision-making. These rules would then describe how the available fish can be utilized to meet various needs. For example, the following key progresses from no fishing through a full commercial fishery:

Monitoring Zone – well below the conservation limit

- Fishing mortality severely limited to approved scientific monitoring activities. Fishing mortality will be relatively constant at an extremely low level. There will be no significant by-catches allowed in other fisheries.

Incidental By-catch Zone – below the conservation limit

- Additional fishing mortality limited to incidental catch to permit other directed fisheries to occur where the catch of the by-caught species is not significant and all reasonable measures have been implemented to minimize by-catch.
- Fishing mortality will vary, to a cap at a very low level.

By-catch Zone

- Additional fishing mortality limited to by-catch normally caught in other directed fisheries without a specific cap.
- Fishing mortality at a low level, catch varies relative to biomass of stock as well as biomass of stock of directed species.

Normal Fishing Zone

- Additional fishing mortality subject to commercial/recreational fisheries occurring, limited by a TAC and defined by the above characteristics.
- Above this point, fishing mortality would be held at a moderate level, and a stepped approach to changing TACs could be used.

Benchmark Decision Rules – Applying the Precautionary Approach

Moving between each of the above benchmark zones implies a significant set of fisheries management actions aimed at changing the fishing mortality of the stock, creating a significant inflection point in the Catch/Biomass relationship. Movement between zones, must be guided by a pre-determined set of decisions, which can be formulated on a stock-specific basis. It is proposed that these zones and the inflection points be set based on the stock status and the productivity regime, the above harvest control factors, and the targets of the fishery.

Some characteristics of the stock status are:

- Abundance
- SSB
- Mortality rates

Some characteristics of the productivity regime are:

- Recruitment
- Growth rate
- Condition index
- Age at maturity
- Geographic distribution

Some characteristics of decision rules could include:

- Catch levels must increase more slowly than they decrease
- Both the status of the stock and the productivity regime must be demonstrably positive for a increase in catch across an inflection point to occur.
- Decision rules must be based on achieving pre-determined objectives
- Keep fishing mortality moderate and promote rebuilding when the spawning biomass is low.

This framework was discussed in a subgroup during the workshop but specific levels for action (management benchmarks) in the three cod stocks discussed were not defined. The conceptual framework was discussed and directions were identified for further consideration. In general, it is not possible to develop firm and final harvest control rules in isolation from stakeholders.

Considerations with respect to re-opening a closed fishery.

It was agreed that the same criteria should be used for re-opening as for closure. An explicit hysteresis (i.e. an opening reference point higher than the one for closure) was not advocated. However, it was observed that changes in the factors affecting production, especially recruitment, could introduce a hysteresis.

Most of the discussion had been around a limit based on SSB, but if a more informative metric were available, it should be used. Such metrics, for example spawning potential, might well exhibit hysteresis in terms of biomass. That is, more biomass might be required to produce the same spawning potential if a regime had changed during or after a closure was invoked. Other metrics such as size, age structure of the stock or maturation rates are probable candidates for regime dependent factors. Furthermore, if growth rates or natural mortality rates were changed, the time to recovery could also be affected. The change in recovery rate could affect fishing mortality rates under risk management.

As the duration of a current regime is difficult to predict, the definition of the recovered state might also be poorly determined. It was suggested that the direction of the stock trajectory alone could be useful. However, studies in other stocks (ICES) suggest that management uncertainties or implementation “error” could be key factors in preventing recovery. These risks should be quantified for any stock under consideration for re-opening.

Finally, it was observed that the fishing strategy should be designed so that the fishing practices do not prolong or exacerbate a non-productive regime. Furthermore, because of changes in stock structure or stock dynamics at low abundance, recovery time could be much longer than the time taken to reduce productivity.

Discussion

Although poor recruitment can occur over a range of SSBs, the probability of poor recruitment increases substantially with decreasing spawning stock biomass for all stocks considered except Pacific Hake, where no pattern was present. For the three stocks considered in detail, it would be necessary to maintain the SSB at levels that are much higher than the present SSB in order to keep the probability of poor recruitment low.

Ideally, the limit reference points should be compared across stocks for consistency with stock dynamics. The limits should “scale” appropriately (make sense across stocks given their productivity) and be robust (insensitive to small changes in input data). At present, however, we have little experience in making such comparisons (meta-analyses). Nevertheless, for the three stocks reviewed, the $Sb_{50/90}$ limit tended to scale reasonably well across stocks. $B_{recover}$ does not scale as well across stocks, perhaps because limits based on that method were affected by the degree to which past recoveries were the result of particular circumstances. The same holds for RK50, BH50 and NP50, for which across-stock comparisons were made difficult because of widely different goodness-of-fit (see above).

In summary, five methods were retained for defining limit reference points on these stocks. One of the five is based on the lowest historical biomass level from which a recovery was observed in the past. The other four seek to identify the level of stock spawning biomass below which recruitment is likely to be poor. Another approach, based on time to recover, was suggested as a way to validate the results. Due to the nature of the data and assumptions of the methods, these methods can give widely different values for a particular stock. The best estimates of the spawning biomass limit for the three stocks reviewed here were as follows:

- Although values were relatively similar for cod in the southern Gulf, a wider range was observed for northern cod and cod in the northern Gulf. The best estimate of the limit reference point for cod in the southern Gulf was a stock spawning biomass of 80,000 t. For cod in the northern Gulf, it was estimated at 200,000t with the recognition that there were few data in the 100,000-200,000 t range. However, until the stock has been well within this range for at least a few years, it will not be possible to evaluate what SSB would be sufficient to keep the risk of poor recruitment low. Once the SSB has rebuilt well into the range of 100,000-200,000 t, and productivity of the stock at those biomasses has been estimated, further analyses could shed light on whether the stock has moved out of the range of impaired productivity before SSB has reached 200,000 t.

- For northern cod, it was not possible to identify a limit for the stock spawning biomass. However it was clear that the limit associated with impaired recruitment would have to be higher than 300,000 t. Furthermore, spawning aggregations would have to be widespread in the offshore before it would be likely that recruitment would cease to be impaired. There was agreement that, as the stock spawning biomass approaches 150,000 t, we can then review the data and re-evaluate the estimation if they are sufficiently informative to support estimating a conservation limit. If not, there would at least be enough information to set a new benchmark SSB to reach, while gathering further information about the stock productivity dynamics.

- These methods were considered generally appropriate for all stocks for which time series of stock and recruit data are available. Although some stocks may present the types of difficulties encountered with northern Gulf cod (large range of SSB over which there is little information on potential productivity) and Pacific Hake (time series dominated by few years of very large recruitments), the methods are appropriate to at least explore SSB limits for many more stocks.

- As more data are acquired, these limits will be reviewed periodically. It is suggested that limits should be re-evaluated at five year intervals.

Limit reference points in terms of biomass and fishing mortality may not be sufficient to adequately implement a precautionary framework. When considering serious harm, other and even non-quantitative issues should be considered. These include loss of spawning components, age structure, production and genetic diversity. It is recommended to evaluate these on a case-by-case basis until they can be evaluated systematically.

Figure 4 illustrates the relationship between limit reference points for fisheries management and reference points associated with species-at-risk action. This figure is from a FAO report on CITES that J. Pope and J. Rice were involved in, placing limit reference points in a wider context of risk management (FAO Fisheries Circular 954, 2000). It should be noted that fisheries limit reference points are many orders of magnitude above the biomass associated with threatened or endangered species.

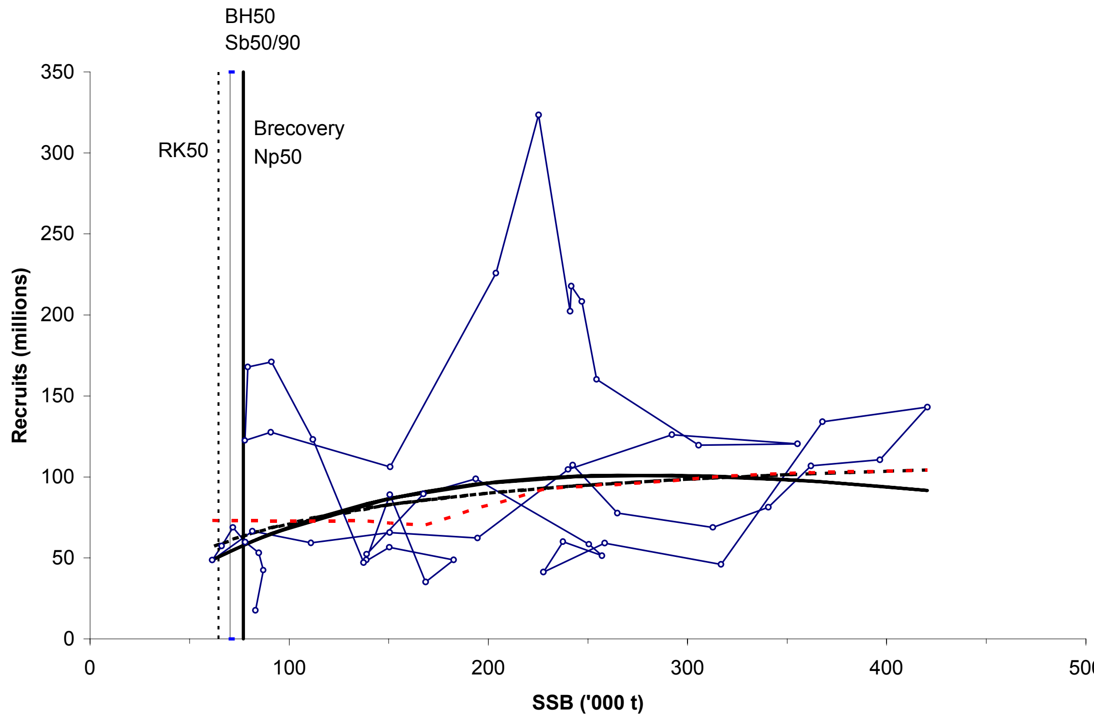

Figure 1: Limit Reference Points for Southern Gulf Cod (4TVn)

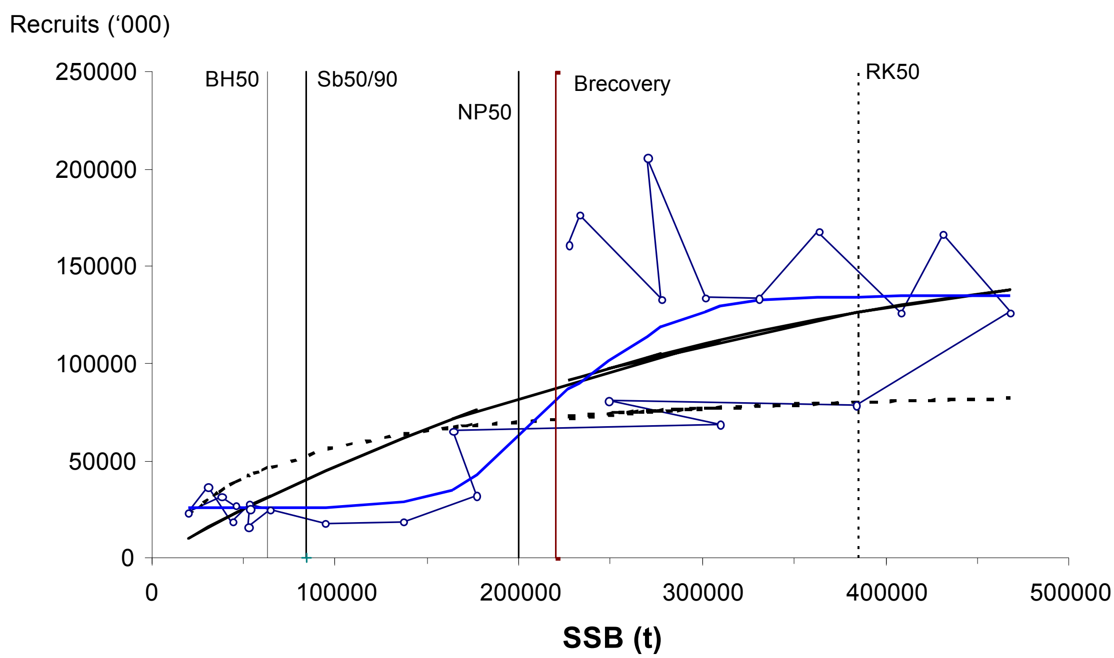

Figure 2: Limit Reference Points for Northern Gulf cod (3Pn4RS)

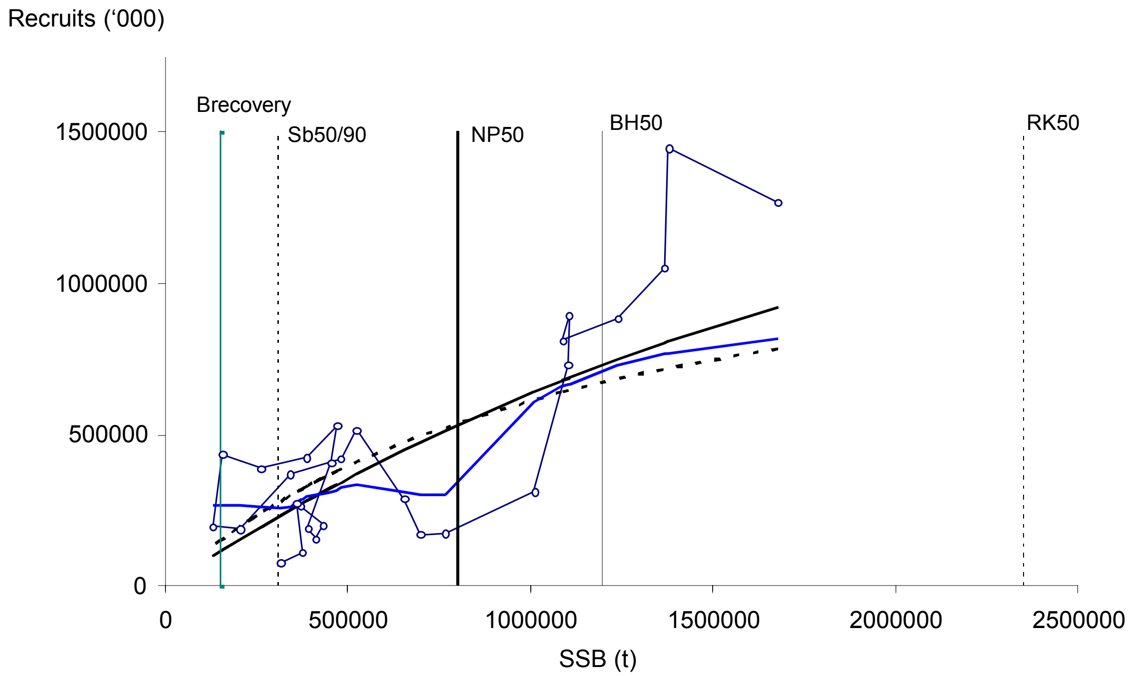

Figure 3: Limit Reference Points for Northern cod (2J3KL)

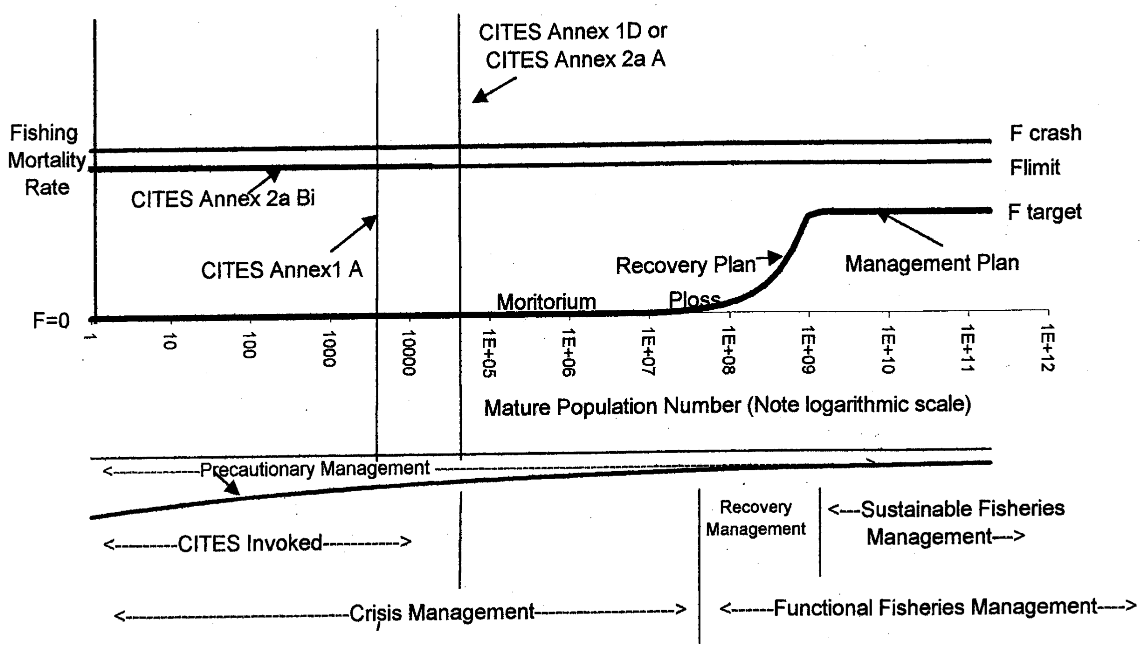

Figure 4: Reference points in context of Precautionary Management and CITES. SSB limit reference points are at the cusp between functional and crisis fisheries management. Read COSEWIC for CITES for Canadian context. *[Figure from FAO Fisheries Circular 954, 2000]*.

Annex I: List of participants

National Workshop on reference points for Gadoids

Participants:

1. Annand, Chris – DFO Maritimes
2. Bevan, David – DFO NCR *
3. Cadigan, Noel – DFO Newfoundland - Science
4. Castonguay, Martin – DFO Quebec – Science
5. Chapman, Bruce – FRCC
6. Chouinard, Ghislain – DFO Gulf – Science
7. de March, Larry – DFO C&A - FM
8. Duplisea, Daniel – DFO Quebec – Science
9. Fréchet, Alain – DFO Quebec – Science
10. Fu, Caihong – DFO Pacific – Science
11. Gavaris, Stratis – DFO Maritimes – Science
12. Gillis, Dave – DFO NCR – Science
13. Hébert, Réjean – DFO Gulf – FM
14. Kristmanson, James – DFO NCR – Science
15. Labonté, Serge – DFO NCR – Science *
16. Lane, Dan – FRCC - University of Ottawa
17. Lilly, George – DFO Newfoundland – Science
18. MacDonald, Al – DFO Pacific - FM
19. Maguire, Jean-Jacques – FRCC
20. Mashal, O'Bai – DFO NCR – Science *
21. McQuinn, Ian – DFO Quebec – Science
22. Mohn, Bob – DFO Maritimes – Science
23. O'Boyle, Bob – DFO Maritimes – Science
24. Perry, Jaqueline – DFO Newfoundland – FM
25. Pope, John – FRCC
26. Rice, Jake – DFO NCR - Science
27. Rivard, Denis – DFO NCR – Science
28. Russell, Roy – DFO Newfoundland – FM
29. Shelton, Peter – DFO Newfoundland – Science
30. Sinclair, Alan – DFO Pacific – Science
31. Vermette, Michel – DFO FM
32. Vienneau, Rhéal – DFO Gulf – FM
33. Watson-Wright, Wendy, DFO NCR - ADM Science *

* Partial attendance

Annex II: Terms of Reference

National Workshop on reference points for Gadoids
Ottawa, November 5 to 8 (until noon), 2002

Steering Committee:
G. Chouinard, S. Gosselin, J. Kristmanson, B. O'Boyle, J. Rice, D. Rivard, P. Shelton, A. Sinclair, M. Vermette

Venue: Lord Elgin Hotel, Ottawa

Format:
Two workshops to be held in parallel:
- one by FM on management reference points and decision rules;
- one by Science on conservation reference points and how to handle uncertainties and risk.

Opening joint sessions: on framework(s) and data.
Separate sessions: working style, analytical methods, estimation of candidate values for reference points.

Midpoint joint session on progress and problems.
Closing joint session on results.

Focus:

<u>On Gadoids</u>:
- Key stocks will include: northern cod, northern and southern Gulf cod, Pacific Hake, Pacific cod:
- Other gadoid stocks depending on attendance (*need to set up list)*

<u>On methodological approaches:</u>
- Must have systematic analytical basis for setting conservation reference points and quantification of uncertainty
- Must have biological & statistical rationales for the analytical approach(es)
- Must have clear guidance on linkage between analytical treatments of uncertainty and decision rules, to ensure risk averse decision-making, whether through use of "buffer/precautionary" reference points or other tools.
- Should have clear statement of limitations (if any) on generality of analytical basis, and guidance for practice when cases fall outside general limitations.

<u>On reference points:</u>
- Must come out with candidate reference points for conservation for all key stocks, and as many others as possible in time available.
- Desirable to come out with candidate reference points and decision rules for management.

Annex III: Agenda

Day 1:

Review of core concepts on limit reference points:
(*Shelton, Rice, Cadigan, Gavaris, Mohn*)

Conservation limit reference point (point of serious harm)
Avoidance with "high probability"
"Currencies" of reference points (SSB, F, possibility of others, acknowledging need for consistency).

Review of core concepts of uncertainty

What sources of uncertainty need to be considered? (Take uncertainty from assessment results, or construct uncertainty from its components)
Role of uncertainty and risk management (approaches to trigger action before conservation limit is reached)

Experience so far:

4X cod and haddock (*O'Boyle and Lane*)

Science Framework - For each key stock:
(*Chouinard, Fréchet, Fu, Shelton, Sinclair*)

Key data (recruitment, SSB, catch trends, R-SSB plots)
Assessor's view of conservation limits, sources and magnitudes of key uncertainties, what constitutes "impaired" productivity.

Management framework - For each key stock, manager's view of:
(*Vermette et al.*)

Target reference points for management
Decision (or Harvest Control) rules
Management benchmarks [e.g. in the context of the "staircase approach"]
Risk tolerances

Day 2: Science and FM break in separate working sessions

Day 3: Morning: Joint session - progress report

Afternoon: Working session followed by Plenary on:

PA and management framework for key stocks
(*Chouinard, Fréchet, Shelton, Sinclair*)
PA and management framework for other stocks
(*selected participants*)

Day 4: Morning (only): Wrap-up Session

Principles and methods for:

Establishing conservation limits
Quantifying uncertainty and risk
Managing risk - explicit vs buffers or precautionary points
Setting management targets
Applying formal decision rules