STANDARD METHODS GUIDE

FOR FRESHWATER FISH AND FISH HABITAT SURVEYS IN NEWFOUNDLAND AND LABRADOR: RIVERS & STREAMS

Canada

STANDARD METHODS GUIDE FOR FRESHWATER FISH AND FISH HABITAT SURVEYS IN NEWFOUNDLAND AND LABRADOR: RIVERS & STREAMS

By

Darrin R. Sooley[1]
Eric A. Luiker [2]
Marvin A. Barnes[1]

March 1998

[1] Department of Fisheries and Oceans
Marine Environment and Habitat Management Division
Science Branch
P. O. Box 5667
St. John's, Newfoundland
AIC 5X1

[2] Jacques Whitford Environment
607 Torbay Road
St. John's, Newfoundland
A 1 A 4Y6

The correct citation for this document is:

Sooley, D. R., E. A. Luiker and M. A. Barnes. 1998. Standard Methods Guide for Freshwater Fish and Fish Habitat Surveys in Newfoundland and Labrador: Rivers & Streams. Fisheries and Oceans, St. John's, NF. iii + 50 pp.

Published by:

Department of Fisheries and Oceans
Science Branch
P. O. Box 5667
St. John's, NF
AIC 5X1

[ISBN 0-662-26703-6]

Catalogue No. Fs 53-3/1998E

Printed in Canada on recycled paper

Printed by Sterling Press

TABLE OF CONTENTS

Page No.

LIST OF TABLES

Page No.

LIST OF FIGURES

ACKNOWLEDGMENT

The following guide was developed by Jacques Whitford Environment Limited under a contract funded by Marine Environment and Habitat Management Division, Department of Fisheries and Oceans. The authors wish to thank personnel from Jacques Whitford Environment Limited - Bruce Bennett - and Department of Fisheries and Oceans - Dr. John Bratty, David Scruton, A1 Pitcher, Leon King, Frank Walsh, Randy Blundon and Ron Burton - who assisted in the development of this guide.

1.0 INTRODUCTION

1.1 Guideline Rationale

The Department of Fisheries and Oceans (DFO) participates in the environmental assessments and reviews of proposed undertakings that have the potential to impact fish and fish habitat. During these environmental assessments and reviews, DFO often makes standard requests to project proponents for information to allow the potential impacts on fish and fish habitat to be assessed, and to determine whether the proposed project will likely result in the harmful alteration, disruption or destruction of fish habitat (HADD). Depending on the nature of the proposed undertaking, a project proponent may be requested to undertake any or all of the following:

- surveys to determine the quantity (amount) and quality (type) of fish habitat that may be affected by the proposed undertaking;
- field surveys to determine habitat use by fish species present;
- fish disease profiles;
- determine and monitor baseline mercury and heavy metal levels in fish;
- design intake screens for water intake structures to prevent fish entramment; and
- describe water withdrawal requirements and potential implications on the flow regime in the system.

The *Fisheries Act* defines fish habitat as those parts of the environment "on which fish depend, directly or indirectly, in order to carry out their life processes". Preferred habitat varies amongst fish species, and different species can be found in particular habitat types at different times of the year. Fish habitat types can be classified in various ways, however the most general classification system is based on fish life history. Habitat types included in this general classification are spawning, rearing, nursery, overwintering and migration routes.

Section 35(1) of the *Fisheries Act* prohibits any work or undertaking that results in HADD of fish habitat. If a project is likely to result in HADD, then DFO must issue an authorization for HADD pursuant to Section 35(2) of the *Fisheries Act,* and ensure that a plan for compensation for harmfully altered fish habitat is developed by the proponent in accordance with the *DFO Policy* for *the Management* of *Fish Habitat* (1986) and the no net loss guiding principle. Prior to issuing the Section 35(2) *Fisheries Act* authorization, DFO is obligated to complete an environmental assessment of the project in accordance with the *Canadian Environmental Assessment Act (CEAA).* It is important for the project proponent to provide the information required in order to allow DFO to assess the potential impacts of the proposed development on fish and fish habitat and to finalize the required Section 35(2) authorization.

It is often not clear to proponents what information requirements have to be met in order to provide DFO with sufficient information to assess the potential impacts of a proposed project. DFO staff are often requested by project proponents to provide general "how to" advice to help facilitate the conduct of surveys that have been requested by DFO.

1.2 Guideline Organization

This Standard Methods Guide is intended to provide project proponents with an overview of the DFO project review process, information requirements for the assessment of potential impacts on fish and fish habitat, and procedures for collecting required information. The review process and information requirement chapters should be reviewed.by project developers so as to gain an appreciation for both the process followed by DFO when reviewing a project proposal and, the information required for such a review.

Section 1 of this document provides a brief overview of the purpose and organization of the document, and a general description of how the document should be used by the project proponent.

Section 2 reviews the project review process followed by DFO; including when a Section 35(2) authorization is needed, and the interrelationship between the requirement for an authorization, the requirement for review as per CEAA and the requirement for habitat compensation in accordance with DFO Policy Management of Fish Habitat.

Section 3 details the types of information that may be required in the project review process.

Section 4 is a guide to the standard methods recommended by DFO for the collection of required fish and fish habitat information. Each section contains a brief discussion of the types of information that can be derived from the various surveys or studies, a general outline of the suggested methodology for conducting the collection of information, an outline of the way in which information should be presented in a submission to DFO and a list of references that can be consulted for further information. The recommended standard methods outlined in this document for the most part (as indicated by the title) are intended for use in fluvial freshwater habitats i.e. rivers and streams. It should be noted that it is authors' intentions to publish a "companion" document describing the recommended standard methods for fish and fish habitat surveys in lacustrine freshwater habitats i.e. lakes and ponds. In the interim proponents are encouraged to consult with DFO staff prior to the conduct of fish and fish habitat surveys within lakes and ponds to ensure acceptable methods are being utilized.

Section 5 provides a list of DFO personnel in various regions of the province that can be contacted for further information and guidance with respect to review of proposed projects.

2.0 THE PROJECT REVIEW PROCESS

The project review process (Figure 2.1) begins when a project proposal and supporting fish and fish habitat information is submitted to DFO. Following a review of this submission, DFO determines whether the proposed project will result in HADD. If DFO determines that HADD of fish habitat will not occur or that it can be avoided through mitigation, no Section 35(2) authorization is required. In such a case a Letter of Advice will be issued to the proponent confirming that a Section 35(2) authorization is not required and, identifying measures that could be implemented by the proponent to avoid harmful effects to fish habitat.

If DFO determines that the project will result in HADD, the project will require issuance of a Section 35(2) *Fisheries Act* authorization. Prior to the issuance of this authorization, an assessment in accordance with the *Canadian Environmental Assessment Act (CEAA)* must be completed and a habitat compensation plan must be developed and submitted to DFO. It is the proponent's responsibility to develop a compensation plan, and the proposed plan will be reviewed by DFO. Guidance for the preparation of fish habitat compensation plans is provided in Section 2.3. Proponents are encouraged to consult with Regional DFO personnel when preparing a compensation proposal. Following the negotiation and signing of a compensation agreement between the proponent and DFO, a formal Section 35(2) Authorization is issued by DFO.

It should be noted that the review process requires in-depth reviews of the existing environmental conditions and predicted impacts of a proposed project on fish and fish habitat. Therefore, the proponent should be aware that authorization/approval cannot be expected within a matter of weeks.

2.1 How Information is Used to Make a HADD Determination

The sequential decision-making process for determining whether a Section 35(2) *Fisheries Act* authorization is necessary and should be granted is comprised of four essential questions about the nature of a proposed project:

a. *Is fish habitat present at the project site or in the area to be affected by the project?*

   The answer to this question frequently depends upon the presence of a fishery which the affected habitat supports either directly or indirectly. The specific nature of the fishery (e.g. whether it is commercial, recreational, or subsistence) is not a consideration. In addition, it is not necessary that the fishery be active, although there should be a reasonable potential for a fishery based upon the habitat which may be affected by the project. The collection of this baseline information on the presence of fish and fish habitat is the focus of several of the following sections of this document.

b. *Does the project have the potential to affect fish habitat adversely?*

This question is answered by considering the biophysical pathways through which the proposed project activities may affect fish habitat.

c. *Can the impacts of the project be fully mitigated?*

This step asks whether a HADD or effects on fish can be avoided by making changes in the project design or through the implementation of mitigative measures. This technical question is essentially the same as question b) except that it evaluates modifications to the project design and the implementation of applicable mitigative measures.

d. *If the answer to question c) is no, or if mitigation can only be partly achieved, then: Is compensation an appropriate option?*

The answer to this question will involve consideration of the fisheries management objectives for the affected area and the technical feasibility of compensation being successfully implemented. If it is determined that compensation is appropriate, the proponent is advised that a compensation proposal should be submitted to DFO.

The project review (assessment) process is summarized in Figure 2.1. If no HADD exists and authorization (under Section 35(2) of the *Fisheries Act)* is not required, a Letter of Advice will be issued to the proponent confirming that a Section 35(2) authorization is not required and identifying measures that could be implemented by the proponent to avoid harmful effects to fish habitat.

If effects cannot be fully mitigated, then HADD will result from the project, a Section 35(2) *Fisheries Act* authorization will be required, and fish habitat compensation must be developed. Figure 2.2 summarizes the project review process including the determination of HADD and subsequent steps required in accordance with the *Fisheries Act* and *CEAA*.

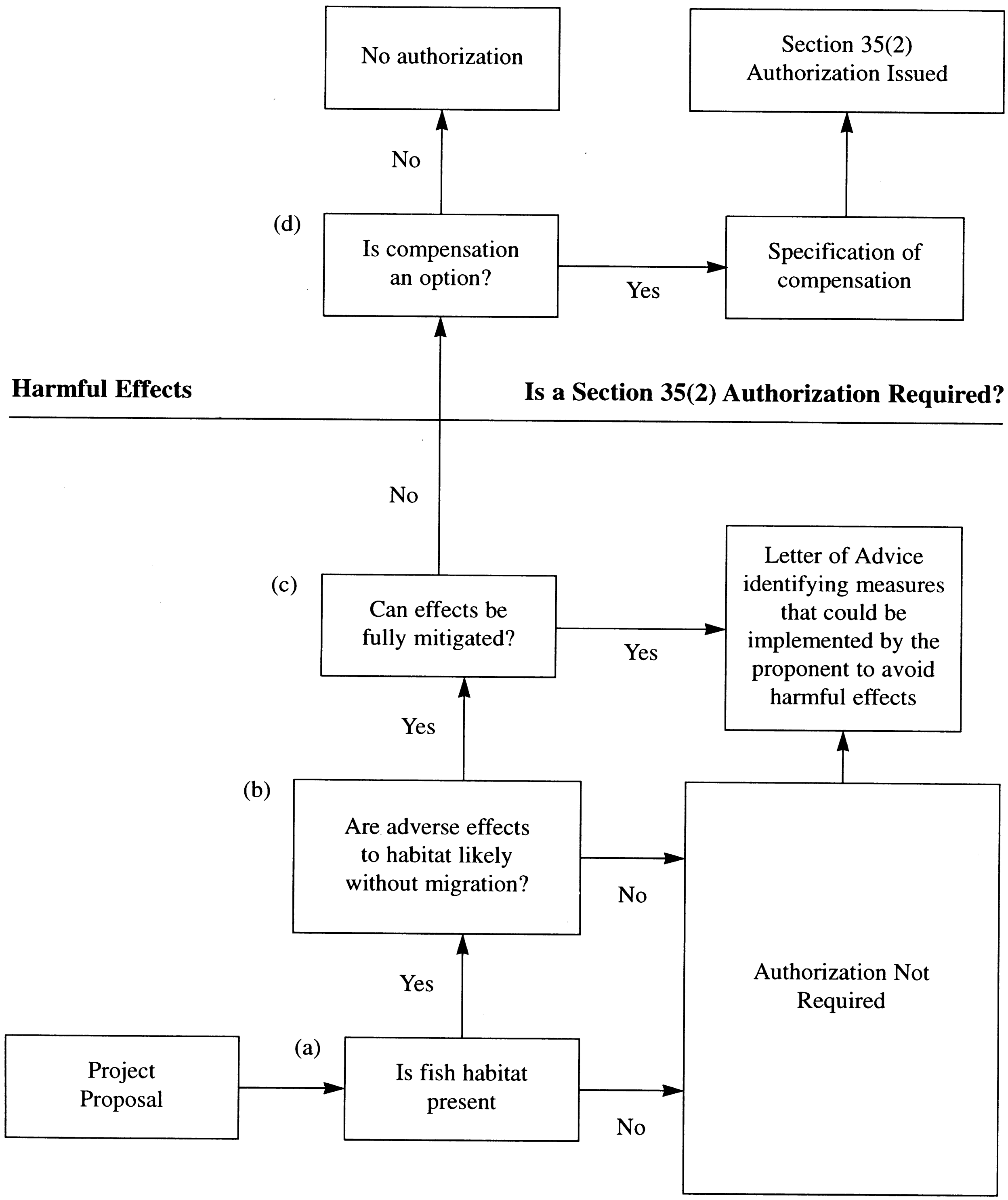

Figure 2.1 Steps in the Project Review Process

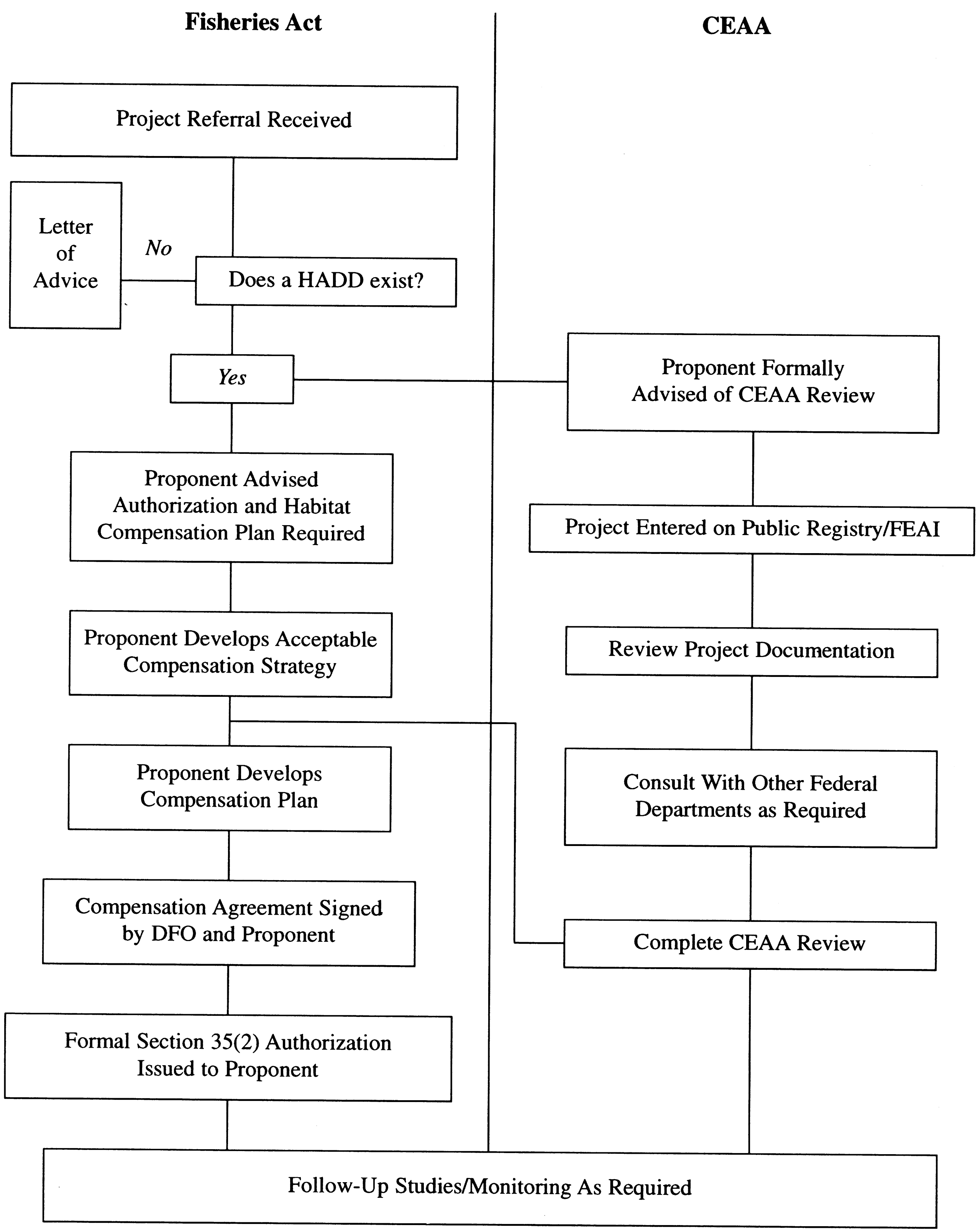

Figure 2.2 HADD Determination/Compensation and CEAA Review Processes

2.2 Relationship with the *Canadian Environmental Assessment Act (CEAA)*

If DFO determines that HADD exists for a proposed project and that a Section *35(2) Fisheries Act* authorization is required, then the requirement to conduct an assessment as per *CEAA is* triggered. The CEAA environmental assessment must be completed prior to issuing the Section *35(2) Fisheries Act* authorization. Figure *2.2* details the relationship between Section *35(2)* authorization under the *Fisheries Act* and environmental assessment review under the *CEAA*. The *CEAA* assessment and the *Fisheries Act* requirements (authorization/compensation) occur simultaneously. As a general rule, a conclusion of significant impact on fish habitat under *CEAA* would be reached in situations where HADD would occur and compensation was not feasible. For further information on the requirements of *CEAA* and the roles of the proponent and Federal authorities (i.e., DFO) during a *CEAA* assessment please refer to *"Responsible Authority's Guide to The Canadian Environmental Assessment Act"* available from the Canadian Environmental Assessment Agency.

2.3 Habitat Compensation Guidelines

The objective of the *Department of Fisheries and Oceans (DFO) Policy for the Management of Fish Habitat is* to achieve an overall net gain in the productive capacity of fish habitats, either freshwater or marine. In order to prevent further erosion of the productive capacity of existing habitat the `No Net Loss' (NNL) guiding principle will be applied to all project developments when evaluating potential impact(s) to fish habitat. Under this guiding principle DFO will work with the proponent to design projects in such a way that fish habitat productive capacity is maintained. Where this is not possible, unavoidable losses in habitat productive capacity are to be evaluated on a case-by case basis and compensated for by habitat creation or restoration.

Once DFO determines that a project will result in impacts resulting in harmful alteration, disruption, or destruction of fish habitat, a compensation plan will become a requirement as part of the authorization issued under Section *35(2)* of the *Fisheries Act.* It is the responsibility of the proponent to provide DFO with an acceptable compensation strategy followed by a detailed compensation plan including compensation measures to be undertaken, monitoring strategy to determine effectiveness, and details on the implementation of any corrective measures.

Guidance in the preparation of such a compensation plan is contained in the document "DFO Guidelines to Development of a Compensation Plan".

2.4 Literature for Further Information

Greig, L. and D. Meisner. 1996. Decision Framework for the Determination and Authorization of Harmful Alteration, Disruption or Destruction of Fish Habitat. Prepared for the Department of Fisheries and Oceans, Habitat Management and Environmental Science, Ottawa, Ontario. 16 pp. + App

Canadian Environmental Assessment Agency. 1995. Responsible Authority's Guide to the Canadian Environmental Assessment Act. Canadian Environmental Assessment Agency. Hull, P.Q.. 195 pp + Glossary.

3.0 INFORMATION REQUIREMENTS FOR THE ASSESSMENT OF POTENTIAL IMPACTS ON FISH AND FISH HABITAT

Information requirements by DFO to make a HADD determination and to allow the assessment of potential impacts on fish and fish habitat is determined by the nature of the activities associated with a proposed project and the fish and fish habitat present. The following section outlines the types of information that may be required to determine the potential impacts on fish and fish habitat for the general purpose of environmental assessment of a project. Chapter 4 details the procedures for collecting the required information.

1. Fish Habitat Surveys

Fish habitat surveys involve the collection of habitat information (e.g. substrate, flow, depth, cover) for streams or sections of streams that may be affected by a proposed project. These surveys are a necessary requirement for most projects that interact with aquatic environments to establish and quantify the existence of fish habitat in the project area.

2. Fish Surveys

Fish surveys involve the collection of fish from aquatic habitats. The preferred method for stream fish surveys is through the use of an electrofisher. Electrofishing is a non-lethal fish sampling technique. For pond fish surveys, netting (gill nets, fyke nets, seine nets) is generally used. Data obtained from electrofishing and pond netting can be used to determine habitat use, and provide information on the size and general characteristics of fish populations in the study area.

3. Fish Disease Profiles

Fish disease profiles are required under the *Fisheries Act* for projects that propose to divert water or transfer individual fish between watersheds, since these activities can serve as a pathway for the transfer of disease between fish populations.

4. Heavy Metals and Mercury Levels in Fish Tissue

Some projects (i.e. mining, reservoir operation) have the potential to cause bioaccumulation of mercury and/or heavy metals in fish. Monitoring heavy metal and mercury in fish tissue may be required to ensure that fish resources do not pose a health risk for human consumption and that fish health is not negatively affected.

5. Hydrological Information

Hydrological information is generally required to assess instream flow needs (IFN) as part of the overall assessment of environmental impacts. There are several techniques and models used for collection of this data, these are briefly summarized in section 4.5.

6. Information on Proposed Small Scale Water Withdrawals

Information on proposed water withdrawals, including baseline hydrological information and predicted effects of withdrawal on stream hydrology, allows DFO to assess potential impacts related to instream flow needs (IFN). Information on the design of end-of-pipe fish screens is important to ensure that fish using the habitat in the proposed intake location are not injured or killed by improperly designed end-of-pipe fish screens.

It should be noted that depending on the activities associated with the proposed project, one, some or all of the above information items may be required by DFO.

4.0 PROCEDURES FOR COLLECTING REQUIRED INFORMATION

The survey methods outlined in this guide are recommended by DFO to allow the assessment of potential impacts of the development on fish and fish habitat. Proponents wishing to adjust the methods outlined or to follow other scientifically sound survey methods should consult with DFO staff to ensure that the proposed methods are appropriate for the area being studied and the data required.

4.1 Fish Habitat Surveys

4.1.1 Rationale for Information Collection

In making a determination of potential impacts to fish and fish habitat, it is first necessary to establish the quantity, type, and availability of fish habitat in the area of potential disturbance. This information is best gathered by means of Fish Habitat Surveys. These surveys will provide both the proponent and DFO with detailed and useful information on the habitat under examination. A thorough, accurate, well conducted stream survey provides the following information:

- the amount of habitat, both accessible and inaccessible to resident and anadromous populations, which is available for fish production;
- the distribution and proportion of habitat types within the areas of interest in the watershed, including the key habitat attributes that determine habitat types (e.g. substrate type, water depths and velocities, etc.);
- the location and physical description of any barriers to migrating fish using the habitat;
- the location, types and amounts of stream side vegetation and the stability of stream banks;
- the location and description of areas where habitat has been degraded or destroyed;
- the accessibility of the watershed if future work is proposed;
- the status of any recreational, commercial, aboriginal or subsistence fisheries; and
- other resource users in the watershed area under review (including recreational, commercial, and/or aboriginal).

When planning and conducting fish habitat surveys, the proponent may want to consult some of the reference materials listed in Section 4.1.4.

4.1.2 A Suggested Methodology for Completing Habitat Surveys

By determining the types of fish habitat in a proposed project area the proponent can evaluate the importance of this habitat to the fish present. Fish habitat can be classified according to biophysical characteristics within the stream ecosystem. A suggested methodology is described below.

Habitat Classification (Type I, II, III, IV)

Habitat survey information should be used to group similar habitat types. The preferred habitat classification system was developed by Beak (1980), which grouped salmonid macro-habitat into four classifications for easy reference. Table 4.1 presents flow, current, depth and substrate parameters used to categorize habitat into the four classification types.

Table 4.1 Characteristics of the Four Habitat Classification Types Identified by Beak (1980)

Type I	Good salmonid spawning and rearing habitat; often with some feeding pools for larger age classes: **flows:** moderate riffles; **current:** 0.1 - 0.3 m/s; **depth:** relatively shallow, 0.3 - 1 m; **substrate:** gravel to small cobble size rock, some larger rocks or boulders; and **general habitat types[1]:** primarily riMe, pool.
Type II	Good salmonid rearing habitat with limited spawning, usually only in isolated gravel pockets, good feeding and holding areas for larger fish in deeper pools, pockets or backwater eddies: **flows:** heavier riffles to light rapids; **current:** 0.3-lm/s; **depth:** variable from 0.3 - 1.5 m ; **substrate:** larger cobble/rubble size rock to boulders and bedrock, some gravel pockets between larger rocks; **general habitat types[1]:** run, riffle, pocketwater, pool.
Type III	Poor rearing habitat with no spawning capabilities, used for migratory purposes: **flows:** very fast, turbulent, heavy rapids, chutes, small waterfalls, **current:** 1 m/s or greater; **depth:** variable, 0.3 - 1.5 m; **substrate:** large rock and boulders, bedrock; and **general habitat types[1]:** run, pocketwater, cascades.
Type IV	Poor juvenile salmonid rearing habitat with no spawning capability, provides shelter and feeding habitat for larger, older salmonid (especially brook trout): **flows:** sluggish; **current:** 0.15 m/s; **depth:** variable but often 1 m; **substrate:** soft sediment or sand, occasionally large boulders or bedrock, aquatic macrophytes present in many locations; and **general habitat types[1]:** flat, pool, glide.

Further described in Table 4.2.

To classify fish habitat in this manner, detailed information on fish habitat needs to be collected based on existing information or from the completion of field surveys.

Section Characteristics

For each section of stream/river surveyed, characteristics that should be recorded include but may not be limited to:

- section length and width (m);
- water level (low, moderate, or high);
- water temperature (° C);
- surface velocity (m/s); and
- gradient (%).

For smaller streams, Scruton et al. (1992) recommend that at least three cross sections be taken per section at the start (top) of the section, in the middle of the section, and at the end (bottom). If the stream is surveyed with consecutive sections there is no need to repeat the start cross section as it will be the same as the end cross section of the previous section. For each cross section, the following information should be recorded:

- location (m from start of section);
- channel width and wetted width (m);
- depth (m) at distances of 1/4, '/2 and 3/4 the wetted width of the stream;
- bank height (m); and
- maximum flood height.

Habitat Characteristics

Fish habitat characteristics within a section can be subdivided into areas of similar characteristics or "meso-habitats." Stream meso-habitats are best described by quantifying the various types including pools, riffles, runs, steadies or flats, rapids, etc. An estimate of the proportion of each habitat type within the section should be recorded. The basic characteristics of these habitat types are outlined below and in Table 4.2.

Pool Characteristics

The pool characteristics that should be recorded for each section are:

- number of pools;
- pool/riffle ratio;
- an estimate of the length and width in metres (to the nearest 0.1 metre in small streams) and depth in centimetres for each recognizable pool in the section; and

- any comments that can further describe the quantity and quality of pool habitat in the section.

Table 4.2 General Habitat Types

Habitat Type[1]	Definition
Run	Swiftly flowing water with some surface agitation but no major flow obstructions, coarser substrate (gravel, cobble, and boulders).
Riffle	Shallower section with swiftly flowing, turbulent water with some partially exposed substrate (usually cobble or gravel dominated).
Pocketwater	Turbulence increased greatly by numerous emergent boulders which create eddies or scour holes (pockets) behind the obstructions.
Flat (or steady)	Water surface is smooth and substrate is made up of organic matter, sand, mud, and fine gravel. This habitat differs from a pool as described by Scruton and Gibson(1994) due to the length, associated with low gradient. This habitat type generally has a flat bottom.
Pool	Deeper area comprising full or partial width of stream, due to the depth or width flow velocity is reduced. Pool has rounded surface on bottom.
Cascade (rapids)	Areas of steeper gradient with irregular and rapid flows, often with turbulent white water. Rapids are primarily associated with larger stream sections and rivers. In larger rivers it is recommended that the survey crew not attempt to conduct cross sections in these types of habitat.
Glide	Wide, shallow pool flowing smoothly and gently, with low to moderate velocities and little or no surface turbulence. Substrate usually consists of cobble, gravel and sand.
‘Major mese-habitat types are identified according to terminology consistent with Gibson et al. (1987), Scruton and Gibson (1995), Scruton et al. (1992) and McCain et al. (1990). The criteria have been modified to be less sensitive to der,th and velocity in order to be aDDlicable through a wider range of discharges.	

Substrate

An estimate of the proportion (as a percent) of each of the substrate types listed below should be recorded. The sum of the substrate types should total 100%. It is often best to conduct two independent estimates of the substrate and compare. Substrates are classified according to size as per the following:

Bedrock - continuous solid rock exposed by the scouring forces of the river/stream.

Large boulder - large boulder sized rocks greater than 1 m in diameter.

Small boulder -	boulder sized rocks from 25 cm to 1 m in diameter.
Rubble -	large rocks from 14 to 25 cm in diameter.
Cobble -	Moderate to small sized rocks from 6 to 13 cm in diameter.
Pebble -	small rocks to stones from 3 to 5 cm in diameter.
Gravel -	small stones from 2 mm to 3 cm in diameter.
Sand -	sand sized deposits frequently found on margins of streams or between rocks and stones, from 0.06 to 2 mm in diameter.
Mud/clay -	very fine deposits from mud to silt on stream margins, between rocks, and on top of other substrates.
Siltation -	the relative degree of siltation in the section should be described and it should be determined if there is much silt deposit on top of and between other substrate rocks. This could be either descriptive or defined as a percentage of the substrate by silt and to what depth.

Cover

Cover can be used for hiding areas or to provide food and shade. There are three types of cover available to fish: overhanging; instream; and canopy cover. Instream cover can be broken into that provided by vegetation or that provided by large rocks/boulders, logs and other debris. The relative proportion of each cover type as a percent of the section should be estimated. The cover types are defined as follows and are further described in Scruton et al. (1992):

Overhanging - cover provided by streamside grasses and shrubs up to 1 m in height. This vegetation lies along the stream edge or hangs out over the stream.

Instream (substrate, logs, debris, etc.) - cover actually in the stream bed as provided by fallen trees and logs, rocks and boulders, and other accumulated debris. This can also include undercut banks.

Instream (vegetation) - cover in the stream bed as provided by live aquatic vegetation including grasses, macrophytes, water weeds, mosses, algae and other stream plants.

Canopy - cover provided by mature hardwood and softwood trees along the sides of a stream (includes only those trees which have branches/foliage hanging over the stream).

Riparian Vegetation

Riparian vegetation includes vegetation growing on or near the banks of a waterbody on soils that exhibit some wetness characteristics during some portion of the growing season (MacDonald et al. 1991). The percent of surrounding vegetation within about a 5 metre distance from both stream banks should be estimated. The vegetation types to be used in this estimate are as follows:

Hardwood - mature deciduous (trees that lose their leaves in winter) trees, including maples, birch etc.

Softwood - mature coniferous (tress that maintain their foliage year-round) trees, including spruce, fir, pine etc.

Alders, etc. - larger, hardwood shrubs such as mountain ash (dogwood), willow, aspen etc. up to 2 m in height.

Shrubs - smaller, softwood shrubs, including Labrador tea, blueberry, fireweed, ferns, etc.

Grasses - all natural grasses on the stream edge and in association with surrounding vegetation.

Bog - all surrounding wetland including bogs and fens.

Streamside vegetation provides organic matter as an energy source for aquatic organisms. Vegetation also provides stream bank stability, thus preventing erosion and subsequent silt deposit into the stream. The presence of stream bank erosion should be indicated (yes/no) and the percent of bank erosion within the stretch should be estimated. Both banks of the stream must be taken into account for this estimate (i.e. if one bank only is eroded for the entire section, the amount of the erosion in the site is 50%). Erosion is indicated by the absence of vegetation along the bank and evidence of soils and other debris slumping into the river. Bank scour from ice and high water is evidence of some small erosion. The stability of the bank should be rated as:

- good (more than 80% of bank is stable and well vegetated);
- fair (50 to 80% stable banks with minimal evidence of erosion); or
- poor (less than 50% stable banks and considerable evidence of erosion).

The presence and amount of undercut banks should be indicated. These banks occur where the stream has actually cut into the bank and water is flowing under the stream bank. Undercut banks are excellent habitat for salmon and trout and the percent of undercut bank on each of the left and right hand banks (facing upstream) should be noted. The location and extent of undercut banks should be included on the section drawing (described below).

Obstructions

Obstructions are areas that may be potential barriers to the movement of juvenile and adult fish. Obstructions can be natural (i.e. debris blockage, falls) or man made (i.e. culverts, dams). Water speed can also be a barrier when the velocity of the water at a site, due to constriction or some other reason, is too great for fish to swim against. The existence of a velocity barrier is difficult to determine and further investigation should be carried out by experienced personnel.

It is important to document all obstructions as they can determine the production potential of a stream. The presence and number of obstructions in each section should be noted and the following information should be recorded for all obstructions:

- the type of barrier (i.e. dam, debris, logjam, beaver dam, falls etc.) should be indicated.
- the vertical height (estimated or measured) of the barrier from the water surface at the bottom of the barrier to the top of the barrier in metres.
- the slope of the barrier should be estimated (i.e. the angle from the bottom of the barrier to the top). This is used mostly for falls.
- the length and width of the barrier in metres should be estimated or measured in metres.
- any additional comments that could help to describe the barrier should be recorded (i.e. the depth of water under a falls).

As well, a photograph should be taken of each obstruction. This photograph should include a means of measuring the barrier height (i.e. have someone stand beside the barrier). The obstruction should also be sketched and its location included in the schematic drawing of the section (described below).

Schematic Sketch or Drawing

It is desirable, but not essential, to include a diagram or drawing of each section surveyed. This is intended to be a schematic sketch identifying key features and location of measurements. The sketch can include locations of pools, undercut and eroding banks, obstructions, springs, tributaries, distribution of habitat types, etc.

4.1.3 Presentation of Information

Information should be presented to DFO in a clear, concise form. The submission should include the following components:

- a brief outline of the proposed project including those aspects which may interact with fish and fish habitat (i.e. nature of the project, location);
- a summary of the habitat survey field work (i.e. methods used, areas surveyed, dates/times of field work, weather conditions, etc.);
- a text summary of the major characteristics (i.e. substrate types, gradient, habitat types, vegetation, flow, dimensions) of the stream(s) surveyed, accompanied by a table summarizing the data collected for each stream and tributary;
- a summary of the amount of available habitat for each habitat type (e.g., Type I = X units);
- photographs of stream sections; and
- copies of original stream survey forms for each stream section surveyed (appended to document).

4.1.4 Literature for Further Information

Adams, M.A., and I.W. Whyte. 1990. Fish Habitat Enhancement: A Manual for Freshwater, Estuarine and Marine Habitats. Department of Fisheries and Oceans Canada. DFO 4474. 330 p.

Beak Consultants Ltd. 1980. Fisheries Investigation for the Upper Salmon Hydroelectric Development. Report prepared for: Newfoundland and Labrador Hydro, St. John's, NF. 95 p. + appendices and figs.

Carlander, K.D. 1969. Handbook of Freshwater Biology. Volume 1. Iowa State University Press, Ames, Iowa. 752 p.

Department of Fisheries and Oceans and British Columbia Ministry of Environment. 1989. Fish Habitat and Information Program Stream Survey Field Guide.

Dodge, D.P., G.A. Goodchild, J.C. Tilt, and D.G. Waldrif£ 1979. Manual of Instructions. Aquatic Habitat Inventory Surveys. Ontario Ministry of Natural Resources, Fisheries Branch. 168 p.

Environment Canada. 1983. Sampling for Water Quality. Water Quality Branch, Inland Waters Directorate, Ottawa, Ontario. xi + 55 p.

Gibson, R.J., T.R. Porter, and K.G. Hillier. 1987. Juvenile Salmonid Production in the Highlands River, St. George's Bay, Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. 1538, v + 109 pp

Hamilton, K. And E.P. Bergersen. 1984. Methods to Estimate Aquatic Habitat Variables. U.S. Fish and Wildlife Service and the Colorado State University, xvi + 331 p.

McCain, M., D. Fuller, L. Decker, and K. Overton. 1990. Stream Habitat Classification and Inventory Procedures for Northern California. FHR Currents... No. 1, U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Region.

MacDonald, L.H., A.W. Smart, and R.C. Wissmar. 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. EPA, Center for Streamside Studies, Seattle.,

Riche, L.G. 1972. An outline of methods used in stream surveys and estimation of salmon production with a suggested value for Atlantic salmon sports fish in Newfoundland. Fisheries and Oceans, Resource Development Branch, St. John's, NF. Progress Report 82:23 p.

Scruton, D.A., and R.J. Gibson. 1995. Quantitative Electrofishing in Newfoundland. Results of a Workshop to Review Current Methods and Recommend Standardization of Techniques. Can. Manuscr. Rep. Fish. Aquat. Sci. 2308: vii + 148 pp. + app.

Scruton, D.A., T.C. Anderson, C.E. Bourgeois, and J.P. O'Brien. 1992. Small Stream Surveys for Public Sponsored Habitat Improvement and Enhancement Projects. Can. Manuscr. Rep. Fish. Aquat. Sci. No. 2163: v + 49 p.

Waldron, D.E. 1974. Codes used in the Newfoundland commercial and recreational fisheries. Resource Development Branch, Fisheries and Marine Service, Newfoundland Region, Data Record Series No. NEW/D-74-2, 128 p.

White, R.J. and O.M. Brynildson. 1967. Guidelines for management of trout stream habitat in Wisconsin. Wisconsin Department of Natural Resources, Division of Conservation Technical Bulletin No. 39, 64 p.

4.2 Fish Surveys

4.2.1 Rationale for Information Collection

The habitat surveys described in the previous section allow the proponent to survey and describe fish habitat. Depending on the nature of a project, fish surveys of various levels of detail may be required to provide the following information on fish utilization of available habitat:

- the presence/absence of fish in the habitat;
- the species, size class, age distribution, relative abundance and external observations of fish which use the habitat;
- how the habitat is used by different fish species; and
- additional information useful for verification of habitat classifications, (i.e. presence of fry in spawning habitat).

Fish presence/absence can often be determined by direct observation or local knowledge. Confirmatory sampling can be accomplished using electrofishing techniques which allow non-lethal sampling in stream habitat. Captured fish can be examined to confirm species and estimate age class (young-of-the-year will indicate localized spawning activity). This method allows the fish to be released unharmed. Electrofishing techniques can be applied at different levels of effort to obtain data at corresponding levels of precision:

Quantitative Electrofishing - involves electrofishing a contained area of a stream or river with successive sweeps (generally four sweeps). Electrofishing stations are enclosed using barrier nets. By recording catches within this contained area and analyzing catch data using computer software programs (e.g. MICROFISH or CAPTURE in Van Deventer and Platts 1989), estimations can be made regarding the total number of fish and biomass within the area that was electrofished. This information can be standardized to number of fish, or biomass/ 1 unit (1 unit = 100m' of habitat).

Index Eleetrofishing - Can be used to supplement quantitative electrofishing and is conducted opportunistically. The time fished or approximate stream area is recorded and the fishing effort is confined to a localized area so that the results provide a comparative indication of fish density. Data recorded for captured fish include species and fork length, which gives an indication of size classes present. This method is used when water conditions do not allow for the installation of block nets or when sufficient areas for quantitative sampling are lacking. Index capture rates for nonquantitative stations are generally compared to the first 100 seconds of fishing at quantitative stations.

Electrofishing may also be used to obtain fish for mercury and heavy metal sampling (see Section 4.4) or disease profiles (see Section 4.3). The following section presents a detailed overview of quantitative electrofishing, however, in designing an electrofishing survey, the proponent may want to consult some of the reference materials listed in Section 4.2.4.

4.2.2 Methodology for Conducting Quantitative Electrofishing Surveys

Prior to survey work, a collection permit (Scientific Licence) must be obtained from DFO for any fish sampling (see Contact List). All conditions of the licence will apply during the period specified.

4.2.2.1 Site Selection

In order for the information collected by electrofishing to be most useful, it should relate as directly as possible to the proposed undertaking. If the waterbody under examination has several habitat types, care should be taken to ensure that representative surveys are done to enable complete assessment of all habitat types. Sites should be selected so that each meso-habitat (riffle, run, pool) present is sampled, allowing for quantification of standing stock estimates throughout the entire area surveyed.

Among other factors, it is important to consider the location at which habitat impacts are likely to occur. Sites should be selected above, below, and at the site of potential perturbation to ensure that the location is well understood in terms of population use and that it is put in context of its surrounding habitat. The selection of sites in this manner also establishes a baseline which will assist in any further assessment or monitoring work that may be required.

4.2.2.2 Collection of Data

Recommended Standard Electrofishing Procedures adapted from Scruton and Gibson (1995):

1. The selection of site, stratification and replication of habitat types, sub-sampling procedures, and other general aspects of study design should be left to the discretion of individual researchers based on the objectives of their respective projects.

2. The preferred timing for electrofishing studies would be determined by the objectives of the study. Generally, the preferred conditions for electrofishing would be sampling during low flow conditions after a period of stable water flow, after fiy have emerged and distributed to preferred habitats, and during the summer growth period of salmonids. This is generally the period when habitat is limiting and electrofishing is most efficient. In insular Newfoundland, this period would be from mid to late July through to early September and could vary by

location. Fishing earlier in the year (e.g., June) could result in harm to, or mortality of, newly emerged salmonid fry. Later in the fall, water temperatures decline, and juvenile salmonids become less territorial and often burrow into the substrate to overwinter, making electrofishing less effective and meaningful. Additionally, it would also be preferable to not electrofish until after smolt emigration (end of June for most areas) and not after early September as precocious maturation of male salmon parr could alter fish distribution.

3. Sites (stations) should be established within one discrete habitat type (i.e., riffle, run, pool, flat, etc.) as discussed previously. Small pools are often associated with riffle habitats and should be completed as part of a `riffle' station and the presence of pools would bedescribed by the habitat attribute data used to define this station.

4. The size or dimensions of an electrofishing station should be in consideration of obtaining as large a sample of fish as is practical since the validity of the estimate increases with sample size (i.e., population estimation based on sample sizes of less than 30 areconsidered poor; if estimates are subset by age groups this 30 fish minimum would apply to each age group). Practical considerations relating to the size of contiguous reaches of one habitat type, time spent to complete each station, effective deployment of humanand monetary resources, efficiency of capture at a given site, etc., will also play a role in determining the appropriate size of the station. Generally sites are set up to cover up to 200 m^2 (two or more units). The objective is to improve the precision of the population estimate by whatever means possible and practical.

5. Due to low conductivity waters prevalent in insular Newfoundland and Labrador, it is recommended that all quantitative electrofishing stations should be completely closed by barrier nets wherever possible. This includes stations that completely encompass the widthof the river, with the standard upstream and downstream barrier nets. `Three sided' stations (see previous description) would require a net to be run the length of the station, to meet the upstream and downstream barrier nets, to fully enclose the site. The mesh size of the barrier net must be fine enough so as not to permit the passage of salmonid young-of-the-year (YOY as small as 30-40 mm in length). Closure of the station also ensures adhering to one of the major assumptions of population estimation, that there is no immigration into or emigration from the site during the period of sampling.

6. The preferred crew size for completing a quantitative electrofishing station will be determined by the size and physical attributes of the site, and ultimately the project budget. For most applications, a crew size of 3 to 4 people would be suitable. This would include one individual on the electrofisher (or handling the probe), one holding the captured fish (with buckets, etc.) and being responsible for survival of captured fish (i.e., may need to

replenish or re-oxygenate water to prevent mortalities) and one or two persons using dip nets. Another individual may be required for teams using shore based electrofishing units in order to feed the electric cord through the station and to ensure the cord does not get caught up on the substrate, etc. In many instances available human and monetary resources will dictate crew size; however, a crew of three would be considered minimum for most situations. For extremely small streams (e.g., less than 2 m width) it may be possible to effectively electrofish with a crew of only two. Additional crew members may be desirable in larger streams (greater than third order) to assist in setting up the station (e.g., placement of barrier nets), provide additional assistance in netting fish, or assist in the processing of captured fish and data collection.

In some instances, depending on water velocity, depth and clarity, it may be desirable to employ a lip seine (or pole seine) as a replacement for, or in addition to, a standard dip net(s).

It is recommended that all crew members use polarized sun glasses to improve ability to see into the water column and thereby improve the ability to capture stunned fish.

7. Holding containers, placed in the stream but outside of the effective electric field, can be used to hold fish for extended periods during the process of completing an electrofishing station. Oxygenation of water and temperature stability to reduce potential mortalities must be ensured. These containers should have holes or be constructed of mesh to permit percolation of water. The use of vegetation or some other water surface cover also reduces stress on fish.

8. At least one dip netter should have a small, flexible aquarium net of very fine mesh size to assist in retrieving YOY from the substrate. The electrofisher probe can also be outfitted with netting to act as an additional net. The mesh size of the dip nets must be fine enough so as not to permit the passage of salmonid YOY.

9. As consistency of sampling effort is very important to a reliable population estimate, it is recommended that the same individual conduct all sweeps at a given sampling station. If a timer is available on the electrofisher (only the type that actually records time when the power is on), then it should be employed to monitor sampling effort and the number of seconds for each sweep should be recorded.

10. Electrofishing should be conducted in a discontinuous fashion, turning the power on and off between passes with the probe, in order to use the `element of surprise' to improve capture efficiency and in order not to drive or herd the fish.

11. A total of 4 sweeps should be considered minimum with respect to population estimates based on the removal method. Requirements for additional sweeps should be based on the rate of decline in catch and researchers should be familiar with the populations estimators in order to make field decisions on the need for, and benefit of, additional electrofishing sweeps. At present, the effect of previous sweeps on salmonid behaviour is not well documented, and research is necessary to determine the length of time required for fish to recover from the effects of electrofishing. It is recommended that crews allow as much time as is practical between electrofishing collections (sweeps), with one half hour being considered minimum.

12. It is not a concern whether electrofishing sweeps are conducted in an upstream or downstream direction and there are advantages for sweeping in either direction. Sweeping in an upstream direction ensures that all debris and silt stirred up by the crew is removed by the water flow thereby ensuring good visibility. Electrofishing in a downstream direction may be effective in `driving' fish into the lower barrier net where they will be efficiently captured. If numbers are high at the lower net, this may result in poor dip net efficiency or possibly in the over shocking of fish. It is most important that sweeps be carefully completed to ensure all habitat is covered in an even and effective manner. The crew should also ensure that they do not enter any habitat area until after it has been electrofished (e.g., install the lower barrier net with as little disturbance as possible, then walk along the bank away from the station to install the upper net).

13. The removal method is recommended for estimation of population size in order to provide for maximum comparability of results. Calculation of the estimate using weighted maximum likelihood estimators is the preferred method. At present, use of the CAPTURE program for the U.S. Fish and Wildlife Service is highly recommended, owing to its ability to generate probability of capture estimates for each sweep, while the MICROFISH 3.0 program, also developed by the U.S. Fish and Wildlife Service, would be acceptable. Both these programs can run on personal computers under DOS, and therefore should be available to a wide number of users. It is recognized there is an inherent bias (underestimate) in the MICROFISH estimate associated with the assumption of constant probability of capture.

    Where catch rates permit, separate estimates should be calculated by species, and age or length class. Previous studies have suggested estimates can be derived for all fish, for each species (if sufficiently abundant), and separately for fry and older age/size groups for each species.

    Mark-recapture techniques for population estimation are also recommended in habitats where electrofishing equipment may be inefficient, such as in deep water (i.e., pools, flats, lakes).

For these estimates, fish captured from the first sweep (either by electrofisher, beach seine, etc.) are marked (fin clipped or some other technique) and returned to the station. After sufficient time for redistribution and recovery (overnight if possible), the unmarked fish in the second sample is derived by the Petersen method (Ricker 1975). This process can be repeated for more sampling and a multiple-mark recapture (e.g., Schnabel) estimate obtained (Ricker 1975).

14. All fish collected at a station should be identified to species and have a fork length measured (mm) and, where possible, a weight (± 0.1 g) taken. A sub-sample of fish, sufficient to establish a length-age key, should have scale samples collected for subsequent ageing (e.g., a minimum of 5 per 1.0 cm length group). Collections of scales from all fish and then subsequent sub-sampling for aging, if required, based on length frequencies is also recommended. For mark-recapture estimates, it is preferable to collect scales on the final sweep. The decision as to sub-sampling protocol based on each station, tributary, habitat type, stream order, etc. is at the discretion of the individual researchers according to the project objectives.

15. The use of an anaesthetic to measure and collect data/samples from fish captured by electrofishing is recommended. A variety of products have been used and no particular one anaesthetic is endorsed; however, the use of Alka-Seltzer tablets (dissolved COZ) and benzocaine have been employed by DFO and are considered effective and relatively safe for the fish. Should other products be considered for use, it will be necessary for the researcher to seek permission/approval for use from the necessary authorities and use of the particular anaesthetic should be included in the collection permit. Handling of fish should be minimized, and fish should be released into slow moving water ensuring that fish are resuscitated and able to swim away.

16. Habitat attribute data should also be collected in association with electrofishing data. Habitat classification is discussed in detail in Section 4.1, and the information relevant to electrofishing data includes:

- habitat type;
- station dimensions;
- substrate;
- depth;
- velocity;
- undercut banks; ice scour height;
- flood debris height; and
- water temperature;
- air temperature;
- cover;
- bank stability;
- riparian vegetation;
- pools.

This listing identifies parameters that should be collected at all stations in order to measure and describe the site as well as a set of optional parameters that could be collected to assist in research studies related to understanding productive capacity, selection of habitats by juvenile salmonids, development of habitat-based stock assessment and habitat evaluation methods, etc.

17. Wherever possible, data should be collected to assist in the evaluation of the potential application of fixed effort INDEX estimates. The catch in the first 300 seconds of the first sweep for any station being sampled for removal estimates should be recorded to assist in determining the relationship between INDEX (fixed effort) catches as compared to removal population estimates. Some general habitat attribute data (e.g., water temperature, flow, substrate, area covered) should also be collected.

18. Electrofishing should not be conducted when water temperatures are high (18°C or greater for salmonids) as mortalities are likely to occur. If mortality rates become high electrofishing should be discontinued for a period of time until temperatures diminish. In addition, electrofishing should not be conducted at lower temperatures (less than 7°C) owing to the behavioral changes of juvenile salmonids at low temperatures (i.e., the tendency to burrow into coarse substrate) which could make fish more susceptible to effects of repeated electrofishing and/or invalidate quantitative estimates.

19. In order to facilitate a standardized approach to electrofishing technique, the wider use and availability of data collected by electrofishing, and the subsequent archiving of these data, a standard set of field collection data sheets and forms and specifications for computer entry of data are recommended for use by all researchers.

20. Electrofishing is a technique that can be very harmful to juvenile fish if used improperly (for example by over shocking using an excessively high voltage) and can be potentially dangerous to crews not familiar with the technology and equipment. It is highly recommended that each field crew contain at least one individual with considerable electrofishing experience, knowledge of safety considerations and First Aid experience. This individual should be the one to use the electrofishing probe, make all settings and adjustments on the equipment, and assign tasks to less experienced crew members until others have demonstrated a capability to participate in the functions.

21. It is recommended that researchers and other practitioners of electrofishing for population estimation include an estimate of bias (in the population modeling) as a component of the standard protocol. This would be considered a mandatory requirement for major studies and for research where publication of results is anticipated.

Habitat

At each electrofishing station, a standard set of data should be collected to describe the meso-habitat and dimensions of the station. It is important to measure station dimensions accurately as they will be used later to estimate the standing stock of the stream. Width of the station between the two banks as well as length of the stream between the upstream and downstream barrier nets should be recorded. Several measurements of station depth from within the area sampled should be recorded. Following procedures and classifications included in the habitat survey methods (Section 4.1), the substrate and cover of the habitat at the sampling site should be recorded. Using meters, the conductivity and temperature of the water should be taken and recorded. The use of standard data record sheets is recommended as it will allow consistent and complete data collection and avoid inter-station variations in data collection.

4.2.3 Presentation of Information

Information should be presented to DFO in a clear, concise form. The submission should include the following components:

- a brief outline of the proposed project including those aspects which may interact with fish and fish habitat (i.e. nature of the project, location);
- a summary of the electrofishing field work (i.e. methods used, areas surveyed, dates/times of field work, weather conditions, etc.);
- a text summary of the species present, age and size characteristics and catch rates at each electrofishing stations surveyed, accompanied by a table summarizing the catch rates and number of individuals of each species captured at each station (raw data for each fish captured should be appended to the submission document);
- a description of the habitat types represented by each electrofishing station; and
- standing stock estimates, as determined by a computer program such as CAPTURE or MICROFISH 3.0.

4.2.4 Literature for Further Information

British Columbia Ministry of Environment, Recreational Fisheries Branch. 1989. Electrofishing Student Workbook.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 pp.

Scruton, D.A. and R.J. Gibson. 1995. Quantitative Electrofishing in Newfoundland and Labrador: Result of Workshops to Review Current Methods and Recommend Standardization of Techniques. Can. Manuscr. Rep. Fish. Aquat. Sci. 2308: vii +145 pp., 4 appendices.

Van Deventer, John S. and William S. Platts. 1989. Microcomputer Software System for Generating Population Statistics From Electrofishing Data - User's Guide for MICROFISH 3.0. United States Department of Agriculture, Forest Service. 30 pp.

4.3 Collecting And Handling Fish For Disease Profiling

4.3.1 Rationale for Information Collection

Once fish presence (Section 4.2) and habitat use has been established, it may also be necessary to determine disease profiles of fish in the habitat. Information on the health of the fish population from a disease perspective is useful particularly if the project involves potential inter-basin transfers of fish or diversion of water between watersheds, since these activities may present a new pathway for distribution of disease. This information on fish health is most often determined by means of disease profiles - detailed investigations into the prevalence of various fish diseases in the population being studied. Section 4.4 discusses the determination of baseline fish tissue concentrations of heavy metals and mercury, which may also be used in determining potential contamination or the suitability of fish for human consumption.

The following section presents an overview of procedures for determining a disease profile of a fish population. The proponent may also want to consult some of the reference materials listed in Section 4.3.4.

4.3.2 Methodology for Collecting and Handling of Fish for Disease Profile Information

Legislation is in place to address the issue of fish health. The Manual of Compliance to the *Fish Health Protection Regulations* under Canada's *Fisheries Act* outlines the administrative and inspection procedures to be followed and provides step-by-step procedures for handling fish samples to test for the major bacterial, viral, and myxosporean pathogens of salmonids.

Specimens must be laboratory tested by a Fish Health Official for all disease agents listed in Schedule 2 of the *Fish Health Protection Regulations:*

- redmouth bacterium *(Yersinia ruckeri);*
- furunculosis bacterium *(Aeromonas salmonicida);*
- protozoans causing whirling disease *(Myxobolus cerebralis)* and ceratomyxosis *(Ceratomyxa shasta);*
- viral agents including but not limited to those causing viral hemorrhagic septicemia infectious hematopoietic necrosis, and infectious pancreatic necrosis; and
- other filterable replicating agents considered to be potentially harmful.

The following modifications should be confirmed with the Local Fish Health Officer of Newfoundland (see Section 5):

- analysis for whirling disease *(Myxobolus cerebralis)* and ceratomyxosis *(Ceratomyxa Shasta)* need not be conducted as these are not known to occur at this point in time in Newfoundland, and the analysis is very expensive; and
- analysis for furunculosis (both typical and atypical) should be conducted.

4.3.2.1 Fish Collection

It is desirable that fish for disease profiles be collected during the required fish sampling surveys. This helps minimize duplication of effort and time required for data collection.

Sampling Requirements

Live versus Lethal Sampling

It is preferable that fish specimens for disease profiling be shipped alive to the laboratory for testing. This may not always be possible, since some project locations are too remote to allow a reasonably short delivery time to laboratory facilities. The type of sampling to be carried out (live or lethal) will determine the capture method (discussed below). Prior to sampling, both the Local Fish Health Officer and the analysis agency should be consulted to verify methods, procedures, and scheduling of delivery.

Number of Specimens Required

In order to obtain meaningful results, fish must be sampled at a rate that will give a 95 percent probability of detecting an infected specimen in the total catch, assuming the minimum prevalence is 5 percent. Generally, 60 individuals should be examined from each of the donor and receiving populations. If the size of the population being studied is such that the capture of 60 fish is unreasonable or difficult, the proponent should consult with DFO to determine a more appropriate sample size.

Age/Size Requirements for Fish Specimens

Except for very small specimens, the tissues of one fish are sufficient to perform bacteriological, virological and myxosporean analysis. Bacteriological analysis is technically more difficult for fish smaller than 4 cm in fork length. For this reason, sampling should be limited to fish averaging more than 4 cm fork length except in cases where unusual mortality rates or disease signs are observed in this smaller size class.

Collection Methods

Methods of Capture

If live capture and shipping is possible, the preferred methods of capture are trap or fyke nets, wire cage traps or electrofishing. Trap and fyke nets are restricted to near-shore or shallow areas of a lake and can be used in streams where depth and flow pennit. Wire cage traps are vertically stratified and permit deep water sampling. They can also be baited to enhance capture efficiency. Electrofishing is discussed in detail in Section 4.2. Nets/traps should not be left unsupervised and should be checked regularly to retrieve catches.

Sample Processing

All specimens collected should be placed in clean buckets (containing fresh water) and submitted to the following procedure:

- species identification, measurement of total length (mm) and weight (g);
- collection of anatomical parts (scales, otoliths, fin rays or gill covers) for age determination; and
- minimize handling and avoid interference with the disease analysis (additional sampling should be performed with the cooperation of the lab, i.e., otoliths, stomachs, other tissues).

Specimens should be bagged separately in clean plastic bags and labeled to indicate the sample identifier, station identifier, date and collector. The lab may suggest pooling samples in groups of' five. In addition to labels, a data sheet should be completed for each sampling station, recording the following information:

- specimen identifiers;
- station;

- date/time;
- water temperature;
- weather/temperature;
- location (latitude and longitude);
- crew members;
- habitat descriptors; and
- photograph number (if taken)

Sample Handling and Transfer

Fish samples must be handled rapidly in such a way that degenerative changes do not render diagnosis unreliable or impossible. If samples cannot be brought to the laboratory alive, they should be stored on ice or refrigerated for no longer than 48 hours. Delivery and transfer of samples should be coordinated with the laboratory.

Live Fish

Live fish should be transported in sealed plastic bags that have been partly filled with water and charged with oxygen. The bags may then be placed with ice in insulated containers. Under these conditions anaesthetics are not usually required.

Dead Fish

Fish samples that the lab will accept as dead should be placed in sealed plastic bags (dead or moribund fish should be kept separately from healthy fish) that are packed in an insulated container with a layer of ice around each bag.

4.3.2.2 Disease Profiling of Fish

Determination of disease profiles of fish must be conducted by a certified laboratory and is therefore often carried out by an individual or company other than the proponent or person conducting the sampling. Typical resources which may be used include academic institutions (Universities), private companies, or government agencies. Prior to sampling, both the Local Fish Health Officer, Newfoundland (see Section 5) and the analysis agency should be consulted to verify methods and procedures.

4.3.3 Presentation of Information

Information should be presented to DFO in a clear, concise form. The submission should include the following components:

- a brief outline of the proposed project including those aspects which may interact with fish and fish habitat(i.e. nature of the project, location);
- a summary of the disease profile sampling procedure (i.e. methods used, areas surveyed, dates/times of field work, weather conditions, etc.);
- a summary, including a copy of a written report directly from the fish disease laboratory, of the diseases found in the specimens collected and the prevalence of each disease in the sample group; and
- based on the survey sample, the disease profile of each fish species surveyed.

4.3.4 Literature for Further Information

Department of Fisheries and Oceans. 1984. Fish Health Protection Regulations: Manual of Compliance. Fish. Mar. Serv. Misc. Spec. Publ. 31 (Revised): 43 pp.

Ossiander, F.J. and G. Wedemeyer. 1973. Computer program for sample sizes required to determine disease incidence in fish populations. J. Fish. Res. Board Can. 30:1383-1384.

North Atlantic Salmon Conservation Organization, North American Commission. 1992. Protocols for the Introduction and Transfer of Salmonids. Edited by T.R. Porter. NAC/NASCO Scientific Working Group on Salmonid Introductions and Transfers. NAC(92)24. 119 pp.

North Atlantic Salmon Conservation Organization, North American Commission. 1994. Amendments to the Protocols for the Introduction and Transfer of Salmonids. NAC(94)14. 27 pp.

4.4 Collecting And Handling Fish For Determining Baseline Heavy Metal And Mercury Concentrations

4.4.1 Rationale for Information

Heavy metals and mercury can bioaccumulate in fish. Some projects (i.e. mining, alteration ofreceiving waters, reservoir operation) have the potential to cause an increase in heavy metals or mercury concentration in fish. By sampling fish, and having their tissue analyzed, concentrations of heavy metals and mercury can be monitored to ensure that fish resources do not pose a health risk for human consumption and that fish health is not negatively affected.

This section discusses analysis of fish tissues for heavy metal and mercury baseline determination. In the case of long-term projects, heavy metal and mercury analysis of fish populations in a proposed project area prior to project initiation allows for the identification of baseline levels that can be used for comparison in future body burden or contaminant monitoring programs.

The following section presents an overview of procedures for determining baseline levels of mercury and heavy metals (in tissue) of a fish population. The proponent should also consult some of the reference material listed in 4.4.4.

4.4.2 Methodology for Collecting and Handling of Fish For Baseline Heavy Metal and Mercury Determination

4.4.2.1 Fish Collection

It is desirable that fish collection for baseline heavy metal and mercury determination be carried out in concert with other fish sampling (e.g., sampling for disease profile, electrofishing). This helps minimize duplication of effort and time required for data collection.

Sampling Strategy

Generally, a length stratified sample of 30 individuals is collected for each species present in the proposed project area. Stratified sampling allows for the determination of changes in contaminant concentrations over a short time period, i.e., mercury in a reservoir. An example of a strategy for a length stratified sample is presented in Table 4.3. In addition to the goal of length stratification, sampling should aim to provide a uniform distribution of lengths within a single length class. If a given size class cannot be completed from the individuals harvested, supplementary individuals should be taken from neighbouring classes. Finally, the smallest and largest specimen harvested should be kept for analysis.

Since different species demonstrate different uptake rates, each species present in the proposed project area should be subject to sample collection and body burden analysis (i.e., a stratified sample of 30 individuals should be collected and analyzed for each species present).

Table 4.3 Example of a Sampling Strategy for a Length Stratified Sample. Note that a stratified sample of 30 individuals should be collected for each species present in the proposed project area.

Length Class (mm)	Number of individuals collected
< 100	5
101-140	5
141-180	5
181-220	5
221-260	5
> 261	5
Total Sample Size	**30**

Fish specimens should be collected at fixed locations that are clearly identified (e.g., using a global positioning system) for future reference. Sampling locations should be provided in the submission of information to DFO for review.

The standard method of capture for body burden sampling in pond or large stream environments is gillnetting. Gillnets are a commonly used capture technique which can be selective for size and species depending on the mesh size and net design. Gillnetting is usually considered a lethal technique, and thus is appropriate for the lethal sampling required for body burden determination. Gillnetting should be carried out by individuals with prior experience. Nets should not be left unsupervised, and should be checked regularly to retrieve catches. Frequent checking ensures that unwanted fish (i.e., fish of the wrong size class) can be released alive. Body burden samples can also be collected by electrofishing in stream environments or other techniques, including angling and use of fyke nets.

All specimens collected should be submitted to the following procedure:

- species, sex and state of maturity identification, measurement of fork length (mm) and weight (g);
- collection of anatomical parts (scales, otoliths, fin rays or gill covers) for age determination;
- collection of a portion of muscle tissue (fillet) free of skin and abdominal bones. Fillet samples should not be taken from small fish (minimum size for filleting can be identified by the laboratory conducting the analysis). Instead, small specimens should be frozen whole to

ensure adequate amounts of tissue for analysis. Sometimes other selected tissues (e.g., liver) may be analyzed;

- visual identification of stomach contents (i.e., invertebrate or fish). Any evidence of piscivory (fish consuming other fish) should be noted due to the implications of this feeding habit on mercury and heavy metal accumulation; and
- mesh size of capture should be recorded for each specimen.

All procedures involving contact with the body burden tissue must be extremely clean, with the proper equipment used to minimize contamination of the sample. The laboratory conducting the analysis or other agencies can provide proper sampling protocols. Prior to collection, the laboratory conducting the analysis should be contacted to determine minimum tissue size required (see Section 4.4.2.2).

Tissue samples should be bagged separately in clean plastic bags and labeled to indicate the sample identifier, station identifier, date and collector.

Catch and effort data should also be recorded for each gillnet station. This should include the amount of sampling gear deployed, duration of the net set, mesh sizes and catch per unit effort.

Sample Handling and Transfer

Fish samples must be handled rapidly in such a way that degenerative changes do not render analysis unreliable or impossible. Samples should be stored on ice, and frozen as soon as possible. Tissues should be shipped (frozen) to the laboratory for analysis. For some laboratory requirements, samples should be shipped in dry ice, or liquid nitrogen.

4.4.2.2 Heavy Metals and Mercury Analysis

Samples gathered in the field should be analyzed by a certified laboratory. It is important to establish a relationship with a laboratory prior to sample collection. The lab will specify what sample sizes they require and the limits of quantitation (LOQs) which will accompany varying sample sizes. The lab may also specify preservation or shipping methods which they require to ensure quality control.

4.4.3 Presentation of Information

Information should be presented to DFO in a clear, concise form. The submission should include the following components:

- a brief outline of the proposed project including those aspects which may interact with fish and fish habitat (i.e. nature of the project, location);
- a summary of the heavy metal/mercury level sampling procedures (i.e. methods used, areas surveyed, dates/times of field work, weather conditions, etc.);
- a summary of the catch success (i.e., catch per unit effort) in the areas sampled:
- field observations on the stomach contents of specimens;
- a text summary of mean mercury and other heavy metal concentrations found in the tissue samples analyzed for each test species at each sampling site, accompanied by a summary table (a table containing the raw data for baseline metal concentrations in the fish sampled should be appended to the submission); and
- interpretation of results and comparison with other studies.

4.4.4 Literature for Further Information

Aquamin Working Groups 7 and 8. 1996. Final Report: Assessment of the Aquatic Effects of Mining in Canada: Aquamin. Prepared for the Aquamin Steering Group.

Brouard, D., C. Demers, R. Lalumière, R. Schetagne and R. Verdon. 1990. Summary Report. Evolution of mercury levels in fish of the La Grande hydroelectric complex, Québec (19781989). Joint report. Vice-présidence Environnement, Hydro-Québec and Groupe Environnement Shooner inc., 97 pp.

CCME (Canadian Council of Ministers of the Environment). 1995. Canadian Water Quality Guidelines. Prepared by the Task Force on Water Quality Guidelines of the Council of Resource and Environment Ministers. Inland Waters Directorate, Environment Canada.

Scruton, D.A., E.L. Petticrew, L.J. LeDrew, M.R. Anderson, U.P. Williams, B.A. Bennett, and E.L. Hill. 1994. Methylmercury Levels in Fish Tissue from Three Reservoir Systems in Insular Newfoundland, Canada. In: Mercury Pollution: integration and synthesis, Ed. Carl J. Watras and John W. Huckabee.

4.5 Collection of Hydrological Information

4.5.1 Rationale for Information Collection

Hydrological information is required where project activities cause changes in stream hydrology which can have implications with regard to impacts on fish and fish habitat. These changes include:

- instream structures or modifications, i.e., dredging will change the areas of scouring and deposition;
- increased flows will increase scouring, bedload movement thus changing the local and downstream substrate character, increased flows will also change the suitability for fry and parr and may create velocity barriers for adults;
- decreased flows will allow for sedimentation, reduce bedload movement, change suitability for species, and reduce the wetted area, i.e., available habitat; and
- impoundment of water will create standing water above a dam and eliminate flow below a dam if no mitigations are applied.

The application of hydrological information in developing mitigative measures to protect fish and fish habitat could include:

- Activities such as bridge construction, dam/dyke construction and culvert installation require hydrological data to ensure that the design of these structures will allow fish passage and will resist washouts (which can have devastating effects in fish habitat).

- The effects of stream diversions on downstream hydrology must be modeled to determine the level of potential habitat loss or the possibility of disrupting fish migration.

- In order to provide the information on expected effects of a water withdrawal on stream hydrology, baseline hydrological data on the stream of interest will have to be collected. This baseline information can be used to model the effects of a water withdrawal on the flow, depth and other hydrological characteristics of the stream during and after water withdrawal activity.

4.5.2 Methodology for Collection of Hydrological Information

The following section provides an outline of the equipment required and proper procedures for the collection of hydrological data. When designing a hydrological data collection program, the proponent should consult the reference materials listed in Section 4.5.4.

4.5.2.1 Data Required

Hydrological data collection generally involves the establishment of permanent or temporary data collection stations.

The location and number of data collection stations and monitoring locations is project-specific. Data collection is generally focused at areas of project interaction with aquatic ecosystems, as well as at downstream areas that may be affected by the proposed development.

Stream Discharge Measurements

The simplest method of gathering stream hydrological data is to estimate or measure the discharge at a predetermined stream site. A rough field estimate of discharge can be derived by measuring (or estimating) the width and average depth of a cross section. Flow velocity can be estimated by timing the movement of a floating object (e.g., an orange ball) over a known distance. This measurement should be repeated three times and averaged to obtain an estimate of flow velocity. The discharge is roughly the velocity times the cross sectional area of the stream - expressed in cubic metres per second.

A more accurate method of data collection follows the standard procedures described in the field techniques manuals Environment Canada Water Surveys or those of the Instream Flow Incremental Methodologies (IFIM) (JWEL et al. 1996a, 1996b). Complete sets of depth (metric wading rod) and mean column water velocity (using a mechanical or electrical current meter) are collected along a cross section. Stations along the cross sections are established to have a minimum of 15 to 20 cells across the channel width. Numerous cells, each representing approximately 5% of the transect width, will accommodate heterogenous conditions and produce more accurate results. That is to say, the discharge is the sum of the cells (area times mean velocity) across the transect (cross section). This is a method that is easily applied and can produce very accurate results when conducted by trained personnel using good quality and properly calibrated equipment.

A staff gauge can be installed to permit recording the water level at different measured discharges. By calibrating the staff gauge to measured discharges, additional discharge values can be estimated from the water level.

Semi-Permanent Hydrological Stations

These stations are installed at areas of concern to allow the assessment of changes that might be attributable to proposed project activities. Data collection stations are equipped with data loggers that record information which can be downloaded to a computer during regular station visits. Permanent stations are often outfitted with specialized digital data loggers equipped with satellite transmitters to allow instantaneous access to conditions at the data collection station. ‘this specialized equipment is housed in permanent gauge shelters. Temporary stations generally consist of the following equipment:

- single channel data logger in a weatherproof aluminum enclosure;
- 5 psi pressure transducer; and
- staff gauge.

Retrieval of Data from Hydrological Stations

Permanent stations should be visited a minimum of four times a year to download data, data from temporary stations should be downloaded monthly.

During the visits to permanent stations, information that should be collected includes; hydrometric discharge meter measurements; current meter measurements; and water level measurements.

Spring Runoff Monitoring

Spring runoff monitoring involves the collection of data and photographs that will allow for the comparison of snow and water levels from different observations days, thus allowing for a description of the progression and characteristics of runoff in the study area. In preparation for a spring runoff monitoring program, at least one permanent feature at each site that is expected to remain above water levels should be marked. This mark should appear in all photographs taken to allow as a reference point for water level.

Winter Snow, Ice and Water Measurements

Monitoring snow, ice and water conditions can be important for detecting hydrological changes during the winter months. Measurements that should be taken over the winter include; snow, ice and water levels at pre-determined winter monitoring locations; manual measurements of water levels; under ice flow measurements and snow densities at streamflow monitoring stations; manual meteorological measurements; and weekly snow depths at a small number of selected locations.

Extrapolating Information for Ungauged Watersheds

It is possible to extrapolate hydrological information for an ungauged watershed from the information obtained from hydrological data collection stations on another watershed. This method is successful only when the watershed being used for data extrapolation is similar to the ungauged watershed in a number of features. The four main factors that must be considered when extrapolating data from a gauged watershed are:

- watershed drainage;
- physiographic characteristics;

- orientation of the basin; and
- proximity and similarity of the two water sheds (i.e., climate, evapotranspiration, terrestrial land types, etc.).

In order to obtain meaningful and scientifically defensible hydrological data from a gauged watershed, data extrapolation and analysis should be performed by a professional hydrological engineer or hydrologist in consultation with DFO personnel as required.

Hydraulic Modeling

In situations where a valued habitat is at risk, there are tools that permit assessment of instream flow needs (IFN) that would be required for the conservation and protection of fish habitat. Three specific methods that have been reviewed to assess applicability to Newfoundland are:

- Tennant (Montana), a hydrologic fixed flow method - the most widely known of the fixed flow methods for setting stream flow regimes intended to protect fish and wildlife resources. The Tennant method prescribes a fixed percentage of the mean annual flow during specific time periods.

- Wetted Perimeter, a hydraulic fixed flow method - is an example of a hydraulic rating method. It is a fixed flow method based on the hydraulic relationship between flow and wetted perimeter and is a standard setting technique. The flow corresponds to the wetted perimeter (wetted width of the stream cross-section) that is estimated to minimally protect all habitat needs.

- Physical Habitat Simulation (PHABSIM), an incremental method - is a series of computer models linking open channel hydraulics with known elements of fish behavior. PHABSIM is a tool used in the IFIM process, which is a method with a broader scope, integrating planning concepts of water supply, analytical models of physical and chemical parameters, alternatives analysis, and negotiation. An important difference between an incremental method (e.g.. PHABSIM) and a standard setting fixed flow meter used for (e.g.,Tennant Method or WPM) is that a flow recommendation does not arise from an incremental method. The incremental method may lead to a flow recommendation, but only after discussion and interpretation of results. By contrast, the Tennant Method and the WPM lead directly to flow recommendations.

These methods have been reviewed by JWEL et al. (1996c; 1997).

4.5.3 Presentation of Information

Information should be presented to DFO in a clear, concise form. The submission should include the following components:

- a brief outline of the proposed project including those aspects which may interact with fish and fish habitat (i.e. nature of the project, location);
- a summary of the hydrological data collection field work (i.e. methods used, areas surveyed, dates/times of field work, weather conditions, etc.); and
- a text and tabular summary of the hydrological data (i.e. existing flow regime versus altered flow regime, daily, monthly, average, median, peak and minimum flow levels, run off characteristics, etc.) collected at the hydrological stations (raw data should be appended to the submission).

4.5.4 Literature for Further Information

Environment Canada. 1981. Hydrometric Field Manual - Measurement of Streamflow. Inland Waters Directorate Water Resources Branch, Ottawa.

Environment Canada. 1984. Hydrometric Field Manual - Leveling. Inland Waters Directorate Water Resources Branch, Ottawa.

Environment Canada. 1983. Hydrometric Field Manual - Measurement of Stage. Inland Waters Directorate Water Resources Branch, Ottawa.

Jacques Whitford Environment, Acres International Ltd. and T. R. Payne & Associates. 1996a. Evaluation of Instream Flow Needs Assessment Methodologies in Newfoundland. 2. West Salmon River. Report to the Canada-Newfoundland Agreement Respecting Water Resources Management and the Green Plan, Habitat Action Plan. vii + 38 pp.

Jacques Whitford Environment, Acres International Ltd. and T. R. Payne & Associates. 1996b. Evaluation of Instream Flow Needs Assessment Methodologies in Newfoundland. 3. Pinchgut Brook. Report to the Canada-Newfoundland Agreement Respecting Water Resources Management and the Green Plan, Habitat Action Plan. viii + 56 pp.

Jacques Whitford Environment, Acres International Ltd. and T. R. Payne & Associates. 1996c. Evaluation of Instream Flow Needs Assessment Methodologies in Newfoundland. 1. Review of Methodologies. Report to the Canada-Newfoundland Agreement Respecting Water Resources Management and the Green Plan, Habitat Action Plan. vi + 44 pp.

Jacques Whitford Environment, Acres International Ltd. and T. R. Payne & Associates. 1997. Evaluation of Instream Flow Needs Assessment Methodologies in Newfoundland. 5. Guidelines for Use. Report to the Canada-Newfoundland Agreement Respecting Water Resources Management and the Green Plan, Habitat Action Plan.

4.6 Small Scale Water Withdrawal From A Waterbody/Watercourse

4.6.1 Rationale for Information Collection

Water withdrawal from a freshwater source is a common practice associated with construction and operation of various developments. Water intakes have the potential to cause fish loss or damage due to entrainment or impingement. Entrainment occurs when fish are drawn into a water intake and cannot escape. Impingement occurs when fish are held in contact with an intake screen and are unable to free themselves. Water withdrawals also have the potential to alter the natural flow regime of a watercourse or waterbody.

To mitigate against these potential effects of water withdrawal, intakes should be equipped with screens designed on a site-specific basis, taking into consideration the size and location of the proposed intake and the characteristics of the fish population in the proposed intake location. Requirements for the design of end-of-pipe fish screens are discussed in Section 4.6.3. When planning and designing water intakes and fish screens, the proponent is directed to consult some of the reference material listed in Section 4.6.4.

Proponents should note that the information contained in the following sections applies to smallscale water withdrawals. Large-scale water withdrawals (greater than 125 L/s) require more stringent planning and investigation to ensure fish and fish habitat protection. Proponents of largescale water withdrawals (greater than 125 L/s) should consult with DFO to determine appropriate fish screen design and flow maintenance requirements.

4.6.2 Information Requirements

As outlined in the Freshwater Intake End-of-Pipe Fish Screen Guideline (DFO 1995), the information pertinent to the review of a small-scale water intake (less than or equal to 125 L/s) and fish screen proposal includes general and site information, biophysical information, water use information and details on the proposed fish screen design.

4.6.2.1 General and Site Information

General and site information required for review of proposed water intakes and fish screens includes:

- gazette or common name of the watercourse;
- location of the watercourse;
- type of watercourse (i.e. lake, stream);
- type of water intake; and
- other activities associated with the development or construction of the intake screen/ structure.

4.6.2.2 Biophysical Information

Biophysical information that may be required for review of proposed water intakes and fish screens includes:

- fish presence, species and possible fish size or fish habitat conditions at the project site;
- physical description of the watercourse at the intake site;
- location and position of the intake within the watercourse, including dimensions, alignment, depth in the water column, wetted area, etc.; and
- description of the site features and characteristics, including site access.

The required biophysical information described above can be obtained using methods outlined in other sections of this document. The determination of the fish species present and the age and size characteristics of these populations can be determined using the electrofishii:a survey methods described in Section 4.2 of this document. The characteristics of the fish habitat present in the proposed intake location can be determined by a fish habitat survey in the affected stream, as described in Section 4.1 of this document.

4.6.2.3 Water Use Information

Water use information that may be required for review of proposed water intakes and fish screens includes:

- purpose of water withdrawal;
- average rate, or ranges of rates, of withdrawal from the watercourse;
- duration and time of withdrawal;

- estimates of ranges of flow (i.e. daily, weekly, monthly) in the watercourse during times of withdrawal with dates and times of year (with particular consideration to periods of low flow);
- expected effects of withdrawal on existing watercourse (i.e. drawdown, downstream dewatering);
- description of structures or activities associated with the development of the intake;
- whether the application is for a new intake, or re-development or upgrading of an existing structure; and
- other water resource users or uses.

The water use information required for the review of water intakes and fish screens is project-specific and would be determined by project planners based on the anticipated water requirements of the proposed project. Methods of collecting information on the hydrological characteristics (i.e. flow characteristics and seasonal variation) of the affected waterbody are discussed in Section 4.5 of this document. Once baseline hydrological information has been obtained, the expected effects of a withdrawal on the hydrology of the affected area can be predicted using hydrological calculations and computer modeling.

4.6.2.4 Fish Screen Information

Fish screen design information that may be required for review of proposed water intakes and fish screens includes:

- screen open and effective areas;
- physical screen parameters with respect to the intake and the watercourse;
- screen material, method of installation and supporting structures; and
- screen maintenance, cleaning or other special requirements.

4.6.2.5 Other Useful Information

Other information that is useful in the review of proposed water intakes and fish screens includes:

- site plans/sketches indicating intake site and location (detailed on 1:50,000 topographic map); and
- photographs or video footage of the proposed site.

4.6.3 Proper Procedures Required to Design Intake Screens

The appropriate design of a fish screen is largely dependent on the species and the size of fish requiring protection. The Freshwater Intake End-of-Pipe Fish Screen Guideline (DFO 1995) places emphasis on the protection of freshwater fish with a minimum fork length of 25 mm, since most eggs and fish larvae remain in bottom substrates until they reach the fry stage (i.e. 25 mm fork length).

This guideline also assigns different open screen area (i.e. the area of all open spaces on the screen available for free flow of water) requirements based on the swimming mode of the fish species in question. Swimming modes addressed in the Freshwater End-of-Pipe Fish Screen Guideline (DFO 1995) are subcarangiform (trout or salmon-like movements, with movement consisting of undulation in the posterior third or half of the body) and anguilliform (eel-like movements, with movement consisting of undulation of most or all of the body). Swimming mode is an important consideration in intake screen design because mode of swimming is related to the flexibility of a fish. Anguilliform swimmers are very flexible and could proceed through a screen opening more easily than a subcarangiform swimmer. Swimming mode and flow-specific open screen area requirements are outlined in Table 4.4.

Once the required open screen area has been determined, the *effective screen area* must be calculated. This value represents the area occupied by the open spaces and the screen material available for the free flow of water. Effective screen area is calculated by dividing the open screen area by the percent of open screen area. The percent open screen area is determined by screen material. Table 4.5 presents the percent open screen areas for some common screen materials.

The effective screen area is calculated using the following equation:

$$EffectiveScreenArea = \frac{OpenScreenArea}{\left(\frac{PercentOpenArea}{100}\right)}$$

Note that if the percent open screen area is maximized, then the effective screen area required for a given flow is minimized. The narrowest dimension of any opening on the screen is referred to as the design opening. The maximum design opening for a fish of 25 mm fork length is estimated at 2.54 mm. Guidelines on screen openings and materials, as well as screen installation and maintenance, are presented in the Freshwater Intake End-of-Pipe Fish Screen Guideline (DFO 1995), and are outlined below:

- Screen openings should not have any protrusions that could injure fish.
- Screen materials should be resistant to corrosion and UV light.

- Where possible, screens should be located in areas and depths of water with low concentrations of fish throughout the year, away from natural or constructed structures which may attract fish that are migrating/spawning or in rearing habitat, and at a minimum of 300 mm above the bottom of the watercourse/waterbody to prevent entrainment of sediment and aquatic organisms associated with the bottom.

Table 4.4 Open Screen Area Required for End-of-Pipe Water Intakes

Flow of Water into intake (L/s)	Open Screen Area Requirements for Subcarangiform Swimming Mode m2	Open Screen Area Requirements for Anguilliform Swimming Mode m2
1	0.01	0.03
5	0.05	0.13
6	0.06	0.16
8	0.07	0.21
10	0.09	0.26
12	0.11	0.31
14	0.13	0.37
15	0.14	0.39
16	0.15	0.42
18	0.17	0.47
20	0.18	0.52
22	0.20	0.58
24	0.22	0.63
25	0.23	0.65
26	0.24	0.68
28	0.26	0.73
30	0.28	0.79
32	0.30	0.84
34	0.31	0.89
35	0.32	0.92
36	0.33	0.94
38	0.35	0.99
40	0.3 7	1.05
45	Q.42	1.18
50	0.46	1.31
55	0.51	1.44
60	0.55	1.57
65	0.60	1.70
70	0.65	1.83
75	0.69	1.96
80	0.74	2.09
85	0.78	2.23
90	0.83	2.36
95	0.88	2.49
100	0.92	2.62
110	1.02	2.88
120	1.11	3.14
125	1.16	3.30
Source: Freshwater End-of-Pipe Fish Screen Guideline (DFO 1995)		

Table 4.5 Examples of Common Screen Materials

Material mm	Wire Thickness (mm)	Opening Width	% Open Area
8 x 8 Stainless Steel Alloy Mesh	0.711	2.4460	
#7 Mesh Wire Cloth	1.025	2.54	51
#8 Mesh Wire Cloth	0.875	2.25	52
#8 Mesh Wire Cloth	0.7	2.54	62
#60 Wedge Wire Screen	1.5	2.54	63
#45 Wedge Wire Screen	1.1	2.54	69
Source: Freshwater End-of-Pipe Fish Screen Guideline DFO 1995			

- The screen face should be oriented in the same direction as the flow, and flow should be evenly distributed over the screen surface.
- Regular maintenance should be provided, including the removal, inspection, and cleaning of screens to prevent debris fouling and impingement of fish.
- Heavier cages or trash racks can be fabricated out of bar or grating to protect the finer fish screen, especially where there is debris loading (woody materials, leaves, algae mats, etc.). A 150 mm spacing between bars is typical.
- Under certain site specific winter conditions, it may be appropriate to remove screens to prevent damage.

The dimensions of the fish screen are calculated after the correct shape, configuration, location and method of installation have been determined by a site investigation and guideline review. Common screen shapes and the associated dimensions and area formulae are presented in Figure 2 of the Freshwater Intake End-of-Pipe Fish Screen Guideline (DFO 1995). Figures 3, 4 and 5 of the 1995 guideline document illustrate some of the various configurations, applications and screen material types of end-of-pipe fish screens.

4.6.4 Presentation of Information

Information should be presented to DFO in a clear, concise form. The submission should include the following components:

- a brief outline of the proposed project (i.e., general and site information) and its water withdrawal requirements (i.e., water use information);
- a summary of the hydrological data collection field work (i.e. methods used, areas surveyed, dates/times of field work, weather conditions, etc.);

- a text and tabular summary of the hydrological data (i.e. peak and minimum flow levels, etc.) collected at the hydrological stations (raw data should be appended to the submission);
- based on the existing hydrological features in the affected area, an estimate of the effects of water withdrawal on the hydrology of the area;
- appropriate biophysical information on fish species present, population sizes and age and size distributions of fish populations; and
- details on the selection and design of the fish screen (i.e., fish screen information).

4.6.5 Literature for Further Information

Department of Fisheries and Oceans. 1995. Freshwater Intake End-of-Pipe Fish Screen Guideline. Communications Directorate, Department of Fisheries and Oceans. Ottawa, ON.

Department of Fisheries and Oceans. n.d. Factsheet No. 21 - Freshwater Intake End-of-Pipe Fish Screen.

5.0 CONTACT LIST

Local Fish Health Officer, Newfoundland

Fish Health Officer, DFO, St. John's Tel: (709) 772-2891 Fax: (709) 772-4188

Licensing Section, Newfoundland Region

Licensing Clerk Tel: (709)772-4406 Fax: (709)772-5133

Area Habitat Coordinators, Department of Fisheries and Oceans, Newfoundland Region

The administration of DFO in the Province of Newfoundland and Labrador is divided into five areas. The area covered by each office is shown in Figure 5.1 and the Coordinators are:

AREA 1: Area Habitat Coordinator
Department of Fisheries and Oceans
Suite 301, Viking Bldg., 136 Crosbie Road
St. John's, NF AIB 3K3 Tel: (709) 772-5597 Fax: (709)-772 2659

AREA 2: Area Habitat Coordinator
Department of Fisheries and Oceans
P.O. Box 580, Federal Bldg., Church Street
Grand Bank, NF AOE 1WO Tel: (709) 832-0010 Fax: (709) 832-2292

AREA 3: Area Habitat Coordinator
Department of Fisheries and Oceans
Suite 200, 4A Bayley Street
Grand Falls-Windsor, NF A2A 2J9 Tel: (709) 292-5197 Fax: (709) 292-5203

AREA 4: Area Habitat Coordinator
Department of Fisheries and Oceans
P.O. Box 7003, Station A
Building 397, CFB Goose Bay
Goose Bay, Labrador, NF AOP 1 SO Tel: (709) 896-2642 Fax: (709) 896-8419

AREA 5: Area Habitat Coordinator
Department of Fisheries and Oceans
P.O. Box 2009, Federal Bldg., 12 Herald Ave.
Corner Brook, NF A2H 6Z6 Tel: (709) 637-4349 Fax: (709) 637-4445

Figure 5.1 Boundaries of DFO Management Areas - Newfoundland and Labrador Region