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Science Technology Transfer Workshop – Science Contributions Towards Improving Fish Habitat Management

December 10-11, 2003
ByWard Market, Ottawa

Atelier sur le transfert des technologies des Sciences – Contribution des Sciences à l'amélioration de la gestion de l'habitat du poisson

Les 10 et 11 décembre 2003
marché By (Ottawa)

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EXECUTIVE SUMMARY

To enhance communication between Science and Fish Habitat Management (FHM), a national workshop entitled Science Contributions Towards Improving Fish Habitat Management was held in Ottawa (10, 11 December 2003). The objective was to report the results of recent and ongoing habitat science projects that were designed to provide applied science support for fish habitat management. These projects were primarily funded from the Environmental Sciences Strategic Research Fund (now part of the Strategic Science Fund). On day one, results of 15 individual studies were presented, each addressing one or more of four themes: measuring habitat productive capacity, threshold response to habitat alteration, effectiveness of compensation, and managing risk and uncertainty. Each theme was discussed in more detail on day 2 with facilitated, directed discussions to address application of the science results. Although the projects discussed on day 1 were from freshwater habitats, many of the concepts and conclusions from the theme sessions applied to marine habitat as well (a future workshop to specifically address marine case studies was recommended).Thirty-five professionals from Science and FHM, representing all Regions, attended the national Workshop (Appendix 1). As evidence that this inter-Sector activity was fruitful, a key recommendation was to develop a National Habitat Science Advisory Working Group that could meet annually to address pending habitat issues of mutual priority to Oceans (FHM) and Science.

Habitat science is fairly new but significant progress has been made on designing studies for measuring productive capacity that will benefit habitat management. A scale mismatch exists between Science and FHM but this disconnect can be resolved. Habitat biologists manage habitat at specific sites (referrals) while science studies fish-habitat linkages by taking a more

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Pour améliorer la communication entre les Sciences et la Gestion de l'habitat du poisson (GHP), un atelier national intitulé Contribution des Sciences à l’amélioration de la gestion de l’habitat du poisson a été tenu à Ottawa, les 10 et 11 décembre 2003. Le but de l’atelier était de partager les résultats de projets sur les sciences de l'habitat, en cours ou récents, projets dont l’objectif était de fournir le soutien en sciences appliquées nécessaire à la gestion de l'habitat du poisson. Ces projets ont été principalement financés par le Fonds de recherche stratégique en sciences environnementales (maintenant intégré au Fonds stratégique des sciences). Au cours de la première journée, les résultats de 15 études ont été présentés. Ces études portaient sur au moins un des quatre thèmes suivants : mesure de la capacité de production de l'habitat; seuil de réaction à la détérioration de l'habitat; efficacité des mesures de compensation; gestion des incertitudes et des risques. Chaque thème a été débattu plus en profondeur pendant la deuxième journée dans le cadre de discussions animées et dirigées, au cours desquelles on s’est penché sur l'application des résultats des travaux scientifiques. Même si les projets examinés au cours de la première journée visaient des habitats d'eau douce, nombre des concepts et des conclusions issues des séances thématiques s’appliquaient également aux habitats marins (on a recommandé l’organisation d’un atelier consacré spécifiquement à l’étude de cas en milieu marin). Trente-cinq professionnels des Sciences et de la GHP représentant toutes les régions ont pris part à l'atelier national (annexe 1). La pertinence de cette activité intersectorielle est bien démontrée par une importante recommandation concernant l’établissement d’un groupe consultatif national sur les sciences de l'habitat qui pourrait se réunir chaque année pour étudier les questions en suspens concernant l'habitat revêtant un intérêt commun pour les Océans (GHP) et les Sciences.

Même si les sciences de l'habitat représentent un domaine relativement nouveau, d’importants progrès ont été accomplis dans la conception d’études pour mesurer la capacité de production, une donnée utile pour la gestion de l'habitat. Une divergence d’échelle existe entre les Sciences et la GHP, mais ce problème peut être résolu. Les biologistes spécialistes de l'habitat gèrent les

holistic approach. Habitat function can only be understood by investigating habitat-specific process rates of different life stages of fish at a lake, watershed or oceanic scale. A two-tiered approach for managing fish habitat could benefit from science input and help to bridge the scale gap between Sectors. First tier assessment of habitat capacity could be based on broad scale maps of habitat productive capacity generated for large areas by science. The maps would be minimum coarse-scale classifications but nevertheless useful for making first order evaluations of capacity. This low resolution classification used together with other habitat sensitivity indicators (e.g., SAR) would be analogous to the 'traffic light' approach being used for fisheries management. Broad scale mapping would be useful for developing databases of habitat supply, which if linked to the FHM Habitat Referral Tracking System (HRTS) database, would provide insight into cumulative impacts. Distinction between sensitive and resilient habitats could be determined at the site level using these broad scale maps. More detailed (second tier) investigations of habitat capacity and sensitivity could then be initiated if warranted for specific projects or classes of habitat alteration. Presentations at the workshop indicated that tools and expertise for determining broad-scale classifications and first-tier screening are available now or will be available soon for many freshwater areas (and by inference, marine areas as well). A longer- term priority for Science will be to continue to investigate habitat-dependent process rates at a population level. Results will be useful for both broad-scale and site-scale habitat management.

habitats de sites spécifiques (soumissions liées à l'habitat), tandis que les Sciences étudient les liens entre les habitats du poisson selon une approche plus holistique. On ne peut comprendre la fonction des habitats qu'en étudiant les processus spécifiques existants dans ceux-ci, pour différents stades de développement des poissons, à une échelle donnée (lac, bassin hydrographique ou océan). Une approche à deux volets pour la gestion de l'habitat du poisson peut tirer profit des travaux des scientifiques et contribuer à réduire les écarts d'échelle entre les Sciences et la GHP. Le premier volet de l'évaluation de la capacité des habitats pourrait être fondé sur des cartes à grande échelle de la capacité de production de l'habitat produites pour de grandes régions par les Sciences. Ces outils de recensement à grande échelle seraient néanmoins utiles pour effectuer les premières évaluations de la capacité. Cette classification à faible résolution utilisée avec d'autres indicateurs de la vulnérabilité des habitats (par exemple, les espèces en péril) serait semblable à l'approche des feux de circulation employée pour la gestion des pêches. Les cartes à grande échelle seraient utiles pour la création de bases de données sur les habitats disponibles qui, si elle était reliée à la base de données du Système de suivi des dossiers touchant l'habitat (SSDH), nous donnerait un aperçu des effets cumulatifs. La distinction entre les habitats vulnérables et les habitats résilients pourrait être établie en fonction du site à l'aide de ces cartes à grande échelle. Des études plus détaillées (deuxième volet) sur la capacité et la vulnérabilité des habitats pourraient alors être entreprises au besoin pour des projets spécifiques ou pour des catégories de détériorations de l'habitat. Les présentations faites au cours de l'atelier indiquent que l'on dispose ou que l'on disposera sous peu des outils et de l'expertise nécessaires pour établir les classifications à grande échelle et les évaluations préliminaires (premier volet) pour plusieurs régions d'eau douce (et par conséquent, des régions marines aussi). La poursuite de l'étude des processus liés aux habitats au niveau de la population constitue une priorité à long terme des Sciences. Les résultats de cette étude seront utiles pour la gestion des habitats tant à grande échelle qu'à l'échelle même d'un site.

In addition to the scale issue, the discussion of productive capacity was a reminder that two key issues for FHM remain conjectural: 1) a need for accepted benchmarks (timeframe and spatial scale) against which changes in capacity can be

Les échanges sur la capacité de production nous rappellent que, en plus du problème d'échelle, deux questions principales pour la GHP demeurent conjecturales : 1) besoin de repères acceptés (échelle temporelle et spatiale) pour assessed; 2) a need for self-sustaining fish community targets, in most Regions. These issues are inter-connected and should be addressed at a future workshop involving both habitat and fisheries science.

Responses by fish populations to habitat modification are often not linear. Long-standing studies of stock and recruitment dynamics for fisheries assessment have shown that many populations are inherently resilient in that certain process rates leading to production increase if population abundance is low. This resilience makes it a challenge to detect habitat-induced responses by fish; examples of threshold effects are rare. Threshold (non-linear) responses to habitat change are not implicit in the Fish Habitat Management processing of HADD, and the criteria for determining HADD are vague. This is not surprising given the uncertain and dynamic nature of fish-habitat linkages. Consistent with the above conclusion, the role of science in developing HADD criteria would be to provide information and context for thresholds at a watershed and population or community scale, rather than at a site-specific (referral) scale. Research on thresholds requires long-term commitment because of the complexity. The potential use of an adaptive management framework for quantifying HADD was recommended as a promising approach. The need for a GIS-based tracking system within FHM for documenting HADDs on a site-by-site basis was emphasized, and would complement the mapping of productive capacity outlined above.

Presentations from FHM and discussion of the compensation theme at first appeared pessimistic in that compliance was low, records were incomplete, and net losses of habitat productive capacity were occurring despite the significant management efforts designed to prevent loss. The more insightful message was that FHM, by being accountable and by learning from past experience, is continuing to evolve and improve. Adaptive management is already being explored at a high level by senior managers. Uncertainty about appropriate compensation ratios and the

évaluer les changements de capacité; 2) besoin de populations cibles durables de poissons dans la plupart des régions. Ces questions sont liées et devraient être débattues dans un atelier futur sur les sciences de l'habitat et des pêches.

Souvent, les réactions des populations de poissons aux modifications de l'habitat ne sont pas linéaires. Des études menées pendant de nombreuses années sur la dynamique du recrutement et des stocks (pour l'évaluation des pêches) ont démontré que plusieurs populations affichent une résilience inhérente en ce sens que certains processus sous-jacents à la production augmentent lorsque la population est peu abondante. Cette résilience complique les choses lorsque vient le temps de détecter les réactions des poissons en lien avec l'habitat; les exemples d'effets de seuil sont rares. Les seuils de réaction (non linéaires) aux changements touchant l'habitat ne sont pas implicites dans le processus de traitement de la DDP de l'habitat par la Gestion de l'habitat du poisson, et les critères pour déterminer la DDP sont vagues. Cela n'est pas étonnant compte tenu de la nature incertaine et dynamique des liens relatifs aux habitats du poisson. Selon cette conclusion, le rôle des Sciences dans l'élaboration des critères de DDP des habitats serait de fournir l'information et le contexte pour l'établissement de seuils à l'échelle des bassins hydrographiques et des populations ou des communautés plutôt qu'à l'échelle des sites. La recherche sur les seuils exige un engagement à long terme en raison de la complexité de la question. L'utilisation d'un cadre de gestion adaptative pour quantifier la DDP des habitats serait une approche prometteuse. On souligne qu'un système de suivi d'information géographique (SIG) devrait être utilisé par la GHP pour documenter la DDP de l'habitat site par site; il s'agirait d'un complément à l'exercice de cartographie de la capacité de production susmentionnée.

Les présentations de la GHP et la discussion portant sur le thème de la compensation ont d'abord semblé pessimistes en raison du faible niveau de conformité, de données incomplètes et de pertes nettes de la capacité de production des habitats malgré les efforts de gestion considérables consentis pour prévenir ces pertes. Ce que l'on retient surtout, c'est que la GHP, étant donné ses responsabilités, apprend de ses expériences passés et continue à s'améliorer et à évoluer. La gestion adaptative est un concept déjà exploré par les cadres supérieurs à des effectiveness of compensation particularly in the long term can be dealt with by applying adaptive management at the field (referral) level as well. There is a need for 1) techniques to determine the most effective sampling designs; 2) for determining the best indicators to assess change; 3) for accepted and standardized methods for monitoring these indicators; and 4) for using the results as a basis for management decisions. The need for GIS-based databases of compensation activities is paramount. Inter-Regional strategy and collaboration between FHM and Science will be key for implementing any adaptive management program, which will include science-based designs for monitoring and the data needs. The use of cash as a tool for compensation remains controversial and Region-dependant emphasizing that inter-Region and inter-Sector communication to address this issue and others remains a priority.

niveaux élevés. L'incertitude au sujet des ratios de compensation appropriés et de l'efficacité de la compensation, en particulier à long terme, peut également être prise en considération par l'application de la gestion adaptative sur le terrain (soumissions liées à l'habitat). On a besoin : 1) de techniques pour déterminer les concepts d'échantillonnage les plus efficaces; 2) de meilleurs indicateurs pour évaluer les changements; 3) de méthodes acceptées et normalisées pour la surveillance de ces indicateurs; 4) de résultats comme base pour la prise de décisions de gestion. Les bases de données de SIG sur les activités de compensation sont essentielles. La mise en œuvre d'une stratégie et d'une collaboration interrégionale entre la GHP et les Sciences est essentielle dans la mise en place d'un programme de gestion adaptative, lequel doit comprendre des concepts scientifiques pour la surveillance et les besoins en données. La compensation monétaire demeure controversée et dépend de la région; la communication entre les régions et entre les secteurs quant à cette question et à d'autres questions demeure une priorité.

Plans for the near-future refinement of management practices are currently underway. New procedures are proposed for incorporating a 'pathways of effect' approach and a risk assessment framework for dealing with referrals. The pathways model may be used by FHM to determine the potential effects of in-water and land-based activities in a standardized way, to provide transparency in this determination to user groups, and to determine mitigation/design plans to avoid potential negative effects. The pathways approach is flexible and can be applied to the different habitat ecozones of Canada leading to the best management practices for each specific area and situation. Remaining residual effects after mitigation, if any, will then be examined in the context of the severity of impact of that effect, and the sensitivity of habitat in the receiving environment. This severity and the habitat sensitivity will be used to determine the risk category associated with the project. Both the pathway of effects model and the risk assessment framework are described and illustrated in more detail later in this Proceedings. FHM is looking to Science for assistance in making the pathways of effect and risk assessment frameworks operational. Based on past experience, habitat management practices are continuing to evolve and adapt.

Des projets d'amélioration à court terme des pratiques de gestion sont actuellement mis en oeuvre. On propose de nouvelles pratiques pour incorporer une approche fondée sur la séquence des effets et un cadre d'évaluation des risques pour traiter les soumissions liées à l'habitat. Le modèle de séquence des effets peut être employé par la GHP afin de déterminer les effets potentiels des activités en milieu aquatique et terrestre d'une manière normalisée, de faire preuve de transparence quant à cette détermination vis-a-vis les groupes d'usagers et, finalement, d'établir des mesures d'atténuation ainsi que concevoir des plans pour éviter les effets négatifs potentiels. L'approche de la séquence des effets est souple et peut être appliquée aux différentes écozones d'habitats du Canada, ce qui permettra l'application des meilleures pratiques de gestion pour chaque région et chaque situation. Les effets résiduels post-atténuation, le cas échéant, sont alors examinés en fonction de l'importance de l'impact de cet effet et de la vulnérabilité de l'habitat dans le milieu récepteur. L'importance de l'effet et la vulnérabilité de l'habitat détermineront la catégorie de risque posé par le projet. Le modèle fondé sur la séquence des effets ainsi que le cadre d'évaluation des risques sont décrits et illustrés plus en détail plus loin dans le présent document. La GHP a besoin des Sciences pour rendre opérationnelle l'approche fondée sur la séquence des effets et le cadre d'évaluation des risques. Selon l'expérience acquise, les pratiques de gestion de l'habitat continuent à évoluer et à s'adapter.

Quantifying uncertainty and managing risk was the focus of the final theme session. Most participants agreed that the current *ad hoc* and informal methods of dealing with risk should be replaced with more formal objective and consistent National methods. As noted in the previous paragraph, plans are already in place to incorporate risk into the management framework. Elsewhere during the workshop, parallels and differences between habitat and fisheries science were noted. Quantifying risk has been well-developed for fisheries management and their tools and lessons are transportable to habitat management. Again, inter-Sector communication and increased awareness are paramount.

La quantification de l'incertitude et la gestion du risque sont au centre des discussions de la séance thématique finale. La plupart des participants reconnaissent que les méthodes actuelles, *ad hoc* et officieuses, utilisées pour évaluer le risque doivent être remplacées par des méthodes nationales plus officielles, objectives et conformes. Tel qu'indiqué au paragraphe précédent, des plans sont déjà en place pour intégrer le risque au cadre de gestion. Au cours de l'atelier, des parallèles et des différences entre les sciences de l'habitat et des pêches ont été signalés. La quantification du risque est au point pour la gestion des pêches et les outils et leçons s'y rapportant peuvent être transférés à la gestion de l'habitat. Une fois de plus, la communication entre les secteurs et l'accroissement de la sensibilisation sont primordiales.

Because of the complexity, a road map was recommended to provide a guidance framework for dealing with referrals, including a screening and assessment process, data requirements and management, risk assessment tools, and monitoring within an adaptive management framework. This process has already been initiated with the pathways framework. The road map would be applicable to both freshwater and marine situations. Such a road map should be tabled, reviewed and refined by a National Habitat Science Advisory group, if this group is formed as recommended. Addressing the knowledge gaps listed at this workshop and future strategic research planning would be part of this process. Details and direction for continuing collaboration between FHM and Science would also be an obvious product.

En raison de la complexité de la question, on recommande l'établissement d'un plan pour orienter les soumissions liées à l'habitat, comprenant un processus d'examen préalable et d'évaluation, les exigences en matière de données et la gestion de celles-ci, les outils d'évaluation des risques et le suivi dans un cadre de gestion adaptative. Ce processus est déjà lancé avec le cadre relatif à la séquence des effets. Le plan s'appliquerait tant aux situations en eau douce qu'aux situations en milieu marin. Ce plan devrait être déposé, examiné et amélioré par un groupe consultatif national sur les sciences de l'habitat, si on donne suite à la recommandation formulée à cet effet. Le processus permettrait notamment de faire le point sur les lacunes au chapitre des connaissances relevées pendant l'atelier et d'effectuer la planification stratégique concernant des recherches futures. Les détails et orientations pour une collaboration continue entre la GHP et les Sciences seraient évidemment à l'ordre du jour.

In summary, ten key recommendations resulted from the Workshop:

1. Establish a National Habitat Science Advisory Working Group to promote continual collaboration and communication between

En résumé, dix recommandations principales sont ressorties de l'atelier :

1. Établir un groupe consultatif national sur les sciences de l'habitat pour favoriser la collaboration et la communication continues

Oceans (FHM) and Science.

2. Plan and implement a workshop on the productive capacity and management of marine habitat.

3. Plan a workshop to establish consistent inter-Region benchmarks for determining NNL.

4. Establish GIS based inventories of habitat supply, linking with HRTS, to deal with cumulative impacts.

5. Implement objective methods for risk assessment for referrals.

6. Science is to provide methods for determining first-tier maps of habitat capacity and sensitivity.

7. Adopt an adaptive management strategy for assessing compensation measures. Develop protocols, criteria, and data standards for monitoring, along with guidelines for enforcement.

8. Develop operational guidelines for determining HADD.

9. Develop a road map for the referral process, with both FHM and Science input.

10. Disseminate the results of habitat science as CSAS Research Documents and Advisory Documents.

entre les Océans (GHP) et les Sciences.

2. Planifier et tenir un atelier sur la capacité de production et la gestion de l'habitat marin.

3. Planifier un atelier pour établir des points de référence uniformes entre les régions pour la détermination d'aucune perte nette (APN)

4. Produire des inventaires SIG des habitats disponibles, en lien avec la base de données du SSDH, pour évaluer les effets cumulatifs.

5. Mettre en œuvre des méthodes objectives d'évaluation des risques pour les soumissions liées à l'habitat.

6. Implication des Sciences pour fournir des méthodes pour établir des cartes sur la capacité et la vulnérabilité des habitats (premier volet).

7. Adopter une stratégie de gestion adaptative pour évaluer les mesures de compensation. Élaborer des protocoles, des critères et des normes sur les données pour la surveillance ainsi que des lignes directrices pour l'application réglementaire.

8. Élaborer des lignes directrices pour déterminer la DDP de l'habitat.

9. Élaborer un plan pour le processus de traitement de soumissions liées à l'habitat, avec les contributions de la GHP et des Sciences.

10. Diffuser les résultats des sciences de l'habitat sous la forme de documents de recherche et de documents comprenant des avis du SCCS.

FOREWORD

Two literature-based questions were shown at the beginning of the Workshop largely for warm-up entertainment during introductions, but each was relevant (perhaps remotely) to the theme of the workshop:

> Why did Walcott (palaeontologist) mistake *Anomalocaris ('a two-foot terror of the Cambrian seas')* for *Peytoia* (a Burgess jellyfish)? Quote (italics) from Stephen J. Gould, Wonderful Life. The Burgess Shale and the Nature of History. 1989.

Professor Walcott was a world-renowned palaeontologist at the Smithsonian Institute who discovered and classified invertebrate fossils from the Burgess Shale of British Columbia. *Anomalcaris,* one of the largest marine invertebrates found in the Shale deposits, was initially misidentified because only part of the animal was found in the fossil record. Walcott did not realize that he was looking at the mouth parts of a much larger animal. Because of the incomplete record and incorrect scale, the animal was incorrectly classified. Complete information and the appropriate scale are also important for classifying and evaluating fish habitat. The story of the Burgess Shale is fascinating and beautifully described by Gould and is recommended reading (although the link to habitat science may seem remote).

> *'A 30-megawatt installation would cover a square kilometre of sea and provide enough electricity for 20,000 homes'* Quote from M. Knott, Power From the Waves, New Scientist, September 2003. Refers to ongoing research on power generation from waves, Orkney Islands. Would this facility affect the productive capacity of the coastal habitat (yes or no)?

Alternate sources of energy are being aggressively researched, including the potential use of marine wave energy. We value water and habitat for fish production, but increasingly water and habitat will be used for other reasons. The reference to the article in *New Scientist* was a reminder of the large scale of some facilities,

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Deux questions en lien avec la littérature ont été posées au début de l'atelier; leur but premier est de détendre l'atmosphère pendant l'introduction, mais chacune d'elle se rapporte (peut-être de loin) au thème de l'atelier.

> Pourquoi Walcott (le paléontologiste) a-t-il confondu *Peytovia*, « une méduse du schiste de Burgess », et *Anomalocaris, «* une terreur de deux pieds des mers du Cambrien »? Citations entre guillemets de Stephen J. Gould, *Wonderful Life. The Burgess Shale and the Nature of History.* 1989.

Le professeur Walcott était un paléontologue de renommé internationale du Smithsonian Institute qui a découvert et classifié des fossiles d'invertébrés du schiste de Burgess, en Colombie-Britannique. *Anomalcaris,* l'un des plus grands invertébrés marins retrouvés dans les dépôts de schiste, a été mal identifié au départ du fait que seule une partie de l'animal a été trouvée dans le registre des fossiles. Walcott ne s'était pas rendu compte qu'il avait devant lui les parties de la bouche d'un animal beaucoup plus grand. En raison du registre incomplet et de l'échelle incorrecte, l'animal a été mal classé. Une information complète et une échelle appropriée sont également importantes dans la classification et l'évaluation de l'habitat du poisson. L'histoire du schiste de Burgess est fascinante et admirablement décrite par Gould, dont la lecture est recommandée (bien que le lien avec les sciences de l'habitat puisse sembler distant).

> *« Une installation de 30 mégawatts couvrirait un kilomètre carré de mer et fournirait assez d'électricité pour 20 000 résidences. »* Citation de M. Knott, *Power From the Waves*, New Scientist, septembre 2003. Cette information réfère aux recherches ininterrompues sur la production d'électricité par les vagues, aux îles Orcades. Cette installation affecterait-elle la capacité de production de l'habitat côtier (oui ou non) ?

L'homme, qui recherche de nouvelles sources d'énergie, s'est notamment intéressé à l'énergie des vagues de la mer. L'eau et l'habitat ont une valeur pour la production de poissons. Cependant, l'habitat sera de plus en plus exploité pour d'autres raisons. L'extrait de l'article paru dans *New Scientist* nous rappelle l'étendue de even when considered in the context of large marine areas. Interestingly, most participants responded with a 'yes', although some were cautious because of the lack of details. Most realized that blocking a square km of water surface from sunlight would have ramifications on primary productivity and thus fish production at some level. Scaled down, is there an analogy between this marine example and building docks in freshwater lakes? Beyond a certain threshold, losing habitat area will always lead to detectable decreases in fish production.

certaines installations, même dans le contexte de grandes zones marines. Il est intéressant de constater que la plupart des participants ont répondu oui, bien que certains aient été prudents en raison du manque de détails. La plupart ont cependant convenu que le fait d'empêcher un kilomètre carré de surface marine d'être exposé à la lumière du soleil aurait des répercussions sur la productivité primaire et, donc, sur la production des poissons à certains niveaux. À plus petite échelle, y a-t-il une analogie entre cet exemple et la construction de quais sur des lacs d'eau douce? Au-delà d'un certain seuil, la perte d'une portion d'un habitat se traduira invariablement par une diminution tangible de la production de poissons.

INTRODUCTION

Effective and continuing communication between the Oceans (Fish Habitat Management, FHM) and Science Sectors of Fisheries and Oceans Canada is paramount for ensuring the conservation and protection of fisheries resources and their habitat. To further collaboration between Science and FHM, a workshop entitled 'Science Contributions Towards Improving Fish Habitat Management' was held at Ottawa during December 2003. About thirty-five professionals from Science and FHM attended the Workshop (Appendix 1).

The inter-Sector communication objectives of the workshop were to: 1) present the latest results of fish habitat research; 2) determine the implications of the research results for Fish Habitat Management; and 3) together, guide the next generation of research programs to ensure maximum benefit to Fish Habitat Management. For the first goal, the results of four DFO projects funded by the Environmental Sciences Strategic Research Fund were presented (Field Measurement of Productive Capacity, Defensible Methods, Experimental Habitat Manipulation, and Empirical Models of Productive Capacity). For the latter two projects, only preliminary results were presented as the projects are currently ongoing (completion in 2004).

To successfully achieve the workshop goals, presentations were synthesized into four theme areas, each relevant to Fish Habitat

INTRODUCTION

Des communications efficaces et continues entre le secteur des Océans (Gestion de l'habitat du poisson, ou GHP) et le secteur des Sciences de Pêches et Océans Canada sont essentielles si l'on veut assurer la conservation et la protection des ressources halieutiques et de leur habitat. Pour améliorer la communication entre les Sciences et la GHP, un atelier national intitulé Contribution des Sciences à l'amélioration de la gestion de l'habitat du poisson a été tenu à Ottawa en décembre 2003. Environ trente-cinq professionnels des Science et de la GHP ont participé à cet atelier (annexe 1).

Les objectifs de communication intersectorielle de l'atelier étaient : 1) de présenter les derniers résultats des recherches sur l'habitat du poisson; 2) de déterminer les implications des résultats de ces recherches pour la Gestion de l'habitat du poisson; 3) d'orienter, de façon concertée, la prochaine génération de programmes de recherche pour que la Gestion de l'habitat du poisson puisse en profiter au maximum. Pour le premier objectif, les résultats de quatre projets du MPO financés par le Fonds de recherche stratégique en sciences environnementales (mesure sur le terrain de la capacité de production, méthodes défendables, manipulation expérimentale de l'habitat et modèles empiriques de la capacité production) ont été présentés. Dans le cas des deux derniers projets, qui devraient être achevés au cours de 2004, seuls des résultats préliminaires sont présentés.

Pour atteindre les objectifs de l'atelier, on a regroupé les présentations sous les quatre thèmes suivants, qui sont en lien avec la gestion

Management:

1) How can you tell the relative productivity, productive capacity, sensitivity and 'value' of different habitats?

2) How can you determine when a HADD does or does not occur (i.e. severity of impact vs. threshold for HADD determination)?

3) How can you measure and detect the effect of habitat compensation or manipulation?

4) How to deal with risk and uncertainty.

The workshop took place over two days (10 and11 December, 2003). On day 1, fifteen oral presentations were shown, each addressing one or more of the Workshop themes. In addition to reporting their key findings, researchers were asked to comment on the usefulness and potential application of their results for Fish Habitat Management. The final two talks of day 1 reported on analysis of the effectiveness of habitat compensation in Canada. Day 2 started with two FHM presentations on a new hierarchical approach for managing habitat based on habitat capacity, sensitivity and the concept of pathways of effects (to be described later). The four themes were then addressed, each starting with a brief presentation followed with directed workshop discussion. Knowledge gaps, methods for more effective communication between Sectors, and future research planning were addressed in a wrap-up session.

Results of the workshop are documented in these Proceedings. An Executive Summary of the key findings is followed by a detailed account of each component of the Workshop, including a synthesis of the presentation material, workshop discussion of each of the four Theme sessions, and a strategy for future research planning. A list of participants, the workshop program, and details of the presentation material are provided in

de l'habitat du poisson :

1) Comment définir la productivité relative, la capacité de production, la vulnérabilité et la « valeur » des différents habitats ?

2) Comment déterminer qu'il y a ou on une DDP de l'habitat (i.e importance de l'impact versus le seuil de détermination d'une DDP de l'habitat) ?

3) Comment mesurer et détecter l'effet d'une compensation ou d'une manipulation de l'habitat?

4) Comment aborder la question des risques et des incertitudes?

L'atelier s'est échelonné sur deux jours, soit les 10 et 11 décembre 2003. Le premier jour, quinze présentations orales ont eu lieu, chacune portant sur l'un des thèmes retenus ou plus. En plus de partager leurs principales découvertes, les chercheurs ont été invités à commenter l'utilité et l'éventuelle application de leurs découvertes pour la gestion de l'habitat du poisson. Les deux dernières présentations de la première journée ont porté sur l'analyse de l'efficacité de la compensation des habitats au Canada. La deuxième journée a débuté par deux présentations de la GHP portant sur une nouvelle approche hiérarchique pour la gestion des habitats fondée sur la capacité de l'habitat, sa vulnérabilité et le concept de la séquence des effets (décrit plus loin). Les quatre thèmes ont par la suite été traités en commençant par une brève présentation du thème, suivie d'une discussion dirigée en atelier. Les lacunes au chapitre des connaissances, les méthodes pour améliorer la communication entre les secteurs et la planification des recherches futures ont été les sujets abordés au cours d'une séance de récapitulation.

Les résultats de l'atelier sont documentés dans le présent compte rendu. Un sommaire des principales découvertes précède le rapport détaillé de chaque composante de l'atelier. Le lecteur trouvera également une synthèse des présentations, les discussions tenues lors des quatre séances thématiques et une stratégie pour la planification des recherches futures. Une liste des participants, le programme de l'atelier et des appendices.

détails sur les présentations sont fournis en annexe.

A key recommendation discussed during wrap-up was the need to hold an annual joint workshop to facilitate on-going collaboration between Science and Fish Habitat Management, possibly by developing a new National Habitat Science Working Group with representatives from both the Science and Oceans Sectors and all DFO Regions. In addition, to provide timely advice to habitat managers, researchers were encouraged to document the results of future habitat science projects in the Canadian Science Advisory Secretariat Proceedings and Research Document Series.

Pendant la séance de récapitulation, on a débattu de la tenue d'un atelier annuel mixte pour faciliter le maintien de la collaboration entre les Sciences et la Gestion de l'habitat du poisson. Cette recommandation importante pourrait se concrétiser par la création d'un nouveau groupe de travail national sur les sciences de l'habitat constitué de représentants des secteurs des Sciences et des Océans et de toutes les régions du MPO. En outre, afin de conseiller les gestionnaires d'habitat, on incite les chercheurs à documenter les résultats de leurs futurs projets en sciences de l'habitat dans les séries de comptes rendus et de documents de recherches du Secrétariat canadien de consultation scientifique.

Following this recommendation, this Workshop document was prepared as an example of the CSAS Proceedings Series publication format.

Conformément à cette recommandation, le présent compte rendu d'atelier a été préparé à titre d'exemple de document de la série de comptes rendus du SCCS.

SYNTHESIS OF PRESENTATION MATERIAL

Day One

Fifteen oral presentations on day one of the workshop addressed one or more of the four workshop themes of habitat productive capacity, threshold response, compensation and uncertainty (workshop program in Appendix 2). Although based on different study objectives, ecosystem type and geographic location, many of the talks were consistent and reached similar conclusions on key issues, each of which were elements of the four workshop themes. The goal of this synthesis is to highlight the consistencies and common conclusions from the presentation material and to discuss their significance to managers. The key generic conclusions were:

1) impacts of habitat alteration on productive capacity are best assessed at a population spatial scale (or populations);

2) more knowledge is needed of the functional relationships between habitat and the different life stages of fish (habitat-dependent process rates);

SYNTHÈSE DES PRÉSENTATIONS

Première journée

Les 15 présentations orales de la première journée abordent au moins l'un des quatre thèmes de l'atelier que sont la capacité de production de l'habitat, le seuil de réaction, la compensation et l'incertitude (programme de l'atelier à l'annexe 2). Bien qu'elles portent sur des objectifs d'étude, des types d'écosystèmes et des lieux géographiques différents, nombre de ces présentations tournent autour des même questions clés et arrivent à des conclusions semblables, dans la foulée des quatre thèmes de l'atelier. Le but de la présente synthèse est de faire ressortir les points communs et les conclusions communes de ces présentations et d'évaluer leur importance pour les gestionnaires. Les conclusions génériques principales sont les suivantes.

1) Il est préférable d'évaluer les effets de la détérioration de l'habitat sur la capacité de production à l'échelle des populations.

2) Il faut approfondir nos connaissances sur les relations fonctionnelles qui existent entre l'habitat et les différents stades de développement des poissons (processus liés à l'habitat).

3) fish-habitat linkages are dynamic and, despite much research on habitat productivity capacity, generalization and extrapolation of habitat capacity remains uncertain;

4) fish responses to changes in habitat alteration are often non-linear (e.g., threshold; Figure 1 and Table 1);

5) habitat evaluation is best achieved using a multi-tier approach, with the level of detail dependent on the objectives of the project.

Despite the challenges evident in these issues, all presenters showed how the results were relevant, useful and applicable to fish habitat management. Several participants emphasized that a similar workshop is needed to address marine habitat issues.

Participation by both science and habitat managers was a major strength of the workshop. As evidence of this strong collaboration, the presentation material is synthesized in this section by focusing on the application of the four themes to habitat management based on the input from both Sectors. For further reference, abstracts of the individual presentations, together with workshop questions and discussion are provided in Appendix 3. Presentation slides are reproduced in Appendix 5.

The feasibility and utility of measuring habitat-dependent capacity and production was introduced in the presentation on inland lakes by Pratt et al. Results were presented from three Canadian Shield areas in Ontario: Swan Lake Reserve in Algonquin Park, Turkey Lakes watershed near Sault Ste. Marie, and the Experimental Lakes Area (ELA) of northwestern Ontario. For all areas, the *a priori* classification of lake habitat was kept to a minimum. Fish density was habitat-dependent: habitats with diverse cover had the highest potential production. An important conclusion was that methods for assessing habitat should be kept as simple as possible. Less time-consuming estimates of

3) Les liens entre l'habitat et les poissons sont dynamiques et, malgré l'importante somme de recherches sur la capacité de production des habitats, la généralisation et l'extrapolation de la capacité des habitats demeurent incertaines.

4) La réaction des poissons à la détérioration de l'habitat est souvent non linéaire (p. ex.:seuil; figure 1 et tableau 1).

5) L'habitat sera mieux évalué en utilisant une approche à plusieurs volets et un niveau de détail adapté aux objectifs du projet.

Malgré les défis évidents entourant ces questions, tous les présentateurs démontrent la pertinence, l'utilité et l'applicabilité des résultats pour la gestion de l'habitat du poisson. Plusieurs participants soulignent la pertinence d'un atelier semblable sur les questions relatives aux habitats marins.

La participation des gestionnaires des secteurs des sciences et des gestionnaires d'habitats est l'un des points forts de l'atelier. Pour démontrer la bonne collaboration qui existe, on résume le contenu des présentations dans cette section en mettant l'accent sur l'application des quatre thèmes à une gestion de l'habitat fondée sur la contribution des deux secteurs. À titre indicatif, le lecteur trouvera à l'annexe 3 les résumés des différentes présentations ainsi que les questions et débats soulevés pendant l'atelier. Les diaporama des présentations sont quant à eux reproduits à l'annexe 5.

La faisabilité et l'utilité de la mesure de la capacité et de la production liées aux habitats ont fait l'objet d'une présentation de Pratt *et al*. portant sur les lacs intérieurs. Les résultats de trois régions ontariennes du Bouclier canadien sont présentés. Il s'agit de la réserve de Swan Lake, dans le parc Algonquin, du bassin hydrographique de Turkey Lakes, près de Sault Ste. Marie, et de la région des lacs expérimentaux (ELA) du nord-ouest de l'Ontario. Pour toutes les régions, la classification *a priori* d'habitat lacustre a été maintenue au strict minimum. La densité des poissons était dépendante de l'habitat : les habitats dont le couvert est varié offrent le plus grand potentiel de biomass based on visual methods were correlated with more time-consuming estimates of production using the instantaneous growth rate method. Based on the results of these studies and others, it would likely be possible to reach consensus on a cursory but defensible habitat capacity classification scheme for small Shield lakes in Ontario (and probably elsewhere) with a panel of experts at a future workshop, if such a classification scheme was judged to be useful by habitat managers.

Evaluating habitat productive capacity in large rivers is more challenging and has received less attention than in inland lakes. Franzin et al. showed that catch rates of fish by electrofishing in large rivers were dependent on depth, substrate, water visibility and the size of fish. Although challenging to survey, the habitat of large rivers is determined by fluvial processes, that may be predictable using physical process models (such as erosion, transport, deposition; ETD). Effective surveys can be designed using a stratified random design, with substrate, depth and spatial scale as strata. Significantly, similar survey designs were developed in the Prairies and Ontario using these strata criteria. Experience of evaluating habitat productive capacity in large rivers was instructive in showing that electrofishing efficiency was habitat dependent (thus calibration is needed to standardize the catches by habitat type), and that habitat is spatially dynamic. Both conclusions apply to other ecosystems as well. With refinement of the physical process models, and with further work defining fish-habitat links, coarse habitat classification schemes for rivers will be achievable in future.

The influence of physical processes on fish habitat was equally evident in the Great Lakes, where the nature of the physical habitat and fish

production. L’une des conclusions importantes tirée est que les méthodes d’évaluation de l'habitat doivent demeurer le plus simple possible. On a établi des corrélations entre des évaluations plus expéditives de la biomasse fondées sur des méthodes visuelles et des évaluations moins expéditives de la production en utilisant la méthode du taux de croissance instantané. D’après les résultats de ces études et ceux d'autres travaux, il serait probablement possible d’obtenir un consensus concernant un plan de classification préliminaire mais justifiable de la capacité des habitats pour de petits lacs du Bouclier situés en Ontario (et probablement ailleurs) au sein d’un groupe d’experts au cours d’un éventuel atelier, si une telle méthode de classification était jugée utile les gestionnaires d'habitats.

L’évaluation de la capacité de production des grands cours d’eau est plus difficile et suscite moins d’intérêt que celle des lacs intérieurs. Franzin *et al.* démontrent que les taux de capture par la pêche à l’électricité dans les grands cours d’eau sont fonction de la profondeur, du substrat, de la visibilité dans l'eau et de la taille des poissons. Bien que difficile à évaluer à l’aide de relevés, l'habitat des grands cours d’eau est déterminé par les processus fluviaux, qui peuvent être prévus au moyen de modèles basés sur les processus physiques (tels que l'érosion, le transport, les dépôts; « *ETD* »). Il est possible d’obtenir des relevés efficaces en utilisant un échantillonnage aléatoire stratifié, les strates étant le substrat, la profondeur et l’échelle spatiale. On a élaboré des concepts de relevés semblables dans les Prairies et en Ontario en utilisant ces critères de strates. L’expérience en matière d’évaluation de la capacité de production des habitats des grands cours d’eau nous apprend beaucoup en démontrant que l'efficacité de la pêche à l’électricité dépend de l'habitat (il faut donc procéder à un étalonnage pour normaliser les prises par type d'habitat) et que l'habitat possède une dynamique spatiale. Ces deux conclusions s'appliquent à d'autres écosystèmes aussi. En améliorant les modèles sur les processus physiques et en travaillant davantage pour définir les liens entre les habitats et les poissons, des modèles généraux de classification des habitats des cours d’eau pourront être mis au point.

L'incidence des processus physiques sur l'habitat du poisson est également évidente dans les Grands Lacs, où la nature de l'habitat physique et occurrence was correlated with coastal exposure. Randall et al. showed that habitat productive capacity as measured by seasonal fish biomass could be predicted from knowledge of site exposure (fetch distance). More accurate regression tree models resulted if other habitat features were used together with fetch as predictors. Using these results and approach, maps of habitat productive capacity in the near shore areas of the lower Great Lakes can be developed for most shorelines. Although providing only rudimentary estimates of capacity, the maps would be useful for deciding if a more detailed habitat assessment was needed depending on the location, scale and nature of each specific project.

de la présence de poissons est mise en corrélation avec l'exposition côtière. Randall *et al.* ont démontré que la capacité de production de l'habitat, telle que mesurée à partir de la biomasse saisonnière de poissons, pourrait être estimée à partir des connaissances sur l'exposition du site (fetch). Des modèles d'arbre de régression plus précis sont obtenus lorsque d'autres caractéristiques de l’habitat sont utilisées avec le fetch comme variables indicatives. En utilisant ces résultats et cette approche, des cartes de la capacité de production des habitats des zones situées près des côtes des Grands Lacs inférieurs peuvent être produites pour la plupart des rivages. Bien qu’elles ne fournissent que des estimations rudimentaires de la capacité, les cartes peuvent être quand même utiles pour déterminer si une évaluation plus détaillée de l'habitat est nécessaire selon l'endroit, l’échelle et la nature de chaque projet.

Multi-tiered and multi-scale assessment of fish habitat was a key theme of the talks from Newfoundland and Labrador. Although the habitat of coldwater salmonids is well-known compared to other fish taxa, Scruton and Clarke emphasized that habitat use by fishes in Newfoundland is unique because of the small number of species that inhabit the watersheds. Also, water productivity is low and there is a close interface between the land and the water because of the abundance of fluvial habitat and numerous small lakes in the watersheds. At this point in the workshop, the contrast in ecosystem type and geography was a timely reminder that the biotic community and system productivity influences habitat use by fishes, reinforcing the earlier conclusion that habitat is spatially and temporally dynamic. Generalizations about habitat use are bounded with uncertainty. Habitat classification in Newfoundland and to a less extent Labrador has a long history that has evolved from salmon (*Salmo salar*) focused meso-scale classification to a multi-species 3-scale (micro, meso, and macro-habitat) classification approach. The level of detail of habitat evaluation depends on the objectives and magnitude of the project. Productive capacity in Newfoundland is first limited by productivity, and then by habitat availability. Winter habitat, proximity to different habitats and variable seasonal use are all important factors. Research on habitat supply links to population production is currently being investigated at a study watershed in Newfoundland (Northeast Trepassey) and New Brunswick (Catamaran). Examples of

Les évaluations de l’habitat du poisson à volets et échelles multiples sont l’un des thèmes clés des discussions de Terre-Neuve et du Labrador. Bien que l'habitat des salmonidés d’eau froide soit bien connu comparativement à celui d'autres groupes de poissons, Scruton et Clarke soulignent que l'utilisation de l’habitat terre-neuvien par les poissons est unique en raison du nombre restreint d'espèces qui peuplent les bassins hydrographiques. De plus, la productivité de l'eau est faible, et il existe une interface étroite entre la terre et l'eau en raison de l'abondance des habitats fluviaux et des nombreux petits lacs dans les bassins hydrographiques. À ce stade de l'atelier, le contraste entre le type d'écosystème et la géographie constitue un rappel opportun de l’incidence qu’ont la biocénose et la productivité des systèmes sur l'utilisation de l’habitat par les poissons, ce qui vient renforcer la conclusion précédente à l’effet que l'habitat est dynamique sur les plans spatial et temporel. Les généralisations au sujet de l'utilisation de l’habitat sont limitées par les incertitudes. La classification des habitats à Terre-Neuve et, à un degré moindre, au Labrador, a une longue histoire qui débute avec une classification d’échelle moyenne fondée sur le saumon (*Salmo salar*) à une approche de classification multi-espèces à trois échelles (micro, méso et macro habitats). Le niveau de détail de l'évaluation de l'habitat dépend des objectifs et de l'ampleur du projet. La capacité de production à Terre-Neuve est d'abord limitée par la productivité, puis par la disponibilité des habitats. L'habitat d'hiver, la proximité des différents habitats et l'utilisation saisonnière compensation actions were mentioned and the potential use of adaptive management was introduced. Adaptive management as a means of dealing with uncertainty became a focal point for discussion on day 2. Riverine habitat science in Newfoundland was relevant to all four workshop themes.

variable sont des facteurs importants. Les liens existant entre les habitats disponibles et la production de population font présentement l'objet d'une étude dans un bassin hydrographique terre-neuvien (Northeast Trepassey) et un bassin néo-brunswickois (Catamaran). Des exemples de mesures de compensation sont donnés, puis on présente la possibilité d'utiliser la gestion adaptative. Le recours à la gestion adaptative pour résoudre les incertitudes devient le centre du débat de la deuxième journée. La science des habitats riverains de Terre-Neuve est pertinente pour les quatre thèmes de l'atelier.

Meso-scale habitat classification was used for a detailed comparative study of salmonid production in two watersheds on the west (Copper Lake) and east coasts (Stoney Pond) of Newfoundland. The production studies were conducted seasonally in both riverine and lake habitat, and provided a contrast between a single species watershed (*Salvelinus fontinalis* in Copper Lake) and a multispecies community in Stoney Pond (4 salmonids, eels and stickleback), a situation which is unusual for Newfoundland. Clarke and Scruton reported that salmonid density, production and P/B ratios were higher in fluvial than in lake habitat within each watershed. Fluvial habitat was important for spawning, recruitment and early growth and the small lakes were used by older fish for feeding, growth and as winter refugia. Use of lake habitat was thus both life-stage and season-dependent. On a unit area basis, fluvial habitat was judged to be more sensitive than lake habitat because of its role as a source of recruitment, high relative production and a corridor for inter-habitat movements. The occurrence and magnitude of seasonal movements of salmon and trout between the lacustrine and fluvial habitat were relevant to HADD (dependence of life-stage production on migration corridors), compensation (need for different river and lake compensation ratios), and risk (uncertainty of fish movement in unstudied areas). The Clarke and Scruton watershed studies demonstrated the need to evaluate localized habitat projects at a population and watershed scale.

La classification des habitats à l'échelle moyenne est utilisée dans une étude comparative détaillée sur la production des salmonidés dans deux bassins hydrographiques de la côte ouest (Copper Lake) et de la côte est (Stoney Pond) de Terre-Neuve. Les études sur la production, menées sur une base saisonnière dans les habitats fluviaux et lacustres, révèlent un contraste entre un bassin hydrographique contenant une seule espèce (*Salvelinus fontinalis* à Copper Lake) et une communauté de plusieurs espèces à Stoney Pond (quatre salmonidés, des anguilles et des épinoches), une situation peu commune à Terre-Neuve. Clarke et Scruton rapportent que la densité, la production et les rapports P : B des salmonidés sont plus élevés dans les habitats fluviaux que dans les habitats lacustres et ce, dans les deux bassins hydrographiques. L'habitat fluvial est important pour le frai, le recrutement et la croissance précoce, tandis que les petits lacs sont utilisés par les poissons plus âgés comme aire d'alimentation et de croissance ainsi que comme refuge hivernal. L'utilisation des habitats lacustres est donc dépendante du stade de croissance et de la saison. Sur la base d'une zone unitaire régionale, les habitats fluviaux sont considérés comme plus vulnérables que les habitats lacustres en raison des rôles qu'ils jouent dans le recrutement et en tant que couloirs inter-habitats ainsi que par leur production relative élevée. L'occurrence et l'ampleur des mouvements saisonniers des saumons et des truites entre les habitats lacustres et fluviaux sont des paramètre pertinents pour la DDP de l'habitat (dépendance de la production selon les stades de développement dans les couloirs de migration), la compensation (besoin de rapports de compensation distincts pour les rivières et les lacs) et l'établissement du risque (incertitudes entourant les mouvements de poissons dans les régions non étudiées). Les études de bassins hydrographiques de Clarke et Scruton démontrent la nécessité d'évaluer les projets d'habitats localisés à l'échelle des populations et des bassins hydrographiques.

Ridgway continued the theme of assessing trout habitat at a watershed scale in his presentation of *Salvelinus* thermal habitat in central Ontario. Strong collaboration between hydrologists and biologists showed that a 'Topographic Index (TI)' could be used to predict the location of coldwater feeder streams that provided critical habitat for age 0 trout that was important for reproduction and early life history. Because of the close land-water ecotone, small lakes were shown to be more important than large lakes for providing groundwater and critical thermal habitat for trout. Ridgway concluded that habitat managers should focus on the protection of these feeder-stream hydrologic units rather than the traditional perimeter buffer zone (donuts), as alterations to these critical thermal habitats would be considered to be a HADD. The occurrence of age 0 trout habitat could be predicted using TI with reasonable confidence, indicating the importance of the need for collaboration between fish biologists, hydrologists, and habitat managers.

Ridgway a enchaîné avec le thème de l'évaluation de l'habitat des truites à l'échelle des bassins hydrographiques dans sa présentation sur la niche thermique de *Salvelinus* du centre de l'Ontario. Une collaboration soutenue entre les hydrologues et les biologistes démontre qu'un indice topographique (IT) peut être employé pour prévoir l'emplacement des cours d'eau froide qui fournissent l'habitat critique dont ont besoin les truites à l'âge 0 (habitat important pour la reproduction et les premiers stades de développement). En raison de liens étroits entre l'écotone terrestre et aquatique les petits lacs sont plus importants que les grands lacs en tant que milieux capables de fournir les eaux de résurgence et l'habitat thermique critique dont la truite a besoin. Ridgway conclut que les gestionnaires de l'habitat devraient se concentrer sur la protection de ces unités hydrographiques situées à la tête des bassins versants plutôt que la protection de l'habituelle bande riveraine tampon étant donné qu'une détérioration de ces habitats thermiques critiques serait considérée comme étant une DDP de l'habitat . L'occurrence des habitats pour les truites à l'âge 0 peut être prévue avec un certain degré de confiance à l'aide de l'IT, ce qui indique l'importance de la collaboration entre les biologistes axés sur les poissons, les hydrologues et les gestionnaires de l'habitat.

Further south in Ontario, Stanfield showed the threshold effect of urban development on the stream biota of Lake Ontario tributaries (Figure 2). Continuing the theme of evaluating habitat at a landscape scale, multivariate and GIS techniques were used to show the non-linear relationship between species occupancy and richness (fish and invertebrates) and percent imperviousness (a correlate of urban development) of the watersheds. The threshold effects by the Stanfield et al. study was later referred to as a prime but rare example of a threshold response between habitat disturbance and biota. The results were also significant in showing HADD at a watershed scale: aquatic resources are impacted negatively if human development exceeds certain definable limits in these Ontario watersheds. Results will be useful for developing regional fish habitat management plans.

Stanfield a démontré l'effet de seuil qu'a le développement urbain plus au sud de l'Ontario sur le biote des tributaires du lac Ontario (figure 2). Pour poursuivre sur le thème de l'évaluation de l'habitat à l'échelle des paysages, des techniques multidimensionnelles et le SIG ont été utilisés pour démontrer le rapport non linéaire existant entre l'occupation et la richesse des espèces (de poissons et d'invertébrés) et le pourcentage d'imperméabilité (une corrélation du développement urbain) des bassins hydrographiques. Les effets de seuil démontrés dans l'étude de Stanfield *et al.* ont été par la suite reconnus en tant qu'exemple important mais rare d'un seuil de réaction entre la perturbation d'habitat et le biote. Les résultats démontrent également la DDP de l'habitat à l'échelle d'un bassin hydrographique : les ressources aquatiques sont affectées si le développement humain dépasse certaines limites définissables dans ces bassins hydrographiques de l'Ontario. Les résultats seront utiles pour élaborer des plans régionaux de gestion d'habitat des poissons.

For individual populations, threshold rather than linear responses to habitat change are often likely to occur. Minns argued convincingly that the links between the quantity (supply) of different habitats and fish population response can only be understood (context of HADD) by studies of the ontogenetic use of habitat by fishes. In this context, and using density-fish size relationships, Minns calculated the area-per fish requirements (API) at different life stages to investigate and model the sensitivity of population dynamics and population resilience to habitat supply. The working hypothesis was that habitat bottlenecks determine the trajectory and outcome of population dynamics. A sensitivity analysis showed that a population of *Salvelinus namaycush* was most sensitive to habitat supply at the juvenile and adult stages rather than at the spawning stage, a result that was contrary to conventional expectation. The important inference was the immediate need for habitat management to shift away from site specific evaluations, and assess potential HADD at a population scale instead. This conclusion was consistent with the primary theme of many of the Workshop presentations that preceded and followed, but the Minns talk was unique in actually quantifying and demonstrating the impact of habitat supply on the population, with relevance to threshold response, HADD and uncertainty. The sources of uncertainty in fish life stage-habitat models are discussed later. API models have much potential as a tool for science with direct application to habitat management.

Pour certaines populations, il est plus probable que les changements touchant les habitats provoquent des réactions par seuils plutôt que des réactions linéaires. Minns a expliqué de façon convaincante que les liens entre la quantité (disponibilité) de différents habitats et les réactions des populations de poissons ne peuvent être compris (contexte de DDP de l'habitat) que par des études sur l'utilisation ontogénétique de l'habitat par les poissons. Dans ce contexte, et en se servant des relations entre la densité et la taille des poissons, Minns a calculé la superficie requise par poisson à différents stades de développement afin d'étudier et de modéliser la sensibilité de la dynamique et de la résilience des populations vis-à-vis de la disponibilité des habitats. L'hypothèse de travail est que les goulots d'étranglement dans les habitats déterminent la trajectoire et le résultat de la dynamique de population. Une analyse de vulnérabilité démontre qu'une population de *Salvelinus namaycush* est plus vulnérable à la disponibilité des habitats aux stades juvéniles et adultes qu'au stade du frai, un résultat contraire à ce que l'on s'attend habituellement. L'importante conclusion tirée est que les gestionnaires d'habitats remplacent l'actuelle évaluation propre au site par l'évaluation de la DDP potentielle de l'habitat à l'échelle de la population. Cette conclusion est conforme au thème principal de la plupart des présentations qui ont précédé et qui ont suivi, mais les propos de Minns exposent et démontrent bien l'impact de la disponibilité des habitats sur la population, en faisant un lien avec le seuil de réaction, la DDP de l'habitat et les incertitudes. Les sources d'incertitude des modèles fondés sur les stades de développement des poissons et l'habitat sont discutés plus loin. Les modèles basés sur la superficie d'habitat requis par poisson ont beaucoup de potentiel comme outil pour la science tout en permettant une application directe à la gestion des habitats.

Many of the talks implicitly or explicitly linked productive capacity to habitat sensitivity. Another important habitat sensitivity factor is the occurrence of aquatic species-at-risk (SAR). Knowledge of the occurrence of sensitive species obviously impacts on the risk associated with habitat management; the at-risk status of many species resulted historically from habitat

Nombre des discussions relient de façon implicite ou explicite la capacité de production à la vulnérabilité de l'habitat. Un autre facteur important associé à la vulnérabilité de l'habitat est la présence d'espèces aquatiques en péril. La présence connue d'espèces vulnérables a un effet sur le risque associé à la gestion de l'habitat; le statut d'espèce en péril de plusieurs espèces deterioration. Mandrak developed a web-based mapping tool to be used by FHM for determining the presence of SAR in Ontario. Based on a large GIS database of species occurrence, the presence/absence of SAR species can be determined at two scales, regional (tertiary watershed) or local (specific stream segments). The web-tool is useful for the day-to-day management of referrals in Ontario. Work is ongoing to develop models of critical habitat and meta-population structure of SAR; both are priority topics for developing restoration programs. The web-based tool demonstrated the value of collaboration between Science and Fish Habitat Management. In addition to awareness of SAR, knowledge of species occupancy will be useful to habitat and fisheries managers for other reasons.

résulte de la détérioration des habitats. Mandrak a élaboré un outil cartographique sur le Web pour que la GHP puisse déterminer la présence d'espèces en péril en Ontario. À partir d'une grande base de données SIG sur l'occurrence des espèces, il est possible de déterminer la présence ou l'absence d'espèces en péril à l'échelle régionale (bassin hydrographique tertiaire) ou à l'échelle locale (segments précis de cours d'eau). L'outil cartographique sur le Web est utile pour la gestion quotidienne des soumissions liées à l'habitat en Ontario. Des travaux sont en cours pour mettre au point des modèles d'habitat critique et de structure de métapopulation d'espèces en péril; ces travaux prioritaires permettront la mise sur pied de programmes de rétablissement. L'outil cartographique sur le Web démontre la valeur de la collaboration entre les Sciences et la Gestion de l'habitat du poisson. En plus de permettre une sensibilisation en regard des espèces en péril, la connaissance de la présence de ces dernières est utile aux gestionnaires de l'habitat et des pêches pour d'autres raisons.

Another screening tool useful to FHM developed in the Pacific Region to address the issue of water extraction for small-scale hydro facilities was described by Bradford and Hatfield. Bradford et al. developed a decision framework and screening tool for determining instream flow (IF) requirements to maintain the functionality of fish habitat (Fig. 3). The screening tool was developed using local expertise and consensus in a series of workshops and meetings. The resulting process differentiated between tributaries with and without fish, and resulted in agreed-upon discharge guidelines for determining minimum but conservative flow requirements that if exceeded would result in a HADD. Protocols for monitoring and data collection are also being documented. As with the web-based database described above, the IF tool will be useful for pre-screening habitat referrals in the Pacific Region. The pre-screening tool would lead to a 2-stage process for evaluating habitat management needs (Fig. 3). The concept, method and products could be applied to other Regions as well if the tool was revised and customized for other regional landscapes. Water extraction for non-fish use (energy, consumption, recreation etc.) will be a continually expanding issue in all Regions of Canada with increases in the human population.

Bradford et Hatfield ont décrit un autre outil d'évaluation préliminaire utile pour la GHP qui a été mis au point dans la région du Pacifique pour étudier la question de l'extraction d'eau associée aux petites installations hydroélectriques. Bradford *et al.* ont élaboré un cadre décisionnel et un outil d'évaluation préliminaire pour déterminer le débit minimal requis pour maintenir les fonctions de l'habitat du poisson (fig. 3). L'outil d'évaluation préliminaire a été élaboré avec le concours d'experts locaux et de consensus obtenus dans une série d'ateliers et de réunions à ce sujet. On a ainsi pu différencier les tributaires abritant des poissons de ceux sans poisson et établir des lignes directrices pour déterminer un débit minimal mais prudent qui, s'il est dépassé, provoquerait une DDP de l'habitat. Des protocoles de suivis et de récolte de données sont aussi documentés. À l'instar de la base de données Web décrite précédemment, l'outil d'évaluation du débit minimal sera utile pour faire l'évaluation préliminaire des soumissions liées à l'habitat dans la région du Pacifique. L'outil d'évaluation préliminaire devrait enclencher un processus d'évaluation en deux étapes des besoins relatifs à la gestion de l'habitat (fig. 3). Le concept, la méthode et les produits pourraient aussi s'appliquer à d'autres régions si l'outil est mis à jour et adapté aux caractéristiques géographiques régionales. L'extraction de l'eau pour un usage autre que pour l'utilisation par le poisson (énergie, consommation, loisirs, etc.) est une question qui prendra de l'importance dans toutes les régions du Canada avec l'augmentation de la population humaine.

Contrasts in resilient and threshold responses to habitat alteration by fishes were indicated in the experimental manipulation projects of Smokorowski, Mills, and Blanchfield et al. Despite using a sensitive and data-intensive Before-After-Control-Impact (BACI) survey design, the Smokorowski study was unable to detect significant responses in the fish community (largely cyprinids) after controlled habitat removal or addition experiments. The results were surprising to some because of the spatial scale of the experiments: woody debris cover was removed from 50% of the shoreline area. Smokorowski et al. concluded that less demanding CPUE data were as useful as more time-consuming mark-recapture studies. The BACI approach was not effective for detecting functional responses between fish and their habitat. The authors recommended that the study areas continue to be monitored in the future, and also the scale of the habitat alteration should be expanded beyond 50% to show and detect a threshold response. The Smokorowski et al. project was instrumental in showing 1) experimental manipulation, although expensive, was invaluable for making significant advances in our knowledge of habitat science (resilient response); and 2) determining the effects of habitat compensation is a challenge because of the variability in the fish measures; and 3) dealing with uncertainty is a paramount issue in habitat science. The latter two issues, compensation and uncertainty, are fully discussed later as Workshop themes.

Les contrastes au niveau des seuils de réaction et de la résilience des poissons vis-à-vis de la détérioration de l'habitat sont dans les projets de manipulation expérimentale de Smokorowski, Mills et Blanchfield *et al*. Malgré le recours à un concept d'étude de type BACI (avant-après-témoin-impact) sensible et à grand volume de données, Smokorowski n'a pu détecter de réaction significative dans la communauté de poissons (en grande partie des cyprinidés) dans le cadre d'expériences contrôlées sur le retrait ou l'ajout d'habitats. Les résultats peuvent être surprenants en raison de l'échelle spatiale des expériences : le couvert de débris de bois ayant été enlevé sur 50 % de la superficie du rivage. Smokorowski *et al.* concluent que des données sur les CPUE, plus faciles à obtenir, sont aussi utiles que les données recueillies dans le cadre d'études plus longues réalisées par marquage et recapture. L'approche BACI n'est pas efficace pour détecter les réactions fonctionnelles entre les poissons et leur habitat. Les auteurs recommandent que l'on poursuive le suivi des zones d'étude et que l'échelle de la perturbation de l'habitat soit élargie à plus de 50 % pour que l'on puisse démontrer et détecter un seuil de réaction. Le projet de Smokorowski *et al.* démontre : 1) que la manipulation expérimentale, bien que coûteuse, s'est révélée fort utile pour faire progresser les sciences de l'habitat (réponse de résilience); 2) que la détermination des effets de la compensation pour les pertes d'habitats n'est pas chose facile en raison de la variabilité des mesures sur les poissons; 3) que l'incertitude est une question primordiale en sciences de l'habitat. Les deux dernières questions, à savoir la compensation et l'incertitude, ont été revues plus en profondeur plus tard en tant que thèmes de l'atelier.

Experimental removal of macrophytes was assessed at a population level and in contrast to the above study, the impacts were detectable and obvious at the Experimental Lakes Area study site of Mills et al. Recruitment, growth, biomass and production of northern pike (*Esox lucius*) significantly declined after the macrophytes were harvested. Co-habiting species were also shown to be impacted. The study was conducted over several years, and pike growth and production responded positively after the macrophyte

Le retrait expérimental de macrophytes a été évalué au niveau des populations et, contrairement à l'étude précédente, les impacts sont observables et manifestes sur le site de la zone d'étude des lacs expérimentaux de Mills *et al*. Le recrutement, la croissance, la biomasse et la production du brochet nordique (*Esox lucius*) ont diminué considérablement après que les macrophytes aient été récoltés. Les autres espèces ont également été affectées. L'étude réalisée sur plusieurs années a démontré que la harvesting was discontinued. Pike is known to have a close association with vegetated aquatic habitat at several stages of its life history (spawning substrate; predator-prey cover). This functional association may partially explain the difference between the Mills pike study and the Smokorowski cyprinid study.

croissance et la production du brochet a augmenté après l'arrêt de la récolte des macrophytes. On sait que le brochet est étroitement associé aux habitats aquatiques végétalisés pendant plusieurs étapes de son cycle biologique (substrat de frai; couverture prédateur-proie). Cette association fonctionnelle peut en partie expliquer la différence entre l'étude sur les brochets de Mills et l'étude sur les cyprinidés de Smokorowski.

The value of whole lake experimentation was further demonstrated with the study of the dramatic and immediate effect on lake whitefish (*Coregonus clupeaformis*) to water draw-down in the Experimental Lakes Area. Blanchfield et al. showed that experimental drawdown resulted in a significant decrease in lake surface area and lake volume. The draw-down resulted in recruitment failure, and reduced survival (reduction in over-winter survival via oxygen reduction) and consequently reduced population abundance. Mechanisms included egg loss from dewatering, loss of productivity from the littoral habitat, and lower oxygen levels leading to lower over-winter survival. A major finding was that the whitefish population did not recover quickly after the drawdown experiment ended. The slow response to the habitat restoration was in contrast to known faster recoveries of populations after exploitation is lessened. Implications to Fish Habitat Management were that the timing and extent of drawdowns must be highly regulated, and compensation measures (artificial spawning areas) need to be investigated.

La valeur d'une expérimentation sur un lac entier est davantage démontrée avec l'étude de l'effet immédiat et drastique qu'ont occasionnés des baisses du niveau de l'eau des lacs expérimentaux sur le grand corégone (*Coregonus clupeaformis*). Blanchfield *et al.* ont démontré que ces baisses expérimentales du niveau de l'eau ont provoqué une diminution significative de la superficie du lac et de son volume, ce qui a occasionné l'échec du recrutement et une baisse des taux de survie (réduction de la survie hivernale en raison d'une réduction des concentrations d'oxygène dans l'eau) et, par conséquent, une réduction de l'abondance de la population. Parmi les problèmes créés, mentionnons la perte d'œufs due à l'assèchement, la perte de productivité de l'habitat du littoral et la baisse des concentrations d'oxygène, qui a entraîné une baisse de la survie hivernale. L'étude a notamment permis de constater que la population de grands corégones n'avait pas récupéré rapidement après la fin de l'expérience d'abaissement du niveau de l'eau. Le rétablissement plus lent des populations observé suite à la restauration de l'habitat se distingue des rétablissements rapides des populations notés suite à une réduction de leur exploitation. Pour la Gestion de l'habitat du poisson, cela signifie que la durée des baisses de niveaux de l'eau doit être fortement réglementée et que des mesures de compensation (aires de frai artificielles) doivent être envisagées.

Compensation is the best test of our knowledge of habitat capacity and the final two presentations of day 1 addressed the effectiveness of compensation in achieving No Net Loss of productive capacity. Harper and Quigley conducted a detailed file and literature review of projects authorized between 1986 and 2002. Results of this survey showed that often the assessment of compensation was based on qualitative rather than quantitative methods. The quality of the authorization files was often poor, and the effectiveness of compensation remained

La compensation est le meilleur moyen pour vérifier l'état de nos connaissances sur la capacité d'un habitat. Or, les deux dernières présentations de la première journée portent effectivement sur l'efficacité des mesures de compensation à éliminer toute perte au chapitre de la capacité de production. Harper et Quigley ont procédé à une revue complète des dossiers et de la littérature concernant les projets autorisés entre 1986 et 2002. Les résultats de cette étude prouvent que, souvent, l'établissement des mesures de compensation requise est fondé sur unknown and uncertain. Harper and Quigley concluded that resource managers and Science should work together to develop a national evaluation program within an adaptive management framework.

des méthodes qualitatives plutôt que sur des méthodes quantitatives. La qualité des dossiers d'autorisation laisse souvent à désirer, et l'efficacité des mesures de compensation demeure inconnue et incertaine. Harper et Quigley concluent que les gestionnaires de ressources et les Sciences devraient collaborer à l'élaboration d'un programme national d'évaluation dans un cadre de gestion adaptative.

In a complementary study, Quigley and Harper measured compliance for 52 projects and effectiveness for16 projects involving HADD that were authorized by DFO across Canada. Habitat productivity was assessed using information on periphyton biomass, invertebrate density, fish biomass and riparian density. The results of the study were instructive and indicated that contrary to the intent, habitat capacity was being lost. Compliance rate was low, and the actual field area of HADD was significantly greater than the area indicated in the Authorization file. A Net Loss of habitat area occurred in most (67%) of the cases. Generally, riparian habitat compensation was not sufficient to compensate for the habitat loss. Even if compliance was 100%, it was unlikely that NNL would be achieved. Because of the uncertainty of the effectiveness of compensation habitat, compensation ratios of 1:1 are not sufficient to ensure NNL. Based on their study, the authors concluded that 'our ability to replicate ecosystem function is clearly limited'. The results of this important study emphasized the need for increased monitoring and enforcement of authorized habitat projects, and the need to prepare new guidelines on appropriate compensation ratios. The presentations by Quigley and Harper prompted much constructive discussion at the workshop, and indicated that the FHM program is dynamic and constantly evolving.

Dans une étude complémentaire, Quigley et Harper ont mesuré la conformité de 52 projets et l'efficacité de 16 projets impliquant une DDP de l'habitat qui ont été autorisés par le MPO au Canada. La productivité des habitats a été évaluée à partir de l'information sur la biomasse de périphyton, la densité des invertébrés, la biomasse de poissons et la densité riveraine. Les résultats de l'étude sont enrichissants et indiquent que, contrairement à l'objectif visé, il y aurait une perte de la capacité de production de l'habitat. Le taux de conformité était faible, et la zone réelle de DDP de l'habitat était sensiblement plus grande que la zone indiquée dans le dossier d'autorisation. Une perte nette en superficie d'habitat a été constatée dans la plupart des cas (67 %). Généralement, les mesures de compensation pour l'habitat riverain ne suffisent pas pour compenser la perte réelle d'habitat. Même si on constate une conformité de 100 %, il est peu probable que le principe « d'aucune perte nette » d'habitat soit atteint. En raison de l'incertitude quant à l'efficacité des mesures de compensation, des rapports de compensation de 1/1 ne sont pas suffisants pour assurer le principe d'aucune perte nette. D'après leur étude, les auteurs arrivent à la conclusion que « notre capacité de reproduire les fonctions de l'écosystème est nettement limitée ». À la lumière des résultats de cette étude importante, il faut de toute évidence accroître le suivi, respecter les exigences relatives aux projets d'habitat autorisés et préparer de nouvelles lignes directrices sur les ratios de compensation. Les présentations de Quigley et Harper suscitent des échanges constructifs et indiquent que le programme de la GHP est dynamique et en constante évolution.

Uncertainty of habitat productive capacity was mentioned in the presentations from both science and Fish Habitat Management, providing a nice lead to day 2. Dealing with uncertainty using an adaptive management framework and the need for continued and frequent collaboration between Science and Fish Habitat Management are discussed further in the Theme sessions.

L'incertitude quant à la capacité de production des habitats est mentionnée dans les présentations des Sciences et de la Gestion de l'habitat du poisson, ce qui prépare le terrain pour la deuxième journée. Dans les séances thématiques, on discute plus en profondeur de la résolution de la question de l'incertitude à l'aide d'un cadre de gestion adaptative ainsi que de la nécessité d'une collaboration soutenue et régulière entre les Sciences et la Gestion de l'habitat du poisson.

Day Two

INCREASING EFFICIENCIES IN THE HABITAT MANAGEMENT PROGRAM
- C. STONEMAN AND N. WINFIELD

It is recognized that opportunities exist to more efficiently use the resources allocated to reviewing and assessing referrals within the Habitat Management Program without compromising the Program's desired outcome of conservation and protection of Canada's fisheries resources. In order to determine how resources can be used more efficiently, it is proposed that the notion of risk management be applied to making regulatory decisions about fish habitat. This approach involves assessing and managing risks to fish habitat to ensure that negative effects are eliminated or minimized to the extent possible and practicable. The assessment of risk helps establish the nature and degree of risk to fish habitat based on scientific evidence.

The proposed risk management approach is comprised of two key components:

Pathways of Effects model for determining effects on fish habitat as a result of any given work or undertaking;

Risk Matrix incorporating the components of severity of impact and sensitivity of fish habitat to make a final determination of risk category.

In the habitat program, referrals are received for a wide array of works, ranging from small development proposals to large-scale operations with significant environmental impact. Proponents forward their proposal for review as they wish to receive assurance that they are protected from prosecution under the Fisheries Act.

For any given proposal, it must first be determined what the potential effects on fish habitat could be. Inconsistency in this

Deuxième journée

AMÉLIORATION DE L'EFFICACITÉ DU PROGRAMME DE GESTION DE L'HABITAT
- C. STONEMAN ET N. WINFIELD

Il est reconnu qu'il existe des possibilités pour une utilisation plus efficace des ressources dédiées à la revue et à l'étude de soumissions liées à l'habitat au sein du Programme de gestion d'habitat et ce, sans que les résultats visés en matière de conservation et de protection des ressources halieutiques du Canada ne soient pour autant compromis. Pour déterminer comment optimiser l'utilisation des ressources, on propose d'appliquer la notion de gestion des risques au processus de prise de décisions en matière de réglementation sur l'habitat du poisson. Cette approche implique l'évaluation et la gestion des risques pour l'habitat du poisson en ayant comme objectif d'éliminer les effets négatifs ou de les réduire le plus possible. L'évaluation du risque établit la nature et l'importance du risque pour l'habitat du poisson d'après des données scientifiques.

L'approche de gestion des risques proposée comporte deux volets clés.

Le modèle de la séquence des effets, pour déterminer les effets sur l'habitat du poisson résultant d'un ouvrage ou d'une entreprise.

La matrice des risques, qui incorpore l'importance de l'impact et de la vulnérabilité de l'habitat du poisson pour établir la catégorie de risque.

Dans le Programme de gestion de l'habitat, les soumissions liées à l'habitat sont associés à un vaste ensemble de travaux, des petits projets aux activités à grande échelle ayant des impacts environnementaux significatifs. Les promoteurs soumettent leur proposition à des fins d'examen, car qu'ils veulent obtenir l'assurance qu'ils sont conformes à la *Loi sur les pêches*.

Pour toute proposition, il faut tout d'abord déterminer quels sont les effets potentiels sur l'habitat du poisson. On a constaté un manque determination has been identified as a problem in our application of the program nationally. To determine the potential effects in a standardized way, and to provide transparency in this determination to user groups, a "Pathways of Effects" (PoE) approach is being proposed (see below). DFO biologists, partner agencies and proponents can use the PoEs to determine what the concerns are, and to develop mitigation/design plans to avoid potential effects. Any residual effects are then examined in closer detail to determine if they are indeed negative (some effects may be positive or neutral).

d'uniformité à cette étape dans l'application du programme à l'échelle nationale. Pour normaliser la détermination des effets potentiels et pour faire preuve de transparence vis-à-vis des groupes d'usagers, l'approche fondée sur la séquence des effets est proposée (voir ci-après). Les biologistes du MPO, les organismes partenaires et les promoteurs peuvent utiliser cette approche pour dresser un bilan des préoccupations ainsi que pour élaborer des mesures d'atténuation et concevoir des plans pour éviter les effets potentiels. On examine ensuite les effets résiduels plus en détail pour déterminer s'ils s'agit d'effets négatifs (certains effets peuvent être positifs ou neutres).

If the residual effects are negative, these would then be examined in the context of the severity of impact of that effect, and the sensitivity of habitat in the receiving environment (Fig. 4). These two factors are then used to determine the risk category associated with the residual effect(s).

Lorsque les effets résiduels sont négatifs, on les examine d'après l'importance de leur impact et la vulnérabilité de l'habitat dans l'environnement récepteur (fig. 4). On utilise ensuite ces deux facteurs pour déterminer la catégorie de risque liée à l'effet résiduel.

With this type of process in place, proponents will have less regulatory burden associated with low impact/low risk works, with increasing regulatory requirements and review periods when the proposed works are of higher impact and/or in increasingly sensitive habitat. Proponents therefore have additional incentive to remain "in the green" and plan projects using environmentally friendly practices.

Avec un tel processus, le fardeau réglementaire des promoteurs est allégé dans le cas des projets présentant un risque et des effets peu importants. Les exigences réglementaires et les périodes d'examen s'accroissent lorsque les travaux proposés ont un impact plus important ou sont réalisés dans un habitat plus vulnérable. Les promoteurs sont ainsi davantage incités à incorporer des pratiques écologiques à la planification de leurs projets.

Pathways of Effects Model

DFO is developing a methodology termed "Pathways of Effects" to standardize aquatic effects assessment and identify regulatory requirements under the Fisheries Act. This approach provides a standard framework for impact assessment, while allowing flexibility for differences in habitat characteristics amongst the ecozones of Canada and to allow for a range of best management practices to be applied by different industrial sectors.

Mitigation is defined as: "Actions taken during the planning, design, construction and operation of works or undertakings to alleviate potential adverse effects". At present, when DFO assesses projects with the potential to cause adverse effects, a series of management options are considered for the purposes of habitat conservation and protection. These management

Modèle de la séquence des effets

Le MPO travaille à la mise au point de la méthode de « la séquence des effets » pour normaliser l'évaluation des impacts en milieu aquatique et pour définir les exigences réglementaires en vertu de la *Loi sur les pêches*. Cette approche fournit un cadre standard pour l'évaluation des impacts, mais demeure souple quant aux différences concernant les caractéristiques des habitats des différentes écozones du Canada et permet aux diverses industries d'appliquer à une gamme de bonnes pratiques de gestion.

Les mesures d'atténuation sont des mesures prises pendant la planification, la conception, la construction et l'exploitation d'ouvrages ou d'entreprises pour réduire les effets négatifs potentiels. Présentement, quand le MPO évalue des projets susceptibles d'avoir des effets négatifs, on considère une série d'options de gestion dans le but de conserver et de protéger options include relocating, redesigning or applying mitigation measures to the project to ensure effects are either avoided or reduced to an acceptable level. The “Pathways of Effects” (PoE) builds a biologically-based model that outlines the potential effects on fish habitat as a result of any given activity. The PoE methodology improves the consistency in the identification of, and request for, mitigation measures. The diagrams enable clear identification of where mitigation is required to prevent adverse effects from being transmitted into the aquatic environment.

l'habitat. Ces options de gestion comprennent la relocalisation, la modification ou l'application de mesures d'atténuation au projet pour s’assurer que les effets sont évités ou réduits à un niveau acceptable. Les relations de la séquence des effets constituent un modèle à fondement biologique qui décrit les effets qu’une activité donnée peut avoir sur l'habitat du poisson. La méthode de la séquence des effets améliore l'uniformité au chapitre de la détermination des mesures d'atténuation et des présentations de demandes à cette fin. Les schémas indiquent clairement où des mesures d’atténuation sont requises pour éviter que des effets négatifs touchent le milieu aquatique.

The PoE models have been designed based on significant input from habitat practitioners and habitat scientists. At present, 18 different pathways have been developed, 10 water-based and 8 land- based activities (Figure 5). Any work or undertaking proposed involves a combination of these 18 different pathways. A summary of the common types of aquatic effects found in the pathways is summarized in Table 2.

Les modèles de séquence des effets ont été conçus à la lumière des contributions significatives des praticiens et des scientifiques du domaine de l'habitat. Présentement, 18 relations de séquence des effets ont été élaborées, dix pour l'eau et huit pour la terre (figure 5). L’ensemble des ouvrages et des entreprises envisagés comporte une combinaison de ces 18 relations de séquence des effets différentes. Le tableau 2 présente un résumé des types courants d'effets sur le milieu aquatique rencontrés dans les relations de séquences des effets.

PoE models enable DFO and/or proponents to identify where mitigation is required. It is ultimately the proponent’s responsibility to develop and implement the appropriate mitigation measures.

Les modèles de séquences des effets permettent au MPO ou aux promoteurs de déterminer les cas où des mesures d’atténuation sont nécessaires. En bout de ligne, il reviendra au promoteur d’élaborer et de mettre en œuvre les mesures d'atténuation appropriées.

The PoE for vegetation clearing (Figure 6) identifies all the potential effects from vegetation removal adjacent to a fish-bearing stream. In this example, the proponent proposes to retain a riparian buffer of 20 metres adjacent to the stream channel. As stated, the primary mitigation measure proposed in this example is the retention of riparian vegetation; however, other mitigation measures are also required. Table 3 is a summary of the mitigation that was proposed for this hypothetical clearing example.

Le modèle de séquence des effets associée au défrichage (figure 6) indique tous les effets que peut avoir l’élimination de la végétation en bordure d'un cours d'eau abritant des poissons. Dans cet exemple, le promoteur propose de conserver une zone tampon riveraine de 20 mètres à côté du chenal. Tel qu’indiqué, la principale mesure d'atténuation proposée dans cet exemple est la conservation de la végétation riveraine; cependant, d'autres mesures d'atténuation sont également exigées. Le tableau 3 présente un résumé des mesures d'atténuation proposées pour cet exemple de défrichage hypothétique.

Quantifying the Severity of Residual Effects

Quantification de l’importance des effets résiduels

Where proposed mitigation measures result in

Lorsque les mesures d'atténuation proposées ont residual effects, consideration must be given to the magnitude of the residual effects. Work is currently underway to quantify residual effects using the following factors:

1. Size
2. Duration
3. Intensity
4. Reversibility
5. Detectibility

This approach will assist in determining whether or not, a project will create a HADD. This approach will also assist in determining whether or not a project is acceptable and if so, if a Section 35(2) authorization is required. It will also focus compensation efforts for HADDs on the component of the habitat that is directly affected by the project.

des effets résiduels, il faut considérer l'ampleur de ces effets. On travaille présentement à quantifier les effets résiduels en utilisant les facteurs suivants.

1. Taille
2. Durée
3. Intensité
4. Réversibilité
5. Détectabilité

Avec cette approche, on pourra plus facilement déterminer si un projet créera une DDP de l'habitat. Le cas échéant, on pourra facilement déterminer si le projet est acceptable et par la suite si une autorisation en vertu du paragraphe 35(2) est requise. Elle fera également en sorte que les efforts de compensation pour la DDP de l'habitat seront axés sur le composant de l'habitat directement affecté par le projet.

PoEs and Guidelines

Once a PoE model has been developed for each type of work or undertaking, these could then be used by Industry to develop guidelines for each type of work or undertaking. Each Industry sector likely has specific mitigation (or best management) techniques that they would typically use at each site. The PoE models will provide the framework under which guidelines are developed. As with site specific plans, DFO staff would review the guidelines to determine if the proposed mitigation is adequate to break the "links" and therefore avoid effects to fish habitat and approve the guidelines for use in the field. In many cases it may not be possible to break all links, and further review will be needed to determine if a *Fisheries Act* authorizations or any other approval may still be required. However, both Industry and DFO staff will have a higher degree of certainty regarding what works or undertakings will require authorization, and the baseline mitigation required at each site.

Séquence des effets et lignes directrices

Lorsqu'un modèle sur la séquence des effets est mis au point pour un type d'ouvrage ou d'entreprise, il peut alors être employé par l'industrie pour élaborer des lignes directrices propres à chaque type de projet. Chaque industrie dispose probablement de techniques d'atténuation (ou de bonnes pratiques de gestion) qui lui sont propres et qu'elle utiliserait à certains emplacements. Les modèles de séquence des effets fourniront le cadre pour l'élaboration de lignes directrices. Comme dans le cas des plans spécifiques à l'emplacement, le personnel du MPO passerait en revue les lignes directrices pour déterminer si les mesures d'atténuation proposées sont suffisantes pour briser les « liens » et, de ce fait, éviter que les effets ne se fassent sentir sur l'habitat du poisson, et approuverait les lignes directrices pour l'utilisation sur le terrain. Dans de nombreux cas, il se peut que les liens ne puissent tous être rompus; un examen supplémentaire sera alors nécessaire pour que l'on puisse déterminer si une autorisation en vertu de la *Loi sur les pêches* ou un autre type d'approbation est requis. Cependant, l'industrie et le personnel du MPO seront mieux fixés quant aux projets nécessitant une autorisation et aux mesures d'atténuation minimales requises à chaque emplacement.

THEME SESSIONS – FORMAT

Each session begins with an abstract from the theme presentation, followed by the three questions that provided the focus for the theme discussion at the workshop. The workshop theme discussion is summarized and interpreted with conclusions in a final section. Rapporteur records of the workshop discussion are provided in Appendix 4, and the theme presentation slides are provided in Appendix 5.

Theme Session 1 – Productive Capacity

Abstract: Habitat productive capacity and fish productivity: definitions, indices, units of field measurement, sensitivity, and a need for standardization – *B. Randall*

Effective aquatic resource conservation involves the management of fish populations and their habitat. Differences between habitat and fisheries science in the use of terms like productivity and productive capacity are highlighted to emphasize that a common terminology should be adopted. Habitat evaluation should occur, implicitly or explicitly, at a spatial scale that encompasses entire fish populations. Knowledge of the spatial scale of populations is often poorly known but the spatial scale of many habitat projects (referrals) is likely smaller than the population scale. This mismatch is a challenge for science.

Productive capacity is a characteristic of fish habitat, while productivity is a characteristic of populations. The concepts and measurement units of fish production (kg ha^{-1} yr^{-1}), productivity (survival, e.g., recruits per spawner) and habitat productive capacity (kg ha^{-1}) are defined and explained in a manner that bridges both habitat and fisheries science (Fig. 7). Fish production is measured for fisheries assessment of individual populations, but it is usually not measured for habitat management. Rather, biological indices of production (density, biomass, richness, IBI, HPI) and physical habitat surrogates (area, cover,

SÉANCES THÉMATIQUES – FORMAT

Chaque séance commence par un résumé de la présentation du thème; on a enchaîné avec les trois questions qui orientent la discussion sur le thème. La discussion a ensuite été résumée et interprétée avec les conclusions dans une section finale. Les notes du rapporteur de la séance de discussion sont fournies à l'annexe 4, tandis que les diaporamas des présentations thématiques se trouvent à l'annexe 5.

Séance thématique 1 – Capacité de production

Résumé – Capacité de production de l’habitat et productivité du poisson : définitions, indices, unités de mesure sur le terrain, vulnérabilité et normalisation – *B. Randall*

La conservation efficace des ressources aquatiques repose sur la gestion des populations de poissons et de leur habitat. On met en évidence les différences dans l’utilisation de termes comme « productivité » et « capacité de production » par les spécialistes de l’habitat et les spécialistes des poissons pour souligner l’importance d’uniformiser la terminologie. On doit évaluer les habitats, implicitement ou explicitement, à une échelle spatiale englobant les populations entières de poissons. Dans la plupart des cas, on connaît mal les niveaux des populations à l’échelle spatiale, mais l’échelle de nombreux projets d’habitats (soumissions liées à l’habitat) est sans doute inférieure à celle de la population. Cet écart est un défi pour les scientifiques.

La capacité de production est une caractéristique de l’habitat du poisson, tandis que la productivité est une caractéristique des populations. Les concepts et les unités de mesure de la production de poissons (kg ha^{-1} an^{-1}), de la productivité (survie, ou recrues par géniteur) et de la capacité de production de l’habitat (kg ha^{-1}) sont définies et expliquées d’une manière qui établit des parallèles entre les sciences de l’habitat et les sciences halieutiques (fig. 7). La production de poissons est mesurée pour l’évaluation des pêches visant des populations précises mais, généralement, elle ne l’est pas pour la gestion de l’habitat.

substrate, depth, pools, riffles, Defensible Methods) of productive capacity are used. Habitat biologists must be mindful of the limitations and implied assumptions (habitat dependent growth and survival) when indices or surrogates are used to assess the productive capacity of fish habitat. Nevertheless, if habitat surrogates have a sound science basis and if they are used consistently on a national basis, surrogates of capacity can be used to differentiate between sensitive and resilient fish habitat.

On utilise plutôt des indices biologiques de la production (densité, biomasse, richesse, indice d'intégrité du biote et indice de productivité de l'habitat) ainsi que des mesures de l'habitat physique (superficie, couvert, substrat, profondeur, fosses, radiers et méthodes défendables) comme variables substitutives de la capacité de production. Les biologistes de l'habitat doivent être conscients des limites et des postulats implicites (croissance et survie liées à un milieu) quand des variables substitutives ou des indices sont utilisés pour évaluer la capacité de production de l'habitat du poisson. Néanmoins, si les valeurs substitutives de l'habitat sont fondées sur des principes scientifiques reconnus et si elles sont utilisées de façon constante, sur une base nationale, des variables substitutives de la capacité peuvent être utilisées pour différencier les habitats vulnérables des habitats résilients.

The Canadian Science Advisory Secretariat (CSAS) publication series provides a national forum for reporting both science and management advisories, and highlights the parallels between habitat and fisheries science.

La série de publications du Secrétariat canadien de consultation scientifique (SCCS) constitue une tribune nationale pour la communication d'avis scientifiques et d'avis sur la gestion et souligne les liens entre les sciences de l'habitat et les sciences halieutiques.

Abstract was revised from Randall (2003).

Le résumé de Randall (2003) a été révisé.

Theme 1 – Discussion Questions

Questions:
1. How do you classify and validate habitat types with different capacities?
2. How do you measure habitat-specific productivity? What are the assumptions?
3. How do you measure and integrate i) fish and ii) fish habitat sensitivity?

Facilitator: Hugh Bain
Rapporteur: Julie Perrault, with additional notes from Angie Wagner.
Rapporteur notes: Recorded in Appendix 4.

Thème 1 – Questions pour la discussion

Questions
1. Comment classifier et valider des types d'habitat de capacités différentes?
2. Comment mesurer la productivité propre à un habitat? Quelles sont les hypothèses?
3. Comment mesurer et intégrer : i) le poisson; ii) la vulnérabilité de l'habitat du poisson?

Facilitateur : Hugh Bain
Rapporteur : Julie Perrault, avec notes supplémentaires d'Angie Wagner.
Notes du rapporteur : voir l'annexe 4.

Theme 1 - Summary and Interpretation:

Discussion of the measurement of productive capacity of fish habitat continues to generate some very instructive but often basic questions

Thème 1 – Résumé et interprétation

La discussion sur les mesures de la capacité de production de l'habitat du poisson continue de soulever certaines questions très intéressantes, from both Science and Fish Habitat Management. Habitat is classified and managed because it supports fish production. Whether to classify habitat based on a single target species or a fish community continues to be a challenge and is to some extent region-dependent (Newfoundland coldwater salmonids versus species-rich Great Lakes). There was agreement that habitat-caused changes to a fish community constituted a change in productive capacity, but the reference level or baseline for judging change is often difficult to ascertain. There was a consensus that habitat capacity needs to be evaluated and classified at a population or landscape scale, and that we need to understand more about the function of habitat in determining fish productivity. Understandably there was uncertainty of how these concepts might be translated into everyday referral management at a site level. This spatial disconnect between Science and FHM should be addressed. Determining the relationship between habitat function and supply at different life stages will continue to be a priority in science. Quantifying habitat-dependent rate processes that lead to fish production is the goal (key rate processes are recruitment, survival, growth and production to biomass ratios). Quantification of the process rates is paramount for the accurate and unbiased classification of sensitive habitat, but it will require continued long-term commitment from science. Awareness of habitat-dependent process rates was a key communication outcome of the workshop.

mais souvent fondamentales, autant du côté des Sciences que du côté de la Gestion de l'habitat du poisson. On classifie et on gère l'habitat pour favoriser la production de poissons. Que l'on classe l'habitat simplement en fonction d'une espèce cible ou d'une communauté de poissons, la tâche reste importante et demeure dans une certaine mesure fonction de la région (les salmonidés d'eau froide de Terre-Neuve versus les diverses espèces des Grands Lacs). On reconnaît que les changements liés à l'habitat d'une communauté de poissons provoquent un changement dans la capacité de production, mais il est souvent difficile d'établir le niveau ou les conditions de référence pour évaluer ces changements. Selon l'opinion générale, la capacité de production de l'habitat doit être évaluée et classifiée à l'échelle de la population ou de l'écopaysage, et nous devons en apprendre davantage sur la fonction de l'habitat pour déterminer la productivité du poisson. Naturellement, on ne sait pas encore comment ces concepts pourront être appliqués à la gestion quotidienne des soumissions liées à l'habitat au niveau des sites. Cette différence d'échelle spatiale entre la science et la gestion de l'habitat du poisson doit être étudiée. La détermination de la relation entre la fonction et la disponibilité des habitats pour les différents stades de la vie continuera d'être une priorité pour les Sciences. La quantification de la vitesse des processus dépendants de l'habitat qui assurent la production de poissons (les processus clés sont : le recrutement, la survie, la croissance et les rapports production/biomasse de la population) représente l'objectif visé. La quantification de la vitesse des processus est primordiale pour la classification précise et non biaisée d'un habitat vulnérable. Toutefois, pour ce faire, il faudra un engagement continu et à long terme des scientifiques. La sensibilisation à la vitesse des processus dépendants de l'habitat est un résultat important de l'atelier en matière de communication.

In the meantime, science can help FHM develop broad-scale tools that will aid the evaluation of habitat capacity at the site level. One such tool is the determination and mapping of habitat productive capacity for large areas to develop regional fish habitat management plans (FHMP). Because of their application over large spatial scales, these are necessarily first-order determinations of habitat capacity. An example is the Severn Sound Classification Model (Minns et al. 1999) where littoral habitat is classed as Red,

Entre-temps, les Sciences peuvent aider la GHP à élaborer des outils à grande échelle qui faciliteront l'évaluation de la capacité de l'habitat au niveau du site. L'un des moyens que l'on peut utiliser à cette fin est la détermination et la représentation sur des cartes de la capacité de production de l'habitat des grandes régions, outils que l'on peut utiliser pour élaborer des plans régionaux de gestion de l'habitat du poisson. En raison de leurs applications sur une grande échelle spatiale, il faut tout d'abord procéder à

Yellow or Green to guide allowable and excluded shoreline activities. A marine example of large-scale habitat classification for both fish and invertebrate taxa is given by Brown et al. (2000). Randall et al. (2004) showed that the productive capacity of large areas of the near shore in the Great Lakes can be classified based on GIS-derived predictors. A key output of this Workshop was the declaration of the knowledge and expertise to develop broad scale regional classifications of lake and watershed habitats. Regional broad-scale classification can be used by FHM as the first-stage of a two-stage (or multi-stage) habitat evaluation scheme to determine if site habitat is sensitive or resilient. By analogy, a broad scale multiple-indicator 'traffic-light' approach was developed in fisheries management as a precautionary tool for guiding the regulation of fishing effort (Halliday et al. 2001). Science cannot provide advice to FHM on individual referrals, but it can provide broad-scale context for specific sites. Broad-scale maps of habitat supply and classification would also provide the tool needed to track cumulative changes to habitat.

une détermination de premier ordre de la capacité de l'habitat. Par exemple, le modèle de classification du bras Severn (Minns *et al.*, 1999), qui représente l'habitat du littoral en diverses catégories (rouge, jaune ou vert) pour orienter les activités littorales admissibles ou exclues. Un exemple de classification de l'habitat à grande échelle pour les poissons et les invertébrés est donné par Brown *et al.* (2000). Randall *et al.* (2004) montrent que la capacité de production de grands secteurs près des côtes des Grands Lacs peut être classifiée à partir de variables explicatives dérivées du SIG. L'un des résultats importants de cet atelier est la communication des connaissances et de l'expertise concernant l'élaboration de classifications régionales à grande échelle des habitats lacustres et des milieux humides. La classification régionale à grande échelle peut être utilisée par la Gestion de l'habitat du poisson à la première étape d'un projet d'évaluation de l'habitat à deux volets (ou à volets multiples) pour déterminer si l'habitat est vulnérable ou résilient. Par analogie, une approche de type à feux de circulation avec un indicateur multiple à grande échelle a été élaborée pour la gestion des pêches comme outil de prévention pour orienter la réglementation de l'effort de pêche (Halliday *et al.,* 2001). Les Sciences ne peuvent fournir des avis à la Gestion de l'habitat du poisson concernant certaines soumissions liées à l'habitat, mais elles peuvent fournir un contexte à grande échelle pour des sites précis. Des cartes à grande échelle des habitats disponibles et de classification des habitats sont également des outils importants pour le suivi des changements cumulatifs de l'habitat.

Guidelines for establishing objective benchmarks to detect change over the short and long term, a persistent point of conjecture for both FHM and Science, needs to be resolved. In addition, assessing the productive capacity of fish habitat requires firmly established targets for regional fisheries and fish communities, emphasizing the need for close links between habitat and fisheries science. Generic guidelines for these connected issues could be established by a panel of experts at a future workshop.

L'élaboration de lignes directrices pour l'établissement de points de repère objectifs pour détecter les changements à court et à long terme est une question qui doit être réglée pour la GHP et les Sciences. En plus, on a besoin de cibles bien établies pour les pêches régionales et les communautés de poissons si l'on veut être en mesure d'évaluer la capacité de production de l'habitat des poissons. Des liens étroits sont donc essentiels entre les sciences de l'habitat et les sciences halieutiques. Les lignes directrices génériques pour ces problèmes connexes pourront être établies par un groupe d'experts au cours d'un atelier ultérieur.

Theme Session 2 – Thresholds

Abstract: HADDs, thresholds and fish population dynamics – *T. Pratt*

The conservation and protection of fish habitat in Canada, as mandated by Section 35 of the *Fisheries Act,* is the responsibility of Fisheries and Oceans Canada Fish Habitat Management Program. A primary responsibility of the Program is to review development proposals occurring in or near water to ensure that no harmful alteration, disruption or destruction (HADD) of fish habitat arises as a result of said development. Understanding what types of development activities are of higher risk in producing an actual HADD remains a priority for Fish Habitat Management.

Fish Habitat Management assesses proposals using the only currency available to them, physical habitat changes, with the assumption that changes in habitat will lead to corresponding changes aquatic productivity. Surprisingly, detecting responses in fish populations to seemingly obvious HADDs to physical habitat has proven difficult. Fish responses to alterations in key abiotic habitat variables (e.g. oxygen, temperature) may lend themselves to predictable HADD thresholds, but it is unlikely that stepwise or linear outcomes will arise from most HADDs. Fisheries stock-recruitment models are built on the assumption that key life history characteristics are flexible enough to compensate for increased mortality (typically from fishing pressure, but increased mortality from habitat alterations would result in similar life history changes). Predicting thresholds for HADDs in the presence of compensatory mechanisms (demographic processes that regulate abundance) is extremely challenging; recent efforts to develop life-stage based habitat supply models provide one means for determining habitat supply requirements.

Séance thématique 2 – seuils

Résumé : DDP de l’habitat, seuils et dynamiques des populations de poissons – *T. Pratt*

La conservation et la protection de l’habitat du poisson au Canada, telles que stipulées à l’article 35 de la *Loi sur les pêches*, sont sous la responsabilité du Programme de gestion de l’habitat du poisson du ministère des Pêches et des Océans du Canada. La principale responsabilité du Programme est de passer en revue les projets de mise en valeur qui doivent avoir lieu dans l’eau ou à proximité de l’eau afin de s’assurer qu’aucune détérioration, destruction ou perturbation (DDP) de l’habitat du poisson ne survienne à la suite de ladite mise en valeur. L’une des priorités de Gestion de l’habitat du poisson est de comprendre quel type d’activités de mise en valeur sont les plus susceptibles de produire une DDP de l’habitat.

La Gestion de l’habitat du poisson évalue les propositions en s’appuyant sur la seule base fiable disponible, à savoir les changements touchant l’habitat physique, en présumant que ces changements auront des répercussions équivalentes au chapitre de la productivité aquatique. La détection de la réaction des populations de poissons à une DDP de l’habitat physique en apparence évidente s’est toutefois révélée difficile. Les réactions des poissons à la détérioration des variables abiotiques clés de l’habitat (oxygène, température, etc.) peuvent les amener à un seuil de DDP de l’habitat prévisible, mais il est improbable que des résultats progressifs ou linéaires puissent résulter de la plupart des DDP de l’habitat. Les modèles de recrutement des stocks de poissons sont fondés sur l’hypothèse que les caractéristiques clés du cycle de vie sont suffisamment souples pour compenser l’augmentation de la mortalité d’ordinaire causée par la pression de la pêche; toutefois, l’augmentation de la mortalité attribuable à la détérioration de l’habitat devrait se solder par des changements similaires dans le cycle de vie. Il est très difficile de présumer du seuil de DDP de l’habitat en présence de mécanismes compensatoires (processus démographiques qui régularisent

l'abondance); grâce à des efforts récents pour mettre au point des modèles sur la disponibilité de l'habitat d'après les stades de développement, on dispose d'un moyen pour déterminer les besoins en habitats.

Theme 2 –Discussion Questions

Questions:

1. At what point does the severity of a human-induced habitat impact constitute harmful alteration, disruption or destruction of fish habitat?
2. What are the functional responses between habitat and fish production?
3. What are the appropriate methods to use to determine thresholds?

Facilitator: Christine Stoneman
Rapporteur: Keith Clarke, with additional notes from Angie Wagner and Christine Brousseau.
Rapporteur notes: Recorded in Appendix 4.

Thème 2 – Questions pour la discussion

Questions

1. À quel moment l'importance d'un effet sur l'habitat causé par l'homme constitue-t-il une détérioration, une perturbation ou une destruction de l'habitat du poisson?
2. Quelles sont les réactions fonctionnelles entre l'habitat et la production de poissons?
3. Quelles méthodes doit-on utiliser pour déterminer les seuils?

Facilitateur : Christine Stoneman
Rapporteur : Keith Clarke, avec notes additionnelles d'Angie Wagner et de Christine Brousseau.
Notes du rapporteur : voir l'annexe 4

Theme 2 - Summary and Interpretation:

The concept of HADD acknowledges that a negative biotic response will occur if fish habitat area is lost or altered beyond a certain buffer level. Discussion for this theme session made it clear that thresholds (non-linear response to habitat change) are not implicit in the Fish Habitat Management of HADD, and the criteria for determining HADD are vague. Adding to this uncertainty, the measurement of thresholds present a challenge for science: clear examples of threshold responses are rare.

Traditionally, whether or not a HADD has occurred has been determined by case law as decided by expert witness and court precedent. Demonstrating biological impact is not always a prerequisite. FHM would benefit if Science aided in developing defensible guidelines for determining HADD. Operational guidelines are needed.

Science was cautious in the discussion of

Thème 2 – Résumé et interprétation

Le concept de la DDP de l'habitat reconnaît qu'une réaction biotique négative se produira si l'habitat du poisson est perdu ou détérioré au-delà d'un certain niveau tampon. Les discussions tenues pendant cette séance thématique nous permettent de voir que les seuils (réaction non linéaire aux changements de l'habitat) ne sont pas implicites dans la gestion de l'habitat du poisson en rapport avec la DDP de l'habitat, et que les critères pour déterminer la DDP de l'habitat sont vagues. En plus de cette incertitude, la mesure des seuils représente un défi pour les scientifiques : les exemples clairs de seuils de réaction sont rares.

Jusqu'à maintenant, on s'est servi de la jurisprudence pour démontrer si une DDP de l'habitat est survenue ou non (d'après le témoignage d'experts et des décisions antérieures des tribunaux). La démonstration de l'impact biologique n'est pas toujours requise. La GHP profiterait d'une contribution des Sciences à l'élaboration de lignes directrices valables pour déterminer la DDP de l'habitat. Des lignes directrices opérationnelles sont nécessaires.

Les représentants des Sciences sont prudents thresholds. Science acknowledged that it does not have a lot to offer with setting thresholds at this time. As noted by Pratt in his presentation, fish stock and recruitment processes often show compensatory density-dependence, such that populations at low abundance respond with increased survival and growth. These processes make it difficult to detect habitat-induced threshold responses. Consistent with the previous theme discussion of productive capacity, the role of science would be to provide information and context for thresholds at a watershed and population or community scale, rather than at a site-specific (referral) scale. At a broad scale, results could be used to address the issue of cumulative impacts. As was mentioned previously, research on thresholds requires long-term commitment. The potential use of adaptive management in future for identifying HADDs was also discussed as a promising approach, but with caution as is discussed in the compensation theme session.

dans la discussion sur les seuils. Ils reconnaissent qu'ils n'ont pas beaucoup à offrir pour l'instant pour l'établissement de seuils. Comme l'a souligné Pratt dans cette présentation, le stock de poissons et les processus de recrutement affichent souvent une dépendance à la densité compensatoire qui fait en sorte que des populations peu abondantes réagissent par une survie et une croissance accrues. Ces processus masquent le seuil de réaction causé par l'habitat. Dans la foulée de la discussion thématique précédente sur la capacité de production, le rôle des Sciences devrait être de fournir l'information et le contexte pour des seuils à l'échelle de la population et de la communauté ou du bassin hydrographique plutôt qu'à l'échelle d'un site particulier (soumissions liées à l'habitat). Sur une grande échelle, les résultats pourraient être utilisés pour étudier la question des impacts cumulatifs. Comme il a été mentionné précédemment, la recherche sur les seuils nécessite un engagement à long terme. On discute aussi de l'utilisation potentielle de la gestion adaptative pour relever les cas de DDP de l'habitat comme d'une approche prometteuse, mais en prenant des précautions, comme on l'a mentionné dans la séance thématique sur la compensation.

The need for a GIS-based tracking system within FHM for documenting HADDs on a site-by-site basis was emphasized.

On parle également de la nécessité d'avoir un système de suivi de type SIG au sein de la GHP pour documenter la DDP de l'habitat sur une base ponctuelle.

Theme Session 3 – Compensation

Abstract: Habitat compensation to achieve No Net Loss – assessing available experimental and case study – *K. Smokorowski*

> Under the *Fisheries Act*, any activity that could result in a harmful alteration, disruption or destruction (HADD) of fish habitat is prohibited, unless authorized at the discretion of DFO. The authorization of a HADD always includes some action designed to achieve "No Net Loss" in the productive capacity of fish habitat by following a hierarchy of compensation options, and using greater than 1:1 compensation ratios to account for uncertainty of success and lag time in habitat functionality. In all cases some type of monitoring program is required (compliance or effectiveness), dependent on the complexity of the compensation.

Séance thématique 3 – Compensation

Résumé : Compensation de l'habitat pour éviter les pertes nettes – évaluation d'études de cas et d'études expérimentales – *K. Smokorowski*

> En vertu de la *Loi sur les pêches*, toute activité qui peut entraîner la détérioration, la destruction ou la perturbation (DDP) de l'habitat du poisson est interdite, à moins qu'elle ne soit autorisée par le MPO. Lorsqu'on autorise une DDP de l'habitat, on prend toujours certaines mesures pour qu'il n'y ait aucune « perte nette » dans la capacité de production de l'habitat du poisson. On établit donc une hiérarchie dans les possibilités de compensation et on utilise des coefficients de compensation plus élevés que 1/1 pour tenir compte de l'incertitude de la réussite et de la période de perte de fonctionnalité de l'habitat. Dans tous les cas, on exige la mise en place d'un certain type

de programme de surveillance (de la conformité ou de l'efficacité), selon la complexité de la compensation.

Experimental research designed to test the heretofore-assumed direct effect of habitat on fish production has been ongoing, and results are beginning to emerge. Recent efforts have been made to evaluate the effectiveness of habitat enhancement or creation via a critical review of habitat compensation literature, an examination of DFO compensation case studies, and surveys of fish habitat biologists involved in referral activities. Synthesizing the latest scientific knowledge surrounding habitat manipulation will reveal the efficacy the compensation approach used by DFO to fulfill its mandate in managing fish habitat. Management and science should work together to identify critical gaps in knowledge, which could then be reduced via scientifically designed effectiveness monitoring and research, thereby iteratively improving the standardization, validity and defensibility of the referral authorization process.

Une recherche expérimentale sur l'effet direct (considéré jusqu'ici comme implicite) de l'habitat sur la production de poissons est en cours, et on commence à en voir les résultats. On a récemment évalué l'efficacité de l'amélioration ou de la création d'habitats en faisant une analyse critique de la documentation sur la compensation de l'habitat, un examen des études de cas menées par le MPO sur ce sujet et un examen des relevés de biologistes spécialisés en habitat du poisson qui participent aux activités concernant les soumissions liées à l'habitat. En synthétisant les dernières connaissances scientifiques sur la manipulation de l'habitat, on sera en mesure de connaître l'efficacité de la méthode de compensation utilisée par le MPO pour remplir son mandat en matière de gestion de l'habitat du poisson. Le personnel de la Gestion de l'habitat du poisson et des Sciences doit collaborer pour déterminer quelles sont les lacunes importantes dans nos connaissances, que l'on pourra par la suite combler par l'intermédiaire de recherches et d'une surveillance de l'efficacité reposant sur des fondements scientifiques. On améliorera ainsi graduellement la normalisation, la validité et la justification du processus d'autorisation des soumissions liées à l'habitat.

Theme 3 –Discussion Questions

Questions:

1. What types of habitat enhancement have been used and which have been shown to be effective to achieve their objectives (incl. compensation ratios)?
2. What types of compensation habitat are more productive and what is the timeframe to reach full productivity?
3. How do we determine the effectiveness of compensation activities?

Facilitator: Dave Scruton
Rapporteur: Christine Brousseau, with additional notes from Angie Wagner
Rapporteur notes: Recorded in Appendix 4.

Thème 3 – Questions pour la discussion

Questions

1. Quels genres d'amélioration de l'habitat a-t-on utilisées et lesquelles se sont montrées suffisamment efficaces (inclure les coefficients de compensation)?
2. Quels genres d'habitats compensatoires sont les plus productifs et quel est le délai avant l'atteinte d'une pleine productivité?
3. Comment détermine-t-on l'efficacité des activités de compensation?

Facilitateur : Dave Scruton
Rapporteur : Christine Brousseau et notes complémentaires d'Angie Wagner
Notes du rapporteur : voir l'annexe 4.

Theme 3 - Summary and Interpretation

Compensation monitoring is a field test of our knowledge of habitat capacity and function. Results of literature surveys conducted by both Science and FHM are both negative and positive. Short term effects are sometimes monitored, but long term monitoring is rare. The efficacy of many compensation methods often remains unknown or nebulous at best. On the positive side, by tracking the effectiveness of compensation, DFO is being accountable and adaptive, and this is leading to proactive improvements in the habitat management program.

Several key issues were discussed in this theme session: uncertainty of compensation ratios; uncertainty of effectiveness of compensation, particularly the long-term effects; a need to track compensation activities; ineffective communication of compensation results (inter-Region or to field staff); inadequate funds and manpower to conduct effectiveness monitoring; and uncertainty about cash compensation, specifically its value, appropriateness (for DFO), and guidelines and planning strategies for the use of the money.

Improved communication should be a priority to relate successful and unsuccessful compensation activities to field staff, both within and across Regions. The need for GIS-based databases of compensation activities is paramount. Uncertainty was a common theme for all of the above issues. Would adopting an adaptive management approach using strategic survey designs at the site level not be the best way to deal with compensation? Close collaboration between Science, FHM and industry would be needed to implement adaptive management.

Thème 3 – Résumé et interprétation

Le suivi de la compensation consiste à vérifier sur le terrain nos connaissances sur la capacité de production et les fonctions de l'habitat. Les résultats des examens de la documentation effectués par les Sciences et la GHP sont à la fois négatifs et positifs. Ainsi, on surveille parfois les effets à court terme, mais on le fait rarement pour ceux à long terme. L'efficacité d'un grand nombre de méthodes de compensation est souvent inconnue ou, tout au mieux, nébuleuse. Par contre, en faisant le suivi de l'efficacité des mesures de compensation, le MPO est responsable et adaptatif, ce qui le mène à apporter des améliorations proactives dans son Programme de gestion de l'habitat du poisson.

On aborde plusieurs questions clés au cours de la séance thématique : incertitude quant aux coefficients de compensation; incertitude quant à l'efficacité des mesures de compensation, particulièrement des effets à long terme; besoin de faire le suivi des activités de compensation; communication inefficace des résultats des mesures de compensation (entre les régions ou au personnel sur le terrain); insuffisance de fonds et de main-d'oeuvre pour assurer la surveillance de l'efficacité; incertitude quant à l'à-propos de la compensation monétaire (pour le MPO), plus particulièrement de sa valeur, ainsi que des lignes directrices et des stratégies en matière de planification de l'utilisation des fonds.

On doit considérer l'amélioration de la communication comme une priorité afin que le personnel sur le terrain, à la fois dans les régions et dans tout le pays, puisse être informé des réussites et des échecs au chapitre des initiatives de compensation. On a vraiment besoin de bases de données de type SIG sur les activités de compensation. L'incertitude est un thème commun à toutes les questions soulevées. L'adoption d'une gestion adaptative s'appuyant sur des relevés conçus de façon stratégique ne serait-elle pas la meilleure façon d'aborder la question de la compensation? Il faut d'une collaboration étroite entre les Sciences, la GHP et l'industrie pour mettre en place cette gestion adaptative.

Theme Session 4 – Uncertainty and Risk

Abstract: Incorporating uncertainty and risk into fish habitat management decision-making – *K. Minns*

There are many potential forms and sources of uncertainty and risk surrounding any natural resource management. Aquatic resource management is especially difficult given that our ability to observe phenomena and events are severely limited compared to terrestrial ecosystems.

Fish-habitat linkages may be uncertain both with respects to both the functional form of those links and the statistical nature of those links. Uncertainties tend to be generic rather than specific as it rarely possible to gain sufficient levels of direct data and understanding for site-, species- and habitat- specific circumstances. Knowledge of which habitats or habitat features are important (critical, essential, necessary, etc.) to particular species' life stages is still often uncertain, if not unknown, and relationships between habitat and fish metrics are often highly variable, e.g., the well-known 'wedge phenomenon' (Terrell et al. 1996).There are often incompletely known risks associated with many aspects of specific habitat alterations. Loss of a specific piece of habitat may or may not lead to dramatic changes in abundance as spawning or recruitment fails. Mitigation and compensation measures may have prior records of varying success, e.g., created compensation spawning channels may go unused or may never produce measurable numbers of hatched larvae. More often these risks are unknown or un-quantified though in recent years some investigations of performance success have been undertaken for particular mitigation and compensation activities.

Séance thématique 4 – Incertitude et risque

Résumé : Intégration de l'incertitude et du risque dans le processus décisionnel concernant la gestion de l'habitat du poisson – *K. Minns*

Dans le domaine de la gestion des ressources naturelles, il existe un grand nombre de formes et de sources d'incertitude et de risque. La gestion des ressources aquatiques est particulièrement complexe du fait que nos capacités d'observation de phénomènes et d'événements dans ce milieu sont grandement limitées, si on les compare à nos capacités d'observation dans les écosystèmes terrestres.

On est incertain des liens qui existent entre les poissons et leur habitat, à la fois en ce qui concerne la forme fonctionnelle et la nature statistique de ces liens. Les incertitudes ont tendance à être génériques plutôt que spécifiques, puisqu'il nous est rarement possible d'obtenir des quantités suffisantes de données directes et de comprendre les facteurs particuliers entourant l'emplacement, les espèces et l'habitat. Notre connaissance de l'importance des habitats ou de leurs caractéristiques (sont-ils critiques, essentiels, nécessaires, etc.) pour chaque étape de vie des espèces est encore souvent limitée, si ce n'est nulle. La relation entre l'habitat et la taille des poissons est souvent variable, par exemple, le phénomène bien connu de la compensation (Terrell et al. 1996). Il y a souvent des risques qu'on ne connaît pas complètement et qui sont liés à un grand nombre d'aspects de la détérioration de l'habitat. La perte d'un élément de l'habitat particulier peut entraîner des changements importants dans l'abondance, comme des échecs dans le frai ou dans le recrutement. Les mesures d'atténuation et de compensation peuvent parfois ne donner aucun résultat valable, par exemple des chenaux de reproduction compensatoires créés artificiellement peuvent ne pas être utilisés ou peuvent ne jamais permettre la production d'un nombre mesurable de larves écloses. La plupart du temps, ces risques sont inconnus ou ne sont pas quantifiés. Cependant, au cours des dernières années, on a entrepris quelques études sur la réussite d'activités particulières d'atténuation

et de compensation.

Incorporating uncertainty and risk information into decision-making can lead to changes in reference points for decisions and sometimes lead to outcomes different from those obtained with simpler decision methods. Methodologies for incorporating uncertainty and risk into decision-making have been expanding in recent years with evidence of their utility present in fisheries management. These methodologies and experiences can be transferred into fish habitat management decision-making though it will require consistent application of robust tools and less reliance on autonomous assessment and decision-making on the front-line.

L'incorporation de l'information sur l'incertitude et le risque dans le processus décisionnel peut mener à des changements quant aux points de référence sur lesquels les décisions sont fondées et peut parfois entraîner des résultats différents de ceux obtenus avec des méthodes décisionnelles plus simples. Au cours des dernières années, on a mis au point un nombre accru de méthodes d'intégration de l'incertitude et du risque dans ce processus alors que l'on a constaté leur utilité pour la gestion des pêches. On peut transférer ces méthodes et ces expériences au processus décisionnel en matière de gestion de l'habitat du poisson, bien que cela nécessite l'application uniforme d'instruments robustes et une moins grande confiance à l'égard des évaluations autonomes et des prises de décision de première ligne.

Theme 4 –Discussion Questions

Questions:

1. How does knowing the sources and magnitude of uncertainty and understanding the associated potential risk affect decision making?
2. Can formal methods for expressing uncertainty be used in decision making or might the use of safety factors, or 'rules of thumb', be preferred?
3. How does the degree of formality in methods of decision-making interact with the need for adaptive management?

Facilitator: Mike Jones
Recorder: Ken Mills
Rapporteur notes: Recorded in Appendix 4.

Thème 4 – Questions pour la discussion

Questions

1. À quel point la connaissance des sources d'incertitude et de l'ampleur de cette incertitude ainsi que la compréhension des risques possibles influent-elles sur la prise de décisions?
2. Peut-on utiliser des méthodes officielles pour exprimer l'incertitude dans le processus décisionnel ou est-il préférable d'employer des facteurs de sécurité ou des règles empiriques?
3. Dans quelle mesure le caractère officiel des méthodes de prise de décisions interagit-il avec le besoin pour une gestion adaptative?

Facilitateur : Mike Jones
Rapporteur : Ken Mills
Notes du rapporteur : voir l'annexe 4.

Theme 4 – Summary and Interpretation

Awareness of risk assessment tools and a strategy for the implementation of risk management are key issues for dealing with uncertainty. Most agreed that uncertainty should be incorporated into the management of habitat referrals. In the past, methods of assessing risk have been *ad hoc* and informal. Objective and consistent methods of dealing with uncertainty need to be adopted. Formal procedures for

Thème 4 – Résumé et interprétation

La conscientisation à l'égard des instruments d'évaluation du risque et la mise en place d'une stratégie de gestion du risque sont des points clés lorsque vient le temps de parler d'incertitude. On s'entend pour dire que l'on devrait incorporer l'incertitude à la gestion des soumissions liées à l'habitat. Dans le passé, les méthodes d'évaluation du risque étaient improvisées et officieuses. Or, il faut adopter des méthodes dealing with risk are available in the literature, but these tools are not being used. There was a lack of consensus on whether or not formal methods or 'rules of thumb' should be adopted, although there was consensus that objective procedures should be developed and documented, whether or not they are formal or informal.

objectives et uniformes pour tenir compte de l'incertitude. On peut trouver dans la littérature des méthodes officielles concernant le risque, mais celles-ci ne sont pas utilisées. Il n'y a pas consensus quant à l'adoption de méthodes officielles ou de règles empiriques. Toutefois, on s'entend au sujet de l'élaboration et de la documentation de méthodes objectives, qu'elles soient officielles ou officieuses.

Adaptive management was viewed as a potentially useful tool for managing risk, consistent and complementary to compensation monitoring as discussed above. Because of the increased complexity, a road map is needed to provide a guidance framework for dealing with referrals. The framework would include a screening and assessment process for referrals, data requirements and data management, guidelines for tool selection of risk assessment and adaptive management. The framework would be flexible to accommodate the various types of referrals.

On considère que la gestion adaptative est un instrument potentiellement utile pour gérer le risque, qui assure l'uniformité et qui est complémentaire au suivi des mesures de compensation (tel que discuté précédemment). En raison de la complexité accrue de la question, il faut élaborer un plan cadre pour orienter le traitement des soumissions liées à l'habitat. Le plan cadre inclurait un processus d'évaluation préalable et d'évaluation des soumissions liées à l'habitat, des exigences en matière de données et de gestion des données. Il inclurait aussi des lignes directrices sur le choix des instruments d'évaluation du risque et de gestion adaptative. Le cadre doit être souple et peut donc s'adapter aux divers types de soumissions liées à l'habitat.

FINAL QUESTIONS, DISCUSSION AND WRAP-UP

Facilitator: Christine Stoneman Wrap-up: Bob Randall

1. What are the key knowledge gaps arising from the workshop?
2. How does FHM develop a process for articulating questions that science can answer?
3. What are the critical next steps for science in supporting a risk-based approach to habitat referrals?

QUESTIONS FINALES, DISCUSSION ET RÉCAPITULATION

Facilitateur : Christine Stoneman
Récapitulation : Bob Randall

1. Quelles lacunes principales au chapitre de nos connaissances a-t-on relevées pendant l'atelier?
2. Comment procède la GHP pour élaborer un processus de formulation des questions auxquelles les Sciences peuvent répondre?
3. Quelles sont les prochaines étapes critiques pour les Sciences concernant le soutien d'une approche fondée sur le risque pour les soumissions liées à l'habitat?

Knowledge gaps:

- Role of wetlands (freshwater and marine)
- Habitat function and management in marine environments
- Testing and trial use of indices of productive capacity (case studies)
- Communication and marketing tools for FHM

Lacunes au chapitre de nos connaissances :

- Rôle des milieux humides (eau douce et mer)
- Fonctions et gestion de l'habitat dans les milieux marins
- Essai et test des indices de la capacité de production (études de cas)
- Instruments de communication et de mise

- Guidelines for compensation monitoring
- Determination of compensation effectiveness, with feedback to habitat biologists
- Methods for quantifying habitat
- Determine and quantify the function of different habitats
- Compare and contrast the results of the ELA and Turkey Lakes Watershed (TLW) habitat manipulation experiments
- Expand experimental habitat-removal projects (larger proportion of TLW lake area)
- Habitat dynamics (spatial and temporal variation in habitat use by fishes)
- Critical habitat – what is it and how is it identified?
- Determine guidelines for identifying the appropriate scale for measuring compensation

en valeur pour la GHP

- Lignes directrices sur le suivi de la compensation
- Détermination de l'efficacité de la compensation, avec communication des résultats aux biologistes spécialisés en habitat
- Méthodes pour quantifier l'habitat
- Détermination et quantification des fonctions de différents habitats
- Comparaison et opposition des résultats des expériences de manipulation de l'habitat de la RLE et du bassin hydrographique des lacs Turkey
- Expansion des projets expérimentaux de retrait d'habitat (une plus grande proportion de la région des lacs Turkey)
- Dynamique de l'habitat (variations spatiale et temporelle de l'habitat du poisson)
- L'habitat critique – qu'est-ce que c'est et comment l'identifie-t-on?
- Établissement de lignes directrices pour choisir l'échelle de mesure de la compensation appropriée

Process for FHM articulation of questions for Science:

- Have scientists ask the questions. If I gave this information to you, how would you use it?
- The issue of scale is important, as FHM is concerned mainly with the micro-scale (referrals) while science takes a more holistic approach
- Develop a more systematic approach for dealing with referrals. Habitat biologist should identify knowledge gaps in the referral process, and ask if science can help
- Tools are not being implemented or the tools being used are not helpful: need a direct feedback link to the referral process
- There is a disconnect and lack of integration between the habitat experiments and management. Better communication is needed. What needs to change?
- Need a National Habitat Advisory Committee to take a more strategic approach
- More workshops like this would lead to a better articulation of questions for both

Processus pour la formulation de questions par la GHP à l'intention des Sciences :

- Amener les scientifiques à poser les questions. Si je vous donne cette information, de quelle façon l'utiliserez-vous?
- La question de l'échelle est importante car la GHP travaille davantage à petite échelle (soumissions liées à l'habitat), alors que les Sciences adoptent une méthode plus holistique
- Il faut élaborer une approche plus systématique pour les soumissions liées à l'habitat. Les biologistes spécialisés en habitat du poisson doivent relever les lacunes dans les connaissances dans l'analyse des soumissions liées à l'habitat et doivent demander si les Sciences peuvent les aider
- On ne met pas les instruments en application ou, encore, ceux utilisés n'ont pas été utiles : il faut donc établir un lien de rétroaction directe avec le processus d'analyse de soumissions liées à l'habitat
- On constate une déconnexion et un manque d'intégration entre les expériences sur l'habitat du poisson et la gestion de cet habitat. Une meilleure

FHM and Science. Progress would be cumulative
- Plan and implement a marine habitat workshop equivalent to this workshop
- Plan a workshop to address compensation alone

communication est nécessaire. Que doit-on changer?
- Il faut instaurer un comité consultatif national sur l'habitat pour adopter une approche plus stratégique
- La tenue d'un plus grand nombre d'ateliers comme celui-ci mènerait à une meilleure formulation des questions tant pour la Gestion de l'habitat du poisson et que pour les Sciences. Les progrès seraient cumulatifs
- Il faut planifier la tenue d'un atelier sur l'habitat marin similaire au présent atelier
- Il faut organiser un atelier qui ne porterait que sur la compensation

Next steps for risk-based approach

- Develop a National Habitat Science Advisory Board involving Science and Oceans
- Watch for DFO Strategic Science Fund priorities for Environmental Science
- Need to develop a better structure for dealing with habitat issues and for determining national priorities for Environmental Science
- More inter-Regional collaboration and discussion is needed, to avoid inconsistent approaches
- Dynamic management approaches are needed to build on past experience and new knowledge

Prochaines étapes concernant l'approche fondée sur le risque

- On doit former un conseil consultatif national des sciences de l'habitat en collaboration avec les Sciences et les Océans
- Il faut établir les priorités du Fonds stratégique des sciences du MPO en ce qui concerne les Sciences de l'environnement
- On doit mettre au point une meilleure structure pour traiter les problèmes d'habitat et pour déterminer quelles sont les priorités nationales concernant les Sciences de l'environnement
- Il faut accroître la collaboration et les discussions entre les régions pour éviter l'adoption d'approches incongrues
- On a besoin d'approches de gestion dynamiques qui sauront tirer profit de l'expérience et des nouvelles connaissances

Wrap-up

Effective communication between Science and Fish Habitat Management, the main goal of this workshop, resulted in much constructive discussion of the workshop themes that led to tangible output (Table 4). Participation by both Sectors was strong, synergetic and mutually beneficial. Development of these workshop Proceedings was iterative: the intent was for all participants to provide feedback on the first draft, to aid in the clarification and documentation of the key points. If the recommendations are followed, future collaboration on an annual basis between FHM and Science will be the legacy of this

Récapitulation

Une communication efficace entre les Sciences et la Gestion de l'habitat du poisson était le but principal du présent atelier. Les discussions très constructives qui ont été tenues sur les thèmes de l'atelier ont donné des résultats tangibles (tableau 4). La participation des deux secteurs a été importante, synergique et avantageuse pour les deux parties. L'élaboration des comptes rendus des ateliers s'est déroulée par itérations : nous voulions connaître l'avis de tous les participants sur la première version du document afin de le clarifier et de documenter les faits saillants de l'atelier. Si les recommandations workshop.

sont appliquées, le présent atelier aura permis une collaboration annuelle entre la GHP et les Sciences.

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GLOSSARY

Adaptive Management: considers management alternatives as experimental treatments; deals explicitly with uncertainty in natural resource management (Bearlin et al. 2002; Walters and Hilborn 1978).

API: Area-Per-Individual habitat supply model, where area-per-individual is calculated from the inverse of the density-fish size relationship (Minns 2003).

Compensation (for Loss): The replacement of natural habitat, increase in the productivity of existing habitat, or maintenance of fish production by artificial means in circumstances dictated by social and economic considerations, where mitigation techniques and other measures are not adequate to maintain habitats for Canada’s fisheries resources (DFO 1986).

Compensation ratio: ratio of compensation area to HADD area, both in square meters.

Ecotone: boundary between two ecosystems (e.g. land-water interface).

HADD: Harmful Alteration, Disruption or

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Gestion adaptative : considération d’autres modes de gestion tels que des essais expérimentaux; couvre explicitement l'incertitude dans la gestion des ressources naturelles (Bearlin *et al.,* 2002; Walters et Hilborn, 1978).

SPI : modèle d’habitat basé sur la superficie convenable disponible par individu. La superficie est calculée à partir de l'inverse du rapport entre la densité et la taille des poissons (Minns, 2003).

Compensation (pour la perte) : remplacement de l'habitat naturel, augmentation de la productivité de l'habitat ou maintien de la production de poissons par des moyens artificiels dans les circonstances dictées par des considérations sociales et économiques, où les techniques d’atténuation et d'autres mesures ne suffisent pas pour maintenir les habitats pour les ressources halieutiques du Canada (MPO, 1986).

Rapport de compensation : rapport entre l’aire de compensation et l’aire de DDP de l’habitat, exprimé en mètres carrés.

Écotone : frontière entre deux écosystèmes (p. ex. interface terre-eau).

DDP : Détérioration, destruction ou perturbation

Destruction of fish habitat, a term that is defined in Section 34(1) of the *Fisheries Act*. Under Section 37(2) of the Fisheries Act, the Minister of Fisheries and Oceans has the authority to modify, restrict or prohibit any work or undertaking which is likely to result in a HADD (DFO 1986).

de l'habitat du poisson, comme le définit le paragraphe 34(1) de la *Loi sur les pêches*. En vertu du paragraphe 37(2) de cette Loi, le ministre des Pêches et des Océans peut modifier, limiter ou interdire tout ouvrage ou entreprise susceptible de provoquer une DDP de l'habitat (MPO, 1986).

Mitigation measures: Actions taken during the planning, design, construction and operation of works and undertakings to alleviate potential adverse effects on the productive capacity of fish habitats (DFO 1986).

Mesures d'atténuation : Mesures prises pendant la planification, la conception, la construction et l'exploitation d'un ouvrage ou d'une entreprise pour atténuer les effets nuisibles qu'il peut avoir sur la capacité de production des habitats du poisson (MPO, 1986).

Habitat Referral: Proposal from a proponent for a site-specific land-based or in-water activity that may impact on fish habitat.

Soumission liée à l'habitat : Proposition d'un promoteur pour une activité qui sera réalisée sur terre ou dans l'eau et qui est susceptible d'avoir un effet sur l'habitat du poisson.

Habitat Referral Tracking System (HRTS): Computer database of referrals (see http://oceans.ncr.dfo-mpo.gc.ca/habitat/hrts_e.asp**).**

Système de suivi des dossiers touchant l'habitat (SSDH) : Base de données des dossiers touchant l'habitat (voir http://oceans.ncr.dfo-mpo.gc.ca/habitat/hrts_e.asp**).**

Pathway of Effect: biological-based conceptual model that links land-based or in-water activities (anthropogenic) to potential effects on fish habitat and fish. Cause-effect pathway linking habitat changes to ecological effects (Jones et al. 1996).

Séquence des effets : modèle conceptuel à fondement biologique qui relie les activités menées sur terre ou celles menées dans l'eau (anthropiques) aux effets potentiels sur l'habitat du poisson et les poissons. Relation de cause à effet associant les changements touchant l'habitat aux effets écologiques (Jones *et al*. 1996).

SAR: species-at-risk (see: http://www.speciesatrisk.gc.ca).

Espèces en péril (voir : http://www.speciesatrisk.gc.ca).

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

Sensibilité (du modèle) : Évaluation d'un modèle en accentuant les paramètres qui ont la plus grande incidence sur les résultats du modèle (McCarthy *et al.*, 1995).

Statistical procedures cited in presentations:

CCA: Canonical Correlation Analysis, a multivariate technique to determine the amount of linear relationship between two sets of variables (Stanfield et al. presentation).

Regression trees: classification or

Méthodes statistiques citées dans les présentations

ACC, ou analyse de corrélation canonique : technique à variables multiples utilisée pour déterminer le degré de relation linéaire entre deux ensembles de variables (présentation de partitioning of a response variable (e.g., fish biomass) using one or more predictor variables (e.g., habitat features) (Randall et al. presentation).

BACI: Before, After, Control, Impact – recommended standardized survey and monitoring design to evaluate the impact of habitat alteration on biota using detailed Analysis of Variance models (Smokorowski et al. presentation).

Stanfield *et al*.).

Arbres de régression : classification ou division d'une variable de réaction (p. ex. biomasse des poissons) à l'aide de une ou de plusieurs variables explicatives (p. ex. caractéristiques de l'habitat) (présentation de Randall *et al*.).

BACI : avant-après; témoin-impact **–** concept de surveillance et de relevé normalisé recommandé pour évaluer l'effet des changements touchant l'habitat sur le biote à l'aide de modèles d'analyse détaillée de la variance (présentation de Smokorowski *et al*.).

Threshold response: non-linear response of a fish population or community to habitat alteration or loss (see also linear, resilient, fragile and catastrophic responses in Figure 1).

Seuil de réaction : réaction non linéaire d'une population ou d'une communauté de poissons à une perturbation de l'habitat ou à la perte d'habitat (voir également les réactions linéaires, résilientes, fragiles et catastrophiques à la figure 1).

TI: Topographic Index, a function of up-slope area and slope of small feeder streams draining into lakes. TI was used to predict areas of suitable thermal habitat for brook trout in small Ontario lakes (Ridgway et al. presentation).

IT, ou indice topographique : fonction du secteur ascendant et de la pente de petits cours d'eau se déversant dans des lacs. L'IT est employé pour prévoir les secteurs offrant un habitat thermique approprié pour l'omble de fontaine dans de petits lacs de l'Ontario (présentation de Ridgway *et al*.).

Uncertainty: The incompleteness of knowledge about the state or processes of nature (FAO 1995).

Incertitude : imperfection des connaissances au sujet de l'état ou des processus de la nature (FAO, 1995).

TABLES **TABLEAUX**

Table 1: Workshop presentations demonstrating or implying linear or non-linear responses to habitat supply. Assignment of the possible response functions are tentative.

Tableau 1 : Présentations lors de l'atelier démontrant ou impliquant des réactions linéaires ou non linéaires à la disponibilité de l'habitat. L'attribution des réactions possibles est expérimentale.

Presentation / *Présentation*	Response function / Réaction	Habitat supply / Disponibilité de l'habitat	Measure / Mesure
Smokorowski *et al.*	resilient or threshold / résilience ou seuil	cover / couvert	species production / production d'espèces
Stanfield and / et Kilgour	threshold / seuil	% imperviousness / % d'imperméabilité	fish community composition / composition de la communauté de poissons
Minns	threshold (modeled) / seuil (modélisée)	area by life stage / superficie par stade de vie	lake trout abundance /abondance du touladi
Mills *et al.*	threshold / seuil	cover / couvert	pike production / production de brochets
Blanchfield *et al*.	threshold / seuil	spawning and littoral / frai et littoral	whitefish recruitment / recrutement du grand corégone
Randall *et al*.	threshold / seuil	coastal exposure / exposition côtière	IBI, HPI / indice de l'intégrité du biote, indice de productivité de l'habitat
Ridgway *et al*.	linear or fragile / linéaire ou fragile	thermal habitat / habitat thermique	trout occurrence / occurrence de truites
Clarke and / et Scruton	linear / linéaire	fluvial area / zone fluviale	trout production / production de truites
Bradford	threshold / seuil	discharge / débit	conceptual / conceptuel

Table 2: Summary of common aquatic effects found in the key pathways involving in-water and land-based activities (see Master List of Pathways, Figure 5).

Tableau 2 : Résumé des effets aquatiques communs constatés dans les principaux modèles de séquence des effets impliquant des activités réalisées dans l'eau et sur terre (voir la liste des principales relations activité-effet à la figure 5).

Habitat quantity / Quantité d'habitats	• Habitat area, volume / Superficie de l'habitat, volume
	• Habitat features (cover, structure) / Caractéristiques de l'habitat (couvert, structure)
Habitat quality / Qualité des habitats	• Sediment dynamics / Dynamique des sédiments
	• Suspended sediment concentration / Concentration des sédiments en suspension • Thermal regime / Régime thermique • Nutrient regime / Régime des éléments nutritifs • Food supply / Disponibilité des aliments • Contaminants / Contaminants
Flow / Débit	• dewatering leading to stranding / assèchement menant à l'échouement • velocity barriers / obstacles à la vélocité
Direct or indirect mortality / Mortalité directe ou indirecte	

Table 3. Proposed mitigation measures for the vegetation removal pathway (Figure 6).

Potential Cause of Effect	Mitigation	Effect Avoided Yes/No
Change in fish passage	• No addition or removal of structure within stream channel.	Yes
Change in cover	• No removal of cover features adjacent to or within channel. 20 m of riparian vegetation to be retained.	Yes
Change in sediment concentrations	• Erosion and Sediment Control Plan • 5m machine free zone adjacent to channel to prevent compaction or bank destabilization. • Work undertaken during periods of low flow • Timing of work consistent with prescribe restrictions for in water work	Yes
Change in thermal regime	• Cover will be maintained. 20 m of riparian vegetation to be retained.	Yes
Change in food availability and type	• Upstream and adjacent food sources will be maintained.	Yes
Change in nutrient dynamics	• No change in allochthonous inputs. 20 m of riparian vegetation to be retained.	Yes
Change in contaminants	• Clean all equipment away from channel where it cannot be re-introduced to the channel.	Yes

Tableau 3. Mesures d'atténuation proposées pour la séquence des effets associée à l'enlèvement de la végétation (figure 6).

Cause potentielle de l'effet	Atténuation	Effet évité Oui/Non
Changement touchant le passage des poissons	• Aucun ajout ou retrait de structures dans le chenal.	Oui
Changement touchant le couvert	• Aucun retrait de caractéristiques offrant un couvert dans de chenal ou à proximité. 20 m de végétation riveraine à maintenir.	Oui
Changement touchant les concentrations de sédiments	• Plan de lutte contre l'érosion et la sédimentation • Zone de 5m interdite a la machinerie de chaque côté du chenal pour empêcher le tassement ou la déstabilisation des berges. • Travaux entrepris pendant les périodes de faible débit • Synchronisation des travaux conforme aux restrictions prescrites pour les travaux menés dans les plans d'eau	Oui
Changement touchant le régime thermique	• Maintien du couvert. 20 m de végétation riveraine à conserver.	Oui
Changement touchant la disponibilité et le type d'aliments	• Maintien des sources d'aliments en amont et à proximité.	Oui
Changement touchant la dynamique des éléments nutritifs	• Aucun changement des apports allochtones. 20 m de végétation riveraine à conserver.	Oui
Changement touchant les contaminants	• Nettoyage de l'équipement à bonne distance du chenal pour éviter toute réintroduction de matériaux dans le cours d'eau.	Oui

Table 4: Summary of key recommendations from the Workshop.

:
1. Establish National Habitat Science Advisory Working Group to promote continual collaboration and communication between FHM and Science
2. Plan and implement a workshop on marine habitat
3. Workshop to establish consistent inter-Region benchmarks for determining NNL
4. Establish GIS based inventories of habitat supply, linking with HRTS, to deal with cumulative impacts
5. Implement objective methods for risk assessment for referrals
6. Science to provide methods for determining first-tier maps of habitat capacity and sensitivity
7. Adopt adaptive management strategy for assessing compensation measures. Develop protocols, criteria, and data standards for monitoring.
8. Develop operational guidelines for determining HADD
9. Develop a road map for the referral process, with both FHM and Science input
10. Disseminate the results of habitat science as CSAS Research Documents and Advisory Documents.

Tableau 4 : Résumé des recommandations clés issues de l'atelier.

:
1. Établir un groupe consultatif national sur les sciences de l'habitat pour favoriser la collaboration et la communication continues entre la Gestion de l'habitat du poisson et les Sciences
2. Planifier et tenir un atelier sur l'habitat marin
3. Planifier un atelier pour établir des points de référence uniformes entre les régions afin d'établir le principe d'aucune perte nette (APN)
4. Produire des inventaires SIG des habitats disponibles, en lien avec la base de données du SSDH, pour évaluer les effets cumulatifs
5. Mettre en œuvre des méthodes objectives d'évaluation des risques pour les soumissions liés à l'habitat
6. Élaboration par les Sciences des méthodes pour établir les cartes sur la capacité et la vulnérabilité des habitats
7. Adopter une stratégie de gestion adaptative pour évaluer les mesures de compensation. Élaborer des protocoles, des critères et des normes sur les données de le suivi.
8. Élaborer des lignes directrices pour déterminer la DDP de l'habitat
9. Élaborer un plan pour le processus de traitement des soumissions liés à l'habitat, avec les contributions de la Gestion de l'habitat du poisson et des Sciences
10. Diffuser les résultats sur les sciences de l'habitat sous la forme de documents de recherche et documents contenant des avis du SCCS.

FIGURES

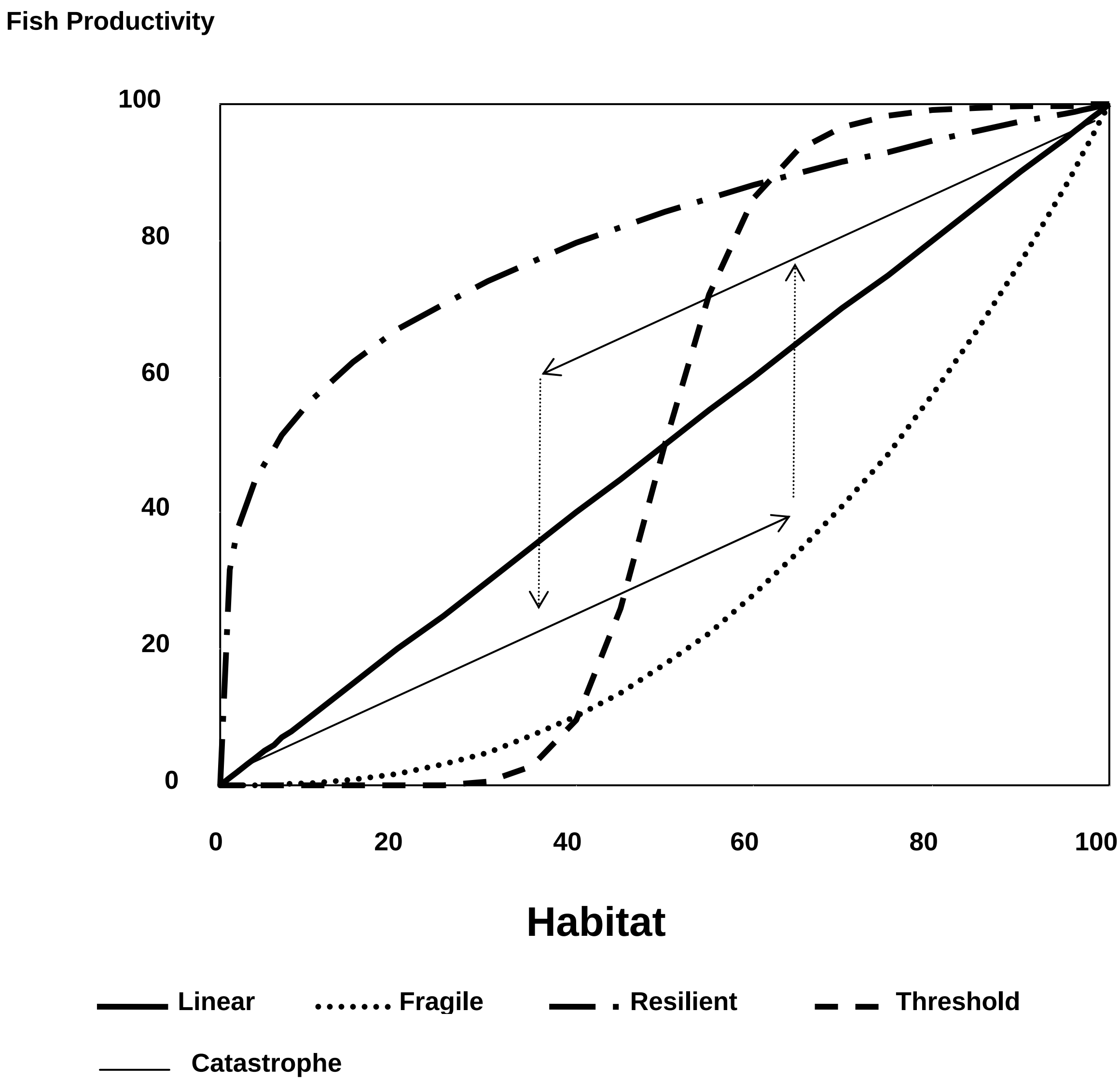

Figure 1. Potential linear and non-linear responses of fish production to habitat supply. From the presentation of K. Minns (Appendix 5).

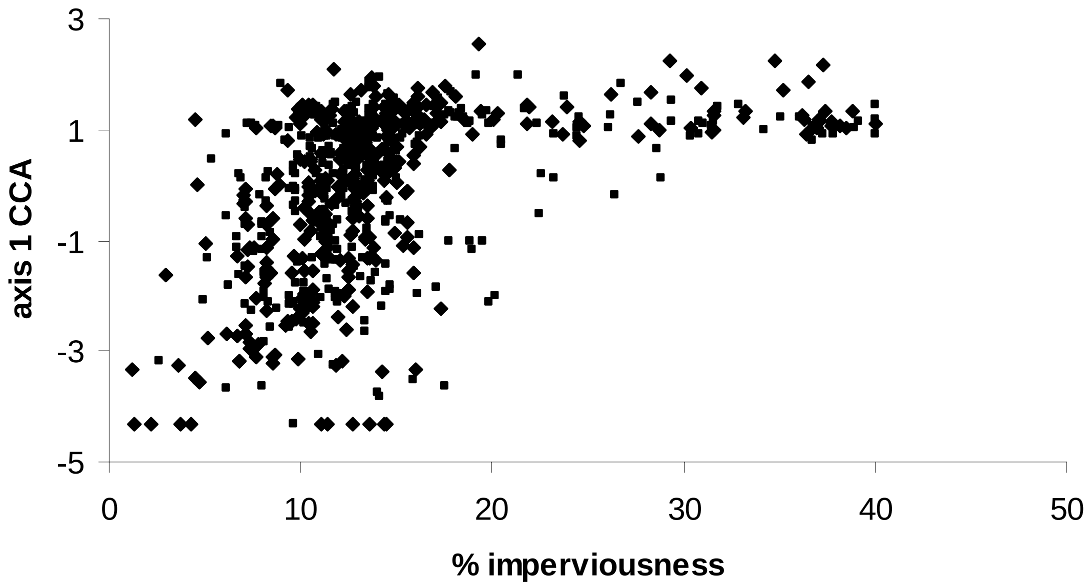

Figure 2. Threshold response between fish community indices (CCA axis 1) and percent imperviousness of Ontario watersheds. From presentation of L. Stanfield and B. Kilgour (Appendix 5).

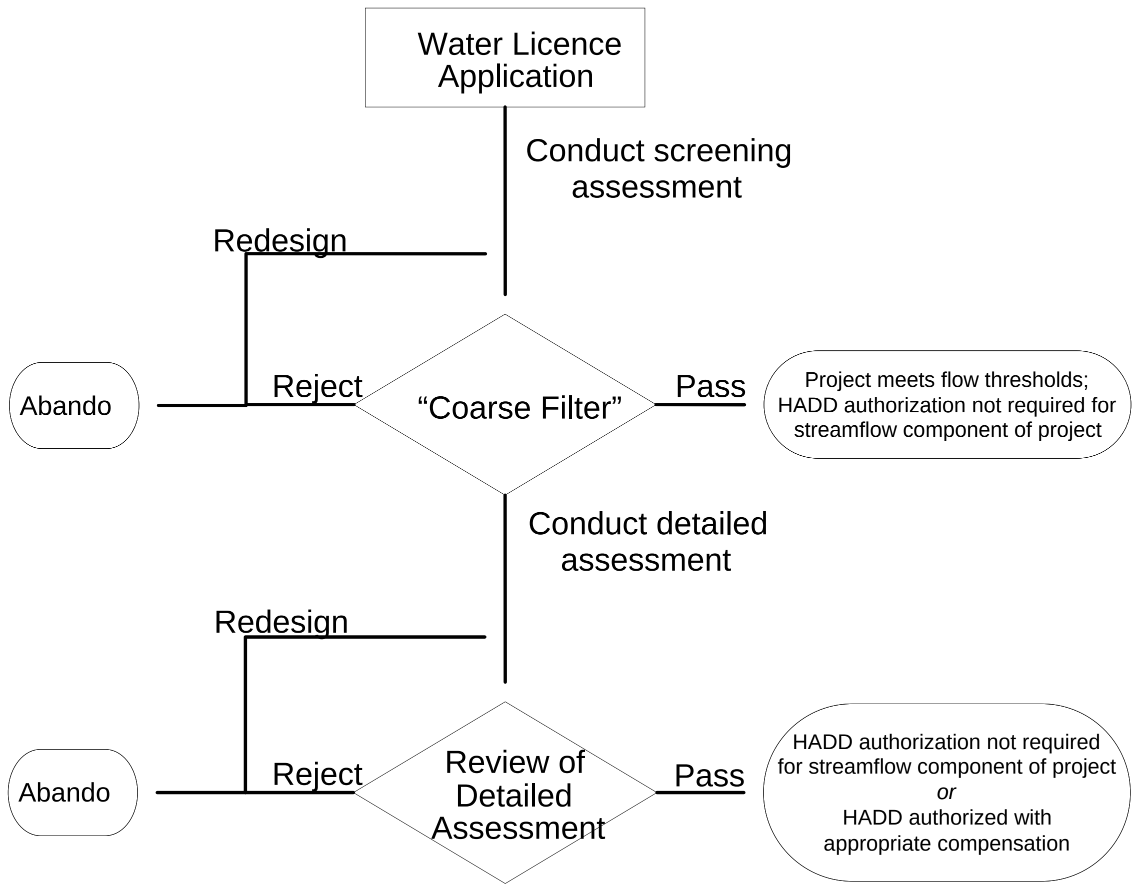

Figure 3. Two-stage decision flow chart for conducting screening or detailed assessment of water licenses for small-scale hydro projects in British Columbia. From the presentation of M. Bradford and T. Hatfield (Appendix 5).

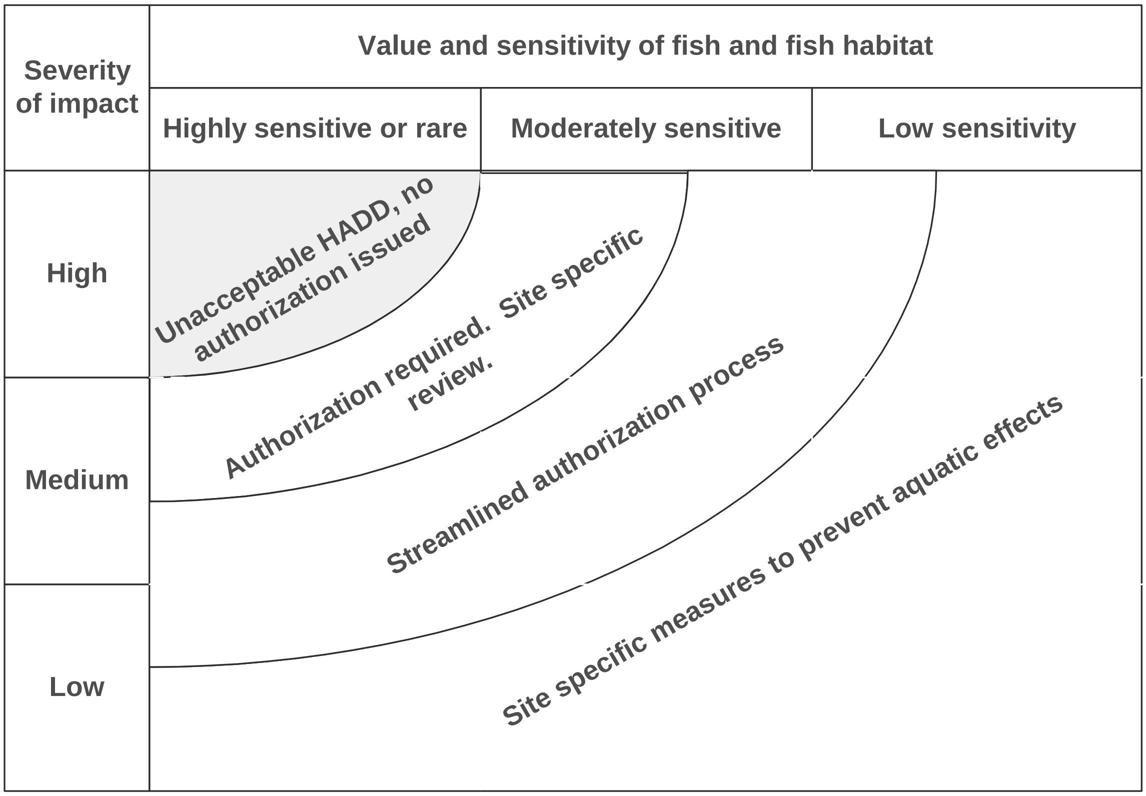

Figure 4. A Risk Assessment Framework (from the presentation of C. Stoneman; Appendix 5).

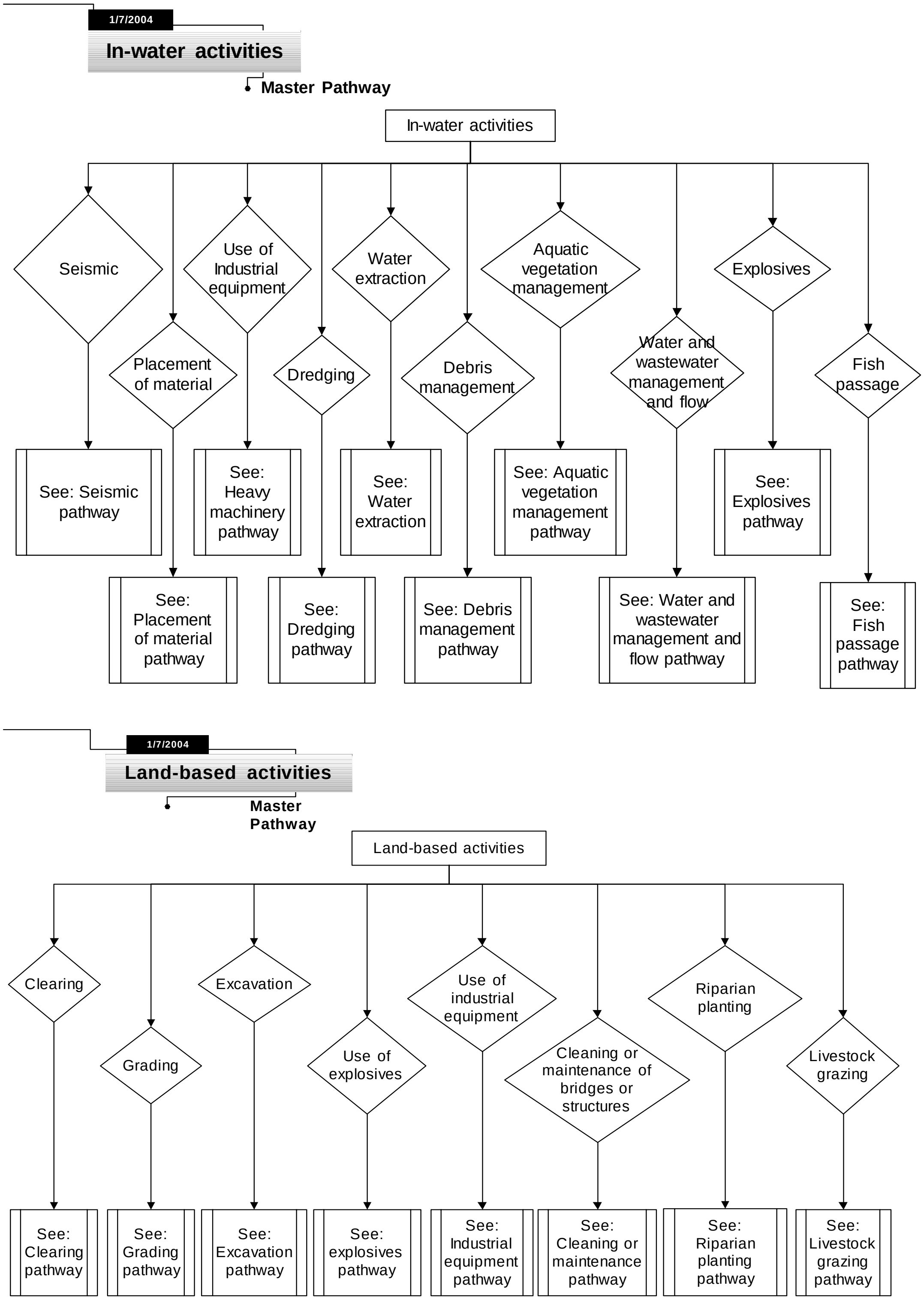

Figure 5. Master list of pathways for in-water (upper) and land-based activities (from the presentation of N. Winfield).

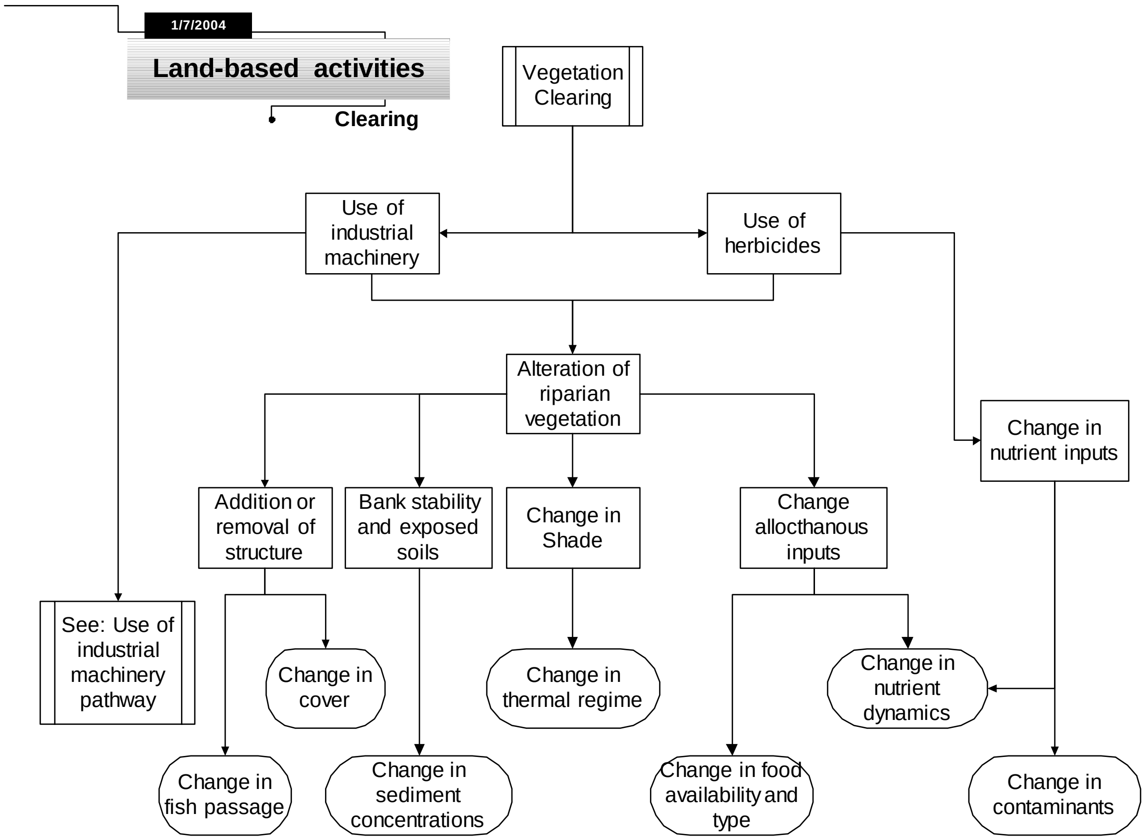

Figure 6. Example of a Pathway of Effect diagram that identifies all potential effects from vegetation removal adjacent to a fish-bearing stream (from the presentations of N. Winfield and C. Stoneman; Appendix 5).

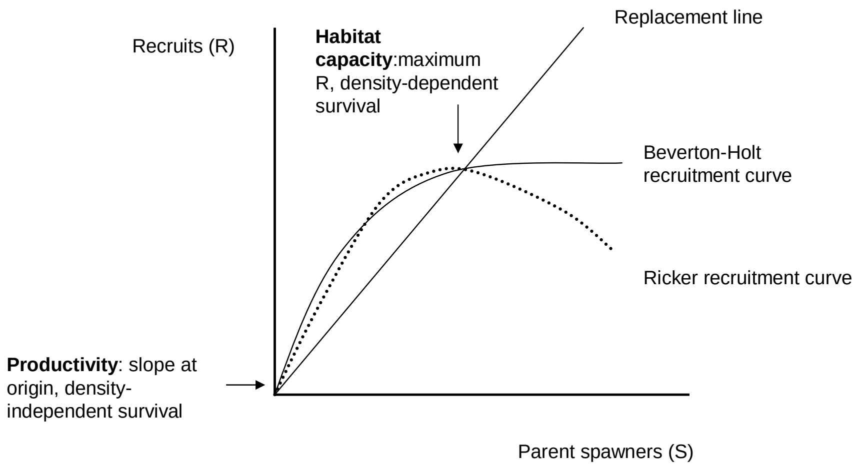

Figure 7. Generalized fish population stock and recruitment curve (from Randall 2003), explicitly linking habitat productive capacity to population dynamics.

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30.	Scruton, Dave[2]	DFO, St. John's	ScrutonD@dfo-mpo.gc.ca
31.	Smokorowski, Karen[1]	DFO, SSM	SmokorowskiK@dfo-mpo.gc.ca
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[1]Steering Committee; [2]Facilitators; [3] Rapporteurs

APPENDIX 2: WORKSHOP PROGRAM

Day 1 – Wednesday December 10, 2003

Time	Topic	Presenter	Themes addressed
7:30-8:45	*Continental Breakfast*		
8:45-9:00	Welcome, Purpose, and Introductions	Randall, Bob	
9:00– 9:20	1. Habitat-Specific Production in Inland Lakes	Pratt, Tom	1,2
9:20-9:40	2. Habitat Classes and Productive Capacity of Large Rivers (including ETD model)	Franzin, Bill	1,2,3
9:40-10:00	3. Coastal Exposure as a First-Order Predictor of the Productive Capacity of Near Shore Habitat in the Great Lakes	Randall, Bob	1, 3, 4
10:00-10:20	4. Riverine Habitat Classification in Newfoundland and Approaches to the Measurement of Habitat Productive Capacity and/or Surrogates, for Stream Salmonids	Scruton, Dave	1,4,3
10:20-10:40	*Break*		
10:40-11:00	5. Production Dynamics of Salmonids in Newfoundland: Investigating the Role and Linkages of Lucastrine and Fluvial Habits	Clarke, Keith	1,2,3
11:00-11:20	6. Landscape Predictors of Trout Production in Ontario.	Ridgway, Mark	
11:20-11:40	7. A Bioregional Model for Predicting Thresholds of a Change for Lake Ontario Tributary Streams	Stanfield, Les	1,2
11:40-noon	8. Using Area-Per-Individual (API) Model for Identifying HADD Thresholds in Fish	Minns, Ken	2,4
12:00-1PM	Lunch		
1:00-1:20	9. Web Mapping Tool for Fish Species at Risk in Ontario	Mandrak, Nick	2,1,4
1:20-1:40	10. Development of an Instream Flow Screening Tool and Guidelines for Small Hydro in the Pacific Region	Bradford, Mike	2,3
1:40-2:00	11. Experimental Manipulation of Habitat Capacity in Inland Lakes	Smokorowski, Karen	1, 3, 2

APPENDIX 2 (Cont'd): WORKSHOP PROGRAM – DAY 1

2:00-2:20	12. Impacts of Macrophyte Removal on Northern Pike Biomass and Production	Mills, Ken	1,2,3
2:20-2:40	13. The Decline and Recovery of a Lake Whitefish (*Coregonus clupeaformis*) Population From Winter Drawdown in a Small boreal Lake	Blanchfield, Paul	1,2,3
2:40-3:20	Break		
3:20-3:40	14. No Net Loss of Fish Habitat: Trends and Patterns relating to Section 35(2) Fisheries Act Authorizations and Fish Habitat Compensation in Canada.	Harper, David	1,3
3:40-4:00	15. Effectiveness of Fish Habitat Compensation in Canada	Quigley, Jason	1,3
4:00-4:30	Discussion		

APPENDIX 2 (Cont'd): WORKSHOP PROGRAM

Day 2 –Thursday December 11, 2003

	Theme	Lead	Keywords
7:00-8:00	Continental Breakfast		
8:00-8:15	A Risk Management Approach to Habitat Referrals	C. Stoneman	
8:15-8:30	HADD Determination – Pathways of Effects	N. Winfield	
8:30-8:45	Productive Capacity	B. Randall	Production, productivity, productive capacity, area, habitat classes (lakes, Great Lakes, rivers), sensitivity, indices and assumptions, validation.
8:45-9:30	PC Discussion	H. Bain	
9:30-9:45	Thresholds and HADD	T. Pratt	Harmful alteration, disruption or destruction (HADD), HADD detection, severity of impact, frameworks, thresholds, compensatory mechanisms.
9:45-10:30	Threshold Discussion	C. Stoneman	
10:30-11:00	Break		
11:00-11:15	Habitat Manipulation and Compensation (No Net Loss)	K. Smokorowski	Habitat manipulation, enhancement, experimental research, compensation ratio, No Net Loss, effectiveness monitoring, scientific evaluation, efficacy.
11:15-12:00	Compensation Discussion	D. Scruton	
12 :00-1 :30	Lunch		
1:30-1:45	Incorporating Uncertainty and Risk into Fish Habitat Management Decision-Making	K. Minns	Uncertainty, risk, decision-making, minimum safe levels, precautionary, probability, non-monetary cost-benefit analysis, scientists, managers.
1:45-2:30	Risk Discussion	M. Jones	
2:30-3:00	Break		
3:00-4:00	General Discussion/ wrap-up	Stoneman/ Randall	

ANNEXE 2 : PROGRAMME DE L’ATELIER

Jour 1 – Le mercredi 10 décembre 2003

Heure	Sujet	Présentateur	Thèmes
7 h 30 à 8 h 45	*Petit déjeuner continental*		
8 h 45 à 9 h 00	Mot de bienvenue, but et présentations	Randall, Bob	
9 h 00 à 9 h 20	1. Production propre à l’habitat dans les lacs intérieurs	Pratt, Tom	1,2
9 h 20 à 9 h 40	2. Catégories d'habitats et capacité de production des grands cours d’eau (y compris le modèle ETD)	Franzin, Bill	1,2,3
9 h 40 à 10 h 00	3. Exposition côtière en tant que variable explicative de premier ordre pour la capacité de production de l'habitat à proximité du rivage dans les Grands Lacs	Randall, Bob	1, 3, 4
10 h 00 à 10 h 20	4. Classification des habitats riverains à Terre-Neuve et approches pour la mesure de la capacité de production des habitats et/ou des habitats de remplacement dans les cours d'eau à salmonidés	Scruton, Dave	1,4,3
10 h 20 à 10 h 40	*Pause*		
10 h 40 à 11 h 00	5. Dynamique de la production des salmonidés à Terre-Neuve : étude du rôle et des liens entre les comportements en milieux lacustre et fluvial	Clarke, Keith	1,2,3
11 h 00 à 11 h 20	6. Variables explicatives du paysage pour la production de truites en Ontario.	Ridgway, Mark	
11 h 20 à 11 h 40	7. Un modèle de biorégional pour prévoir les seuils d'un changement dans les tributaires du lac Ontario	Stanfield, Les	1,2
11 h 40 à midi	8. Utilisation du modèle API (aire par individu) pour établir des seuils de DDP de l’habitat chez les poissons	Minns, Ken	2,4
12 h 00 à 13 h 00	Déjeuner		
13 h 00 à 13 h 20	9. Outil de recensement Web pour les espèces de poissons en péril de l’Ontario	Mandrak, Nick	2,1,4
13 h 20 à 13 h 40	10. Élaboration d'un outil d’évaluation préliminaire et de lignes directrices concernant le débit des cours d’eau pour les petites centrales électriques de la région du Pacifique	Bradford, Mike	2,3
13 h 40 à 14 h 00	11. Modification expérimentale de la capacité des habitats dans les lacs intérieurs	Smokorowski, Karen	1, 3, 2

ANNEXE 2 (suite) : PROGRAMME DE L'ATELIER – JOUR 1

14 h 00 à 14 h 20	12. Effets de l'enlèvement des macrophytes sur la biomasse et la production du grand brochet	Mills, Ken	1,2,3
14 h 20 à 14 h 40	13. Déclin et rétablissement de la population de grand corégone (*Coregonus clupeaformis*) à la suite de l'abaissement du niveau en hiver d'un petit lac boréal	Blanchfield, Paul	1,2,3
14 h 40 à 15 h 20	Pause		
15 h 20 à 15 h 40	14. Aucune perte nette d'habitat du poisson : tendances et profils concernant les autorisations en vertu du paragraphe 35(2) de la *Loi sur les pêches* et compensation de l'habitat du poisson au Canada	Harper, David	1,3
15 h 40 à 16 h 00	15. Efficacité de la compensation de l'habitat du poisson au Canada	Quigley, Jason	1,3
16 h 00 à 16 h 30	Discussion		

ANNEXE 2 (suite) : PROGRAMME DE L'ATELIER

Jour 2 – Le jeudi 11 décembre 2003

	Thème	Responsable	Mots-clés
7 h 00 à 8 h 00	Petit déjeuner continental		
8 h 00 à 8 h 15	Une approche de gestion des risques pour les soumissions liées à l'habitat	C. Stoneman	
8 h 15 à 8 h 30	Détermination de la DDP de l'habitat – Modèle de la séquence des effets	N. Winfield	
8 h 30 à 8 h 45	Capacité de production	B. Randall	Production, productivité, capacité de production, superficie, catégories d'habitats (lacs, grands lacs, cours d'eau), vulnérabilité, indices et hypothèses, validation.
8 h 45 à 9 h 30	Discussion sur la capacité de production	H. Bain	
9 h 30 à 9 h 45	Seuils et DDP de l'habitat	T. Pratt	Détérioration, destruction ou perturbation (DDP) de l'habitat, détection de la DDP, importance de l'effet, cadres, seuils, mécanismes compensatoires.
9 h 45 à 10 h 30	Discussion sur les seuils	C. Stoneman	
10 h 30 à 11 h 00	Pause		
11 h 00 à 11 h 15	Modification et compensation de l'habitat (aucune perte nette)	K. Smokorowski	Modification de l'habitat, amélioration, recherche expérimentale, rapport de compensation, aucune perte nette, surveillance de l'efficacité, évaluation scientifique, efficacité.
11 h 15 à 12 h 00	Discussion sur la compensation	D. Scruton	
12 h 00 à 13 h 30	Déjeuner		
13 h 30 à 13 h 45	Incorporation de l'incertitude et du risque dans la prise de décisions concernant la gestion de l'habitat du poisson	K. Minns	Incertitude, risque, prise de décision, niveaux minimaux sûrs, précaution, probabilité, analyse des coûts-avantages non monétaires, scientifiques, gestionnaires.
13 h 45 à 14 h 30	Discussion sur le risqué	M. Jones	
14 h 30 à 15 h 00	Pause		
15 h 00 à 16 h 00	Discussion générale / récapitulation	Stoneman/ Randall	

APPENDIX 3: ABSTRACTS OF PRESENTATIONS AND WORKSHOP QUESTIONS FROM DAY 1

Workshop questions (Q), author responses (R), and comments (C) are provided, identifying the speaker if recorded, after each abstract. Workshop discussion was recorded in brief (not *verbatim*), and errors and omissions may have occurred

Habitat-Specific Production in Inland Lakes

Pratt*, T., P. Blanchfield and M. Ridgway
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Estimating habitat-specific production rates is a difficult but crucial component of meeting Fisheries and Oceans Canada policy of 'no net loss of productive capacity of fish habitats' as outlined in the *Fisheries Act*. In three separate studies from north-western (Experimental Lakes Area), central (Turkey Watershed) and eastern (Swan Lake Research Reserve) Ontario, we used underwater snorkeling transects set perpendicular to shore in combination with DISTANCE software to estimate habitat-specific littoral zone fish densities. Habitat classes were broadly defined and based on simple physical habitat features such as substrate and the presence of vegetation and coarse wood. Passive fish traps (minnow traps, fyke nets, hoop nets) were concurrently fished in specific habitat types, and captured fish were weighed. These weights, when used in combination with the available density estimates and estimates of habitat availability, provided habitat-specific biomass estimates for each species. In all studies, habitat-specific production was estimated by multiplying habitat-specific biomass estimates with published species-specific production: biomass ratios to determine habitat production indices (HPI). Production was also estimated in two of the studies by conducting visual censuses and capturing and weighing fish over two time periods.

The underwater visual method for determining habitat-specific densities was validated by conducting a concurrent mark-recapture population estimate in the five Turkey Lakes Watershed lakes. The 95% confidence intervals from visual and mark-recapture population estimates overlapped for 90% of the species censused, indicating that our underwater visual method is capable of providing habitat-specific densities. Fish densities were significantly higher in structurally complex habitats, as beaver lodges contained higher densities of fish than all other habitats, and coarse wood and vegetation had higher densities than open habitats. HPI estimates demonstrated a similar pattern, with beaver lodges having significantly higher HPI estimates than vegetated, rocky or open habitats, and coarse wood habitats having significantly greater HPI estimates than open habitats. Production estimates too followed a similar pattern, but were more variable and there was no statistical difference among habitat types. We examined habitat fidelity (an assumption of our methods is limited movement among habitats), and found that fish captured in specific habitats were most likely to be recaptured in those habitats.

Our research provides many valuable insights for Fisheries and Oceans Canada Habitat Management Program. Structurally complex habitats contained the highest fish densities and biomass, and provided the greatest potential for production. Coarse wood habitats were 11.5, 4.5, and 3.3 times more productive than open, rock and vegetated habitats respectively. Given the variability in actual habitat-specific production estimates, the use of underwater visual methods for determining habitat-specific density estimates, in combination with published production:biomass ratios provide a simple and effective method for estimating habitat-specific production.

Workshop discussion:

Q (Bradford): Are there day versus night differences in fish catches? R: Surveys were done during the daytime. Some species are only active at night. Day species are quieter at night, resting on the bottom. Bigger fish are in deeper water during the day, which may affect detectibility. If the surveys are done at night, the results may be different.

Q (Stanfield): Are the patterns different at night? Does open habitat become more important at night? R: Possibly. C (Blanchfield): We have worked at night, but found no difference in the patterns. Open water was poor during both day and night.

Q: Are you able to assess the differences in observability of fish in different types of habitats? R: The density-estimation software produces different detection functions if the data are strong enough (i.e., having a sufficient number of observations).

Q: Are you assuming they are equally observable in different habitat types? R: No. Detectibility is habitat dependent.

Q (DeBruyn): What are the effects of coastal processes on smaller, inland lakes? R. Small lakes are not affected by fetch. Could possibly tease out data with knowledge of slope and wind direction. This technique has been used on small lakes versus large lakes.

Complexities in the Classification of Fish Habitat in Large Rivers with Implications for Estimates of Productive Capacity

William Franzin[1]*, Leon Carl[2] and Karen Smokorowski[3].
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This presentation is a compilation of work done in large rivers in Ontario and the Prairie Provinces. The complex nature of stream habitats at different scales is provided along with potential fishing approaches to sample across those habitat scales. We show four examples of sampling designs used in river sampling, the types of data that are produced by them and the sources of error and levels of confidence associated with riverine fish and fish habitat sampling. Two studies were conducted to estimate biodiversity while the other two assessed abundance and biomass. Most riverine fish communities are sampled using backpack or boat-mounted electrofishers. The effects of fish size, water depth and transparency/turbidity on capture success at constant power levels were modeled as part of one of the studies. These data indicate that a healthy amount of scepticism should be applied to interpretation of electrofishing results. All of these factors reflect on estimates of productive capacity of fish habitat in rivers based on fish captures. The following two tables summarize approaches to sampling riverine habitat and fishes over a broad range in scale.

Workshop discussion: No questions because of limited time.

Scaling Habitat Classification and Fish Use in Rivers:

Typology	River Scale		Fish and Fish Habitat Sampling Scale		Modeling
	Small	Large	Small	Large	
Geomorphology	Harder; higher slope	Softer; lower slope	Headwater species, geological substrates	Large river/lake species; ETD substrates	Below
Watershed	Primary: a few to 10s of kilometres, few stream orders	Secondary or tertiary: 100s of kilometres, multiple stream orders	Kilometre reference segments, habitat in metres^2, Communities, IBI, indicator species, etc., reference barriers	Reference segments, habitat in hectares communities, IBI, indicator species, etc., reference barriers	1-D models for hydrology, PHABSIM, River2D for habitat at reference sites
River mainstem, natural or man-made barriers	Hectometres to kilometres; stream widths<10m	Kilometres to 100s of kilometres; stream widths >10m	Reference Reaches Mesohabitats (riffle, pool, run, glide, pocket water) Metres^2 Fish guilds, reference barriers	Macrohabitats (inside / outside meander bends crossovers, backwaters and side-channels, hectares reference reaches by segment, fish guilds	1-D model for hydrology, PHABSIM, MESOHABSIM, River2D for habitat at reference sites
River or valley segment or reach, length variable, natural or man-made barriers	Dekametres	Kilometres	Microhabitats (HSI for depth, velocity, substrate, cover), guilds, species, life stages	Reference reach, microhabitats at metres^2 level, guilds, species, life stages	PHABSIM, River2D preferred
Site, 12-20 stream widths	Metres^2	Metres^2 to hectares	Microhabitats at metres^2 level	Microhabitats, at metres^2 level	PHABSIM, River2D preferred
Temporal Issues	Seasonal changes in hydrograph dramatically affect habitats at all levels of watersheds.				

Scaling Sampling Designs for Determining Fish Use of Habitat in Rivers:

Habitat Scale	River Sampling Units		Expected Fish Species / Biodiversity		Fishing Gears
	Small	Large	Small	Large	
Watershed	Tributary network by stream order; valley segments stratified random sampling (SRS) of tributaries by order or mean width	Valley segments, major tributaries; SRS by segment, revert to small scale up watershed tagging, telemetry	Mainly small fish species and specialists in local mesohabitats; low-moderate biodiversity, increasing down watershed, effects of barriers	More large fish species, high, variable biodiversity, distributions influenced by local habitat structure, pelagic (lake-type) species enter down watershed, effects of barriers	A variety: backpack, positioned array, push boat and large boat shockers, seines, passive gear (various nets, traps etc.)
River mainstem, natural or man-made barriers	SRS of habitat units such as mesohabitats, barriers	Large scale SRS of transects or macrohabitats, barriers, telemetry	Position of sample in watershed determines fish communities	Position of sample in watershed determines fish communities	Backpack to Large boat shockers, trawls, large seines, gillnets, traps etc.
River valley segment or reach, length variable, natural or man-made barriers	Random sweeps, habitat sampling	SRS of short transects or macrohabitats, possibly mesohabitats, barriers, telemetry	Biodiversity may be differentiated by mesohabitats, pool and riffle communities	Mesohabitats largely indistinguishable, community biodiversity organized among macrohabitats	Backpack, boat or push boat shockers, seines, traps, surrounding gears
Site, 12-20 Stream widths	Barrier netted sections, positioned arrays, grids	SRS of smaller scale, possibly mesohabitats, telemetry	Microhabitat variables become useful, HSI parameters may be determined	Microhabitat variables become useful, HSI parameters may be determined	As above, also in small streams, Hess-type samplers on microhabitat
Temporal Issues	Seasonal changes in hydrograph dramatically affect fish sampling at all levels of a watershed.				

Coastal Exposure as a First-Order Predictor of the Productive Capacity of Near Shore Habitat in the Great Lakes

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Regression tree analysis with coastal exposure (fetch distance) as a predictor of fish biomass was used to evaluate the productive capacity of near shore habitat in the Great Lakes. Regression tree models were developed using survey data collected at coastal wetlands, harbours and natural shorelines in 1994 (n=100) and validated using data from other areas surveyed in other years (1990 to 1999, n = 273). Coastal habitat characteristics that influence fish distribution, including the occurrence and abundance of submersed macrophytes, water temperature and substrate characteristics were related to maximum fetch distance in a consistent manner in the model and validation data sets. Three classes of macrophyte density (absent, moderate and dense cover), were predicted from substrate size and fetch distance: plant cover was highest where the predominant particle size was fine (silt or smaller) and maximum fetch was < 12.6 km. Fetch was a significant predictor of the biomass of three species (*Lepomis gibbosus, Perca flavescens, and Alosa pseudoharengus*), each with different habitat preferences, and two fish community indices (Index of Biotic Integrity [IBI], and the Habitat Productivity Index [HPI]). IBI and HPI were used as measures of the diversity and production components of habitat productive capacity, respectively. For all fish response variables, classification was improved if fetch was used together with associated habitat attributes as predictors. The degree of resolution of habitat classification (number of classes that were discernible) was limited to 2 to 4 classes, depending on the fish response variable. Proportional reduction in error for the regression trees ranged between 0.30 and 0.76. Four classes of *Lepomis* habitat were determined and validated, but the number of habitat classes for *Perca* and *Alosa* was less. For the whole fish assemblage, four habitat classes were identified using IBI and HPI together in a two-axes approach for evaluating productive capacity, along with fetch and water temperature as predictors. Knowledge of site exposure and the associated habitat covariates can be used to determine and map first-order estimates of coastal habitat productive capacity in the Great Lakes.

Workshop discussion:

Q (Franzin): Is the correlation between fetch and particle size or fetch and cover? R: Both. There is a correlation between fetch and substrate, but the model for predicting cover is improved if you combine the two predictors (fetch and substrate). You can have a fetch value that is quite low, less than the criterion of 12 km, but if the substrate is coarse or bedrock, there will be no vegetation.

Q (DeBruyn): Is fetch important in both small inland and large lakes? R: Fetch distance is orders of magnitude greater in the Great Lakes than in inland lakes. C (Pratt): There are wind driven processes in small lakes but the effect on habitat is less than in large lakes. Even on small lakes, most of your aggregations (woody debris) are going to be occurring on the leeward side; therefore fetch may have some bearing on site productive capacity.

Riverine Habitat Classification in Newfoundland and Approaches to the Measurement of Habitat Productive Capacity and/or Surrogates, for Stream Salmonids

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It is well recognized that the spatial and temporal dynamics of habitat quantity and quality are a major determinant of fish production and fish populations. Riverine ecosystems are particularly dynamic owing to the stochastic nature of precipitation events and anthropogenic influences either dampening (e.g. regulation) or exacerbating (e.g. hydro peaking, urbanization) this variability. The habitat requirements of a particular fish species will vary from location to location owing to differences in biotic (e.g. species complexity, inter- and intra-specific competition, predation, food availability, etc.) and abiotic (e.g, climate, geomorphology, hydrology, etc.) conditions. Habitat requirements for fish may also vary seasonally or on shorter time scales as they progress through different life stages and often the relative location of habitats (e.g. adjacency) is important. Further, the habitat requirements of a species can be defined at different scales (microhabitat, meso-habitat, river reach, and watershed). Conceptually, it is also thought that fish populations may be controlled by habitat limiting events or conditions embraced in concepts such as 'critical habitats' and habitat 'bottlenecks'. All of these influences will confound and complicate efforts to measure habitat productive capacity (HPC).

In Newfoundland, the classification of stream habitat has evolved from a macro-habitat based approach (the Beak habitat classification system, circa 1979) to a tiered approach embracing macro-habitat, meso-habitat (e.g. run, riffles, pool, etc.), and microhabitat (e.g. depth, velocity, substrate) scales. These habitat classification strata will be discussed in the context of methods to identify and measure physical habitat attributes towards quantification of habitat. Considerations unique to Newfoundland including a depauperate fish community, co-existence of resident and anadromous populations, Salmo-centric focus, dilute and low fertility of waters, and the high proportion of water on the landscape are described. The various metrics and/or surrogates, including fish-based and habitat based measures that have /can be used to describe or quantify habitat productive capacity will be discussed. Issues associated with temporal (diel, seasonal) and spatial variability in fish habitat utilization, and the definition and measurement of habitat productive capacity, is discussed using examples from fluvial salmonid habitat studies in Newfoundland. Two-dimensional habitat hydraulic modeling will be presented as a tool to examine effect of flow changes on habitat productive capacity and to demonstrate sensitivity to habitat criteria (models) used. Habitat supply based fish population modeling will be presented as a means of integrating habitat productive capacity across life stages, meso-habitats, and considering the marine life phase of anadromous fish. Fluvial habitat productive capacity will be discussed in the context of the workshop themes: (i) sensitivity and standardization of HPC measures; (ii) HADDs and thresholds; (iii) habitat compensation; and (iv) risk and uncertainty in the measurement of HPC. Finally, the classification of fluvial habitats in Newfoundland will be discussed in relation to the Habitat Management program's 'Risk Management Framework.'

Workshop discussion:

Q: What is EEM? R: Environmental Effects Monitoring.

Production Dynamics of Salmonids in Newfoundland: Investigating the Role and Linkages of Lucastrine and Fluvial Habitats

Clarke* K. D. and D. A. Scruton
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Freshwater fish communities of insular Newfoundland are generally characterized by a depauperate fish assemblage and low production when compared to their mainland counter parts. The species present are all hyposaline and are generally dominated by salmonids. This reduction in species has been hypothesized to allow for an expansion of useable habitat such that salmonids extensively utilize both lacustrine and fluvial habitats for production and many of the classical habitat associations derived from the literature are only very generally applicable. The linkage between these habitats is poorly understood and we tend to manage them as separate entities, although they are often highly linked from a population viewpoint. To further complicate the matter it has been shown that individuals within these low productivity systems do not always exhibit a high habitat affinity and large inter-habitat migrations, occurring on a variety of spatial and temporal scales, do occur.

The situation described above has a number of consequences when managing habitat within the Newfoundland and Labrador Region. Since most species found in Newfoundland systems use both lakes and streams, either inter-changeably within the same year or during a specific stage of their life cycle, the question arises as to which of these very distinct habitats are more important to the overall production of the population. Furthermore, due to this plasticity in habitat utilization, situations may arise were development resulting in the alteration of one habitat type into another or compensating for one habitat type with another would benefit from an estimate of production 'equivalency' between the differing habitat types.

To investigate the variety of functions provided by these habitats with respect to salmonid production, habitat based production estimates and movement patterns within two very different Newfoundland freshwater systems were compared. The first study system is a small headwater system located in western Newfoundland, which is inhabited by brook trout as its only fish species. The second system studied is located on the Avalon Peninsula with easy access to the marine environment. The latter has a diverse fish assemblage, by Newfoundland standards, with six species, brook trout, brown trout, Atlantic salmon, American eel, rainbow smelt, and three-spine stickleback, all with a variety of anadromous and non-anadromous life history strategies. Extensive movement between lakes and streams was observed in both systems with some movements being associated with changes in life history stage and others having a seasonal pattern. Production estimates are presented within each habitat or meso-habitat as appropriate. Information on temporal habitat use and movement is also presented to investigate the relative role each of these major habitat classes has on the productive capacity of salmonids in Newfoundland.

Workshop discussion:

Q: What winter sampling methods were used other than telemetry? R: Pit tags will be used in addition to telemetry this winter. A series of antennae arrays (rather than active searching) will be used in a small stretch of river to determine fish movements and foraging. It is difficult to sample in the winter.

Q (Jones): Population scale is important. Streams are more productive than lakes, but why does this make them more sensitive to habitat change? R: Much work has been done on trout production in Copper Lake and recruitment from stream habitat is of key importance. Changes (habitat alteration) are more dramatic in streams, and more subtle in lakes.

Q Do we need a different definition of production for streams? The older juvenile trout and salmon are using the ponds; maybe that's the critical habitat in your system? R: Ponds are extremely important to the production of salmonids. There are many of these ponds and we sometimes overlook their role in population production. Much tagging has been done over the last four years to track movements. Movement is extremely important in these systems and anything that affects movement is critical. Protection of continuity between habitats should be a priority.

Q (DeBruyn): How do we make our decisions? On a site specific or population based system? R: The *Fisheries Act* stipulates that we cannot destroy habitat. We need to support the concept of management on a population basis (to be discussed later).

Lake Size and the Availability of Young-of-Year Brook Trout Habitat in the Land/Lake Ecotone - 'Death to Donuts'.

Jason Borwick, Mark Ridgway*, Jim Buttle & David Evans
Ontario Ministry of Natural Resources, Harkness Laboratory & Trent University, Peterborough

Abstract not available.

Workshop Discussion:

Q: Do we not need donuts (i.e., buffer zones) around lakes? R: Our new predictive model for trout habitat works in the Canadian shield and in northern Ontario streams. We want to move away from protecting places not connected to brook trout. Our model will be discussed at a Forestry workshop in North Bay in February.

Q. Regarding your pie slice (i.e., subwatershed/drainage area) approach: Instead of a donut around a lake, do you need a donut around the whole watershed? R: No, multiple sections tend to be continuous. Large reaches around lakes are simply out of the picture. What we don't know yet is whether we're increasing or decreasing the amount of protected area.

Q. Is this a species-specific forest management technique? R: Yes, as it is mainly related to brook trout. Lake trout guidelines are more liberal, as more forestry cutting is allowed near the lake. This method is species-specific because the habitat guidelines are species-specific.

A Bioregional Model for Predicting Thresholds of Change for Lake Ontario Tributary Systems

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Ecosystems are organized hierarchically with large-scale features such as hydrography, geology, topography, climate and natural disturbance history having a primary influence on determining the finer-scale features such as channel form, structure, riparian conditions, and biological composition. Landuse modifies the landscape, which in turn modifies the physical and chemical features at a stream site, and thus the biological condition. Landuse-related decisions cannot be justified without knowledge of how landuse affects biophysical properties of streams. The first challenge to this task is understanding the relationship that catchment features impose on the streams and how the overall pattern of development influences these features.

The overall objective of this project is to quantify the effect of landuse on stream health, using techniques that quantify the scales of effect and identify the pathways of the disturbance. This phase of the analysis is intended to characterize the reference state for a variety of biophysical properties of wadable streams. Further, we wish to quantify the effect of a composite of disturbance on stream health and to explore the degree to which thresholds of change exist within these systems. We will focus on the fisheries metrics in this report.

Since 1995, biophysical data (fish, inverts, instream habitat, temperature etc) have been collected on wadable streams flowing into the Lake Ontario basin using the OSAP protocol (Stanfield et. al., 1996). Recently a GIS application (ALIS) was developed by the MNR to characterize mainly the landscape conditions for each site. Many of the landscape features are measured from within the drainage basin for each site which is developed for each site using a DEM. For each of the 700 sites, biophysical data and GIS information (drainage area, geology, landuse, slope, stream length and climatic conditions) were summarized. Once summarized, we developed two composite metrics to include in the analysis. The baseflow index (BFI) was calculated for each site by summing the composite score for each geology class and its rating of contribution to baseflow. The percent imperviousness was estimated by summing the product landclasses and their impervious ratings.

Canonical correlation analysis (CCA) was used to illustrate the general relationships between fish communities and landscape features. Indices of fish community composition (i.e., ordination axis scores, total fish community biomass, richness, and brook trout biomass) were modeled (multiple regression) in relation to catchment area, slope of the stream reach, BFI, and imperviousness. We also visually examined plots of indices of fish community composition, in relation to percent imperviousness, for thresholds of disturbance.

The ordination analysis demonstrated that salmonids, lamprey and sculpins were generally found at sites with high amounts of forest cover and high baseflow. Sites with low forest cover, but more urban and agricultural landuses had few salmonids, lampreys or sculpins. The ordination also showed that sites with high slope/elevation had higher proportions of brook trout and brook sticklebacks, while sites with larger upstream catchments had fewer brook trout, and more pumpkinseeds and rainbow darters.

One multivariate index of fish community composition (the first ordination axis) showed a very strong threshold response to imperviousness. Significant changes in indices of fish community composition were evidence where forest cover was reduced to around 20%. Below that threshold there was considerable variance in the data, suggesting that local landuse and instream habitat were influencing the fish community to a greater degree in those areas.

The multiple regression models were stronger for the multivariate indices of community composition (R^2 = 0.36 to 0.39) than for the species richness (R^2 = 0.17) or the brook trout model (R^2 = 0.31). Variations in each index of the fish community were at least in part related to imperviousness, and variations in all but one index were related to catchment area. BFI explained variations in two multivariate indices of composition, and in brook trout biomass, while slope explained variations in three indices of composition.

We were able to estimate the reference condition for each site using the predictive multiple regression models, and hind-casting the expected “historical” condition assuming no development. Hind-casting with these multiple regression models is one way to evaluate the sensitivity of indices of composition to disturbance on the landscape. For each site, we also determined the deviation from the expected historical condition in an undisturbed state and classified each site as to whether it was within 1, 2 or 3 standard deviations from its estimated “historical” or “reference” condition.

Within the Lake Ontario dataset, there were 45 species of fish that were infrequently found and that were not used in the multivariate ordination procedure because of their rarity and potential influence on ordination output. Those species, however, have been “projected” onto the multivariate ordination, providing an opportunity to explore the landscape conditions that might be suitable for these taxa.

Next steps include developing similar models for metrics of instream habitat, temperature and invertebrates. Preliminary results of invertebrate work indicate that indices of benthic community composition respond in similar ways to the same list of landscape variables as do fish communities, although they appear to be less sensitive than the fish metrics used here. Managers will be able to plot site data against the background condition, to assist with diagnosing local verses far effects.

Finally, these results provide rationale for identifying those sites that at present are below thresholds of change for the fish communities that are more likely to be influenced by local features of habitat and biological interactions. Research will now focus on developing an understanding of which local habitat features are important influences on the fish communities and how best management practices (i.e., adjacent landuse and riparian vegetation condition) influence the biophysical conditions of these sites.

Workshop Discussion:

Q (Stoneman): Did you look at the soil type under the impervious surface? R: Yes, the Base Flow Index (BFI) incorporates geology and area.

Q. Can we focus development into areas where impacts will not be as severe? Do we know the natural state of the substrate? R: Resource reporting will allow us to manage development by taking all information into consideration.

An Area-Per-Individual (API) Model for Identifying HADD Thresholds in Fish

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How limited supplies of suitable habitat influence the size and dynamics of fish populations is the key to determining the harm arising from habitat alteration, disturbance, and destruction (HADD). There may be four basic relationships between habitat supply and fish performance: linear (a one-to-one relationship between habitat supply and fish response), fragile (small decreases in habitat produce big fish changes), resilient (large habitat decreases must occur before significant fish declines occur), and threshold (a sigmoid relationship where initial habitat losses produce little change but then small changes produce large changes in fish). Fish habitat management practice is primarily based on the linear model with some intuitive precautionary leaning to the fragile model. Empirical evidence suggests the resilient or threshold models are more likely outcomes in nature. However, it is unlikely that the form of particular relationships or significant harm can be identified by simple inspection of habitat information alone. Dynamic population models provide an integrated quantitative framework for examining fish-habitat linkages and their consequences for productive capacity. Simple habitat assessment schemes are unlikely to discern life history bottlenecks and hence identify critical habitats whose loss will lead to a HADD. While our knowledge of most fish species is incomplete, science has developed a formidable understanding of population dynamics and the role habitat supply might play. A simple multi-stage population model for a freshwater fish is presented as a basis for examining how population size and structure respond to changes in life-stage specific habitat supplies. Central to the model development are the well-known relationships between population density and body size seen in all biota, including fish; the inverse of a density-size relationship is area-per-individual (API). Animals, and plants, have minimum space requirements for completing their life histories and the inverse size-density curves provide benchmark estimates of space needs. The life history rate processes and space requirements of spawning, yoy, and one+ life stages in fish are considered. For fish there are many *a priori* expectations regarding rate processes and space use that can guide model development and parameterization. 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. The patterns of fish life history strategies are well-known. How habitat quantity can affect population success is examined. Results are presented for a representative lake fish species (lake charr, *Salvelinus namaycush*). A sensitivity analysis indicates that yoy habitat is most limiting for lake charr followed closely by adult and with spawning habitat a distant third. This result contradicts the instinctive bias of most fish habitat biologists towards protecting spawning habitat. The order of yoy and adult habitats in limiting population performance can be changed by altering the relative amounts of life stage habitat supply. Approaches to parameter estimation for API models are explored. The uncertainties and limitations associated with an API approach are discussed. The API approach may be extended to more complex life histories and should be broadly applicable. More complex assessments can consider habitat quality and the operation of ideal-free distribution (IFD) rules. This fish-habitat modeling points to the need for fish habitat management to be targeted more at a population or ecosystem scale and away from the site-level. The model illustrates the difficulties involved in identifying population thresholds related to habitat supply and the importance of acknowledging uncertainties and natural variability in decision-making.

Workshop discussion:

Q (Kelso): Can you give examples to support the habitat supply relationships (linear, fragile, resilient; Fig. 1)? R: Long term Great Lakes fishery data supports the resilience curve, as total production hasn't declined much over 200 years, although there have been changes in species composition. John Gunn's work is another example of the resilient-curve response. There are more examples of the green curve (resilient) than the red curve (fragile).

Q. The thresholds emerge because of the relationships between API and survival, etc. How comfortable are you with the model and what do we need to do to define linkages between life stages and habitat loss? How comfortable are you with the definition of the relationship? Which life stages are most important re habitat loss? R. Long term observation may allow you to extract the relationship with different life stages. Experimental manipulation is needed to reveal responses.

C: Example of red curve (Fragile) - E.g. brook trout spawning area; all or none phenomenon - if habitat is changed, the result could be devastating for the population, as they are locked into that site. But this is not true for most species.

C: Different curves may reflect different metrics of productivity (e.g., diversity, composition, IBI, HPI). You might expect different metrics to respond differently. R: The graph was based on population biomass/production as the response variable.

Web Mapping Tool for Fish Species at Risk in Ontario

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The Species at Risk Act (SARA) aims to protect fish and wildlife species at risk from becoming extinct or lost from the wild with the ultimate objective of helping their numbers to recover. To protect SAR and their habitat, it is necessary to have an understanding of their distribution, abundance and life history. Currently, there is no single database that houses this information. A user-friendly fish SAR intranet site is under development to provide easy access to relevant information (e.g. COSEWIC reports, recovery strategies) and a mapping tool for fish SAR. The mapping tool will provide the capability to produce maps of the known distributions of fish SAR at regional (i.e. tertiary watershed) and local scales (i.e. stream segments). The mapping tool is based on a distribution database currently containing over 200,000 records for all species in Ontario primarily from OMNR lake and stream inventories, Royal Ontario Museum, DFO and Canadian Museum of Nature. In addition, modeling based on landscape and in-stream attributes will be undertaken to predict the occurrence of fish SAR in unsampled stream segments. The intranet site will be used by DFO Fish Habitat Management and its partners to review proposed development projects for potential impacts to fishes and fish habitat. The site will assist in expediting the review process by providing geo-referenced, up-to-date information on fishes, including fish SAR and their recovery plans, so that informed decisions can be made to minimize impacts on fish SAR.

Workshop discussion:

Q. If only part of a stream contains a species and the rest is deemed unsuitable habitat, how do you deal with these upstream reaches? R: Science and habitat need to sit down together to discuss the rules for interpreting these maps. The process is evolving.

C (Stanfield): Suggested to add an additional (fourth) colour for extirpated species. Areas where a species doesn’t occur but the habitat is suitable could be identified as areas for restoration.

Q. Is this tool being taken up to the national level? R: Not yet. However, the data are taken from a national database, and other Regions are interested.

Q. Could SAR other than fish be incorporated into this tool? R: Absolutely, molluscs are next and more taxa will be added. Species found in riparian zones will eventually be incorporated to the stream segment.

C: Too many colours could create a difficult situation for managers. There is a need to base categories on ground truthing to be meaningful to fish habitat, to be assured of the designation.

Q. What about drain classification? Quality of data - QA/QC? Are SAR in those data? Needs to be confirmed. Q: Are drains under the Ontario Drainage Act or artificially created drains? R. Both.

Q/C: How would you manage habitat differently if there is a SAR present? Avoid the area? What is the critical component that is valuable to the SAR? Red dots on stream segments have done nothing to provide information for that species.

Q (Randall): You are providing SAR distribution data to FHM, but does it work the other way around? Does FHM provide data on fish distribution? R: Not so far but the data exchange is expected to eventually work both ways.

C: Poster handouts give an overview of this presentation.

Development of an Instream Flow Screening Tool and Guidelines for Small Hydro in the Pacific Region

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Recent directives by the Provincial government to expand the network of small (<50 MW) hydro projects has resulted in over 300 applications that need to be reviewed by environmental agencies. To facilitate the processing of these applications in a timely fashion the development of guidelines and screening tools was deemed desirable.

Small hydro projects are often the run-of-the-river design. Water is diverted via a low head dam and penstocks around a high gradient reach of the stream before passing through a power house and returning to the stream channel. The diversion reach can range from a few hundred metres to 5-10 kilometres. The proportion of water that can be diverted from the channel for generation is a critical element of the financial viability of the project.

The fishery resources of these streams varies from being fishless tributaries of larger fish-bearing systems, to being habitat to populations of trout and other game fishes. With the exception of some species of concern, most streams do not support high value resources.

Instream flow guidelines were developed after a lengthy series of meetings and workshops which highlighted the lack of experience of the application of the *Fisheries Act* and the habitat policy for instream flows in the Region. Although there was a hope that a single instream flow method could be used to determine HADDs and the need for s35 authorizations, it soon was realized that this was a complicated problem and simple solutions were not likely.

We then focused on a simpler question: could a screening tool be devised for the initial application (with limited information being available) that would indicate if instream flows were likely to be an issue for fisheries agencies? The tool would ultimately be web-based and have accompanying guidebooks for data collection and processing and would allow the proponents to determine the status of the project themselves.

We settled on the following principles:

1. Projects meeting the screening guidelines would not incur a HADD and would not need a s.35 authorization for flow diversions at or less than the guidelines.
2. The screening would be based on limited site-specific data, and would thus be relatively risk-adverse.
3. Projects not passing the screen would most likely require more information to allow a site-specific evaluation
4. The screening tool would distinguish between fish and non fish-bearing waters, and would be less restrictive for fishless streams.
5. A 100% diversion was not permitted (i.e. dry channel below dam)

6. The post-project instream flow regime would have as many of the attributes described by the recent Instream Flow Council book as possible, including the maintenance of minimum flows as well as higher flows required for riparian connectivity, channel maintenance and other ecological functions.

The screening tool that we developed was based on monthly median flows estimated from limited site-specific hydrology data and regional analyses. For fish-bearing streams a sliding scale of allowable diversion rates was developed, with the lowest diversions being permitted in the low-flow months. This recognizes long-standing concerns about low flows during late summer in many areas, and limitations to fish by low flows in winter in the Interior and northern regions. Greater diversions were permitted in high flow months. We also imposed a cap on the maximum diversion rate, so that flood flows would not be captured by the project, and would travel through the diversion reach.

For fishless streams we set the minimum flow for all months as the median flow for the lowest month in order to assure connectivity; the maximum diversion cap again allowed high flow events to occur in the diversion reach.

On average, these flow rules allow for about 20-30% of the annual flow to be diverted in fish-bearing streams, and over 50% in fishless ones. It was recognized that these rules might be very conservative in some streams and that many projects would not pass the screen successfully. In these cases more site-specific information will be required to evaluate the effects of the altered flow regime on fish and fish habitat. However, the screening tool does force some level of rigor and consistency in data collection, and does help to identify the periods when there is the greatest potential conflict between instream flow needs and other water uses.

Workshop discussion:

Q. How does the stream flow alteration affect the whole watershed? R: We have focused mainly on the impact on a site-specific basis without considering the effects on the whole watershed.

Q. Have you considered bedload movement, organic debris movement or other geomorphic processes? R: Not really, we are dealing mostly with stream flows/power - if streamflow is maintained, bedload should not be an issue. These facilities will not capture high flows.

Q. What is the application for agriculture? R. Interior BC has agricultural competition for water. These are small, incremental effects that are too difficult to deal with. Those who deal with agricultural impacts are interested in flow standards to assist the flow managers. We tend to stick to hydro projects.

Q. It seems that there are different standards for hydro and agricultural projects - how can this be reconciled? Are there concerns with setting standards for the hydro industry? R. This system allows very little water diversion in low flow months.

Q (Randall): Is there documentation of your process that other regions in Canada could use regarding instream flow needs? R. Document for instream flow in BC is available.

Experimental Manipulation of Habitat Capacity in Inland Lakes

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The *Fisheries Act* protects fish habitat from any work or undertaking resulting in its harmful alteration, disruption, or destruction (HADD) through a policy of No Net Loss of the productive capacity of fish habitat. To achieve the goal of this policy when a HADD is authorized, habitat enhancement or creation must be used to compensate the loss of habitat productive capacity. Woody material (e.g. brush bundles, root wads, tree drops) and other fish habitat structures (e.g. reefs, wetlands) have been placed in lakes and streams, often with the explicit goal of increasing fish production, or to compensate for a HADD. However, the success of habitat enhancements is rarely assessed from a biological perspective (i.e. by measuring changes in fish biomass or production resulting from designed changes in habitat). One assumption underlying these compensation decisions is that habitat availability and quality are directly related to fish production. To test this assumption, a whole-lake habitat manipulation (wood removal and habitat additions) experiment was conducted to determine the effect of nearshore habitat perturbation or enhancement on the fish communities in a suite of small aquatic systems.

In three experimental lakes (< 25 ha each) in the Algoma region of Ontario, we decreased nearshore habitat diversity (2 in 1999, 1 in 2000), and referenced the changes in biological metrics to an unperturbed system and to pre-manipulation conditions in each experimental system. Habitat manipulations mimicked the effects of human encroachment into aquatic habitat (e.g. cottage development) by reducing the complexity of physical habitat available to fish in the nearshore areas. At a workshop attended by managers and scientists, it was determined that a 50% alteration of the shoreline within a lake would be considered a HADD. Consequently, coarse woody debris was removed from 50% of the nearshore area (50% of total shoreline distance, to a depth of 2 m or 10 m from shore) in the three systems. Additionally, in one of the lakes a portion of the same nearshore bottom substrate was covered with a water/gas permeable geotextile cover (1999). In three other experimental systems (2 gravel pit ponds and 1 quarry pond – considered to have sparse natural habitat variability) in Southern Ontario, we increased habitat diversity (2 in 2000, 1 in 2001) and referenced changes to an unperturbed system and to pre-manipulation conditions in each experimental system. Habitat enhancements were designed to represent typical Habitat Management compensation for a HADD, and included re-grading littoral slope and planting wetland vegetation, creating a rock-rubble reef, and adding tree-brush bundles.

While fish response was the main indicator of interest, an ecosystem approach was adopted to help clarify the mechanism(s) behind any observed change in fish parameters. Consequently, water chemistry, phytoplankton chlorophyll a, zooplankton, invertebrates on wood, and chlorophyll a in periphyton on wood, as well as fish catch-per-unit-effort, mark-recapture abundance, biomass, production, and habitat-specific distribution were monitored. A modified BACI ANOVA design was used in the analysis whereby each system in each year was assigned to a category of either 'Before or After' (time) and 'Control or Impact' (treatment) with the resulting 'treatment x time' interaction as the statistic of interest. A significant interaction would indicate that the experimental systems responded differently over time than unperturbed control systems and that our habitat manipulations affected the Impact systems. Due to an unrelated fish kill in our "habitat addition" control system, we used the lake control systems as our control in the BACI ANOVA. As this analysis provided a coarse measure of impact, we also conducted analyses that might allow detection of more subtle effects within an impact system.

By the 6th year of our experiment, any changes that were appearing to emerge in earlier analyses disappeared, and all parameters tested under the BACI design were not significant. At no time in our analyses over the years did we detect an effect on water chemistry, chlorophyll a, or invertebrates on wood. Earlier analyses indicated that fish community shifts were occurring in the wood removal lakes, whereby catch of smaller fish decreased, and catch of larger fish increased, supporting the hypotheses that habitat complexity serves as cover from predation. This effect is no longer significant. In addition, it appeared that some minnow species known to be more sensitive to perturbation (e.g. *Notropis* sp.) disappeared from our lakes, but in 2003 one of the species was again captured in our impact lakes. In the habitat addition systems, it appeared that the wetland creation was having a significant and positive effect on the fish community (biomass and production), but in 2003 total biomass decreased to below pre-manipulation conditions. While it now appears that the rock-rubble reef addition is having a positive influence on fish catch and biomass, this effect is currently not significant relative to controls. At no time did we detect a change in total fish biomass resulting from habitat manipulations; supporting the theory that total fish community biomass is one of the more stable parameters in aquatic systems.

These results do not provide support for the assumption that habitat supply is directly related to productive capacity, nor do they support the perception that a 50% habitat perturbation constitutes a HADD. Our design was not conducive to detecting a functional relationship between habitat alteration and fish response. Our results also do not provide insight into what type of physical habitat creation is more effective than another in enhancing productive capacity. The level of effort required to obtain a reliable abundance estimate from mark-recapture is large even in our relatively small and manageable systems. The resulting one-number-per-system-per-year also reduces the power to detect an effect from such a measure. Fish catch per unit effort in most cases was a reasonable surrogate for abundance, so the recommendation is that a standardized netting program used in conjunction with measures of biomass would be adequate for monitoring purposes. The transient and ephemeral results provide support for the need of long-term monitoring to avoid adopting erroneous conclusions. In fact, the results presented here could change with additional years of data since we included a maximum of only four years post-treatment monitoring to date. If financing long-term monitoring is an issue, we recommend conducting a focused, standardized effort in alternate years to extend the timeframe of monitoring at a similar overall cost.

Workshop discussion:

Q. Was there any fish community response to removals? R. Basically habitat removals were detrimental to small fish but had a positive impact on large fish though the effects were not significant. In the habitat addition pits and quarries, the response was positive in both directions. In the habitat removal lakes, it appears we lost or greatly reduced some sensitive species (*Notropis*), but more robust species increased to make up for the biomass. There were some shifts but not at a whole system scale. What are we trying to manage for? What are we calling productive capacity of these systems? This adds more credence to the use of several metrics. It may take several fish life-cycles for an impact to occur.

C: The term HADD is being used inappropriately – it is not a HADD unless it is based on case law. We should use another term for ‘approaching’ HADD not supported by case law. A lot of confusion exists on the legislative side between what the law says and what is acceptable in authorizing the HADD. Authorization of HADD should be based on science, but it is not always possible to relate HADD occurrence to loss of productive capacity. Harmful or not, this was a serious alteration to habitat. The area where 50% of wood was taken was pretty much sanitized. A significant alteration of habitat is still a HADD even if the affect on production cannot be determined.

Impacts of Macrophyte Removal on Northern Pike Biomass and Production (Experimental Lakes Area).

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Abstract not available.

Workshop discussion:

Q: There was an improvement in recruitment after harvesting. Why? R: There was improvement in the recruitment of small pike, likely due to the lower adult biomass in the lake, reduced cannibalism, and greater numbers of alternate prey, e.g., small pumpkinseed and perch.

Q: What was the percentage of macrophytes for the total lake? R: Macrophytes covered 40% of littoral zone and 50% was removed. The lake was not completely covered by macrophyte beds. We found few perch, pumpkinseeds or pike in areas with rock-substrate shores. YOY pike, pumpkinseeds and perch were mostly found in the macrophyte areas of the lake.

Q: (Smokorowski): Did you look at community shifts? Did you detect changes in total biomass? R: The community data are available and they will be analysed. There was likely no change in total biomass, only changes in species-specific components. Nutrients were not altered (i.e., cut macrophytes were removed).

The Decline and Recovery of a Lake Whitefish (*Coregonus clupeaformis*) Population From Winter Drawdown in a Small Boreal Lake

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Water level fluctuations are one of the most important disturbances affecting aquatic systems. For temperate or boreal reservoirs, the drawdown of water occurs during the winter when precipitation is low and power generation demand high, such that water levels do not replenish until the following spring. Reservoirs are often subjected to other perturbations that confound the direct link between physical habitat manipulation and changes in fish populations. Given this, whole-lake experimentation can be a powerful tool to clearly demonstrate the impacts of physical habitat on fish populations. A winter drawdown experiment was conducted on Lake 226 at the Experimental Lakes Area to examine the impacts of water level fluctuations on fish and fish habitat. The focus was on the lake whitefish population, and the goal of the drawdown was to mimic the type of impacts typical of hydroelectric reservoirs.

The main study took place over six years, with data collection occurring one year prior to drawdown, during the three years of drawdown and two years of recovery. A control structure was built at the outflow of Lake 226 and water levels were reduced from December to February of 1994-1996. The first water level reduction decreased water levels by 2 m, and over the subsequent two winters, water levels were reduced by 3 m. The drawdown exposed large portions of the littoral zone that resulted in decreases in lake surface area and lake volume by up to 24% and 45%, respectively.

Automated fish-positioning systems were employed to document the movement of lake whitefish during the spawning season. The results showed that whitefish typically spawned in shallow water on specific substrate types, and that these spawning shoals were exposed during the winter drawdowns. The drawdown of water after whitefish spawning resulted in complete recruitment failure for each year of drawdown, something that had never been observed for the previous 29 years in which the Lake 226 whitefish population was studied. Survival also showed significant declines during the years that Lake 226 water levels were drawn down, most likely related to anoxic overwinter conditions. The lack of recruitment and low survival resulted in an 80% decline in whitefish abundance compared to pre-manipulation levels.

The recovery of the Lake 226 whitefish population did not conform to expectations of a rapid recovery based on results from exploited populations. Instead, we observed weak year classes, poor condition and minimal increases in abundance. There are numerous reasons why the Lake 226 whitefish population did not recover as expected. The production of small year classes in poor condition may have been related, in part, to the disruption of the food supply and overall changes in the lake due to drastic loss of littoral habitat. In summary, poor environmental conditions likely hampered the ability of whitefish to rebound once drawdown was relaxed.

The research presented here advances our understanding of the negative impacts of winter drawdown on lake whitefish populations and suggests various recommendations for Fish Habitat Management when dealing with fluctuating water levels. Perhaps a more important point to emphasize is that our expectation of lake whitefish population recovery, based on exploitation studies, was not met. This finding underlines the fact the recovery of fish populations that have declined due to loss of habitat will be fundamentally different than those recovering solely from exploitation. This study highlights the fact that whole-lake manipulation can provide a strong demonstrative tool linking fish habitat destruction to declines in fish populations, as well as the complexity of population recovery due to ecosystem processes.

Workshop discussion:

C: Habitat alteration affects recruitment which isn't necessarily true for exploitation. Recruitment still occurred after (some) adults were removed from the stock and there was an increase in survival of age 0 fish.

Q (Jones): Is it an ELA policy never to use controls? R: There were control data but they were not shown in the presentation. There is a comparable lake that has been monitored for many years; there were no year class failures (except at a lake that was acidified).

C (Blanchfield): Complete recruitment failure was not expected as whitefish spawn at different depths. The spawning takes place in November; draw-down occurred from December to February. Eggs were exposed. We observed complete recruitment failure, which was surprising, give that there was some spawning lower down. The purpose of this experiment was to mimic what goes on in a reservoir. In Ontario, draw-down is regulated to occur before spawning.

C. Impacts were not permanent after the impact was removed although recovery has been slow. This population has taken five years to come back. After the water level rose, the whitefish came back to spawn.

Fish Habitat Compensation in Canada: A Detailed File Review and Analysis of Past Evaluations

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An evaluation of the performance of Fisheries and Oceans Canada (DFO) in achieving no net loss (NNL) through habitat compensation was initiated in 2000. As part of this evaluation, a literature review and a file review were conducted.

For the literature review, studies that evaluated the effectiveness of habitat compensation projects in achieving NNL in Canada between 1986 and 2002 were compiled and reviewed. Data from these studies were pooled to summarize findings relating to the fish habitat compensation projects that have been assessed.

Only ten studies were conducted within this timeframe. These studies have assessed a total of 103 compensation projects, representing less than 4% of the compensation projects in Canada. Most of the studies employed qualitative methodologies when assessing compensation projects, limiting the inferences that can be drawn from them. Of the assessments conducted, 88% were a combination of qualitative file reviews and compliance assessments; 11% were effectiveness assessments; and 1% was research. Combined, the compensation projects in these studies created and/or restored 493,205 m² of fish habitat to off-set losses of 1,142,648 m². There was an estimated net loss of 649,443 m² of fish habitat.

The majority of the compensation projects assessed were a result of impacts to estuarine and marine habitats. The development activities that were associated with the greatest percentage of compensation projects included urban development and forestry. Post-construction monitoring of the compensatory habitat was required for only 51% of the projects. The mean duration of the monitoring period was 3.6 years. Sixty-four percent of the compensation projects achieved NNL.

For the file review, files relating to 124 *Fisheries Act* Section 35(2) authorizations issued by DFO for the harmful alteration, disruption, and destruction of fish habitat (HADD) in Canada from 1994 to 1997 were collected and reviewed. Data extracted from the files were pooled to summarize findings relating to fish habitat compensation projects. Proponent compliance and the effectiveness of the compensation projects in achieving NNL were determined.

The loss of fish habitat as a result of the authorized HADDs was 419,562 m^2 while the gain as a result of compensation was 1,020,388 m^2. The mean compensation ratio per project (compensation area: HADD area) was 1.27:1. A quarter of compensation projects had a compensation ratio that was less than 1:1. In-channel and riparian habitats were the most frequently impacted. Urban development and roads and highways resulted in the greatest loss of habitat. The compensation options that were most often selected included creation of in-kind habitat (50%), increasing in-kind habitat productivity (22%), and creation of out-of-kind habitat (12%). The mean duration of post-construction monitoring programs associated with the authorizations was 3.7 years. There was a 43% compliance rate with monitoring requirements. Determinations of NNL could only be made for 17 authorizations as a result of poor file quality, poor proponent compliance with monitoring requirements, and the qualitative assessment procedures used in the monitoring programs. Improvements in file management and the use of scientifically-based, quantitative monitoring programs are required to ensure that the assessment of NNL is possible.

Studies evaluating the effectiveness of habitat compensation in achieving NNL are essential to adaptive management. Future studies should aim to employ quantitative methodologies when assessing NNL rather than the qualitative methodologies used in the past. Resource managers and scientists should work together to develop a national evaluation program through which the attainment of the conservation goal of NNL can be assessed on an ongoing basis.

Workshop discussion:

Q: Compensation is a hierarchal process – what type of compensation was asked for? R: 86% were based on like for like compensation.

Q: How many fish habitat management staff bypassed this process and looked for bottlenecks to production and based their compensation on this information? R: This has not been addressed - hardly any authorizations identified this information (bottlenecks).

Q : Are financial securities appropriate for habitat and science staff to follow-up on their own projects? R: Only 34 of the 134 projects had financial security.

Q (Stoneman): CEAA has requirements. Were they looked at? R: No. These were early files and screening reports were on record.

Q (Morry): Areas in lower Fraser region were 25 square meters. If something is not a HADD, why not? Was there confusion about the application of HADD? R: That would make a good study.

Q (Kelso): What proportion of projects are done by government agencies? R: Not very many, probably less than 10%. Roads and highways would have been done by Ministries in different provinces. That proportion would have been the highest development activity, about 25% done by government.

Effectiveness of Habitat Compensation in Canada

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Canada contains approximately one quarter of the world's wetlands that support a rich biodiversity of over 198 fish species. Approximately one seventh (20 million ha) of Canada's wetlands have been lost in the last century. In North American freshwaters, 73% of fish extinctions can be attributed to habitat alterations. In response, Fisheries and Oceans Canada (DFO) enacted the habitat provisions of the *Fisheries Act.* A "harmful alteration, disruption, or destruction to fish habitat" (HADD) cannot occur unless authorized with legally binding compensatory habitat to off-set the HADD. Canada's conservation goal is no net loss of the productive capacity of fish habitats (NNL) provided by the *Policy for the Management of Fish Habitats* (Habitat Policy). DFO's performance in achieving its conservation goal has never been evaluated on a national scale.

We investigated 52 habitat compensation projects across Canada to determine biological, physical, and chemical compliance with authorization specifications. We further evaluated the effectiveness of compensation habitat in off-setting losses in habitat productivity at 16 projects across Canada. Periphyton biomass, invertebrate density, fish biomass and riparian vegetation density were used as indicators of habitat productivity and compared between reference and compensation sites.

Of the 52 projects investigated, compliance with biological requirements was the lowest (58%) and compliance with chemical requirements the highest (100%). Approximately 86% of authorizations had larger HADD and/or smaller compensation areas than authorized. These were not small differences. On average, HADDs in riverine habitat were 389% larger than authorized. Consequently, 45% of in-channel compensation projects and 72% of riparian projects resulted in net losses in habitat area. Probable *Fisheries Act* violations were prevalent at 50% of the projects. Multiple regression analyses indicated violations were negatively associated with the occurrence of a DFO field inspection, providing empirical support for increased monitoring.

Of the 16 projects evaluated for effectiveness, approximately 12% achieved a net gain in habitat productivity. These projects were characterized by mean compensation ratios (compensation area: HADD area) of 5:1. Twenty-five percent of projects achieved NNL and 63% of projects resulted in net losses in habitat productivity. These projects were characterized by mean ratios of 1.1:1 and 0.7:1 respectively. We demonstrated that artificially increasing ratios to 2:1 was not sufficient to achieve NNL for all projects. Our ability to replicate ecosystem function is clearly limited. This illustrates that compliance does not ensure ecological success.

Habitat compensation, as currently implemented in Canada, is at best slowing the rate of habitat loss. Increasing the amount of authorized compensatory habitat in the absence of institutional changes will not reverse this trend. Improvements in both compensation science and institutional approaches are recommended to achieve Canada's conservation goal. Limited success in achieving NNL does not erode or invalidate the value of this goal of the Habitat Policy. Rather, it provides the impetus for change. It is critical for Canada's fisheries resources that DFO engages in adaptive management to build on successes and learn from past mistakes.

Recommendations to improve success include larger compensation ratios, creation and documentation of the functionality of compensation habitats prior/concurrent to HADDs, maintenance programs, increased monitoring and enforcement, and attention to limiting factors on a watershed basis. However, it is important to acknowledge that compensation does not mean never having to say no to development proposals. Some habitats may not be possible to compensate for. Failure to acknowledge the limitations of compensatory science will hamper Canada's efforts to conserve fish habitat.

Workshop discussion:

Q (Franzin): What was the regional breakout of the compensation projects? R: Of 52 compliances, roughly 25 were in BC, and 5-6 were in each of the other provinces. The 16 effectiveness projects were evenly distributed across Canada. There was no obvious geographic trend - results were poor across Canada. Results were distributed to FHM staff across Canada. We will see how it results in changes and how programs are managed in future. Some failures maybe were not filed. Some files are gone now.

Q (Pratt): Projects that you looked at were conducted between 1994 and 1997, before FHM was ramped up with increased staff and responsibility. Have things improved or stayed the same? A: Good question and it would be interesting to repeat this project. Since the increase in staff, more authorizations have been issued. There has been less monitoring and no changes in terms of follow-up. Some compensation techniques ceased in BC but were still carried out in other regions.

Q: What if any value was there in the FHM Habitat Referral Tracking System (HRTS), which was designed to transfer knowledge from one Region to another? R: The problem was that there were no links to the actual studies. A study was completed, but the link (file) was to an individual user's computer (hard drive), who may no longer be working (individual transferred). HRTS was not used then as much as now and was of limited value.

C: More public registry compliance will now be required (recent bill will allow the information to be entered electronically). There was not enough documentation of compliance in the past.

Q (Jones): You paint a dismal picture of habitat management in Canada right now. What can we do differently? What has to happen? R: Recommendations are being made and recorded, including core changes to FHM to ensure monitoring. The current program is reactive and crisis driven. Alternative approaches to compensation are being considered (e.g., create compensation projects prior to HADD to determine functionality before project approval is given).

C: This problem is not the science - it's the FHM program. Is this the right science for understanding fish and their habitat? How can we go in the field during or after a project when we don't have time prior? A good monitoring program is needed. A lot of work is just being written up now and presented to senior management as part of the DAAP. Do we need to look at rewriting habitat policy? Or is policy implementation the problem? Do we just need more guidance documents? People don't have the time to beef up the documentation and do a good job. Some change will result from this work down the road.

C: Process and paper work alone is huge. Email has not improved this situation at all as it is time consuming and prohibits fieldwork. Need more people. Need to develop standards that would apply to everyone across the country. Need data sets to answer questions addressed through this study. Need more detailed compensation packages for effectiveness as time goes on. At present there is no documentation for standards. Need better guidance. Have been lots of guidance documents previously but doesn't mean advice has been translated into action on the ground. Need training and rules of behavior; an accountability for processing referrals.

Wrap-up Discussion for Day 1 Presentations

C: (Morry): In organizing this workshop, was it deliberate to avoid discussing marine environmental issues? Will there be a parallel session to this one in the area of least knowledge?

R (Randall): The science projects that we are reporting on at this Workshop resulted from four ESSRF funded projects that were based solely in freshwater. However, note that often lessons (principles, methods) from freshwater are transferable and apply to the marine environment as well. For example, you mentioned that the construction of the Confederation Bridge was a potential HADD. To investigate a potential HADD, similar questions would be addressed in both marine and freshwater areas. [Note added after the Workshop: Whether or not a workshop is currently being planned to discuss marine issues is not known. In retrospect, we (i.e., the Steering Committee) should have made it clearer to FHM that we would be reporting on freshwater projects. The Workshop however benefited greatly by having participants with both freshwater and marine expertise. A key recommendation from the Workshop was the need to have a similar workshop on marine issues].

C: To follow-up on marine issues, DFO issues $30K authorizations in marine areas by the thousands every year with no net compensations. CMP does not have habitat protection on their priority list. As a department, we must look at habitat protection seriously. This will mean specialized enforcement people. Small instream compensations (e.g. 25 square meters) are hardly worth chasing.

C: The value of complex habitats and their structure was discussed. What is a HADD? What is compensation? Regarding water drawdown, specifically with regard to the whitefish example, we need to follow-up on hydro dam operations for this SAR.

C (Jones): None of the science presentations were really about learning directly from actual management of habitat as opposed to doing experiments, observations to simulate habitat management. No examples of adaptive habitat management were given. Adaptive management should have a more important role to play in habitat management, to provide guidance for habitat management in future. Who will pay for it?

C (Smokorowski): Projects are taking place at present in relation to adaptive management, i.e. effects of ramping rates on fish in the Magpie River. Manipulations are expensive to do. Experiments are happening across Canada; we should take advantage of this knowledge. Where will we file this information?

C: Adaptive management is proponent driven and DFO support of such projects is weak. Some offices are not authorized to proceed with it. There is a perceived conflict of interest where the proponent is willing to become involved but also want to make sure that their project will receive funding to go ahead. Perhaps have third party NGO’s looking over your shoulder with regard to proponent participation. Needs to be investigated more thoroughly but cost would be too high for both parties. Need a cooperative way of doing it.

C (Franzin): For the Cumulative Environmental Management Agency (Oil Sand in Alberta); most funding comes from industry but there is no control over the project. Work gets done by consensus.

C: Seismic survey work is being done off the coast of Cape Breton. Government agencies do not conduct environmental effects monitoring, as this is the proponent’s responsibility. There has been much discussion as to how to deal with this. A solution that everyone can live with is needed.

C: DFO cannot answer questions regarding the Confederation Bridge because they understood the meaning of the legislation was they should not be involved. The proponent should do it. Proponents and DFO science are put in a catch-22 situation. DFO needs to support the research; and the proponent is not involved in the design. If it’s a joint effort, how can DFO say it’s not for them to touch? How can the government not get involved and still use the results in policy and decision-making? It’s been traditionally stated that the proponent pays for the monitoring research.

C: Some of today’s science was old science. Some of the direction that science has taken in the past 2-3 years is interesting and useful. We’re starting to evaluate habitat at a population/geographic scale and this is promising. The habitat supply driven modeling is a useful approach. We are starting to get a handle on habitat science. Adaptive management has to happen but there is DFO conflict of interest to deal with. We are in a position to show some productivity.

C: We can have cutting-edge science taking place in support of FHM but unless the information gets down to the guy reading the file and making a decision, the whole thing is for not. Information is not reaching the field biologists: there is a communication problem. There should be a National Habitat Advisory Board that meets on an annual basis. Advisory documents could become mandatory reading for FHM managers and environmental science researchers.

C: There is a process on the west coast where FHM can go to science to ask questions which Science then addresses (the Habitat Advisory Subcommittee, Pacific Scientific Advice Review Committee (PSARC)).

C (Murphy): There is a need to spend more time on marine habitat. Often this overlaps with freshwater science. For example, with human population development, more than 50% of the soil amendments used since farming was industrialized have been added to soils in the last 15 years. The impacts of these are just occurring. This will impact on both freshwater and marine environments (e.g. potato farms in PEI impacting on receiving tributaries and estuaries).

APPENDIX 4: WORKSHOP DISCUSSION OF THEMES

Notes from the workshop disccussion of each theme are provided (questions and comments), identifying the speaker if recorded. Discussion notes were recorded in brief (not *verbatim*), and errors and omissions may have occurred.

Theme 1 – Productive Capacity

Facilitator: Hugh Bain
Recorder: Julie Perrault, with additional notes from Angie Wagner.

Questions:

1. How do you classify and validate habitat types with different capacities?
2. How do you measure habitat-specific productivity? What are the assumptions?
3. How do you measure and integrate i) fish and ii) fish habitat sensitivity?

After a summary presentation by Bob Randall, Hugh Bain initiated the session by asking if the three questions were appropriate for driving the discussion.

Kelso: The second question is innocuous. What are important are the assumptions for classifying habitat (related to perceived or probable function of that habitat class) and not simply because you can measure it. Why are fish there? They are there for a reason. This is the key that science has been missing.

Bain: Habitat is managed because it produces fish – not for the sake of habitat alone. Habitat must be classified with a production element in mind, either implicitly or explicitly. The theme is how specific habitats contribute to productivity.

Question 1: How do you classify and validate habitat types with different capacities?

Jones: How do we quantify productive capacity? The biggest challenge is that the value of individual habitats is context-dependant because fish do not rely on only one type of habitat. Capacity is difficult to measure without bearing context in mind. With (static) measurements of biomass etc. there is no direct link to population movements and dynamics.

Kelso: We are good at measuring fish in certain types of habitat classes. An area of open habitat with very few fish is difficult to measure as fish are passing through – the issue of time spent and what activities happen in that habitat needs to be measured (rate functions).

Stanfield: We need to focus on one scale for our discussion. DFO tends to work at the micro scale, and OMNR works at the watershed level.

Bain: Perhaps an underlying problem is that we don’t look at habitat management at a population or larger watershed scale - we spend too much time at a site level.

Murphy: Waters in Chesapeake Bay were filtered every day historically but that has changed. What was the productive capacity 40 years ago, and what is it today? What is an appropriate reference level for measurement (baseline)?

Bain: This has a bearing in NNL and compensation. What is the starting point at which we judge productive capacity to invoke compensation if the objective is to achieve NNL?

Stoneman: An argument from CEA might be that a reservoir increases productive capacity, and is therefore not considered to be a HADD. A cold water sensitive trout stream may not necessarily have high biomass.

Bain: A watershed approach would aid in resolving this argument.

Bradford: The Pacific Region does not manage on the basis of fish production. In the case of the reservoir, this would be considered to be a negative impact on salmonid fish stocks. We are managing based on impacts to fish populations, and not necessarily trying to increase the biomass of fish. Biomass of fish is not the only measure used.

Stoneman: Changing a community is an impact in itself.

Bain: The idea of valued species comes into play.

Potter: PEI estuaries are used as nurseries for a variety of species. Large mussel aquaculture farms have changed the energetics and flow of energy. Different fish species are now there: the community/system has changed.

Winfield: Most of the discussion over the past two days has been about lakes. Rules for one lake may not apply to another. No research was presented on marine effects. A classification system to divide the basic types of systems (e.g., stream, lake, estuary) based on effects on processes and dynamics is needed. We have the possibility of regulating the system based on potential change in dynamics – does the system move to a different state? Productive capacity is not always the endpoint to be measured; we also need to measure change.

Bain: Is it possible to look at this in the context of productive capacity?

Winfield: Not really, unless it is a production area for Fisheries & Oceans Canada.

Bain: What are you measuring?

Minns: Metrics should be rate process measures in place of biomass. The effect on production is translated as a rate, not a static process.

Bain: Is there a link between rate change and production change?

Minns: Yes. Rate could be a surrogate for productive capacity. Habitat produces fish, hence we manage habitat.

Pratt: A pristine community can be changed into a different community, where biomass has actually gone up.

Franzin: The question of value comes up. Two approaches are possible: a species–specific (e.g. salmonid) approach where we must understand how that species uses particular habitat, or a community approach with a developed matrix to look at how different species use different elements of the habitat. For large systems with a large group of species, a species approach is almost impossible. The only approach is to develop a matrix of habitat value and use.

Ming: What do we us as a measure of productive capacity? What do we use to determine if compensation is effective or not? Habitat management measures at a site-specific scale.

Bain: We need simple but meaningful surrogates for measuring capacity?

Ming: We need a method to determine if a measure is working in terms of mitigation or compensation.

Metikosh: To clarify, if you could classify and validate habitat types of different capacities what would you do with this information?

Stoneman: Must fit with the referral process. We may not have the science needed but decisions have to be made. If science can say there is an effect or not, then it can link back to determining if that is a HADD or not.

Bain: When are the cumulative elements going to have enough of a picture to create a HADD?

Question 2: How to measure habitat-specific productivity (assuming we can classify and validate the productive capacity of habitat)?

Stanfield: Science has made a valid effort to classify based on landscape/disturbances, but is this the right path forward? Is this approach conducive to making good management decisions? What is the biology telling us is the appropriate measure?

Bain: Do we need to step back and look at a broader scale?

C: If these measures are not taken into the larger scale and integrated with rate processes, it is not valuable for habitat management. Maybe the proper tools are available but how these tools fit together into a habitat management context is still unknown. How can we use this information in a meaningful way?

Ming: Is the goal of the research to provide habitat management with tools for referrals? Or is it for a broader scale?

Bain: Hopefully the large scale research is defensible and useful, and will make the work easier for habitat management, by providing context.

Metikosh: Habitat management may need to learn which tool works best when, given the availability of a whole set of tools.

Ming: For smaller projects, large scale tools may not be feasible.

Ridgway: It is difficult to make the link between science and management. A common language for classification of habitat is needed. A GIS approach allows using simple rules like ETD to make site specific informed decisions and identify sensitivities. Does DFO have the capacity to implement GIS tools? Can we invest in the software and people needed to use these potentially useful tools? Not scale-based battles, but site-based battles: the GIS environment may provide a more effective link between science and FHM (proven and defensible models/methods).

Assume that all habitats are fish-producing, with higher productivity where there are more fish. For example, a certain amount of a delta habitat is worth 10 times more than estuary or coastline habitat; this would affect site-specific decisions, as science could say with confidence that the compensation (ratio) must be 10 times.

As an example, GIS tools aided response to the Walkerton crisis. Parkland designations in Ontario came from GIS arguments. We need rules to generate answers more than we need to worry about different scales.

Kelso: A scientist is not needed to deal with each referral. There is a disconnection between habitat management in the field and science in the lab. Management needs practical easy to apply systems for micro managing; science works to put this function into a context. Science does not do management.

Bain: Are these questions not going to put the functions in context?

Stoneman: Habitat management must justify decisions with science.

Kelso: Rate, process, function is translatable. Not sure that GIS tools are going to help.

Ridgway: But GIS is useful for determining how much habitat there is. Otherwise foolish decisions will be made about allocation and use.

Question 3: How do you measure and integrate fish and fish habitat sensitivity?

Stanfield: GIS allows you to determine sensitivities on a landscape scale (green, yellow or orange). Science is working to fill gaps of sensitivities at the landscape scale.

Ming: Habitat management is not asking for support on every referral, but for tools that are applicable and generically useful.

Stoneman: What should we be looking for in a proposal? Is it okay? Is it a HADD? This is where science can help us.

Q: Assuming FHM knows what to measure and how to measure it, what then do you do with this information? There are many tools available to measure at the site-specific scale but the question becomes which to use. We need science to put the micromanagement into context to learn the sensitivities of habitat at a landscape scale. If we can define sensitivities then we will know what to look for. For example, culverts – what should we ask about culverts? How we look at this issue is important, but we also need the big scale to put things into context. GIS capacity is essential.

Smokorowski: Limited for time; feel free to provide additional comments and questions in writing.

Theme 2 – Thresholds

Facilitator: Christine Stoneman
Recorder: Keith Clarke, with notes from Angie Wagner and Christine Brousseau.
Questions:

1. At what point does the severity of a human-induced habitat impact constitute harmful alteration, disruption or destruction of fish habitat?
2. What are the functional responses between habitat and fish production?
3. What are the appropriate methods to use to determine thresholds?

After a presentation on the threshold theme by Tom Pratt, Christine Stoneman opened the discussion by reiterating the FHM need for thresholds for the determination of HADD and the requirement that these thresholds be defensible from a scientific viewpoint.

Bradford: Asked the question if under current practices, a HADD could occur without affecting fish populations?

Stoneman: Indicated that physical habitat has been the surrogate most often used to date and a basic assumption that is that any reduction in physical habitat will result in a HADD. FHM uses a precautionary approach. Thus, a direct link to fish population processes is not always the case.

Ming: Used the example of ‘dredging’ as a project type where a physical alteration would not normally be considered to be a HADD.

Murphy: Expressed the opinion that case law should be the determinate of HADD; successes (in court) can be used as benchmarks.

Stoneman: Reiterated the need for the department to have a process which is defensible by science irrespective of case law decisions.

Quigley: Expressed a need to be careful when basing HADD on case law as some of the effects proven in court have not always been fully detectable by science but decisions were largely based on expert witness during the legal proceedings.

Stoneman: Noted that a case loss in court could still have been a HADD which could set a dangerous precedent.

Murphy: Reiterated that he still viewed case law as providing the benchmark.

Metikosh: Expressed the opinion that the department needs an operational definition of HADD for the habitat program which is scientifically defensible.

Stanfield: Commented that there were two major challenges to developing thresholds for HADD: First most habitats are not in a pristine state. This leads to the second challenge in that we require a quantitative measure of the pristine state (plus Standard Deviation) where we can measure changes in some biological metric (i.e. productive capacity or species richness etc.). The methods for arriving at this quantitative measure could either be empirically based or derived through a model.

Franzin: Stated that the demonstration of ‘harmful’ is often difficult. For example a resistant population would continue despite any changes to its environment yet there may have been effects on productive capacity through possible reductions in growth and/or recruitment.

Morry: Commented that the word harmful only refers to (habitat) alterations.

Antcliffe: Suggested that the Department would also have to show that a disruption was harmful.

Morry: Suggested that some thresholds could then be time sensitive and bridge Section 36 (of the *Fisheries Act*). For example: over nutrification without toxicity, would this be considered a HADD?

Potter: What are the different types of HADD and can we break them down with respect to alteration, disruption or destruction (related but also different)? Perhaps it would be helpful for discussing the threshold issue. Ted also expressed the opinion that we need to question if the change was important and/or a significant risk to the population in question.

Jones: Suggested that the theory of a threshold for HADD is advanced beyond our empirical evidence. He used Les Stanfield’s example of imperviousness and biotic community change (presented during day 1) as a good empirical example showing a significant change but suggested other examples were rare. Because of this lack of empirical evidence, a threshold measure that cites one standard deviation from a reference condition as constituting a HADD may not be the best approach at present.

Metikosh: Suggested that HADD is not entirely a science problem; the HADD process can be arbitrary.

Jones: Agreed that science does not have a lot to offer in setting thresholds for HADD at this time.

Metikosh: Science would help set threshold levels for change in time, space and duration.

Franzin: Water withdrawals are a big issue currently. The example of lake 226 (presentation day 1 on lake whitefish by Blanchfield) was certainly a HADD. Do we now have to start fine tuning this experiment to see where the harmful withdrawal lies?

Stoneman: Question to the group -- How does Habitat Management set thresholds without information from science?

Stanfield: Science should define the reference site or condition and the expected variation around this reference. Habitat management needs to define the threshold and/or target for deviation from this reference condition. The combination of the two approaches provides the definition of HADD.

Stoneman: Should we be using adaptive management?

Murphy: The loss of ‘area’ is important within the HADD context.

Ming: We are already making decisions regarding HADD (not always science based) and could use the monitoring process to develop thresholds.

Antcliffe: Physical loss of habitat is much easier to prove and defend in court that a reduction in quality. These issues require different thresholds; use both qualitative and quantitative thresholds.

Smokorowski: There is a risk to using adaptive management for developing thresholds. It would potentially lead to some harmful situations. There is a need to come back to the idea of productive capacity within our management approach.

Franzin: Two questions: 1) Are there good reference sites with long term empirical data? 2) Do we have the understanding of the variation within these data to form thresholds?

Samis: If we set thresholds for HADD, would it tie the hand of management?

Metikosh: Why is the habitat program interested in setting thresholds? Management cannot cope now with the present definition of HADD. Maybe there is a need for a regulation for HADD analogous to Section 36 (Deleterious Substances).

Stoneman: The department needs to avoid mistakes.

Minns: If science works on thresholds, we will be contributing at the community or cumulative scale but not be at the site-specific scale.

Stoneman: The department needs to be comfortable with any thresholds developed.

Ming: Habitat managers need science to tell them how much change is harmful.

Minns: Science is not likely to be able to provide this information on a site-specific basis. Science may be able to set thresholds at a watershed scale.

Antcliffe: Two points: 1) set the thresholds in science and 2) the decision making process resides with management.

Quigley: HADD is subjective. We currently allow some activities that are beneficial for other reasons than fisheries that possibility would constitute HADDs.

Kelso: It is easy to assess habitat, which is where habitat management now acts (i.e. area, or habitat loss). It is much more difficult to define a threshold without understanding the functional responses of habitat. The investigation of these functional responses is the primary role of science. Acid rain was a good example of setting thresholds. Habitat functions are much more difficult to understand. Until we can define the role of habitat we cannot define thresholds for change. The front line approach for management is to stay with physical habitat. Science must move forward with defining the function of this habitat.

C: Issues such as permanence, scale, repetition and resilience need to be measured and compared against measurement thresholds (not biological). The threshold values can be set on a sliding scale where numbers and values vary by region, but the total of these numbers would determine if a threshold was reached. The question is then raised as to how to assign values – additive? Limiting?

Stoneman: Thus the referral process would stay with physical disruptions?

Kelso: Need to use time scale in the process.

Winfield: There are habitat thresholds currently available (e.g., work in the forestry sector).

Stoneman: If there are two projects in the pathways model with similar scores but one has a large effect that lasts a short duration and another has a minimal effect but is expected to last a long time, which project is more risky? They would have the same score but potentially different outcomes.

Smokorowski: These still would require consideration of cumulative effects in a landscape scale.

Kelso: There is also the issue with the tracking process.

Stoneman: It appears we need a GIS-based system for tracking.

Potter: With a 'quota' based system you run the risk of promoting harmful operations to occur quickly before the threshold is reached.

Ridgeway: These discussions are at the municipal planning level, not DFO jurisdiction. Furthermore, some thresholds are not at the watershed level (e.g., groundwater points and trout habitat).

Metikosh: This is usually not a decision to be made by DFO although the Department can help with integrated management.

Quigley: Some work has been conducted on the thresholds for cumulative effects (e.g. the 25% of a catchment can be harvested before effects are observed). This threshold has been established through research.

Stanfield: When we identify thresholds we should also provide boundaries of acceptable change which will promote better planning.

Potter: Integrated Resource Management within the Oceans Act is very similar to this approach and it has many of the same issues. There is however a great deal of 'judgment' involved. This is similar to the question of sustainable development – what kind of environment do we want – pristine environment at the expense of development?

Stoneman: We have to set thresholds based on biology before we deal with the social aspects.
Science may have to focus on cumulative effects and habitat management on physical habitat for now.

Potter: There is always the question of scale especially in the ocean environment.

Antcliffe: We still need to identify the factors leading to a HADD.

The discussion was ended on this note due to a lack of time but many of the same themes were central to the other discussion periods on Productive Capacity, Compensation and Risk.

Theme 3 –Compensation

Facilitator: Dave Scruton
Recorder: Christine Brousseau, with notes from Angie Wagner
Questions:

1. What types of habitat enhancement have been used and which have been shown to be effective to achieve their objectives (incl. compensation ratios)?
2. What types of compensation habitat are more productive and what is the timeframe to reach full productivity?
3. How do we determine the effectiveness of compensation activities?

After a summary presentation by Karen Smokorowski, David Scruton introduced the theme questions. Compensation ratios can be used to address NNL with a spreadsheet format. Many of the key workshop elements discussed beforehand apply to this theme: uncertainty and risk of compensation; the ecological function of different habitats; habitat supply-bottlenecks in the system; relative value of different habitats and species-specific use of these habitats.

Question 1: What types of habitat enhancement have been used and which have been shown to be effective to achieve their objectives (include compensation ratios)?

Potter: Referred to the day 1 presentations by Quigley and Harper: There has been significant progress with compensation and change within FHM since 1986. There is more work to do but we are heading in the right direction. It is important to take this positive message back to regions, indicating where compensation has been successful. On the issue of cash for compensation – creation of habitat costs money, so accepting cash for other habitat compensation is basically the same thing.

C: Guidelines are needed on how to manage money if dollars are accepted for compensation.

C: DFO's workload has increased substantially. Less money is being spent on assessment and monitoring.

C: More compensation without assessment means incurring ever increasing financial costs and potential environmental costs without knowing the benefits.

C: DFO has a hierarchical approach for dealing with habitat compensation, looking at compensation in the broader context fish populations and communities. The issue of cash compensation should be considered more often as the funds can be used to conduct research to address important questions and uncertainty.

C: For looking at artificial perturbation and the effects, patience is needed. We often measure short-term effects, but long-term effects are rarely determined. Some large scale projects have failed in the long-term.

C: Can we determine for the majority of the cases if compensation has been effective? Many cases have proven that it has not been effective. Compensation funds need to go to an environmental damages fund. We need to be innovative with compensation ratios - there has to be a positive impact on productive capacity.

Scruton: In Newfoundland, a lot of money is being spent on compensation projects that are unlikely to succeed. Proponents would rather see the money set aside and used elsewhere.

Murphy: For shellfish enhancement, a 1:1 ratio is used. Techniques have been well developed and the industry value has gone from $395,000 to over 6 million dollars (oysters). There are existing techniques that can be used. There are success stories.

Samis: In 1997, DFO accepted 1.5 million for compensation from BHP for spending elsewhere.

Quigley: Regarding cash compensation – may be a deviation from policy leading to problems since financial security won't meet the policy. If NNL isn't achieved from a compensation effort, then there is a mechanism to go back and say fix it. But if cash is accepted there is no mechanism to go back and ask for more money. Since the inception of CEA and SARA, the workload for DFO has increased and there is less time for compliance monitoring.

What types of compensation habitat are more productive and what is the timeframe to reach full productivity?

Ridgeway: Is it easier to enhance wetlands or hard substrates?

C: Success and failure varies depending on the system. The Metro Toronto Conservation Authority has had success with wetland restoration.

C: Less successful projects should be reported on. Most discussion has focused on finfish, not shellfish. Watershed management plans can help guide compensation, including the identification of candidate sites for remediation.

Ming: We must communicate the success stories as FHM staff are often not aware of the outcome. We need to find a mechanism to transfer this information to help them to make better decisions. I support cash for compensation. We still operate with the like for like onsite approach but often compensation is not achieved because the site is not suitable. Maps and GIS can help us find alternate compensation sites. We need a means for relating the message (presentations to FHM staff, a compensation manual, or a website).

Metikosh: If we are not monitoring compensation projects how do we know what is succeeding?

Stanfield: Successful projects have taken a process-led approach (ETD).

Franzin: Are there guidelines for what type of habitat is preferred for compensation?

Stoneman: No, compensation doesn't have to be on the same site. It can be in the same ecosystem. There are candidate sites for remediation.

Winfield: Government needs to provide more guidance for selecting these sites. Literature exists on successful compensation projects. Habitat banking guidelines will provide opportunities to move this issue forward and achieve more successful compensation.

Metikosh: We need to sort out the issues. Real estate is an issue and it is difficult to find offsite areas for compensation. Is expropriating a highly degraded property for restoration an option?

Stanfield: There is a natural channel design conference in Ottawa next spring - there will be successful compensation projects and DFO staff should attend. Also there is an EcoHydraulics conference in Madrid.

Quigley: Our study found that techniques were not the problem, rather compliance was the problem. Habitat enhancement techniques (expropriation of property, fencing streams to prevent cattle access etc.) have been successful in British Columbia and some areas in the United States.

Blanchfield: Suggested incorporating a tax (1 to 2%) into compensation that goes into a research fund to answer some of the questions we are trying to answer.

Ridgeway: Cash for compensation can be used by Universities to fund graduate students to evaluate compensation projects. The work gets done but it is controlled.

Stoneman: Cash for compensation needs to be carefully managed because of the regulation issues.

Metikosh: Habitat banking is a better suggestion.

Minns: Instead of accepting cash, pay a fee (dollar per square metre for destroying habitat) and put the money into another management project.

Kelso: Is compensation an issue during restoration? What is the range of options? If like for like is appropriate then this form of compensation is used. If not, use other options - cash, or implement compensation somewhere else where it is beneficial.

Smokorowski: It is difficult to find reports that show successful compensation; existing reports are not based on ecological processes on a large scale. We need to be cautious with habitat banking - in the United States, the wetland banking system is not effective. In many instances a remote (or protected) productive wetland bank has been drawn upon to allow repeated and excessive habitat destruction elsewhere, and the result has been continual degradation of many areas. In some cases, wetland banks are established in isolation from the rest of the watershed which has led to the degradation of that wetland due to lost connectivity and watershed functioning.

C: What is DFO's science role in conducting research? DFO seems reluctant to get involved in projects that evaluate the effectiveness of compensation. We need to select some projects as case studies.

Theme 4 –Uncertainty and Risk Management

Facilitator: Mike Jones
Recorder: Ken Mills (with notes from Wagner, Randall and Smokorowski)
Questions:

1. How does knowing the sources and magnitude of uncertainty and understanding the associated potential risk affect decision making?
2. Can formal methods for expressing uncertainty be used in decision making or might the use of safety factors, or 'rules of thumb', be preferred?
3. How does the degree of formality in methods of decision-making interact with the need for adaptive management?

Ken Minns presented the state of knowledge regarding incorporating uncertainty into the decision making process, after which Mike Jones led the discussion on risk and uncertainty. Mike has considered risk and uncertainty in his research for many years and opened the discussion by presenting his views. A paper by Hornbaker and Cullen (2003; see references) was recommended.

1. How does knowing the sources and magnitude of uncertainty and understanding the associated potential risk affect decision-making?

Jones: There are two areas of impact of uncertainty. The first is if the sources of uncertainty are known and incorporated into decision making. This was dealt with in Ken's talk. The second is where the outcome is unknown.

C: Every time we make a decision, we take a risk because we don't know what the outcome will be. Do we formally make decisions that account for uncertainty? What is the risk versus the cost and effort? What is the cost of being overly optimistic versus overly pessimistic? If every decision is a risk, then what is the tolerance?

Stoneman: Yes, we often do take the magnitude of uncertainty into consideration. Sometimes the risk is underestimated and sometimes it is overestimated.

Jones: The process is subjective. There is always the probability that something negative could happen.

Ming: Typically we ask for contingency plans when there is uncertainty. Methods for assessing risk are often very informal. Being informal tends to make things less conservative. Contingency is usually based on negotiation that sometimes is hopelessly optimistic instead of conservative.

Bain: The magnitude of uncertainty has to be taken into consideration. We need to understand risks to be able to make an objective decision but this doesn't happen because of the informality. How do you bring objectivity into risk tolerance? Degree of subjectivity makes it problematic.

C: Risk assessment should be objective and more formal.

C: The answer to question 1 is that uncertainty and risk do affect decision making, but is the current mode of incorporating risk and uncertainty (that is, subjective and informal) worse than ignoring it?

2. Can formal methods for expressing uncertainty be used in decision-making or might the use of safety factors or 'rules of thumb' be preferred?

Jones: Formal consideration of uncertainty has become a growth industry, particularly in fish population dynamics/ stock assessment. Incorporating uncertainty into habitat management decisions is more difficult. Software and tools (e.g., fisheries management; Ken Minns) are available but they are not being used for habitat management.

C: The alternative to a formal process is to use informal 'rules of thumb' or safety factors.

C: Do those rules of thumb need to be put on the table and subjected to scrutiny? Or do we decide by simply saying there is an uncertainty?

C: A number of frameworks have been developed to incorporate into the referral management process. They are mandated but are often not used.

C: A formal process can be developed, but they are tedious and this may be why they have not been used. It is not always possible to include social or economic values up front; these are often dealt with in an informal way. FHM is not allowed to keep a list of companies that do not comply; may lead to decisions based on company records.

Jones: Perhaps have rules of thumb for assessing risk, and then take uncertainty into consideration. These would be useful to FHM. But do not consider uncertainty in every referral, just for the high risk projects. Try to determine the degree of risk associated with particular decisions; if risk is high, this would trigger the application of a more formal method of expressing uncertainty.

Q: How does FHM evaluate the uncertainty? Why are some methods developed but not embraced? Are they arcane and frightening to managers? Is the effort needed to incorporate them into the decision making process too great? Are they too new or too numerous?

Stoneman: Response was that yes, the procedures were new, and habitat biologists don't know where they fit into the big picture. Decisions are not necessarily quantitative or science based. Risks are not always monitored. There are informal ways of dealing with risks and uncertainties. For example, mitigation is a form of risk management.

3. How does the degree of formality in methods of decision-making interact with the need for adaptive management?

Bradford: FHM managers can be afraid to make a decision in case it's the wrong one.

Jones: There must be a way of expressing the view that it's okay to tolerate risk. Risk is a tough sell to the front lines because failure is involved. By their nature, public institutions tend to reward risk aversion and to penalize risk-takers. We should allow decisions to be made that provide us with information on the consequences of those decisions to quantify risk as a distribution of outcomes. This fits under the umbrella of adaptive management.

Paradis: It is not easy for front line decision makers to advance an adaptive management agenda unless this approach is being encouraged from upper management. The message should be carried forward to upper management.

C: There are huge technical challenges in sampling and measuring response. Monitoring and follow-up on small compensation projects is unrealistic. It is also unrealistic to have proponents undertake adaptive management themselves because the results are for DFO. Is adaptive management a high priority for FHM operations in the future? Confirmation, advice and support from managers that this approach is a priority are needed.

C: Learning from past decisions must be a high priority to ensure that any past mistakes are not repeated.

C: Most consultants are happy to do the monitoring if they see that there is a positive feedback.

C: Consistent standards (process and data collection) are needed across the province. Proponents are eager to collect data provided the government provides the standards

C: The west coast discontinued monitoring because the information was not being used for better management. It takes time and money to monitor properly.

C: FHM must take into consideration the proprietary nature of information being collected by the proponents. Sometimes proponents are reluctant to provide information that will provide a competitor with an advantage - e.g., the competitor then does not have to do the same level of monitoring. Need control/rules as to how the information will be used; guidelines for data disclosure are required.

Kelso: There is a need to generate a road map for the management processes that will work, including the screening and assessment process for referrals, tracking of loss, data requirements a priori, data management for post assessment of cumulative information, risk assessment and adaptive management.

C: The road map will be determined by the types of referrals received by FHM. The majority of referrals will be handled easily and cut out of the mapping process early. The current road map is in the form of guidelines applied on an ad hoc basis. The Pathways of Effect process is meant to formalize the process.

Ridgway: Has there been an attempt to collect proposals to assemble an adaptive management process?

C: FHM would like to link referrals to science and different types of mitigation that work well. The outcome could dictate the measures being negotiated. FHM could use a monitoring and mitigation agreement instead of an authorization. An Authorization triggers compensation, so it doesn't always work for industry. An Agreement is the key: start with an agreement at the outset with trigger points and actions.

C: FHM cannot constantly change criteria as the project progresses as industry will become frustrated. Proponents also become frustrated when follow-up to monitoring is not done. FHM needs a structured mechanism for monitoring; use success to garner further success.

Randall: Regarding the1986 Habitat Management Policy document: Is the current policy document being revised, in view of the new approaches being taken by FHM (sensitive vs. resilient habitat; risk assessment; pathways of effect)?

Stoneman: No, the Policy document will not be changed. A productive capacity component will be included in the new framework. A guidance document is in the process of being developed (currently at the consulting stage).

APPENDIX 5: PRESENTATION SLIDES

Day 1: Talks 1 to 5
Day 1: Talks 6 to 11
Day 1: Talk 12
Day 1: Talks 13-15

Day 2