Proceedings of the 1997 Science for Fish Habitat Management Workshop

N.P. Lester, K.J. Cornelisse, L. Greig, C.K. Minns and M.L. Jones

Fisheries and Habitat Management Branch
Central and Arctic Region
Department of Fisheries and Oceans
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Aquatic Ecosystems
Science Section
Ontario Ministry of
Natural Resources
P.O. Box 7000
Peterborough, Ontario
K9J 8M5

December 1997

Canadian Manuscript Report
Fisheries and Aquatic Sciences
2439

Canada

Ontario

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901–1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426–1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2439

December 1997

PROCEEDINGS OF THE 1997 SCIENCE FOR FISH HABITAT MANAGEMENT WORKSHOP

by

N.P. Lester[1], K.J. Cornelisse[2], L. Greig[3], C.K. Minns[4] and M.L. Jones[5]

Fisheries and Habitat Management Branch
Central and Arctic Region
Department of Fisheries and Oceans
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Aquatic Ecosystems Science Section
Ontario Ministry of Natural Resources
P.O. Box 7000
Peterborough, Ontario
K9J 8M5

This is contribution # 97-09 of the Aquatic Ecosystem Science Section, OMNR.

---

[1] Aquatic Ecosystems Science Section, Ontario Ministry of Natural Resources. 300 Water Street, P.O. Box 7000, Peterborough, Ontario, K9J 8M5, Canada.

[2] L155 Inkerman Street, Rockwood, Ontario, N0B 2K0, Canada.

[3] ESSA, #308-9555 Yonge Street, Richmond Hill, Ontario L4C 9M5.

[4] Great Lakes Laboratory for Fisheries and Aquatic Science, Dept. of Fisheries and Oceans. P.O. Box 5050, Burlington, Ontario, L7R 4A6, Canada.

[5] Dept. of Fisheries and Wildlife. 13 Natural Resources Bldg. Michigan State University. East Lansing, MI 48824-1222, U.S.A.

Cat. No. Fs 97-4/2439 ISSN 0707-6473

Correct citation for this publication:

Lester, N.P., K.J. Cornelisse, L. Greig, C.K. Minns and M.L. Jones. 1997. Proceedings of the 1997 Science for Fish Habitat Management Workshop. Can. MS. Rep. Fish. Aquat. Sci. 2439: vi+36p.

TABLE OF CONTENTS

ABSTRACT

Lester, N., K. Cornelisse, L. Greig, C.K. Minns and M. Jones. 1997. Proceedings of the 1997 Science for Fish Habitat Management Workshop. Can. MS Rep. Fish. Aquat. Sci. 2439.

This workshop brought together representatives from Canadian natural resource agencies to share information about current directions in fish habitat management and to set direction for the development of better management tools. The workshop was held March 5-7, 1997, at Barrie, Ontario. Invited speakers gave a series of background presentations covering both management and research topics on fish habitat. Then, after a plenary session to discuss the range of topics raised, the participants were divided into two groups. One group discussed impact assessment and prediction while the other examined inventory issues.

The impact group's discussion, recognizing that there are many unanswered questions especially regarding fish-habitat linkages, emphasized the following areas: 1) Assessment of the significance of impacts in habitat management is closely linked to clear definitions of fishery objectives; 2) Innovative use of compensation agreements as a form of experimental management to gather data on the impact of habitat alterations; 3) Large-scale experiments on selected habitat alteration actions to validate the evidence gathered in 2; 4) Greater efforts to translate science into guidelines and tools for management, with greater emphasis on synthesis; 5) Development of area-based habitat management plans as a context for site-specific development activities; and 6) Increase consultation and collaboration among regulatory agencies (involving both science and management expertise) and between agencies and private sector industry associations.

The inventory group's discussion developed two themes: 1) The need to have a clear framework for application of the data before designing and conducting inventory programs; and 2) Matching inventories scales (temporal and spatial) to the scales of development activities affecting fish habitat. Discussion on these themes highlighted significant mismatches between the scales at which most scientific evidence is gathered and the scales at which most habitat management decisions are made. Two main types of inventory, with clear purposes, were identified: those needed for resource management and those supporting scientific research.

There was broad consensus that current management efforts are hampered by unclear objectives and insufficient scientific knowledge. Fish community objectives are needed before harmful effects of habitat changes can be evaluated. Furthermore a better understanding of fish habitat linkages is needed to predict effects on various species. All participants agreed that workshops like this can enhance the use of science in fish habitat management and establish research priorities.

RÉSUMÉ

Lester, N., K. Cornelisse, L. Greig, C.K. Minns and M. Jones. 1997. Proceedings of the 1997 Science for Fish Habitat Management Workshop. Can. MS Rep. Fish. Aquat. Sci. 2439.

Cet atelier a rassemblé des représentants d'organismes canadiens des ressources naturelles afin de faciliter le partage d'informations concernant des tendances actuelles en gestion de l'habitat du poisson et afin d'orienter le développement de meilleurs outils de gestion. Cet atelier a été tenu du 5 au 7 mars 1997 à Barrie (Ontario). Des conférenciers invités ont donné une série de présentations générales portant sur des questions de gestion et de recherche reliées à l'habitat du poisson. Ensuite, après une assemblée plénière pour la discussion de toute la gamme des questions soulevées, le participants se sont divisés en deux groupes. L'un d'eux a examiné la question de l'évaluation et de la prévision des répercussions, et l'autre, les questions d'inventaire.

Le groupe qui discutait la question des répercussions, reconnaissant qu'il existe de nombreuses questions encore sans réponse, surtout pour ce qui est des rapports entre le poisson et son habitat, a souligné les points suivants : 1) l'évaluation des répercussions pour la gestion de l'habitat, qui est étroitement reliée à des définitions précises des objectifs des pêches; 2) les types innovateurs d'accords de compensation pouvant servir de cadre expérimental de gestion afin d'obtenir des données sur les répercussions des altérations subies par l'habitat; 3) les expériences à grande échelle portant sur des altérations sélectionnées de l'habitat afin de valider les hypothèses formulées au cours de l'étape 2; 4) les efforts plus importants visant à traduire les résultats scientifiques en lignes directrices et en outils de gestion, avec un accent accru sur la synthèse; 5) le développement de plans de gestion de l'habitat basés sur les particularités d'une région pour des activités de développement propres aux sites; 6) l'augmentation de la consultation et de la collaboration entre les organismes de réglementation (faisant appel à des connaissances expertes en sciences et en gestion) et entre ces organismes et des associations industrielles du secteur privé.

La discussion du groupe étudiant les questions d'inventaire a porté sur deux thèmes: 1) le besoin d'un cadre précis pour l'application des données avant la conception et la réalisation des programmes d'inventaire; 2) l'ajustement des échelles des inventaires (temporelle et spatiale) à celle des activités de développement touchant l'habitat du poisson. La discussion de ces thèmes a mis en évidence des écarts importants entre les échelles auxquelles la plupart des données scientifiques sont recueillies et celles auxquelles la plupart des décisions de gestion de l'habitat sont prises. On a identifié deux principaux types d'inventaires dotés d'objectifs précis : ceux qui sont nécessaires pour la gestion des ressources et ceux qui servent au soutien de la recherche scientifique.

D'une façon générale, on convenait que les efforts actuels de gestion sont gênés par des objectifs mal définis et par l'insuffisance des connaissances scientifiques. On doit définir des objectifs pour les communautés de poissons avant l'évaluation des effets néfastes des changements dans l'habitat. De plus, on doit avoir une meilleure compréhension des différents rapports qui existent entre l'habitat et le poisson pour la prévision des effets sur diverses espèces. Tous les participants ont convenu que des ateliers comme celui-là pouvaient améliorer l'utilisation de la science pour la gestion de l'habitat du poisson et pour la définition des priorités de recherche.

1.0 INTRODUCTION

Section 35(1) of the Federal Fisheries Act states that 'no person shall carry-on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat'. The *Policy for the Management of Fish Habitat* (DFO, 1986) gives direction for interpreting and administering this act through the guiding principle of *'no net loss of productive capacity of fish habitats'*. This principle acknowledges the integral link between fish productivity and fish habitat. However, its application in management decisions is often problematic because this link is not well defined. Effective management of fish habitat must:

- be based on science that describes the link;
- specify criteria for use in management decision-making; and
- describe cost-effective, standard methods of collecting the required data.

The tools currently in use for managing fish habitat are in the early stages of development. Teamwork among staff from the policy, science, and field sectors within provincial and federal agencies can expedite the process of developing a better habitat management capability. That capability will ensure sustainable aquatic resources while avoiding unnecessary restrictions on resource use. These sectors must share their respective knowledge, recognize knowledge gaps, and reach a common understanding of the science needed and the type of habitat inventory (i.e. data gathering) required to implement effective policy. This understanding supplies a base for developing 1) objective decision-support systems and 2) standardized, cost-effective habitat assessment programs.

The "1997 Science for Fish Habitat Management Workshop" brought together staff from provincial and federal resource management agencies to initiate this process. This workshop was intended as a first step toward the development of a new generation of fish habitat management tools. The purpose of the workshop was to:

- share information about current directions and pressures in fish habitat management; and,
- identify the 'best next steps' for policy, field and research initiatives.

The three-day workshop included 43 participants drawn mainly from the Ontario Ministry of Natural Resources (OMNR) and the federal Department of Fisheries and Oceans (DFO) along with some representatives of other provincial and territorial agencies (see Appendix 1 for a list of participants). The workshop was held March 5-7, 1997, at the Kempenfelt Training Centre, near Barrie, Ontario. The workshop began with a series of presentations organized into the following topic areas:

- the harsh realities of fish habitat management
- measuring fish habitat
- assessing impacts
- approaches to managing fish habitat

The extended abstracts from each talk are contained in Appendix B.

Following the presentations, a list of issues and questions was assembled in a plenary session. The steering committee had prepared a straw-man listing and organization of issues as a starting point. Proposals put forward in the plenary were used to refine the charges for discussion groups. Then the participants were divided into 2 working groups. Each group had a facilitator and a rapporteur. The working groups were asked to consider different sets of questions and report back at a final plenary session. The working group questions were gathered under two headings:

Group 1. Impact Assessment and Prediction Needs

- What is an impact?
- How is evidence of an impact obtained?
- What types of impacts need assessment?
- Who sets the standards for impact assessment?
- Who should assess impacts?

Group 2. Inventory Needs

- What is an inventory?
- Why do an inventory?
- How does the scale of the issue affect the inventory needs?
- How does one decide on the components to measure?
- What methods should be used?
- Who sets the standards for inventories?
- Who collects the data?

Reports from each working group are presented in the following sections.

2.0 IMPACT ASSESSMENT AND PREDICTION NEEDS

2.1 What is an impact and when is it harmful?

An impact can be defined as a response to human intervention involving a change in fish productive capacity or in the fish community. Fish production alone is not a sufficient currency for measuring an impact and deciding whether it is harmful. Although the no net loss of productive capacity exists as an overriding principle in the *Policy for the Management of Fish Habitat* (DFO, 1986), a species connotation is implicit. Since habitat changes affect different fish species in different ways, harmful effects cannot be evaluated without reference to fish community objectives. ***When these objectives have been established, an impact is said to be harmful if it results in a loss of production within the desired fish community.***

Building consensus on fish community objectives requires public forums guided by science. Scientific research identifies ecological constraints and provides a "filter" on society's resource use goals. Many environment problems continue to exist because society does not accept the ecological constraints. In the future, the municipalities in Ontario will be called upon to identify the fish community objectives and decide if development proposals are potentially harmful. OMNR must ensure they are provided with the information to make these decisions.

2.2 How do we predict impacts?

There are conceptual models describing linkages between fish and fish habitat which can assist in the prediction of impacts. For example (Fig. 1), the impact of a proposed development is predicted by tracing its effects on physical / chemical processes and, from there, on biological processes. The effects of development at the level of physical / chemical processes are reasonably understood. ***Most uncertainty exists at the biological processes level, making it difficult to predict the effects on fish.*** Some of the biological science may already exist in the literature but habitat managers often have little time to stay abreast of new science. ***Synthesis of the literature needs to be done on a regular basis.*** This is one area where the OMNR Science Transfer and Technology Units (STTU) can play an important role.

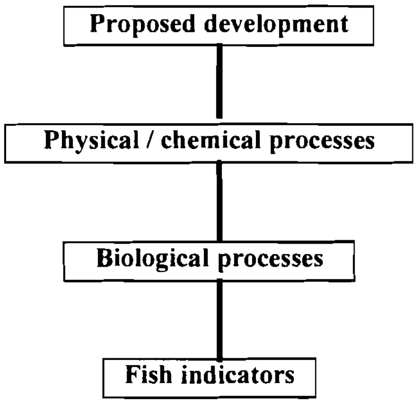

Figure 1. Conceptual model to predict impacts.

There was agreement on the need for more research to understand the linkages between fish and fish habitat. Traditional experimental methods for studying these linkages are expensive and require a long time commitment. Experiments need to be conducted at scales appropriate to the habitat manipulation being considered. Controls and replicates are necessary. There are many different forms of habitat manipulation occurring, pointing to the need for many different experiments. In the past, only government science agencies had the resources and continuity needed to conduct such studies. In this era of government downsizing, the agencies no longer have the means to conduct such work. A broader range of approaches will be needed to secure the scientific understanding.

Experimental management is viewed as an appropriate means of filling this gap. It was proposed that compensation agreements required as part of authorizations under the Fisheries Act be used to secure real-world experimental evidence of impacts. Building an experiment around a Fisheries Act authorization agreement provides an opportunity that would otherwise never arise.

Fisheries Act authorizations were not intended for hypothesis testing, but there is no reason why they could not be used in this way. The current lack of knowledge about which mitigation and compensation methods work and where they are appropriate, provides a basis for managing on an experimental basis. The group unanimously supported the idea of doing experiments through compensation agreements.

However, it was also acknowledged that more conventional experimental research must be done around development projects as a means of verifying the results obtained in compensation studies. Indeed, situations where the results from several compensation studies are inconsistent might provide a basis for priorizing agency investments in full-blown experiments.

2.3 Who sets the standards for impact assessment?

Teams involving scientists from OMNR and DFO should design experiments to study the effectiveness of mitigation and compensation techniques. These designs must specify sampling requirements including the number of replicates and controls, the number of years of study, and the data collected each year. Several scientists already involved in stream and lake manipulations were proposed as potential candidates for science design teams. For lake manipulations, the list includes John Kelso, Ken Minns, John Gunn, Bill Cole, Mark Ridgway, David Evans and Rob Steedman. For streams, the list includes Jack Imhof, Rob Mackereth, John Seyler, Les Stanfield, George Duckworth and Mike Jones.

Joint science and operational teams should develop standardized assessment protocols for obtaining useful feedback on the effectiveness of compensation and mitigation actions via compensation agreements. The assessment protocols should take account of the types of habitat alterations, ecosystem types, the scale of the intervention, the cost-effectiveness of various measurement and sampling tools. As the results from number of such compensation agreement accumulate, statistical procedures for pooling and assessing individual results should be applied.

2.4 Who pays for the assessment?

Successful experimental management programs will depend on a cooperative approach with experiments designed by a team of scientists and treatments provided by proponents - free of charge. Who pays for data collection and analysis the data to evaluate impacts will be an issue? Proponents should be able contribute, however, it would be unfair to ask one proponent to pay for an experiment, from which all others could receive a benefit. Therefore industry associations, not individual companies, should be invited to participate, partnering with the regulatory agencies. Reductions in the regulatory uncertainties and inconsistencies faced by individual development proposals, should provide a strong financial incentive for association to become involved. ***Design teams should work to develop proposals with substantial input from industry associations. Establishment of new experimental management partnerships with industry sectors should be a high priority.***

2.5 Science needs for habitat management and impact prediction

The group agreed that available scientific understanding and data are currently under-used in the management of fish habitat. There is a need to provide operations and policy staff with scientifically sound guidelines about mitigation and compensation techniques. These guidelines should include assessment techniques and tools and the conditions in which each is best suited should be documented.

The group identified a list of areas where further study or synthesis of existing information are needed (Table 1).

2.6 Habitat management in Ontario

The OMNR is no longer reviewing development proposals. This is now done by the municipalities. It is the responsibility of the OMNR to provide them with the tools (training manuals) for recognizing and protecting fish habitat during the planning process. The OMNR has created the 'Guide to Fish Habitat Protection' web page that guides people through the thought and decision making process for the protection of fish habitat. ***Further science is needed to support the guidelines presented on this web page and to make them scientifically defensible.***

Some of the science can be supplied by a synthesis of the literature. There will be no absolute answers for guidelines such as a '30 m buffer strip', but the literature can provide information from which we can make best estimates, thereby creating scientifically defensible methods.

The current approach to mapping habitat includes an inventory from which the fish habitat is classified into 4 categories (OMNR, 1994):

- Type 1 - limits the overall productive capacity
- Type 2 - does not limit productive capacity
- Type 3 - does not contribute significantly to fish production
- Unknown

Problems with this approach were discussed. ***It was suggested that the mapping should include only 2 habitat types. The first type would be areas where the habitat is known to have a function that is limiting. All other habitat would be indicated as 'Unknown', and would require a habitat assessment. Criteria for Type 1 habitats should be developed as should standards for habitat assessment.***

This site-based management of habitat has other problems. For example, key habitat areas can be protected but may cumulatively lead to the creation of disconnected islands of undeveloped habitat. The best approach for fish habitat management would be area-based (e.g. lake, stream, watershed) habitat management plans. Site-specific development would then be judged against area-based fishery objective and complementary habitat conservation targets.

Table 1. Science needs for habitat management and impact prediction, identified by group one.

Issue	Concerns and Comments
Mitigation techniques	• Do they address the requirements of all life history stages (e.g. over wintering habitat in streams)?
Habitat compensation structures	• Do these structures increase productive capacity or redistribute it?
Scale of disturbance	• What is the scale of disturbance that limits a watershed? • Need for area-based management rather than site specific.
Buffer strips	• Consider sediment, nutrients, temperature, allochthonous inputs, slope and soils • How much forest can be cut before you reach a threshold and see a hydrological effect? • 100' buffer strip around a lake trout lake is not defensible • 50' buffer strip around a warmwater community is not defensible
Shoreline protection	• What are the impacts of boathouses, breakwalls and water lines?
Floating docks and pole docks	• Are they harmful?
Pressure treated wood docks	• Do they leach contaminants?
Aquatic vegetation control / planting	• What patch size or quantity is important for fish? • Sometimes used as compensation tool, when and where appropriate?
Woody debris	• The contribution of woody debris to fish habitat structure and bank stability
Wetland protection	• Role of wetlands in fish community dynamics? • Many wetlands are converted into marinas.
Water level and distribution	• Effects on spawning success and fish communities. • Much information is available from reservoir studies and this should be synthesized in a literature review. • Conservation Authorities should be involved in review this topic.
Heat loops	• What are the impacts?
Submarine cables	• Concerns for lead, copper, oils, magnetic fields and physical disturbance.
Silt fences	• Where and under what conditions do silt fences work? • How much control is enough? • The Ontario Ministry of Transportation is currently studying this topic.
Roads	• Impacts of primary, secondary and tertiary road development. • Road abandonment has impacts as unmaintained roadbeds decay.
Road crossings	• What are the overall impacts?
Bridges and culverts	• When and where to use different sizes and forms.
Infiltration techniques	• Develop the science basis for conserving recharge areas • Consider baseflow and the distribution of discharge and spawning
Stormwater management	• Water quantity and quality. • Sediment quantity and quality. • Dry ponds vs. wet ponds.
Sewage treatment plants	• Nutrients are the major concern • Ontario Ministry of the Environment and Energy should be involved
Agricultural practices	• Impacts of cover crops, fertilizer, feed lots, waste, cropping, tillage, etc. • Ontario Ministry of Agriculture, Food and Recreation should be involved. • Data exist for the Maitland River and Lake Simcoe drainage areas.
Decommissioning of mines (permanence)	• This is a largely unexplored issue.

3.0 INVENTORY NEEDS

The *Inventory Needs* Working Group began their discussions with a set of questions designed to provide a starting point for considering the need for resource inventory in fish habitat management. In particular, the group considered:

- What is an inventory?
- Why do an inventory?
- How does scale of the issue affect inventory needs?
- What components should be measured in an inventory?
- What methods should be used in an inventory?
- Who should set the standards for data collection in an inventory?
- Who should collect the data in an inventory?

Two general themes emerged from sub-group discussions. First, the OMNR does not conduct inventories unless there is a purpose behind them. Two purposes for conducting inventories were identified: 1) to collect broad scale data for planning purposes (using broad scale, extensive inventories); and 2) to collect site specific data (small scale, intensive) to support and enable research aimed at assessing the nature and extent of human impacts on resources and to provide the platform from which to identify additional data needs (e.g., identify ecological functions impacted by development in each sector and design inventories to study how those functions respond to development-related stresses).

The second theme is that, habitat management issues today are typically related to industry activities and require resource information on a particular scale and of a particular type. For example, the impacts of timber harvest tend to be at the landscape scale (macro) and are managed in the planning process (i.e., mitigating impacts by setting the maximum proportion of a watershed that can be harvested). On the other hand, mining impacts are typically on the meso scale and management nearly always involves compensation. Other sector-based habitat management issues identified by sub-group participants included: gas pipelines installation (specific stream crossing at the micro scale); hydro-electric development (watershed impact on a macro scale); cottage lot development (whole lake on a meso scale); individual permits (micro scale); drainage projects for agriculture (meso scale).

In addition to these two themes we observe that there is currently a mis-match between the scales at which scientific understanding is strongest and the scales over which resource management operates. Science is strongest at the micro scale and there is a relatively weak link with management which tends to operate at the meso and macro scales. Helping to strengthen this linkage by improving scientific understanding of ecological processes at the scales over which management operates is one of the most compelling needs for well designed and executed inventory programs.

3.1 Recommendations

Based on the discussions at the workshop, sub-group participants agreed that there is a need to:

- Support science in its efforts to strengthen knowledge of the link between fish habitat and fish production so decisions can be made about what inventories need to be done;

- Direct OMNR's Fish and Wildlife Branch to take the lead in establishing working groups that will set the standards for conducting inventories; and
- Develop a set of standards for data collection, analysis, and interpretation to make habitat management decisions for all industrial sector issues;
- Develop a standard for data storage and handling to ensure the information collected can be used by everyone involved in habitat management decisions, both within and outside of the responsible government agencies;
- Incorporate the new standards into Policy to provide support for the inventory program;
- Support an inventory program to coordinate standardized data collection on both large and small scale issues;
- Review the issue of data ownership and sharing;

The following sections summarize the working group discussion with regard to each of the questions used to guide the group discussion.

3.2 What is an inventory?

Although there was considerable discussion surrounding the meaning of "inventory", a broad definition might simply be "the collection of point-in-time data that quantifies some component of the resource", in this case fish and fish habitat. Fish habitat is a resource that can and should be inventoried in order to provide information about what habitats currently exist and in what proportions they exist in Ontario's lakes, rivers and streams.

Historically, inventories were done to satisfy curiosity about "what was out there" and to collect the information necessary to characterize the resource for management purposes. Inventories provided managers with the information they needed to identify stocking requirements, to determine resource allocations, and to develop fish management plans. Such inventories were not typically hypothesis-directed, but focused instead on providing a basic accounting of the resource, e.g., what species live where and how many? For years, it was considered satisfactory to collect species and habitat information about Ontario's lakes, rivers and streams. In recent years, however, information needs have changed and such inventory data do not provide the focus needed to answer the kinds of questions being asked of resource managers today.

Two general types of inventories are: 1) provincial or regional scale, spatially extensive data collections that are designed to support management planning; and 2) smaller scale, intensive collections that provide the foundation for scientific research. Although inventories can be conducted on any scale (from broad, extensive sampling to a site-specific intensive census), today's fiscal environment tends to limit the government inventory activities to conducting broad scale extensive inventories, requiring project proponents to undertake the site-specific intensive data collections.

Inventories may be conducted for several reasons, including: the need to make decisions about fish allocation; the need to undertake fish and fish habitat planning; conducting science (e.g., synthesis of information); and state of the resource reporting. In order to ensure that an inventory will be utilized it is desirable that it be "product-targeted" and hence to identify a specific objective or question to be answered by the inventory program. The question asked will also determine the scale of the inventory.

Inventory studies can provide the building blocks on which other studies (e.g., studies of ecosystem process and function) can be based. Inventories can be either directed (e.g., before/after studies, monitoring over time) or non-directed (e.g., broad scale, extensive data collections aimed at gathering background information over broad geographic scale). A general process for inventory definition and conduct was suggested to be:

- assess data needs (define objectives and design the inventory program),
- conduct inventory,
- assess results and determine what else needs to be done, and
- conduct additional inventories as needed to address new questions.

The suggested process is iterative with additional inventory needs and collections being defined as new knowledge of the important attributes of habitat is acquired.

3.3 Why conduct inventories?

Inventories are needed for three broad levels of activity in government: research (for hypothesis testing); management (for land use planning and the development of sub-regional plans); and impact assessment (requires trend-through-time inventories). In this context, the group identified the following applications for inventory programs:

- provide the data required to: generate and test hypotheses; test ecological process questions (e.g., identify and model the link between fish habitat and production)
- provide input to the process of selecting research sites
- identify areas or sites with unique conditions, e.g., ground water upwelling areas
- provide input to the administrative and planning process (e.g., ecological land use plans, sub-regional plans)
- provide data required to classify or characterize areas (e.g., Forest Ecosystem Classification system for northern boreal forest)
- identify areas or sites with unique conditions, e.g., ground water upwelling areas
- provide the data required for developing defensible methods and defining habitat suitability indices (HSI)
- resolve conflicts over resource use and to determine reasonable compensation

- provide the baseline data (benchmark) required to identify and assess the impacts over time of development activities
- state of environment reporting; identify changes over time that will help managers to understand current conditions (e.g., knowing how fast and how much habitat has changed over time will provide insight into current habitat conditions)

In each of these areas, a major function of the information derived from inventories is to provide an essential context in which to evaluate a particular habitat site or feature. For example, inventory data may be used to determine the relative uniqueness of a habitat, its general geographic distribution or abundance. This determination can be important for each of the three major activities, research, management and impact assessment. It is unlikely that inventory data alone would be sufficient for impact assessment but its role of providing a broad context for assessment may be critical. Also, if the additional information collected for specific assessments is made available in a format consistent with available inventory data then the overall scope of the inventory collections can be increased as new developments are assessed. Doing this may also be important to updating the inventory, especially where development will change the nature of habitats.

3.4 How does the scale of the issue affect inventory needs?

The reason for collecting inventory data (i.e., the question being asked) will determine the scale of the inventory to be conducted and the type of information required. The scale of the issue will influence the list of parameters selected for measurement as well as the detail (resolution and intensity) of the data collected.

The OMNR deals with development issues at all scales, e.g., from acid deposition (extensive, province-wide) to cottage lot development (whole lake) to stream crossings (site-specific, micro scale). Table 2 presents a series of examples of resource management issues for which inventory data are needed to provide the appropriate context for analysis and decision-making across a wide range of scales.

Table 2: Examples of resource management issues at different scales.

Provincial	Large Scale (Watershed)	Meso Scale (Lake / River)	Small Scale (Site)
Acid precipitation Climate change	Acid precipitation Timber harvest / forest management Urbanization (fragmentation) Agricultural drainage	Cottage lot development Urban site development Shoreline development Agricultural drainage	Stream crossings Shoreline development

The entries in Table 2 illustrate not only that different sorts of developments tend to operate at different scales but also that any one type of development may need to be considered at multiple scales. Resource issues in southern Ontario tend to be driven by small or meso scale developments (e.g., road crossings, urban site development, agricultural drainage, nutrient loadings, shoreline development). Cumulatively, though, numerous site-specific developments tend to have large scale impacts. In general, a substantial amount of development at one scale may lead to cumulative effects at larger scales. Consequently, for the decision-makers, large scale inventory data are at least as important as intensive site specific data because they provide the context with which to assess how the loss of a specific site might add to the cumulative affect of development. In northern Ontario, resource issues are typically driven by timber management and tend to be on a larger scale at the outset. Nevertheless, small and meso scale developments such as shoreline development from cottaging are also an issue in the north, however, generally lower levels of such development to date have reduced cumulative impacts relative to southern areas.

To date, the OMNR has focused its efforts on medium to large scale inventories; sub-group participants agreed that these are not providing adequate information with which to answer the development-related questions being asked now. For example, ecosystem models that help to predict whole-lake impacts cannot answer questions about the site specific impacts of dock construction on a certain stretch of shoreline and vise versa. Current science has not yet established a good link between small and large scale effects.

3.5 How do we decide which components to measure in an inventory?

The decision of what to measure in a habitat inventory program is determined by the needs of managers in meeting program objectives for three critical functions, namely: resource management planning; research to increase management understanding and effectiveness; and assessment of development impacts on the resource. In this context two primary requirements define the needs for inventory data. The first requirement is the need to be able to describe the nature of the change in the environment (habitats) caused by activities within a sector. Since impacts of human activity are determined by the nature of the activities undertaken there is a need to consider the question of inventory design on a sector specific basis. To ensure efficiency and the broadest possible application of inventory data, there is an equally important need to ensure consistency in the collection of inventory data that are common to different sectoral impacts.

The second requirement is the need to be able to characterize habitat in terms of its significance (quality, productive capacity) for sustaining healthy fish populations. As this requirement deals with characterizing the resource, it is common across sectors. Despite the specific differences between sectors in the way in which impacts are caused, the basic management process for different sectors is also common, namely that for any sectoral activity the manager must be able to:

- predict how it will likely impact the resource;
- identify the steps, if any, that can be taken to mitigate (break) the impact; and

- apply the techniques (or develop the techniques and then apply them) necessary to mitigate the impact.

If impacts cannot be eliminated through mitigation then it is also necessary that the manager be able to:

- determine the impact on fish production that will arise as a result of the lost habitat, and
- specify what additional environmental manipulations could off-set (compensate) for the impacts of the development.

A large part of habitat management is simply the identification and protection of critical habitats, e.g., prevention of modifications to critical habitats by development activities. To accomplish this, habitat management requires an understanding of how habitat quality is changing, which in turn requires that managers know what habitat components constitute "quality" and how to recognize change in them. Habitat management also includes habitat rehabilitation, improvement and creation. To be able to accomplish these management functions it is essential to understand the link(s) between fish habitat and fish production.

Since the activities in different sectors tend to operate at different scales, the inventory needs for understanding how sectoral activities will affect habitats and subsequent fish production will tend to be targeted at different scales for different sectors. This does not mean however that all of the inventory needs for understanding and managing the impacts of a single sector will be limited to a single scale. For example, the data listed in Table 3 are used for developing timber management and sub-regional plans (on the macro and meso scales); for planning subdivisions (on the meso and micro scales); for severances and site planning (on the meso and micro scales); and for documenting unique or special features at all scales, such as a unique view (macro scale), burial grounds (meso scale), or ground water seepage (micro scale).

Table 3: Examples of habitat inventory data collected at different scales.

Scale	Inventory Variables
Macro	• lake type (i.e., cold, cool, warm) • thermal regime (temperature profiles) • existing development in the watershed (include lakes and streams) • trophic status (e.g., oligotrophic, eutrophic) • fish communities present • physiography (including shoreline features, e.g., slope) • classify the aquatic resources present • water quality and quantity (today, managers are required to partition water resources by allocating certain quantities to fish, to hydro developments, etc.) • watershed to lake area ratio • land use patterns in the area • unique features • conservation reserves
Meso	• water chemistry (e.g., dissolved oxygen, pH, etc.) • thermal regime (i.e., temperature profiles) • fish communities present • physiography (including shoreline features, e.g., slope) • composition of the substrate • water quality and quantity (today, managers are required to partition water resources by allocating certain quantities to fish, to hydro developments, etc.) • extent of wetlands • unique features • conservation reserves
Micro	• composition of the substrate • unique site characteristics, e.g., ground water seepage

When considering the design of inventory programs for any specific sector it is also useful to consider *What common habitat components, if any, should be measured in different inventories?* Since the variables to be measured within any habitat inventory are to be determined based on their utility in understanding the impacts of sectoral activities on habitat availability and function, the existence of commonly measured variables across inventories is thus an indication of commonalities in the mode of impact or the basic descriptors of habitat function. The following elements were suggested as examples of habitat variables that may be common across different sector based inventories:

- substrate as an indicator of food-producing habitat, reproductive habitat, and cover;
- riparian zone slope, riparian zone fragmentation, and area (as a proportion of the total watershed area) as a indicators of nutrient cycling and productive capacity of the habitat; and
- water quality, physical habitat structure, diversity of physical habitat structure, and dynamic stability of the habitat as an indicators of habitat productive capacity.

Given that such commonalities exist, it is essential that different inventories are collected utilizing standard methods of observation so that the common data from different programs may be pooled to extend the utility of individual collections. In this regard it is useful to identify any common issues that each sector presents and then to:

- design standard data collection methodology with which to gather information required to quantify and assess specific impacts on fish habitat;
- apply knowledge obtained from the information gathered about these common issues elsewhere in the province; and
- attempt to develop predictive models that can be used by others.

Additionally, it may be helpful to identify the ecosystem functions (e.g., sediment loading) altered by human activity and design inventories to study how they relate to habitat quality. Although this may appear to be too general to be useful in the decision-making process, there is the potential that examining seemingly disparate impacts by different sectors in terms of ecosystem function could lead to improved understanding and efficacy of management activities.

Finally, one way to assess current needs for inventory data is to consider the question *what are we missing that is essential to operationalize habitat management?* In this regard the sub-group identified the following points as requirements to operationalize habitat management:

- the currency with which to measure habitat quality, i.e., a common standard for measuring habitat quality (a list of the habitat components to measure and how to do it) is needed; this "currency" must be defensible, i.e., founded on sound science;
- the link between fish habitat and fish production needs to be established; measurable habitat attributes that can be used to monitor and predict changes in fish production must be identified
- the human resources to conduct the work;
- resource managers need to be knowledgeable about what types of development activities are occurring, what impacts on fish habitat are likely to occur; and in what ways projects can be modified to minimize those impacts (this last point may require an intimate understanding of the industry involved);
- a qualitative knowledge of the fish community in the water body to be impacted by development or, if the scale of the project is very large, a qualitative knowledge of the fish communities typical of the region; knowledge of the life histories of each of the fish species identified (different fish species display sensitivity to disturbance at different times of the year and careful timing of construction activities can mitigate impacts);
- educate the public and industry that development can often be carried out in such a way as to minimize impacts on fish habitat; and
- need to identify what community or habitat attributes will "trigger" a habitat management decision, e.g., the presence of a rare, threatened or endangered species; the presence of spawning habitat; a certain minimum amount of living space; this approach would allow managers to focus on critical data needs and avoid wasting dollars and time collecting data that won't contribute to the final decision.

In order to ensure that the gathering of key data occurs in a standardized way, an over arching program to coordinate inventory design and conduct is needed.

3.6 What data collection methods should be used in inventories and who sets the standards?

There is an urgent need to provide outside agencies and project proponents with data collection standards and protocols to ensure that studies conducted by them generate the data required to enable habitat managers to assess potential impacts and to make decisions regarding authorization and compensation.

Sub-group participants agreed that the OMNR should set the standards for approach and data collection methods. Working groups should be established to determine scientifically defensible standards for each industrial sector that reflect a certain degree of statistical precision and accuracy. These groups will also need to obtain Executive Committee approval to entrench the standards in Policy. OMNR's policy staff within the Fish and Wildlife Branch should take the lead in setting up the working groups that will develop the standards, with input from research, assessment and operations staff. Others that may be able to contribute to the setting of standards based on their scientific or logistic expertise are: industry; DFO (which comes to the table with its own national standards); and possibly the end users of the standards, such as municipalities, community groups, private sector consultants, and universities. Standards development should be an iterative process. The team should identify specific science needs as it works towards developing standards. As scientific understanding improves, data collection standards can be revised so that inventories can focus on the ecosystem components most likely to provide the information required for a management decision. In addition to setting methodological standards, the working groups should determine a standard approach to inventory studies. Specifically, there is a need to identify the type of information and the level of detail required to enable habitat managers to make decisions about proposed developments in each sector (e.g., develop a list of questions, the answers to which would provide the necessary information).

3.7 Who collects the data for inventory studies?

Which agencies conduct the inventories and collect the data will be scale dependent. Large scale, extensive inventories most likely to be conducted by government agencies, but site specific small scale inventories will typically be done by project proponents. Methods and expectations must be standardized and the people conducting the inventories must be trained to apply those standards.

Data are considered by many to be a commodity today and may not be easily procured from sources outside government. It may be necessary for the OMNR to develop a policy statement that requires co-operators to surrender raw data to the OMNR at some point following its collection.

3.8 Summary

Habitat management involves: the identification and protection of critical fish habitat; an understanding of how habitat quality changes following development impacts; rehabilitating degraded habitat; creating new habitat. The enabling assumption inherent here is that managers understand what habitat is and that it can be managed. The objective of habitat managers is to use the resource in such a way as to optimize benefits, i.e., manage habitat for sustained use.

Inventory studies take place at all scales, from the watershed level (macro) through the whole lake level (meso) right down to the site-specific stream crossing (micro) scale. The most useful inventories are product-targeted, i.e., designed to provide the information needed for resource management and scientific research. There is a need to develop a standard approach to conducting inventories as well as scientifically sound, defensible methods for data collection.

Two broad categories of product-targeted inventory were identified: 1) extensive, large scale studies (useful for building management plans); and 2) smaller scale, intensive studies designed to support and enable research (e.g., to identify relationships between ecosystem function and process; to provide the data required to classify fish habitat, etc.).

1. *Inventories conducted for resource management:*
   - should focus on ecological functions;
   - should be as simple as possible; and
   - need to be based on an understanding of impacts.

2. *Inventories conducted for scientific research:*
   - will be more intensive than management inventories;
   - must explore a large enough range of parameters to develop scientific understanding; and
   - should provide the basis for a fish habitat classification system.

Some general recommendations were tabled by the sub-group. Inventories need to be focused and product-targeted, i.e., designed to answer specific questions. There is a need to understand the link between fish habitat and fish production so inventories can be designed to focus on key ecosystem components. When linkages are in doubt, it will be necessary to design broader inventories to collect the information required to identify those links and key components. There is a need to develop scientifically defensible standards for data collection, analysis, interpretation, storage and handling. There is a need to incorporate inventory needs (e.g., intensity of data collection and analysis) and standards (i.e., methodology and approach) into policy to provide support for the decision-making process.

A final caution was discussed. Data are considered to be a commodity today and may not be easily recovered from non-government collectors. Care must be taken in the wording of partnership agreements with cooperators to ensure that the OMNR will ultimately come into possession of all raw data collected in its jurisdiction.

4.0 REFERENCES

DFO, 1986. The Department of Fisheries and Oceans policy for the management of fish habitat. Dept. Fisheries & Oceans, Ottawa, Ontario. 30p.

OMNR, 1994. Fish habitat protection guidelines for developing areas. Ontario Ministry of Natural Resources, Toronto, Ontario.

OMNR, 1996. Standards for fish habitat classification and mapping in Ontario. Ontario Ministry of Natural Resources, Toronto, Ontario.

5.0 ACKNOWLEDGEMENTS

We want to especially thank the OMNR internal reviewers, Mark Ridgway and Peter Hulsman, for thier assistance in the completion of this report.

APPENDIX 1. ORGANIZING COMMITTEE AND PARTICIPANTS

The number in parenthesis indicates the work group participation.

Organizing Committee
Greg Deyne, OMNR Bracebridge Area ( )
David Evans, OMNR, Aquatic Ecosystems Science, Peterborough (1)
Randy French, OMNR Southcentral Region, Peterborough, (1)
Peter Hulsman, OMNR Fish and Wildlife Branch (2)
Mike Jones, OMNR, Aquatic Ecosystems Science, Peterborough (1)
Steve Kerr, OMNR, Southcentral Science ( )
Nigel Lester, OMNR, Aquatic Ecosystems Science, Peterborough (2)
Ken Minns, DFO, Great Lakes Laboratory for Fisheries and Aquatic Science, Burlington (1)
Serge Metikosh, Senior Biologist, DFO, Fish Habitat Management, Burlington (1)
Ken Cornelisse, Workshop Convener (1)

Participants
Diane Abraham, ESSA, Workshop Recorder (2)
Kim Armstrong, OMNR, Science Development and Transfer Branch, Thunder Bay (2)
Dave Bell, OMNR, Peterborough District (2)
Ian Buchanan, OMNR, Maple District (2)
Steve Burgess, DFO, Policy and Program Planning, Ottawa (1)
Leon Carl , OMNR, Aquatic Ecosystems Science, Peterborough (2)
Robin Craig, OMNR, Midhurst District, Bracebridge (1)
Ken Crutchfield, AEP, Fisheries Management Division, Edmonton (2)
Ed Debruyn, DFO, Fish Habitat Management, Burlington (2)
Nick Degraff, Dept. of Renewable Resources, Fish and Wildlife, Yukon (1)
Warren Dunlop, OMNR, Muskoka Lakes Fisheries Assessment Unit, Bracebridge (2)
Vince Ewing, OMNR, Bancroft District (1)
Kathy Fisher, DFO, Habitat Management Division, Freshwater Institute, Winnipeg (1)
Gareth Goodchild, OMNR, Fish and Wildlife Branch, Peterborough (2)
Lorne Greig, ESSA Technologies Ltd, Workshop Facilitator (2)
John Gunn, OMNR, Aquatic Ecosystems Science, Sudbury (1)
Joel Hunt, MMNR, Fisheries Branch, Winnipeg (2)
Jack Imhof, OMNR, Aquatic Ecosystems Science, Cambridge (1)
John Kelso, DFO, Great Lakes Laboratory for Fisheries and Aquatic Science, Sault Ste. Marie (1)
Rob Mackareth, OMNR, Ctr. for Northern Ecosystem Forest Research, Thunder Bay (1)
Steve McGovern, OMNR, Science Development and Transfer Branch, Timmins (1)
Mike McMurtry, OMNR, Lake Simcoe Fisheries Assessment Unit, Sutton (2)
Ken Mills, DFO, Environmental Science Division, Freshwater Institute, Winnipeg (1)
Rick Orr, SMERM, Fish and Wildlife Branch, Regina (2)
Mike Powell, OMNR, Science Development and Transfer Branch, Bracebridge (2)
Bob Randall, DFO, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Burlington (2)
Mark Ridgway, OMNR, Aquatic Ecosystems Science, Peterborough (2)
Margo Shaw, DFO, Great Lakes Laboratory for Fisheries and Aquatic Science, Sault Ste. Marie (1)
Keith Sherman, OMOEE, Severn Sound RAP Coordinator, Wye Marsh, Midland (1)
Les Stanfield, OMNR, Aquatic Ecosystems Science, Glenora (2)
Evan Thomas, OMNR, Fish and Wildlife Management, Peterborough ( )
Milan Vukelich, OMNR, Timmins District (1)
Donna Wales, OMNR, Fish and Wildlife Management, Peterborough (1)
Neville Ward, OMNR, Kenora District (2)

APPENDIX B. EXTENDED ABSTRACTS

B.1 THE HARSH REALITIES OF FISH HABITAT MANAGEMENT

No Net Loss in the *'Real'* World

Serge Metikosh, Department of Fisheries and Oceans, Fish Habitat Management, P.O. Box 5050, 867 Lakeshore Road, Burlington, ON, L7R 4A6; 905/336-4637; FAX 905/336-4819; METIKOSHS@DFO-MPO.GC.CA

Introduction

The Habitat Management program is responsible for administering the habitat protection provisions of the *Fisheries Act* and implementing Department of Fisheries and Oceans' *Policy for the Management of Fish Habitat.* The concepts of *Productive Capacity* and *No Net Loss* are central to accomplishing this task. Habitat managers are constantly forced to make decisions based on relatively abstract definitions of these terms. Such decisions often appear to be inconsistent and are always difficult to defend when challenged. Setting research priorities to improve methods for assessing productive capacity must take into account the 'non-scientific/non-research' aspects of delivering this program. In planning research priorities, science needs to be aware of the legislation and the policies that drive it, the science needed to support it and the role that operational personnel must play to weave these components into something called habitat management. In the following I provide a brief summary of the habitat protection provisions of *Fisheries Act* and the *Policy for the Management of Fish Habitat.* I will also outline how the legislation and the policy are used together to manage habitat; my impression of our success in achieving No Net Loss; and what I believe to be needed research.

Legislation and Policy

Fisheries Act .

The Fisheries Act is federal legislation dating back to the time of Confederation. It was established to manage and protect Canada's fisheries resources and applies to all fishing zones, territorial seas and inland waters. It is also binding on federal, provincial, and territorial governments and by virtue of the *Doctrine of Paramountcy* it supersedes provincial legislation. The habitat protection and pollution prevention provisions the *Fisheries Act* were included in the early 1970's. These appeared as general prohibitions that forbade the harmful alteration, disruption or destruction of fish habitat and the discharge of deleterious substances. Section 35(1) and section 35(2) specifically deal with habitat protection. It is these two subsections that provide the legal basis for the habitat management program.

According to Section 35(1), the harmful alteration, disruption or destruction of fish habitat (*HADD*) is prohibited. Note that this is a general prohibition for which there is no defense. It simply says anyone harmfully altering disrupting or destroying fish habitat is guilty of an offense. Section 35(2) however does provide a way out. It says that no one violates the prohibition of Section 35(1) if the Minister of Fisheries and Oceans has given them the authority to harmfully alter, disrupt or destroy fish habitat. It is not mandatory for a proponent to have an Authorization to proceed with a project. However, penalties consisting of fines up to one million dollars and/or imprisonment provide proponents with the motivation to seek Authorization.

Policy for the Management of Fish Habitat I

In October 1986 the federal Department of Fisheries and Oceans (DFO) released its *Policy for the Management of Fish Habitat.* The Policy recognized that fish habitats constitute healthy production systems for Canada's fisheries resources and reaffirmed the need for their management and protection. The overall objective of the Policy, was to obtain a ***NET GAIN*** in the productive capacity of fish habitat The objective is reached through achieving the following three goals:

- **Conservation** of existing habitats;
- **Restoration** of damaged habitat; and

- **Development** of new habitats.

Conservation, the first goal towards achieving the net gain objective, requires that the current productive capacity of existing habitats be maintained through the application of the *NO NET LOSS* guiding principle. Under this principle, existing fish habitats are protected while unavoidable habitat losses are balanced with replacement habitat.

Implementation - Link Between the Fisheries Act and the Policy

The requirement under the *Fisheries Act* for authority to harmfully alter, disrupt or destroy fish habitat and the guiding principle of ***No Net Loss*** outlined in the *Policy* are used together to conserve and protect fish habitat.

The first choice is to avoid the harmful alteration, disruption or destruction of fish habitat through mitigation (*actions taken during the planning, design, construction and operation of works and undertakings to alleviate potential adverse effects*). By definition, mitigation measures, if applied successfully, will avoid harmful alteration disruption or destruction of fish habitat (*HADD*). If *HADD* is avoided there is no violation of Section 35(1) of the *Fisheries Act.* No Authorization is required.

However, if mitigation fails to prevent *HADD*, the proponent will require an Authorization from DFO to avoid prosecution under Section 35(1) of the *Fisheries Act.* Authorizations are issued on the condition that the proponent implements measures to compensate (*replace natural habitat or increase the productivity of natural habitat*) for the habitat harmfully altered disrupted or destroyed as a result of the undertaking. Generally, no Authorizations are issued without compensation or in cases where a the loss of a specific habitat type is unacceptable.

The word ***harmful*** is critical to the application of Section 35(1) of the *Fisheries Act*. The alteration and disruption (and presumably destruction) of fish habitat can occur provided it is not harmful. Although fish habitat is defined, by the *Fisheries Act,* there is no clear definition of what constitutes ***'harmful'***. One way of approaching the problem is to interpret the *Fisheries Act* definition of habitat (*"spawning grounds and nursery, rearing, food supply migration and any other areas on which fish depend directly or indirectly in order to carry out their life processes)* as representing those physical features that, in addition to good water quality, provide for the basic life requisites of Food, Reproduction , Cover and the Corridors that connect them. Then, any changes that adversely affect the abilities of the physical habitat to provide these basic life requisites can be considered a ***harmful*** alteration, disruption or destruction of fish habitat. For example, if work on a shoreline changes the physical habitat such that it no longer provides food then that activity can be considered *harmful*. This definition provides a simple way for consistently interpreting the word harmful; one that had some basis in science and can be applied in an operations context.

Generally, habitat managers do not encounter difficulties in determining whether there is fish habitat present or whether a given activity results in a *HADD.* Most difficulties are encountered when assigning a '*value*' to the habitat affected by the undertaking and determining the compensation measures. The value of a particular habitat type or its relative productive capacity is difficult to determine. There are no consistent methods. This becomes even more complicated when issues such as uniqueness, supply and incremental loss become factors. Decisions are often based on a combination of science and intuition. They are rarely quantitative. Similarly, decisions on the appropriate compensation measures and the amount of compensation needed to achieve ***No Net Loss*** are generally made on the basis of professional judgment. In the majority of cases, the compensation measures implemented are a balance between what the habitat biologist considers reasonable and what the proponent is prepared to do. These too are rarely quantitative or defensible. Typical projects appear in the following table:

ACTIVITY	COMPENSATION
• Shore Alteration In Filling Erosion Control	"*Soft*" Engineering Structure Substrate Diversity Shore Line Vegetation Aquatic Macrophytes Slope Modification Island Construction
• Water Management Structures Small Hydro Electric Flood Control	Reservoir Regime Flow Regime Structure Substrate Diversity Channel Modification Fishways
• Water Course Diversion Channelization	"Natural" Channel Design Channel Modification Structure Substrate Diversity Riparian Vegetation
• Water Crossings Bridges and Culverts Pipelines	Channel Modification Riparian Vegetation Structure Substrate Diversity

Such projects generally account for the bulk of the Authorizations issued. For the most part these are small to medium in size and take no more than twelve to sixteen months to complete. It is tempting to suggest that impact of these activities is trivial, yet incrementally they represent a major source of habitat losses. Ignoring the small ones in favor of the large ones will not lead to ***No Net Loss***.

The above projects are also "typical" because a set of compensation measures (albeit untested) is available. There are other projects involving whole lake destruction, conversion or transfer of habitat type (e.g. changing flowing rivers into manipulated reservoirs) or wetland destruction that are atypical in that compensation methods are largely unknown or unavailable.

In the absence of more quantitative procedures, the current approach to making habitat management decisions has worked reasonably well, particularly for the typical projects. However, where there is disagreement on the '*value* " of the habitat or the compensation measures required, conflicts arise between the habitat manager and proponent. Generally there is no simple resolution to these conflicts. Indeed, such disagreements are often resolved either by the courts or at the political level. Either way the result is rarely ***No Net Loss***.

Is No Net Loss Achieved?

The short answer is we don't know. However, it is unlikely that true *No Net Loss of Productive Capacity* has been achieved. At best it is possible that we are approaching ***No Net Loss*** of physical habitat. Nevertheless, it is not possible to determine whether mere replacement of physical habitat actually equates to the replacement of the habitat productivity originally lost. The nagging question yet to be answered is: Does construction of a new channel really replace the productivity of the existing channel lost to development? If achieving No Net Loss is unlikely, what has been achieved by the habitat program? There has been a tangible change in attitude and an increased awareness of the *Fisheries Act* and the importance of fish habitat. Mitigation measures that were at one time rare or appeared only when specified in permits or letters of advice are now routine. Fish habitat considerations have become major components of most project proposals. It is safe to say that since the implementation of the *Policy* the rate of habitat loss has declined.

Problems and Solutions

What are the reasons for being unable to determine if ***No Net Loss*** was achieved? There are many. Some are related to the lack of supporting science; others are due to a lack of appropriate and well defined policies. The ones I feel are the most important are summarized below:

- No consistent scientifically defensible quantitative method to determine Productive Capacity;
- No consistent scientifically defensible quantitative method to assess habitat quality;
- No link between quality and quantity of habitat and fish production;
- Limited number of proven compensation methods;
- No quantitative methods for assessing effectiveness of compensation measures;

The effort directed towards habitat research and policy development needs to be linked in order to resolve these problems. Policy must evolve from the science. Science must develop the tools that will permit habitat managers to make defensible decisions. Policies that guide habitat management decisions must be developed on the basis of the defensible methods provided by science. This is a task for both the research and policy sides of the Department. Specific needs for both are outlined in the following table.

SCIENCE	POLICY
• Develop a quantitative scheme for *NNL* Accounting	• Relate habitat management to sustainable and achievable fish community objectives
• Develop simple but scientifically defensible tools for assessing habitat quality and quantity	• Develop unambiguous scientifically defensible policy to deal with whole lake destruction
• Develop simple but scientifically defensible tools for linking habitat quality and quantity with fish production	• Develop unambiguous scientifically defensible policy to deal with wetland destruction
• Develop simple but scientifically defensible tools for predicting project impacts on productive capacity	• Develop unambiguous scientifically defensible policy to deal with habitat conversions
• Develop simple but scientifically defensible tools for compensating *HADD*	• Develop defensible procedures and policies to rationalize habitat losses with socio-economic benefits
• Develop simple but scientifically defensible tools assessing effectiveness of compensation measures	
•	

Fish Habitat Management In Ontario: New Realities - New Approaches

Evan Thomas, Ministry of Natural Resources, P.O. Box 7000, 300 Water Street, Peterborough, ON, K9J 8M5; 705/755-1906; FAX 705/755-1957; THOMASEV@EPO.GOV.ON.CA

As we move forward with new political and environmental realities there has never been a greater need for a strong scientific basis for the way we manage fish and fish habitat. This workshop could not have been more timely, and based on the participation and the agenda there is every reason to expect a landmark outcome.

The Fish and Wildlife Mission

Since 1996, direction for the fisheries program has come from the new Fish and Wildlife Business Plan. The mission identified for the F&W program, "to ensure that fish and wildlife resources are sustained for present and future generations" reflects the directions provided in Direction '90s, Moving Ahead 1995 and SPOF II. Ensuring long-term health of aquatic and terrestrial ecosystems and working towards rehabilitating those ecosystems which have been degraded are fundamental steps to achieving the mission.

The core business identified for the F&W program recognizes the important role of Science in achieving the mission. Core business components that are particularly relevant to Science are:

- defining "the conservation line" between protection and use of the resource, and;
- generating scientific information and knowledge, including results of research, resource inventory and assessment.

The Federal Fisheries Act

We are still working under federal-provincial roles and responsibilities defined in the Canada - Ontario Fisheries Agreement (COFA) which was drafted ten years ago. This agreement sets out general framework for determining federal-provincial roles and it laid the ground work for a subsidiary agreement on fish Habitat Management. A Memorandum of Intent, signed in March of 1989, is based on the understanding that Ontario accepts the objectives of the Federal Policy for the Management of Fish Habitat and sets out how and what the Habitat Subsidiary Agreement will be, as well as a number of other subsidiary agreements. The Interim Referral Process sets out procedures for when and how proponents are referred to DFO for authorization of projects. Although this process has never been finalized as a signed agreement, it has worked well for the last 8 years.

Ontario and the DFO have been discussing delegation of authority for the alteration of fish habitat since 1994. Fisheries Act amendments, now in 2nd reading, provide enabling legislation that will allow partial delegation of Section 35(2) to the provinces. Regardless of the outcome, habitat decisions are under close scrutiny by environmentalists, therefore all decisions require a strong basis in science.

New Realities

The current Provincial government's agenda is to reduce the size and cost of government and "get out of people's faces", thereby increasing efficiency. Jobs and the economy are the top priorities.

Just about every Ontario ministry is smaller than it was 2 years ago. In the MNR, staff has been reduced by one third. That, coupled with significant reductions in operating dollars means we now have less direct operational capability. The provincial government has promised to reduce unnecessary or inappropriate regulatory measures that effect businesses or institutions. This was started with the red tape review, designed to reduce administrative / regulatory burdens to business. A "less paper/more jobs test" just now be applied to all new legislation, regulations, policies etc.

In order to increase efficiency, the MNR has been forced to focus on core business. The intent is to eliminate duplication of effort among government agencies and to provide a one window approach to clients.

These priorities are reflected in recent legislation amendments. A couple that are relevant to MNR and particularly to habitat management include:

- Bill 26 (the Omnibus Bill) which resulted in major amendments to permitting under the Public Lands Act and Lakes and Rivers Improvement Act. The amendments eliminated the requirement for a Work Permit for many activities (e.g. some cottaging, mining, timber extraction) and from a fisheries perspective, this has reduced our involvement in reviewing many small scale development proposals (small docks, some vegetation removal).

- Bill 20, which was proclaimed in May 1996, introduced changes to the province's municipal planning processes. The intent of these changes is to provide a faster, cheaper planning system and empower local planning authorities with decision making.

Some of the impacts of these changes include increased development with less direct MNR involvement. A very real concern is increased risk to habitat which, in turn drives the need for improved habitat information and guidelines.

New Approaches

Our challenge is to ensure fish habitat protection and rehabilitation in the face of these new realities. To deliver this we will require new approaches and they must be supported with sound science. Examples of new approaches include:

- Forest Management Planning (GIS/NRVIS) and the sensitive fish habitat mapping for planning purposes;
- Municipal Planning - Municipalities are assuming a greater role in decision making. Tools provided to them include standardized mapping and risk assessment guidelines;
- Agricultural Drains - Class Authorization - guidance provided, expansion potential;
- Ecological Land Use Planning - Lands for Life; Resource Based Tourism; Natural Heritage; Forest Allocation - habitat classification system needed; and
- Lakeshore Development Capacity - new models being developed based on cottage lot development impacts.

Roles for Science

Inventory Methods - The planning processes require that we identify significant habitat / aquatic ecosystem values. Data describing habitat locations and features is needed to do this. But first science must describe the basic set of information that is required and the scale and methods of data collection.

Quantitative Methods for Impact Assessment - Our approach to habitat management in the past has generally been subjective, based largely on professional judgment. As development pressure increases we can expect our decisions to be challenged more frequently. To deal with this we need more quantitative approaches for assessment of impacts.

Define the Line - Defining the line between resource use and resource protection is a core business of the Fish and Wildlife program. How can this be accomplished most effectively, given the current pressures to narrow the limits on this line? Habitat inventory methods must be developed with quantitative methods to assess effects of habitat change, defining the line.

To cope with this increasing pressure in an effective way we need science to support our decisions. We must be able to rationalize or defend our decisions on the basis of science, otherwise we will be challenged at every step and loose credibility. Where there is uncertainty, we need capability to reasonably estimate the level of risk associated with the decision.

However, we need to recognize that the cost of using the science must be reasonable and our challenge is to develop tools and approaches that are cost effective yet defensible. We need quantitative and cost effective methods.

B.2 MEASURING FISH HABITAT

A Predictive Methodology for Determining Fish Community and Salmonid Biomass from Habitat Features that is Objective, Quantitative and Efficient.

Les W. Stanfield* and Gord Wichert, Ministry of Natural Resources, R.R. # 9, Picton, ON KOK 2T0; 613/476-3255; FAX 613/476-7131;STANFIELD (or WICHERT)@GLENFISH.COM.CA

Michael Jones, Department of Fisheries and Wildlife, 13 Natural Resources Building, Michigan State University, East Lansing, MI, 48824-1222; 517/353-0647; FAX 517/336-1699; JONESM30@PILOT.MSU.EDU

John Parish, Ortech International, 2395 Speakman Dr., Mississauga, ON L5K 1B3; 905/822-4111 ext. 538; FAX 905/832-1446; JPARISH@ORTECH.ON.CA

Bruce Kilgour, Department of Biology, University of Waterloo, Waterloo, Ont. N2L 3G1;519/766-0795; FAX 519/766-0795; BKILGOUR@MGL.CA

In this study we tested the ability of a point transect habitat survey to predict the fish community and salmonid biomass in southern Ontario streams. Data on the physical habitat features, cover, channel stability, sediment transport, invertebrate communities and temperature was collected from over 200 sites in southern Ontario. At each site crews also collected fish community data. A data base was developed to standardize interpretation of the field data and provide summary information on important variables. A parallel exercise resulted in the development of habitat suitability criteria for each stream dwelling fish species, which was summarized in a data base format. A data base model was developed which summarized the habitat data for each site, and compared its suitability for each fish species and compared relative abundance and biomass to the predicted condition based on the habitat suitability model.

Results to date show greater success in predicting fish guilds (i.e., cold water, benthic dwelling, cover seeking species) than in predicting the presence and relative abundance of individual species comprising each guild. In this presentation we will emphasize the development of the suitability curves for each species and the results of the testing of the model.

Measuring Physical Habitat in Oligotrophic Lakes[1]

Warren I. Dunlop, Ministry of Natural Resources, Muskoka Lakes Fisheries Assessment Unit, RR# 2 Bracebridge, ON, P1L 1W9; 705/645-8747 ext. 5533; FAX 705/645-8372; DUNLOPWA@EPO.GOV.ON.CA

Mark R. Stirling, Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit, Sutton West, ON., L0E 1R0; 905/722-5512; FAX 905/722-3797; SIMCOEFA@EPO.GOV.ON.CA

Central Ontario lakes are characterized by high recreational use and shoreline development of cottage properties. Most of these lakes are low productivity, oligotrophic lakes and are, therefore, sensitive to the effects of shoreline development and cultural eutrophication. The fish communities of these lakes are, for the most part, dominated by lake trout (*Salvelinus namaycush*) and smallmouth bass (*Micropterus dolomieu*).

Much work has been done to quantify the impacts of phosphorus inputs on hypolimnetic habitat volumes for adult lake trout. The littoral zones of these oligotrophic lakes are, however, important to early life stages of lake trout, smallmouth bass, and various life stages of the other centrarchid and cyprinid members of the fish community. Impacts of physical alterations in these littoral zones have been much less studied. In an effort to quantify littoral zone physical habitat on this class of lakes, the Muskoka Lakes Fisheries Assessment Unit (MLFAU), has established a fish habitat inventory program on Lakes Rosseau, Joseph, and Muskoka.

The FAU core data program (OMNR, 1990) recommends classifying shoreline sectors based on the composition of littoral zone macrophytes, shoreline substrate and shoreline vegetation, however there is little detail about methodology. Rather than classify shoreline sectors, the MLFAU has adopted a mapping approach. Littoral zone substrate, natural bottom cover, natural shoreline cover, macrophyte density & composition, smallmouth bass and lake trout spawning locations, and shoreline alterations have been mapped on 1:10 000 OBM map series. Because littoral features are georeferenced on the OBM sheets, data can be entered into a GIS for manipulation and modeling.

The advantages of the MLFAU approach are that features are quantifiable and can be analyzed spatially. There are, however, also some drawbacks to the mapping approach: direct observation of littoral zone substrate is not suitable for eutrophic or stained water lakes; field collection of data is very labour intensive, as is subsequent capture of those data into a GIS. Other approaches need to be explored for more cost effective data capture (e.g. remote sensing). Analysis of previous mapping approaches (e.g. OLS) could also be explored to see whether data are adequate for our purposes.

Some important questions remain. What are the important components of physical habitat to measure? What is an appropriate level of precision to measure habitat, given the low precision with which we often measure fish populations? What are the links between quantity of physical habitat and the productive capacity of fish populations?

Severn Sound Remedial Action Plan Nearshore Fish Habitat Management Program, Inventory of Nearshore Fish Habitat.

Keith Sherman, OMOEE, Wye Marsh Wildlife Centre, P.O. Box 100, Highway # 12, Midland, ON, L4R 4K6; 705/526-7809; 705/526-3294; SSRAP@CSOLVE.NET

Project Team: Robin Craig, MNR, Midhurst District; Cam Portt, Cam Portt and Associates Ltd.; Keith Sherman, MOEE, Severn Sound RAP; Peter Brunette, GIS Consultant

Funding Partners: MNR, RAP Program and Midhurst District;MOEE, Program Development Branch, RAP Program; OMAFRA, GIS Unit; DFO

Severn Sound, an area in southeastern Georgian Bay, was listed as one of 43 Great Lakes Areas of Concern due to problems associated with eutrophication and destruction of nearshore and stream habitat. The Severn Sound Remedial Action Plan (SSRAP, 1994) was developed in response to the Great Lakes Water Quality Agreement between Canada and the United States (as amended, 1987).

One of the principle remedial actions initiated to address impairment of uses in Severn Sound is the enhancement and restoration of nearshore fish habitat through the Severn Sound Nearshore Fish Habitat Management Plan (FHMP). The goal of this plan is 'to identify and priorize nearshore habitat and wetlands ...and provide a method of protecting them' (SSRAP, 1994).

An interim FHMP was released following a series of workshops in 1994. The interim plan was based on the knowledge available at the time and presented at a scale of 1:90,000. A commitment was made to revisit the Fish Habitat Management Plan once a more detailed inventory of nearshore habitats was complete.

The resulting program consists of the following three activities:

1. conduct an inventory of nearshore fish habitat,
2. relate this habitat information to the fish community, and
3. develop and implement a management strategy to protect and enhance fish habitat in the nearshore areas of Severn Sound.

The purpose of the presentation today is to summarize methods of collecting and documenting the nearshore habitat inventory that has recently been completed.

Nearshore habitats were inventoried during the years 1989-1994. A combination of aerial photography and ground truthing through extensive transects was used to determine the habitat and shoreline development. Base mapping consisted of OBM or Canadian Hydrographic Service charts. The base maps were enlarged to a scale of 1:2000 or 1:2400 for use as field maps to record habitat characteristics including: depth contours, substrate, shoreline materials and vegetation.

Each "layer" of information was recorded in the field and later digitized into the appropriate GIS coverage (point, arc, polygon), retaining as much detail as possible. We used ARC/INFO as the GIS program because it was useful for large format output, and it was generally comparable with other systems. Coverages were created for each individual survey year and then consolidated into a single set of coverages for all of Severn Sound. The individual coverages are described as follows:

- Depth contours (arc) - Depth contours of 0.5m, 1.0m, and 1.5m were recorded from the field transects and plotted as arcs. The location of the long-term high-water mark, based on visual changes in vegetation, was also recorded.
- Shoreline materials (arc) - With the shoreline arc, the shoreline materials were also documented. For example, shorelines with gabion or sheet metal walls were recorded separately from natural bedrock shoreline.
- Vegetation (polygon) - Relative percent cover of emergent and submergent plants was recorded as polygons with dominance of plant genera within each polygon.
- Shoreline features (point) - Shoreline development features (building, docks, breakwalls etc.) were recorded as point information along the shoreline.
- Substrate (polygon) - Substrate was recorded as polygons indicating the percent cover of particle size categories, anthropogenic materials (eg. sawdust, slash)

Now that the inventory is complete and available on GIS, the other activities associated with the revised FHMP can proceed, especially working with local planning departments in an appropriate scale and level of detail for planning decisions. In addition, the detailed database can now be easily supplemented or updated for future exercises.

An important lesson learned from the exercise is to choose a single base mapping system for any similar project that will allow simple creation or modification of coverages without problems of matching. This was not possible in our project which started before a unified digital base was available.

B.3 ASSESSING IMPACTS

Field Validation of Habitat Indicators of Productive Capacity.

R.G. Randall, Department of Fisheries and Oceans, Great Lakes Laboratory for Fisheries and Aquatic Sciences, P.O. Box 5050, 867 Lakeshore Road, Burlington, ON, L7R 4A6; 905/336-4496;
FAX 905/336-6437; RANDALLR@DFO-MPO.GC.CA

Field validation of habitat indicators of productive capacity is an important prerequisite to assessing impacts of habitat alteration. Assessments are based on good habitat inventories and the assignment of habitat suitability using a composite of habitat indicators. Links between the habitat indicators and fish utilization and productivity must be clearly defined and scientifically defensible. Habitat measures should be mappable and not too detailed: the key habitat indicators are water depth, cover and substrate type. All three attributes have been used as indicators of habitat suitability in both freshwater (lake and river) and marine coastal areas, confirming their status as key an generic indicators. In near shore areas of the Great Lakes, exposure to wind fetch also influences fish distribution, and is an important indicator.

The validity of using substrate, cover and other habitat attributes as surrogates of productive capacity has been investigated using field data from hear shore areas of the Great Lakes. Survey transects followed the 1.5 m depth contour: electrofishing surveys were conducted to determine fish species richness, composition and abundance; habitat surveys were conducted to determine substrate type, macrophyte density (% bottom cover), water clarity, littoral slope, temperature, and shoreline characteristics. A large number of samples have been collected, covering altered (Areas of Concern) and unaltered habitats, exposed and unexposed shorelines, and natural wetlands.

Fish:habitat links have been investigated using both univariate and multivariate statistical methods (regression, discriminant analyses, principal components and clustering). Several fish measures have been used, individually or collectively, as dependent surrogates of fish production, including species presence:absence, species richness, density, fish size and biomass. The analyses have been instructive in showing that : 1. Links between habitat features and fish utilization of near shore habitats in the Great Lakes are discernible. 2. several habitat attributes are useful indicators of fish distribution and density, including substrate type, cover (particularly submerged macrophytes), fetch (expose to wind) and water quality (phosphorus concentration, temperature). Statistically significant models have been identified, validating that habitat indicators can be used. The precision of the predictive models is only moderate (R2 about equal to or less than 0.60; power of resolution of about 2 or 3 groups). These results are consistent with the results and accuracy of fish/habitat modeling in other habitats (e.g., fluvial systems). Location dependent responses, collinearity and non-linear relationships between fish and habitat variables are factors that must be considered when studying links between fish measures and habitat.

Analysis is ongoing to improve the accuracy of the predictive models, to identify generic models that will be useful to habitat managers, and to confirm the important habitat indicators of productive capacity. Field validation of habitat indicators in near shore areas of the Great Lakes will continue to be a research priority.

An Experimental Study of the Effects of Loss of Reproductive Habitat on the Behavior and Recruitment of Lake Trout

John M. Gunn, Ministry of Natural Resources, Aquatic Ecosystems Science, Cooperative Freshwater Ecology Unit, Laurentian University, Sudbury, ON, P3E 2C6; 705/675-4831; FAX 705/675-4859; JGUNN@NICKEL.LAURENTIAN.CA

We are conducting a habitat-manipulation experiment to test the effects of progressive loss of reproductive habitat on the behaviour and recruitment of lake trout (Salvelinus namaycush). A 67 hectare research sanctuary lake, Whitepine Lake (47°17', 80°50'), located 90 km north of Sudbury, Ontario, is being used for this experiment. The lake is a single basin (max. depth 22 m) headwater lake (elevation 412 m) with a 4.7 km shoreline. Our small field station is the only building within a 328 hectare forested (an early successional forest from a 1975 fire) watershed. The lake has been closed to angling since 1980 and few human disturbances occur at this remote location. The present fish community is dominated by a dense population of native lake trout (approximately 1000 adults; about 10 kg/ha). Yellow perch and a few species of cyprinids make up the remainder of a very simple fish community.

This experiment began in 1991 by mapping all of the traditional spawning sites used by the lake trout. Spawning fish were located by cruising the entire shoreline of the lake each night of the spawning season (10-20 days in October) and spotting, with the aid of flashlights, aggregations of lake trout. Identified sites were later confirmed by examining the substrate for the presence of deposited eggs. In 1991 and 1992 egg deposition rates were measured using funnel collectors buried in the substrate (Gunn 1995).

To perform the habitat manipulation we temporarily removed reproductive habitat by covering known spawning sites with plastic tarpaulins. The attached table describes the timing of these manipulations. The covers were left on the sites throughout the year(s). Once access to all of the historic sites was eliminated in 1994, we proceeded to cover all the new (Alternate 1 sites in attached figure) sites that displaced fish had selected. These alternate sites were then eliminated as well in 1996, and fish were again forced to select new sites (creating Alternate 2 sites). To track the effects of these changes we conducted detailed studies of annual abundance, age and size structure of the population, and the timing, location and extent of spawning site use (McAughey and Gunn 1995, Gunn et al. 1996). Physical characteristics of all egg deposition sites were measured and mapped using GIS. Site characteristics are described in an attached table.

We are only now (1997) reaching the period when our sampling program can detect possible effects of the habitat manipulation on lake trout recruitment (i.e. because of the difficulty in sampling young fish), but the study has already produced some surprising results. First we were surprised by the fact that lake trout selected sites with such small substrate (<10 cm) and that so little reproductive space appeared to be needed. The total surface area of the historic egg deposition sites was only about 40 m^2. This surface area requirement remained about the same during the first stages of the manipulation, but expanded rapidly in 1995 and 1996 when the fish selected (or were forced to select) what appeared to be much poorer quality sites on the northeast shore of the lake - sites that were heavily infilled with sand. Surprising too was the fact that displaced fish did not readily move to existing spawning sites when historic sites were still available in 1992 (McAughey and Gunn 1995), but rather they selected a large number of new sites, many of which were very tiny (<0.5 m^2).

Prior to this experiment we would not have guessed that there were so many potential spawning sites in Whitepine Lake. The lake has long stretches of exposed bedrock and many areas covered with silt and organic detritus. In the previous ten years we had not observed lake trout using any but the seven historic sites. Only when we recognized that the fish would use small patches of small substrate was it clear that "usable habitat" was indeed widespread (Gunn et al. 1996). However, we do not know whether these alternate sites will actually produce enough fry to maintain recruitment.

The Whitepine Lake experiment needs to be continued until an impact on recruitment can be detected. The experiment should also be replicated elsewhere and tested under varied conditions (e.g. exploited populations, complex fish communities, presence of major egg predators, etc.).

Spawning Site Characteristics:

Year	Number of sites	Total Area (m^2)	Site Area (m^2) _(range)	Site Depth (m) _(range)	Dist. from shore(m) _(range)
1991 Historic	7	40.0	5.6(0.5-21.0)	0.4(0.3-1.5)	1.6(0.4-4.5)
1992 Historic	3	34.0	11.0(4.0-21.0)	0.4(0.3-0.8)	1.8(0.4-4.5)
$Alternate_1$	12	40.8	3.4(0.5-6.0)	0.6(0.2-2.0)	not available
1993 Historic	1	21.0	21.0	0.3	1.0
$Alternate_1$	17	43.9	2.5(0.5-6.0)	0.6(0.1-1.2)	not available
1994 $Alternate_1$	41	40.3	0.9(0.1-5.0)	0.6(0.1-2.0)	1.3(0.5-4.0)
1995 $Alternate_1$	44	82.7	1.9(0.2-10.0)	0.5(0.3-0.8)	0.5(0.3-0.9)
1996 $Alternate_2$	39	195.3	5.0(0.9-42.0)	0.4(0.1-1.5)	1.1(0.4-2.7)

Amount (%) of Habitat Removed:

Year	Historic Sites	Alternate Sites
1991	0	
1992	15	
1993	50	
1994	100	
1995	100	
1996	100	100
1997	100	100
1998	0	0

References

Gunn, J.M. 1995. Spawning behaviour of lake trout: effect on colonization ability. J. Great lakes Res. 21 (Suppl. 1): 323-329.

McAughey, S.C. and J. M. Gunn. 1995. The behavioral response of lake trout to a loss of traditional spawning sites. J. great lakes Res. 21 (Suppl. 1): 375-383.

Gunn, J.M., M. Conlon, R.J. Kirk and S.C. McAughey. 1996. Can trained observers accurately identify lake trout spawning habitat? Can. J. Fish Aquat.Sci.(Suppl. 1) 53:327-331.

Effects of Development on Lake Trout Habitat: the Offshore.

David O. Evans, Ministry of Natural Resources, Science Development and Transfer Branch, Aquatic Ecosystems Science Section, 300 Water Street, Peterborough, ON, K9J 8M5; EVANSDA@EPO.GOV.ON.CA; Chris Davis, Dept. of Biology, York University, Toronto, ON M3J 1P3.

This paper develops a framework for evaluating the effects of phosphorus loading on the offshore habitat of lake trout in Ontario lakes. Three aspects of this problem were addressed: 1) habitat use by young-of-the-year and juvenile lake trout in the deep offshore zone; 2) a case study of phosphorus loading and fish habitat loss in Lake Simcoe, Ontario; and 3) the lake trout metabolic niche and development of a habitat objective for lake trout based on scope-for-activity. A remote operated vehicle (ROV) was used to determine the distribution and densities of lake trout in three lakes, Source and Victoria lakes near Algonquin Park in south-central Ontario, and Squeers Lake, in northwestern Ontario, west of Thunder Bay. Depth-stratified random surveys were conducted in each lake during mid to late summer (July-September). Line transect, and distance sampling methods were used to estimate fish densities. YOY lake trout were found at 10-25 m in Source and Victoria lakes and 15-25 m in Squeers Lake. Juveniles (1-4 yr) were observed at 10-35 m in Source and Victoria lakes and 20-35m in Squeers Lake. Juveniles were also observed at 10-15 m during the night suggesting either movement to shallower depths or greater visibility at shallower depths at night. Temperatures inhabited were 6-8 and 6-9 C for YOY and juvenile lake trout, respectively. Dissolved oxygen conditions inhabited by YOY varied from 4-9 mg/L with highest densities at 6-8 mg/L in Source and Victoria lakes. In Squeers Lake YOY were observed at 3.5-6 mg/L. Similarly juvenile lake trout were observed at 3.5-10 mg/L with highest densities at dissolved oxygen concentrations >6 mg/L in Source and Victoria lakes. In Squeers Lake juvenile lake trout were observed at 3.0-5.5 mg/L. Maximal densities of YOY were >300 fish/ha and 100 fish/ha at 5-10 m at night in Source and Victoria lakes, respectively. Nighttime observations were not available for Squeers Lake, but maximal daytime densities were 10 fish /ha at 15-20 m. Maximal densities of juvenile lake trout were 200 fish/ha at 10-15 m at night in Source Lake, 40 fish/ha at 20-25 m during the day in Victoria Lake and 60 fish/ha at 25-30 m during the day in Squeers Lake. Adult lake trout were observed only rarely during these surveys therefore direct comparisons with YOY and juvenile distributions were not possible. Published observations suggest that adults prefer temperatures from 8-12 C and in general are probably distributed at shallower depths than the YOY and juveniles. Use of the deep hypolimnion by YOY and juvenile lake trout necessitates protection of this habitat and focuses environmental concern on the linkages between watershed disturbance, phosphorus loading, algal production and hypolimnetic dissolved oxygen conditions.

A case study of the Lake Simcoe watershed provides clear evidence of the linkages between watershed disturbance, phosphorus loading and loss of fish habitat. A twenty year time series of temperature and dissolved oxygen data was used to assess recent changes in the hypolimnetic summer habitat of lake trout in Lake Simcoe. Phosphorus load to the sediment increased from an annual background of about 30 metric T/yr prior to European settlement (about 1800) to 75 T/yr for the period 1975-1985 (Johnson and Nicholls 1989). The increased loading was initially due to deforestation and agricultural practices, and more recently to urbanization. Since 1960 the point source load of soluble P increased 4-5 fold as human population in the basin tripled from 100,000-300,000 residents. Vertical temperature and dissolved oxygen profiles were collected biweekly at 33 and 38 m in the main basin and Kempenfelt Bay, respectively, from June 1 to September 29, 1975-1993. Volume-weighted, temperature-corrected hypolimnetic dissolved oxygen concentrations from August 30-September 20 declined from 4.5 mg/L in 1975 to 2.0 mg/L in 1993. Within year oxygen depletion rates from June 1-September 19, 1975-1993 also increased significantly from 0.06 to 0.09 mg/L/day. From August 30-September 20, 1975-1993, 100% of the preferred thermal habitat (8-12 C) having >7mg/L dissolved oxygen was lost, as was 20-80 of the habitat having >3 mg/L dissolved oxygen. These concentrations correspond to the incipient response and incipient lethal thresholds for salmonid fishes. Coincidental with these changes in water quality major and persistent population declines occurred in lake trout, lake whitefish and lake herring during the 1960s, 1970s and 1980s, respectively.

The lake trout metabolic niche is characterized by the scope-for-activity, metabolic envelope within the species zone of thermal tolerance. Scope-for-activity is the difference between standard and active metabolic rates and defines the energy available for all locomotory activities and associated behaviour, including feeding , avoidance of predators, spawning and migration. Published metabolic data for lake trout (Gibson and Fry 1954) was used to determine the metabolic scope-for-activity and the ambient dissolved oxygen thresholds at ¼, ½, and ¾ scope thresholds. Comparisons with published metabolic data for sockeye salmon indicated that most comparable routine activities of lake trout would be satisfied by attainment of ¾ metabolic scope. Ambient dissolved oxygen corresponding to ¾ scope-for-activity of lake trout at 8-16 C was 7.0 mg/L. This value was proposed as the appropriate dissolved oxygen objective for conservation and sustainability of wild lake trout stocks. Existing published models can be used to set P loads to achieve this objective in lakes inhabited by lake trout. Failure to achieve this objective has practical implications including lost fish production and associated legal ramifications under the fish habitat section of the Fisheries Act of Canada. Ethical concerns, including the obligation of humans to protect and conserve healthy environments for other species, also require consideration within the broader management context.

How Much Sampling is Needed to Detect a Change in Fish Abundance?

Nigel P. Lester, Ministry of Natural Resources, Science Development and Transfer Branch, 300 Water Street, Peterborough, ON, K9J 8M5; 705/755-1548; FAX 705/755-1563; LESTERNI@EPO.GOV.ON.CA

Warren I. Dunlop, Ministry of Natural Resources, Muskoka Lakes Fisheries Assessment Unit, RR# 2 Bracebridge, ON, P1L 1W9; 705/645-8747 ext. 5533; FAX 705/645-8372; DUNLOPWA@EPO.GOV.ON.CA

Cam C. Willox, Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit, Sutton West, ON., L0E 1R0; 905/722-0251; FAX 905/722-3797; SIMCOEFA@EPO.GOV.ON.CA

Index fishing programs are used to evaluate the effects of habitat change and other human impacts on the abundance of fish. To test whether a fish population responds to a change in habitat, sampling must be done before and after the change occurs. In planning the study, one must decide: 1) what index fishing method will be used; 2) how much sampling will be done each year; and 3) how many years of sampling (at this intensity) will be needed to detect a change. Several index fishing standards have been developed by the Fisheries Assessment Unit network for surveys of Ontario lakes and the data collected by the network are being used to develop sample size guidelines. In this paper, we show how these sampling requirements can be determined from historical data. We demonstrate the approach and discuss implications using data from Nearshore Community Index Netting, a standardized trapnetting method.

This method uses 1.8 m trapnets to sample juvenile and adult life stages of several nearshore species (e.g. smallmouth bass, rock bass, pumpkinseed, white sucker) during the late summer months. Nets are set overnight at randomly determined sights and relocated daily. Sampling records the number caught by species and obtains basic biological data (e.g. length, weight, age, etc.). To calculate sampling requirements, we obtained 3 years of data from each of 5 lakes. We calculated mean catch and variance of catches (among-sites) for each year on each lake. Because variance increased with the mean we used a logarithmic transformation to standardize variance. We then calculated (for log-catch data) among-site and among-year variance components and used the sample size formula for a t-test to calculate how many years (n) and sites per year (m) are needed to detect a specified magnitude of change in abundance.

The results indicate that, for m=45 sites per yr, 7 yr of sampling before and after the perturbation would be needed to detect a 2-fold change in abundance of any species (1-tailed t-test, alpha = 0.05, beta = 0.10). This sampling requirement cannot be greatly reduced by increasing the number of sets per yr because the among-year variance component is large. Evaluating the effects of habitat changes within a shorter period would require improvements in sampling method that reduce the annual variation in catchability.

If similar habitat changes (and response) occur in several lakes, the number of years needed to detect an effect could be reduced by analyzing lakes as a group rather than individually. The approximate number of years per lake is simply the single lake requirement divided by the number of lakes and rounded up to the next integer. We show that increasing the number of lakes not only reduces the study length, but may do so without greatly increasing costs. When appropriate, the most effective way to evaluate a habitat alteration (or other factor) is to study several lakes at a relatively low sampling intensity (i.e. sites per year).

B.4 APPROACHES TO MANAGING FISH HABITAT

Guide to Fish Habitat Protection

Donna Wales, Ministry of Natural Resources, Fisheries, P.O. Box 7000, 300 Water Street, Peterborough, ON, K9J 8M5; 705/755-1904; FAX 705/755-1957; WALESD@EPO.GOV.ON.CA

Background

Reforms to Ontario's land use planning system, introduced under the Planning Act on May 22, 1996 give municipalities greater authority in decision making around fish habitat. To assist municipal staff with their new role, MNR has agreed to provide them with fish habitat information, and the tools and techniques for interpreting this information. The maps and these interpretive tools will help to ensure that development does not result in harmful alteration of fish habitat.

Fish Habitat Mapping Standards

Fish habitat mapping standards were developed in June 1996 and distributed to all District offices (Standards for Fish Habitat Classification and Mapping in Ontario, July 1996). The mapping standards include two levels of mapping, Broadscale and Detailed.

Guide to Fish Habitat Protection

The Guide to Fish Habitat Protection interprets the fish habitat maps. A draft of the Small Scale Development Chapter is now complete. The Guide and the habitat maps will assist municipal staff, proponents and others in assessing the risk of damage to fish habitat for development proposals submitted under the Planning Act.

A Web-based application of the Guide will also be developed. The computer application facilitates using the Guide by providing an interactive easy to use product. It is in its early stages of development but a demo has been prepared.

The purpose of the presentation is to outline the broadscale and detailed habitat mapping standards and using a case study, illustrate the Web-based interactive demo of the Small Scale Development Chapter.

Using Science for Fish Habitat Management

Charles K. Minns, Department of Fisheries and Oceans, Great Lakes Laboratory for Fisheries and Aquatic Sciences, P.O. Box 5050, 867 Lakeshore Road, Burlington, ON, L7R 4A6; 905/336-4874; FAX 905/336-6437; MINNSK@DFO-MPO.GC.CA

The federal Fisheries Act and Policy for Fish Habitat Management provide the basic impetus for using science to guide decision-making. Use of science in renewable resource management requires that quantification be an essential feature of decision-making. Two aspects of DFO's efforts to develop scientific, quantitative tools for fish habitat management are described: A) The Net Change Equation framework and B) Defensible Methods of Assessing Fish Habitat.

The Net Change Equation framework provides a quantitative basis for assessing net gain or loss of productivity of fish habitat, a requirement stated in the guiding principle of the federal policy. The equations distinguish between areas of habitat loss and habitat modification. Loss areas are charged at the full productive capacity rate, i.e., the maximum natural productivity rate, while modified areas are charged, or credited, at the difference of the productivity rates prevailing now and after project completion. The equations have important implications both for the choice of compensation ratios when trading improvements for losses, and for setting overall conservation targets and development limits.

'Defensible Methods' represents both conceptual and practical approaches to the management of proposals to alter, disrupt, destroy, and create fish habitat on a day to day basis. Conceptually 'Defensible Methods' represents the requirements for use of science: consistent, systematic, and reproducible methodologies; testable hypotheses and predictions; quantification; transparent documentation and reporting. Those wanting to change habitats and those charged with managing such changes want to know up-front what the specific requirements are for submitting a proposal for assessing and obtaining approval to proceed. This can allow the burden of proof to be shifted to proponents. Where significant uncertainty as to development effects remains, the precautionary principle can be usefully applied and the priorities for new research identified. Qualitative, subjective approaches are inherently indefensible and vulnerable to undue influence and pressure. Practically 'Defensible Methods' is a tool for assessing the effects of physical habitat changes on the productivity of lacustrine fish assemblages in the Great Lakes. As implemented in a Windows-based software package, suitability indices are assigned to habitat units based on the depth/substrate/cover attributes present and aggregations of the documented habitat requirements of fish assemblages. Habitat requirements for three life stages are considered now: spawning, young-of-the-year, and adult. Fish species can be grouped and groups weighted differently in accordance with local fishery objectives. Productivity units are the product of area and suitability. and are the currency of pre-/post- impact assessments. The habitat-specific suitability assignments can be validated via systematic fish:habitat assessment studies. Defensible Methods can be extended to riverine and marine ecosystems, and new productivity metrics can be added. Although developed for pre/post development assessments on a site-specific basis, Defensible Methods can be used to evaluate the productivity of whole ecosystems, thereby providing a basis for area fish habitat management in support of sustainable fishery objectives.

The Net Change Equations and Defensible Methods, along with other, similar science-based tools, provide a sound basis for the conservation and protection of fish habitats in Canada. Such tools can help stop the steady net loss of productive fish habitat and support the restoration and repair needed if natural, self-sustaining fisheries are to thrive.