Fisheries and Oceans Canada Science | Pêches et Océans Canada Sciences

National Capital Region

Canadian Science Advisory Secretariat
Science Advisory Report 2005/054

A FRAMEWORK FOR DEVELOPING SCIENCE ADVICE ON RECOVERY TARGETS FOR AQUATIC SPECIES IN THE CONTEXT OF THE *SPECIES AT RISK ACT*

Figure 1: Map of the Department of Fisheries and Oceans' (DFO) six administrative regions.

Context

The Species at Risk Act (SARA) has required the Science Branch, Department of Fisheries and Oceans (DFO), to develop a number of new programmes, including providing recovery teams with the information that they need to develop recovery plans. SARA does not define recovery in the Act, but expert groups must reach consensus on the biological characteristics of a population which would constitute "recovery", as a core part of science support to recovery planning. This has sometimes been difficult.

Recovery targets are also important because while a Recovery Plan is in place for a species, activities that might kill, harm, harass, or destroy the species or its residence can only occur under conditions specified explicitly in the Recovery Plan. Thus, both the credibility of the Department's programmes and principles of good governance require that consistent standards be used in advising on recovery targets across species. This is not straightforward, because recovery targets may be needed for species with very different life histories, historic distributions, and population sizes.

A national workshop was held to consider what comprises "recovery" for aquatic species possibly at risk. The meeting reviewed a wide range of case histories, including a small whale, freshwater fishes, marine fishes which have been targeted commercially and which have been largely taken as bycatch, anadromous fishes, and both a marine and a freshwater invertebrate. In each case, information was presented on past and present population sizes, distribution, and biology, in part structured by a common template to organize the information consistently. From that body of information, guidelines have been developed to help science advisors provide consistent interpretations of "recovery" in their advice to recovery teams developing recovery plans.

SUMMARY

- The "precautionary framework" currently being finalized for fisheries management was considered suitable as the starting point for recovery of species at risk as well. The framework has three zones for a population: healthy, cautious, and critical.

- There are both strengths and weaknesses to placing a biologically-based recovery target at either the critical-cautious boundary, or at the cautious-healthy boundary. There is at present no compelling *science* argument pointing definitively to one position or the other, or any specific position between them

- Recovery plans which aim to increase biomass or abundance to the cautious-healthy boundary are expected to result in stocks not assessed as Threatened or Endangered by COSEWIC, whereas recovery plans which only aim to increase a population to the critical-cautious boundary may find that COSEWIC assessments still conclude that the population is at unacceptable risk of extinction in the medium term.

- Sixteen biological attributes were reviewed for each of fifteen case histories, with regard to their usefulness as components of recovery descriptions and recovery plans. Direct measures of Abundance and Total Range Occupied emerged as the preferred biological traits to use in specifying recovery targets and focusing recovery efforts.

- Several other traits were considered to be valuable supplementary features to consider in recovery targets and recovery plans. There are circumstances where supplementary traits may be as important as direct measures of abundance and range.

- A reasonable suite of attributes to include in a description of recovery, and address in recovery plans, would be an abundance goal in the context of the historical population size, a population growth rate or level of surplus production, an age composition, and an abundance-weighted description of range. This list comprises a useful starting point for case-specific discussions by recovery planning teams, and scientists supporting those teams.

DESCRIPTION OF THE ISSUE

Three parts of SARA address recovery planning and the setting of targets for recovery of threatened or endangered species and populations. Sections 37 - 42 address the contents and development of formal Recovery Plans (throughout this document "Recovery Plans" is intended to include both the Recovery Strategy and the Action Plan specified in SARA.) Although developed via a consultative process, they must be based on sound science. Sections 73 – 76 address the conditions under which a species (or population) may be killed or harmed during the interim period between being listed under the Act and the time when a formal Recovery Plan is in place (the "Allowable Harm" provisions). Sections 83 – 86 discuss "Exceptions" to the normal prohibitions in SARA, when a Recovery Strategy and Action Plans have been adopted, and which may or may not be the same as those specified in the initial decisions guided by Section 73.

Of these provisions, Section 41 is most specific regarding recovery targets, requiring the Recovery Plan to specify:

- 41(b) Identification of threats to species and habitats & description of "broad strategy"
- 41(d) "statement of population and distribution objectives" and a general description of research and management activities needed to meet these objectives
- 41(c) description of critical habitat.

Section 42 requires the Minister of the accountable jurisdiction to place the Recovery Plan on the Public Registry. Although the initial purpose is to inform a consultation process, as Recovery Plans are adopted and Action Plans implemented, listing on the Public Registry places the authority of the jurisdiction behind the provisions of the Recovery Plan.

Because the Minister of Fisheries and Oceans is accountable for the provisions of the recovery plans of aquatic species, it is necessary to ensure that the recovery targets are scientifically well-based. This science basis should be available early in the planning process for recovery; SARA is explicit that development of Recovery Plans is to be done by inclusive groups with strong stakeholder participation and including all affected aboriginal groups. Providing a sound scientific bases on which these groups can build Recovery Plans maximizes the likelihood that Ministerial accountability and stakeholder based processes will converge constructively.

Moreover, failure to set Recovery Targets appropriately would have undesirable consequences. Recovery targets which are too low would not ensure that the species receives adequate protection while on the path to recovery, and/or could remove necessary protection before the status of the species was secure. Recovery targets which are too high might provide the recovery teams with unreachable goals, and might constrain economic, social, and cultural activities which affect the species even after the restrictions were no longer necessary for good conservation. In addition, a commitment to equity and good governance implies that a consistent standard for conservation and protection of threatened and endangered species should be applied to the scientific input used in the subsequent processes that consider the social and economic consequences of striving to achieve the recovery targets.

There are scientific challenges in achieving this consistent standard. SARA applies to all species (and distinct populations below the species level), and species can be at risk for many different reasons. Many aquatic species have complex life histories, and although evidence of "recovery" may be measured most easily in the adult portion of such populations, characterizing recovery may also require considering the status of immature stages including eggs and larvae. Some species may be sedentary whereas others may be highly migratory, including different stages which use both freshwater and marine or estuarine habitats, or have eggs and larvae which are dispersed widely. Some SARA-listed species may have small ranges and population sizes, whereas others may have undergone substantial declines in abundance and/or range. Some species may have highly specialized habitat requirements which are important to recovery, whereas others may appear to have generalized habitat needs, at least in the life history stages which can be monitored.

To bring consistency to this diversity of species and recovery issues, only general guidelines are possible. These guidelines need to be clear and specific enough so that they can be interpreted in a similar way for all of these cases, to ensure that a consistent and defensible standard of conservation is being applied in science advice on recovery targets. Nonetheless, they have to be applicable to very different kinds of information and indicators of status, and flexible enough to accommodate the differences in life histories found in aquatic species.

ASSESSMENT

Approach

Many aquatic listings are below the species level, so these guidelines generally refer to populations but they also are appropriate when the listing is at the species level. A list of attributes which might be used to characterize recovery was prepared prior to the workshop, including:

Ecological Function: population (or species; because many aquatic listings are below the species level, these guidelines generally refer to populations, but they also are appropriate when the list is at the species level) is of a size and distribution that allows it to play its historical role in the ecosystem structure and function.

Population Size: population abundance is sufficiently large to be secure and/or may meet some comparative standard with its historical size. (In this document “Biomass” and “Abundance” are used interchangeably as attributes reflecting population size. On a species by species basis, one or the other likely will be used more commonly in assessment of status, depending on the species’ biology and past practice.)

Range: population distribution is sufficiently large to be secure and/or may meet some comparative standard with its historical size.

Traditional Ecological Knowledge: current population status is considered by those with extensive experiential knowledge of the species to compare well with its status historically.

Minimum Number of Individuals: The minimum estimate of the population size, allowing for uncertainties in estimation, is substantially above the minimum size for a secure population, as estimated by population viability analysis or some other method appropriate for the species.

Recruitment Productivity: The population is producing enough recruits that it is expected on average to have a stable or increasing population, and/or production of recruits may meet some comparative standard with its historical productivity.

Growth Productivity: The population is showing somatic growth rates that are considered healthy for the type of species, and/or that may meet some comparative standard with its historical rate of somatic growth.

Sex composition: the adult sex ratio does not deviate markedly from the sex ratio characteristic of a healthy population of the species

Age Composition: the age composition of the population is not badly truncated, with neither old nor young animals markedly uncommon relative to that expected from a stable age distribution of a healthy population.

Body Condition and maturation: Individuals in the population have a reasonable weight at age, and an age of sexual maturity that may meet some comparative standard with its historic maturation rate.

Contaminants: Individuals in the population have body burdens of contaminants and exposure and accumulation rates that do not threaten the well-being and security of the population as a whole, although some individuals may have high levels of some contaminants.

Disease and Parasites: the levels of disease and parasitism in the population do not threaten its security, and may meet some comparative standard with historical incidences.

Subpopulation Structure: the population has enough subpopulations that it is secure and/or that it may meet some comparative standard with its historical population structure.

Spatial Distribution: Not only is the total range occupied by the population adequately larger, but the pattern of distribution of the population with the total area occupied is such that the population is not abnormally exposed to local catastrophic events, and or its pattern of distribution may meet some comparative standard with its historic pattern of occurrence.

Habitat: Not just the status of the population has improved, but the habitat that the population requires is also available in adequate amounts and suitable configurations, and is secure from major threats.

This list of attributes is a mixture of properties of a population, some of which can be considered as states or conditions (population size, range, etc), some as rates (productivity measures), and some as threats (contaminants, diseases). One topic for consideration was whether all three types of attributes were equally useful in establishing the science basis for recovery goals. If not, what were the most appropriate roles for each type of attribute?

Based on these attributes, case histories were reviewed for the following species or populations:

- Beluga whale
- Pacific Herring
- Wavy-rayed lampmussels
- Black Redhorse
- Lake Sturgeon
- Boccacio and more general Pacific rockfish
- Winter skate
- Grand Banks yellowtail
- Upper Fraser River coho salmon
- Eulachon
- Pacific Abalone
- Carmine Shiner
- Cusk
- Porbeagle
- Newfoundland cod stocks

Some but not all of these populations and species have been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Threatened or Endangered. In some cases, the full list of candidate attributes were evaluated with regard to several questions including:

- Is the attribute biologically relevant for this type of species?
- Is there an adequate conceptual or theoretical basis for information on this attribute to be interpreted in the context of recovery from risk of extinction?
- Do methods exist to quantify this attribute in the field?
- Are there sufficient historic data on the attribute to interpret estimates of present status relative to historic status of the population?
- Is the attribute being monitored at present?

- Can a recovery target be estimated from the information (data and theory) that are available at present?

In other cases, only some of these questions or some of the attributes were addressed in order to explore particular aspects of setting criteria for setting recovery targets. Additional detail on some of the biological attributes was provided in work presented for the meeting, and discussed in the context of the case histories.

A Framework for considering recovery

A framework for application of the precautionary approach in science advice on fisheries harvests has been developed. This framework has three zones:

> Critical: Zone where stock biomass is evaluated as being at or below a level where there is a high risk of serious or irreversible harm to stock productivity. When stock biomass is within this zone, exploitation rates should be as low as possible, with no directed fisheries and practical bycatch reduction measures in place. Rebuilding of the stock should be the sole consideration in allocating surplus production.
>
> Healthy: Zone where stock biomass is evaluated as being within the historical range of the stock when science advisors did not recommend that priority be given to rebuilding the stock. When stock biomass is in this zone exploitation should be at rates which are sustainable in the long term, but social and economic considerations are the main factor in deciding what proportion of surplus production from the stock should be devoted to harvests.
>
> Cautious: Zone between the Critical and Healthy Zone, which reflects uncertainty about the estimation of annual stock status and the biomasses at which stock productivity begins to decline and becomes at risk of serious or irreversible harm. Exploitation rate should decline progressively from sustainable in the long-term at the Healthy-Cautious Boundary to as near zero as possible at the Cautious-Critical Boundary, as the priority given to stock rebuilding grows and the priority given to social and economic uses of surplus production declines.

This framework provides a starting point for determining the state of a species or population when it is “recovered”. To be used in species-at-risk and recovery contexts, it is necessary to establish where within this framework a population would be assessed by COSEWIC as at risk and where a population is considered “recovered”. It is also necessary to establish that the concepts behind this framework apply to all the attributes of a population which may be involved in assessing recovery, as well as to biomass, for which the framework was developed.

Where is a species “at risk” in this framework?

For an orderly relationship between the protection of species at risk and the management of sustainable fisheries, it is necessary for the boundary of the population being assessed as at risk of extinction be well below the critical – cautious boundary. This is not always the case at present. This situation presents many difficulties for credibility of the scientific basis of both assessments of species-at-risk, and prosecuting fisheries on stocks in the Cautious zone. Although work is needed to establish the correct relationship between criteria used in assessing risk of extinction of aquatic species and reference points used in fisheries management, any reasonable description of “recovery” would be at least a stock healthier than either the critical-cautious boundary or the risk criteria of COSEWIC. Therefore, it should be possible to progress on providing guidelines on recovery targets while this issue is being explored.

Where is a species “recovered” in this framework?

There were strengths and weaknesses associated with each of two different interpretations of where “recovery” would lie within this framework. Biomass will be used in describing these two positions, because it is a trait with which there is usually most information and if it is available DFO generally uses it as a basis for fisheries management advice. (The closely related trait Abundance is the attribute most likely to be used by COSEWIC to assess risk of extinction of aquatic species). These two interpretations correspond to two key “trigger points” present in the precautionary fisheries management framework.

Position 1: The critical-cautious boundary - conceptually the position on the biomass axis where all human-induced mortality should be as close to zero as possible.

Position 2: The cautious-healthy boundary - conceptually the position on the biomass axis where all human activities that impact the population (kill individuals, damage habitat, etc) could be conducted at rates consistent with overall good management and sustainable use, and no special measures are required to sustain the population.

Positions intermediate between these two boundaries (i.e. within the Cautious zone) are also possible to use in specifying recovery, but they would merely reflect different weightings of the strengths and weaknesses associated with the two boundary conditions.

The key strengths of Position 1 include:

- It separates the region on the biomass axis where socio-economic decisions are being made within a fisheries management context from the region covered by the Recovery Plan.

- It provides two distinct management domains – one where management of the stock is based on the provisions and tools of SARA, and one where management of the stock is based on the provisions and tools of the Fisheries Act, thus avoiding conflicting management guidance from two different pieces of legislation.

- It is likely to be high enough that it can be argued that it meets the definition of recovery used by the Canadian Inter-Departmental Working Group on Recovery, and the one used by the US Fish and Wildlife Service.

- It considers an appropriate recovery target to be a biomass where survival of the population is secure, but stringent management control on human-induced mortality (including fishing) will still be necessary for that status to be maintained. It is consistent with the COSEWIC criteria for “Special Concern” and “Not at Risk” which may correspond to biomasses where stringent management controls would still be necessary, as long as those controls were considered effective in protecting the population from persistent decline.

The key weaknesses of Position 1 include:

- It appears to present a logical inconsistency by having DFO state that within a SARA framework, a population is "recovered" when within a fisheries management framework, fishing mortality should be as close to zero as possible and a very high priority should be given to rebuilding the stock further.

- In cases examined so far under the Precautionary Approach (PA) framework, at the critical-cautious boundary, not just Spawning Stock Biomass (SSB – or other indicator of population size) but many other informative indicators of stock status indicate that stock status is poor and the long-term health of the stock at that state is not secure. This does not necessarily mean the stock is at risk of extinction, but it is at risk of further declines without exceptional vigilance by DFO.

- Under current practice by DFO and COSEWIC, stocks at Position 1 may be assessed by COSEWIC as still Threatened or Endangered because the critical-cautious boundary in the PA framework often corresponds to a biomass smaller than the biomass consistent with a 70% decline from historically observed biomasses and hence (depending on timing issues) still at risk under the "decline" criterion.

- Security of the stock will depend critically on the effectiveness of management to keep human-induced mortality near zero, and at Position 1, the inference of long-term security may not be robust to high uncertainty.

- It has generally proven very difficult to rebuild stocks from around this critical-cautious boundary to above the cautious-healthy boundary, where maximum socio-economic benefits would be derived. Rebuilding only to this boundary would allow restricted fisheries to open at low stock levels, making it likely that socio-economic benefits would remain limited in the long term.

Stakeholders engaged in taking social and economic benefits from the stock may support using this position as the "recovery" objective; stakeholders in conservation groups may consider it too low.

The key strengths of Position 2 include:

- It is logically consistent in that DFO does not state that a stock has "recovered" until there is no biological imperative to improve further, and it is in a state where it can produce maximum socio-economic benefits. The allocation of *surplus* production between further increase in the stock biomass and social and economic uses is strictly a societal decision, with neither having an inherent priority. This seems to be consistent with how "recovery" is used in other fields, such as public health and economic development.

- It has a functional consistency, in that it gives a consistent objective for management to aim for the same stock status whether the issue is recovery under SARA or rebuilding under the Fisheries Act. It is also consistent with the approaches of the International Union for Conservation of Nature (IUCN), the United States Marine Mammal Protection Act and revisions to the Magnusson –Stevenson Fishery Conservation and Management Act.

- At the cautious-healthy boundary, experience suggests that many indicators of stock status are likely to indicate a good or fair status (“green” or “yellow”) for the stock, suggesting that the term “recovered” is appropriate for a stock in this condition.

- There is little likelihood that a stock assessed to be at or above the cautious-healthy boundary would be assessed as Threatened or Endangered by COSEWIC, even under the decline criterion.

- Security of the stock would be robust to many sources of uncertainty, including implementation error.

The key weaknesses of Position 2 include:

- Throughout the cautious zone, DFO would have two sets of policies and tools which would apply to management of the stock – one set from SARA and another from the Fisheries Act. For the same stock, some of these policies and tools could be in conflict, making management very difficult. For two stocks in a similar current state and with similar recent trajectories, management could be very different if one had been assessed by COSEWIC in the past and found to be at risk, and the other had not been assessed by COSEWIC, or not considered to be at risk at the time of the assessment.

- It has generally proven very difficult to rebuild stocks from around the critical-cautious boundary to above the cautious-healthy boundary, so the Recovery Plan often would constrain extraction of social and economic benefits from the stock for much longer than would be the case if the Recovery Plan ceased to be in effect at the critical-cautious boundary.

- Reaching the cautious-healthy boundary would appear to be more ambitious than the definition of recovery favoured by the Inter-departmental Committee on Recovery.

Stakeholders in conservation groups may support using this position as the “recovery” objective; stakeholders engaged in taking social and economic benefits from the stock may consider it too high.

There is at present no compelling *scientific* argument pointing definitively to one position or the other. There was strong consensus that a recovery target should be well above a biomass (or state of any other trait) which would ensure that COSEWIC would consider the population as neither Threatened nor Endangered. Unfortunately that consensus does not guide a choice between the critical-cautious and the cautious-healthy boundaries, or a specific position in between. Both positions would meet that objective for a population listed as at risk because of absolute numbers or absolute area occupied. However, to this point, the few aquatic species assessed by COSEWIC as Threatened or Endangered on those criteria were usually species inherently restricted to specialized or isolated habitats, where ecologically sound Management Plans may not be able or may not consider it appropriate to increase numbers or range substantially.

More aquatic species were assessed as Threatened or Endangered because of the substantial declines in abundance and / or range. As noted above, application of the IUCN-based decline criterion may assess a species as being at risk of extinction at biomasses in the cautious zone, when fisheries management considers that there is still scope for some directed harvesting. For orderly management and good governance, this contradiction needs to be resolved independent of how "recovery" is interpreted. However, it is premature to judge if the resolution arises more from moving the critical-cautious boundary to higher biomasses or from requiring lower biomasses before the decline criterion can be invoked as a justification for assessing a population as Threatened or Endangered.

The current contradiction between the COSEWIC and DFO fisheries management benchmarks are affecting credibility and effectiveness of both groups, and a high priority should be given to finding a resolution. The process of reconciling the two approaches to evaluating the management actions necessary or appropriate for a population may help clarify the best interpretation of a recovery target as well. Given the slow recovery rate of very many depleted fish stocks, whether assessed as at risk or not, any relevant insights from this work to reconcile the COSEWIC and fisheries management benchmarks should be available long before populations have been rebuilt to biomasses where the difference between Position 1 and Position 2 matters in practice. In the short term, both interpretations of recovery require that stringent conservation measures be applied to listed stocks. The proper science-based interpretation of recovery will be revisited before it is likely that there will biological grounds for serious debate that a stock has improved enough to justify lifting the prohibitions required under SARA. However, for planning purposes, recovery plans which aim to increase biomass or abundance to the cautious-healthy boundary will result in stocks not assessed as Threatened or Endangered, whereas recovery plans which only aim to increase a population to the critical-cautious boundary may find that COSEWIC assessments still conclude the population is at unacceptable risk of extinction in the medium term.

Guidelines and Considerations Regarding the Possible Attributes

Which Attributes to Use:

The preparatory work and discussion at the workshop resulted in a tabulation of the usefulness of each feature for each case history. The entries in Table 1 indicate whether the feature could be useful in evaluating recovery directly from existing knowledge (Y [Yes]); was likely to be useful if additional data extraction and analyses were conducted (P [Possible]), or was unlikely to be useable at all, or after only significant new research and/or monitoring (U [Unlikely]).

It is apparent that **direct estimates** of **Total Population size**, and **Total Range Occupied** emerged as the preferred "currencies" for specifying recovery targets and focusing recovery efforts. This is a practical finding, because biomass and range also correspond to COSEWIC assessment criteria, and are widely used in fisheries management as indicators of the status of a population. It is stressed that these attributes have to be estimated correctly. For example, whenever possible, survey indices need to be corrected for catchability of the survey gear, uncertainty in the survey-based estimate must be represented realistically, and age and / or maturity stage should be dealt with in a method appropriate for the species' life history. Range estimates commonly need observations of occurrence to be weighted for abundance using a robust estimator.

There will also be instances when it is not possible to estimate biomass and / or range. In such cases, there are alternative attributes which may be suitable for specifying biological recovery targets. Even when abundance and range can be estimated and used to specify recovery targets, the descriptions of recovery may be made more biologically meaningful if additional considerations can be included. Among the potential alternative or supplementary attributes are:

- **Fragmentation** and **connectivity of habitat** is complementary to total range or area occupied
- **Age** and/or**-size composition** are complementary to abundance
- **Population-substructure** and **genetic diversity** may be complementary either to abundance or range

Cases where these attributes are used as alternatives to abundance or range rather than as supplementary features need to be considered carefully on a case by case basis. However they are used, it should be possible to apply reasoning consistent with that presented above for Biomass, and make them operational in the overall framework.

Attributes that are **biological rates**, such as productivity in growth or recruitment, are best used as ancillary features to direct measures of population status in abundance and distribution. Biological rates, particularly productivity measures are sufficiently important to the status of a population that often it may be desirable to include them in the specification of a recovery target, but usually in a conditional way. Usually, it will not be appropriate to consider a population recovered just because its growth or reproduction rates are typical of healthy populations of the species. Although such observations would be encouraging, indicators that a population is likely to be on the road to recovery, will require achievement of the abundance and/or range targets. The important use of rate measures is when abundance or range has improved substantially, but biological rates are still depressed. In such cases, the population may still not be secure, and particularly cautious management measures, possibly including protections assured by SARA, may still be necessary. Such conditions might be most likely when the stock is in the cautious zone. During that period, targets in both biomass and productivity would encourage keeping the stock in a condition where further increases in biomass would occur rapidly, and biomass targets would be reached quickly. Biological rates are particularly important in determining the time to recovery.

Attributes that are **threats,** such as contaminant levels or diseases, are rarely appropriate to include in the definition of recovery targets. Rather they may comprise an important aspect of the recovery plan. Reducing the threat to a safe level may be an essential initial objective of a recovery plan to allow the population to commence recovery. It is noted that the assumptions about threats will be different if recovery is considered to be represented by the critical-cautious boundary or by the cautious-healthy boundary. Use of the lower boundary means that all threats are assumed to be at their lowest feasibly-attainable level. Use of the higher boundary means that all threats are assumed to be at levels consistent with sound management in a “business-as-usual” context, with no special provisions for the population that is the subject of the recovery plan.

Regardless of the type of attribute, when an attribute is used in specifying recovery targets, the general fisheries management precautionary framework of Critical, Cautious, and Healthy zones may be adapted for use. Conceptually, it should be possible to develop comparable recovery objectives to move the status of the population above the zone boundaries for any of the other features, as it is for Biomass and Range. These objectives, in turn, should provide substantial guidance for the contents of recovery plans. The decision if additional attributes should be used in specifying recovery targets, and which ones to use, will be case specific. Use of additional attributes will be justified primarily when some biological characteristic of the population is known to be strongly deviant from its state in a healthy population, and returning the population to a healthy state will require correcting the deviation as well as increasing numbers and / or range. In some cases, the additional attributes may be alternatives to Biomass and Range, because one or both of those features cannot be estimated, whereas in other cases, they would be incremental to Biomass and Range targets, and correspondingly require development of multiple numeric boundaries and targets within the conceptual PA framework.

Special Circumstances with Some Traits.

Habitat itself was not considered to be appropriate to include as a component of a recovery *target* but may play a major role in the recovery *plan* when it has been lost or damaged. The exception to this general guideline is when habitat restoration or recovery is deemed to not be technically feasible. In such cases, it is pointless to put features in a recovery plan which are biologically impossible to implement, and the recovery target may have to be adjusted to be achievable with the maximum amount of habitat that is possible to protect and restore. This admission that it is impossible to fully recover a population is a serious concession of DFO's fundamental conservation mandate and should not be made lightly. Rather, the burden of proof is reversed in these instances, and it should be assumed that sufficient habitat can be protected or restored to support populations which have met their abundance and/or range targets, unless there is compelling evidence to the contrary. However, much loss of aquatic habitat occurred many decades ago, and before important habitat provisions were added to the Fisheries Act in 1979. A very strong biological rationale would be needed to propose recovery goals which involve turning the clock back half a century or more on human activities which have impacted aquatic habitats, and almost certainly proposing to impose huge social and economic costs to achieve them.

Traditional Ecological Knowledge (TEK) is not an attribute of a population, but a source of information about populations, past and present. Specifying recovery targets for any of the attributes, and particularly historical ranges and semi-quantitative indications of abundance, can always be informed by TEK, if it is available or can be acquired efficiently. In many non-commercial species, or species that supported subsistence harvests, it may be one of the major information sources. However, specification of what constitutes a recovered population will not include having some specific quantity of TEK available. It is noted that in many parts of the country, DFO is not well positioned or experienced to draw on the knowledge held by traditional uses of aquatic resources, or other observant naturalists. Priority should be given to improving DFO's ability to acquire and use appropriate methods on this information, and use it in many activities, including recovery planning.

The attribute of recovering a population to the state where it is able to play "its **historical ecological role in the ecosystem**", presents particular difficulties. Conceptually, the attribute is fundamental to the notion of conservation of biodiversity, and is therefore important. However, it is rarely possible to make the concept operational. To begin with, it is difficult to evaluate the *historical* role of a species in an ecosystem; it is challenging enough to quantify the *present* role of many species in their ecosystems. Moreover, because ecosystems are undergoing change due to both environmental (e.g. climate variation and climate change) and anthropogenic forcing, the "ecological role of a population in the ecosystem" is a moving target.

It was also noted that including the ecological role of a population in specification of its recovery targets would make recovery objectives into ecosystem management goals. This goes beyond the mandate and responsibility of SARA into the domain of integrated management under an ecosystem approach, as specified in the Oceans Act. Hence DFO needs to deal with this concept, but not directly in recovery targets and recovery plans for threatened or endangered species.

Special Ecological Considerations

In addition to the above considerations, there are other special ecological circumstances which may have to be taken into consideration in specifying recovery targets and developing recovery plans.

There may be cases where especially **tight ecological linkages** are present between species, such as between a parasite and its host. When a linkage is especially tight, it may not be possible to achieve any single-species recovery objective (either the higher or the lower boundary) without considering the other co-dependent species. In such cases, it is likely to be necessary to include the related species in the recovery *plan*, but it seems unlikely that the related species would comprise part of the *description* of recovery for the listed species. Such relationships are likely to exist between parasites and their hosts. Predator-prey linkages can also be strong in aquatic ecosystems, and several were considered at the workshop. None of the linkages were thought to be sufficiently obligatory to make it necessary to include management measures for *specific* predators or prey in the recovery plan for a listed species, although it might be appropriate to include general provisions to ensure adequate prey availability and predation levels that did not preclude increase in the listed species.

There is growing interest in **natural productivity regimes.** Where these are documented to exist, the recovery plan usually will have to address the possible levels of system productivity. The recovery targets for abundance and range should be high enough for the population to be considered secure during the plausible worst-case productivity regimes. The projected time for recovery will also have to take account of the typical durations of different productivity regimes, and the time necessary to achieve recovery targets will be highly uncertain. The expected path to recovery should include periods when there may be little potential for population increase, even if management is exerting control over all sources of mortality that are subject to management regulation. During low productivity regimes, management should be exceptionally risk averse relative to potential harm to listed species or populations. Even with risk averse management, however, population growth to overall recovery targets may not be achievable during low productivity regimes. Then the question of whether the low productive regime will eventually be replaced by a higher productive regime becomes crucial to planning. If the change to low productivity is considered permanent, then a recovery target appropriate for the new productivity characteristics of the species should be sought. If a regime change to higher productivity is expected in the future, then the recovery target should be appropriate for those productivity characteristics, with the Recovery Plan allowing for periods when little progress can be made towards the target and management must focus on keeping the population in a state where it can take full advantage of improved productivity when the regime shift occurs.

Considering both the ecological role of a population in the ecosystem and natural productivity regimes leads to consideration of major and persistent **changes in ecosystem structure and function resulting from the past decline in the population** considered to be Threatened or Endangered. If the population did decline to only, say, a tenth or less of its historical abundance, then other competitors, predators, and prey of the species will have had to alter some of their ecological traits as well. The exact nature of these alterations will generally be challenging to even describe, however, and nearly impossible to quantify accurately. It has proven very difficult to demonstrate that any specific ecosystem changes are a direct result of the decline of a marine species, even in the case of Atlantic cod on the Grand Banks and Gulf of St Lawrence, where the declines were large and role of cod in the ecosystem was well studied compared to most marine species. There was consensus that the possibility of such ecosystem changes often need to be taken into account in the recovery plans, especially for populations that where formerly abundant and important as either predators exerting top-down control on the ecosystem, or as a major prey species. However, few ideas of how they should be included in the actual descriptions of recovery, or even in assessing the feasibility of recovery, were proposed at the workshop. This is another area of high priority for further investigation.

Particular problems are encountered when developing recovery targets and plans for **species for which Canada represents only part of the range**. When there is a Canadian subsidiary population, it is treated like any other Canadian species: When there is no population component solely within Canadian jurisdiction and the threats are not under Canadian jurisdiction the science components of the recovery *plan* should focus on mitigating sources of harm that are under Canadian jurisdiction. The recovery *target* should be for the entire population, but if there is a subcomponent that is reliably within Canadian waters for part of each year, the description of recovery may have ancillary objectives for improving the status of that subcomponent as well. In all cases, the recovery plan should be developed to work constructively with recovery plans in place or under development by other jurisdictions in which the listed population or species is found.

WAY FORWARD

Taken together, the above considerations suggest that a reasonable suite of attributes to include in a description of recovery, and address in recovery plans, would be an abundance goal in the context of the historical population size, a reasonable population growth rate or level of surplus production, an appropriate age composition, and an abundance-weighted description of range. Some of these may not be feasible to monitor, or require costly new monitoring programmes, and could be deleted, and specific cases may make it desirable to add additional traits. However, that list comprises a useful starting point for case-specific discussions by recovery planning teams, and scientists supporting those teams.

Many aspects of this issue require further research. Particular priority is given to reconciling the benchmarks used by COSEWIC in assessing species relative to their categories of risk and those used by DFO in managing exploited resources. There are also great needs for better understanding of how ecosystems adjust to large declines in key species, and what these adjustments mean for recovery of depleted populations. In addition, there needs to be regular opportunities to pool experience to improve practice, and to determine how to quantify and take account of uncertainty throughout the framework.

Table 1. For the species or populations considered at the workshop, a tabulation of the likelihood that features of the various types would be useful as indicators of status relative to recovery: Y (yes it can be used), P (It would be possible to use, but only with some additional research and/or new monitoring), U (It would be unlikely to be informative, or else unlikely to be possible to monitor in a cost-effective manner.)

Species	**Ecol. Function**	**Abun/Biomass**	**Range/Area**	**TEK**	**Minimum #**	**Prod.-Recruit**	**Prod-Growth**	**Sex Comp.**	**Age Comp**	**Condition/Size**	**Path./Contam.**	**Subpopulation**	**Pop Growth Rate**
Beluga (EHB)	U	Y	Y	Y	Y	P	U	U	U	U	U	U	P
Upper Fraser Coho*	P	Y	Y	Y	Y	Y	Y	U	U	U	U	Y	Y
Lake Sturgeon	U	Y	Y	Y	U	P	P	Y	Y	P	U	Y	P
Wavy-rayed Lampmussel	U	Y	Y	U	P	P	U	U	P	P	U	Y	P
Abalone*	U	Y	Y	P	Y	P	U	P	P	P	U	P	P
Carmine Shiner	U	Y	Y	U	U	U	U	U	U	U	U	U	U
Black Redhorse	U	P	P	U	U	P	Y	Y	Y	Y	U	P	P
Eulachon*	U	Y	Y	P	P	U	U	U	U	U	U	Y	U
Pacific Herring	U	Y	Y	P	P	Y	P	U	Y	U	U	P	U
Porbeagle	U	Y	U	U	Y	Y	P	U	Y	U	U	U	Y
Thorny Skate **	U	Y	Y	U	P	?	?	?	U	P	U	U	P
Cusk	U	Y	Y	U	U	P	P	U	P	P	U	U	P
Rockfish/Bocaccio	U	Y	Y	U	Y	U	U	U	P	U	U	Y	U
Yellowtail **	U	Y	Y	U	P	P	P	U	P	P	U	U	P
Cod **	U	Y	Y	?	P	***	P	U	P	P	U	P	***

* Also Habitat measures
** Only range and abundance considered
*** As reproduction potential measurements (e.g. egg production), depending on the stock

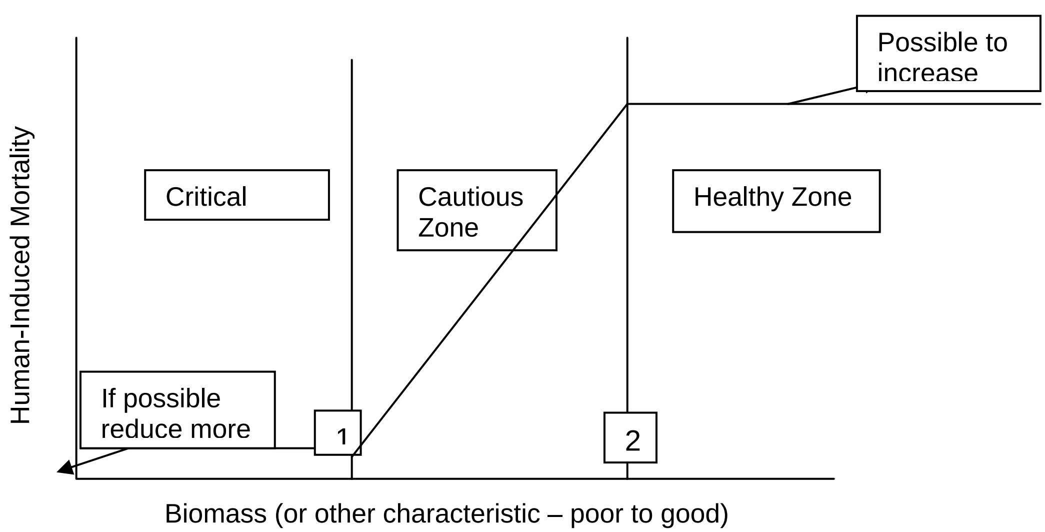

Figure 2: The fisheries management framework being considered for use in recovery descriptions and planning. Positions 1 and 2 correspond to the critical-cautious and cautious-healthy boundaries described in the text.

SOURCES OF INFORMATION

DFO, 2004. Proceedings of the National Peer Review Meeting on the Level of Allowable Harm for Newfoundland and Labrador Atlantic Cod, Laurentian North Atlantic Cod, Cusk and Bocaccio in Support of Species at Risk. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2004/040. 73 p.

DFO, 2006. Proceedings of the Meeting of the Science Working Group on the Precautionary Approach; October 20-21, 2005. DFO Can. Sci. Advis. Sec. Proceed. Ser. In prep.

FOR MORE INFORMATION

Contact: Jake Rice
Canadian Science Advisory Secretariat
Department of Fisheries and Oceans
200 Kent Street
Ottawa, Ontario
K1A 0E6
Tel: (613) 990-0288
Fax: (613) 954-0807
E-Mail: RiceJ@dfo-mpo.gc.ca

This report is available from the:

Canadian Science Advisory Secretariat
Department of Fisheries and Oceans
200 Kent Street
Ottawa, Ontario
K1A 0E6

Telephone: (613) 990-0293
Fax: (613) 954-0807
E-Mail: CSAS@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

ISSN 1480-4913 (Printed)

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION

DFO, 2005. A Framework for Developing Science Advice on Recovery Targets for Aquatic Species in the Context of the *Species At Risk Act*. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/054.