SUBTIDAL STUDY NUMBER 5

Study Title: Injury to Shrimp

Lead Agency: ADF&G

PROJECT JUSTIFICATION

PART I

This project is aimed at assessing possible injury to spot shrimp, (Pandalus platyceros), due to oil spilled from the T/V Exxon Valdez, and is a continuation of Fish/Shellfish Study 15 conducted during 1989 and 1990 and Subtidal Study 5 conducted in 1991.

Spot shrimp is a representative species of the deepwater nearshore benthic ecosystem, serving as a food source for a variety of fish and shellfish. Spot shrimp share aspects of their distribution and food habits with other economically important fish and shellfish species (Butler 1980). Spot shrimp themselves support important commercial, subsistence and recreational fisheries in Prince William Sound. This species favors steep, rocky habitat which is found in patches throughout Prince William Sound. Much of this habitat is contained within the traditional harvest area of the spot shrimp commercial pot fishery, which includes the area west of a line from Montague Point to Bidarka Point. A large portion of this harvest area was in the direct path of the 1989 Exxon Valdez oil spill.

Adult spot shrimp, along with other pandalid shrimp, are known to be sensitive (lethal and sublethal effects) to oil contamination (Anderson et al. 1981, Rice et al. 1979, Sanborn and Malins 1980, Stickle et al. 1987, Vanderhorst 1976). Larval and juvenile shrimp are known to be more sensitive than adults: lower concentrations of oil will kill half the study group in less time (Brodersen et al. 1977, Brodersen 1987, Mecklenburg et al. 1977, Rice et al. 1984). Also, larval and juvenile shrimp may be exposed to higher concentrations of oil contamination toxins than adults since larvae occur in surface waters and juveniles tend to inhabit shallow subtidal areas while adults live well below the surface (Barr 1971, Barr 1973, Butler 1964, Butler 1980).

Sample collection for spot shrimp takes place in the fall, leaving no time for sample analysis prior to the reporting period at the end of November each year. Consequently, peer reviewers have not had an opportunity to adequately review 1991 results. The Trustee Council has approved a sufficient budget to analyze and report 1991 results which will be forwarded to peer reviewers. Based upon their

recommendations, the project will go forward with additional sampling in the fall of 1992 or be terminated. Two budgets appear at the end of this detailed plan. The first is the budget authorized through the end of 1991 sample analysis and reporting (Part I). The second is the budget which may be authorized by the Trustee Council if peer reviewers recommend continued sampling (Part II).

OBJECTIVES

1. Determine the relative abundance by weight, number and sex of spot shrimp, as well as the relative abundance by weight of incidentally caught pink (Pandalus borealis) and coonstripe (Pandalus hypsinotus) shrimp, in oiled and non-oiled areas, and compare these values to those obtained from surveys conducted in 1989, 1990, and 1991.

2. Use historic catch data from the commercial spot shrimp fishery to estimate fishing mortality and effort to:

a). Evaluate the feasibility of incorporating fishing mortality into relative abundance estimations, to improve accuracy of stock assessment estimates.

b). Compare fishing effort in oiled and unoiled areas between pre- and post-oil spill years.

3. Compare size and age frequencies of spot shrimp (by sex) among sites using various methods of length frequency analysis (mixture modal analysis).

4. Compare fecundity, egg mortality, and other sublethal effects between oiled and non-oiled areas over time, and determine whether these effects caused decreased reproductive viability.

5. Document injury to spot shrimp tissue samples and compare differences between oiled and non-oiled sites and among years.

6. Synthesize information on spot shrimp stock status, hydrocarbon exposure and injuries to determine whether a restoration plan to manage the spot shrimp resource is needed.

PART II

The following field work will proceed only if peer reviewers recommend additional sampling after review of 1991 results.

Methodology developed in previous studies (Kimker and Donaldson 1987, Donaldson 1989, Donaldson and Trowbridge 1989, and Kruse and Murphy 1989) will be used again this year.

Data obtained in this study when combined with 1991 study results, will indicate whether spot shrimp juveniles and larvae were exposed to lethal levels of oil contamination (though little knowledge will be gained on whether sublethal exposure occurred). Given the sampling gear used and the growth rate of spot shrimp, 1991 would have been the first year in which recruitment from the 1988 and 1989 year classes would have been observed. In the 1992 season, all of the 1988 and most of the 1989 year classes should have recruited in to the sampled population.

To determine what effects hydrocarbons from the spill had on spot shrimp, samples will be collected from the same three oiled and three non-oiled sites in western Prince William Sound surveyed in 1989 and 1990. An additional oiled site (Snug Harbor), first sampled in 1991, and an unoiled site (Whale Bay) to be sampled for the first time this year, will be added to the study to give a more balanced design and to use an unoiled area in the southwest Prince William Sound.

METHODS/DATA ANALYSIS

Samples will be collected during November 1992 using the ADF&G research vessel Montague. This time frame, while a departure from the 1990 study plan, follows the 1991 study plan in which samples were taken following the fall molt and when egg extrusion was completed. Specific data to be collected are described below.

Study Sites

Spot shrimp habitat within Prince William Sound was divided into oiled and unoiled strata. Localized spot shrimp distribution in these areas was determined from commercial fishermen interviews and results of previous ADF&G studies. Unoiled areas are generally located in the northwestern portion of Prince William Sound: Unakwik Inlet, a site used for previous ADF&G studies on abundance and growth of spot shrimp (Kimker 1984, 1985; Kimker and Donaldson 1986, 1987); Port Wells (Golden); Culross Passage; Whale Bay. Oiled areas are located in central and southwestern Prince William Sound:

Green Island, an ADF&G test fishing site in 1981, Chenega Island (northeast corner); Herring Bay; Snug Harbor.

Sample Design

Each of the eight sites will be sampled at depths between 35 and 130 m. This approach differs from the sampling design used in 1989, 1990 and 1991 in which depths greater than 130 m were also sampled. Data collected during the last three survey years has shown that spot shrimp were not abundant below 130 m at all sample sites. Thus to lower necessary effort and to make a more balanced statistical design, only one depth stratum will be used this year. Also, 1992 sampling will be directed at younger individuals which tend to occur at shallow depths. Reduction in sampling effort at each site will allow two additional sites to be sampled in 1992.

Eleven commercial pots of a standard size, spaced 18.5 m apart, will be fished on a long line. Each string of pots, spanning a distance of 185 m, constitutes a sampling station. A minimum of three stations will be fished at each site. Thus, a total of 264 pots (33 pots at each of the 8 sites) will be deployed over the course of the survey. If necessary, pots will be reset and deployed an additional day at each site to obtain adequate sample sizes for length frequency analysis. Spot shrimp caught in these extra sets will not be included in relative abundance estimates, since extra sets will be made at depths where large concentrations of shrimp were caught during previous sets.

Data Collection

Station information including location (latitude and longitude), depth (fathoms) and time (hours) pots were fished will be recorded by the vessel skipper on a standard form.

Environmental Samples

Water temperature, salinity, and dissolved oxygen concentration at each site will be recorded using a Sea Bird Electronics Conductivity, Temperature and Depth (CTD) meter. Data will be transferred from the CTD to a micro-computer and stored on diskette. CTD casts will be taken within 1 km of each site. The CTD will be lowered at a rate of 60 meters per minute, to provide environmental data at half meter intervals. Due to the configuration of the CTD, only readings from the downcast will be used.

Biological Samples:

Total weight of catch, subsample weight, and total weight of each species in a subsample will be recorded at the time each pot is retrieved on a standard form. Total weight of shrimp per pot will be determined by weighing the contents of each pot on an electronic scale. The average number of shrimp per kilogram will also be determined. If less than 500 spot shrimp are estimated caught at a station all of them will be sampled. If more than 500 spot shrimp are estimated caught at a station a constant proportion by weight will be subsampled from each pot to obtain approximately 500 spot shrimp.

All spot shrimp in samples and subsamples will have their carapace length measured to the nearest 0.1 millimeter using a digital caliper, and their sex determined according to the methods (Standard Operating Procedure) described by Trowbridge and Coyer (1989: Appendix C). For female spot shrimp the following information will be noted: egg color and stage of development (eyed or uneyed); relative clutch size; presence of breeding dress, occurrence of egg and external parasites. Each female retained for fecundity analysis will be identified with a code number to allow cross-referencing of fecundity and other data. All data collected will be recorded on a standard data form.

Histopathology Samples:

Specimens to be used for histopathology analysis will be removed from pots before catches are weighed and processed. This will ensure that only freshly killed samples are analyzed. Twenty shrimp from a single station will be selected randomly for each histopathology sample. Each histopathology sample will be weighed and recorded on a standard form. Histopathology samples will be labeled with the date, station number, latitude and longitude, sample number, project leader's name, species, and agency. Samples will be prepared according to methods specified by Dr. Donald Lightner, associate professor, University of Arizona.

Fecundity Samples:

Fifteen egg-bearing females will be randomly selected from each station to estimate fecundity and egg mortality. This will yield a total of 360 females. Specimens from each station will be individually labeled with a fecundity number, their carapace length measured, and placed together in a plastic bag. Each sample bag will be labeled with the project leader's name, species name, "eggs", date, station, and agency. Data taken at the time of subsampling will be

recorded on a standard form and later entered into an R:base computer file.

Fecundity will be determined by removing all eggs from the pleopods, drying each egg mass to a constant weight, weighing a subsample containing a known number of eggs, and multiplying the weight of the entire clutch by the number of eggs per unit weight in the subsample.

Total number of spot shrimp examined for fecundity estimation will be determined by time and budget constraints. If all 15 shrimp from each of the station samples cannot be processed, subsamples will be processed from each station. A minimum of ten shrimp from each station will be sampled to provide an adequate sample size for detecting differences in fecundity among oil impact areas.

Fish Tickets and Log Books:

Voluntary log books from commercial spot shrimp fishermen will be collected and copied in Cordova. Fish ticket information will be accessed through the ADF&G records in Juneau. The fish ticket records will be sent on computer diskettes via the United States Postal Service.

Data analysis

Objective number 1 (estimation of relative abundance) will be addressed by calculating average species catch per pot by weight, number, and sex. Analysis of variance (ANOVA) will be used to test for significant differences (p-value < .05) in each of these categories among sites and between oiled and non-oiled areas, using the following model:

where μ is the grand mean, α_i is the oiling effect, $\gamma_{j(i)}$ is the site effect nested within oiling strata and ε_{ijk} as the error term.

Changes in average catch per pot over time among different sites and between oiled and non-oiled areas will be analyzed using the above ANOVA model with a time term, β_1, added.

To meet objective number 2 (examination of fishery trends), information from commercial fishing log books and fish tickets collected both before and after the Exxon Valdez oil spill, will be used to estimate effort and catch in areas frequently fished. A weighted fishing intensity term, θ_m, may be added to the above ANOVA model to determine whether differences occurred among sites and between oiled and unoiled areas. A weighted fishing intensity term will be used since information may be incomplete and biased and differences in effort occurred throughout Prince William Sound.

A size frequency distribution of spot shrimp will be made by sex to address objective number 3 (determination of differences in size and age composition). The hypothesis that no significant difference exists among oil impact areas in size frequency distribution of spot shrimp catches will by tested using quantile-quantile plots, Chi-square (χ^2) tests or other appropriate methods. A t- or Mann-Whitney test will be used to test for similarity between means. Changes in size frequency distribution over time will be examined using either a t- or Mann-Whitney test for comparing means and an appropriate method for comparing frequency distributions.

To meet objective number 4 (examination of sublethal effects), the relationship between spot shrimp size and fecundity will be examined. For each station the following will be determined: percentage of female spot shrimp bearing

eggs; stage of egg development; percentage of egg fouling and mortality; fecundity by size; relative clutch size. χ^2 tests will be used to test for site differences and treatment levels since data will be expressed as percentages. Differences in fecundity and relative clutch size among sites, and between oil and unoiled areas will be tested using ANOVA procedures.

To address objective number 5 (documentation of injury), the percentage of shrimp with abnormal tissues in oiled and non-oiled areas will be determined. A χ^2 test will be used to determine whether differences in the percentage of shrimp with abnormal tissues among sites, and between oiled and unoiled areas.

To meet objective number 6 (development of restoration plans), it will be necessary to examine changes in catch per unit effort, age class strength, and reproductive viability to determine whether management actions implemented to restore injured stocks are having the desired effect. Further regulation of human use, including time and area closures may be necessary to reduce fishing mortality on oil-injured stocks and allow them to recover. Additionally, the need for continued stock monitoring to evaluate effectiveness of recovery methods will be assessed.

All catch, size, and station data will be entered into R:BASE computer files using portable micro computers. Statistical tests will be conducted using commercially available software such as SAS, Minitab, Lotus and SYSTAT software.

SCHEDULES AND REPORTS

Date(s)	Activity
November 1992	Field program will last approximately 10 days. (Approximately Nov., 1992); Sampling will occur daily while in the field. One of the eight sites will be sampled each day, day one will be used for travel to the area and setting the initial 3 strings of pots. The remaining time will be used for resetting pots at sites for which 500 spot shrimp were not obtained.

December-February 1993 Data entry & analysis

February-March 1993 Preliminary report on impacts of oil on shrimp.

December 1993 Final report on damage assessment on spot shrimp

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Table 1. ADF&G SPOT SHRIMP SAMPLING PLAN

I. SITES

A. Non-oiled
1. Unakwik Inlet
2. Port Wells (Golden)
3. Culross Pass
4. Whale Bay

B. Oiled
1. Herring Bay
2. Chenega Island
3. Green Island
4. Snug Harbor

II. STATIONS

A. Exact station locations at each site were chosen with the help of fishermen experienced at spot shrimp fishing in those areas.

B. Each station will consist of one string of eleven pots fished on a long line. Pots will be spaced 18.5 m (approximately 10 fathoms) apart for a total length of 185 m for each string of pots.

III. FISHING PLAN

A. Weekly Schedule
1. Day 1 Sail to Unakwik Inlet set stations 1, 2 and 3.
Day 2 Pick Stations 1, 2 and 3. Sail to Port Wells and set stations 4, 5 and 6.
Day 3 Pick stations 4, 5 and 6. Sail to Culross Passage and set stations 7, 8 and 9.
Day 4 Pick stations 7, 8 and 9. Sail to Herring Bay and set stations 10, 11 and 12.
Day 5 Pick stations 10, 11 and 12. Sail to Chenega Island and set stations 13, 14 and 15.
Day 6 Pick stations 13, 14 and 15. Sail to Whale Bay and set stations 16, 17 and 18
Day 7 Pick stations 16, 17 and 18. Sail to Snug Harbor and set stations 19, 20 and 21.
Day 8 Pick up Stations 19, 20, 21. Sail to Green Island and set stations 22, 23 and 24.
Day 9 Pick stations 22, 23 and 24. Return to Cordova, end of trip.

Additional days will be allocated at a given site if the sample size objective of 500 shrimp per site is not achieved.

B.Daily Schedule

1.Gear will fish a standardized overnight period of 16 to 18 hours.

2.Pots will be pulled in the morning and subsequently set such that the desired soak time will be achieved. If the desired soak time cannot be achieved, pots will be fished to minimize variance from this desired fishing time.

BUDGET ($K)
(Part I - 1991 Analysis and Report only)

Salaries	$17.3	
Travel		0.8
Contracts		0.9
Supplies	0.8	
Equipment		0.2
Subtotal	$20.0	
General Administration		2.7
Total		$22.7

BUDGET ($K)
(Part II - Full Study Pending Peer Reviewer Recommendations)

Salaries	$43.0	
Travel		1.8
Contracts		12.3
Supplies	2.4	
Equipment		1.9
Subtotal	$61.4	
General Administration		6.5
Total		$67.9