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REVIEW OF ATLANTIC SALMON ASSESSMENT PROGRAMS
IN THE FRESHWATER AND ANADROMOUS DIVISION
BIOLOGICAL SCIENCES BRANCH
SCOTIA-FUNDY REGION

APRIL 30 - MAY 3, 1991

Table of Contents

I	Preamble	2
II	Overview of the Salmon Assessment/Enhancement Section	2-3
II	Stock Assessment Advice	3-9
IV	Research Involvement	9-14
V	Highlights	14-19
Appendix	I Agenda of the meeting with the Review Team	20
Appendix	II Terms of reference for salmon assessment review	21
Appendix	III Project review, evaluation and planning 1990/91 for Stock Assessment and Enhancement Section of Freshwater and Anadromous Division, Scotia-Fundy Region	22-25
Appendix	IV Mandate of Biological Sciences Branch and of Freshwater and Anadromous Division, Scotia-Fundy Region	26
Appendix	V Stock Assessment & Enhancement Section 1991/92 budget by Collator	27
Appendix	VI Stock Assessment & Enhancement Section 1991/92 O&M and personpower	28
Appendix	VII Stock Assessment and Enhancement Section organization chart showing proportion of person years used for salmon assessment	29
Appendix	VIII Stock Assessment & Enhancement Section organization chart showing proportion of person years used for salmon enhancement	30

SCIENCE REVIEW OF SCOTIA-FUNDY REGION ATLANTIC SALMON ASSESSMENT PROGRAM

APRIL 30-MAY 3, 1991

Review team:

M. Henderson, Biological Sciences Branch, Vancouver
C. Hudon, Biological Sciences Branch, Halifax
D. Meerburg, Fisheries Research Branch, Ottawa

Also present:

M. Sinclair, Biological Sciences Branch, Halifax
J.-J. Maguire (April 30 only), CAFSAC, Quebec

I PREAMBLE

The Review Team met with staff of the salmon assessment program on April 30 (items 1-5 on the Agenda - Appendix I) and continued their interviews for items six to eight for one-half of May 1. During the remainder of May 1 and 2, this report was prepared in draft form for presentation/consultation with program staff on May 3, after which the report was finalized.

The terms of reference for the Review Team are listed in Appendix II. Each of the section's activities listed in the expected outputs for 1990/91 in the PREP document (Appendix III) was examined in the context of each of the terms of reference. Assessment/ management and science related activities are discussed in sections three and four below respectively. Highlights of the team's findings are summarized in section five.

II OVERVIEW OF THE SALMON ASSESSMENT/ENHANCEMENT SECTION

Comparison of the Salmon Stock Assessment Section of Scotia-Fundy with its counterparts in other DFO regions shows major differences in structure, mandate and general operation, in that it is the only region in which the responsibilities for assessment, enhancement and research are found within the same Section. This structure greatly facilitates the linkages between the three activities. For example, it allows program biologists to assess directly the effects of enhancement, to use hatchery-reared fish to test research hypotheses or to orient research towards assessment needs. The concentration of the three activities presumably reduces the duplication of data gathering efforts and increases overall program efficiency. The most obvious drawback is in the potential for conflict in resource allocation between activities in times of budgetary constraints.

The Section's regional mandate extends over the Atlantic drainage basin, comprising most of Nova-Scotia (except western Cape Breton) and the Bay of Fundy coast of New-Brunswick (primarily the Saint John River system). However, in the upper Saint John River basin, the management responsibility is under the Gulf Region (eg. Tobique River). Parts of watersheds in New Brunswick also cross international borders (i.e. Aroostook River of the Saint John drainage and the St. Croix River). The Scotia-Fundy Region includes several Indian bands, whose food fishing allocations are currently being negotiated. This situation results in sometimes elaborate dealings with various levels of authority, in order to gather statistics, assess the stocks, and allocate the fish resources. The area also comprises vastly different river systems, in terms of their sizes, physiography, the environmental problems affecting them (dams, acid deposition, low water levels), and the level of fishing pressure they experience.

Since the level of resolution required in fisheries monitoring data from angling catches is higher than that supplied by the Statistics Division, the Section is gathering most of its basic statistical information (angling catches, fishway counts, long term monitoring data, etc.). The estimates of adult salmon angling catches is particularly time consuming since it involves salmon licence stubs returns, the effectiveness of which varies between provinces (licensing is under provincial jurisdiction). This task is an important part of the Section's activities and should be spelled out in its mandate.

In addition, the committee noted the important involvement of the Section with management issues, well beyond that of scientific advice. This situation stems partly from historical development of the Section and from its staffs' lengthy involvement in salmon issues compared to staff of Fisheries and Habitat Management Branch (FHMB). This gives Section staff a privileged standpoint from which to weigh the available alternatives to satisfy often conflicting views among resource users. Again, this situation incurs benefits and costs. Although this arrangement is very efficient to answer queries from management, it could easily be done at the expense of assessment and research activities which constitute the essential part of the Section's mandate (Appendix III). Given the often urgent (crisis) nature of management requests and the absence of clear boundaries for resource and time allocation, long-term ongoing programs (often research-oriented) are likely to be the ones delayed or compromised.

III STOCK ASSESSMENT ADVICE

The assessment of Atlantic salmon in Scotia-Fundy Region is accomplished through a variety of monitoring activities. These monitoring activities include direct counting/estimation of various life stages of salmon in many of the approximately 60 salmon rivers in the Region and through the annual estimation of harvest by anglers in each of these rivers. The purpose of having these monitoring activities is to be able to respond routinely to requests (both direct and implied) from fishery managers on the current and historic status of salmon stocks, the past effect of specific management measures and the expected availability of salmon, by sea-age class, in coming years, as well as the effect of any proposed management changes. Assessments are routinely conducted of either the status of any particular stock or the availability of salmon in coming years incorporating the idea of either a minimal or optimal spawning escapement target, in terms of the number of eggs needed, in a particular watershed. Many of the "implied" requests for stock status advice are responded to by annual input into the Anadromous, Catadromous and Freshwater Fisheries Subcommittee (ACFF) of the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC); each activity usually results in the release of information to user groups as CAFSAC advisory documents and/or CAFSAC research documents. The word "implied" was used here as the Region is not asked specifically by CAFSAC (nor apparently is CAFSAC asked specifically by fishery managers) for advice on any particular river. As well as this route for advice to fishery managers, the staff of this division are also expected to provide direct advice to regional fishery managers on day-to-day issues.

A representative of the Fisheries and Habitat Management Branch (FHMB) in the Region (Mr. G. Stevens) presented an overview to the Review Team of the requirements for advice. He indicated that the clients for such advice are the three user groups in the Region:

1. The commercial fishermen - there are relatively few (about 40)

of these left now as commercial fishing for salmon has been closed in this Region since 1984 and many fishermen have accepted voluntary termination of their licenses through "buy back" programs.

2. The recreational fishermen - These are the most numerous client group, and are licensed by the two provinces (N.B. and N.S.) in which they fish. They have not been allowed to retain large salmon (> 63 cm) since the 1984 Salmon Management Program was introduced.
3. The Native food fishermen - This group has had a minor role in salmon harvesting in most of the Region in the past, the exception being the Saint John River. Up until recently, only 3 of 16 bands had Indian Food Fishery permits. Recent court decisions however are expected to change their participation as their right to salmon (for food) has been determined to be second only to conservation, and ahead of either recreational or commercial users.

Mr. Stevens outlined the types of requests for advice from the Division that had arisen in the past few months. They included estimation of surpluses which may be available for Indian Food Fisheries, the possible impact of allowing large salmon to be retained by anglers on specific rivers, the degree of success in stocking programs in the Inner Bay of Fundy, the impact of possible changes in angling seasons, and the consequences of "scheduling" of rivers. In the future, he indicated that the Division could expect increasing requests for advice on a river-by-river basis as this appears to be the direction salmon management is taking; his ultimate goal was stated to be the identification of numbers of Atlantic salmon by sea age class, available for harvest on a yearly basis by river and estimated about 6 months prior to the fishing seasons. As well as requests on Atlantic salmon stocks, he also indicated that advice is sought from this Division on other anadromous (shad, gaspereau, striped bass), catadromous (eels) and freshwater (smallmouth bass) fishes.

The Review Team was surprised with the complexity and volume of the requests, almost all of which are delivered verbally with an expected response in matters of days or hours. It appears difficult to foresee all such requests but it would nevertheless clarify the requirements of the Division if FHMB were to seek the majority of such advice in a written fashion, preferably well in advance of the time it is needed. As well, it would seem sensible that staff of FHMB assist in the annual review of the Division, (in October-November) when work plans for the coming year are being developed, by identifying at that time their priorities/objectives for the future. Mr. Stevens indicated an extremely high level of satisfaction with the advice received from, and the relationships with the staff in the Division. He also noted that demands placed on the Atlantic salmon stock assessment staff by FHMB were greater than those placed on stock assessment staff in other divisions; this related to the large number of discrete salmon stocks, the management process by zones (involving numerous advisory meetings) and the large and varied number of user groups. The Review Team was pleased to see such rapport and satisfaction between stock assessment staff and their major client, the FHMB.

The following were the stock assessment related goals/expected outputs for 1991/92. They are ordered based on our perceived priority; numbers in parentheses refer to their order in the PREP document.

1. (1) Prepare required assessments of Atlantic salmon stocks to define stock

1. (1) Prepare required assessments of Atlantic salmon stocks to define stock status, such as Saint John, St. Croix, LaHave, Stewiacke, Liscomb, St. Mary's, Grand, Middle and inner Fundy rivers and where possible, forecast future returns.

The methodology to accomplish these goals will primarily be the monitoring of various age classes of salmon in the rivers during the coming six months. The most important of these operations are those used for the enumeration of adults at fish passage facilities on the rivers. In most cases, these facilities are upriver from tide and assessment is only on that portion of the watershed above the facility, resulting in an incomplete estimate of total river returns. Expected spawning escapement in numbers of fish by sea-age is converted to egg deposition (generally using river-specific biological characteristics), which is divided by the estimated area of suitable rearing habitat for parr in the appropriate river section. The result is then compared to a standard of 2.4 eggs per m² which has been adopted as a minimum target, pending completion of research to modify this value. As well as providing this estimate of status, the assessments document the catches by user groups along with their effort levels, where known.

The Review Team recognizes the above process to be the principal goal of the stock assessment component of the Division and clearly part of its mandate. While nine rivers are expected to be assessed this year, and this is an increase of two over last year's intentions, concern was expressed by both regional reviews and this Team that resources may be insufficient for such an ambitious program. We recommend that consideration be given, in the context of current budgets, to consolidation of the numbers of rivers reviewed with possible expansion of the assessments on major rivers, such as the Saint John, to include those portions of the watersheds below the enumeration facilities. This seems to be particularly relevant where a majority of enumerated fish are principally of enhanced origin and the downstream component are of wild origin. The priorities assigned seem reasonable and the Review Team recommends that the Division should try to annually undertake at least four river assessments, generally on the same rivers each year. At least one system should be represented in each of the following four areas; Cape Breton (SFA 19), Atlantic Coast (SFA 20, 21), Inner Bay of Fundy (SFA's 22-23) and the Saint John River (SFA 23).

The Review Team recognizes the additional effort undertaken by the Region to incorporate assessments on both the enhanced and wild components of the adult returns; this necessitates extra expenses in terms of recognition of such fish (by scale characters, external characteristics) but is valuable as a documentation and evaluation of the enhancement program. The ease by which this is accomplished is probably accounted for by the organization of duties combining both assessment and enhancement activities under the same biologist. In other Regions, where there are separate Sections or Divisions responsible for enhancement, there is a much less rigorous evaluation of enhancement production. The Scotia-Fundy model has probably developed as a result of the high dependence by this Region on enhancement stocks (up to 50% of total adult returns).

The major concern identified about the salmon assessments was the reliance for New Brunswick assessments on angling data of unknown quality and lack of comparability over time; we recommend that this should be addressed as it implicates assessments for New Brunswick rivers within the Scotia-Fundy Region as well as the Gulf Region. As was indicated during this review, angling statistics are often the only parameter currently available that can be used to interpret stock status on rivers which do not have counting

facilities.

The Review Team was encouraged to see the development of alternate methods for adult enumerations in rivers (diver counts, electrofishing surveys, etc). We recommend the validation of such techniques, where and when possible. As well, the initiation of smolt monitoring on the Little and LaHave rivers is recognized as an important addition to the program, to assist in providing forecasts of grilse returns as well as investigating variability in marine survival of wild and/or hatchery smolts.

2.(2) Prepare timely biological advice and recommendations for internal and external clients and service, particularly the biological information needs of the Zone Management Advisory Committees (ZMAC). Involve external clients where feasible and desirable in the collection of biological data.

All biologists in the stock assessment portion of the Division participate in the ZMAC process; this allows them regular contact with the user groups (both external and internal) which is valuable in terms of the understanding of the development of the fisheries management plans and the utility of the scientific advice. As well, by assignment of particular SFA's to individuals, a sense of responsibility for the resource in that area is also imparted. These are the very positive aspects of such an organization of duties; the downside however is the requirement of each of the individuals to prepare assessment reports and attend scientific and advisory meetings, sometimes diverting attention from other important issues such as documentation of research results. It is recognized by the Review Team that there is a delicate balance of the allocation of time between the two areas.

The provision of advice to clients is obviously part of the mandate of the Division and, as expressed by FHMB as well as indicated by the numerous public group contacts (and sources of extra funding), is a job well done. With the combination of knowledge and expertise in the combined areas of enhancement, assessment and fish culture in the Division, a very powerful group from the client's point of view has been created. They hold the knowledge of individual user group's harvests in each river, escapement counts, juvenile information as well as the capacity to change production levels via the enhancement/fish culture activities. This often means that the Division is approached directly by client groups on questions which, for other species may be more generally asked of FHMB.

3. (12) Develop and prepare required regional input for special CAFSAC investigations for Canada's input to ICES and for Canada's input to NASCO.

The development and provision of scientific advice to international bodies which have a direct bearing on management of Canada's anadromous fish stocks is routinely noted as a high national priority. ICES is contracted by NASCO to provide scientific advice for the conservation and management of Atlantic salmon stocks throughout the North Atlantic; advice on the status of stocks in homewaters and the interception and/or exploitation rates in distant waters has been used by NASCO to both change seasons and quotas of fisheries affecting Canadian salmon stocks. The Review Team felt the level of regional participation and cooperation in these bodies was both necessary and, as well, advantageous to the Region in terms of development of innovative assessment approaches. Because of the concentration of NASCO on interception reduction, the knowledge provided by Scotia-Fundy Region with both numerous tagging data bases and adult enumeration facilities is extremely valuable and merits further development (see Section IV).

4. (9) Plan, coordinate and conduct the continuing cooperative sonic tagging project for studying adult Atlantic salmon movements and behaviour on the Saint John River.

The project, cooperatively undertaken with New Brunswick Power and interested Atlantic salmon recreational users (i.e. ASF), is investigating the potential problems of having a "free swim" policy on the Saint John River and of the holding characteristics of adult salmon in the area of the Hartland Pool. A "free swim" policy will be a necessity in the future management of the Saint John River. Until recently, all fish returning to Mactaquac could be directly transported to the Tobique River, the main production area of the middle Saint John, bypassing three dams. With the development of the Aroostook River by the U.S. and the developing program of enhancement on the Upper Saint John, it will no longer be reasonable to transport all fish to the Tobique. Selective transporting of Aroostook or Upper Saint John fish is not possible as individual identification of these fish is not feasible. This tagging/tracking program is therefore being undertaken to investigate and propose improvements to fish passage facilities on the Beechwood and Tobique dams, sites which are known previously from simple external tag studies to be very inefficient at passing fish. The tracking study is allowing some insight into fish behaviour at different distribution sites and approach paths taken towards passage facilities.

The attainment of a policy for salmon management on the Saint John which is satisfactory to all users is a priority. The cooperation to date with groups such as the N.B. Power and the ASF, using their resource contributions, is valuable and expected to continue; without it, this project would not have been undertaken.

The use of sonic tracking gear is new to the Division (at least in recent years) and this project therefore allows the development of expertise which may be useful in coming years for other investigations.

5. (11) Direct biological investigations carried out under the pilot "river-specific management" project for the St. Mary's River.

This project is a cooperative venture on the St. Mary's River with the St. Mary's River Association and is funded primarily by DFO (FHMB) for \$60 K annually for a proposed 3-5 year period. Project plans include: estimation of the habitat production potential, estimation of adult salmon catch by creel survey, collection of stock-specific biological characteristics, estimation of parr production and determination of spawner distribution. Approximately 1/2 of the budget is paid as salary to a biologist hired by the Association to implement the projects with the remainder going towards operation of the projects. The Biological Sciences Branch in Scotia-Fundy is involved in the organization of the project and in the provision of advice on methodology but not extensively in the financing of the study. Results from this project will be useful to the Division as it will increase the knowledge base on salmon stocks in this river and could also be used as a pilot for future expansion of assessment capabilities if any new funding became available. The extensive public involvement is good for the Department's image, both on the management and stock assessment sides. There is however concern that public expectation on this river, as well as others which do not currently have such projects, is being raised for management plans tailored to individual rivers. Without such additional projects (including resources), scientific advice for other rivers will be difficult to provide. Indeed, it was identified during the review that, even on the St. Mary's River this year, funding for this study was almost

eliminated, even though movement toward river management is said to be a major objective of salmon managers.

6. (13) Provide consultation and direction on the choice and use of salmon stocks and on the distribution program for adult and all stages of juvenile salmon.

The decision on where and at what stage to stock salmon is an important one. In 1990, advice was given concerning the collection of 23 salmon broodstocks (assistance was directly provided in 12 of these operations), approximately 12,000 adult salmon on the Saint John were transported to specific sites requiring this unit's direction and over 2 million juveniles were stocked. This goal seems to be primarily in the area of salmon enhancement of the Division's mandate however, knowledge of the productive capabilities of the various life stages, stocked in different places, arises from stock assessment activities. The amount of time or resources involved in reaching this objective was unclear to the review team. However, it was recognized that there can be extensive pressures (both political and by public groups) which affect such distribution plans. Accordingly, even though there may be strong scientific reasons for proceeding in a certain direction, these options may be overruled by other forces. Rationale for specific stocking plans as well as production expected to result from them should be annually documented.

7. (14) Continue preparation of individual river management plans, to the extent time permits.

The expectation is that, for the coming year, this Division will be participating in the preparation of development and management plans for the St. Croix and Saint John rivers. The mandate for doing so, by the Biological Sciences Branch, is, at best, unclear. While the Department is probably attaining maximum efficiency in terms of staff and resources by having knowledgeable staff in the Freshwater and Anadromous Division participate, and in fact perhaps even initiate such processes, it is somewhat of a "grey area" in terms of responsibility that in some regions would be handled by the Fisheries Management Branch.

8. While neither mentioned as part of the mandate or under the goals for the coming year, the routine collection of angling statistics for Nova Scotia is expected to require significant staff and resource time. Such a system has been in place since 1983 when the decision was made to eliminate angler catch estimation as part of Fishery Officer's responsibilities.¹

Unlike other Divisions, who also depend on catch statistics to provide stock assessments, the Atlantic salmon assessment group had to develop and fund (at least in part) the annual estimation of angling catches in all N.S. rivers; such information is also used by Gulf Region assessment biologists for their portion of N.S. In other Divisions, statistics are provided by the Economics and Statistics Branch.

¹The review team was subsequently informed that some of these goals had been incorporated into another PREP document. It was not, however, previously noted as a portion of the Division's mandate.

The model developed (license stub returns) and indeed, the science involved in the process, has been documented, ground-truthed using creel surveys, and optimized in terms of costs (i.e., one mail-out now rather than two). Such effort involves extensive collaboration with the Provincial government, who provide financial support for some of the mail returns. The Review Team felt this program to be a necessity, although somewhat a strange obligation for Biological Sciences Branch. As was mentioned during the review, angling statistics (preferably precise and unbiased) are often the only data we have on rivers for which no formal assessments have been provided; they can give indications of stock status and available harvest, assuming some varying levels of exploitation rate.

As was mentioned in 1 previously, a major gap in knowledge exists in comparable statistics for the New Brunswick recreational fishery; such data is needed by the Gulf Region also. With the Nova Scotia model in place, the Review Team recommends that increased pressure should be brought to bear on the Province of New Brunswick to adopt a similar system.

IV RESEARCH INVOLVEMENT

The following were the research related goals/expected outputs for 1991/92. They are ordered based on our perceived priority; numbers in parentheses refer to their order in the PREP document.

1. (6) Salmon production capacity of rivers

A substantial amount of effort has been devoted to describing parr density as a function of river gradient and distance from head of tide. This project is well designed and makes a very significant contribution to our understanding of the biology of Atlantic salmon. Results from this project will allow estimates to be made of optimum female spawning escapement by stream or river and greatly assist in environmental impact analysis. This project is consistent with all four functions of the Freshwater and Anadromous Division. We recommend:

i) the results of this study be published in the primary literature as soon as possible. This is necessary to ensure that the project receives adequate and independent review (i.e. it was not possible in the available time for the Review Team to accomplish a detailed review and evaluation). Publication will ensure that the results are available to, and accepted by, others responsible for the assessment and management of Atlantic salmon stocks. It is our view that publication of the results from this study in the primary literature is the number one priority with respect to the scientific activities of the Freshwater and Anadromous Division.

ii) that once accepted, the methodology be applied to other salmon stocks in the Scotia-Fundy Region as a means of estimating the optimum number of juveniles and thereby female spawners.

2. (6) Parr density and age at smoltification

A preliminary study by personnel of Freshwater and Anadromous Division suggests there is an inverse relationship between parr abundance and age of smoltification. The objective of the proposed project is to document and quantify this relationship. The effect of parr density on age of smoltification has important implications for the acid rain study (3.(7) below) and for the study of salmon production capacity of rivers (1.(6)

above). In particular, overall survival to the adult stage, and hence productivity, will decrease with increases in the time spent in fresh water.

The past and current focus of this project is well defined, and the results are important from both a scientific and management/assessment perspective. The project is consistent with functions one, two, and three of the Freshwater and Anadromous Division. We recommend:

- i) the project continue as planned;
- ii) the results be incorporated into the acid rain model and,
- iii) the results be published in the primary literature as soon as practical.

3. (7) Effects of acid rain on Nova Scotia salmon stocks

Acidification of streams and rivers has a demonstrated serious effect on Atlantic salmon production in the Scotia-Fundy Region. To deal with this concern, personnel of the Freshwater and Anadromous Division worked with staff of Environmental and Social Systems Analysis Ltd (ESSA) to develop a model for the Scotia-Fundy Region simulating the effects of acidification on salmon production. The product of the workshops and modelling activities included i) the potential for initiating the development of river-specific salmon management strategies and for the exploration of alternate management strategies for acidified systems, ii) improving communication and integration of research activities and, iii) the development of research priorities. This project has provided a good scientific basis on which to develop required management and research studies related to the effects of acidification on Atlantic salmon and is consistent with functions one, two and three of the Freshwater and Anadromous Division (APPENDIX IV).

We think the implementation of the acidification project provides an excellent example of one means by which personnel in the Freshwater and Anadromous Division can proceed in carrying out good science in the face of limited resources and P/Ys. In this case non-A-based money was used to establish a contract with a firm in the private sector that had considerable expertise in the area dealing with the effects of acidification on fish. We encourage this type of arrangement, where possible and practical, in the future.

Further progress on model development and in making inferences regarding the effects of acidification on streams and appropriate mitigative actions will be dependent, in large part, on the acquisition of new data and information. We recommend:

i) personnel of the Freshwater and Anadromous Division carry out a detailed review of the additional data and information requirements for the biological and hydrochemical components of the model as described in the ESSA report. A considerable amount of time and resources have been expended on this project and now is an appropriate time to evaluate the future overall direction of the project and particular steps that should be taken in the near future, if any.

ii) additional data and information requirements, as identified in the review described in i) above, be collected whenever possible as part of current monitoring programs. We do not recommend new field programs to acquire the data or information at this time. We make this recommendation to secure the

integrity of existing field monitoring programs and to ensure that current research projects are brought to a successful conclusion prior to the initiation of major, new activities.

4. (5) Changes in the proportion of MSW salmon in mainland stocks

There has been a decline in the MSW proportion of the total salmon return to the Scotia-Fundy Region in recent years. The CAFSAC document 90/84 reports on the derivation of a new regression methodology for estimating the return of MSW salmon to the Saint John River. The regression, based on grilse abundance and fork length in year $t-1$ (Ylen), accounted for over half the variation in MSW returns in year t . This study has a good scientific basis, provides a useful management tool for forecasting MSW returns, and is consistent with functions one and two of the Freshwater and Anadromous Division. However, a number of uncertainties remain including, environmental effects on the tendency to mature as 1SW versus MSW, the applicability of the regression to other river systems, and the causes of variation in marine growth of 1SW fish. As a result of the importance of understanding the mechanisms behind the possible shift in population structure from MSW to 1SW fish (grilsification) from both a management and scientific perspective, we recommend:

- i) the study continue and remain a high priority;
- ii) attempts be made to include Canadian origin salmon stocks from outside the Scotia-Fundy Region in the analyses;
- iii) results of the study be published in the primary literature at the earliest possible date and,
- iv) the regression between MSWS and Ylen be re-examined in light of the observation that the nature of the regression is dictated by the very large estimates of Ylen in four of the last five years. This suggests the possibility of an environmentally-induced effect and raises questions about long-term climate change.

5. (4) Recreational catch as an indicator of stock size

A proposal has been made to develop a model of recreational catch that would enable the use of catch as an indicator of stock size (i.e. in the river). Such estimates are needed for estimating the total return to a river for the post season analysis and, for making inseason estimates of stock size on which decisions could be made regarding the opening and closure of recreational fisheries. Estimates of stock size would also be used in conjunction with the results from the project on salmon production capacity of rivers (1.(6) above) to determine optimum spawning escapement. It should be noted that translating the recreational catch estimate into an estimate of total stock size would require a calibration process whereby the recreational catch and an independent estimate of total stock size is available for at least some systems (ideally for all where the technique will be used) for one or more years.

Currently, there are no reliable estimates of stock size for many of the salmon rivers in the Scotia-Fundy Region. This is a major problem from the perspective of stock assessment and management. Results from this project would represent a valuable contribution to applied fisheries science and to the management of Scotia-Fundy salmon stocks. Further, the project is

consistent with functions one and two of the Freshwater and Anadromous Division. We think this project, incorporating the recommendations listed below, is a high priority. We recommend:

i) the project be implemented. We think the development and testing of a model that can be used to estimate stock size in rivers is not a trivial task. We suggest that considerable thought should be given to exactly what is required by way of output from the model. For example, what levels of precision and accuracy are required in the estimates of stock size, what are the appropriate temporal and spatial scales for the estimates of stock size, and can an estimate of stock size from one system be used as an index of stock size in adjacent river systems? Fortunately, there is a large amount of information, both theoretical and applied, available in the primary literature that deals with the issue of relating indices of abundance, effort, catchability and catch to total stock size.

ii) some effort be made to evaluate the relative merits of other techniques for estimating in-river stock size. These should include acoustic and mark-recapture in-river methods.

6. (5) Interception of Scotia-Fundy salmon in distant waters

Studies of various Atlantic salmon stocks in the Scotia-Fundy Region indicate that there has been historically a substantial harvest of these fish in distant-water fisheries. Information on the distant water harvest, along with estimates of the harvest in home waters, is necessary to reconstruct the total stock size and thereby allow estimates to be made of the productivity of stocks. The distant water interception project is consistent with functions one and two of the Freshwater and Anadromous Division.

We think that generating estimates of distant water harvest will be important in explaining year-to-year variation in recruitment of salmon to home waters and rivers of the Scotia-Fundy Region. This in turn is essential information for determining the relative importance of freshwater and marine effects on recruitment. Partitioning total survival into freshwater and marine components will assist in determining the probable outcome of freshwater enhancement activities.

It is difficult to make recommendations as to the future direction of this project. On one hand, reconstructed annual estimates of total stock size are important for the reasons cited above. However, it is not clear that techniques are available for generating accurate annual estimates of stock composition for distant water fisheries, particularly in Newfoundland waters. Based on these considerations we recommend:

i) additional efforts be made to develop techniques that will allow accurate estimates to be made of the catch of major stocks of Scotia-Fundy salmon in Newfoundland fisheries. If such a technique can be developed, the next step would be to develop coordinated sampling programs with other regions and/or countries;

ii) after the techniques and sampling programs described above are available, renew attempts to reconstruct the total stock size by year for major Scotia-Fundy salmon stocks and,

iii) refrain from further efforts to quantify the catch of Scotia-Fundy salmon stocks in Newfoundland fisheries until the conditions described in i) above are met.

7. (3) Pre-season and in-season forecasts

Annual forecasts of MSW returns are generated for a small number of rivers in the Scotia-Fundy Region. These are generally based on the return of 1SW fish in the previous year. More recently, forecasts based on regressions using additional variables have also been used with limited success. Efforts to generate models for preparing in-season forecasts are very limited. The one exception is the study of the relationship between recreational catch and in-river stock size described below. The attempts made to date to construct models for generating pre-season and in-season forecasts are consistent with functions one and two of the Freshwater and Anadromous Division.

Discussions with the Anadromous Advisor of FHMB made it clear to us that both pre-season and in-season forecasts of returns were very desirable. This would suggest that more scientific effort be devoted to the subject of forecasting. However, we are also aware of the very limited data base on which to generate and test models for forecasting. Further, our lack of understanding of the mechanisms in the marine environment that control survival make it difficult to construct models that would be robust. Consequently, we recommend:

i) resources devoted to preparing pre-season and in-season models for forecasting salmon returns should remain at current levels as it is unlikely that substantial progress can be made until the time series of data is increased and there is a better understanding of marine mechanisms controlling survival.

8. (8) Use of image processing system for scale pattern analysis

An image processing system has been acquired for the purpose of scale pattern analysis. The system would be useful for making various types of growth measurements from scales (eg. marine and freshwater growth), for distinguishing between hatchery and wild salmon, and for providing the data necessary for stock identification studies. Although the image processing system could, and undoubtedly will, be an important research tool at some stage, our major difficulty is that it is not clear at this time how it will be used and for what purpose. The situation is further complicated by the lack of a person dedicated to "debugging" the system and who can provide training in the use of the equipment for others. As a result, it is not possible to identify any particular Division function that is currently being met by having the equipment available. Based on these concerns and the limited resources available to the Division, we recommend:

i) one individual in the Division be responsible for the security of the system until such time as it is in regular use. We do not recommend that anyone in the Division spend much time familiarizing themselves with the system (at least to the extent that this would impact on other ongoing programs) until there is a well defined need for the equipment.

ii) other personnel in the Biological Sciences Branch be made aware of the availability (at least over the short term) and the capabilities of the system.

9. (10) Causes of recruitment failure of inner Bay of Fundy stocks

The recruitment of salmon and grilse from inner Bay of Fundy stocks, as

indicated by recreational catches, has been below expectations in each of the last four years and has been very low in three (1987, 1988 and 1990) of these years. The low level of recruitment has been attributed to events in the marine environment. Five possible mechanisms have been postulated; i) exploitation, ii) predation, iii) competition, iv) changes in the physical or chemical environment of the Bay of Fundy and, v) disease. Preliminary results suggest the recruitment failure is not related to exploitation, competition, or to changes in the physical or chemical environment in the Bay of Fundy. Predation also appears unlikely to account for the recruitment failure although these results are less certain.

Infection with the bacteria Vibrio sp. does appear to be a reasonable mechanism that could explain the low marine survival witnessed in recent years. The bacteria can be lethal to Atlantic salmon. Further, the marine distribution of Bay of Fundy stocks in relation to aquaculture facilities could be making these salmon particularly vulnerable. An experiment, based on the vaccination of inner Bay of Fundy salmon smolts against Vibrio, has been initiated to test this hypothesis. The smolts used in the experiment were marked with Carlin tags.

The current status of the project dealing with the cause(s) of recruitment failure for inner Bay of Fundy salmon stocks is a well designed scientific study and is consistent with functions one and two of the Freshwater and Anadromous Division. There is no doubt that identifying the cause of the recruitment failure and possibly rectifying or mitigating the situation is an important goal for the Scotia-Fundy Region.

Our only major concern regarding the project relates to the recovery of tagged fish when they return to home waters as maturing adults. Less than 10,000 smolts (vaccinated and unvaccinated) were used in the experiment (i.e. 1989 and 1990 releases). This is a relatively small tag release group and raises the concern as to whether recoveries will be sufficient (particularly as no facility is available to provide complete counts of river returns) to permit an adequate test of the hypothesis.

We recommend:

- i) efforts be made to maximize the rate of tag recovery;
- ii) the experimental vaccination study be monitored closely and carried through to completion;
- iii) the results of the experimental vaccination be published as soon as possible after the completion of the study and,
- iv) consideration of testing the other hypotheses described above be deferred at least until the completion of the experimental vaccination study.

Recommendation iv) is made based on the lack of convincing information supporting any of the other hypotheses described above and is intended to help ensure that enough personnel and resources are available to complete other important ongoing research projects.

V HIGHLIGHTS

1. Resources

In view of its mandate and activities, the section uses remarkably little financial (O&M) and human (P/Y) resources (Appendix IV). As was said

earlier, this efficiency is in part due to the overlap between activities requiring common data. The permanent staff members appear to have well defined niches which are closely articulated to each other, making it largely self-contained in terms of the routinely required expertise. On a superficial level, each niche appears to have been developed to suit not only individuals' job description but also their respective character and abilities. This balance suggests a well seasoned team, with the stability and cumulative acquired knowledge required to efficiently answer its clients. However, it is important that enthusiasm, creativity and drive be maintained by periodical change/addition/training of personnel and/or reorganization. In this respect, members of the Review Team were surprised to note the classification level of the Special Projects Biologist. In other regions, similar positions are classified at higher levels in the BI category or alternatively in the RES category. The Section should also consider obtaining a new RES position to enhance the science component of its activities.

In the mid-1980's, as a result of Atlantic-wide reviews, resources for Atlantic salmon assessment were reduced by about 11% in Scotia-Fundy Region, to somewhat less than 9 Py's per year in 1987/88. This level of staff has been maintained to this year (1990-91). Further reductions are expected in 1991-92 as a result of downsizing. Accordingly, some reorganization is expected to take place in the Division this year to cover the expected losses. As usually is the case, managers try to obtain required reductions by decreasing term staff and not permanent personnel. The difficulty for this Division, compared to others, is its heavy reliance on term personnel for fishway monitoring, broodstock collection, etc. For example, about 1/4 of the current staff in the stock assessment area in this Division are term personnel. The same goes for the possibility of contracting out special expertise not currently available within the Section.

With respect to financial resources, we determined that the O&M allocation is in the order of \$10-15 K per permanent PY. The Review Team felt that some insight could be gained by comparing this allocation to the allocation for professionals in other divisions with similar responsibilities both in and outside of the Scotia-Fundy Region. We note the Section does not use resources external to the Branch such as ship time, and must devote a large part of its budget (\$79K/\$130K) to travel, transportation and communication, and fuel costs. The numerous routine activities such as maintaining counting facilities, handling mail to anglers, and entering data or reading scales take away precious time from permanent personnel and/or operation money for term and contract employees. Inclusion of statistics gathering in the Section's mandate would acknowledge the effort spent and better justify the present funding allocation, which should not be the entire burden of a Science Branch Division.

The Review Team questioned the implication of hypothetical further budget reductions, as well as hypothetical increases to try to ascertain the Division outlook on priorities. The responses are shown below, as much as possible in order of priority on projects which would be undertaken. The Review Team agreed with these outlooks.

Budget Reductions

1. Recreational Catch Statistics - maintain and continue to improve
2. Salmon Assessment - Saint John, LaHave, Liscomb and Inner Fundy
3. Maintain client consultation

4. Estimation of Freshwater Production - main research thrust
5. CAFSAC participation maintained at minimal level
6. Continue to provide enhancement program direction
7. Management plan development where and when possible

Budget Increases

N.S.

1. Recreational Catch Statistics - verify data system/creel surveys
2. Smolt Enumeration - LaHave River
3. Smolt and Adult Enumeration - Stewiacke River
4. St. Mary's River - river-specific management
5. Extension of river-specific management to other rivers

N.B.

1. Recreational Catch Statistics - develop systems and creel survey
2. Lower Saint John Adult Monitoring
3. Lower Saint John Smolt Monitor
4. Counting fences for smolt and adults on small rivers
5. Expansion of wild and hatchery smolt tagging with nose-tags
6. Big Salmon River Inseason monitoring capability.

2. Clients

The Section must deal with requests for information from a variety of clients from the public sector (private individuals, promoters, Native groups, anglers associations, provincial governments), within DFO (fisheries managers, CAFSAC) and internationally (ICES, NASCO). The level of satisfaction expressed by this diverse group of clients is indicative of the priority given to their requests by Section personnel.

With respect to public groups, the Section not only provides the information and advice, but often must interpret the data at hand to supply options to solve conflicts among users of the resource. This latter function is facilitated by the composition of the Section but is outside of its strict mandate. The coordination of assessment, enhancement and research

within the same Section provides ample negotiating power to harmonize resource users' needs. For instance, depending on their status relative to acid rain impact, enhancement requirement, wild stock status, etc. river systems may be earmarked for native fisheries, anglers or research. However, this high degree of latitude puts a heavy burden on the Section, which often operates without the council of peer review traditionally given through CAFSAC.

The different status and operation of the Section (and of the Freshwater and Anadromous Division within Biological Sciences Branch) becomes particularly apparent through the CAFSAC reviews. The large number of stocks, their small size, the complexity of the salmon life cycle and the lack of control over the marine part of the life cycle are only a few of the factors which complicate stock assessment procedures. This situation forces biologists to interpret, extrapolate, or guesstimate parameters indicative of stock status in a much more open manner than for traditional marine fisheries. This however only further stresses the importance of CAFSAC as a forum for internal peer review and repository for written records.

ICES and NASCO requests do not appear to take an inordinate part of the Section's time, as ICES scientific participation is usually in the form of regional information already vetted through the CAFSAC process.

The requests from fisheries managers appear to be the primary need for advice, since they are the main vector of general public enquiries. Since requests of this type are predominantly verbal and short-term, their overall relevance and feasibility are difficult to assess on a yearly basis. Planning of the Section's activities would certainly benefit from the presentation of a written list of prioritized items of public concerns rather than the present ad hoc arrangement. Meeting with a regional manager highlighted requests for yearly allocations of a number of surplus fish in individual river systems, river by river management plans, short-term forecast, within season management of fisheries, enhancement and native fisheries allocation. Many of these requests appear unrealistic in view of the resolution scale, forecasting ability, and data available in the Section. These topics will be dealt with in the following section.

3. Resolution Scale

As was noted previously, requests by fisheries managers for advice may be expected to increase, particularly in response to Native food fishery requests as well as a general move to more river-by-river management. As a result of decreases in the marine and freshwater exploitation rate in the past decade, as well as some suggestion of marine exploitation reduction in the future, there is an air of optimism that most stocks will be able to sustain increased freshwater exploitation in the near future. With concomitant changes in fisheries regulatory capabilities, it is expected that there will be an increased demand for in-season regulation advice in relation to target spawning escapements. It is envisaged that, where appropriate monitoring capabilities exist, this Division may be able to provide an estimate prior to the fishery season of available harvest that could be modified (either up or down) dependent upon in-season return estimates. It will be difficult however to provide this advice on all river systems as, even if catch/abundance relationships are developed for certain rivers, catch statistics will not be available in the time frame needed (i.e., in mid-season). Moving towards obtaining in-season catch estimates will require increased resources.

The allocation of time and resources to assessment to a large number of small salmon stocks in a variety of environments poses the question of the resolution scale of the information, since it is obviously impossible to measure everything, everywhere, all the time.

Given these constraints, and in view of the continuing requests for specific quantitative information in the absence of detailed scientific knowledge, it could be advisable to derive a systemic approach for classification of stock status used for decision making. This would ensure the consistency of scientific advice, the integration of all available scientific (and other) knowledge and the removal of the pressure for misleadingly precise assessment figures of individual stock status. Such a system could rely on a regional division of stocks sharing biological or environmental similarities (for example: inner Bay of Fundy rivers, acid-impacted eastern shore stocks, lower Saint John River tributaries, etc.) coupled to a general assessment of classes of stock status (good, fair, poor) based on all available information and considerations. Furthermore, this would allow for progressive inclusion of additional information and the eventual transition to a primarily objective measurement of the freshwater production of each system once it is developed by research projects currently underway. This approach could be a compromise with respect to the ongoing debate between present responsibilities and future assessment capabilities of the Section.

Time-flexible management advice could provide guidelines with respect to the frequency of advice required for systems of different status, also corresponding to the available information. Long-term (5-yr) forecasts could be made for large scale areas, complemented by 1-yr advice for areas where stock status is precarious. At a shorter time-scale, the possibility of ongoing fisheries monitoring (i.e. catch and/or exploitation rate) of specific river systems using water level appeared feasible to the Review Team and could be explored as resources allow.

4. Priorities

The Review Team's division of the expected goals/outputs for 1990/91 brought forward the respective importance of assessment and research programs carried out within the Section. In general, the committee felt that the emphasis of priorities was primarily put on the assessment/enhancement side of the mandate. Although this situation is justifiable from historical and operational standpoints (see Overview), it nevertheless results in a lesser emphasis on purely scientific endeavours, which is also a key mandate of the Biological Science Branch (Appendix IV).

Concerning priorities, the Review Team felt that completion and publication (in a primary publication format) of the model of salmon freshwater production (item 1 in Section IV) should be given the highest priority among research projects. The potential ramifications of this project for the assessment of stocks and acid rain impact (ESSA model, item 2) make it interesting for applied as well as fundamental reasons. The Review Team would put the determination of the causes of recruitment failure for inner Bay of Fundy stocks at the other end of the priority list, due to the small size of the stocks and the expected low tag returns, which will complicate tests of significance, following the ongoing immunization experiment.

Members of the Review Team identified two areas where they thought a more intensive research focus was required than is reflected in the existing mix of activities within the Section. First, we think it is necessary to

begin developing projects that focus on explaining the *mechanisms* that control marine growth and survival of Atlantic salmon, particularly during the early marine stage. The information generated from such studies are required to permit the preparation of accurate forecasts of returns, to define the overall productivity of stocks, to understand changes in life history patterns (eg. the declining proportion of MSW salmon), and to evaluate the likely outcome of enhancement initiatives.

Members of the Review Team also thought a concerted effort should be made to describe the potential effect of global climate change over the next 100-150 years on Atlantic salmon production in the Scotia-Fundy Region. This study is particularly important as Atlantic salmon are near the southern end of their geographic distribution in the Scotia-Fundy Region. A knowledge of the likely response of salmon to climate change has very important implications for how we should proceed, now and in the future, with the management and enhancement of the stocks.

5. Communications/Publications

At the present time, most of the written output of the Section goes through CAFSAC research documents, with a small number of primary publications. This allocation adequately fills the need for a permanent written record of monitoring/assessment data available to clients and members of the scientific community. CAFSAC provides a forum for in-house peer review as well as exchanges among scientists dealing with anadromous fish stocks. The limited circulation of the documents was not perceived as a major drawback, since clients make direct requests for research documents and summary sheets to the Section members as well as the CAFSAC Secretariat. Primary publication of research results is encouraged, especially in the case of studies which results might be applicable to (or validated in) other Atlantic regions: this applies particularly to stream production estimates and methodology.

As was mentioned by Section members, occasions for communication/exchange with other members of the scientific community have often proved unexpectedly beneficial to activity planning, prioritization and the general functioning of the section. In view of its small size and of the different nature of its activities/structure from that of other Scotia-Fundy Scientific divisions, it is particularly important that outside scientific contribution/collaboration be encouraged whenever possible.

APPENDICES

- I Agenda of the meeting with the Review Team
- II Terms of reference for salmon assessment review
- III Project review, evaluation and planning 1990/91 for Stock assessment and enhancement Section of Freshwater and Anadromous Division, Scotia-Fundy Region
- IV Mandate of Biological Sciences Branch and of Freshwater and Anadromous Division, Scotia-Fundy Region
- V Internal budget and P/Y allocation for 1991/92 budget by Collator
- VI Stock Assessment & Enhancement Section 1991/92 O & M and personpower
- VII Stock Assessment and Enhancement Section organization chart showing proportion of person years used for salmon assessment
- VIII Stock Assessment & Enhancement Section organization chart showing proportion of person years for salmon enhancement

APPENDIX I

Scotia-Fundy Region: Science Sector
 Biological Sciences Branch
Stock Assessment and Enhancement Section

SCIENCE REVIEW OF ATLANTIC SALMON ASSESSMENT PROGRAM
 April 30-May 3, 1991

Review Team: J.-J. Maguire, Review Chairperson, CAFSAC, Quebec
 D. Meerburg, Fisheries Research Branch, Ottawa
 M. Henderson, PSARC Vancouver
 C. Hudon, Biological Sciences Branch, Halifax

Pre-review of mailed written materials

- organization chart and green book
- related CAFSAC research documents
- last year's Program Review and Evaluation sheets

Tues. 09:00, April 30, 1991, Library Conference Room;
 1707 L. Water Street, Halifax

1. Welcome and conduct of review
 J.A. Ritter, Chief, Freshwater and Anadromous Division
2. Mandate and clients (Ritter)
 - Branch and Division mandates
 - Relationship of SA&E Section to other sections of the Division
 - Relationship of salmon assessment to enhancement and other species
 - Identification of clients and their requirements
3. Service and advice required by regional managers (Stevens, FHMB)
4. Introduction to Salmon Assessment program (Cutting)
 - Program mandate
 - Resource levels in 1991/92
 - Brief history of the program
 - Framework for providing advice (CAFSAC, ZMAC, ICES)
 - Types of advice provided
5. Description of program activities
 - Monitoring activities (Marshall)
 - Research initiatives (Amiro, Marshall, Jessop)
6. Assessment program for 1991
 - Activities and objectives (panel of Marshall, moderator, Amiro, Cutting, Jessop, O'Neil, Ritter)
7. Future direction (Cutting)
 - Long-term outlook and identification of recognized deficiencies
8. Final remarks and general discussion (Ritter)

Wed. and Thurs. Hollis Building, 3rd Floor, 1649 Hollis Street

Meeting with participants and preparation of report

Fri. Start time TBA, adjourn 12:00, Library Conference Room

Report of the Review Team and discussion

APPENDIX II

Terms of Reference for Salmon Assessment Review
Scotia-Fundy Region

DFO has undertaken a general review of the use of science in its biological programs, and the Director of Biological Sciences, Scotia-Fundy Region, has approved such review for the Atlantic salmon assessment program in the Freshwater and Anadromous Division. Members of the Review Team are: Jean-Jacques Maguire, CAFSAC Steering Committee Chairperson, Quebec City; Dr. Mike Henderson, PSARC, Vancouver; D.J. Meerburg, Fisheries Research Branch, Ottawa, and C. Hudon, Biological Sciences Branch, Halifax. The Review Team will meet to address the following terms of reference:

- a. Is the present Atlantic salmon assessment program meeting its objectives?
- b. In the face of excessive demands, have the priorities been set adequately for the identified areas of work?
- c. In a qualitative sense, is the application of science appropriate; identify areas of strength and those of weakness or deficiency?

The review will take three and one-half days.

April 16 1991

APPENDIX III

PROJECT REVIEW, EVALUATION AND PLANNING 1990/91

Division: Freshwater and Anadromous

Project No.: 311

Section: Stock Assessment and Enhancement

Project Title: Salmon Assessment Research

Project Leader: Marshall, T.

Other Researchers: Amiro, P; Boudreau, P.; Cutting R.; Jessop, B.; O'Neil, S.; Ritter, J.

Work Activity: W.A.1.1.1.1

Key Words: salmon; assessments; assessment research

1. Project Description:

Enumeration and monitoring of adult and juvenile stocks and Atlantic salmon harvest, preparation of required stock assessment documents, research into methodologies for improvement and expansion of salmon stock assessments, and provision of regional input to Canadian input on international matters involving Atlantic salmon.

2. Long-Term Objectives:

The Departmental legislated mandate includes the responsibility for managing anadromous fish resources according to current, sound scientific information. The long-term objectives of the project are to develop required data bases, conduct pertinent studies and analyses, and prepare biological advice and recommendations on a timely basis for internal and external clients having interests in the valuable Atlantic salmon resources.

3. Goals/Expected Outputs vs. Accomplishments in 1990:

1. Prepare required assessments of Atlantic salmon stocks to define stock status, such as Saint John, LaHave, Stewiacke, Liscomb, St. Mary's, Grand and Middle rivers and, where possible, forecast future returns. (Marshall, Amiro, Cutting, Jessop)

Stock Assessments for the upper Saint John, Grand and Inner Fundy rivers were vetted at ACFF Subcommittee, CAFSAC, and upgraded to Research Documents. Detailed assessments of the other rivers were not attainable with the limited available resources although each, plus the St. Croix, was reviewed within the context of assessing the regional stock status by Salmon Fishing Area (item 3).

2. Publish the model for determining salmon production capacity of rivers through use of information derived from remote sensing, and complete, if possible, survey information data base for New Brunswick rivers. Conduct study on parr density and age-at-smoltification, as resources permit. (Amiro)

Submission of the model for publication was preempted by the requirement to prepare documents (see item 7iii) for a special ACFF Subcommittee meeting to address the usefulness of various attributes for evaluating the Department's "Policy for the Management of Fish Habitat" and background material for a special workshop to establish the framework for modelling the effects of acidification on the regional production of Atlantic salmon. Both processes contributed invaluable peer review of the model and should assist in the acceptance of same in a primary journal. Ages of smolts on Little River (Stewiacke), were sampled and will be used to complement ongoing studies of density-dependent growth of parr and subsequent age-at-smoltification. Resources were inadequate for the completion of the remote-sensed data base for New Brunswick rivers.

3. Prepare timely biological advice and recommendations for internal and external clients and service, particularly the biological information needs of the Zone Management Advisory Committees. Involve external clients where feasible and desirable in the collection of biological data. (Marshall, Amiro, Cutting, O'Neil, Jessop)

Prepared stock status report (see item 7iii) for all SFA's of the region. Participated in and provided regional (CAFSAC) and other advice to five zone management committees and area managers based on diver counts, electrofishing of juveniles and adults, counts of salmon at fishways and angling statistics. Attended, advised and cooperated with sport fishing associations/Indian Bands/corporations/commissions in the execution of various assessment-related projects (e.g., operated adult counting facilities in fishways on the Tobique, main Saint John and St. Croix rivers, advised and assisted in a field program to identify biological variables potentially important to establishing "river-specific management" for the St. Mary's, conducted a salmon tracking study to investigate attributes of the Hartland salmon pool and impediments to fishway entry on the Saint John River (item 4 below), and conducted creel surveys on the Kennebecasis and main Saint John rivers.

Advised regional managers on the Tobique Indian food fishery and Scotia-Fundy managers on the Eskasoni and Wagmatcook food fisheries, in particular. Testified as an expert witness in the Paul vs Denny court case re: status of stocks in Eskasoni Brook and advised on the Bras d'Or Lakes fishery development proposal. Advised and participated in management decisions involving Canada-U.S. boundary waters of the St. Croix, Aroostook and Saint John watershed above Grand Falls. Vaccinated and held groups of wild smolts from the Stewiacke River to ascertain their vulnerability to Vibrio - a bacteria ubiquitous to the Bay of Fundy-Scotian Shelf and hypothesized as a possible factor impacting survival of inner Fundy salmon stocks.

4. Plan, coordinate and conduct the cooperative sonic tagging project for studying adult Atlantic salmon movements and behaviour on the Saint John River. (Marshall)

Multi-sponsored project (item 6i; responsibilities largely carried out by DFO and NB Power) was an unqualified success in cooperation and data collection. Preliminary results on holding conditions preferred by salmon in Hartland and Bristol pools and stage and discharge conditions at Beechwood when salmon chose either to enter the fishway gallery or return downstream, as well as creel census and hydrological data, were reviewed in committee (often 20 or more people representing various interest groups) and used to plan the second of a planned two-year study.

5. Participate in initiatives to examine distant interception of S-F Region stocks; formulate and test hypotheses and propose data collections (e.g., indices of change in marine environment, marine growth, sex ratio of smolts) to explain MSW changes in mainland stocks. (Marshall, Ritter, Cutting, Boudreau)

Presented analyses on harvest and exploitation of Saint John salmon in homewater and distant fisheries and a MSW salmon predictor for the Saint John River (item 7iii). The predictor implicated mean length, sex ratio and mean smolt age of 1SW returns in the subsequent return of MSW salmon and supports the hypothesis that marine conditions which contribute to exceptional growth during the first year at sea may well contribute to the maturation of more individuals after one winter at sea, and a reduction in those later returning as maiden 2SW fish. Captured and micro-tagged approximately 4,000 wild smolts (first time) in the Beechwood Dam forebays for the study of survival and distant exploitation of wild (as opposed to hatchery) salmon.

6. Develop and prepare required regional input for special CAFSAC investigations, for Canada's input to ICES and for Canada's input to NASCO. (Marshall, Ritter, Boudreau)

Described events of the 1990 fisheries in S-F Region and Canada; assisted the Canadian delegation in the development of run re-construction models of Canadian stocks for input to a global North Atlantic (global) model; assisted in the evaluation of the effects of the 1990 quotas in the commercial salmon fishery of Newfoundland and Labrador and provided a Canadian compilation of microtag, finclip, and external tag releases. Reviewed U.S. models of Canadian interception of U.S. stocks, Greenland interception of Canadian stocks, and new approaches to assessing interception in distant waters, presented MSW predictor model for Saint John River (item 5), and advised CAFSAC and ICES as appropriate.

7. Provide consultation and direction on the choice and use of salmon stocks and on the distribution programs for adult and all stages of juvenile salmon. (Marshall, Amiro, Cutting, Jessop)

Provided advice and direction to the fish culture program involving collection of some 23 salmon broodstocks (personnel and equipment directly involved in some 12 collections), re-deployment of 12,000 Saint John adult salmon, and distribution of over two million juvenile salmon. Continued the release of 60,000 micro-tagged hatchery smolts at seven locations in the upper Saint John to assess variable survival and potential for development of areas from which downstream migrants would have to pass through/over hydroelectric facilities and measured the first 1SW returns.

8. Continue preparation of individual river management plans, to the extent time permits. (Marshall, Cutting, Amiro, Ritter)

Provided input to the St. Mary's River and Tobique River Steering Committees and finalized with public interest groups, U.S. agencies, provincial government representatives and within DFO, a strategy for conservation and enhancement (including temporary fish passage facilities at Grand Falls) for the Saint John River salmon resource above Mactaquac Dam. Developed a draft operational plan for development and management of the St. Croix anadromous fish resources.

4. Additional Accomplishments:

1. Marshall is the regional delegate to the ICES Study Group on North American Salmon Fisheries and the Working Group on North Atlantic Salmon. He is also regional core member of ACFFS (CAFSAC), a member of the International Technical Advisory Subcommittee on Water Quality in the Saint John River and the Biological Subcommittees of the St. Croix and Tobique River Steering Committees.
2. Ritter is the Science representative on the Canada-U.S. Steering Committee for the development and management of the fish resources of the St. Croix River.
3. Amiro was principal contributor to the contract with ESSA (Environmental and Social Systems Analysts Ltd.) to model the effects of acidification on Atlantic salmon production. As Past President of the A.I. Chapter, American Fisheries Society, he successfully authored, submitted, presented and won the bid for the Chapter to host the annual meeting of the American Fisheries Society (potential of 800 delegates) in Halifax, August 1994.
4. Cutting will direct the presentation of the Division's salmon assessment program to a scientific review committee in January.

5. Goals/Expected Outputs for 1991:

1. Prepare required assessments of Atlantic salmon stocks to define stock status, such as Saint John, St. Croix, LaHave, Stewiacke, Liscomb, St. Mary's, Grand, Middle and inner Fundy rivers and, where possible, forecast future returns. (Marshall, Amiro, Cutting, Jessop)
2. Prepare timely biological advice and recommendations for internal and external clients and service, particularly the biological information needs of, the Zone Management Advisory Committees. Involve external clients where feasible and desirable in the collection of biological data. (Marshall, Amiro, Cutting, O'Neil, Jessop, Ritter)
3. Develop and/or improve pre- and in-season forecast models. (Marshall, Amiro, Cutting)
4. Develop models of recreational catch that would enable use of catch as an indicator of stock strength. (O'Neil, Cutting, Jessop, Ritter).
5. Participate in initiatives to examine distant interception of S-F Region stocks; formulate and test hypotheses and propose data collections (e.g., indices of change in marine environment, marine growth, sex ratio of smolts) to explain MSW changes in mainland stocks. (Marshall, Ritter, Cutting, Boudreau)
6. Publish the model for determining salmon production capacity of rivers through use of information derived from remote sensing, and complete, if possible, survey information data base for N.B. rivers. Conduct study on parr density and age-at-smoltification, as resources permit. (Amiro)
7. Participate in the modelling exercise to assess the effects of acid rain on the production of N.S. salmon stocks. (See Acid Rain Research project for details). (Amiro, Cutting, Marshall)
8. Set-up image processing system for analyzing scale patterns. (O'Neil, Amiro)
9. Plan, coordinate and conduct the continuing cooperative sonic tagging project for studying adult Atlantic salmon movements and behaviour on the Saint John River. (Marshall)
10. Plan and implement, pending availability of funds, investigations to determine the cause(s) for recruitment failure common to inner Bay of Fundy stocks in four of the past five years. (Amiro)
11. Direct biological investigations carried out under the pilot "river-specific management" project for the St. Mary's River. (Jessop, Cutting)
12. Develop and prepare required regional input for special CAFSAC investigations, for Canada's input to ICES and for Canada's input to NASCO. (Marshall, Ritter)
13. Provide consultation and direction on the choice and use of salmon stocks and on the distribution programs for adult and all stages of juvenile salmon. (Marshall, Amiro, Cutting, Jessop)
14. Continue preparation of individual river management plans, to the extent time permits. (Marshall, Cutting, Amiro, Jessop, Ritter)

6. Background:

Highlights:

Initiation of a significant collaborative research effort on modelling the potential of rivers to produce Atlantic salmon under various stages of acidification; investigations to determine an approach to "river-specific management" on the St. Mary's River, and cooperative spirit exhibited by the numerous non-DFO factions involved in the Saint John River salmon tracking study.

Selected Involvements:

i. Collaborative Research -

Project biologist hired by the St. Mary's River Salmon Association pursuant to a funding grant from DFO for the investigation of river-specific management; NB Power (office space, substantial loans of equipment, 5 Challenge '90 students, 2 Crew leaders, 2 seasonal trap operators, 1 vehicle and a \$15k account, etc.) and to a lesser extent NBDNRE, Water Surveys Canada, Atlantic Salmon Federation, NB Salmon Council, Tobique Indian Band, Fraser's Inc., Town of Hartland, Fredericton Branch Saint John River Salmon Association, Central Branch Saint John River Association, Tobique Salmon Protective Association, Atlantic Salmon for Northern Maine and Northwest Salmon Association on the Saint John River salmon tracking study.

ii. University Liaison -

iii. Communications -

Press, radio and TV coverage of various aspects of the salmon tracking study.

iv. Contracts Administered -

BSSA (Vancouver) to model the effects of acidification on production potential of Atlantic salmon.

v. Other -

Collaborated with Kennebecasis River Salmon Association in their conduct of a creel survey and both Tobique Salmon Protection Association and Northwest Salmon Association in the use of stream-side incubators; East Richmond Wildlife Association and the Cobequid Salmon Association assisted with projects on Grand and Little (Stewiacke) rivers, respectively.

7. Publications:

i. Primary -

Amiro, P.G. 1990. Variation in juvenile Atlantic salmon population densities between consecutive closed sections of streams. pp.96 - 101 In I.G. Cowx [editor], Developments in Electric Fishing, Fishing News Books, Cambridge, 358 p.

Amiro, P.G. 1990. Evaluation of some electrofishing capture techniques used to estimate populations of juvenile Atlantic salmon in enclosed areas of streams. pp.174 - 185 In I.G. Cowx [editor], Developments in Electric Fishing, Fishing News Books, Cambridge, 358 p.

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ii. Interpretive Scientific -

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Ingram, J.H. and B.V. Ensor. 1990. Capture of Atlantic salmon in the Mactaquac area and their distribution in the Saint John River system, N.B., from 1983-1988. Can. Data Rep. Fish. Aquat. Sci. 791: 55 p.

Marshall, T.L. 1990. Assessment of Atlantic salmon of the Saint John River, N.B., above Mactaquac, 1989. CAFSAC Res. Doc. 90/00, 00 p.

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iv. Popular and Miscellaneous -

8. Review and Evaluation:

The goals established for 1990 were met or good progress was made towards their completion. The goals for the coming year both encompass the wide range of research priorities and are service oriented to clients (i.e., FHMB and public). A major concern is that the goals seem overly ambitious considering the limited person-year and fiscal resources that have been assigned to this project in the past.

APPENDIX IV

SCOTIA-FUNDY REGION

MANDATE

Within the Scotia-Fundy Region, and elsewhere as programs require, the mandate of the Biological Sciences Branch is to:

1. Conduct research on aquatic ecosystems and renewable resources and their fisheries, monitor relevant variables, and acquire and disseminate scientific technical knowledge for:
 - a) conservation, protection, restoration, development, and enhancement of fisheries resources and their supporting habitat and ecosystems;
 - b) management, allocation, and control of commercial, native, and recreational fisheries, including aquaculture; and
 - c) description, understanding, and prediction of biological processes and their influence on aquatic systems in the broadest sense; geochemical cycles; and climate.
2. Identify information needs and, by collaboration, relate knowledge acquired in the Physical and Chemical Sciences Branch and other agencies to the productivity, abundance, distribution, and health of fisheries resources, to marine, estuarine, and freshwater ecosystems, to aquaculture, and to the future world climate.
3. Provide professional services at local, regional, national, and international levels and to effectively communicate scientific information and advice.
4. Develop and refine scientific methodology and technology needed to discharge the biological science program.

FRESHWATER AND ANADROMOUS DIVISION

The Freshwater and Anadromous Division conducts research and enhancement activities on freshwater-dependent fish populations. Effort is concentrated mainly on anadromous species, particularly Atlantic salmon. The Division operates six hatcheries throughout the Scotia-Fundy Region.

Functions

1. Develop and provide biological advice for the rational management of the existing freshwater-dependent fisheries.
2. Rehabilitate and enhance stocks of freshwater-dependent fish by applying knowledge of fisheries biology, engineering technology, and fish culture practices.
3. Undertake applied research on chemical, physical, and biological changes to freshwater-dependent resources and their supporting habitat, with particular emphasis on the effects of acid rain.
4. Develop and provide biological and engineering advice on mitigation measures for protecting freshwater fish habitat.

APPENDIX V

Stock Assessment and Enhancement Section
1991/92 Budget by Collator (\$000)*

		<u>5922</u> <u>(Resource Enhancement)</u>	<u>5924</u> <u>(Stock Assessment)</u>	<u>Total</u> <u>Section</u>
Salaries	(103)	\$216.9	\$766.3	\$983.2
O&M	(203)			
Travel		9.0	57.0	66.0
Trans. & Comm.		4.0	11.0	15.0
Info.		0	3.0	3.0
Other Prof. Serv.		0.5	3.0	3.5
Scient. Serv.		0	9.0	9.0
Other Rentals		0.5	1.0	1.5
Rental of Ships		0	0	0
Repairs		1.0	5.0	6.0
Other Mat. & Supp.		4.0	28.8	32.8
Fuel		4.0	11.0	15.0
All Other		0	1.0	1.0
	Subtotals	23.0	129.8	152.8
<u>Capital</u>	<u>303</u>	0	\$13.2	\$13.2

*Subject to allocation adjustments after April 30, 1991.

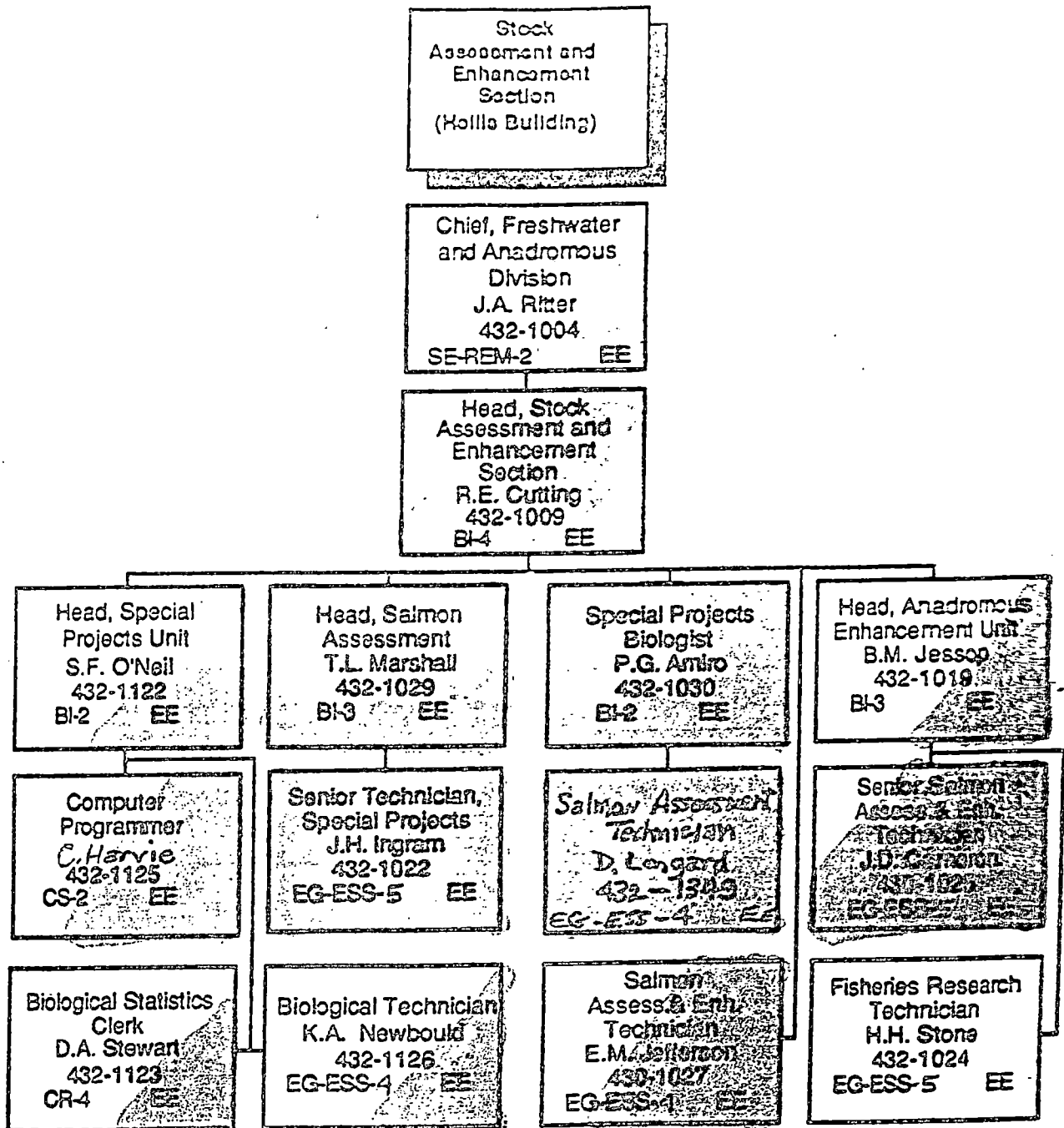
APPENDIX VI

Stock Assessment and Enhancement Internal Allocations*
1991/92 O&M (\$000) and Personpower

<u>Staffer</u>	<u>O&M Allocation</u>	<u>Personpower</u>	
		<u>CFT (PY)</u>	<u>Term (PM)</u>
Amiro (5924) Salmon Assessment Research	19.6	2.0	11.8
Marshall (5924) Salmon Assessment & International	37.6	1.23	8.1
Jessop (5922) Salmon Enhancement	23.0	2.6	20.8
Jessop (5924) Non-salmonid Research	10.0	1.7	11.6
O'Neil Statistics & Computing and Tagging**	33.6	4.0	3.0
Cutting Administration and topups	29.0	0.7	7.1
 Section totals	 \$152.8	 12.23 PY	 62.4 PM

*Subject to allocation adjustment after 30 April 1991.

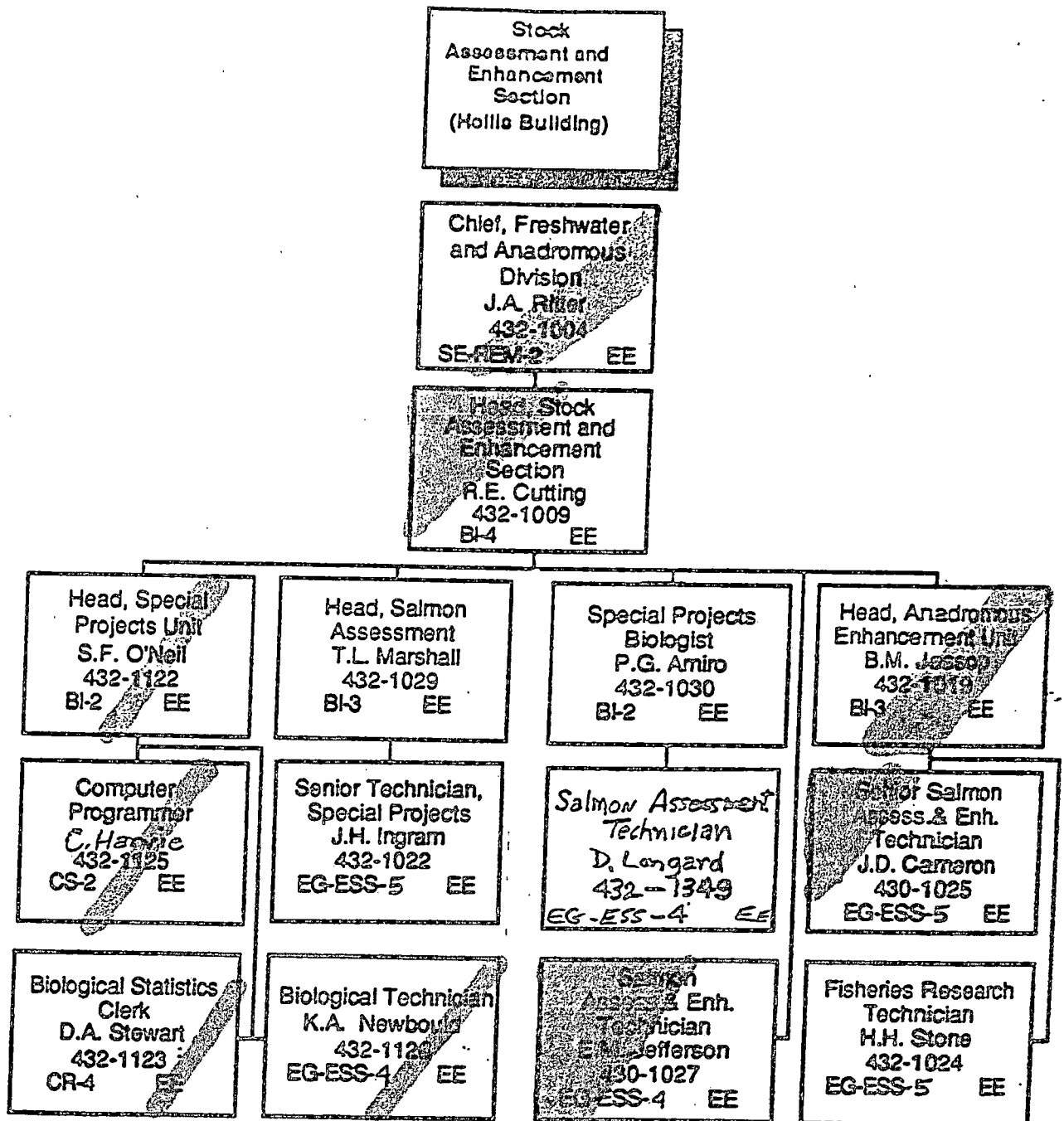
**Includes Tag Clearing house, tag purchases, and computing services which are shared with other division personnel and programs.



Position Language Designation: EE - English essential

Shading shows proportion of person year in

SALMON ASSESSMENT



Position Language Designation: EE - English essential

Shading shows proportion of person year in

SALMON ENHANCEMENT