# PACIFIC SALMON COMMISSION
# NORTHERN BOUNDARY TECHNICAL COMMITTEE REPORT

# RESEARCH NEEDS AND PRIORITIES FOR SOCKEYE, PINK, CHUM, AND STEELHEAD SALMON IN THE NORTHERN BOUNDARY AREA

## REPORT TCNB (93)-1

PACIFIC SALMON COMMISSION

JOINT NORTHERN BOUNDARY TECHNICAL COMMITTEE

# RESEARCH NEEDS AND PRIORITIES FOR SOCKEYE, PINK, CHUM, AND STEELHEAD SALMON IN THE NORTHERN BOUNDARY AREA

REPORT TCNB (93)-1

Prepared for the

Standing Committee on Research and Statistics,

Pacific Salmon Commission

November 1993

## TABLE OF CONTENTS

**TABLE OF CONTENTS** (Continued)

## TABLE OF CONTENTS (Continued)



## LIST OF TABLES

## EXECUTIVE SUMMARY

The Standing Committee on Research and Statistics of the Pacific Salmon Commission (PSC) requested each technical committee to identify and prioritize their information and research needs. The Northern Boundary Technical Committee addressed this request by providing the Research and Statistics Committee with a draft of this report at their November 4-5, 1992, meeting. This document finalizes this November 1992 report as an official PSC publication. We have not attempted to make this report current to November 1993.

Escapement enumeration, stock identification, and inseason abundance estimation activities were identified as research priorities for sockeye, pink, and chum. Programs to better estimate catch, escapement, and management options for reducing catches of steelhead, Skeena River steelhead in particular, are a priority. The highest priority need for joint research activities facing the Northern Boundary Technical Committee are: application of scale pattern-based stock identification to sockeye harvested in Northern British Columbia fisheries, and complete the reanalysis of adult tagging data for pink salmon and apply to annual interception estimates. Maintaining funding for existing stock assessment programs was recognized as a top priority by both countries.

# INTRODUCTION

Long-term goals established by the Pacific Salmon Commission (PSC) include achieving optimum salmon production and providing each Party benefits equivalent to the salmon production originating in its own waters while at the same time providing for security and long-term stability of the Parties' fisheries. If these goals are to be realized, careful planning of programs designed to address them must be undertaken. Research needs identified in this report are intended to support these long-term goals of the PSC, address the standing assignments for the Northern Boundary Technical Committee (NBTC), detailed in Annex IV, Chapter 2, of the Pacific Salmon Treaty, and comply with a November 1991 request from the Research and Statistics Committee of the PSC for a report on research needs and priorities from each technical committee.

This report complements another NBTC report (NBTC 1991a), titled "Conduct of Fisheries and Status of Sockeye, Pink, and Chum Salmon Stocks in the Northern Boundary Area". To avoid duplication with that "Stock Status Report", this report will focus strictly on current and long term research needs identified by NBTC; thus, detailed descriptions of current research and monitoring programs are limited.

The NBTC has identified several Treaty related activities which could benefit from acquiring additional or improved information from the Northern Boundary Area (NBA). These are:

1. spawning escapement estimation;
2. freshwater productivity assessments;
3. stock specific run reconstruction;
4. development of spawning escapement goals;
5. forecasting future returns;
6. in-season management;
7. management evaluation;
8. interception estimation; and
9. enhancement potential evaluation.

The purpose of this document is to develop a long-term research plan for addressing these needs by determining their relative priority, developing approaches for addressing them, and prioritizing specific programs. In some cases, entirely new programs will be required, while in others, further analysis of existing information may be sufficient. This report will provide the Commission with a sense of direction for Northern Boundary programs. The report should also provide information to assist the various government agencies in funding allocation decisions. It is recognized that objectives sometimes change and this research plan must be considered flexible in order to respond to change.

## SOCKEYE SALMON

### *Stock Assessment*

Effective management of sockeye salmon fisheries in the NBA depends on knowledge of production potential of major sockeye stocks and an understanding of their current status. Then target escapement goals, or goal ranges, can be determined which maximize sustained yield under average environmental conditions. Formal, or informal, escapement goals have been estimated for the principal Northern British Columbia (NBC) sockeye systems and for some southern Southeast Alaska (SSA) sockeye stocks. However, the derivation of these escapement goals is not well documented and most were based on subjective estimates of spawning and rearing habitat and on historical catch and escapement patterns. The current assessments and the need for further research center around three techniques: recruitment analysis, exploitation rate indicators, and habitat assessments.

### *Recruitment Analysis*

A common technique for evaluating stock productivity is to compare the adult returns from a time series of escapements. This requires accurate estimates of escapements and subsequent returns at age by stock. Preliminary reconstructions of the Nass and the Skeena systems have been attempted.

### Catch

Accurate catch statistics, by appropriate gear, area, and time strata, is an essential prerequisite to run reconstruction. In SSA, Alaska Department of Fish and Game (ADF&G) maintains saleslip data in a relational computer data base which ties together catch, effort, escapement, fishery performance, and several biological datasets. The usefulness of this data is dependent on its completeness, accuracy, timeliness, and accessibility. The maintenance of this "Integrated Fisheries Data Base" and needed application programming requires a considerable annual commitment of money. This activity is a high priority for funding at the current level.

The catch reporting system in Northern British Columbia (NBC) is based on inseason hailed catch by subareas which are then prorated post-season by the sales slip information available by statistical area. The sockeye catch sampling and associated biological sampling programs have been improved over the last two years to sample finer strata and to meet the statistical sampling requirements of our domestic age sampling and the joint sockeye stock ID (scales) program. This program needs to be jointly evaluated to confirm that the sample size and strata are appropriate. Native harvests for personal consumption are currently estimated from Canadian Department of Fisheries and Oceans (CDFO) staff observations but are not based on documented technically reviewed programs with the exception of the Nass where a quality program was implemented in 1992.

Common access to agreed catch, effort, escapement and 'biological' databases would enhance the ability of the NBTC to meet the PSC desires. To this end, the NBTC has recently agreed to a common format for presenting historical catch and effort data by gear, area, week, and year in the committee's annual report (see NBTC (92)-1).

**Stock Identification**

Catch data alone is insufficient to allow reconstructions if harvests are of mixed stocks. Stock identification techniques are used to partition catch to specific stocks or stock groupings. The details of sockeye stock identification have been reviewed in detail in the NBTC stock status document. The available techniques which can be used alone or in conjunction with other methods include: adult tagging; fry or smolt tagging; electrophoretic, and other genetic stock identification methods; scale pattern analysis; age and size composition; thermal or chemical marking; and parasite prevalence. The best method for stock separation would be a combination of all of the available methods. However, the incremental accuracy achieved by using combinations of techniques must be weighed against the increased resources required to collect and analyze the information.

Beginning in 1982, ADF&G has used age and scale pattern data to estimate the stock composition of sockeye harvested in southern Southeast Alaska fisheries (Marshall et al. 1984; Oliver and Farrington 1989). The NBTC currently endorses the scale pattern and age analysis over a combined program of scales, electrophoretic analysis, and parasites because of the greatly increased costs of a combined program and because the scale program has proven to provide good discrimination of the three major stock groups - Alaska, Nass, and Skeena. The scale program is also compatible with the PSC's scale-based stock identification program for estimating catches of Fraser sockeye on NBA fisheries. The NBTC places a high priority on extending this scale pattern-based stock identification program to sockeye harvested in NBC fisheries. This information is needed both for making annual estimates of interceptions (see below) and for reconstructing Nass, Skeena, and Alaska runs. Funds are needed to enhance collection of representative samples from net fisheries in Areas 1, 3, and 4 and for digitizing, analysis, and reporting of project data. This activity will be relatively straightforward and inexpensive if a cooperative program is setup between ADF&G and CDFO which avoids duplicate digitizing of standards or catch samples. The NBTC is interested in continuing to cooperate with PSC staff in estimating the annual contributions of Fraser sockeye to NBA fisheries using age, scale pattern, and parasite (*Philonema onchorhynchi*) data.

Bailey and Margolis (1987), Wood et al. (1989), and Moles et al. (1990) have developed a stock identification method for sockeye salmon using a brain parasite. In general, sockeye in small lake systems on islands and in coastal lakes on the mainland have a high prevalence of this parasite. Sockeye in lakes and tributaries to long rivers, in general, lack the parasite; therefore, in NBA fisheries the majority of non-parasitized sockeye are of Canadian origin. Baselines for *Myxobolus neurobius* are mostly complete for the major stocks in British Columbia and Southeast Alaska. Auke Bay Laboratory (ABL) staff are presently adding smaller stocks in Southeast Alaska into the baseline. NBTC members recognize the potential utility of brain parasite markers for stock discrimination. We would seek to incorporate this characteristic in mixture models if finer stock resolution is needed than that obtainable with analysis of scale patterns.

A genetic stock identification (GSI) method, using electrophoresis of inherited proteins, has been developed for identification of stocks of sockeye salmon. Personnel at ABL and Pacific Biological Station (PBS) have been developing a GSI baseline in Southeast Alaska and British Columbia since 1982 (Guthrie et al., In Press). Several new variable loci have been identified and these new loci are being added to the baseline. Potentially useful variation in nuclear and mitochondrial DNA has also been identified in sockeye but more work is required to develop a complete baseline. Accuracy of stock estimates made by scale methods could be improved by incorporating other methods along with scale characters in a single integrated analysis. NBTC members are evaluating a stock identification method using scale characters, genetic characters, and the brain parasite in a single analysis. The additional genetic characters and parasite information could be used if the PSC desires more precise stock identification of sockeye salmon than possible with scale pattern and age and length data. However, the cost would be much higher than just using the scale method alone.

NBTC members wish to keep abreast of new methods for stock identification. The potential of mass marking fish with thermal or elemental marking of calcified structures shows promise. Natural differences in elemental compositions or otolith patterns might also be useful for stock identification.

**Escapement**

In **SSA** sockeye are produced in 60+ systems but escapements are directly enumerated in only two systems: Hugh Smith and McDonald Lakes. It is impractical to index escapements using foot or aerial surveys because of the number of systems and the difficulty of seeing sockeye in the tannin stained lakes. Instead, escapement can be estimated from estimates of catch (scale pattern analysis) and exploitation rate (CWT mark-recovery studies) of Alaskan sockeye. The current program of sampling 15+ sockeye salmon producing systems in southern Southeast for scale (age), sex, and length data (Oliver and Blick 1991) needs to be expanded at a cost of $10,000. This activity provides scale data needed for the stock contribution estimates. A positive benefit from the coded wire tag mark-recovery program proposed in the Exploitation Rate Indicators section (below) for southern Southeast Alaska stocks is that escapements will be accurately estimated for each wild stock or hatchery release group.

In **NBC**, fishway and fence (weir) counts for the largest sockeye systems in the Nass and Skeena areas are available. The Meziadin River fishway was constructed on this Nass tributary in 1966 primarily to enumerate the sockeye run. Post-season calculations of non-Meziadin sockeye escapements can be calculated from the known proportion of Meziadin sockeye in the test fishery (from electrophoretic and parasite sampling). The Meziadin counts are accurate. However, the accuracy of the prorating of the other systems is dependant on the assumption that the test fishery is representative of the escapement entering the river and that subsequent native harvests are not disproportionate among stocks. This assumption has not been adequately evaluated but information from a second gillnet test fishery and from two fish wheels operated in 1992 as part of the Nisga'a interim measures program may provide an indication of any bias. Skeena sockeye escapements are counted through a fence in the Babine system and escapements to all other Skeena systems are derived from visual observations. The Babine escapements are accurate and comprise approximately 90 percent of the total Skeena escapement. The accuracy of the escapements to the other systems is unknown. The relative importance of the requirement

to improve the accuracy of escapements to small systems depends on future management directions and the extent to which evaluations of smolt abundance are used as measures of freshwater stock abundance. Select small stocks may be designated as indicators of escapement, or exploitation rates and for these purposes accurate escapements would obviously be essential. There is a need to document and evaluate the escapement methods currently used for the visual enumeration of sockeye with the intention of implementing consistent documented methodologies.

**Joint Analysis**

Joint run reconstructions for Nass, Skeena, and Alaska sockeye stocks should be developed. These run reconstructions will form the basis for spawner-recruit modeling of escapement goals and for preseason forecasting models. The consequences of management actions can also be evaluated with help of these run reconstruction models. To develop these run reconstructions the committee needs to compile available information from age composition, scale pattern, CWT, and historical adult tagging studies. The implementation of an annual stock identification program (see Stock Identification above) for NBC fisheries is a prerequisite for the development of reliable run reconstruction estimates for sockeye in the boundary area.

### *Exploitation Rate Indicators*

In **SSA** coded wire tag (CWT) mark-recovery programs are needed for two of the largest wild stocks (McDonald and Salmon Bay) and each hatchery release group. This index stock assessment program will cost $60,000 for McDonald Lake and $60,000 for Salmon Bay Lake (includes costs to tag smolts and count and sample escapements). An indicator stock tagging program is already in place for Hugh Smith Lake sockeye (Koerner et. al. 1992). These stocks will serve to represent three sockeye salmon stock groups in the upper Clarence, upper and lower Behm Canal, and western Prince of Wales areas.

Releases of coded wire tagged sockeye in SSA are increasing as several enhancement programs begin and as the use of this tool for assessment of several wild stocks increases. These mark-recovery programs will greatly improve our understanding of migration routes, timing, fishery contributions, and exploitation rates of these wild and enhanced stocks. A representative indicator stock tagging program combined with annual fishery contribution estimates will enable us to estimate total returns and escapements of Alaskan sockeye. ADF&G needs to establish a set of CWT index stocks that represent the sockeye production for defined stock groups in SSA.

These studies will be incomplete unless sockeye harvested in NBC fisheries are sampled for CWT data. If the CDFO initiated a program to sample sockeye harvested in NBC fisheries then total exploitation rates for SSA stocks could be calculated.

**Canada** currently has no sockeye CWT programs in NBC. Instead, Canada intends to develop estimates of lake smolt capacity for comparison with current smolt utilization to assess stock status, rather than

implementing CWT programs. If a northern boundary program for sockeye CWT recovery were implemented there are stocks on the QCI where escapements are enumerated through a fence that would be natural candidates for CWT application to explore the interception patterns on these stocks. Genetic stock identification programs could be used as an alternative to CWT for many Canadian sockeye stocks.

### *Habitat Assessment*

Biologists with ADF&G, Commercial Fisheries Management and Development Division, Limnology Section, have been studying the production potential of lakes in **Southeast Alaska**. Their research has identified factors limiting sockeye production in several systems. Estimates of the sockeye rearing capacity and MSY escapement goals based on each lakes euphotic volume and other habitat factors have been made. Additionally, sockeye production enhancement activities in several systems include lake fertilization, back plants, and out plants. NBTC supports this research which will permit estimation of MSY escapement goals based on spawning and rearing limitations in the freshwater environment. This work also is needed to evaluate the opportunities/options for natural enhancement programs including the outplanting of fry to barren lakes, backplants to supplement existing production, or lake fertilization, spawning channels, fish ways, or other habitat modifications.

With the exception of the Babine Lake system, sockeye escapement goals for Canadian systems are based on subjective assessments of the spawning and rearing habitat and historical catch and escapements. The derivation of these assessments are generally not documented and their accuracy is not evaluated. Technical programs for evaluating lake productive potential have been developed as part of the Salmon Enhancement Program Lake Enrichment Program and may prove useful for comparison to the subjective assessments. Surveys have been implemented in many NBA sockeye systems over the last decade, and nine systems within the Nass drainage have been evaluated in 1992. A major review of the Babine Lake system has recently been proposed to evaluate the impacts of the increased fry recruitment over the past decade. These independent methods of evaluating stock productivity are essential for most NBC sockeye stocks because reconstructions are based on stock identification methods which usually cannot separate individual small stocks.

## MANAGEMENT

### *Preseason Forecasting*

Reliable preseason forecasts of the returning stock size of boundary area sockeye salmon would help managers in planning fishery openings and industry prepare for processing and marketing of catches.

In **Southeast Alaska**, ADF&G staff have made informal forecasts of the returns to several lake systems. These forecasts are usually based on applying an average estimate of smolt-to-adult survival to the estimated number of smolts. These estimates are specific to each lake system with smolt-to-adult survival generally ranging between 9 and 15 percent.

Expectations for **Canadian** sockeye stocks are simply escapement estimates multiplied by a standard expected age specific return rate, generally the average over the past 10 years. Current methods are very crude and have not been recently reviewed. Further evaluations of forecasting methodologies are recommended, particularly for the Nass stocks which have been highly variable (unpredictable) in recent years.

### *Inseason Abundance Estimates*

The abundance of sockeye salmon returning to the NBA can likely be reliably estimated inseason using regression models of historical and current fishery performance data. The return by major stocks or stock group could also be estimated if combined with an inseason stock identification program. The NBTC should evaluate the performance of these inseason forecast models to evaluate alternative management options.

In **SSA**, a tremendous investment opportunity exists to increase yield (harvests) of sockeye salmon from McDonald Lake. McDonald Lake is at present the single largest producer of sockeye salmon in SSA, this is due in part to the success of a lake fertilization program. Escapements have greatly exceeded the 70,000-85,000 escapement goal in recent years. This overescapement results in a direct loss of harvest opportunity and possible suboptimal returns in future years. Increased benefits from this valuable resource are possible if a comprehensive program were in place for forecasting returns inseason. A smolt enumeration, CWT, and catch and escapement sampling program would enable inseason estimation of run strength as well as postseason estimation of exploitation rates and entry patterns. Hydroacoustic technology could be employed to estimate the abundance of McDonald Lake sockeye in Yes Bay prior to commercial purse seine openings. The escapement goal for McDonald Lake sockeye should be reevaluated; these new research programs will enable spawner-recruit-based estimation of escapement goals. These new programs total $90,000 but would be only $60,000 if a companion CWT program was in place for McDonald Lake coho salmon. This moderate investment in assessment of McDonald Lake sockeye salmon will likely increase average annual yield $300,000-$800,000, since sockeye salmon average over $10/fish and 30,000 to 80,000 additional fish would likely be harvested annually.

In **NBC**, inseason abundance estimates for Nass and Skeena stocks in Canadian 'terminal' fishing areas are derived from a combination of catch rates in NBA fisheries, and escapements as indicated from the Skeena and Nass test fisheries. Considerable additional benefit would be gained from a review and documentation of the current process particularly for the Nass sockeye where potential in-season conservation issues may need to be adjudicated.

### *Management Strategies*

In **SSA,** a significant portion of the SSA sockeye harvest is taken incidentally in fisheries targeting on pink salmon. The primary management objectives for SSA fisheries which target on sockeye is to comply with current annex provisions and minimize, to the extent possible, the interceptions of weak stocks.

ADF&G attempts to assess the status of the sockeye salmon resource in SSA through monitoring of annual catch and effort data, escapement enumeration programs on two systems (Hugh Smith and McDonald Lake), lake productivity studies conducted by Commercial Fisheries Management and Development Division's Limnology Section staff, and annual estimates of catches by stock (Alaska, Nass, Skeena, or "south migrating"). Hatchery releases of 0-check sockeye salmon is increasing rapidly in this area. All of these release groups are represented with a coded wire tag which will permit the run reconstruction analysis needed to estimate migration routes, timing, and exploitation rates if mark and recovery data are adequate.

ADF&G needs to develop a program to monitor annual returns of sockeye salmon to Southern Southeast Alaska. This program should combine wild and hatchery indicator stock coded wire tagging programs with the scale pattern-based stock identification catch composition program. This will permit run reconstruction for the key indicator stocks along with an estimate of the total returns and exploitation rates from which to determine the adequacy of annual escapements.

The current basic **Canadian** management strategies for harvesting sockeye stocks is to strike a balance between harvesting available surplus stocks in native, commercial and sport fisheries while minimizing the impacts on less productive stocks harvested incidentally. The fishery on Skeena sockeye is restricted to less than the exploitation rate required to fully exploit the enhanced Babine production because of concerns for the summer run coho and steelhead. Canada implemented a program in 1992 to selectively harvest Babine sockeye in the Skeena River and is moving towards more stock specific management of the sockeye stocks within the NBA.

## INTERCEPTION ESTIMATES

Interception estimates are currently derived from scale stock identification programs and by extrapolating from the Pacific Salmon Treaty (PST) NBA tagging program. The NBTC is working towards a consistent agreed joint sampling and analysis program for estimating stock compositions in NBA fisheries, including a common estimation of the Fraser sockeye interceptions in the NBA.

## ENHANCEMENT

In **SSA**, reliable estimates of the contribution of enhanced sockeye salmon are needed because returns are expected to be large relative to natural production. A comprehensive program is needed to estimate annual fishery contributions, by gear and district, of hatchery origin sockeye. Management needs to account for the contribution of enhanced sockeye salmon to avoid over harvesting of wild stocks. Future annex arrangements may include a provision to exclude estimated Alaska hatchery production from the catch limits. If this arrangement were negotiated, the contribution of enhanced sockeye also needs to be accounted for in Treaty annexes governing the District 101 gillnet fishery and the District 104 seine fishery. This activity will cost $25,000 to support biologist/biometrician staff time needed to effectively analyze and report on these CWT-based estimates. In the future, thermally induced otolith marking might be the stock identification method of choice.

Large numbers of 0-check sockeye produced from hatcheries in SSA could complicate discrimination of Fraser and non-Fraser fish using the percentage of *Philonema* infected fish in the catch. Historical baseline samples generally show a low rate of infection for Fraser sockeye and a high rate for non-Fraser fish. Samples taken in 1992 show an extremely low incidence of this parasite in the Alaskan 0-check hatchery sockeye. *Philonema* based stock contribution estimates will need to be based on standards collected inseason from inside (non-Fraser) fisheries or be age specific. NBTC members are interested in working with PSC staff in applying this method to fisheries in the NBA.

The Babine spawning channels are the only current Canadian sockeye enhancement in the **NBA**. No additional projects are contemplated in the short term.

## PINK SALMON

### *Stock Assessment*

In **SSA**, index escapement goals have been set for pink salmon in each district. The derivation of these escapement goals is not well documented. Generally, they are based on a subjective assessment of the spawning and rearing habitat and historical escapement levels for all streams in a district. Spawner-recruit modeling of escapement goals is limited by poor estimates of total escapement and lack of reliable stock composition estimates.

Escapement goals are assigned for all **NBC** pink streams. The targets are based on subjective assessments of available spawning and rearing habitat, historical catch and escapement patterns and on crude stock recruitment analysis (Skeena pink). There has been no qualitative assessment of the habitat capacity for spawning. The potential for stock specific reconstructions are limited by the very poor stock specific catch information.

### *Recruitment Analysis*

Reliable estimates of the annual catch and escapement by major stock or stock grouping is needed for recruitment analysis. If a time series of data is available it can be used to estimate MSY escapement goals, forecast returns, and estimate interceptions. Unfortunately, practical methods to make annual postseason estimates of pink catch by "stock" have not been developed. The NBTC supports a program to fully explore the potential for pink stock reconstructions once the review of the PST NBA tagging is completed. The NBTC should also look at pooling NBA area stocks.

### Catch

ADF&G's catch reporting and data retrieval program in **Southeast Alaska** meets current requirements; this activity is given high priority for continued funding. Timely reporting of catches in the Annette Island Fishery Reserve is required.

The catch reporting system in NBC in based on a combination of in-season hailed catch by subareas which is then prorated post-season by the sales slip information available by statistical area. The catch sampling in Canadian Statistical Areas 3 and 4 has been improved over the last two years to sample finer strata. This program needs to be jointly evaluated to confirm that the sample size and strata are appropriate.

### Stock Identification

The high cost of joint adult tagging studies precludes using this method for making direct estimates of the annual stock compositions in Boundary Area fisheries. We are interested, however, in keeping abreast of new methods in stock identification.

The GSI method using electrophoresis of inherited proteins is being evaluated by ABL and a preliminary report on the results for odd-year pink salmon in the SSA showed a broad geographic separation of stocks (Gharrett et al., 1990). Data from odd-year pink salmon in NBC and northern Southeast Alaska have now been added to the baseline. The 'island' stocks of both SSA and NBC tended to be different from the stocks on the mainland. A final report on the odd-year pink salmon will be ready in the fall of 1993. Tissue collections of even-year pink salmon in the NBA are mostly complete; however, laboratory analysis has not begun. Programs to evaluate genetic methods using mitochondrial and nuclear DNA on pink salmon in the NBA have not been initiated.

The feasibility of discriminating pink stocks based on natural differences in scale patterns or otolith patterns has not been evaluated. Pink salmon scales are formed after the fry leave the streams; therefore, scale patterns are unlikely of value for stock discrimination. The feasibility of discriminating stocks using otolith pattern analysis should be evaluated. Measurable differences in otolith patterns might be found since all stocks other than the Skeena pinks originate from relatively short island and coastal systems.

Differences in migration timing of SSA and NBC pink runs might enhance stock separation potential for some fisheries. Sex ratio and maturity data could be used along with catch and effort data in this analysis.

**Escapement**

In SSA, estimating desired escapement targets will involve reconstructing the annual returns of pink salmon to predefined stock groups and applying this data to spawner-recruit models. This involves defining stock groups which have similar migration routes and timing, estimating the stock composition of the catch by broad stock groupings, and estimating total escapement to each stock group. A program is needed to calibrate observers and expand the existing escapement indexing program to an estimate of total escapement. We recommend operation of two weirs on an annual basis, one each in the Ketchikan and Petersburg Management Areas, for estimating survey life and estimating counting rates for individual aerial and foot surveyors. An effort will be made to count escapements on systems with different spawning densities and physical survey characteristics. This will involve operating the weirs on different systems in successive years. There will be an overlap in surveying these weired streams between the area management biologists. This information, as well as results from prior studies, will be used to estimate the counting rate for all observers and expand index counts to total escapements. Funding is needed to support additional escapement surveys to selected index streams within each stock group, inseason tracking and modeling of pink salmon escapement data, and maintenance of escapement records in ADF&G's Integrated Fisheries Data Base. Funds needed to support estimating the escapement of pink salmon total $55,000 per management area. These proposed expenditures are small relative to the earnings from harvests of pink salmon. These efforts to improve our understanding of escapement goals and ability to monitor escapements inseason could substantially increase the production and value of pink salmon production in the region.

In NBC, pink escapement surveys are conducted by CDFO staff usually by foot surveys, by river float, or aerial surveys. Many factors such as stream flows, water clarity, presence of chum salmon, and differences among observers affect the accuracy of the counts. A standard form to record details from each stream visitation was introduced in 1988 and is currently in use in most areas. The intensity of the monitoring varies with the importance of the stream, and escapement estimates may be based on as few as one visit to as many as ten or more. An estimate of the annual total escapement is extrapolated from the available data and this information is entered into a computer database maintained at the Pacific Biological Station.

**Joint Analysis**

We recommend the boundary area pink reconstructions be done jointly since considerable interpretation of the available data will be required. The reconstructions would be attempted once the current program of reviewing the PST tagging programs are completed.

### *Exploitation Rate Indicators*

Coded micro-wire tag technology has not been applied toward stock identification of pink salmon in the boundary area. The tremendous expense and practical limitations of marking and examining the number of fish needed to make precise estimates significantly reduces the utility of pink CWT's programs.

Advances in mass-marking and processing technology might in the future provide opportunities for the use of thermal or elemental marks. However, the application of these induced marks for wild stocks has obvious technical problems. A number of hatchery-reared, mass-marked, remote-released, indicator stocks could be useful for estimation of migration patterns, catch distributions and exploitation rates; however, these hatchery programs do not currently exist.

### *Habitat Assessment*

As mentioned above, the pink salmon index escapement goals in SSA were based on a subjective habitat-based assessment of spawning and rearing habitat. The potential of applying an extensive habitat inventory data base maintained by the U.S. Forest Service to estimate freshwater production capacity has not been attempted.

For all Canadian NBA pink stocks, other than the Skeena, escapement goals are based on subjective estimates of the available spawning habitat. The derivation of the goals is generally not documented and there has not been an evaluation the targets. The Skeena escapement objective is to provide escapements in proportion to the returning stock size with a set minimum target.

## MANAGEMENT

### *Preseason Forecasting*

In SSA, the existing program of forecasting pink salmon returns preseason needs to be expanded to include additional information related to factors affecting survival in the early marine and ocean environments. Pink salmon survival during their early marine and ocean residency period is highly variable. Survival conditions during these periods needs to be factored into forecasts to improve accuracy and functional use by industry and ADF&G. Several programs which might help to improve forecasts include monitoring the growth and survival of SSA pink salmon during the first few months of ocean residence and the use of hydroacoustic technology for estimating the biomass of pink salmon fry in the near shore environment. This information is anticipated to enable estimation of escapement goals based on spawner-fry relationships in the Eastern Behm Canal, Boca de Quadra, and Cholmondeley Sound areas.

The spawner-fry relationships should be more precise for estimation of escapement goals than spawner-recruit relationships since the variability in early marine and ocean survival is not a factor. This activity will cost $35,000. ADF&G prioritizes inseason run strength and timing forecasts above preseason forecasts.

Expectations for **Canadian** pink stocks are simply escapement estimates multiplied by a standard expected return rate, either a coastal standard or a recent average. Current methods are very crude and have not been recently reviewed. Further evaluations of forecasting methodologies are recommended.

### *Inseason Abundance Estimates*

In **SSA**, additional funds are needed to support inseason estimation of pink salmon run strength and timing. These funds would support timely collection of fishery performance data and sex composition data from selected fisheries. Staff time will also be needed to fully develop and apply run timing and run strength models. ADF&G is supporting a graduate student's research on the applicability of pink sex composition data for improving inseason estimates of run timing and run strength. Responsive management of intercepting fisheries requires an accurate assessment of run strength so fishing can be directed on stocks returning in excess of escapement needs and the fish can be harvested at times and in areas where they are of highest possible quality. The industry's increased emphasis on fish quality is an important consideration in ADF&G's management. In most circumstances this will mean harvesting the pink salmon at some distance from their natal streams and under mixed-stock conditions. In addition, since males return earlier than females (on average) fishery management should avoid the tendency to delay fishing until escapement needs have been met because this results in a disproportionate number of males in the escapement.

Catch and effort data is available from commercial seine fishery openings for inseason forecasting of pink salmon returning to SSA through the Dixon Entrance and Sumner Strait corridors. However, an additional $30,000 is needed to effectively sample and analyze the catch, effort, and sex composition data needed to make timely and reliable inseason forecasts.

In **NBC**, in-season abundance estimates for Skeena stocks are derived from a combination of catch rates in NBA fisheries, and escapements as indicated from the Skeena test fishery. The management of other Canadian pink stocks is based on fishery catch rates and in-season escapement estimates in coastal stocks as measures of abundance. These programs have not been technically evaluated. Considerable additional benefit would be gained from a review and documentation of the current process.

The NBTC should coordinate run strength models to forecast returns of all pink salmon in the NBA.

### *Management Strategies*

In **SSA** the information available for management of pink salmon stocks is generally limited to preseason and inseason forecasts of returns and catch, inseason counts of escapements in a non-standardized escapement monitoring and fishery overflight program, and catch, effort, and sex composition (run timing) data (see Table 1 in the Joint Objectives and Goals chapter for Southeast Alaska). Preseason forecasts have performed poorly in some recent years and the success of new projects for forecasting returns inseason still need to prove themselves over time. Management depends heavily on subjective assessments of the run strength and timing of pink salmon to be harvested in mixed stock fishing areas. The overall management objective is to achieve a subjective index escapement goal for each district's stock group and to have this escapement adequately distributed through time and systems.

The fishing industry and ADF&G recognizes a need for refined management of commercial purse seine and drift gillnet salmon fisheries which target on each species in SSA. A better understanding is needed of what the manageable stock groupings are, an accurate and quantifiable estimate of their optimum escapements, and the ability to recognize and harvest surplus production in an orderly and efficient manner.

The recommended management program for pink salmon has three main facets: (1) develop reliable estimates of the upper and lower bounds of the escapement targets, by stock group, which will likely result in maximizing average annual returns; (2) develop reliable pre- and inseason estimates of run strength, by stock group or groups; and (3) incorporate this information into plans and inseason actions which efficiently harvest pink salmon in excess of spawning stock needs in times and areas where the fish are of highest value. Management of fisheries targeting on pink salmon will take into account conservation and allocation concerns of by-catch species. Programs to improve the management program for pink salmon are directed mainly toward purse seine fisheries since 90% of the pink salmon are harvested by purse seine gear and pink salmon are the target species in most purse seine openings.

The current basic **Canadian** management strategies for harvesting pink salmon stocks is to strike a balance between the harvest of available surplus stocks in native, commercial and sport fisheries and minimize the impacts on less productive stocks harvested incidentally. The fishery on Skeena pink is restricted to less than the exploitation rate required to fully exploit the production because of concerns for the summer run coho and steelhead. A specific challenge in QCI pink management is to establish the appropriate balance between early fisheries that greatly improve fish quality but increase the risk of fishing into escapement and later fisheries that assure escapements but increase the proportion of dark fish.

## INTERCEPTION ESTIMATES

Joint Pacific Salmon Treaty adult tagging studies were conducted in the northern Boundary Area in 1982, 1984 and 1985. The main purpose of these tagging studies was to estimate stock compositions in NBA fishing areas so that estimates of interceptions could be made. We anticipate that results from this tagging study, combined with an iterative "abundance adjustment" procedure, will be useful for annual estimation of interceptions and returns to each nation. A Canadian review of a report of the final U.S. estimates (Pella et al., 1993) is needed before the committee can proceed with revising the estimates. This activity has, and continues to be, a high priority of the NBTC. NBTC members are currently working on a joint re-analysis of this tagging data in the hope of developing mutually agreeable estimates. This re-analysis involves verification that the mark-recovery and catch data sets, interception estimate formulas and release and recovery strata are consistent between parties. Once jointly developed and agreed estimates are calculated for the tagging years then NBTC can further work on applying these estimates to non-tagging years and jointly reconstruct returns by nation for past and future years. This information is needed to evaluate domestic escapement goals using spawner-return modelling. This information would improve our understanding of stock status and be an asset both for domestic management and development of future Treaty annexes.

The NBTC should review the findings and techniques of research conducted into GSI stock identification of pink salmon in the NBA.

## ENHANCEMENT

Enhancement of pink salmon in **SSA** has been limited to relatively small releases from Burnett Lake and Tongass hatcheries. There is no plan to increase hatchery releases of pink salmon in SSA.

Currently the only pink enhancement program in **NBC** is the Atnarko spawning channel in Area 8. This is a small controlled flow improved channel that is intended to act as insurance to rebuild the natural pink spawning run if the river is decimated by adverse environmental conditions. No significant pink enhancement programs are anticipated in the near future.

## CHUM SALMON

### *Stock Assessment*

Minimum escapement goals have been informally set for some SSA chum streams. These targets are based on subjective assessments of spawning and rearing habitats and historical escapement patterns.

Target escapements are assigned for all NBC chum streams. The targets are based on subjective assessments of available spawning and rearing habitat, and on historical catch and escapement patterns. There have been no qualitative assessment of the habitat capacity for spawning or rearing. Adequate information on age specific catch and escapement by stock is not available, and this precludes assigning targets based on technical approaches such as stock-recruitment relationships.

### *Recruitment Analysis*

There is currently no realistic prospect for reconstructing most NBA chum stocks since age specific catch and escapement information are generally not available. The exceptions may be for QCI fall chum if it is assumed there are no interceptions in off-island fisheries.

### Catch

The SSA catch reporting system for chum is the same program described for pink salmon in section III.

The catch reporting system in NBA is based on a combination of in-season hailed catch by subareas which is then prorated post-season by the sales slip information available by statistical area. The catch sampling has been improved over the last two years to sample finer strata. This program needs to be jointly evaluated to confirm that the sample size and strata are appropriate.

### Stock Identification

Joint Pacific Salmon Treaty adult tagging studies were conducted in the NBA in 1982, 1983, 1984 and 1985. The main purpose of these tagging studies was to estimate pink and sockeye stock compositions in NBA fisheries to provide estimates of interceptions. Unfortunately the results of the chum tagging program cannot be used to generate estimates of stock composition in the NBA fisheries.

Scales hold small promise for stock identification. The fry have already exited the freshwater streams before circuli start forming. The circuli formed on the scales of chum salmon represent marine growth with few exceptions.

A GSI using electrophoresis of inherited proteins is being evaluated by the ABL. A preliminary report on the genetic diversity of SSA chum salmon populations is available (Kondzela et al., 1989). A preliminary report on the laboratory analysis of tissue samples from NBC and SSA is now complete (Kondzela et al., In Press). An evaluation of the utility of chum stock identification will follow from simulations using this baseline.

Genetic methods utilizing mitochondrial and nuclear DNA on chum salmon have been initiated at PBS and the Northwest Fisheries Science Center in Seattle, Wa.; however, these studies are not presently directed at NBA problems. ABL staff plans to initiate research on NBA chum salmon DNA in 1995.

### Escapement

ADF&G seeks to improve the indexing of chum salmon escapements in **SSA**. Most surveys counts are made coincidentally during pink salmon surveys.

Chum escapement surveys are conducted by CDFO staff usually by foot, float, or aerial surveys. A standard form to record details from each stream visitation was introduced in 1988 and is currently in use in most areas. The intensity of the monitoring varies with the importance of the stream. An estimate of the annual total escapement is extrapolated from the available data and this information is entered into a computer database maintained at the Pacific Biological Station in Nanaimo.

### Joint Analysis

A high priority is placed on the ABL completion of the analysis of chum GSI data.

## *Exploitation Rate Indicators*

A quantitative program to index annual escapements by stock group is needed for summer- and fall-run chum salmon in southeast Alaska. This will cost $28,000 annually with costs split between area management offices. Additionally, $20,000 is needed to support indicator stock tagging (CWT) programs for several hatchery releases in southern Southeast Alaska. The ADF&G Port Sampling Program needs $8,000 to representatively sample chum catches for age, sex, and length data. The annual monitoring of this escapement, catch, and age/length composition data is needed to accurately assess trends in summer chum production and identify harvest opportunities and conservation concerns. A comprehensive program is needed to make inseason estimates of returns and escapements of fall run chum salmon to systems along the eastern Prince of Wales Island. This will cost $10,000.

The ADF&G implemented a CWT program on Fish Creek chum in 1986 and the program completed the second year of significant returns in 1992. Chum catches in NBA fisheries are sampled for tags and the

escapements are monitored from weir counts. The results provide exploitation rate patterns of Fish Creek chum salmon. Efforts to sample chum in the NBA should continue until the program is complete in 1995.

Canada has no exploitation rate indicator programs.

### *Habitat Assessment*

Chum escapement goals in **SSA** are based on subjective assessments of spawning habitat and historical escapements. The habitat inventory data base maintained by the U.S. Forest Service could be used to estimate the chum production potential.

For all **NBC** chum stocks escapement goals are provided based on subjective estimates of the available spawning habitat and historical catch and effort information. The derivation of the goals is generally not documented and there has not been an evaluation the targets.

## MANAGEMENT

### *Preseason Forecasting*

Published catch projections for chum in the **SSA** are recent 5 year averages. ADF&G staff modelled the relationship between brood year returns and size-at-age to informally forecast chum returns in 1992. The accuracy of this forecast was encouraging.

Expectations for Canadian chum stocks are simply escapement estimates multiplied by a standard expected age specific return rate, either a coastal standard or a recent average. Current methods are very crude and have not been recently reviewed. Further evaluations of forecasting methodologies are recommended as a low priority.

### *Inseason Abundance Estimates*

Fishery performance and inseason escapement counts are used to assess returns of chum salmon in **SSA**. Models to quantitatively forecast returns inseason have not been developed although the potential exists.

In-season abundance estimates for **NBC** chum stocks are derived from a combination of fishery catch rates and in-season escapement estimates as measures of abundance. These programs have not been technically

evaluated. Most Canadian NBA chum harvests are taken incidentally and chum harvests are not driven by in-season abundance estimates.

### *Management Strategies*

In **SSA** chum salmon are generally caught incidental to the harvest of pink salmon and other salmon species. Management is passive with only catch, catch per effort, and non-indexed escapement counts available to assess stock status (see Table 1 in the Joint Objectives and Goals chapter for Southeast Alaska). Efforts to reduce exploitations on chum salmon stocks is usually based on a review of historical catch data. Hatchery production of chum salmon in SSA is significant and many release groups are coded wire tagged. However, this information has not been incorporated into an indicator stock tagging program to represent hatchery and wild production. Fish Creek, near Hyder, is the only wild system where run reconstruction is possible thanks to a Pacific Salmon Treaty funded CWT mark-recapture and escapement estimate program.

Most **NBC** chum harvested in Canadian NBA fisheries are taken incidentally and chum harvests are not driven by inseason abundance estimates. A specific challenge in QCI chum management is to establish the appropriate balance between early fisheries that greatly improve fish quality but increase the risk of fishing into escapement and later fisheries that assure escapements but increase the proportion of dark fish. Also, of particular interest is evaluating the lack of rebuilding in the chum stocks of the West Coast of the QCI where all known harvests have been severely curtailed for two decades.

## INTERCEPTION ESTIMATES

There is no hope for developing quantitative interception estimates in the foreseeable future. The NBTC still places a priority on finding a practical chum stock separation methodology.

## ENHANCEMENT

Details of SSA and Canadian NBA enhanced chum production were provided in the stock status review submitted to the PSC in December of 1992.

## STEELHEAD

The U.S. assessment of research needs for steelhead was roughly summarized in NBTC's joint report on the status of steelhead in SSA and NBC (NBTC 1991b). The ADF&G Division of Sport Fish staff are primarily responsible for research and management of steelhead in SSA.

A cursory summary of NBC steelhead catch and escapement information was reported in NBTC 1991b.

## STOCK ASSESSMENT

Steelhead have an extremely complex age structure and the lack of any stock specific escapement and catch information precludes any stock recruitment analysis. Stock assessments largely rely on habitat based assessments of productive potential and current utilization.

### *Recruitment Analysis*

Recruitment analysis for NBA steelhead is not possible even in a crude context as there is no age specific catch or escapement information.

### Catch

In **NBC** the steelhead catch in commercial fisheries is known to be inaccurate as misreporting and personal consumption are common and variable between years depending on the political sensitivity of the issue. Catch and release initiatives for commercial net fishermen also reduce the consistency of steelhead landings. Steelhead harvests by Indian Food Fisheries are generally poorly understood although the British Columbia provincial MELP has improved surveys for the Skeena in recent years. Sport harvest data is available for the major fishing areas and the Skeena has been closed to steelhead retention for a number of years.

Steelhead catch reporting from commercial fisheries in **SSA** is also believed to be of questionable accuracy for reasons similar to those in Canada. Sport catches are estimated annually from a statewide mail-out harvest survey of license holders and a U.S. Forest Service cabin postal survey conducted in Southeast Alaska.

### Stock Identification

Techniques for using differences in scale patterns to separate stocks has been evaluated and does show some promise. There are currently no baseline genetic data to permit GSI of steelhead.

### Escapement

In **NBC**, the Skeena test fishery provides an index of steelhead escapement, however there is no method to calibrate the index to provide an estimate of actual abundance. This is particularly troublesome since the annual calibration of the sockeye index from the known escapement indicates a doubling of the index expansion factor over the past 20 years. This suggests the test fishery is also not a consistent index for species other than sockeye. Actual estimates of escapement are not attempted on a consistent basis although some data from fence counts or float surveys is available.

In **SSA**, steelhead escapement counts are available for some systems and years but a consistent multi-year database is not available for evaluating historical trends in escapement to any system or stock group. In the spring of 1992, ADF&G, Division of Sport Fish, initiated a program to get foot survey counts of steelhead in 26 southeast Alaska streams, most of these streams are on Prince of Wales Island in SSA. ADF&G also started two weir projects in 1992 for estimating steelhead escapements and counting rates for the biologists who conduct the foot surveys of the 26 index streams. One weir is located on Ward Creek near Ketchikan and assesses the production of an enhanced stock. The other weir will be rotated each year between a set of the important index streams. Age (scales), sex, size, and scar data is collected from steelhead at the weir sites.

### Joint Analysis

The NBTC should evaluate the quality of the steelhead catches and escapements in the NBA and the prospects to obtain improved assessments.

## *Exploitation Rate Indicators*

Returns from Skeena steelhead CWT programs were obtained from NBA fisheries in 1991 and 1992. The information will not be sufficient for the stocks to serve as exploitation rate indicators since escapements are not assessed.

There are no steelhead exploitation rate indicators in Alaska. Hatchery production of steelhead in SSA is limited and there are no releases suitable as a CWT indicator stock. Commercial fisheries in SSA are not routinely sampled for CWT'ed steelhead.

### *Habitat Assessment*

The productive potential of the Skeena watershed has been assessed by MELP and agreed (between CDFO and MELP) escapement goals have been derived.

The productive potential and escapement goals for steelhead have not been assessed for SSA systems.

## MANAGEMENT

### *Preseason Forecasting*

No preseason forecasts are made.

### *Inseason Abundance Estimates*

Inseason abundance of Skeena steelhead is indicated by the test fishery steelhead index and from fishery catch rates.

### *Management Strategies*

In **NBC**, the management strategies for steelhead are the subject of significant domestic discussions in Canada. Commercial net fisheries are restricted to a maximum of 4 days per week (since 1983) to reduce the incidental harvest of Skeena steelhead and coho. There is a significant allocation issue as additional steelhead are desired for sport and native utilization and more importantly there is an unresolved issue of whether there is a conservation problem for some Skeena steelhead stocks. The assessment requirements for Canada may change if current policies are altered.

In **SSA**, catch and release regulations are imposed in specific systems where returns are poor. ADF&G may implement regionwide catch and release by sport fishermen if a current public review process finds it appropriate.

## INTERCEPTION ESTIMATES

Steelhead interception estimates are currently not part of the JIC estimates.

## ENHANCEMENT

Steelhead enhancement is very limited in NBC and SSA and there are no plans for additional programs at the present time.

## SUMMARY

The focus of NBTC's joint research priorities are consistent with the basic principals of the Treaty - to prevent overfishing and provide for optimal production and provide for each party to receive benefits equivalent to the production of salmon originating in its rivers. To achieve these objectives, NBTC needs to promote: (1) the understanding of factors influencing salmon production; (2) provide managers with the capability to manage fisheries in a manner that allows escapement needs to be met; and (3) the ability to achieve harvest sharing arrangements. Management requires knowledge of run sizes, stock compositions, distribution of stocks among fishing areas, and the timing and migration routes of adults returning through the fishing areas.

The focus of NBTC's joint research priorities is generally toward the improvement of our understanding of stock productivity and the ability to control harvests to meet biological and allocative needs. Since our fisheries harvest a shared resource, we recognize the mutual benefit from knowing what spawning escapements are needed to optimize production, what each stock group's migration route, timing, and magnitude is, and the planning and implementation of management measures which permit efficient harvesting of returns in excess of escapement needs.

Many of NBTC's research priorities involve improvements to existing programs or analysis of existing information. The costs for these refinements to existing programs are generally less than the implementation of new programs. Maintaining funding for existing programs is critical.

A summary of the research priorities for sockeye, pink, chum, and steelhead is provided in Table 1. The relative priority, cost and whether the program is existing or new is indicated.

Escapement enumeration, stock identification, and inseason abundance estimation activities were identified as research priorities for sockeye, pink, and chum. Programs to better estimate catch, escapement, and management options for reducing catches of steelhead, Skeena River steelhead in particular, are a priority.

The highest priority need for joint research activities facing NBTC are: application of scale pattern-based stock ID to sockeye harvested in NBC fisheries; and complete reanalysis of adult tagging data for pink salmon and apply to annual interception estimates.

## REFERENCES


Bailey R.E. and L. Margolis. 1987. Comparison of parasite fauna of juvenile sockeye salmon (*Oncorhynchus nerka*) from southern British Columbia and Washington State lakes. Can J. Zool. 65:420-431.

Gharrett, A.J., R.B. Wilson, B.M. Baker, C.M. Guthrie, C.M. Kondezela, and H.R. Carlson. 1990. Preliminary report on genetic diversity of southern Southeast Alaska pink salmon populations. NWAFC Processed Report 90-03. Auke Bay Laboratory, Auke Bay, Alaska. 50p.

Guthrie, C.M., J.H. Helle, P. Aebersold, G.A. Winans, and A.J. Gharrett. In Press. Preliminary report on the genetic diversity of sockeye salmon populations from Southeast Alaska and northern British Columbia. AFSC Processed Report, Auke Bay Laboratory, Auke Bay, Alaska.

Koerner, J.F., B.W. Van Alen, and D.J. Blick, Jr. 1992. Project operational plan: Hugh Smith Lake sockeye stock assessment. Alaska Department of Fish and Game, Division of Commercial Fisheries, Region I, Juneau. (unpublished report).

Kondzela, C.M., C.M. Guthrie, R.B. Wilson, H.R. Carlson, and A.J. Gharrett. 1989. Preliminary report on genetic diversity of southern Southeast Alaska chum salmon populations. NWAFC Processed Report 89-12, Auke Bay Laboratory, Auke Bay, Alaska. 63p.

Kondzela, C.M., C.M. Guthrie, S.L. Hawkins, C.D. Russell, J.H. Helle, and A.J. Gharrett. In Press. Genetic relationships among chum salmon populations in Southeast Alaska and northern British Columbia. Lowell Wakefield Fisheries Symposium - Genetics of Subarctic Fish and Shellfish, May 1993, Juneau, Alaska.

Marshall, S.L., G.T. Oliver, D.R. Bernard, and S.A. McPherson. 1984. Accuracy of scale pattern analysis in separating major stocks of sockeye salmon (*Oncorhunchus nerka*) from southern Southeastern Alaska and northern British Columbia. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 230, Juneau.

Moles A., P. Rounds, and C. Kondzela. 1990. Use of the brain parasite *Myxobolus neurobius* in separating stocks of sockeye salmon. Amer. Fish. Soc. Symp. 7:224-231.

NBTC (Northern Boundary Technical Committee). 1991a. Conduct of fisheries and status of sockeye, pink, and chum salmon stocks in the Northern Boundary Area. (Unpublished, presented to the Pacific Salmon Commission, Bilateral Northern Panel, December 12, 1991.)

NBTC. 1991b. Review of steelhead stock status, harvest patterns, enhancement and migrations in the Northern Boundary Area. Pacific Salmon Commission, Northern Boundary Technical Committee Report, TCNB (91)-1.

## REFERENCES (Continued)

NBTC. 1992. U.S./Canada Northern Boundary Area 1992 Salmon Fisheries Management Report and 1993 preliminary expectations. Pacific Salmon Commission, Northern Boundary Technical Committee Report, TCNB (92)1.

Oliver G. and D.J. Blick, Jr. 1991. Project operational plan: sockeye stock assessment, southern Southeast Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Region I, Juneau. (unpublished report).

Pella, J., M. Hoffman, S. Hoffman, M. Masuda, S. Nelson, and L. Talley. 1993. Adult sockeye and pink salmon tagging experiments for separating stocks in northern British Columbia and southern Southeast Alaska, 1982-1985. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-18.

Wood, C.C., D.T. Rutherford, and S. McKinnell. 1989. Stock identification of sockeye salmon (*Oncorhynchus nerka*) stocks in mixed-stock fisheries in British Columbia and Southeast Alaska using biological markers. Can. J. Fish. Aquat. Sci. 46:2108-2120.

Table 1. Research priorities for sockeye, pink, chum, and steelhead salmon in the Northern Boundary Area.

| Species/ Category | By Whom | Activity/Status/Cost/Priority<br><br>Status: **E**xisting or **N**ew program.<br>Cost: **L**ow (<$20K); **M**oderate ($20-50K); **H**igh (>$50K); or adequately **F**unded now.<br>Priority: **3** (High); **2** (Higher); or **1** (Highest). | Status | Cost | Priority |
|---|---|---|---|---|---|
| Sockeye | Alaska | - Fully support existing stock ID program (escapement sampling and scale pattern analysis research) | E | L | 1 |
| | | - Fully support existing escapement enumeration and sampling program at McDonald Lake | E | F | 1 |
| | | - Fully support CWT mark-recovery and escapement enumeration at Hugh Smith Lake | E | F | 1 |
| | | - Fully support existing genetic stock ID research | E | F | 2 |
| | | - Fully support FRED Divisions lake productivity studies | E | L | 2 |
| | | - Initiate CWT mark-recapture and escapement enumeration program at McDonald and Salmon Lake | N | H | 3 |
| | | - Review, assist, and analyze hatchery CWT data with hope of developing indicator stock tagging program | N | M | 2 |
| | | - Develop representative indicator stock CWT tagging program for wild and enhanced stocks in SSA | N | M | 2 |
| | | - Estimate annual escapements to SSA using SPA and CWT results | N | F | 2 |
| | | - Estimate escapement goals, by stock group, using habitat models | N | H | 3 |
| | | - Develop a "management information system" for management of boundary area sockeye | N | M | 3 |
| | B.C. | - Improve and complete implementation of annual scale pattern-based stock ID in NBC fisheries | N | M | 1 |
| | | - Sample sockeye harvested in northern B.C. fisheries for CWT data | N | M | 2 |
| | | - Document and evaluate current escapement methods | E | M | 1 |
| | | - Evaluate the benefits of sockeye CWT indicator stock tagging program vs. genetic stock ID | N | L | 3 |
| | | - Evaluate Babine Lake - impact of enhancement | N | H | 1 |
| | | - Evaluate Babine Lake - contribution of lake spawners | E | H | 1 |
| | | - Evaluate lake productivity data collected to date | N | H | 1 |
| | | - Continue sockeye "fence" operation at Babine and Meziadin | E | H | 1 |
| | | - Implement new lake production potential surveys | N | H | 1 |
| | | - Document and evaluate Nass sockeye inseason management model | N | L | 1 |
| | | - Document and evaluate Skeena sockeye inseason management model | N | L | 2 |
| | | - Review Nass test fish program | N | L | 1 |
| | | - Review Skeena test fish program | N | L | 2 |
| | | - Evaluate Skeena in-river genetic stock ID program | E | L | 1 |
| | | - Evaluate Nass genetic stock ID sampling program | E | L | 1 |
| | | - Review sockeye forecasting methods | N | L | 3 |
| | | - Evaluate the native selective harvest initiative | E | L | 1 |
| | | - Document and evaluate Skeena sockeye in-river stock specific model | E | L | 1 |
| | | - Evaluate Skeena selective gillnet studies | E | L | 2 |
| | | - Continue Babine smolt enumeration program | E | L | 1 |
| | | - Evaluate Nass IFF monitoring | E | L | 1 |
| | | - Evaluate Skeena IFF monitoring | N | L | 1 |
| | Joint | - Continue to review and refine the sampling and analysis of Fraser sockeye catch in NBA | E | L | 2 |
| | | - Reconstruct annual returns to Nass, Skeena, and Alaska using available data | N | L | 2 |
| | | - Evaluate alternative management strategies for NBA sockeye salmon | N | L | 2 |
| | | - Evaluate technical basis for Alaska hatchery sockeye add-on | N | L | 2 |
| | | - Review adequacy of catch and biologic sampling programs | N | L | 2 |
| | | - Explore alternative management strategies for NBA sockeye salmon | N | L | 3 |
| | | - Evaluate utility of GSI results | N | L | 3 |

Table 1. (Page 2 of 3)

| Species/ Category | By Whom | Activity/Status/Cost/Priority<br><br>Status: Existing or New program.<br>Cost: Low (<$20K); Moderate ($20-50K); High (>$50K); or adequately Funded now.<br>Priority: 3 (High); 2 (Higher); or 1 (Highest). | Status | Cost | Priority |
|---|---|---|---|---|---|
| Pink | Alaska | - Develop standardized index of pink salmon escapement by stock group using available data | E | L | 1 |
| | | - Incorporate pink sex composition data into inseason abundance estimate models | E | L | 2 |
| | | - Initiate annual program to estimate counting rates for staff who survey escapements | E | H | 2 |
| | | - Estimate total escapements, by stock group, for years 1960 to present using available data | E | L | 2 |
| | | - Reinstate early marine project to estimate size and abundance/biomass of pink in the spring | N | M | 3 |
| | | - Review sampling program for pink sex composition data | E | L | 2 |
| | | - Evaluate applicability of video reconnaissance for counting escapements and calibrating observers | E | M | 3 |
| | | - Develop IFDB graphic and mapping application for inseason monitoring of escapements | E | F | 1 |
| | | - Refine preseason forecasts models | E | F | 3 |
| | | - Use available spawner-recruit data to estimate escapement goals | E | F | 2 |
| | | - Estimate sex composition of annual escapements and develop S-R models for females only | E | L | 3 |
| | B.C. | - Evaluate pink run reconstruction potential after tag analysis | N | L | 1 |
| | | - Evaluate current catch sampling and sub-area reporting program | N | L | 2 |
| | | - Document and evaluate the NBC pink escapement goal | N | H | 2 |
| | | - Evaluate Skeena test fishery program | N | L | 2 |
| | | - Evaluate pink forecast methodology | N | L | 3 |
| | | - Evaluate management initiative - Skeena pink mesh restriction | N | L | 2 |
| | | - Explore utility of pink sex composition data | N | L | 3 |
| | Joint | - Complete reanalysis of adult tagging data | E | L | 1 |
| | | - Apply results from joint adult tagging study to estimate of annual interceptions | E | F | 1 |
| | | - Evaluate feasibility of discriminating pink stocks using otolith pattern analysis | N | L | 2 |
| | | - Explore alternate management strategies for NB pinks | E | F | 2 |
| | | - Support existing genetic stock ID research and interpret utility of results | E | L | 2 |
| Chum | Alaska | - Fully support Fish/Marx Creek CWT and escapement enumeration study | E | L | 1 |
| | | - Develop standardized index of chum salmon escapements using available data | E | F | 3 |
| | | - Review, assist, and analyze available hatchery CWT data | E | L | 2 |
| | | - Develop hatchery indicator stock CWT program | N | M | 2 |
| | | - Use catch-at-age and length-at-age to forecast returns | N | L | 3 |
| | | - Estimate catch and age composition of summer and fall chum using age and grade data | N | L | 3 |
| | | - Initiate program to representatively index chum salmon escapements | N | H | 3 |
| | | - Initiate program to estimate abundance of chum inseason, by stock group | N | M | 3 |
| | | - Estimate escapement goals, by stock group, using habitat models | N | H | 3 |
| | B.C. | - Document and evaluate current escapement survey methods | N | M | 3 |
| | | - Evaluate and document NBC chum escapement goal derivation | N | L | 3 |
| | | - Evaluate chum forecast methodologies | N | L | 3 |
| | | - Evaluate and document inseason abundance estimates | N | L | 3 |
| | Joint | - Evaluate alternative management strategies for NB chum harvests | N | L | 3 |
| | | - Evaluate management strategies for management of Portland Canal chum and pink stocks | N | L | 3 |
| | | - Interpret utility of GSI results | E | L | 2 |
| Steel-head | Alaska | - Estimate commercial and sport catch of steelhead | N | M | 2 |
| | | - Estimate production of steelhead from SSA systems | N | H | 2 |
| | | - Conduct research to better understand the life history, migratory patterns, and exploitation rates | E | H | |

Table 1. (Page 3 of 3)

| Species/ Category | By Whom | Activity/Status/Cost/Priority<br><br>Status: **E**xisting or **N**ew program.<br>Cost: **L**ow (<$20K); **M**oderate ($20-50K); **H**igh (>$50K); or adequately **F**unded now.<br>Priority: **3** (High); **2** (Higher); or **1** (Highest). | Status | Cost | Priority |
|---|---|---|---|---|---|
| | B.C. | - Evaluate Skeena steelhead stock status (DFO&MELP) | E | L | 1 |
| | | - Review Skeena test fishery - steelhead escapement indices | E | M | 1 |
| | | - Evaluate utility of steelhead commercial net release program | E | L | 1 |
| | | - Evaluate Skeena steelhead run timing (DFO&MELP) | E | L | 1 |
| | | - Develop model to evaluate harvest impact on Skeena steelhead (DFO&MELP) | E | L | 1 |
| | | - Conduct juvenile Skeena steelhead abundance survey (MELP) | E | M | 1 |
| | | - Conduct assessments of Skeena steelhead escapements (MELP) | E | M | 1 |
| | | - Monitor Skeena steelhead native harvest (MELP) | E | M | 1 |
| | | - Evaluate alternative management strategies to reduce steelhead harvests (DFO&MEP) | E | L | 1 |
| | | - Monitor Skeena steelhead sport catch and effort | E | M | 1 |
| | Joint | - Review steelhead commercial catch data | N | L | 2 |
| | | - Review Skeena steelhead CWT results | E | L | 2 |
| General | Alaska | - Continue support for "Integrated Fisheries Data Base" applications and analysis | E | F | 1 |
| | | - Refine estimate of effort (boats and days) for CPUE calculations | E | F | 1 |
| | B.C. | - Continue to enhance accuracy and availability of sub-area catch statistics | E | L | 1 |
| | Joint | - Develop joint data base of "rolled up" catch, effort, and escapement statistics | N | M | 2 |
| | | - Prepare and exchange project operational plans and research reports | E | L | 2 |