Landlocked salmon	-	5 maximum possession
Smallmouth (Black) bass	-	5 maximum possession

Bag limit for all trout (speckled, brown, rainbow) and landlocked salmon is 0 from September 1 to September 30.

Size Limits

Brown trout	-	No more than 4 may be greater than 35 cm in length
Rainbow trout	-	No more than 2 may be greater than 35 cm in length
Speckled trout	-	No more than 2 may be greater than 25 cm in length
Landlocked salmon	-	No more than 1 may be greater than 45 cm in length. None may be greater than 62 cm in length.
Smallmouth bass	-	No more than 2 may be greater than 30 cm in length.

In addition to the aforementioned initiatives described in the NSDOF Recreational Fisheries Management Plan (Hill 1990) and the proposed fishing regulation changes described previously, the consultants suggest additional options for consideration to rebuild and expand freshwater recreational fisheries in Nova Scotia.

- Establish a multi-species approach to managing and developing the recreational fisheries resource and fish habitat in each watershed;
- Improve communication and cooperation between Federal (DFO) and Provincial (NSDOF) agencies in the planning and implementation of recreational fisheries initiatives;
- Strengthen the infrastructure of both the Federal and Provincial agencies in terms of staff, fiscal resources and facilities required to implement the strategic plan;
- Biological and technical advice and fiscal resources are required to support Native and Community groups (Watershed Groups) in initiating recreational fisheries projects;
- Establish a Native Fisheries Involvement Program (NFIP), Community Fisheries Involvement Program (CFIP), Experimental Lakes Program (ELP), Fisheries Assessment Program (FAP), Resource Development Program (RDP) and a Recreational Fisheries Information System (RFIS) which will standardize and improve the collection, storage, analysis and sharing of databases between government agencies and also stakeholders;
- Improve government agencies' capability to provide the quantity, quality and genetic composition of hatchery reared salmonids with an emphasis on wild broodstocks from local stocks;
- Streamline existing consultative mechanisms i.e. Federal/Provincial, (ZMAC, RFAC) and management zones (RFAs, and SFAs). A Federal/Provincial working group should be established to

discuss consolidation and streamlining these management mechanisms as discussed under Program Delivery;

- Streamline enforcement activities by combining the resources and staff from the respective government agencies (DFO, NSDOF, NSDNR, DOE, NSDOE), and Natives to form an Inland Recreational Fisheries Conservation Unit. Community Groups could assist through volunteer mechanisms and education (Report a poacher, River Watch, 1-800 numbers, and hiring river wardens where watershed (river/lake) specific management is introduced. Consideration should be given to a ticketing system and suspension of fishing privileges as appropriate;
- Establish "no-kill" or "catch and release" zones in designated streams and lakes in each RFA;
- Establish sanctuaries in designated streams and lakes in each RFA;
- Under the Experimental Lakes Program described in this report implement the closure of clusters of lakes on a rational basis (e.g. Highland Lakes) in each RFA;
- Control the access to designated lakes by controlling access on private logging roads;
- Develop a comprehensive stocking policy. For example, the policies should emphasize wild broodstock and endemic speckled trout; naturalized species such as brown trout and rainbow trout would receive lower priority for designated streams and lakes; landlocked salmon would be stocked in lakes where they currently exist (e.g. Grand Lake) or in areas where potential exists without impacting on other species. Put-and-take urban or community stocking would be another important aspect of the policy where private interests (economic development) and isolated lakes would be considered for stocking, fishing derbies/tournaments and winter ice-fishing;
- Implement fish habitat improvements in streams and lakes in cooperation with watershed groups;
- Implement applied research on a number of issues/techniques discussed in this report in cooperation with other government agencies and watershed groups;
- Implement stock assessments, resource, water quality and habitat data collection initiatives in cooperation with other government agencies and watershed groups;
- Projects identified in class "A" and class "B" waters should be given preference because of more suitable water quality;
- Wild speckled trout stocks should be managed in class "A" waters using techniques such as fish habitat improvement, more restrictive harvests (e.g. 5 trout/day), "no kill" zones, and sanctuaries where no harvest is permitted. This approach could be used by closing clusters of lakes on a 3 - 4 year cycle to rehabilitate stocks and provide for trophy fishing in designated lakes (e.g. Highland Lakes) once they have recovered;
- Enhanced wild speckled trout stocks should be rehabilitated through the techniques identified for "pure wild" trout stocks but by using wild broodstock from that stream or lake or a local wild strain and implementing other techniques such as semi-natural rearing, satellite rearing or streamside incubation boxes. Community involvement would be essential for both "pure wild" and "enhanced

wild" trout projects. These techniques should be used to "kick-start" rehabilitation of these populations which would then be managed as "pure wild" trout stocks;

- Since stocking costs are high the consultants suggest that the stocking of progeny of "enhanced hybrid" and "enhanced hatchery" be reviewed by NSDOF fishery staff and replaced with other techniques suggested in this report to "kick-start" trout rehabilitation in class "A" and "B" waters;
- Urban or Community Recreational stocking should remain a priority since it will be used to provide angling opportunities for the disabled, educate anglers regarding conservation (bag limits), stimulate interest (derbies), take pressure off wild trout stocks and create opportunities for recreational fishing during the shoulder tourist season and winter ice fishing in designated lakes. Private enterprise could be considered under this category for economic development i.e. U-Fish Ponds or intensive stocking of isolated fisheries in a pristine environment for economic development objectives. Consideration could be given to stocking rainbow trout in selected projects to increase biodiversity and providing a variety of angling experiences under this category. These fisheries would additionally provide recreation for the disabled, the elderly and novice angler;
- Consideration should be given to shorter seasons for designated lakes/streams i.e. later season opening such as May 15 and earlier closures such as September 1 where watershed groups wish to adopt this approach; catch and release could be applied in lieu of closures for these time periods (i.e. April 1 - May 15; September 1 - 30);
- Consideration should be given to catch and release of all speckled trout greater than 25 cm in length in designated lakes/streams where watershed management groups concur;
- Consideration should be given to the draft policies on fishing derbies and tournaments, and the introduction policy for smallmouth bass prepared by NSDOF (Appendix VI and VII)

New or Improved Management Regimes

River/Lake Specific Management (Watershed Specific Management)

River or lake specific management is a refinement of the concept of Zonal Management or management by Recreational Fishing Area (RFA). It includes the management of specific river or lake fish stocks taking into consideration the biological, social and economic information for each river or lake. As in the Zonal/RFA management concept, the harvest by all user groups and the river are controlled through fishing seasons, gear types, quantities of fish taken, licensing strategies, bag limits and overall quotas.

It consists of a working/advisory committee which develops an action plan centered on governing principles and management elements for presentation to the Zonal Management Advisory Committee

(ZMAC) or Recreational Fishing Advisory Council (RFAC). **It is suggested that a common consultative mechanism be adopted by both Federal and Provincial fishery managers combining the concepts of ZMAC and RFAC.**

Four major goals of river or lake specific management are :

- (i) To manage (i.e. restore, develop and maintain) the fisheries resource in order to achieve production levels consistent with production capacities throughout the species range in each RFA;
- (ii) To generate optimum socio-economic benefits from the fisheries resource, based on an appropriate allocation balance among all user groups, native food fisheries being the first priority after spawning requirements are met;
- (iii) To foster cooperation among levels of government and the private sector with respect to management of the fisheries resource;
- (iv) To conserve and protect the fisheries resource.

The governing principles on which these goals are based are :

- (i) Manage the resource utilizing comprehensive Integrated Resource Management Policies;
- (ii) Continue and improve the scientific basis of fisheries management;
- (iii) Ensure maintenance and restoration of fish habitat;
- (iv) Maintain fish production at optimum levels;
- (v) Optimize the socio-economic benefits from the fisheries resource while ensuring its wise and responsible use;
- (vi) Ensure the active participation of public and private interest groups in the management of the resource;
- (vii) Work towards the maximum production of the largest fish (trophy) possible within the capabilities of the river or lake;
- (viii) Strive towards discrete stock management in rivers or lakes to the extent this is possible;
- (ix) Improve communication and consultation with user-groups, industry, members of the general public and all levels of government;
- (x) Develop information and education packages to promote the conservation of the fisheries resource;
- (xi) Develop and improve systems which can provide accurate and timely catch and effort statistics;
- (xii) Strive to achieve compliance with regulations and improve the effectiveness of enforcement activities.

(xiii) Work towards the development of accurate biological and economic databases which could be used for management.

The St. Mary's River in eastern mainland Nova Scotia is the site of a test project on River Specific Management (RSM) by the Department of Fisheries and Oceans (DFO), Scotia Fundy Region. The river was chosen as an index site because it has a strong local river organization and a salmon population comprised of 1SW, 2SW and 3SW early run salmon. The 1988 Salmon Management Plan proposed an outline for a river specific project including the optimal production of Atlantic salmon which would provide user groups with maximum benefits without adversely affecting the production potential of other species. The goal of this project was to achieve more informed decision making on the management of Atlantic salmon stocks with respect to conditions unique to that river. This entailed collecting information on the biology and population structure of the Atlantic salmon stock and on environmental conditions of the watershed with the aim of increasing fish populations for all user groups. Since there was no formal characterization of the St. Mary's salmon stock, the priority of this project was immediately recognized as the collection of research data on this subject. Once this information has been obtained, management strategies involving river stewardship programs will be proposed.

While this river specific management project targets Atlantic salmon the principles on how to achieve river/lake specific management outlined below would apply to the management of all fisheries resources in a river or lake.

a) Define the objectives of the program. Perhaps the most important ingredient to this decision making process would be determining the need for such a program and the desire within the communities in the watershed for river specific management.

b) Characterize the resource, both biological and physical. Establish resource use estimating procedures (e.g. methods for estimating fish harvest). Complete a floodplain map of the watershed, land use map, wetland grading, environmental sensitivity grading of the watershed or lake and various other related wildlife inventories (bird, wildlife, etc.).

c) Identify ways to improve the socio-economic benefits from the resource in a way which would protect the integrity of the resource.

d) Determine the feasibility of managing the river or lake from the legal point of view, either with an autonomous body, with an adjunct to existing municipal governments, or with a joint volunteer-government steering committee.

e) Review water and land use practices within the watershed or lake. A clear indication of those uses in the future will be necessary before implementing a RSM or LSM plan. The economic and social surveys described in (f) and (g) should address 'future' use

f) Conduct an economic survey to determine the impact of the various management options available to meet the objectives from (a). The survey must encompass all current businesses within the watershed or lake.
g) Examine the social implications of the RSM or LSM options, and in particular, the creation of a watershed or lake authority.
h) The data needed for (f) and (g) will also provide the impact of the RSM or LSM on land use practices within the watershed (i.e. mining, agriculture, forestry, industrial development, etc.).
i) Identify the sources for funding to establish and operate a river or lake management plan in the long-term.
j) Define who will do what under the RSM or LSM regime.
k) Proceed with the necessary steps to establish the management agency.

Other examples of watershed management models such as the Restigouche, St. Croix and ZEC (Quebec) models are outlined in Appendix VIII. For example, the Bras d'Or Lakes may be an example where lake specific management could be undertaken.

Experimental Lakes Program

In areas where it is recognized that wild trout populations are in serious decline a program of alternating closures to angling in clusters of lakes should be carried out. The principle reason for these closures would be to enable these populations of wild fish to rebuild but at the same time focusing research on the reasons for these declines. The goal would be to improve angling opportunities when the experimental lakes are reopened. Utilizing a program such as this would lead to the reclamation of lakes from overexploitation and habitat degradation. Unique wild strains of trout and trophy size trout would result.

Lake Specific Management (LSM) techniques can be used with particular restrictions designed to suit the area where specific management efforts are required. Restrictions such as flyfishing only, barbless hooks (i.e. barbs bent down) and restrictions on hook size, no kill areas, or a limit on the number of rod days in specific lakes on crown land may prove effective in the protection of existing stocks in heavily fished areas.

The introduction of new species could prove an effective method of reducing pressure on native species. After a period of careful research, introduction of new gamefish species could be carried out where it is proven that little or no harm would result to native stocks of gamefish or rare or endangered species that occur in these areas. Alternatively, introduction of new gamefish could be made, after careful study, in adjacent, isolated lakes to reduce angling pressure on endemic species of speckled trout or Atlantic salmon. Introductions of popular gamefish such as smallmouth bass and landlocked salmon in specific lakes where there would be no significant impact on native species would provide excellent opportunities for recreational angling.

An Experimental Lakes Program (ELP) that allows for the closure of areas would be an excellent vehicle for the control of species such as yellow perch and chain pickerel that are less valued by anglers. By controlling species that are in competition with popularly angled species, these latter sportfish populations could be enhanced, and techniques such as this could reduce the high demand for restocking programs.

In order to carry out such an Experimental Lakes Program additional equipment and person years would be necessary. **The implementation of such a program would provide an excellent opportunity for cooperative research with universities, consultants, different government agencies and community groups.**

Delegation of Responsibility

Management of recreational fisheries resources should rest more in the hands of those benefiting from the resource. Local volunteer groups should be actively involved in providing themselves and tourists in their areas with better angling. This would result in direct economic benefits to their community through the provision of employment in stream enhancement work and increased tourist revenues for local businesses. With a vested interest in the success of programs, they may be better run by those directly involved. Stewardship programs could be used to assist managers in identifying potential problems through the implementation of local River Watch and Conservation Guardian programs in cooperation with government agencies. Strong partnerships between community groups and both levels of government are needed for this management approach to be successful.

RFA Specific Management

Each Recreational Fishing Area should be managed as a specific area with its own merits and should maintain close cooperation with areas that have overlapping interests.

In cases where rivers or lakes have significant recreational fishery potential or based on their uniqueness, management through RSM or LSM is recommended. However, for the vast majority of rivers and lakes, they should be classified based on their water quality, presence of predators/competitors, species composition and the availability of suitable spawning and nursery habitat. While the watersheds would be managed for the principle recreational species present, individual river/lakes could be managed for a target species (e.g. Atlantic salmon, speckled trout, landlocked salmon, smallmouth bass) with the greatest recreational fishery potential, with lesser emphasis placed on other species. **It is suggested that in most cases the fisheries resources of the province should be managed by Units (e.g. in RFA 1 : Bras d'Or Lakes; Highland Lakes; major rivers; smaller streams) or by Zones in each RFA.** However, within these Units or Zones strategic plans for Atlantic salmon, speckled trout, rainbow trout, smallmouth bass and other recreational fish species would need to be developed.

Native Involvement and Participation

Native peoples have a vested interest in the successful management of the fisheries resource. For this reason Native groups should be directly involved in the management and enhancement of these resources. There is a move among some Native peoples to view the fisheries resource as an opportunity to create jobs and income rather than solely a food resource. The recreational fishery would provide jobs and income through the provision of lodges, cottages and guides that cater to the sport fishery. This has been shown in many cases to be of greater economic benefit to those involved. However, native rights to a food fishery is entrenched after spawning requirements are met.

Sanctuaries and No-Kill Zones

With increasing pressure on recreational fishery resources there is a need to conserve our remaining stocks of wild fish if we are to preserve a quality sport fishery in the future. In areas where large brook trout broodstock congregate during the heat of summer or later in the year for spawning it may prove effective to impose a moratorium on fishing and provide a temporary or permanent sanctuary. **Where there is heavy angling pressure in an area, no-kill zones could be implemented providing anglers with catch-and-release fishing only.**

Other Approaches

Other new or improved management approaches to reduce the harvest of wild stocks have been discussed under the recommendations for recreational fisheries management such as :

- put-take or put-grow take artificial fisheries;
- winter ice-fisheries;
- sea ranching;
- trophy fisheries;

- fishing derbies and tournaments;
- utilization of non-traditional species;
- controlling access to designated lakes/streams;
- catch and release (April 1 - May 15; September 1 - 30).

Integrated Resource Management

A successful Recreational Fisheries Development Plan should involve all users. Communication between government, industry, forestry, agriculture, hydro-electric development and local user groups is necessary. Consultative committees e.g. RFAC/ZMAC could provide a forum for communication by inviting industry representatives to sit on these boards; implementing information sessions would also help. Forestry companies could help stream enhancement groups through the provision of fiscal resources and equipment; communication between these groups could result in fewer conflicting practices such as forest harvesting in areas where stream enhancement is being carried out. Cooperation with agriculture, mining, hydro and other industries would also be essential in implementing a focused approach to improving the recreational fisheries. **In summary, the development of comprehensive watershed management plans combined with a thorough review of these plans would promote communication, education, cooperation and conflict resolution where all consumptive and non-consumptive fisheries/wildlife resources would achieve their full economic and recreational potential in harmony with existing agricultural, forestry, mining, hydro and other industries located in the watersheds.**

Fish Habitat Protection

The protection of fish habitat is essential for the continued maintenance and improvement of the recreational fishery. The preservation of fish habitat is protected by DFO under Sections 20 - 22, 28 - 30, 32, 35 and by DFO and DOE for Section 36 of the Federal Fisheries Act. However, a number of Provincial agencies are also involved in protecting fish habitat either through regulations or guidelines, namely: NSDOE and NSDNR. Legislation and guidelines are designed to protect the environment against improper practices in forestry, agriculture, road construction, cottage development, industrial and urban development and energy production. Some practices within these sectors are not covered adequately by present guidelines and need to be strengthened by legislation and more adequate enforcement. The following guidelines with various industries have been implemented to provide protection to fish habitat.

Forestry

Forestry activities follow specific guidelines established in Forest/Wildlife Guidelines and Standards for Nova Scotia (prepared by Nova Scotia Department of Lands and Forests). These guidelines require the forester to protect a watercourse from any damage that may result during his activities.

He is required to leave a "special management zone" adjacent to the aquatic resource, which increases in width as the slope of the adjacent land increases. He must also follow such guidelines as :

i) exclusion of heavy machinery within a prescribed distance of the watercourse;

ii) prevent the entry of woody debris into the watercourse;

iii) minimize blowdown in special management zones.

Road construction and stream crossings adjacent to an aquatic resource must also follow certain standards described in Environmental Standards for the Construction of Forest Roads and Fire Ponds in Nova Scotia. The guidelines governing forestry road construction were established by DFO, NSDNR and NSDOE. Infractions resulting in damage to fish habitat are handled by DFO; NSDOE may lay charges under the Water Act, etc. to fulfill their mandate which often also protects fish habitat.

Road Construction

Nova Scotia Department of Transportation and Communication (NSDOTC) provides environmental controls on highway projects before they go to tender.

1) Project Screening

   In February, 1992 it became mandatory that twinning projects receiving Federal/Provincial cost sharing, undergo environmental screening. Up to this time the Nova Scotia Department of the Environment only carried out environmental assessment on highway projects of more than 1 km of road, of 4 or more lanes, or projects disrupting 2 or more hectares of wetland. Currently, all stream crossings require a water rights permit which are reviewed by NSDOE and DFO. The screening process identifies and reviews all potentially adverse and possible environmental effects of a project complying with the Federal Environmental Assessment Review Process (EARP).

2) Preparation of Water Rights Permits

   In the past, Nova Scotia Department of Transportation and Communication relied on the assistance of DFO in on-site review of project proposals. Due to DFO resource constraints, NSDOTC has utilized more of their own personnel as well as consultants in developing environmental control plans. These plans would show such things as culvert locations, detailed erosion control devices, etc.. DFO reviews all environmental control plans prepared by NSDOTC and these must meet approval. Work sites are monitored for compliance by DFO staff.

3) Preparation of Specifications

NSDOTC has been trying for the past 2 years to make contract specifications for Environmental Control more specific for each individual project. They hope to meet specific environmental concerns for each project and paint a clearer picture for the contractor. It is NSDOTC's hope that a better understanding by the contractor will ensure his compliance with environmental requirements in the project. Nonetheless, all work sites are monitored by DFO for compliance and where needed contractors are advised of remediation efforts needed.

Environmental controls which are placed on projects which go out to tender should also apply to projects which do not follow the tendering process. This would ensure that all projects through NSDOTC would consider possible environmental damage that may result during such activities.

DFO is responsible for dealing with infractions under Sections 20 - 35, while DOE and DFO deal with infractions under Section 36 of the Federal Fisheries Act.

Agriculture

Agriculture plays a vital role in the Nova Scotia economy. Guidelines have been established by the Nova Scotia Department of Agriculture and Marketing (in consultation with DFO and NSDOE) to prevent the degradation of watercourses and fish habitat. Guidelines pertain to the following activities;

- land clearing
- pasturing livestock
- stream crossings
- stream bank conservation
- manure storage

If a farmer wishes to receive financial assistance (from NS Department of Agriculture) he must follow the standards of NS Department of Agriculture. Farmers who are not seeking financial assistance from NS Department of Agriculture are not required to follow such standards. This in turn makes it very difficult to protect fish habitat.

Policies should be developed for government land being leased for agricultural activities. Certain conditions should be written into the lease providing protection to watercourses through the establishment of greenbelts, grass waterways restrictions, cattle access, etc..

As a safety net, the preservation of fish habitat is guaranteed under Sections 20 - 22, 28 - 30, 32, 35 and 36 of Federal legislation as explained in the foregoing description.

Dredging

With the narrowing of many of our waterways and the increase in size of ships, dredging has made more waterways accessible. The Department of Environment controls the disposal of dredge spoil in coastal waters through the Ocean Dumping Control Act. Permits for dumping of spoil are reviewed by government, DOE and DFO to ensure that no damage occurs to fish and fish habitat.

As explained, the preservation of fish and fish habitat is guaranteed under Sections 20 - 35 (DFO) and under Section 36 (DOE and DFO) of the Federal Fisheries Act.

The protection of fish habitat through the development of guidelines for various industries is a positive step. Further work is necessary in making protection of fish an integral part of their work plan when activities are adjacent to watercourses. **It is important to note however that guidelines do not have the stature of legislative regulations and therefore at times are difficult to enforce or to prosecute violators.**

Issues of concern exist in many industries, for example, mining, agriculture (uncontrolled cattle access), cottage and road development adjacent to shorelines. Any activities near a watercourse require a watercourse alteration permit from NSDOE. Possibly through such permit system, more environmental conditions could be attached to provide protection of the fisheries resource.

The most substantial losses of fish habitats occur as the result of resource-use conflicts. Habitats can be lost as the direct result of timber harvesting, farming, water management, cottage development, and the indirect result of industrial development and energy production (e.g.. acidic precipitation, fish passage problems). The preservation of fish habitats in the past has always been a concern, but is now guaranteed under Sections 20 - 22, 28 - 30, and 35 - 36 of the Federal Fisheries Act. Consequently, fishery managers have the legal authority to enforce and maintain fish habitats in Nova Scotia. Further discussion of fish habitat protection and environmental issues and processes (EIA and EARP) is found in the section of this report on Water Quality, Quantity and Pollution Sources. The plan should adopt the following process for protecting and maintaining fish habitats:

a) Continue to **develop appropriate enforceable regulations from the current guidelines and standards available for the protection of fisheries resources and fish habitats in Nova Scotia.** For example, the Guidelines for the Management and Use of Animal Manure in Nova Scotia, Woodlot Roads/Stream Crossings, Forest/Wildlife Guidelines and Standards for Nova Scotia, Fish Habitat and Forestry, and Fish Habitat and Mining. These new regulations would be enforceable under Sections 35 - 36. Additional guidelines must address cattle access to water bodies (siltation, eutrophication, and bacterial contamination), buffer zones between cash crops and water bodies (soil erosion and siltation), construction or clearing of irrigation channels (loss of natural sediment filters or direct loss of habitat), cottage and road development adjacent to shorelines - including set-backs and limits on cottage development per lake (siltation and altering groundwater pathways and wetlands), construction of docks and piers (loss of reproductive habitats), and the placement of septic systems adjacent to water bodies (eutrophication and bacteria). Brochures should be prepared which clearly describe the rationale for environmentally sound development (e.g.. health of the ecosystem, sustain angling opportunities), the available resources to assist proponents adhere to the guidelines (e.g.. scientific, financial, and logistic support), the different sections of the Federal Fisheries Act and the legal consequences for failure to comply with the guidelines/regulations. Guidelines should be developed into regulations which are enforceable wherever this is feasible.

The regulations must be based on the available scientific knowledge of life history strategies and tactics of individual species. This knowledge is not always complete. Deficiencies should be identified and their reconciliation pursued by fisheries managers. Mechanisms should be established to encourage university and college researchers to be involved in such studies. Sometimes potential overlap between Federal and Provincial jurisdictions prevents action. For example, the development of regulations which would affect land use.

b) **Once regulations are in place,** they must be delivered to the various resource users in the province (e.g.. agriculture, forest industry, anglers, etc.). **The objective should be the saturation of targeted users through advertisements, seminars, or short-courses provided by fisheries and other resource managers (i.e. DFO, DOE, NSDOE and NSDNR).** These should include field excursions that display and provide direction for appropriate techniques, for example, providing cattle access to streams and ponds.

c) After this period of delivery (~ 1 year), follow-up visits must occur to evaluate the progress of development within the regulations. These follow-ups are required to display the commitment of the fisheries managers to the regulations, and if necessary, reiterate the consequences of failure to comply.

d) Following the delivery and follow-up programs, it may be necessary to enforce the Federal Fisheries Act. Minor violators should be avoided in initial prosecutions to avoid trivializing the process of habitat protection. Violations should also be made public to demonstrate the commitment of fisheries managers to the established regulations.

e) The adopted process of protecting and maintaining fish habitats in Nova Scotia, that is a) - e), must also be communicated to the public and resource users to ensure their awareness of the commitment of fisheries managers to protect fish habitats.

Fish Habitat Improvement

For an increasing number of fisheries in Nova Scotia, protecting and maintaining present habitats will be insufficient to sustain ongoing fisheries. Both loss of habitat and increasing angler pressure (presently estimated at over 100,000 anglers) have stressed these fisheries resources. To sustain these fisheries into the future, restoration of lost fish habitat will be required as one component in a suite of management objectives.

Many habitat improvement initiatives are already in place in Nova Scotia. **Guidelines for enhancement of the habitats of individual species throughout their life history stages must be established**, e.g. enhancing brook trout spawning habitat in lakes, increasing overwintering habitats of Atlantic salmon in rivers, stabilizing stream banks to reduce siltation, protecting shoreline habitats for spawning and early life history stages of fish. These guidelines should be developed for an audience of fisheries managers. **They must be based on the available scientific knowledge of life history strategies and tactics.** Deficiencies should be identified and their reconciliation pursued by fisheries managers. Mechanisms and funding should be established to encourage university and college researchers to be involved in such studies.

As part of the guidelines, criteria for initiating a habitat improvement project must be identified. These criteria should include the identification of a potential need (e.g. public concern regarding declining angling opportunities, observed habitat degradation), an assessment of the habitat including comparisons with historic data, identification of habitat improvement options, and the methods for fulfilling these options.

An overall strategy to improve fish habitats is outlined in the following section where native and non-native community groups form an integral part of the education and implementation components of the strategy. **The Adopt-a-Stream manual will be revised to become a key document for community involvement in aquatic habitat restoration** (B. Rutherford[1], pers. comm.). This manual will form the basis of the program that DFO Habitat Management and NSDOF will implement. The manual will cover the aquatic habitats from the headwater lakes and marshes to the estuary, describing the requirements for each of the major recreational species and the common impacts human activity is having on them. Since there are numerous groups already working in this area, a workshop is needed (possibly in late 1993 or early 1994) to give them direction and establish governments' role as facilitators and technical advisors rather than doers. Funds should be targeted to revise the manual and implement the workshop.

Community groups will be encouraged to get to know their watershed, identify current resources and impacts, document historical land and water uses, and carry out a basic stream survey to establish current conditions and opportunities. This will be followed by meetings between government staff and the community group to prepare a watershed management plan. Funds should be provided for consultant services or contract staff to assist in preparing the plans and collecting the required field data. **The watershed plan will look at the inventory, the objectives of all stake-holders in the watershed including natives, DFO and NSDOF, industry, and should include a multi-species approach.**

The habitat goals should be stated and priorities placed on opportunities for enhancement to achieve the recreational fishery with the best social and economic benefits. Techniques exist to restore or improve habitats for bass, yellow perch, trout species, salmon, etc.. However, depending on site specific conditions, recommendations should be made regarding the major target recreational species and their habitat needs.

The benefits of restoration depend on the costs involved to create the needed habitats and how many additional fish would be produced per unit area. The best areas are those with good chemical water quality. In prime areas, costs are low. In borderline cases, refuges can be created (i.e. pH 5.0 to 5.5 average); where pH is very low, costs are high and ongoing, and can only be justified to maintain unique genetic stocks.

In areas with historical damage, restoration is aimed at creating the required physical habitats, cleaning sand and silt out of the substrate, and providing refuges for fish during times of stress. Total costs for 20km of stream (at 9 test sites), in streams up to 10m wide, have ranged from \$3,000 to \$8,000

[1]. Bob Rutherford, Head, Habitat Planning, Habitat Management Branch, Department of Fisheries and Oceans, Halifax, Nova Scotia.

per km of stream depending on the availability of materials and access. An average of $3,500 is a realistic cost to use for this type of work. The benefits depend on several parameters including gradient and substrate composition, and of course how productive the habitat carrying capacity was before the work was done. Typically, salmonid parr densities might be brought up to 40 - 50 per 100 sq. m from current levels less than 20 in damaged areas, however, the optimum productivity varies from site to site (B. Rutherford, pers. comm.). Work done 5 years ago is still in excellent condition and it is expected that it will last 25 years with only minor maintenance needed annually. This estimate corresponds well with the experience of those who did similar work in Nova Scotia in the 1930's; unfortunately, very little was written about that work.

Sites with on going problems from poor land use practices can be restored by correcting the practice. This could be cost effective if combined with other objectives i.e. the control of soil loss from farm land or the loss of land to bank erosion. These sites are usually high profile and costs can be very high. Funding is needed to support direct habitat improvement and stewardship programs for land owners adjacent to critical habitats. Community groups have a variety of sources of money from government and private funds as well as volunteer and donated services. This needs to be supplemented through a cost sharing program where up to 50% of the cost could be paid by the Canada-Nova Scotia Cooperation Agreement on Recreational Fisheries. This is particularly important since once the agreement is in place other sources of funding such as the Environmental Partners Fund will redirect money from habitat restoration to other types of work. Funds will also be required to hire contract staff to provide program co-ordination, instream technical planning and layout services. Ideally this could be linked to the native guardian program to provide year round habitat officers.

While techniques are currently in use with excellent results there is a need for research into more cost effective methods. There is also a need for evaluation of the current methods, development of techniques more suited to local species and rivers, and techniques to restore habitats in larger rivers to provide better angling opportunities during summer months. This can be done in cooperation with community groups. Current techniques tend to produce habitat which ranks better against salmon models than speckled trout due to weaknesses in the cover component.

Through education, community groups develop an understanding of how aquatic ecosystems work and how they are impacted by human activity. However, through participation in restoring these systems they develop a feeling of ownership or stewardship of the resource. This is the core of any environmentally based program because it is this stewardship which will keep the restored systems from destruction and maintain fisheries resources for angling long after funding from the agreement has stopped. Stewardship agreements with land owners can be negotiated but the costs of negotiation and legal cost for reviewing documents requires funding similar to the wetlands agreements with Wildlife

Habitat Canada. If there is matching funds available from other sources, stewardship refuge areas could be established.

River Watch programs are already in place in Nova Scotia under several names. Publicizing this system, the types of activities to report and information required, is key to protection of fish habitat and the fish it produces. Funding is needed to prepare a pamphlet explaining these initiatives.

The major freshwater habitat problems that account for almost all of the habitat degradation in Nova Scotia are related to siltation (mostly from poor agricultural practices and road construction in areas where forest harvesting operations are underway), **acid rain toxicity, and fish passage problems** (mostly from hydroelectric development and improper culvert installations).

Siltation

Stream and lake sedimentation not only degrades freshwater fish habitat but also adversely impacts on shellfish beds in estuaries which are smothered by silt carried downstream during floods and periods of high water discharge. Other problems relate to fertilizer and manure runoff, improperly treated human sewage, stormwater drainage and discharge of industrial or agricultural chemicals into streams. These pollution problems cause bacterial and chemical contamination of both freshwater and estuarine habitat thereby contributing to eutrophication of streams and lakes, and closure of valuable shellfish harvesting areas.

Fish habitat improvement is the most important enhancement strategy in rehabilitating the overall fisheries resource and in the restoration of trout and salmon stocks in specific lakes or streams. The range in fish habitat improvement techniques to reduce problems associated with stream siltation include : (a) modification of forest road construction practices, construction of diversion ditches with silt control traps (gabions), hydro seeding road banks and ditches to stop the input of sediment to streams from roads or gravel pits; (b) agricultural practices should be modified as explained in the adjoining parts of this section to alleviate siltation problems. The excavation of large pits adjacent to streams to catch sediment from agricultural fields has been employed successfully in the Montague and West rivers in Prince Edward Island. **Forestry operations which cause sedimentation problems could reduce their impact on streams by constructing diversion ditches and silt traps, implementation of selective cutting near streams and establishing streamside greenbelts.** Other fish habitat improvement techniques currently in use which would be effective in streams include: in-stream debris removal, the installation of cover logs and boulders, pool restoration using digger logs, bank stabilization using rock gabions, log rip-rap or rock rip-rap, streamside fencing, streamside planting of trees, shrubs and natural grasses, creation of artificial redds and improvement of groundwater springs.

Longer Crop Rotations

Good crop rotation involves planting cereals and forage crops in sequence with row crops. The *Atlantic Potato Guide*, for example, recommends growing potatoes only once every three years on the same land.

Advantages

- decreases erosion by maintaining cover over a longer period within the rotation
- improves soil structure and decreases erosion
- reduces soil compaction and improves soil drainage
- increases organic matter
- improves soil fertility and weedcontrol
- promotes soil fertility and weed control
- reduces disease incidence
- improves crop quality and marketable yields

Disadvantages

- requires more land
- may require more equipment
- may limit choice of crops to those which grow well in sequence

Conservation Tillage

Conservation tillage is a practice that promotes the minimum tillage required to grow a crop.

Advantages

- crop residue is left onthe surface, protecting soil from erosion by wind and water
- improves the ability of the soil to absorb water
- encourages growth of unharvested grain in cereal fields, improving cover
- residue left on or near the soil surface provides erosion control for the crop planted in the following year
- reduces fuel andlabour costs

Disadvantages

- may require other tillage equipment
- tillage must be carried out atthe proper time and performed correctly
- surface residue may create greater potential for disease carry-over

Fall Cover Crops

Cover crops include grasses or cereals which grow after the harvest of the row crop.

Advantages

- controls erosion by reducing the impact of raindrops on the soil surface
- slows the surface flow of water increasing the soil's ability to absorb water
- adds organic material to the soil
- if established early, cover crops will reduce nitrate leaching into ground water
- keeps topsoil from blowing away

Disadvantages

- most row crops are harvested too late too establish a cover crop
- extra time and expense required to plant a cover crop
- excessive seedbed preparation late in the season can cause increased erosion

Mulching

Mulching involves spreading straw or hay on fields after row crops are harvested.

Advantages

- controls erosion by reducing the impact of raindrops on the soil surface and by slowing the speed of surface run-off
- allows the soil to absorb more water
- increases organic matter level in the soil
- mulch can be applied much later in the season than it is possible to plant a cover crop
- if applied early enough, mulch will reduce nitrate leaching into ground water

Disadvantages

- equipment, fuel and labour required to bale, transport and spread hay or straw
- additional nitrogen may be necessary for the breakdown of organic matter

Chisel Plowing after Potatoes

Correct use of a chisel plow after the harvest involves plowing the field on an angle across the slope.

Advantages

- small channels direct the flow of water across the slope
- reduces compaction
- improves capacity of the soil to absorb and hold water

Disadvantages

- unsuitable or poorly adjusted equipment could significantly increase erosion
- if chisel plowing is not done right, erosion will be significantly increased

Greenbelts

Greenbelts provide a buffer zone of shrubs, trees and grass between cultivated land and waterways.

Advantages

- surface run-off will be filtered before entering stream
- improves habitat for fish and wildlife
- improves sport fishing by reducing siltation and pollution of streams
- reduces siltation of estuaries and contributes to an improved shellfish industry

Disadvantages

- farm land adjoining streams will have to be taken out of production

Cross Slope Farming

Cross slope farming involves cultivating and planting the field across the general slope rather than up and down.

Advantages

- cultivation across the slope reduces speed of water flow, allowing the soil to absorb more water
- increases the amount of water available to the crop
- results in up to 50 percent less erosion compared to cultivating up and down the slope
- lowers horsepower and fuel costs

Disadvantages

- it may be awkward to farm some long, narrow fields across the slope
- grassed waterways will have to be established in low areas
- equipment may have to be modified

Strip Cropping

Strip cropping involves growing row crops with alternate strips of forages and/or cereals across the slope.

Advantages

- erosion rates can be reduced by 70 percent when compared to similar three-year rotations planted up and down the slope
- no additional capital costs required
- cereal and forage residue trap sediment and reduce erosion
- reduces horsepower and fuel costs
- reduces erosion because of lowered water flow

Disadvantages

- it may be awkward to farm some long narrow fields across the slope
- grassed waterways will have to be established in low areas
- damage can result from herbicide drift
- increases travel

Diversion Terraces

Terracing involves moving soil to build permanent parallel ridges across the slope of the field to control run-off. Terraces are required when a combination of strip cropping, crop rotation and sound management practices cannot reduce erosion to tolerable levels.

Advantages

- controls erosion by reducing the length of slope over which water can travel
- leads to cross slope farming
- decreases horsepower and fuel costs

Disadvantages

- cost of construction
- requires annual maintenance including mowing, weed control, and periodic silt removal
- not suitable on long narrow fields which run up and down the slope
- takes a portion of land permanently out of production

Hedgerows

Hedgerows are used to protect open fields from erosion by the wind.

Advantages

- reduces wind speed at ground level
- fields next to hedgerows receive more snow, leaving less soil exposed to wind erosion
- conserves soil moisture
- reduces wind damage and results in additonal heat units available to the crop
- provides wildlife habitat

Disadvantages

- length of time to establish
- competes for water, light and nutrients at the edge of fields
- sensitive to certain herbicides
- land is taken permanently out of production
- requires maintenance

Containing Livestock

Cattle can cause severe damage to stream and river banks where they are allowed access to the waterway for drinking. Streambanks erode causing siltation of the waterway.

Advantages

- prevents extreme erosion of stream banks
- reduces siltation
- eliminates loss of fish and wildlife habitat
- eliminates bacterial contamination of the stream

Disadvantages

- cost of fencing to restrict livestock from access to the waterway
- water must be pumped to the animals

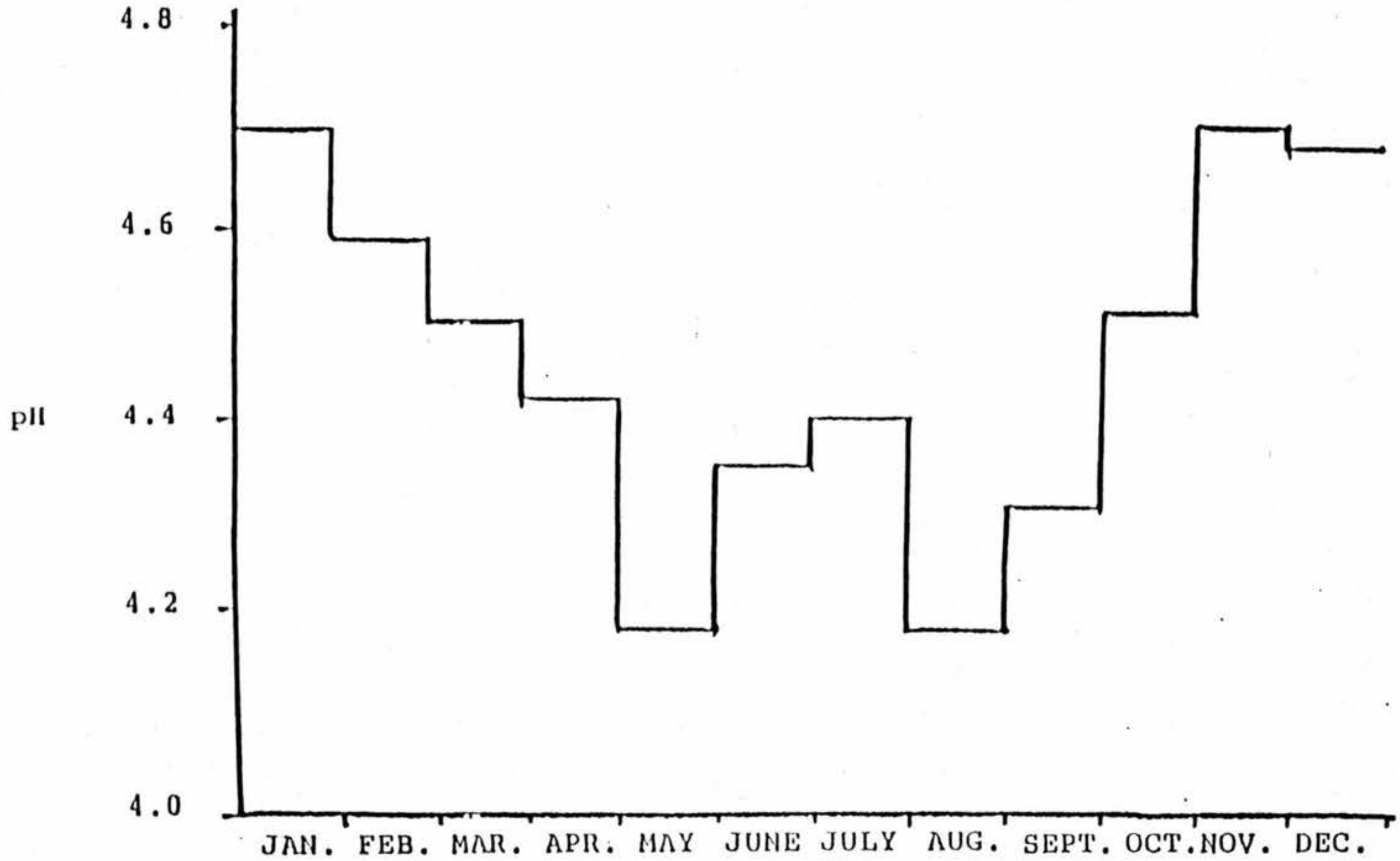

Figure 5. Mean monthly pH of precipitation in Nova Scotia averaged over three stations and 4 yr. (1977 - 1980). (after Watt 1983)

Acid Rain Mitigation

A number of mitigation techniques have been deployed to increase pH in areas impacted by acid rain toxicity. Mean monthly pH of precipitation in Nova Scotia is summarized in Figure 5 (Watt, 1983). While some of these techniques have been deployed, on-going research is required on the amelioration of this serious habitat degradation problem. The impact of acid rain and pH levels on some species are given in Table 24.

Table 24. The impact of pH on some fish species.

pH < 5.5	Rainbow trout and smallmouth bass fail to reproduce.
pH 6.5 to 4.6	Growth of brook trout slowed.
pH < 5.2	Lake trout, white perch, fail to reproduce.
pH 5.5 to 4.5	Brown trout fail to reproduce. Adult deaths of lake trout begin.
pH 5.2 to 4.7	Brown bullhead and white sucker fail to reproduce.
Below pH 5.0	Atlantic salmon fail to reproduce. Impaired survival of SMB and brown trout.
pH 5.0 to 4.5	Brook trout fail to reproduce.
pH 4.7 to 4.5	Yellow perch and lake chub fail to reproduce.
pH 4.5	Adult deaths of Atlantic salmon begin.
pH 4.5 to 3.5	Adult deaths of brook trout.

(a) Limestone Barriers

Limestone barriers constructed from gabions or from large limestone rock held in place by wooden dam structures have been identified as possible techniques for the mitigation of acidic precipitation in streams and tributaries to larger rivers (Zurbuch, et al., 1984). Although these methods may provide a continuous and lasting increase in the ambient pH of the watershed during warm weather, little or no mitigation can be expected during peak flows or during cold spring and winter temperatures. Unfortunately, peak flows and cold water temperatures usually occur at the same time during the spring runoff when juvenile fish are at their most vulnerable stage with respect to low pH. Limestone barriers do not generally provide a refuge for juvenile fish at critical periods of low pH, nor do they effectively change the pH of the system year round. The logistics of building and maintaining these structures are probably beyond the scope and funding of most user-groups. Another fundamental problem associated with these structures is the fact that they act as barriers to fish passage, which makes the building of fishways a possibility when considering their use. **One alternative to complete limestone barriers is using perforated, limestone-gravel filled barrels suspended and only partially submerged within the waterway.** This eliminates the fish passage problem and also keeps the gravel in a dynamic situation where all surface area is in contact with water (the drums rotate on a fixed axis). However, the limitations of peak flows and cold water temperatures still apply.

(b) Lake Liming

Some Nova Scotian lakes have poor buffering capacity as a result of their general chemistry and underlying bedrock. These lakes are particularly prone to drops in pH as acid deposition increases. Studies by Watt (1986) indicated that lake liming could be an effective method of combating acidic waters, but could be expensive to conduct on a continuous basis on large lakes. The turnover rates of many lakes would require them to be limed at least annually, and a lapse in treatment could be devastating to the ecology of the sites. The possibility of using a limestone powder, which would be spread evenly on the ice covering the lake in early spring has been studied in different areas including Timber Lake, East River (Chester), Nova Scotia and in Sweden. This technique addresses the problem of high acidity during spring snow melt and runoff. The limestone powder mixes with the lake water during this critical time and therefore provides a possible solution. The amount of limestone used requires careful consideration, since a dramatic increase in pH could shock fish and other aquatic organisms. This technique could be effective for lakes which are particularly acid stressed during spring run-off, but have generally acceptable pH for the rest of the year. Spreading limestone dust is a relatively simple method of application, and could be quite cost effective on a small scale.

The best pH for fish reproduction is between 6.5 and 8.5. Within the same species some strains may develop a degree of tolerance to acidic conditions. Research on acid resistant strains of speckled trout and salmon could therefore be beneficial in parts of Nova Scotia impacted by this problem.

(c) Limestone Gravel Application to Streambeds

This method is one of the most inexpensive and effective acid mitigation techniques. Studies carried out on the West Branch of the Liscomb River (Gray, 1981, unpublished) and in other rivers by Farmer (1992), Mayhew (1989) and Lacroix (1992) have shown that this is a feasible method for creating a refuge area for juvenile salmonids in acid stressed waters. Since the improvement to pH in the water column is dependent on flow rate and water temperature, the ameliorating effect is critically important during high flow periods, such as early spring when fish are emerging from the gravel after hatching. The application of 1" - 2" crushed limestone gravel should be placed in small streams or headwater tributaries which are used as spawning sites for salmonids. The sites should be easily accessible by road, for efficient placement of gravel. Amounts of gravel in the range of 30T - 100T are required in order to create a sufficient change in pH, depending on water flows. Amounts must be calculated according to peak flows to ensure effectiveness. The placement of gravel in large 'bars' spanning the width of the streambed (minimum length of 15' and about 2' deep) should take place during low flow periods in the late summer. The gravel may take up to a year to settle, and therefore does not provide a dependable rearing area for fish in the first year of placement. The physical parameters of the stream sites are of key importance to the success of this type of acidic mitigation, and stream hydrology should be studied carefully. Care should be taken to place gravel in areas which have fairly level substrate, shallow riffle or run hydrology with no sharp bends in stream direction. Limestone gravel placement appears to work well with other fish habitat improvement devices e.g. above digger logs and cobble in pools after they are dug (B. Rutherford[1] , pers. comm.).

Although it would be impractical to consider liming all acidic streams in Nova Scotia, small scale treatments, such as the one performed by NSDOF (Mayhew, 1989) could be of remedial value to acidic systems. Sites which could be considered for a program should fulfill the following criteria in order to be considered cost-effective : (1) availability of active groups of volunteers who have a direct interest in the watershed (e.g., the St. Mary's River Association); (2) availability of a source of limestone gravel located within a short distance of the watershed, in order to reduce the cost of trucking; (3) water chemistry with a pH level which will support survival of salmonid populations when increased by 0.4 pH units; (4) availability of treatment sites which are easily accessible by road.

Liming is not a solution to the problem of acid rain toxicity, but it can relieve the immediate threat and possibly ensure the survival of some indigenous genetic fish stocks, allowing time for a reduction of acid emissions. It is interesting to note that the interstitial pH (water within the streambed gravel) was substantially higher than that of the water column in the Fifteen-Mile Brook study (Mayhew, 1989) even in untreated sections of the stream. This suggests that interstitial water tests may be appropriate and worthwhile for sites before decisions are made to use this methodology.

The following data summarizes the actual costs of liming in two study sites used by NSDOF to determine the feasibility of limestone gravel application as a pH mitigation technique. The costs do not include gravel dispersal within the site and assumes that interested user groups would be involved in on-site manipulation of the limestone.

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[1]. Bob Rutherford, Head, Habitat Planning, Habitat Management Branch, Department of Fisheries and Oceans, Halifax, Nova Scotia.

Parameters	15-Mile Brook, Queen's County	Wallace Branch, Sissibboo River, Digby County
Limestone Gravel Size	1 1/2" graded	1 1/2" graded
Limestone Gravel Type	dolomitic limestone	dolomitic limestone
Amount of Gravel used for Treatment	200 tons	75 tons
Cost of Gravel (1987 Canadian Dollars)	$1,100.00	$412.20
Cost of Trucking (1987 Canadian Dollars)	$2,926.00	$1,323.75
TOTAL COST	**$4,026.00**	**$1,735.95**

The following is a cost-estimate for treating areas of the Medway River with dolomitic limestone (G. Farmer, 1992). These costs include gravel, trucking, backhoe rental and 15% contingencies.

Location	Mean December Flow Rate (m^3/s)	Tonnes of Gravel	Cost
West Branch Medway River	3.05	610	$14,700.00
East Branch Medway River	4.87	973	$23,190.00
Westfield River	9.13	1,826	$45,000.00

The required amounts of gravel are calculated for increasing pH by 0.4 units during December at water temperatures of 1°C. Feeding fry would therefore be protected in specific streams where this pH increase would be successful for initiation of feeding in young fry since mean flows in May are less than those for December.

Fish Passage Improvements

Hydroelectric developments, water storage reservoirs, improperly installed culverts and fallen trees, logs and accumulation of debris in streams associated with beaver activity in certain areas contribute to fish passage problems. Debris clogged streams not only enhance deposition of sedimentation, but create impassable barriers to fish migration. The purpose of in-stream removal of debris is to encourage natural stream currents to scour accumulated silt and debris and remove barriers to fish migration.

These problems should receive first priority in improving fish passage. Efforts to correct improperly installed culverts should also be a high priority. Construction and maintenance of fishways (vertical slot, pool and weir, denil, etc.) and bypass structures are essential to provide efficient fish passage for speckled trout, salmon, smelt, gaspereau, blueback herring, etc.. This is particularly important where obstructions block fish passage near the mouth of a stream or obstruct passage to important spawning and rearing habitat in upstream locations. A list of fishways presently in use in Nova Scotia is summarized in the last section of this report (Tables 38, 39, 41, 43).

Obstructions requiring remedial action should be priorized according to specific criteria and their associated costs and benefits. The following criteria should be considered when prioritizing fish passage requirements:

(a) length of stream obstructed, (b) priority of the stream, (c) proximity to the head of tide, (d) is removal of the obstruction an option, (e) production potential of the stream obstructed, (f) recreational fishing opportunities above the obstruction, (g) estimated benefits and costs, (h) impact on existing and potential fisheries resources, (i) proposed fishway design, (j) nature of obstruction: complete vs partial barrier; its height; could it be modified to allow fish passage, (k) quality of fish habitat above the obstruction, (l) abundance of anadromous fish frequenting waters downstream of the obstruction, (m) impact on other wildlife resources and (o) other related projects, proposed or underway, in the watershed such as other fish habitat improvements or stock enhancement.

A list of fish habitat improvement, fish passage and development projects is outlined in Table 25 and Figure 6.

A list of major obstructions which require construction, modification or maintenance of fish passage facilities is outlined in Tables 40,42, and 44 These obstructions were identified during the consultations by NGO's, government agencies or in published reports. The list is not complete because of the lack of data on some streams. Hence, during the planning and review process for each stream, current information on all fish passage problems should be identified. Later, expert advice will be required to recommend appropriate fishway design, modifications, and estimate costs. Each fish passage problem should be reviewed according to the criteria suggested. **Fish passage improvements are critical in Nova Scotia streams since in-stream obstructions not only impede the ascent of migrating fish species but also negatively affect water discharge and in some streams contribute to the warming of downstream waters.** Lastly, most impoundments should have draw down structures to create freshets or meter out water as required to encourage trout and salmon stocks to move into the river for angling or to establish maintenance flows for the survival of resident salmonids. Flow regulation will also maintain lake levels.

Table 25. A list of fish habitat improvement, fish passage and development projects identified by DFO engineers.

PROJECT	WATERSHED	PROJECT DESCRIPTION	BIOLOGICAL STATUS	ENGINEERING STATUS	COMMENTS
E1	Moose River West Branch	Fishway required at Timber Dam		Fishway has been designed, construction anticipated in 1993	Ministerial approval given
E2	Parrsboro	Provide fish passage at causeway	Fishway required, for trout, alewives and Atlantic salmon	Design in progress	Should proceed
E3	Nappan River	Restore fishway at Concrete Dam (Amherst)		Fishway constructed in 1990. M-2873	
E4	Carleton Lake	To Improve runaround channel	Ideal For Gaspereau and salmon migrations	Fishway Constructed in 1989	Fishway in good operation
E5	Tusket River	Improve upper leg of Tusket Falls fishway		Trap improvements, weir modifications	Improvements carried out in 1989-90
E6	Tusket River	Improvements to fishway entrance	Trapping facilities installed in 1990	Improvements to fishway entrance	Good operation in 1990
E7	East River Sheet Harbour	Add to baffles D/S and a trap		Proposed for 1993	14 pool fishway completed 1990
E8	Mersey River	Improve Milton Dam fishway		Bottom two pools reconstructed in 1989-90	Repairs implemented in 1991
E9	Meadow Pond Brook	Construct fishway at highway culvert		Fishway completed in 1990 D.U.	Fishway operating well
E10	Morrison's Brook Middle River	Install fish passage facilities in culvert		Fabrication complete	Install in 1993
E11	Mersey River at Deep Brook	Enhancement work required at the Diversion Dam (The Guzzle)	Electrofishing and Habitat survey carried out in 1989	Four Pool fishway has been designed	Construction proposed in conjunction with NSPC
E12	Canada Hill Bog	Fish passage needed at culverts, if water quality is improved	pH 4.4 in 1988	On hold	Prerequisite that pH be improved

Table 25 cont'd.

PROJECT	WATERSHED	PROJECT DESCRIPTION	BIOLOGICAL STATUS	ENGINEERING STATUS	COMMENTS
E13	Gold River	Flow control dams being considered	Wallabeck Lake only feasible site	Surveys carried out in 1988-89	Flow control dam and fishway designed for Wallabeck Lake
E14	Medway River	Flow control dam(s)		On hold	
E15	Pembrooke River	Fishway required at Falls	Good Potential and good water quality	Engineering survey (topographical) in 1989	
E16	Sackville River	Fishway at Falls	Salmon stocking	Fishway designed and constructed in 1989-90	12 pool fishway operating well. Minor Modifications in 1992
E17	Little Sackville River	Install fish passage facilities in culvert at highway 101	Fisheries enhancement potential good	Yet to be designed	
E18	Nictaux River	Martin's Mill Dam Fishway		Reconstruction required	Survey carried out in 1991
E19	North Gaspereau River	Improve run-around at Barrier Dam.	Need has been verified	NSPC have made improvements	Slope reduced
E20	Mersey River	Beaverdam Brook, improvements needed	Assessment required	Pending	
E21	Bear River	Fishway required at falls (dutchman slip)	Feasibility study required	Hydrology report done	Solution pending
E22	Jordan River	Water treatment and flow control	pH being monitored	Designed bern and water intake	Under review
E23	Marshall Falls	Upstream and D/S passage required		Surveyed in Dec. 1991	Preliminary design completed
E24	Wittenburg	Timber culvert-Kane's Brook tributary to St. Andrews River		Survey carried out at site	D/S end of culvert to be modified to pass fish
E25	Apron Rock (North River) Lunenburg Co.	Flow improvements for fish migration		Flow was divided in 2 channels to improve fish migration	
E26	Grafton Lake	Kejimkujik National Park	Fishway proposed	Functional fishway designed in 1989	Parks Canada, awaiting funds
E27	Black River	Porcupine Brook, Kings Co., N.S.	Barrier to fish	Design required	
E28	Hebb's Lake Dam		Fishway required for alewives	Survey needed	Town of Bridgewater

Table 25 cont'd.

PROJECT	WATERSHED	PROJECT DESCRIPTION	BIOLOGICAL STATUS	ENGINEERING STATUS	COMMENTS
E29	Hebb's Lake (Lunn's Prop.)	Dam and Canal	Fishway required	Site surveys have been carried out	Privately owned
E30	Paper Mill Lake		Fishway required pH is good	Drainage areas and hydrology completed	
E31	St. Mary's River	Gauging stations established on East and West Branch	Biology studies carried out in 1990-91	Determine the feasibility of flow control dams	Continuing
E32	Lake Banook and Sullivan's Pond	Culverts and flow control barriers to fish passage		Preliminary design done	
E33	Minamkeak Lake	Improve fish passage at storage dam for town of Bridgewater		Survey required	
E34	Meteghan River	Improve fish passage at Indian Falls		Hydrology done. Survey to be completed in 1993	
E35	Petite Riviere	Improve run-around channel		Site visit needed and design	
E36	Gaspereau River	Improve downstream passage at White Rock		Pending	
E37	East River	Improve downstream passage at Malay Falls		Surveys and design required	Funding ?
E38	East River Sheet Harbour	Upstream fishway required at Malay Falls		Surveys done in '91, design required	
E39	East River Sheet Harbour	Improve downstream fish passage at Marshall Falls		Survey done in '91, design required	
E40	East River Sheet Harbour	Upstream fishway required at Marshall Falls		Surveys done in '91, design required	
E41	East River Sheet Harbour	Improve downstream passage at Anti-Dam		Design required	To be surveyed
E42	Clyde River	Improve fish passage at Sawmill dam		Design by DFO	Fishway completed in 1992
E43	Herring Cove Brook at Nickerson's Pond	Improve fish passage at pumping station	Biology studies required	Survey required to determine elevations	

Table 25 cont'd.

PROJECT	WATERSHED	PROJECT DESCRIPTION	BIOLOGICAL STATUS	ENGINEERING STATUS	COMMENTS
E44	Shubenacadie River restoration	Provisions for fish passage		Consultants report on file O'Halloran and Campbell	
E45	Medway confluence East & West Brook	Liming Project		Hydrology completed March 19, 1992	Pilot project in place
E46	Jordan River	Salmon holding pool and dry hydrant intake		Surveyed Oct. 1991. Design completed	See drawing M-2992
E47	Jordan Lake	Fishway & Maintenance flows		Project on hold	
E48	McAlpines Brook	Town Lake Liverpool, N.S.	Biology input required	Hydrology completed	D.A. = 2.49 $Mi.^2$
E49	Meteghan River	Mill Dam to be restored	Louis Gaudet fishway needed	Hydrology completed	D.A. = 21.5 $Mi.^2$

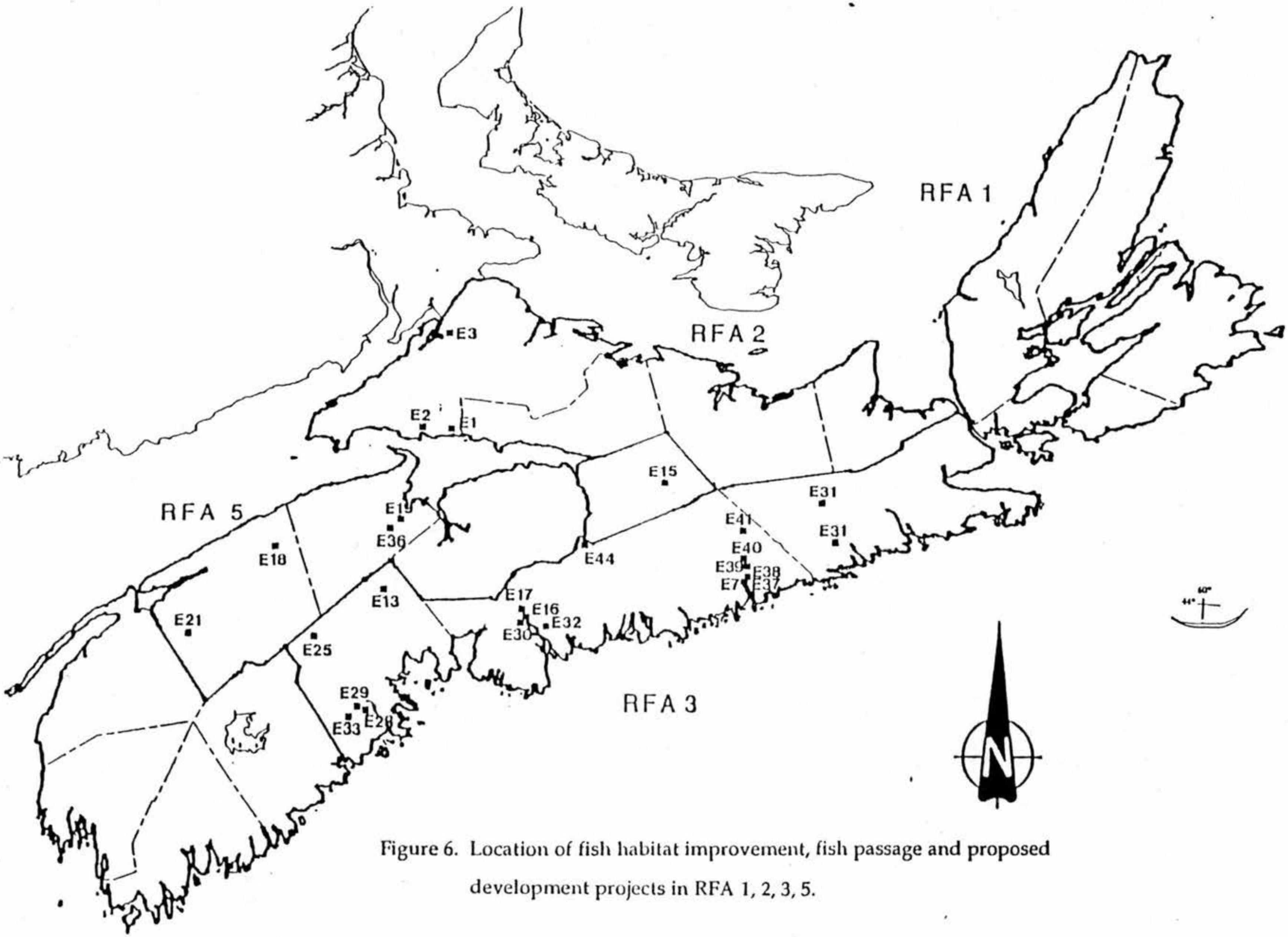


Figure 6. Location of fish habitat improvement, fish passage and proposed development projects in RFA 1, 2, 3, 5.

Resource Enhancement

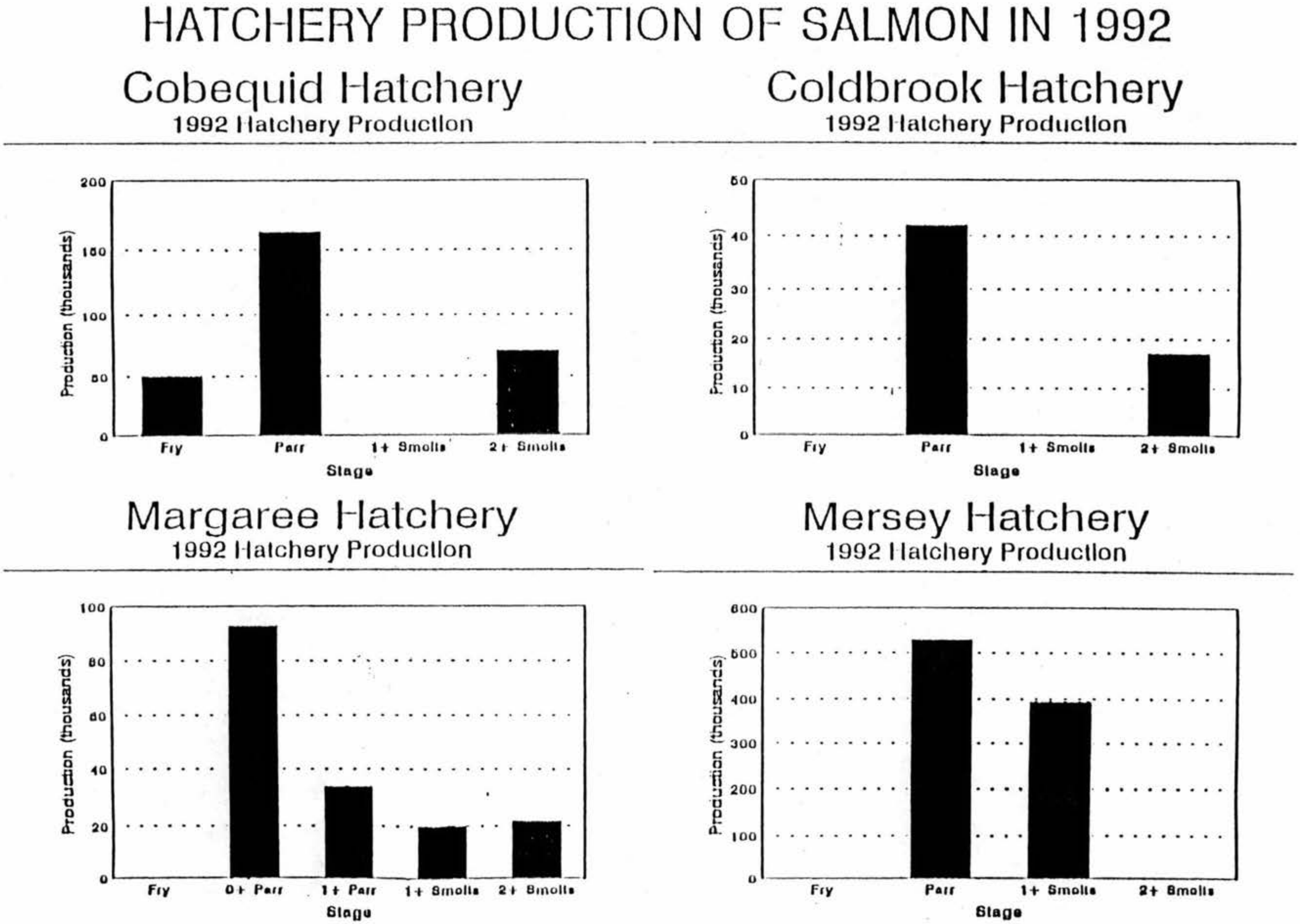
Preservation, maintenance, and enhancement of fish habitats ultimately increases fish production and improves the potential for increased angling opportunities. However, angling pressure in Nova Scotia continues to increase with harvests that likely surpass the ability of fish habitat alone to sustain the fishery. In these situations, stock enhancement strategies must be incorporated in the suite of management options available to fishery managers.

Hatchery Stocking

The most direct method of stock enhancement is the stocking of reared fish. A new stocking policy should be developed for both Federal and Provincial hatcheries. For example, the policy should identify : a) stocking to create new and diversified angling opportunities for native or "naturalized" species establishing these as self-sustaining or put-and-take fisheries; and b) stocking to enhance or sustain established populations. The policy should also establish objectives for the introduction of "naturalized" or "exotic" species such as smallmouth bass and rainbow trout, e.g. **"It is the policy of the NSDOF to provide angling opportunities for native sport fish species of Nova Scotia as the first priority. Native sport fish are brook trout, Atlantic salmon. If a native fish population is lost and cannot be re-established or native fish have not inhabited a waterway, then introduction of "exotic" species can occur".**

The stocking policy should reflect available scientific knowledge. Stocking should attempt to minimize the introduction of domesticated strains in systems managed as self-sustaining fisheries. Lake and stream assessments should also be used to determine habitat limitations prior to stocking. Establishing such criteria will minimize inflated expectations among anglers and reduce the economic costs of perpetuating unplanned, put-and-take fisheries.

Hatchery stocking from federal and provincial hatcheries is an integral part of the future development of the recreational fishery in Nova Scotia. However, the underlying problems which have led to declines in species or fish stock abundance should be identified since stocking by itself cannot sustain the fishery. A clear set of stocking guidelines needs to be developed for stocking Nova Scotia lakes and streams. Current stock strategies and levels of stocking are provided in Figures 7 - 11 and Tables 26 - 30.



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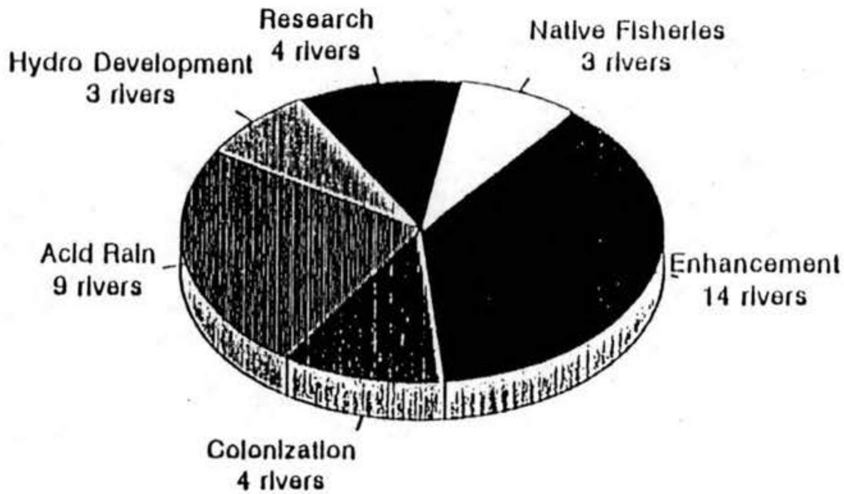
Reasons / Objectives for Stocking



Total 1992 Hatchery Production

DFO Hatcheries (Nova Scotia)

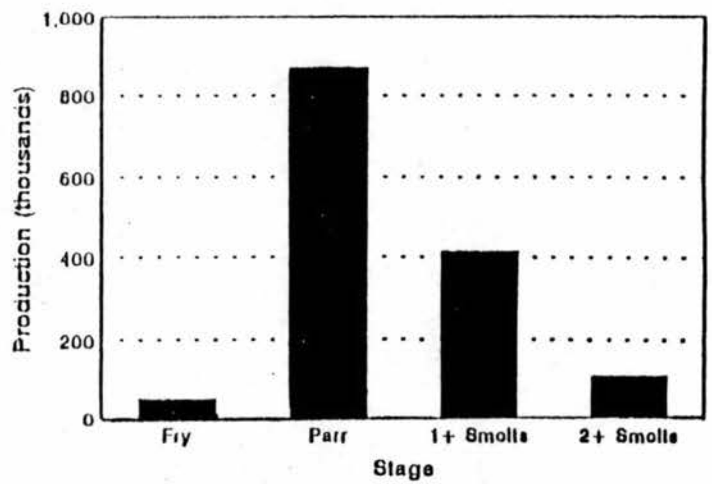


Figure 8. Current stock strategies and production from DFO hatcheries, 1992.

Enhancement Programs by Salmon Fishing Area

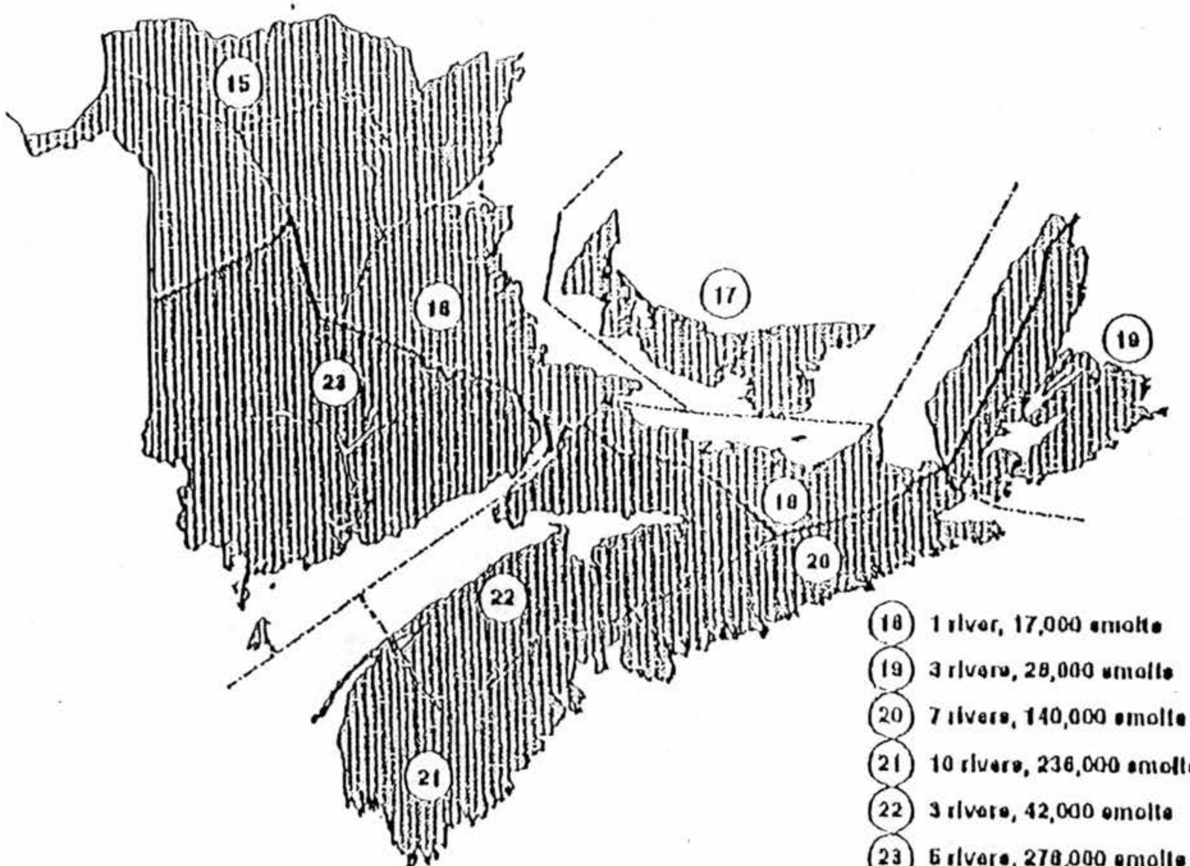
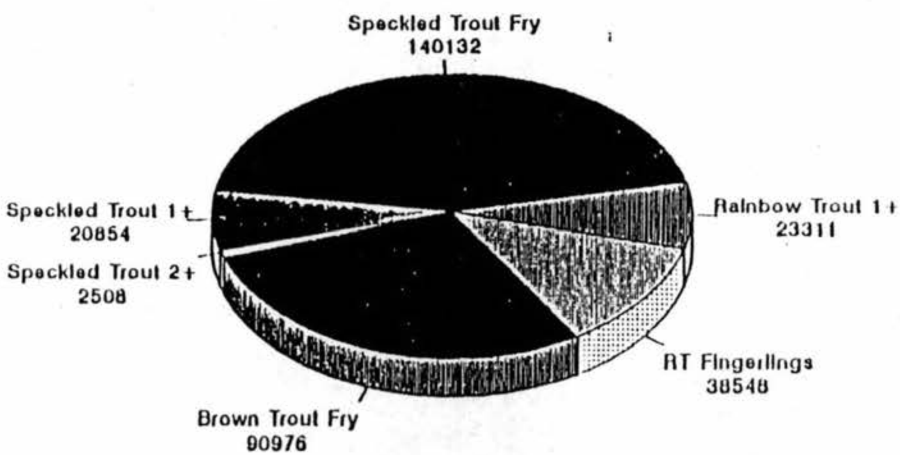


Figure 9. Enhancement programs by Salmon Fishing Area.

TROUT STOCKING BY HATCHERY FOR 1992

Frasers Mill Hatchery

1992 Trout Stocking



McGowan Lake Hatchery

1992 Trout Stocking

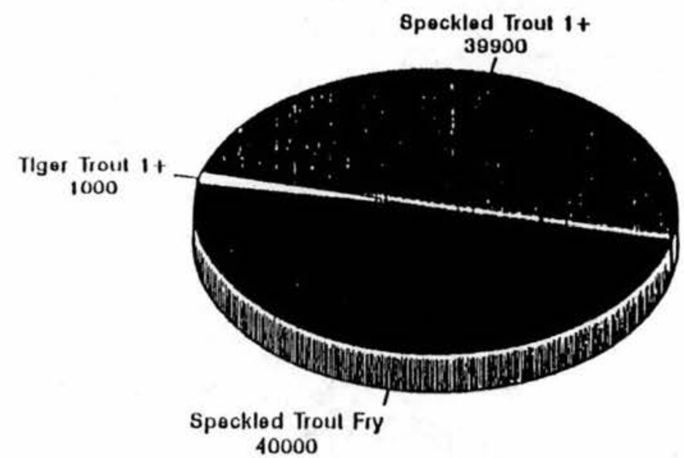


Figure 10. Trout stocking from NSDOF hatcheries, 1992.

TROUT STOCKING IN 1992 FOR RFA 1, 2, 3, AND 5.

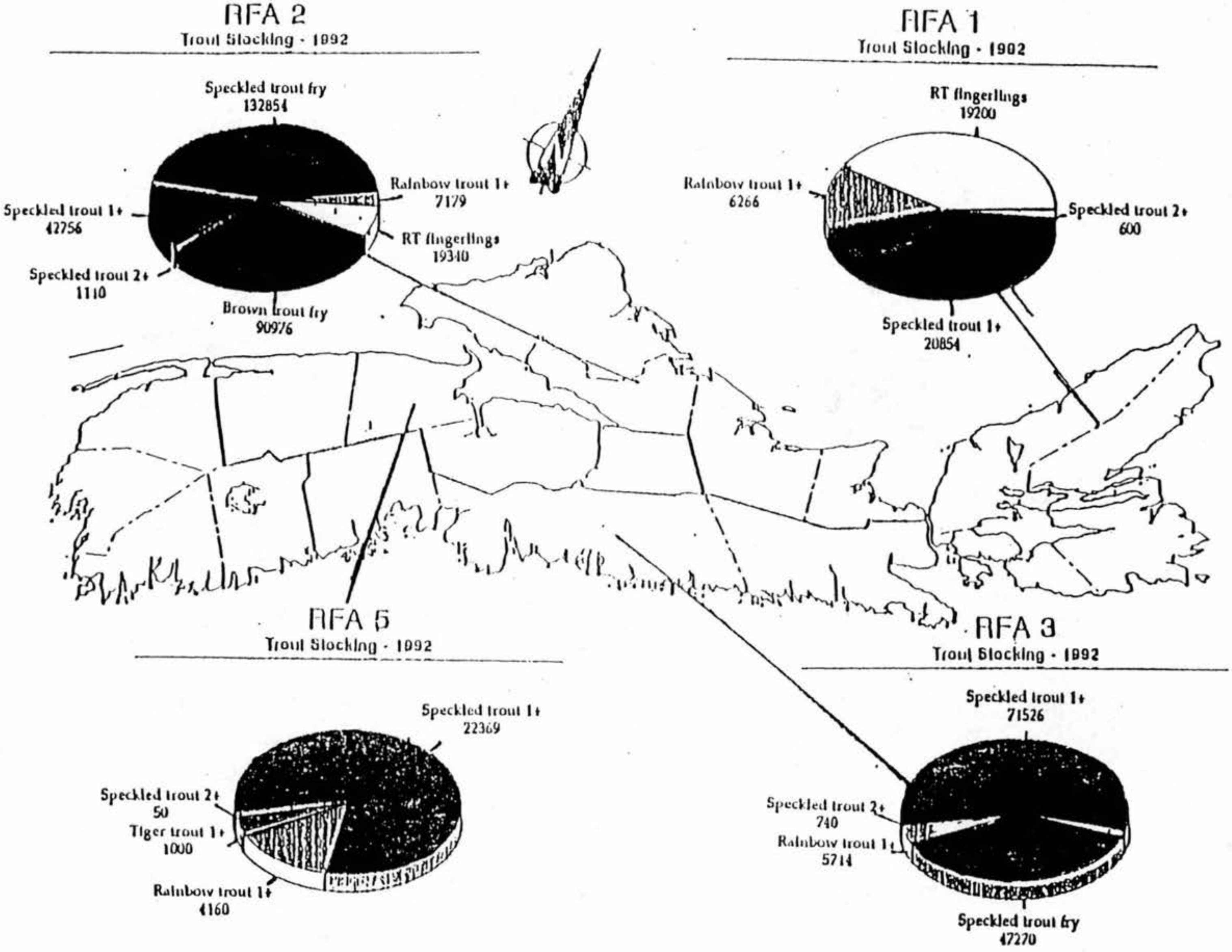


Figure 11. Trout stocking in RFA 1, 2, 3, and 5, 1992.

Table 26. Number of Atlantic salmon smolts and parr released to the Margaree River 1976 - 1992 by parent stock origin (MAR = Margaree River; RB = Rocky Brook; or Miramichi River). Rearing locations are : MAR = Margaree, COB = Cobequid; MER = Mersey. Data taken from Chaput, et al. 1992.

		SMOLT				PARR			
		2+		1+		1+		0+	
YEAR	REARING LOCATION	MAR	RB	MAR	RB	MAR	RB	MAR	RB
1976	MAR	8,791							
1977	MAR					5,022			
1978	COB		15,250						
1979	COB		15,927 ?						
1980	COB		14,960						
1981	COB		15,950						
1982	MER			8,481		1,098			
1983	COB MAR	13,486 3,783						9,853	
1984	MAR MER COB	 11,210		 14,483 	10,195 @ 				
1985	MAR COB	 13,660		2,669	1,303	5,882 7,320	834 5,860		
1986	MAR COB	 8,820	 9,684	2,105		8,754		25,000 6,750	
1987	MAR COB	6,369 18,337		8,599		5,400		40,000 12,429	
1988	MAR COB	4,136 12,785		22,313		2,201		40,000 6,300	
1989	MAR COB	2,500 * 18,500		13,000		10,000		150,000 6,000	
1990	MAR COB	4,119 * 15,976		14,200		21,425		60,500	
1991	MAR COB	12,100 * 10,200		20,000		22,000 4,000		110,000	
1992	MAR COB	21,300 * 16,900		20,000 0		33,600 3,500		92,500 9,800	

* Reared in the Lake O'Law cages.

@ MSW hatchery return broodstock collected from Margaree River and crossed with wild Margaree River salmon. The hatchery return broodstock would have been 2SW fish originating from Rocky Brook 2+ smolts released in 1981.

? Milbank broodstock.

TROUT STOCKING IN RFA 1 - 1992

LAKE OR RIVER	LAT/LONG	HATCHERY	DATE	SPECIES	STOCK	STAGE	NUMBER
LEVERS	4551 6011	FRASERS	8/07/92	RAINBOW	1	fingerling	19200
LEVERS	4551 6011	FRASERS	19/05/92	RAINBOW	1	yearling	1500
BRAS D'OR LK EAST BAY SAND BAR	4601 6024	FRASERS	3/06/92	RAINBOW	1	yearling	1000
# 20 DAM	4612 5958	FRASERS	21/05/92	RAINBOW	1	yearling	1501
BRAS D'OR LK BLACK R DUNDEE	4542 6106	FRASERS	19/05/92	RAINBOW	1	yearling	1000
BRAS D'OR LK BLACK R DUNDEE	4542 6106	FRASERS	17/06/92	RAINBOW	1	yearling	1025
# 20 DAM	4612 5958	FRASERS	11/05/92	RAINBOW	1	yearling	240
						TOTAL	25466
WRECK COVE (RESERVOIR)	4633 6030	FRASERS	22/06/92	SPECKLED	12	yearling	784
CONDON	4538 6047	FRASERS	19/06/92	SPECKLED	5	yearling	1000
GRAND LAC	4633 6101	FRASERS	5/06/92	SPECKLED	12	yearling	2495
FORREST	4530 6056	FRASERS	1/06/92	SPECKLED	5	yearling	588
McINTYRE	4539 6117	FRASERS	29/05/92	SPECKLED	5	yearling	2000
McINTYRE	4539 6117	FRASERS	26/06/92	SPECKLED	5	yearling	1496
POTTIE	4532 6101	FRASERS	1/06/92	SPECKLED	5	yearling	588
# 20 DAM	4612 5958	FRASERS	11/05/92	SPECKLED	5	yearling	2196
AECL HEAVY WATER RESERVOIR	4608 5958	FRASERS	18/06/92	SPECKLED	12	yearling	2156
MCPHERSON	4606 6004	FRASERS	18/06/92	SPECKLED	12	yearling	980
SOUTHWEST BROOK LINGAN BAY	4613 6005	FRASERS	8/05/92	SPECKLED	5	yearling	610
BROWN'S	4611 6010	FRASERS	11/06/92	SPECKLED	12	yearling	2000
GRAND	4533 6103	FRASERS	1/06/92	SPECKLED	5	yearling	1176
CRANBERRY	4614 6017	FRASERS	15/05/92	SPECKLED	5	yearling	1500
SUSIE	4521 6141	FRASERS	20/05/92	SPECKLED	5	yearling	279
HECTOR	4539 6122	FRASERS	26/06/92	SPECKLED	5	yearling	1006
SUSIE	4521 6141	FRASERS	20/05/92	SPECKLED	5	two years	50
GRAND LAC	4633 6101	FRASERS	5/06/92	SPECKLED	5	two years	50
SOUTHWEST BROOK LINGAN BAY	4613 6005	FRASERS	8/05/92	SPECKLED	5	two years	25
McINTYRE	4539 6117	FRASERS	29/05/92	SPECKLED	5	two years	100
WRECK COVE (RESERVOIR)	4633 6030	FRASERS	22/06/92	SPECKLED	5	two years	325
CRANBERRY	4614 6017	FRASERS	15/05/92	SPECKLED	5	two years	50
						TOTAL	21454

Table 27. Trout stocking in RFA 1 in 1992.

TROUT STOCKING IN RFA 2 - 1992

RIVER OR LAKE	LAT/LONG	HATCHERY	DATE	SPECIES	STOCK	STAGE	NUMBER
POMQUET R MEADOW GREEN RIVER	4533 6149	FRASERS	3/06/92	BROWN	201	fry	15000
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	3/06/92	BROWN	201	fry	30000
SOUTH RIVER (UPPER)	4527 6204	FRASERS	15/07/92	BROWN	201	fry	30976
POMQUET R BLACK RIVER	4535 6148	FRASERS	3/06/92	BROWN	201	fry	15000
						TOTAL	90976
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	13/07/92	RAINBOW	1	fingerling	5528
GILLIS	4532 6158	FRASERS	13/07/92	RAINBOW	1	fingerling	5528
CAMERON	4531 6159	FRASERS	13/07/92	RAINBOW	1	fingerling	5520
DUCKS UNLIMITED POND	4530 6159	FRASERS	13/0/792	RAINBOW	1	fingerling	2764
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	24/07/92	RAINBOW	1	yearling	1000
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	20/05/92	RAINBOW	1	yearling	1392
CAMERON	4531 6159	FRASERS	26/06/92	RAINBOW	1	yearling	562
DUCKS UNLIMITED POND	4530 6159	FRASERS	26/06/92	RAINBOW	1	yearling	520
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	26/06/92	RAINBOW	1	yearling	1664
GILLIS	4532 6158	FRASERS	26/06/92	RAINBOW	1	yearling	562
GILLIS	4532 6158	FRASERS	20/05/92	RAINBOW	1	yearling	725
CAMERON	4531 6159	FRASERS	20/05/92	RAINBOW	1	yearling	754
						TOTAL	26519
ST.JOSEPH'S	4532 6205	FRASERS	13/07/92	SPECKLED	5	fry	6000
WEST R JAMES RIVER	4534 6205	FRASERS	13/07/92	SPECKLED	5	fry	10500
LOCH KATRINE (SOUTH R. LK)	4526 6156	FRASERS	15/07/92	SPECKLED	5	fry	5454
SOUTH RIVER (UPPER)	4527 6204	FRASERS	15/07/92	SPECKLED	5	fry	10900
SOUTH RIVER PINEVALE BROOK	4532 6158	FRASERS	24/06/92	SPECKLED	5	fry	50000
POMQUET R BLACK RIVER	4535 6148	FRASERS	24/06/92	SPECKLED	5	fry	50000
CAMERON	4531 6159	FRASERS	3/06/92	SPECKLED	12	yearling	2112
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	24/07/92	SPECKLED	5	yearling	2000
POMQUET (LITTLE)	4537 6159	FRASERS	29/06/92	SPECKLED	12	yearling	1032
MILL BROOK BARRIE POND	4543 6243	FRASERS	24/06/92	SPECKLED	5	yearling	500
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	3/07/92	SPECKLED	5	yearling	1960
TRACADIE (JACKSONS)	4537 6136	FRASERS	29/06/92	SPECKLED	12	yearling	1462
CAMERON	4531 6159	FRASERS	13/07/92	SPECKLED	12	yearling	1700

Table 28. Trout stocking in RFA 2 in 1992.

CAMERON	4531 6159	FRASERS	27/04/92	SPECKLED	5	yearling	1000
DONNELLYS (HEALY)	4533 6141	FRASERS	29/06/92	SPECKLED	12	yearling	1548
TRENTON STEELTOWN PARK POND	4537 6238	FRASERS	4/05/92	SPECKLED	5	yearling	1500
TRENTON STEELTOWN PARK POND	4537 6238	FRASERS	22/06/92	SPECKLED	5	yearling	600
GILLIS	4532 6158	FRASERS	13/07/92	SPECKLED	12	yearling	1700
BOYDS	4531 6158	FRASERS	28/05/92	SPECKLED	5	yearling	920
STEWART (MACMILLAN)	4529 6202	FRASERS	9/06/92	SPECKLED	12	yearling	826
GAIRLOCH	4529 6250	FRASERS	4/05/92	SPECKLED	5	yearling	1500
GAIRLOCH	4529 6250	FRASERS	24/06/92	SPECKLED	5	yearling	1500
DRYDEN	4523 6247	FRASERS	10/06/92	SPECKLED	12	yearling	2016
NAPPAN R PUMPING STATION	4547 6410	FRASERS	22/05/92	SPECKLED	5	yearling	1660
QUARRY POND	4541 6245	FRASERS	5/06/92	SPECKLED	5	yearling	650
LOCHABER	4525 6202	FRASERS	3/06/92	SPECKLED	5	yearling	1496
GILLIS	4532 6158	FRASERS	3/06/92	SPECKLED	12	yearling	2112
PETER BILLS (TAILOR'S POND)	4526 6204	FRASERS	29/06/92	SPECKLED	5	yearling	1040
GILLIS	4532 6158	FRASERS	27/04/92	SPECKLED	5	yearling	1000
CAMERONS LAKES	4533 6208	FRASERS	27/04/92	SPECKLED	5	yearling	1000
LITTLE DYKE (GLENHOLME)	4523 6333	FRASERS	14/05/92	SPECKLED	5	yearling	1890
GRAVEL PIT TRURO (KIWANIS)	4522 6317	FRASERS	22/05/92	SPECKLED	5	yearling	1800
BLAIR	4548 6413	FRASERS	23/06/92	SPECKLED	12	yearling	3488
BIG	4544 6344	FRASERS	23/06/92	SPECKLED	12	yearling	2744
BOYDS	4531 6158	FRASERS	28/05/92	SPECKLED	5	two years	50
GAIRLOCH	4529 6250	FRASERS	24/06/92	SPECKLED	5	two years	100
GAIRLOCH	4529 6250	FRASERS	4/05/92	SPECKLED	5	two years	80
TRENTON STEELTOWN PARK POND	4537 6238	FRASERS	4/05/92	SPECKLED	5	two years	80
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	20/05/92	SPECKLED	12	two years	70
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	17/06/92	SPECKLED	12	two years	70
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	13/05/92	SPECKLED	12	two years	70
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	27/05/92	SPECKLED	12	two years	70
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	3/06/92	SPECKLED	12	two years	70
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	2/07/92	SPECKLED	12	two years	70
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	6/05/92	SPECKLED	12	two years	70
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	10/06/92	SPECKLED	12	two years	70
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	28/04/92	SPECKLED	12	two years	70
GRAVEL PIT TRURO (KIWANIS)	4522 6317	FRASERS	22/05/92	SPECKLED	5	two years	50
SOUTH RIVER (DUNMORE)	4532 6156	FRASERS	24/06/92	SPECKLED	12	two years	70
NAPPAN R PUMPING STATION	4547 6410	FRASERS	22/05/92	SPECKLED	5	two years	50
						TOTAL	176720

Table 28. Trout stocking in RFA 2 in 1992, cont'.

TROUT STOCKING IN RFA 3 - 1992

RIVER OR LAKE	LAT/LONG	HATCHERY	DATE	SPECIES	STOCK	STAGE	NUMBER
ALBRO	4441 6334	FRASERS	26/06/92	RAINBOW	1	yearling	300
ROUND	4441 6351	FRASERS	15/06/92	RAINBOW	1	yearling	1650
PENHORN	4440 6333	FRASERS	28/04/92	RAINBOW	1	yearling	500
ALBRO	4441 6334	FRASERS	25/06/92	RAINBOW	1	yearling	600
ALBRO	4441 6334	FRASERS	28/04/92	RAINBOW	1	yearling	756
ALBRO	4441 6334	FRASERS	27/05/92	RAINBOW	1	yearling	1508
OATHILL	4440 6333	FRASERS	28/04/92	RAINBOW	1	yearling	400
							5714
NARROW	4524 6151	FRASERS	15/07/92	SPECKLED	5	fry	5454
FROG	4517 6155	FRASERS	15/07/92	SPECKLED	5	fry	1816
LAHAVE RIVER FORTY RIVER	4444 6435	MCGOWAN	1/07/92	SPECKLED	5	fry	10000
GOLD RIVER LARDER RIVER	4444 6430	MCGOWAN	1/07/92	SPECKLED	5	fry	10000
MIDDLE RIVER	4438 6420	MCGOWAN	1/07/92	SPECKLED	5	fry	20000
MAPLE	4438 6405	MCGOWAN	22/05/92	SPECKLED	5	yearling	500
NEW CANADA (HEN)	4429 6441	MCGOWAN	20/05/92	SPECKLED	5	yearling	1000
CLEARLAND	4428 6424	MCGOWAN	20/05/92	SPECKLED	5	yearling	1000
ROMKEY POND	4416 6417	MCGOWAN	20/05/92	SPECKLED	5	yearling	750
SUCKER	4429 6436	MCGOWAN	20/05/92	SPECKLED	5	yearling	500
STILLWATER	4443 6351	MCGOWAN	22/05/92	SPECKLED	5	yearling	2000
COOPER	4444 6351	MCGOWAN	16/06/92	SPECKLED	5	yearling	500
SAWLER	4439 6404	MCGOWAN	22/05/92	SPECKLED	5	yearling	1000
BUTLER	4443 6441	MCGOWAN	20/05/92	SPECKLED	5	yearling	500
LEWIS	4448 6424	MCGOWAN	5/06/92	SPECKLED	5	yearling	750
MOOSE	4417 6434	MCGOWAN	10/06/92	SPECKLED	5	yearling	500
VINEGAR	4441 6403	MCGOWAN	16/04/92	SPECKLED	5	yearling	1000
SPECTACLE	4434 6414	MCGOWAN	20/05/92	SPECKLED	5	yearling	1000
WALLACE	4416 6432	MCGOWAN	10/06/92	SPECKLED	5	yearling	750
BARRETT	4449 6341	MCGOWAN	11/06/92	SPECKLED	5	yearling	750
HUEY	4423 6444	MCGOWAN	10/06/92	SPECKLED	12	yearling	500
GOVERNOR	4438 6342	MCGOWAN	22/05/92	SPECKLED	5	yearling	1000
FIRST	4416 6339	MCGOWAN	11/06/92	SPECKLED	5	yearling	1000
LONG	4437 6338	MCGOWAN	11/06/92	SPECKLED	5	yearling	1000

Table 29. Trout stocking in RFA 3 in 1992.

LONG	4437 6338	MCGOWAN	22/05/92	SPECKLED	5	yearling	1000
LOVETT	4438 6341	MCGOWAN	16/06/92	SPECKLED	5	yearling	500
SECOND (KEOUGH)	4446 6339	MCGOWAN	11/06/92	SPECKLED	5	yearling	1000
MEISNER	4441 6311	MCGOWAN	22/05/92	SPECKLED	5	yearling	500
HOLBERT	4437 6434	MCGOWAN	20/05/92	SPECKLED	5	yearling	500
KINSAC	4550 6339	MCGOWAN	11/06/92	SPECKLED	12	yearling	1000
CHURCH	4433 6438	MCGOWAN	20/05/92	SPECKLED	5	yearling	500
ROUND	4441 6351	MCGOWAN	22/05/92	SPECKLED	5	yearling	1000
LONG	4418 6443	MCGOWAN	20/05/92	SPECKLED	5	yearling	500
HENNIGAR	4438 6420	MCGOWAN	20/05/92	SPECKLED	5	yearling	500
COOKS	4500 6316	FRASERS	29/05/92	SPECKLED	5	yearling	1517
ALBRO	4441 6334	FRASERS	26/06/92	SPECKLED	5	yearling	1005
LAKE ECHO	4443 6324	FRASERS	24/06/92	SPECKLED	5	yearling	5000
OTTER	4446 6324	FRASERS	24/06/92	SPECKLED	5	yearling	1650
PENHORN	4440 6333	FRASERS	2/06/92	SPECKLED	12	yearling	2000
KELLS	4521 6156	FRASERS	24/06/92	SPECKLED	5	yearling	945
GIANT	4523 6153	FRASERS	27/04/92	SPECKLED	5	yearling	1000
LONG	4512 6203	FRASERS	25/06/92	SPECKLED	12	yearling	1560
ROUND	4504 6220	FRASERS	1/06/92	SPECKLED	12	yearling	1000
THREE MILE	4520 6105	FRASERS	25/06/92	SPECKLED	12	yearling	2018
DOBSON	4520 6113	FRASERS	25/06/92	SPECKLED	12	yearling	1000
OTTER	4446 6324	FRASERS	25/06/92	SPECKLED	5	yearling	1035
WHISTLEHOUSE	4520 6102	FRASERS	25/06/92	SPECKLED	12	yearling	1000
TWO MILE (LOCHIEL)	4521 6204	FRASERS	9/06/92	SPECKLED	12	yearling	2000
LAKE ECHO	4443 6324	FRASERS	25/06/92	SPECKLED	5	yearling	3105
ALBRO	4441 6334	FRASERS	25/06/92	SPECKLED	5	yearling	3000
ALBRO	4441 6334	FRASERS	2/06/92	SPECKLED	12	yearling	4080
SALMON RIVER	4522 6144	FRASERS	20/05/92	SPECKLED	5	yearling	279
DONAHUE	4518 6130	FRASERS	9/06/92	SPECKLED	12	yearling	2945
BEAR	4502 6218	FRASERS	1/06/92	SPECKLED	12	yearling	1300
LOON LAKES	4516 6244	FRASERS	10/06/92	SPECKLED	12	yearling	1500
MACPHERSON	4526 6125	FRASERS	12/06/92	SPECKLED	12	yearling	2832
KELLY	4503 6220	FRASERS	1/06/92	SPECKLED	12	yearling	2332
UP.IND.HBR. 5TH (NIMRODS REST)	4510 6157	FRASERS	21/05/92	SPECKLED	5	yearling	994
KINDERVATER	4503 6218	FRASERS	1/06/92	SPECKLED	12	yearling	1000
PRINGLE	4522 6157	FRASERS	24/06/92	SPECKLED	5	yearling	945
BILL NEDS	4511 6202	FRASERS	25/06/92	SPECKLED	12	yearling	784
UP.IND.HBR. 5TH (NIMRODS REST)	4510 6157	FRASERS	9/07/92	SPECKLED	5	yearling	800
UP.IND.HBR. 5TH (NIMRODS REST)	4510 6157	FRASERS	21/05/92	SPECKLED	5	two years	70
MACPHERSON	4526 6125	FRASERS	12/06/92	SPECKLED	5	two years	200
LONG	4512 6203	FRASERS	25/06/92	SPECKLED	5	two years	110
SALMON RIVER	4522 6144	FRASERS	20/05/92	SPECKLED	5	two years	50
UP.IND.HBR. 5TH (NIMRODS REST)	4510 6157	FRASERS	9/07/92	SPECKLED	5	two years	310
						TOTAL	119630

Table 29. Trout stocking in RFA 3 in 1992, cont'.

TROUT STOCKING IN RFA 5 - 1992

LAKE OR RIVER	LAT/LONG	HATCHERY	DATE	SPECIES	STOCK	STAGE	NUMBE
RUMSEY (RAMSEY)	4454 6516	FRASERS	10/06/92	RAINBOW	1	yearling	1000
RUMSEY (RAMSEY)	4454 6516	FRASERS	12/05/92	RAINBOW	1	yearling	1200
SUNKEN	4500 6427	FRASERS	11/05/92	RAINBOW	1	yearling	960
RUMSEY (RAMSEY)	4454 6516	FRASERS	9/06/92	RAINBOW	1	yearling	1000
						TOTAL	4160
PARRSBORO ABOITEAU	4524 6420	FRASERS	23/06/92	SPECKLED	12	yearling	2000
SHORTTS	4512 6319	FRASERS	14/5/92	SPECKLED	5	yearling	1113
ENFIELD DERBY	4458 6333	FRASERS	12/06/92	SPECKLED	5	yearling	708
MATTATAL	4542 6328	FRASERS	23/06/92	SPECKLED	12	yearling	2548
UPPER WRIGHTS	4444 6522	MCGOWAN	26/05/92	SPECKLED	5	yearling	600
UPPER WRIGHTS	4444 6522	MCGOWAN	3/06/92	SPECKLED	5	yearling	750
ST. CROIX POND	4458 6401	MCGOWAN	5/06/92	SPECKLED	5	yearling	2000
SANDY	4456 6514	MCGOWAN	3/06/92	SPECKLED	5	yearling	1200
LOWER WRIGHTS	4444 6523	MCGOWAN	26/05/92	SPECKLED	5	yearling	600
LOWER WRIGHTS	4444 6523	MCGOWAN	3/06/92	SPECKLED	5	yearling	500
SANDY	4456 6514	MCGOWAN	8/07/92	SPECKLED	5	yearling	500
WATERLOO	4444 6459	MCGOWAN	29/06/92	SPECKLED	5	yearling	750
LAKEVILLE (SILVER)	4507 6436	MCGOWAN	4/06/92	SPECKLED	5	yearling	500
MILBURY	4450 6527	MCGOWAN	8/07/92	SPECKLED	5	yearling	500
GEORGE	4456 6442	MCGOWAN	4/06/92	SPECKLED	12	yearling	500
GEORGE	4456 6442	MCGOWAN	1/05/92	SPECKLED	12	yearling	1000
MILBURY	4450 6527	MCGOWAN	3/06/92	SPECKLED	5	yearling	100
SPRINGFIELD	4439 6451	MCGOWAN	6/07/92	SPECKLED	5	yearling	1500
AYLESFORD	4457 6440	MCGOWAN	1/05/92	SPECKLED	12	yearling	1000
MCGRATH	4500 6342	MCGOWAN	11/06/92	SPECKLED	5	yearling	750
COCKSCOMB	4456 6351	MCGOWAN	5/06/92	SPECKLED	5	yearling	750
PIGOTT	4456 6353	MCGOWAN	5/06/92	SPECKLED	5	yearling	750
LILY	4455 6354	MCGOWAN	5/06/92	SPECKLED	5	yearling	750
AYLESFORD	4457 6440	MCGOWAN	4/06/92	SPECKLED	12	yearling	500
ENFIELD DERBY	4458 6333	FRASERS	12/06/92	SPECKLED	5	two year	50
						TOTAL	21919
ELLIOT	4456 6511	MCGOWAN	12/05/92	TIGER	205	yearling	250
ELLIOT	4456 6511	MCGOWAN	12/05/92	TIGER	205	yearling	750
						TOTAL	1000

Table 30. Trout stocking in RFA 5 in 1992.

With declining fiscal resources at both the provincial and federal levels of government, funding and person year assistance for native and non-native community groups, and contract funds (capital and operational) will be required to strengthen priority areas in hatchery infrastructure and improve the efficiency of these operations.

Watershed groups (native and non-native) could also have a role to play in assisting at hatchery facilities or in rearing speckled trout, rainbow trout, steelhead trout or Atlantic salmon for local enhancement projects or fishing derbies through construction of smaller rearing facilities such as satellite rearing, semi-natural pond/cage rearing or use of streamside incubation boxes. Care must be taken that adequate biological/technical advice be provided to these groups to avoid fish disease problems and ensure suitable genetic strains are distributed to these groups from government hatchery facilities.

All resource enhancement initiatives assume that spawning escapements are below target spawning requirements and the reasons for the deficits are known and can be corrected. It also assumes that fish will be stocked into suitable fish habitats in order to rehabilitate fish populations.

Satellite Rearing

Satellite rearing entails the rearing of feeding trout or salmon fry to the fall fingerling stage in 8' - 10' fiberglass tanks. Water is gravity fed to the tanks (8 - 10 gpm) which have "V" shaped cover roofs to prevent bird predation, provide shade and reduce the stress of disturbances caused by human activity near the tanks. Juvenile salmonids can be fed by automatic belt feeders or hand fed; these tanks can be located in isolated areas without electricity. Resultant fall fingerling trout or salmon would be stocked out in streams in late fall after bird predators are reduced in number and have less time to prey on young salmonids prior to ice formation.
The consultants recommend the use of this technique in Nova Scotia streams. It can be easily utilized by native and non-native community groups as a low-tech enhancement technique for the rehabilitation of individual streams or lakes, is cost effective, stimulates community interest and stewardship and reduces space requirements at hatcheries.

Semi-Natural Pond Rearing

Traditionally, hatchery stocking of speckled trout and salmon has been used to rehabilitate salmonid runs. Semi-natural rearing lends itself well to rearing salmonids in spring-fed ponds and presents a cost effective opportunity to rear salmonids for resource enhancement (Gray et al, 1992). Yearling parr or fall fingerlings are stocked in a spring-fed pond and feed on natural food organisms. Their natural diet is supplemented by an artificial dry pellet diet during the growing season from May to November.

The objectives of this enhancement technique is to develop salmonid characteristics similar to those observed in the wild, improve survival rates, reduce the cost of production and expand the production capability of hatcheries. The original research was carried out using Atlantic salmon, however, this technique should work equally well with speckled trout which could be reared to either the yearling stage or age 2+ for distribution to other specific lakes or streams.

Survival rates in the semi-natural rearing pond from stocked yearling salmon parr to two year old salmon smolts ranged from 58 - 61%. The major predators were herons, kingfishers, cormorants, and mink. Juvenile salmon were conditioned to a more natural environment and survival at sea was much higher (6 - 13%) compared to smolts reared in a traditional hatchery regime (2 - 4%). The consultants suggest that a pilot semi-natural rearing pond could be constructed to rear wild speckled trout for rehabilitation of trout stocks in priority lakes and streams

Semi-Natural Lake/Pond Cage Rearing

Speckled trout and salmon enhancement research has shown that juvenile salmonids reared semi-naturally from the fall fingerling or 1+ parr stage either in spring-fed semi-natural ponds or in lake net cages (Lake O'Law, Cape Breton, MacCormack Reservoir N.B., Caribou Lake N.B.) **have characteristics closer to wild fish and have higher survival rates than those reared artificially in concrete ponds or fiberglass tanks in a hatchery environment.** Scientific data for speckled trout have not been collected; however, the technique is currently being used for speckled trout in Caribou Lake, N.B. for trophy fishing and to date is working well.

With the proposed lake net cages (50' x 25' x 15') it should be possible to rear 5000 - 8000 speckled trout or 4000 good quality salmon smolts for stocking. Young salmonids are stocked in the cages and feed on natural food organisms in the lake or pond; their diet is usually supplemented by a diet of artificial dry pellets twice (2) each day (AM; PM). Bird predation nets which cover the cages and otter/mink predation nets which surround the lake net cage reduce predation. It is possible to utilize automatic belt feeders on the cage (if calibrated carefully) to reduce the person power necessary to operate such a facility. Person power (volunteers and/or hired staff) is required to provide security, fill the fish feeders and clean the net cages as required. The consultants recommend the use of this enhancement technique in specific spring-fed ponds or lakes as a less costly capital investment to semi-natural pond rearing.

Broodstock Transfers

Broodstock transfers entail the collection of genetic broodstock from the same or nearby stream which have similar biological characteristics and their release prior to spawning in the specific stream or lake to rehabilitate the resource. This technique has many advantages, however, broodstock transfers are not recommended for scarce genetic strains of speckled trout or salmon since more effective technology is available for these scarce genetic strains.

Salmonid Broodstock Reconditioning

Atlantic salmon reconditioning has been the subject of applied research in the Maritime Provinces for a number of years (Hill, 1976; Gray, 1976;Gray et al 1987; Johnston et al. 1987; Johnston et al 1990; Johnston et al 1992) it has subsequently been utilized in several other areas such as the Miramichi River estuary, Quebec and the New England States. **It is a proven technique to recondition Atlantic salmon kelts for the production of good quality eggs, for harvest by native communities and commercial fishermen, for release in streams or ponds for freshwater angling or estuarial trolling, for the sale of eggs to aquaculture or enhancement projects, for broodstock transfers to streams requiring specific genetic strains, etc. when the technology is implemented by experts in this field.**

The same principle could be applied to rehabilitate scarce genetic strains of wild speckled trout broodstock so that broodstock efficiency is improved. The consultants suggest that this broodstock reconditioning technique could be utilized to rehabilitate scarce genetic salmonid stocks: (a) to provide trout eggs, fry or fingerlings for stocking in barren habitat or for rearing in satellite rearing facilities operated by native and non-native community groups, and (b) to provide juvenile Atlantic salmon for resource enhancement in suitable streams.

Stream Sanctuaries : No-Kill Zones

Many conservationists have recommended the establishment of stream sanctuaries and no-kill zones to rehabilitate trophy speckled trout stocks in designated streams. The question of whether "hook and release" or "no fishing" should occur in these zones requires further discussion and should form part of the stream enhancement plan for specific areas.

The consultants suggest that stream sanctuaries be established in designated streams or lakes to alleviate angling pressure on heavily exploited stocks. The "no fishing" approach should be implemented in streams sanctuaries where the potential exists to establish trophy speckled trout fishing or establishment of sea-run trout as a world class angling opportunity. "No-Kill" or "hook and release" zones should be established in other streams in order to rehabilitate the resource and ensure self-sustained trout stocks for improved angling. These two approaches need to be discussed with local watershed groups; they could be implemented on a voluntary basis or by the implementation of appropriate regulations after consultation.

Streamside Incubation Boxes

Upwelling streamside incubation boxes using astro-turf substrate come in various designs and sizes. The most practical incubation boxes are models similar to the "Wynn Incubation Box" constructed of plywood with aluminum screens and astro-turf. This type of upwelling incubation box was designed to incubate approximately 20,000 - 30,000 salmonid eggs. Another useful design is constructed of fiberglass utilizing the same upwelling principle but capable of incubating approximately 60,000 salmonid eggs. Utilization of the technique requires that water is gravity fed to the box. The resultant unfed trout fry could be stocked in satellite rearing tanks for subsequent growth and release, or released directly into target streams or lakes. **This enhancement technique improves incubation survival rates and should work well when fry are stocked into barren habitat.** The public relations and educational value of streamside incubation is excellent. An evaluation of the utility of streamside incubation projects under different stream situations is needed; however, the technique is cost-effective and would stimulate the interest of watershed groups as well as their stewardship in the resource. It is not recommended by the consultants for scarce genetic strains of salmonids.

Stakeholder Involvement and Collaboration

All Nova Scotians are stakeholders in the fisheries resource and this relationship carries with it the responsibility for careful stewardship. There is a need to clarify the roles, responsibilities and consultative mechanisms needed for effective participation by native and non-native groups in the recreational fishery. In the past government agencies have sometimes been reluctant to involve stakeholders in policy and decision making. The consultants suggest that attitudes must change with respect to stakeholder involvement in the recreational fishery so that strong partnerships are formed between native and non-native groups and government agencies. **Stakeholder involvement and collaboration should be extended to participation in rehabilitating the fisheries resource, harvesting the resource, policy formulation, and decision-making to establish sound resource management strategies and to foster stewardship.**

Education and dialogue should be initiated to work out details of the respective roles of stakeholders since it is generally recognized that government agencies can no longer shoulder complete responsibility for all components of the recreational fishery in view of fiscal and person power constraints. Strong partnerships and collaboration with all stakeholders will help governments carry out their mandate to manage the fisheries resource. Consultative mechanisms are already in place (i.e. Recreational Fisheries Advisory Council (RFAC) in each Recreational Fishing Area or Zone Management Advisory Committee (ZMAC) in each Salmon Fishing Area or Salmon Management Zone) to discuss issues and concerns. A select number of individuals from the native and non-native sectors could represent stakeholders on an Advisory or Steering Committee established to formulate policy and decision-making regarding future resource management strategies for the recreational fishery.

There are a variety of projects where native and non-native (watershed) groups could participate in rehabilitating the fisheries resource and developing the industry. Some activities where watershed groups could participate are listed below :

1. Formulation of conservation principles;
2. Stock assessment projects e.g. operating counting fences, electrofishing, lake surveys, creel census, snorkeling surveys, redd counts;
3. Collection of specific information required to manage the fisheries e.g. creel census;
4. Installation of fish habitat improvement devices;
5. Resource enhancement projects such as stocking, streamside incubation boxes, satellite rearing, salmon kelt reconditioning, pond/lake cage semi-natural rearing, broodstock transfers, broodstock collection;
6. Collection of stream habitat inventory data;
7. Water quality sampling;
8. Clearance of stream debris and minor improvements to fish passage - gravel bars, natural and man made barriers causing partial obstructions (blasting, small fishways);
9. Stream bank stabilization;
10. Selective cutting of trees along stream banks;
11. Improvements to rearing habitat (e.g. boulder placement, half logs, gabions);
12. Improvements to spawning habitat (e.g. gravel placement);
13. Broodstock collection and holding;
14. Broodstock transfers;
15. Stream acidity control - (e.g. lake liming, liming wheels/barrels, placement of limestone spawning gravel);
16. Stream/lake fertilization;
17. Assistance in monitoring flows or construction of flow control dams;

18. Applied research projects;
19. Holding and angling pool restoration;
20. Stocking juvenile salmonids (unfed fry, fall fingerlings) from hatcheries;
21. Collection of catch and effort statistics;
22. River protection and surveillance regarding the establishment of broodstock sanctuaries, pollution, gravel removal, and other habitat disruptions;
23. Monitoring fishway traps;
24. Assistance in biological evaluation of enhancement projects;
25. Assistance at hatcheries - feeding, cleaning ponds, tagging;
26. Harvesting the resource such as guiding and outfitting enterprises, operating fishing lodges, conducting tournaments, conducting winter ice-fishing derbies;
27. Establishment of fly fishing schools/tackle shops;
28. Developing value added products such as smoking reconditioned salmon and trout;
29. Sea-ranching and terminal harvest where stocking provides surplus salmonids;
30. Education and public awareness projects.

These activities, among others, would create employment and income opportunities associated with the recreational fishery. Along with the many opportunities listed above native communities could create employment and income by rearing rainbow trout (e.g. triploids) or speckled trout for fishing derbies at specific locations in their respective RFAs; establish smoke houses for reconditioned salmon or trout grown by the band or create year round angling opportunities in designated lakes for winter ice-fishing.

The effective participation of native and non-native groups in habitat and resource protection, conservation and enhancement is inextricably linked to the long-term preservation and expansion of the recreational fishery. Native and non-native communities will require education, training and assistance in terms of biological/technical advice in the planning and implementation of projects related to the recreational fishery.

A long-term comprehensive plan should be developed with aboriginal communities in Nova Scotia which would include their participation in the development of the recreational fishery, stream rehabilitation, and resource enhancement. Such a plan would also identify job creation and economic opportunities for native communities in the fisheries/tourism and aquaculture sectors. Many of these are listed in this section, others include :

1. *Wilderness Camping and Canoeing :*
    - provision of supplies at check points
    - conduct education/training programs for canoeists : how to pack supplies, building canoes, fly tying, paddling, poling
    - rental of canoes
    - management and clean-up of camp sites

2. *Stock Assessment :*
    - participation at counting fences, barriers, electrofishing, redd counts, etc.
    - assist in operating tag and recapture traps on a continuous annual basis

3. *Resource Protection :*
    - train Native Conservation Officers with similar powers to DFO Fishery Officers
    - patrol the native fisheries as well as other lakes and rivers to enforce fishery, environmental, and hunting regulations

4. *Develop Hunting and Fishing Lodges :*
    - guiding, charter boat operations
    - operating the lodge facilities
    - training sport fishermen to fly fish, fly tying
    - training in canoeing, wilderness camping, tracking, hunting
    - tourism activities

Education and Public Awareness

The NSDOF through its Adopt-A-Stream program, extension activities, and trout education packages have embarked on a meaningful program of education and public awareness. Similar efforts have been on-going by DFO through the preparation of fact sheets on various species for public information and education, slide talks, visits to schools, and meetings with community groups. Some community groups have also independently initiated education programs in their local areas.

These initiatives will be vastly expanded by the Atlantic Salmon Federation through their ASF School Education Program. This ASF program is expected to last four (4) years and is structured on the successful program carried out by S.E.P. in British Columbia. Curriculum material will be directed at three (3) groups : kindergarten and early grades, grades 4 - 6 and grades 7 - 9. Instruction and training for designated teachers will be carried out at St. Andrews, with a second session held in Newfoundland. **This initiative is a welcomed component of the Sport Fishery Enhancement Program and should have a very positive impact on youth regarding conservation, protection and enhancement of the fisheries resource.** It should also stimulate interest in the recreational fishery and the need to protect and enhance fish habitat and the fisheries resource in Nova Scotia. However, more can be done. **Education and cooperative projects undertaken with various industries are required. Resource users, industry, legislators, judiciary and other government agencies also require more education regarding the value of the resource and sharing the resource. More education and communication is needed on the introduction of specific exotic species to designated areas where damage to native stocks could occur, on-going research and a variety of other issues related to the recreational fishery.**

Education programs describing the importance of healthy aquatic ecosystems must be created for both anglers and non-anglers. Packages directed at different target groups could be developed around one or a series of videotapes that use high profile individuals to explain the importance of aquatic ecosystems. For example, angling audiences would respond to popular conservationists describing the reasons for protecting fish habitats or catch-and release angling in Nova Scotia. Seminars promoted by these individuals could be conducted across the province; videotapes, television and radio advertisements, posters, and brochures could be prepared. Various promotional devices could be employed to maximize the participation in the aforementioned seminars such as lotteries for fishing trips, boats, canoes, fishing equipment and scenic paintings or prints.

Developing education packages for younger audiences that would be distributed to schools should be a principle objective. Young people will be the resource users in future years and they are also more adaptable to "new" ideas than many longtime users.

The Nova Scotia Recreational Fisheries Strategic Development Plan should promote education and public awareness of the need for conservation of the fishery resource. It should also foster public awareness of the importance of all wildlife species and the need to integrate fishery development initiatives with those of other wildlife and natural resources as a means of resolving potential conflicts in Nova Scotia watersheds. In summary, conservation, recreational fisheries management, fish habitat protection and improvement, and enforcement activities are all dependent on education. It is recommended that :

- the public, anglers, industry and legislators be educated regarding the value of the recreational fishery so that a better understanding is fostered of the need to protect healthy aquatic ecosystems and the fisheries resource;

- all stakeholders be educated on the need for conservation and the limitations of the fisheries resource;

- all stakeholders be educated to change angler attitudes towards overharvest, the need to utilize other species (e.g. yellow perch, white perch, gaspereau, shad, striped bass, brown trout, etc.) and reduce their catch of declining stocks of speckled trout and salmon;

- fish habitat and resource enhancement initiatives be implemented to foster involvement, understanding, ownership and respect for conservation of fisheries resources;

- fact sheets, brochures, posters, TV videos, radio advertisements, seminars and other communications (communication plan) be prepared and distributed to target groups such as schools, the public, all stakeholders, industry, tourism, the judiciary and legislators on topics such as : conservation, under-utilized species, resource conflicts (species, hydro development, forestry and agricultural practices, industries), industrial and municipal pollution and sewage treatment, applied research, enforcement efforts, fishing regulations, enhancement projects, new fishing opportunities, sport fishing techniques (e.g. fly fishing, trolling, and angling techniques for shad, striped bass, gaspereau, smallmouth bass, yellow perch, white perch) and winter ice fishing;

- cooperative projects be undertaken with industry and other government agencies to promote Integrated Resource Management and an understanding of the recreational and economic value of the recreational fishery.

Applied Research

There are some specific concerns for the management of recreational freshwater fisheries in Nova Scotia. These include rehabilitating acidified lakes and streams to establish viable fish populations, rehabilitating speckled trout fisheries in lakes dominated by stunted perch populations, and determining the impacts of introduced smallmouth bass on speckled trout populations. These types of problems are complex and require intensive efforts for their resolution. Additional funds, university research, consultant studies and contract funds dedicated to addressing the research requirements for fisheries management in the province are required. **Research initiatives should concentrate on basic fisheries research and experimental management studies designed to enhance provincial fisheries.** Research studies could include determining the effects of large predator introductions (e.g. adult brook trout) on dwarf or stunted perch populations in lakes, determining levels of contaminants (pesticides, herbicides, and heavy metals) from agricultural practices on fisheries resources, the feasibility of liming to restore brook trout in acidified lakes, alternative angling opportunities for acidified lakes such as put-and-take fisheries for non-traditional species, and examining the ecological and economic impact of stocking 1+ versus 0+ brook trout in various lake and stream types. Such projects could be identified and prioritized by fisheries managers and undertaken by fisheries researchers. Experimental management studies should be carried out with incentives for cooperative research with university and college researchers - incentives could include provisions for financial support (e.g. establishing a Nova Scotia University Fisheries Research Fund) and logistic support (e.g. providing equipment, personnel, etc.).

Stock Assessment

Successful management of a fish stock requires an understanding of its size and structure over several generations. Population abundance and structure must be described to determine limits on production for management of a fishery, and to detect changes in fish populations due to long term trends in ecosystem dynamics or as the result of unpredictable perturbations. **A program should be initiated to undertake lake and stream assessments of fish communities across the province.** The long term goal of the assessment program should be the description of all lakes and streams in the province. However, in the short term there will be priority water bodies for assessment in each RFA (e.g. Highland lakes of Cape Breton, reservoir lakes of Kings County); index lakes and streams could be considered in each RFA.

The assessment should be designed to provide the most accurate estimate of the fish community and the limnology of the waterbody. Fish population estimates for sport and forage species should be based on accepted fisheries techniques (e.g. mark-recapture studies). Assessment of Atlantic salmon stocks in the major rivers should continue to be a high priority. These stock assessment studies should be implemented in cooperation with native and non-native community groups.

Experimental Lakes Program

The Experimental Lakes Program should consist of the following components among others : lake surveys; stock assessment; limnological studies including their physical and chemical profiles,

plankton, benthos, bathymetry, littoral and shoreline structure, and availability of lake spawning and rearing habitats for various species; lake management scenarios; mitigation of acidic precipitation; interspecific interactions between various species such as speckled trout, rainbow trout, brown trout, yellow perch, smallmouth bass, white perch, landlocked salmon, etc.; lake fertilization; and improvement of lake fish habitat.

Other areas for applied research include :

i) Acid Mitigation in streams and lakes;
ii) Control of Siltation;
iii) Fish Passage Problems and Flow Control/Regulations;
iv) Fish Habitat Improvement;
v) Dynamics of fish communities;
vi) Cost effective techniques to enhance Atlantic salmon, sea-run speckled trout, resident speckled trout, shad, striped bass, smallmouth bass and other potential recreational species;
vii) Socio-economics of recreational fisheries;
viii) Techniques to standardize data collection, storage and analyses;
ix) Potential of estuaries to grow salmonids and other recreational species;
x) Stream and lake productivity;
xi) Smallmouth bass, shad, striped bass, white perch, landlocked salmon;
xii) Spawning requirements of recreational species;
xiii) Recreational fishery enhancement and management in the Bras d'Or Lakes;
xiv) Overwinter habitat for salmonids;
xv) Development of winter recreational fisheries for stocked rainbow and speckled trout, white perch, smelt, etc.;
xvi) Saltwater stocking of juvenile salmonids;
xvii) Put-grow-take fisheries for recreational fishing, fishing derbies or winter ice-fishing.

New Recreational Fishing Opportunities

Excellent opportunities exists for the expansion of recreational fisheries for speckled trout, sea-run speckled trout, Atlantic salmon, rainbow trout, brown trout, striped bass, smallmouth bass, shad, white perch, yellow perch, gaspereau, and smelt in specific areas of the province. However, it should be noted that certain species have declined in some RFAs and cannot withstand current or expanded recreational fishing exploitation. For example, except in certain lakes in Cape Breton (RFA 1), Guysborough County (RFA 3) and a few lakes in RFA 2, speckled trout stocks have declined and are in need of restoration. Atlantic salmon stocks in the Inner Fundy rivers have experienced serious declines, whereas fall runs of salmon along the Northumberland Strait (RFA 2) are in better shape e.g. Margaree River (RFA 1). Current opportunities for sea-run speckled trout fishing are modest and restricted to specific rivers in RFA 1, 2, 3. Currently brown trout fishing in specific rivers along the Northumberland Strait (RFA 2), Guysborough County (RFA 3) and some Inner Fundy rivers (RFA 2) are good. Striped bass fisheries in the Annapolis River (RFA 5) and Stewiacke - Shubenacadie rivers (RFA 5) are good while in certain rivers along the Northumberland Strait (RFA 2) such as East River (Pictou), River Philip, and Pugwash, they are modest. Recreational fisheries for shad in the Annapolis River and some other rivers in RFA 5 are excellent; shad fisheries in RFA 3 offer modest opportunities except in the LaHave Rive where the potential is good. Smallmouth bass fisheries offer excellent potential in RFA 5 and also in certain lakes in RFA 3. Gaspereau, a relatively unexploited recreational species offers excellent potential in several rivers in each RFA including the S/W Margaree (RFA 1), LaHave (RFA 3), Gaspereau (RFA 5) and River Philip (RFA 2).

Opportunities exist to develop new recreational fisheries where these are cost effective :

i) Recondition black salmon for release into rivers or lakes for angling and natural spawning;

ii) Introduction of landlocked salmon into designated lakes identified in Table 31 after studies of these lakes have been carried out regarding their suitability (e.g. Grand Lake);

iii) Bras d'Or Lakes is perhaps the best recreational fishery opportunity in the province and should receive the highest priority for development;

iv) Large scale enhancement of speckled trout stocks in the Highland lakes of Cape Breton, and other suitable lakes in RFA 1, 2, 3, 5 offer great potential;

v) Enhancement of sea-run speckled trout stocks in the streams/rivers of RFA 1, 2 and some streams/rivers in RFA 3 and 5 where pH conditions are suitable offer excellent potential;

vi) Striped bass and shad recreational fisheries have excellent potential in specific rivers at present and these can be expanded;

vii) Smallmouth bass recreational fisheries offer excellent potential;

viii) Winter ice-fishing for smelt, speckled trout, rainbow trout, white perch, yellow perch, etc. have excellent development potential in designated areas;

ix) Development of summer, fall and winter fishing derbies offer excellent potential; in a few cases these could be based on wild trout stocks, however, in the majority of situations these would be based on put-grow-take trout stocking techniques. Other species that would provide excellent potential for tournaments would include, shad, smallmouth bass, smelt, rainbow trout, brown trout, striped bass, yellow perch, etc.;

x) U-Fish enterprises offer good potential for expansion;

Table 31. Potential landlocked salmon lakes greater than 200 hectares in size (B. Sabean, pers. comm.).

Lake name	County	Area (Ha.)	% area of Hypolimnion	Watershed number	Watershed name	Species Caught	Max. depth. (m)	Mean depth.	Conduc-tivity	Colour	ph	Potential for natural spawning and rearing streams*	Conflict wi Atlantic Salmon**
Grand	Anna.	263.8	65	DD02E	Anna. R.	7,9,11,15,16,23,29	15.0	3.8	35.0	11	6.5	3	1
Big Mollyupsim	Anna.	507.3	25	DD03C	Anna. R.	9,11,15,16	10.5	2.6	26.0	75	6.0	3	1
McGill	Anna.	221.5	50	DD03C	Anna. R.	7,9,11,15,16,23	15.6	4.7	24.0	60	6.0	2	1
Lochaber	Anti.	307.2	75	ED01F	St. Mary's R.	7,9,3,15,16,23	52.4	21.8	46.6	8	6.8	4	5
Gabarus	C.B.	440.0	25	FJSD12	Belfry L.	2,7	22.8	9.6	83.0	22	7.0	3	3
Antidam Flowage	Hfx.	201.9	25	EM01B	East R.	2,11,16,18,20	14.0	N/A	19,5	N/A	5.5	3	1
Charlotte	Hfx.	1485.7	70	EL05AA	Ship Hbr.	2,7,11,15,16,23,28,29,32	51.0	11.4	22.0	22	6.2	4	3
Chezzetcook	Hfx.	244.9	40	EK03C	Chezzetcook R.	2,7,11,13,15,8,23,29,32	18.3	4.3	28.0	20	5.9	4	1
Dollar	Hfx.	215.1	80	EK01RR	Musquodoboit R.	15,16,29	33.5	11.6	27.0	30	6.5	3	3
Grand (Shubie)	Hfx.	1841.3	75	DG01HM	Shubie R.	N/A	45.0	16.5	53.0	N/A	6.1	3	3
Pace	Hfx.	302.7	25	EK02A	Little R.	2,15,16	51.2	13.7	32.0	10	6.2	3	2
Petpeswick	Hfx.	256.8	30	EK03B	Chezzetcook R.	2,7,11,16,29,32	19.8	4.9	35.0	0	6.8	2	2
Porters	Hfx.	1651.1	50	EK04H	Porter's L.	2,7,12,15,16,23,29,32	30.5	N/A	N/A	N/A	N/A	3	2
Southwest	Hfx.	203.1	40	EM02P	West R.	2,7,9,16,23,29	15.6	5.7	30.0	7	6.7	2	2
William	Hfx.	235.0	60	DJ01FF	Shubie R.	6,7,16	28.4	11.5	28.0	N/A	6.7	2	1
Panuke	Hants	1638.9	60	DE01B	Avon R.	2,9,11,15,16	34.8	N/A	76.0	N/A	5.5	4	1
Ainslie	Inv.	5735.8	0	FD02B	Margaree R.	2,7,16,22,26,29,32	18.0	5.7	200.0	2	7.0	3	4
Caribou	Lunen.	273.9	70	EG040	Mushamush R.	7,9,15,16,23,32	50.0	20.3	32.0	6	7.5	2	2
Big Mushamush	Lunen.	1088.7	0	EG04E	Mushamush R.	7,9,11,15,16,32	25,0	8.1	33.0	16	7.5	2	2
Mushamush	Lunen.	425.3	2	EG04W	Mushamush R.	7,9,11,14,15,16	16.0	5.2	29.0	20	7.0	3	3
Molega	Queens	1995.9	5	ED02M	Medway R.	7,9,11,15,16,29	26.0	5.0	25.0	40	5.5	3	4
Loch Lomond	Rich.	671.3	7	FJ052	Grand R.	2,12,20	18.0	6.9	N/A	N/A	7.0	3	3
Vaughan	Yar.	467.4	3	EA04JJ	Tusket R.	7,9,11,16,23	18.0	5.1	34.0	31	6.8	2	3
Sherbrooke	Lunen.	166.0	-	EF02G	LaHave R.	3,16,9,25,32	-	-	-	-	-	4	5

* 1 Poor, 5 excellent.
** 1 nil, 5 extreme.

xi) Black salmon fishing in designated rivers where target spawning requirements have been met (e.g. Margaree River) offer modest potential;

xii) Other opportunities are discussed in the section on each RFA.

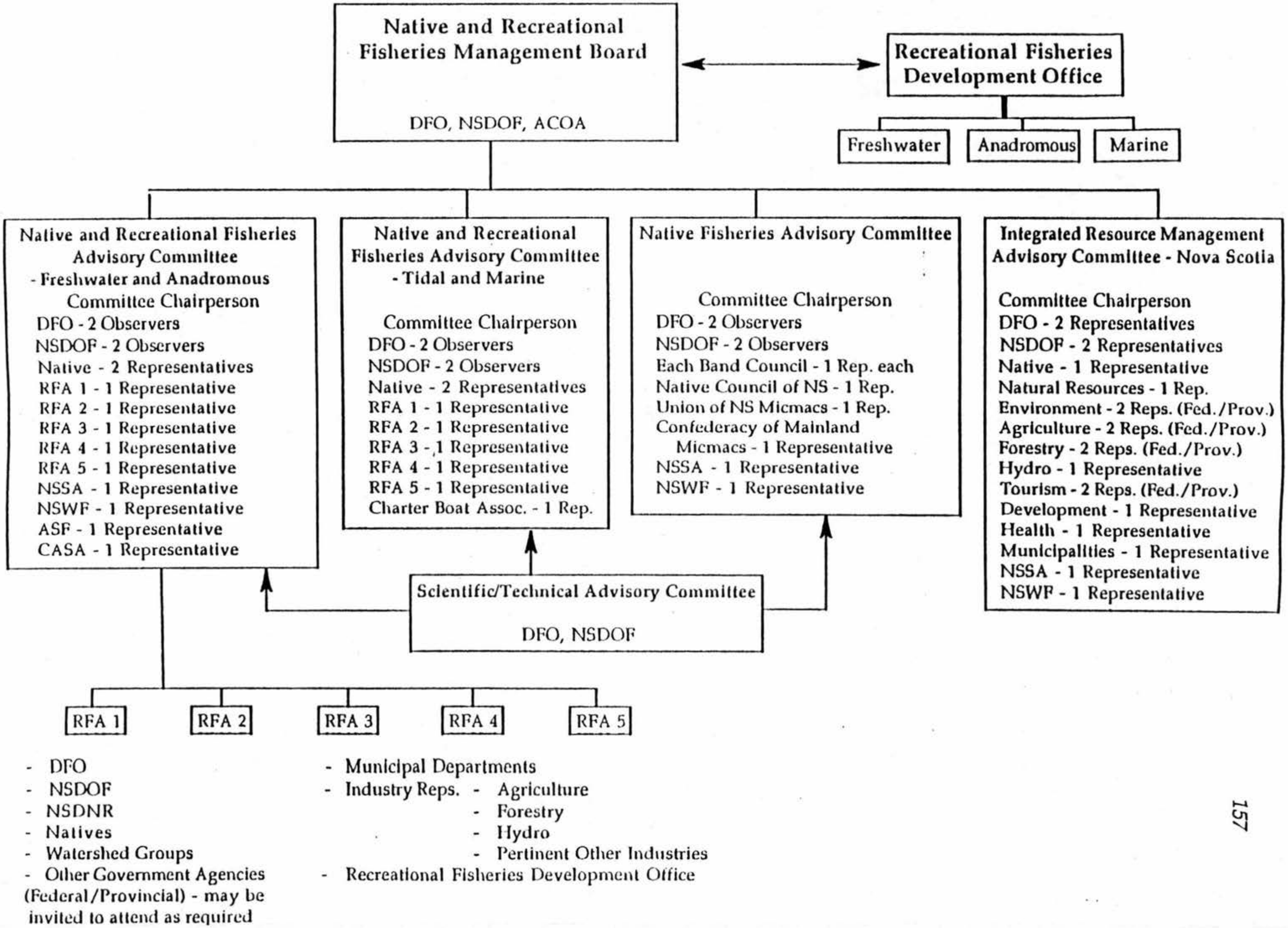
Promotion of the Recreational Fishery

The Nova Scotia Department of Tourism and Culture is targeting recreational fishing as part of its 1993 marketing strategy. It is important that effective communication occurs between DFO, NSDOF and NSDOTC to ensure that the recreational fishery is promoted in the best interests of the province. In other words, tourism should be aware of the species having the best potential for recreational fishing in each part (RFA) of the province (i.e. rivers, lakes). For example, promotion of Atlantic salmon fishing in the Inner Fundy rivers would be misleading to say the least. Rather, promotional efforts (brochures, TV, other media, sportsman shows, etc.) should target species which are in good shape.

Program Delivery and Evaluation

Infrastructure

During the consultations and studies carried out by the consultants, native and non-native community groups expressed concern about the need to clarify the roles and responsibilities of Federal (DFO) and Provincial (NSDOF) agencies regarding recreational fisheries management, the need to recognize native rights, and the need for governments to delegate more responsibility to stakeholders in all aspects of the planning, development and implementation of the new strategic plan. Concern was also expressed about the lack of Integrated Resource Planning and Management in the province. Many community or watershed groups identified the lack of biological and technical advice available to them in preparing watershed management plans, collecting accurate biological data, assessing stock status in rivers and lakes, acquiring the necessary permits, implementing stream enhancement projects and evaluating progress in their projects. In recognition of these concerns the consultants have proposed a schematic diagram of one of several approaches which could meet the needs of stakeholders and governments in implementing the strategic plan for the Canada-Nova Scotia Cooperation Agreement on Recreational Fisheries.


Native and Recreational Fisheries Management Board
DFO, NSDOF, ACOA
Recreational Fisheries Development Office
Freshwater
Anadromous
Marine
Native and Recreational Fisheries Advisory Committee - Freshwater and Anadromous
Committee Chairperson
DFO - 2 Observers
NSDOF - 2 Observers
Native - 2 Representatives
RFA 1 - 1 Representative
RFA 2 - 1 Representative
RFA 3 - 1 Representative
RFA 4 - 1 Representative
RFA 5 - 1 Representative
NSSA - 1 Representative
NSWF - 1 Representative
ASF - 1 Representative
CASA - 1 Representative
Native and Recreational Fisheries Advisory Committee - Tidal and Marine
Committee Chairperson
DFO - 2 Observers
NSDOF - 2 Observers
Native - 2 Representatives
RFA 1 - 1 Representative
RFA 2 - 1 Representative
RFA 3 - 1 Representative
RFA 4 - 1 Representative
RFA 5 - 1 Representative
Charter Boat Assoc. - 1 Rep.
Native Fisheries Advisory Committee
Committee Chairperson
DFO - 2 Observers
NSDOF - 2 Observers
Each Band Council - 1 Rep. each
Native Council of NS - 1 Rep.
Union of NS Micmacs - 1 Rep.
Confederacy of Mainland Micmacs - 1 Representative
NSSA - 1 Representative
NSWF - 1 Representative
Integrated Resource Management Advisory Committee - Nova Scotia
Committee Chairperson
DFO - 2 Representatives
NSDOF - 2 Representatives
Native - 1 Representative
Natural Resources - 1 Rep.
Environment - 2 Reps. (Fed./Prov.)
Agriculture - 2 Reps. (Fed./Prov.)
Forestry - 2 Reps. (Fed./Prov.)
Hydro - 1 Representative
Tourism - 2 Reps. (Fed./Prov.)
Development - 1 Representative
Health - 1 Representative
Municipalities - 1 Representative
NSSA - 1 Representative
NSWF - 1 Representative
Scientific/Technical Advisory Committee
DFO, NSDOF
RFA 1
RFA 2
RFA 3
RFA 4
RFA 5
- DFO
- NSDOF
- NSDNR
- Natives
- Watershed Groups
- Other Government Agencies (Federal/Provincial) - may be invited to attend as required
- Municipal Departments
- Industry Reps. - Agriculture
- Forestry
- Hydro
- Pertinent Other Industries
- Recreational Fisheries Development Office

It is suggested that the Native and Recreational Fisheries Management Board meet as required during the year to manage the Recreational Fisheries Development Program. The Management Board could hold formal meetings with the (a) Native and Recreational Fisheries Advisory Committee - Freshwater and Anadromous; (b) Native and Recreational Fisheries Advisory Committee - Tidal and Marine; (c) Native Fisheries Advisory Committee; and (d) Integrated Resource Management Advisory Committee, as required but normally once each year. The four advisory committees would provide advice on policy and direction to the Management Board, would review projects, and would serve to stimulate cooperation among various government agencies (Federal/Federal; Provincial/Provincial; Federal/Provincial), Native people (Native/Federal; Native/Provincial; Native/Native; and Native/Non-Native), and other community or watershed groups i.e. non-government organizations (NGO/Federal; NGO/Provincial; NGO/Native; and NGO/NGO). The composition of the four advisory boards is flexible and only suggestions are provided by the consultants.

It is suggested that existing consultative mechanisms (RFAC, ZMAC) be streamlined into one body - tentative representation on the Regional Fisheries Advisory Committees for each RFA is suggested. It is also proposed that the designated Recreational Fishing Areas by DFO and NSDOF be streamlined into one zonal categorization. A Federal/Provincial working group should be established to discuss these issues in the context of multi-species recreational fisheries management and recognizing that similar membership lists currently exist for both ZMAC and RFAC.

Projects submitted by watershed groups would be reviewed at the Regional Fisheries Advisory Committee level first and the best projects would be forwarded to the Native and Recreational Fisheries Advisory Committee - Freshwater and Anadromous for review and approval. Projects submitted by the Saltwater Recreational Fisheries/Charter Boat operators would be considered separately by the Native and Recreational Fisheries Advisory Committee - Tidal and Marine because of their different needs. Projects submitted by native groups would be reviewed by the Native Fisheries Advisory Committee.

A Scientific/Technical Advisory Committee with representatives from DFO and NSDOF would provide advice to the three provincial advisory committees (Freshwater and Anadromous; Tidal and Marine; Native) on science and management issues or technical aspects of the program as requested. They would also liaise with the Technical Review Committee during the final screening and review process as requested.

It is suggested that a Recreational Fisheries Development Office (RFDO) be created to carry out the day to day operations of the program, provide direct assistance to watershed groups or project proponents in the freshwater, anadromous or marine sectors and implement a communications plan. The office could be divided into two or three sections to provide advice/expertise and administer various components of the recreational fisheries (Freshwater, Anadromous, Marine). Fiscal resources would be required to hire biological, technical and administrative contract staff to operate the program effectively. Consideration could be given by DFO and NSDOF to providing PY's to the Recreational Fisheries Development Office as part of their contribution to the Canada-Nova Scotia Cooperation Agreement on Recreational Fisheries. Other considerations in staffing would be a native advisor, a community planner, a biological advisor, and administrative, clerical and secretarial staff. Access to the Scientific/Technical Advisory Committee for expert advice, and input from other Federal/Provincial experts on fish habitat improvement, stream/lake fertilization, liming techniques, hatchery production, engineering, stock assessments, marine fisheries, resource enhancement technology, etc. would be essential for the Recreational Fisheries Development Office to be effective.

Physical infrastructure requirements to implement the program (NGO equipment, DFO/NSDOF hatcheries, fishways, resource enhancement and fish habitat improvement infrastructure, etc.) are described elsewhere in this report.

Watershed Management Plans

Comprehensive watershed management plans should be developed for each watershed by a community group with assistance from the RFDO. Components of a typical watershed management plan are outlined in Appendix IV; it is suggested that these be prepared during the first year of the program. Thereafter, in years 2 - 4, the plans would be implemented.

Screening and Review Process

The proposed screening and review process for each project is outlined in Figure 12. It is suggested that all applications for funding and/or approval should reach the Recreational Fisheries Development Office (RFDO) by January 31, each year. The proposal would be briefly reviewed by the RFDO to ensure pertinent information was present in the application and then forwarded to the **Technical Review Committee** (TRC). If required, the TRC would seek advice from the Scientific/Technical Advisory Committee or other appropriate government agencies/experts for comment or advice; otherwise it would be reviewed by the TRC. The function of the TRC would be as follows :

- To review the proposals according to a list of approved criteria and in the context of Integrated Resource Planning and Management.

- To provide bio-engineering advice re: design and efficiency of fish passage facilities e.g. fishways, culverts, draw down structures, hydrology, etc..
- To ensure the project has the required licenses, watercourse alteration permits, and ensure that these were being reviewed and/or approved by the appropriate Watercourse Alterations authority (NSDOE, DFO) or by EIA or EARP if required.
- To ensure the proposal was reviewed/approved by the Fish Health and Introductions Committee if required.
- To provide scientific and technical advice on stream survey methodology, fish habitat improvements, assess the need for stocking and ensure that appropriate stream/stock enhancement techniques were suitable.
- To review/advise on estuary or coastal/deep sea recreational fishery projects, opportunities, fishing derbies, promotion, etc..
- To review project costs and make recommendations regarding the proposal to the RFDO by February 15.

It is suggested that the Management Board would review project applications and RFDO recommendations in the context of available funds for specific components of the Canada-Nova Scotia Cooperation Agreement on Recreational Fisheries and provide a decision. This decision would be sent back to the proponent by March 31.

Project Evaluation Criteria

Some of the suggested criteria for evaluating individual projects are outlined:

I. *Watershed Management* : Does the project demonstrate initiatives to control harvest/demand, enforcement initiatives, promote conservation and sustainable development goals. Is a multi-species approach advanced in the project's objectives. Is stock assessment part of the project at its beginning.

II *Watershed Planning/Project Design Feasibility* : Does the project contain initiatives oriented towards accurate data collection to improve the resource and habitat databases. Will the project develop a sound watershed plan whose elements are consistent with the goals and long-term objectives of the Canada-Nova Scotia Strategic Development Plan. Are species and user conflicts considered in the plan? Is the project well thought out? Does it propose to use the best technology available? Has advice from the RFDO, DFO, NSDOF or consultants been used to design the project and assist in its implementation and evaluation?

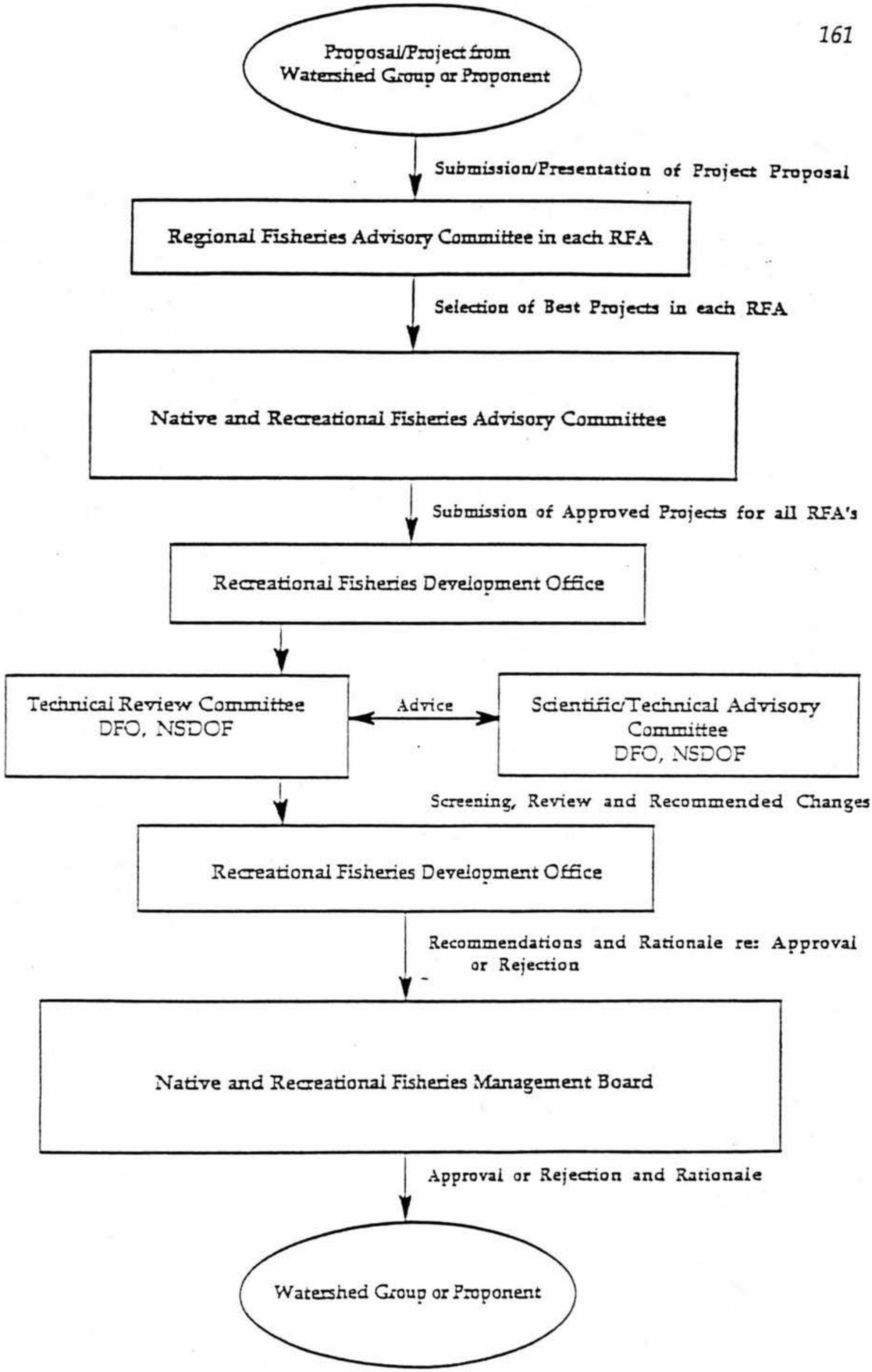


Figure 12. Proposed screening and review process for projects.

III *Enforcement* : Does the watershed group have initiatives (e.g. education, river watch, report-a-poacher, river wardens, 1-800 numbers) to improve and complement enforcement efforts regarding regulations, surveillance of potential environmental problems, poaching, public relations, conservation/education (e.g. signs, literature, etc.).

IV *Integrated Resource Management* : Have the project proponents involved industry in the planning; do they have support from industry and other government agencies to avoid conflict and achieve the benefits projected? Has the watershed group, outfitter, charter boat operator, U-Fish pond operator, obtained support for their proposal from other stakeholders?

V *Watershed Group* : What is the experience/commitment of the group? Have they implemented successful projects in the past? Will this project involve a long-term commitment which the group accepts responsibility for?

VI *Funding* : Does the proponent have other funding sources? How much funding is requested annually? What is the proportion of funding generated from other sources? What is the benefit:cost of the project?

VII *Regional Fish Production Goals for Recreational Fisheries* : What are the fish production and recreational fisheries harvest projections from the project? Are all RFAs considered for funding? Are the best opportunities funded in each RFA? Will the project take pressure off the harvesting of wild stocks? Will the project initiate new fishing opportunities or utilization of non-traditional species?

VIII *Applied Research : Evaluation* : Is the project targeted at applied research carried out in cooperation with DFO or NSDOF to advance knowledge/technology associated with fish habitat improvements, resource enhancement, stock assessments, modeling, species interactions, stream/lake productivity, etc.? Is the project to be evaluated using appropriate methodologies?

IX *Education, Public Awareness and Communication* : Does the project promote education of youth, industry, legislators, judiciary, anglers or other watershed groups? Will improved public awareness and education be imparted in the communications proposed in the project, e.g. newsletters, brochures, videos?

X *Socio-Economic Development* : Will the project contribute to viable private enterprises where job creation, income and economic impact is significant? Are the economic impacts in rural areas? What is the benefit:cost of the project? Are regional economic goals of the Canada-Nova Scotia Cooperation Agreement on Recreational Fisheries advanced by the project?

Program Evaluation

A crucial aspect of any development program is a system to monitor and evaluate its progress. Performance indices are required to measure the performance of the projects in terms of key criteria established for the program. These criteria should reflect societal and governmental objectives for the program.

Indices related to fish production, job creation, income generation are included as well as indices related to the aspirations of resource users and resource managers. Target performance levels should be set for projects and programs; a system to collect the information required to measure the actual performance of projects should be built into the design of the program. Evaluation of the program should take place at periodic intervals.

The overall success of the Recreational Fisheries Development Program could be evaluated by a variety of factors. The consultants have attempted to identify some of these parameters including the intangible benefits which are difficult to measure. (Not necessarily in order of priority).

1. How has cooperation between government agencies, native peoples, and watershed groups been improved?
2. Have the consultative mechanisms implemented been streamlined and do they provide effective communication between stakeholders and governments?
3. Have the roles and responsibilities of various government agencies been clarified and agreements or M.O.U.'s developed?
4. Has an effective program delivery mechanism been developed?
5. Has infrastructure been improved to maintain the recreational fishery into the 1990's?
6. Has an effective communications plan been developed with brochures, newsletters, fact sheets, TV videos, radio advertisements, and newspaper stories?
7. Has education initiatives such as those identified in this report changed angler attitudes, improved awareness of, and implementation of conservation practices, improved the sport harvest on non-traditional species, improved technology transfer, increased public involvement and commitment, reduced resource user conflicts, and improved integrated resource management?
8. Has enforcement been improved?
9. Has a diversity of fishing experiences been developed?
10. Has species diversity improved and are effective regulations in place to control undesirable introductions?
11. Has the overall enjoyment of fishing improved?

12. Has the health of aquatic ecosystems been improved?
13. Have recreational harvests of endemic species such as speckled trout and Atlantic salmon met target projections? Have recreational harvests of non-traditional species increased?
14. What is the quantity of fish habitat that has been improved? Has water quality improved?
15. How much has habitat productivity improved?
16. How much has fish production increased?
17. Has recreational fisheries management adequately addressed the supply and demand equation?
18. Are long-term funding mechanisms in place to sustain a significant portion of the costs associated with maintaining the recreational fishery?
19. Do stakeholders feel the investment has been a success?
20. Have required development objectives been achieved?
21. Have regional socio-economic goals for job creation and income been achieved?
22. Have goals for native people been achieved in terms of food, jobs and income?
23. Has the number of fishing days, number of anglers and number of desired species caught per unit of effort increased?
24. Has new knowledge been generated? Is an effective applied research program in place?
25. Has the economic impact and economic value (willingness to pay more to fish) of the recreational fishery achieved target levels?
26. Have the aspirations of recreational fishermen, non-consumptive users, industries related to fishing, and the general public been met?
27. Have the major problems and issues identified in this report been resolved?
28. Have the intangible societal benefits been met?

Sustaining the Recreational Fisheries Development Plan

One of the aspects of the study was to examine mechanisms for long term funding which could be implemented to support recreational fisheries development initiatives. This is extremely important because the funds raised could be used as seed money to access other government departments for matching funds or work in-kind. Some recreational fisheries groups estimate that for every $10,000 they raise, this can generate in the vicinity of $40,000 of additional funds from other sources.

The 1990 Survey of Sports Fishing in Nova Scotia asked the anglers "How much more would you be willing to pay to fish?". A large percentage said they would be willing to pay $5 - $20 or more per day to fish. This suggests that the license fee or similar fee could be raised to provide further funds.

Fish Stamp

In a number of meetings the consultants attended there was overwhelming support for the concept of a recreational fish stamp similar to the duck stamp for hunters. This support was contingent on the revenue raised by the stamp being given to an umbrella non-government group to administer. The suggested cost of the stamp varied from $3 to $10.

In the Nova Scotia Survey, anglers were asked among other financial questions their current opinion of the price of a license; 2.9% said it was too low, 69.7% said it was appropriate and 25.7% said it was too high. Yet when the same anglers were asked a different question: "Would you be willing to pay more for a license?" - 58.3% said yes, 39.1% said no and 2.5% were undecided.

It appears that the majority of anglers would be willing to pay for a fish stamp. The projected income from a fish stamp is as follows :

Projected Revenues from Fish Stamp			
Licenses Issued	Cost of Stamp		
	$3	$5	$10
70,000	210,000	350,000	700,000
80,000	240,000	400,000	800,000
100,000	300,000	500,000	1,000,000

If each angler, whether licensed or not had to buy a fish stamp at a cost of $5 then there would be $500,000 raised as seed money to undertake recreational fisheries initiatives. If the fish stamp cost was $10, projected revenue for recreational fisheries projects would be $1,000,000 annually.

Trust Fund

A second idea to generate an ongoing source of funding was a trust fund where individuals and firms could make tax deductible contributions to the Recreational Fisheries Trust Fund. The income generated by the fund would be used each year for the development of the recreational fisheries and would be administered by the same group administering the recreational fish stamp. In spite of the many trust funds in existence and competition for these dollars the sport fishery has a large number of participants with wealth who could decide to make sizable donations to a charitable fund which would be used to improve their favorite sport. A large fund would be needed before there was a substantial source of interest revenue.

Trust funds that would allow for the issuance of tax deductible receipts would attract the attention of private and corporate sponsors of the plan especially if the donations were used directly for restoration and conservation purposes and some publicity were afforded to the donors.

Private Corporations

Private corporations such as pulp and paper or mining corporations have large holdings of land and are responsible for the development of road networks. If these were made accessible to the public for recreational fishing, allowances could be made for these companies to charge a user fee to offset the cost of maintaining these roads. This idea of an access "pass" or "permit" would be acceptable to many anglers if a portion of the funds collected were applied to the development of recreational fisheries and these corporations were involved with watershed groups in the management of fish and wildlife on their lands.

Another concept would be for a company to adopt a river and contribute tax deductible funds each year to the watershed group responsible for improving that watershed.

Sponsorship

Many companies would be willing to assist in specific projects if it would be of mutual benefit to the sponsor and the angling group. For example, if an event was hosted at a specific hotel or motel the participants would get a group rate plus a "free weekend" as a prize for a fund raising raffle, etc.. This approach has been successful in the sponsorship of fishing derbies in the tidal waters. An event similar to the Halifax Boston Whaler Sea Derby could be developed with company sponsors who have a commercial interest in the growth of the sport.

Habitat Restoration Fund

There is a need to establish a habitat restoration fund which would be administered by a nonprofit umbrella community group. The fund would accept money from different sources and use it to support community based restoration of fish habitats or stewardship programs to ensure the productivity of fish habitats.

This might be similar to Wildlife Habitat Canada or the Provincial Environment Funds. Funding could be partially from government, however, the majority would come from tax deductible donations, conservation stamps, compensation payments from industry for the inevitable habitat losses and court fines that ensue from their business activities. Compensation payments are sometimes offered to fish habitat managers by proponents who are willing to pay for inevitable habitat degradation caused by their project. In many cases they are unwilling or unable to undertake fish habitat restoration themselves. This leaves fishery managers in a tough position and approval is often given without a compensation agreement. A habitat fund would provide an arms' length solution for both groups. Funds would in most cases be targeted for specific stocks or watersheds and could be restricted to the implementation of a detailed restoration plan.

Court fines have been used for this type of work: however, changes in the Fisheries Act may be needed to enable government experts more authority in directing how fines should be used to ameliorate environmental damage. Since DFO cannot accept fines for this work it could go into a trust fund to implement restoration. Funding would be required to establish the legal framework to implement this approach.

Other Ideas

The sale of prints, stamps, raffles and dinners promoted by Ducks Unlimited, the Atlantic Salmon Federation and other wildlife groups have been very successful in the past and could be implemented by the aforementioned umbrella, community or watershed group.

A pilot project suggested by the consultants for watershed specific management on the Margaree River discussed some funding options which could be adapted to other rivers or lakes. A brief description of this approach follows.

I. The "sanctuary" on the Margaree River should remain closed for conservation reasons. However, the consultants proposed that a pilot project involving controlled angling (8 rods/day) be initiated in 1993 in a section of the sanctuary from the Big Interval Bridge upstream to the First Fork Brook, including the Old McKenzie Pool and the Breakwater Pool. This pilot project proposed that a specific number of fall run MSW salmon could be retained. This would provide valuable information on a new management regime and provide funds for River Specific Management. The proposal is outlined briefly and follows the format used for angling privileges in the ZECS in Quebec.

The sanctuary zone could be opened up for maybe 8 rods per day @ $50 per rod-day. The sale of these daily permits could proceed as follows :

a) Four rods per day could be allocated during a winter draw. Each person would complete a maximum of 25 entry forms @ $5/form. Successful candidates could take one additional angler along, but the person whose name was drawn would be required to go themselves or relinquish their right of pass;

b) A draw for the four remaining rods could be made each day, 48 hours in advance of the angling day. Each angler, would have only one entry form per day (@ $5) and those drawn would be required to buy their daily pass before 8 A.M. of the angling day or renege their privilege. At 8 A.M. each day, unclaimed daily passes from either the winter or summer draw would be made available through a simple draw.

c) All angled fall run MSW salmon would have to be taken to a registration station (i.e. Margaree Interpretive Centre) where appropriate biological data would be collected on the fish.

Fishing Season in the Sanctuary : September 1 - October 31. (61 days)

A. February Draw : (4 rods/day)
Restriction of 25 applications/person
Cost of each application = $5
Successful daily permits = $50/rod-day

# Applications/Person	# Potential Anglers	# rods/day	Revenue
2	500	6	5,000
5	500	6	12,500
10	300	6	15,000

i) Assume 2 applications x $5 x 500 anglers = $5,000 (Range 5000 - 15,000)

ii) At 4 rod-days x $50/rod-day x 61 days = $12,200

Total minimum revenue from February draw = $17, 200.

B. Summer Draws : (4 rod/days; drawn within 48 hours of fishing)
Restriction - 1 applicant per person @ $5
Assume potential number of anglers = 25
Successful daily permits = $50/rod-day

Summer Draw : 25 anglers x $5 x 61 days = $7,625

Successful permits : 4 rod/days x $50/rod-day x 61 days = $12,200

Total Revenue (Summer Draw) = $19,825.

C. Grand Total revenue from Sanctuary = $37,025.

II. The proposed Margaree Watershed Management Board could be issued with 500 stamps or tags by DFO for the catch and retention of fall run MSW fish (surplus to spawning requirements). These special stamps or tags would be available for purchase @ $50 each and each angler could only buy one. All angled MSW salmon would have to be taken to a registration station (e.g. Margaree Interpretive Centre) where appropriate biological data would be collected on the fish (same as per deer registration stations).

Revenue = 500 x $50 = $25,000.

III. Total revenue raised for river or watershed specific management = $62,025 annually.

OVERVIEW of RECREATIONAL FISHING AREAS and RECOMMENDATIONS

Fish Habitat Information

Fish habitat information such as the quantity, quality and distribution of freshwater fish habitat in RFA 1, 2, 3, 5 is available in a number of individual documents for streams and lakes published by DFO and NSDOF or prepared through consultant studies. However, depending on the watershed, much of the database is fragmented, outdated and only available in unpublished files in various government agencies. Some of this habitat information is found in Data or Technical Reports published by various authors by DFO from the mid 1920's to the present for the major salmon rivers (e.g Margaree, St. Mary's, Liscomb, East and West (Sheet Harbour), LaHave, etc.) and by NSDNR or NSDOF for specific trout streams and lakes in each RFA. Other sources of habitat data have been collected by NSDOF in "Resource Inventory - Lakes"; this series of data on lakes in each county are summarized in binder format by Recreational Fishing Area for each of the five (5) RFAs. Numerous other unpublished documents and studies are sources of habitat data among which are : Nova Scotia Atlantic Salmon Enhancement Plan (1981); Atlantic Salmon : Definition of the Problems and Solutions (1983); Economic Evaluation of Nova Scotia Atlantic Salmon Fisheries (1984); Acid Rain and the Atlantic Salmon in Atlantic Canada (1986); and Preliminary Recreational Fisheries Development Plan for the Annapolis River Basin (1989), and An Identification of Possible Causes for the Downturn of Salmon Stocks of the Inner Bay of Fundy (1989).

The current understanding of Nova Scotia lakes is derived from a variety of limnological and fisheries biological studies which have been conducted for different purposes over the past seventy-five years. Results of these studies are reported in a variety of sources such as primary publications, manuscript reports, data reports, theses, and consultant reports under topics as diverse as hydro-electric power development, urban subdivision design, and fish stock enhancement opportunities. Data in various electronic forms also exist in working files in the federal and provincial departments of Environment (including Parks Canada), and Fisheries. It would be useful to compile and maintain an electronic database of these materials within the Nova Scotia Department of Fisheries and the Department of

Fisheries and Oceans. This inventory would be particularly valuable prior to the expansion of current or new comprehensive lakes studies.

The most comprehensive compilation of physical data exists in the Nova Scotia Recreational Lakes survey (1988) database which is retained by the Nova Scotia Department of the Environment. The most comprehensive fisheries biology database is the report by Alexander, Kerekes and Sabean (1986) and the Nova Scotia Recreational Fisheries Lake Inventory which has been compiled by the Nova Scotia Department of Fisheries. The Bras d'Or Lakes, the largest quasi-inland surface water body in the province is only partially described in these databases but it is also described in a number of other reports and databases.

The Department of the Environment has just completed a comprehensive inventory of all surface waters in Canada, including Nova Scotia. This electronic inventory has been created with land satellite photographs. It is also compatible for use in Geographic Information Systems (G.I.S.). The same study group also compiled an ecological classification system for the entire province based on a variety of measured parameters. Although this work was originally conducted a decade ago, it is only becoming available for publication in 1993. The availability of this information presents an excellent opportunity to have a comprehensive surface waters database. This information combined with limnological and fisheries biological data would give a more comprehensive spatial and temporal database than what currently exists. It would be useful if the water chemistry data for these lakes were also maintained and readily available in the NAQUADAT system which is operated by the federal Department of the Environment. The system has stringent quality control procedures for collecting, analyzing and reporting values for numerous parameters. Until now the system has been limited to inventories of data collected in government managed programs. With the introduction of programs for handling "third party" and "private corporation" data as well as the possible conclusion of negotiations between NAQUADAT officials and the Nova Scotia Department of the Environment, the opportunity for managing lake waters data through NAQUADAT is possible.

An outline of key databases and summary reports of streams and rivers in Nova Scotia is provided in Table 32. A list of known obstructions, an inventory of fishways in Nova Scotia and a list of proposed fish passage, habitat improvement and development projects are provided in this report. Major rivers and streams in Nova Scotia are summarized in Appendix V.

Table 32. Key databases and summary reports of rivers and streams in Nova Scotia.

DATA INVENTORIES & SUMMARY REPORTS	AQUATIC and/or STREAM BED	DATA TYPE PHYSICAL	CHEMICAL	BIOLOGICAL
Historical Streamflow Summary. Atlantic Provinces. To 1990. Inland Waters Directorate Water Resources Branch, Water Survey of Canada, Ottawa, Canada 1991.	A	√		
Surface Water Data Reference Index. 1992. Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa.	A	√		
Historical Streamflow Summary. Atlantic Provinces. To 1988. Inland Waters Directorate. Water Resources Branch, Water Survey of Canada, Ottawa 1989.	A	√		
Stream Inventory Database - Peter Amiro, Catadromous & Anadromous Branch, Scotia Fundy Region, Department of Fisheries & Oceans, Halifax. Fine resolution based on data collected by remote sensing.	S	√		
Atlantic Canada Surface Waters Study. Environment Canada (To Be Released May 1993) Cited In: Helle, R.G., G.M. Wickwire and M. Sloh (draft March 1993). Qualitative Assessment of Surface Waters at Risk Due to Acidification In Eastern Canada. Economics and Conservation Branch, Ecosystem Sciences and Evaluation Directorate.	A S	√ √		
Canoe Routes of Nova Scotia. Canoe Nova Scotia Association, Camping Association of Nova Scotia. Numerous maps, descriptions of flow conditions and obstructions.	A S	√ √		
Canoe Waterways of Nova Scotia Map Series & Index. 1988. Compiled by George Masto Compiled by George Maston. Prepared by Canoe Nova Scotia, Nova Scotia Sport and Recreation Commission and Maritime Resource Management Service Inc.	A S	√ √		
NAQUADAT - National Water Quality Database. 1969-present day. Water Quality Branch Inland Waters Directorate, Environment Canada. (Atlantic Region - Moncton, N.B.)	A S	√ √	√ √	
List of Trout and Salmon Fishing Streams In Nova Scotia. Report No. B128. Dept. of Marine and Fisheries, Ottawa (Issued for the "exclusive use of Fishery Officers") 1929.	A S	√ √		√ √
Atlantic Salmon Management Zone Profiles. Compendium to: Strategies for the Long-Term Management of Atlantic Salmon. Report of the Special Federal/Provincial Atlantic Salmon Working Group. December 1988. Prepared by the federal and provincial representatives to the special Federal/Provincial Atlantic Salmon Working Group.	A S	√ √		√ √

Table 32 cont'd.

DATA INVENTORIES & SUMMARY REPORTS	AQUATIC and/or STREAM BED	DATA TYPE PHYSICAL	CHEMICAL	BIOLOGICAL
Stream Survey Inventory. At least 184 streams. Nova Scotia Department of Fisheries. Hard copy data sheets and Electronic Database. Some summarized in following reports.	A S	√ √	√ √	√ √
Miles, B. and D. Murrant. 1983. Report on Trout Stream Surveys: Richmond and Victoria counties, Nova Scotia. Manuscript and Technical Report Series No. 90-02. N.S. Department of Fisheries.	A S	√ √	√ √	√ √
Miles, B.L. 1984. Supplementary report on trout stream surveys: Cape Breton County, Nova Scotia. Manuscript and Technical Report Series No. 90-03. N.S. Department of Fisheries.	A S	√ √	√ √	√ √
Miles, B.L. 1984. Report on Trout Stream Surveys: Inverness County, Nova Scotia. Manuscript and Technical Report Series No. 90-04. N.S. Department of Fisheries.	A S	√ √	√ √	√ √
Miles, B.L. 1983. Report on Trout Stream Surveys: Cape Breton County, Nova Scotia. Manuscript and Technical Report Series No. 90-05. N.S. Department of Fisheries.	A S	√ √	√ √	√ √
Miles, B.L. 1983. Report on Trout Stream Surveys: Cape Breton, Richmond and Victoria counties. Manuscript and Technical Report Series No. 90-07. N.S. Department of Fisheries.	A S	√ √	√ √	√ √
Miles, B.L. 1983. Report on Trout Stream Surveys: Antigonish and Inverness counties, Nova Scotia. Manuscript and Technical Report Series No. 90-18. N.S. Department of Fisheries.	A S	√ √	√ √	√ √
Miles, B.L. 1983. Report on Trout Stream Surveys: Pictou County, Nova Scotia. Manuscript and Technical Report Series No. 90-01. N.S. Department of Fisheries.	A S	√ √	√ √	√ √
Miles, B. L. 1984. Supplementary report on trout stream surveys: Halifax County, Nova Scotia. Manuscript and Technical Report Series No. 90-14. N.S. Department of Fisheries.	A S	√ √	√ √	√ √

Table 32 cont'd.

DATA INVENTORIES & SUMMARY REPORTS	AQUATIC and/or STREAM BED	DATA TYPE PHYSICAL	CHEMICAL	BIOLOGICAL
Miles, B. L. 1983.	A	√	√	√
Supplementary report on trout stream surveys: Hants and Lunenburg counties, N. S.	S	√	√	√
Manuscript and Technical Report Series No. 90-06. N.S. Department of Fisheries.				
Miles, B. L. 1983.	A	√	√	√
Supplementary report on trout stream surveys: Kings County, Nova Scotia.	S	√	√	√
Manuscript and Technical Report Series No. 90-10. N.S. Department of Fisheries.				
Miles, B. L. 1984.	A	√	√	√
Supplementary report on trout stream surveys: Digby County, Nova Scotia.	S	√	√	√
Manuscript and Technical Report Series No. 90-08. N.S. Department of Fisheries.				
Habitat Alteration Referral System Database	A	√	√	√
Habitat Management Branch, Scotia Fundy Region, Dept. of Fisheries & Oceans.	S	√	√	√
Molluscan Shellfish Growing Waters Classification Index for Nova Scotia. (1992)	A	√	√	√
Third Edition. Prepared by Conservation and Protection Branch, Atlantic Region,	S	√	√	√
Environment Canada, Dartmouth, N.S.				
Wastewater Treatment and Disposal Database. 1993. N.S. Dept of the Environment.	A	√	√	√
For communities of more than 300 persons.	S	√	√	√

Table 32 cont'd.

DATA INVENTORIES & SUMMARY REPORTS	AQUATIC and/or STREAM BED	DATA TYPE		
		PHYSICAL	CHEMICAL	BIOLOGICAL
Indexes & Geo-Political References				
Nova Scotia Volume, Gazetteer of Canada, 1977	A	√		
	S	√		
Preliminary Watershed Report for Nova Scotia. Compiled 1970 by Maritime Resource Management Service. Prepared for the Nova Scotia Department of the Environment.	A	√		
	S	√		
Watershed Report for Nova Scotia. 1982. Prepared by Maritime Resource Management Service. Prepared for the Nova Scotia Department of the Environment.	A	√		
	S	√		
Watershed Maps, (Topographic Series) Maritime Resource Management Service.	A	√		
	S	√		
Aquatic Resource Planning, Comprehensive				
Hydrological Network Review; Nova Scotia. 1985. Jointly prepared by the Nova Scotia Department of the Environment and Environment Canada.	A	√		
	S	√		
Maritime Provinces Water Resources Study. Stage 1. Volume 4; Nova Scotia. Books 2, 3 and 4. Prepared for the Atlantic Development Board by Montreal Engineering Comp. Ltd January 1969. Numerous maps and tables.	A	√	√	√
	S	√	√	√
Aquatic and Land Use Planning, Comprehensive				
Summary of Nova Scotia Rivers as Candidates for the Canadian Heritage Rivers Program Nova Scotia Department of Lands and Forests	A	√	√	√
	S	√	√	√
Watershed Specific Databases				
Annapolis River and Estuary				
Water Quality and Quantity in the Shubenacadie Headwaters				

Water Quality, Quantity and Pollution Sources

A number of key aspects and activities concerning the management of the water resources in Nova Scotia are illustrated in Figure 13. Much of the information in this section of the report has been summarized from the Resource Atlas of Nova Scotia, Halifax (1986); Environmental Quality in the Atlantic Region (1985); Nova Scotia Department of the Environment Submission to the Royal Commission on Forestry (1989); Historical Streamflow Summary, Atlantic Provinces, Inland Water Directorate, Water Survey of Canada, Environment Canada (1989, 1991); Maritime Provinces Water Resources Study - Montreal Engineering Co. Ltd. (1989). Reference to these key documents and others provided in Table 32 will provide more detailed information on the quality and quantity of water resources throughout the province.

Clean water is a necessity for almost every type of human activity. Ensuring the continued quality and quantity of freshwater resources for consumption, fisheries and industrial usage must be a primary objective of any government. Problems frequently develop when competing interests for water usage (e.g. hydro vs. fish; forestry vs. fish; agriculture vs. fish or other industrial users vs. healthy aquatic ecosystems/fish) are in conflict and governments are called upon to make decisions.

Often the options are not based on Integrated Resource Planning and are one-sided or single minded requests, without appropriate comprehensive studies of potential impacts on other users, when presented to government for "quick" decisions. Immediate job creation, income and economic impact are often the yardsticks used for decisions and since the recreational fishery has been under-valued in the minds of the public and the government in the past, healthy aquatic ecosystems and the fisheries resource has often been left "empty handed" at decision time. For this reason, it is incumbent on the part of community/watershed groups to become organized as a provincial lobby to educate the general public and legislators of the importance and compatibility of clean water for consumption and healthy aquatic ecosystems for fish. By aligning all appropriate water users whose objectives are to protect the quality and quantity of water available in Nova Scotia, and by educating the public and legislators regarding the economic and recreational value of the fisheries resource, and the long-term health of residents who consume the water, governments would have "facts" and "political support" to protect water resources in the province. In Nova Scotia, this responsibility is vested in the Department of the Environment under the authority of the Environmental Protection Act, the Water Act, the Well Drilling Act as well as various sections of the Federal Fisheries Act.

The province is traversed by a multitude of water courses of all sizes which provide drainage from the interior to the sea. In all, forty-six primary drainage areas have been identified for management and monitoring purposes. These, in turn, have been sub-divided into numerous secondary and tertiary areas. Only the major river systems are shown (Figure 13).

Monitoring sites

Both surface and groundwater resources are closely monitored. In the case of surface water, stream flow data have been collected in Nova Scotia, under cooperative Federal-Provincial agreements, since 1915. Information has been collected from over 100 sites, 53 of which are now in use for streamflow water quantity analyses. Of these, 20 are also used for quality sampling and 3 for sediment sampling. Records for these sites are maintained by the Inland Waters Directorate of Environment Canada.

Groundwater levels have been recorded at the locations shown (Figure 13), since as early as 1965, to establish normal and extreme ranges of fluctuation. These sites are also used to monitor water quality and influences such as surface water, precipitation, and tidal effects.

Groundwater Regions

The delineation of groundwater regions is dictated by the bedrock in which lie the aquifers, or water bearing zones. Knowledge of the bedrock is important for understanding potential pumping rates, water quality, and the monitoring and control of pollutants. Although geological maps can provide general indications of the groundwater resource in a region, specific site examinations are essential in order to obtain detailed information for any given location.

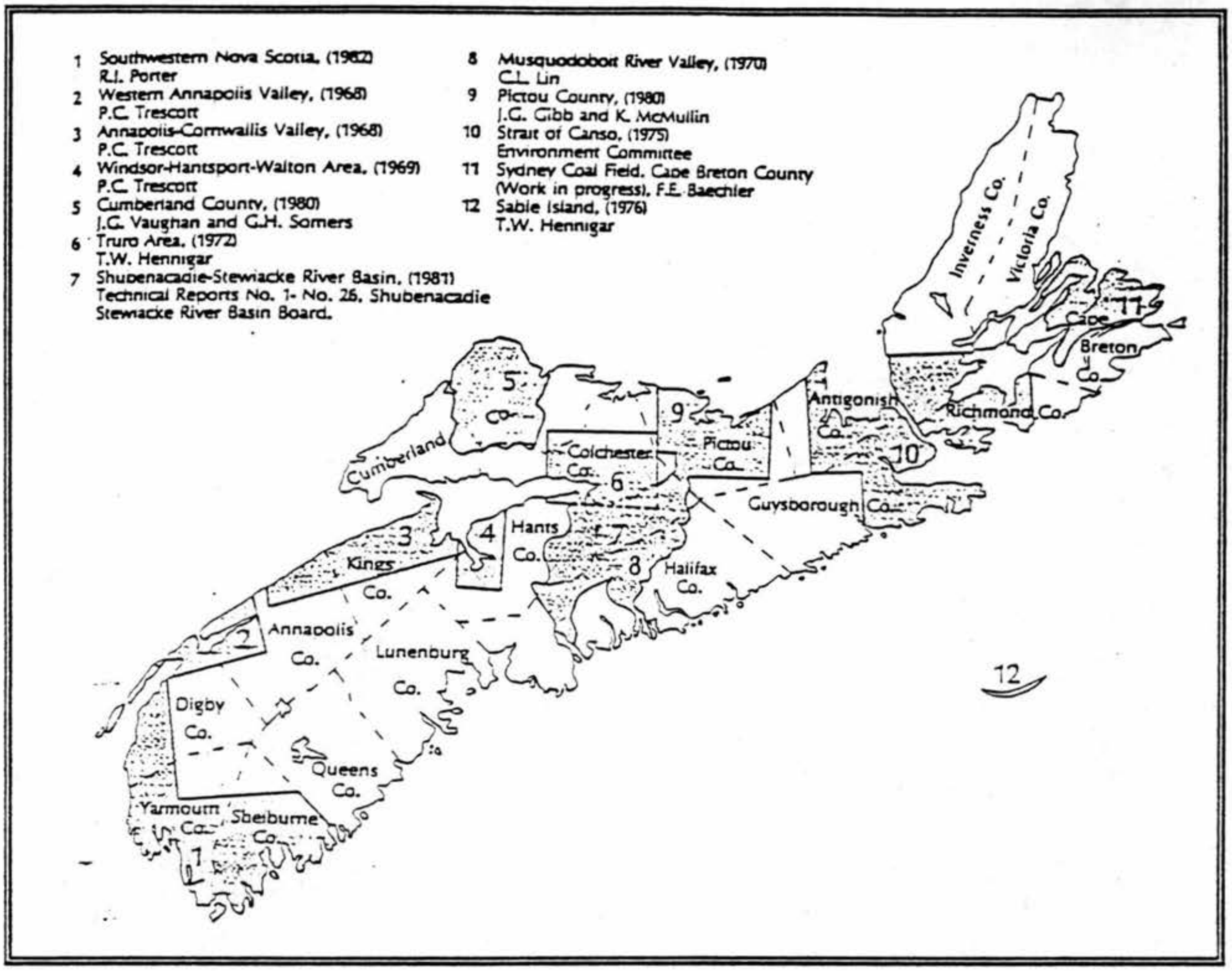
Water Resource Evaluations

As has been indicated, the monitoring of Nova Scotia's water resources is an ongoing process. To date, regional water resource evaluations have been completed for the twelve evaluation areas shown in Figure 14. The areas were chosen for analysis because of their particular demands and peculiarities and qualitative study of both their surface and groundwater resources.

Community Water Supply Systems

Although the scale does not permit every central water supply system in the province to be shown in Figure 13, there are presently 79 in operation. The water quality of these systems is monitored regularly, and is required to meet standards set by the Nova Scotia Department of Health.

Figure 14. Regional water resource evaluation areas. (From Eaton, Hildebrand and d'Entremont (1986))



Twenty of these central systems rely, at least partially, on groundwater as their source of supply. Surface water provides the remainder with their requirements, while residents outside the areas served by such systems depend, for the most part on individual drilled wells for their water supply.

Lakes and rivers used by municipalities or industries as water supplies, including all or part of their watersheds, may be designated as Protected Water Supply Areas. The designation order may be used in addition to municipal zoning by-laws, or land acquisition and control by the owner of the water works, as a means of protecting the source of the water supply. Any activities which might impair the quality of water in an area which has been so designated may be prohibited or regulated.

Regulations in force in the designated watersheds marked in Figure 13 can vary greatly. They range from direct prohibition of recreational use of the area waters for purposes like swimming, fishing, boating and snowmobiling, to control of industrial activities such as forestry and mining operations on lands within the watershed.

Issues Related to Water Quality and Quantity

In the last two decades there has been concern across eastern North America about evidence of increasing acidity in many natural bodies of water. Information from a variety of sources has been used to compile the lines (isopleths) in Figure 13 which indicate the acidity of Nova Scotian Lakes.

Acidity is expressed in terms of pH. A pH reading of 7.0 represents a neutral state, neither acid nor alkaline, while lower numbers indicate greater acidity. Thus it can be seen that the most acidic waters in Nova Scotia are found in the southwestern interior, where pH levels as low as 4.5 are reported. In contrast, the lakes on the north-central region were found to be at or near the neutral point.

Although data were sparse for several parts of the province, the outline of isopleths indicate that regional variations in pH do bear some resemblance to the borders of calcareous/non-calcareous (limestone/non-limestone) bedrock zones. The most acidic waters were found in areas where granites and quartzite's are widespread. These rocks are resistant to weathering and release dissolved minerals very slowly. Humified (decomposed) organic materials such as peat moss can also contribute to acid conditions. However, there is evidence of recent acidification in some rural lakes that are not known to be influenced by sources of natural acidity. In this regard, it has been noted that the atmospheric deposition of acids - the so-called "acid rain" phenomenon - is most intense in southwestern Nova Scotia.

The data on streamflow are too comprehensive for inclusion in this report but are summarized in Historical Streamflow Summary, Atlantic Provinces (1989, 1991). Although the consultants were not requested to analyze historical daily discharge data, it is generally acknowledged that stream discharge patterns in the province in terms of timing and retention have changed over the past several decades.

A variety of factors may be influencing these changes in discharge patterns among which may be climatic changes, forestry, agricultural, urban development, hydro development and other land/water use practices. These impacts have generally resulted in lower lake levels, reduced discharge and channel wetted parameters, warmer water and reduced fish production capacities in many watersheds. The options to reverse these impacts are complex and costly but should be addressed on a priority basis by all government agencies responsible for water use through the Sustainable Development Strategy and Integrated Resource Planning and Management. **All private water users and the aforementioned**

government agencies have a responsibility to provide programs and resources to study and resolve water resource problems which negatively impact on the quantity and quality of water available in the province for human consumption and the production of aquatic resources including the fisheries resource.

The inland water resources of Nova Scotia support fish and wildlife, and supply water for drinking, agriculture, industry, power generation and aesthetic enjoyment. Most of the public water supplies in Nova Scotia are considered to be of acceptable quality in terms of public health and aesthetics, but some other water uses are suffering from varying degrees of degradation.

Many of the popular sport fish populations have been declining over the past several decades, among other factors, due to decreased water quality and quantity as well as habitat disruption. Heavy inputs of sediment, and excessive nutrients and bacteria, compounded by the insidious effects of acid rain and certain toxic chemicals, have resulted in reduced oxygen levels in certain water bodies, producing reductions in productivity and occasional fish kills.

Improvements have been achieved through concerted efforts from federal, provincial, and international agencies concerned with pollution control, and through the improved compliance of industries and municipalities with effluent quality regulations. Similarly, some advancements are now being made in controlling erosion and siltation of streams and lakes by reducing land disruption in forestry and construction activities, by encouraging the use of vegetated buffer strips around the borders of water bodies, and by the use of proper techniques in agriculture which were outlined in an earlier section of this report.

Groundwater contamination has only recently been recognized as a serious threat in Nova Scotia, as increasing numbers of cases of contamination from bacteria, salt, nitrates, pesticides and petroleum products are being found. Materials disposed of, or spilled on or in the ground, are showing up increasingly in groundwater. It is expected that, in the future, more evidence of contamination will be found.

The coastal marine environment is heavily affected by human activities - it is also one of the most sensitive areas. Although Atlantic coastal waters are generally uncontaminated, Nova Scotia does have some areas where the levels of contaminants are high, where biota are at risk, and where implications to the fishery and human health are uncertain. Since most of the population of Nova Scotia lives on or near the coast and much of the industry is located there as well, the majority of problems occur along the shoreline, in estuaries and in shallow water as the result of either industrial or municipal pollution, or runoff from the land. Although continuous improvements are being made in the quality of the effluents from many of the major coastal industries, similar progress has not been realized with municipal sewage and non-point source pollution. This is reflected in the growing number of shellfish areas closed to harvesting each year. Past abuses continue to create problems in the form of highly contaminated sediments which have led to lobster fishing closures (e.g. Sydney, N.S.).

As pointed out, freshwater is a vital requirement for agriculture, industry, power generation, recreational activity, drinking and aesthetic enjoyment. In order to protect the various uses of surface water, the federal and provincial governments have established water quality objectives. Water quality is measured through regular monitoring programs which determine if the parameters of concern meet or exceed these objectives. In general, where a parameter exceeds its objectives, there is a threat to one or more of the uses of the water. For example, in the case of contact recreation, a high bacteria count may mean that an area should be posted as closed to swimming. In the case of freshwater aquatic life, low dissolved oxygen or high metal levels may mean the death of a proportion of the fish population, or the occurrence of a chronic effect, depending on the specific objective and the amount by which it is exceeded.

Although no overall assessment of the quality of freshwater resources in Nova Scotia is possible at this time, data from some of the more intensively monitored water bodies provide some evidence of the state of the resource. Table 33 outlines the various uses of surface water in the region and how the quality of water is judged.

An abundant supply of freshwater is a basic requirement in all major industrial and agricultural activities. Such requirements include fish and food processing plants, pulp mills and steel plants, and water for irrigation and livestock watering. The most important criteria is sufficient supply, although the quality of the water is important in some instances (e.g. fish and food processing, irrigation, and drinking water for livestock).

Most of these water supply demands are met by systems separate from domestic water supply systems. Most of the pulp and paper and fish plants have their own water supply systems, as do many of the major food processing industries. Although freshwater is generally abundant and most needs are met, it is not always abundant where it is most desired and some problems do occur with respect to quality.

Sport fishing is one of the most popular wilderness recreational activities in Atlantic Canada, and is a strong attraction for many tourists. Two of Nova Scotia's most important fish, the Atlantic salmon and speckled trout, are dependent on good water quality. The recreational fishery can be considered to be good when there is an adequate quantity of desirable fish that are safe to eat. Obviously should salmon and trout be replaced by less popular sport fish, or their numbers become greatly reduced, it can be said that the quality of the recreational fishery has been degraded. The same is true if the levels of contaminants accumulated in the fish preclude their consumption, or impact negatively on their survival.

Table 33. Assessment of surface freshwater quality in the Atlantic Region. (From Eaton, Hildebrand and d'Entremont (1986))

Assessment of Surface Freshwater Quality in the Atlantic Region

Beneficial Uses	Definition of "Good" Quality	Measure of Quality	Status
Domestic Supply	Potability.	Guidelines for Canadian Drinking Water Quality (1978).	Most of the public water supplies meet the "Acceptable"* Limits most of the time. Some fail to do so on an unacceptably regular basis. Very few achieve the "Objective"** Limits.
Industrial and Agricultural Supply	Sufficient quantity in all cases. Sufficient quality for irrigation and livestock watering.	Site specific needs for quantity. Federal/provincial objectives for quality.	Generally adequate supply. Only a few cases of shortages. Insufficient data to assess quality.
Sport and Commercial Fishing	Water of sufficient quality and quantity to ensure adequate fish populations that are safe to eat.	Catch statistics (Effort vs Catch). Species compositions of catches. Concentrations of contaminants in edible tissue.	No quantitative assessment available. Salmon and trout populations appear to have been declining over the last 25 years. Tissue levels rarely exceed acceptable levels.
Recreation	Waters that are safe and attractive for use in swimming, boating or water contact sports. Relate mostly with health hazards but also to aesthetics and nuisance conditions.	Guidelines for Canadian Recreational Water Quality (1983).	No quantitative assessment available.
Aesthetics	Clean or healthy water as perceived by someone sitting on the bank or floating in a boat.	Subjective — Presence of materials that will settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odour, taste or turbidity; or leading to the growth of undesirable aquatic life.	No quantitative assessment available.

*Drinking water that contains substances in concentrations greater than these limits is either capable of producing deleterious health effects or is aesthetically objectionable.
**This level is interpreted as the ultimate quality goal for both health and aesthetic purposes.

The continued health of fishery resources depends on the quality and quantity of fish habitat. Habitat includes not only the freshwater fish live in, but also the surrounding physical, chemical and biological conditions that interact to make life possible. There are many activities which impact negatively on fish and fish habitat. As a result, over the past 25 years or so, many of the "desirable" species of fish which are particularly susceptible to the adverse effects of habitat disruption, have been declining, both in abundance and species composition. Mining effluents, pesticides, pulp mill and food processing plant effluents, municipal discharges, siltation, agricultural runoff, obstructions to fish passage, and acid rain have all negatively impacted on fish habitat. These disruptions result in the physical loss of fish habitat or restriction of fish movements; also chemical pollution by toxic metals and organics have lowered pH and dissolved oxygen levels. Contaminants such as lead, zinc, copper, pesticides and oil are also lethal to fish in very small quantities. These problems have all contributed to the aforementioned declines and changes in fish populations; however, poaching and overfishing has also had a negative impact.

The occurrence of arsenic and mercury in fish found in waters close to former gold mining areas in Waverley and Montague, N.S., just outside of Halifax, has been documented. The muscle tissue of many of these fish (white perch and white suckers) contained levels of mercury which made them unsuitable for human consumption (0.5 mg/kg wet wt.). Human health is probably not threatened in this particular situation, because these fish are not popular gamefish and are unlikely to be consumed in large quantities.

Salmon and trout require water with at least 5 mg/l of dissolved oxygen. In the last 10 years, improvements have been made to severely oxygen depleted rivers, particularly those affected by pulp mills and municipal sewage. The regulation of river flows for hydroelectric power generation increases water temperature and reduces base flows during warm weather periods. With regard to physical obstructions, considerable efforts have been made in the past decade toward the installation of fishways around hydroelectric developments, however, low flow conditions represent a threat to recreational species of fish. Such conditions have repeatedly precipitated closures of the inland sport fishery.

A less tangible benefit to be derived from surface waters is that gained by simply observing "clean, healthy" waters. This is obviously a very subjective measure of quality, but provides a real benefit to the individual. Generally, aesthetic quality can be considered to be impaired by : the presence of materials that settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odor, taste or turbidity, or leading to the growth of undesirable aquatic life. There is no quantitative assessment of the degree of aesthetic impairment of surface waters in Nova Scotia at this time.

Siltation

Siltation is a common problem in all four Atlantic Provinces, although the major causes are different in each case. Logging, mining, agriculture, road building and general construction are principal sources of siltation problems. Current farming practices are a major contributor to siltation problems. Larger field areas with fewer protective hedgerows provide less resistance' to wind erosion. It is also common practice to plough in the fall, which exposes the soil to even more erosion by wind and water during winter and spring. In the absence of green belts or other protective measures, as much as 25% to 40% of the soil that runs off a field reaches a water body. Various agricultural practices which can reduce siltation have been discussed elsewhere in this report.

Highway upgrading and road construction are important causes of siltation in Nova Scotia. The main concerns are associated with culverts and bridge crossings. When a highway is built with excessive bank cutting or with steep grades and is not properly drained or protected with silt traps or diversion ditches, a heavy rain can cause washouts and result in extreme siltation of nearby streams or lakes. In Nova Scotia, construction standards for stream crossings and siltation control have been developed, and a manual on erosion and sediment control which describes proper mitigative measures has been developed.

Careless logging operations represent a major source of siltation in Nova Scotia. Access roads, skidder trails and stream crossings are the major sources of sediment from forestry operations. Road crossings and fords may constitute a continuing source of sediment, as culverts wash out, and ditches empty their load of sediment into streams after each rainfall. Forestry-caused siltation is a significant concern because it is so widespread, and thus has the potential to affect large areas of fish habitat.

In response to these concerns, environmental standards for forest road construction were recently established in Nova Scotia and follow-up site monitoring is more commonly being made to ensure adherence to the guidelines and standards developed for the industry.

Siltation resulting from mining and construction is of less importance regionally, although sedimentation rates from individual operations can be significant and the localized impacts on water quality may be severe. Erosion rates from individual construction sites are typically 10 to 20 times that of agricultural lands, and runoff rates can be as high as 100 times greater.

Local flooding, erosion and siltation have been common problems associated with land development around large urban centres. For example, a major residential development in Dartmouth, N.S., resulted in heavy loadings of sediment to Cranberry Lake, where the sediment traps were inadequate and poorly maintained. In March 1982, in an effort to overcome these problems, the province of Nova Scotia and the municipality of Halifax prepared a design criteria manual for the construction of drainage systems to control runoff. This was done for the purpose of preserving and restoring those portions of the urban streams within its jurisdiction as productive aquatic ecosystems, instead of merely storm water ditches.

Salmon and trout are probably the greatest victims of siltation, as they required clean, silt-free gravel in which to spawn. Sedimentation of the interstitial spaces in the gravel reduces the flow of water through the redds thus preventing the flow of oxygen to salmon or trout eggs. The result of stream siltation results in higher mortality during incubation and hatching but also smothers and eliminates aquatic invertebrates, such as insect larvae, which are an important food source for salmonids.

Significant efforts have been made recently by the aforementioned proponents toward the reversal of damaging trends. However, more needs to be done e.g. adoption of environmental guidelines for the construction of forest access roads, the establishment of vegetated buffer strips along streams throughout Nova Scotia, improvement in agricultural practices as described in this report and continued improvements to highway construction and urban development practices would greatly reduce the siltation problem.

Nutrients and Bacteria

Agriculture runoff, municipal sewage, industrial outfalls and urban runoff all contribute excess nutrients and bacteria to freshwater systems in the Atlantic region. The two nutrients of most concern are phosphates and nitrates which, in excess quantities, can lead to impairments of recreational activities, affect the potability of water, and in particular lower the dissolved oxygen content necessary for aquatic life. The effects of fecal bacteria and pathogenic microorganisms, on the other hand relate to human health. This can lead to eutrophication, particularly in freshwater lakes and streams with low flows. Although poorly quantified, problems of eutrophication in Nova Scotia freshwater systems are by far the exception rather than the rule.

With regard to the disposal of sewage in water systems, Atlantic Canada lags behind much of the country in the development of treatment facilities. While many small communities have sewage treatment systems, many larger centres, including Halifax, Dartmouth and Sydney do not.

Other Surface Water Quality Issues

Acid rain and toxic chemicals are two other factors which significantly affect the quality of surface waters in Nova Scotia.

Aquatic environments in parts of Nova Scotia have been altered due to acidic deposition. The pH of nine river systems in Nova Scotia has declined since 1955, to the point where Atlantic salmon cannot reproduce successfully. Salmon populations in twenty-two other Nova Scotian rivers are seriously threatened. In a study of 42 rivers in Nova Scotia, 13 had a pH less than 4.7, 13 had a pH in the range of 4.7 to 5.0 and only 16 had a pH higher than 5.0. Continuous sampling of the Medway River, in southwestern Nova Scotia, has indicated a statistically significant reduction in pH over the past 30 years (Figure 15).

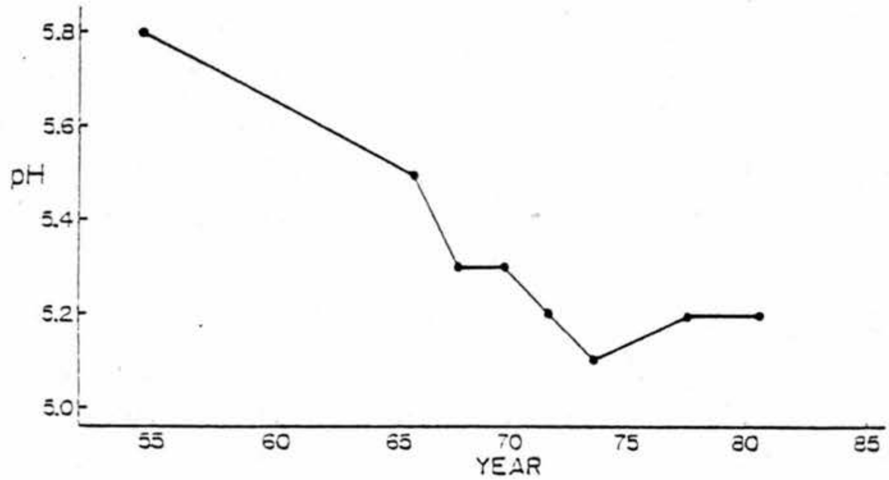


Figure 15. pH decline in the Medway River, Nova Scotia (1955 - 1980) (From Eaton, Hildebrand and d'Entremont (1986)).

An estimated 47% of Nova Scotia lakes, are highly sensitive to acid rain and are likely being affected by current pH levels. Lakes located close to Halifax have deteriorated noticeably, some with a pH dropping below 5.0. There is also emerging evidence that other lakes in Nova Scotia are being acidified, but the degree of acidification is difficult to determine due to the lack of accurate historical pH data. Small declines in summer pH over historical values were, however, noted for 4 out of 7 lakes sampled in Nova Scotia in 1980 - 1981.

It is difficult to determine the effect of acid rain on aquatic life, especially in relation to other stresses such as over-fishing, physical alteration of habitat and the discharge of other contaminants. Deleterious effects appear to occur in fish at a pH below 5.0; below pH 4.5 most fish populations are wiped out. In an ongoing study at Kejimkujik National Park, only yellow perch and American eel were present in lakes with a pH below 4.6. In a study of salmon angling statistics for 22 Nova Scotian rivers, salmon populations virtually disappeared from rivers with a pH less than 5.0.

Increased acidity can alter phytoplankton populations which serve as food for fish or their prey. Low pH acts on fish by altering their salt balance, and by inhibiting spawning, embryonic development and hatching success. In addition, early life stages tend to be more sensitive to acidification than adults. Fish kills have been reported in Europe and North America, particularly when elevated spring runoff from melting snow has caused a ten-fold increase in stream acidity within a 2 to 3 week period.

Acidic waters also mobilizes or dissolves metals from sediments into the water column, thus increasing the concentration of metals that fish are exposed to. This exposure can affect fish in two ways - through the direct toxic action of metals such as aluminum, and through the accumulation of other metals (such as mercury and cadmium) in their tissues. In addition, low pH influences the chemical form of some metals. For example, low pH enhances the process by which the highly toxic methyl mercury is formed from inorganic mercury. Studies have indicated elevated mercury levels in fish from poorly buffered lakes and streams in Quebec, New Brunswick, Minnesota, New York and Maine.

Some of the most important impacts of acid rain are felt in freshwater aquatic systems. Important among the impacts are a lowering of the pH of some poorly buffered waters, loss of effective reproduction in certain fish populations, mobilization of potentially toxic metals and alteration in plant abundance and composition.

Toxic Chemicals of Concern

The chemicals discussed in this section have been identified as being of particular concern in Nova Scotia. Although they are distributed in air, water, sediments and biota throughout the region, they are primarily of concern in specific locations where elevated levels and adverse impacts have been noted. These chemicals have been more closely investigated than others in the region, although much still remains to be learned about their potential environmental impacts. These chemicals, organic and inorganic, originate from both natural and man-made sources, within and outside of the region. The concern over their presence in freshwater stems from the fact that they tend to be widely dispersed, may be highly persistent, may be accumulated in biological tissues, and cause biological change, even in trace concentrations.

Mercury

Mercury is an ubiquitous, silver-white, liquid metal which is widely recognized as one of the most toxic environmental pollutants occurring in the environment. Mercury fulfills no known biological function, and its presence at even slightly elevated levels is not tolerated by most biota. High mercury levels have been recorded in waters of the LaHave River estuary (0.05 - 0.38 μg/g), in sediments from Eddy Point (4.6 μg/g) and Halifax Harbour (10.3 μg/g) and in eels (0.02 - 3.5 μg/g) and striped bass (0.77 μg/g) in the Shubenacadie River in Nova Scotia.

Some microorganisms in aquatic bottom sediments are able to convert inorganic mercury to the highly toxic methyl mercury, which is accumulated in fish and humans.

Sources of mercury contamination in the Atlantic region include : geological release; long range atmospheric transportation and deposition; municipal sewage; paint application; fluorescent tube breakage and industrial point sources including chlor-alkali plants, smelters, fertilizer plants, pulp mills, coal mining and washing operations and coal-fired power stations. In 1978, the chlor-alkali plants at Pt. Abercrombie, N.S., discharged the largest quantities of mercury in the region, although mercury emissions had declined by 75% in 1985. Increased coal combustion for the generation of electricity has made thermal power plants the largest anthropogenic source of mercury emissions in the region (approximately 1,000 kg per year). Municipal sewage has been estimated to contribute 19% of all mercury loadings to coastal waters.

Other pockets of mercury contamination have been identified in Nova Scotia. The Shubenacadie and LaHave rivers have elevated mercury concentrations in the water column. Fish from these and several other rivers exceed the 0.5 μg/g Health and Welfare Canada guideline for mercury (Figure 16). For example, average mercury concentrations (in muscle tissue) for older striped bass caught in the Annapolis River and younger striped bass caught from the Shubenacadie River were 0.77 μg/g and 0.51 μg/g, respectively. These elevated mercury levels are likely to be the result of low-level geological release. Acidic waters which are common in parts of Nova Scotia can mobilize mercury from sediments, thereby increasing its availability and concentration in water.

Mercury levels in most swordfish caught off Nova Scotia exceed the 0.5 μg/g Health and Welfare Canada guideline. As a result, swordfish was banned for sale for human consumption in 1971, but upon re-evaluation in 1979, the ban was lifted.

Cadmium

Cadmium is a soft, silvery white metal which occurs naturally in the earth's crust and can act as a cumulative and highly toxic chemical. Cadmium is used in the electroplating industry, and in the manufacture of long-life batteries, television picture tubes, super phosphate fertilizers, paint pigments, poly-vinyl plastics, ceramics and motor oil. Sources of cadmium contamination in Nova Scotia include the Surrette Battery plant near Springhill, N.S., base metal mines, electroplating operations and thermal power plants.

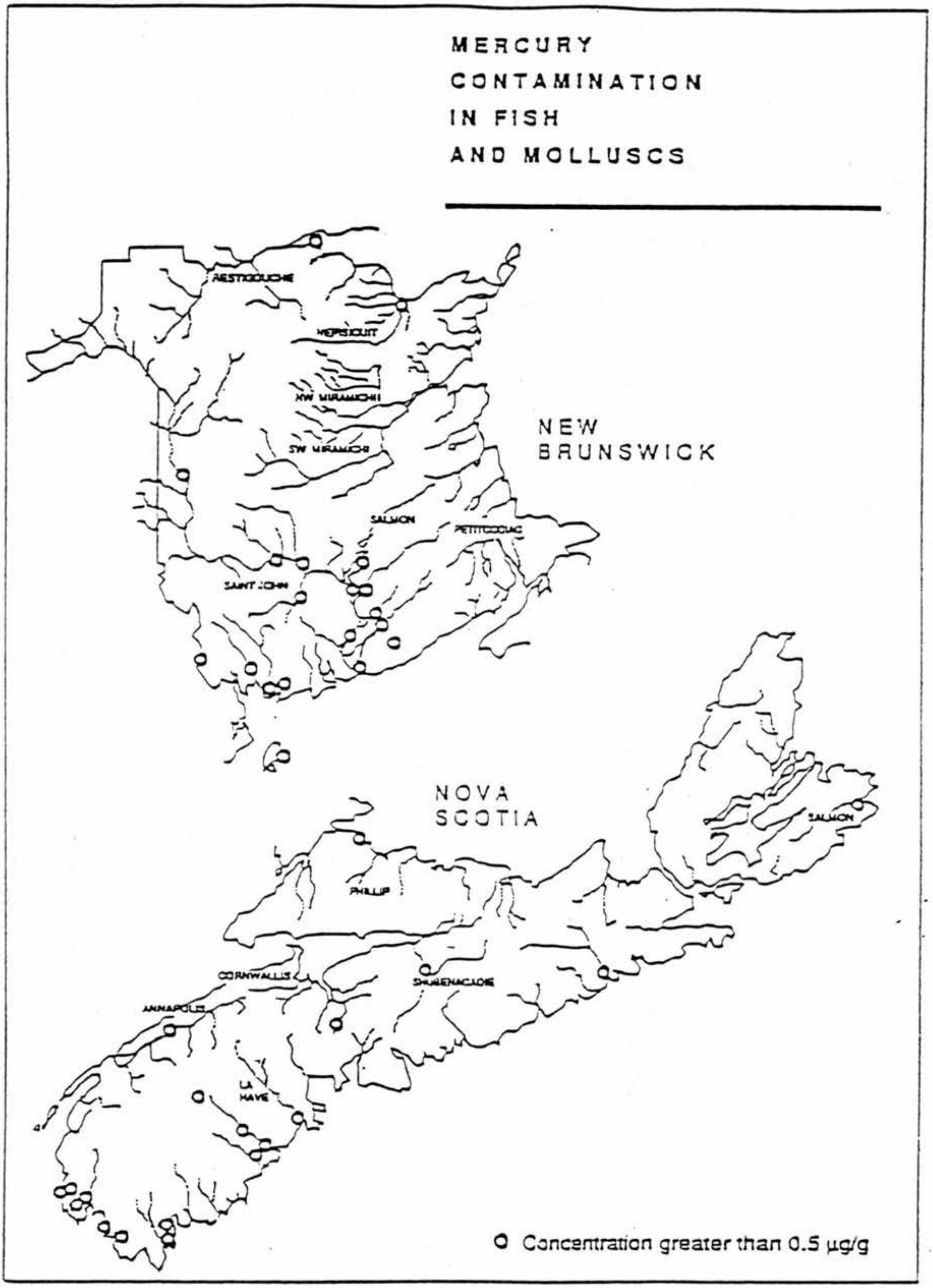


Figure 16. Mercury contamination of fish and molluscs in New Brunswick and Nova Scotia. (From Eaton, Hildebrand and d'Entremont (1986))

Background levels of cadmium in soils in the Atlantic region range from 0.012 to 0.470 µg/g. Background levels of cadmium are 1 to 2 µg/g in freshwater sediments and below 0.5 µg/g in marine sediments. Several harbours in the region have sediment values above the Ocean Dumping Control Act Limit of 0.6 µg/g; these include Halifax and Canso, Nova Scotia. Elevated levels have been found in air near the Surrette Battery plant (0.023 $\mu g/m^{3}$) at Springhill, in water at the Sydney Mines pond (1 - 14 µg/l), and in the water supply to Sherbrooke (20 µg/l), in sediments in Salmon River, Cape Breton (0.9 - 32.0 µg/g), and in lobster in Pictou Harbour (3.7 - 79.1 µg/g).

Cadmium acts as a cumulative poison due to its long persistence in the environment, although there is little evidence that cadmium is biomagnified in the food chain. While cadmium is highly toxic to some plants, other edible plants can concentrate cadmium without obvious signs of damage, consequently posing a threat to human health. Cadmium in the aquatic environment at concentrations less than 0.05 µg/l can accumulate in tissues of seaweeds, crustaceans, polychaete worms and molluscs. In general, cadmium is more bioavailable in freshwater, as it is strongly associated with chloride ions in saltwater.

Documented effects of cadmium on fish and aquatic invertebrates include gill damage, behavioral changes, altered respiratory rates, internal organ damage, reproductive impairment and direct mortality. Concentrations of cadmium in the water column as low as 8 - 10 µg/l have been lethal to fish, while concentrations as low as 0.001 µg/g in sediment have been observed to have chronic sub-lethal effects on the common brook trout. In general, although pockets of contamination occur in the Atlantic region, ambient concentrations are of the magnitude where widespread lethal or sub-lethal effects are unlikely.

Lead

Lead is a soft, bluish grey metal which occurs naturally in the terrestrial and aquatic environment. Lead serves no beneficial biological functions and is one of the few metals considered to be a contaminant in the open ocean. Excellent pliability and corrosion resistance have made lead one of the most useful non-ferrous materials available. Lead is used as a gasoline anti-knock additive, and is also used in water pipes, storage batteries, solder, bearings, pesticides, paints, glass, ceramics, enamel coatings, radiation shielding, printing type and in various alloys.

Anthropogenic sources of lead in Nova Scotia include : the Surrette Battery near Springhill, N.S.; urban runoff; sewage sludges, and dredging which increases the availability of lead which was previously immobilized in sediment. Seepage from base metal mines is also a major source of lead, and concentrations should not exceed the 0.2 μg/l guideline under the Fisheries Act.

Lead has been demonstrated to accumulate in most biota. Plants can absorb airborne lead deposited on leaves or can absorb lead from soils. Aquatic microorganisms can also accumulate lead from water, and fish can absorb lead through their body surface or from food they consume. Benthic organisms, especially mussels, are strong accumulators of lead from water and sediment. Lead can also accumulate in humans, in fact the average daily intake of lead from food in Canada is only 2 - 3 times below levels which would result in unacceptable lead accumulations.

Lead poisoning in humans can result in learning difficulties, fatigue, impaired reproduction, and in severe cases, brain damage and death. Exposure to airborne lead from vehicle exhausts is an important health concern, although monitoring at 11 stations in the Atlantic region has shown a decline in annual average lead levels between 1974 and 1983. The ingestion of lead from paint chips and urban dusts has led to elevated blood-lead levels in children from both large and small cities. Lead in street dusts has not been extensively monitored in Nova Scotia, but due to the increased use of unleaded gasoline, concentrations in dusts have likely decreased.

Arsenic

Arsenic is a semi-metallic element which can be found at low levels in air, water, soil and living organisms. High natural levels occur near deposits of minerals such as gold, pyrite and slate. Activities such as gold mining, quarrying and construction have distributed rock formations, thus increasing the availability of arsenic, resulting in elevated concentrations in soils and watercourses. Plants growing in tailings areas at abandoned gold mines in Nova Scotia had arsenic concentrations at least one order of magnitude higher than similar plants collected away from the tailings areas (up to 834 μg/g dry/wt.).

Other anthropogenic sources of arsenic contamination in the Atlantic region include the industrial smelting of zinc and lead ores, the combustion of fossil fuels, and the agricultural use of arsenical herbicides, pesticides and defoliants.

Arsenic contamination of groundwater is a major problem in Nova Scotia. The basis of the problem lies with naturally high arsenic concentrations in underlying bedrock, particularly in Halifax and Guysborough counties. Wells having arsenic concentrations above the 0.05 mg/l Health and Welfare Canada guideline for drinking water quality have been discovered in the Waverly and Eastern Shore areas of Nova Scotia. Arsenic contamination has often been inadvertently increased by using arsenic contaminated rock to line dug wells. High arsenic concentrations have also been measured in sediments of 7 lakes in the Waverley area (up to 804 ppm, dry wt.), making them highly questionable as alternative surface water supplies.

The average daily intake of arsenic by Canadians is approximately 0.03 mg from food, while the equivalent intake from contaminated Nova Scotia well water is between 0.12 and 0.45 mg. This has resulted in some cases of chronic arsenic poisoning. Increased incidence of cancer has been related to chronic consumption of water with arsenic concentrations greater than 0.30 mg/l in Taiwan and Chile, although no data exists to demonstrate this link in Canada.

Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are man-made liquids which are highly stable, non-corroding and resistant to both heat and biological degradation. These and other characteristics such as excellent insulating and thermal properties contributed to their widespread use after they were first manufactured on a commercial scale in 1929. PCBs have been used in electrical transformers, capacitors, hydraulic fluids, heat transfer fluids, paints, adhesives, cutting oils, lubricants, inks, flame retardants, water proofing agents and carbonless reproduction papers.

PCBs are of environmental concern because of their wide dispersal, persistence, chronic toxicity, bioaccumulative capacity and biomagnification along the food chain. Human exposure to PCBs has been associated with skin disorders, liver function abnormalities, growth depression in children and respiratory impairment.

PCBs ceased to be used in industrial processes in Canada in 1978 and are now banned from all new uses. New electrical equipment containing PCBs has been prohibited since July 1, 1980, although transformers or capacitors in service before that date may still contain PCBs.

Background levels of PCBs in the marine environment are approximately 5 - 20 ng/g in sediments, 1 to 100 ng/l in surface waters and from 0.01 to 5.0 μg/g wet wt. in finfish. PCBs can slowly accumulate in fish, therefore tissue concentrations in large, older fish may exceed the 2 ng/g Health and Welfare Canada guideline. PCB levels in eastern Canadian fish are higher than those found in the Arctic, but lower than those found in fish from the North Sea. Elevated levels of PCBs were found in striped bass in the Annapolis River. This may be the result of the prevalence of older fish which slowly accumulate PCBs.

PCBs are distributed in the environment throughout the Atlantic Region, but more serious contamination is restricted to several specific locations throughout the region. PCB levels of 52,200 ng/g were found in sediments sampled in Muggah Creek near the Sydney Coke ovens. This decreased to 20 ng/g at the mouth of the Muggah Creek in Sydney Harbour. PCB contaminated sediments have also been sampled at Canso, NS (1-27,000); Halifax, NS (17-22,000) and Petit-de-Grat, NS (24-20,000). The elevated concentrations of PCBs in sediments in Petit-de-Grat, and other small harbours in Nova Scotia, may have resulted from fish offal being discharged into the harbour from local fish processing plants. Process wastewater carried PCBs from fish tissue into the harbour.

Dioxins

Chlorinated dibenzodioxins (dioxins) are a highly toxic group of chemicals which are by-products formed during the production or combustion of organic chemicals or materials. The main anthropogenic sources of dioxin include the use of the phenoxy herbicides 2,4-D and 2,4,5-T, the production and use of pentachlorophenol (PCP) as a wood preservative, and the incineration of municipal garbage. Other potential combustion sources include forest fires and cigarette smoking.

In Nova Scotia a wood preserving plant at Truro, N.S., uses the dioxin-containing PCP to protect wood against insect attack and decay. Effluent from the plant has resulted in some dioxin buildup in the underlying sediments of adjacent streams, but this is not expected to result in any adverse impacts. Soil contamination where treated wood is stored, or at the base of PCP treated utility poles is also a concern.

Elevated levels of the highly toxic 2,3,7,8-TCDD were detected in the herbicide 2,4,5-T used in the region during the early 1970s. Prior to this, a mixture of 2,4,5-T and 2,4-D used by the US armed forces may have contained up to 100 μg/g of the TCDD. TCDD content of 2,4,5-T is presently regulated at 0.1 μg/g under the Federal Pest Control Products Act.

Continuous or intermittent low level exposure to dioxins is the major human health concern. Chloracne (a boil-like acne) and neurological disorders have been identified in workers exposed to dioxins in industrial accidents, but the relationship between dioxins and reproductive failure, birth defects, and cancer is uncertain. Under the Food and Drug Act, no food may be sold if contaminated with detectable levels of dioxins. Fish is the exception; the acceptable level is 20 ppt TCDD, at a consumption rate of 113 g (.25 lb.) per week. Many Atlantic Canadians consume larger quantities of fish, but fish caught in the region contain substantially less dioxin than those caught in the Great Lakes, upon which the standard is based.

Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are among the oldest known carcinogens in humans, having been identified as the active ingredient associated with soot which caused tumors in chimney sweeps during the 18th Century. PAHs are found in small but detectable concentrations in water, soil and sediments. The main route to the environment is via atmospheric emissions and subsequent fallout, although surface runoff and industrial effluents are also important. The principle anthropogenic sources of PAH include : thermal power plants; vehicle exhausts; coke ovens; creosoted wharf pilings; incinerators; oil refineries; wood burning appliances; sewage and oil spills. The conversion of power plants from oil to coal, the increased level of residential fuel-wood burning and potential increases in coke production threaten to increase PAH emissions in Nova Scotia.

Prior to 1980, regional monitoring centered upon the release of PAH from creosoted wood products. Investigations determined that PAH concentrations in marine sediments and shellfish immediately adjacent to creosoted wharf structures were considerably higher than background levels. Monitoring has continued on PAH uptake from creosoted structures, but has also recently focused on PAH discharges from the steel plant and coke ovens at Sydney, N.S., where approximately 3.5 million kg of PAH are estimated to be contained in sediments in Muggah Creek. Sediment PAH values in the South Arm of Sydney Harbour are 20 times the highest values recorded for Boston Harbour and PAH in lobsters is 26 times the background levels for Atlantic coastal lobsters.

Elevated levels of PAH have also been detected in air and water samples from industrial sources in Cape Breton. Particulate PAH concentrations at two sites downwind of the Sydney coke ovens averaged 31.16 and 36.56 ng/m^3, as compared to 3.48 ng/m^3 at an upwind control site. These values are higher than PAH concentrations sampled at larger cities in Ontario. Runoff from the coke oven dumps at Sydney contained up to 5.7 ng/l of benzo[a]pyrene, an extremely toxic PAH.

The uptake of PAHs has been demonstrated in microorganisms, plants, invertebrates and vertebrates. Metabolism of PAH is fairly rapid, therefore, biomagnification up the food chain is unlikely. Since ambient PAH levels are generally low in the Atlantic region, no acute toxicity problems of a widespread nature should be encountered. The primary concern is chronic mutagenic and carcinogenic effects, but there is virtually no published literature on possible health effects of ambient levels of PAH on the general public (Table 34).

Pesticides

Toxic chemicals are usually thought of as harmful substances and wastes which accidentally escape into the environment. Chemical pesticides include insecticides, fungicides and herbicides, which are consciously released into the environment to control plant and animal pests. The old rule of thumb, that if pesticides are used according to the directions on their label there will be no harm, is not always tenable. For example, the early organic, artificially synthesized pesticides were properly used in this narrow sense, yet subsequent research has demonstrated their significant, long term effects on the health of ecosystems. Although many early pesticides, including DDT and dieldrin, have now been banned from use, the number of different chemicals used as pesticides has steadily grown. For example, as of January 1, 1985, 514 chemicals were registered for use in Canada as compared to 30 in 1940 and approximately 400 in 1979.

Table 34. PAHs in the Atlantic Region. (From Eaton, Hildebrand and d'Entremont (1986))

Polycyclic Aromatic Hydrocarbons (PAHs) in the Atlantic Region

Medium	Background Levels	Elevated Levels	Guidelines or Regulated Limits
Air	0.38 ng/m^3 (national U.S. average BaP) 0.10 ng/m^3 (U.S. average rural — BaP)[2]	36.56 ng/m^3 (Sydney, N.S.) 3.74 ng/m^3 BaP (Sydney) 0.34 ng/m^3 BaP (1.66 ng/m^3 worst case) (Lower Sackville, N.S.)	No guidelines for ambient levels
Water	L1.0 ng/L (total PAH)	6.9 ng/L BaP (Lingan mine outfall on shoreline)	10 ng/L total PAH (International Joint Commission (IJC) Guideline to protect aquatic life)
		5.7 ng/L BaP (Runoff from coke oven dumps, Sydney)	2.8 ng/L total PAH (U.S. EPA criteria for human health)
Sediments	10-20 ng/g PAH	21,110 ng/g (4 PAH adjacent to creosoted wharf timbers) 110,000 ng/g BaP: 2.800,000 ng/g PAH (Muggah Creek) 150-10,000 ng/g PAH (Sydney Harbour)	1000 ng/g (IJC Guideline to protect aquatic life)
Biota			
Lobster	L5 ng/g BaP (digestive gland) L10 ng/g BaP (marine biota)	387-2240 ng/g (wet wt.) BaP (digestive gland) (South Arm, Sydney Harbour) 8-43 ng/g (wet wt.) BaP (tail muscle) (South Arm, Sydney Habour) 545 ng/g BaP (digestive gland) (creosoted lobster pounds — Atlantic region)	1000 ng/g BaP (IJC Guideline to protect upper levels of food chain)
Mussels	5 ng/g BaP	221 ng/g BaP (Sydney Harbour) 4,100 ng/g total PAH (Sydney Hbr.)	1 ng/g BaP (recommendation for foodstuffs in Canada)[7]

BaP — Benzo(a)pyrene

Pesticides enter the terrestrial and aquatic environments by direct application, mobilization in intermittent stream channels, surface runoff, leaching, drift from nearby spray areas, wind erosion and precipitation. Direct application is an important short-term route of entry and may result in acute toxic effects on non-target organisms. Overland flow and intermittent streams are important modes of entry to non-target areas, especially after precipitation. Aerial, and to a lesser degree ground spraying, can result in significant deposition of pesticides outside target areas, although drift may be mitigated through the use of a buffer zone at the edge of the spray block.

Forestry Herbicides

The use of herbicides in the forest industry has received considerable public attention in the Atlantic region. The "herbicide trial" in Nova Scotia in 1983 highlighted the apparent conflicts within the scientific community regarding the effects of herbicides on human health. The implications of herbicide spraying on the environment are, however, well documented, although most data is generated from outside of the region.

Herbicides Used in the Region

The phenoxy herbicides 2,4,5-trichlorophenoxyacetic acid (2.4.5-T) and 2.4-dichlorophenoxyacetic acid (2,4-D) are the herbicides which have been most widely applied in forestry operations in the past, however, they are no longer approved for forest husbandry. The prime use of these herbicides was to stimulate the growth of conifers in the forest industry by controlling deciduous trees and broadleaf weeds. They were also used to control brush on crops, rangeland, rights-of-way, industrial property and lawns. Phenoxy herbicides were used because they were harmless to most conifers, but at the same time were highly toxic to unwanted shrubs and deciduous trees such as maple and birch. Currently, "round-up" is the most commonly used herbicide. However, 2,4-D and 2,4,5-T are still used in various forms by homeowners for weed control and on power lines.

Residues of 2,4-D or 2,4,5-T in surface water courses tend to drop below non-detectable levels within several days or months of application. Water characteristics such as flow rates, temperature, oxygen concentration and microorganisms affect the rate of herbicide loss from water.

Water quality characteristics are also known to modify the toxic potential of phenoxy herbicides. For example, regional studies have demonstrated 2,4-D to be 20 times more toxic to rainbow trout at pH 4.5 than at pH 7.0. These results are important because acidified waters in southwestern Nova Scotia have been recorded at pH below 5.0.

Atlantic salmon and several species of trout are highly sensitive to the acute toxic effects of phenoxy herbicides, particularly during the early life stages. These species, when exposed to 2,4-D at levels of 2 mg/l and higher, have shown a variety of sublethal effects, including behavioral changes. Both 2,4,5-T and 2,4-D are not accumulated in higher levels of the food chain but can be concentrated by phytoplankton. Fish do not appear to accumulate substantial residues of phenoxy herbicides.

Forestry Insecticides

Fenitrothion and aminocarb are two chemical insecticides which currently have limited use in the control of the spruce budworm in the Atlantic region. BT (*Bacillus thuringiensis* (B.t.) is now the most common non-chemical application used to control the spruce budworm in Nova Scotia.

Environmental monitoring conducted in the Atlantic region has shown that fenitrothion and aminocarb are rather short-lived in the environment and residues in most environmental samples decrease rapidly with time. Matacil 1.8 F formulation of aminocarb has been shown to be significantly less toxic to biota than previous aminocarb sprays. Aminocarb is generally less persistent than fenitrothion, and is readily broken down by light and biological activity.

Agricultural Pesticides

Agricultural pesticides enhance crop production by combating pests such as insects, weeds and fungi. In spite of the heavy use of pesticides in North America, 36% of agricultural crops are annually lost to pests in the United States, and a similar percentage is likely lost in Canada. If pesticides were no longer used, damage would range from insignificant losses in some crops to the total loss of other crops, although losses could be significantly reduced through the adoption of alternative agricultural practices. Fungicides such as mancozeb, captan, and chorothalonil represent the largest quantities sold, followed by herbicides dinoseb and diquat, and the insecticides phorate, disulfoton, carbofuran, and aldicarb.

Agricultural lands in Canada currently receive 15 times more insecticide than forests. The heavy use of insecticides has resulted in the major global problem of pests developing a resistance to the pesticides used. The number of insects and other arthropods that are resistant to insecticides has grown from 224 in 1970 to 428 in 1980. Thirty-five plant diseases are now also resistant to pesticide treatment. In numerous instances pests resistant to one pesticide seem to quickly develop resistance to others.

One possible method to alleviate the resistance problem, and a more environmentally sound agricultural practice, is the concept of Integrated Pest Management (IPM). IPM reduces pest damage to tolerable levels through a variety of techniques, including the introduction of genetically resistant crops, the release of natural predators and parasites, the release of sterile pests and the modification of agricultural practices to include techniques such as crop rotation and intercropping. IPM may still require pesticides, but often in smaller quantities, applied less frequently, on critical occasions.

Pesticide Contamination and Fish Kills

Fish kills occur when high concentrations of chemicals enter a water body in a short period of time from a chemical spill, or from runoff entering a stream following pesticide applications. Many fish kills are caused by washing or loading spray equipment at streamside, or carelessly storing chemicals where they could accidentally be spilled into a water body. These types of incidents caused several hundred fish kills in the Atlantic region in the late 1960s, until each Atlantic province eventually passed regulations (PEI, Nfld., and NB) or guidelines (NS) dealing with the use or misuse of spray equipment. Evidence indicates that the number of fish kills has subsequently been reduced.

Fish kills due to pesticide misuse can still occur. For example, in 1982, several hundred fish were killed in Chute Brook, King's County, Nova Scotia, after the insecticide Guthion was spilled while loading spray equipment. Guthion powder residues were also found on the ground adjacent to the stream. Two weeks later, a fish kill was reported in a tributary of the Cornwallis River, King's County, NS. In this case the fungicide captan was spilled when spraying equipment was overfilled adjacent to a brook.

Sources of Hazardous Wastes

An estimated 131,700 tonnes of hazardous wastes are generated annually in the Atlantic region. This represents 5% of the Canadian total. Large industries such as petroleum refineries, pulp and paper mills, and chemical plants generate 90% of the total. Smaller generators of hazardous wastes include community businesses such as dry cleaners, furniture finishers or photography studios, and institutions such as hospital or university laboratories. Electric power generation facilities are also a source of hazardous wastes such as PCBs. The average citizen also generates small quantities of hazardous wastes such as solvents, cleaning fluids, insecticides, herbicides or home and vehicle maintenance chemicals.

Approximately 93% of hazardous wastes in the Atlantic Provinces are generated in New Brunswick and Nova Scotia. Newfoundland generates about 6%, and PEI less than 1%. Oily wastes account for approximately one-half of the wastes generated, followed by acid solutions, alkalis and solvents.

Disposal Methods

A survey of 110 industries in the Maritime Provinces revealed that the use of municipal dumps, on-site dumps, waste treatment and on-site storage were the preferred or only available waste disposal methods. Several industries used a combination of methods. In Newfoundland, 36% of hazardous wastes are disposed of in poorly operated on-site landfills. A similar amount is disposed of in municipal dumps, while the remainder is disposed of in sewers, by burning, or is stored on-site. A significant quantity of waster or used oil is used as a dust suppressant on roads throughout the region. This oil may contain contaminants such as lead, PAH and PCBs.

There are many alternative methods available to properly dispose of hazardous wastes. These include physical treatment (which includes filtering and precipitation), chemical treatment (which incorporates oxidation and neutralization), recycling, high temperature incinerators, secure landfills and waste exchanges. Many industries, such as the wood preservation industry, send their hazardous wastes to central Canada for treatment or incineration. Landfarms, whereby natural decomposition is allowed to take place, are used by refineries to dispose of 6,000 to 10,000 tonnes of oily wastes annually.

Many of the dumpsites identified in the region contained buried transformers, capacitors or pesticide containers. There is some concern that pesticides or PCBs may have leached from dumpsites to groundwater supplies or surface watercourses. For example, problems with PCB contamination at the Amherst landfill still remain after the removal of 120 drums of PCB waste in 1978. An estimated 17 tonnes of PCB contaminated waste are still buried at the site. PCB concentrations in topsoil several metres downhill from the dumpsite range up to 210 ppb, considerably higher than the background level of 50 ppb. Very low levels of PCB have also been recorded at the Nappan River, 1.5 km away.

The transportation of dangerous goods is covered in Nova Scotia under legislation proclaimed in 1982, the "Dangerous Goods Transportation Act"

Industries : Point Sources of Pollution

Pulp and Paper Industry

The pulp and paper industry is an important resource sector in Nova Scotia with approximately five (5) plants in operation. Most of the plants discharge potentially toxic oxygen demanding wastes (BOD) and suspended solids to coastal waters. As a result, there have been heavy build-ups of decaying wood fiber in the vicinity of these plants, which has led to physical smothering of the benthos, changes in benthic habitat and oxygen depletion of bottom waters. Research is ongoing to determine the impact of pulp and paper effluent on salmon migrations, where plants discharge to the mouths of rivers. Fishermen at some locations commonly complain of fouling of their nets, foul smells from anoxic sediments and ice-rafting of wood chips and fiber. Up until the early 1960s, mercury was used as a fungicide in pulp and paper mills, which resulted in the contamination of marine sediments. This persists at lower levels in the vicinity of the plants today.

For the pulp and paper industry as a whole, in the Atlantic Region the discharges of BOD and suspended solids (SS) have been steadily declining. Approximately 60% reductions in BOD and 51%

reductions in SS were realized in the period 1969 - 1984. Much of the reduction so far has resulted from combinations of process changes, in-plant controls and external treatment.

More significant perhaps, has been the 5-year federal-provincial modernization program which was initiated at 13 of the 20 mills in the Atlantic region in 1980 - 1981. By 1984, 9 plants were in compliance with the Federal Pulp and Paper Effluent Regulations of the Fisheries Act for suspended solid discharges, with another 3 near compliance. Ten plants were in compliance for BOD discharge if all modernization plans are completed. Eight plants had discharges which met the toxicity requirements and were non-acutely lethal to test fish, but about half of the plants will still have toxic discharges by the end of the program.

Petroleum Refining

The petroleum refining industry, long established in the Atlantic region, has resulted in considerable concern over both the quantity and quality of its liquid effluents. Oil refining in this region has suffered economically in the last several years. Nova Scotia originally had three refineries based at Port Hawkesbury and Dartmouth. It is not known what the status of these refineries is at present regarding operational regimes.

A wide range of organic and metal pollutants are present in refinery wastewaters, oil being the most common contaminant. In an effort to limit these discharges, the federal government, in consultation with the provinces and industry, developed the National Petroleum Refining Effluent Regulations and Guidelines (1974) under the Fisheries Act. The intent was to limit the discharge substances which are deletious to fish. The five regulated parameters are : oil and grease, sulfides, ammonia, total suspended matter (TSM), and phenol.

Since 1980, all refineries have been in compliance more than 98% of the time. On an individual basis, the maximum authorized limits were not exceeded significantly by any refinery. The improved compliance by the refineries is attributable to efforts by the industry to meet the applicable requirements. These have primarily involved the installation or upgrading of treatment facilities.

Fish Processing

There are over 300 fish processing plants along the coasts of the Atlantic region. Effluents from these plants discharge substantial loadings of oxygen demanding organic matter, suspended solids, oil and grease, fecal bacteria and certain organic/inorganic contaminants. Although the effluents from this industry are not routinely monitored, impacts in the vicinity of fish plant outfalls are considered to be very localized and of little anticipated consequence to the overall quality of the receiving environment.

Fish meal plants are considered to have greater environmental impact, because of high BOD and potential toxicity as a consequence of lowered dissolved oxygen. This impact is also local, and individual plants are not viewed as having a broad geographical influence. Quite often, the problem of odors and flies around fish meal plants receives more community response than the problem of effluent discharges.

Most marine fish contain small quantities of polychlorinated biphenyl (PCB). As the oil and wastewater from their cleaning and processing are discharged, the PCBs may accumulate in the sediments in the vicinity of the plants. PCB concentrations greatly in excess of background concentrations (0.005 μg/g) have been measured in samples obtained from several harbours in the Atlantic region which receive effluents from fish processing plants.

One of the harbours which has been observed to be most severely contaminated is Petit-de-Grat, NS., located on the southeast corner of Cape Breton. A number of process effluents from the fish meal plant contained PCB residues up to 0.83 mg/l and sediment concentrations there were as high as 20 μg/g dry weight. Samples which were especially high in PCBs consisted principally of fish offal.

An investigation of several other harbours in the region with operating fish/fish meal plants found PCBs in the majority of the collected samples, but at levels approximately two orders of magnitude lower than those measured at Petit-de-Grat. Significant accumulations of PCBs are likely only to occur where the discharge of high strength effluents and/or the poor dispersal of effluents by receiving water (such as in the partially enclosed, low energy harbour at Petit-de-Grat) leads to sediments highly enriched in fish waste. There are at least 18 harbours in the region where PCB sediment concentrations are in excess of 1.0 μg/g. Dredging and disposal conflicts arise when it becomes necessary to dredge harbours with PCB sediment concentrations in excess of the Ocean Dumping Control Act limit of 0.1 μg/g.

Municipal Sewage

Installation of sewage treatment systems in Atlantic Canada has lagged behind many other parts of the country. "Ribbon development" along the coast is common, and many sewage treatment facilities impact on the marine environment. There are, in addition, many untreated sources ranging in size from single family dwellings to major cities. In the Atlantic provinces, approximately 55% of the population is served by sewers which collect the wastewaters, but only about 20% of the population is served by central wastewater treatment. About 788,000 people therefore discharge municipal wastewater to collection systems that are not connected to wastewater treatment facilities. In terms of organic loading, assuming an average BOD of 200 mg/l, approximately 80 tonnes of BOD are being discharged daily, (about the equivalent of the combined daily BOD loading from three of the biggest newsprint mills in the region). Municipal wastewater discharges are, however, numerous and widely dispersed throughout the region, so that adverse impacts are considerably diluted (Table 35).

Table 35. Urban population served by sewage treatment systems in the Atlantic Region. (From Eaton, Hildebrand and d'Entremont (1986))

Urban Population Served by Sewage Treatment Systems*

	% of Urban Population Served	Number of Communities with Sewage Treatment Plants
Nfld.	17%	42
P.E.I.	100%	22
N.S.	28%	76
N.B.	60%	73
Canada	63%	
U.S. (1980)	67%	

*Excludes septic tanks serving non-urban populations of less than 1,000 people.
Source: National Inventory of Municipal Waterworks, 1981[78], (with updating through 1982).

Steel Industry

The Sydney steel plant has been discharging toxic and environmentally hazardous wastes into the South Arm of Sydney Harbour for over 80 years. Aqueous effluent emanating from coking operations, and other plant waste material and by-products, are discharged to a nearby site close to Muggah Creek, commonly referred to as the "Tar Pond". A complex mixture of hazardous chemicals has accumulated in the Tar Pond, the most predominant of which are polycyclic aromatic hydrocarbons (PAHs). The coke ovens were shut down from December 1983 to December 1985, but in 1981, when the coke ovens were operating at 25% capacity, PAH releases were estimated at 3.5 tonnes/year. The release of PAHs under full coke plant operation was at least 14 tonnes/year and likely higher. The major toxicological concern with respect of PAHs is their chronic mutagenic and carcinogenic effects.

The Tar Pond covers approximately 38 ha and is about 1.5 m deep in tar/coal product wastes that contain approximately 1% PAH. The total quantity of PAH compounds in the Muggah Creek estuary is estimated to be 3.5 million kg. The area is tidally influenced and movements of toxic waste materials to the South Arm is occurring (Net release of PAH from the mouth of Muggah Creek into Sydney Harbour is approximately 100 kg/year). Although the coking operation has been shut down for two years and had previously been operating at reduced production for several years before that, the continuous discharge of PAH-contaminated wastes, and the leaching of the Tar Pond through tidal action has, over many years, led to severe contamination of South Arm sediments and biota.

The most elevated levels of PAH have been detected near the outlet of Muggah Creek. Levels of PAH (mostly phenanthrene, fluoranthene, benzo[a]anthracene and pyrene) in sediment and biota samples from the South Arm of Sydney Harbour were significantly in excess of typical background levels. For example, sediment values were as high as 20 times the highest values found in Boston Harbour, and South Arm lobsters contained 26 times the background levels in Atlantic coastal lobsters. Levels of benzo[a]pyrene in pooled hepatopancreatic samples from South Arm lobsters ranged between 387 - 2240 ng/g wet/wt. (mean = 1030 ng/g), while tail muscles were 10 to 100 times lower (range of 8 - 43 ng/g wet wt., mean = 32.3 ng/g). Benzo[a]pyrene levels in lobsters captured in uncontaminated areas were less than 5 ng/g in hepatopancreatic and barely detectable in tail muscles. DFO responded to these findings in 1982 with a lobster fishing ban in the South Arm, which affected 6 boats fishing 925 traps.

Shellfish PAH concentrations also greatly exceeded concentrations in mussels from other contaminated areas. The effect, if any, that such concentrations of PAH are having on shellfish populations in Sydney Harbour has not been studied. Although the carcinogenicity of PAH compounds has been known for some time in mammalian species, their effect on aquatic organisms are less clear.

Concern over the vast quantity of PAH-contaminated materials in the disposal area led to the commissioning of a federal-provincial study of potential options for control and/or cessation of PAH release from the Tar Pond. The preferred alternative for dealing with the Tar Pond was to excavate the material and incinerate it to destroy the PAHs.

Chlor-Alkali Industry

Canso Chemicals in Abercrombie, NS., is a mercury-cell chlor-alkali plant producing chlorine and caustic soda. This plant discharges to the marine environment, with mercury being the major contaminant of concern in its liquid effluent, (as well as in their atmospheric emissions and solid wastes). These liquid effluents have been in compliance with the Chlor-alkali Mercury Liquid Effluent Regulations since 1972 (monthly averages) and on every operating day since 1977. However, the effluents remain acutely toxic to test fish, as a result of high concentrations of chlorine.

Coal Mining

Coal development and utilization is considered to be an important element in the energy and industrial strategies of Nova Scotia. With the increasing emphasis on coal as a replacement for oil, the potential for environmental problems and resource use conflicts associated with its mining, preparation, transportation, utilization and waste disposal will be increased significantly. The principal noxious components of waste waters from coal mining activities are high acidity and high levels of heavy metals (particularly iron) and suspended solids.

It is extremely fortunate that most of the effluents from coal related activities in the Maritimes discharge directly to the sea, and not to more sensitive freshwater systems. Sea water has a high buffering capacity, which assists in rapidly neutralizing and precipitating materials from acid wastes, and limiting the impact of such wastes to the immediate area around discharge points.

Bridgeport Basin is a highly productive shallow tidal inlet in northeast Cape Breton, which receives the wastes from concentrated coal mining and related activities. Despite evidence of elevated levels of contaminants in some sediments, water quality in the watershed and basin is indicative of a relatively clean environment with sufficient capacity to absorb the existing pollution load.

Coal mining generates large quantities of waste rock which, at some sites in Cape Breton, is disposed of on shore, to be dispersed naturally by wave action and currents. An average of 69,000 tonnes/year of waste rock has been dumped along the shore from the Number 26 colliery for 58 years, with no apparent adverse impact. With new mines coming on line in the area however, waste rock volumes in excess of 400,000 tonnes/year may be generated for more than half a century. More detailed studies of the possible impact of these larger quantities of eroding waste rock on the local lobster habitat are presently underway.

Base Metal Mining

The base metal industry has three components : mining, shipping and smelting. Several new mines came into operation in Nova Scotia in 1985 and 1986, including the Georgia Pacific gypsum mine "Sugar Camp Lake" near Port Hawkesbury, NS., the Rio Algom tin mine near East Kemptville, Nova Scotia, and several gold mining operations in Nova Scotia.

Acid generation from mineralized rock is another problem which occurs in many parts of Nova Scotia, and particularly around Halifax International Airport. The airport is situated on a band of slate which, when distributed and exposed to the atmosphere, produces acidic runoff which adversely affected the surrounding watershed over the past two decades. Great care has been taken during the construction of recent developments on or around the airport to minimize the amount of slate that is exposed. Collection and buffering of the drainage has also substantially lessened the impact on the environment. There is still work to be done however, to overcome chronic problems associated with past activities.

Non-Point Sources of Pollution

It is becoming increasingly apparent that point source discharges represent only a portion of the total pollution loading to Atlantic coastal waters. Non-point sources include diffuse or dispersed loadings which do not enter at discrete or identifiable locations, but which may reach the sea through rivers, or along exposed coasts.

Non-point source pollution is tied directly to existing land-use practices. In Nova Scotia runoff from agricultural, forestry and urban areas are the major contributors to a pollution problem which cannot be controlled by the usual abatement measures applied to direct municipal and industrial discharges. Many of the impacts of this runoff are felt initially in freshwater systems, but ultimately impact on coastal waters.

Agricultural runoff is a major non-point source of pollution and the major source of sediment loading in streams and lakes. Agricultural runoff may contain high concentrations of nutrients, fecal coliform bacteria, and pesticides, which could contaminate surface and groundwater or result in shellfish closures.

Persistent arsenic residues in some soils have resulted from the wide use of sodium arsenite in potato fields. Lead and mercury residues in orchard soils in Nova Scotia are attributable to pesticide use. Residues of synthetic pyrethroid insecticides have been detected in aquatic sediments and ethylene thiourea, a breakdown product of several fungicides, has been detected in soils. The herbicide atrazine has occasionally been detected in the Annapolis - Cornwallis River systems in Nova Scotia.

There is also concern about the potential effects of other pesticides such as endrin, carbofuran and azinphos-methyl in agricultural runoff.

Urban runoff or runoff by street dusts or deposits, has been identified as a significant source of hydrocarbons and nutrients to aquatic systems. For example, the total annual input of hydrocarbons to Halifax Harbor from urban runoff may be up to 15 times greater than the input from the Imperial Oil refinery. In addition, metal concentrations from runoff collected at a parking lot in Dartmouth, NS., were higher than for those from raw domestic sewage entering a treatment plant located nearby at Eastern Passage. Trace concentrations of aluminum, iron, potassium, sodium, magnesium, lead, calcium and titanium were all found in street dusts in Halifax.

Forestry is another major contributor of sediment and pesticides. Clearcutting exposes extensive areas of forest to rapid erosion and it is only recently that vegetated buffer strips are helping to reduce siltation of adjacent watercourses. Recent efforts to restrict the movement of heavy equipment across streams is also lessening the amount of sedimentation. In rural areas, sediment, metals and organic matter readily run off the land due to the reduced filtration and collection of this runoff in sewers.

All of these land-use practices result in siltation of streams. lakes and estuaries and introduce toxic metals and organics which can destroy fish habitat, and reduce dissolved oxygen levels. These effects may result in fish kills (or other chronic effects), reduced productivity, impaired recreational use and shellfish closures in coastal areas.

Physical Degradation

The construction of causeways, dams, breakwaters or piers can result in the degradation of sensitive coastal ecosystems. This degradation is often due to changes in circulation patterns which ultimately alter oceanographic parameters such as temperature, salinity and sedimentation rates. These changes, in turn, affect biological communities. For example, the construction of the Canso Causeway has changed benthic species composition in St. Georges Bay and the Strait of Canso. A smaller causeway at Barrington Passage, NS., has cut off a summer mackerel migration route and has resulted in the smothering of lobster habitat. The causeway at Windsor, N.S., has resulted in extensive sedimentation and the displacement of benthic communities.

The Strait of Canso is an area of concentrated industrial activity located between Cape Breton and the mainland of Nova Scotia. Anthropogenic sources of contamination include an aggregates loading facility, a gypsum wharf, pulp mill, thermal power plant and oil refinery (inactive since 1980). Vessel traffic related to offshore exploration activity has also increased in the last few years. A 1983 survey of the Strait demonstrated the continued extension of a molluscan barren zone (along the eastern side of the Strait south of the causeway) through a previously diverse area of the Strait. This was paralleled by an order-of-magnitude decrease in the average density of polychaetes between 1969 and 1983. There is also a trend of higher metal and organochlorine concentrations in the Strait sediments, compared with those from the mouth of Chedabucto Bay (62 km out), and south along the essentially clean Eastern Shore of the mainland.

Other Environmental Problems

Forestry

Forests have been used for three centuries to provide the raw material for the production of lumber, pulpwood, fuelwood and other products. Although forestry is the most obvious industrial use of our forests, other users are also important. Over 100,000 hunters are active each year in Nova Scotia alone and further recreational enjoyment is obtained from fishing, camping, picnicking, nature photography or the simple enjoyment of walking through the woods. The forests of the Atlantic region are also used for scientific research and education. Educational uses range from formal university field courses to interpretive walks through the woods for young children. In other words, this variety of uses touches in some way nearly every resident of the Atlantic region, therefore proper forest management practices are not only important to the forest industry, but to all Nova Scotians.

Forest Regions

The forests of Nova Scotia are classified under the Acadian Forest Region. Each forest region is further subdivided into a number of ecologically distinct areas with differing forest compositions.

The characteristic climax forest of the Acadian Region includes yellow birch, eastern hemlock, white pine and red spruce. Other important species include balsam fir, sugar maple, red pine, black spruce, red oak, white elm, black ash, red maple, white birch, grey birch, trembling aspen and balsam poplar. Within the Acadian Region there are several areas of varying forest composition from predominately coniferous, through mixed woods to predominantly hardwood.

The composition of the forests of Nova Scotia have changed greatly from their state at the time of European settlement. The 300 year history of forest exploitation, an increase in the incidence of fire, and major losses by disease and insects have had a profound effect on the forests. The result has been changes in species composition and distribution.

Present forestry practices may also change forest composition. Clearcutting has favored the regeneration of balsam fir, which has drawbacks in terms of commercial utility and budworm susceptibility. Succession, particularly following clearcutting of high value hardwood, mixed and spruce/pine stands, has frequently been undesirable. Approximately 1/3 of the clearcuts on the Cape Breton Highlands do not regenerate adequately to commercial species in adequate numbers. Clearcuts of fir/spruce stands have resulted in a preponderance of fir regeneration, which is extremely vulnerable to spruce budworm infestations which may require expensive treatment to combat the infestations.

Clearcutting results in an initial loss of nutrients through the removal of nutrients tied up in the harvested stand, the loss of nutrients bound to eroded soil particles and the accelerated decomposition of litter and organic matter on exposed cutovers. Mechanical clearing equipment which eliminates on-site vegetation or results in ground disturbance and redistribution of slash and organic debris, may also redistribute or deplete nutrients. This depletion of nutrients also reduces the soil's ability to buffer acid rain, which may be compounded by the loss of hardwoods, whose deep root systems bring neutralizing agents from deeper soil layers. The significance of nutrient losses following disturbances is however, expected to be minor on better quality sites.

In the absence of fertilization, the nutrient reserves of a forest build slowly through a natural process which may take up to 100 years. The trend in the Atlantic region towards short-rotation forestry (i.e. a cycle of 40 years) and whole tree harvesting is consequently of concern because of the potential for long-term reductions in forest productivity. Whole-tree harvesting removes additional nutrient-rich materials such as branches and tree tops from the site. Whole-tree harvesting can increase nutrient removal by 100 - 200%, resulting in a possible loss of the productive capacity of the site and the lengthening of the next rotation.

Clearcutting reduces cover for many small mammals and birds, leaving them open to predation. Clearcutting may, however, be beneficial to animals such as white-tailed deer, moose and the snowshoe hare, whose principal foods consist of vegetation that normally grows in abundance during the first few decades after an area has been clearcut. Large clearcuts are not utilized by game animals because they lack sufficient cover.

Increased disturbance from logging roads may be of greater concern to some fisheries and wildlife populations. Shy sensitive species such as lynx or cougar are particularly vulnerable to such disturbances. Forested areas, because of their remoteness and relatively undisturbed nature, are very important to the continued survival of these species. The network of forestry roads have in some cases been known to result in erosion, and the subsequent siltation of local streams can degrade fish habitat. **Siltation is particularly deleterious to salmon and trout which require silt-free gravel in which to spawn and which are already at risk from acid rain and pollution. The network of forestry roads has also dramatically increased access to even the most isolated lakes and streams thereby contributing to the problem of overfishing.**

Skidder logging operations have been shown to result in ground disturbance of varying severity on cutovers. Poor or suppressed growth of softwoods and establishment of weedy broadleaf species has been correlated with severely disturbed or compacted portions of cutovers. This site degradation may result in reduced forest productivity over the long term.

The knowledge application of available silvicultural techniques (especially the various regeneration cutting methods) could reduce problems which have undesirable successional trends. The shelterwood harvesting system, for example, is an effective method of obtaining spruce and fir regeneration that can also be used to reduce the proportion of fir (or any other undesirable stand component). This method (which involves cutting strips of trees and allowing conifers to establish themselves between the strips) is also effective in reducing shade-intolerant broadleaf species to manageable levels. The group selection system of uneven age management (harvesting of a small group of trees) similarly results in improved species composition and stand density. The shelterwood harvesting system is used successfully on a small but significant scale in Nova Scotia.

The Spruce Budworm and Other Epidemics

Outbreaks of the indigenous spruce budworm (*Choristoneura fumiferana*) have resulted in conifer defoliation, cessation of growth and widespread mortality of conifers, particularly in the Cape Breton Highlands. The most recent outbreak has essentially destroyed the spruce and fir forests of the Cape Breton Highlands, killing the equivalent of 15% of the volume of wood harvested in a typical year in Canada. Projections indicate that this may result in a severe wood shortage by the turn of the century and the potential loss of between 4,350 and 5,600 jobs in Cape Breton and northeastern Nova Scotia. Spruce budworm epidemics were first recorded in Nova Scotia in 1846, and most probably occurred for centuries before that. The salvage clearcutting practices in the Cape Breton Highlands have probably impacted on fish in a variety of ways, including, improved access to lakes and subsequent overexploitation, loss of stream cover, run-off patterns and changes to stream discharge.

The release of biological control agents such as *Bacillus thuringiensis* (B.t.) is one alternative to the use of chemical insecticides. B.t. tends to be more selective and less toxic to non-target organisms, but it is expensive to use and does not reduce a stand's vulnerability to future infestations. Long-term and perhaps more cost-effective solutions include the large-scale adoption of alternative cutting practices which favour the natural regeneration of resistant species and result in a more diversified and less vulnerable resource base.

Refined Petroleum Products

The use of heavy and light fuel oils for energy production is, however, decreasing due to the increased coal-fired generating capacity in the region and greater oil use efficiencies in the industrial and transportation sectors. The 350 MW Tuft's Cove generating station in Dartmouth, is a large oil-fired generating station in Nova Scotia.

Although the share of motor gasoline rose to 23.3% of the total refined petroleum products in 1982, the actual amount consumed declined slightly from 1978. This decrease occurred despite a 29.6% increase in the total number of registered vehicles in Nova Scotia. Greater fuel efficiency in today's smaller, lighter and more aerodynamic automobiles is the primary reason for the drop in gasoline demand.

The combustion of oil emits significant quantities of sulphur dioxide (SO_2), oxides of nitrogen (NO_x), carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons and heavy metals into the atmosphere. In comparison, coal releases greater quantities of these compounds than oil, and natural gas significantly less. Coal fired plants in Nova Scotia emit large quantities of SO_2 and/or NO_x. For example, SO_2 emissions from the Tuft's Cove and Water Street stations in Halifax have contributed with other Halifax area sources to the acidification of local lakes. Sulphur deposition and lake acidification have been correlated with distance from sulphur emitting sources in the Halifax area.

Coal

Coal is primarily used in the Atlantic Region for the generation of electricity, with smaller quantities used in the industrial and commercial sectors. Coal resources in Nova Scotia are estimated at 3.2 billion tonnes, by far the largest reserves in all of eastern Canada. Coal use is expected to increase and eventually stabilize at 22% of the Atlantic Region's energy demand, and 40% of Nova Scotia's demand, by the late 1990s.

The coal used at the Lingan generating station, located near New Waterford, N.S., will displace 6 million barrels of oil per year when operating at its full 600 MW capacity. The 210 MW Trenton, N.S., station, and 100 MW generating station at Glace Bay, N.S., are the other major coal-fired units in Nova Scotia.

The increased use of coal in electrical generation could lead to significant environmental impacts. Coal mining can lead to "acid drainage", which may lead to reduced water quality and cause fish kills. Transportation of coal releases dust particles which can contribute to local air and water pollution. Acid runoff from coal cleaning can lower the pH and increase toxic metal concentrations in receiving waters. For example, wash water and runoff from the Minto, N.B., coal preparation plant in the late 1970s left 6 km of stream devoid of streamside vegetation and aquatic life.

Major contaminant plumes are found in the soil and underlying bedrock at the Victoria Junction coal cleaning plant, and the Nova Scotia Power Corporation's dry ash landfill at Lingan. In addition, 2 wells have been contaminated north of the Gardiner Mines abandoned waste rock dump.

Coal combustion, due to its sulphur content, contributes significantly to the formation of acid precipitation. Some local coals are high in sulphur and contain significant amounts of lead, chromium, aluminum, uranium and arsenic, which can be concentrated in the ash. Emissions of SO_2, NO_x and particulates could produce local adverse environmental effects and health problems, such as an increase in respiratory ailments, damage to sensitive species of vegetation, aesthetic problems and material damage to buildings, metals and paints.

High stacks often reduce local impacts, but contribute to the long range transport of air pollutants. Ambient air monitoring in the vicinity of urban thermal power stations indicates that concentrations of SO_2 and NO_x are generally within acceptable ranges. Based on ambient air quality data, SO_2 levels close to the Lingan plant are not expected to cause any problems under normal weather conditions.

New combustion technologies are being tested at Summerside, P.E.I., Pt. Tupper, N.S., and at Chatham and CFB Gagetown, N.B. These new coal burning methods (including fluidized bed combustion, coal and water slurry, and limestone injection burner) will substantially reduce SO_2 and NO_x emissions from coal-fired plants.

The combustion of coal and other fossil fuels is a major factor in increased global carbon dioxide levels. CO_2 levels are rising at about 0.3% per annum, possibly contributing to a universal warming of the earth's surface. This phenomenon, called the "greenhouse effect", may have pronounced climatic effects, including increasing sea levels, which could affect the Atlantic Region in the future. These changes may become so significant as to warrant limits to the combustion of fossil fuels, particularly coal.

Hydro Power

Hydro power accounts for 79% of the total electricity produced in the Atlantic Region. Newfoundland generated 92% of the total hydroelectricity in the region in 1982, while in contrast, Prince Edward Island had no hydro capacity, and Nova Scotia and New Brunswick generated most of their electricity from thermal stations. Much of the electricity generated in Labrador is exported to Quebec and is, therefore, unavailable for regional consumption. It is estimated that by the year 2000, hydro power will constitute 71% of the total regional electrical generation.

The 5,225 MW Churchill Falls, Labrador, generating plant is by far the largest electrical generating facility in the region. Other hydro developments in the Atlantic region are small in comparison and include the Mactaquac, N.B. (660 MW), Wreck Cove, N.S. (200 MW), and Baie D'Espoir (450 MW) and Twin Falls (200 MW) generating stations in Newfoundland. Most of the potential for developing future generating capacity is located in Labrador, with lesser potential on the island of Newfoundland, New Brunswick and only limited potential in Nova Scotia.

Hydro power displaces the combustion of fossil fuels for energy generation, therefore it can be beneficial in improving air quality. Although hydro stations do not produce SO_2, NO_x, waste heat or nuclear wastes, they can adversely affect fish and wildlife. For example, hydroelectric development on the Saint John River has reduced the river's capacity to assimilate wastes, thus resulting in fish kills due to oxygen depletion in the head pond. Suspended sediments and reduced light penetration inhibiting photosynthesis can result from erosion.

Significant quantities of spawning and rearing habitat for salmonids were lost when the Tobique Narrows, Beechwood and Mactaquac dams were constructed. Fish habitat may be destroyed (or enhanced) in the reservoir or in streams between the dam and the tailrace overflow. Hydro dams often become physical barriers to fish migration, either reducing access to spawning areas or damaging fish which stray into intakes and pass through the turbines. Seaward migrating Atlantic salmon juveniles have suffered significant injury from turbines, thus potentially reducing adult numbers. Populations of shad and striped bass have declined due to reduced access to upstream habitat. In contrast, alewife, blueback herring, white sucker and smallmouth bass populations have increased due to an increase in their habitat in the Mactaquac headpond.

Environmental Management

Nature Conservation

National parks, migratory bird sanctuaries, wildlife management areas, ecological reserves, provincial parks and provincial game sanctuaries all offer varying degrees of wildlife and habitat protection. The most notable recent conservation achievement in the region has been the establishment of 12 federal wildlife management areas over the past 8 years. These sites are owned and managed by the Canadian Wildlife Service and offer full legislative protection from adverse development. Although three provinces in Atlantic Canada have passed ecological reserves legislation since 1976, progress towards the establishment of these reserves is slow. By the end of 1984, only 16 of 176 sites identified by the International Biological Programme have actually been protected as permanent or provisional ecological reserves. With few exceptions, provincially designated game sanctuaries do not offer legislative protection from development, or for habitat preservation, although there are often restrictions on hunting and trapping. In addition, provincial parks, unlike national parks, tend to be oriented to recreational, and not wildlife conservation.

Of importance in the establishment of ecological reserves is the lack of attention given to fisheries resources or stream sanctuaries and it will be important to identify such areas as part of the strategic development plan for recreational fisheries in Nova Scotia as part of the overall management of the fisheries resource.

Environmental Impact Assessment (EIA)

The process called Environmental Impact Assessment (EIA) was developed in the early 1970s to identify potential environmental impacts resulting from the construction, operation and abandonment of proposed developments, and to incorporate environmental considerations at the planning stage. EIA in the Atlantic Provinces is carried out under provincial authority or by the federal government, under the Environmental Assessment and Review Process (EARP). Major projects may also be subject to a joint federal-provincial review.

Provincial EIA in the Atlantic Region

A brief review of provincial EIA processes for New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland is outlined below. Although there is no formal EIA process in Prince Edward Island, some environmental issues may be addressed under the Provincial Planning Act.

Nova Scotia derives the authority to require an EIA from the Environmental Protection Act (1977) and the Water Act (1973). The Nova Scotian process is not restricted to government-sponsored projects. Public hearings are not mandatory, although they have been conducted by the Nova Scotia Department of the Environment (NSDOE), provincial-federal review panels, or the Environmental Control Council (ECC). The ECC is an advisory council with members appointed from outside the provincial public service. If requested to comment on an EIA, the ECC may recommend that a project be permitted to proceed, with or without exceptions, or be refused.

Provincial (and Federal) EIA processes tend to be consultative rather than regulatory. Impacts are noted, and mitigative measures are generally recommended, but not necessarily legally enforced. This system has resulted in some tangible environmental benefits. For example, control structures and improved tidal gates were constructed to mitigate adverse drainage of agricultural lands behind the Annapolis tidal barrage, and monitoring programs and on-site inspections may have been improved due to the EIA process in Newfoundland.

Federal Environmental Assessment and Review Process (EARP)

The federal government's Environmental Assessment and Review Process (EARP) was established by Cabinet in December 1973, amended in 1977 and formalized by an Order-in-Council in 1984. The EARP applies to proposals undertaken or sponsored by the federal departments or agencies, for which federal funds are committed, or which involve federal property or areas of federal jurisdiction. **The process is administered by the Federal Environmental Assessment Review Office (FEARO), which reports to the Minister of the Environment, but is an agency separate from Environment Canada.**

The initial stage of the EARP is a self-assessment process; if an initiating department determines that a project may have significant environmental effects, the proposal must be referred to FEARO for review. This review may include an Environmental Impact Statement (EIS), which is prepared by the project proponent, and includes an analysis of how the project could adversely affect the environment. The Environmental Assessment Panel (EA Panel) has the prime responsibility for developing guidelines for the EIS, reviewing the EIS, arranging public meetings and issuing final recommendations on the acceptability of the proposal. The implementation of EA Panel recommendations is not mandatory, but may be negotiated between the Minister of the Environment and the Ministers responsible for the project.

Seven proposals in the Atlantic region have been referred to FEARO for formal EA Panel reviews since 1974. A completed EA Panel review includes an EIS, public hearings and final recommendations. EA Panels have issued recommendations for 4 projects in the Atlantic region. The Pt. Lepreau nuclear station and the Wreck Cove hydroelectric project are the only two which are currently operational; the Lower Churchill hydro project is not being pursued and the economic viability of the Venture gas development is currently being determined. To avoid duplication of EIA reviews, many EA Panels have federal/provincial composition, allowing one activity to satisfy both review processes. Most EA Panel recommendations have addressed the need for monitoring programs and the filling of knowledge gaps.

Informal Environmental Assessments

In addition to formal EA Panel reviews, assessments of smaller projects such as the development of the Donkin-Morien coal mine, the Denison Mines potash development and the Annapolis tidal power project have been routinely carried out. These non-EA Panel assessments generally involve federal/provincial government review of documentation prepared by the proponent. There are no public hearings, and the environmental impact statements are similar, but smaller, than those prepared for panel projects. Construction and operational requirements are incorporated into a provincial permit. The provinces normally act as the lead agency, with federal input throughout the process.

The majority of proposals from federal agencies never require an EIS or a formal review, but are routinely reviewed by Environment Canada and other agencies through a system of referrals. Individual referral systems include the Navigable Waters Protection Act (NWPA) referral for coastal developments, Department of Public Works (DPW) for construction and maintenance projects, Small Crafts Harbours (SCH) for land acquisitions and wharf extensions, Department of Regional Industrial Expansion (DRIE) funded proposals, and selected Atlantic Region Pesticide Advisory Council (ARPAC) referrals. Routine reviews are also conducted by EPS under the Ocean Dumping Control Act (ODCA). Parks Canada screens proposals within national parks as part of their conservation mandate, and the Canadian Forestry Service screens several thousand small projects related to forestry activities, such as thinning, site preparations and stand conversions. As part of the Nova Scotia Forestry Resource Development Agreement (FRDA), herbicide applications are forwarded to EPS for review.

Many proposed projects, including several which fall under the NWPA, SCH, DPW and DRIE referrals above, are registered with the Regional Screening and Coordinating Committee (RSCC). The RSCC registers both EARP and non-EARP proposals, and serves to identify projects which require further review. Only 7 out of 2,724 proposals registered with the RSCC between 1974 and 1983 resulted in a completed or ongoing EA Panel review in the Atlantic region. Therefore over 99% of registered proposals are routinely reviewed and closed within 2 - 4 months. As in the case with formal reviews, environmental concerns and possible mitigating measures are identified and incorporated into the project. For example, effective waste treatment facilities have been constructed as a result of problems identified by DRIE referrals. Sensitive ecosystems and fish habitat, such as the Chezzetcook salt marsh in Nova Scotia, have been protected due to the mitigation of problems originally defined by referral through the NWPA. A summary of major environmental referrals in the Atlantic Region is given in Table 36.

Management of Toxic Chemicals

Regional pollution concerns from toxic chemicals have been thoroughly discussed. This section examines controls over toxic chemicals and measures for ensuring their safety to the environment and human health. Safety may be threatened when toxic chemicals are used improperly, are spilled accidentally, or where inadequate disposal methods are used. Even when they are used in a prescribed manner, toxic chemicals can still threaten the safety of the environment or human health because of unforeseen inputs due to a lack of knowledge, lack of proper or adequate testing, or from the cumulative impacts from more than one chemical. There is always some risk when toxic chemicals are used, and it is important to be able to assess this risk accurately and to minimize it through environmental controls.

One of the major challenges of government organizations has been the establishment of suitable systems for managing toxic chemicals. Such organizations have been instrumental in advocating better controls on the part of industry and federal and provincial agencies dealing with agriculture, transportation, and forestry. These controls form the basis of an improving management scheme.

Table 36. A summary of major environmental referrals in the Atlantic Region. (From Eaton, Hildebrand and d'Entremont (1986))

Major Environmental Referrals in the Atlantic Region

Referral	Number 1980	Number 1983	Agencies Involved in Referral	Proponent or Sponsoring Agency	Environmental Considerations
Ocean Dumping Control Act	120	142	EPS, DFO provinces	DPW, NHB, MOT	Controls dumping or burning of chemicals at sea. Controlled re-distribution of contaminants in dredge spoils. Some habitat protection and reduced conflict with fishery.
Navigable Waters Protection Act	83	118	EPS, DFO, may include CFS, IWD, and provinces	MOT approves applications	Habitat protection and increased environmental awareness. MOT solely concerned with navigation; EPS coordinates environmental review and deals with proponent.
Department of Public Works	25	49	EPS, DFO	Several agencies, including DPW	Incorporates mitigating measures in construction. Advises on waste treatment facilities.
Small Craft Harbours	21	35	DFO, EPS	DFO	DFO has major role in environmental screening. Some protection of benthic habitat.
Atlantic Region Pesticides Advisory Committee	38	102	EPS, AES, CFS, CWS, IWD, AC	Provinces issue permits; AC issues federal research permits	Ensures that spray operations are conducted in an environmentally safe manner. Protects sensitive areas from pesticides and herbicides.
Forest Resource Development Agreement	—	60	EPS, AES, CFS, CWS, IWD, AC	NSDOE issues permits	Keeps herbicides away from sensitive ecosystems, watercourses and non-target areas.
Department of Regional Industrial Expansion	131	156	EPS, DFO and provinces	Industry proponents; DRIE provides funding	DRIE normally will not fund a project unless it obtains environmental approval. Significant reduction of local pollutant input.
Parks Canada	37	115	PARKS, may consult DFO	DPW, CWS, private industry	Protection of sensitive habitat within national parks and Parks Canada land.
Canadian Forestry Service	—	3334	CFS and provincial lands and forests departments	Private industry, provincial agencies	Protects habitat and watercourses. Ensures activities fall within forest management plans.

AES-Atmospheric Environment Service; AC-Agriculture Canada; CFS-Canadian Forestry Service; CWS-Canadian Wildlife Service; DFO-Department of Fisheries and Oceans; DPW-Department of Public Works; IWD-Inland Waters Directorate; MOT-Ministry of Transport; NHB-National Harbours Board; NSDOE-Nova Scotia Department of the Environment.

Control Mechanisms

Control over toxic chemicals is mainly exerted through legislation, with accompanying regulations and guidelines which define the products that are acceptable, their safe uses, and their acceptable levels in the environment. The federal and provincial legislation relevant to toxic chemical control in the Atlantic region is outlined in Table 37.

Table 37. Federal and provincial legislation related to the control of toxic chemicals. (From Eaton, Hildebrand and d'Entremont (1986))

Federal and Provincial Legislation Pertinent to the Control of Toxic Chemicals in the Atlantic Region

Name of Act	Agency(ies) Responsible	Date of Act and Revisions
Federal		
Environmental Contaminants Act	National Health & Welfare/Environment Canada	1981
Pest Control Products Act	Agriculture Canada	1968
Ocean Dumping Control Act	Environment Canada	1975
Oil and Gas Production and Conservation Act	Energy Mines & Resources	1968,'70
Fisheries Act	Fisheries & Oceans/Environment Canada	1970,'77
Radiation Emitting Devices Act	Atomic Energy Control Board	1970,'82
Clean Air Act	Environment Canada	1971,'81
Arctic Waters Pollution Prevention Act	Environment Canada	1970
Atomic Energy Control Act	Atomic Energy Control Board	1946,'76
Hazardous Products Act	Consumer & Corporate Affairs	1960,'83
Transport of Dangerous Goods Act	Environment Canada/Transport Canada	1980
Food and Drugs Act	Health & Welfare Canada	1954
Pesticide Residue Compensation Act	Agriculture Canada	1970
Provincial		
P.E.I.		
Pesticides Control Act	P.E.I. Dept. of Agriculture	1984
Environmental Protection Act	P.E.I. Dept. of Community & Cultural Affairs	1975,'83
Dangerous Goods (Transport) Act	P.E.I. Dept. of Highways & Public Works	1981
Fish and Game Protection Act	P.E.I. Dept. of Community & Cultural Affairs	1974
N.S.		
Environmental Protection Act	N. S. Department of the Environment	1973,'77
Pest Control Products Act	N.S. Department of Agriculture	1970
Dangerous Goods Transportation Act	N.S. Department of Transportation	1982
Fisheries Act	N.S. Department of Fisheries	1977
N.B.		
Clean Environment Act	N.B. Department of Municipal Affairs & Environment	1973,'83
Pipeline Act	N.B. Department of Natural Resources	1976,'82
Pesticides Control Act	N.B. Department of Municipal Affairs & Environment	1973,'82
Oil and Natural Gas Act	N.B. Department of Natural Resources	1976,'83
Nfld.		
Pesticides Control Act	Nfld. Department of Environment	1970,'81
Waste Material Disposal Act	Nfld. Department of Environment	1973,'81

Source: Environment Canada, EPS, 1985[134].

In much of this legislation, toxic substances control is not the primary purpose (e.g. the Fisheries Act, the Oil and Gas Production and Conservation Act, and the Food and Drug Act), but there is some legislation specifically designed to manage toxic substances. The federal Pest Control Products Act, for example, deals exclusively with the registration, marketing, and utilization of pesticides. The Environmental Contaminants Act controls the production, commercial use, disposal, and sources of entry to the environment of substances deemed to be contaminants under the Act. The Clean Air Act and the Ocean Dumping Control Act seek to control the discharge of contaminants into specific media (the air and the oceans). Regardless of whether legislation is designed to deal with substances, products, or the protection of the environment, it is obvious that considerable governmental effort is being made to manage toxic substances.

In addition to legislative controls, toxic chemicals are dealt with in other ways including management programs, inventories, and public education. The Toxic Chemicals Management Program of Environment Canada is an example of one of the major efforts to integrate the huge task of controlling toxic substances and minimizing their adverse effects on the environment. This program has helped to address chemicals on a national basis, i.e. assess their hazard or risk, develop control strategies, evaluate impacts, and set priorities. In this way a piece-meal approach to the management of toxic substances has been avoided. Although the program offers a comprehensive approach to the management of most toxic substances, there are instances where regional problems must be dealt with separately to effectively tackle unusual, or emergency situations such as PAH contamination at Sydney, N.S.

An important step in managing toxic chemicals is to determine the quantity and distribution of certain chemicals in use, in storage, or in waste disposal sites. In the Atlantic region, inventories are being conducted to determine the toxic waste generation potential of regional industries, the location of active and abandoned waste disposal sites, the location and quantity of PCBs both in use and in storage in the region, and the extent of pesticide use in the region. With this information, efforts are being directed toward cleaning up abandoned disposal sites where toxic wastes have been buried. Also, with this information, the production and use of toxic chemicals can be controlled better, as can the disposal of toxic wastes.

Efforts to increase the public awareness of toxic chemicals and their threat to human health and the environment is an important component of regional programs. Information brochures and fact sheets on toxic chemicals or hazardous wastes are produced by federal and provincial environmental and health agencies. These cover such topics as hazardous household wastes, pesticide safety, problems with

PCBs, or disposal of hazardous waste. Others provide information to the public on specific legislation such as the Environmental Contaminants Act or the Ocean Dumping Control Act. Agencies in the region also conduct seminars, workshops or public lectures on toxic chemical management.

Recreational Fishery Catch Statistics

The total number of fishing licenses sold in Nova Scotia from 1966 - 92 is shown in Figure 17. The survey of Sport Fishing in Nova Scotia is part of the National Survey of Sport Fishing in Canada; this latter survey is taken every five years and provides the sport fishery with comparative data on itself at regular intervals. Based on these surveys, license stub return data and the number of licenses sold, recreational fishery catch statistics are compiled. Unfortunately, the data are not detailed enough to provide accurate trends in the fishery for watersheds or RFAs. Secondly, since the data are completed at the end of the fishing season, its accuracy depends in the vast majority of cases on the angler's recollection of the number of individual species caught, their identification and location of capture. Since the number of stub returns is low, questions arise as to whether the data are very accurate. The data series over time may provide trends in the recreational fishery which would be useful to the fishery manager. Overall, improvements are needed in sport fishery catch and effort statistics so that the data are more useful for managing the recreational fishery by watershed, county and RFA.

If it is assumed that the number of fish caught per stub return reflects the average catch per angler, the data for each species is graphically illustrated for the whole province in Figures 18 to 25 for the period 1966 - 92. Also, since the license stub return rate is low, the consultants suggest that the data have limited value in assessing fish stock levels. Unfortunately, data was not available by county or RFA to carry out a similar analysis which might indicate stock trends in various parts of Nova Scotia.

From this data speckled trout, brown trout, striped bass and yellow perch catches per angler (Figures 18, 20, 23 - 24) have declined while rainbow trout catch per angler (Figure 19) appears to have stabilized since the large catches observed in the late 1970's and early 1980's due to large numbers of escapees from aquaculture sites in the Bras d'Or Lakes. Smallmouth bass catches per angler (Figure 21) have increased in response to the introduction and spread of this species in RFA 3, 4, 5 and the rise in popularity of this species as a sport fish. Shad have shown wide fluctuations in catch per angler (Figure 22) over time; however, catches appear to be increasing also reflecting the increased popularity of this species as a gamefish. If these catch per angler trends reflect population size, this corroborates public observations that speckled trout stocks are in trouble.