FISH/SHELLFISH STUDY NUMBER 28

Study Title:Salmon Oil Spill Injury, Life and Run Reconstruction

Lead Agency:ADF&G

PROJECT JUSTIFICATION

This project will quantify the injury to the wild salmon stocks of the Prince William Sound from the Exxon Valdez oil spill. Understanding this injury is necessary for continuing fishery management of injured stocks and rational restoration. One of the main tools being developed to reach this goal is a run reconstruction model. This model will be used to estimate production from each of the Prince William Sound wild stock groups, both before and after the oil spill. The adult tagging study described below will provide information that will improve the already good foundation of this run reconstruction model.

Because of extremely large increases in hatchery production, Prince William Sound as a whole is producing salmon at all-time record levels. These hatchery salmon are essentially inputs to the fishing industry. The wild stocks, which are an important component in the natural ecosystem, originate from a multitude of natal stream locations throughout the Prince William Sound. The aggregate hatchery component of the total production can be determined with coded-wire tags. The estimated percent of the hatchery pink salmon in the Prince William Sound harvest has fluctuated from slightly over 50% in 1987 to in excess of 90% in 1988 and the gap in proportions of wild and hatchery contributions to the run seems to be getting bigger.

The stock-specific origins of the wild portion of the harvest are unknown. This information is necessary to understand oil spill injury to manage the fishery, to protect affected wild stocks, and to begin other restoration measures. The run reconstruction model is a tool for detecting these stock-specific origins. This model is a mathematical description of wild stock return patterns, accounting for removal by harvest in a series of mixed stock fisheries. This accounting of the harvest, by stock, in mixed stock fisheries is the heart of the model.

The University of Alaska, Juneau Center for Fisheries and Ocean Sciences, has developed a run reconstruction model for this project for a single fishing district, although work continues on a computer implementation. The next level of complexity, the multi-district model, requires spacial and temporal information on the migratory movement of pink salmon in Prince William Sound. Data from previous adult tagging studies could not be used to

complete this task. Exhaustive efforts were made to use the historical data. These data have proved unsuitable because they are too incomplete: no record was made of the fraction of the fishery sampled to collect those tags that were recovered. An adult tagging study will take place during the 1992 season to estimate these key missing parameters. The study will use radio or sonic tags on a small number of fish. Rather than infer movement patterns from the recovery of a large number of tags, the study will attempt to directly observe the movement of a smaller number of fish.

OBJECTIVES

The objective of the Pink Salmon Adult Tagging Study is to quantify the migratory movement and rates of pink salmon through the Prince William Sound as they proceed to their natal streams. Movement of salmon through the Prince William Sound will be modeled by a probability transition matrix whose elements are the probabilities of salmon moving from one district to another.

Currently, it is assumed that pink salmon enter Prince William Sound through the Southwest District (226) and proceed in a clockwise direction through the Prince William Sound to their natal streams. This study will be used to examine this hypothesis and estimate daily district-to-district migratory rates.

Salmon Migration Example

As a hypothetical example, consider 100 salmon entering into the Prince William Sound via District 226 on an arbitrary day. Using the clockwise migration hypothesis the model will move the salmon toward Districts 223 and 222. Once in District 222 they are permitted to enter District 221 then into 228. The model will also allow salmon to exchange between Districts 226 and 227. A hypothetical transition matrix that will induce this type of movement is presented below.

[redacted] $\Theta = (\theta_{ij})$

	j	1	2	3	4	5	6
i	district	221	222	223-24	225-26	227	228
Northeast	1	221	0.95	0	0	0	0	0.05
Northern	2	222	0.05	0.95	0	0	0	0
Coghill	3	223-24	0	0.01	0.99	0	0	0
Southwest-ern	4	225-26	0	0.02	0.02	0.95	0.01	0
Montague	5	227	0	0	0	0.01	0.99	0
Southeast-ern	6	228	0	0	0	0	0.01	0.99

Here each entry is the probability of salmon moving from the row district to the column district. Now, the simulation of movement is created by taking powers of the transposed transition matrix and pre-multiplying with the vector $\boldsymbol{n}^T = (0, 0, 0, 100, 0, 0)$ (note the 100 in the fourth position represents 100 fish released into the fourth district, or Districts 225-26). This is denoted mathematically as

[redacted]

where k is the number of days in the Prince William Sound (see the Data Analysis section for more details).

The table below shows the hypothetical number of salmon in each district after $k = 1, 2, 5, 10, 20$ and 30 days in the Prince William Sound.

district	Number of days in the Princ 0	1	2	5	10	20	30
221	0	0	0.1	0.87	3.08	8.15	11.82
222	0	2	3.82	8.33	13.29	17.18	17.03
223-24	0	2	3.88	8.86	15.30	23.11	26.62
225-26	100	95	90.26	77.47	60.21	36.84	23.09
227	0	1	1.94	4.43	7.66	11.70	13.92
228	0	0	0	0.05	0.46	3.02	7.51

The reason for this simplified demonstration is not only to show how the transition matrix induces movement in the simulation model, but also to point out one property of the transition matrix: with large powers of the transition matrix the rows converge to constant values. That is, each row becomes identical. The example transition matrix converges to (0.0588, 0.0588, 0.1471, 0.0735, 0.3676, 0.2941) as k gets large (about 60 days). The implication is that the transition matrix does impose stock-like restrictions on the salmon: it determines the long run distribution of salmon among the districts at the end of the season. The key point to be made here is that one cannot arbitrarily create a transition matrix and use it in the run reconstruction model to estimate stock- specific catch rates without seriously biasing the results.

METHODS

Throughout July of 1992, a small number of adult pink salmon are to be tagged on the southern perimeter of the Prince William Sound

each week. The tagged fish will then be move through the Prince William Sound to spawning areas. Some will be harvested in subsequent fishing periods. They will be turned in by fishermen. Some will escape the fishery and move into freshwater areas.

Tags

Fish will be tagged with a radio or sonic tag. The most appropriate tag has not yet been determined. Fish with one of these radio or sonic tags will also be tagged with an external spaghetti tag indicating the district of tagging, and each will bear a unique number and Alaska Department of Fish and Game identification.

Tagging Operations

If possible, fishing vessels will be recruited on a volunteer basis with the use of giveaway hats and tee shirts with a tagging study logo. If necessary boats will be chartered on a daily basis from the Prince William Sound purse seine fishing fleet. One project scientist or technician will be aboard to actually conduct the tagging, provide instructions, record data, and control quality. Pre-printed, waterproof data sheets will provide for date, location, vessel, set number, personnel, time of day, weather conditions, tag numbers, and the number of injured or unsuitable fish. At the end of each tagging operation, the data will be transferred to a computer spreadsheet which will be backed up onto a diskette.

After the seine is set, the bunt end will be left in the water to form a bag alongside the boat. Each sampled salmon will be lifted into a tagging cradle, and the tags inserted. Each single set will constitute a tagging operation.

Number to Tag

The number to tag will be determined by the actual cost of the tags.

Tag Recovery

Tags will be detected by means of aircraft overflights if radio tags are used, or line transacts if sonic tags are used. Fishermen will be offered souvenir hats and tee shirts to return externally tagged fish that were harvested, if information on date and place of capture is provided.

DELIVERABLES

Data and report submission schedule

During 1992, the data collected by this study will allow the estimation of key parameters of the run reconstruction parameter model, as it exists now. A final report on the run reconstruction model, including the adult tagging operation, will be made by the fall of 1992. During the late fall of 1992, efforts will be redirected to the Salmon Life History Model, with particular attention to joining the run reconstruction with the life history information. After slight fine-tuning from the life history model, the run reconstruction model will be altered for use in other years, and estimates will be generated for several years before and after the oil spill.

Three basic reporting tasks are currently envisioned. First, there is to be a report documenting the run reconstruction model methods. The authors will include the cooperating scientists at the University of Alaska Fairbanks, and the two Alaska Department of Fish and Game investigators. Second, there is to be a document or series of documents covering the adult tagging operation. Third, documentation of the run reconstruction estimates themselves will be provided as an Alaska Department of Fish and Game technical report.

The life history model and injury estimates should follow similar reporting lines: a report documenting methods for the primary scientific literature, and a report of actual estimates. The documentation of the life history model will complete Study 28. A single final report covering all of the above will be prepared.

SCHEDULES & PLANNING

APPROXIMATE DATE	ITEM
1992	
March 15.	Begin purchasing equipment, tags, etc.
March 15.	Begin Life History data organization
May 15.	Hire Fishery Biologist I
Late June	Begin tagging operations in District 226
July 1.	Begin overflights or line transacts
Aug. 30.	Begin to assemble database
September	Continue on Life History model development
September	Provide basic data to run reconstruction modelers
November	UAF model fully completed

NovemberBegin Life History model reports
1993
FebruaryFinal Reports due

	BUDGET ($K)
Salaries	$ 91.8
Travel	56.0
Contractual	43.0
Supplies	18.5
Equipment	25.7
Subtotal	$ 235.0
General Administration	16.8
Total	$ 250.6