Report on the Marine Fish Workshop and Recommendations for COSEWIC

Halifax, Nova Scotia, 2-4 March 2005

Executive Summary

The purpose: The mandate of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is to assess the status of species that are considered to be at risk of extinction in Canada. This workshop addressed concerns about how COSEWIC assesses the probability of extinction in marine fishes. The workshop participants provided their expert observations and recommendations for consideration by COSEWIC.

The theory:
The COSEWIC definition for extinction seems appropriate. Some participants, however, questioned whether "extinction" should be used to refer to the disappearance of the last individual of a species, or the point at which numbers are so low that the species no longer plays an ecological role in its environment.

There are many examples of local extinctions of marine fish, although there are few examples of species-level extinctions. Marine fish are as vulnerable to extinction as other taxa at similar population levels and with similar life-history traits. Loss of populations is the first step towards global extinction. Even if there are millions of individuals left after a significant decline, they may still be at risk. The number of individuals remaining after significant population decline may not be as important as other life-history factors that affect the viability of the remaining population.

There was consensus that major ecosystem shifts have occurred following severe stock depletion. Examples were provided.

The data:
It is important to include all available information in status reports and in assessments, recognizing the strengths and weaknesses of each type of information. For marine fish, data such as catch per unit effort for trends in abundance, age structure, age at maturity, sex ratios, and reconstructed biomass estimates from these metrics are useful. Other examples were provided. Special consideration should be given to species with particular habitat requirements.

There needs to be a cooperative approach during the preparation and review of species status reports; both COSEWIC and the jurisdictions involved can improve in key areas.

- Continue to ensure that jurisdictional data (inventories and analysis) are obtained and incorporated into status reports before COSEWIC assessment and SARA listing.
- There was consensus that jurisdictions need to pay earlier attention to the candidate lists so that key information can be collected to support assessments and reduce uncertainty.

The scientific community should be consulted as widely as possible (e.g., including fisheries assessment scientists outside of the Department of Fisheries and Oceans).

Community knowledge is a potentially important source of information. COSEWIC should investigate ways to access reliable community knowledge throughout its process.

The assessment process:
COSEWIC's process of assessing a species against quantitative criteria (including a decline criterion), and then considering other available information (such as age and size at maturity, vulnerability to fishing and Allee effect/inverse density dependence) is appropriate. Specific suggestions for enhancement of the existing life-history guidelines were provided.

COSEWIC should consider the work done by FAO, CITES, and NMFS on assessment criteria as part of its ongoing work to improve its assessment process. In particular, COSEWIC could consider the 'modifying factors' proposed by these groups, such as the role of extent of decline vs. rate of decline and the role of absolute population size relative to population decline. There was a difference of opinion regarding whether extent of decline (decline from a normal historic baseline) should be a modifying factor for the existing decline criterion (criterion A), a replacement for it, or an additional criterion.

Better communication by COSEWIC:
The meaning of the term "risk of extinction" must be clarified. Risk refers to the probability of extinction. COSEWIC needs to better communicate what it means by "imminent" and "extinction" to ensure that all members of COSEWIC and the public understand what each assessment means.

It is important to provide better information on how COSEWIC operates, how it does its assessments and on the outcome of deliberations.

All sources of information considered and all sources of uncertainty in the assessment should be clearly presented in the status report. It would be very helpful if COSEWIC explained why certain criticisms and/or information obtained during the review process were not accepted as central to the status report and/or assessment.

Fisheries management vs. conservation:
There is a need to clarify the relationships between reference points used in fisheries management and criteria used by COSEWIC.

1. Introduction

1.1. About COSEWIC

The mandate of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is to assess the status of species that are considered to be at risk of extinction in Canada. The COSEWIC assessment process begins with the selection and prioritization of species requiring assessment, leading to the Prioritized Candidate list; continues with the compilation of available knowledge into the COSEWIC status report; and ends with the assessment of a species' chance of extinction or extirpation and the COSEWIC status designation.

COSEWIC categorizes each species into one of six status categories: extinct, extirpated, endangered, threatened, special concern, or not at risk. COSEWIC uses quantitative criteria as a tool for assessing the probability that a species may become extinct. After application of the criteria, COSEWIC also considers rescue effect (immigration of individuals from other populations), significant life-history characteristics not addressed by the criteria (such as age at maturity, dispersal characteristics, longevity), threats, and consistency with its definitions of the status categories. The assessment process used at the time of the workshop is available at: http://www.cosewic.gc.ca/pdf/assess_proc_e.pdf

COSEWIC was designated as an advisory body under the Species at Risk Act (SARA). In this role, COSEWIC provides the results of its assessments to government to consider for legal listing. Legal listing of a species as extirpated, endangered or threatened leads to automatic prohibitions on killing or harming of a species, and to the preparation of recovery plans and action plans, or management plans. Although the government's decision of whether to legally list a species also takes into account potential economic and social implications of legal listing, COSEWIC's assessments, based solely on available knowledge, carry substantial weight.

1.2. The purpose and format of the workshop

There has been concern that the methods that COSEWIC uses to classify species according to probability of extinction do not work well for marine species. In particular, there appears to be disagreement over the suitability of the quantitative criteria for evaluating the probability of extinction in marine fishes (or other species with similar life-history traits).

Canada's Minister of the Environment asked COSEWIC to hold a workshop to address concerns about the process that COSEWIC uses for assessing probability of extinction in marine species. That workshop was held in Halifax, Nova Scotia, Canada on 2-4 March 2005. It involved a variety of international experts on marine species and the use of quantitative criteria, including representation from COSEWIC, the Department of Fisheries and Oceans (DFO), the Government of Newfoundland and Labrador, industry representatives, non-government organizations, IUCN and other international experts (see Appendix 1).

The workshop began with a set of presentations on various topics of particular relevance to those assessing probability of extinction in marine species. The participants then formed four breakout groups, each tasked with a set of questions. Discussions within the breakout groups, and during plenary sessions, allowed the groups to refine their recommendations and comments for COSEWIC.

This report details the discussion topics and results of the workshop, with specific recommendations from the participants: a) to assist COSEWIC in its assessment process and to improve upon the data used to assess marine fish species; b) to improve the means by which COSEWIC communicates its objectives and results; and c) to identify topics for further consideration by COSEWIC.

2. Presentations

Eleven presentations on the first day of the workshop informed the participants of various perspectives regarding the assessment of marine species, provided history and context for using quantitative criteria in assessing species (by COSEWIC and other organizations such as IUCN and CITES) and investigated some of the diversity within marine species with respect to probability of extinction. This allowed the participants to establish a common terminology and basis for subsequent discussions in breakout groups and during the plenary sessions.

Abstracts for each of the presentations are provided in Appendix 2.

3. Discussion Topics and Recommendations

The intention of the workshop was not to achieve consensus on all the topics discussed. Rather, each working group was tasked to identify areas of uncertainty, note consensus or disagreements and, when possible, provide recommendations to COSEWIC for consideration.

3.1 Which data are useful to assess the probability of extinction in marine fish?

Issue: While there are many different types of data available for assessing the chance of extinction in marine fish, not all may be equally useful.

Questions: What data are available to assess extinction probability in marine fish (e.g., scientific surveys, catch statistics, morphometric data, and age ratios)? What is the minimum time series required for estimating probability of extinction? What are important sources of uncertainty? What are the strengths, weaknesses and relative values of different sources of information?

Data to use in assessing extinction probability of marine fish:

It is important include <u>all available information</u> (including DFO or industry or other stock assessments).

<u>Recognize strengths and weaknesses of different types of information (not all data provide equally appropriate metrics of distribution and abundance):</u>

- Both fisheries-dependent and fisheries-independent data have to be considered. Fisheries-dependent data generally are nonlinear indicators of decline in targeted species but can, in some cases, provide useful metrics of abundance for non-targeted species; fisheries-independent data (scientific surveys) generally are the most useful metrics of abundance and distribution, although their limitations and potential biases (e.g., coverage, catchability) need to be recognized.
- Context is needed for interpreting fisheries-dependent data (what variables

may drive the trends, changes in fish abundance, changes in gear, effort, market price etc.). All available data (including both fisheries-dependent and fisheries-independent data) should be presented in COSEWIC status reports with a discussion (if required) of their relative merit.

Specific types of data that are most useful for assessment of temporal changes in abundance, distribution, and population status include: catch per unit effort (CPUE) for trends in abundance, age structure, age at maturity, sex ratios, and reconstructed biomass estimates resulting from these metrics. However, in most cases, CPUE from directed fisheries is well known to be non-linearly related to actual abundance of the target species. This nonlinearity occurs in such a way as to underestimate the amount of decline in actual abundance.

Community knowledge is a potentially important source of information. COSEWIC must improve its communication with the fishing industry early in the assessment process and seek useful information that the industry may provide.

The scientific community should be consulted widely as possible, including fisheries assessment scientists outside of DFO.

Assessment of probability of extinction should give special consideration to species with special habitat requirements, especially:

- Anadromous species;
- Species that are estuarine-dependent; and
- Species whose marine habitats are potentially vulnerable to physical disturbance, especially habitats essential for critical life-history stages.

Documenting sources of data and uncertainties

All sources of information considered should be clearly presented in the status report. It would be very helpful if COSEWIC explained why certain criticisms and/or information obtained during the review process were not accepted as central to the status report and/or assessment.

Identify all sources of uncertainty (e.g., differences in coverage of surveys and the range of the species, type of habitat, as well as the timing of the survey).

3.2 Should we apply the decline criterion to marine fish whose populations still number in the millions?

Issue: Of the five quantitative criteria used by COSEWIC, the decline criterion (http://www.cosewic.gc.ca/pdf/assess_proc_e.pdf, Table 2, Criterion A) is most commonly applied to marine fish. This criterion has been criticized as being inappropriate for commercially exploited marine fish because the threshold values in the COSEWIC guidelines are thought by some to result in placement in a status category when the probability of extinction is not sufficient to warrant concern. Another contentious issue concerns the appropriate means of estimating decline and the time period over which the decline is quantified.

Questions: What is the justification for using a 50 or 70% population decline as a reference point? How should the distribution and the dispersion of the remaining fish be considered in assessments? What reference points should be used when estimating decline, e.g., decline in relation to what past level of abundance? Over what period of time should the decline be quantified?

The assessment process

As part of COSEWIC's ongoing work to improve its assessment process, the work done by FAO, CITES and NMFS on assessment criteria should be considered further (e.g., FAO 2001; Mace et al. 2002).

A decline criterion has a legitimate role in assessing probability of extinction. In COSEWIC's process, it functions as a starting point for discussion about the status of the species, and that discussion includes consideration of all other available information. This is an appropriate use of all the criteria, including the decline criterion.

Modifying factors

COSEWIC should undertake a careful consideration of potential modifying factors to be used in interpreting decline criteria.

Several modifying factors can be taken into account in interpreting the decline criterion (or other criteria; e.g., absolute numbers, genetic diversity, vulnerability to disease). The relevance of modifying factors will be case specific, as will the availability of information.

The absolute population size *is* a factor to consider in interpreting the degree to which a given decline provides a reliable metric of extinction probability. Some participants felt that the appropriate critical values for absolute remaining population size (criterion C) generally should be much larger for many marine fish species than for many other taxa (e.g., FAO 2001).

The interpretation of absolute population size should consider other modifying factors because population size alone is not sufficient for evaluating probability of extinction. The relationship of absolute population size to effective population size should be clarified in assessments, in cases when they are unlikely to be similar.

In interpreting the absolute population size relative to a population's decline, the degree to which the decline is continuing should have a great deal of weight. The weaker the evidence that the rate of decline is decreasing as the abundance declines, the less importance should be given to how many individuals are left.

Also, the steeper the slope of the decline overall, the less weight should be given the remaining population size.

Extent of Decline vs. Rate of Decline

Extent of decline: Extent of reduction should be calculated from the average unfished (historic) baseline and not from a recent short-term peak. Use as long a time series as possible, which may mean using multiple information sources to establish a baseline.

Rate of decline: Decline in recent years or recent generations (used in COSEWIC quantitative criteria, http://www.cosewic.gc.ca/pdf/assess_proc_e.pdf, Table 2).

There was a difference of opinion regarding whether extent of decline from the historic baseline should be a modifying factor for the existing decline criterion (criterion A), a replacement for it, or an additional criterion. There was agreement that the history of the population and particularly its exploitation history will be important to interpreting the degree to which extent or rate of decline are informative about the probability of extinction.

Because of the diversity of interpretations of "decline" (e.g., extent of decline vs. rate of decline), each status report should make clear which one is being used.

The Interface of Management and Conservation

There is a need to clarify the relationships between reference points used in fisheries management and criteria used by COSEWIC, and where possible, to harmonise them. Many participants argued that it is important to ensure that the zones for threatened and endangered do not overlap the zone of fisheries management reference points. Others argued that, at least in some cases, there is no need for this concern, as commercial exploitation would have ended already by the time a population decline triggered assessment by COSEWIC (Dulvy et al. in press). How close the boundaries between fisheries management reference points and criteria used by COSEWIC should be is a crucial question with both a science and a policy component. The group had neither consensus on how close they should be, nor necessarily even if a scientific basis for positioning exists.

3.3 What is the evidence for large-scale or local extinction of marine fish?

Issue: There are few recorded extinctions of entire species.

Questions: What do we really mean by 'extinction'? At what point does a 'management' problem become a 'conservation' concern because recovery becomes unlikely? What factors affect recovery rates? What is the evidence for major ecosystem shifts following severe stock depletion? Do the life-history characteristics of marine fish make them less likely to become extinct than other taxa for a given population size?

The COSEWIC definition for extinction seems appropriate (a wildlife species that no longer exists). Some participants, however, questioned whether “extinction” should be used to refer to the disappearance of the last individual of a species, or the point at which numbers are so low that the species no longer plays an ecological role in its environment. “Imminent” probability of extinction can be informed by COSEWIC’s criterion E (e.g., 20% chance of extinction in the longer of 20 years or 5 generations; http://www.cosewic.gc.ca/pdf/assess_proc_e.pdf)

There are many examples of local extinctions of marine fish. There are few examples of species-level extinctions (Dulvy et. al 2003). It should be noted, however, that because many marine fish species are widely distributed, “local” extinctions can occur at a large scale.

The ability to predict future population trajectories often declines as the size of the population declines, so uncertainty increases. A precautionary approach should be used in such cases.

Zones of unacceptable risk to fisheries (outside biological stock abundance limits) overlap with higher probability of extinction and possibly low likelihood of recovery; recruitment can be impaired.

Likelihood of recovery is difficult to predict, however, we can identify conditions that need to be met for recovery to occur.

There was consensus that major ecosystem shifts have occurred following severe stock depletion. Examples discussed included dramatic increases in the abundance of shrimp following the collapse of Atlantic cod throughout much of the North Atlantic (Worm and Myers 2003), and increases in pelagic fish concomitant with declines in the abundance of groundfish (Hutchings and Baum 2005).

Communication of processes and results

COSEWIC needs to better communicate what it means by “imminent” and “extinction” to ensure that all members of COSEWIC and the public understand what each assessment means. Both terms are already defined by COSEWIC.

COSEWIC should strive for better communication of its processes and assessments:

- The process COSEWIC uses to derive a status assessment (i.e., use of quantitative guidelines followed by expert opinion decision-making; http://www.cosewic.gc.ca/pdf/assess_proc_e.pdf) seems appropriate;
- Provide more comprehensive and detailed reason for a species’ designation, capturing the essence of the discussion at the assessment

meeting, and how different information sources contributed to conclusions. The reason for designation should also emphasize importance of the species to biodiversity;

- Better explanation of the COSEWIC process should be reflected in the FAQs on the COSEWIC website; and
- Explain any relationship between designatable units and management units so that people understand the assessment better.

COSEWIC should communicate why some criticisms and information obtained during the review process are not accepted as central to the status report and/or assessment. A written response on main issues raised by jurisdictions could be provided. Significant divergences of scientific interpretation should be addressed in the report.

Improving the review process to increase the quality of reports and assessments

COSEWIC should continue to ensure that all available data are incorporated into reports:

- There needs to be a cooperative approach during the preparation and review of species status reports; both COSEWIC and the jurisdictions involved can improve in key areas.
    - Continue to ensure that jurisdictional data (inventories and analysis) are obtained and incorporated into status reports before COSEWIC assessment and SARA listing.
    - There was consensus that jurisdictions need to pay earlier attention to the candidate lists so that key information can be collected to support assessments and reduce uncertainty.
- Six-month interim reports should be provided to a broad range of experts to ensure that no relevant data or interpretations are overlooked.
- COSEWIC needs to investigate ways to access reliable community knowledge throughout its process (e.g., using accepted social science methodology, atlas programs that have been established for birds, Fisherman Research Society in Nova Scotia, sociological studies looking at different fishing patterns through time).
- Engagement of community and other stakeholders will increase the confidence that stakeholders have in the COSEWIC species assessment process.

The life-history characteristics of marine fish do not make them any less likely to become extinct than other taxa.

There is much variability in probability of extinction for marine fish: low-productivity species such as sharks, skates and rays are predicted to have higher extinction probabilities than high-productivity species such as herring (Hutchings 2001a,b; Dulvy et al. 2003). There is some archaeological evidence that marine fish haven't become extinct as often as other species (McKinney 1997). However, there should not be complacency about marine fish extinction.

Important life-history and other ecological characteristics to consider for marine fish include: habitat, life history (including very low fecundity for some species), genetic drift, susceptibility to bycatch, concentrated and predictable spawning locations, Allee effect, environmental variability, multi-species interaction (e.g., Reynolds et al. 2002; Dulvy et al. 2003; Hutchings and Reynolds 2004; see also section 3.4).

3.4 What life-history and other ecological characteristics of marine fish affect their probability of extinction?

Questions: Fecundity? Age at first reproduction? Use of certain habitats? Susceptibility to different fisheries? Trophic level? How should these variables be included in an assessment of probability of extinction?

<u>Marine fish are as vulnerable to extinction as other taxa at similar population levels and with similar life-history traits</u>. There was consensus that even though marine fish have highly diverse life-history characteristics, they are not different from other taxa with regard to this diversity. Additionally, there is no reason to believe that marine fish species are any more or less resilient than other taxa in their responses to threatening processes, including exploitation, habitat loss, environmental changes, and pollution. There is no evidence that highly fecund species are any more resilient than less fecund species. Life-history traits such as body size and age at maturity can be used to predict vulnerability of fishes to specific threatening processes, in the same way that they predict vulnerability of terrestrial species (Reynolds 2003).
<u>Loss of populations is the first step towards global extinction.</u> There are a few hundred documented examples of local marine fish extinctions (although the various causal factors, including fisheries, have not been established in many cases), but very few examples of species extinctions (Dulvy et al. 2003). However, normally, loss of populations is the first step towards global extinction. Although it is difficult to scale-up local losses to global extinction in widespread species of marine fishes, it is conceptually no different from making similar extrapolations in other taxa.
<u>Even if there are millions of individuals remaining after a significant decline, the population may still have a high chance of becoming extinct.</u> The number of individuals remaining after a population decline may not be as important as other factors. For example, the viability of the remaining population may be affected by size of individuals, condition, age and size at maturity, viability of eggs, recruitment rate, spatial distribution and population structure of remaining individuals, and by how these variables change over time.
<u>COSEWIC's application of the life-history guidelines is an integral part of the assessment process</u> (http://www.cosewic.gc.ca/pdf/assess_proc_e.pdf, Table 5). However, the guidelines can be enhanced: • There is no evidence that high fecundity makes fish populations

particularly resilient to, or likely to recover from, human impacts (Sadovy 2001). Therefore fecundity should not be used as part of the criteria for assessing vulnerability to extinction or potential for recovery. (Add this as footnote to Table 5)

- The level of threat to important habitats for various life stages is an important consideration during the assessment, but it is particularly weakly documented for nearly all marine species.
- In its assessments, COSEWIC should continue to consider effective conservation, protection and management measures that may be in place.
- Species that aggregate at certain stages of their life cycles are potentially vulnerable to human impacts, e.g., during spawning or overwintering, or in nursery areas; COSEWIC already considers these factors when calculating Area of Occupancy (A of O; tables 2 and 3), but may need to highlight this explicitly when A of O is not part of the quantitative criteria that apply to a particular species.

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5. Appendices

Appendix 1. List of Attendees.

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Appendix 2. Abstracts from presentations.

1. Clarifying objectives and terminology about risk (Randall M. Peterman)

To identify appropriate, measurable indicators of biological risk, COSEWIC's risk assessment process for classifying fish populations (or other units) into categories of "endangered", "threatened", or "special concern" must use clearly stated objectives. For instance, if the only concern is to avoid absolute extinction, then one appropriate metric is the chance of having zero fish left at some future date. However, if an objective is to avoid persistent low fish abundance, then analysts must estimate two components of biological risk, i.e., the range of possible future abundance "states" and the probability of each one occurring. Here "state" of the fish population can also mean, for example, size/age structure of the stock, amount of depletion in biomass from the unfished state, or future ability to recover from a state of low abundance or productivity. A risk assessment process should explicitly consider how uncertainties in the original data and assumptions affect estimates of the: (1) past changes in measures of the state of the population, (2) current state, and (3) future changes in state. Management actions must also be considered. Such a process will result in estimated frequency distributions of indicators of biological risks. It is important to remember that this biological risk <u>assessment</u> step provides input to the risk <u>management</u> step, in which decision makers also consider other information not included in the biological risk assessment, e.g. economic and social risks. However, decision makers should also consider the often-ignored uncertainties in economic and social measures of risk. Based on the stated management objectives and the relative weightings placed on different indicators, decision makers will make a decision, each one implying some trade-off among various risks.

2. IUCN threatened species criteria: background, uses and abuses (Georgina Mace)

IUCN – the World Conservation Union, has maintained lists of threatened species since the 1960's. However, whereas the early lists tended to be rather *ad hoc* and based on observations and personal knowledge, major efforts in the past 15 years have been taken to develop the list into a programme that meets two key goals. These goals are: (1) to identify the most seriously threatened species, and (2) to document trends in a representative range of species to provide an index of biodiversity. In practice, different processes are needed to achieve these two goals. The first requires systems to identify groups of species that are assessed in detail to identify those most in need of conservation. The second requires some more unbiased survey across species using a common approach to assessing the likelihood of extinction.

New criteria and categories for IUCN's system were adopted in 1996 and revised, following a review, in 2000. The IUCN categories and criteria aim to classify species into relative risk categories according to their likelihood of extinction, within a specified time period, under current conditions. Threat assessment is not a priority rank for conservation action, though it should contribute to the priority. Rather it is a simple method to determine the urgency with which a full assessment should be undertaken. A full assessment will determine whether the criterion-based risk assessment is accurate, and what kinds of actions are appropriate to reverse the trend. The categories, determined by the criteria, can however be used to track the overall status of selected groups, as an indicator of biodiversity.

The criteria were derived from a broad-based review of the factors that determine extinction risk to species. These are both intrinsic factors, i.e. biological traits making species more vulnerable to extinction (e.g. small population size, high variability in population size, low genetic variability, long lifespan/slow reproductive rate, specialized diet or habitat, small geographical range, low population density, high trophic level, large body size, large home range size), and the extrinsic threatening processes (habitat change, loss and degradation, overexploitation, introduced species, as well as chains of extinction from interactions among and between these processes). Whatever the exact cause, the *symptoms* of high extinction probability are (1) very small populations (facing demographic stochasticity), (2) populations under decline, -i.e.. with long term negative average growth rates (facing eventual population sizes of 0), and (3) populations with long term stable or positive growth rates but facing environmental variability causing population fluctuations that can also lead to population sizes of 0. These symptoms are the basis for the criteria A, B, C and D in the current IUCN system. Each criterion has a set of quantitative thresholds that were determined from both basic theory and from surveys of species within characteristic taxonomic and habitat groups. A species need only meet one of the criteria to qualify for listing in a particular category. Not meeting the criteria has no bearing on listing so the fact that some criteria appear inappropriate for certain species is not an issue. The criteria can be regarded as a set of alternative filters.

Data used to test species against the criteria are adjusted to reflect life history and ecological traits characteristic of individual species. For example, area of occupancy and extent of occurrence reflect habitat specialization, niche distinctiveness and fragmentation. Importantly, especially for very abundant populations and species, population size is measured only by a specifically defined measure of the number of mature individuals. This is designed to approximate the effective population size by taking account of population fluctuations, variation in reproductive success between individuals and between sexes, and any interspecific dependencies. Finally, generation time is used to scale temporal measures in the criteria to the natural timescales of different species, reflecting reproductive rate, mortality rates and lifespan. Approaches to incorporating uncertainty are now included in the criteria rules and processes.

Listing in one of the threatened categories by the IUCN criteria is expected to be only a first step for most species. The system is designed to provide a broad review of all species, not a precise assessment of any one species. Listing is intended to raise awareness about species' status, not to prescribe a particular course of action – this should be the next step. Local agencies and managers will have better information for specific analyses relevant to management. Therefore, diagnosis, analysis and then action are responses to listing, not immediate action.

IUCN's categories and criteria have been successfully applied over the past 5 years to allow improved assessments of the status of species, the areas and locations facing highest risks and to start monitoring trends over time. Problems with their application have arisen where assessors have misapplied them, e.g. changing the criteria for local or specific uses, choosing to only use certain criteria, simplifying the criteria by removing the subcriteria, omitting the generation length time scale, failing to use the definitions (especially for mature individuals), and using categories to predict extinction rates.

3. COSEWIC Assessment of Marine Fishes (Mart Gross)

COSEWIC's assessment of marine fishes involves IUCN criteria at several stages. First, at the Prioritized Candidate List stage, the Marine Fishes SSC uses the Red List software program by RAMAS, developed from IUCN criteria, to help identify those species that may be at greatest risk of extinction. The SSC also uses other sources of information (e.g., General Status Assessment by DFO; various expert inputs), and then submits its prioritized SSC Candidate List to COSEWIC for the across-taxa COSEWIC Candidate List that is put out for status report bids. Second, the COSEWIC Status Reports use a template that highlights the ICUN criteria in the organization and analysis of information. The Marine Fishes SSC then extracts from the Status Report the information needed to evaluate the status of the species against the IUCN criteria. The SSC's analysis is then submitted to COSEWIC, showing for each IUCN criteria the status that would be assigned if only the criteria were followed. Third, the COSEWIC assessment reviews the information provided by the SSC and again discusses the information in the status report against the IUCN criteria, finally determining the status and recording in the minutes the IUCN criteria which qualify. Finally, the COSEWIC status assignments (e.g., endangered, threatened, special concern) closely follow but are not exactly the same as those of the IUCN. Throughout this process, COSEWIC is guided by the IUCN criteria but does not use the IUCN criteria in a prescriptive manner.

COSEWIC has currently assessed 20 marine fishes. Of these, 11 were designated as endangered or threatened. For all species, the IUCN decline rate criterion was applied (for 1 species, a PVA was also available). This contrasts with other taxa where all 5 criteria are applied depending on the species, and the decline rate is usually applied to less than one-quarter of the species. The difference among taxa appears to reflect the capacity of the Marine Fishes SSC to extract information from fisheries and survey data that may not be available for other taxa.

Six of the marine fishes are designated endangered, and have an average decline rate of 87% over the time period analyzed (usually 3 generations). Five are designated threatened, and have an average decline rate of 92%. The fact that threatened species have a slightly greater average decline rate than endangered species reflects the use by COSEWIC of additional factors than just IUCN decline rate criteria. A comparison of endangered and threatened listings shows that the former had continuing declines, and/or very small populations (<1000 mature individuals) compared to the latter. COSEWIC has also designated a marine fish as special concern when the IUCN decline criteria would suggest it is endangered. In this case, the large number of individuals still remaining was a factor in the designation by COSEWIC.

In summary, COSEWIC uses the IUCN criteria to help initiate its prioritization of marine fishes for assessment, it uses the criteria as non-prescriptive guidelines for designation of status, and it uses the criteria to standardize the documentation. In practice, however, the IUCN criteria have had limited application for designation of the status of marine fishes. This is for two reasons. First, only one of the five IUCN criteria, decline rate, is being widely applied because data on declines are available and because many marine fishes do not fall into the other criteria. Second, the rate of decline of the marine fishes pre-selected for assessment has greatly exceeded that of the IUCN decline rate criteria and thus the criteria are not themselves triggering the designations. The primary threat factor for marine fishes has been fisheries exploitation (leading cause in at least 10 of 11 species), and the rate of decline for endangered and threatened species has averaged about 90% across 3 or more generations in most COSEWIC designations. These species are considered at risk of extinction because of the marked declines in their number, and additional life history attributes. COSEWIC does not use the IUCN criteria in a prescriptive, narrow or rigid manner but rather as a guide in the assessment process.

4. Are fish different? Biological correlates of threat status in comparison with terrestrial taxa. (John Reynolds)

Should we assess the threatened status of fish species using different criteria from those used for other groups of organisms? Perhaps fish respond differently to the two major threats that they and terrestrial species face: habitat loss and over-exploitation. I consider whether we can use basic principles derived from studies of ecology and life histories of other taxa to predict how fish species will respond. Our comparative studies of marine fishes have provided strong support for the 'big=vulnerable' paradigm. This is not only due to greater fishing mortality on large-bodied species, but also due to demographic effects of correlated life histories, such as late age at maturity. However, comparative studies of freshwater fishes suggest a more complicated picture. Whereas large-bodied species are more at risk when direct exploitation is the main human impact, we found the opposite result when habitat loss is the problem, with small-bodied species facing higher risk of extinction. These findings match new research in birds, mammals, and reptiles. That is, for all species, including fishes, we can predict responses to habitat loss and over-exploitation according to the same life history traits.

For COSEWIC, there are three conclusions. First, the evidence is that fishes and terrestrial animals have similar biological correlates of threat status: they respond in the same way to extrinsic problems according to intrinsic characteristics of their biology. Second, modifications can be made to COSEWIC's guidelines for threat assessments, particularly the criteria in Table 5 involving age at maturity and body size. Third, the guidelines should continue to ignore fecundity, as there is no evidence to support the contention that high fecundity has anything to do with the responses of fish (or other animal) populations to human impacts.

5. Perceptions and caveats regarding the assignment of extinction probability in marine fish (Jeff Hutchings)

Two key perceptions provide the basis for many management strategies, recovery plans, and conservation programmes for marine fish. The first is that marine fish have lower probabilities of extinction than other taxa. This purportedly increased resilience has been variously attributed to high fecundity, extraordinary temporal variability in abundance, broad dispersal distances, and higher rates of maximum population growth. The second perception is that fishing mortality is the primary, or sole, factor limiting the recovery of over-exploited populations. Contrary to the first perception, there is neither theoretical nor empirical support for the assertions that high fecundity confers increased resilience, that the breeding population sizes of marine fish are more variable than those of birds and terrestrial mammals, that marine fish have faster rates of population growth than other taxa, or that they are more likely to recover following historically unprecedented declines. Regarding the second perception, empirical analyses indicate that while reductions in fishing pressure are necessary for recovery, they are often not sufficient to ensure recovery.

Key questions concerning the extinction probabilities of marine fish pertain to: (a) the possibility that minimum viable population sizes for marine fish are considerably greater than those of other taxa; (b) the spatial scale of population structure and adaptive variation (relevant to the identification of appropriate designatable units); (c) the relationship between census population size and both the effective genetic and demographic population sizes; and (d) the genetic basis of, and consequences to recovery resulting from, life history trait changes (such as reductions in age and size at maturity) concomitant with prolonged over-fishing.

6. Revision of the criteria and guidelines for listing species on CITES appendices (Pamela Mace) (Abstract not available)

7. Patterns of disassociation: fecundity, recovery potential and extinction risk (Yvonne Sadovy)

There has long been an assumption that fish species producing large numbers of pelagic phase eggs/larvae, and that are commercially exploited, are particularly resilient to the threat of extinction, or able to recover readily from very low population levels. Partly for this reason, there has been less concern over extinction risk and more optimism over the potential for severely reduced populations to recover once fishing pressure is released, than is warranted.

There is little empirical support for high fecundity and resilience being positively associated in fishes, nor evidence that compensatory responses occur more in this group than in other taxa. The reason for this is that fish life history requires them to produce a great many eggs to ensure the survival of a few, since mortality rates in the egg and larval stages are so high. Long life and sporadic spawning (i.e. in a range of different long-lived species, females do not necessarily reproduce every year) is another facet of this life history strategy, compared with a mammalian strategy, for example, in which a few young are produced each with a much higher chance of success. Therefore, many years and millions of eggs may be needed for fecund fishes to replace themselves, and only some years might produce successful recruitment or be environmentally suited for long-lived adults to spawn. Indeed, several threatened commercially exploited species are large, long-lived and highly fecund (specific examples of threatened species are the Nassau grouper, *Epinephelus striatus*, and the Giant yellow croaker, *Bahaba taipingensis*).

While there are examples of compensatory responses to heavy fishing in some fish stocks, such as reduced age of sexual maturation, increased fecundity or growth rates, such responses have not been noted in many other species or stocks. Moreover, it is not clear to what extent such compensation actually increases overall population (hence fishable stock) reproductive output, since it acts at the individual and not population level. Therefore, there is no sound reason to suppose that compensatory responses occur as populations become seriously reduced. Since there is no evidence that maximum reproductive rates in pelagic spawning fish species exceed those of other taxa, there is no *a priori* reason to treat declines in fecund fish any less conservatively.

8. Do threat criteria produce false alarms? (Nicholas Dulvy)

Threat listing of exploited marine species has been controversial because of the scientific uncertainty of extinction risk as well as the social, economic and political costs of management procedures that may be triggered by designation of species as threatened. We apply three threat criteria to 76 stocks (populations) of 21 exploited marine fish and invertebrate species. Two criteria are based on decline rates: World Conservation Union (IUCN A1) and the American Fisheries Society (AFS). The third set of criteria, based on population viability (IUCN E), is assessed using non-parametric simulation and two diffusion approximation methods. We compared extinction risk outcomes (threatened or not) against the exploitation status of each stock as reported in fish stock assessments (inside or outside safe biological limits). For each combination of threat and exploitation we assessed the rate of *hits*, *misses* and *false alarms*. Our analyses suggest that decline rate criteria provide risk categorisations consistent with population viability analyses when applied to exploited marine stocks. Nearly a quarter of the fish and invertebrate populations (n=18) considered met one or more of the threat criteria. None of the threat metrics produced *false alarms* – where sustainably exploited stocks were categorised as threatened. The quantitative IUCN E metrics both produced higher *hit* rates than the decline rate metrics (IUCN A, AFS) and all of the metrics produced similar *miss* rates. However the IUCN E methods could be applied to fewer stocks (12-14) compared to IUCN A decline rate criteria and AFS criteria, both of which could be applied all 76 stocks. Threat criteria are met only after fisheries limit reference points have been exceeded. Our results suggest that scientists with different backgrounds and objectives should usually be able to agree on the stocks for which the most urgent management action is needed. Moreover, IUCN decline rate metrics may provide useful indicators of population status when the information needed for full fisheries stock assessment is not available.

9. Industry viewpoint (Bruce Chapman)

The mandate for conservation of marine fish rests with the Minister of Fisheries & Oceans under the Fisheries Act. COSEWIC's mandate under the Species At Risk Act (SARA) is limited to assessing the risk of extinction of marine fish. "Extinction" is defined in Webster as "no longer existing". The Parliament of Canada did not intend that COSEWIC be mandated to address the conservation of marine fish beyond what was directly related to the threat of extinction.

There are only three known extinctions of true marine fish at the species level, and these were not as a result of overfishing. Extinctions and extirpations of marine fish at the population level have all involved loss of very specific types or localized habitat, and/or are characterized by low fecundity, high age at maturity and/or low mobility. Criteria and its application related to risk of extinction should be judged against the backdrop of actual extinctions.

In addition to the debate as to whether the current criteria are appropriate for marine fish because of their biological characteristics, there are other important considerations. We cannot see fish to count them. There are parts of the sea bottom where most sampling or fishing gear cannot operate, so that there are refugia even where there are no legislated protected areas. While research vessel sampling might function adequately to create survey (or minimum trawlable) estimates of abundance and to detect changes in relative abundance over time, it seems to be a rather blunt instrument in the context of assessing abundance related to risk of extinction.

All sets of criteria agree that natural fluctuations should not be considered a decline, but go on to say that a decline should not be considered part of a natural fluctuation unless there is evidence for this. It seems unacceptable to manage risk simply on the basis of reverse onus.

The option of combining different population components of a species has obvious merit when considering risk of extinction at a species level, but in the marine fisheries context does not make much sense when each stock is harvested separately and can be subjected to stock specific management controls.

Managed exploitation conducted under the authority of the Fisheries Act, particularly when structured within a defined Precautionary Approach framework, should be a factor explicitly recognized by listing criteria for the respective species. Where they exist, Limit Reference Point(LRPs) for spawning stock biomass levels should be the demarcation point below which designation of “Special Concern” should be triggered. Designation of “Threatened” status should be triggered at appropriate points significantly below the LRP.

For stocks managed by DFO, COSEWIC’s assessment process should be integrated into DFO’s Regional Advisory Process.

Industry factual and interpretative knowledge should be accessed by COSEWIC in a meaningful way.

10. The American Fisheries Societies analysis of extinction risk in marine and diadromous fishes of North America (John A. Musick)

In evaluating the risk of extinction of marine fishes The American Fisheries Society (AFS) recognizes populations or Distinct Population Segments (DPSs) within species when the information is available. Categories of risk recognized include *endangered*, *threatened*, *vulnerable*, and *conservation dependent*. The IUCN system of using standardized quantitative risk criteria, although laudable in intent,is not very useful in predicting risk of extinction and, in fact, may be arbitrary because it ignores much of the enormous range in life history parameters and other ecological features that contribute to the vulnerability of different taxa. The IUCN decline criteria in populations often over-exaggerate extinction risk in fishes.

Instead, AFS developed the following criteria to evaluate the risk of extinction among fishes taking into account the context of the biology of the DPS under consideration: Rarity, Specialization in Habitat Requirements and Endemicity or Small Range, all of which are assessed qualitatively considering the unique conditions associated with each DPS. Population Decline, another criterion, is evaluated quantitatively according to the productivity or resilience of the DPS in question with four levels of productivity defined (High, Medium, Low, and Very Low). These productivity levels may be estimated using the intrinsic rate of increase, age at maturity, maximum age, the Von Bertalanffy growth coefficient, and to a lesser extent fecundity, whichever data are available.

The AFS criteria seek to identify DPSs at risk at a sufficiently early stage to avoid listing as *threatened* or *endangered* but try to minimize the probability of exaggerating the extinction risk. The AFS criteria attempt to utilize the best current knowledge of stock dynamics at low population levels, and retain the flexibility to allow experts with the greatest knowledge to contribute to the determination of the conservation status of DPSs. Initially DPSs that may be in trouble are classified as vulnerable, then subsequently assessed by experts to determine by consensus whether to increase the risk level to threatened or endangered.

Using this system AFS published a list of marine and diadromous fishes at risk of extinction in North America (exclusive of Pacific salmonids). They recognized 82 species and subspecies of marine fishes which included DPSs vulnerable to extirpation (or worse) in North American waters. Many of these are vulnerable to more than one risk factor. The analyses of risk factors showed that life history limitations (51 species or sub-species) were by far, the most important, followed by habitat degradation (33 species or sub-species). Twelve species each were listed as endemic (or with small range) and/or as rare. Virtually all species that scored in these two categories were also vulnerable because of life history limitations or habitat degradation or both. Twenty two species could be considered to be at least *vulnerable* to global extinction, because all their DPSs were found to be at risk or because some species were comprised of one DPS, whose entire range was included in the assessment.

Among groups that are particularly vulnerable because of life history limitations are 14 scorpaenids, 13 serranids (mostly large species), 11 elasmobranchs, 5 sturgeons, and small numbers in other families. Most species that are vulnerable because of life history limitations are large (>50 cm TL) in size. Probably the greatest threat to these species with low productivity are anaylsis of extinction risk in marine species.wpd mixed species fisheries, where more highly productive species continue to drive the fishery, while those with low productivity are reduced to stock collapse or extirpation. Among those groups identified to be vulnerable because of habitat destruction or degradation, 18 are anadromous (ascending from the sea into freshwater to spawn) or amphidromous (ascending from the sea into freshwater habitats but not for the purpose of spawning). Five species or subspecies of sturgeons are in the diadromous group, followed by five gobies, three smelts, two snooks, one syngnathid, one alosine herring, and the Atlantic salmon. Freshwater habitats in general are more vulnerable to anthropogenic perturbation than most marine habitats, and the preponderance of diadromous species in this list comes as no surprise. The well documented plight of Pacific coast salmonids provides ample documentation of this fact. The sturgeons are of particular concern because they are doubly at risk, having late maturity and long life spans in addition to being subjected to disruption or destruction of spawning and nursery habitats.

Among other groups that were found to be at risk because of threats to habitat, five syngnathids, one sciaenid, and one goby inhabit sea grass beds which have undergone (and continue to undergo) massive destruction along the south-eastern coast of the U.S. Likewise, four species of cyprinodontiform fishes were recognized to be at risk because the mangrove or marsh grass habitats that they require have been destroyed by human development. The vast majority of species recognized to be at risk because of habitat degradation are small in size (<250 mm TL) (with the obvious exceptions of the sturgeons, Atlantic salmon and a few others). The single most important factor in habitat degradation is mismanagement of freshwater systems that directly affect diadromous species or indirectly affect estuaries or marine ecosystems by altering natural freshwater inflow.

11. The Threatened Status of Chondrichthyan Fishes (Jack Musick) (abstract not available)