FISH/SHELLFISH STUDY NUMBER 27

Study Title:Sockeye Salmon Overescapement

Lead Agency:ADF&G

PROJECT JUSTIFICATION

This study is a continuation of the oil spill damage assessment program initiated in 1990. Recent findings have suggested major economic damage to commercial, subsistence, and sport fisheries may result from overescapement. The continuing program is essentially identical to the previous study plans with minor modifications. These modifications are highlighted in the following revised plan.

Commercial fishing for sockeye salmon in 1989 was curtailed in Upper Cook Inlet, the outer Chignik districts, and the Kodiak areas due to presence of oil and subsequent contamination of catches in the fishing areas from the Exxon Valdez oil spill. As a result, the number of sockeye salmon entering four important sockeye producing systems (Kenai/Skilak, Chignik/Black, Red, and Frazer Lakes) and two less important lake systems (Akalura and Afognak or Litnik lakes) greatly exceeded levels thought to be optimal. Sockeye salmon spawn in lake-associated river systems. Adult salmon serve an extremely important role in the ecosystem, providing food for marine mammals, terrestrial mammals, and birds. Additionally, carcass decomposition serves to charge freshwater lake systems with important nutrients. Juvenile salmon which rear in lakes for one or two years serve as a food source for a variety of fish and mammals. Sockeye salmon are also an important subsistence, sport, and commercial species. The ex-vessel value of the commercial catch of sockeye from these lake systems has averaged about $42 million per year since 1979, with the 1988 catch worth $115 million. Sockeye salmon returns to the Kenai River system support some of the largest recreational fisheries in the State.

Overly large spawning escapements may result in poor returns by producing more rearing juvenile sockeye than can be supported by the nursery lake's productivity (Kyle et al. 1988). In general, when rearing fish abundance greatly exceeds the lake's carrying capacity, prey resources are altered by changes in species and size composition (Mills and Schiavone 1982, Koenings and Burkett 1987, Kyle et al. 1988) with concomitant effects on all trophic levels (Carpenter et al. 1985). Because of such changes, growth of juvenile sockeye is reduced, mortality increases, larger percentages holdover for another year of rearing, and the poor quality of smolts increases marine mortality. Where escapements are two to three times normal levels, the resulting high juvenile densities crop the prey resources to the extent that more than one year is required to return to normal productivity. Rearing juveniles from subsequent brood-years suffer from both the poor quality

of forage and from the increased competition for food by holdover juveniles (Townsend 1989). This is the brood year interaction underlying cyclic variation in the year class strength of anadromous fish.

This project will examine the effects of large 1989 spawning escapements on the resulting progeny for a select subset of the above mentioned sockeye nursery lakes. Three impacted lake systems where the 1989 escapements were more than twice the desired levels (Kenai/Skilak in Upper Cook Inlet; Red and Akalura lakes on Kodiak Island) were selected. Tustumena Lake in Upper Cook Inlet and Upper Station Lake on Kodiak did not receive a large escapement and will be examined as controls.

This study is necessary to obtain a more timely assessment of impact as adult sockeye, produced from the 1989 escapement, will not return until the 1994/1995 season. Further, total return data are not available for individual Kodiak sockeye systems due to the complex mixed-stock nature of the commercial fisheries and the inability to estimate stock-specific catches.

In addition to continuing previously identified activities, several new activities are proposed to ensure study results are valid. The Red River system is being evaluated based on fry and smolt production of Red Lake. Estimation of spawner distribution outside of Red Lake will be completed by establishing an adult weir on Red River immediately below the lake. In addition, the very low numbers of outmigrating smolt estimated by the current mark-recapture method has raised some doubt about violating assumptions of the technique. Approximately 60% of the river flow is intercepted by the traps but recapture efficiency remains below 10%. This indicates avoidance by the marked fish, violating the assumption that all fish have the same probability of being captured. If avoidance rate is great then significant biases may occur. A full smolt weir is proposed to enumerate smolt and verify the current smolt mark-recapture method.

On the Kenai River system additional smolt samples will be collected from the Russian River to verify the aging techniques. The current method is suspect because age classes known to be produced from the Russian River do not appear in the smolt traps further downstream. Smolt trapping will also be continued into July to insure current projections of smolt production failure from the Kenai River lake systems are not an artifact of some unknown sampling bias.

Finally, a late fall fry sampling period will be conducted on the major Kenai Peninsula lakes. Approximately 50% of the weight gain from fry to smolt on the Kenai River system occurs outside of the current sampling regime. If poor survival occurs because of limitations in rearing habitat quality during this period, these data are crucial for determining the validity of density of fry causing decreased over-wintering survival.

OBJECTIVES

A. Estimate the number, age, and size of sockeye salmon juveniles rearing in selected freshwater systems.

B. Estimate the number, age, and size of sockeye salmon smolts migrating from selected freshwater systems.

C. Determine effects of large escapements resulting from fishery closures caused by the Exxon Valdez oil spill on the rearing capacity of selected nursery lakes through:

a. Analysis of age and growth of juveniles and smolts;
b. Examination of nursery area nutrient budgets and plankton populations.

METHODS

Numbers of adult sockeye salmon that entered selected spawning systems outside Prince William Sound prior to and during 1989 have been estimated at weir stations or by sonar. This information was collected during projects routinely conducted by the ADF&G as part of their resource management program. Optimal escapement levels, which on the average should produce maximum sustained yield, have been based on either past relationships between spawners and returning progeny or the extent of available spawning and rearing habitat. The baseline program will continue at each site including, but not limited to, estimates of adult sockeye escapement and collection of scales for age analysis.

For each of the 4 lake systems identified, the response (abundance, growth, and freshwater age) of rearing juveniles from the 1989 escapement will be studied through its likely period of freshwater residence, early summer 1990 to spring 1992.

The total number of juvenile sockeye in each lake will be estimated through hydroacoustic surveys conducted during the summer (late June) and fall (September-October) of 1990, 1991, and 1992. Age and size information as well as diet items will be obtained from samples of juvenile sockeye collected from concurrent mid-water trawl netting surveys. Survey transect designs for hydroacoustic sampling and tow-netting have been established for Kenai and Skilak lakes (Tarbox and King 1989), and will be developed for each additional lake in the study. The basic survey design will be a stratified random sample where each lake is subdivided into areas and survey transects randomly selected in each area. Such programs, funded through other studies, are already in place for Tustumena and Afognak lakes. Depending on densities of rearing juvenile sockeye, estimates of fish densities will be made for

each transect either by echo integration or by echo counting. Total fish population estimates will be computed, by summing transect populations, along with 95% confidence intervals (Kyle 1989).

Freshwater growth and age of sockeye salmon rearing juveniles from all study systems will be determined from scale and otolith measurements made either by direct visual analysis of scales or on an Optical Pattern Recognition system. In cases where data are available (e.g., Kenai and Skilak Lakes), growth of progeny from the 1989 spawning escapements will be compared with growth (size) of progeny produced from spawning within these systems during prior years.

Scale analysis used to age Kenai River smolt has been questioned because the numbers of two year old smolt from the Russian River system is far below expectation. Therefore, smolt samples will be taken during the summer of 1992 from the Russian River to verify that these smolt appear in the Kenai River smolt traps and that the current aging techniques are accurate.

The total number of smolt migrating from each system will be estimated with a mark-recapture study during 1990, 1991 and 1992 using inclined plane traps after Kyle (1983), and Tarbox and King (1989). Smolt will be captured in traps, sampled for age and size information, marked with Bismark Brown Y (a biological dye), and transported upstream of the traps and released for subsequent recapture (Rawson 1984). Periodic retesting will determine the capture efficiency of the traps under changing river conditions during the spring. Total population estimates (with 95% confidence intervals) will be made using catch efficiencies, and weekly number weighted smolt size and age information will be calculated using a computer spreadsheet developed by Rawson (personnel communication, 1985). Size and ages of sockeye smolts from the 1989 spawning escapements will be compared with smolt information from spawning within these systems during prior years. Finally, smolt programs consistent to those for the study lakes are planned, under separate funding, for Tustumena and Afognak Lakes.

In addition, a full weir will be established on the Red River to get a total enumeration of outmigrant smolts. This will be manned 24 hours a day and will be used in comparison with the traps established the previous year for smolt estimation.

Limnological studies will monitor the response of the lakes to the high juvenile rearing densities and to estimate the carrying capacity parameters of euphotic volume, nutrient budgets (carcass enrichment), and zooplankton biomass, body-sizes, and population shifts. Approximately six limnology surveys will be conducted at two stations, during 1992 to determine zooplankton species abundance and body sizes, nutrient chemistry, and phytoplankton abundance for Kenai/Skilak, Red, Akalura, and Upper Station lakes. Carrying-capacity parameters exist

for Afognak and Tustumena lakes based on ongoing studies by FRED and Commercial Fish Divisions.

In cases where seasonal data are available (e.g., Akalura, Kenai, and Skilak lakes), limnological parameters taken during residence of the juveniles from the 1989 spawning escapements will be compared to parameters within these systems during prior years.

The holistic approach proposed here involves several evaluation procedures to assess the effects of sockeye salmon overescapement.
First, freshwater production from the 1989 escapements will be assessed in Kenai/Skilak, Red, Akalura, and Upper Station lakes. This will be accomplished through analysis of growth, freshwater survival (in particular over-winter survival), and freshwater age of sockeye smolt populations. Any anomalies will be determined by analysis of freshwater growth recorded on archived scales, historical freshwater age composition, and modeled freshwater survivals; and from results of previous studies as well as the 1991 smolt characteristics from each of the study systems. Also, planktonic food sources will be assessed through estimation of abundance of zooplankton prey biomass and numbers of species.

Second, future sockeye salmon production from the 1989 parent year and subsequent parent years will be estimated based on spawner/recruit relationships incorporating a brood-year interaction term. Losses of adult sockeye production from subsequent parent years may result from negative effects of progeny of the 1989 escapement on the lake's carrying capacity. The spawner/recruit relationships will be estimated from historical stock specific return data (where available), and generalized spawner/recruit data scaled to the carrying capacity parameters (i.e., euphotic volume and zooplankton biomass) of the nursery lakes where stock specific return data are not available (Geiger and Koenings 1991). If it is determined that in any of the affected systems, the density dependent effects are occurring outside of the traditional models, the effects will be isolated by examining a broader time window of the rearing life history of these species.

Third, experimental and empirical sockeye life history/production models (Koenings and Burkett 1987, Koenings et al 1989) will be used to compare salmon production by life-stage at escapement levels consistent with management goals to the 1989 escapements.
Additionally, in the case of the Kenai system, effects of the 1989 escapement will be viewed independently of the effects on previous brood years with high escapement.

DATA ANALYSIS

Analysis of the data will follow the techniques outlined in the references cited in the methods section. Where new analysis and

problems are identified upon review of data obtained, appropriate standard techniques will be utilized.

DELIVERABLES

A report will be submitted by November 27, 1992. Format and content will follow the two previous reports. Damage assessment final report will be submitted at deadlines and in the format to be decided by the Trustees. Data collection on injury may continue up until recovery has been observed in the populations of sockeye salmon under investigation.

SCHEDULE AND PLANNING

This study is a continuation of ongoing investigations. Continued processing of field samples collected during the previous summer is occurring presently. Upon breakup, field sampling schedules will resume following sampling schedules as reported in the NRDA Annual Report for 1990 under FS #27. Enhanced sampling activities will require collection of samples later in the fall and early winter of 1992-93. Other activities will parallel those as reported previously and as described in previous detailed study plans.

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	BUDGET ($K)
Salaries	$329.9
Travel	12.0
Contractual	124.8
Supplies	52.1
Equipment	6.0
Subtotal	$524.8
General Administration	58.2
Total	$583.0