FY12 INVITATION
PROPOSAL SUMMARY PAGE

Project Title: PWS Herring Research and Monitoring - Fatty Acid Analysis as Evidence for Winter Migration of Age-0 Herring in Prince William Sound

Project Period: October 1, 2011 – September 30, 2016

Primary Investigator(s): Ron Heintz & Johanna Vollenweider
Co-operating Investigator:

Study Location: Prince William Sound

Abstract: This project is a component of the integrated Long-term Monitoring of Marine Conditions and Injured Resources and Services submitted by McCammon et al. Monitoring of age-0 herring should be an important component of the Trustee herring program, but the appropriate spatial scale for monitoring is unknown. The current program assumes age-0 herring remain in their nursery bays over winter. If true, observations of differences among bays in terms of age-0 condition and marine conditions will allow for identifying conditions that lead to improved recruitment to age-1. We propose to test the assumption by monitoring the fatty acid (FA) composition of age-0 herring over winter. The FA composition of depot lipids derives from diets (Budge et al. 2006), so differences in the prey fields in different bays should produce differences in the FA compositions of herring in those bays (Otis et al. 2009). Therefore, the FA composition of age-0 herring in fall can act as a natural tag for identifying migration. Changes in FA composition due to winter feeding are likely to be minimal because age-0 herring experience energy deficits in winter, proscribing lipid storage. We plan to test this assumption in a laboratory study. We hypothesize that migration of herring will result in increasing similarity of herring FA compositions over winter. Alternatively, if the FA composition of age-0 herring in given bays remains constant over winter then migration must be limited.

Estimated Budget:
EVOSTC Funding Requested:
(breakdown by fiscal year and must include 9% GA)

FY 12	FY13
$18,400	$47,100

Non-EVOSTC Funds to be used:
(breakdown by fiscal year)

Date: May 18, 2011

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PROJECT PLAN

I. NEED FOR THE PROJECT

A. Statement of Problem

Robust Pacific herring populations, suitable for exploitation by commercial roe fisheries are typically sustained by periodic recruitment of strong year classes into the adult spawning population; however, the Prince William Sound herring population has not had a strong recruitment class since 1989, when the *Exxon Valdez* Oil Spill (EVOS) occurred. In the EVOS settlement herring were identified as an injured resource and they remain listed as an unrecovered species by the EVOS Trustee Council (EVOSTC). Understanding why herring have not recovered in Prince William Sound (PWS) requires understanding potential bottlenecks in the herring life cycle. The identification of the limiting conditions to herring recovery requires a series of focused process studies combined with monitoring of the natural conditions that affect herring survival.

What is described here are a series of projects that make up a program that enhance the current monitoring efforts of the Alaska Department of Fish and Game (ADF&G), and examine aspects of particular life stages to allow better modeling of herring populations. **The long-term goal of the program is to improve predictive models of herring stocks through observations and research.** While we don't anticipate that there will be a major change in our modeling ability in the next five years, we expect that the combination of monitoring and focused process studies will provide incremental changes over the next twenty years and result in a much better understanding of herring populations by the end of the program.

B. Relevance to 1994 Restoration Plan Goals and Scientific Priorities

The proposed program addresses the goals and priorities outlined in the 1994 Restoration Plan (http://www.evostc.state.ak.us/Universal/Documents/Publications/IHRP%20DRAFT%20-%20July%202010.pdf) and in the FY 2012 invitation for proposals. In particular it addresses the need to "Conduct research to find out why Pacific herring are not recovering" and "Monitor recovery," listed on page 48 of the 1994 Restoration Plan. It will lead to the development of new tools to improve herring management. The latter will be accomplished by providing the information needed to develop, or test, biological and physical models of herring growth and recruitment rather than relying on empirical models.

In November 2006, a Herring Steering Committee was formed and tasked with developing a focused Restoration Program that identifies strategies to address recovery and restoration of herring, recognizing that activities in the program must span an ecologically relevant time frame that accounts for herring population dynamics and life history attributes. A draft Integrated Herring Restoration Program (IHRP) was completed in the fall of 2008 and was further refined in July of 2010. The main goal of the program is to determine what, if anything, can be done to successfully recover the Pacific herring in PWS from the effects of EVOS. In order to determine what steps can be taken, the program examines the factors limiting recovery of herring in PWS,

identifies and evaluates potential recovery options, and recommends a course of action for achieving restoration.

Based on the recommendations of the IHRP the Trustee Council has stated in the FY12 request for proposals that they have chosen Restoration Option #2, Enhanced Monitoring, as the focus for their research interests. The program described below aims to meet the goals of this option by utilizing a combination of monitoring efforts to provide more information about the existing stock and process studies to elucidate aspects of the herring lifecycle necessary to move us from an empirical modeling approach towards an analytical modeling approach.

II. PROJECT DESIGN

A. Objectives

The Herring Monitoring Program goal is to improve predictive models of herring stocks through observations and research. To meet this goal we have arrived at the following objectives for the first five-year period.

1) *Provide information to improve input to the age-structure-analysis (ASA) model, or test assumptions within the ASA model.* The ASA model is currently used by ADF&G for estimating herring biomass. The proposed monitoring efforts are designed to address this objective by either expanding the data available for the existing ASA model or by providing information about factors that determine the size of recruitment events.

2) *Inform the required synthesis effort.* Proper completion of a detailed synthesis means being able to access and manipulate different sources of data and information. We are proposing projects that make data available to all researchers.

3) *Address assumptions in the current measurements.* Many of the existing studies were put together based on historical or logistical constraints. We are proposing research necessary to put the existing measurements into context spatially and temporally. This effort will allow the design of the most accurate and efficient monitoring program.

4) *Develop new approaches to monitoring.* With technological advances we have the potential to improve our monitoring programs so they require less effort or reduce the need to collect fish.

Monitoring age-0 herring should be an important component of the herring program, but the appropriate spatial scale over which they should be monitored is unknown. If age-0 herring remain in their nursery bays over winter, then age-0 monitoring can use a series of index bays to evaluate the relative health of herring cohorts. Observations of differences among bays in terms of age-0 condition and marine conditions can provide a basis for identifying conditions which lead to improved recruitment to age-1. However, if age-0 fish move about Prince William Sound in winter, then measurements of fish condition are limited to inter annual variation, severely constraining our ability to identify the conditions leading to the recruitment of large year classes. Thus the current herring monitoring program requires validation of the assumption that age-0 herring remain in their nursery bays over winter.

In support of program goal #3, the goal of this study is to test the assumption in the current studies that age-0 herring remain in their nursery bays over winter by monitoring the fatty acid (FA) composition of age-0 herring over winter. Herring foraging on different prey fields likely have different FA compositions because the FA composition of depot lipids derives from diets (Budge et al. 2006). Differences in the prey fields in different bays should produce differences in the FA compositions of herring in those bays (Otis et al. 2009). Therefore, the FA composition of age-0 herring in fall can act as a natural tag for identifying migration during winter. During periods of food deprivation, fish FA compositions are conserved (Figure 1). Changes in FA composition due to winter feeding are likely to be minimal because age-0 herring experience energy deficits in winter, proscribing lipid storage. We hypothesize that migration of herring will result in increasing similarity of herring FA compositions. Alternatively, if the FA composition of age-0 herring in given bays is constant over winter then migration must be limited.

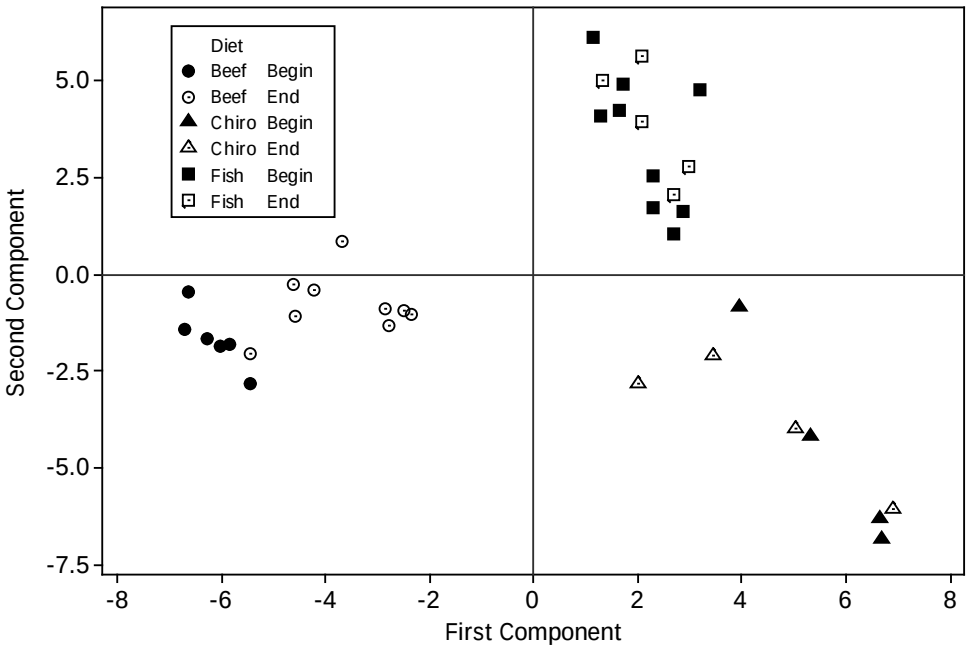

Figure 1. Principle components analysis of the fatty acid composition of coho salmon fed three different diets and fasted under the same conditions for 60 days. All fish came from the same wild population and were fed the different diets for 100 days before fasting commenced. Symbols show component scores for the fatty acid compositions of fish before and after fasting.

Field sampling and FA analysis will identify the spatial scale of winter movement by addressing the following questions:

1. Do FA compositions differ between bays at the beginning of winter?
2. Are FA compositional differences between fish from eastern (e.g., Port Gravina, Port Fidalgo) and western PWS (e.g., Whale Bay) conserved over winter?

3. Are FA compositional differences between fish in two adjacent bays conserved over winter?
4. Are FA compositional differences between two adjacent fjord systems (Port Gravina and Port Fidalgo) conserved over winter?
5. Are FA compositional differences between separate bays within a fjord system conserved over winter?

The assumptions underlying the FA approach used in this study will be examined under laboratory conditions to determine:

6 Are the FA compositions of starving herring conserved over winter?
7 Does winter feeding alter the FA composition of starving herring?

B. Procedural and Scientific Methods

Field sampling:

We anticipate that this study can be completely integrated into the proposed monitoring program. Samples collected during the intensive survey proposed by Kline and Heintz will provide samples to answer question 5. Samples collected under the long term monitoring program will answer questions 1 through 4. The laboratory study will answer questions 6 and 7. Under the intensive monitoring study we propose to sample fish from Simpson and Windy Bays in November and March. These bays are roughly adjacent in Orca Bay. Under the monitoring program we propose to sample herring from various bays in eastern and western Prince William Sound in early winter and repeating these at the end of winter. Ideally our collection will include samples from one of each of the SEA bays. However, we will modify the study design as necessary based on the samples collected as part of the current herring monitoring program, while aiming to maximize our ability to understand the spatial scales of age-0 herring movement over winter (e.g., between adjacent bays, between fjords, or across the sound).

Lab rearing:

For the laboratory component testing the validity of the FA approach, we propose to use fish collected near our lab in Auke Bay. Fish will be collected by beach seine in late summer, transferred to our lab and divided into two groups. The groups will be fed different diets to create two groups with distinct fatty acid compositions. Each of the groups will have a fasted component and a second component that is periodically offered some prey, but still maintained at an energy deficit

Fatty acid analysis:

FA compositions will be determined by gas chromatography and mass spectrophotometry at the Auke Bay Lab, following established protocols (Heintz et al. 2010). Concentrations of 32 fatty acids will be reported as percentages of the observed total mass of fatty acids.

C. Data Analysis and Statistical Methods

Differences in FA compositions among fish from different locations will be identified by non-metric multidimensional scaling and analysis of similarities (Heintz et al. 2010). Differences between bays or logical groups will be tested by ANOSIM.

D. Description of Study Area

The study area includes all of Prince William Sound. However, most of the projects will focus on the four bays (Zaikof, Whale, Eaglek, and Simpson) that were extensively studied during the Sound Ecosystem Assessment study and PWS Herring Survey program (Figure 1). This allows the work to build upon the historical research completed in those bays. These bays also cover four different quadrants of the Sound. We anticipate a potential build out to include other bays or contraction based on the results from the synthesis. As part of the synthesis effort we will be reviewing the question "What is the appropriate sampling distribution?" as applied to the questions of juvenile herring condition and providing an index of juvenile abundance.

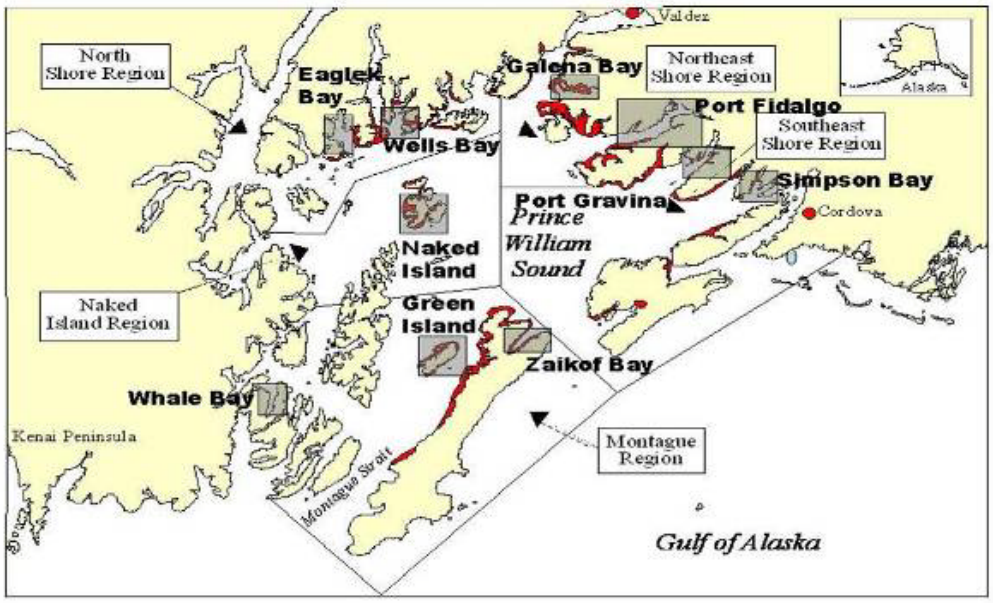

Figure 2. PWS study area, including the four SEA bays (Whale, Zaikof, Eaglek, and Simpson, as well as other bays historically important for juvenile herring.

E. Coordination and Collaboration with Other Efforts

This proposal is part of the integrated "PWS Herring Research and Monitoring" proposal submitted by the Prince William Sound Science Center to the Exxon Valdez Oil Spill Trustee Council. It includes the collaboration and coordination described there for work within the herring research group and with the Long-Term Monitoring proposal submitted by the Alaska Ocean Observing System.

III. SCHEDULE

A. Project Milestones

October 2011:	Receive funding, acquire wild fish near Juneau for lab study
January 2012:	Begin fasting herring in laboratory
March 2012:	Acquire spring herring samples from intensive study , end fasting study
January 2013:	Report preliminary results at AMSS

March 2013:	Complete acquisition of herring from monitoring program
September 2013:	Complete chemistry
April 2014:	Submit final report

B. Measurable Project Tasks

FY 12, 1st quarter (October 1, 2011-December 31, 2011)

September Collect herring for laboratory study by beach seining (Auke Bay)
Maintain herring in laboratory in preparation for experimental trials

FY 12, 2nd quarter (January 1, 2012-March 31, 2012)

January Begin laboratory study, receive first set of samples from intensive surveys in PWS
March Receive rest of field samples from intensive study, end lab study

FY 12, 3rd quarter (April 1, 2012-June 30, 2012)

April Begin analyzing samples
May Attend annual herring meeting Cordova

FY 12, 4th quarter (July 1, 2012- September 30, 2012)

September Complete analysis of samples from first year

FY 13, 2nd quarter (January 1, 2013-March 31, 2013)

January Attend AK Marine Science Symposium
March Acquire samples from monitoring program

FY 13, 3rd quarter (April 1, 2013-June 30, 2013)

April Begin sample analysis of fish from monitoring project
May Attend annual herring meeting Cordova

FY 13, 4th quarter (July 1, 2013-September 30, 2013)

September Finish analysis of samples

FY 14, 2nd quarter (January 1, 2014-March 31, 2014)

January Attend AMSS report preliminary results

FY 14, 2nd quarter (Jan 1, 2014- April 30, 2014)

April Submit final report

IV. BUDGET

Below is the budget for the project. Funds are requested for only two years, outlying years are not shown as they incur no cost to the Trustee Council.

Budget Category:	Proposed FY 12	Proposed FY 13	TOTAL PROPOSED
Personnel	$0.0	$0.0	$0.0
Travel	$0.0	$3,970.0	$3,970.0
Contractual	$15,000.0	$36,000.0	$51,000.0
Commodities	$2,000.0	$3,185	$5,185.0
Equipment	$0.0	$0.0	$0.0
TOTAL	$17,000.0	$43,155	$60,155

Budget Justification:

FY12

Personnnel:

No funds requested

Travel:

No funds requested

Conractual : Request contracts for:

Processing ($15/sample), lipid extraction ($50/sample) and transesterification of samples ($35/sample) collected during the monitoring survey and lab studies conducted in FY12. 110 samples x $100/sample = $11,000

Fish culture (200 hours x $20/hour) = $4,000

Commodities:

Sample collection and preparation : vials, lables, bags
$3.00 per sample x 110 samples = $330

Lipid extraction : solvents, hydromatrix, vials, sand, nitrogen, machine time
$10.20 per sample x 110 samples = $1120

Transesterification: nitrogen, pipettes, solvents, reagents, vials, caps, misc. supplies
$5.00 per sample x 110 samples = $550

Equipment:

No funds requested

FY13

Personnnel:

No funds requested

Travel:

Funds are requested for Heintz and Sewall to travel to the 2013 AMSS meeting in Anchorage.
Funds are requested for Heintz and Sewall to travel to the annual herring meeting in Cordova

Conractual :
Request contracts for:

Processing ($15/sample), lipid extraction ($50/sample) and transesterification of samples ($35/sample) collected during the monitoring survey and lab studies conducted in FY13.
175 samples x $100/sample = $17,500

Process transesterified samples by GC/MS
$35/sample x 385 samples (285 fish + 100 QA) = $13,500

Data management contract $5,000

Commodities:

Sample collection and preparation: vials, labels, bags
$3.00 per sample x 175 samples = $525

Lipid extraction : solvents, hydromatrix, vials, sand, nitrogen, machine time
$10.20 per sample x 175 samples = $1785

Transesterification: nitrogen, pipettes, solvents, reagents, vials, caps, misc. supplies
$5.00 per sample x 175 samples = $875

Equipment:

No funds requested

LITERATURE CITED

Budge, S. M., S. J. Iverson and H.N. Koopman. Studying trophic ecology in marine ecosystems using fatty acids: a Primer on analysis and interpretation. Marine Mammal Science 22(4):759-801.

Heintz, R. A., M. S. Wipfli and J.P. Hudson. 2010. Identification of marine-derived lipid in juvenile coho salmon and aquatic insects through fatty acid analysis. Transactions of the American Fisheries Society 139:840-854.

Otis, E.O., R. Heintz, and J. Maselko. 2010. Investigation of Pacific herring (Clupea pallasii) stock structure in Alaska using otolith microchemistry and heart tissue fatty acid composition. Exxon Valdez Oil Spill Restoration Project Final Report (Restoration Project 070769), Alaska Department of Fish and Game, Division of Commercial Fisheries, Homer, Alaska.

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Transesterification: nitrogen, pipettes, solvents, reagents, vials, caps, misc. supplies
$5.00 per sample x 110 samples = $550

Equipment:
No funds requested

FY13
Personnnel:
No funds requested

Travel:

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Funds are requested for Heintz and Sewall to travel to the annual herring meeting in Cordova

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