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Proceedings of the National DFO Workshop on Quantifying Critical Habitat for Aquatic Species at Risk.

Compte rendu de la réunion de l'atelier national du MPO sur la quantification de l'habitat essentiel des espèces aquatiques en péril.

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Executive Summary

Species at Risk Act and Science support: Science will play a key role in managing aquatic species-at-risk (SAR) by providing methods for identifying and mapping critical habitat (CH). The Species at Risk Act (SARA) was passed by the House of Commons in 2002 and was given Royal Assent on December 12, 2002. Proclamation of the Act is expected sometime in 2003/2004. The Minister of Fisheries and Oceans Canada is competent minister for all aquatic species, both marine and freshwater. Species status assessment, legal listing, protection and recovery are all key components of the Act (Figure 1). After a species is listed as endangered, threatened or extirpated, the protection and recovery steps have legislated timelines, and the involvement of aboriginal people and other stakeholders is required. Objective methods for quantifying and mapping critical habitat, a requirement of recovery plans, must have a sound science basis.

Habitat loss and/or degradation is a contributory factor leading to population decline for many species, and the importance of habitat protection was a key issue during the development and revision of SARA. Critical habitat is defined in the Act as 'that habitat that is necessary for the survival or recovery of a listed wildlife species'. Once a species is listed, recovery planning is mandatory, and the recovery strategy must include 'an identification of the species' critical habitat, to the extent possible, based on the best available information.

The critical habitat provision of SARA is one of several tools for protecting aquatic species-at-risk, and may only have a narrow application, as noted below. The Fisheries Act and Oceans Act, which have a broader scope (Figure 2), will be used as legislative instruments before the critical habitat provisions of SARA are invoked. Because the protection of critical habitat is likely to be controversial, science-based methods for the identification and quantification of critical habitat are essential. There will be a need to demonstrate cause and effect linkages between specific habitat and species survival before critical habitat is designated.

Workshop objectives: To provide a science perspective for this task, a DFO workshop on critical habitat was planned and implemented in December 2002. The objectives of the workshop were to:

1. identify quantitative, science-based methods for measuring critical habitat for aquatic species-at-risk;
2. prioritize the approaches and develop performance criteria to guide the use of methods in recovery plans;
3. determine the biological and habitat data needed to measure critical habitat, and
4. recommend research activities required to understand more fully the nature and scale of quantifying critical habitat.

Despite the limited time-frame of the workshop, an effective scoping of the Science issues was accomplished.

The workshop program included formal presentations (Table 1) and five breakout discussion sessions. To address the four workshop objectives, breakout sessions focused on five themes:

- What items need to be specified for a SAR before we can proceed to define, map and quantify its critical habitat?
- What methods are available for the identification and measurement of CH in freshwater and marine environments?
- How do life-stage ontogenies and/or metapopulation factors affect the identification and measurement of CH?
- Identify interim guidelines/criteria for selecting methods/approaches to defining and mapping CH;
- Identify key information, conceptual gaps and a priorization of research for improving the toolbox and guidelines/criteria.

Each session began with a keynote talk by a specialist either from the United States or Canada, followed by presentations from DFO scientists, and then by directed discussion in smaller breakout groups. Notes from each session discussion are summarized in this report (Synthesis of Breakout Notes, pg. 2).

Salient points from the breakout group notes and from presentations that address the four workshop objectives are given below.

1. Methods for measuring critical habitat: Several quantitative science-based methods for measuring critical habitat were proposed in the presentations and during the breakout discussions. The approach and methods depend on the level of information available for the at-risk species (Table 2, modified from T. Bigford). Five Information Levels were identified, ranging from 0 (know nothing) to 4 (knowledge of productivity). Population targets for recovery will be qualitative and critical habitat targets will be broad in scope and geographic area if the information level is low. If the information level is high, population targets will be quantitative and critical habitat will be narrowly defined. In addition to helping determine the appropriate methods for determining CH, the matrix can be used to identify data gaps.

Workshop presentations are listed by information level in Table 3. If no information is available on habitat needs for the SAR (no presentations fitted this category), the priority would be to conduct a comprehensive search of relevant data and to conduct basic research on biology and habitat requirements. Approaches for operating with limited data included the use of surrogate species, the Traditional Ecological Knowledge (TEK) method (see below), and inference. Guidance will be needed to determine a standard for ‘extent possible’ and the adequacy of or minimum information needed to designate critical habitat. Experience from the United States will be useful (*cf.* Data Quality Act). If the information is inadequate for designating CH, other tools are available (Figure 2).

Knowledge of presence-absence, distribution and migration corridors, the next information level, can be generated from visual observation, field survey and tagging data (e.g., marine mammals) and by TEK (Table 3). Presence-absence data can be used to generate cursory maps of species distribution, range and habitat. Designated Marine Protected Areas (MPA, Oceans Act) can be used as a tool for protecting habitat over large areas and can be beneficial for several target species. The assumption is that MPA’s include critical habitat for certain target species.

Knowledge of population density, life stage growth and survival rates and productivity will allow the application of increasingly detailed models for identifying critical habitat (information levels 2 to 4 in Tables 2 and 3). Density-fish size regression models can be used to determine area-per-individual (API) and hence the habitat area requirements of a population, if density is known for different fish sizes and habitats. In many instances, habitat-dependent functions are poorly known. Further research is needed, using existing or new methods to link fish density and habitat (Probability Density Function [PDF], Ideal Free Distribution [IFD] and other models). Knowledge of life-stage specific rates and functional linkages with habitat will allow the use of sophisticated Meta-population or Population Viability Analysis (PVA) to determine critical habitat (Table 3). Many participants emphasized that PVA models can only be applied to 'data-rich' species (including knowledge of density-dependent survival), and they need to be validated for each species. At-risk species with level 4 information (productivity) are rare. Long-term data on fish productivity and demonstrated linkages with habitat can be used to quantify critical habitat with reasonable confidence. Fraser River coho salmon on the west coast and inner Bay of Fundy Atlantic salmon on the east coast are two examples of at-risk populations for which productivity data are available.

Additional generic methods identified during the breakout discussions were complementary to the techniques specified in the presentations. Methods common to both freshwater and marine environments were: 1) life history approaches (e.g., models specified previously in Table 2 with information level 3 or higher); 2) mapping techniques, ranging from simple occurrence data, intermediate GIS approaches using local knowledge (TEK) data, to more sophisticated habitat mapping (e.g., hydroacoustic multibeam) with associated ground-verification of habitat types and species use; 3) modelling techniques, from simple to sophisticated depending on the amount of data, with sensitivity analysis to identify potential life stage or habitat bottlenecks; 4) experimental approaches; 5) micro-habitat approaches, but with the reservation that it is often difficult to link the results to a population level scale; and 6) behavioural approaches (e.g., using acoustic tags).

Similarities between freshwater and marine methods were: both require hierarchical approaches depending on available information: as knowledge increases, uncertainty decreases and CH can be defined more precisely; both involve assessment across scales and ecotones (landscape, estuaries, transition zones); the need to couple life history and habitat; and a common focus on modelling. Dissimilarities are also apparent: marine environments are larger scale that requiring remote sensing tools and dynamic habitat (i.e., habitat associated with phenomena rather than specific places) may be a more frequent feature of marine systems (upwelling, ice edge) than freshwater systems. Tracking dynamic habitat is a challenge. In this context, experiences in the United States for designating Essential Fish Habitat will be helpful (geographically explicit versus oceanographic conditions). MPA's are an important management tool in marine areas and potentially in freshwaters.

2. Guidelines/criteria for selecting methods: The second workshop objective was to prioritize approaches and develop performance criteria to guide the use of methods. The Information Level categories (Table 2) provide an effective tool for prioritizing approaches. The recovery plan goals, approach and the appropriate methods for identifying critical habitat will depend on the level of available information for each species.

The objective of breakout Session 5 was to address performance criteria, and a listing of operational guidelines for assessing critical habitat was presented in a flow chart (Figure 3). The four steps in the chart, assessment, decision to designate regardless of cost, decision based on cost, and defer, emphasize that the process is iterative.
These guidelines were preliminary as workshop discussion did not advance far enough to provide details on several key issues.

The list of advice to managers generated by the breakout groups was extensive but not necessarily complete (Table 4). To ensure that decision making for identifying and protecting critical habitat is transparent, a strong communication plan will be a priority. Effective communication is needed between the Oceans (MPA's; Fish Habitat Management [FHM]) and Science Sectors (Fisheries Act), as critical habitat is only one of several tools for protecting populations and habitat. Not all habitat is critical. Other (non-habitat) stressors must be managed as part of the recovery strategy (e.g., exploitation; by-catch). Effective communication with stakeholders is mandatory, as is communication with provincial, territorial and international jurisdictions if trans-boundary migratory species are involved. Uncertainty and precaution should be explicit at all stages of the process. Recovery management activities need to be monitored to evaluate effectiveness; performance indicators and adaptive management provisions should be part of the plan. Science peer review of all aspects of the recovery plan would be consistent with a precautionary approach and would lead to advice for refinements as more information became available.

Key implementation issues were apparent. A broad operational definition of critical habitat is needed for both Science and managers, that must include physical, biological and water quality aspects, as all affect survival and population viability. Habitat can be either spatially static (specific geographic area) or dynamic (gyres, upwelling), emphasizing that recovery plans must be flexible and encompassing. A workshop between managers and Science is needed to develop guidelines and an operational manual for characterizing critical habitat. These implementation tasks will require input from Science (see *Next Steps* below).

3. Information needs: The biological and habitat data needed to measure critical habitat were discussed in Session 1 and at varying levels of detail in other breakout groups and in all presentations. At the outset, survival and recovery goals in recovery plans should be quantitative. Therefore both population (target size; survival parameters) and habitat goals (geographic range in area; habitat quality requirements) need to be defined. Basic life stage information for each species and habitat use by each stage is a prerequisite for identifying critical habitat. Knowledge gaps will be a challenge for many species, and therefore dealing with uncertainty and adopting a precautionary approach will be paramount, particularly for data-poor species.

4. Research priorities: Five basic research priorities were identified by the final breakout group (Table 5) that parallel the information needs. Increased knowledge of functional linkages between habitat and population dynamics (survival, growth, recruitment) is a research priority for all at-risk species, even for well-studied species. Survival and recovery goals need to be determined by Science, including the determination of a minimum viable population size. Knowledge of carrying capacity and production is needed in addition to the basic life stage information mentioned above. Adopting a life-stage approach for identifying CH was advocated by all participants. The initial identification of critical habitat by Science will be interim, acknowledging that it will be an iterative process that requires refinement as the knowledge level increases.

Undertaking **case studies** was identified as a research priority by all breakout groups. In addition to increasing knowledge about a particular species, case studies will point out knowledge gaps needing redress, serve as models for less well-studied species, and also, if revisited periodically, be used as a measure of ground-truthing the effectiveness of approaches to CH.

Additional Science priorities (detailed by breakout groups in Table 6) were: 1) Test **model approaches** by conducting case studies and simulations. A modelling approach was judged to be useful for species at all information levels (Table 3). A consensus recommendation was to maintain or preferably increase DFO's Science capacity for modelling. 2) Establish a **standardized database** structure for SAR, including geo-referencing. 3) Provide Science advice for **habitat mapping**. To be useful, maps need to be comprehensive (physical, chemical, biotic, multispecies linkages, high productivity areas) and at an appropriate spatial scale for the target species. 4) Design and help implement **monitoring programs** for recovery plans. Monitoring programs can be used to validate CH models, and to support an adaptive management approach for recovery programs. Monitoring programs and directed research would also be useful for evaluating MPA's. On-going monitoring projects to provide data for stock assessment (Atlantic cod, Atlantic salmon, coho salmon) are invaluable for dealing with at-risk species. 5) Identify the **appropriate biological unit** for conservation, management and information collection (ensuring the information applies to the appropriate life history stage as well as the appropriate taxonomic unit). 6) Undertake **reference species** studies to allow extrapolation within species guilds and/or index habitats. 7) Investigate the relationship between **abundance and habitat use** (source – sink habitat, as evidenced in the presentations on coho salmon and cod in the Gulf of St. Lawrence). Additional priorities and details are provided in Table 6.

Next steps: The future steps requiring Science input are:

- co-ordinate case studies of 4 or 5 key species (models for identifying critical habitat need to be tested on species varying from data-rich to data-poor);
- prepare draft guidelines for the process of designating critical habitat;
- set guidelines for information standards (standards for 'extent possible'); and
- plan and implement a peer review workshop to define critical and important habitat.

Science-based methods for identifying critical habitat of terrestrial species are being developed by other agencies. The mandate of the Interdepartmental Critical Habitat Working Group (ICHWG) is to 'recommend a co-ordinated process and guidance for implementation of the legal and policy components of SARA that relates to critical habitat'. Agency members of ICHWG are Environment Canada (Canadian Wildlife Service), Parks Canada and DFO. To ensure consistency of approaches for the 'next step' tasks, DFO will continue to participate and collaborate as a member of the ICHWG.

Sommaire

Loi sur les espèces en péril et soutien des Sciences : Les Sciences joueront un rôle majeur dans la gestion des espèces aquatiques en péril en fournissant des méthodes pour identifier et cartographier les habitats essentiels. La *Loi sur les espèces en péril*, adoptée par la Chambre des Communes en 2002, a reçu la sanction royale le 12 décembre 2002 et devrait être proclamée en 2003 ou en 2004. Le ministre des Pêches et des Océans du Canada est le ministre compétent pour toutes les espèces marines et d'eau douce. L'évaluation de la situation des espèces en péril, leur inscription sur la liste des espèces en péril, leur protection et leur rétablissement sont tous des éléments clés de la Loi (figure 1). La protection et le rétablissement des espèces en péril, menacées ou disparues figurant sur la liste des espèces en péril sont assujettis aux délais prescrits par la Loi et nécessitent la participation des peuples autochtones et d'autres intervenants. Les méthodes objectives utilisées pour quantifier et cartographier les habitats essentiels qu'exigent les plans de rétablissement doivent reposer sur des fondements scientifiques solides.

La perte d'habitats ou la dégradation de ceux-ci est l'un des facteurs qui mènent au déclin de la population de nombreuses espèces. C'est pourquoi l'importance de la protection de l'habitat était l'un des principaux points à considérer dans l'élaboration et la révision de la *Loi sur les espèces en péril*. La Loi définit un habitat essentiel comme étant l' « habitat nécessaire à la survie ou au rétablissement des espèces sauvages inscrites ». Dès qu'une espèce est inscrite, il est impératif de planifier son rétablissement. Le programme de rétablissement doit comprendre la désignation de l'habitat essentiel de l'espèce, fondée sur la meilleure information accessible, dans la mesure du possible.

La disposition relative aux habitats essentiels de la *Loi sur les espèces en péril* est l'un des nombreux outils servant à protéger les espèces aquatiques en péril. Comme il est indiqué ci-après, il est possible de l'appliquer de façon restreinte seulement. La *Loi sur les pêches* et la *Loi sur les océans*, qui ont une plus grande portée (figure 2), seront employées comme instruments législatifs avant que la disposition sur les habitats essentiels de la *Loi sur les espèces en péril* ne soit invoquée. Puisque la protection des habitats essentiels est susceptible de prêter à controverse, des méthodes scientifiques pour désigner et quantifier ceux-ci sont indispensables. Il faudra établir la relation de cause à effet entre l'habitat spécifique et la survie de l'espèce avant de désigner un habitat essentiel.

Objectifs de l'atelier du MPO : En vue d'obtenir une perspective scientifique de cette tâche, le MPO a tenu un atelier sur les habitats essentiels en décembre 2002. Voici les objectifs de cet atelier.

1. Trouver des méthodes quantitatives scientifiques pour mesurer l'habitat essentiel des espèces aquatiques en péril.
2. Classer les approches par ordre de priorité et définir des critères de rendement pour orienter l'utilisation des méthodes exposées dans les plans de rétablissement.
3. Déterminer quelles données sur les caractéristiques biologiques et l'habitat sont nécessaires pour mesurer les habitats essentiels.
4. Recommander des activités de recherche qui nous aideront à mieux connaître la nature et l'échelle de quantification des habitats essentiels.

Malgré la durée limitée de l'atelier, les questions liées aux Sciences ont été traitées de façon efficace.
L'atelier comportait des exposés magistraux (tableau 1) et cinq séances en petits

groupes. Pour atteindre les quatre objectifs de l'atelier, les séances en petits groupes ont été axées sur les cinq thèmes énumérés ci-après.

- Quels éléments doit-on préciser pour une espèce en péril avant de pouvoir définir, cartographier et quantifier son habitat essentiel?
- Quelles méthodes peut-on utiliser pour désigner et mesurer un habitat essentiel dans des environnements d'eau douce et marins?
- Comment l'ontogénie et les facteurs de métapopulation se répercutent-ils sur la désignation et la mesure de l'habitat essentiel?
- Établir des critères provisoires de sélection des méthodes/approches pour désigner et cartographier les habitats essentiels.
- Dégager l'information clé et les lacunes conceptuelles et classer les recherches par ordre de priorité pour améliorer la boîte à outils et les critères.

Chaque séance commençait avec l'exposé d'un spécialiste des États-Unis ou du Canada, suivi de présentations de scientifiques du MPO, puis d'une discussion dirigée en plus petits groupes. On trouve un résumé du compte rendu de chaque discussion à la section Synthèse des comptes rendus des séances en petits groupes du présent document.

Voici les points saillants des discussions et des présentations portant sur les quatre objectifs de l'atelier.

1. Méthodes pour mesurer les habitats essentiels : Dans les présentations et au cours des discussions en petits groupes, on a proposé plusieurs méthodes quantitatives scientifiques que l'on peut utiliser pour mesurer les habitats essentiels. Le choix de l'approche et des méthodes repose sur l'information disponible pour l'espèce en péril (tableau 2). Cinq niveaux d'information ont été établis, de 0 (aucune information) à 4 (connaissance de la productivité). Si le niveau de l'information est faible, les objectifs de rétablissement des populations seront qualitatifs et les objectifs liés aux habitats essentiels auront une grande portée et couvriront un vaste secteur géographique. Si le niveau de l'information est élevé, les objectifs liés aux populations seront quantitatifs et l'habitat essentiel sera défini avec précision. La matrice peut non seulement être utilisée pour déterminer les méthodes appropriées nécessaires à la définition de l'habitat essentiel, mais aussi pour faire ressortir les données manquantes.

Les présentations données au cours de l'atelier sont énumérées dans le tableau 3 en fonction du niveau de l'information transmise. Si aucune information sur les besoins relatifs à l'habitat n'est disponible pour l'espèce en péril cible (aucune présentation ne portait sur ce sujet), la priorité serait de procéder à une recherche exhaustive pour obtenir des données pertinentes et de mener des travaux de recherche fondamentale sur les besoins biologiques et les exigences en matière d'habitat. Les méthodes mettant en œuvre des données limitées font appel notamment à une espèce de remplacement, au savoir écologique traditionnel (SET) — voir ci-après, et à l'inférence. Des orientations seront nécessaires pour l'établissement d'une norme définissant la portée de l'expression « dans la mesure du possible » et le type ou la quantité minimale d'information nécessaire pour désigner un habitat essentiel. L'expérience des États-Unis sera utile (*Data Quality Act* [Loi sur la qualité des données]). Si l'information ne permet pas de désigner l'habitat essentiel, d'autres outils sont disponibles (figure 2).

Divers moyens permettent d'obtenir des données sur la présence ou l'absence d'une espèce, sa répartition, ses corridors de migration et le niveau d'information suivant :

observation, étude sur le terrain, marquage (mammifères marins, par ex.) et SET (tableau 3). Les données sur la présence ou l'absence de l'espèce peuvent servir à produire des cartes sommaires de la répartition de l'espèce, de son aire de répartition et de son habitat. Il est possible d'utiliser les zones de protection marines (ZPM) désignées (*Loi sur les océans*) pour protéger des habitats de grandes superficies; les ZPM peuvent être salutaires pour plusieurs espèces cibles. L'hypothèse alors avancée est que les ZPM abritent l'habitat essentiel de certaines espèces cibles.

La connaissance de la densité de la population, de ses taux de croissance et de survie en fonction de ses stades de développement et de sa productivité permettra la mise au point de modèles de plus en plus précis pour désigner les habitats essentiels (niveaux d'information 2 à 4 dans les tableaux 2 et 3). Des modèles de régression de la densité-taille du poisson peuvent être utilisés pour déterminer l'aire par individu (API), laquelle permettra ensuite de calculer la surface d'habitat nécessaire pour une population, si on connaît la densité pour différentes tailles et différents habitats de poisson. Dans bien des cas, les fonctions qui dépendent de l'habitat sont mal connues. Il faut poursuivre les recherches, au moyen de méthodes existantes ou de nouvelles méthodes, afin de corréler la densité de poisson et l'habitat (fonction de densité, répartition idéale libre et autres modèles). La connaissance des taux de croissance spécifiques aux stades de développement et des liens fonctionnels avec l'habitat rendra possible l'utilisation d'analyses poussées de la viabilité d'une métapopulation ou d'une population pour déterminer l'habitat essentiel (tableau 3). Un grand nombre de participants ont souligné que les modèles d'analyse de la viabilité d'une population ne peuvent être appliqués qu'aux espèces bien documentées (dont on connaît notamment le taux de survie en fonction de la densité), et qu'ils doivent être validés pour chaque espèce. Les espèces en péril pour lesquelles on détient de l'information de niveau 4 (productivité) sont rares. Des données à long terme sur la productivité des poissons et les liens établis avec l'habitat peuvent servir à quantifier l'habitat essentiel de manière relativement fiable. Le saumon coho du fleuve Fraser, sur la côte ouest, et le saumon atlantique de l'intérieur de la baie de Fundy, sur la côte est, sont deux exemples de populations en péril pour lesquelles on dispose de données sur la productivité.

D'autres méthodes génériques mentionnées au cours des discussions en petits groupes apportent un complément aux techniques citées dans les présentations. Les méthodes communes aux environnements d'eau douce et marins sont : 1) les méthodes qui mettent en œuvre le cycle biologique (par exemple, modèles du tableau 2 indiqués précédemment avec information de niveau 3 ou plus); 2) les techniques de cartographie employant des données à occurrence unique, en passant par celles qui ont recours à un système d'information géographique (SIG) intermédiaire utilisant le savoir écologique traditionnel et par les techniques de cartographie de l'habitat plus poussée (par exemple, cartographie hydroacoustique à faisceaux multiples) combinées à la réalité de terrain des types d'habitat et de l'utilisation des espèces; 3) les techniques de modélisation, simples ou complexes, selon la quantité de données, avec analyse de la vulnérabilité pour déterminer les goulots d'étranglement potentiels de l'habitat ou des stades de développement; 4) les méthodes expérimentales; 5) les méthodes axées sur les microhabitats, avec la réserve qu'il est souvent difficile de lier les résultats à une échelle de niveaux de population; 6) les méthodes axées sur le comportement (par exemple, utilisant des étiquettes acoustiques).

Voici les similitudes entre les méthodes employées pour les environnements d'eau douce et les environnements marins : approches définies par le niveau d'information disponible : plus la quantité de données accessibles est élevée, plus l'incertitude est faible et, par conséquent, plus l'habitat essentiel est précis; évaluation à toutes les échelles et dans tous les écotones (paysages, estuaires, zones de transition); nécessité de lier le cycle biologique et l'habitat; degré d'importance semblable accordé à la modélisation. Les différences sont également évidentes : les environnements marins présentent des échelles plus larges qui nécessitent des dispositifs de télédétection; l'habitat dynamique (c.-à-d., l'habitat lié à des phénomènes plutôt qu'à des endroits spécifiques) peut être plus fréquent dans les environnements marins (remontées d'eau, lisières de glace) que dans les environnements d'eau douce. Le suivi d'un habitat dynamique est un défi en soi. Les expériences menées aux États-Unis pour désigner l'habitat essentiel du poisson seront donc utiles (géographiquement explicite par rapport à certaines conditions océanographiques). Les ZPM constituent un important outil de gestion dans le cas des zones marines et un outil de gestion potentiel dans le cas des eaux douces.

2. Critères de sélection des méthodes : Le deuxième objectif de l'atelier consistait à classer les approches par ordre de priorité et à établir des critères de rendement pour orienter l'utilisation des méthodes. Les niveaux d'information (tableau 2) sont des outils efficaces pour classer les approches par ordre de priorité. Les objectifs des plans de rétablissement, l'approche et les méthodes appropriées pour désigner les habitats essentiels sont fonction du niveau de l'information disponible pour chaque espèce.

L'objectif de la cinquième séance en petits groupes était d'établir des critères de rendement. Une liste des lignes directrices opérationnelles concernant l'évaluation de l'habitat essentiel a été présentée sous forme d'organigramme (figure 3). Les quatre étapes comprises dans l'organigramme — évaluation, décision de désigner une espèce indépendamment du coût, décision fondée sur le coût et report — indiquent bien que le processus est itératif. Ces lignes directrices ne sont qu'au stade de l'ébauche, la durée de la discussion n'ayant pas permis que l'on obtienne des précisions sur plusieurs questions clés.

La liste des conseils aux gestionnaires (tableau 4) issue des groupes de discussion est exhaustive, sans être nécessairement complète. Afin d'assurer la transparence du processus de décision concernant la désignation et la protection des habitats essentiels, il est impératif de disposer d'un plan de communication bien étayé. La communication entre le MPO (ZPM; gestion de l'habitat du poisson) et les Sciences (*Loi sur les pêches*) doit être efficace, puisque les habitats essentiels ne représentent que l'un des divers outils servant à protéger les populations et l'habitat. Tous les habitats ne sont pas essentiels. La gestion d'autres facteurs d'agression (non liés à l'habitat) doit faire partie de la stratégie de rétablissement (par exemple, l'exploitation et les prises accessoires). Si des espèces migratrices transfrontalières sont en cause, il faut que la communication avec les intervenants soit bonne, tout comme la communication avec les entités provinciales, territoriales et internationales. L'incertitude et les mesures de précaution doivent être explicites à toutes les étapes du processus. Il est nécessaire de surveiller les activités de gestion du rétablissement pour évaluer l'efficacité; le plan doit comprendre des indicateurs de rendement et des dispositions de gestion adaptative. L'examen par des pairs des Sciences de tous les aspects du plan de rétablissement doit être conforme à une approche préventive et doit mener à la proposition d'améliorations, puisque davantage d'information sera disponible.

Les questions clés relatives à la mise en application étaient évidentes. Une définition opérationnelle générale des habitats essentiels est nécessaire pour les Sciences et les gestionnaires. Elle doit couvrir les aspects physiques et biologiques et la qualité de l'eau, puisqu'ils ont un impact sur la survie et la viabilité de la population. L'habitat peut être statique sur le plan géographique (secteur géographique précis) ou dynamique (gyres, remontées d'eau); les plans de rétablissement doivent donc être souples et englobants. Les gestionnaires et des représentants des Sciences doivent se réunir en atelier pour élaborer des lignes directrices et un manuel opérationnel sur la caractérisation des habitats essentiels. Ces tâches de mise en œuvre nécessitent la participation des Sciences (voir les *Prochaines étapes* ci-après).

3. Information nécessaire : La question des données biologiques et des données sur l'habitat requises pour mesurer l'habitat essentiel a été traitée à la première séance et à divers niveaux dans d'autres groupes de discussion ainsi que dans toutes les présentations. Au début, les objectifs concernant la survie et le rétablissement inscrits dans les plans de rétablissement doivent être quantitatifs. En conséquence, des objectifs de population (taille cible; paramètres de survie) et d'habitat (aire de répartition; exigences relatives à la qualité de l'habitat) doivent être définis. L'information de base sur les stades de développement de chaque espèce et sur l'utilisation de l'habitat à chaque stade est nécessaire pour que l'on puisse désigner les habitats essentiels. L'insuffisance de données constituera un obstacle dans le cas de bien des espèces et, par conséquent, il sera primordial de gérer l'incertitude et d'adopter une approche prudente, en particulier pour les espèces peu documentées.

4. Priorités de recherche : Au cours de la dernière séance en petits groupes (tableau 5), on a défini cinq priorités de recherche fondamentale qui correspondent aux besoins d'information. La connaissance accrue des liens fonctionnels entre l'habitat et la dynamique des populations (survie, croissance, recrutement) est une priorité de recherche pour toutes les espèces en péril, y compris celles qui ont fait l'objet d'études exhaustives. Ce sont les Sciences qui doivent fixer les objectifs de survie et de rétablissement, y compris la taille de population minimale viable. En plus de l'information de base sur les stades de développement mentionnée ci-dessus, il est nécessaire de connaître la capacité de support et la production. L'adoption d'une approche reposant sur les stades de développement pour désigner les habitats essentiels a été préconisée par tous les participants. La désignation initiale des habitats essentiels effectuée par les Sciences est temporaire, puisqu'il s'agit d'un processus itératif à améliorer au fur et à mesure que le niveau des connaissances augmente.

Selon tous les groupes de discussion, la réalisation **d'études de cas** est une priorité de recherche. Les études de cas repoussent les limites de la connaissance d'une espèce particulière et en plus, font ressortir les lacunes à combler sur le plan des connaissances, servent de modèles pour les espèces qui ont fait l'objet d'études moins poussées et, enfin, si elles sont réexaminées périodiquement, peuvent être employées comme mesure sur le terrain de l'efficacité des approches servant à définir l'habitat.

D'autres priorités ont été établies pour les Sciences (énoncées par groupe de discussion au tableau 6). 1) Mettre à l'essai des **approches types** en procédant à des études de cas et à des simulations. La modélisation a été jugée utile pour toutes les espèces, indépendamment du niveau de l'information détenue sur chacune d'elle (tableau 3). Tous se sont entendus pour recommander le maintien ou, de préférence, l'augmentation de la capacité de modélisation du secteur des Sciences du MPO. 2)

Établir une structure de **base de données normalisée** pour les espèces en péril, y compris le géoréférencement. 3) Conseiller les Sciences concernant **la cartographie de l'habitat**. Pour être utiles, les cartes doivent être complètes (données physiques, chimiques et biotiques, liens entre espèces multiples, aires de productivité élevée) et à une échelle géographique appropriée pour l'espèce cible. 4) Concevoir et aider à mettre en œuvre des **programmes de monitorage** des plans de rétablissement. Les programmes de monitorage peuvent être employés pour valider des modèles d'habitats essentiels et pour soutenir une approche de gestion adaptative mise à profit dans des programmes de rétablissement. Des programmes de monitorage et des recherches dirigées peuvent également être utiles pour évaluer les ZPM. Les projets de monitorage en cours destinés à fournir des données pour l'évaluation de stocks (morue atlantique, saumon atlantique, saumon coho) sont d'une valeur inestimable pour le rétablissement des espèces en péril. 5) Déterminer l'**unité biologique appropriée** pour la conservation, la gestion et la collecte d'information (en veillant à ce que l'information corresponde au stade approprié du cycle biologique et à l'unité taxonomique appropriée). 6) Effectuer des études sur les **espèces de référence** pour permettre une extrapolation dans des guildes ou pour répertorier des espèces. 7) Étudier le rapport entre **l'abondance et l'utilisation de l'habitat** (habitat source-puits, comme il a été démontré dans les présentations sur le saumon coho et la morue dans le Golfe du Saint-Laurent). D'autres priorités et données figurent au tableau 6.

Prochaines étapes : Voici les prochaines étapes qui nécessiteront la contribution des Sciences.

- Coordination des études de cas de quatre ou cinq espèces clés (des modèles pour définir l'habitat essentiel doivent être mis à l'essai pour des espèces allant de bien documentées à peu documentées).
- Formuler des lignes directrices concernant le processus de désignation des habitats essentiels.
- Établir des lignes directrices pour fixer la définition d'un terme ou d'une expression (dans la mesure du possible).
- Planifier et réaliser un atelier avec examen par les pairs pour définir les habitats essentiels et importants.

Des méthodes scientifiques pour désigner l'habitat essentiel d'espèces terrestres sont élaborées par d'autres agences. Le mandat du Groupe de travail interministériel sur l'habitat essentiel est de recommander un processus et une orientation coordonnés pour la mise en application des composantes juridiques et d'orientation de la *Loi sur les espèces en péril* qui portent sur les habitats essentiels. Le groupe de travail précité est formé de représentants d'Environnement Canada (Service canadien de la faune), de Parcs Canada et du MPO. Afin d'assurer l'uniformité des approches pour les « prochaines étapes », le MPO continuera d'apporter sa participation et sa collaboration à titre de membre du groupe de travail.

Introduction

Estimating the critical habitat requirements for a species-at-risk (SAR) depends on knowing both the viable population size and the amounts of habitats needed to support it. For recovery planning as well, it will be necessary to ensure that sufficient amounts of suitable habitat are available for the population as it rebuilds, even if the remnant population does not appear habitat limited. A preliminary feasibility assessment of methods for estimating critical habitats for aquatic SAR was investigated at a national workshop. Results of the Workshop are reported in this document, along with a consensus on priority research to further investigate and implement recommended methods for managing Canada's aquatic SAR.

Workshop Format

A DFO Science Steering Committee (Appendix 1) planned and implemented a 4-day workshop to examine the scientific challenge of identifying and quantifying critical habitat for aquatic species-at-risk. While there is much experience and literature extant regarding critical habitat in terrestrial ecosystems, our knowledge and understanding of critical habitat in aquatic ecosystems is more limited. The purpose of the Science workshop was to bring together keynote speakers from the United States and Canada, as well as a number of scientists from within DFO to examine the state of the art, to identify and prioritize some potential approaches to identification and quantification of critical habitat, to develop performance criteria that will guide the use of different approaches by those developing conservation and recovery plans for specific aquatic species listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and to recommend next steps for the further development, testing, and application of potential tools.

The workshop was by invitation and was limited to 40 people (Appendix 1). In addition to keynote speakers, the workshop Steering Committee solicited abstracts from the Regions for consideration in the development of the workshop program. The number of presentations was limited to 17 (Table 1) to allow time for breakout discussion. In addition, participants were encouraged to submit a working paper for use at the workshop and inclusion in the proceedings.

The steering committee sought two types of presentation: 1) case studies of individual aquatic animals (that may or may not be COSEWIC-listed) showing how critical habitat was identified and quantified in particular instances; 2) presentations on tools, approaches, or new ideas that have the potential for application to the critical habitat issue. Few have worked directly on the critical habitat question but some may have ideas for new approaches or new uses of existing data and knowledge. In either instance, the emphasis was on rigorous methods that lead directly to the mapping of critical habitats. Mapping of critical habitats using geographic information systems is required for the operational and regulatory application of the species-at-risk legislation.

Results of the workshop are presented in this Proceedings document. An Executive Summary is followed by a description of the Workshop Format and detailed synthesis notes from the five breakout sessions. The list of participants is in Appendix 1, abstracts of presentations and working papers are in Appendix 2, and Terms of Reference for the Workshop are in Appendix 3.

Workshop papers are currently being reviewed for possible upgrade to Research Document status. Copies of presentations will be available upon request (from R. Randall).

Synthesis of Breakout Session Notes

Session/ 1: What items need to be specified for a species-at-risk (SAR) before we can proceed to define and map its critical habitat ?/Quels éléments doivent être précisés pour les espèces en péril avant de définir et de délimiter leur habitat essentiel?

	Group A	Group B	Group C
Facilitator	Chris Wood	Ken Minns	Patrick O'Reilly
Rapporteur	Brian Nakashima	Anne Phelps	Peter Achuff

Discussion by the three break-out groups resulted in a list of items/issues that need to be specified or considered before critical habitat can be defined or mapped. As expected, many of the issues and discussion items were similar among the groups; the list below was edited to reduce replication. The first 8 issues were identified as high priority by one or more breakout groups. Management advice and research priorities identified during session 1 and all subsequent sessions are provided in Table 4 and Table 6, respectively.

Items/ issues from session 1:

1. Designating critical habitat: dealing with **uncertainty** and adopting a **precautionary** approach:
   - two options are 1) designate a large area initially, and then redefine as data become available, or 2) start defensively by designating a smaller (defensible) area and then expand as required. Much time (70%) is spent on this scale issue in the United States. In the first round, everything is designated as essential habitat;
   - as information increases over time, the view of critical habitat may change;
   - the peer review process is considered to be part of a precautionary approach;
   - the Oceans Act touts 'start large' as a precautionary approach;
   - what thresholds of information are needed to identify critical habitat?

2. What is **survival or recovery** (= viability)?
   - it is important to state survival and recovery goals clearly at outset. Otherwise how do you know when a species has recovered?
   - recovery goals should include abundance, distribution and habitat goals;
   - recovery can be defined as the probability of survival based on numbers and time;
   - survival is when numbers reach a minimum threshold (k1) where the population is no longer declining. Probability of survival = probability(N>k1 within t1 yr/gen). The time frame needs to be defined (years or generations);
   - recovery is achieved when numbers reach a threshold (k2) allowing downgrading to a less-at-risk status and/or delisting;
   - quantitative population parameters need to be identified, i.e., population extinction and recovery rates;
   - there is a difference in the effective population size (Ne) among fish taxa. Ratios of effective population size to census population size (Ne/Nc) for freshwater and anadromous species are different than for marine species at low population levels;
   - it is important to consider current versus historical distributions.

3. **Spatially-dynamic habitat** and migratory species:
   - dynamic habitat is mobile, such as patches, fronts and warm core rings. Relates to species without clear spatial habitat designations, such as pelagic species and marine mammals;
   - may need to define habitat in terms of its function (e.g., broken ice for whales) rather than as a spatially-explicit feature;
   - aquatic habitat is likely to be more dynamic than terrestrial habitat;
   - seasonal habitat, like flooded terrestrial habitat, may be critical;
   - how do we deal with environmental variability effects on habitat (climate changes, exotic species, changes in competitors and predators)? Parameterize PVA model with historic data, extrapolate trends, and track changes in location of habitat with environmental change.

4. How inclusive is 'habitat' of **other factors/threats** that affect viability?
   - other stressors/threats include exploitation, pollution, nutrients, ecosystems, prey levels;
   - in the U.S., threats are identified and mitigated after the area is defined as critical;
   - habitat is not just quantitative, but is also qualitative. Quality is defined by population parameters;
   - should we designate CH based on human or natural effects?
   - in marine areas, water characteristics are habitat features;
   - need to know primary cause of decline of population;
   - classification of stressors to identify species-at-risk due to habitat threats.

5. **Species life stage table** with spatial and temporal habitat needs:
   - for each life stage, need location (GPS, GIS), critical/risk, time of year, survey method, substrate, stressors;
   - known population abundance, locations, characteristics;
   - critical life stage bottlenecks (e.g., estuaries); limiting factors that drive abundance;
   - habitat per individual;
   - in the United States, Habitat Suitability Indices (HSI) are known for many species, providing a quantitative method of deriving life history information. However, HSI indices are often lacking for SAR.

6. Is **habitat quality** necessary to identify critical habitat?
   - habitat quality influences on population viability are important. Some habitat of low quality may not be sufficient for recovery. Information on habitat quality is needed to access risk. It is important to identify source and sink areas, to identify unoccupied habitat for potential range expansion or re-introduction, and to determine why the habitat is unoccupied;
   - focus recovery plan on area of most return (best habitat, i.e., habitat that enhances population viability);
   - knowing presence of a species is the first step, determining quality is the second step. Knowledge of pressures on the population (see 4) is important for this process;
   - classify habitat into high and medium importance, and map. Classification should be hierarchical;
   - certain areas may be easier to manage than others (e.g., poaching and abalone) and should be given priority.

7. Need to evaluate **PVA** as a tool for identifying critical habitat:
   - PVA is data demanding, because of the need for age-structured data;
   - all variables in a PVA model must be supported with quantitative information.

8. Must deal with **data-poor species**:
   - Use a tiered approach depending on different levels of information.
   - Use inference from other species.
   - Is it valid to extrapolate results from other areas (different latitudes), e.g., the United States?

9. Identify **target population size**:
   - given a population size goal, how much habitat is needed for that population?
   - assume carrying capacity;
   - managers want to know area (km^2), but the food requirements for a species may be difficult to estimate on an area basis (e.g., consumption requirements of blue whale).

10. Synergies of **critical habitat for multiple species** (umbrella effect):
    - recovery of one species could affect another (cod versus scallop harvest on Georges Bank; sea otters versus abalone on the Pacific coast).

11. **Range of occurrence** versus area of occupancy (patches):
    - should look at range for pelagic species;
    - there is a difference between maximum range and the more narrow scale of critical habitat.

12. Can critical habitat be created?
    - e.g., artificial reefs off Florida;
    - SARA deals with natural populations, not created ones (hatchery stocks).

Session/ 2: What methods/ideas are available for the identification and measurement of critical habitats in freshwater environments?/ Quelles sont les méthodes et les idées don't on peut s'inspirer pour identifier et mesurer les habitats essentiels dans les environnements d'eaux douces?

	Group A	Group B	Group C
Facilitator	Mike Bradford	Robert Jones	Glen Jamieson
Rapporteur		Pedro Nilo	Ken Mills

All discussion groups in session 2 focused on generic conceptual approaches for measuring critical habitat in freshwater. Both group A and group B concluded, significantly, that the identification of critical habitat would depend on the level of information known for the species at risk; a table from group B is provided as Table 2. The breakout groups used a different structure for reporting their findings, so the summary notes are provided separately for each group.

Session 2, group A (summarized by Mike Bradford):

Discussion followed a progression of data information and needs, leading towards the ideal case of being able to develop a habitat-based population model. This would allow for the quantification of habitat necessary to allow the population to reach the recovery goals. Such a model would also allow the identification of restoration activities, as well as the evaluation of 'harm' (i.e., fishing). By necessity, CH will depend in the level of understanding, and might be as large as the range in the case where only rudimentary information is available.

1. First steps: In the case where **little or no information** is available, the first steps might involve:
   - canvas local knowledge, capture information etc., to develop an approximate range for the species. Establish the range when the population was not endangered to keep the current status in context;
   - other tools like radio-telemetry or tagging will help to determine the areas that are used;
   - available information, or that from similar species, might be invoked to develop a periodicity table to identify the macrohabitats that are used seasonally by different life stages .

2. The next step might be the more **detailed assessment of habitat preferences**:
    - sampling of the target species would be coupled with the collection of data on the habitat in the area of capture to begin to develop species-habitat linkages (i.e., Habitat Suitability Index, HSI). Habitat data would include physical parameters, as well as biological measures, where appropriate. Diet preferences might indicate habitat use;
    - this work would be collected by life stage;
    - these broad habitat preferences would then allow mapping of the preferred habitats within the overall species range, and would likely result in a reduction in the area that might be designated as CH.

3. The **specification of a habitat-population model** requires more detailed information on the linkages between individual and population performance and habitat attributes:
    - among the habitats used, are there some that result in increased survival/growth/etc. over other habitats?
    - what are the attributes of that habitat that lead to improved performance, and can they be mapped?
    - might also consider individual-based measures of performance such as behaviour, predation risk, and body constituent measures.

4. Finally, begin to develop a population **model that links habitat and population performance.** Initially, this might be very simple, such as numbers/km of stream or ha of lake, based on biostandards, or it might be more detailed, such as a life-stage specific model with habitat-based survival rates.

Session 2, group B:

Modifying and developing the Information Level table from group B (Table 2) helped structure and direct discussion for the remainder of the workshop. Other notes:

Scoping:

- there are uncertainties related to interpreting critical habitat - does it constitute habitat in a strictly biological sense (and incorporating natural processes) or should anthropogenic effects be considered (e.g., oil drilling and effects of effluent on fish species downstream)?
- population modelling: PVA is demanding (in terms of data requirements) to yield results with minimum assumptions and uncertainties. Not many species at risk will have a high level of information, particularly marine species;
- SARA requires CH be identified for ALL species at risk regardless of whether or not they are habitat-limited; the level of effort in identifying CH should be adjusted accordingly;
- amount of critical habitat required for survival/recovery will be driven by population targets, as specified in the recovery strategy;
- availability of habitat vs. use of habitat OR occupied vs. potential habitat - what are the rules for designating unoccupied habitat?
- how broad will geographic scope of CH designation be (spawning bed, riparian zones, upstream effects)?
- need to summarize current extent of knowledge on species on a life history stage basis - a pre-requisite for population modelling and for setting recovery/critical habitat targets.

Discussion:

- recognize need to identify generic approaches/tools (e.g., protocols, models) that recovery teams could use to meet species-specific objectives:
    - Area per Individual (API);
    - occurrence data (both direct through sampling and observer data, and indirect through remote sensing);
    - define ecosystem parameters, look at species occurrence data within each (both at individual level, population level);

- need to describe structure/hierarchy of approaches for each species as part of scoping information exercise;
- look at the best available information for each life history stage, identify the habitat required to support each stage, and examine the mechanisms available to set both the recovery targets and critical habitat targets.

Conclusions:

- group didn't address specifics of question, only identified a framework in which to address key issues for identify recovery/critical habitat goals and objectives;
- all recovery teams should consider applying this framework when developing recovery strategies/action plans;
- details of how teams will go about identifying critical habitat (based on available information, species-specific characteristics) still need to be fleshed out (focus of further work);
- concluded that any approach used to identify CH must be sound (based on science, identify uncertainty) and defensible.

Session 2, group C: Methods:

Listed in order of priority, with equal priority for first two:

1. **Life history approach:**
   - for many freshwater species, information on habitat use by life stage is still largely unknown, particularly cyprinids. Bait fishermen or aquaculture may be a potential source of information on habitats;
   - use information from surrogate species;
   - describe habitat quality within an ecosystem context, including both physical and biological attributes. May be necessary to characterize critical habitat of prey or predator species in order to describe habitat of target SAR. That is, consider predators, prey, and community as part of the habitat. Understanding food chains is important if there are predator/prey limits to recovery;
   - use Eilers et al. (1984), Schindler et al. (1989) and Minns et al. (1990) approach (literature-based species presence in relation to pH);
   - develop standardized methods to characterize species profiles (literature review, gap analysis);
   - there may be a variety of habitats at different scales needed for one life stage (see also CH mosaic in 4 below);
   - can CH be created? If not, it is lost forever, and therefore, must not be destroyed;
   - characterize habitat in low abundance situations. Home range may be a function of abundance.

2. **Modelling:**
   - link to GIS;
   - conduct sensitivity analysis, to identify sensitive life stage (needed to prioritize restoration efforts);
   - in the absence of data for all life stages (see 1), modelling can help identify bottlenecks in life histories.

3. **Experimental:**
   - relate lab studies to field, recognizing the limitations;
   - use energetics approach to define food requirements;
   - use habitat manipulations to identify tolerances;
   - temporary habitat may be needed (e.g., seasonal flooding).

4. **Micro-habitat approach:**
   - there are many examples of micro-habitat methods, but the challenge is to link these to the population scale (extrapolation may be tenuous);
   - geographic scaling is a challenge for defining critical habitat. Habitat is a mosaic involving different scales;
   - use remote sensing for scaling.

5. **Behavioural approach:**
   - use new technology, such as small acoustic tags.

Session/ 3: What methods/ideas are available for the identification and measurement of critical habitats in marine environments?/ De quelles méthodes ou idées peut-on s'inspirer pour identifier et mesurer les habitats essentiels dans les environnements marins?

	Group A	Group B	Group C
Facilitator	Jean Munro	Jim Reist	Debbie Ming
Rapporteur	Colin Levings	Doug Swain	Jean-Francois Gosselin

For measuring critical habitat in marine environments, all 3 breakout groups discussed methods, but the structure of the discussion was different for each group. Group A followed a section on methods with a comparison of the Fisheries Act and SARA. Group B, in discussing general methods and concepts, compared similarities and dissimilarities in measuring critical habitat in marine and freshwater environments. Group C addressed critical habitat using two case studies, using the Information Level concept (Table 2) outlined in the previous session.

Session 3, group A - Methods

1. **Mapping techniques:**
   - mapping distribution and density, using local knowledge (e.g., TEK) if necessary;
   - mapping of bathymetry and substrate using Canadian Hydrographic Service (CHS) multibeam or single beam acoustics, with gound-truthing;
   - mapping of food concentrations (e.g., krill for whales); upwelling areas; seabird concentrations; centres of high productivity;
   - associations between physical parameters, biological attributes and population distribution; develop habitat types.
2. **Modelling and correlation:**
   - modelling population dynamics with habitat properties and/or dynamics;
   - use surrogate species to get an idea of what life stage or habitat may be limiting.

3. **Sources of information:**
   - examine historical information on species distribution. How has habitat usage changed with harvesting and declining abundance? Identify the core areas, i.e., the areas used when the population was at high and low abundance;
   - use all the information available (e.g., length, weight, condition factor, fishing gear type) and all sources (fishery, observers).

4. **Dealing with large scale systems:**
   - remote sensing is important (e.g., satellite transmitters in whales);
   - critical habitat is potentially dynamic in marine areas. Track and predict where it is using oceanographic models and tracking methods that apply to large scales.

5. **Interspecies interactions:**
   - interspecies interactions and shared habitats must be considered;
   - examine connections with other species protection initiatives (e.g., MPA, IM). Examine the fate of the whole biological community in the context of designating only a portion of the habitat (CH).

6. **Discussion of Fisheries Act versus SARA:**
   - the burden of proof that a given portion of habitat is critical should come from SARA scientists, based on reasonable information and research;
   - designating large areas as critical in the face of high uncertainty might not be defensible. Designating minimal areas initially is more likely to be defensible, with the understanding that more information can be gathered in the longer term and the area of critical habitat may change accordingly;
   - developing a strategy should involve many possible approaches: examination of information from various sources; identification of potentially limiting life stage or habitat; start big to show that you have used all the information available ('to the extent possible');
   - it is not possible to designate all habitat as critical. One needs to use the concept of critical habitat as the habitat necessary to achieve recovery;
   - if habitat can be compensated for, then it is not critical habitat;
   - use Fisheries Act before SARA; need to demonstrate cause and effect (link between habitat and species survival) before designating critical habitat;
   - important in the approach is to have a goal concerning your estimation of size of CH. How precise do you want it to be? Try to estimate the probability of error, the risk of making such an error, and the cost of more certainty.

Session 3, group B - Methods and concepts:

1. Three general aspects of identifying CH were discussed:
   - biologists describe available habitats, their distribution, and identify habitat features that are thought to be important;
   - organisms identify what is important by their spatial distribution and spatial patterns in relation to productivity (e.g., growth, survival);
   - research is conducted to understand the linkages between habitats and biology (all life stages and seasons) that make a habitat critical.

2. Unique features of CH in the marine environment:

For many marine species (whales, large pelagics), CH is dynamic and not tied to a particular place. It may involve large scale phenomena and ephemeral events like upwellings or eddies, or variable phenomena like polynas. In these cases, CH may be a phenomenon or event rather than a specific place. One possibility is to identify the event or the phenomenon rather than a particular place as the CH. Another would be to map the probability of occurrence of the critical event in space and time, and use this to identify a particular region as CH. In this case, the area designated as CH would have to be sufficiently large to encompass a high probability of occurrence for the critical event. It was noted that two different approaches are taken in the United States for designating Essential Fish Habitat (EFH; analogous to critical habitat) in these situations. For whales, EFH is geographically explicit, with different areas designated for different seasons. For other highly migratory species, EFH is defined as comprising particular oceanographic conditions but is not mapped.

3. Prey, predators and competitors as features of CH:
    - It is clear that prey availability is a component of CH. Predators, competitors, parasites and diseases are also components of habitat quality that may determine the amount of CH that is required.

4. Scaling down from the entire range to CH:

    Need a life history/migration model, with knowledge of the following:
    - target population size;
    - population structure;
    - rate function describing population persistence (stock-recruitment relationship);
    - modelling link between habitat and population dynamics.

5. Similarities with CH issues in freshwater:
    - there is a hierarchy of approaches with increasing knowledge requirements. As knowledge increases, CH can be defined more precisely. As knowledge decreases, uncertainty increases. With minimum knowledge, using a precautionary approach, designated CH expands to be the full range of the species;
    - assessment across geographic scales is needed for both marine and freshwater species. Linkages between terrestrial, freshwater, estuaries and marine environments are important. Landscape approaches and knowledge of transition zones are often needed.
    - coupling life history and habitat using models.

Session 3, group C – Marine Case Studies

As noted in Session 2 (Table 2), recovery plan objectives will differ depending on the level of information available for the SAR. Five levels were identified: 1) none; 2) presence/absence; 3) density; 4) process rates (growth, survival); and 5) production rates. To investigate methods, group C chose to use two case studies with contrasting information levels: killer whales (level 4) and wolffish (level 1 or possibly 2).

At the outset of their discussion, the group noted that 1) it is difficult to define and measure CH in marine situations – is it an oceanographic feature (upwelling) or an area? 2) higher levels of precision will be more costly; and 3) it may not be possible to identify simple practical advice and objectives that cover all species.

Case study: southern resident killer whales in British Coumbia

Background and issues: Feeding aggregations may indicate critical habitat for killer whales. Where and how much available food is there, and is some of the food toxic? What are the human impacts on areas where food is concentrated (contaminants, whale watching)?

Approach for identifying CH involves the following steps:

1. Food resources:
   - foraging areas appear to be bottlenecks;
   - analysis to determine where food resources are present by linking with fish surveys: are areas with high food densities associated with high killer whale densities?
   - bioenergetics model to predict growth rates for different life stages;
   - how do we define sets of conditions, such as food level (tons of prey per km^2) ?

2. Consider human impact on whales in the identification of critical habitat:
   - if contaminants in food is a threat, then areas away or not affected by the source of pollution may be a criterion to identify critical habitat;
   - human demographic modelling: it will be useful to predict how pollution level will change in time to predict which habitat may be important in the future.

3. Reproductive rates:
   - is reproduction rate habitat dependent?

4. Mortality:
   - the population trend is known: abundance has decreased significantly;
   - what do we know about mortality? An investigation of pod dynamics and mortality factors is needed.

5. To transpose the needs onto a map:
   - retro-analysis is needed to determine if the animals are using the same (presumably best) habitat over time. A long time scale is needed to determine historical movements of these highly mobile populations;
   - for southern resident killer whales, there is a need to protect areas with high prey densities with low contaminant levels;
   - conduct probability analysis to determine sensitive areas to be closed to human activities.

6. Management objectives:
   - define target population (number);
   - define the CH in terms of quality (food, shelter, other attributes, sets of conditions/thresholds that provide requirements of animals) and quantity;
   - analyse growth and survival rates;
   - quantify the human impact on spatial distribution;
   - combine all of the above information to determine viability models.

7. Determine if target is met:
   - if yes, then species and habitat must still be protected.

Wolffish:

Background: Wolffish have a patchy distribution and inhabit areas with a rocky bottom (in holes under boulders). They are captured as by-catch in trawling gear. A priority at the outset would be to verify the factors that led to the listing of this species. It would be important to calculate efficiency of trawls for determining the density of specific life-stages. To fill knowledge gaps, a directed stock assessment of wolffish is recommended.

Approach :

- because only presence/absence data are available, adopt a precautionary approach;

- use presence /absence information to make a habitat map, as specific habitat information for this species is lacking;
- use an experimental approach to investigate if fishing is having an impact on population abundance. Are the current management measures sufficient?
- first, simulate (model) the interaction between fishing and population growth, but this could be a challenge with a slow growing species. Then design a controlled trawling/experimental trawling survey (e.g., video cam on trawl) to investigate the impacts of trawling;
- monitor the population during the experimental fishing. Use the experimental fishing study to learn more about the life cycle and habitat requirements of wolffish;
- determine the proportion of area/habitat to close for the experiment via modelling. Even a crude model, possibly using a proxy species, would be useful.

Advice/comments to managers re wolffish case study:

- following a precautionary approach, to get a reasonable expectation of recovery, a large area may need to be protected initially. Presence/absence catch data would be used to determine the habitat used by wolffish, and areas with these or similar characteristics would be protected;
- when more information is available (e.g., the impacts of trawling), the area to protect may be reduced. Other management options may be applicable (e.g., restrict gear to minimize by-catch).

Session/ 4: How do life stage habitat ontogenies and/or metapopulation factors affect the identification and measurement of CH?/ Présentation sur la façon don't le changement d'habitat en fonction du stade de développement et les facteurs de métapopulation a une incidence sur l'identification et la mesure de l'habitat essentiel?

	Group A	Group B	Group C
Facilitator	Ken Frank	Susan Cosens	Kent Prior
Rapporteur	Carole Bradbury	Corey Morris	Peter Ross

Most species use different habitats for spawning, early development and growth, and as mature adults. All three breakout groups discussed factors relating to life-stage specific habitat and metapopulation factors that affect the measurement of critical habitat. The factors were not prioritized by the groups, but several were raised by two or more groups, emphasizing their importance. As in previous sessions, the list of factors/issues was edited to reduce replication. Group C discussed life-stage specific habitat using case studies as a focus.

Factors/issues from session 4:

1. Distribution of species and their habitat may be outside Canada's jurisdiction (e.g., sea turtles, salmon, right whales).
   - a critical life stage may occur outside of Canada, possibly with limited or no access to data in these areas. Usually this can be dealt with through international cooperation and agreements;
   - is there a mechanism in SARA for international co-operation? Extensive consultation and communication will be needed.

2. A specific life-stage sensitivity may be the key (weakest link) to survival and therefore recovery.
3. Is the habitat of the critical life stage critical?
   - easier to identify critical life stage than critical habitat (e.g., key factor analysis);

- if habitat supply is not limiting then it will be necessary to identify other extraneous factors causing decline;
- model structure is important;
- CH will generally be a subset of the total available habitat.

4. Distinction between source and sink habitats is important:
   - to qualify as source habitat, population growth rate (lambda) must be > 1;
   - sink habitat cannot be maintained without immigration; look at genetics of sub-populations to try and determine stray rate;
   - can perform sensitivity analyses on metapopulations;
   - re-colonization of previously occupied sites is important (cannot predict time scale);
   - traditional measures of habitat quality in sinks may not be useful (density, condition, etc.);
   - sink habitat likely needs to be protected to maintain persistence of a population.
5. Contiguity of habitat between life stages is an important factor:
   - methods of how to characterize contiguity have not been well studied;
   - the estimate of supply of rearing habitat may depend on supply of adjacent spawning habitat (e.g., Lake Erie walleye - reef and river spawners), such that if rearing habitat is not in correct proximity to spawning habitat, it may not be fully utlized;
   - spatial relationships among habitats are important. Larval transport is often passive and survival depends on larvae finding suitable habitat. Disruption of 'corridor' habitat will cause problems.
6. If species is at risk and a critical life stage is missing from the current population (as determined during the assessment phase), this stage must be included in the recovery plans:
   - good historical data on habitat preferences are essential.
7. Modelling is required to aid CH identification because of the connection between life stages or sub-populations and habitat:
   - modelling of different life stages is dependent on available data and there will be gaps in knowledge. Sensitivity and gap analysis will be needed. Analyse the difference between what is known and what is needed to identify population and habitat targets. Test model performance to help refine targets;
   - will simple, less data-intensive models be sufficient in some cases?
   - ground-truthing of models is a priority.
8. Habitat capacity and density-dependent effects of different life stages should be assessed:
   - two options would be to expand or improve habitat and determine the sort of improvements that would be expected.
9. Examine or determine habitat requirements of all life stages:
   - typically, the more information that is available, the better the understanding regarding species habitat requirements and this will effectively result in smaller areas that need to be protected;
   - conversely, the less information available, the poorer our understanding of species habitat requirements and the greater the area that will need to be protected.
10. Recognition of spatial (place) and non-spatial (function or phenomenon such as eddies, upwelling) components of habitat is particularly important when considering the CH of life stages. Habitat may be mobile.
11. Ephemeral, episodic, marginal habitats may be important for certain life stages and population recovery.
12. Habitat quality is an integral part of critical habitat, as suitable habitat encompasses physical, chemical and biological features. Ignoring external quality issues (e.g., low pH, toxics, nutrients, exotics, climate) may impair recovery if these stressors target sensitive life stages.
13. A 'discrete' habitat approach for defining CH may be possible for some species (reef, stream), and preferable to managers, but a more 'comprehensive' habitat approach may be preferable for migratory species (Pacific salmon and killer whales). Discrete may be elusive for mobile species with life stage-dependent habitats. Food (prey) may be a more important habitat need for top predators than any discrete physical habitat feature.
14. Linkages between ecotones (terrestrial, freshwater, estuary, marine) in a life stage dependent manner are important for certain species (salmonids, eels, sturgeon, killer whales).

15. Multispecies synergies for shared habitat (patches, upwellings, reefs) deserve attention, particularly in marine areas.
16. Generic strategies for defining CH of different species may be possible for species with similar life histories (anadromous salmon).
17. (Added by J. Reist after the workshop): The three important aspects of habitat which affect recovery (and therefore make it critical) are: quality, quantity and diversity, with these being tied to the life history stages/critical life parameters in some way (i.e., act as choke/release points for survival, productivity).

Table from group C. Comparison of abalone and barndoor skate as case studies to investigate life stage specific critical habitat. Although preliminary, these contrasting case studies led to inclusion of factors/issues 12-16 above and to additional management advice (Table 4).

Similarities

- both are marine, long-lived species;
- mature at an old age;
- heavily exploited (fishing, by-catch and poaching);
- certain life stages that are mobile, with different habitats.

Differences

Abalone	Barndoor skate
• small body size, small home range	• large body size and home range
• high fecundity (1 million)	• low fecundity(?)
• controlled by natural predator, life stage directed (sea otters, crabs)	• predation not a factor for different life stages(?)
• littoral, coastal habitat (< 20 m depth) that varies with life stage	• shelf/shelf edge habitat for adults (<300 m); juveniles uncertain.

Session/ 5 Group A: Draft interim science-based guidelines/criteria for selecting methods/approaches to defining and mapping CH/ Lignes directrices ou critères scientifiques provisoires préliminaires pour le choix des méthodes ou des approches en vue de définir et de délimiter les habitats essentiels.

	Group A
Facilitator	Chris Wood/Mike Bradford
Rapporteur	Becky Sjare

Group A suggested a flow chart approach for listing operational guidelines for assessing critical habitat (reproduced in Figure 3). The group was concerned however that the workshop did not advance far enough to provide details on key issues.

Session / 5 Group B : Key information and conceptual gaps and some priorization for improving the toolbox and improving the guidelines/criteria/ Données principales et écarts conceptuels et priorisation pour améliorer la polyvalence et les lignes directrices et les critères.

	Group B
Facilitator	Bob Gregory
Rapporteur	Peter Amiro

Research priorities and operational protocols identified by group B are given in Table 5.

Table 1. List of presentations and working papers at the workshop on critical habitat.

Keynote talks

Howard Powles, Fisheries and Oceans Canada (DFO), Ottawa: Legislation and science for management of aquatic species-at-risk.

Tom Bigford, NOAA, Maryland: Describing and identifying essential fish habitat in U.S. waters.

Resit Akçakaya, Applied Biomathematics, Setauket: Using viability as a criterion for critical habitat determination.

Geoff Evans, DFO, St. John's: Acoustic proxies for habitat: a probabilistic assessment of how useful they are.

Richard Zabel, Seattle: Quantitative approaches to fish habitat designation – life history analysis.

Presentations

Ken Minns, DFO, Burlington: An area-per-individual (API) model for estimating critical habitat requirements in aquatic species-at-risk.

Mike Bradford, DFO, Burnaby: Critical habitat and interior Fraser coho salmon.

Brian Nakashima, DFO, St. John's: Critical habitat of spawning capelin.

Jean Munro, DFO, Mont-Joli: Atlantic sturgeon: recent attempts to define essential habitat and major human stressors.

Peter Amiro, DFO, Halifax: Identification and designation of critical habitat and recovery of inner Bay of Fundy Atlantic salmon (*Salmo salar*).

Doug Swain, DFO, Moncton: Identifying and quantifying critical habitat of marine fish: an example with Atlantic cod (*Gadus morhua*) in the southern Gulf of St. Lawrence.

Susan Cosens, DFO, Winnipeg: The challenge of defining critical habitat of marine mammals.

Becky Sjare, DFO, St. John's: Integrating scientific and local knowledge to identify potentially critical habitats: a case study in Placentia Bay, Newfoundland.

Bob Gregory, DFO, St. John's: Critical nursery habitat for juvenile fish species in the nearshore coastal marine environment.

Colin Levings, DFO, Vancouver: Provisional criteria for determining critical habitat for aquatic species at risk in estuaries and nearshore habitat, Pacific Region.

Jean-Francois Gosselin, DFO, Mont-Joli: Quantifying habitat use by beluga in the St Lawrence.

Howard Powles, DFO, Ottawa: Wrap-up:Broad concensus and next steps.

Working papers (* indicates material used in presentations. Working papers are being reviewed for possible upgrade to CSAS Research Documents).

*Amiro, P.G., J. Gibson and K. Drinkwater. 2002. Identification and designation of critical habitat for survival and recovery of inner Bay of Fundy Atlantic salmon (*Salmo salar*). *CSAS Working Paper.*

* Gregory, R.S., B.J. Laurel, and J.E. Linehan. Critical nursery habitat for juvenile Atlantic cod in the Newfoundland coastal marine environment. *CSAS Working Paper.*

*Levings, C.D. and W.A. Nelson. 2002. Review of critical habitats for estuarine and nearshore coastal species in Pacific Region: a contrast of white sturgeon (*Acipenser transmontanus*) and northern abalone (*Haliotis kamtschatkana*). *CSAS Working Paper.*

*Minns, C.K. 2002. An area-per-individual (API) model for estimating critical habitat requirements in aquatic species-at-risk. *CSAS Working Paper*.

Morris, C. and A. Power. 2002. Habitat mapping and considerations at potential Marine Protected Areas in the Newfoundland Region. *CSAS Working Paper*.

*Nakashima, B.S. and C.T. Taggart. 2002. Is beach-spawning success for capelin, (Mallotus villosus (Muller), a function of the beach? ICES Journal of Marine Science 59: 897-908. ICES Journal of Marine Science 59: 897-908.

*Nakashima, B.S. and J.P. Wheeler. 2002. Capelin (*Mallotus villosus*) spawning behaviour in Newfoundland waters – the interaction between beach and demersal spawning. ICES Journal of Marine Science 59: 909-916.

*Munro, J., F. Caron, P. Nellis, and D. Hatin. 2002. Defining primary habitat of Atlantic sturgeon in the St. Lawrence. Executive summary. *CSAS Working Paper.*

Randall, R.G. and C.K. Minns. 2002. Using density-fish size relationships to predict the critical habitat area of species-at-risk in the Great Lakes. *CSAS Working Paper.*

*Sjare, B., B. Nakashima and D. Mercer. 2002. Integrating scientific and local knowledge to identify potentially critical habitats: A case study in Placentia Bay, Newfoundland. *CSAS Working Paper.*

Table 2. Hierarchy of Information Level and the corresponding gradient in detail for population targets and critical habitat targets for at-risk species. From T. Bigford, as modified by K. Minns and the breakout group for Session 2, group B.

Information Level	Life History Stage			Habitat or ecosystem features			Model(s)	Population Target	Critical Habitat Target
	a	b	c	i	ii	iii			
0 - Know nothing							TEK, surrogate species, inference	Qualitative	Broad in scope & area; precautionary
1 - Presence/ absence data							Hanski model[1]; cursory mapping		
2 - Population density data							API, stock assessment techniques		
3 – Life stage process rates (survival, growth, fecundity)							PVA, Meta-population; others (as applicable to species, available information)		
4 -Productivity							Population – habitat capacity models	Quantitative	Narrow, well-defined

[1]Hanski (1982; see references)

Table 3. Summary of proposed methods for identifying critical habitat as discussed at the workshop. Methods are grouped by Information Level (see Table 2).

Information level	Presentation or working paper	Species	Methods	Data used	Importance
0 Nothing	No examples				
1 P/A	S. Cosens	Marine mammals	Field observation	Tagging and visual observation	Unpredictable spatially dynamic habitat leads to large scale and high uncertainty when mapping CH
1	B. Sjare et al.	Multispecies, multitrophic	Traditional Ecological Knowledge (TEK) ; GIS	Questionnaire	Areas of high diversity and productivity were tractable and could be mapped.
1	J-F. Gosselin	Beluga whale	Field observation; tissue analysis of carcasses and biopsies	Systematic surveys; photo ID; VHF radio; genetic; telemetry; fatty acids and stable isotopes for diet.	Habitats are sex and age dependent; boundaries are not fixed but vary with availability of resources.
1	C. Morris and A. Power	Multispecies, marine	MPA's, habitat mapping.	Multibeam acoustic bathymetry, video	MPA (Oceans Act) as a tool for protecting habitat.
2 Density	G. Evans	Surf clams; haddock	PDF models	Maps of seabed characteristics from acoustic surveys. Population distribution relative to habitat type.	Novel PDF and habitat-dependence functions are needed; on-going research.
2	D. Swain et al.	Cod	IFD theoretical framework; density-fish size relationship	Time series of trawl catches including years of high and low abundance (density, condition, length-at-age).	Knowledge of important habitat when population is at a low level. Habitat use was dependent on abundance. Habitat use at low abundance indicates critical habitat.
2	J. Munro and F. Caron	Atlantic sturgeon	BACI	Occurrence by life stage (spawning or pre-spawning, feeding areas). Acoustic and trawl determination of density.	Habitat categorization and mapping is a key component.
2	B. Gregory	Multispecies; marine littoral	Various (statistical); collaborative field research	Field research, includes survival and growth rates of young fish	Both biotic (predators) and physical structure is important for survival; multispecies dependency on critical habitat areas.
2	B. Nakashima et al.	Capelin	Field research	Knowledge of site-specific spawning substrate and egg viability	Life stage bottleneck at spawning, as year-class strength is determined during egg incubation.
2	B. Randall and K.	Yellow perch and	Density-fish size	Electrofishing survey in littoral Great	Area per fish is habitat dependent but

Information level	Presentation or working paper	Species	Methods	Data used	Importance
	Minns	pumpkinseed	regression	Lakes	quantifiable; broadly applicable model.
3 Process rates (survival, growth, fecundity)	R. Akcakaya	Generic	Habitat-based Meta-population model	Functional links (d-d survival) between life history stages and habitat	Both amount and configuration of habitat is important.
3	R. Zabel	Chinook salmon; canary rockfish	PVA model	Life stage specific population vital rates and habitat needs.	Sensitivity analysis to determine the response of population growth to changes in vital rates, which in turn are linked to habitat characteristics.
3	K. Minns	Lake charr; deepwater sculpin; generic	Area per individual (API) model	Three life stages; literature population rates, density-size relationships by life stage.	Indicates viability is related to rearing and adult habitat moreso than spawning. API model is broadly applicable.
3	P. Amiro et al.	Atlantic salmon	Meso habitat models (gradient) in FW; thermal and migration mapping in marine.	Historical data; freshwater, juvenile abundance; marine, mark-recapture data	When marine survival is low, all FW habitat is critical for population survival; PVA needed.
3	C. Levings	White sturgeon, abalone	Habitat mapping; age-structured population model	Literature, includes process rates for white sturgeon	Appropriate scale for mapping and other criteria for determining CH are needed.
4 Productivity	M. Bradford	Coho salmon	Population dynamic model;metapopulation dynamics; regression.	Existing life stage specific data. Temporal trends in smolt production and knowledge of habitat types; distribution and habitat use at low population abundance.	Simple population dynamic model; knowledge of important habitat when population is at a low level.

Table 4. Management advice from the workshop breakout discussion. Items are listed by Session.

Session 1 Information needs for quantifying critical habitat:

- Workshop of managers/policy/Science to resolve practicalities of uncertainty;
- Participation of stakeholders to resolve acceptable precaution, explain uncertainty, and ensure transparent decision making. A precautionary process, including legal issues, should be developed at the outset of the recovery plan. Management should define the precautionary process, as it is a societal issue;
- Compile life history and physical habitat data already available; provide funds if basic data are lacking. Include all targeted species before critical habitat is identified. Develop a geo-referenced database. (Oceans is doing this). Prioritize where GIS information is needed;
- Establish numerical survival/recovery goals;
- Link Oceans Act (MPAs) and Fisheries Act in relation to SARA;
- Dynamic habitat will require international agreement for protection;
- Organize a workshop on how to deal with dynamic critical habitat;
- Assuming viability is survival, then the definition of habitat is broad and includes physical/chemical attributes, population parameters, ecosystem and biotic attributes;
- Ensure communication with Oceans and habitat managers, and involve provincial and territorial jurasdictions to deal with adjacent habitat issues;
- MPA's may be an appropriate tool for some species/situations, but they should be evaluated (adaptive management). Species objectives for MPA's should be clear. Stewardship arrangements need to be evaluated and monitored;
- Recovery management activities need to be monitored to evaluate effectiveness;
- Establish interface between Science and managers. Develop a translation aspect to take science and synthesis into a useable form. Involve HM in recovery plans;
- Establish if decline is due to habitat and identify other stressors. What habitats need to be managed/conserved?
- Peer review of recovery strategies;
- Contingency plans in case of disasters;
- A strong communication plan is needed.

Session 2 Methods for identifying critical habitat in freshwater:

- Even a rudimentary population model can assist in the evaluation of habitat and other causes in the decline in the population. That model could be parameterized by data from other populations or species as a starting point;
- Modelling approaches need to be validated. This might be possible for a non-endangered species where abundance information is available. Simulate an endangered state, and consider impacts of different CH designations;
- When a species is greatly reduced in abundance, there may be CH that is currently not used or under used. This is a caution on interpreting CH with occurrence data. This also applies to interannual variation in habitat use (wet/dry/warm/cold years). Unless the linkage between the habitat function and population processes is understood, the precautionary approach may be needed to ensure that all potential types of habitats are designated as CH;
- Aquatic ecosystems are affected by landscape changes. The protection/restoration afforded to CH will have to consider that status of upland areas, and changes in that status overtime.

Session 3 Methods for identifying critical habitat in marine areas:

- Realize that CH studies and proposed areas are only part of a whole process;
- Management needs to set a standard for adequacy of information leading to CH designation (e.g., United States standards of information: Data Quality Act);

- Achieve transparency by involving all interested parties from the start;
- Maintain attention to possible clumping of protected sites/areas (links with IM / MPA).
- Is there provision for CH monitoring after designation?
- Workshop (managers and Science) to develop rules for characterizing CH (Guidelines, operational manual);
- Prepare/commission literature reviews on key species expected to be designated as SAR;
- Fund Science;
- Develop agreements with other agencies; start dialogue and consultation with stakeholders now;
- Support a workshop on case studies.

Session 4 Life stage ontogenies and metapopulation factors affecting the identification of critical habitat:

- Require establishment of robust criteria in decision-making;
- Remove stressors (e.g., over-exploitation, contaminants, poor industrial practices, etc.) that are reducing populations. Need to be able to illustrate that removal of these stressors will improve populations (i.e., improve survival, promote recovery);
- Should identify levels of uncertainty associated with provision of scientific advice to managers;
- Important to listen to Science;
- Recovery teams should include Science representatives in addition to various other stakeholders;
- The point that '**Not all habitat is critical**' needs to be emphasized;
- SARA is one tool (specific and defensible), but others are available (FA, Oceans);
- Develop mechanisms for regulating non-spatial (gyres etc.) and spatial critical habitats;
- Encourage stewardship and education initiatives. Education and awareness would be beneficial to protect habitat that is not formally designated and defined by a boundary;
- Include performance measures/indicators and adaptive management provisions in the recovery plan. Periodically review the recovery status relative to the target, and adjust the plan if needed. Collect baseline data concurrently with recovery strategy to assist adaptive management;
- Protect seasonal habitats;
- Support an experimental approach, and apply knowledge of similar well-studied species;
- Fund basic science, to provide information on life stage specific habitat use;
- Develop an operational definition of critical habitat, for both habitat managers and Science;
- Leverage effectiveness by using multispecies synergies (e.g., MPA);
- View species and habitat in broad context (habitat as community, predator prey, salmon restoration vs. sturgeon loss, production hotspots);
- Start with elementary mapping in the absence of comprehensive life history knowledge.

Table 5. Research priorities and operational guidelines identified during breakout Session 5, Group B.

Research needs:

1) Link habitat and population dynamics through literature, laboratory and field studies.
2) Research on carrying capacity:
    - establish lower limits on unit area requirements per individual;
    - literature reviews on carrying capacity and production.
3) Define quantitative survival and recovery goal protocols:
    - factor in variance;
    - lamda > 1;
    - establish minimum population size;
    - COSEWIC benchmarks.
4) Basic life-stage information.
5) Establish interim definition (identification) of critical habitat (= important habitat);
    - use information from surrogate species were appropriate (if information on target species is limited);
    - refine definition as information improves on the SARA target species;
    - this will be an iterative process.

Operational Protocols:

1) Role of scientists in the Recovery Team process needs to be clarified.
2) Scientific peer-review must be incorporated into the process at all stages/steps.
3) Clarity of the Recovery Team objective at all stages/steps of the process.
4) Clear statements of uncertainty on all information.
5) Identify appropriate tools to use.

Table 6. Details of research priorities from the individual breakout Sessions.

Session 1 Information needs for quantifying critical habitat:

- Develop tools that acknowledge/incorporate uncertainty;
- Fund long term Science to reduce parameter (survival) uncertainty;
- Indicator or reference species studies required for extrapolating within guilds/index habitats;
- Put effort into geo-referencing for –1) developing information base; 2) using technology to recover previously unavailable information; 3) data mining;
- Need a common established database and decision rules for species being assessed;
- Habitat mapping, including physical, environmental, chemical, biotic, community, multispecies linkages, highly productive areas. Valid habitat maps at appropriate scale for listed species;
- Develop capacity to track and predict dynamic critical habitat;
- Develop interdisciplinary process (sea- or landscape) to predict how population parameters will change (trends, threats either anthropogenic or natural);
- Provide managers with tools to mitigate predicted threats as part of the recovery plan;
- Long term research on interactions between aquatic and riparian, inter-jurisdictional habitats;
- Need information to complete a stage-structured life table for all listed species. Many cells may have inadequate information (uncommon species). Identify survival rates rather than just densities of life stages. Also structure by habitat quality;
- Identify biological unit for conservation, to be defined and agreed upon by COSEWIC. Information needed on spatial structuring of populations and unit of conservation (genetic variability). Management units often don't reflect population structure adequately to identify/model populations;
- Require information on non destructive sampling protocols to monitor SAR;
- Research to better understand limiting factors, including habitat;
- Need to do case study workshop.

Session 2 Methods for identifying critical habitat in freshwater:

- Maintain or increase Science capacity for modelling;
- Need methods for filling life history gaps for species. E.g., university graduate theses; development of species status reports.

Session 3 Methods for identifying critical habitat in marine areas:

- Models could be used to verify the process, various types, e.g. qualitative, quantitative, habitat-population needs to be part of the process (population viability analysis);
- Use survey data at high and low densities to estimate density dependence of CH size or attributes (e.g., multispecies correlates);
- There should be a concurrent goal of defining monitoring parameters in the process of CH assessment; mapping densities should be considered as basis for monitoring; population surveys frequently and habitat monitoring perhaps less frequently;
- Protection, Conservation and Research should develop a data base by species on important and critical habitat features;
- Research to evaluate the efficacy of the methods using case histories, retrospective analyses and simulation;
- **Case studies:** Pick several species to see whether we can identify & quantify CH (e.g. summer flounder case study in US – identifies what is required, whether it is do-able) Recommend picking one species for which much information is available and one information-deficient species that is listed. Voted on groups to use for case studies. Selected demersal fish (Atlantic cod, northern wolfish) and marine mammals (harp or grey seals and NE Pacific resident killer whales);

- workshop to examine organism/habitat linkages and identify critical habitat in order to identify gaps;
- Modelling training, to increase expertise in DFO Science, and for recovery teams.

Session 4 Life stage ontogenies and metapopulation factors affecting the identification of critical habitat:

- Monitoring must be guided by recovery plan objectives (e.g., need to determine if recovery plans are successful relative to survival and recovery targets);
- Need to maintain/enhance modelling experience within DFO (e.g., PVA) especially if Science staff are to be involved in Recovery Teams. Need to ensure that basic data requirements are available; PVA and other data intensive methods are inapplicable if species and stock information are poorly known;
- Validate models using monitoring programs;
- Need to test assumption that the currently occupied habitat is optimal. One way of doing this is to compare current habitat utilization patterns with historical habitat utilization;
- For SARA species, determine life stage habitat use and metapopulation structure;
- **Use case studies to test model approach;**
- Establish closer links between Science and management sectors;
- Develop criteria for prioritizing efforts and funding. For example, high risk, low knowledge areas may be where new information is needed the most to address uncertainty about critical habitat and future recovery;
- Use well known habitat (experimental or model system) to make inferences about poorly studied areas.

Figure 1. Species at Risk Act : Identifying and protecting critical habitat of aquatic species (from H. Powles, summary presentation)

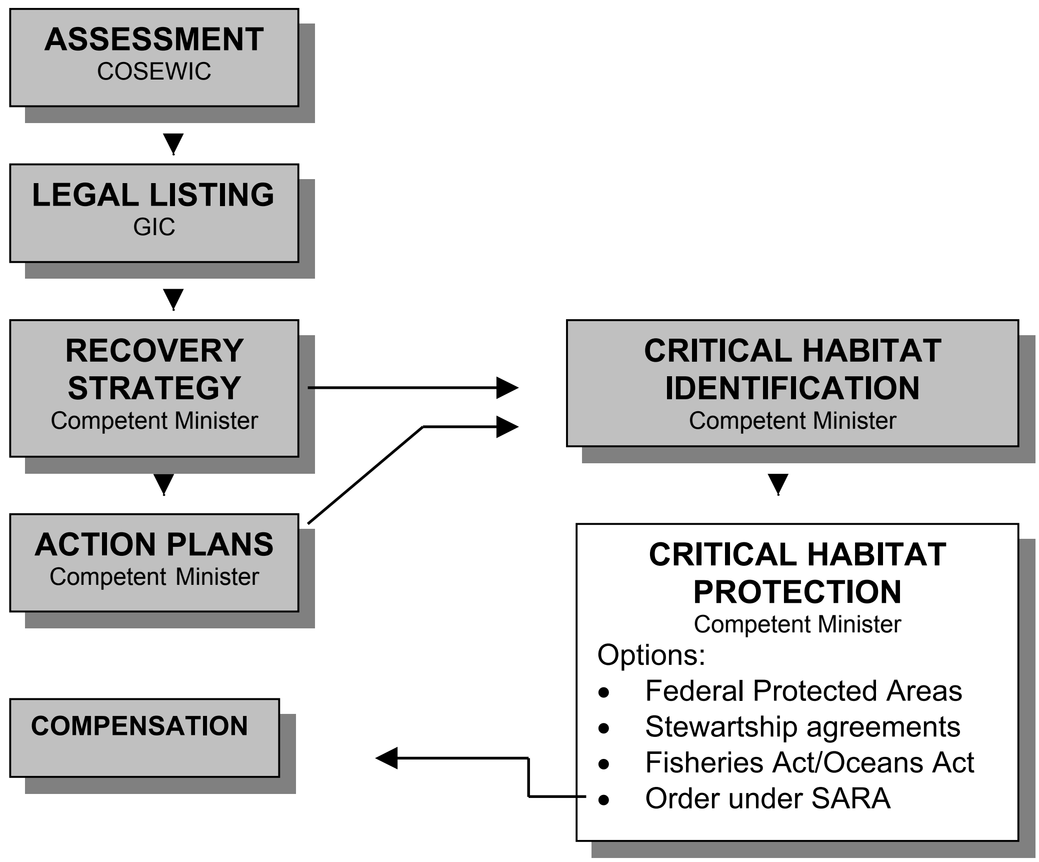

Figure 2. Critical habitat is one of an array of tools for protecting habitat of aquatic species-at-risk (from H. Powles, summary presentation).

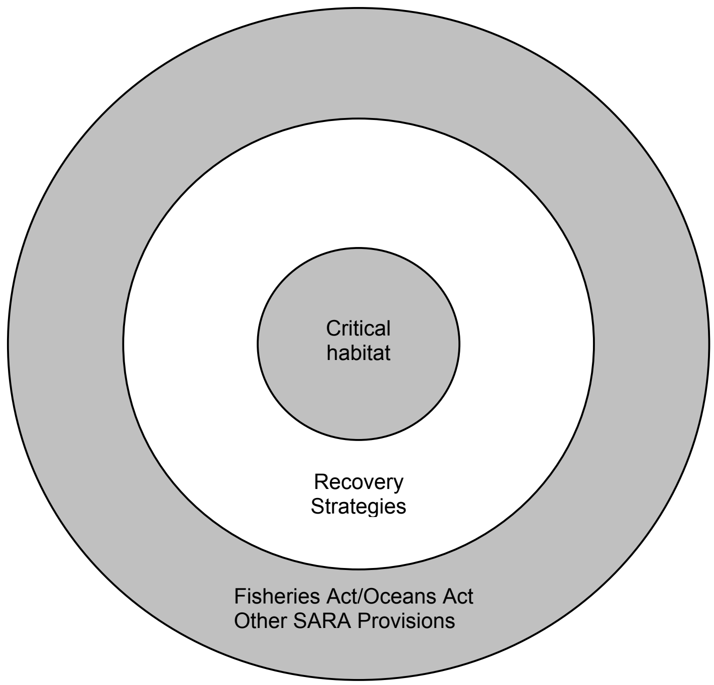

Figure 3. Flow chart for listing operational guidelines for assessing critical habitat (from Session 5, breakout group B).

1. **Step 1 Assessment:**
    - Recovery team required to assess habitat necessary for recovery.
    - Consider threats (as identified by COSEWIC at time of listing).
    - Undertake quantitative assessment (modelling):
        - comprehensive search for relevant data;
        - consider surrogate species, allometric relationships;
        - identify sensitive parameters (assumptions) and thus, information gaps.

2. **Step 2 Decision:**
    - Is a “critical” designation necessary, regardless of cost?
        - Standard for type 1 vs type 2 critical values must be identified by policy or precedent;
        - Accepting this burden of proof, can some habitat be identified as necessary for recovery?

    If yes, then designate as critical habitat;
    If no, then go to Step 3.

3. **Step 3 Decision continued:**
    - Is a “critical” designation worthwhile?
        - Could habitat protection reasonably be expected to improve viability?
        - Consider probable benefits of habitat protection;
        - Consider costs of designation.
    - Use “decision analysis” (including uncertainty and stakeholder input), to determine whether expected value of designation outweighs costs.

    If yes, then designate;
    If no, then go to Step 4.

4. **Step 4 Defer designation of critical habitat:**
    - Pursue recovery by other means;
    - Conduct additional research on habitat requirements;
    - Re-assess ***(go back to step 1... when ready).***

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Information and advice provided by the keynote speakers from the United States (T. Bigford, R. Akçakaya and R. Zabel) during the workshop were invaluable. The support and advice of Isabelle Rondeau and Stephanie Crook (Canadian Science Advisory Secretariat, Ottawa) were appreciated. This workshop was funded by Fisheries and Oceans Canada (Species at Risk Coordination Espèces en Péril, SARCEP).

Glossary

Adaptive management: ‘tool that aims to deal explicitly with uncertainty in natural resource management through a process of identification and analysis of critical aspects of management strategies’. ‘Considers management alternatives as experimental treatments’ (Bearlin et al. 2002; Walters and Hilborn 1978).

API: Area per Individual fish, calculated from the inverse of density fish-size regressions (Minns presentation, Table 1).

COSEWIC: Committee on the Status of Endangered Wildlife in Canada (www.cosewic.gc.ca/).

Critical habitat (CH): ‘that habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in the recovery strategy or in an action plan for the species’ (Species at Risk Act, sec. 2).

Dynamic habitat: important habitat feature that is spatially variable over time (e.g., ice edge, upwelling, gyres, spawning substrate in fluvial systems).

FHMP: Fish Habitat Management Program, Oceans Sector, Fisheries and Oceans Canada. (http://oceans.ncr.dfo-mpo.gc.ca/).

Habitat: ‘Spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes’ (*Fisheries Act*, sec. 31.5)

Ideal Free Distribution (IFD): 'conceptual framework relating the spatial distribution of animals to resource availability, competition and predation risks' (Giannico and Healey 1999; source references cited by these authors; Swain *et al*. presentation, Table 1).

Lambda (λ): Annual population growth rate. If λ >1, the population will increase; if λ<1, the population will decrease (Pielou 1974; Hayes 2000; Zabel presentation, Table 1).

MPA: Marine Protected Areas (www.dfo-mpo.gc.ca/canwaters-eauxcan/oceans/mpa-zpm/index_e.asp).

Precautionary approach: 'A set of agreed cost-effective measures or actions, including future courses of action, which ensures prudent foresight, reduces or avoids risk to the resources, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the potential consequences of being wrong. ' (Garcia 1996).

A DFO perspective on interpreting and implementing the precautionary approach is provided by Rice and Rivard (2002). This report includes a section on species-at-risk Powles (2002).

Population Viability Analysis (PVA): 'quantitative methods to predict the likely future status of a population or collection of populations of conservation concern' (Morris et al., 2002; Zabel presentation, Table 1).

Probability Density Function (pdf): Non-parametric estimation methods for determining the association between dependent and independent variables (e.g., fish abundance/habitat relationships). PDF methods make no assumptions about the shape of the association, or about the underlying distribution of the variables (Evans and Rice 1988; Evans presentation, Table 1).

SARA: Species at Risk Act (pending) (www.speciesatrisk.gc.ca/species/strategy/index_e.cfm).

Sensitivity analysis: Model evaluation by 'highlighting parameters that have the greatest influence on the results of the model' (McCarthy et al. 1995).

TEK: Traditional Ecological Knowledge (Sjare et al. presentation, Table 1; Neis et al. 1999).

Uncertainty: 'The incompleteness of knowledge about the state or processes of nature' (FAO 1995). In statistics, 'the estimated amount or percentage by which an observed or calculated value may differ from the true value' (Houghton Miflin 1992).

Appendix 1: Workshop Participants

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* Steering Committee members. Also on the Steering Committee but absent from the workshop were Jake Rice (NCR) and Rob Stephenson (Maritimes).

Appendix 2: Abstracts of Presentations and Working Papers

Keynotes

Legislation and Science for Managing Aquatic Species at Risk in Canada.

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At the time of the workshop, the proposed Species at Risk Act (SARA) is in the final stages of the legislative process in Canada's Senate. Habitat protection was a very visible issue during the debates leading to SARA's current form, with pressures to provide mandatory protection for as much habitat of listed species as possible, to not unduly impede economic activities because of habitat considerations, and to not infringe on provincial jurisdiction in this area. In SARA critical habitat (defined as habitat essential for survival or recovery of listed species) must be identified to the extent possible in recovery strategies and recovery action plans, which must be prepared for species listed as extirpated, endangered or threatened. Destruction of identified critical habitat of species under federal jurisdiction is prohibited, and protection must be in place within 180 days of the recovery strategy or action plan being published, either through agreements, through action under other Acts of Parliament, or through Orders under SARA. Aquatic species are under federal jurisdiction, and the Minister of Fisheries and Oceans is the competent Minister under SARA for aquatic species. Because critical habitat protection is likely to be controversial, it will be important for the scientific advice on identification of critical habitat to be developed in a rigorous manner, through a peer review process, in line with current Canadian guidelines on developing scientific advice for government activities. In addition to the legislated critical habitat provisions, SARA refers to habitat issues in several areas, including protection of « residences » of listed species and the need to consider habitat threats generally in developing recovery strategies and recovery action plans.

Describing and Identifying Essential Fish Habitat in U.S. Marine Waters.

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In the United States, key habitats of commercial and recreational marine species have been quantified under authorities granted to the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) in the Magnuson-Stevens Act (16 U.S.C. 1801 *et seq.*), as reauthorized by the Sustainable Fisheries Act on October 11, 1996. The "essential fish habitat" (EFH) component of the law is explained in a final rule published on January 17, 2002, in the Federal Register (see, also, title 50 of the Code of Federal Regulation, Part 600). That final rule expands on the congressional definition of EFH so each of eight regional fishery management councils and NOAA Fisheries can describe the key characteristics of those habitats deemed essential, identify where those habitats exist in marine waters, and develop measures to conserve and enhance habitats designated as EFH. Subsets of EFH deemed to be special or unique may be designated as "habitat areas of particular concern" (HAPC) and may receive special scientific or management considerations.

For fishery management plans already in place when the law was amended in 1996, those habitats were designated in 1999 and 2000; new plans now designate EFH when the plans become effective. Altogether, 42 fishery management plans now cover more than 700 species, including several complex assemblages of hard and soft corals. The final rule requires that each designation be reviewed at least once every five years to consider whether new information warrants revisiting the EFH or HAPC designations. The initial EFH designations and associated management measures from five of the eight regional councils were challenged in court, also requiring new environmental review documents that could lead to new EFH or HAPC designations.

This presentation will focus on processes used to designate EFH in the late 1990s and subsequent efforts to revisit those designations based on new information or legal challenge. This presentation will not cover the "consultation" process whereby federal agencies whose actions may adversely affect EFH are required to correspond with NOAA Fisheries to minimize the effects of their actions.

Using viability as a criterion for critical habitat determination.

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There are two main steps in critical habitat determination. The first step is characterizing the habitat requirements of the species, based on its life-history attributes and the habitat features that support these attributes. This step involves a study of the life history of the species and a statistical evaluation of habitat variables that contribute to its presence, density, and demography in different landscapes. The end products of this step are quantitative functional relationships between life history variables and habitat variables. These relationships describe presence of the species, as well as its life history variables as functions of habitat variables.

The second step is determining and locating the amount and configuration of habitat required for the survival or recovery of the species. Viability can be defined as the chance (probability) of the survival of the species, or its recovery to a predetermined level. Thus, it is an endpoint that is appropriate for this purpose. More importantly, only an overall measure of viability can integrate the various factors that determine persistence and recovery. Habitat is only one of these factors; others include population demography (survival, reproduction, variability and density dependence in survival and reproduction) and metapopulation dynamics (spatial subdivision, dispersal and recolonization). Even the same demography and the same amount of habitat can result in different dynamics and different chances of persistence, depending on the spatial configuration of the habitat. Therefore, critical habitat determination must take into account both types of factors, and rely on measures, such as viability, that can integrate the effects of these different factors.
Viability can be used as a criterion for determining critical habitat by employing habitat-based metapopulation models. These models integrate demographic models (age-, stage- and/or sex structured models of population dynamics) with habitat models (species-habitat relationships identified by resource selection functions and other methods). They define the spatial structure of the metapopulation (number, size, and location of the populations) based on the distribution of suitable habitat, and the demographic parameters of the model (carrying capacities, survivorships, fecundities, etc.) in terms of habitat variables in each habitat patch. For a given configuration and amount of habitat, these models can be used to determine whether the area can support a population that has a low risk of decline and/or a high probability of recovery.

Acoustic proxies for habitat: a probabilistic assessment of how useful they are.

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This talk deals with techniques related to two aspects of quantifying important habitat: testing the idea that a type of habitat is important, and estimating how much important habitat (or how much integrated 'importance') there is in a region. Being important for a species does not inevitably mean higher abundances of a target species, but instead higher probabilities of achieving any given level of abundance. So the underlying problem is to estimate the probability distribution for abundance and how it depends on some covariate such as habitat type. This problem must be addressed in the absence of any trusted theory either for the form of the pdf or for the form of the dependence. Maps of seabed characteristics derived from acoustic surveys are likely to become a major potential source of information about marine habitats; there is a need to determine how they relate to the apparent requirements of organisms. The techniques will be illustrated with an easy application to surf clams on the Grand Bank and then a more difficult application to haddock on the Scotian Shelf.

Quantifying habitat effects using life cycle analyses.

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Demographic Population Viability Analysis (PVA) has become a standard tool for conservation biologists. Demographic PVA involves constructing a population projection matrix based on the vital rates (survival and fecundity) of an at-risk species. From the population projection matrix, we can estimate the annual population growth rate (λ) to determine whether the population is growing or declining. Further, by conducting sensitivity analyses, we can estimate the responsiveness of λ to changes in various vital rates. By linking these vital rates to particular habitats, we can prioritize habitat actions based on expected improvements in λ. This type of analysis is particularly relevant for species with complex life histories that occupy separate habits during distinct ontogenetic stages. We present examples of demographic PVAs for Snake River spring/summer chinook salmon (*Oncorhynchus tshawytscha*) and canary rockfish (*Sebastes pinniger*). For both these species, λ is sensitive to changes in juvenile survival rate, and thus their juvenile rearing habitats are prime candidates for preservation. We also present efforts to measure juvenile survival of chinook salmon and understand how it varies with habitat quality. Juvenile survival is depressed in streams invaded by non-indigenous brook trout (*Salvelinus fontinalis*). Finally, we present an analysis of the effects of juvenile fish size, compared within and among populations, on survival through subsequent life stages.

Presentations

An Area-Per-Individual (API) Model For Estimating Critical Habitat Requirements In Aquatic Species-At-Risk.

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Identifying and mapping critical habitats will be a primary element in efforts to protect and restore of Canada's aquatic species at risk once minimum safe population sizes are established. A simple multi-stage population model for freshwater fishes is presented as a basis for estimating how much habitat will be needed. Spawning, yoy, and one+ life stages are considered. Links between area-per-individual (API) of available suitable habitat and life stage processes provide a means for estimating habitat requirements and identifying potential productivity bottlenecks. Life history strategy affects the dynamics of populations and the patterns of life-stage habitat requirements. How habitat quality can affect population success is examined. Results are presented for representative freshwater fish species (lake charr which is well known and deepwater sculpin which is a poorly known species-at-risk). Approaches to the estimation of API are explored. The model may be extended to more complex life histories and should be broadly applicable to other aquatic species-at-risk.

Critical habitat and Interior Fraser Coho salmon.

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The interior Fraser complex of coho salmon has recently been declared as "Endangered" by COSEWIC, largely because of a dramatic decline in abundance between 1988-2000. This decline has lead to major changes in the Pacific salmon fishery, including the complete closure of the coho salmon fishery in southern BC.

The identification of "critical habitat" as defined by SARA has not been attempted for Interior Fraser coho salmon. Like other migratory species, coho salmon utilize a variety of habitats during their life cycle, and acceptable conditions are required in each habitat in order for the population to sustain itself, and provide, at times, a harvestable surplus. Coho salmon are particularly reliant on small streams for spawning and nursery areas, and these habitat are very vulnerable to human impacts. Larger rivers form the migration corridors for juveniles moving downstream, and adults migrating to reproduce. The Fraser River estuary is an area of transition between freshwater and marine habitats, and it has been heavily impacted by urban and industrial developments. Finally, all subpopulations of Interior Fraser spend 18 months in the North Pacific Ocean, and are affected by interannual and decadal trends in ocean conditions.

All habitats used by coho salmon are protected by the provisions of the Fisheries Act. However, identifying the importance of particular habitats might be useful for land-use planning and restoration activities. Two approaches will be discussed. In the first, a simple stage-specific population dynamics model will be used that identify potential limits to production, and the responses that might be expected from alteration of different habitat types. The second approach examines the metapopulation dynamics of interior Fraser coho, to identify the freshwater habitats that appear important when the population recently reached critically low levels of abundance. Both approaches make use of existing data, but limitations caused by the type and quality of available data will generate considerable uncertainty in the outputs.

Critical Habitat for Spawning Capelin.

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Capelin recruitment in the northwest Atlantic is established early in the life history. Mortality during egg incubation and the yolk sac larval stage are correlated to yearclass strength. Capelin eggs adhere to the substrate and take 10 to 30 days to develop dependent on ambient temperatures. Yolk sac larvae reside in the substrate from 1 to 7 days. Studies have shown that environmental and hydrographic conditions during the egg and yolk sac stages are significantly correlated to survival. The substrate composition of beaches and their orientation with respect to onshore winds can be used to classify beach spawning habitat for capelin. Substrate composition has also been used to identify nearshore demersal spawning sites. The physical characteristics of beaches and demersal sites can be used to identify potential spawning areas, however environmental conditions and spawner abundance determine the timing and magnitude of the spawning itself.

Atlantic sturgeon : recent attempts to define essential habitat and major human stressors.

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In the St. Lawrence Atlantic sturgeon populations have been declining over the years. Concurrently major human activities, potentially disrupting the population or the habitat, have taken place in the river and the estuary. Identifying specific human stressors associated with life stages or habitat types through examination of historical correlations was not possible, commercial landings of adolescent and adult sturgeon being nearly the only source of biological information. An important research program was thus launched by provincial authorities to define population structure, identify migration patterns and locate principal habitats especially spawning habitat. Major output has been the location of some spawning areas as well as feeding and pre-spawning concentration areas. The finding of concentrations of adolescent Atlantic sturgeon in the vicinity of an important sediment dumping zone led to an additional program launched this time through FRSSE federal funding, and aimed at assessing impacts of sediments dumping. Assessing the impact of annual small scale deposits on the dumping site and along the pathway of current entrained sediments was done using comparative BACI experiments dealing with fish occupation, and benthos and sediment transformations. Assessing the impact of major deposits done in periods of depth extension of the St. Lawrence Navigation Channel was performed by 1) identifying the deposits and surface covered, using sonar imagery 2) classifying the habitat value of such surfaces within a scale of four reference areas representing four grades of habitat quality. The latter were characterised as to sediment, benthos, suprabenthos, and fish distribution using multi-channel sonar imagery, oceanographic sampling, benthic collection techniques, and acoustic transects for fish distribution validated with bottom trawl sets. Detailed classification and cartography of the four reference areas will be extrapolated over the whole upper mid-estuary, using correlation with oceanographic and sediment data, allowing for identification of sensitive areas and information useful for all fish species.

Identification and designation of critical habitat for survival and recovery of inner Bay of Fundy Atlantic salmon (*Salmo salar*).

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Wild anadromous Atlantic salmon (*Salmo salar*) of the inner Bay of Fundy (iBoF) have declined 90% or more in abundance since 1989. Based on numeric and genetic assessments of salmon populations within 32 rivers of the iBoF the entire stock complex of iBoF salmon was listed as *endangered* by the Committee On the Status of Endangered Wildlife In Canada (COSEWIC) in May, 2001. The iBoF Salmon Advisory Group has been designated as a "iBoF Salmon Recovery Team" in accordance with impending Species At Risk legislation for Canada. Among the requirements of this team is the designation of critical habitat for survival or recovery of the stock complex. The implications of survival and recovery strategies on the designation of critical habitat are examined for iBoF Atlantic salmon. Historic data and published methodology were used to delineate critical habitat for both survival and recovery. Complications to the designation of critical habitat introduced by uncertainties in competing life-history strategies, meta-population structure and recovery targets are discussed.

Because anadromous fish use freshwater habitat for reproduction and juvenile growth and the marine environment for follicular growth, designation of critical habitat is dependent on the strategy chosen. Strategies to attain survival through supportive breeding and rearing to maturity of genetically representative fish require only critical freshwater habitat. Strategies based on recovery require designation of critical marine habitat as well. Historic freshwater population data and analysis provided evidence of the distribution and density of juvenile salmon and therefore habitat value within the freshwater environment of iBoF rivers. To date, population, genetic and physical habitat inventories have recognized 42 rivers and delineated 12.7 $x10^6$ m^2 of productive salmon habitat within 22 rivers. Survival of the stock through live gene banks that mitigate the marine phase may utilize only portions of the freshwater habitat. The marine habitat for iBoF salmon has been demonstrated to be more localized than other Atlantic salmon populations. However, the extent and frequency of use of the local marine habitat by the closer-migrating proportion of the iBoF salmon population is uncertain. Based on historic tagging, thermal requirements of salmon at sea, sea surface temperatures and currents in the Bay of Fundy and Gulf of Maine, critical marine habitat for recovery of iBoF salmon is proposed.

Identifying and quantifying critical habitat of marine fish: an example with Atlantic cod (*Gadus morhua*) in the southern Gulf of St. Lawrence.

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We attempted to identify optimal foraging grounds for cod in the southern Gulf of St. Lawrence based on spatial patterns in cod density, condition and length-at-age, using data from an annual bottom-trawl survey conducted during the feeding season. A theoretical framework was provided by the ideal free distribution (IFD), a theory from behavioural ecology that predicts the distribution of foragers between habitats of different quality. As predicted by the IFD, cod distribution was density-dependent, with geographic range expanding as abundance increased and contracting as it declined. However, contrary to IFD predictions, cod densities were highest in different habitats at different population sizes. Density was highest in shallow water when abundance was low and at intermediate depths when abundance was high. This shift may reflect variation in competitive ability and/or an interaction between density-dependent and density-independent factors. At high abundance, inferior competitors may be displaced to intermediate depths or may select the colder waters at these depths in order to reduce metabolic costs when food ration is low. Also contrary to IFD predictions, spatial patterns were evident in cod condition and length-at-age, possible indicators of foraging success. Patterns in condition were density-dependent and contrasted the patterns in cod density. At all population sizes, condition was lowest in deep waters. In periods of low abundance in the 1970s and 1990s, condition was high over shallow and intermediate depths, with peak condition at intermediate depths where cod density was low. During the high abundance period in the 1980s, condition was highest in shallow water and declined to low values at the intermediate depths where cod density was highest. Patterns in length-at-age were consistent across abundance periods. Length-at-age was high in both shallow and deep water and low at intermediate depths. Thus, considered singly, the different potential metrics of habitat quality lead to different conclusions about optimal habitat. Likewise, the same metric suggests different patterns in habitat quality in different abundance periods. Considered jointly and over all abundance periods, the spatial patterns in density, condition and length-at-age suggest that the best feeding grounds are in relatively shallow (<50 m) inshore areas.

Density - fish size relationships can be used to estimate the area required to support a particular population size. A significant negative relationship occurred between cod density and average individual weight, with a slope close to the value predicted by theory. However, variation around this relationship was wide (R^2=0.03). Residuals from this relationship can be used to map habitat quality. We also tested for differences in this relationship between habitat types (depth zones: <50 m, 51-150 m, >150 m). In the low abundance period in the 1990s, slope did not differ between depth zones but the elevation of the regression line (intercept) differed significantly between zones (shallow > intermediate > deep). However, in the high abundance period in the 1980s, both the slope and the intercept differed between depth zones, with high values in the intermediate depth zone. This effect of population abundance on density – fish size relationships complicates their use in quantifying critical habitat. The relationships at low population sizes would be the appropriate ones to use in a species-at-risk context.

The Challenges of Defining Critical Habitat of Marine Mammals.

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Bill C-5 defines habitat of aquatic species as spawning grounds and nursery, rearing, food supply, migration and or any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes. Critical habitat refers to the habitat that is necessary for the survival or recovery of a listed wildlife species. Resources used by terrestrial species tend to be spatially predictable because the abiotic and biotic habitat features are non-mobile. The defining features of habitat can therefore be treated in a deterministic way by identifying substrate characteristics, plant species, microclimates and associated food sources and nesting or denning sites. Animals, such as caribou, may move between different types of spatially predictable habitats, all of which can be defined and geographically identified by their abiotic and biotic features. Although habitat use by some marine mammals is spatially predictable and sites are relatively easy to identify, that of some species such as bowhead whales and to some extent belugas, is difficult to define because both abiotic (ice cover) and biotic (high density patches of plankton in the case of bowheads) features are spatially unpredictable from year to year. Furthermore, in the case of bowheads, age class segregation and an apparently high degree of individual variability in movement patterns result in a very large spatial scale being needed to enclose functional areas such as summer feeding grounds and migration corridors. These issues and possible solutions will be discussed.

Integrating Scientific and Local Knowledge to Identify Potentially Critical Habitats:A Case Study in Placentia Bay, Newfoundland.

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Placentia Bay is a large, biologically productive bay that supports a diverse range of marine species as well as valuable commercial and recreational fisheries. Over the next two decades there will be significant coastal and marine developments in the Bay area associated with offshore oil production and transportation. The Oceans Programs Division in Newfoundland has identified the region as a priority for the development of an integrated management (IM) plan. Although there is a considerable amount of baseline ecological data available for a few commercial fish, sea bird and marine mammal species, little is known about many others and an integrated knowledge base for the coastal region is not available. We initiated a Traditional Ecological Knowledge (TEK) Program to link our research interests in marine mammals (harbour seals), pelagic fish (capelin and herring), and identification of environmentally sensitive areas from an IM planning perspective. Local residents (n=38), the majority being current and retired fishers, from communities along Placentia Bay were interviewed by DFO personnel familiar with marine mammals and pelagic fishes. The questions and discussions were designed to obtain comprehensive information on the seasonal distribution, relative abundance, reproductive biology, habitat use and sensitivity of a particular species and/or habitat. Coastal areas covered by those interviewed overlapped so that information could be cross-validated. All data were compiled in a relational database and map locations provided by residents were digitized using Mapinfo. Locations of capelin spawning beaches, winter and spring aggregations of herring and harbour seal pupping and haul-out sites throughout the Bay were identified. However, more importantly, there were clear spatial and temporal links between pelagic forage fish distribution, marine mammal distribution and resident's perception of environmentally sensitive areas in the Bay. These productive 'hot spots' were associated with a high diversity and biomass of marine species at certain times of the year and they warrant further study as potential critical habitats.

Critical nursery habitat for juvenile fish species in the nearshore coastal marine environment.

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Vegetated habitat in the nearshore coastal environment constitutes a significant nursery for the juveniles of several marine fish species. The complexity of such nursery areas provides an enriched prey environment and a refuge for young fish from predators, which promotes elevated juvenile survival, growth, and abundance. In a nearshore study conducted since 1995, a series of inter-related projects has identified the population recruitment and behavioural mechanisms responsible for the importance of vegetated habitats in the nearshore coastal environment of Newfoundland. Surprisingly, spatial distribution of juvenile marine fish appears to be poorly predicted on the basis of food supply. Juvenile density is best predicted by habitat complexity and predator distribution. Such relationships have significant implications for the abundance, distribution, habitat use, and survival of juvenile fish in coastal nurseries. Many of these habitats are in decline worldwide, especially along the eastern seaboard of North America. There has been no evidence of similar declines in Newfoundland coastal waters at this time. Consequently, this study has afforded the opportunity to investigate the ecological dynamics of critical nearshore nursery habitat, which still remains in a nearly pristine state.

Provisional criteria for determining critical habitat for aquatic species at risk in estuaries and nearshore habitat, Pacific Region.

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Anthropogenic changes are quickly changing the characteristics of estuarine and nearshore fish habitat in Pacific Region and there is an urgent need for scientifically defensible criteria to recognize and measure critical habitat for species at risk. In this paper we propose metrics and methods to assess critical habitat for estuaries, focusing on white sturgeon (*Acipenser transmontanus*), and nearshore marine habitats, focusing on abalone (*Haliotis kamtschatkana*). These two species are on the COSEWIC list and are representative of other organisms adapted to the habitats being considered. Several of the existing criteria are based on water column characteristics (e.g. temperature, salinity, dissolved oxygen, and toxicants), mostly from laboratory measurements of tolerance. For both species, metrics for substrate and related biophysical features are not well developed and are confusing because spatial relationships between organisms and habitats are poorly understood. As an example at the macroscale (1:1 M) about 70 % of estuarine habitat has been lost in the Fraser River estuary owing to urbanization. Preliminary results from an age-structured density-independent model for white sturgeon populations in the lower Fraser River and estuary are presented. The simulations suggested that access, water flow, and sediment exchange between slough and channel habitat are key ecological processes for this species. It is not clear if the remaining habitat in its degraded configuration is sufficient to maintain white sturgeon. As an example at the mesoscale (1:50 K), this scale of mapping, routinely used by agencies, is not capable of identifying key abalone habitat and to allow managers to prevent damage by expanding coastal industries. These criteria problems are key for habitat protection for species at risk because physical habitat loss is recognized as a pervasive and ongoing problem in estuaries and nearshore areas.

Quantifying habitat use by beluga in the St Lawrence.

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Beluga is the best studied marine mammal in the St. Lawrence and its summer distribution is relatively confined. The St. Lawrence population was reduced by intense hunting in the first half of the twentieth century and the population is now estimated to be around 1000 individuals. In the 1930's, belugas were seen throughout the year from Île-aux-Coudres to Pointe-des-Monts on the north shore, to Sainte-Anne-des-Monts along the south shore, and as far up as Chicoutimi in the Saguenay River. The year round distribution is now limited to the St. Lawrence estuary in the central portion of the former distribution, extending from the mouth of the Saguenay River to Bic. The Manicouagan banks which used to be the major concentration and from where most of the landings came from are no longer used in summer. Higly frequented areas have been identified through the summer range by compiling the locations of groups observed during systematic surveys conducted over the last 30 years. There is evidence of segregation in the different areas of the estuary in summer, where groups of adults believed to be males are seen in deeper and colder waters of the maritime estuary, and groups of adults with juveniles are seen in shallower waters of the estuary. Photo identification and genetics work are used to track long-term (seasons, years) movements, frequency of visits, residency periods, minimum number of individuals visiting each area and to assess site fidelity of individuals. Detailed information on movements on shorter time scales (hours to a day) can be obtained from radio (VHF) tracking, which provide residency, exact travelling paths and precise movements of individuals or groups between highly frequented areas. To evaluate the sub-surface use of the habitat, radio trackings are coupled with deployment of telemetric instruments that provide information such as dive patterns, dive profiles and swimming speed. This three-dimensional movement information of beluga movements provides an incomplete representation of habitat use without information on feeding, resting and socialising behaviour. For diet composition, the traditional hunting approach is not applicable for this endangered population and the stomach and intestines from stranded carcasses that are often empty are of limited use. Fatty acids and stable isotope analyses of tissues from carcasses and biopsies are used as alternative and complementary methods to provide more general diet composition integrated on longer periods of time. The description of a critical habitat for the St. Lawrence beluga or other marine mammal will combine information on abundance and distribution to provide geographic locations for management purposes. But the critical limits or boundaries should not be unique and fixed. Sets of limits or boundaries associated with risk of disturbance or percentage of resources requirements by the animals should be set and refined as we improve our knowledge of habitat use by the animals and our understanding of interference by human activities.

Additional Working Papers Tabled at Workshop

Habitat mapping and considerations at potential Marine Protected Areas in the Newfoundland Region.

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Three potential MPA sites, located at Leading Tickles, Eastport, and Gilbert Bay, have been identified in the Newfoundland Region, under the *Oceans Act*. Describing habitat has been a part of the ecological assessment conducted at each site, during the site evaluation phase. Among the three Areas of Interest (AOIs) two general methods were used to quantitatively describe habitat, 1) multibeam bathymetry mapping and substrate classification, and 2) underwater video. Reasons for protecting habitat as part of the MPA program may differ from Species At Risk legislation regarding critical habitat, but methods may be useful. The Leading Tickles AOI is developing a multispecies approach for MPA establishment and critical habitats are not defined at this site. At Gilbert Bay, habitat protection measures have been implemented to protect a unique local population of Atlantic cod. At Eastport, no take zones were established around preferred lobster habitats to promote a sustainable commercial lobster fishery in the area. The identification of habitat within each AOI has been based on substrate characteristics, water column characteristics, and geography, in connection with life history characteristics of particular species, and is site specific.

Using density-fish size relationships to predict the critical habitat area of species-at-risk.

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Fish catch was negatively correlated with average fish size in samples from different habitats in near shore areas of the Great Lakes. Density-fish size relationships for the whole fish assemblage and for individual species indicated regression slopes that were not significantly different from –0.9, consistent with the energetics equivalence hypothesis, but the elevations were habitat dependent. For example, the average density of *Perca flavescens*, adjusted for fish size, was five times higher at coastal wetlands than at harbour areas. The inverse of the density-fish size relationship can be used to estimate the area per fish required for the conservation and restoration of endangered species. A preliminary predicative equation was: $\log_e \mathrm{Area} = -0.81 + 1.02\log_e W_{mat} + 0.69\mathrm{Capacity}$, where Area was the area per fish (m^2), W_{mat} was weight-at-maturity (g), and Capacity was a habitat capacity factor (1 for moderate and 0 for good habitat). Based on this equation, the area needed for a species that matures at 150 g, assuming a minimum viable population size of 3,000 fish and assuming moderate habitat capacity, was calculated to be about 67.5 ha (95% CL=40.5,113.4). Adopting a precautionary approach, the upper bound of this estimate should be used in recovery plans. To make the predictive model more broadly applicable, more research is needed to quantify the use of different habitats at different life history stages, and to determine density-fish size relationships for marine species.

Appendix 3: Terms of Reference/Mandat de l'atelier

Objectives/ Objectifs:

- to identify quantitative, science-based methods for measuring critical habitat for aquatic species-at-risk/ déterminer des méthodes scientifiques quantitatives de mesure de l'habitat critique des espèces aquatiques en péril.

- to prioritize the approaches and develop performance criteria to guide the use of methods in recovery plans/ établir la priorité des approches et préparer des critères de rendement pour orienter l'utilisation des méthodes dans les plans de rétablissement.

- to determine the biological and habitat data needed to measure critical habitat/ déterminer les données biologiques et environnementales requises pour mesurer l'habitat critique.

- to recommend to DFO line management research activities required to more fully understand the nature and scale of quantifying critical habitat/ recommander aux gestionnaires fonctionnels du MPO des activités de recherche requises pour mieux comprendre la nature et l'amplitude de la quantification de l'habitat critique.

Scope/Portée

- All threatened species relevant to DFO management, i.e., marine, anadromous and freshwater finfish, shellfish, and marine mammals/ Toutes les espèces menacées qui concernent la direction du MPO, c'est-à-dire marines, anadromes et d'eau douce, mollusques et crustacés et mammifères marins.

Approach/ Approche :

(See page 1)

Issues to be addressed during break-outs/ Questions à aborder au cours des discussions :

- Is it possible to adopt common approaches, despite the diversity of taxa, species, life-histories, habitats and range in spatial scales? / Est-il possible d'adopter des approches communes malgré la diversité des taxa, des espèces, des cycles de vie, des habitats et des différences d'échelle spatiale?
- To be useful, areas of critical habitat must be identified on maps (GIS)/ Pour être utiles, les zones d'habitats critiques doivent être déterminées sur des cartes (GIS).
- There is a lack of specific information on habitat needs for some species/ Il y a un manque d'information particulière sur les besoins d'habitat de certaines espèces.
- Uncertainty regarding confounding stressors that led to decline/ Incertitude au sujet d'agents de stress confus qui ont entraîné un fléchissement.
- Need for anticipatory and precautionary management/ Besoin d'une gestion de prévision et de précaution.
- Need for collaboration between environmental and fisheries Science, and between Science and fisheries and habitat management/ Besoin de collaboration entre les sciences de l'environnement et des pêches et entre les gestionnaires des sciences et des pêches et de l'habitat.

Output/ Résultats :

- publication of presented papers, workshop discussion, synthesis and conclusions as a Workshop Proceedings (secondary and primary literature)/ publication des documents présentés, des discussions, de la synthèse et des conclusions à titre de compte rendu de l'atelier (documentation secondaire et primaire).
- advice to SAR co-ordinators on the type of information (species and habitat data) needed and approaches to evaluate critical habitat in restoration plans/ conseils aux coordonnateurs des espèces en péril sur le type d'information (espèces et habitats) requise et les approches pour évaluer les habitats critiques dans les plans de rétablissement.
- recommendations for DFO managers on research needs to quantify critical habitat of SAR species/ recommandations aux gestionnaires du MPO quant aux besoins de recherches pour quantifier l'habitat critique des espèces en péril.