Appendix A

EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
PROGRAM PROPOSAL SUMMARY PAGE

Program Title

Herring Research and Monitoring

Program Lead Name and Affiliation

W. Scott Pegau, Prince William Sound Science Center

Date Proposal Submitted

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Program Abstract

This proposal addresses the Herring Research and Monitoring section of the EVOSTC FY17-21 Invitation for Proposals.

The overall goal of the Herring Research and Monitoring (HRM) program is to: **Improve predictive models of herring stocks through observations and research**. The program objectives are to:

1) Expand and test the herring stock assessment model used in Prince William Sound.
2) Provide inputs to the stock assessment model.
3) Examine the connection between herring condition or recruitment to physical and biological oceanographic factors.
4) Develop new approaches to monitoring.

We are proposing a program made up of eight projects; Modeling and Stock Assessment of Prince William Sound Herring; Surveys and Age, Sex, and Size Collection and Processing; Adult Pacific Herring Acoustic Surveys; Herring Disease Program; Studies of Reproductive Maturity among Age Cohorts of Pacific Herring; Annual Herring Migration Cycle; and HRM Coordination.

Through these projects we expect to address areas of interest numbers 2, 3, 4, 5, 6, 7, and 9 outlined within the herring research and monitoring section of the invitation for proposals. The modeling project and a postdoctoral fellow in the coordination project are envisioned as two integrating projects that use data and information from all of the others. The postdoc will also work with the Gulf Watch Alaska and Data Management programs. The primary beneficiaries of our efforts are expected to be Alaska Department of Fish and Game and Prince William Sound herring fishermen.

Dr. Pegau will serve as the program lead to ensure the proper coordination within the program, with other EVOS funded programs, and as a point person for communications with the EVOSTC. An independent scientific oversight group exists that will provide feedback on the program.

EVOSTC Funding Requested *(must include 9% GA)* - All amounts are in $1,000s

FY17	FY18	FY19	FY20	FY21	TOTAL
$1,252.9	$1,390.8	$1,292.7	$1,215.1	$870.8	$6,022.3

Non-EVOSTC Funding Available – This does not include the value of existing equipment

FY17	FY18	FY19	FY20	FY21	TOTAL
$157.2	$159.7	$160.7	$162.7	$149.7	$790.0

Appendix A

1. Executive Summary
Provide a summary of the program including the overall goals that the program is designed to address.

Program goals and objectives

This project addresses the Herring Research and Monitoring component of the FY17-21 Invitation for Proposals. The overall goal of the Herring Research and Monitoring (HRM) program is to: **Improve predictive models of herring stocks through observations and research**. The program objectives are to:

1) *Expand and test the herring stock assessment model used in Prince William Sound.* This builds upon the work of the previous five years, during which the age-structure-analysis (ASA) model used by Alaska Department of Fish and Game was built into a Bayesian framework. The model is now ready to be expanded to include earlier life stages, environmental conditions, and new metrics for disease. It is also possible to test the importance of model inputs and assumed relationships, such as the age-of-maturity function.

2) *Provide inputs to the stock assessment model.* Operation and testing of the model depends on input data. To expand the model to include environmental conditions requires that the model continue to be provided input data on the age structure, biomass indices, and environmental conditions to determine if the model output is consistent with observations.

3) *Examine the connection between herring condition or recruitment to physical and biological oceanographic factors.* Understanding how herring respond to environmental conditions requires understanding the distribution and movement of herring between oceanographic realms, such as from PWS to the Gulf of Alaska. Research has shown that recruitment patterns extend over broad spatial domains, thus requiring not only examining local phenomena, but also regional and even global relationships.

4) *Develop new approaches to monitoring*. Changes in technology and testing of existing approaches lead to important advances in our sampling techniques and design that can either provide simpler data collection, improved measurement accuracy necessary as a basis for future research, or provide more relevant measures of important factors, such as disease.

Two hypotheses have arisen that guide our current efforts. Individual projects have additional hypotheses that they will address.

H1: Herring recruitment is driven by bottom up forcing and mortality is primarily determined by disease and predation.

The program is designed around this hypothesis with data collection and modeling efforts necessary to provide the basic information to test this hypothesis. It is also connected to the third objective of the program. A postdoctoral research position is proposed to allow a focused analysis of new and historic data to test this hypothesis. Testing this hypothesis is expected to inform the population modeling effort in a manner that improves the predictive capacity of the modeling. The improved model would then lead to resource managers having a better understanding of potential changes in the population.

Appendix A

H2: Larger herring migrate out of PWS during the summer, while smaller ones remain in PWS.

Age-sex-length observations of herring collected in the summer by ADF&G, observations of fishermen in PWS, and sampling from the forage fish project suggest that herring remaining in PWS during the summer tend to be smaller than many of the fish observed during the spring spawn. This is similar to the concept of resident and migrant herring populations observed off British Columbia (Beacham et al., 2008). Knowing if there is a separation by size or age through periods of the year can help managers understand which portion of population fisheries would target at different times of year. The location of the adult herring population is also important for understanding the relevant oceanic conditions they are exposed to, guiding the efforts to test the first hypothesis.

Our goal and first objective directly addresses the overall program goal provided in the RFP and area of interest 3. The second objective is necessary to run the model in the first objective and addresses topics 4, 6, and 9 of the RFP. The third objective addresses topics 2, 5, 6, 7, 9. It also connected to topics 1, 8, 10, and 11. The fourth objective lays to foundation of future research and monitoring. Achieving these objectives requires collaboration with the Gulf Watch Alaska team that are collecting much of the environmental data.

Program design

The program design is similar to the previous HRM program. Administratively, the program coordination is provided by a single Program Lead (Dr. Pegau). He is responsible for ensuring coordination within the program and with the Gulf Watch Alaska and Data Management programs. The program is designed around a series of projects that inform two integrative efforts. The first integrative project is the stock assessment modeling. Most of the other projects provide data needed to run the model, expand the model, or assess parameterization within the model. The second integrative project is the coordination project that includes the coordination, outreach, and a postdoctoral fellowship. The postdoctoral fellowship will examine connections between herring and oceanographic conditions, so it will connect information collected within the program with that from the Gulf Watch Alaska (GWA) program. The big difference between the proposed work and the previous effort is that the focus has shifted from overwintering survival of juvenile herring to one more focused on adult herring.

Program projects

The program is made up by the following projects:

Modeling and Stock Assessment of Prince William Sound Herring
Surveys and Age, Sex, and Size Collection and Processing
Adult Pacific Herring Acoustic Surveys
Herring Disease Program
Studies of Reproductive Maturity among Age Cohorts of Pacific Herring
Annual Herring Migration Cycle
HRM Coordination

Brief descriptions of each project follow. Additional details are available in the project proposals.

Modeling and Stock Assessment of Prince William Sound Herring (P.I. Branch)

We propose a modeling component to the long-term herring research and monitoring program. The goals of the modeling effort are to develop an understanding of the current status of PWS herring, the factors affecting its lack of recovery, and an assessment of research and fishery needs into the future, with the following key products:

1. The core product of the modeling project is the maintenance and updating of the new Bayesian age-structured assessment (BASA) model based on the ASA model used by ADF&G, including annual assessment updates of

PWS herring and the revision of BASA to fit to new data sources such as the condition data and updated age at maturity.

2. Adapting the BASA model to better model the disease component of natural mortality. Specifically, this would be based on new methods for detecting antibodies of viral hemorrhagic septicemia virus (VHSV) in archival and planned future collections of herring serum.
3. Continued collection and expansion of catch, biomass, and recruitment time series from all herring populations around the world to place the lack of recovery of PWS herring into context given patterns of change in herring populations around the world.
4. An initial exploration of factors that may be used to predict herring recruitment, including oceanography, climate, competition, and predation.
5. A management strategy evaluation to test alternative harvest control rules for managing the fishery in the future, given realistic variability in productivity over time, and the possibility that the population has moved into a low productivity regime. Ecological, economic and social factors would be considered in the MSE.
6. Simulations to evaluate which data sources are the most useful in assessing future herring biomass, based on an MSE of the impact of each form of data on the accuracy of the BASA model.

This project will address hypothesis H1 and may need to be refined based on the finding of H2.

Surveys and Age, Sex, and Size Collection and Processing (P.I. Moffitt)
This proposed project will conduct spring aerial surveys to document Pacific herring (*Clupea pallasii*) milt distribution and biomass, as well as the distribution and abundance of sea lions, other marine mammals, and birds associated with herring schools or spawn. This proposed project will also provide a research platform (R/V Solstice) for an adult herring acoustics survey and disease sample collection and processing. Finally, this project will collect and process age, sex, and size samples of herring collected by the acoustics survey, spawning surveys, and the PWS Herring Research and Monitoring Program disease sampling. Aerial survey and age, sex, and size data have collected since the early 1970s and are an essential part of the age-structured model used by the Alaska Department of Fish and Game to estimate the historical and future biomass for fisheries management. Acoustics surveys have been conducted consistently since 1995 and the age-structured model is also tuned to acoustics biomass estimates. This project will be help to meet the overall program goal to **improve predictive models of herring stocks through observations and research** by providing necessary inputs to the age-structured assessment models of the Alaska Department of Fish and Game and the *PWS Herring Research and Monitoring Program* Bayesian model.

This project provides data necessary for testing of hypotheses H1 and H2.

Adult Pacific Herring Acoustic Surveys (P.I. Rand)
We propose to continue a long-term data-set of acoustically derived biomass estimates of the spawning population of Pacific herring in Prince William Sound. This proposal primarily addresses the HRM program Objectives 1 (expanding and testing the herring ASA model, and 2 (providing input to the ASA model). Since 1993, the Prince William Sound Science Center (PWSSC) has been carrying out acoustic surveys as a cost-effective approach to estimate the biomass of adult Pacific herring just prior to the spawning period.

Prince William Sound herring stock biomass estimates from hydroacoustic surveys provide a measure of the stock abundance for use in the age-structured assessment (ASA) model that is the forecasting tool used for management. Prior to 2001, the hydroacoustic surveys were conducted exclusively by the Prince William Sound Science Center (PWSSC). Since 2001, the effort has been shared between PWSSC and the Cordova office of Alaska Department of Fish and Game (ADF&G). While the ADF&G considers the hydroacoustic surveys to be critical (Steve Moffitt, pers. comm.), the lack of a commercial herring fishery in PWS since 1998 has reduced ADF&G's management priorities for herring. Thus the PWSSC contribution has become critically important for the long-term, especially if a future fishery appears only a remote possibility. With the level of effort available over the past several years, PWSSC and ADF&G individually have achieved herring biomass estimates with a precision of about ±30%. As in recent years, we intend to continue to survey the two main spawning aggregation regions (Port Gravina and Fidalgo, and the north coast of Montague Island). This will help allow us to continue generating accurate estimates of the total herring spawning biomass in PWS and provide an alert to changes in biomass in these two different regions. Beginning in FY2017 and continuing through 2021, hydroacoustic surveys will be conducted in spring (March-April) to assess adult spawning biomass. This project will use the ADF&G data from direct sampling for age, sex and length in the estimates of biomass. The estimate will then be provided to the modeling project.

This project provides data necessary for testing of hypothesis H1.

Herring Disease Program (P.I.s Hershberger and Purcell)
Using an approach that involves a combination of field- and laboratory-based studies, we propose to investigate fish health factors that may be contributing to the failed recovery of Pacific herring populations in Prince William Sound. Field studies will provide infection and disease prevalence data that will inform the ASA model, serological data that will indicate the prior exposure history and future susceptibility of herring to VHS, and diet information that will provide insights into the unusually high prevalence of *Ichthyophonus* that occurs in juvenile herring from Cordova Harbor. Laboratory studies will validate the newly-developed plaque neutralization assay as a quantifiable measure of herd immunity, provide further understanding of disease cofactors including temperature and salinity, investigate the possibility of an invertebrate host for *Ichthyophonus*, and assess the virulence of other endemic pathogens to Pacific herring. Information from the field and laboratory studies will be integrated into the current ASA model, a novel ASA-type model that is based on the immune status of herring age cohorts, and a novel mixture-cure simulation model for VHS. The Herring Disease Program (HDP) is embedded within the Herring Research and Monitoring Program, and the success of the HDP relies heavily on contributions from companion Principle Investigators including Steve Moffitt (platform for the collection of pathogen prevalence data), Dr. Kristen Gorman (collection of juvenile Pacific herring from Cordova Harbor), and Dr. Trevor Branch (incorporation of pathogen and resistance information in to the ASA models). Additionally, this project relies on contributions from Principle Investigators in the Long Term Monitoring Program (Dr. Rob Campbell – zooplankton collections).

This project provides data necessary for testing of hypothesis H1.

Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (P.I. Gorman)
A series of studies are proposed that aim ***to improve the HRM program's updated (Bayesian) PWS herring Age-Structured Assessment model's ability to more accurately predict the total population's biomass by empirically assessing reproductive maturity among age cohorts***. Currently, the age at maturity function in the ASA model is not based on empirical data. An improved understanding of age at maturity will allow for more accurate estimates of the total population biomass, which is central to the management of this fishery. The objectives of the studies proposed here are fourfold: 1) assess the seasonal timing (spring, summer, and fall) that allows for accurate determination of both previously spawned and maturing female herring based on ovary histology to determine maturation states; 2) couple histology results with annual scale growth information at the individual level, within specific age cohorts, to understand if scale growth patterns reflect reproductive investment; 3) assess whether annual scale growth patterns can be used to infer age at maturity at the individual level across age cohorts given results from objectives 1 and 2, and 4) assess inter-annual variability in age at maturity based on coupled histology and scale growth over a five-year period by focused, increased sampling during the optimal seasonal period given results from objectives 1-3. The proposed approach will advance preliminary worked conducted previously by HRM investigators by testing the appropriate sampling time of wild PWS herring for ovary characteristics, as opposed to lab-based studies, and increasing sample sizes for more powerful analyses. Studies proposed here address a key demographic parameter, therefore, this research will not only contribute to the management of Prince William Sound herring, but also to a more general understanding of herring

demography. As world-wide herring populations encounter more variable environmental conditions in the future, basic knowledge of herring demography and ecology will be invaluable.

This project provides data necessary for testing of hypothesis H1 and is dependent on sampling for H2.

Annual Herring Migration Cycle (P.I. Bishop)
Within Prince William Sound (PWS), adult Pacific herring (*Clupea pallasii*) movements between spawning, summer feeding, and overwintering areas are not well understood. Addressing this knowledge gap will improve our ability to assess biomass trends and recovery of this ecologically important species. In 2013 we documented post-spawn migration of herring from Port Gravina to the PWS entrances by acoustic tagging adult herring and collecting data from the Ocean Tracking Network acoustic arrays, which are located in the major entrances and passages connecting PWS with the Gulf of Alaska (GoA). However, the 2013 study could not establish if herring were seasonally leaving PWS and migrating into the GoA. With funding from EVOS in FY16, we will improve our ability to detect movements between PWS and the GoA by deploying additional acoustic receivers at the Ocean Tracking Network arrays. The primary goal of the proposed project is to clarify the annual migration cycle of PWS adult herring by leveraging this expanded acoustic infrastructure. The specific objectives of this project are to 1) document location, timing, and direction of Pacific herring seasonal migrations between PWS and the GoA; 2) relate large-scale movements to year class and body condition of tagged individuals; and 3) determine seasonal residency time within PWS, at the entrances to PWS, and in the Gulf of Alaska.

This project tests H2 and provides data to inform the testing of H1.

HRM Coordination (P.I. Pegau)
This project is to provide coordination of the Herring Research and Monitoring (HRM) program. In addition to the coordination efforts it includes a postdoctoral researcher to analyze the relationships between herring stocks and physical and biological oceanographic conditions. Furthermore it covers the community involvement and outreach activities of the program. The goal of the project is to provide coordination within the HRM program and with the Gulf Watch Alaska (GWA) and Data Management (DM) programs. The objectives of the project are:

1) *Coordinate efforts among the HRM projects to achieve the program objectives, maximize shared resources, ensure timely reporting, and coordinate logistics*.
2) *Oversee a postdoctoral researcher*.
3) *Provide outreach and community involvement for the program*.

The proposed approach follows that used during the Prince William Sound Herring Survey and initial HRM programs. Coordination will primarily be through e-mail and teleconference. The management team of GWA and the lead of DM will be included in the emails to HRM PIs to ensure they are aware of our activities. We also plan joint PI meetings and community involvement activities.

The postdoctoral researcher will be recruited in year one and has an expected duration of two years. The focus area of the research is to overlap with the activities of both HRM and GWA programs.

Outreach efforts will be focused on providing up-to-date information on the projects and their findings. Community involvement includes regular communications with stakeholders, such as the herring division of the Cordova District Fishermen United and Alaska Department of Fish and Game to stay aware of their findings and observations. We also are planning listening sessions in two of the villages to seek additional local and traditional ecological knowledge.

The postdoctoral researcher associated with this project will test hypothesis H1 and complete the analysis necessary to achieve the HRM program objective 3.

Appendix A

Approach and benefits

The first programmatic objective, *expand and test the herring stock assessment model used in Prince William Sound*, is to be addressed by the *Modeling and Stock Assessment of Prince William Sound Herring* project. The model will be run with inputs collected by other projects in the program. The model will be adapted to fit new data sources such as the presence of antibodies for viral hemorrhagic septicemia virus, and oceanographic data. The modeling efforts will also address the retrospective analysis of herring populations.

The first objective addresses the overall goal and the area of interest of retrospective analysis of herring populations listed in the invitation for proposals. The modeling effort integrates results from all the other projects and helps to synthesize the data into a format that is more useful to fisheries managers and the public. The model produces population estimates that are required for determining if a fishery can be opened, so this objective benefits the fishing community through determining if the population will support a fishery. This has become more important because of the reduced effort that ADF&G is expected to apply to herring fisheries. Furthermore, we expect that addressing the first objective will help guide future data collection requirements.

The second program objective, provide inputs to the stock assessment model, delivers the inputs necessary to run the model to evaluate changes in the herring population and the factors that may affect those changes. The *Surveys and Age, Sex, and Size Collection and Processing, Adult Herring Acoustic Surveys, and Herring Disease Program* all collect input data for the model. The effort of the postdoctoral researcher in the *HRM Coordination* project is expected to contribute oceanographic data need by the modeling effort. The *Studies of Reproductive Maturity among Age Cohorts of Pacific Herring* addresses the maturity function within the model. The *Annual Herring Migration Cycle* project will be assessing the survival as it relates to age and body condition. Survival is a parameter in the model that has not been determined empirically. Potentially, the survival from summer and winter periods can be determined. The population model is capable of using different seasonal survival numbers if they become available.

The modeling effort cannot succeed without inputs of both current and historical data. These inputs include ensuring the long-term data that was collected by ADF&G to support fisheries management is continued. The lack of a fishery for nearly two decades and the reduced state funding means these data would not be collected without the HRM program. The objective addresses the need for comprehensive spawn surveys through aerial milt surveys and the acoustic surveys. Data collected under this objective will also address the invitation for proposals' herring areas of interest of the role of disease, relationship between herring and oceanographic factors, age at maturity, and studies of herring movements.

Objective three also uses the various datasets collected under objective two. The postdoctoral fellowship component is our primary approach for addressing objective three, *examine the connection between herring condition or recruitment to physical and biological oceanographic factors*, and is contained within the HRM Coordination proposal. The fellowship will be responsible pulling together the oceanographic data, but will also be dependent on the existing ADF&G data along with data collected by the *Surveys and Age, Sex, and Size Collection and Processing, Adult Herring Acoustic Surveys, Studies of Reproductive Maturity among Age Cohorts of Pacific Herring, and Herring Disease Program* to characterize the herring. The *Annual Herring Migration Cycle* project is expected to contribute to the analysis through identifying where the adult herring are at different times of year. This objective is also meant to be cross-cutting in that it combines data collected through the efforts of GWA and HRM and made assessable by the Data Management program. The desire is to explore the appropriate temporal and spatial scales of oceanographic factors and their connections to herring recruitment or condition. The objective addresses the invitation to proposals' herring areas of interest on postdoctoral fellowship, and analysis of the relationship between oceanographic factors and herring. The primary benefit of this objective is to improve our understanding of factors controlling aspects of herring recruitment or condition. Relationships that are found are expected to inform the expansion of the modeling effort.

The fourth objective is to *develop new approaches to monitoring*. The *Herring Disease Program* examines new serological and plaque neutralization assays to examine disease prevalence and provide a measure of herd immunity. The other projects are not proposing new techniques, but we continue to look for ways to improve survey design or the type of equipment used to improve efforts in the future. The *Annual Herring Migration Cycle* continues earlier work on using acoustic tags as a new approach to provide information on the movement of herring.

2. Relevance to the Invitation for Proposals

Describe the results you expect to achieve during the program, the benefits of success as they relate to the Focus Area under which this proposal is submitted, and the potential recipients of these benefits.

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 17-21 invitation for proposals. In particular our program 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 also addresses the goals and areas of interest listed in the Herring Research and Monitoring Program in the FY17-21 Invitation for Proposals (IP).

The overall goal of the Herring Research and Monitoring program is to: **Improve predictive models of herring stocks through observations and research**. Our goal aligns with the Overall Program Goal listed in the FY17-21 IP, the continued development and testing of an updated age-structured assessment (ASA) model in collaboration with ADF&G. Projects within the program address the areas of interest identified in the FY17-21 IP to include a post-doc fellowship (area of interest 2), retrospective analysis of herring populations (3), comprehensive spawn assessments (4), study of movement of herring (5), study of the role of disease in herring recovery (6), analysis of the relationship between oceanographic factors and herring (7), and estimate and corroborate herring age at maturity (9). It includes a coordination component that addresses the components that address the need for a program lead.

Each project in the program addresses one or more areas of interest in the IP.

Modeling and Stock Assessment of Prince William Sound Herring – This project addresses the overall program goal of the HRM portion of the FY17-21 IP. In doing so it also provides the information necessary to determine if the herring recovery goal has been met. One aspect of the modeling effort is to address area of interest #3 in conducting a comparative retrospective analysis of herring populations.

Surveys and Age, Sex, and Size Collection and Processing – The data collected in this project is needed by the modeling project described above. It addresses area of interest #4 to provide comprehensive spawn assessments. It also forms the basis of the work to be done by the postdoctoral fellow identified in the IP area of interest #2. This is the minimalistic dataset required to run the model and determine if the stock has met the conditions of recovery identified in the Integrated Herring Restoration Plan and is large enough to have a fishery.

Adult Pacific Herring Acoustic Surveys – These data are also used by the modeling project. It addresses area of interest #4 to provide comprehensive spawn assessments. The program uses acoustics and aerial milt surveys to provide population level indices. Because of the errors in both methods, it is good to have multiple indices to provide checks on each other.

Herring Disease Program – This addresses area of interest #6 to continue studies of the role of disease in herring recovery.

Studies of Reproductive Maturity among Age Cohorts of Pacific Herring - This addresses area of interest #9 to estimate and corroborate herring age at maturity.

Annual Herring Migration Cycle - This addresses area of interest #5 to study adult herring movement between PWS and the continental shelf.

HRM Coordination – The primary purpose of this project is to provide the coordination and integration required by the IP. The project also provides the outreach efforts of the program and includes a postdoctoral fellow that addresses both areas of interest #2 and #7. Area of interest #2 is the development of a postdoctoral fellowship, and area #7 is the analysis of the relationship between physical and biological oceanographic factors. The postdoctoral fellow links the various projects together in their effort to address #7.

The primary beneficiaries of the program are expected to be Alaska Department of Fish and Game, and Prince William Sound herring fishermen. ADF&G is expected to benefit from the program through lessons learned in this effort and that may be applicable to other regions. Such efforts include assessment of model input value, means to measure underlying model parameters, and connections between the herring populations and oceanographic conditions. Local fishermen are expected to benefit by the program continuing to provide the data and modeling required to assess if a fishery can be opened. This has become critical, as ADF&G does not have funding to support the PWS research and assessment due to budget cuts.

Individual projects are expected to contribute to the stock assessment modeling through either modeling of stocks, providing the necessary data to run the model, or to tests underlying algorithms and parameters contained in the model. A postdoctoral fellowship within the HRM Coordination project is expected to integrate results from all the projects and to contribute environmental data to the modeling effort.

The research and monitoring effort is focused within Prince William Sound, thereby meeting the mandatory requirement to be focused within the spill-affected area.

3. Program Personnel

Provide the CV of the Program Lead and any other senior personnel involved in the program. They should include a list of professional and academic credentials and complete contact information. Provide information on each person's duties as they relate to the program and the percentage of their time that will be dedicated to the program.

Dr. W. Scott Pegau will serve in the role of Program Lead. He will be responsible for program coordination, ensuring reports and proposals are turned in, and be the contact person for the program. He is requesting salary support for 15% of his time for this effort. An additional 15% of his time can be dedicated to the program if necessary using salary from the Oil Spill Recovery Institute. He served as the program coordinator for both the PWS Herring Survey and the first phase of the HRM programs.

An assistant to the coordinator will dedicate 25% of their time to the project. Duties of the assistant may be split between personnel. The assistant will be responsible for website updates, meeting logistics, and other duties as necessary.

All project leads were involved in the design of the program. Their CVs can be found in the individual project proposals.

Appendix A

W. Scott Pegau (Program Lead)

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Education:

1990 B.S., Physics, University of Alaska, Fairbanks
1996 Ph.D, Oceanography, Oregon State University

Professional Experience:

1996-1997 Research Associate (Post Doc), Oregon State University
1997-1999 Faculty Research Associate, Oregon State University
1999-2010 Assistant Professor, Oregon State University
2002-2003 Senior Scientist, Kachemak Bay Research Reserve
2003-2007 Research Coordinator, Kachemak Bay Research Reserve
2007-present Research Program Manager, Oil Spill Recovery Institute

Research Interests:

Determining the relationship between oceanographic conditions and fisheries. Developing novel oil spill detection and tracking approaches. Understanding the fate and behavior of oil spilled in cold water environments. Development of response options for oceans with sea ice present. Understanding circulation patterns in Prince William Sound, Cook Inlet and the Gulf of Alaska and the associated larval transport.

Publications

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Appendix A

Collaborators

Mary Abercrombie (USF), Christopher Bassett (WHOI), Mike Banner (UNSW), Job Bello (EIC), P. Bhandari (UM), Mary Anne Bishop (PWSSC), Rob Bochenek (Axiom consulting), Emmanuel Boss (U Maine), Kevin Boswell (FIU), Tim Boyd (SAM), Trevor Branch (UW), John Bradford (BSU), Evelyn Brown (Flying fish), Michele Buckhorn, Lindsay Butters (PWSSC), Rob Cambell (PWSSC), Regina Carns (UW), L Carvalho (UCSB), Grace Chang (UCSB), Yi Chao (JPL), Paula Coble (USF), Robyn Conmy (EPA), Zoe Courville (CRREL), Tim Cowles (OSU), Helen Czerski (U Southhampton), M. Darecki (PAS), Tommy Dickey (UCSB), C. Dong (IGGP), Hajo Eicken (UAF), Bruce Elder (CRREL), Peter Eriksen (Norbit), David Farmer (URI), Jim Farr (NOAA), Scott Freeman (NASA), Jessica Garron (UAF), J. Gemmrich (UVic), P. Gernez (U Nantes), Kristen Gorman (PWSSC), Scott Guyer (BLM), Jeff Guyon (NOAA), Nate Hall-Patch (IOS), Mark Halverson (PWSSC), Hayley Hoover (PWSSC), Ron Heintz (NOAA), Paul Hershberger (USGS), Ben Holt (JPL), S. Jiang (UCSB), Mark Johnson (UAF), C. Jones (UCSB), George Kattawar (TAMU), T. King (BIO), Tom Kline (PWSSC), Cory Koch (Wetlabs), Gary Kofinas (UAF), Kathy Kuletz (USFWS), J. Lacoste (Dalhousie), Andone Lavery (WHOI), D. LeBel (Lamont), Ken Lee (BIO), L. Lenain (SIO), Marlin Lewis (Satlantic), Bonnie Light (UW), Y. Liu (MIT), L. Logan (UMiami), Ted Maksym (WHOI), Darek Manov (UCSB), Hans-Peter Marshall (BSU), W. Melville (SIO), Scott Miles (LSU), Steve Moffitt (ADF&G), Mark Moline (Cal Poly), Rue Morison (UNSW), Dave Musgrave, F. Nencioli (MIO), Marc Oggier (UAF), Carter Ohlmann (UCSB), Don Perovich (CRREL), Sean Powers (USA), Pawel Pacwiardowski (Norbit), Pete Rand (PWSSC), B. Reineman (SIO), Ian Robbins (Cal Poly), B. Robinson (BIO), Chris Roman (WHOI), R. Rottgers (HZG), Scott Ryan (BIO), H. Schultz (UMass), Fletcher Sewell (NOAA), Li Shen (Johns Hopkins), M. Shinki (CRI), Matt Slivkoff(ISMO), M. Sokolski (PAS), Frank Spada (Sea Engineering), Nate Statom (SIO), Darius Stramski (SIO), Peter Sutherland (SIO), Hanumat Singh (WHOI), Dajun Tang (UW), Richard Thorne (PWSSC), Mike Twardowski (Wetlabs), S. Vagle (IOS), Ronnie Van Dommelen (Satlantic), Johanna Vollenweider (NOAA), Ken Voss (UMiami), Ian Walsh (Wetlabs), Libe Washburn (UCSB), J. Wei (Dal), Chris Wiggins (IGM), Hemantha Wijesekera (NRL), Sharon Wilde (NOAA), Amanda Whitmire (OSU), Jeremy Wilkinson (POS), Michelle Wood (UO), O. Wurl (Old Domin), D. Yang (John Hopkins), Dick Yue (MIT), Len Zabilansky (CRREL), Ron Zaneveld (Wetlabs), Chris Zappa (Lamont), Brian Zelenke (Cal Poly)

4. Program Administration

Provide an administrative plan for overall program management including an organization chart. At minimum, the plan should include a list of what services are covered by your indirect rate; a schedule for the production and implementation of data and reporting policies which must include a plan for addressing non-compliant PI's and programs; and a listing of any costs and staff time associated with meetings.

We have a minimal approach to program administration. This has worked through the PWS Herring Survey and initial HRM programs. The size of the program and the history of the PIs working together allow for a single level of program management. Program coordination will be provided by Dr. Pegau as described in the HRM Coordination proposal. He will be responsible for ensuring coordination within the program, with the EVOSTC, and with other EVOS funded programs (Figure 1). He has increased his time dedicated to program management and administration by a month each year to meet the program needs as learned from the past two programs. Administration of non-trustee contracts will be performed by the Prince William Sound Science Center through indirect costs on those proposals.

Appendix A

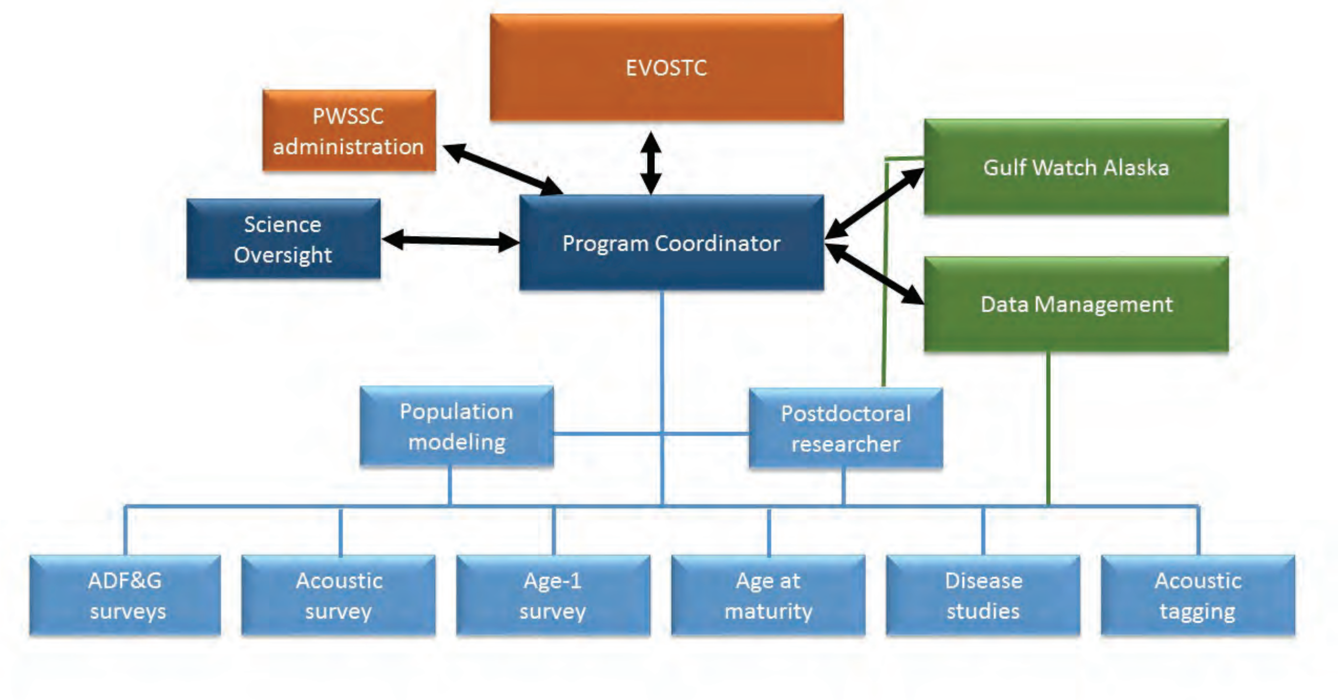

Figure 1. The envisioned organizational chart. This does not show the connections between projects or the connection between HRM projects and individual projects in GWA.

Contract administration will be covered by the indirect costs of PWSSC projects. The PWSSC indirect is negotiated with NOAA and covers items allowed in the super circular. These include items such as the cost of maintaining an office for the researcher (rent, utilities, building maintenance, insurance, etc.), and administrative personnel (contracting, billing, and President), it also covers costs associated with the financial audits. Subcontracts for non-trustee agency organizations are charged indirect for the first $25,000 of the subcontract over the five-year period.

To enable us to meet the EVOS and NOAA reporting requirements, all investigators are required to submit their annual proposals to the Program Lead no later than August 17th each year. This allows the Program Lead to develop the annual program proposal and submit by September 1st. Similarly, semi-annual project reports are due to the Program Lead by February 14th to allow for the development of a semi-annual program report. All reports are then submitted by March 1st.

We will adopt the following data policy.

The EVOSTC requires data sharing in its agreements among all principal investigators (PI) and program components. For this Program, all PIs shall adhere to these policies unless individual agency or legal requirements require restrictions contrary to these policies. The primary data repository will be the HRM workspace. The HRM program workspace is password protected to ensure confidentiality among PIs.

- All data should be posted on the HRM Program Workspace as they become available following collection in order to promote internal integration and sharing between projects.
- A final QA/QC'd data will be added, in a simple to identify folder, when available.
- Comprehensive metadata using FGDC (or ISO) standards are required for the QA/QC'd dataset.
- Data from monitoring projects will be made available to the public as soon as it has been QA/QC'd or within 1 year following collection, whichever is sooner.

- Anyone making public use of another team member's data should contact the collector of the data and provide appropriate attribution and credit.
- The HRM coordinator must agree to any deviations from these policies in advance.

Compliance with the reporting and data management policies will be confirmed during the semi-annual reporting and annual proposal submission. Any investigator out of compliance will be given a written notice that they are out of compliance. If they are not compliant within six months the Program Lead will recommend discontinuing funding until the project is in compliance. Final reports will be required from all projects by April 2021. The Program Lead will be responsible for ensuring scientific review of those reports.

All PIs will be expected to attend at least a two-day program meeting each year. The meeting will be timed to be consecutive with the GWA investigator meeting in order to encourage exchange of information between the programs. At a minimum, the program lead will be expected to attend the GWA meeting. For project investigators the expected time in meetings, including travel, encompasses three to four days. For the Program Lead the meeting time is five days and another five days is budgeted for preparing for the meeting.

5. Science Program Design and Implementation

Describe the plan for the management of the scientific projects. At minimum, the plan should include:

- A plan for the selection and implementation of an internal science panel.
- A plan for ensuring that changes to project protocols recommended by the program's internal science panel are adopted by the individual projects.
- A plan for the evaluation of program projects to ensure that they are meeting their milestones and are still relevant to the goals of the program.
- A plan for the distribution of Program science panel and EVOSTC work plan comments to the PIs.

Science management is primarily through collaboration between the PIs with oversight from the Program Lead. The initial level of management is through email and phone calls. The reporting/proposal requirements in February and August are two points in time during which many aspects of program management is expected to occur. The annual PI meeting provides a third time for implementing program management needs. The Program Lead is provided assistance in evaluating the progress of the projects and program by an internal science panel. Additional input to the program design is provided in the EVOSTC annual work plan comments.

During the first phase of the HRM program we assembled an internal science panel that consisted of an ADF&G person (Sherri Dressel), a person with historic knowledge of research in the area (Jeep Rice), and a population dynamics modeler (Steve Martell). All three have agreed to continue to serve on that panel in the future program. The internal panel is invited to all of the PI meetings and are on the program email list serve so they are kept aware of what is happening and the findings of the projects. All proposals and annual reports will be made accessible through the Ocean Workspace. Comments from the science panel to the program lead are then passed to the investigators as necessary. Aspects of the proposed program are a direct result of input from the science panel.

All recommended protocol changes will be passed from the Program Lead to the project investigator. The project investigator will be required to respond in writing the action to be taken in association with the recommendation. If there isn't agreement on implementing the recommendation, the Program Lead will pass on the reasoning. If further discussion is necessary the Program Lead will work with the science panel to determine if it better to have a science panel member discuss the issue directly with the investigator or continue to communicate through the Program Lead.

Appendix A

Progress on projects will be evaluated during the reporting/proposal phases in February and August each year. A third review occurs during the annual PI meeting. During the report/proposal writing the PIs are required to identify the status on progress toward milestones and explain any deviation from meeting the milestones. Not reaching milestones two reports in a row will result in the Program Lead working with the PI to establish a plan for getting caught up with the established milestones, or establish a new schedule of milestones. A new schedule will be provided to the internal science panel for their comment and included in future proposals to EVOS.

We generally receive comments from the EVOS Science Panel in the EVOSTC work plan. The work plan is sent to each of the PIs by the Program Lead to ensure they can review the comments. The Program Lead will discuss any major comments with the PI to ensure a plan is in place to address those comments. PIs will submit a written explanation of how the Science Panel comments will be addressed.

6. Program Data Management

Describe how the Program will ensure that data and associated metadata collected by the projects are accurate and provided to the data managers based on the data policy. The data policy must provide a clear timeline for the submission of data and metadata by individual researchers and when the data will be made available to the public. Data collected by researchers employed by any federal agency must comply with Federal Open Data Policy Requirements.

Dates of cruises and flights are to be reported in the semi-annual reports required by NOAA. Data submission dates will be based on the field collection dates and tracked for compliance in the subsequent semi-annual reports. Accuracy will be determined by ensuring compliance with the QA/QC procedures either included in the proposal. If no QA/QC procedures are in the proposal the investigator will need to file a protocol for data collection and analysis prior to the start of data collection.

The HRM data management policy requires data sharing in its agreements among all principal investigators and program components. For this Program, all PIs shall adhere to these policies unless individual agency or legal requirements require restrictions contrary to these policies. The primary data repository will be the HRM workspace. The HRM program workspace is password protected to ensure PIs have control of data distribution.

- All data should be posted on the HRM Program Workspace as they become available following collection in order to promote internal integration and sharing between projects.
- A final QA/QC'd data will be added, in a simple to identify folder, when available.
- Comprehensive metadata using FGDC (or ISO) standards are required for the QA/QC'd dataset.
- Data from monitoring projects will be made available to the public as soon as it has been QA/QC'd or within 1 year following collection, whichever is sooner.
- Anyone making public use of another team member's data should contact the collector of the data and provide appropriate attribution and credit.
- The HRM coordinator must agree to any deviations from these policies in advance.

Compliance with the data management policies will be confirmed during the semi-annual reporting and annual proposal submission. Any investigator out of compliance will be given a written notice that they are out of compliance. If they are not compliant within six months the Program Lead will recommend discontinuing funding until the project is in compliance.

7. Program Outreach

Provide a public outreach plan focused on providing information to the Trust Agencies for use in their respective outreach and education materials. Outreach efforts by the program should focus on developing and maintaining accurate and timely content for the program's website as a primary source of information on the program.

Provide a proposed schedule for website updates that will provide information to the general public and interested researchers.

The outreach effort is focused on updating and enhancing the HRM website (http://pwssc.org/research/fish/pacific-herring/). Our past efforts were in developing basic descriptions of each of the projects and a transition to a new website when the PWSSC changed its web format. Our plan is to rework sections from the PWS Herring Survey and HRM programs to show what was learned by each of the projects and develop a system for providing regular updates on the findings of the projects. This information is expected to be the basis for any trustee agency outreach and education materials. Website updates will occur during the fall and winter of each year. This is based on personnel availability and access to new data and findings. There are currently 24 pages on the HRM website that will need updating and new pages generated for the upcoming program. Six to eight of the existing pages will be updated each year to show findings from previous efforts. That effort will be combined with generating new pages for the projects in this phase of the HRM program and updating them as results become available.

The outreach efforts are contained in the HRM Coordination proposal.

8. Coordination and Collaboration

Within the Program

Provide a list and clearly describe the functional and operational relationships with the program projects. This includes any coordination that has taken or will take place and what form the coordination will take (shared field sites or researchers, research platforms, sample collection, data management, equipment purchases, etc.).

With Other EVOSTC-funded Programs and Projects

Indicate how your proposed program relates to, complements or includes collaborative efforts with other proposed or existing programs or projects funded by the EVOSTC.

With Trustee or Management Agencies

Please discuss if there are any areas which may support EVOSTC trust or other agency work or which have received EVOSTC trust or other agency feedback or direction, including the contact name of the agency staff. Please include specific information as to how the subject area may assist EVOSTC trust or other agency work.

If the proposed program requires or includes collaboration with other agencies, organizations or scientists to accomplish the work, such arrangements should be fully explained and the names of agency or organization representatives involved in the project should be provided. If your proposal is in conflict with another project or program, note this and explain why.

With Native and Local Communities

Provide a detailed plan for any local and native community involvement in the program outside of the materials created for public outreach.

This is a continuation of the effort that began with the first HRM program. The coordination effort continued through the development of the HRM proposal in response to the FY17-21 RFP. These researchers have worked together on the previous HRM program and have a good working relationship.

Dr. Pegau will act as the program team leader and be responsible for ensuring a coordinated and focused research program that leverages other assets whenever possible. Within program coordination will primarily be through e-mail and phone communications. In-person meetings of participants are expected to occur once a year for exchange of information and to encourage collaboration between projects. This meeting will be held the same week, but on different days as the GWA investigator meeting to allow exchange between the groups.

Coordination between projects is also taking place through scheduling of vessels. All the investigators are required to work together to determine vessel type and number of days needed. The primary overlap we have identified is during the spring adult herring surveys. In that case the vessel will be shared by the ADF&G age-sex-length sampling, acoustic survey, disease sampling, and at least in the first year the age-at-maturity project. Because of the limited berthing available we will need to cycle the non-ADF&G projects on the vessel as appropriate.

Coordination was also achieved through the scheduling of projects to ensure results would be available for projects dependent on samples or data from another project. Information gained from the tagging project is expected to have value to age-at-maturity study in helping determine if there is a segregation by age or size class. It will also inform the work to be done by a postdoctoral researcher on identifying how herring are affected by environmental conditions. We expect that the postdoctoral researcher will facilitate further collaboration as that person will need information from each of the projects to address the relationships between herring and the environmental conditions.

With Other EVOSTC-funded Programs and Projects

There was considerable discussion between the GWA and HRM programs during the development of proposals to identify areas of overlap between programs and to ensure data management needs can be met.

We propose to continue our collaborations with the GWA and Data Management programs. The GWA science lead and a person to be designated from the Data management team will be included on the HRM email list so they are aware of what is going on with the HRM program. Administratively, the annual work plans and reports will continue to be developed together. We plan to have joint PI meetings to encourage individuals to work with people in the other programs. We will work together to design topics for analysis and development of joint scientific manuscripts and cross-program synthesis proposals. We will work with the Data Management project to ensure timely submission of data and metadata.

The HRM program is collecting detailed information on herring and processes that affect them. GWA monitors the oceanographic conditions that drive the growth and recruitment of the herring. One of the strongest connections between programs is through the HRM postdoctoral researcher whose research effort bridges between the HRM and GWA programs. That effort will be looking at the impacts of biological and physical oceanographic conditions on herring populations in PWS. They will be using the detailed information on herring collected in HRM to test the impacts of bottom-up forcing, using information from the environmental drivers component, and top-down forcing using information from the pelagic component.

The HRM modeling effort includes expanding the model to include environmental drivers and predation components. This creates a connection to the environmental drivers group and the GWA Pelagic Integrated Fall/Winter Predator Prey Surveys that encompass surveys for forage fish, humpback whales, and marine birds.

We are working with the GWA pelagic forage fish project to continue sharing the spring juvenile herring surveys data. In that sampling other forage fish are observed. The aerial observation design was determined in consultation with Mayumi Arimitsu of the GWA pelagic forage fish project to ensure it met the needs of both projects. We are working with the forage fish project for possible collection of fish for the age-at-maturity study.

Appendix A

We will be working with the GWA program on future cross-cutting synthesis proposals. Both programs have identified at least one topic for consideration, but need additional time to focus the efforts before putting a proposal together.

With Trustee or Management Agencies

Alaska Department of Fish and Game is the primary trustee and management agency that the HRM program interacts with. The success of the program is highly dependent on the historical information collected by ADF&G and the expertise within the agency so it is imperative that we work with the agency. We will continue to have an ADF&G person on our scientific oversight group. ADF&G efforts are a primary project with the program to ensure the data needed to understand recovery of herring is collected. Interactions with Steve Moffitt in Cordova have provided a close connection between the program and the agency.

With Native and Local Communities

The HRM program has an established working relationship with the Cordova District Fishermen United (CDFU) that provides a means of communication with fishermen in Cordova. This relationship has created better ties between the scientists and fishing community. The HRM program provides annual updates to the herring section of CDFU. That meeting provides the primary means for focused feedback on the research program from the community and for the program to gain local ecological knowledge. Over the years the individual fishermen and scientists have regular communication in casual situations. These have been important in gaining local knowledge.

Ties to the native communities are limited; however, we have established a contact in the village of Tatitlek. They have an interest in learning about fresh spawn near the village for the collection of roe or fish. Providing observations from the HRM program starts a conversation in which local observation are provided. We envision working with GWA to increase our effort to interact with native communities through community involvement activities.

9. Schedule

Program Milestones

Specify when critical program tasks will be completed. Reviewers will use this information in conjunction with annual program reports to assess whether the program is meeting its objectives and is suitable for continued funding.

Measurable Program Tasks

Specify, by each quarter of each fiscal year (February 1 – January 31), when critical program tasks will be completed.

Program Milestones

The program objectives lead to the program milestones.

1) Expand and test the herring stock assessment model used in Prince William Sound.

The proposed program has a series of model expansion and evaluation efforts that are described more fully in the modeling proposals. The major tasks are identified in the Measurable Program Task section.

2) Provide inputs to the stock assessment model.

Inputs are required annually to update the stock assessment. New variables useful to the model will be incorporated as they are determined to be of use.

3) Examine the connection between herring condition or recruitment to physical and biological oceanographic factors.

This is the focus of the postdoctoral fellow and early modeling efforts and will be completed by the end of FY 20.

Appendix A

4) Develop new approaches to monitoring.

This is an ongoing objective. We are proposing efforts in the disease program that span the duration of this proposal. Herring tagging and juvenile acoustic work will be completed by the end of FY 20.

Measurable Program Tasks

FY17 1st Quarter (Feb1- Apr 30)
- Conduct spring adult herring surveys
- Tag herring
- Request proposals for postdoctoral researcher

FY17 2nd Quarter (May1- Jul 31)
- Select postdoctoral research project to include in annual EVOS proposal submission
- Complete processing fish collections
- Age-1 herring surveys
- Juvenile herring acoustic target strength determination

FY17 3rd Quarter (Aug 1 – Oct 31)
- Semi-annual report to NOAA
- FY 18 proposal submitted to EVOS
- Complete analysis of 2017 plasma samples

FY17 4th Quarter (Nov 1 – Jan 31)
- Complete annual website updates
- Complete model simulation study estimating VHSV from antibodies
- Annual PI meeting
- Complete *Vibrio* challenge experiments

FY18 1st Quarter (Feb1- Apr 30)
- Annual ASA model run
- Conduct spring adult herring surveys
- Semi-annual reports to EVOS and NOAA
- Tag herring

FY18 2nd Quarter (May1- Jul 31)
- Ensure data submitted from previous year
- Complete processing fish collections

FY18 3rd Quarter (Aug 1 – Oct 31)
- Semi-annual report to NOAA
- FY 19 proposal submitted to EVOS
- Complete analysis of 2018 plasma samples

FY18 4th Quarter (Nov 1 – Jan 31)
- Complete annual website updates
- Annual PI meeting
- Determine age-at-maturity sampling
- Complete experiments on the effects of salinity on *Ichthyophonus* transmission

FY19 1st Quarter (Feb1- Apr 30)
- Annual ASA model run
- Conduct spring adult herring surveys
- Tag herring
- Semi-annual reports to EVOS and NOAA

FY19 2nd Quarter (May1- Jul 31)
- Preliminary model analysis of factors predicting herring recruitment
- Ensure data submitted from previous year
- Complete processing fish collections

Appendix A

FY19 3rd Quarter (Aug 1 – Oct 31)
- Semi-annual report submitted to NOAA
- FY 20 proposal submitted to EVOS
- Complete analysis of 2019 plasma samples

FY19 4th Quarter (Nov 1 – Jan 31)
- Complete annual website updates
- Update on global herring meta-analysis
- Attend EVOS Joint Science Workshop
- Annual PI meeting
- Complete experiments of the effects of temperature on VHSV shedding

FY20 1st Quarter (Feb1- Apr 30)
- Annual ASA model run
- Preliminary estimate of age-at-maturity function
- Conduct spring adult herring surveys
- Semi-annual reports to EVOS and NOAA
- Analysis of value of survey data to ASA model

FY20 2nd Quarter (May1- Jul 31)
- Ensure data submitted from previous year
- Complete processing fish collections

FY20 3rd Quarter (Aug 1 – Oct 31)
- Semi-annual report submitted to NOAA
- FY 21 proposal submitted to EVOS
- Complete analysis of 2020 plasma samples

FY20 4th Quarter (Nov 1 – Jan 31)
- Complete annual website updates
- Complete analysis of herring tagging data
- Annual PI meeting
- Complete investigation of offal as *Ichthyophonus* host

FY21 1st Quarter (Feb1- Apr 30)
- Annual ASA model run
- Conduct spring adult herring surveys
- Semi-annual reports to EVOS and NOAA

FY21 2nd Quarter (May1- Jul 31)
- Ensure data submitted from previous year
- Complete processing fish collections
- Analysis of harvest control rules

FY21 3rd Quarter (Aug 1 – Oct 31)
- Semi-annual report submitted to NOAA
- Complete analysis of plankton as a host of *Ichthyophonus*
- Complete analysis of 2021 plasma samples

FY21 4th Quarter (Nov 1 – Jan 31)
- Complete annual website updates
- Annual PI meeting
- Annual ASA model run
- FY22 1st Quarter (Feb1- Apr 30)
- Ensure final reports submitted and sent for review

Appendix A

10. Budget

Budget Forms (Attached)

Please provide completed budget forms. Please note that the following items will not be considered for funding:

- Costs associated with international travel for meetings, symposia, or presentations.
- Costs associated with outreach or education efforts that are separate from or in addition to the Program's.

Sources of Additional Funding

Identify non-EVOSTC funds or in-kind contributions used as cost-share for the work in this proposal. List the amount of funds, the source of funds, and the purpose for which the funds will be used. Do not include funds that are not directly and specifically related to the work being proposed in this proposal.

The budget workbook provides a summary of the core projects. Budget numbers are given in $1,000s.

Sources of Additional Funding

The other resources line on the first page of the proposal only includes other sources of funding. Approximately $500K of existing equipment will be used. This includes large nets, several hydroacoustic sensors, and the Ocean Tracking Network array in Prince William Sound.

The additional sources of funding break out as follows:

Up to two months of additional salary (~$27K) for Dr. Pegau will be provided by OSRI to help coordinate the HRM program.

$15K of ship time for downloading data from the Ocean Tracking Network is provided each of the first four years from the Alaska Ocean Observing System. This is the system that collects data on the movement of the tagged herring.

$54.5K of salary of ADF&G permanent employees is provided to oversee the age-sex-size and aerial milt surveys.

Approximately $64K per year of salary support from USGS is provided for permanent employee participation in the project.

References

Beacham, T.D., Schweigert, J.F., MacConnachie, C., Le, K.D., Flostrand, L., 2008. Use of Microsatellites to Determine Population Structure and Migration of Pacific Herring in British Columbia and Adjacent Regions. Trans. Am. Fish. Soc. 137, 1795–1811. doi:10.1577/T08-033.1

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$515.1	$644.0	$668.6	$682.2	$449.5	$2,959.5	
Travel	$37.1	$40.7	$38.6	$37.5	$36.5	$190.3	
Contractual	$198.7	$221.9	$203.4	$143.4	$134.0	$901.4	
Commodities	$192.6	$146.0	$73.4	$67.5	$68.6	$548.1	
Equipment	$5.9	$0.0	$0.0	$0.0	$0.0	$5.9	
Indirect Costs (*will vary by proposer*)	$200.1	$223.4	$201.9	$184.2	$110.3	$919.9	
SUBTOTAL	$1,149.5	$1,276.0	$1,185.9	$1,114.8	$798.9	$5,525.0	N/A
General Administration (9% of subtotal)	$103.5	$114.8	$106.7	$100.3	$71.9	$497.3	
PROJECT TOTAL	$1,252.9	$1,390.8	$1,292.7	$1,215.1	$870.8	$6,022.3	
Other Resources (Cost Share Funds)	$157.2	$159.7	$160.7	$162.7	$149.7	$790.0	N/A

COMMENTS:
This summary page provides an five-year overview of proposed funding and actual cumulative spending. The column titled 'Actual Cumulative' must be updated each fiscal year as part of the annual reporting requirements. Provide information on the total amount actually spent for all completed years of the project. On the Project Annual Report Form, if any line item exceeds a 10% deviation from the originally-proposed amount; provide detail regarding the reason for the deviation.

FY17-21

Program Title: Herring Research and Monitoring
Program Lead(s): W. Scott Pegau

PROGRAM SUMMARY PAGE

Date Prepared: 08/24/2016

17120111-A Herring Program – Program Coordination – P.I. Pegau

Science Panel Comments.

The Panel strongly recommends that the Council consider the addition of funding to support a third year of the post-doc position, which the proposer currently budgets as funded for slightly more than two years. In recommending three years of funding, the Panel notes that much of the first year will be spent becoming familiar with existing programs and data. The proposal also needs to add a mentoring plan for the post-doc position. This plan could profit by including interactions between the post-doc and Hershberger, whose disease research continues to inspire new insights into causes of the lack of herring recovery in PWS.

Based on these comments the post-doc position has been budgeted as a full-time position for three years. A mentoring plan has been added. In order to provide additional overlap with Drs. Herberger and Branch, travel for the post-doc to work at the two labs in the Seattle area has been added to the FY18 budget.

The request for an additional $500,000 in funding to allow for flexibility to respond to changing conditions is not supported by the Panel. If the Program would like to pursue expanded or new work, specific proposals for the expanded or new work should be submitted during the annual proposal cycle to allow for review by the Panel. On the other hand, the Panel supports strongly the need to provide additional assistance to Pegau, whose work load alone is a Herculean task.

The request was removed from the HRM program proposal.

Science Coordinator Comments

I concur with the Science Panel's comments regarding the addition of a third year of funding for the post-doc position. Travel and salary costs to support a science advisory committee should be added to this budget.

The budget has been modified to support the post-doc for three years. The travel and stipend costs associated with the oversight group are included in the budget. $65K in funding is being requested for logistical support (boat or aircraft time) to be able to fill gaps from removing the aerial survey project and be able to address issues such as means to optimize the timing of acoustic surveys or be able to obtain ASL samples after the ADF&G vessel is done with its surveys. The request for logistical support is being placed in this proposal to maximize the flexibility in how it is used.

Appendix C

EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
PROGRAM PROJECT PROPOSAL SUMMARY PAGE

Project Title

HRM Coordination

Primary Investigator(s) and Affiliation(s)

W. Scott Pegau – Prince William Sound Science Center

Date Proposal Submitted

August 12, 2016

Project Abstract

This proposal is to provide coordination of the Herring Research and Monitoring (HRM) program. In addition to the coordination efforts, it includes a postdoctoral researcher to analyze the relationships between herring stocks and physical and biological oceanographic conditions. Furthermore, it covers the community involvement and outreach activities of the program. The goal of the project is to provide coordination within the HRM program and with the Gulf Watch Alaska (GWA) and Data Management (DM) programs. The objectives of the project are:

1) *Coordinate efforts among the HRM projects to achieve the program objectives, maximize shared resources, ensure timely reporting, and coordinate logistics*.
2) *Oversee a postdoctoral researcher*.
3) *Provide outreach and community involvement for the program*.

The proposed approach follows that used during the Prince William Sound Herring Survey and initial HRM programs. Coordination will primarily be through e-mail and teleconference. The management team of GWA and the lead of DM will be included in the emails to HRM PIs to ensure they are aware of our activities. We also plan joint PI meetings and community involvement activities.

The postdoctoral researcher will be recruited in year one and is funded for three years. The focus area of the research was chosen to overlap with the activities of both HRM and GWA programs.

Outreach efforts will be focused on providing up-to-date information on the projects and their findings. Community involvement includes regular communications with stakeholders, such as the herring division of the Cordova District Fishermen United and Alaska Department of Fish and Game to stay aware of their findings and observations. We also are planning listening sessions in two of the villages to seek additional local and traditional ecological knowledge.

EVOSTC Funding Requested ***(must include 9% GA)***

FY17	FY18	FY19	FY20	FY21	TOTAL
$138.4	**$270.2**	**$284.1**	**$256.1**	**$90.7**	**$1,039.4**

Non-EVOSTC Funding Available

FY17	FY18	FY19	FY20	FY21	TOTAL
$26.0	**$26.6**	**$27.2**	**$28.0**	**$28.3**	**$136.1**

Appendix C

Please refer to the Invitation for the specific proposal requirements for each Focus Area. The information requested in this form is in addition to the information requested in each Focus Area and by the Invitation.

1. Executive Summary
Identify the hypotheses the project is designed to address. Describe the background and history of the problem. Include a scientific literature review that covers the most significant previous work history related to the project. Please provide a summary of the project including key hypotheses and overall goals.

The long-term goal of the Herring Research and Monitoring (HRM) program is to improve predictive models of herring stocks through observations and research. Described here is a single project that will coordinate an integrative program focused on enhancing monitoring efforts of the Alaska Department of Fish and Game (ADF&G), and examining aspects of particular life stages to allow better understanding of herring populations.

Statement of the Problem:

Robust Pacific herring (*Clupea pallasii*) populations, suitable for exploitation by commercial fisheries, are typically sustained by periodic recruitment of strong year classes into the adult spawning population. However, the Prince William Sound (PWS) herring population has not had a strong recruitment class since 1988. In the *Exxon Valdez* Oil Spill (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 requires understanding potential bottlenecks in the herring life cycle. Identifying conditions that limit herring recovery requires a series of focused process studies combined with monitoring of herring stocks and the natural conditions that affect herring survival.

Background:

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 effort was to determine what, if anything, can be done to successfully recover the Pacific herring in PWS. In order to determine what steps can be taken, the program examined the factors limiting recovery of herring in PWS, identified and evaluated potential recovery options, and recommended courses of action for achieving restoration.

Based on the recommendations of the IHRP the Trustee Council stated in their FY12 request for proposals that they had chosen Restoration Option #2, Enhanced Monitoring, as the focus for their research interests. This program aims to meet the goals of that 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 life cycle necessary to improve population models.

Another outcome of the IHRP development was the recognition of the need to integrate the herring research projects. In the past there was limited interaction between investigators working on various aspects of herring research. It was recognized that to develop a better understanding of the interactions between the many aspects of research that funding individual projects would need to give way to integrated programs that strove to have investigators interact and to synthesize the knowledge gained from projects within the program. This began with the Prince William Sound Herring Survey Program (2009-2013) and was followed by the first phase of the Herring Research and Monitoring Program (2012-2016). Synthesis reports have been generated by both programs (Pegau 2013, HRM team 2014). These documents can be accessed from the herring program website (http://pwssc.org/research/fish/pacific-herring/).

Program Coordination Goals and Objectives:

The **goal of this proposal is to provide the coordination necessary to continue integrating the research and monitoring projects** to achieve the program goals. This proposal addresses the program lead components identified as required in the FY17-21 invitation for proposals. These include providing a program lead who will work with and be responsive to the Council's objectives and requirements, who will facilitate the most cost-effective and scientifically-supportive stream of funding, provide a program science panel to provide program oversight, and other duties as identified in the invitation for proposals.

The objectives of the coordination project are as follows:

1) *Coordinate efforts among the HRM projects to achieve the program objectives, maximize shared resources, ensure timely reporting, and coordinate logistics*. Integration of the projects throughout the program is necessary to improve our scientific understanding of factors affecting herring and to maximize use of resources, such as ship time. This requires coordination among HRM researchers and the HRM, GWA, and Data Management programs.
2) *Oversee a postdoctoral researcher*. To closely examine the connections between herring stocks and the physical and biological conditions requires a more focused effort than can be provided by the program coordinator. The postdoctoral researcher is expected to assist tying together the information from the various projects to develop greater understanding of herring in PWS.
3) *Provide outreach and community involvement for the program*. Strong ties to Alaska Department of Fish and Game and the fishing community are important for guiding program efforts, gaining new insights, and demonstrating the relevance to both the management agency and the fishing community. This requires sharing of findings and listening to community members.

Program coordination is to be the responsibility of Dr. W. Scott Pegau who was the program coordinator for the PWS Herring Survey and HRM programs. He has an established record for working with investigators in the HRM program and with the leads of the GWA and Data Management programs.

The focus of the postdoctoral research will be to examine connections between herring recruitment and condition with the physical and biological environmental conditions. We will be seeking proposals for the postdoctoral position in which the specifics of the approach will be described. The intent is to address the program's second hypothesis: *Herring recruitment is driven by bottom up forcing and the total population level is determined by disease and predation.* The program was designed around this hypothesis with data collection and modeling efforts necessary to provide the basic information to test this hypothesis. The postdoctoral position is envisioned as being the person dedicated to analyzing the various sources of information to test the hypothesis. Testing this hypotheses is expected to inform the population modeling effort in a manner that improves the predictive capacity of the modeling.

Outreach and community involvement will be achieved through improved information in the HRM website and through efforts targeted for information exchange with managers, the fishing community, and spill affected communities. We will shift the focus of the website from general descriptions of projects to ones that include more of the findings. Regular exchanges of information with managers and community members provides stronger support in the community and a means of gaining local and traditional ecological knowledge.

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2. Relevance to the Invitation for Proposals
Discuss how the project addresses the projects of interest listed in the Invitation and the overall Program goals and objectives. Describe the results you expect to achieve during the project, the benefits of success as they relate to the topic under which the proposal was submitted, and the potential recipients of these benefits.

This proposal is the coordination component of the Herring Research and Monitoring program proposal that addresses the section in the FY 17-21 RFP by the same name. It addresses the requirements associated with a program lead, and outreach efforts. Through the efforts of a postdoctoral researcher we will address the area of interest described in the RFP to analyze the relationship between physical and biological oceanographic factors.

The overall goal of the Herring Research and Monitoring program is to: Improve predictive models of herring stocks through observations and research. The program objectives are to:

1) Expand and test the herring stock assessment model used in Prince William Sound.
2) Provide inputs to the stock assessment model.
3) Examine the connection between herring condition or recruitment to physical and biological oceanographic factors.
4) Develop new approaches to monitoring.

This project addresses the program objectives by ensuring communication between the various researchers that are involved in this program. It is through communication that greater understanding of individual results will allow us to achieve the program objectives. The coordination efforts will assist the individual investigators to ensure timely and proper reporting. It also provides a point person for sharing information with EVOSTC, ADF&G, and the fishing community.

Expected results of the coordination effort are expected to benefit the EVOSTC by providing a program lead who will work with the Council to ensure the program complies with the Council's founding documents and relevant policies and procedures, provide an administrative structure to manage projects, a point person for communications between the program and the Council, a person to ensure the effort is responsive to the Council's objectives, provide the most cost-effective and scientifically-supportive stream of funding, integration of data from all projects, ensuring proper and timely submission of reports and proposals, and other duties outlined in the Invitation for Proposals.

The postdoctoral research component is expected to tie the results of projects within the HRM program and with findings from the GWA program to test the relationships between herring and oceanographic factors in a manner that can help identify potential improvements in the population model. The efforts of the postdoctoral researcher are expected to benefit the other researchers in the program through integration of results from both the HRM and GWA programs.

The outreach efforts address the outreach component of the FY 17-21 IP. They are expected to result in a regularly updated HRM website and any information requested by agency outreach efforts. The benefits are to the agencies and local communities in being able to track the efforts of the program.

Appendix C

3. Project Personnel

The CV's of all principal investigators and other senior personnel involved in the proposal must be provided. Each resume is limited to two consecutively numbered pages and must include the following information:

- A list of professional and academic credentials, mailing address, and other contact information (including e-mail address)
- A list of up your most recent publications most closely related to the proposed project and up to five other significant publications. Do not include additional lists of publications, lectures, etc.
- A list of all persons (including their organizational affiliations) in alphabetical order with whom you have collaborated on a project or publication within the last four years. If there have been no collaborators, this should be indicated.

Program Coordinator

W. Scott Pegau

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Box 705
Cordova, AK 99574
ph: 907-424-5800 x222
e-mail: wspegau@pwssc.org

Education:

1990 B.S., Physics, University of Alaska, Fairbanks
1996 Ph.D, Oceanography, Oregon State University

Professional Experience:

1996-1997	Research Associate (Post Doc), Oregon State University
1997-1999	Faculty Research Associate, Oregon State University
1999-2010	Assistant Professor, Oregon State University
2002-2003	Senior Scientist, Kachemak Bay Research Reserve
2003-2007	Research Coordinator, Kachemak Bay Research Reserve
2007-present	Research Program Manager, Oil Spill Recovery Institute

Research Interests:

Determining the relationship between oceanographic conditions and fisheries. Developing novel oil spill detection and tracking approaches. Understanding the fate and behavior of oil spilled in cold water environments. Development of response options for oceans with sea ice present. Understanding circulation patterns in Prince William Sound, Cook Inlet and the Gulf of Alaska and the associated larval transport.

Publications

Wang, D. W., H. W. Wijesekera, E. Jarosz, W. J. Teague, and W. S Pegau. Turbulent diffusivity under high winds from acoustic measurements of bubbles. *Journal of Physical Oceanography.* In press.

Batten, S.D., S. Moffitt, W.S. Pegau, and R. Campbell. Plankton indices explain interannual variability in first year Prince William Sound herring growth. *Fisheries Oceanography*. In press.

Musgrave, D.L., M.J. Halverson, and W.S. Pegau, Seasonal Surface Circulation, Temperature, and Salinity in Prince William Sound, Alaska, *Continental Shelf Research*, doi:10.1016/j.csr.2012.12.001, 2012.

Halverson, M.J., J.C. Ohlmann, M.A. Johnson, W.S. Pegau, Disruption of a cyclonic eddy circulation by wind stress in Prince William Sound, Alaska, *Continental Shelf Research*, **63**, S13-S25, 2013.

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Montes-Hugo, M. A., K. Carder, R. J. Foy, J. Cannizzaro, E. Brown, and S. Pegau, Estimating phytoplankton biomass in coastal waters of Alaska using airborne remote sensing, *Remote Sensing of Environment.* **98**, 481-493, 2005.

Pegau, W.S., Herring Research and Monitoring Team, Pacific herring in Prince William Sound: A synthesis of recent findings, Science synthesis report for the EVOS Herring Research and Monitoring program 14120111, pp. 106, 2014.

Pegau, W. S., Communitity Involvement, Outreach, Logistics, and Synthesis, PWS Herring Survey Program EVOS Restoration Project 10100132 Final Report, pp. 120, 2013.

Collaborators

Mary Abercrombie (USF), Christopher Bassett (WHOI), Mike Banner (UNSW), Job Bello (EIC), P. Bhandari (UM), Mary Anne Bishop (PWSSC), Rob Bochenek (Axiom consulting), Emmanuel Boss (U Maine), Kevin Boswell (FIU), Tim Boyd (SAM), Trevor Branch (UW), John Bradford (BSU), Evelyn Brown (Flying fish), Michele Buckhorn, Lindsay Butters (PWSSC), Rob Cambell (PWSSC), Regina Carns (UW), L Carvalho (UCSB), Grace Chang (UCSB), Yi Chao (JPL), Paula Coble (USF), Robyn Conmy (EPA), Zoe Courville (CRREL), Tim Cowles (OSU), Helen Czerski (U Southhampton), M. Darecki (PAS), Tommy Dickey (UCSB), C. Dong (IGGP), Hajo Eicken (UAF), Bruce Elder (CRREL), Peter Eriksen (Norbit), David Farmer (URI), Jim Farr (NOAA), Scott Freeman (NASA), Jessica Garron (UAF), J. Gemmrich (UVic), P. Gernez (U Nantes), Kristen Gorman (PWSSC), Scott Guyer (BLM), Jeff Guyon (NOAA), Nate Hall-Patch (IOS), Mark Halverson (PWSSC), Hayley Hoover (PWSSC), Ron Heintz (NOAA), Paul Hershberger (USGS), Ben Holt (JPL), S. Jiang (UCSB), Mark Johnson (UAF), C. Jones (UCSB), George Kattawar (TAMU), T. King (BIO), Tom Kline (PWSSC), Cory Koch (Wetlabs), Gary Kofinas (UAF), Kathy Kuletz (USFWS), J. Lacoste (Dalhousie), Andone Lavery (WHOI), D. LeBel (Lamont), Ken Lee (BIO), L. Lenain (SIO), Marlin Lewis (Satlantic), Bonnie Light (UW), Y. Liu (MIT), L. Logan (UMiami), Ted Maksym (WHOI), Darek Manov (UCSB), Hans-Peter Marshall (BSU), W. Melville (SIO), Scott Miles (LSU), Steve Moffitt (ADF&G), Mark Moline (Cal Poly), Rue Morison (UNSW), Dave Musgrave, F. Nencioli (MIO), Marc Oggier (UAF), Carter Ohlmann (UCSB), Don Perovich (CRREL), Sean Powers (USA), Pawel Pacwiardowski (Norbit), Pete Rand (PWSSC), B. Reineman (SIO), Ian Robbins (Cal Poly), B. Robinson (BIO), Chris Roman (WHOI), R. Rottgers (HZG), Scott Ryan (BIO), H. Schultz (UMass), Fletcher Sewell (NOAA), Li Shen (Johns Hopkins), M. Shinki (CRI), Matt Slivkoff(ISMO), M. Sokolski (PAS), Frank Spada (Sea Engineering), Nate Statom (SIO), Darius Stramski (SIO), Peter Sutherland (SIO), Hanumat Singh (WHOI), Dajun Tang (UW), Richard Thorne (PWSSC), Mike Twardowski (Wetlabs), S. Vagle (IOS), Ronnie Van Dommelen (Satlantic), Johanna Vollenweider (NOAA), Ken Voss (UMiami), Ian Walsh (Wetlabs), Libe Washburn (UCSB), J. Wei (Dal), Chris Wiggins (IGM), Hemantha Wijesekera (NRL), Sharon Wilde (NOAA), Amanda Whitmire (OSU), Jeremy Wilkinson (POS), Michelle Wood (UO), O. Wurl (Old Domin), D. Yang (John Hopkins), Dick Yue (MIT), Len Zabilansky (CRREL), Ron Zaneveld (Wetlabs), Chris Zappa (Lamont), Brian Zelenke (Cal Poly)

4. Project Design

A. Objectives

Appendix C

List the objectives of the proposed research and briefly state why the intended research is important. If your proposed project builds on recent work, provide detail on why the data set needs to be continued and whether any changes are proposed. If the proposed project is for new work, explain why the new data is needed. Describe the anticipated final product.

B. Procedural and Scientific Methods
For each objective listed in A. above, identify the specific methods that will be used to meet the objective. In describing the methodologies for collection and analysis, identify measurements to be made and the anticipated precision and accuracy of each measurement and describe the sampling equipment in a manner that permits an assessment of the anticipated raw-data quality.

If applicable, discuss alternative methodologies considered, and explain why the proposed methods were chosen. In addition, projects that will involve the lethal collection of birds or mammals must comply with the EVOSTC's policy on collections, available on our website www.evostc.state.ak.us

C. Data Analysis and Statistical Methods
Describe the process for analyzing data. Discuss the means by which the measurements to be taken could be compared with historical observations or with regions that are thought to have similar ecosystems. Describe the statistical power of the proposed sampling program for detecting a significant change in numbers. To the extent that the variation to be expected in the response variable(s) is known or can be approximated, proposals should demonstrate that the sample sizes and sampling times (for dynamic processes) are of sufficient power or robustness to adequately test the hypotheses. For environmental measurements, what is the measurement error associated with the devices and approaches to be used?

D. Description of Study Area
Where will the project be undertaken? Describe the study area, including, if applicable, decimally-coded latitude and longitude readings of sampling locations or the bounding coordinates of the sampling region (e.g., 60.8233, -147.1029, 60.4739, -147.7309 for the north, east, south and west bounding coordinates).

A. Objectives

Herring Research and Monitoring Program goal and objectives

The overall goal of the Herring Research and Monitoring program is to: **Improve predictive models of herring stocks through observations and research.** This is consistent with the overall program goal described in the request for proposals (RFP) and the direction provide by the EVOS Trustee Council when they chose the enhanced monitoring option of the Integrated Herring Restoration Program. By working to improve the predictive models of herring stocks we anticipate using the data to provide a tool that may be used by fisheries managers to make more informed decisions.

To achieve the overall goal over the next five years, the program has the following objectives.

Objectives

1) *Expand and test the herring stock assessment model used in Prince William Sound.* This builds upon the work of the previous five years, during which the age-structure-analysis (ASA) model used by Alaska Department of Fish and Game was built into a Bayesian framework. The model is now ready to be expanded to include earlier life stages, environmental conditions, and new metrics for disease. It is also possible to test the importance of model inputs and assumed relationships, such as the age-of-maturity function.

2) *Provide inputs to the stock assessment model.* Operation and testing of the model depends on input data. To expand the model to include environmental conditions requires that the model continue to be provided input data on the age structure, biomass indices, and environmental conditions to determine if the model output is consistent with observations.

3) *Examine the connection between herring condition or recruitment to physical and biological oceanographic factors.* Understanding how herring respond to environmental conditions requires understanding the distribution and movement of herring between oceanographic realms, such as from PWS to the Gulf of Alaska. Research has shown that recruitment patterns extend over broad spatial domains, thus requiring not only examining local phenomena, but also regional and even global relationships.

4) *Develop new approaches to monitoring*. Changes in technology and testing of existing approaches lead to important advances in our sampling techniques and design that can either provide simpler data collection, improved measurement accuracy necessary as a basis for future research, or provide more relevant measures of important factors, such as disease.

Our goal and first objective directly addresses the overall program goal provided in the RFP and area of interest 3. The second objective is necessary to run the model in the first objective and addresses topics 4, 6, and 9 of the RFP. The third objective addresses topics 2, 5, 6, 7, 9. It also connected to topics 1, 8, 10, and 11. The fourth objective lays to foundation of future research and monitoring. Achieving these objectives requires collaboration with the Gulf Watch Alaska team that are collecting much of the environmental data.

HRM Coordination project objectives

The coordination project is designed to help the researcher team achieve the program objectives. The objectives of the coordination project are as follows:

1) *Coordinate efforts among the HRM projects to achieve the program objectives, maximize shared resources, ensure timely reporting, and coordinate logistics*. Integration of the projects throughout the program is necessary to improve our scientific understanding of factors affecting herring and to maximize use of resources, such as ship time. To achieve objective 3 of the HRM program also requires coordination between the HRM and GWA programs.
2) *Oversee a postdoctoral researcher*. Being able to closely examine the connections between herring stocks and the physical and biological conditions requires more focused effort than can be provided by the program coordinator. This person will be responsible for testing the program's second hypothesis: *Herring recruitment is driven by bottom up forcing and the total population level is determined by disease and predation.* The postdoctoral researcher is expected to assist tying together the information from the various projects to develop greater understanding of herring in PWS.
3) *Provide outreach and community involvement for the program*. Strong ties to Alaska Department of Fish and Game and the fishing community are important for guiding program efforts, gaining new insights, and demonstrating the relevance to both the management agency and the fishing community.

This work continues the coordination efforts that have been in place during the PWS Herring Survey and HRM programs. The coordination provides a point contact with the program and is responsible for ensuring timely reporting. The objectives of the project help integrate findings within the HRM program and with findings from the environmental drivers and pelagic components of the GWA program. The postdoctoral researcher is a new component and is designed to tie results from HRM and GWA together. The final product will be a peer-reviewed manuscript.

B. Procedural and Scientific Methods

The wide array of projects that make up PWS Herring Research and Monitoring program required careful integration to ensure the maximum collaboration between projects. Not all observation projects are directly connected to each other, but are connected through the objectives of the program.

To address objective one of the coordination project, Dr. Pegau will act as the program team leader and be responsible for ensuring a coordinated and focused research program that leverages other assets whenever possible. He will be responsible for ensuring proper scientific oversight of individual projects and reporting to the EVOSTC. He will lead the development of annual work plans and the synthesis of findings from these programs. He will be responsible for coordinating the efforts of the Herring Research Monitoring program with those of the Gulf Watch Alaska and Data Management programs. He was the program coordinator for the PWS Herring Survey and HRM programs. He has a record of working with the investigators in the HRM program and with the leads of the GWA and Data Management programs.

Program coordination will primarily be through e-mail and phone communications. A meeting of participants is expected to occur each year. It will be consecutive to the GWA PI meeting in communities within the spill affected area. We anticipate scheduling the meetings so investigators from both programs have the opportunity to learn of recent results and collaborate. These in-person meetings are vital to ensure proper communications within and among the two programs. They also provide an opportunity for the scientific oversight group to ask questions of the investigators. Meetings in spill affected communities are meant to provide an opportunity for outreach and to get local ecological knowledge from community members.

Coordination between projects is also taking place through scheduling of vessels. All the investigators are required to work together to determine vessel type and number of days needed and find ways to share resources whenever possible. While vessel and aircraft budgets are contained within each of the proposals, during the proposal writing phase we identified where there is overlap and minimized the logistics at that time. The remaining efforts are necessary to achieve the objectives of the individual projects. Coordination was also achieved through the scheduling of projects to ensure results would be available for projects dependent on samples or data from another project. For example, the postdoctoral researcher would start when results from the tagging project became available to help understand the appropriate local oceanographic areas being occupied by adult herring. The modeling effort to examine environmental factors was pushed back to allow overlap with the postdoctoral researcher.

We will maintain a scientific oversight group to follow the progress of the research and provide input on scientific quality and potential future direction. The current oversight group consists of Sherri Dressel with ADF&G, Jeep Rice, and Steve Martell.

Objective two involves recruiting a postdoctoral researcher to focus on examining the relationship between herring condition and recruitment and physical and biological oceanographic factors. This focal area was chosen because it has the greatest overlap with the other projects within the program and connects to the long-term monitoring work that has been conducted. This position is the one that will be responsible for testing the HRM Program hypothesis 2. We expect that the person will be able to use information from the inputs to the ASA model as well as results from the stock assessment modeling effort. The tracking project will guide selection of environmental data for local herring stocks. The researcher will be responsible for gathering information regarding local and regional oceanographic and herring conditions for use in their analysis. This will require them to work with investigators in the HRM and GWA programs.

Potential Postdoctoral researchers will be required to submit a proposal describing how they will address testing the hypothesis, *Herring recruitment is driven by bottom up forcing and the total population level is determined by disease and predation.* The proposals will be reviewed and used to select a candidate to offer the position to. The proposal of the selected candidate will be included in the annual package of EVOS proposals from the HRM program to allow review and comment from the EVOSTC as well. We chose to use this method for recruiting a postdoctoral researcher because it allows the applicant to design their own research project, rather than being hired to do previously defined work. It allows the researcher to bring approaches that we might not consider if the project was fully defined from the outset. It provides a writing sample that can be used to identify needs in an Individual Development Plan. The Individual Development Plan is part of the Mentoring Plan that follows.

A program of mentoring activities will be used to enhance the postdoctoral researcher's development while participating in this project. The goal of the mentoring program will be to provide the experience, knowledge, and skills to advance the researcher's scientific capabilities. By working in the coordination project the researcher will also be provided the experience of working with several different researchers to achieve a goal, thus sharpening their collaboration skills. The mentoring plan follows the guidance of the National Academies of Science and Engineering for postdoctoral researcher development. The mentoring will focus on career skills such as writing proposals and reports, writing manuscripts, communicating results, and collaboration with a group of researchers. Specific elements of the mentoring plan include:

- Work with the postdoctoral researcher to develop and implement an Individual Development Plan that establishes short- and long-term goals. Progress will be assessed in informal meetings to occur on at least a monthly basis and a regular annual evaluation meeting.
- Provide an orientation to the research group and their projects.
- Assist the postdoctoral researcher to expand their professional networks by introducing them to other researchers and having them spend time with the other researchers in the HRM program.
- Develop proposal and report writing skills through including them in the annual proposal and semi-annual report writing process. We will look for opportunities to have the researcher review proposals or participate on proposal review panels.
- The researcher will be encouraged to write proposals to develop their own research program.
- Develop communication skills through presentations at community lecture series, outreach events, Principal Investigator meetings, and when possible scientific symposia. Coaching will be provided to help the person refine the approach necessary for the various audiences.
- Develop coordination and collaborations skills through interactions with the HRM and GWA groups.
- Mentoring will occur on the entire publication process from organizing and writing the manuscript to deciding where to submit and responding to peer reviews.

Success of the mentoring plan will be assessed by tracking the progress of the researcher through their Individual Development Plan, interactions with other researchers, and writing of proposals and manuscripts. Discussions and annual evaluations will be used to judge the researcher's satisfaction with the mentoring program.

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The third project objective is for outreach and community involvement. The outreach effort is focused on updating and enhancing the HRM website (http://pwssc.org/research/fish/pacific-herring/). Our past efforts were in developing basic descriptions of each of the projects and a transition to a new website when the PWSSC changed its web format. What needs to be done is to rework sections from the PWS Herring Survey and HRM programs to show what was learned by each of the projects and develop a system for providing regular updates on the findings of the projects.

Community involvement includes planned meetings with Cordova District Fishermen United and other stakeholder organizations to share what we are learning and gain their perspectives into changes in herring behavior or population. We will work with GWA to have a PI meeting in different spill affected communities each year. The PI meetings will be open to the community and we will include time on the agenda to seek input from community members. There are two TEK listening sessions to be held in native communities (e.g. Tatitlek and Nanwalek) to gain their perspectives on the herring populations. The greatest exchange of information is expected to remain the informal channels that have developed over the years. Fishermen have become familiar with the program and will stop researchers as we go past the harbor to let us know what they are finding and learn what we have seen. A person in Tatitlek regularly asks about our herring observations and trades observations. Our intent is to continue to cultivate these informal connections to the various communities.

C. Data Analysis and Statistical Methods

This project does not generate data. The synthesis of results is dependent on the expertise of the project investigators for data analysis and statistical methods. Proposals for the postdoctoral researcher position will be required to address the data analysis and statistical methods.

D. Description of Study Area

The focus of the study area includes all of Prince William Sound (N, E, S, and W boundaries of respectively, ~ 61, -145.5. 60, and -149°, Figure 1). We expect that aspects of the program will require working with regional (Cook Inlet to Sitka) information, and global datasets.

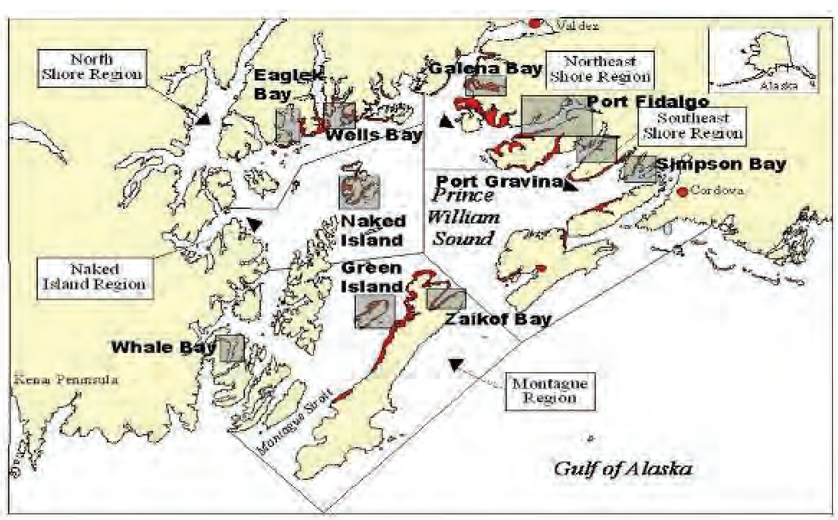

Figure 1. HRM area of focus.

Appendix C

5. Coordination and Collaboration

Within the Program

Provide a list and clearly describe the functional and operational relationships with the other program projects. This includes any coordination that has taken or will take place and what form the coordination will take (shared field sites or researchers, research platforms, sample collection, data management, equipment purchases, etc.).

With Other EVOSTC-funded Programs and Projects

Indicate how your proposed program relates to, complements or includes collaborative efforts with other proposed or existing programs or projects funded by the EVOSTC.

With Trustee or Management Agencies

Please discuss if there are any areas which may support EVOSTC trust or other agency work or which have received EVOSTC trust or other agency feedback or direction, including the contact name of the agency staff. Please include specific information as to how the subject area may assist EVOSTC trust or other agency work.

If the proposed project requires or includes collaboration with other agencies, organizations or scientists to accomplish the work, such arrangements should be fully explained and the names of agency or organization representatives involved in the project should be provided. If your proposal is in conflict with another project or program, note this and explain why.

With Native and Local Communities

Provide a detailed plan for any local and native community involvement in the project.

Within the Program

This project provides the overall coordination between all projects within the program, therefore is directly linked to each project. This is a continuation of the effort that began with the first HRM program. The coordination effort continued through the development of the HRM proposal in response to the FY17-21 RFP. These researchers have worked together on the previous HRM program and have a good working relationship.

Dr. Pegau will act as the program team leader and be responsible for ensuring a coordinated and focused research program that leverages other assets whenever possible. Within program coordination will primarily be through e-mail and phone communications. In-person meetings of participants are expected to occur each year for exchange of information and to encourage collaboration between projects.

Coordination between projects is also taking place through scheduling of vessels. All the investigators are required to work together to determine vessel type and number of days needed. Coordination was also achieved through the scheduling of projects to ensure results would be available for projects dependent on samples or data from another project.

We expect that the postdoctoral researcher will facilitate further collaboration as that person will need information from each of the projects to address the relationships between herring and the environmental conditions.

With Other EVOSTC-funded Programs and Projects

This project provides the primary link between the HRM, GWA, and Data Management programs. Dr. Pegau worked with the GWA team and AOOS/Axiom during proposal development to examine areas of overlap between programs and to ensure data management needs can be met.

We propose to continue our collaborations with these programs. Mandy Lindeberg the GWA science lead and Carol Janzen from the Data management team are included on the HRM email list so they are aware of what is going on with the HRM program. Administratively, the annual work plans and reports will continue to be developed together. We plan to have joint PI meetings to encourage individuals to work with people in the other programs. We will work together to design topics for analysis and development of joint scientific manuscripts. We will work with the Data Management project to ensure timely submission of data and metadata.

We are proposing to have a postdoctoral researcher that bridges between the HRM and GWA programs in that they would be looking at the impacts of biological and physical oceanographic conditions on herring populations in PWS. We expect them to work closely with the environmental drivers and pelagic components of the GWA program to collect the data necessary for their analysis.

With Trustee or Management Agencies

Alaska Department of Fish and Game is the primary trustee and management agency that the HRM program aims to serve. The success of the program is highly dependent on the information collected by ADF&G so it is imperative that we work with the agency. We will continue to have an ADF&G person on our scientific oversight group. We are also incorporating ADF&G into the sample collection of the research program to ensure the data needed to understand recovery of herring is collected.

With Native and Local Communities

The HRM program has an established working relationship with the Cordova District Fishermen United (CDFU) that provides a means of communication with fishermen in Cordova. This relationship has created better ties between the scientists and fishing community. The HRM program provides annual updates to the herring section of CDFU. That meeting provides the primary means for focused feedback on the research program from the community and for the program to gain local ecological knowledge. Over the years the individual fishermen and scientists have regular communication in casual situations. These have been important in gaining local knowledge.

Ties to the native communities are limited; however, we have established a link with the village of Tatitlek. They have an interest in learning about fresh spawn near the village for the collection of roe or fish. Providing observations from the HRM program starts a conversation in which local observation are provided. We envision working with GWA to increase our effort to interact with native communities through community involvement activities.

6. Schedule

Program Milestones

Specify when critical program tasks will be completed. Reviewers will use this information in conjunction with annual program reports to assess whether the program is meeting its objectives and is suitable for continued funding.

Measurable Program Tasks

Specify, by each quarter of each fiscal year (February 1 – January 31), when critical program tasks will be completed.

FY17 1st Quarter (Feb1- Apr 30)
- Request proposals for postdoctoral researcher

FY17 2nd Quarter (May1- Jul 31)
- Select postdoctoral research project to include in annual EVOS proposal submission

FY17 3rd Quarter (Aug 1 – Oct 31)
- Semi-annual report to NOAA
- FY 18 proposal submitted to EVOS

Appendix C

FY17 4th Quarter (Nov 1 – Jan 31)
  Complete annual website updates
  Annual PI meeting
FY18 1st Quarter (Feb1- Apr 30)
  Semi-annual reports to EVOS and NOAA
FY18 2nd Quarter (May1- Jul 31)
  Ensure data submitted from previous year
FY18 3rd Quarter (Aug 1 – Oct 31)
  Semi-annual report to NOAA
  FY 19 proposal submitted to EVOS
FY18 4th Quarter (Nov 1 – Jan 31)
  Complete annual website updates
  Annual PI meeting
FY19 1st Quarter (Feb1- Apr 30)
  Semi-annual reports to EVOS and NOAA
FY19 2nd Quarter (May1- Jul 31)
  Ensure data submitted from previous year
FY19 3rd Quarter (Aug 1 – Oct 31)
  Semi-annual report submitted to NOAA
  Provide the report required for the Joint Science Workshop
  FY 20 proposal submitted to EVOS
FY19 4th Quarter (Nov 1 – Jan 31)
  Complete annual website updates
  Attend EVOS Joint Science Workshop
  Annual PI meeting
FY20 1st Quarter (Feb1- Apr 30)
  Semi-annual reports to EVOS and NOAA
FY20 2nd Quarter (May1- Jul 31)
  Ensure data submitted from previous year
FY20 3rd Quarter (Aug 1 – Oct 31)
  Semi-annual report submitted to NOAA
  FY 21 proposal submitted to EVOS
FY20 4th Quarter (Nov 1 – Jan 31)
  Complete annual website updates
  Annual PI meeting
FY21 1st Quarter (Feb1- Apr 30)
  Semi-annual reports to EVOS and NOAA
FY21 2nd Quarter (May1- Jul 31)
  Ensure data submitted from previous year
FY21 3rd Quarter (Aug 1 – Oct 31)
  Semi-annual report submitted to NOAA
FY21 4th Quarter (Nov 1 – Jan 31)
  Complete annual website updates
  Annual PI meeting
FY22 1st Quarter (Feb1- Apr 30)
  Ensure final reports submitted and sent for review

7. Budget
Budget Forms (Attached)

Appendix C

Please provide completed budget forms. Please note that the following items will not be considered for funding:

- Costs associated with international travel for meetings, symposia, or presentations.
- Costs associated with attendance at meetings, symposia, or presentations outside of those required to coordinate with project members.
- Costs associated with outreach or education efforts.

Sources of Additional Funding

Identify non-EVOSTC funds or in-kind contributions used as cost-share for the work in this proposal. List the amount of funds, the source of funds, and the purpose for which the funds will be used. Do not include funds that are not directly and specifically related to the work being proposed in this proposal.

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	AC CUMU
Personnel	$57.0	$153.3	$164.4	$161.9	$51.7	$588.3	
Travel	$6.4	$9.9	$6.4	$6.4	$6.4	$35.5	
Contractual	$24.7	$26.0	$26.2	$11.0	$4.4	$92.3	
Commodities	$3.8	$1.5	$3.5	$1.4	$1.5	$11.7	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)	$35.1	$57.20	$60.15	$54.2	$19.2	$225.8	
SUBTOTAL	$127.0	$247.8	$260.7	$234.9	$83.2	$953.6	
General Administration (9% of	$11.4	$22.3	$23.5	$21.1	$7.5	$85.8	N
PROJECT TOTAL	$138.4	$270.2	$284.1	$256.1	$90.7	$1,039.4	
Other Resources (Cost Share Funds)	$26.0	$26.6	$27.2	$28.0	$28.3	$136.1	

Budget Justification

Personnel Costs: Dr. Pegau is requesting one and a half to two months of salary support each year for coordination efforts. Another half month in FY 17 and one month in FY 18, 19, and 20 are requested for recruiting and supervising the postdoctoral researcher. Three months of salary support are requested each year for an assistant for Dr. Pegau. That person will be responsible for updating the website, assist with community involvement events, and compiling the reports. For support of the postdoctoral researcher we are requesting $8K, $98.4K, $100.8K, and $104.4K in FY 17, 18, 19, and 20 respectively. Costs the first year are for recruiting and some starting salary.

Travel Costs: Travel support is requested for one person to attend a PI meeting associated with AMSS and two people to attend a joint PI meeting with GWA each year. Funds are also requested to support travel of the HRM scientific oversight group. In FY 18 funds are requested for the postdoctoral fellow to spend three months working with Drs. Hershberger and Branch in Seattle. Housing will most likely be through USGS bunkhouses.

Contractual Costs: Information technology costs are the network costs and are calculated at $100 per man month. Phone and fax costs include $40 per month for telephone and costs associated with teleconferencing. Printing etc. costs cover other means of communication.
The subcontract for Branch is included in this proposal to provide the PWSSC financial oversight of the project.

Commodities Costs: In year one we are requesting funding for a computer for the postdoctoral researcher. We are requesting funding for miscellaneous office supplies that are needed to support the efforts.

Equipment Costs: No equipment purchases are anticipated.

Appendix C

Other Resources: Up to an additional two months of salary support for Dr. Pegau is available from the Oil Spill Recovery Institute to support coordination and other activities that improve our understanding of recovery from the *Exxon Valdez* Oil Spill.

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$57.0	$153.3	$164.4	$161.9	$51.7	$588.3	
Travel	$6.4	$9.9	$6.4	$6.4	$6.4	$35.5	
Contractual	$24.7	$26.0	$26.2	$11.0	$4.4	$92.3	
Commodities	$3.8	$1.5	$3.5	$1.4	$1.5	$11.7	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)	$35.1	$57.20	$60.15	$54.2	$19.2	$225.8	
SUBTOTAL	$127.0	$247.8	$260.7	$234.9	$83.2	$953.6	
General Administration (9% of	$11.4	$22.3	$23.5	$21.1	$7.5	$85.8	N/A
PROJECT TOTAL	$138.4	$270.2	$284.1	$256.1	$90.7	$1,039.4	
Other Resources (Cost Share Funds)	$26.0	$26.6	$27.2	$28.0	$28.3	$136.1	

COMMENTS:
This summary page provides an five-year overview of proposed project funding and actual cumulative spending. The column titled 'Actual Cumulative' must be updated each fiscal year as part of the annual reporting requirements. Provide information on the total amount actually spent for all completed years of the project. On the Project Annual Report Form, if any line item exceeds a 10% deviation from the originally-proposed amount; provide detail regarding the reason for the deviation.

FY17-21

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

NON-TRUSTEE AGENCY SUMMARY PAGE

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Pegau	Project Coordinator	2.0	13.0		26.0
TBD	Assistant	3.0	7.0		21.0
TBD	Post-doc	1.3	8.0		10.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	28.0	0.0	
				Personnel Total	$57.0

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
					0.0
PI meeting with GWA	0.8	2	5	0.3	3.1
Oversight committee to PI meeting	0.8	3	3	0.3	3.3
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$6.4

FY17

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
Information Technology ($100/salary month)	0.8
Printing/mailing/copying	0.5
Communication (phone,fax) ($40/salary month for connection + long distance)	0.4
Stipends for oversight group ($500/person/day for three days for the two non-state employees)	3.0
Boat or aircraft support (8 days @ $2500/day)	20.0
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$24.7

Commodities Costs: Description	Commodities Sum
Misc office supplies	1.8
computer for postdoctoral researcher	2.0
Commodities Total	$3.8

FY17

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY17

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Pegau	Project Coordinator	2.5	13.3		33.3
TBD	Assistant	3.0	7.2		21.6
TBD	Post-doc	12.0	8.2		98.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	28.7	0.0	
				Personnel Total	$153.3

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
					0.0
PI meeting with GWA	0.8	2	5	0.3	3.1
Oversight committee to PI meeting	0.8	3	3	0.3	3.3
Post-doctoral researcher to Seattle area	0.8	1	90	0.0	3.5
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$9.9

FY18

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
Information Technology ($100/salary month)	1.8
Printing/mailing/copying	0.5
Communication (phone,fax) ($40/salary month for connection + long distance)	0.7
Stipends for oversight group ($500/person/day for three days for the two non-state employees)	3.0
Boat or aircraft support (8 days @ $2500/day)	20.0
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$26.0

Commodities Costs: Description	Commodities Sum
Misc office supplies	1.5
Commodities Total	$1.5

FY18

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY18

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Pegau	Project Coordinator	2.5	13.6		34.0
TBD	Assistant	4.0	7.4		29.6
TBD	Post-doc	12.0	8.4		100.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	29.4	0.0	
				Personnel Total	$164.4

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
					0.0
Science panel meeting	0.8	2	5	0.3	3.1
Oversight committee to PI meeting	0.8	3	3	0.3	3.3
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$6.4

FY19

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
Information Technology ($100/salary month)	1.9
Printing/mailing/copying	0.5
Communication (phone,fax) ($40/salary month for connection + long distance)	0.8
Stipends for oversight group ($500/person/day for three days for the two non-state employees)	3.0
Boat or aircraft support (8 days @ $2500/day)	20.0
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$26.2

Commodities Costs: Description	Commodities Sum
Misc office supplies	1.5
Computer for coordinator	2.0
Commodities Total	$3.5

FY19

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY19

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Pegau	Project Coordinator	2.5	14.0		35.0
TBD	Assistant	3.0	7.5		22.5
TBD	Post-doc	12.0	8.7		104.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	30.2	0.0	
				Personnel Total	$161.9

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
					0.0
PI meeting with GWA	0.8	2	5	0.3	3.1
Oversight committee to PI meeting	0.8	3	3	0.3	3.3
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$6.4

FY20

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
Information Technology ($100/salary month)	1.8
Printing/mailing/copying	0.5
Communication (phone,fax) ($40/salary month for connection + long distance)	0.7
Stipends for oversight group ($500/person/day for three days for the two non-state employees)	3.0
Boat or aircraft support (2 days @ $2500/day)	5.0
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$11.0

Commodities Costs: Description	Commodities Sum
Misc office supplies	1.4
Commodities Total	$1.4

FY20

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY20

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Pegau	Project Coordinator	2.0	14.3		28.6
TBD	Assistant	3.0	7.7		23.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	22.0	0.0	
				Personnel Total	$51.7

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
					0.0
PI meeting with GWA	0.8	2	5	0.3	3.1
Oversight committee to PI meeting	0.8	3	3	0.3	3.3
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$6.4

FY21

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
Information Technology ($100/salary month)	0.6
Printing/mailing/copying	0.5
Communication (phone,fax) ($40/salary month for connection + long distance)	0.3
Stipends for oversight group ($500/person/day for three days for the two non-state employees)	3.0
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$4.4

Commodities Costs: Description	Commodities Sum
Misc office supplies	1.5
Commodities Total	$1.5

FY21

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY21

Project Title: HRM Coordination
Primary Investigator: W. Scott Pegau

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

Response to Reviewers: 17120111-B Annual Herring Migration Cycle, P.I. Bishop

Reviewer Comment 1) The Panel was pleased by the work and rapid reporting of results in the literature. While the Panel endorsed the elements and detail of the proposal, we wondered if the work was limited by funding, or whether there were some incremental tasks that might be considered. Specifically, we wondered if additional tag releases, from different areas and different times, might be considered. While speculative, we wondered if additional tagging might address some key hypotheses that cannot be considered within the present level of funding. For example, does the propensity to migrate out of PWS, or stay within PWS, vary with tagging (spawning) location, or perhaps fish size? Would there be merit in tagging at different times of year – and not only in the spawning season? The main comment was to suggest to the PI that additional increments to this work might be considered if such increments were cost-effective and addressed important hypotheses. Additionally, the Panel was very appreciative of the power analyses presented in the proposal, but cautions that sample sizes estimated for simulated herring in Table 1 may underestimate samples actually required for wild herring.

Response: We have increased our budget to provide for additional tagging and monitoring. The EVOS Herring and Research Monitoring (HRM) Alaska Department of Fish & Game aerial spawn surveys will allow for us to receive timely information to undertake tagging operations at both Port Gravina and Montague Island during spawn events. For the upcoming 2017 field season, because of the lead time needed to order tags and equipment, we will only be able to tag at Port Gravina. However, for the FY18 and FY19 field seasons, we will tag at both Port Gravina and Montague Island. In addition, we have increased the total acoustic tags to 210 tags (105 per site) for those two years. We have modified the proposal to reflect these changes, including additional details on our analyses for multiple sites.

With these changes, we have added an additional corollary hypotheses (d) to the proposal:

$\mathbf{H_{2:}}$ The Prince William Sound herring population is composed of migrant and resident individuals.

> d) Herring tagged in Port Gravina will be less likely to migrate into the Gulf of Alaska than herring tagged from Montague Island spawning areas.

The second hypotheses suggested by the reviewers : does propensity to migrate or remain in PWS vary with fish size, is already incorporated in our corollary hypotheses (a & b) shown below:

H_1: Pacific herring populations in PWS make seasonal, post-spawn feeding migrations through major entrances and passages to the Gulf of Alaska.

a) Fish with poor body condition are less likely to migrate.
b) New recruits to the spawning population are less likely to migrate than older herring.

Reviewer Comment 2): The Panel understands that annual migrations within PWS, while potentially interesting, are beyond the scope of the project as envisioned. However, we wonder if there may be supplementary data (e.g., herring bycatch in other fisheries) that may be useful to help cobble together a more complete picture of herring migration within and outside PWS.

Response: The PI has recently been reviewing potential sources of supplemental information for a manuscript she is preparing. Within PWS, the EVOS Herring Research & Monitoring Program has conducted June/early July aerial forage fish surveys since 2009 and has noted location and size (small, med or large) of age 2+ herring schools. Over the next 5 years, the EVOS HRM program will be conducting June herring surveys in PWS that will be an important source of information. NOAA acoustic trawl surveys for walleye pollock caught very little herring during winter 2011, and their most recent 2015 winter survey skipped the inside waters of PWS. In addition, there is some limited historical data available from ADFG for June. Between 1976-2008 ADFG recorded a small number (n = 9) of herring catches during June juvenile salmon seines that provide some location and age data. Otherwise, to date we have not found herring bycatch data that are part of any current PWS fishery.

Information on herring found in nearby areas outside of PWS is more problematic. The NOAA acoustic trawl surveys for walleye pollock surveyed Port Bainbridge and bays west along the Kenai Peninsula in February-March 2015 and caught only 121 herring during 8 midwater trawls. The NOAA Groundfish Assessment Program for the GOA is conducted during summer months and does provide some information that we are putting into a GIS database for mapping. We will continue to investigate possible fisheries that may be able to provide more information.

Reviewers comment 3) A different comment on tagging reflects comments made during our call with Scott Pegau who indicated that recent genetics work showed significant differences between PWS herring and those of Kodiak. Less clear was whether there were any genetic differences found within PWS. Based on previously published work, the Panel thought that the likelihood of genetic differences among herring within PWS to be very small – but, on the other hand, if such differences were found then it would be sensible to ensure that tagging was conducted on each of any potential different stocks or sub-stocks. Perhaps a review of fish genetic research done by the Seebs when they worked for ADFG could reveal comparisons among PWS populations that could inform this issue.

Response: The research done by the Seebs and published by O'Connell et al (1998) examined five microsatellite loci in herring sampled during 1995 and did find differences between Port Chalmers (western Montague Island) and Rocky Bay (north end of Montague Island) as well as St. Matthews and Fish Bay (northeast PWS). More recently as part of the EVOS HRM project, P.I. Wilde examined 15 genetic markers and found evidence of differences between fish spawning at Rocky Bay (north end of Montague) compared with fish from northeast PWS and fish at Stockdale Harbor (nw Montague Island; S. Wilde, pers. comm). Both these results suggest there may be substocks within PWS, and that at least two substocks spawn regularly at Montague Island. Based on these results, we will make every attempt to tag fish at Montague Island during this study, and when possible, at a different site each year to determine if there are differences in migration patterns.

Project Title

PWS Herring Research & Monitoring: Annual Herring Migration Cycle

Primary Investigator(s) and Affiliation(s)

Mary Anne Bishop, Ph.D., Prince William Sound Science Center, Cordova

Date Proposal Submitted

August 12, 2016

Project Abstract

This project is a component of the Herring Research and Monitoring (HRM) program. The goal of the HRM program is to: Improve predictive models of herring stocks through observations and research. Within Prince William Sound (PWS), adult Pacific herring (*Clupea pallasii*) movements between spawning, summer feeding, and overwintering areas are not well understood. Addressing this knowledge gap will improve our ability to assess biomass trends and recovery of this ecologically important species. In 2013 we documented post-spawn migration of herring from Port Gravina to the PWS entrances by acoustic tagging adult herring and collecting data from the Ocean Tracking Network acoustic arrays, which are located in the major entrances and passages connecting PWS with the Gulf of Alaska (GoA). However, the 2013 study could not establish if herring were seasonally leaving PWS and migrating into the GoA. With funding from EVOS in FY16, we will improve our ability to detect movements between PWS and the GoA by deploying additional acoustic receivers at the Ocean Tracking Network arrays. The primary goal of this 2017-2021 project is to clarify the annual migration cycle of PWS adult herring by leveraging this expanded acoustic infrastructure. The specific objectives of this project are to 1) document location, timing, and direction of Pacific herring seasonal migrations between PWS and the GoA; 2) relate large-scale movements to year class and body condition of tagged individuals; and 3) determine seasonal residency time within PWS, at the entrances to PWS, and in the Gulf of Alaska. For this project, we will tag 125 herring in FY17 at Port Gravina in northeast PWS. For FY18 and FY19, we will expand our efforts to two tagging sites, Port Gravina and Montague Island, tagging a total of 210 herring each year.

EVOSTC Funding Requested *(must include 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
381.9	379.5	268.3	201.4		1,231.0

Non-EVOSTC Funding Available

FY17	FY18	FY19	FY20	FY21	TOTAL
415.0 in-kind	415.0 in-kind	415.0 in-kind	415.0 in-kind		415.0 in-kind

1. Executive Summary

Herring Research & Monitoring Program Overview

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 17-21 invitation for proposals. In particular our program 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, and the Herring Research and Monitoring Program in the FY17-21 Invitation for Proposals (IP).

The overall goal of the Herring Research and Monitoring program is to: **Improve predictive models of herring stocks through observations and research**. The program objectives are to:

1) Expand and test the herring stock assessment model used in Prince William Sound.

2) Provide inputs to the stock assessment model.

3) Examine the connection between herring condition or recruitment to physical and biological oceanographic factors.

4) Develop new approaches to monitoring.

Our goal aligns with the Overall Program Goal listed in the FY17-21 IP. Projects within the program address the areas of interest identified in the FY17-21 IP to include a post-doc fellowship (area of interest 2), retrospective analysis of herring populations (3), comprehensive spawn assessments (4), study of movement of herring (5), study of the role of disease in herring recovery (6), analysis of the relationship between oceanographic factors and herring (7), and estimate and corroborate herring age at maturity (9). It includes a coordination component that addresses the components that addresses the need for a program lead.

The program is made up by the following projects:

Modeling and Stock Assessment of Prince William Sound Herring
Surveys and Age, Sex, and Size Collection and Processing
Adult Pacific Herring Acoustic Surveys
Juvenile Pacific Herring Aerial Surveys
Herring Disease Program
Studies of Reproductive Maturity among Age Cohorts of Pacific Herring
Annual Herring Migration Cycle
HRM Coordination

Our first objective, *Expand and test the herring stock assessment model used in Prince William Sound*, is to be addressed by the *Modeling and Stock Assessment of Prince William Sound Herring* project. The model will be run with inputs collected by other projects in the program. The model will be adapted to fit new data sources such as the age-1 aerial surveys, the presence of antibodies for viral hemorrhagic septicemia virus, and oceanographic data. The modeling efforts will also address the retrospective analysis of herring populations.

This objective addresses the overall goal listed in the IP and the area of interest of retrospective analysis of herring populations. The modeling effort integrates results from all the other projects and helps to synthesize the data into a format that is more useful to fisheries managers and the public. Furthermore, we expect that the modeling effort will help guide future data collection information. The model produces population estimates are required for determining if a fishery can be opened, so the objective benefits the fishing community. This has become more important because of the reduced effort that ADF&G is expected to apply to herring fisheries, not only in PWS but through much of the state.

The second program objective, *Provide inputs to the stock assessment model*, is closely linked to the first, in that it will provide the inputs necessary to run the model to evaluate changes in the herring population and the factors that may affect those changes. The *Surveys and Age, Sex, and Size Collection and Processing, Adult Herring Acoustic Surveys, and Herring Disease Program* all collect input data for the model. The effort of the postdoctoral researcher in the *HRM Coordination* project is expected to contribute oceanographic data that the modeling effort. The *Studies of Reproductive Maturity among Age Cohorts of Pacific Herring* addresses the maturity function within the model. The *Annual Herring Migration Cycle* project will be assessing the survival as it relates to age and body condition. Survival is a parameter in the model that has little data to support the number used. Potentially the survival from summer and winter periods may be determined. The model is capable of using different seasonal survival numbers.

The modeling effort of objective one cannot be achieved without inputs of both current and historical data. These inputs include ensuring the long-term data that was collected by ADF&G to support fisheries management is continued. The lack of a fishery for nearly two decades and the reduced state funding means this data would not be collected without this effort. The objective addresses the need for comprehensive spawn surveys through aerial milt surveys and the acoustic surveys. Data collected under this objective will also address the IP's herring areas of interest of the role of disease, relationship between herring and oceanographic factors, age at maturity, and studies of herring movements.

The postdoctoral fellowship component addresses objective 3, *Examine the connection between herring condition or recruitment to physical and biological oceanographic factors*, and is contained within the HRM Coordination proposal. The fellowship is the primary project for pulling together the oceanographic data, but will be dependent on the existing ADF&G data along with data collected by the *Surveys and Age, Sex, and Size Collection and Processing, Adult Herring Acoustic Surveys, and Herring Disease Program* to characterize the herring. The *Annual Herring Migration Cycle* project is expected to contribute through identifying where the adult herring are at different times of year.

Like the modeling objective, objective 3 is expected to integrate results from most of the projects. This objective also connects the HRM program with GWA and Data Management programs. The desire is to explore the appropriate temporal and spatial scales of oceanographic factors and their connections to herring recruitment or condition. The objective addresses the IP's herring areas of interest on postdoctoral fellowship, and analysis of the relationship between oceanographic factors and herring. The primary benefit of this objective is to improve our understanding of factors controlling aspects of herring. Relationships that are found are expected to inform the expansion of the modeling effort.

The fourth objective, *Develop new approaches to monitoring,* is to develop new approaches to monitoring. The *Herring Disease Program* examines new serological and plaque neutralization assays to examine disease prevalence and provide a measure of herd immunity. The other projects are not proposing new techniques, but we continue to look for ways to improve survey design or the type of equipment used to improve efforts in the future. For example, the herring migration cycle project's expanded acoustic array network will increase detection capability thereby improving our ability to estimate movement and survival rates.

Background: Annual Herring Migration Cycle

Conservation concerns about the recovering Pacific herring population in PWS make it increasingly important to document migration patterns to inform our understanding of PWS adult herring survival. Little is understood about adult Pacific herring annual migration movements between spawning, summer feeding, and overwintering areas within and between PWS and the GOA. Elsewhere, it is common for large herring populations to migrate from nearshore spawning areas to coastal shelf areas for summer feeding habitat (Hay and McCarter 1997, Hay et al. 2008). Corten (2002) suggested that observed herring migration patterns are not innate, but are a learned behavior that initially happens when the recruiting year class follows older herring. In his review of migration in Atlantic herring (*C. harengus*) Corten observed that herring migration patterns tend to be stable over years, despite environmental variation. In PWS, Brown et al. (2002) compiled local and traditional knowledge on adult herring movements. In that study, some fishers reported herring moving into PWS through Montague Strait prior to the fall bait fishery while others reported herring moving into PWS in spring through Hinchinbrook Entrance, Montague Strait and the southwest passages of Erlington and LaTouche. These observations suggest that PWS herring are regularly migrating out of PWS and onto the shelf.

During winter, adult Pacific herring along the eastern Pacific Ocean often return to coastal areas and remain close to spawning areas and in nearshore channels (Hay and McCarter 1997). This behavior has also been observed in PWS herring populations, where historically large schools both overwintered and spawned around northern Montague and Green Islands. More recently however, the major biomass of adult herring during winter has shifted to the northeast and southwest areas of PWS. Currently the largest concentration of adult herring overwinters and spawns around Port Gravina and Port Fidalgo (ADFG herring portal http://data.aoos.org/maps/pwsherring/).

Previous studies of Pacific herring movements in the eastern Pacific have used traditional tag-recovery data and CPUE data (*e.g.* Hay and McKinnell 2002, Tojo et al. 2007). Unfortunately, making inferences about herring movement from CPUE data is problematic because fishing effort may not be consistent in all locations or across seasons. Furthermore, recapture rates of conventional tags are typically low (< 10 %) and, as there is currently no active commercial fishery targeting Pacific herring in PWS, tagging and recapturing enough tagged herring to make reliable inferences about movement would take considerable effort.

We propose to utilize acoustic telemetry to investigate seasonal movement patterns of Pacific herring. Post-spawn feeding, winter, and subsequent spawning migrations will be examined by tagging herring on PWS spawning grounds during spring and monitoring their movement patterns with moored acoustic arrays. The use of acoustic telemetry will allow us to look at movement patterns on a variety of temporal and spatial scales, filling in significant gaps in our current knowledge of herring migration.

Our proposed project builds on an EVOS Herring Research & Management (HRM) pilot project of the Principal Investigator M. Bishop and collaborator J. Eiler (NOAA). Our pilot project developed handling and tagging methods designed to minimize physical injuries and stress to wild Pacific herring (Eiler and Bishop 2016). As part of the pilot project, in April 2012, we successfully tagged 25 wild herring on their spawning grounds with acoustic transmitters. Post-release, 23 (92%) of the 25 tagged individuals were detected by a VR2W acoustic receiver multiple times on one or more days post release. Subsequently, the February 2013 installation of the Ocean Tracking Network's (OTN) six acoustic receiver arrays across the entrances to the GOA provided the first opportunity to detect movements from the spawning grounds to the entrances. Building upon the promising results of the 2012 research, in April 2013 we tagged and released 69 adult herring from the Port Gravina spawning area. Tags had an expected life of 263 d. Post-release we detected 93% of the tagged herring (64 of 69) either at Port Gravina and/or the OTN arrays (Eiler and Bishop 2016).

Based on detections at the OTN arrays, we determined that many of the tagged herring remained in and around the entrances to PWS from mid-April through early June. By July, most tagged herring had departed from Hinchinbrook Entrance and Montague Strait areas, with fish at Montague Strait often shifting west and into to the southwest passages (Bainbridge, Prince of Whales, Erlington, and LaTouche). Herring schools appeared to be actively moving throughout fall in and around Montague Strait and the southwest passages, although no equivalent movements were detected at Hinchinbrook Entrance. Herring were detected at the Montague Strait array and the southwest passage arrays right up to when tags expired in early January 2014, indicating that not all herring winter in northeast PWS, and that some herring are highly mobile and may be moving back and forth into the GOA even during winter months (Bishop and Eiler, *in prep*.).

The results of our EVOS pilot study demonstrated the exceptional opportunity to document migration patterns by PWS herring and investigate connectivity between the GOA and PWS. However, during previous Pacific herring acoustic telemetry projects the directionality of movements away from the acoustic arrays could not be determined. With funding from EVOS in FY 2016, we will deploy additional receivers at the OTN arrays in a configuration that will allow us to determine what direction tagged herring travel after detection at the OTN arrays (i.e., back into PWS or out towards the GoA). Leveraging this expanded acoustic infrastructure, we can address hypotheses relating to movements between PWS and the GoA and seasonal residency times in these two habitats. In addition to the OTN acoustic arrays, we will deploy acoustic receivers at herring spawning areas, near release sites. This study design will allow us to document when (Julian date) herring depart from monitored spawning areas and the time of year they return.

2017-2021 Key hypotheses and overall goals: Annual Herring Migration Cycle

The overall program goal of the Herring Research and Monitoring program is the continued development and testing of an updated age-structured assessment (ASA) model in collaboration with ADF&G. To address this goal, our tagging study will gather data to clarify the annual migration cycle of PWS adult herring. For 2017-2021 we will use acoustic telemetry to examine movement patterns on a variety of temporal and spatial scales, filling in significant gaps in our current knowledge of herring migration.

Our study will address the following hypotheses:

H_1: Pacific herring populations in PWS make seasonal, post-spawn feeding migrations through major entrances and passages to the Gulf of Alaska.

a) Fish with poor body condition are less likely to migrate.
b) New recruits to the spawning population are less likely to migrate than older herring.

H_2: The Prince William Sound herring population is composed of migrant and resident individuals.

a) Resident individuals remain within the confines of Prince William Sound.
b) Resident herring are associated with specific spawning grounds.
c) Migrant individuals exit Prince William Sound by mid-June and return to the Sound in either fall or spring.
d) Herring tagged in Port Gravina will be less likely to migrate into the Gulf of Alaska than herring tagged at northern Montague Island spawning areas.

H_3 Survival is related to age and body condition.

H_4: Fine-scale spatial use patterns are associated with individual biological characteristics and vary seasonally.

2. Relevance to the Invitation for Proposals

This study investigates movements by adult Pacific herring (*Clupea pallasii*), a species that has not yet recovered from the *Exxon Valdez* oil spill (EVOS 2014). The proposed study takes place primarily in Prince William Sound, part of the oil spill area and specifically addresses the EVOS 2017-2021 Invitation area of interest *(5) "A study of adult herring movement to provide information on herring movement between PWS and the Continental Shelf"*.

This project addresses integral assumptions of the herring ASA model. Specifically, in past formulations of the assessment model (Hulson et al. 2007) and the recent adaptation of the model into the Bayesian framework (Muradian 2015), the PWS herring population was assumed to be a fully mixed population with no emigration or immigration from other spawning populations. Empirical data from acoustic telemetry studies conducted during 2012 and 2013 (Eiler and Bishop 2016) support the hypothesis that some adult herring seasonally emigrate from PWS. An understanding of the timing and population-level movement rates of PWS herring movement between PWS and the GoA would improve upon our conceptual model of PWS herring population dynamics.

Furthermore, an understanding of the spatial distribution of Pacific herring and how this distribution changes throughout the year is needed to investigate associations between adult herring survival and environmental and biological indices (e.g., water temperature, forage availability, predator density). Thus, this project will provide a foundation for developing a mechanistic understanding of adult herring survival. Relevant to the goals of this program, stock biomass forecasts could be improved by integrating this mechanistic understanding into future iterations of the ASA model (e.g, including time-varying survival rates related to spatially-delineated environmental and biological indices).

In addition to examining large-scale movements out of PWS, this project will provide data on herring spawning area fidelity within PWS. These data will allow researchers to investigate if PWS herring comprise multiple substocks or are a single well-mixed population. As the spatial scale of our data collection will be limited, we intend this project to complement other projects investigating PWS herring stock structure (e.g., genetics) and historical datasets, not to provide a comprehensive evaluation of this complex question.

Overall, our project addresses previously unknown aspects of PWS herring ecology and population dynamics. Successful completion of this project will provide data necessary for evaluating key assumptions of the ASA model. Additionally, natural resource managers and fisheries researchers can use the results of our project to further develop the ASA model and improve forecasts of stock biomass.

3. Project Personnel

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EDUCATION

Ph.D.	Wildlife Ecology, 1988	University of Florida, Gainesville
M.S.	Wildlife and Fisheries Sciences, 1984	Texas A & M University, College Station
B.B.A.	Real Estate and Urban Land Economics, 1974	University of Wisconsin, Madison

RECENT PROFESSIONAL EXPERIENCE

6/99-present	Research Ecologist, Prince William Sound Science Center, Cordova, Alaska
4/90-3/94& 4/97-5/99	Research Wildlife Biologist, Copper River Delta Institute, Pacific Northwest Research Station, U.S. Forest Service, Cordova, Alaska
4/94-3/97	Research Wildlife Biologist, Center for Streamside Studies & Dept. Fisheries, University Washington, assigned to Copper River Delta Institute, Cordova, Alaska

SELECTED SCIENTIFIC PUBLICATIONS (10 of 53 publications)
***** = publication resulting from either acoustic or radio telemetry study (13 total)

***Bishop, M.A.,** J.B. Buchanan, B. McCaffery, J.A. Johnson. 2016. Spring stopover sites used by the Red Knot *Calidris canutus roselaari* in Alaska, USA: connectivity between Copper River Delta and the Yukon-Kuskokwim River Delta. *Wader Study* 123 (2): i*n press.*

Bishop, M.A., J.T. Watson, K. Kuletz, T. Morgan. 2015. Pacific herring consumption by marine birds during winter in Prince William Sound, Alaska. *Fisheries Oceanography*. 24:1-13.

***Bishop, M. A.**, B.F. Reynolds, S.P. Powers. 2010. An *in situ*, individual-based approach to quantify connectivity of marine fish: ontogenetic movements and residency of lingcod. *PLoS One* 5(12):e14267

***Bishop, M.A.**, N. Warnock, and J. Takekawa. 2004. Differential spring migration of male and female Western Sandpipers at interior and coastal stopover sites. *Ardea* 92:185-186.

Bishop, M.A. and S.P. Green. 2001. Predation on Pacific herring (*Clupea pallasi*) spawn by birds in Prince William Sound, Alaska. *Fisheries Oceanography* 10 (1): 149-158.

Cooney, R.T., J.R. Allen, **M.A. Bishop**, D.L. Eslinger, T. Kline, B.L. Norcross, *et al*. 2001. Ecosystem control of pink salmon (*Oncorhynchus gorbuscha*) and Pacific herring (*Clupea pallasi*) populations in Prince William Sound. *Fisheries Oceanography* 10(1): 1-13.

Dawson, N.M., **M.A. Bishop**, K.J. Kuletz, A.F. Zuur. 2015. Using ships of opportunity to assess winter habitat associations of seabirds in subarctic coastal Alaska. *Northwest Science*. 89(2):111-128.

*Eiler, J., and **M.A. Bishop.** 2016. Determining the post-spawning movements of Pacific herring, a small pelagic forage fish sensitive to handling, with acoustic telemetry. *Transactions of American Fisheries Society.* 145(2):427-439. DOI: 10.1080/00028487.2015.1125948

Powers, S.P., **M.A. Bishop**, S. Moffitt, and G.H. Reeves. 2007. Variability in Freshwater, Estuarine and Marine Residence of Sockeye Salmon (*Oncorhynchus nerka*) within the Copper and Bering River Deltas, Alaska. Pages 87-99 in C. A. Woody (ed) *Sockeye salmon evolution, ecology and management*. American Fisheries Society, Symposium 54, Bethesda, MD.

*Reynolds, B.F., S.P. Powers, **M. A. Bishop.** 2010. Application of acoustic biotelemetry to assess quality of created habitats for Rockfish and Lingcod in Prince William Sound, Alaska. *PLoS One* 5(8): e12130.

Professional Collaborations

M. Armistisu (USGS), A Arab (Quanticipate Consulting), J. Buchanan (WDFG), K. Carpenter (CRWP), N. Dawson (PWSSC), J. Eiler (NOAA), N. Hill (MIT), E.N. Ieno (Highland Statistics), J. Johnson (USFWS) K. Kuletz (USFWS), S. Lewandoski (PWSSC), F. Li (Intl. Crane Foundation), B. McCaffrey (USFWS), M. McKinzie (PWSSC/Auburn University), J. Moran (NOAA), T. Morgan (PWSSC/ABR), E. Nol (Trent Univ.), J. Piatt (USGS), S. Powers (U. S. Alabama), R. Porter, B. Reynolds (PWSSC), D. Roby (OSU), J. Runstadler (MIT), A Saveliev (Highland Statistics), A. Schaefer (PWSSC), K. Sowl (USFWS), J. Stocking (PWSSC/UNC-Raleigh), J. Straley (UAS), Y. Suzuki (OSU), A. Taylor (UAA), D. Tsamchu (Tibet Plateau Institute of Biology), E. Weiser (U. Kansas), J. Watson (PWSSC), A. Zuur (Highland Statistics)

4. Project Design

A. OBJECTIVES

Herring Research and Monitoring Program

The overall goal of the Herring Research and Monitoring program is to: **Improve predictive models of herring stocks through observations and research.** This is consistent with the overall program goal described in the request for proposals (RFP) and the direction provide by the EVOS Trustee Council when they chose the enhanced monitoring option of the Integrated Herring Restoration Program. By working to improve the predictive models of herring stock we anticipate using the data to provide a tool that may be used by fisheries managers to make more informed decisions.

To achieve the overall goal over the next five years the program has the following objectives.

1) *Expand and test the herring stock assessment model used in Prince William Sound.* This builds upon the work of the previous five years, during which the age-structure-analysis (ASA) model used by Alaska Department of Fish and Game was built into a Bayesian framework. The model is now ready to be expanded to include earlier life stages, environmental conditions, and new metrics for disease. It is also possible to test the importance of model inputs and assumed relationships, such as the age-of-maturity function.

2) *Provide inputs to the stock assessment model.* Operation and testing of the model depends on input data. To expand the model to include environmental conditions requires that the model continue to be provided input data on the age structure, biomass indices, and environmental conditions to determine if the model output is consistent with observations. It is also important to provide input to sub-models, such as the age-of-maturity function.

3) *Examine the connection between herring condition or recruitment to physical and biological oceanographic factors.* Understanding how herring respond to environmental conditions requires understanding the distribution and movement of herring between oceanographic realms, such as from PWS to the Gulf of Alaska. Research has shown that recruitment patterns extend over broad spatial domains, thus requiring not only examining local phenomena, but also regional and even global relationships.

4) *Develop new approaches to monitoring*. Changes in technology and testing of existing approaches lead to important advances in our sampling techniques and design that can either provide simpler data collection, improved measurement accuracy necessary as a basis for future research, or provide more relevant measures of important factors, such as disease.

Our goal and first objective directly addresses the overall program goal provided in the RFP and area of interest 3. The second objective is necessary to run the model in the first objective and addresses topics 4, 6, and 9 of the RFP. The third objective addresses topics 5, 6, 7, 9. It also connected to topics 1, 8, 10, and 11. The fourth objective lays to foundation of future research and monitoring. Achieving these objectives requires collaboration with the Gulf Watch Alaska team that are collecting much of the environmental data.

Annual Herring Migration Cycle

Our previous tagging efforts suggest that herring are emigrating from PWS into the Gulf of Alaska and then returning (Eiler and Bishop 2016; Bishop and Eiler in prep.). For the next FY17-21 phase of the Herring Research and Monitoring program, this project will contribute to objectives #2 and #3 of the Herring Research and Monitoring Program by acoustic tagging adult herring on their spawning grounds in Prince William Sound. Our project objectives for FY17-21 include:

1) Document location, timing, and direction of Pacific herring seasonal migrations between Prince William Sound and the Gulf of Alaska.
2) Relate large-scale movements to year class and body condition of tagged individuals.
3) Determine seasonal residency time within PWS, at the entrances to PWS, and in the Gulf of Alaska.
4) Compare the migratory behavior of herring from multiple spawning areas within PWS.

Our study will provide a better understanding of the migratory patterns of herring and the potential factors affecting herring movements, survival, and population structure. In addition to peer-reviewed publications, our project will provide valued and requested information to the fishing community, the general public, and resource managers regarding latest research results and Pacific herring ecology.

B. PROCEDURAL & SCIENTIFIC METHODS

Methods - Fish Capture & Tagging

A total of 125 adult herring per year will be tagged during April 2017 with efforts focused at one site (Port Gravina). In 2018 and 2019 we will tag a total of 210 herring, with efforts focused at two sites (Port Gravina and Montague Island). Herring will be targeted on PWS spawning grounds using jigs. Our surgical procedures for acoustic tagging will follow methods developed by Eiler and Bishop (2016) during the EVOS-funded pilot study and are briefly summarized below. Using their methods, 91.4% of tagged fish (N= 94) were subsequently detected in PWS, indicating that measures taken to reduce tagging and handling related stress were successful and post-tagging survival was high (Eiler and Bishop 2016).

Herring will be jigged from a fishing vessel and placed in a holding tank (770 L capacity) on the vessel filled with fresh, circulating sea water. Herring in good condition and meeting our length requirement (described below) will be removed from the tank with a small plastic container and then transferred to a circular tub for sedation (Eiler and Bishop 2016). Once fish are unresponsive, they will be measured (SL, mm), weighed (g), and transferred for tag insertion to a neoprene-lined tagging cradle specifically designed for small pelagic fish that is submerged in an outer cradle filled with circulating sea water (Eiler and Bishop 2016).

A coded acoustic transmitter (Vemco Ltd. V9-2L; power= 146 dB; 4.7 g in air) will be surgically implanted in the abdominal cavity through a small incision (11-12 mm) along the ventral midline. The incision will be closed with simple interrupted, dissolvable sutures (Ethicon Inc.; Chromic Gut). To reduce the risk of an immune-rejection response, prior to use in the field all acoustic transmitters will be placed in separate pouches, sterilized with low temperature anprolene gas and sealed (Eiler and Bishop 2016). Upon completion of surgical procedures, herring will be transferred to a second holding tank (770 L capacity) containing aerated, fresh seawater using the removable neoprene sleeve to minimize handling and injury. A number of untagged herring will be placed in the recovery tank for comparative purposes. Tagged fish will be considered to have recovered when their swimming behavior is indistinguishable from that of the untagged fish. After tagging is completed, all fish (including the untagged individuals) will be released as a group near a school of free-ranging herring (Eiler and Bishop 2016).

Based on the minimum standard length of herring tagged by Eiler and Bishop (2016), the minimum standard length of herring considered for tagging in this study will be 190 mm (age ~3-4 yrs). To address hypotheses related to the relationship between individual biological characteristics and movement and survival, we will ensure that the length distribution of our tagged fish sample is approximately uniform over a wide size range. Specifically, 10-mm length bins ranging from 190 mm to 250 mm (the largest length bin contains fish > 250 mm) will be implemented and each length bin will constitute approximately 14% of the total tagged sample. In addition to standard length, the sex of each tagged herring will be determined and weight (g) data will be collected. Finally, a condition index ($k = weight \cdot length^{-3}$; Slotte, 1999; Kvamme et al., 2003) will be calculated for each tagged herring from individual length and weight data.

Methods – Acoustic Array Monitoring Systems

All transmitters will be pre-programmed to produce a 69.0 kHz pulse train randomly within 90-150 s intervals. Each transmitter emits a unique series of pings that can be decoded and recorded if the tagged herring is within the detection range of a receiver. Codes from successfully decoded transmissions are recorded and stored in the receiver memory along with the date and time they were received. Once the receiver is in hand (VR2W receivers) or connection is made with a Teledyne Benthos surface modem (VR4 receivers) a file containing the complete detection records for the duration of deployment can be uploaded.

In order to monitor post-tagging movements and the timing of outmigration and subsequent migrations back to the area, an array of nine VR2W receivers located near tagging sites in northeast PWS (Port Gravina) will be deployed years 1-3 and a second array of eight VR2AR receivers will be deployed at the Montague Island tagging site in years 2 and 3. The intent of our array configurations will be to maximize the detection probability of tagged fish on the spawning grounds. Data from our arrays will allow the PI to address questions relating spawning site fidelity, monitor post-tagging survival, increase the resolution of movement patterns within PWS, and provide data needed for robust survival estimation. The acoustic receivers will be deployed with acoustic releases and upon retrieval at the end of the first year of data collection (May 2018) they can be redeployed at the 2018 and 2019 tagging sites to monitor their respective tagging cohorts.

As part of the Ocean Tracking Network (http://members.oceantrack.org/data/discovery/GLOBAL.htm) receiver arrays were deployed across the principal entrances into the Sound from the Gulf of Alaska during 2013 – including Hinchinbrook Entrance, Montague Strait, and a series of smaller passageways (Latouche, Elrington, Prince of Wales and Bainbridge) in the PWS. The receivers were placed approximately 0.7 km apart (SD = 0.1), ranging from 0.4 to 0.8 km, to provide adequate coverage based on anticipated reception range. In January 2017, a second line of acoustic receivers will be deployed at each of the four southwest passage arrays. At Montague Strait and Hinchinbrook Entrance a second line will be deployed along the outermost receivers (Figures 1,2). Through a collaborative agreement between OTN and the PWS Science Center, data from the OTN arrays will be uploaded once a year in February.

C. **DATA ANALYSIS AND STATISTICAL METHODS**

Hypotheses $\mathbf{H_1}$, $\mathbf{H_2}$, and $\mathbf{H_3}$ pertain to herring survival rates and large scale movement rates and how these rates change seasonally or in relation to individual biological characteristics. Estimates of survival are needed to generate unbiased estimate movement rates; therefore, our ability to estimate survival will affect the quality of our movement rate estimates. Our analytical approach for addressing these hypotheses has two major components: estimating survival using discrete-time multistate Markov models (Lebreton and Pradel 2002) and estimating herring movement with continuous-time multistate Markov models (Miller and Andersen 2008). Survival will be estimated by binning detection data into discrete intervals (Barbour et al. 2013) and analyzing these data using discrete-time multistate Markov models developed using the RMark package (Laake 2013). Binning continuous-time detection data into relatively large discrete time steps is necessary for estimating survival using the well-established

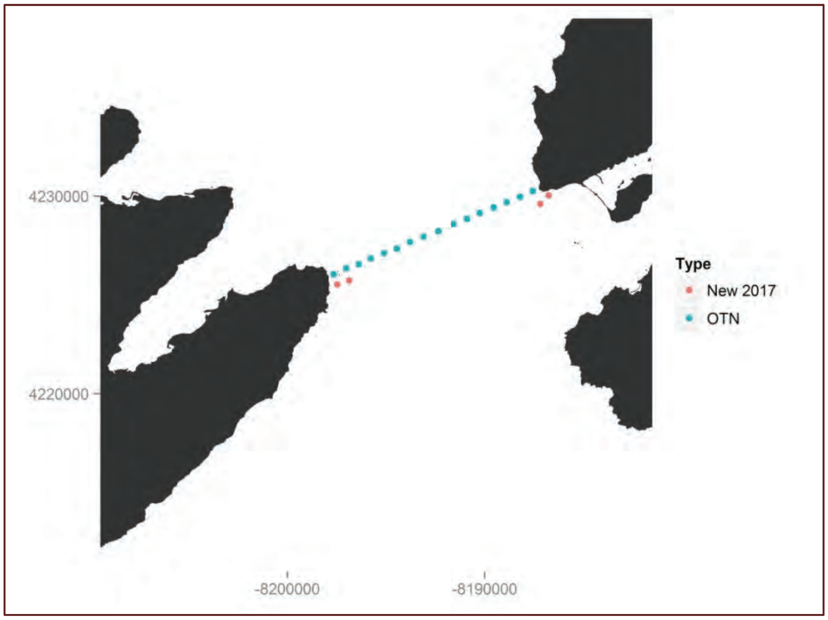

Figure 1. Location of the OTN acoustic array in Hinchinbrook Entrance (blue circles) and locations for receivers to be deployed in January 2017 (red circles).

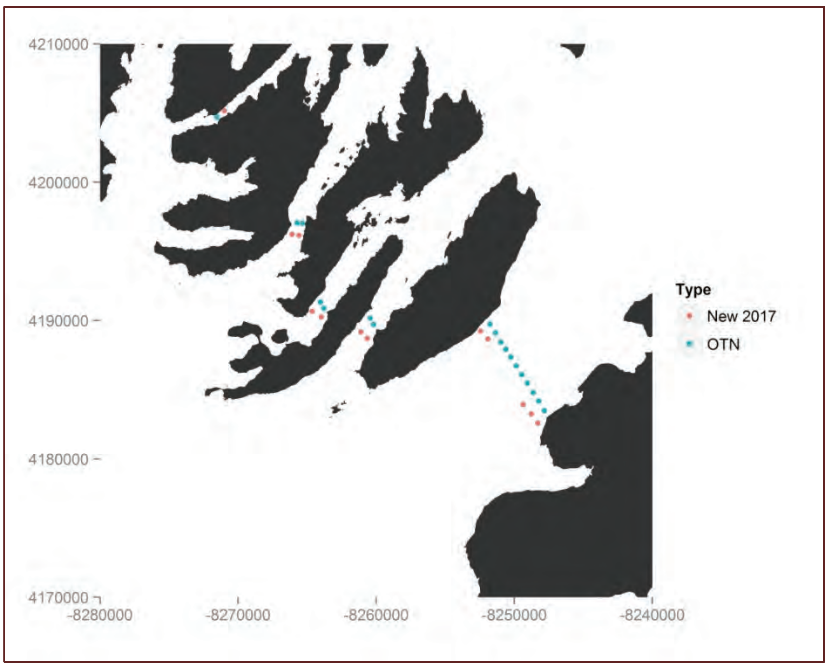

Figure 2. Location of the OTN acoustic array in Montague Strait and the four southwest passages (blue circles) and locations for receivers to be deployed in January 2017 (red circles.

methods developed for convention mark-recapture experiments; however, this diminishes the quality of the data collected by fixed acoustic arrays. To efficiently utilize the high-quality data collected by the acoustic arrays, we will use continuous-time Markov models to estimate herring movement rates and fix the survival rate at the value estimated from the discrete time model. In addition to movement rates, we will use the continuous-time model to calculate seasonal mean residency time in the GOA and PWS.

As emigration from the study area for a period longer than the battery life cannot be distinguished from mortality, the discrete-time model actually estimates apparent survival; however, apparent survival is equal to the true survival rate if tagged herring do not emigrate for more than a year from the study area. Herring emigration out of PWS is likely temporary, and based on the spatial coverage of our acoustic array and the extended battery life of our acoustic tags (400 days), we expect the bias in our survival estimates due to long-term emigration from the study area to be low.

Finally, our hypothesis (**H$_4$**) addressing fine-scale spatial use patterns will be investigated using Brownian bridge movement models (Horne et al. 2007; Pages et al. 2013) and by calculating simple summary statistics for each acoustic receiver.

Survival estimation and power analyses

To address our hypothesis relating to the relationship between individual biological characteristics and survival, we will develop discrete-time multistate Markov models with covariates for size, weight, and condition. A suite of estimation models will be developed and the most parsimonious models will be selected using Akaike's information criterion (AIC) corrected for small sample size bias (AIC*c*) (Burnham and Anderson 2002).

To further support our analytical approach and to determine the sample size needed to generate estimates of herring survival rates, we simulated datasets and conducted a power analysis using our proposed methods to estimate survival. Datasets were generated from a transition intensity matrix with instantaneous transition rates based on estimates from the 2013 pilot project. The instantaneous transition rates describe the movement of herring between states defined by the acoustic arrays. The states that tagged herring could inhabit were: present at an array, undetected in PWS, undetected in the GOA (outside of the entrance arrays), or mortality (Fig. 4). Of these seven states, there are three observable states (one for each array: northeast PWS spawning grounds, inner PWS gate, outer PWS gate), four unobservable states (three undetected states and the mortality state), and 10 instantaneous transition rates based on the spatial configuration of the arrays (Fig. 3).

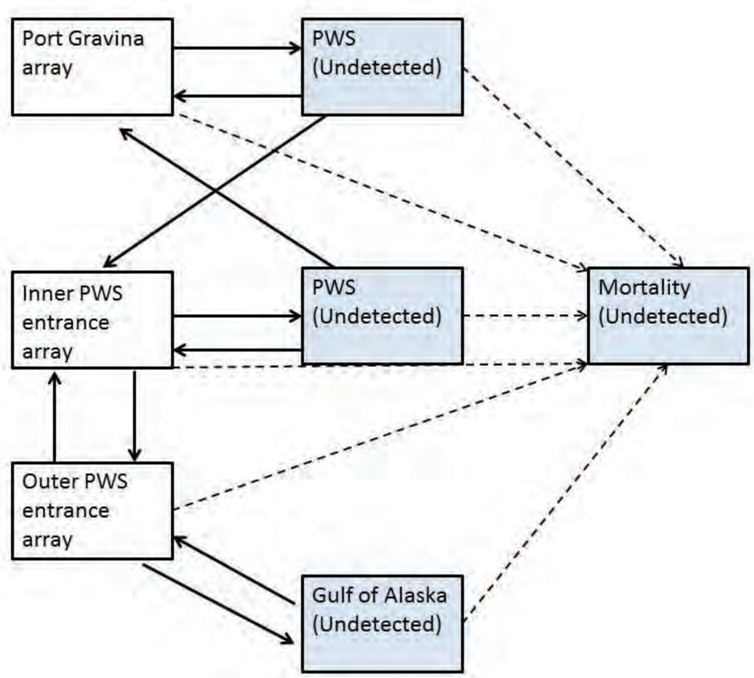

Figure 3. Schematic of the multistate model used to describe herring movements between acoustic arrays (solid line= movement; broken line= mortality) for the 2017 tagging data with a single monitored spawning area.

Survival was assumed to be constant over the duration of the study, while movement rates changed seasonally to describe a herring population that moved towards the entrances after spawning, had a long average residency time in the GOA in the summer, and returned to the spawning area the following spring with high fidelity. Incomplete detection of herring moving through the outer entrance array (detection probability=0.85) was simulated by including an indicator variable for detection at the outer entrance array. The detection indicator variable was populated by a random binomial with a success probability of 0.85. Residency periods at the outer array with a 1 were observed, while residency periods with a 0 were undetected and removed from the dataset.

Additionally, the simulated population had different annual survival rates (S) based on group membership (two groups). Group membership was assumed to be related to length, weight, or body condition and, therefore, would be known to researchers. Two effect sizes, a moderate (S=0.85; S=0.71) or large (S=0.88; S=0.68) difference in annual survival between the two groups, and five sample sizes (60, 80, 100, 120, and 140 herring released with 50% in each group) were considered. During each simulation the data were fit to two models, the full model with two survival rates based on group (the true model) and a reduced model with a single survival rate, and AIC*c* was calculated for each model. For each simulation scenario, 350 datasets were generated and statistics relating to model convergence, model selection, and parameter estimation were recorded. Model section statistics (ΔAIC*c*= AIC*c* full – AIC*c* reduced; percent correct= the percent of simulations where AIC*c* full < AIC*c* reduced) indicate the effect size detected and the probability of selecting the true model. Parameter estimation statistics (percent bias, percent root-mean-square error, 95% CI coverage, and 95% confidence interval half-width) assess the accuracy and precision of the survival estimates (Miller 2015).

The formulas for percent bias and percent RMSE are

$$1)\ \text{Percent bias} = 100 * \left(\frac{S_{est} - S_{true}}{S_{true}}\right),$$

$$2)\ \text{Percent RMSE} = 100 * \sqrt{\left(\frac{S_{est} - S_{true}}{S_{true}}\right)^2},$$

where S_{est} is the estimated annual survival rate and S_{true} is the true annual survival rate of the simulated population. Finally, percent bias, percent RMSE, and 95% CI half-width values from the 350 simulations were calculated for each simulation (N = 350) and the mean value was reported. This analysis was conducted using R (R Core Team 2014) and the RMark package (Laake 2013).

Model convergence in all simulation scenarios was high (0.95–1.00) and the probability of selecting the correct model using AIC*c* increased as sample size or effect size were increased (Table 1). Using the correct model for inferences, estimates on average tended to minimally underestimate the true survival rate (percent bias ranging from 0.4% to -1.8%), while the accuracy of estimates (measured by percent root-mean-square error) improved as sample size was increased. The coverage of the 95% CI for survival (i.e. the percentage of 95% confidence intervals that contained the true survival rate) was near the expected 95% for all simulation scenarios (91-95%), though the precision of the survival estimate (measured by the 95% CI half-width) increased as sample size was increased (Table 1).

Based on these results, a minimum of 120 herring will be tagged each year. This sample size will likely provide researchers enough statistical power to detect large differences in survival in herring based on measured biological covariates. Additionally, with this sample size we expect survival estimates to be both accurate (percent RMSE<11) and precise (95% CI half-width <0.13).

Our power analysis provides an example of the statistical methodology we propose to use to estimate apparent survival and the feasibility of applying these techniques to PWS Pacific herring stocks. Apparent survival of other species with large home ranges have been estimated from fixed acoustic receiver arrays using discreet-time multistate Markov models, including Gulf sturgeon (*Acipenser oxyrinchus desotoi*; Rudd et al. 2014) and broadnose seven gilled shark (*Notorynchus cepedianus;* Dudgeon et al. 2015); thus, this methodology has also been successfully applied to real ecological datasets.

Table 1. Power analysis results for survival estimation and model selection using Multistate Markov models. For each simulation scenario consisting of an effect size (moderate or large) and sample size (N=60, 80, 100, 120, or 140), model selection and survival estimation summary statistics were calculated from 350 datasets generated from a simulated herring population.

	Moderate (S_1= 0.85; S_2= 0.71)					Large (S_1= 0.88; S_2= 0.68)				
Sample size	60	80	100	120	140	60	80	100	120	140
Model convergence	94.9	97.4	99.4	99.4	99.7	94.9	97.4	99.4	99.4	99.7
Model selection										
Median ΔAICc	-1.58	-0.47	-0.01	0.73	1.46	-0.14	1.86	2.82	4.73	5.68
Percent correct	29.4	43.8	49.6	58.5	64.9	49.3	69.3	76.0	85.7	89.4
Survival estimation										
Percent bias (S_1)	-0.9	-0.3	-0.6	-0.2	-0.3	-0.5	-0.1	-0.5	-0.2	-0.1
Percent bias (S_2)	-0.6	-0.8	-1.0	-0.7	-1.3	0.4	-1.1	-1.1	-1.8	-1.6
Percent RMSE (S_1)	7.9	7.7	6.6	6.1	5.5	6.7	6.3	5.9	5.1	4.7
Percent RMSE (S_2)	12.2	10.6	9.9	8.3	8.3	13.2	11.3	10.6	10.5	9.1
95%CI coverage (S_1)	94.1	91.1	94.6	92.6	93.1	91.9	92.9	92.2	93.4	93.7
95%CI coverage (S_2)	93.5	95.4	92.6	95.7	94.9	93.4	95.0	93.1	93.4	92.6
95%CI halfwidth (S_1)	0.135	0.117	0.107	0.098	0.091	0.12	0.105	0.097	0.089	0.083
95%CI halfwidth (S_2)	0.171	0.149	0.134	0.122	0.113	0.174	0.153	0.137	0.125	0.116

Movement rate estimation

The rate of herring movement between PWS and the GOA will be modeled using continuous-time multistate Markov models developed with the *msm* package (Jackson 2011) in R. Continuous time Markov models are commonly used in survival analysis in the medical field (Duffy et al. 1995) and have been used in a fisheries context to model Atlantic bluefin tuna (*Thunnus orientalis)* regional migration (Miller and Andersen 2008). Our approach will be to use the multistate model depicted in Figure 4 and estimate the transition rates (solid lines) and fix the survival rate (broken lines) at the estimated rate from the discrete model output. All of the possible transitions between states form a transition intensity matrix *Q*, such that:

$$Q=\begin{pmatrix} \varphi_{1,1} & \varphi_{1,2} & 0 & 0 & 0 & 0 & \varphi_{1,7} \\ \varphi_{2,1} & \varphi_{2,2} & 0 & \varphi_{2,4} & 0 & 0 & \varphi_{1,7} \\ \varphi_{3,1} & 0 & \varphi_{3,3} & \varphi_{3,4} & 0 & 0 & \varphi_{3,7} \\ 0 & 0 & \varphi_{4,3} & \varphi_{4,4} & \varphi_{4,5} & \varphi_{4,6} & \varphi_{4,7} \\ 0 & 0 & 0 & \varphi_{5,4} & \varphi_{5,5} & \varphi_{5,6} & \varphi_{5,7} \\ 0 & 0 & 0 & \varphi_{6,4} & \varphi_{6,5} & \varphi_{6,6} & \varphi_{6,7} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

where $\varphi_{i,j}$ is the instantaneous transition rate from state *i* to state *j*. The $\varphi_{4,6}$ and $\varphi_{6,4}$ transitions are included to allow for incomplete detection at the outer entrance array (state 5). All rows sum to zero and the probability of remaining in each state (transitions with state *i* = state *j*) is solved by subtraction. All transitions to the mortality state are set to a fixed rate and the remaining 12 transition parameters are estimated via maximum likelihood using the *msm* package (Jackson 2011). Due to incomplete detection at the outer entrance array, censored states need to be included in the analyses. Herring last detected at the inner array either migrated back into PWS (state 3) or moved through the outer array undetected and migrated into the GOA (state 6); thus, these herring are considered to be in a censored state that includes states 3 and 6. Similar to our approach for modeling herring survival, our hypotheses regarding herring movement can be addressed by developing models with covariates relating to time and individual biological characteristics and conducting model selection using AIC*c*.

Seasonal residency time

The estimated mean residency time at a given state can be estimated as $-1/q$, where q is one of the diagonal entries in Q (i.e. a φ value with state *i* equal to state *j*) (Duffy et al. 1995). If transition rates change seasonally, the corresponding seasonal mean residency times can be calculated. Additionally, we will calculate a residency index for each tagged individual as the proportion of calendar days detected at an array during a season and use this index to describe seasonal habitat usage (Cagua et al. 2015).

Spatial analyses

The multistate Markov model we used to estimate herring movement rates contained the minimum number of spatial states needed to describe large-scale herring movements because these models are “data-hungry” and become unwieldy as the number of states is increased. Therefore, spatially explicit Brownian bridge movement models (BBMM) will be used to investigate fine-scale herring movement patterns. These models are commonly used in wildlife ecology (Horne et al. 2007) and have recently been applied to datasets obtained from fixed acoustic telemetry arrays (Pages et al. 2013). In brief, BBMM estimate the probability of a tagged individual occupying an area over a given time period based on known locations collected at an intervals during that time period. From this output, home range size (km^2) can be estimated and the seasonality of spatial use patterns (e.g., preferentially using Montague Strait over Hinchinbrook Entrance post-spawning) can be examined.

Finally, statistics for individual receivers will be calculated to investigate spatial use patterns. The intensity of habitat use will be measured by calculating total number of detections and total number of individual herring for each receiver. Areas primarily used as corridors will be identified by calculating the ratio between non-consecutive detections (first detection after being detected by another receiver) and total detections (Pages et al. 2013). A non-consecutive detection will be defined as the first detection of an individual at a receiver after previously being detected at a different receiver. A high proportion of non-consecutive detections will indicate the area is primarily used as a corridor. Trends in these receiver-based statistics over time will be examined to investigate seasonal and diurnal trends in spatial usage patterns.

Multiple spawning area analyses

Differences in movement rates and residency times between herring tagged in Port Gravina and Montague Island will be assessed both qualitatively and statistically. Tagging area can be included as a categorical covariate in the continuous-time multistate Markov model we will develop to investigate herring movement rates. By additionally allowing for interactions between season and tagging area, movement rates can be estimated for each spawning area and the overall movement patterns for each spawning area can be compared.

The movement patterns of herring from difference spawning areas will be further analyzed by calculating the proportion of tagged fish present at the spawning area array and the proportion of tagged fish known to be in the Gulf of Alaska for each day of the study. These data will be presented graphically and we will visually assess the similarities and differences between the two tagged samples from separate spawning areas.

D. DESCRIPTION OF STUDY AREA

This study is part of an ongoing, long-term project investigating Pacific herring (bounding coordinates: 61.292, -148.74; 61.168, -146.057; 60.273, -145.677; 59.662, -148.238). Our study will continue to take place in the inside waters of Prince William Sound (Figure 4).

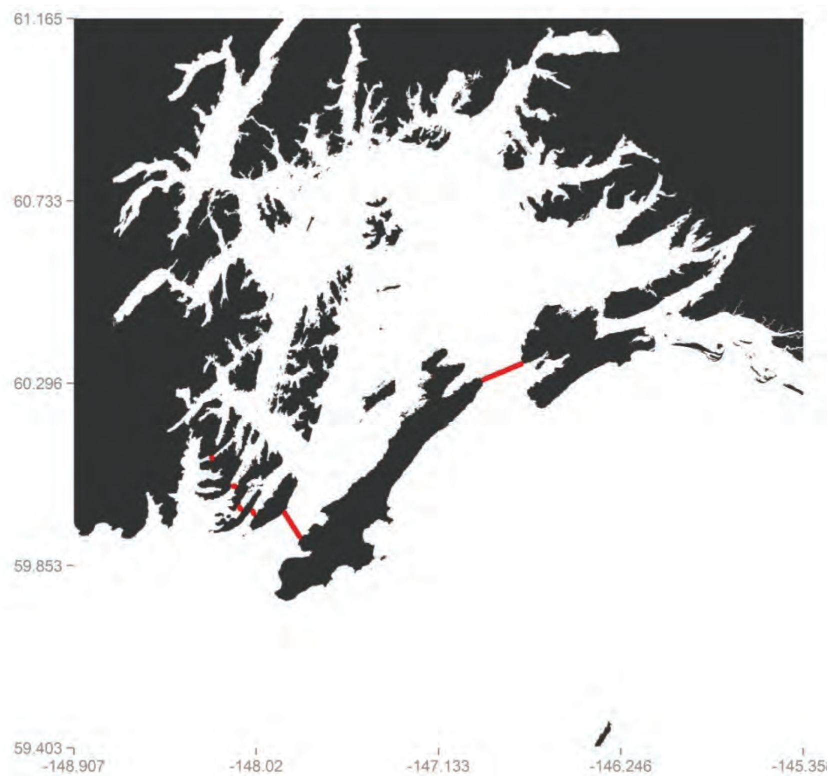

Fig. 4. Prince William Sound, Alaska. Our study will take place around spawning sites in northeast Prince William Sound and northern Montague Island and the Ocean Tracking Network acoustic arrays (noted in red).

5. Coordination and Collaboration

Within the Herring Research and Monitoring (HRM) program

Our study, PWS Herring Annual Migration Cycle, will be a component of the larger, EVOS-sponsored Herring Research and Monitoring (HRM) program. We anticipate that we will coordinate with the all the HRM projects. Our tagging work will inform the *Herring disease* studies (PI Herschberger) by establishing the migration and feeding locations of herring. This knowledge is important for identifying where and when exposure to the pathogens is occurring. This exposure information is a first step in helping to identify possible intermediate hosts for *Ichthyophonus*. From the *Herring hydroacoustic surveys* (PI Rand) we will receive data on adult school locations and will provide data to them on return timing of tagged fish. We also will investigate methods to track acoustic tag fish concurrently during hydroacoustic surveys for adults. The *Program Coordination* (PI Pegau) includes logistical support needed to determine locations of adult herring schools in PWS during summer. Our project will contribute data to *Herring condition connection to environmental factors* (postdoc position) through identifying where the adult herring are at different times of year. Our project will also contribution movement and survival rate data to the project *Modeling and stock assessment* (PI Branch). For the *Herring age at reproductive* maturity (P.I. Gorman) we will share vessel space and will provide samples opportunistically. For the *Herring age, sex, and size collection* (P.I. Moffit) we will provide samples opportunistically. Finally, we will be in constant collaboration and coordination with our fearless HRM Coordinator/leader Scott Pegau, in order to improve and maintain all collaborative aspects of this project with other HRM projects. This includes attending PI meetings, making our data available in a timely matter, and completing reports in a timely matter.

With Gulf Watch Alaska

Our project will also provide information that will complement data collected by the Gulf Watch Pelagic Component's Integrated Predator-Prey Surveys. These joint surveys are being co-conducted by three existing projects:

EVOS Gulf Watch Alaska	
Forage fish distribution, abundance, & body condition in PWS	USGS
Humpback whale predation	NOAA/UAS
Fall and winter seabird abundance & distribution	PWSSC
PWS oceanography	PWSSC

Understanding movements by adult herring throughout the annual cycle will provide valuable information on trophic interactions between herring and piscivorous waterbirds (in particular loons and common murre the major avian consumers of adult herring), humpback whales, and other forage fish competitors. Additionally, the availability of oceanographic data from PWS collected at approximately monthly intervals from April-November provides an opportunity to explore how seasonal changes in herring distribution are associated with environmental drivers.

With Other Council-funded Projects

Except for the EVOS Herring Research & Monitoring Program and the EVOS Gulf Watch Alaska program, there are no other EVOS-funded collaborations.

With Trustee or Management Agencies

Our project relies on information from Alaska Department of Fish and Game to help locate adult herring schools in spring for acoustic surveys and our sampling. To that extent, we work closely with Steve Moffitt at the Cordova office of ADF&G. Information learned about herring migrations will be shared with ADF&G.

Collaborations With Other organizations

This project will synergize with efforts of the Ocean Tracking Network (OTN; Fred Whoriskey, PhD Executive Director, Dalhousie University) and with the Alaska Ocean Observing System (Molly McCammon). In March 2013, OTN installed two, large-scale arrays including one across the mouth of Hinchinbrook Entrance and one across Montague Strait, and four small arrays at the southwest PWS passages of Latouche, Elrington, Prince of Whales, and Bainbridge. With FY16 EVOS funding, in January 2017, PWS Science Center will expand the OTN array. Equipment is assembled and configured by PWS Science Center (PWSSC) personnel in Cordova. Currently PWSSC maintains the array for OTN on an annual basis. OTN maintains a database with detections from their worldwide network. Our data is archived in the OTN databases, as per their guidelines. Beginning in 2017, the PWSSC will receive funding from the Alaska Ocean Observing Network to cover the costs of maintaining the OTN arrays. Funding will be for five years.

Schedule

Program Milestones

Objective 1. Document location, timing and direction of Pacific herring seasonal migrations between Prince William Sound and the Gulf of Alaska.

To be met by January 2021

Objective 2. Relate large-scale movements to year class and body condition of tagged individuals.

To be met by January 2021

Objective 3. Determine seasonal residency inside PWS, at the entrances to Prince William Sound, and in the Gulf of Alaska.

To be met by January 2021

Measurable Program Tasks

Task	FY17				FY18				FY19				FY20				FY21			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Task 1 Field Work																				
Field work prep.	X				X				X											
Fish tagging	X				X	X			X	X										
Data upload from arrays					X				X				X							
Task 2 Data																				
Data summary/analyses		X	X	X		X	X	X		X	X	X	X	X	X	X				
Upload previous FY data/ metadata to workspace					X				X				X			X				
Task 3 Reporting																				
Annual Report	X				X				X				X							
Annual PI meeting				X				X				X								
FY Work Plan (DPD)			X				X				X									
Final Report																X				

<u>FY 17, 1st quarter</u> (February 1, 2017 - April 30, 2017)
- Feb — FY16 Annual report prep & submission
- Mar — field prep
- Apr — herring capture & tagging

<u>FY 17, 2nd quarter</u> (May 1, 2017 - July 31, 2017)
- May-Jul — Data analyses

<u>FY 17, 3rd quarter</u> (August 1, 2017 - October 31, 2017)
- Aug — Annual work plan
- Sep-Oct — Data analyses

<u>FY 17, 4th quarter</u> (November 1, 2017 - January 31, 2018)
- Nov — Herring Research & Monitoring P.I. meeting
- Jan — Data analyses

Jan	Alaska Marine Science Symposium

<u>FY 18, 1st quarter</u> (February 1, 2018 - April 30, 2018)
Feb Annual report prep & submission
Feb OTN data upload; publish metadata from FY 17
Mar upload data to workspace; field prep
Apr herring capture & tagging

<u>FY 18, 2nd quarter</u> (May 1, 2018 - July 31, 2018)
May herring capture & tagging (Montague)
May-Jul Data analyses

<u>FY 18, 3rd quarter</u> (August 1, 2018 - October 31, 2018)
Aug Annual work plan
Sep-Oct Data analyses

<u>FY 18, 4th quarter</u> (November 1, 2018 - January 31, 2019)
Nov Herring Research & Monitoring P.I. meeting
Jan Data analyses
Jan Alaska Marine Science Symposium

<u>FY 19, 1st quarter</u> (February 1, 2019 - April 30, 2019)
Feb Annual report prep & submission
Feb OTN data upload
Mar upload data to workspace; field prep
Mar Publish metadata from FY 18
Apr herring capture & tagging

<u>FY 19, 2nd quarter</u> (May 1, 2019 - July 31, 2019)
May herring capture & tagging (Montague)
May-Jul Data analyses

<u>FY 19, 3rd quarter</u> (August 1, 2019 - October 31, 2019)
Aug Annual work plan
Sep-Oct Data analyses

<u>FY 19, 4th quarter</u> (November 1, 2019 - January 31, 2020)
Nov Herring Research & Monitoring P.I. meeting
Jan Data analyses
Jan Alaska Marine Science Symposium

<u>FY 20, 1st quarter</u> (February 1, 2020 - April 30, 2020)
Feb Annual report prep & submission
Feb OTN data upload
Mar upload data to workspace; publish metadata from FY 19
Apr receiver retrieval spawning grounds

<u>FY 20, 2nd quarter</u> (May 1, 2020 - July 31, 2020)
May-Jul Data analyses

<u>FY 20, 3rd quarter</u> (August 1, 2020 - October 31, 2020)
Aug-Oct Data analyses

FY 20, 4th quarter (November 1, 2020 - January 31, 2021)

Nov	Herring Research & Monitoring P.I. meeting
Jan	Final Report Preparation
Jan	Publish project's database

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6. Budget

Sources of Additional Funding

This project uses Dalhousie University's Ocean Tracking Network, a series of acoustic arrays that are in place at Hinchinbrook Entrance, Montague Strait, and four, smaller passages in southwest PWS. The value of the Ocean Tracking Network acoustic arrays is estimated at $337,200.

This project also piggy-backs on the annual Ocean Tracking Network maintenance cruise (funded by the Alaska Ocean Observing System starting in FY 17) which includes 5d@$3/k day. This EVOS budget only includes an additional 2d ($6k) of charter costs for deploying the new receivers. For the FY17-20 tagging studies, PWS Science Center will also provide in-kind equipment (9 VR2-W acoustic receivers and 9 acoustic releases and 9 floats) for an array that will be deployed at the tagging site. The value of this equipment is estimated at $63k.

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ONLINE RESOURCES

https://workspace.aoos.org/group/3503/project/283150/files

HerringTaggingLog_2012.csv

HerringTaggingLog_2013.csv

AcousticTaggedHerringDetections2012.csv

AcousticTaggedHerringDetections2013.csv

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$121.5	$139.9	$135.6	$138.1	$0.0	$535.0	
Travel	$1.2	$1.2	$1.2	$1.2	$0.0	$4.6	
Contractual	$23.6	$46.3	$47.6	$2.8	$0.0	$120.3	
Commodities	$118.7	$80.5	$5.0	$0.1	$0.0	$204.3	
Equipment	$5.9	$0.0	$0.0	$0.0	$0.0	$5.9	
Indirect Costs (*will vary by proposer*)	$ 79.5	$ 80.3	$ 56.8	$ 42.6	$0.0	$259.3	
SUBTOTAL	$350.3	$348.1	$246.2	$184.7	$0.0	$1,129.4	
General Administration (9% of	$31.5	$31.3	$22.2	$16.6	$0.0	$101.6	N/A
PROJECT TOTAL	$381.9	$379.5	$268.3	$201.4	$0.0	$1,231.0	
Other Resources (Cost Share Funds)	$15.0	$15.0	$15.0	$15.0		$60.0	

COMMENTS:
The PWS Science Center will provide in-kind equipment (9 VR2-W acoustic receivers and 9 acoustic releases) for an array that will be deployed around the tagging site. The value of this equipment is estimated at $63k. This project also uses the Ocean Tracking Network, a series of acoustic arrays installed at the entrances to PWS (in place at Hinchinbrook Entrance, Montague Strait, and 4 southwestern Prince William Sound passages. The current value of these Ocean Tracking Network acoustic arrays is estimated at $337k (not including the FY16 additions funded by EVOS). This project also piggy-backs on the annual Ocean Tracking Network maintenance cruise (funded by AOOS beginning in FY17) which includes 5d@$3/k day.

FY17-21

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

NON-TRUSTEE AGENCY SUMMARY PAGE

Date Prepared: 08.24.16

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
S. Lewandoski	Research Assistant	9.0	5.9		53.1
M.A. Bishop	Principal Investigator	6.0	11.4		68.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	17.3	0.0	
				Personnel Total	$121.5

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
EVOS Herring PI meeting	0.4	1	3	0.3	1.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.2

FY17

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08.24.16

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
network & software subscriptions $100/staff mo	1.5
communications (phone & fax) $50/staff mo	0.7
printing & copying $25/staff mo	0.4
vessel charter 7d @ $3k/d	21.0
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$23.6

Commodities Costs:	Commodities
Acoustic Tags (210@ $350/ea)	73.5
Mooring Supplies (lines, shackles)	1.5
Capture & Tagging Supplies	3.0
Vr2AR (8@ $4000)	32.0
Vr2AR flotation collar (8@ $450)	3.6
Floats (16*$150)	2.4
VR2AR lug replacement kits (8@ $60 ea)	0.5
VHTX Transponding hydrophone 1 @ $2200	2.2
Commodities Total	$118.7

FY17

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08.24.16

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
VR100-200 Active Tracking Receiver	1.0	5.9	5.9
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$5.9

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Acoustic Modem (Ocean Tracking Network)	1	OTN
Vemco VR 4 Receivers (Ocean Tracking Network Arrays)	27	OTN
Vemco VR 2W Receivers (Ocean Tracking Network Arrays)	7	OTN
MFE Acoustic Releases (Ocean Tracking Network Arrays)	7	OTN
Vemco VR 4 Receivers (Ocean Tracking Network Arrays)	9	EVOS
Vemco VR 2W Receivers (Ocean Tracking Network Arrays)	7	EVOS
MFE Acoustic Releases (Ocean Tracking Network Arrays)	7	EVOS

FY17

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08.24.16

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
S. Lewandoski	Research Assistant	9.5	6.1		58.0
M.A. Bishop	Principal Investigator	7.0	11.7		81.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	17.8	0.0	
				Personnel Total	$139.9

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
EVOS Herring PI meeting	0.4	1	3	0.3	1.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.2

FY18

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08.24.16

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
network & software subscriptions $100/staff mo	1.7
communications (phone & fax) $50/staff mo	0.8
printing & copying $25/staff mo	0.4
vessel charter 14d @ $3.1k/d	43.4
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$46.3

Commodities Costs: Description	Commodities Sum
Acoustic Tags (210@ $350/ea)	73.5
Mooring Supplies (lines, shackles)	2.5
Capture & Tagging Supplies	4.5
Commodities Total	$80.5

FY18

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08.24.16

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Acoustic Modem (Ocean Tracking Network)	1	OTN
Vemco VR 4 Receivers (Ocean Tracking Network Arrays)	27	OTN
Vemco VR 2W Receivers (Ocean Tracking Network Arrays)	7	OTN
MFE Acoustic Releases (Ocean Tracking Network Arrays)	7	OTN
Vemco VR 4 Receivers (Ocean Tracking Network Arrays)	9	EVOS
Vemco VR 2W Receivers (Ocean Tracking Network Arrays)	7	EVOS
MFE Acoustic Releases (Ocean Tracking Network Arrays)	7	EVOS

FY18

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08.24.16

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
S. Lewandoski	Research Assistant	9.0	6.4		57.6
M.A. Bishop	Principal Investigator	6.5	12.0		78.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	18.4	0.0	
				Personnel Total	$135.6

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
EVOS Herring PI meeting	0.4	1	3	0.3	1.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.2

FY19

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08.24.16

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
network & software subscriptions $100/staff mo	1.6
communications (phone & fax) $50/staff mo	0.8
printing & copying $25/staff mo	0.4
vessel charter 14d @ $3.2k/d	44.8
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$47.6

Commodities Costs: Description	Commodities Sum
Mooring Supplies (lines, shackles)	2.0
Capture & Tagging Supplies	3.0
Commodities Total	$5.0

FY19

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08.24.16

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Acoustic Modem (Ocean Tracking Network)	1	OTN
Vemco VR 4 Receivers (Ocean Tracking Network Arrays)	27	OTN
Vemco VR 2W Receivers (Ocean Tracking Network Arrays)	7	OTN
MFE Acoustic Releases (Ocean Tracking Network Arrays)	7	OTN
Vemco VR 4 Receivers (Ocean Tracking Network Arrays)	9	EVOS
Vemco VR 2W Receivers (Ocean Tracking Network Arrays)	7	EVOS
MFE Acoustic Releases (Ocean Tracking Network Arrays)	7	EVOS
Vemco VR2AR Receiver w acoustic release	8	EVOS

FY19

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08.24.16

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
S. Lewandoski	Research Assistant	9.0	6.6		59.4
M.A. Bishop	Principal Investigator	6.5	12.1		78.7
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	18.7	0.0	
				Personnel Total	$138.1

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
EVOS Herring PI meeting	0.4	1	3	0.3	1.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.2

FY20

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08.24.16

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
network & software subscriptions $100/staff mo	1.6
communications (phone & fax) $50/staff mo	0.8
printing & copying $25/staff mo	0.4
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$2.8

Commodities Costs: Description	Commodities Sum
supplies	0.1
Commodities Total	$0.1

FY20

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08.24.16

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Acoustic Modem (Ocean Tracking Network)	1	OTN
Vemco VR 4 Receivers (Ocean Tracking Network Arrays)	27	OTN
Vemco VR 2W Receivers (Ocean Tracking Network Arrays)	7	OTN
MFE Acoustic Releases (Ocean Tracking Network Arrays)	7	OTN
Vemco VR 4 Receivers (Ocean Tracking Network Arrays)	9	EVOS
Vemco VR 2W Receivers (Ocean Tracking Network Arrays)	7	EVOS
MFE Acoustic Releases (Ocean Tracking Network Arrays)	7	EVOS
Vemco VR2AR Receiver w acoustic release	8	EVOS

FY20

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08.24.16

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs: Name	Project Title	Months Budgeted	Monthly Costs	Overtime	Personnel Sum
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	0.0	0.0	
				Personnel Total	$0.0

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Travel Sum
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

FY21

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08.24.16

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description		Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required.	**Contractual Total**	$0.0

Commodities Costs: Description		Commodities Sum
	Commodities Total	$0.0

FY21

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08.24.16

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY21

Project Title: Annual Herring Migration Cycle
Primary Investigator: Mary Anne Bishop

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08.24.16

Response to Reviewers: 17120111-C Modeling and Stock Assessment of PWS herring, P.I. Branch

EVOS Science Panel Comments
This is a well-written proposal that clearly shows the linkages with most of the other projects. The proposal lists six tasks, that are listed below (in Italics), with some short comments from the Science Panel on each.
(1) maintenance and updating of the new Bayesian age-structured assessment (BASA) model based on the ASA model used by ADF&G, including annual assessment updates of PWS herring and the revision of BASA to fit to new data sources such as the age-0 aerial survey, condition data, and updated age at maturity.
The Panel wondered what was meant by 'condition data'. Does this refer to the estimates of condition that can be derived from ASL data or does it refer to something else?

RESPONSE: the condition data are the data collected by Thomas Kline looking at over-winter survival of age-0 herring in Prince William Sound, including the condition of the fish during and after winter. The energy stores (condition) of these herring was a good predictor of over-winter survival.

Also, we assume that the updated maturity data would come from the Gorman proposal. The Panel also had some discussion on the benefits of new information on size-at-maturity and age-at-maturity or both for BASA. Regarding maturity data, we repeat that there is broad evidence of temporal and spatial structuring of herring on spawning grounds, and sometimes even in over-wintering areas. During spawning, larger, older fish tend to spawn earliest, and perhaps even at different locations than younger fish. Sampling during the spawning time can lead to bias in estimates of age composition, and may lead to errors in assumptions about age-at-maturity. Therefore, the Panel endorses the approach to provide empirical estimates of age-at-maturity with such temporal and spatial structuring in mind (also see Panel comments on Gorman proposal).

RESPONSE: the model is flexible and can handle changing estimates of age at maturity over time, from the Gorman proposal and any other source that might arise over the next five years. However, modeling spatial structure of herring among different spawning grounds is a much larger task beyond the scope of the current model.

(2) Adapting the BASA model to better model the disease component of natural mortality. Specifically, this would be based on new methods for detecting antibodies of viral hemorrhagic septicemia virus (VHSV) in archival and planned future collections of herring serum.
The Panel endorses this task.

RESPONSE: this task is retained.

(3) Continued collection and expansion of catch, biomass, and recruitment time series from all herring populations around the world to place the lack of recovery of PWS herring into context given patterns of change in herring populations around the world.
The Panel is puzzled and perhaps ambivalent about this. This seems like a worthy task but the implications for PWS seem remote. Providing that this task is not a big-ticket item, it does not present any issues, although it is not clear why this needs to be shown as a distinct task, when it could have been conducted sub-rosa.

RESPONSE: much of this work has already been completed in the first five years, but we believe this work is crucial in interpreting the decline and failure to recover of Prince William Sound herring. In addition to the value of this work towards obtaining a PhD for the graduate student involved, there are two main reasons to retain this part of the project: 1) The potential to develop informative priors for model parameters, based on data from other herring populations. 2) To understand whether the collapse is linked to factors peculiar to Prince William Sound or not. In other words, was the collapse particularly severe, or the period of lack of recovery exceptionally long compared to other herring populations. If not, Prince William Sound herring might just be undergoing natural long-term fluctuations experienced by all herring populations.

(4) An initial exploration of factors that may be used to predict herring recruitment, including oceanography, climate, competition, and predation.
The Panel strongly endorses this task.

RESPONSE: this is retained.

(5) A management strategy evaluation to test alternative harvest control rules for managing the fishery in the future, given realistic variability in productivity over time, and the possibility that the population has moved into a low productivity regime. Ecological, economic and social factors would be considered in the MSE.
The Panel does not foresee the resumption of active herring fisheries in PWS anytime in the near future. Therefore while this task may have eventual worth, it belongs closer to the back-burner than the front.

RESPONSE: our evaluation of other herring stocks shows that nearly all recovered in less than 20 years. Thus there is a good possibility that Prince William Sound herring stock will recover in the next five years, and we should plan ahead for the resumption of the fishery. This MSE will provide a long-term strategic examination of current management rules for when the day of recovery is at hand, and be useful for ADF&G in managing other Alaskan stocks.

(6) Simulations to evaluate which data sources are the most useful in assessing future herring biomass, based on an MSE of the impact of each form of data on the accuracy of the BASA model.
We recommend caution. While it may be sensible to proceed with data evaluation, it also is essential to have a concurrent examination of the efficacy and integrity of some of the key databases used in the assessment model. In particular the factors that might affect the time series of acoustics data have not been well explained in any document to date. Similar comments might be made about some other types of data used in the assessment model (see comments made in response to the Moffitt and Gorman proposals).

RESPONSE: this section is now removed from the proposal.

The proposal would also benefit from a discussion of how this model could be transferred to ADFG for their future use.

RESPONSE: the model is available on the data portal, and is ready for use by ADF&G. The best course of action would probably be a workshop with herring assessment scientists to provide training on how to run this model, since it is implemented in AD Model Builder.

Appendix C

meEVOSTC FY17-FY21 INVITATION FOR PROPOSALS
PROGRAM PROJECT PROPOSAL SUMMARY PAGE

Project Title

Modeling and stock assessment of Prince William Sound herring

Primary Investigator(s) and Affiliation(s)

Trevor A. Branch, Associate Professor, School of Aquatic and Fishery Sciences, University of Washington/

Date Proposal Submitted

August 12, 2016

Project Abstract

Prince William Sound (PWS) herring collapsed shortly after the Exxon Valdez oil spill, and has yet to recover. Here, we propose a modeling component to the long-term herring monitoring project, which has as its chief goal an understanding of the current status of PWS herring, the factors affecting its lack of recovery, and an assessment of research and fishery needs into the future, with the following key products:

1. The core product of the modeling project is the maintenance and updating of the new Bayesian age-structured assessment (BASA) model based on the ASA model used by ADF&G, including annual assessment updates of PWS herring and the revision of BASA to fit to new data sources such as the age-1 aerial survey, condition data, and updated age at maturity.
2. Adapting the BASA model to better model the disease component of natural mortality. Specifically, this would be based on new methods for detecting antibodies of viral hemorrhagic septicemia virus (VHSV) in archival and planned future collections of herring serum.
3. Continued collection and expansion of catch, biomass, and recruitment time series from all herring populations around the world to place the lack of recovery of PWS herring into context given patterns of change in herring populations around the world.
4. An initial exploration of factors that may be used to predict herring recruitment, including oceanography, climate, competition, and predation.
5. A management strategy evaluation to test alternative harvest control rules for managing the fishery in the future, given realistic variability in productivity over time, and the possibility that the population has moved into a low productivity regime. Ecological, economic and social factors would be considered in the MSE.

EVOSTC Funding Requested *(must include 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
$124.3	**$124.8**	**$135.3**	**$139.9**	**$148.9**	**$673.2**

Non-EVOSTC Funding Available

FY17	FY18	FY19	FY20	FY21	TOTAL

Please refer to the Invitation for the specific proposal requirements for each Focus Area. The information requested in this form is in addition to the information requested in each Focus Area and by the Invitation.

Appendix C

1. Executive Summary

Identify the hypotheses the project is designed to address. Describe the background and history of the problem. Include a scientific literature review that covers the most significant previous work history related to the project. Please provide a summary of the project including key hypotheses and overall goals.

The herring modeling project is intended to improve predictive models of Prince William Sound herring through synthesizing the data collected by the other components of the overall herring monitoring project and hence assessing the current status of the population.

Background, history and literature review

Muradian (2015, MS thesis) reviewed the available literature during the first five years of the long-term herring monitoring project; a brief summary is included here. PWS herring are the key forage fish species in Prince William Sound, and have been harvested commercially for at least a century, with catches over 40,000 t in the 1930s (Muradian 2015). After the Exxon Valdez oil spill in 1989, which occurred during a period of high herring abundance, the herring population remained high for three years until collapsing in 1992-3 (Quinn et al. 2001). Since then, the fishery has been closed, except for a brief period during 1996-98. The fishery is managed by ADF&G which keeps the fishery closed if the pre-fishery spawning biomass is less than 22,000 short tons (19,958 mt), has the discretion to set a catch limit of 0-20% if the spawning biomass is 22,000–42,500 short tons, and may open the fishery with a catch limit of 20% of the pre-fishery spawning biomass if this is over 42,500 short tons (Muradian 2015).

The fishery was initially managed using an index of male spawning biomass until 1988 when an age-structured assessment model (the “ASA Model”) was developed that fitted to catch-at-age data and mile-days-of-milt, and used egg deposition data as an absolute estimate of biomass (Funk and Sandone 1990). Later developments included the incorporation of disease data to explain the rapid declines in the population in 1992 (Marty et al. 2003, Marty et al. 2010, Quinn et al. 2001). As hydroacoustic survey biomass estimates became seen as more reliable, they too were added to the model, helping to address the conflict between the trends in mile-days-of-milt and the egg deposition data (Hulson et al. 2008); and a Ricker stock-recruit relation was added to the model to stabilize estimates of recruitment (Hulson et al. 2008). The current version of the ASA model is based on this model, and is used by ADF&G to conduct annual stock assessments. The model is fit to the data by minimizing sums of squares using Solver in Excel.

In the first five years of the herring monitoring program, an updated version of the ASA model was developed at the University of Washington by Melissa Muradian, as outlined in Muradian (2015) and Muradian et al. (in review). The key new features included (1) a translation of the model into AD Model Builder (Fournier et al. 2012), (2) the use of likelihoods to allow a natural statistical weighting of data sets instead of sums of squares, (3) freely estimating recruitment in each year instead of using a Ricker stock-recruit relation, since the data did not support a Ricker model, (4) converting the model to a Bayesian model to allow statistically-based estimates of uncertainty in model parameter estimates and estimated biomass (e.g. Punt and Hilborn 1997). This Bayesian version of the ASA model (which we name “BASA”) provides similar median estimates of pre-spawning biomass as the ADF&G ASA model, but also reports uncertainty in model estimates, as can be seen in model fits to the survey time series (Fig 1) and numbers-at-age data (Fig 2) from 2015 runs of the model by John Trochta (the current graduate student who took over the project after Melissa Muradian graduated). The new BASA model is the underlying basis for our proposal for the next five years of the long-term herring monitoring project.

Appendix C

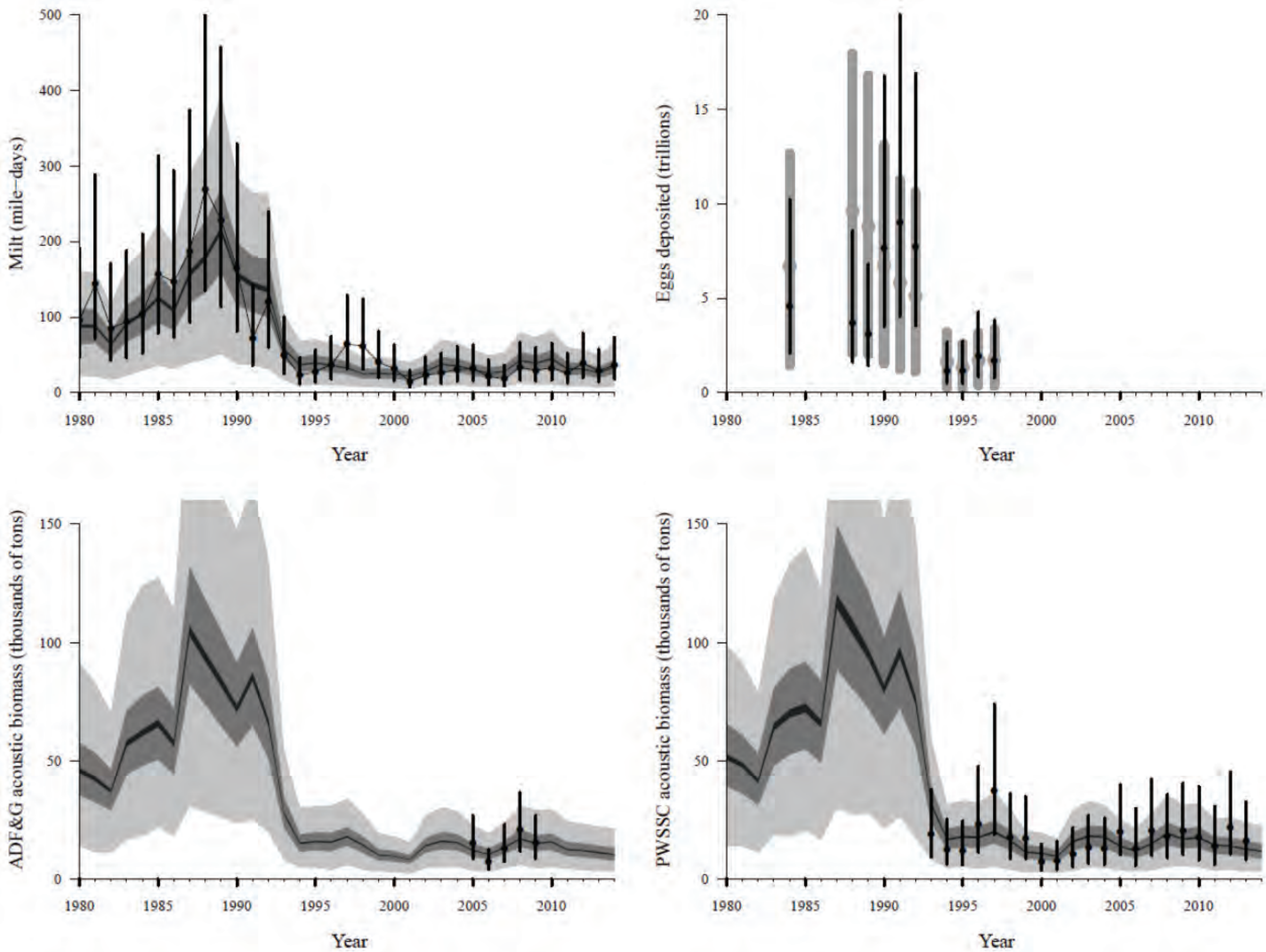

Figure 1 The 2015 Bayesian age-structured assessment (BASA) model estimates of Prince William Sound herring biomass fitted to the four main time series of biomass. Shaded polygons are the model-estimated posterior predictive intervals: 5th percentiles (black), 50th percentiles (dark gray) and 95% percentiles (light gray). Solid circles are the median of the data, and lines are the 95th percentiles including additional variance estimated by the model. Source: John Trochta, using the model described in Muradian (2015).

Appendix C

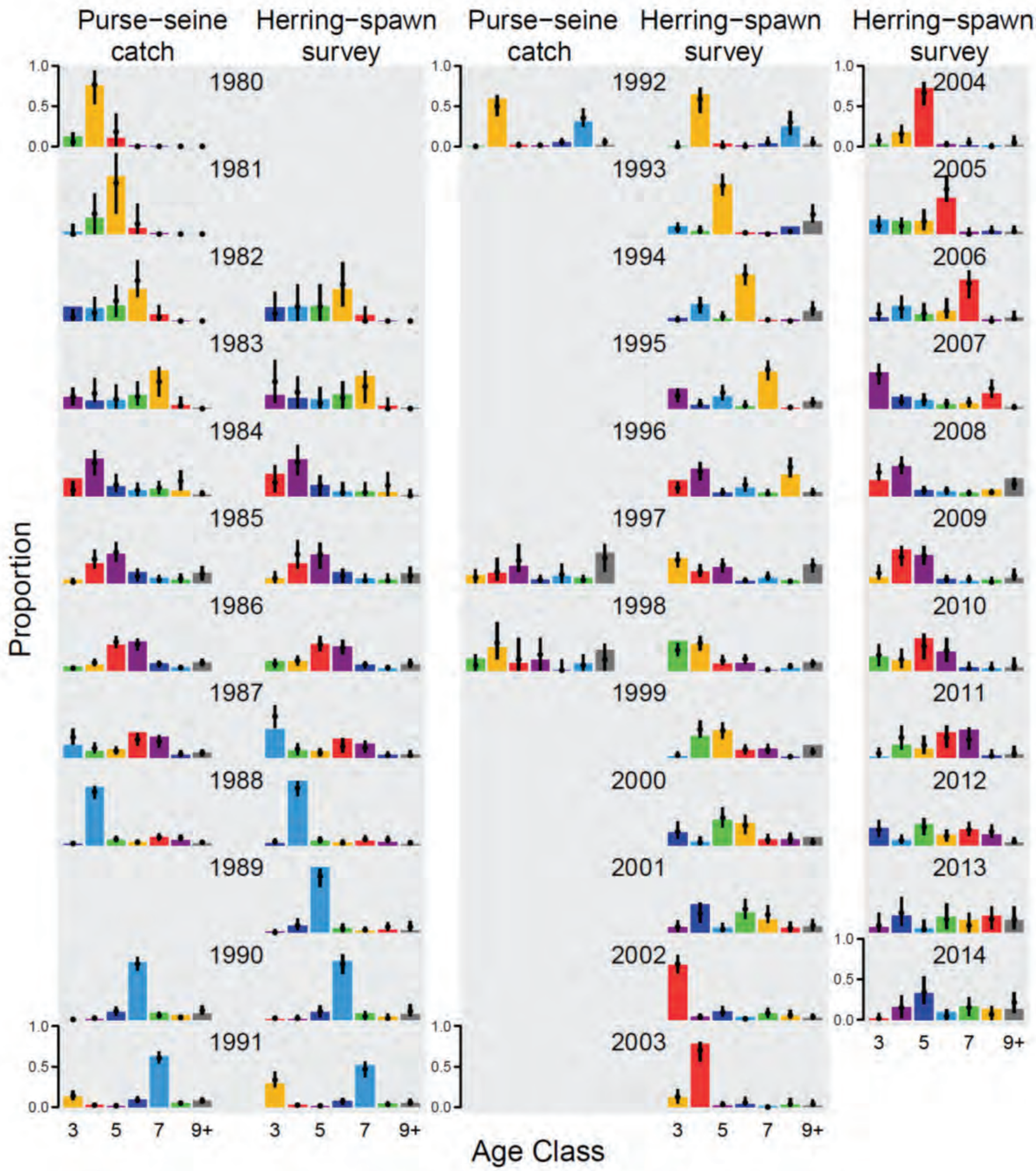

Figure 2. The 2015 Bayesian age-structured assessment (BASA) model fits to the age composition data from purse-seine catches and from the ADF&G herring-spawn survey. Colors track individual cohorts over time, while points and lines indicate the model posterior median and 95% posterior intervals. Source: John Trochta, using the model described in Muradian (2015).

Summary of project: Over the next five years, the BASA model will be revised and updated to provide an annual stock assessment of PWS herring to complement the ADF&G herring assessment. Updates will include model fits to new data sources and a more realistic disease component. We will continue the expansion of the database of herring abundance catch, and recruitment time series to place PWS in context of global trends in herring stocks. We will examine environmental factors that might predict herring recruitment. Finally, we will conduct management strategy evaluations to test alternative harvest control rules for managing the fishery; and evaluate which future data sources will be the most cost-effective at improving the accuracy of the BASA model.

2. Relevance to the Invitation for Proposals

Discuss how the project addresses the projects of interest listed in the Invitation and the overall Program goals and objectives. Describe the results you expect to achieve during the project, the benefits of success as they relate to the topic under which the proposal was submitted, and the potential recipients of these benefits.

This proposal addresses the following topics listed for the Herring Research and Monitoring Program:

1. Overall program goal: The continued development and testing of an updated age-structured assessment (ASA) model in collaboration with ADF&G.
2. Overall program goal: Simulations to evaluate which data sources, if collected under this Invitation, would be the most useful in assessing future herring biomass, trends, and recovery.
3. A comparative retrospective analysis of data from PWS and other herring populations to assist in determining the continued lack of recovery of PWS herring populations.
4. The study of the role of disease in herring recovery.
5. The relation of herring recruitment and abundance to physical and biological oceanographic factors and food web drivers.
6. The inclusion of new estimates of herring age-at-maturity within the ASA model estimates.
7. The development of the model, as in the first five years, can be used to assess the relative likelihood of different hypotheses affecting PWS herring, including those noted in the call for proposals: humpback whale trends, extractive fishing, and fish aquaculture.

3. Project Personnel

The CV's of all principal investigators and other senior personnel involved in the proposal must be provided. Each resume is limited to two consecutively numbered pages and must include the following information:

- A list of professional and academic credentials, mailing address, and other contact information (including e-mail address)
- A list of up your most recent publications most closely related to the proposed project and up to five other significant publications. Do not include additional lists of publications, lectures, etc.
- A list of all persons (including their organizational affiliations) in alphabetical order with whom you have collaborated on a project or publication within the last four years. If there have been no collaborators, this should be indicated.

Prof. Trevor A. Branch will be the lead PI on the herring assessment and modeling project. He will be responsible for coordination, writing proposals and reports, developing new models, and be the contact person for the proposal. He is requesting one month of salary per year of the proposal. Prof. Branch also served as the PI for the modeling portion of the first five years of the HRM program.

A PhD graduate student, likely John Trochta, will dedicate 12 months per year to the project. The student will implement and run the Bayesian stock assessment, conduct and organize datasets, and upload data to the data management system. John Trochta has been working on the project as his MS degree for the last 1.5 years and has a detailed knowledge of the system and the assessment model. The PI and student will jointly write scientific papers, attend meetings, and coordinate with the other HRM partners, Gulf Watch, and other affected parties.

Appendix C

Résumé: Trevor A. Branch, PI

School of Aquatic and Fishery Sciences, Box 355020, University of Washington, Seattle WA, 98195 email: tbranch@uw.edu, phone: 206-221-0776

Academic credentials

University of Washington	Aquatic and Fishery Sciences	PhD	2004
University of Cape Town	Conservation Biology	MSc	1998
University of Cape Town	Zoology	BSc(Hons)	1995
University of Cape Town	Zoology, Computer Science	BSc	1994

Recent appointments

2015–present	Associate Professor, School of Aquatic and Fishery Sciences, Univ. of Washington
2010–2015	Assistant Professor, School of Aquatic and Fishery Sciences, Univ. of Washington
2006–2010	Research Scientist, School of Aquatic and Fishery Sciences, Univ. of Washington
2005–2006	Research Scientist, Marine Resource Assessment and Management Group, Department of Mathematics and Applied Mathematics, Univ. of Cape Town

Five most relevant publications

Hillary RM, Preece AL, Davies CR, Kurota H, Sakai O, Itoh T, Parma AM, Butterworth DS, Ianelli J, Branch TA (2016) A scientific alternative to moratoria for rebuilding depleted international tuna stocks. Fish and Fisheries doi: 10.1111/faf.12121

Szuwalski CS, Vert-pre KA, Punt AE, Branch TA, Hilborn R (2015) Examining common assumptions about recruitment: a meta-analysis of recruitment dynamics for worldwide marine fisheries. Fish and Fisheries 16:633-648

Hilborn R, Hively DJ, Jensen OP, Branch TA (2014) The dynamics of fish populations at low abundance and prospects for rebuilding and recovery. ICES Journal of Marine Science 71:2141-2151

Stachura MM, Essington TE, Mantua NJ, Hollowed AB, Haltuch MA, Spencer PD, Branch TA, Doyle MJ (2014) Linking Northeast Pacific recruitment synchrony to environmental variability. Fisheries Oceanography 23:389-408

Branch TA, Jensen OP, Ricard D, Ye Y, Hilborn R (2011) Contrasting global trends in marine fishery status obtained from catches and from stock assessments. Conservation Biology 25:777-786

Five other significant publications (*n* = 68)

Branch TA, Watson R, Fulton EA, Jennings S, McGilliard CR, Pablico GT, Ricard D, Tracey SR (2010) The trophic fingerprint of marine fisheries. Nature 468:431-435

Branch TA, Lobo AS, Purcell SW (2013) Opportunistic exploitation: an overlooked pathway to extinction. Trends Ecol Evol 28:409-413

Branch TA, Hively DJ, Hilborn R (2013) Is the ocean food provision index biased? Nature 495:E5-E6

Sethi SA, Branch TA, Watson R (2010) Fishery development patterns are driven by profit but not trophic level. Proc Natl Acad Sci USA 107:12163-12167

Worm B et al. (2009) Rebuilding global fisheries. Science 325:578-585

Synergistic activities

1. Elected as Fellow of the American Institute of Fishery Research Biologists (2014).
2. Outstanding Researcher award for the College of the Environment, University of Washington (2013).
3. Ecological Society of America Sustainability Science Award (2011).
4. Aldo Leopold Fellow (2013) “to provide researchers with the skills, approaches, and theoretical frameworks for translating their knowledge to action and for catalyzing change to address the world's most pressing sustainability challenges.”
5. Invited participant, Scientific Committee of the International Whaling Commission, 2000-08,15-16.

Appendix C

Collaborators and coauthors in the last 48 months (n = 177)

Acevedo-Whitehouse, K (UK), Agnew, D (UK), Ahrens, R (Univ Florida), Alagiyawadu, A (Sri Lanka), Allison, C (UK), Altweg, R (South Africa), Anderson, RC (Maldives), Anderson, SC (Simon Fraser Univ), Andrews-Goffs, V (Australia), Atkinson, S (Univ Alaska), Austin, J (Univ Florida), Baker, CS (Oregon State Univ), Baldwin, R (Oman), Balk, MA (Univ New Mexico), Barlow, J (NOAA), Baum, JK (Univ Victoria, Canada), Bell, RJ (Univ Rhode Island), Bellman, MA (NOAA), Benfield, MC (Louisiana State Univ), Berchok, CL (NOAA), Bianci, PL (UC Santa Barbara), Bonhommeau, S (France), Boveng, PL (NOAA), Brodziak, JKT (NOAA), Brownell, RL (NOAA), Butterworth, DS (South Africa), Cabral, B (UC Santa Barbara), Chassot, E (France), Chen, C (Duke Univ), Clavelle, T (UCSB), Collie, JS (Univ Rhode Island), Cooper, AB (Simon Fraser Univ), Cope, JM (NOAA), Cornejo-Donoso, J (Chile), Cosgrove, J (Canada), Costello, C (UC Santa Barbara), Cruz, E (NOAA), Cunningham, CJ (Univ Alaska), Davies, CR (Australia), DaVolls, L (UK), Defeo, O (Uruguay), deJoseph, B (UW), Double, MC (Australia), Dove, ADM (Georgia Aquarium), Doyle, MJ (UW), Dubroca, L (France), Dulvy, NK (Simon Fraser Univ), Dziak, RP (NOAA), Emmons, CK (NOAA), Essington, TE (UW), Evans, DM (UK), Fogarty, MJ (NOAA), Fromentin, JM (France), Gaines, S (UCSB), Gales, N (Australia), Garner, TWJ (UK), Gaskins, LC (Duke Univ), Gedamke, J (NOAA), Gendron, D (Mexico), Gerrodette, T (NOAA), Giles, DA (UC Davis), Gompper, ME (Univ Missouri), Gordon, IJ (UK), Guinet, C (France), Guttierrez, NL (UK), Haltuch, MA (NOAA), Harley, SJ (New Caledonia), Haynie, AC (NOAA), Hancock-Hanser, B (NOAA), Hanson, MB (NOAA), Helm, RR (Brown Univ), Heppell, SS (Oregon State Univ), Hilborn, R (UW), Hillary, R (Australia), Hively, DJ (UW), Hochberg, FGE (Santa Barbara Mus Nat Hist), Hogans, JT (Cascadia Research), Hoggarth, DD (UK), Hollowed, A (NOAA), Holt, MM (NOAA), Hospital, J (NOAA), Houghton, J (UW), Hulson, PJF (NOAA), Ianelli, J (NOAA), Itoh, T (Japan), Ivashchenko, YV (NOAA), Jenner, KCS (Australia), Jenner, M-N (Australia), Jensen, OP (Rutgers Univ), Johnson, JA (Univ N Texas), Kamikawa, KT (Univ Hawaii), Kaplan, D (France), Karachle, PK (Greece), Katzner, TE (W Virginia Univ), Kell, LT (Spain), Kendall, NW (UW), Kleiber, D (Univ British Columbia), Kuriyama, PT (UW), Kurota, H (Japan), Laidre, KL (UW), Larsen, A (UC Santa Barbara), Laverick, S (Australia), LeDuc, RL (NOAA), Lee FB (Duke Univ), Leland, A (Env Defense Fund), Le Paper, O (France), Link, JS (NOAA), Linnell, AE (Miami), Lobo, AS (India), Lotze, HK (Dalhousie Univ), MacIntyre, KQ (UW), Mantua, NJ (NOAA), Marsac, F (South Africa), Marshall, A (Mar Megafauna Foundn), Martell, SJD (Int Pac Halibut Comm), Mashburn, KL (Univ Alaska), Matsuoka, K (Japan), Maunder, MN (IATTC), McClain, CR (Natl Evol Synth Center), McMurray, SE (Univ North Carolina), Melnychuk, MC (UW), Minto, C (Ireland), Miyashita, T (Japan), Moffitt, SD (ADF&G), Monnahan, CC (UW), Muradian, M (UW), Nieblas, A-E (France), Ninnes, C (UK), Oleson, EM (NOAA), Ovando, D (UCSB), Palacios, DM (NOAA), Palomares, MLD (Univ British Columbia), Parma, AM (Argentina), Pettorelli, N (UK), Pons, M (UW), Pope, JG (UK), Preece, AL (Australia), Punt, AE (UW), Purcell, SW (Australia), Ranjan, R (India), Rantanen, E (UK), Rader, DN (Env Defense Fund), Ray, L (UW), Restrepo, VR (ISSF), Ricard, D (Czech Republic), Royer, J-Y (France), Rudd, MB (UW), Rutherford, K (Canada), Sainsbury, K (Australia), Sakai, O (Japan), Samaran, F (France), Saraux, C (France), Schanche, C (Duke Univ), Selden, RL (UC Santa Barbara), Sharma, R (Seychelles), Sistla, S (UC Santa Barbara), Smith, ADM (Australia), Spencer, PD (NOAA), Sremba, A (Oregon State Univ), Stachura, MM (UW), Stafford, KM (UW), Stawitz, CC (UW), Stern-Pirlot, A (UK), Stewart, IJ (NOAA), Stone, SN (Duke Univ), Strauss, CK (Env Defense Fund), Szuwalski, CS (UW), Teck, SJ (UC Santa Barbara), Thaler, AD (Blackbeard Biologic), Thorson, JT (UW), Valencia, SR (UC Santa Barbara), VanBlaricom, GR (UW), Vert-Pre, KA (UW), Wagner, C (UW), Watson, R (Australia), Williams, NE (Australia), Worm, B (Dalhousie Univ)

Graduate advisors: Douglas S. Butterworth and John G. Field, University of Cape Town (MSc); Ray Hilborn, University of Washington (PhD)

Thesis/postdoc advisor (last five years): Cole Monnahan (MS, PhD), Melissa Muradian (MS), Peter Kuriyama (PhD), Merrill Rudd (PhD), John Trochta (MS), Matthew Baker (postdoc), Sean Anderson (postdoc), Lewis Barnett (postdoc). Total graduate students: 5, postdocs: 3.

Appendix C

4. Project Design

A. Objectives

List the objectives of the proposed research and briefly state why the intended research is important. If your proposed project builds on recent work, provide detail on why the data set needs to be continued and whether any changes are proposed. If the proposed project is for new work, explain why the new data is needed. Describe the anticipated final product.

B. Procedural and Scientific Methods

For each objective listed in A. above, identify the specific methods that will be used to meet the objective. In describing the methodologies for collection and analysis, identify measurements to be made and the anticipated precision and accuracy of each measurement and describe the sampling equipment in a manner that permits an assessment of the anticipated raw-data quality.

If applicable, discuss alternative methodologies considered, and explain why the proposed methods were chosen. In addition, projects that will involve the lethal collection of birds or mammals must comply with the EVOSTC's policy on collections, available on our website www.evostc.state.ak.us

C. Data Analysis and Statistical Methods

Describe the process for analyzing data. Discuss the means by which the measurements to be taken could be compared with historical observations or with regions that are thought to have similar ecosystems. Describe the statistical power of the proposed sampling program for detecting a significant change in numbers. To the extent that the variation to be expected in the response variable(s) is known or can be approximated, proposals should demonstrate that the sample sizes and sampling times (for dynamic processes) are of sufficient power or robustness to adequately test the hypotheses. For environmental measurements, what is the measurement error associated with the devices and approaches to be used?

D. Description of Study Area

Where will the project be undertaken? Describe the study area, including, if applicable, decimally-coded latitude and longitude readings of sampling locations or the bounding coordinates of the sampling region (e.g., 60.8233, -147.1029, 60.4739, -147.7309 for the north, east, south and west bounding coordinates).

A. Objectives

1. Maintain and update the new Bayesian age-structured assessment (BASA) model based on the ASA model used by ADF&G.
2. Adapting the BASA model to better model viral hemorrhagic septicemia virus (VHSV) disease epidemics.
3. Expand database of global herring catch, biomass, and recruitment time series to place the lack of recovery of PWS herring into context.
4. Explore factors that might predict herring recruitment.
5. Develop a management strategy evaluation to test alternative harvest control rules for managing the fishery in the future

These objectives aim at continually improving our efforts at assessing the current status of PWS herring. The model development and database of global herring build on previous work and is central to understanding current status and putting this in context of global herring stocks. Expanding data collection improves the accuracy of this work.

The anticipated final product of this work is two-fold: (1) A PhD dissertation on these topics, or perhaps 2 MS theses depending on the level of the students applying to do this work. (2) 3-5 scientific papers describing the new results, with the number of scientific papers depending on the lines explored by the research.

Appendix C

B. Procedural and Scientific Methods

For each objective listed in A. above, identify the specific methods that will be used to meet the objective. In describing the methodologies for collection and analysis, identify measurements to be made and the anticipated precision and accuracy of each measurement and describe the sampling equipment in a manner that permits an assessment of the anticipated raw-data quality.

If applicable, discuss alternative methodologies considered, and explain why the proposed methods were chosen.

1. Maintain and update the new Bayesian age-structured assessment (BASA) model.

Method: the current BASA model is implemented in AD Model Builder, with substantial R code for handling model inputs, model outputs, and the production of figures and tables expanding on the results. AD Model builder is a flexible and extremely fast package for fitting models to data, that enables a Bayesian analysis impossible in the Excel-based ASA model. Alternative Bayesian packages now available, such as WinBUGS, JAGS, and Stan could also be used to implement BASA, but this would require substantial reprogramming, debugging, and code validation, and model performance would be worse for WinBUGS and JAGS. Therefore we have decided to make modifications to the current BASA model structure in AD Model Builder. The model is available for use by ADF&G.

2. Adapting the BASA model to better model viral hemorrhagic septicemia virus (VHSV) disease epidemics.

Method: new research by Paul Hershberger's lab at USGS includes the ability to detect antibodies to VHSV in PWS herring. Antibodies indicate that those herring were exposed to VHSV at some point in their life, which solves one of the most problematic issues with disease inclusion in the BASA and ASA models: VHSV flares up suddenly and then rapidly kills affected fish. Thus measures of current disease detection do not directly measure mortality from VHSV since surviving fish test negative for the virus. However, surviving fish can now be tested for antibody production (P. Hershberger, pers. comm.). Furthermore, samples of herring serum stored since 2012, by age, can be tested for antibodies, and differences in antibody prevalence reveal information about the disease load experienced by each cohort during the lives. Preliminary models suggest that these age-year antibody data can be used to infer the severity of disease outbreaks in each year. We plan to build a complete simulated disease model with antibody production to test whether the antibody data can indeed measure the severity disease outbreaks. If this is successful, as we expect it will be, this model component will be included in the BASA model, with the disease outbreak percent becoming a direct component of natural mortality. However, if the simulations reveal insufficient accuracy about disease outbreaks, the proposed disease model will not be included in the BASA model.

3. Expand database of global herring catch, biomass, and recruitment time series to place the lack of recovery of PWS herring into context.

Method: during the current five-year program, John Trochta has compiled an extensive database of spawning biomass and recruitment time series from stock assessments (Fig. 3), together with time series of catches. These are currently being used to assess how likely it is for an individual herring stock to collapse and fail to recover, as seen in PWS herring. In the next five years, this database will be expanded to include more recent years and herring stocks currently missing from this dataset. The database will serve as a useful resource for herring biologists and be used to obtain informative priors for parameters in the BASA model.

Appendix C

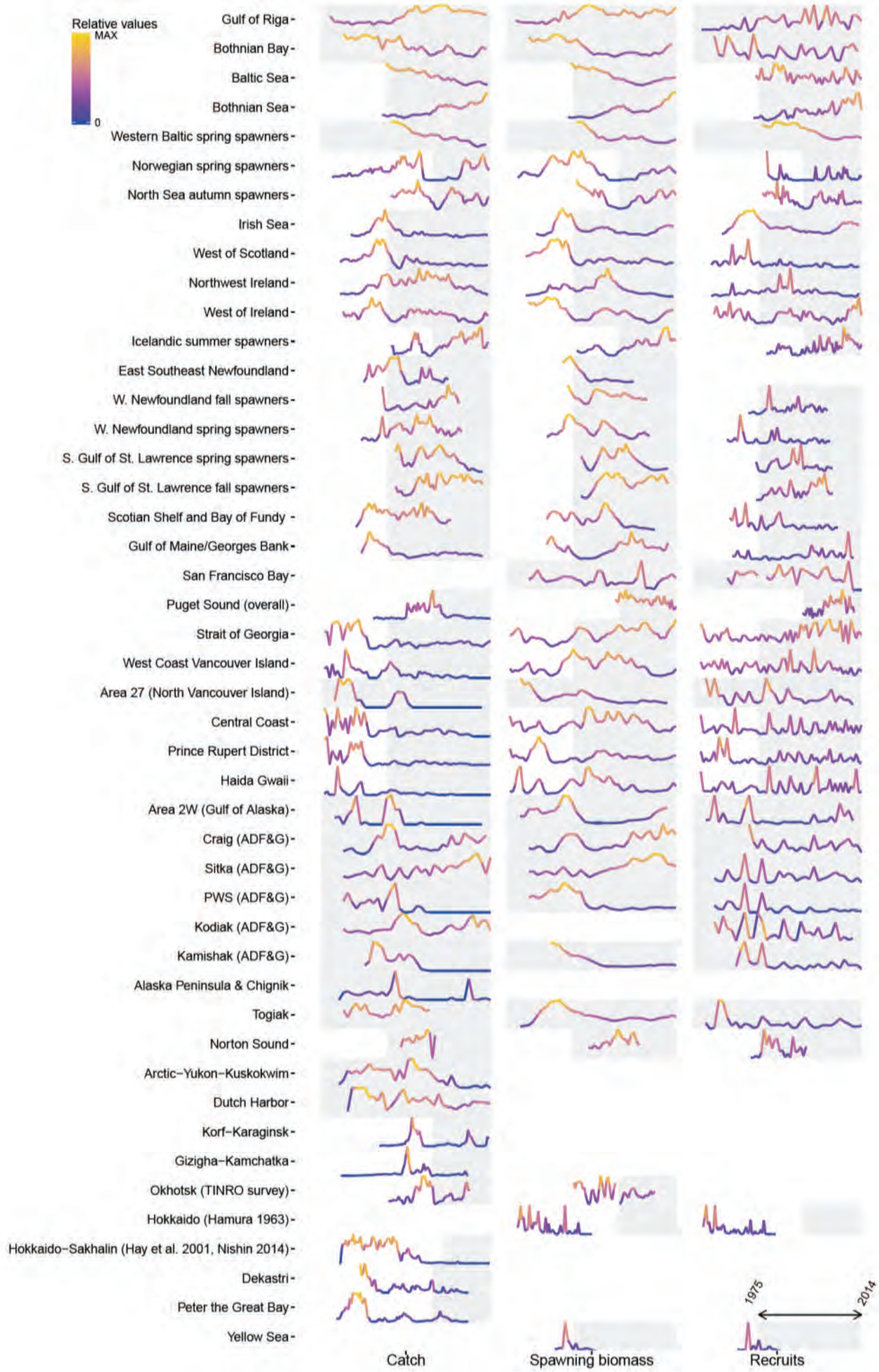

Figure 3. Time series of catch (left column), spawning biomass (middle) and recruitment (right) for 45 herring stocks, compiled by John Trochta.

4. Explore factors that might predict herring recruitment.

Method: this project could provide useful predictions of herring recruitment, but it should be noted that many previous projects attempting to predict recruitment from environmental factors have either found no correlations, or the correlations have disappeared later (Francis 2006, Walters & Collie 1988, Myers 1998). The one exception is species near the edge of the range (Myers 1998) such as PWS herring. However, PWS herring do provide a unique case study with long time series of oceanographic, biological, and climate variables that could be used as correlates. We therefore propose an initial scoping exercise using multiple regressions to see if any of the most obvious time series show strong correlations with recruitment estimated in the BASA model. Given the long time period associated with the herring monitoring program and Gulf Watch, this project has the unique opportunity to make predictions and test those predictions.

5. Develop a management strategy evaluation to test alternative harvest control rules for managing the fishery in the future

Methods: well-established methods exist for running management strategy evaluations (MSE) to test control rules for fisheries (e.g. Hillary et al. 2016, Punt et al. 2016), and efforts are underway for an MSE for Sitka Sound and Haida Gwaii by the Ocean Modeling Forum. Given the current state of the PWS herring fishery (closed for most of the last 26 years), it is possible that there exists a harvest control rule that would allow fishing at minimal risk to the stock. In addition, the herring stock appears to have entered a stable regime of low productivity and low recruitment. The current harvest control rule was tested on high and low recruitment regimes (Zheng et al. 1993). Given many years have passed since the current rule was developed, and our collection of data on global herring populations that allow for much more realistic simulations, we propose revisiting this using a new MSE. The implementation of an MSE would use the BASA model as an operating model to simulate "truth" under different scenarios; the operating model generates "data" that is fed into a control rule which sets the allowable catch the next year. Then the operating model is updated with the allowable catch and the process repeated for many years, and for many combinations of control rules. At the end, the control rules that best balance risk to the stock with catches, while being robust to uncertainty, could be put forward as possible control rules for consideration.

Note: The modeling project does not involve the lethal collection of birds and mammals.

C. Data Analysis and Statistical Methods

Sample size description is not directly relevant to the modeling objectives outlined above.

D. Description of Study Area

The project is focused on herring in the entirety of Prince William Sound.

5. Coordination and Collaboration

Within the Program

Provide a list and clearly describe the functional and operational relationships with the other program projects. This includes any coordination that has taken or will take place and what form the coordination will take (shared field sites or researchers, research platforms, sample collection, data management, equipment purchases, etc.).

With Other EVOSTC-funded Programs and Projects

Indicate how your proposed program relates to, complements or includes collaborative efforts with other proposed or existing programs or projects funded by the EVOSTC.

With Trustee or Management Agencies

Please discuss if there are any areas which may support EVOSTC trust or other agency work or which have received EVOSTC trust or other agency feedback or direction, including the contact name of the agency staff. Please include specific information as to how the subject area may assist EVOSTC trust or other agency work.

Appendix C

If the proposed project requires or includes collaboration with other agencies, organizations or scientists to accomplish the work, such arrangements should be fully explained and the names of agency or organization representatives involved in the project should be provided. If your proposal is in conflict with another project or program, note this and explain why.

With Native and Local Communities

Provide a detailed plan for any local and native community involvement in the project.

Detailed coordination is outlined in the overall project proposal. A few highlights are listed below.

Within the Program: coordination takes place through regular data transfer, emails, phone calls, and two in-person meetings per year. Each of the components of the herring plan has a close connection to the model, from the acoustic survey, to the disease work, to aerial surveys, and assessment of age at maturity.
With other EVOSTC-funded programs and projects: model inputs for oceanographic and predator data (humpback whales, etc.) will come through collaboration with the Gulf Watch program.
With Trustee or Management Agencies: input data for the assessment model (ADF&G survey, age composition, weight at age, etc.) comes from Steven Moffitt (ADF&G), which requires close coordination to understand how the data were collected and how they should be used in the model. Results are transmitted to lead ADF&G scientist such as Sherri Dressel.
With Native and Local Communities: no direct involvement is planned at this point.

6. Schedule

Program Milestones

Specify when critical program tasks will be completed. Reviewers will use this information in conjunction with annual program reports to assess whether the program is meeting its objectives and is suitable for continued funding.

Measurable Program Tasks

Specify, by each quarter of each fiscal year (February 1 – January 31), when critical program tasks will be completed.

There is considerable uncertainty in the timeline here, depending on the duration of time it takes the current graduate student to complete his MS, register for a PhD, and finish the PhD. In addition, modeling projects can be finished quickly, or if they are tricky, may take 2-3 times longer than anticipated.

FY17, 1st quarter, February 1, 2017–April 30, 2017
Initiate project, identify graduate student
FY17, 2nd quarter, end July 31, 2017
FY17, 3rd quarter, end October 31, 2017
FY17, 4th quarter, end January 31, 2018
Simulation study completed on feasibility of estimating annual VHSV infection rate from antibodies in serum.
Annual joint meeting with Gulf Watch
Annual Cordova meeting for PIs
Annual report.
Submit model results and code to Ocean Workspace and ADF&G.

FY18, 1st quarter, end April 30, 2018
Annual assessment update from BASA model
FY18, 2nd quarter, end July 31, 2018

Appendix C

FY18, 3st quarter, end October 31, 2018
Obtain antibody data from herring serum 2012-2017 for inclusion in model.
FY18, 4st quarter, end January 31, 2019
Annual joint meeting with Gulf Watch
Annual Cordova meeting for PIs
Annual report.
Submit model results and code to Ocean Workspace and ADF&G.

FY19, 1st quarter, end April 30, 2019
Update BASA model with antibody disease component
Annual assessment update from BASA model
FY19, 2st quarter, end July 31, 2019
Preliminary examinations of environmental factors affecting recruitment
Submit paper on antibody disease component
FY19, 3st quarter, end October 31, 2019
FY19, 4st quarter, end January 31, 2020
Update on global herring meta-analysis and relevance to PWS herring
Annual joint meeting with Gulf Watch
Annual Cordova meeting for PIs
Annual report.
Submit model results and code to Ocean Workspace and ADF&G.

FY20, 1st quarter, end April 30, 2020
Annual assessment update from BASA model
FY20, 2st quarter, end July 31, 2020
Submit paper on factors predicting herring recruitment (if study is conclusive)
FY20, 3st quarter, end October 31, 2020
FY20, 4st quarter, end January 31, 2021
Annual joint meeting with Gulf Watch
Annual Cordova meeting for PIs
Annual report.
Submit model results and code to Ocean Workspace and ADF&G.

FY21, 1st quarter, end April 30, 2021
Annual assessment update from BASA model
FY21, 2st quarter, end July 31, 2021
Preliminary analysis of harvest control rules.
FY21, 3st quarter, end October 31, 2021
FY21, 4st quarter, end January 31, 2022
Submit paper on harvest control rules suitable for managing herring.
Annual joint meeting with Gulf Watch
Annual Cordova meeting for PIs
Final report for five-year project.
Submit model results and code to Ocean Workspace and ADF&G.

7. Budget
Budget Forms (Attached)

Appendix C

Please provide completed budget forms. Please note that the following items will not be considered for funding:

- Costs associated with international travel for meetings, symposia, or presentations.
- Costs associated with attendance at meetings, symposia, or presentations outside of those required to coordinate with project members.
- Costs associated with outreach or education efforts.

Sources of Additional Funding

Identify non-EVOSTC funds or in-kind contributions used as cost-share for the work in this proposal. List the amount of funds, the source of funds, and the purpose for which the funds will be used. Do not include funds that are not directly and specifically related to the work being proposed in this proposal.

Budget Forms: attached as an Excel file.

Sources of additional funding: None.

Salary

PI Trevor Branch is asking for 1 month of salary per year for five years. His salary is $10,101 in 2015-16. It is assumed to increase at 4% per year for each year of the proposal, with the first year of the proposal corresponding to 2016-17. Benefits are assumed to be 25.3% throughout the proposal.
Salary is requested for 12 months a year for a PhD-level graduate student throughout the 5 years. Graduate student salary in SAFS is 2,444 starting 1 July 2016 and is assumed to increase 6% every 1 July. After 1.5 yr it is assumed the student will be PhD II rates (currently $2630/yr). Benefits are assumed to be 17.0% for all years. Note: in the submitted sponsor budget forms, the mean monthly salary over the sponsor year (1 Feb-31 Jan) is listed for each Sponsor Year.

Tuition

Tuition is $5454 per quarter in the 2016-17 UW year. It is assumed to increase 5% per year. Summer tuition is assumed to be $2000 for 2 credits. Tuition is assumed to be paid in the last two-week period of each quarter (end March, June, September, December).

Travel

One PI meeting per year is planned in Cordova over two days in November for both the PI and the graduate student. In addition, both the PI and the graduate student are budgeted to attend the 5-day AMSS meeting in Anchorage in January each year. The Total cost in Year 1 is $6428. Annual cost increases of 2% are assumed for each year. In addition, in Year 3 an additional meeting in Anchorage is required for the Joint Science Workshop to present interim research to the funders (EVOSTC). This will cost $1181×1.02 for the PI to attend.
Total travel funds requested:
Year 1: $6,428
Year 2: $6,557
Year 3: $7,918
Year 4: $6,821
Year 5: $6,958

Publication costs

One publication will be produced per year, for publication costs (including those incurred for open access and color figures) of $1500 in each of the five years.

Computers

Appendix C

Provision is made for the purchase of one new laptop ($2000) in Year 1, and one number-crunching high-powered desktop computer ($3000) in Year 1, for a total of $5000 in Year 1. No computer purchases are anticipated in the remaining years of the proposal. These do not qualify as capital equipment.

Indirect costs

University of Washington indirect cost rate is 54.5% for 07/01/2016-06/30/2017 (first part of Year 1), 55.0% for 07/01/2017-06/30/2018 (second part of Year 1 and first part of Year 2) and 55.5% for 07/01/2018-06/30/2020 (second part of Year 2 and assumed to continue to the end of Year 5).

References

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EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$48.7	$53.1	$57.2	$60.3	$64.8	$284.1	
Travel	$6.4	$6.6	$7.9	$6.8	$7.0	$34.7	
Contractual	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Commodities	$25.1	$21.1	$22.0	$23.1	$24.2	$115.5	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)	$33.8	$33.8	$37.0	$38.1	$40.7	$183.4	
SUBTOTAL	$114.0	$114.5	$124.2	$128.3	$136.6	$617.7	
General Administration (9% of	$10.3	$10.3	$11.2	$11.6	$12.3	$55.6	N/A
PROJECT TOTAL	$124.3	$124.8	$135.3	$139.9	$148.9	$673.2	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

COMMENTS:
This summary page provides an five-year overview of proposed project funding and actual cumulative spending. The column titled 'Actual Cumulative' must be updated each fiscal year as part of the annual reporting requirements. Provide information on the total amount actually spent for all completed years of the project. On the Project Annual Report Form, if any line item exceeds a 10% deviation from the originally-proposed amount; provide detail regarding the reason for the deviation.

FY17-21

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

NON-TRUSTEE AGENCY SUMMARY PAGE

Date Prepared: 08.24.2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Trevor Branch	Associate Professor	1.0	13.164		13.164
John Trochta	Graduate student	12.0	2.959		35.508
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
		Subtotal	16.123	0.0	
				Personnel Total	48.672

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Joint AMSS and project meeting (PI)	0.400	1	5	0.201	1.405
Joint AMSS and project meeting (grad student)	0.400	1	5	0.201	1.405
PI meeting Cordova (PI)	0.500	1	2	0.172	0.844
PI meeting Cordova (grad student)	0.500	1	2	0.172	0.844
Airport shuttles and taxis (2 people x 2 meetings)	0.180	4			0.720
AMSS conference fee	0.605	2			1.210
					0.000
					0.000
					0.000
					0.000
					0.000
				Travel Total	6.428

FY17

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08.24.2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Publication costs, page charges, color figure costs	1.500
Laptop (graduate student)	2.000
Number-crunching computer	3.000
Tuition	18.635
Commodities Total	25.135

FY17

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08.24.2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY17

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08.24.2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Trevor Branch	Associate Professor	1.0	13.690		13.690
John Trochta	Graduate student	12.0	3.280		39.360
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
		Subtotal	16.970	0.0	
				Personnel Total	53.050

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Joint AMSS and project meeting (PI)	0.408	1	5	0.205	1.433
Joint AMSS and project meeting (grad student)	0.408	1	5	0.205	1.433
PI meeting Cordova (PI)	0.510	1	2	0.175	0.861
PI meeting Cordova (grad student)	0.510	1	2	0.175	0.861
Airport shuttles and taxis (2 people x 2 meetings)	0.184	4			0.734
AMSS conference fee	0.617	2			1.234
					0.000
					0.000
					0.000
					0.000
					0.000
				Travel Total	6.557

FY18

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08.24.2016

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Publication costs, page charges, color figure costs	1.500
Tuition	19.567
Commodities Total	21.067

FY18

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08.24.2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY18

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08.24.2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Trevor Branch	Associate Professor	1.0	14.239		14.239
John Trochta	Graduate student	12.0	3.580		42.960
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
		Subtotal	17.8	0.0	
				Personnel Total	57.199

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Joint AMSS and project meeting (PI)	0.416	1	5	0.209	1.462
Joint AMSS and project meeting (grad student)	0.416	1	5	0.209	1.462
PI meeting Cordova (PI)	0.520	1	2	0.179	0.878
PI meeting Cordova (grad student)	0.520	1	2	0.179	0.878
Airport shuttles and taxis (5 people-meetings)	0.187	5			0.936
AMSS conference fee	0.629	2			1.259
Joint Science Workshop in Anchorage	0.416	1	3	0.209	1.044
					0.000
					0.000
					0.000
					0.000
				Travel Total	7.918

FY19

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08.24.2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Publication costs, page charges, color figure costs	1.500
Tuition	20.545
Commodities Total	22.045

FY19

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08.24.2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY19

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08.24.2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Trevor Branch	Associate Professor	1.0	14.808		14.808
John Trochta	Graduate student	12.0	3.795		45.540
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
		Subtotal	18.6	0.0	
				Personnel Total	60.348

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Joint AMSS and project meeting (PI)	0.424	1	5	0.213	1.491
Joint AMSS and project meeting (grad student)	0.424	1	5	0.213	1.491
PI meeting Cordova (PI)	0.531	1	2	0.183	0.896
PI meeting Cordova (grad student)	0.531	1	2	0.183	0.896
Airport shuttles and taxis (4 meetings)	0.191	4			0.764
AMSS conference fee	0.642	2			1.284
					0.000
					0.000
					0.000
					0.000
					0.000
				Travel Total	6.821

FY20

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08.24.2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Publication costs, page charges, color figure costs	1.500
Tuition	21.573
Commodities Total	23.073

FY20

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08.24.2016

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY20

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08.24.2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Trevor Branch	Associate Professor	1.000	16.555		16.555
John Trochta	Graduate student	12.000	4.023		48.276
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
					0.000
		Subtotal	20.578	0.000	
				Personnel Total	64.831

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Joint AMSS and project meeting (PI)	0.433	1	5	0.218	1.521
Joint AMSS and project meeting (grad student)	0.433	1	5	0.218	1.521
PI meeting Cordova (PI)	0.541	1	2	0.186	0.914
PI meeting Cordova (grad student)	0.541	1	2	0.186	0.914
Airport shuttles and taxis (2 people x 2 meetings)	0.195	4			0.779
AMSS conference fee	0.655	2			1.310
					0.000
					0.000
					0.000
					0.000
					0.000
				Travel Total	6.958

FY21

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08.24.2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Publication costs, page charges, color figure costs	1.500
Tuition	22.653
Commodities Total	24.153

FY21

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08.24.2016

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY21

Project Title: Modeling and Stock Assessement of PWS Herring
Primary Investigator: Trevor Branch

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08.24.2016

EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
RESPONSE TO REVIEWER COMMENTS

PROJECT NUMBER 17120111-D

PROJECT TITLE
Herring Research and Monitoring Program: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (*Clupea pallasii*) in Prince William Sound, Alaska

PRIMARY INVESTIGATOR AND AFFILIATION
Kristen B. Gorman, Prince William Sound Science Center (PWSSC), P.O. Box 705, Cordova, AK 99574

DATE RESPONSE SUBMITTED
August 12, 2016

RESPONSE TO REVIEWER COMMENTS (see INVESTIGATOR RESPONSES 1-5)

Science Panel Comments – FY17
Date: May 2016

The four objectives are:
(1) assess the seasonal timing (spring, summer, and fall) that allows for accurate determination of both previously spawned and maturing female herring based on ovary histology to determine maturation states;
(2) couple histology results with annual scale growth information at the individual level, within specific age cohorts, to understand if scale growth patterns reflect reproductive investment;
(3) assess whether annual scale growth patterns can be used to infer age at maturity at the individual level across age cohorts given results from objectives 1 and 2; and
(4) assess inter-annual variability in age at maturity based on coupled histology and scale growth over a five-year period by focused, increased sampling during the optimal seasonal period given results from objectives 1-3.

This is an ambitious project and the Panel endorses the intentions of the proposed work, but not necessarily all of the details. First, and most importantly, the Panel strongly endorses the objective of determining an ‘empirical’ estimate of ‘age-at-maturity’. It is widely recognized that spawning herring often show spatial and temporal segregation during spawning, with larger, older fish spawning early and smaller, younger fish spawning later. This is well documented for herring and for many other spring-spawning fish species. Ignoring this, by assuming that the age structure of samples taken during spawning represents the population at large can lead to serious errors in age-structured- assessments. Therefore to the extent that this proposal recognized that issue, the Panel is strongly supportive (see AUTHOR RESPONSE 1). To this end the Panel recommends the measurement of gonad size, and the estimation of a gonosomatic index, as the basis for estimating maturity of individuals. Collection of size data will also allow estimation of size-at-maturity, which may be important, as well (see AUTHOR RESPONSE 2).

The Panel also reiterates comments made on the age-structured model here about the likelihood that there is temporal and spatial structuring of herring with respect to size- and age-at-maturity. Estimation of age-at-maturity should keep such temporal and spatial structuring in mind when considering sampling protocols and data analysis (see again AUTHOR RESPONSE 1).

Objectives 2-4 of this proposal are concerned with herring scales and the assumption that growth increments (or some other feature of scales) can provide a meaningful estimate of the age-of-maturation of a herring. If this were possible, the Panel agrees that such a measure would useful, providing the criteria were rigorous and repeatable. However, the Panel has several concerns. One is that this proposal makes no mention of similar work that was recently conducted, and supported by the EVOSTC, by NOAA staff. Namely, is there evidence that this approach will work? This comment applies especially to the proposed study on scales, as potential indicators of age-of-maturity, and ovarian histology objectives. Insufficient information was provided to allow the Panel to evaluate the chances for success of this portion of the proposal. It is essential that this proposal shows that the proposed work will build on existing results and knowledge. Absent some basis for this approach, the Panel is rather dubious of the chances for its success (see AUTHOR RESPONSE 3). The second concern is that there are a number of publications on herring and clupeid maturation, and criteria used for assessing maturation. The revised proposal should make it clear that the PI is aware of this work, and when appropriate, build on the existing knowledge base (see AUTHOR RESPONSE 4). Finally, the Panel does not understand why this work is proposed for five years. It should not require more than a year, or two, to evaluate the utility of scales as indicators of past maturity. The proposal should be revised accordingly (see AUTHOR RESPONSE 5).

Science Coordinator Comments
May 2016
I concur with the Science Panel's comments.

Executive Director Comments – FY17
Date:

Public Advisory Committee Comments – FY17
Date:

Trustee Council Comments – FY17
Date:

AUTHOR RESPONSES

1. This proposal does recognize the important issue of spatial and/or temporal segregation among spawning and non-spawning herring (i.e., spatial segregation), or older more experience fish and younger less experienced fish (i.e., temporal segregation). The first two objectives of the study aim to: 1) assess the seasonal timing (spring, summer, and fall) that allows for accurate determination of both previously spawned and maturing female herring based on ovary histology to determine maturation states; 2) couple histology results with annual scale growth information at the individual level, within specific age cohorts across seasons, to understand if scale growth patterns reflect reproductive investment. Because we plan, over the first two years of the study, to initially sample across seasons (spring, summer, and fall), we anticipate being able to capture spawning and non-spawning cohorts of the PWS population throughout the year. To additionally address this concern of the EVOS Science Panel, we have developed a more comprehensive plan for sampling during spring spawning that includes sampling over the duration of the spawning event to capture any temporal variation in spawning due to age/experience. In addition, during spring spawning, we plan to aerially survey Prince William Sound to identify and sample groups of herring not associated with the main spawning event. Because our original ship time for spring spawn sampling was leveraged with age, sex, and length sampling by ADF&G, we were essentially constrained to spatially sample where ADF&G sampled due to the cost of ship time. However, the HRM program manager (S. Pegau) has requested additional funds to support aerial surveys during spring in order to sample herring not associated with the main spawning event (i.e., non-spawners). We would essentially aerially survey for herring and once spotted, land and sample using a cast net from a raft. Similar methods have been employed by ADF&G in the past. Thus, we feel this is a viable option to obtain samples from non-spawning individuals during spring.

2. As described in the Procedural and Scientific Methods section of the original proposal, fish will be measured for length (mm) and wet weight (g). Ovaries will be dissected from the body and a gonadosomatic index (GSI) will be developed by weighing the gonad separately where GSI = (ovary weight/whole wet weight)*100. Thus, we are planning to measure gonad size and estimate a GSI, specifically for the reason the Panel notes, which is to allow for estimation of size-at-maturity.

3. Specific reference was made in the original proposal regarding previous work supported by EVOSTC and conducted by NOAA staff on age at first spawning by female Pacific herring. As described in the original proposal, "Heintz and Vollenweider (NOAA-Auke Bay Labs) conducted preliminary studies of Pacific herring age at maturity during the current HRM program (2012-2016). Their work included a lab study of southeast Alaska herring to determine the seasonal timing where immature, recruit, and repeat spawners could be identified based on ovary histology to determine maturation. This worked confirmed that histology is an accurate method for discerning these maturation stages. Heintz and Vollenweider also conducted a summer only field study of PWS herring coupling ovary maturation indices with scale growth patterns following similar work conducted on Norwegian Spring-Spawn herring (Engelhard et al. 2003, Engelhard and Heino 2004a, 2005). The Norwegian studies are based on predictable changes in the width and microstructure of the annual scale growth layer relative to the maturation of gonads for this stock (Engelhard et al. 2003). For example, as herring mature and trade-off somatic growth for reproductive investment, a corresponding change in scale growth

occurs where spawning individuals have smaller associated scale growth layers. Finally, Heintz and Vollenweider collected scales only from fish during one spring to detect age at first spawn and also examined ADF&G's long-term (1985-2013) herring scale data regarding annuli widths for age cohorts. Results from these studies were equivocal - scale growth did not appear to be a strong predictor of reproductive investment or age at maturity. However, several aspects of their work warrant further investigation by new studies. First, the initial timing study to discern various maturation states was conducted on laboratory fish from southeast Alaska. Secondly, analyses of coupled maturation state and scale growth were not completed for age-specific cohorts at an optimal time determined for wild PWS fish. Finally, these previous studies used relatively small sample sizes (lab study: n = 15/month, n = 100 fish/age group for coupled histology and scale growth)."

Studies by Heintz and Vollenweider should be considered preliminary work, upon which this proposal builds. Importantly, their worked revealed that histology is an accurate method for discerning maturation stages. Therefore, this eliminates the need to consider other measures of herring and clupeid maturation (see also AUTHOR RESPONSE 4). Thus, this proposal should be viewed as an opportunity to definitively assess the seasonal timing that best determines maturation states, i.e., both post and maturing ovarian follicles, among wild PWS female herring and to rigorously assess the coupled histology and scale growth issue with sample sizes much larger (i.e., 345 fish/year/age cohort) than that accomplished by Heintz and Vollenweider.

4. The Panel is correct in that there are other publications and criteria used for assessing herring maturation. For example, Hay (1985) is an excellent review of Pacific herring reproduction. However, we have chosen to use histology to discern maturation as Heintz and Vollenweider have shown this to be a reliable and accurate technique for this purpose. Thus, the study does not consider other methods.

5. This study is proposed for 5 years to explicitly address inter-annual variability in age at maturity, something Heintz and Vollenweider never addressed in their preliminary work. One of the more compelling results from the literature is that age at maturity among herring can vary based on density or oceanographic conditions (Engelhard and Heino 2004a, b). Since EVOSTC support is a unique opportunity to assess longer-term changes in age at maturity over 5 years among PWS herring, we would like to explore this research objective regarding inter-annual variability, as it would advance the proposed research from simply being a technique validation study to using the technique to understand ecological dynamics in the PWS herring system.

AUTHOR RESPONSES TO S. DRESSEL COMMENTS 8/22/2016

Gorman – Herring Maturity

I'm excited to see this study on maturity and will be really interested to see the scale and histology comparison work.

In the background, the proposal states that maturity is an ASA model inputs. Currently, I believe the maturity function is actually an output estimate (see AUTHOR RESPONSE 6).

The proposal identifies how many fish of each age need to be collected at each sampling time, but never addresses how many fish need to be captured overall or how they will determine whether 345 are collected from each age, as age determination is not determined at the time of sampling. This will be critical in order to ensure that they will be able to achieve their objectives. I expect this may need to be accomplished by converting to length, but length distributions of different cohorts overlap considerably. As such, it may also be necessary to acknowledge in the proposal that sample sizes may not be met (see AUTHOR RESPONSE 7).

I'm concerned that there aren't any citable results from the Heinz and Vollenweider study and that no conclusions from that study are able to be used as a basis for this new study's design and direction. Despite previous funding, the new study doesn't appear to be able to use results gained from the past funding. If there is a final report or manuscript where the methods and results are reported, it would be extremely valuable. Any results from that study are inherently dependent upon the methods used. Without knowing what those were, the EVOSTC will be required to take our word for any conclusions and provide new funding without knowing what happened with previous funding (see AUTHOR RESPONSE 8).

In Hypothesis 1, I expect that "accurate" should be changed to "precise" since bias won't be able to be measured (see AUTHOR RESPONSE 9).

It appears that the proposal is assuming that age-6 fish are 100% mature based on the model output (stated in the Data Analysis section with no reference). However other models in the state estimate that not all age-6 fish are mature. Because the goal of the study is to investigate whether the current model estimates of maturity match empirical estimates, I would tend to also include age-6. If funding is too limited to incorporate another cohort, it would be possible to say that sampling is limited to ages 3-5 because those are the most likely to be partially mature and because those are the most likely to have measurable differences in scale growth, and then openly acknowledge that 100% maturity for age-6 is assumed (see AUTHOR RESPONSE 10).

If there are no results from Heinz and Vollenweider, what dataset is the power analysis based upon? This should be included in the methods (see AUTHOR RESPONSE 11).

AUTHOR RESPONSES

6. In conversation with S. Pegau, for PWS Herring ASA Model the maturity function is a model input, not output like it is in other areas of the State.

7. This is an important point that absolutely should have been better clarified in the original and revised versions of the proposal. I had already submitted the revised proposal when this issue was discussed with S. Dressel via phone on 8/18/2016, and at that time realized these details were lacking from the proposal. I have added these collection details to a second revision of the proposal under Procedural and Scientific Methods.

8. This has been a challenging aspect of pulling this study together. Although it is true that no formal reports are available on previous herring age at maturity work to cite in this proposal, I did discuss at length with J. Vollenweider the results of the past work and received personal communications that have been cited in this proposal.

9. Accurate has been changed to precise.

10. Text has been added to include the issue that age 6+ are assumed to be fully mature. The work will address this issue to some degree because if we find that age 5+ fish are 100% mature, we will be more confident that this is also true for age 6+ fish.

11. The power analysis is not based on a dataset, it is a one-tailed power analysis for single sample proportions. We have used this approach to understand the sample sizes and associated power needed to detect anywhere from a 5-20% reduction in the proportion of in the null proportion of spawners at a 0.05 significance level. The take home message is that with the sample sizes we can afford, we are likely only to be able to detect at least a 10% reduction in proportion of spawners. This information is found under Data Analysis and Statistical Methods.

Literature Cited

Engelhard, G. H., U. Dieckmann, and O. R. Godo. 2003. Age at maturation predicted from routine scale measurements in Norwegian spring-spawning herring (Clupea harengus) using discriminant and neural network analyses. Ices Journal of Marine Science 60:304-313.

Engelhard, G. H., and M. Heino. 2004a. Maturity changes in Norwegian spring-spawning herring before, during, and after a major population collapse. Fisheries Research 66:299-310.

Engelhard, G. H., and M. Heino. 2004b. Maturity changes in Norwegian spring-spawning herring *Clupea harengus*: compensatory or evolutionary responses? Marine Ecology Progress Series 272:245-256.

Engelhard, G. H., and M. Heino. 2005. Scale analysis suggests frequent skipping of the second reproductive season in Atlantic herring. Biology Letters 1:172-175.

Hay, D. E. 1985. Reproductive biology of Pacific herring (Clupea harnangus pallasi). Canadian Journal of Fisheries and Aquatic Sciences 42:111-126.

Appendix C

EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
PROGRAM PROJECT PROPOSAL SUMMARY PAGE

Project Title

Herring Research and Monitoring Program: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (*Clupea pallasii*) in Prince William Sound, Alaska

Primary Investigator(s) and Affiliation(s)

Kristen B. Gorman, Prince William Sound Science Center (PWSSC), P.O. Box 705, Cordova, AK 99574

Date Proposal Submitted

August 12, 2016

Project Abstract

To address the lack of recovery of Pacific herring (*Clupea pallasii*) in Prince William Sound (PWS), Alaska, research by the Herring Research and Monitoring (HRM) Program has been focused on improving predictive models of PWS herring stocks through observations and research. To this end, the goal of the project described here is ***to improve the HRM program's updated (Bayesian) PWS herring Age-Structured Assessment model's ability to more accurately predict the total population's biomass by empirically assessing reproductive maturity among age cohorts***. Currently, the age at maturity function in the ASA model is not based on empirical data. An improved understanding of age at maturity will allow for more accurate estimates of the total population biomass, which is central to the management of this fishery. The objectives of the studies proposed here are fourfold: 1) assess the seasonal timing (spring, summer, and fall) that allows for accurate determination of both previously spawned and maturing female herring based on ovary histology to determine maturation states; 2) couple histology results with annual scale growth information at the individual level, within specific age cohorts across seasons, to understand if scale growth patterns reflect reproductive investment; 3) assess whether annual scale growth patterns can be used to infer age at maturity at the individual level across age cohorts given results from objectives 1 and 2, and 4) assess inter-annual variability in age at maturity based on coupled histology and scale growth over a five-year period by focused, increased sampling during the optimal seasonal period given results from objectives 1-3. The proposed approach will advance preliminary worked conducted previously by HRM investigators by testing the appropriate sampling time of wild PWS herring for ovary characteristics, as opposed to lab-based studies, and increasing sample sizes for more powerful analyses. Studies proposed here address a key demographic parameter. Therefore, this research will not only contribute to the management of PWS herring, but also to a more general understanding of herring demography. As world-wide herring populations encounter more variable environmental conditions in the future, basic knowledge of herring demography and ecology will be invaluable.

EVOSTC Funding Requested *(must include 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
$170.0	172.0	165.1	169.6	173.3	850.0

Non-EVOSTC Funding Available

FY17	FY18	FY19	FY20	FY21	TOTAL
NA	NA	NA	NA	NA	NA

Appendix C

Please refer to the Invitation for the specific proposal requirements for each Focus Area. The information requested in this form is in addition to the information requested in each Focus Area and by the Invitation.

1. Executive Summary
Identify the hypotheses the project is designed to address. Describe the background and history of the problem. Include a scientific literature review that covers the most significant previous work history related to the project. Please provide a summary of the project including key hypotheses and overall goals.

Project Background

Forage fishes, known as abundant and schooling species, are critical marine ecosystem components for their role in energy transfer from lower to higher trophic levels including larger fishes, seabirds and marine mammals (Springer & Speckman 1997). Where one or a few forage fish species tend to be the principal conveyors of energy through an ecosystem, often termed *wasp-waist* (Rice 1995, Cury et al. 2000, Hunt & McKinnell 2006), these populations can often fluctuate greatly in size and even stabilize at higher or lower abundance depending on the form of ecological interactions at play - from bottom-up and top-down forcing, to interspecific and density-dependent competition (Bakun 2006).

Pacific herring (*Clupea pallasii*, hereafter herring) of Prince William Sound (PWS), Alaska, are a regional example of a *wasp-waist* forage fish system that has undergone dramatic changes in population size over the last 35 years. During the 1980's, the PWS herring population sustained a commercial fishery with important subsistence and economic benefit to regional communities. Based on Alaska Department of Fish & Game's (ADF&G) Age-Structured Assessment (ASA) model at this time, biomass of PWS herring was ~60,000-110,000 metric tons (mt). Following the *Exxon Valdez* oil spill in March 1989, the PWS herring fishery remained active, but the population began a precipitous decline falling to ~20,000 mt by 1993. Herring of PWS rebounded, but then collapsed again below ~20,000 mt in 1998 following a short period of commercial harvest. Biomass of PWS herring has remained at ~20,000 mt since 1998 and continues to remain below a level that would allow a commercial catch (Pegau et al. 2013, Pegau et al. 2014).

Factors underlying the initial decline in PWS herring biomass during the early 1990's and the continued lack of recovery are not well understood (e.g., Norcross et al. 2001, Thorne & Thomas 2008, Pearson et al. 2012). To enhance our understanding of the demography, ecology, and population dynamics of PWS herring, the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) supported an integrated herring restoration plan between 2009-2011 initially known as the Prince William Sound Herring Survey, which was focused on 1) identification of juvenile rearing bays, 2) understanding factors limiting herring recruitment such as abiotic and biotic environmental conditions, disease and predation, and 3) enhancing knowledge on spatial and temporal monitoring for future studies (Pegau et al. 2013). This initial program has continued over the past five years (2012-2016) as the PWS Herring Research and Monitoring (HRM) Program. Currently, the program's overall goal is focused on improving predictive models of herring stocks through monitoring and research with the following objectives: 1) provide information to improve input to, or test assumptions within, ADF&G's Age-Structure-Analysis (ASA) model, 2) inform the required synthesis effort, 3) address assumptions in current measurements, and 4) develop new approaches to monitoring (Pegau et al. 2014).

Looking forward to the next five-year research plan for the PWS HRM program, the overall goal remains unchanged in that investigators plan to build off previous studies and continue to *improve predictive models of herring stocks through observations and research*. During the last five years, the ASA model was updated in a Bayesian framework, which allows for estimation of uncertainty in model output (Pegau et al. 2014, Muradian 2015). One of the key ASA model inputs is an age at reproductive maturity function, i.e., the age at which herring spawn for the first time, which is used to adjust estimates of the total population biomass based on the age composition of the spawning population. Validating the estimated proportions of first-spawn (primiparous) individuals in each age class is the key objective of the study proposed here as the current ASA model's age at maturity function (Table 1) is not currently based on empirical data, but simply uses values that best fit the model. Importantly, validating PWS herring age at maturity may improve the predictive capabilities of the current ASA model in terms of the overall population biomass estimates.

Table 1. Current age at maturity function used in Bayesian ASA model for Pacific herring in Prince William Sound, Alaska.

Age	*% Spawning*	*% Spawning*	*% Brood Year 1st Spawn*
	1980-1996	*1997-Present*	*1997-Present*
3	27	48	48
4	89	75	27
5	100	100	25

Age at reproductive maturity is a key demographic parameter, which explains its inclusion in stock assessment models such as the ASA. At the individual level, age at maturity can shape overall lifetime reproductive success (Stearns 1992, Bernardo 1993), and therefore, contribute to stock productivity. There is some evidence that age at maturity might vary with population size. For example, Engelhard and Heino (2004a) showed that age and length at 50% maturity of Norwegian spring-spawning herring was reduced (i.e., age) and increased (i.e., length), respectively, during a period of low stock abundance in comparison with periods before and after the population collapse. The selective factors that likely contributed to this phenomenon include 1) reduced intraspecific competition for food during low abundance that resulted in enhanced growth and early onset of maturity or 2) early reproducing fish were selected for by fishing pressure - the former appears to be a more likely explanation (Engelhard & Heino 2004b).

Within the context of Pacific herring, it is generally understood that age at maturity increases with latitude from about age 2 off California, to age 4-5 in the Bering Sea, western Alaska (Barton & Wespestad 1980, Hay 1985). Given this regional variability in age at maturity, it is unclear whether the proportions of fish spawning for the first time incorporated by the PWS ASA model are valid (Table 1). Heintz and Vollenweider (NOAA-Auke Bay Labs) conducted preliminary studies of Pacific herring age at maturity during the current HRM program (2012-2016). Their work included a lab study of southeast Alaska herring to determine the seasonal timing where immature, recruit, and repeat spawners could be identified based on ovary histology to determine maturation. This worked confirmed that histology is an accurate method for discerning these maturation stages (J. Vollenweider pers. comm.). Heintz and Vollenweider also conducted a summer only field study of PWS herring coupling ovary maturation indices with scale growth patterns following similar work conducted on Norwegian Spring-Spawn herring (Engelhard et al. 2003, Engelhard & Heino 2004a, 2005). The Norwegian studies are based on predictable changes in the width and microstructure of the annual scale growth layer relative to the maturation of gonads for this stock (Engelhard et al. 2003). For example, as herring mature and trade-off somatic growth for reproductive investment, a corresponding change in scale growth occurs where spawning individuals have smaller associated scale growth layers. Finally, Heintz and Vollenweider collected scales only from fish during one spring to detect age at first spawn and also examined ADF&G's long-term (1985-2013) herring scale data regarding annuli widths for age cohorts. Results from these studies were equivocal - scale growth did not appear to be a strong predictor of reproductive investment or age at maturity (Heintz and Vollenweider AMSS 2016 Poster). However, several aspects of their work warrant further investigation by new studies. First, the initial timing study to discern various maturation states was conducted on laboratory fish from southeast Alaska. Secondly, analyses of coupled maturation state and scale growth were not completed for age-specific cohorts at an optimal time determined for wild PWS fish. Finally, these previous studies used relatively small sample sizes (lab study: *n* = 15/month, *n* = 100 fish/age group for coupled histology and scale growth).

Here, studies are proposed to build from previous work by Heintz and Vollenweider. Proposed research will focus on adult female herring caught in the wild from PWS exclusively to determine the seasonal timing (spring, summer, fall) that allows for accurate determination of previously spawned and maturing female herring based on ovary histology. Studies will begin by first considering coupled maturation states and scale growth for age-specific cohorts, in addition to increasing sample sizes of females processed for both ovary maturation and scale growth patterns, particularly in the last three years of the study (*n* = 345 per age class/year). Finally, research will be conducted over the entire five-year period to assess inter-annual variability in age at maturity, something Heintz and Vollenweider never addressed yet has been shown to be a key attribute associated with herring population changes (Engelhard & Heino 2004a, b).

Overall HRM Program and Project-Specific Goals

The overall goal of the proposed Herring Research and Monitoring Program (2017-2021) is *to improve predictive models of PWS herring stocks through observations and research*. To this end, the goal of the project described here is ***to improve the Bayesian PWS herring Age-Structured Assessment model's ability to more accurately predict the total population's biomass by empirically assessing reproductive maturity among age cohorts***.

Key Hypotheses

H1 (NULL). Precise determination of previously spawned and maturing female herring (age 3-5), based on ovary histology to determine maturation states, is similar across seasons (spring, summer, fall).

Because there is limited previous work, we don't have any *a priori* predictions and are therefore testing the null hypothesis. This proposal assumes that age 6+ fish are 100% mature and therefore are not considering in the sampling design.

H2. Maturation status, within a given age cohort (3-5), will correspond to scale growth patterns where spawned females based on ovary status will show a corresponding reduction in the width of the annual scale growth layer for that year as more energy is invested into reproduction and away from somatic growth (see Table 2 for expected relationships for age 4+ females).

Table 2. Expected summer growth of scale layer based on spawning history (example from age 4+ females).

Summer Growth Year	Non-spawner (age 4+)	Spawner (age 4+)
Year 4	Larger	Smaller

H3. Annual scale growth patterns can be used to infer age at maturity at the individual level across age cohorts (age 3+-5+).

Appendix C

a) Age 3+ females are all assumed to be either immature or primiparous. Primiparous age 3+ females will show no evidence of post-ovulatory follicles and will have a smaller year 3 summer scale growth layer in comparison with immature age 3+ fish (Table 3).

Table 3. Expected summer growth of scale layers based on spawning history among age 3+ herring.

Summer Growth Year	Age 3+, Immature	Age 3+, Primiparous
Year 1	Larger	Larger
Year 2	Larger	Larger
Year 3	Larger	Smaller

b) Age 4+ females will be a mix of immature, primiparous and second year spawners. Age 4+ females will differ in the widths of their year 3-4 summer scale growth layers where immature females will have larger year 3 and 4 summer scale growth layers than primiparous or second-year spawners; primiparous females will have smaller year 4 summer scale layers than immature fish, but larger year 3 summer scale growth layers than second-year spawners; second-year spawners will have smaller year 3 summer scale growth layers than immature and primiparous fish and smaller year 4 summer scale growth layers than immature fish, but year 4 summer scale growth layer will not be different than primiparous females (Table 4).

Table 4. Expected summer growth of scale layers based on spawning history among age 4+ herring.

Summer Growth Year	Age 4+, Immature	Age 4+, Primiparous	Age 4+, 2nd Year Spawner
Year 1	Larger	Larger	Larger
Year 2	Larger	Larger	Larger
Year 3	Larger	Larger	Smaller
Year 4	Larger	Smaller	Smaller

c) Age 5+ females will be a mix of primiparous, second and third year spawners. Age 5+ females will differ in the widths of their year 3-5 summer scale growth layers where primiparous fish will have larger year 4 summer scale growth layers than previously spawned females; previously spawned females will have smaller year 3-5 summer scale growth layers depending on if they are second or third year spawners (Table 5).

Table 5. Expected summer growth of scale layers based on spawning history among age 5+ herring.

Summer Growth Year	Age 5+, Primiparous	Age 5+, 2nd Year Spawner	Age 5+, 3rd Year Spawner
Year 1	Larger	Larger	Larger
Year 2	Larger	Larger	Larger
Year 3	Larger	Larger	Smaller
Year 4	Larger	Smaller	Smaller
Year 5	Smaller	Smaller	Smaller

H4. Mature (primiparous, second and third year spawners) female herring will have a higher gonadosomatic index, be heavier and longer than immature female herring for a given age cohort. Similarly, a greater proportion of age 3+ female herring will be primiparous following greater food supply or enhanced environmental conditions during the summer of year 3. A greater proportion of age 4+ female herring will be primiparous following lower food supply during the summer of year 4.

Appendix C

2. Relevance to the Invitation for Proposals Discuss how the project addresses the projects of interest listed in the Invitation and the overall Program goals and objectives. Describe the results you expect to achieve during the project, the benefits of success as they relate to the topic under which the proposal was submitted, and the potential recipients of these benefits.

The overall goal of the Herring Research and Monitoring program is to *improve predictive models of herring stocks through observations and research*. This is consistent with the overall program goal described in the request for proposals (FY17-21 RFP) and the direction provide by the EVOSTC when the enhanced monitoring option of the Integrated Herring Restoration Program was chosen. By working to improve the predictive models of PWS herring stock biomass, it is anticipated that the data will be used to provide a tool for fisheries managers to make more informed decisions. The studies outlined here directly address the area of interest identified in the FY17-21 RFP (draft 11.02.15), #9 - A study to estimate and corroborate herring age at maturity with ASA model estimates. Further, by conducting this work over a five-year period to assess inter-annual variability in age at maturity, the studies proposed here also addresses EVOSTC's interest in retrospective analyses evaluating environmental effects (i.e., physical and biological oceanographic factors) that might be influencing PWS herring populations (#7).

Results from these studies are expected to contribute to the precision of the ASA model for estimating total PWS herring biomass, in addition to increasing scientific knowledge about herring demography and ecology. Potential recipients of the knowledge gained by these studies primarily include herring fisheries managers and commercial fisherman, as well other herring scientists and the public.

Appendix C

3. Project Personnel

The CV's of all principal investigators and other senior personnel involved in the proposal must be provided. Each resume is limited to two consecutively numbered pages and must include the following information:

- A list of professional and academic credentials, mailing address, and other contact information.
- A list of your most recent publications most closely related to the proposed project and up to five others.
- A list of all persons (including their organizational affiliations) in alphabetical order with whom you have collaborated on a project or publication within the last four years.

KRISTEN B. GORMAN

Curriculum Vitae

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PROFESSIONAL APPOINTMENTS

Research Ecologist — Prince William Sound Science Center, Cordova, Alaska
July 2014 – Present

EDUCATION

Ph.D. Sept 2008 – Jan 2015	Dept. of Biological Sciences, Simon Fraser University, Burnaby, BC and Polar Oceans Research Group, Palmer Station LTER-NSF, Antarctica. *Advisors*: Prof. T.D. Williams (SFU) and Dr. W.R. Fraser (Palmer LTER).
M.Sc. Jan 2002 – Apr 2005	Dept. of Biological Sciences, Simon Fraser University, Burnaby, BC and Alaska Science Center – USGS, Anchorage, Alaska. *Advisors*: Prof. T.D. Williams and Dr. D. Esler (SFU), Dr. P.L. Flint (AK-USGS).
B.S. Sept 1992 – May 1996	Dept. of Biology, Dickinson College, Carlisle, PA. *Advisor*: Prof. C. Loeffler.

CURRENT RELEVANT ACTIVITIES

PI. *Comparative Performance in Migration and Reproduction among Wild and Hatchery Pink Salmon (Oncorhynchus gorbuscha) in Prince William Sound, Alaska using Stable Isotope Analysis.* PWSSC project funded by National Fish and Wildlife Foundation, 2016-2017.

PI. *Juvenile Herring Condition Monitoring*. PWSSC project funded by Exxon Valdez Oil Spill Trustee Council, 2014-2016.

PI. *Hatchery-Wild Salmon Stream Interactions*. PWSSC project funded by Alaska Department of Fish & Game – Hatchery Research Program, 2014–2018.

RECENT RELATED PROFESSIONAL EXPERIENCE

PI. *Juvenile Herring Condition Monitoring, Intensives.* PWSSC project funded by Exxon Valdez Oil Spill Trustee Council, 2014.

co-PI *Assessing Breeding Population Genetic Structure of Adélie Penguins (Pygoscelis adeliae) occurring West of the Antarctic Peninsula*. Simon Fraser U project funded by Antarctic Science Bursary, 2012.

co-PI. *Divergent Population Response by Pygoscelis Penguins to Rapid Climate Warming: Nutritional and Physiological Stress Mechanisms.* Simon Fraser U project funded by American Museum of Natural History, 2010; The American Ornithologists' Union, 2009; The Explorers Club, 2009.

Appendix C

SELECTED PUBLICATIONS AND REPORTS (10 of 16, *indicates most closely related)

Knudsen, E., M. Buckhorn, **K. Gorman**, D. Crowther, K. Froning, M. Roberts, L. Marcello, B. Adams, and V. O'Connell, and D. Bernard. 2015. *Interactions of wild and hatchery pink salmon and chum salmon in Prince William Sound and Southeast Alaska*. Prince William Sound Science Center Final Report 2013 and 2014 to Alaska Department of Fish & Game, Contract IHP-13-013. *Work conducted throughout Prince William Sound, Alaska.

Gorman, K.B. 2015. Integrative studies of Southern Ocean food-webs and *Pygoscelis* penguin demography: mechanisms of population response to environmental change. Ph.D. Thesis. Simon Fraser University, Burnaby, British Columbia, Canada. 337 pp. *Includes work on *Pleuragramma antarcticum* a Southern Ocean forage fish similar to Pacific herring.

Gorman, K.B., T.D. Williams, and W.R. Fraser. 2014. Ecological sexual dimorphism and environmental variability within a community of Antarctic penguins (genus *Pygoscelis*). *PLoS ONE* 9(3): e90081.

Schofield, O., H. Ducklow, K. Bernard, S. Doney, D. Patterson-Fraser, **K. Gorman**, D. Martinson, M. Meredith, G. Saba, S. Stammerjohn, D. Steinberg, and W. Fraser. 2013. Penguin biogeography along the West Antarctic Peninsula: Testing the canyon hypothesis with Palmer LTER observations. *Oceanography* 26(3):78-80.

Crossin, G.T., P.N. Trathan, R.A. Phillips, **K.B. Gorman,** A. Dawson, K.Q. Sakamoto, and T.D. Williams. 2012. Variation in baseline corticosterone predicts foraging behaviour and parental care in macaroni penguins. *The American Naturalist* 180(1):E31-E41.

Bestelmeyer, B.T., A.M. Ellison, W.R. Fraser, **K.B. Gorman**, S.J. Holbrook, C.M. Laney, M.D. Ohman, D.P.C. Peters, F.C. Pillsbury, A. Rassweiler, R. Schmitt, and S. Sharma. 2011. Analysis of abrupt transitions in ecological systems. *Ecosphere* 2(12):art129.

Gorman, K.B., D. Esler, R.L. Walzem, and T.D. Williams. 2009. Plasma yolk precursor dynamics during egg production by female Greater Scaup *(Aythya marila*): characterization and indices of reproductive state. *Physiological and Biochemical Zoology* 82(4):372-381. *Work on egg production in waterfowl.

Gorman, K.B., D. Esler, P.L. Flint, and T.D. Williams. 2008. Nutrient reserve dynamics during egg production by female Greater Scaup (*Aythya marila*): relationships with timing of reproduction. *Auk* 125(2):384-394. *Work on egg production in waterfowl.

Gorman, K.B., P.L. Flint, D. Esler, and T.D. Williams. 2007. Ovarian follicle dynamics of female Greater Scaup during egg production. *Journal of Field Ornithology* 78(1):64-73. *Work on egg production in waterfowl.

Gorman, K.B. and T.D. Williams. 2005. Correlated evolution of maternally derived yolk testosterone and early developmental traits in passerine birds. *Biology Letters* 1(4):461-464.

Service to the Scientific Community

Peer-review of manuscripts for *Biology Letters* (4), *Journal of Animal Ecology* (1), *Journal of Avian Biology* (1), *Marine Ecology Progress Series* (4), *Physiological and Biochemical Zoology* (1), *Polar Biology* (3), *The American Naturalist* (1), *Waterbirds* (1).

Collaborators (last 48 months)

S Adlard (BAS), K Bernard (OSU), MA Bishop (PWSSC), G Crossin (Dalhousie U), A Dawson (NERC), S Doney (Woods Hole), A Dawson (C. Ecol Hydrol, NERC), H Ducklow (Lamont-Doherty), D Esler (Simon Fraser U), M Fowler (USGS), W Fraser (Polar Oceans Res Group), R Heintz (NOAA), P Hershberger (USGS), E Knudsen (PWSSC), D Martinson (Lamont-Doherty), M Meredith (Brit Ant Surv), S Pegau (PWSSC), R Phillips (BAS), P Rand (USGS), K Ruck (VIMS), G Saba (Rutgers), K Sage (USGS), K Sakamoto (Hokkaido U), O Schofield (Rutgers U), F. Sewall (NOAA), S Sonsthagen (USGS), S Stammerjohn (CU Boulder), D Steinberg (VIMS), S Talbot (USGS), P Trathan (BAS), T Williams (Simon Fraser U).

Appendix C

4. Project Design

A. Objectives

List the objectives of the proposed research and briefly state why the intended research is important. If your proposed project builds on recent work, provide detail on why the data set needs to be continued and whether any changes are proposed. If the proposed project is for new work, explain why the new data is needed. Describe the anticipated final product.

B. Procedural and Scientific Methods

For each objective listed in A. above, identify the specific methods that will be used to meet the objective. In describing the methodologies for collection and analysis, identify measurements to be made and the anticipated precision and accuracy of each measurement and describe the sampling equipment in a manner that permits an assessment of the anticipated raw-data quality.

If applicable, discuss alternative methodologies considered, and explain why the proposed methods were chosen. In addition, projects that will involve the lethal collection of birds or mammals must comply with the EVOSTC's policy on collections, available on our website www.evostc.state.ak.us

C. Data Analysis and Statistical Methods

Describe the process for analyzing data. Discuss the means by which the measurements to be taken could be compared with historical observations or with regions that are thought to have similar ecosystems. Describe the statistical power of the proposed sampling program for detecting a significant change in numbers. To the extent that the variation to be expected in the response variable(s) is known or can be approximated, proposals should demonstrate that the sample sizes and sampling times (for dynamic processes) are of sufficient power or robustness to adequately test the hypotheses. For environmental measurements, what is the measurement error associated with the devices and approaches to be used?

D. Description of Study Area

Where will the project be undertaken? Describe the study area, including, if applicable, decimally-coded latitude and longitude readings of sampling locations or the bounding coordinates of the sampling region (e.g., 60.8233, -147.1029, 60.4739, -147.7309 for the north, east, south and west bounding coordinates).

Objectives

The objectives of the proposed research follow:

1) Assess the seasonal timing (spring, summer, and fall) that allows for accurate determination of both previously spawned and maturing female herring based on ovary histology to determine maturation states

2) Couple histology results with annual scale growth information at the individual level, within specific age cohorts, to understand if scale growth patterns reflect reproductive investment.

3) Assess whether annual scale growth patterns can be used to infer age at maturity at the individual level across age cohorts given results from objectives 1 and 2.

4) Assess inter-annual variability in age at maturity based on coupled histology and scale growth over a five-year period by focused, increased sampling during the optimal seasonal period given results from objectives 1-3.

Appendix C

The research described here is important. The data produced through these studies will improve the Bayesian ASA model - a biologically meaningful age at maturity function will more precisely adjust estimates for the total PWS herring population biomass. The proposed work builds on previous work by HRM investigators regarding age at maturity of PWS herring. However, there are some clear differences from the past work. First, the proposed research will focus on fish caught in the wild from PWS exclusively to determine the seasonal timing that allows for accurate determination of previously spawned and maturing female herring based on ovary histology to determine maturation states, unlike previous work that focused on lab studies of Southeast Alaska herring only. The proposed research will first assess coupled maturation states and scale growth for age-specific cohorts and increase sample sizes of females processed for both ovary maturation and scale growth patterns in comparison with past work. Finally, the proposed study will be conducted over an entire five-year period to assess inter-annual variability in age at maturity, something not addressed by previous work.

The anticipated final products from this work will be a series of papers that address each of the main hypotheses outlined above, in addition to producing a revised age at maturity function for the Bayesian ASA model.

Procedural and Scientific Methods

Objective 1. This study will be conducted during the first two years of the five-year program. The main focus here is to resolve the time of year female fish can be collected where post-ovulatory follicles (POFs) are still visible from an earlier spawning event, in addition to evidence of newly developing follicles in preparation for the next spawning event.

Female fish will be collected at three times during the year – a) during spring (March/April) collections for age, sex and length (S. Moffitt, ADF&G) and adult herring acoustics (P. Rand, PWSSC). These collections will take advantage of existing ship time to complete the fieldwork. Aerial surveys will also be conducted during spring to identify fish outside the spawning population to sample via raft and cast net; b) during summer (late June) in association with a more limited aerial survey effort simply to identify schools of fish; and c) during fall (September/October) in association with Gulf Watch Alaska (GWA) forage fish surveys (M. Arimitsu and J. Piatt, USGS). There may also be the possibility of collecting fish in December as part of the GWA whale/forage fish survey (R. Heintz and J. Moran, NOAA). Thus, it is anticipated that there will be at least three collection periods including spring, summer and fall. Any additional sampling in winter would likely only be conducted in year 1. Females aged 3-5 will be targeted for collection mainly using trawl gear. Sample sizes follow: age 3+ (n = 115 fish/seasonal collection, total 345/year), age 4+ (n = 115/collection, 345/year), and age 5+ (n = 60 fish/collection, 120/year) resulting in a total of 870 fish collected in each of the first two years of the study. In order to reach the sample sizes required for histology and scale analysis of females, over collection of herring will be required and the immediate determination of sex and age in the field in order to target enough female fish per age cohort. Once collected, fish will be processed immediately aboard charter vessels. First, a scale will be removed for aging using a dissecting scope. Once age is determined, an individual fish between the ages of 3+ - 5+ will be further processed. All fish within these ages will be measured for length (mm) and wet weight (g). Gonads will be dissected from the body and a gonadosomatic index (GSI) will be developed by weighing the gonad separately where GSI = (ovary weight/whole wet weight)*100. For female herring, a small mid-section of ovary will be dissected and preserved in formalin for slide mounting and pathology analysis (H. Snyder, President and CEO, and J. Kramer, DVM, Histologistics, Worcester, MA) for discerning maturity states following criteria outlined by Brown-Peterson et al. (2011). Several additional scales from the lateral side of the body for both males and females will be collected and mounted on slides. These scales will be used to measure individual scale annuli of females only using imaging software by an ADF&G Cordova technician. By additionally collecting scales from males, we will archive these samples for any future analyses of male herring scale growth. It is entirely possible that it will be difficult to meet targeted sample sizes, as we do not know in advance what the age structure of fish schools are ahead of sampling.

It is expected that females collected during the spring spawn surveys will have evidence of developed follicles as part of the current spawning event. It is unclear whether POFs will be evident at this time or not. Some proportion of females collected during summer should have evidence of POFs from the prior spring spawning event, while others may not, particularly for age 3 fish. Whether developing follicles for the next spring's spawning event will be evident at this time is not known. Females collected during the early fall likely have the greatest potential to show both evidence of POFs from previous spawning the spring prior as well as developing follicles for the next spawning event. These collections are expected to help resolve the seasonal timing most optimal for understanding both the immediate spring season's spawning history and the future spring's spawning decisions of individuals.

Objective 2. This study will build from the first two years of data collected where ovary maturation characteristics will be compared with annual scale growth data at the individual level within age cohorts. The key to the success of this part of the project is to be able to compare scale growth patterns from individuals of the same age cohort that have differing ovary characteristics. For example, scale growth patterns of age 3+ females, caught in the fall, that have evidence of POFs and developing follicles will be compared with other age 3+ females that have no evidence of POFs and either developing or non-developing ovaries in preparation for the following spring spawning event. The prediction is that age 3+ females with POFs would have a smaller year 3 summer growth layer in comparison with age 3+ females with no POFs. This would confirm that scale growth patterns could help resolve age at reproductive maturity. This analysis will also be applied to age 4+ and 5+ females.

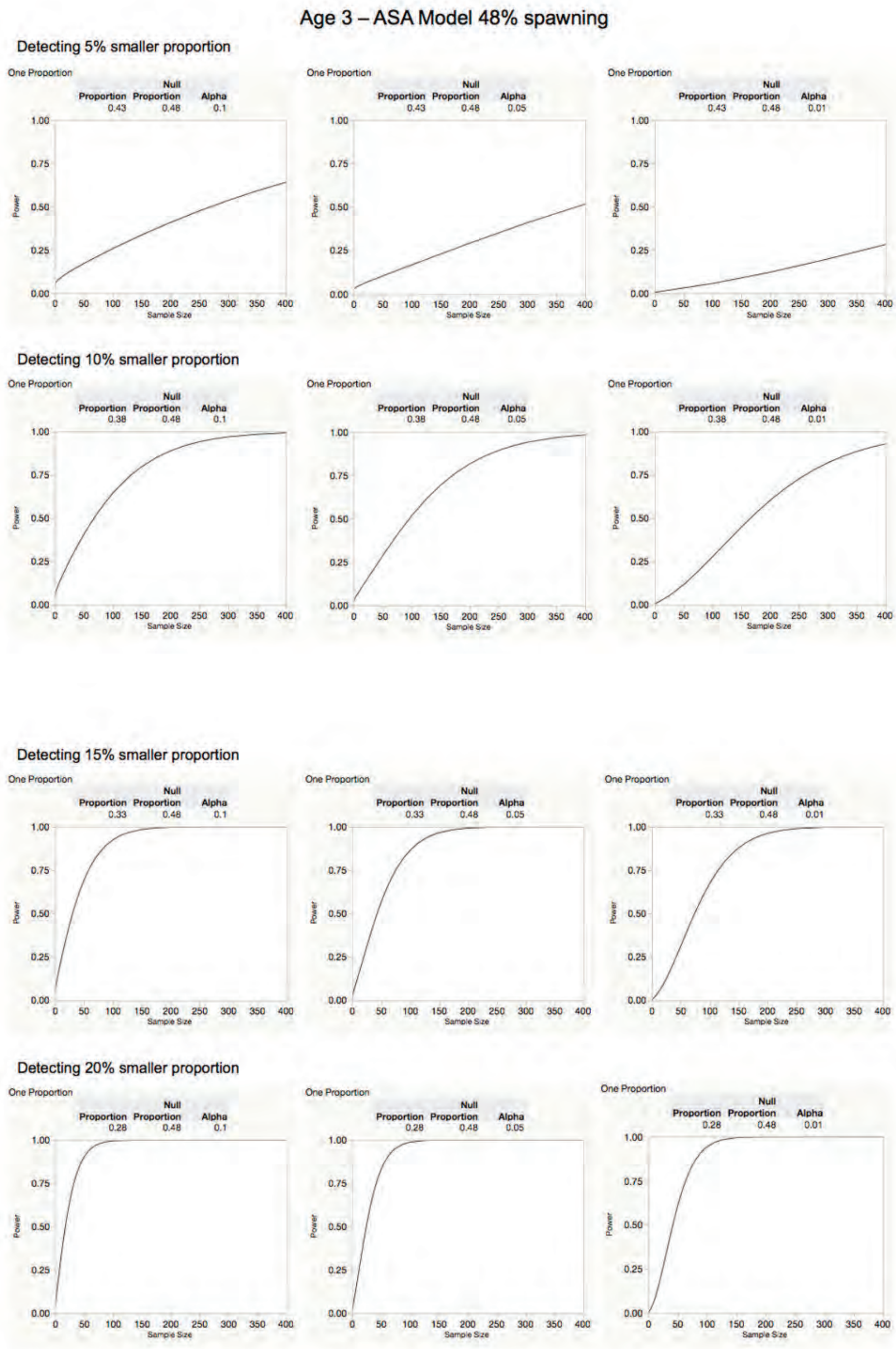
Objective 3. If it appears that ovary maturation does relate to scale growth (objectives 1 and 2), this information will be used to assess age at maturity at the individual level for fish across age cohorts. Scale growth criteria for age at maturation will be developed for each age class based on work conducted as part of objective 2 above. For example, for age class 3+, the difference in summer scale growth between immature and primiparous females for year 3 will be specifically quantified with associated confidence intervals, which then could be used to classify individuals of known reproductive state (discriminant function or similar analyses). These criteria will then be applied to year 3 summer scale growth for age 4+ and 5+ fish to discern if these fish spawned in year 3 or not. Such criteria will also be developed for age 4+ fish and then applied to age 5+ fish for year 4, as well as age 5 fish for year 5.

Objective 4. Once the optimal seasonal timing of sampling is determined by the previous studies during the first two years of the project, the follow three years will focus collections on this one time period and increase the sample sizes for age 3+ and 4+ fish only during this period. Therefore, for years 3-5, samples sizes for age 3+ and 4+ fish during one collection period only will be n = 345 each for a total of 690/year. Data will be collected in the field, a professional pathologist will determine maturation states, and scale growth will be measured using imaging software. Additionally for this study, environmental data collected by GWA researchers (R. Campbell, PWSSC) will be used to characterize the entire five years for temperature, salinity, chlorophyll *a*, and zooplankton abundances in order to characterize the environmental conditions that shape annual proportions of age at maturity and scale growth patterns.

Data Analysis and Statistical Methods

Appendix C

Regarding the sample sizes proposed, a one-tailed power analysis for single-sample proportions was conducted and revealed that a sample size of 115 would result in power 70-95 for detecting a 10–15% reduction, respectively, in the null proportion of spawners (Table 1) at an alpha-level of 0.05 (Fig. 1). Because age 5+ fish should all be spawning individuals, the sample size for this age class in the first two years of the study has been reduced to n = 60/sampling event.



Appendix C

Figure 1. One-tailed power analysis results for single-sample proportions using JMP software. The null proportion is the ASA model's percent of age 4+ spawning proportion. Tests explore power and sample size needed to detect 5-20% reduction in proportions at alpha-levels 0.1-0.01. A sample size of 115 was determined to result in power 70-95 for detecting a 10–15% reduction in proportion.

Statistical analyses will use traditional statistics such as regression or ANOVA in an information-theoretic context (AIC, Burnham & Anderson 2002) to explore questions of interest related to ovary characteristics, scale growth and environmental parameters. For example, ANOVA would be used to determine differences in scale growth between non-spawners and spawners for a given age class (objective 2), with model selection following an AIC framework including a null model. This would allow for weighted parameter estimation. For objective 4, multiple-regression would be used to consider best predictors of age at maturity including a suite of environmental variables. Again, model selection would follow an AIC framework to determine the most parsimonious model and weighted parameter estimates. This statistical approach is particularly well suited for observational studies such as the work described here.

Appendix C

Study Area

The study area will include all of PWS, Alaska (Fig. 2). The spring collections will take place at spawning sites, which have typically been located along the northern coastline in recent years between Valdez and Gravina. Spawning has been known to occur in the southern portion of the sound near Montague Island. Summer and fall collections will take place wherever fish are found based on aerial surveys or other information.

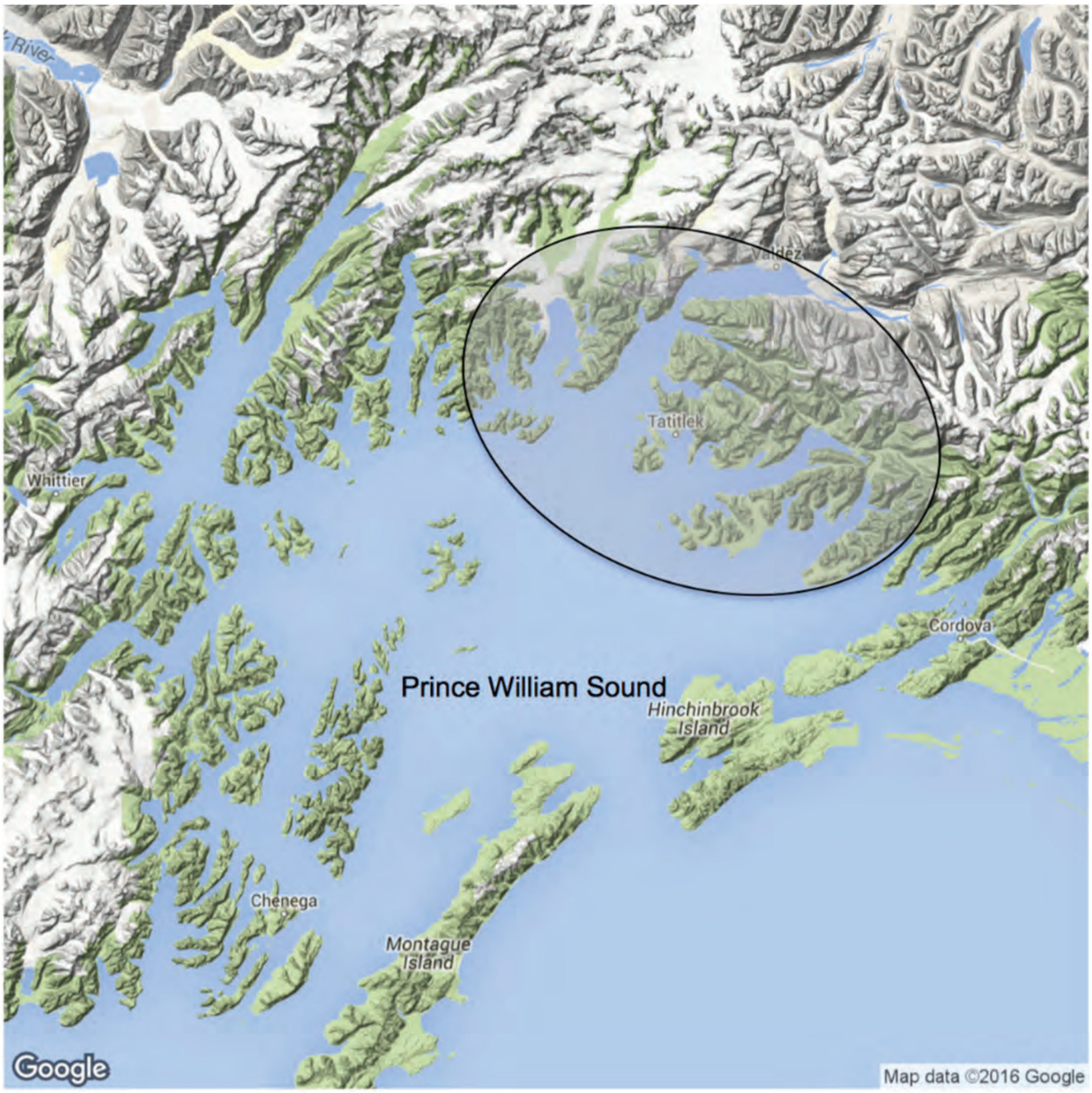


Figure 2. Map of PWS study area. Shaded circle shows northern location where herring have typically spawned in recent years.

5. Coordination and Collaboration

Within the Program

Provide a list and clearly describe the functional and operational relationships with the other program projects. This includes any coordination that has taken or will take place and what form the coordination will take (shared field sites or researchers, research platforms, sample collection, data management, equipment purchases, etc.).

With Other EVOSTC-funded Programs and Projects
Indicate how your proposed program relates to, complements or includes collaborative efforts with other proposed or existing programs or projects funded by the EVOSTC.

With Trustee or Management Agencies
Please discuss if there are any areas which may support EVOSTC trust or other agency work or which have received EVOSTC trust or other agency feedback or direction, including the contact name of the agency staff. Please include specific information as to how the subject area may assist EVOSTC trust or other agency work.

If the proposed project requires or includes collaboration with other agencies, organizations or scientists to accomplish the work, such arrangements should be fully explained and the names of agency or organization representatives involved in the project should be provided. If your proposal is in conflict with another project or program, note this and explain why.

With Native and Local Communities
Provide a detailed plan for any local and native community involvement in the project.

Coordination within the program

The proposed work will couple sampling during the first two years of the study with another HRM investigator coordinating the adult acoustics, as well as the aerial surveys and validation (P. Rand, PWSSC). Further, the data will be used in the Bayesian ASA modeling effort (T. Branch, UW).

Coordination with other EVOSTC-funded programs

The work described here plans to build off relationships established with GWA including maximizing the forage fish (M. Arimitsu and J. Piatt, USGS) and whale survey (R. Heintz, NOAA) efforts to collect samples for this study. Further, environmental data collected by other GWA investigators plan to be used in analyses (R. Campbell, PWSSC).

Coordination with Management Agencies

The scale aging and growth measurement work is collaborative with ADF&G (S. Moffitt, ADF&G Cordova). Initially, scales will be read in the first two years of the study by an ADF&G technician and this will allow for training a PWSSC technician at the same time who will then conducted the analyses in years 3-5.

6. Schedule

Program Milestones
Specify when critical program tasks will be completed. Reviewers will use this information in conjunction with annual program reports to assess whether the program is meeting its objectives and is suitable for continued funding.

Measurable Program Tasks
Specify, by each quarter of each fiscal year (February 1 – January 31), when critical program tasks will be completed.

Appendix C

Project Milestones

February 2017. Begin project.
December 2017. Complete Year 1 work.
December 2018. Complete Year 2 work. Objectives 1-3 completed.
December 2019. Complete Year 3 work.
December 2020. Complete Year 4 work.
December 2021. Complete Year 5 work. Objective 4 completed.
December 2022. Final report submitted.

Measureable Project Tasks

2017	
1nd Quarter (Jan – March)	Mar/Apr: Spring field collections, histology samples sent.
2rd Quarter (Apr – Jun)	Mar/Apr: Spring field collections, histology samples sent. Jun: Summer field collections, histology samples sent.
3th Quarter (Jul – Sept)	Aug: Proposal for 2018 submitted. Sept/Oct: Fall field collections, histology samples sent.
4th Quarter (Oct – Dec)	Sept/Oct: Fall field collections, histology samples sent. Nov: PI meeting. Dec: 2017 scale readings completed.
2018	
1nd Quarter (Jan – March)	Feb: 2017 Annual report completed and 2017 data submitted to AOOS portal. Mar/Apr: Spring field collections, histology samples sent.
2rd Quarter (Apr – Jun)	Mar/Apr: Spring field collections, histology samples sent. Jun: Summer field collections, histology samples sent.
3th Quarter (Jul – Sept)	Aug: Proposal for 2019 submitted. Sept/Oct: Fall field collections, histology samples sent.
4th Quarter (Oct – Dec)	Sept/Oct: Fall field collections, histology samples sent. Nov: PI meeting. Dec: 2018 scale readings completed.
2019	
1nd Quarter (Jan – March)	Feb: 2018 Annual report completed and 2018 data submitted to AOOS portal.
2rd Quarter (Apr – Jun)	
3th Quarter (Jul – Sept)	Optimal field collections (possibly), histology samples sent. Aug: Proposal for 2020 submitted.
4th Quarter (Oct – Dec)	Nov: PI meeting. Dec: 2019 scale readings completed.
2020	
1nd Quarter (Jan – March)	Feb: 2019 Annual report completed and 2019 data submitted to AOOS portal.
2rd Quarter (Apr – Jun)	

3rd Quarter (Jul – Sept)	Optimal field collections (possibly), histology samples sent. Aug: Proposal for 2021 submitted.
4th Quarter (Oct – Dec)	Nov: PI meeting. Dec: 2020 scale readings completed.
2021	
1nd Quarter (Jan – March)	Feb: 2020 Annual report completed and 2020 data submitted to AOOS portal.
2rd Quarter (Apr – Jun)	
3th Quarter (Jul – Sept)	Optimal field collections (possibly), histology samples sent.
4th Quarter (Oct – Dec)	Nov: PI meeting. Dec: 2020 scale readings completed.
2022	
1nd Quarter (Jan – March)	Feb: 2021 Annual report completed and 2020 data submitted to AOOS portal.
2rd Quarter (Apr – Jun)	
3th Quarter (Jul – Sept)	
4th Quarter (Oct – Dec)	Dec: Final report completed.

7. Budget

Budget Forms (Attached)

Please provide completed budget forms. Please note that the following items will not be considered for funding:

- Costs associated with international travel for meetings, symposia, or presentations.
- Costs associated with attendance at meetings, symposia, or presentations outside of those required to coordinate with project members.
- Costs associated with outreach or education efforts.

Sources of Additional Funding

Identify non-EVOSTC funds or in-kind contributions used as cost-share for the work in this proposal. List the amount of funds, the source of funds, and the purpose for which the funds will be used. Do not include funds that are not directly and specifically related to the work being proposed in this proposal.

Budget Narrative

Personnel Costs

Support is requested during each of the five years for two personnel, the PI - Kristen Gorman (6 months each year) and technician – Julia McMahon (3.5-4 months varying across the five years). A 3% cost of living increase was calculated for each year. Benefit amounts vary from 0.58 – 0.62 across the five years to reflect changes in heath care costs or additional benefit requirements of project staff (i.e., number of family plan members). *Overall amount requested $393,597*.

Appendix C

Staff	Year	Base Monthly Salary	Base Monthly Benefits	Total Monthly Salary and Benefits	Number of Months/year	Total Monthly Salary and Benefits
Gorman	2017	5720	0.58	9038	6	54228
McMahon	2017	3150	0.58	4977	3.5	17420
Gorman	2018	5892	0.60	9427	6	56562
McMahon	2018	3245	0.58	5126	3.5	17941
Gorman	2019	6069	0.60	9710	6	58260
McMahon	2019	3342	0.58	5281	4	21124
Gorman	2020	6251	0.60	10127	6	60762
McMahon	2020	3442	0.60	5508	4	22032
Gorman	2021	6439	0.62	10430	6	62580
McMahon	2021	3545	0.60	5672	4	22688
Overall Total						*393597*

Travel
Support is requested for the PI to attend yearly EVOSTC HRM PI meetings, $1,100/year for roundtrip airfare and two nights hotel and per diem. *Total $5100*.

Contractual
Support is requested for the following: PWSSC communications ($150/staff months/year); PWSSC printing and postage ($500/year); Histological analysis of collected ovaries ($15 for slide mounting and $10 for pathology reading/sample; Scale reading by ADF&G in years one and two ($6.02/scale, does not include 21% indirect cost for ADF&G); Vessel charter ($2500/day); Flight charter ($600/hour). *Total $192,468.*

Commodities
Support is requested for the following: A precision field balance to weigh fish and ovaries, requested only in year one ($600); Whirlpaks for storing fish each year ($300/1000 bags); Histology cassettes to store ovary samples each year ($100/1000 cassettes); Bottles to store cassettes in formalin each year ($250/100 bottles); Formalin each year ($800/40 gallons); Slides for mounting scales each year ($225/1440 slides); Vials for otolith preservation each year ($100/1000). *Total $9475*

Total Direct Costs
Total direct costs are estimated at *$599,540*.

Indirect Costs (IDC)
A 30% IDC of all direct costs is calculated for PWSSC in each year of the study. This is not calculated on equipment over $5000, which does not apply to this study. Total indirect costs are estimated at *$179,862*.

Total Direct and Indirect Costs
Total support requested *$779,787*.

Appendix C

8. Literature Cited

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***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$71.5	$74.3	$79.4	$82.6	$85.2	$393.0	
Travel	$1.1	$1.1	$1.1	$1.1	$1.1	$5.5	
Contractual	$45.0	$44.2	$34.2	$34.2	$34.2	$191.8	
Commodities	$2.4	$1.8	$1.8	$1.8	$1.8	$9.6	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)	$36.0	$36.4	$35.0	$35.9	$36.7	$180.0	
SUBTOTAL	$156.0	$157.8	$151.5	$155.6	$159.0	$779.8	
General Administration (9% of	$14.0	$14.2	$13.6	$14.0	$14.3	$70.2	N/A
PROJECT TOTAL	$170.0	$172.0	$165.1	$169.6	$173.3	$850.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

COMMENTS:
This summary page provides an five-year overview of proposed project funding and actual cumulative spending. The column titled 'Actual Cumulative' must be updated each fiscal year as part of the annual reporting requirements. Provide information on the total amount actually spent for all completed years of the project. On the Project Annual Report Form, if any line item exceeds a 10% deviation from the originally-proposed amount; provide detail regarding the reason for the deviation.

FY17

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

NON-TRUSTEE AGENCY SUMMARY PAGE

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Kristen Gorman	Year 1	6.0	9.0	0.0	54.0
Julia McMahon	Year 1	3.5	5.0	0.0	17.5
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	14.0	0.0	
				Personnel Total	$71.5

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting 2017	0.5	1	3	0.2	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.1

FY17

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: xx/xx/xxxx

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
PWSSC Communications (network & phone) ($100/staff mo for network and $40/mo for phone + long distance)	1.5
PWSSC Postage and printing	0.5
Histology - slide mounting ($15/sample)	13.0
Histology - pathology reading ($10/sample)	8.7
ADF&G scale reading	5.2
Charter vessel (5 days at $2.5K/day)	12.5
Charter flights (4 hrs at $600/hr)	3.6
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$45.0

Commodities Costs: Description	Commodities Sum
Portable balance	0.6
Whirlpak bags	0.3
Histology cassettes	0.1
Cassette bottles	0.3
Formalin	0.8
Slides	0.2
Vials	0.1
Commodities Total	$2.4

FY17

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
None			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Imaging software	1	ADF&G

FY18

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
EQUIPMENT DETAIL

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Kristen Gorman	Year 2	6.0	9.4	0.0	56.4
Julia McMahon	Year 2	3.5	5.1	0.0	17.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	14.5	0.0	
				Personnel Total	$74.3

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting 2018	0.5	1	3	0.2	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.1

FY18

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: xx/xx/xxxx

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
PWSSC Communications (network & phone) ($100/staff mo for network and $40/mo for phone + long distance)	1.4
PWSSC Postage and printing	0.5
Histology - slide mounting ($15/sample)	13.0
Histology - pathology reading ($10/sample)	8.0
ADF&G scale reading	5.2
Charter vessel (5 days at $2.5K/day)	12.5
Charter flights (6 hrs at $600/hr)	3.6
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$44.2

Commodities Costs: Description	Commodities Sum
Whirlpak bags	0.3
Histology cassettes	0.1
Cassette bottles	0.3
Formalin	0.8
Slides	0.2
Vials	0.1
Commodities Total	$1.8

FY18

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: xx/xx/xxxx

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
None			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Imaging software	1	ADF&G

FY19

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
EQUIPMENT DETAIL

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Kristen Gorman	Year 3	6.0	9.7		58.2
Julia McMahon	Year 3	4.0	5.3		21.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	15.0	0.0	
				Personnel Total	$79.4

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting 2019	0.5	1	3	0.2	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.1

FY19

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
PWSSC Communications (network & phone) ($100/staff mo for network and $40/mo for phone + long distance)	1.5
PWSSC Postage and printing	0.5
Histology - slide mounting ($15/sample)	10.4
Histology - pathology reading ($10/sample)	6.9
Charter vessel (5 days at $2.5K/day)	12.5
Charter flights (4 hrs at $600/hr)	2.4
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$34.2

Commodities Costs: Description	Commodities Sum
Whirlpak bags	0.3
Histology cassettes	0.1
Cassette bottles	0.3
Formalin	0.8
Slides	0.2
Vials	0.1
Commodities Total	$1.8

FY19

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B CONTRACTUAL & COMMODITIES DETAIL

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
None			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Imaging software	1	ADF&G

FY20

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
EQUIPMENT DETAIL

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Kristen Gorman	Year 4	6.0	10.1	0.0	60.6
Julia McMahon	Year 4	4.0	5.5	0.0	22.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	15.6	0.0	
				Personnel Total	$82.6

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting 2020	0.5	1	3	0.2	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.1

FY20

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
PWSSC Communications (network & phone) ($100/staff mo for network and $40/mo for phone + long distance)	1.5
PWSSC Postage and printing	0.5
Histology - slide mounting ($15/sample)	10.4
Histology - pathology reading ($10/sample)	6.9
Charter vessel (5 days at $2.5K/day)	12.5
Charter flights (4 hrs at $600/hr)	2.4
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$34.2

Commodities Costs: Description	Commodities Sum
Whirlpak bags	0.3
Histology cassettes	0.1
Cassette bottles	0.3
Formalin	0.8
Slides	0.2
Vials	0.1
Commodities Total	$1.8

FY20

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B CONTRACTUAL & COMMODITIES DETAIL

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
None			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Imaging software	1	ADFG

FY21

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
EQUIPMENT DETAIL

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Kristen Gorman	Year 5	6.0	10.4	0.0	62.4
Julia McMahon	Year 5	4.0	5.7	0.0	22.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	16.1	0.0	
				Personnel Total	$85.2

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting 2021	0.5	1	3	0.2	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.1

FY21

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: xx/xx/xxxx

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
PWSSC Communications (network & phone) ($100/staff mo for network and $40/mo for phone + long distance)	1.5
PWSSC Postage and printing	0.5
Histology - slide mounting ($15/sample)	10.4
Histology - pathology reading ($10/sample)	6.9
Charter vessel (5 days at $2.5K/day)	12.5
Charter flights (4 hrs at $600/hr)	2.4
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$34.2

Commodities Costs: Description	Commodities Sum
Whirlpak bags	0.3
Histology cassettes	0.1
Cassette bottles	0.3
Formalin	0.8
Slides	0.2
Vials	0.1
Commodities Total	$1.8

FY21

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B CONTRACTUAL & COMMODITIES DETAIL

Date Prepared: xx/xx/xxxx

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
None			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
Imaging software	1	ADFG

FY21

Project Title: Studies of Reproductive Maturity among Age Cohorts of Pacific Herring (Clupea pallasii) in Prince William Sound, Alaska
Primary Investigator: Kristen B. Gorman

FORM 3B
EQUIPMENT DETAIL

Date Prepared: xx/xx/xxxx

August 11, 2016

Paul Hershberger
U.S. Geological Survey
Marrowstone Marine Field Station
616 Marrowstone Point Road
Nordland, WA, USA

Dear EVOS Trustee Council,

I would like to thank the Science Panel for their thorough review of our proposal "Herring Disease Program IV." Their constructive comments were extremely insightful, and the revised proposal is much stronger as a result of their contributions. In addition to making the appropriate changes in the proposal, my responses to the most direct questions are included below:

1) There was a request to develop SPF herring colonies using stocks of herring from PWS, as inter-stock differences in susceptibility may exist. We were very concerned about this possibility during the first HDP several years ago; as a result, we previously compared the relative susceptibility of 3 genetically distinct herring stocks (including PWS) to VHS. The controlled studies showed no significant differences in susceptibility between the stocks. These results, an associated figure, and reference to the published article have been included in the revised proposal. Because all stocks responded similarly, there is no further need to raise PWS stocks. However, it is possible that the immune responses of these stocks may respond differently after their exposure to PAH's. Therefore, if Dr. Whitehead's new proposal in the Lingering Oil category is recommended for funding, then we will raise herring from the different stocks (including PWS) for his test animals.
2) There was a question about difference in infection prevalence and intensity between different herring populations. We have been performing a comparative assessment of pathogen prevalence and intensity between herring from PWS and Sitka for the past 10 years. Additionally, we assess the health of herring from other locations throughout the NE Pacific, including Puget Sound and Canada, as they are available. The results of these surveys are reported in the annual and final EVOS TC project reports.
3) Per the reviewer's request, the section on final validation and applications of the novel plaque neutralization test has been expanded.
4) There was a request explain why the Fluidigm Biomark technology is not employed in this proposal. The gene chip technology is an exciting tool that has some very specific applications. The real beauty of this tool is its provision of rapid screening platform for numerous microbes. Once presumed positive samples are identified using this technology, verification must occur using standard laboratory techniques; further, their pathogenic status must be confirmed. If the tool was applied to Pacific herring, a list of suspect microbes would certainly be created. However, we already know that herring are infected with dozens of microbes, the majority of which demonstrate negligible, if any pathogenicity. In the HDP study, we have limited our work to the investigation of pathogens that have a demonstrated history of fish kills with associated

population declines in Atlantic and Pacific herring. From a curiosity perspective, it would be interesting to understand more about some of these other herring microbes (many of which we already know exist), but there is certainly no indication that they have ever contributed to herring kills or population declines. In essence, the gene chip tool provides a great first step when investigating a new system containing little or no background information. However, our knowledge of the herring pathogens in PWS and their population-level impacts has advanced well beyond the ability of the Fluidigm Biomark technology to contribute meaningful information.

Again, I would like to thank the Science Panel for their time. Please let me know if I can answer any additional questions.

Sincerely,

Paul Hershberger

Appendix C

EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
PROGRAM PROJECT PROPOSAL SUMMARY PAGE

Project Title

Prince William Sound Herring Restoration and Monitoring Program: Herring Disease Program IV

Primary Investigator(s) and Affiliation(s)

Paul K. Hershberger, Ph.D.
Station Leader, Research Fishery Biologist
U. S. Geological Survey – Marrowstone Marine Field Station
Nordland, WA

Maureen K. Purcell, Ph.D.
Research Microbiologist
U. S. Geological Survey – Western Fisheries Research Center
Seattle, WA

Date Proposal Submitted

August 12, 2016

Project Abstract

Using an approach that involves a combination of field- and laboratory-based studies, we propose to investigate fish health factors that may be contributing to the failed recovery of Pacific herring populations in Prince William Sound. Field studies will provide infection and disease prevalence data that will inform the ASA model, serological data that will indicate the prior exposure history and future susceptibility of herring to VHS, and diet information that will provide insights into the unusually high prevalence of *Ichthyophonus* that occurs in juvenile herring from Cordova Harbor. Laboratory studies will validate the newly-developed plaque neutralization assay as a quantifiable measure of herd immunity, provide further understanding of disease cofactors including temperature and salinity, investigate the possibility of an invertebrate host for *Ichthyophonus*, and assess the virulence of other endemic pathogens to Pacific herring. Information from the field and laboratory studies will be integrated into the current ASA model, a novel ASA-type model that is based on the immune status of herring age cohorts, and a novel mixture-cure simulation model for VHS. The Herring Disease Program (HDP) is embedded within the Herring Research and Monitoring Program, and the success of the HDP relies heavily on contributions from companion projects with Principle Investigators including Steve Moffitt (platform for the collection of pathogen prevalence data), Dr. Kristen Gorman (collection of juvenile Pacific herring from Cordova Harbor), Dr. Trevor Branch (incorporation of pathogen and resistance information in to the ASA models). Additionally, this project relies on contributions from Principle Investigators in the Long Term Monitoring Program (Dr. Rob Campbell – zooplankton collections).

EVOSTC Funding Requested *(must include 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
$197.8	$204.4	$212.2	$218.8	$226.6	$1,059.8

Non-EVOSTC Funding Available

FY17	FY18	FY19	FY20	FY21	TOTAL
$61.7	$63.6	$64.0	$65.2	$66.9	$321.4

Appendix C

Please refer to the Invitation for the specific proposal requirements for each Focus Area. The information requested in this form is in addition to the information requested in each Focus Area and by the Invitation.

1. Executive Summary

Identify the hypotheses the project is designed to address. Describe the background and history of the problem. Include a scientific literature review that covers the most significant previous work history related to the project. Please provide a summary of the project including key hypotheses and overall goals.

The biomass of adult herring in Prince William Sound (PWS) collapsed from 111,000-121,000 mt in 1988-1989 to 30,000 mt in 1993; since then, the population has remained depressed, fluctuating between 10,800-32,500 mt. Consequently, the PWS herring population is currently classified as an "injured resource" that is "not recovering" (EVOSTC 2002) and commercial herring fisheries have remained severely curtailed or closed. In addition to the human economic impacts of the population decline, the prolonged ecological impacts were devastating. In marine systems, particularly upwelling-driven systems like PWS, forage fishes, including Pacific herring, represent the primary energy link in the biological community, exerting both top-down control over primary and secondary production (phytoplankton and zooplankton) and bottom-up control over higher order predators (Rice 1995 and Currey et al 2000). The critical ecological position occupied by forage fishes is equally important in bridging the flow of inorganic nutrients (mobilized by primary and secondary production) and organic nutrients (utilized by higher trophic level predators).

Definitive cause(s) of the herring population decline and failed recovery in PWS remain undetermined; however, a leading hypothesis involves chronic and epizootic mortality that result from infectious and / or parasitic diseases (Marty et al 1998 and 2003). In 1993 only 20% of the anticipated adult herring biomass appeared in the known spawning areas. Returning fish were lethargic and demonstrated external hemorrhages consistent with viral hemorrhagic septicemia (VHS). The etiological agent, VHS virus (VHSV), was later isolated from moribund individuals. Subsequently, other suspected pathogens were identified in the PWS herring population, including *Ichthyophonus hoferi*, Anisakid worms, lymphocystis virus, *Goussia* sp (an intestinal parasite), *G. clupearum* (a liver parasite), a testicular coccidian, a myxosporean in the gall bladder, *Ortholinea orientalis*, *Ceratomyxa auerbachi*, *Gyrodactylus spp* (monogenean trematodes), branchial ciliated protozoans, a renal myxosporean, *Epitheliocystis*, gastric trematodes, intestinal trematodes, intestinal cestodes (Marty et al 1998), and erythrocytic necrosis virus (ENV; Hershberger et al 2009). Among the pathogens occurring in PWS herring, VHSV, *Ichthyophonus*, and ENV are considered the primary pathogens of concern because they have been associated with epizootics in populations of wild herring, pilchards, and other forage species (Meyers et al. 1986, Hershberger et al. 2009, Garver et al, 2013, Burge et al. 2014). Alternative and complementary hypotheses accounting for the herring population dynamics include competition with pink salmon for limited resources (Deriso et al 2008) and predation on herring populations by humpback whales and other predators.

The North American strain of VHSV (Genogroup IVa) is periodically associated with epizootics (Garver et al. 2013) in wild marine fishes, where it can be highly virulent (Kocan et al. 1997). Monospecific VHS epizootics involving wild Pacific herring were reported during 1994 in Port Fredrick (Alaska), 1993 in Prince Rupert Sound (British Columbia; Traxler and Kieser 1994, Meyers and Winton 1995), and presumably 1942 in the Strait of Georgia (British Columbia; Tester 1942). Epizootics of mixed host assemblages involving Pacific sardines and Pacific herring occurred during 1998-1999 in Queen Charlotte Strait (British Columbia) and 2001-2002 Kyuquot and Nootka Sounds (British Columbia; Hedrick et al. 2003); similar mixed assemblage VHS epizootics involving Pacific herring, Pacific hake, and walleye pollock occurred during 1998 in Lisianski Inlet (Alaska; Meyers et al. 1999). Furthermore, capture and confinement of Pacific herring, Pacific sandlance, and surf smelt routinely results in locally severe VHS epizootics among the confined populations (Hershberger et al 1999, Kocan et al 2001, Hedrick et al 2003). As larvae (Hershberger et al 2007) and juveniles (Kocan et al 1997), Pacific herring are highly susceptible to VHS, with laboratory exposures resulting in 66-100% mortality. In the wild, juvenile herring are exposed to VHSV as early as 3 months post-hatch, shortly after their metamorphosis from larvae (Kocan et al 2001). The prevalence and severity of VHSV in confined adult herring captured for spawn-on-kelp roe fisheries decreases with age (Hershberger et al 1999), suggesting a mechanism of adaptive immunity in adults that originates from previous exposures to the virus.

Ichthyophonus hoferi is a member of the Mesomycetozoea, a monophyletic class of protists that includes several other important pathogens (Ragan et al 1996, Herr et al 1999, reviewed in Mendoza et al 2002). Currently *I. hoferi* (reviewed in McVicar 2011) and *I. irregularis* (Rand et al 2000) are the only two recognized species in the genus, but other species have likely been grouped with *I. hoferi* based on the plasticity of morphological characteristics (McVicar 1999, Rasmussen et al 2010). Recent molecular phylogenetic studies indicate that distinct genetic types of the parasite exist (Criscione et al. 2002, Halos et al 2005, Rasmussen et al. 2010, Gregg and Hershberger unpublished data); therefore, the organism will be referred to generically as *Ichthyophonus* hereafter. From 1898 through the mid 1950's, six major *Ichthyophonus*-related epizootics were described in Atlantic herring (*Clupea harengus*) from the Western North Atlantic (Sindermann 1990, McVicar 2011, Burge et al. 2014). More recently, a massive *Ichthyophonus*-related epizootic killed an estimated 300 million Atlantic herring in waters around Sweden and Denmark during the early 1990's (Rahimian and Thulin 1996), and epidemiological data implicate *Ichthyophonus* as a primary factor responsible for mortality in wild Pacific herring (*Clupea pallasii*) from estuarine waters of Washington State (Hershberger et al 2002). Unpublished reports of large *Ichthyophonus* epizootics in the waters around Iceland during the fall and winter of 2008 resulted in the capture of massive numbers of herring that were unmarketable as a result of *Ichthyophonus*-induced tissue changes.

Information gaps addressed in this proposal:
A better understanding of the epidemiological principles governing herring diseases in PWS is necessary for the development of adaptive management strategies intended to mitigate the effects of diseases to wild herring populations. Early studies of known herring pathogens in PWS were conducted by Dr. Gary Marty, and provided valuable information on trends of infection prevalence and intensity since 1994. In an effort to document changes in pathogen prevalence and severity within the PWS herring population, these surveillance efforts were continued by Hershberger et al., in the form of the Herring Disease Program (HDP) from 2007 – present. The incorporation of laboratory-based manipulations and observations in the HDP has led to the realization that some of our prior assumptions of these diseases were incorrect. For example, in a typical herring population, the prevalence of VHSV generally falls below the realistic detection threshold obtained from 60-fish subsamples of a population. Even though the endemic prevalence is typically extremely low, an epizootic can occur very quickly as a result of changing host and environmental conditions (reviewed in Hershberger et al 2016). As such, the incorporation of VHSV prevalence data into the ASA model as a forecaster of future disease potential is inconsequential from an epidemiological perspective. For example, a prevalence of 0% (0/60) in a pre-spawn herring population provides no indication of whether the population previously experienced a VHS epizootic, or an epizootic is likely to occur in the future. For this reason, we have developed a serological assay (50% plaque neutralization assay - PNT) that is capable of determining whether herring have survived previous exposure to VHSV. This knowledge is extremely important from a disease forecasting perspective because survivors of prior VHSV exposure remain refractory to the disease for a very long time; presumably for life (reviewed in Hershberger et al. 2016). Here, we will begin to apply the novel PNT assay to the level of herring populations by proceeding with a series of validation experiments intended to determine the temporal and geographic scales of serological sampling that are required to assess population herd immunity against VHS. It is anticipated that this approach can be used to assess the future potential for VHS impacts in wild herring populations - a critical piece of information that will be useful for assigning the amount of disease risk associated with opening certain herring fisheries (eg. spawn-on-kelp).

These and other required updates and possible changes to our modeling approaches will be assessed by working closely with the ASA and other modelers to begin to develop disease-based models that are more built upon biologically-relevant disease principles. For example, we will continue to provide infection and disease data for the current ASA model, provide herring antibody results to Dr. Branch who will assemble a novel VHSV-based

ASA-type model (see his separate proposal), and provide other VHSV epizootiological data to USGS modelers who will develop a mixture cure-type simulation model for VHS in herring.

Although *Ichthyophonus* is one of the most significant parasites of wild marine fishes, causing recurring population-level impacts during the past century (reviewed in Burge et al. 2014), very little in known about its natural life cycle. From a disease forecasting perspective, the most important information gap involves unresolved routes of exposure and transmission to planktivorous fishes. Laboratory studies indicate that the parasite is not readily transmitted from herring-to-herring via direct contact or through the water (Gregg et al. 2012). Recently, we have successfully established infections in herring by habituating them to the consumption of large quantities of infected fish tissues (Hershberger et al 2015); however, the relevance of this exposure route to wild populations of Pacific herring remains questionable, as herring are generally considered planktivores. These and other results have resulted in the elevation of a hypothesis that an invertebrate, intermediate host may be involved in completing the *Ichthyophonus* life cycle. However, until recently, appropriate scientific tools did not exist for examining the possibility of an *Ichthyophonus* intermediate host. Recent work performed in the Herring Disease Program was successful in developing novel tools (quantitative PCR and chromogenic in situ hybridization) that will be useful for assessing wild zooplankters as intermediate hosts for *Ichthyophonus*. Here we will continue to assess possible natural route(s) of *Ichthyophonus* transmission by expanding laboratory studies to assess horizontal transmission, examining a particular location (Cordova Harbor) where *Ichthyophonus* infection prevalence is unusually high, and by screening common herring food items as possible intermediate hosts for the parasite.

Finally, we will continue to advance our understanding of basic epizootiological principles that govern the primary diseases of herring by continuing to employ specific pathogen-free (SPF) laboratory animals in controlled laboratory experiments. For example, we will further evaluate the importance of temperature as a VHS perpetuation cofactor factor and we will evaluate the susceptibility of herring to *Vibrio* spp. – likely the most prevalent bacterial pathogens of marine fishes in the world (Actis et al. 2011).

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2. Relevance to the Invitation for Proposals

Discuss how the project addresses the projects of interest listed in the Invitation and the overall Program goals and objectives. Describe the results you expect to achieve during the project, the benefits of success as they relate to the topic under which the proposal was submitted, and the potential recipients of these benefits.

This proposal addresses the overall goal of the Herring Research and Monitoring Program outlined in the Invitation for Proposals:

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> "The continued development and testing of an updated age structures assessment (ASA) model in collaboration with ADF&G…."

In particular, we will continue to provide infection and disease prevalence information that feed into the current version of the ASA model. Additionally, we will provide results from the novel VHSV antibody assay to Dr. Branch, who will design a novel ASA-type model that assesses past and future susceptibility of the PWS herring population to VHS. Finally, we will work with USGS modelers to provide relevant VHS data that will be incorporated into a mixture-cure visualization model that can assess the relative importance of disease cofactors in forecasting the potential for future epizootics.

Additionally, this proposal addresses a particular area of interest identified in the Invitation for Proposals:

> "6. The continuation of the work to study the role of disease in herring recovery and the potential for developing tools to aid management agencies in the detection and management of disease outbreaks."

During the previous 5 year project, we successfully developed a serological tool that is capable of retrospectively assessing the exposure history of herring to VHSV. Here, we will continue the advancement of this tool by performing a series of validation tests using wild herring in the laboratory. Additionally, we will continue with laboratory-and field-based experiments intended to understand the basic principles that govern the primary diseases of Pacific herring. These principles will then be used to develop additional disease forecasting tools.

Finally, for the reasons listed above, this proposal also nests within Objectives outlined by Dr. Pegau for the proposed Herring Research and Monitoring Project (FY'17-'21):

> "Expand and test the herring stock assessment model used in Prince William Sound…."
> "Provide inputs to the stock assessment model…"
> "Develop new approaches to monitoring…"

Appendix C

3. Project Personnel

The CV's of all principal investigators and other senior personnel involved in the proposal must be provided. Each resume is limited to two consecutively numbered pages and must include the following information:

- A list of professional and academic credentials, mailing address, and other contact information (including e-mail address)
- A list of up your most recent publications most closely related to the proposed project and up to five other significant publications. Do not include additional lists of publications, lectures, etc.
- A list of all persons (including their organizational affiliations) in alphabetical order with whom you have collaborated on a project or publication within the last four years. If there have been no collaborators, this should be indicated.

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Education:

Ph.D. Fisheries, University of Washington: 1998
M.S. Fisheries, University of Washington: 1995
B.S. Chemistry & Biology, Northland College (Manga Cum Laude): 1993

Recent Positions

2003 - Present: Station Leader & Research Fishery Biologist – USGS, Marrowstone Marine Station
2010 – Present: Affiliate Associate Professor - School of Aquatic and Fishery Sciences, University of Washington
2014 – 2015: Past-President, American Fisheries Society, Fish Health Section
2013 – 2014: President, American Fisheries Society, Fish Health Section
2012 –2013: President Elect, American Fisheries Society, Fish Health Section
2011 – 2012: Vice President, American Fisheries Society, Fish Health Section
2004 – 2010: Affiliate Assistant Professor: School of Aquatic and Fishery Sciences, University of Washington.

Five Publications Relevant to this Proposal

Purcell, M.K., S. Pearman-Gillman, R.L. Thompson, J.L Gregg, L.M. Hart. J.R. Winton, E.J. Emmenegger, P.K. Hershberger. 2016. Identification of the major capsid protein of erythrocytic necrosis virus (ENV) and development of quantitative real-time PCR assays for quantification of ENV DNA. Journal of Veterinary Diagnostic Investigation 28: 382-391.

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Five Additional Publications

Hershberger, P.K., J.L. Gregg, L.M. Hart, S. Moffitt, R. Brenner, K. Stick, E. Coonradt, T. Otis, J. J. Vollenweider,K. A. Garver, J. Lovy, T.R. Meyers. 2016. The parasite *Ichthyophonus* sp. in Pacific herring. Journal of Fish Diseases 39: 309-410.

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Burge, C. A., C. M. Eakin, C. S. Friedman, B. Froelich, P. K. Hershberger, E. E. Hofmann, L. E. Petes, K. C. Prager, E. Weil, B. L. Willis, S.E. Ford, C. D. Harvell. 2014. Climate change influences on marine infectious diseases: implications for management and society. Annual Review of Marine Science 6: 249-277.

Recent PI Collaborators and Co-Authors (Past 5 years):

E. Bromage (U. Mass – Dartmouth), C. Burge (U. Maryland), C. Closek (Penn State U.), D. Elliott (USGS), M. Eakin (NOAA Coral Reef Watch), E. Emmenegger (USGS), B. Foelich (UNC – Chapel Hill), S. Ford (Rutgers U.), C. Friedman (U. Washington),L. Fuess (U. Texas – Arlington), A. Gannam (USFWS), K. Garver (DFO), F. Goetz (NOAA – Fisheries), J. Hansen (USGS), C.D. Harvell (Cornell U.), I. Hewson (Cornell U.), E. Hofmann (Old Dominion U.), R. Kocan (UW-SAFS), G. Kurath (USGS), S. LaPatra (Clear Springs Foods), N. Lorenzen (Danish National Veterinary Institute), J. Lovy (New Jersey F&W), M. Mesa (USGS), T. Meyers (ADF&G), M. Moritsch (Northeastern U.), K. Prager (UCLA), M. Purcell (USGS), L. Rhodes (NOAA – Fisheries), S. Roberts (U. Washington), K. Toohey-Kurth (U. Wisconsin), E. Weil (U. Pureto Rico), J. Willis (James Cook U.), J. Winton (USGS).

Appendix C

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M.S.	1997	University of Maine	Zoology
B.S.	1993	Washington State University	Zoology

Recent Positions

2007 to present: Research Microbiologist; Western Fisheries Research Center, US Geological Survey
2013 to present: Affiliate Associate Professor; School of Aquatic and Fishery Sciences, U. of Washington
2005 to 2007: Microbiologist; Western Fisheries Research Center, US Geological Survey

Five Publications Relevant to this Proposal:

Purcell, M.K., S. Pearman-Gillman, R.L. Thompson, J.L Gregg, L.M. Hart. J.R. Winton, E.J. Emmenegger, P.K. Hershberger. 2016. Identification of the major capsid protein of erythrocytic necrosis virus (ENV) and development of quantitative real-time PCR assays for quantification of ENV DNA. Journal of Veterinary Diagnostic Investigation 28: 382-391.

Conway, CM, Purcell MK, Elliott DG, Hershberger PK. 2015. Detection of *Ichthyophonus* by chromogenic *in situ* hybridization. Journal of Fish Diseases 38: 853-857.

Purcell MK, Bromage ES, Silva J, Hansen JD, Badil SM, Woodson JC, Hershberger PK. 2012. Production and characterization of monoclonal antibodies to IgM of Pacific herring (*Clupea pallasii*). Fish Shellfish Immunol. 33:552-558.

Hansen JD, Woodson JC, Hershberger PK, Grady C, Gregg JL, Purcell MK. 2012. Induction of anti-viral genes during acute infection with Viral hemorrhagic septicemia virus (VHSV) genogroup IVa in Pacific herring (*Clupea pallasii*). Fish Shellfish Immunol. 32:259-267.

Purcell MK, Laing KJ, Winton JR. Immunity to fish rhabdoviruses. Viruses. 2012 4:140-166

Five Additional Publications

Purcell MK, McKibben CL, Pearman-Gillman S, Elliott DG, Winton JR. 2015. Effects of temperature on *Renibacterium salmoninarum* infection and transmission potential in Chinook salmon, *Oncorhynchus tshawytscha* (Walbaum). J Fish Dis. Oct 9. doi: 10.1111/jfd.12409.

Purcell MK, Marjara IS, Batts W, Kurath G, Hansen JD. 2011. Transcriptome analysis of rainbow trout infected with high and low virulence strains of infectious hematopoietic necrosis virus. Fish Shellfish Immunol. 30:84-93.

Metzger DC, Elliott DG, Wargo A, Park LK, Purcell MK. 2010. Pathological and immunological responses associated with differential survival of Chinook salmon following *Renibacterium salmoninarum* challenge. Dis Aquat Organ. 90:31-41.

Rasmussen C, Purcell MK, Gregg JL, LaPatra SE, Winton JR, Hershberger PK. 2010. Sequence analysis of the internal transcribed spacer (ITS) region reveals a novel clade of Ichthyophonus sp. from rainbow trout. Dis Aquat Organ. 89:179-183.

Hershberger PK, Pacheco CA, Gregg JL, Purcell MK, LaPatra SE. 2008. Differential survival of *Ichthyophonus* isolates indicates parasite adaptation to its host environment. J Parasitol. 94:1055-1059.

Appendix C

Recent PI Collaborators and Co-Authors (Past 5 years):

Amos, Kevin (NOAA), Applegate, Lynn (USGS), Bader, Joel (USFWS), Batts, Bill (USGS), Blair, Marilyn (USFWS), Breyta (Life), Rachel (University of Washington), Brieuc, Marine (University of Washington), Brito, Ilana (Cary Institute), Busch, Robert (Deceased), Chen, Martin (NW Indian Fish Commission), Conway, Carla (USGS), Dale, Ole Bendik (Norwegian Veterinary Institute), Elliot, Diane (USGS), Evered, Joy (USFWS), Falk, Knut (Norwegian Veterinary Institute), Ferguson, Paige (Cary Institute), Fringuelli, Elena (Veterinary Sciences Division, AFBI, Belfast), Garver, Kyle (PBS DFO – Canada), Gregg, Jake (USGS), Hard, Jeff(NOAA), Hart, Lucas (USGS), Hawley, Laura (PBS DFO – Canada), Hershberger, Paul (USGS), Johns, Robert (Center for Aquatic Animal Health, BC), Kennedy, David (Penn State), Kerwin, John (WDFW), Kurath, Gael (USGS), LaDeau, Shannon (Cary Institute), LaPatra, Scott (Clear Spring Food, Inc.), McKibben, Connie (USGS), Meyers, Ted (ADF&G), Morrison, Diane (Marine Harvest Canada), Mueller, Anita (PBS DFO – Canada), Naish, Kerry (University of Washington), Neeley, Kathleen (NOAA), Palmer, Alexander (University of Illinois), Pearman-Gillman, Schuler (University of Vermont), Read, Andrew (Penn State), Richard, Jon (PBS DFO – Canada), Richmond , Zina (Center of Aquatic Animal Health, BC), Saksida, Sonja (Center of Aquatic Animal Health, BC), Savage, Paul (Veterinary Sciences Division, AFBI, Belfast), Siah, Ahmed (Center of Aquatic Animal Health, BC), Snekvik, Kevin (Washington State University), Stewart, Bruce (NW Indian Fisheries Commission), Thompson (Powers), Rachel (USGS), Warg, Janet (USDA APHIS), Wargo, Andrew (Virginia Institute of Marine Sciences), Warheit, Kenneth (WDFW), Winton, James (USGS).

Appendix C

4. Project Design
A. Objectives
List the objectives of the proposed research and briefly state why the intended research is important. If your proposed project builds on recent work, provide detail on why the data set needs to be continued and whether any changes are proposed. If the proposed project is for new work, explain why the new data is needed. Describe the anticipated final product.

B. Procedural and Scientific Methods
For each objective listed in A. above, identify the specific methods that will be used to meet the objective. In describing the methodologies for collection and analysis, identify measurements to be made and the anticipated precision and accuracy of each measurement and describe the sampling equipment in a manner that permits an assessment of the anticipated raw-data quality.

If applicable, discuss alternative methodologies considered, and explain why the proposed methods were chosen. In addition, projects that will involve the lethal collection of birds or mammals must comply with the EVOSTC's policy on collections, available on our website www.evostc.state.ak.us

C. Data Analysis and Statistical Methods
Describe the process for analyzing data. Discuss the means by which the measurements to be taken could be compared with historical observations or with regions that are thought to have similar ecosystems. Describe the statistical power of the proposed sampling program for detecting a significant change in numbers. To the extent that the variation to be expected in the response variable(s) is known or can be approximated, proposals should demonstrate that the sample sizes and sampling times (for dynamic processes) are of sufficient power or robustness to adequately test the hypotheses. For environmental measurements, what is the measurement error associated with the devices and approaches to be used?

D. Description of Study Area
Where will the project be undertaken? Describe the study area, including, if applicable, decimally-coded latitude and longitude readings of sampling locations or the bounding coordinates of the sampling region (e.g., 60.8233, -147.1029, 60.4739, -147.7309 for the north, east, south and west bounding coordinates).

4A. Objectives

i. Provide pathogen and disease prevalence data to inform the ASA model
ii. Produce specific pathogen-Free (SPF) Pacific herring for laboratory experiments
iii. Process new and archived herring plasma samples for indications of prior VHSV exposure
iv. Validate the novel plaque neutralization assay using wild herring
v. Contribute to novel disease modeling approaches
vi. Determine the effects of temperature on VHSV shedding
vii. Determine the susceptibility of Pacific herring to *Vibrio*
viii. Investigate the possibility of an invertebrate host for *Ichthyophonus*
ix. Determine the causes for abnormally high *Ichthyophonus* prevalence among juvenile Pacific herring that establish temporary residency in Cordova Harbor
x. Determine the impacts of salinity on fish-to-fish transmission of *Ichthyophonus*

4B. Procedural and Scientific Methods

i. *Provide pathogen and disease prevalence data to inform the ASA model*
Disease is a component in the Age-Structure-Analysis model for Prince William Sound; however, it is not part of the ADF&G sponsored surveys. We will provide the disease information for the ASA model by determining annual prevalence and intensity data for the most virulent pathogens occurring in the PWS herring populations, including viral hemorrhagic septicemia (VHS), viral erythrocytic necrosis (VEN), and ichthyophoniasis. Monitoring efforts will consist of the annual collection and processing of sixty adult

herring per site from each of three sites in PWS and Sitka Sound to test for infection and disease prevalence. Diagnostic techniques for these pathogens will follow standard procedures described in the "Blue Book: Standard procedures for the detection and identification of select fish and shellfish pathogens (American Fisheries Society)." Additionally, plasma samples will be collected from sampled fish in PWS and Sitka; samples will be processed using a novel serum neutralization assay that is capable of determining prior VHSV exposure history. Similar pathogen sampling will occur from Pacific herring populations in Puget Sound, WA and other locations throughout the NE Pacific as sampling opportunities become available.

ii. *Produce specific pathogen-Free (SPF) Pacific herring for laboratory experiments*
A critical component of both the field surveillance efforts and the empirical disease process studies involves the availability of laboratory host animals with known exposure and disease histories. We have developed techniques to rear specific pathogen-free (SPF) herring and we currently maintain several thousand SPF herring in each of 4 age classes (age 0, 1, and 2 yr) for use as experimental animals. Additional colonies will be reared to satisfy the needs described in this proposal.

As the susceptibility to VHS is similar among Pacific herring from genetically diverse stocks throughout the NE Pacific (Figure 1), SPF herring colonies will be initiated from Puget Sound herring eggs. However, SPF herring from additional stocks will be reared if the need arises. For example, we have agreed to provide SPF herring for the EVOST TC project proposed by Dr. Andrew Whitehead. This proposed project is intended to assess the effects of oil exposure on Pacific herring genes that are directly or indirectly linked to a robust immune response. This response will be evaluated using SPF herring from several distinct populations, including PWS. The functional effects of the any gene adaptations will be evaluated by performing pathogen challenge studies at the Marrowstone Marine Field Station. If funding is approved for the proposed project by Dr. Whitehead, then additional colonies of SPF herring from the appropriate populations will be reared.

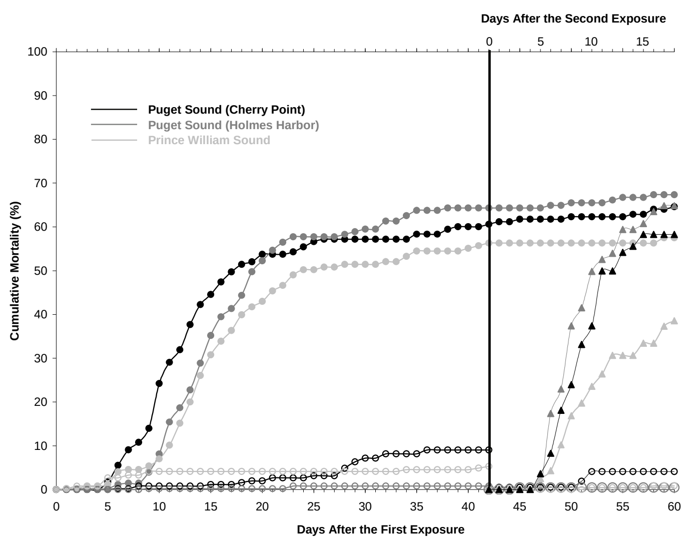

Figure 1 (from Hershberger et al. 2010). Relative susceptibilities of Pacific herring from three different stocks (Holmes Harbor, Cherry Point, and Prince William Sound) to VHS. Closed circles indicate treatment groups exposed to VHSV and open circles indicate negative control groups (exposed to saline). All survivors in the VHSV treatment groups from the first exposure were re-exposed to VHSV in the same tanks 42d later. All survivors in the negative control groups after 42 days were split into two groups (positive controls and negative controls) for the second exposure. Positive controls for the second exposure (closed triangles starting on day 42) were exposed to VHSV for the first time on day 42. Negative controls for the second exposure (open circles starting on day 42) were re-exposed to saline on day 42.

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iii. Process new and archived herring plasma samples for indications of prior VHSV exposure

In anticipation of the development of a future serological assay capable of identifying prior VHSV exposure, plasma samples have been collected from annual sampling trips of pre-spawn adult herring in Prince William Sound and Sitka Sound since 2012An effective serological assay, capable of quantifying VHSV neutralizing titers in herring plasma, has now been developed; a manuscript describing the methods of this modified plaque neutralization assay is currently in preparation. This assay has two very unique applications. First, it may provide a quantitative assessment of the potential for future VHS epizootics. For example, populations with high levels of herd immunity (i.e high antibody levels) would be assigned a low potential for future VHS impacts; conversely those with low levels of herd immunity (i.e. low antibody levels) would be assigned a high potential for future disease impacts if exposure occurs under the appropriate host and environmental conditions. Second, the assay will provide an *a priori* method to assess prior impacts of VHS to specific age cohorts within the population. For example, all archived and future plasma herring samples from PWS correspond to the ADF&G herring stock assessment database that includes age data. By pairing these age data with the PNT results, we can track the exposure history of specific year classes to determine if and when VHSV exposure occurred. When paired with population recruitment data from annual herring surveys, these temporal insights into VHSV exposures may inform the possible involvement of VHS in herring year class failures from Prince William Sound.

Here, we propose to process all the archived (2012- 2016) and newly-collected (2017-2021) herring plasma samples using the optimized PNT methods.

iv. Validate the novel plaque neutralization assay using wild herring

Although the newly-developed PNT is effective at identifying VHSV neutralizing titers and exposure histories in laboratory-reared herring (approximately 90% test sensitivity), the interpretation of PNT the values on a population scale requires further validation. For example, the optimized PNT indicates the percentage of individuals demonstrating virus neutralizing activity in their plasma and provides a quantitative assessment of these neutralizing titers. However, the application of the PNT to wild herring, with a more robust exposure history, requires further investigation. Additional vetting is also required for the interpretation of the PNT values from wild herring that correspond to demonstrated herd immunity and documented prior exposure. Further, questions of sample size and geographic scale of sampling need to be addressed.

These final PNT validation studies will be addressed using wild herring, with deduced exposure histories and demonstrated levels of herd immunity. For example, the collection of susceptible age 0 herring from bait balls and their subsequent confinement in laboratory tanks often elicits a VHS epizootic among the confined cohorts (Kocan et al. 2002). An epizootic will not occur among the confined cohorts for two possible reasons:

- The population was susceptible to VHS, but no viral carriers occurred among the captured cohorts
- The population is refractory to VHS because it survived prior exposure

To evaluate the ability of the optimized PNT methods to demonstrate herd immunity based on deduced VHS exposure history, groups of age 0 yr Pacific herring will be collected, transported alive back to Marrowstone, and maintained in tanks. Subsamples of these fish (n = 30 / day) will be collected at the following intervals:

- Day 0 (immediately after transport to the laboratory)
- Day 7
- Day 14
- Day 21

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At this point, each experiment will bifurcate into one of 2 directions:

1) **If a VHS epizootic does not ensue by day 21:** then we will know that either:
   A. The fish were refractory to VHS or
   B. The fish were susceptible to VHS, but no VHSV carriers were present in the tank to serve as a source of VHSV exposure.

   To test these 2 scenarios, the remaining fish in this tank will be separated into 2 tanks on day 21. Herring in one tank will be exposed to an aliquot of VHSV isolate (5 x 10^4 PFU / mL) for 2 hr. Herring in the other tank will remain unexposed. Afterwards, fish will be subsampled from each tank (n = 30 /d) on days 28 (7d post exposure), 42 (21d post-exposure), and 84 (63d post-exposure).
   If a VHSV epizootic fails to occur in the tank of VHSV-exposed herring by day 42 (21d post-exposure), then it will be assumed that the fish were refractory.
2) If a VHS epizootic does occur by day 21, then we have determined that the fish were susceptible to VHS when captured, and that VHSV transmission occurred from positive carriers in the tank.
   If this is the case, then we will document the development of VHSV neutralizing activity in the plasma of survivors; further, we will document that those survivors are now refractory to VHS. Fish will remain in this tank until 84d post capture (63d post exposure), then subsampled (n=30) and separated into 2 tanks. Fish in one tank will remain unmanipulated, and fish in the other tank will be exposed to an aliquot of VHSV isolate (5 x 10^4 PFU / mL) for 2 hr. Mortality will be assessed through day 105 (21d post-exposure), after which the experiment will be terminated.

   Negative Controls will consist of age 0 yr SPF herring (N≈500) in a separate tank. Whenever a subsampling event occurs from the wild fish, these negative controls will also be subsampled (n= 10 fish / subsampling day). Additionally, whenever exposure to a lab aliquot of VHSV occurs, these fish will be exposed to PBS. Positive Controls, employed whenever a laboratory exposure to VHSV occurs, will consist of approximately 100 age 0 yr SPF herring that are also exposed to an aliquot of VHSV.

v. *Contribute to a novel disease modeling approaches*

We will work closely with Dr. Trevor Branch to provide data for a novel disease forecasting model that incorporates the serum-neutralization data, dating from 2012, into a newly-formed age-structured model for herd immunity. Additionally, we will work with USGS modelers, Drs. Russell Perry and John Plumb to develop a mixture cure model for VHS and herring. This simulation model will assess disease impacts under various scenarios that incorporate VHS covariates (including immune fraction, temperature, host aggregations, etc).

vi. *Determine the effects of temperature on VHSV shedding*

We previously demonstrated an inverse relationship between temperature and VHS potential in Pacific herring, with cooler temperatures resulting in elevated mortality, earlier onset and increased magnitude of viral shedding, and delayed up-regulation of genes responsible for the early anti-viral immune response (Hershberger et al. 2013). Similarly, the course of VHS epizootics tend to be longer in cooler temperatures, where the virus tends to enter a neurotropic stage and persist for extended periods in immune-privileged cells and tissues (Hershberger et al. 2010, Lovy et al. 2012).

Here, we will investigate the influence of temperature on the ability of VHS survivors to transfer the infection to naive cohorts through waterborne shedding of infectious virions. Colonies, each containing several thousand laboratory-reared SPF herring, will be established at each of two temperatures (7 and 11^{o}C). VHS epizootics will be initiated in both colonies by controlled waterborne exposure to VHSV isolates. To assess how long any shed virus from the exposed colonies can initiate VHS epizootic in sympatric groups of naïve herring, the effluent water from these donor colonies will be spilled into the supply water for other tanks containing sentinel SPF herring. If present and virulent, shed VHSV from the donor colonies will initiate VHS epizootics in the tanks containing sentinel herring. This exposure of sentinels to effluent water from the donor colonies will proceed for 3 wk; after which, all the sentinel survivors will be euthanized and tissues will be assessed for VHSV. The sentinel tanks will then be completely disinfected, and dried for 7d; after which, another group of SPF sentinel herring will be transferred to the sentinel tanks and exposed to effluent water from the donor tank. Using this experimental approach, we will employ a new colony of sentinel herring every 4 wk, in an effort to determine how long shed virus from the donor colony remains infectious.

The experimental design will also contain donor colonies of unexposed (negative control) groups at both temperatures, the effluent of which will be spilled into analogous sentinels. All mortalities from both the donor colonies and the sentinel tanks will be assayed for VHSV titer in the tissues by plaque assay. Similarly, all surviving sentinels will be euthanized after each 3 week exposure period and tissues will be assessed for VHSV.

vii. *Determine the susceptibility of Pacific herring to Vibrio spp.*
Vibrio ordalii and *Listonella anguillarium* (formerly *V. anguillarium*) are among the most common bacterial pathogens of marine organisms in the Pacific Northwest, with the resulting diseases often causing mortality to wild and aquacultured marine fishes and shellfishes. Here, we will examine the susceptibility of Pacific herring to infection and disease from *L. anguillarium* and *V. ordalli. A* group of SPF Pacific herring will be exposed to the live *L. anguillarium* and *V. ordalii* isolates. Positive controls will consist of groups of similarly-exposed coho salmon that are known to be susceptible to the disease. Mortality will be monitored, and all fish (mortalities and euthanized survivors after 21d) will be evaluated for *Vibrio* spp. infections by culture on bacterial agar.

xi. Investigate the possibility of an invertebrate host for Ichthyophonus
Ichthyophonus is one of the most cosmopolitan marine fish parasites worldwide, with the resulting disease causing recurring epizootics in wild marine fishes, particularly clupeids (reviewed in Burge et al. 2014). Although the parasite can be easily transmitted to piscivorous fishes through the consumption of infected prey, the natural mode(s) of transmission in planktivorous fishes remains poorly understood. Recently, it was determined that Pacific herring can become infected by consuming infected tissues in the laboratory (Hershberger et al 2015); however, this route is mostly likely artificial, with the possible exception of some small herring schools that habituate to feeding around offal discharges from fish processing plants. Failure to establish the natural route(s) of transmission to Pacific herring and other clupeids has led to the prevailing hypothesis that the parasite is likely transferred trophically through an as-yet-unidentified intermediate host (reviewed in Mc Vicar 2011).

Until recently, diagnostic tools were unavailable to aid in the identification of *Ichthyophonus* from intermediate hosts. For example, the traditional means of identifying the parasite in fish tissues include explant culture of tissue explants histology with generalized stains (Hershberger 2012). However, the parasite is extremely pleomorphic, often exhibiting unique morphologies under different culture conditions. For this reason, it was feared that the appearance of the parasite in an intermediate invertebrate host would not be recognized or would be mischaracterized using these traditional techniques.

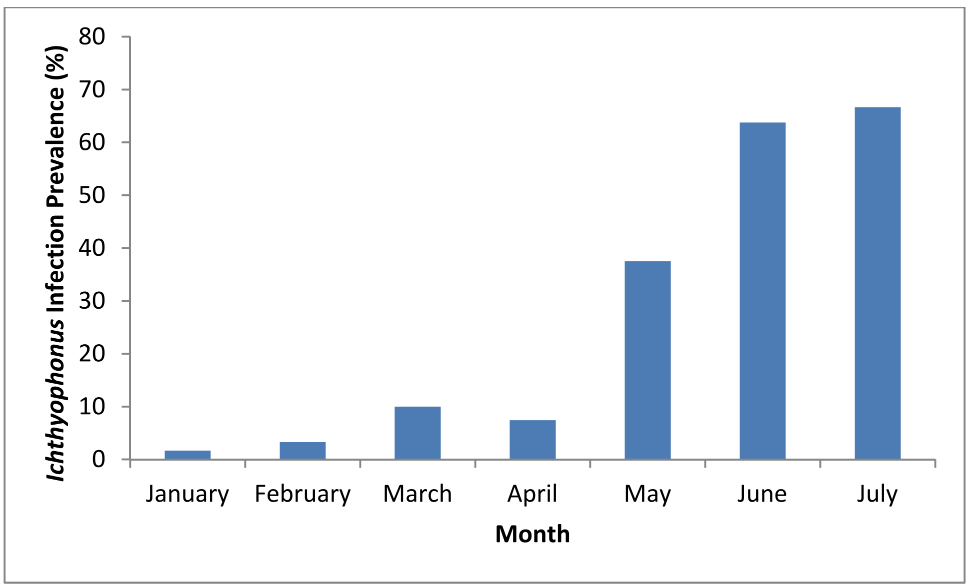
Within the past 10 years, molecular PCR-based tools with *Ichthyophonus*-specific primers have been developed (Whipps et al 2006, White et al. 2013). These tools now enable the rapid screening of large zooplankton samples for the presence of *Ichthyophonus* DNA. This tool is will be useful as an initial screening tool to assess wild zooplankton for *Ichthyophonus*. Further, cryptic or unrecognizable parasite morphologies are inconsequential for the success of this tool. However, any positive qPCR samples will need to be further evaluated with a confirmatory diagnostic technique, as a positive result could simply represent a contaminant or external adsorption of the parasite to the host carapace. Therefore, confirmation of a positive PCR sample will require further microscopic observation of the parasite within the body cavity of the suspected intermediate host.

We recently developed a chromogenic in situ hybridization assay that is capable of selectively binding to a portion of the *Ichthyophonus* genome; the tool allows for microscopic observation and confirmation of the parasite in histological sections, regardless of the parasite morphology. We propose to employ this novel CISH assay, to confirm any positive samples that are returned from the qPCR survey. Specifically, we plan to screen common herring food items, including *Neocalanus spp*. using *Ichthyophonus*-specific primers for a qPCR. If suspected positive samples are identified, then further confirmation will be made using the *Ichthyophonus*-specific CISH.

viii. Determine the causes for abnormally high Ichthyophonus prevalence among juvenile Pacific herring that establish temporary residency in Cordova Harbor

Within a population of Pacific herring, the prevalence of *Ichthyophonus* infections typically increases with age and size, with the prevalence in juvenile cohorts typically occurring below 10% (Hershberger et al 2002, Hershberger et al. 2016). However, on a number of occasions, unusually high infection prevalence has been reported from age 0-1 yr herring that established temporary residency in Cordova Harbor (Hershberger et al. 2015 and Figure 1).

Figure 1. 2015 Monthly Prevalence of *Ichthyophonus* in Juvenile Herring from Cordova Harbor



Cause(s) of this unusually high infection prevalence remain unknown, but have been hypothesized to involve exposure of juvenile herring to infected offal that is discharged from the local fish processing plant.

Here, we propose to collect stomach samples from herring in Cordova Harbor when the *Ichthyophonus* infection prevalence begins to increase during May and June. These stomachs will be fixed in formalin and evaluated histologically (using PAS stain and the newly-developed *Ichthyophonus* CISH assay) to determine whether infected offal was consumed by the residualized herring.

ix. Determine the impacts of salinity on fish-to-fish transmission of Ichthyophonus

There is an apparent discordance between the infection processes that maintain *Ichthyophonus* spp. infections in rainbow trout farms and those that maintain infections in wild Pacific herring. Waterborne transmission is assumed in the trout farms, and has been demonstrated using rainbow trout (Gustafson and Rucker 1956, Yokota et al. 2008); however we have been unable to demonstrate fish-to-fish

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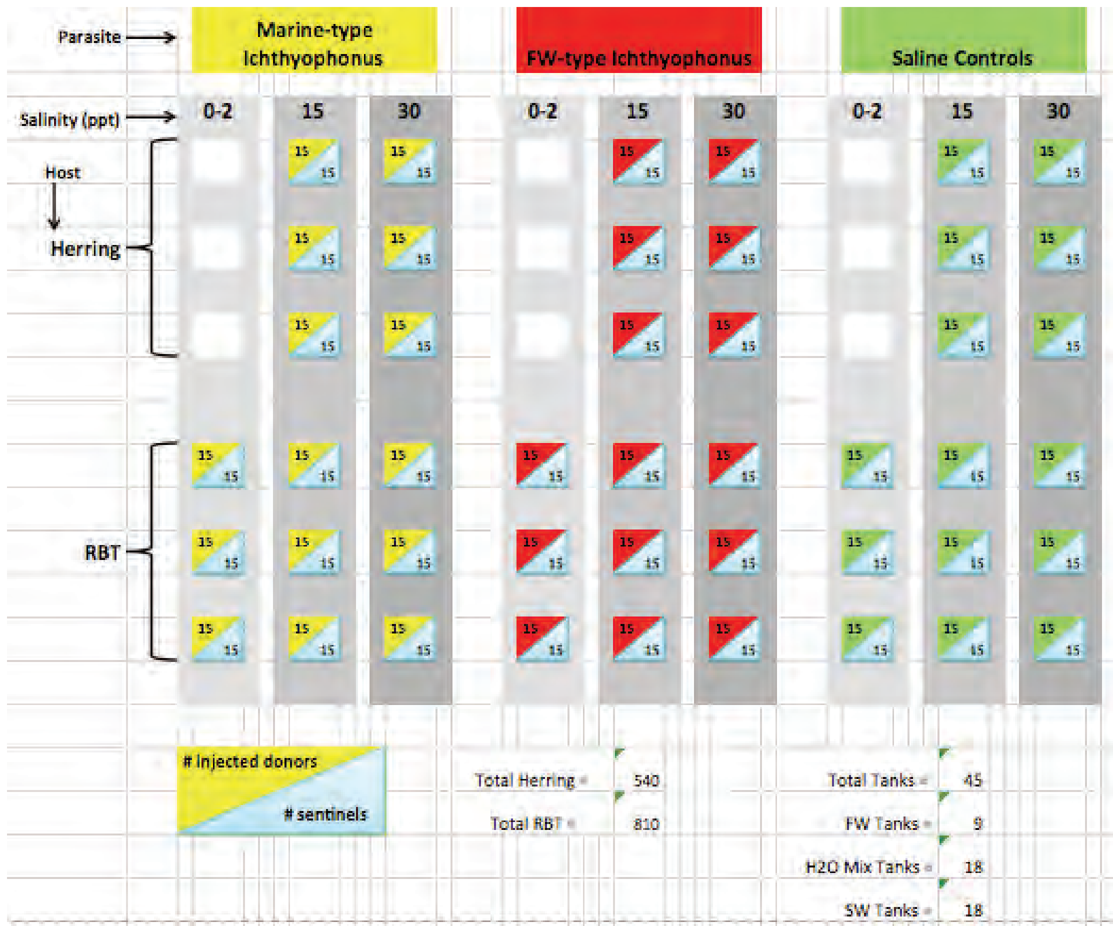
transmission through the water in herring (Gregg et al. 2012). These two infection models differ in host, parasite type (Rasmussen et al. 2010) and environment (freshwater vs seawater).

Here we will determine which of these is causing the differences we see between the two host-parasite systems. The euryhaline nature of rainbow trout and our ability to culture and molecularly identify the two parasite species allow us to design a 3-factor study design with rainbow trout in freshwater as a positive control:



Establishing Infected Donors. Four groups of infected donors (2 parasites x 2 hosts) will be established by injection with either freshwater-type or marine-type *Ichthyophonus* isolates. An uninfected donor group (negative control) for each species will be established by injections with saline. The donor groups will be held in six tanks. Rainbow trout will be held at 0 ppt salinity and herring will be held at 30 ppt salinity during incubation period. Two weeks after injections, 30 fish will be subsampled from the donor tanks to assess infection prevalence, and collect culture for DNA analysis. Three weeks post injection, infected and control donors will be moved to 45 tanks for salinity acclimation. Salinity acclimation of the donors and sentinels will occur synchronously. Sentinels will have lower lobe of caudal fin and left pectoral clipped when they are moved to these acclimation tanks, so they can be distinguished from donor herring later in the study.

After a 9 d acclimation, 15 sentinel fish from each salinity treatment will be cohabitated with the donor conspecifics. This will be Day-0 of the challenge. Cohabitation will be maintained for 3 months, but may be terminated sooner if culture-positive sentinel mortality occurs. Mortalities and all survivors will be assessed for *Ichthyophonus* infection by tissue explant culture.

4C. Data Analysis and Statistical Methods

Standard statistical comparisons for pathogen virulence studies will be employed in all experiments. For example, percent cumulative mortalities in replicate tanks / aquaria will be arc sin transformed and transformed means from all groups will be statistically compared using Student's T-test (1-tailed) or ANOVA followed by the Tukey test for multiple comparisons. In non-replicated tanks, percent mortality in control and treatment groups will be statistically compared using the Chi Square statistic (χ^2). Statistical significance will be assigned to all comparisons with $p \leq 0.05$. Prevalence of infection and disease in wild populations from Prince William Sound, Sitka Sound, and Puget Sound will be based on minimum sample sizes of 60 fish, sufficient to detect 5% prevalence in the population with 95% confidence.

4D. Description of the Study Area

The study area includes locations throughout Prince William Sound and Sitka Sound where pre-spawn herring aggregate.

Laboratory studies described in this proposal will be conducted at the USGS-Marrowstone Marine Field Station, and USGS-Western Fisheries Research Center where facilities ideally designed to safely and responsibly conduct experiments using endemic fish pathogens. The Marrowstone Marine Field Station represents the sole seawater-based biological research facility for the USGS. Facilities include three large wet laboratory buildings with approximately 10,000 square feet of wet laboratory space, replicated with approximately 60,000 liter tank capacity, and supplied with 400 gpm of high quality filtered and UV irradiated seawater. Back-up, redundant water treatment systems are incorporated into the supply water for each wet laboratory. Separate laboratory buildings are designated as specific pathogen-free nursery zones and experimental pathogen manipulation zones. Laboratory effluent water is disinfected with chlorine and treated to insure safe and responsible handling of endemic pathogens. The Western Fisheries Research Center (WFRC) is recognized as an international leader in fish health research. The WFRC maintains fish health laboratory facilities which are among the newest and best in the nation. The facility operates a state-of-the-art fresh water wet laboratory that is completely climate controlled and automated for disease challenges and studies in physiology and pathology. The nation's only Biosafety Level III disease containment wet laboratory for fish is also part of this facility. Additionally, the Center maintains fully equipped laboratories for molecular biology, virology, bacteriology, immunology, and histopathology.

5. Coordination and Collaboration

Within the Program

Provide a list and clearly describe the functional and operational relationships with the other program projects. This includes any coordination that has taken or will take place and what form the coordination will take (shared field sites or researchers, research platforms, sample collection, data management, equipment purchases, etc.).

With Other EVOSTC-funded Programs and Projects

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Indicate how your proposed program relates to, complements or includes collaborative efforts with other proposed or existing programs or projects funded by the EVOSTC.

With Trustee or Management Agencies

Please discuss if there are any areas which may support EVOSTC trust or other agency work or which have received EVOSTC trust or other agency feedback or direction, including the contact name of the agency staff. Please include specific information as to how the subject area may assist EVOSTC trust or other agency work.

If the proposed project requires or includes collaboration with other agencies, organizations or scientists to accomplish the work, such arrangements should be fully explained and the names of agency or organization representatives involved in the project should be provided. If your proposal is in conflict with another project or program, note this and explain why.

With Native and Local Communities

Provide a detailed plan for any local and native community involvement in the project.

5. Coordination and Collaboration

Within the Program

- Herring collections from Cordova Harbor will be provided by Drs Kristen Gorman and Scott Pegau (PWSSC). Stomachs from these fish will be assessed for indications that *Ichthyophonus*-infected offal may contribute to the unusually high infection prevalence detected among juvenile herring in Cordova Harbor.
- Serum neutralization results, to assess herd immunity by quantifying VHSV neutralizing titer, will be shared with Dr. Trevor Branch (U. Washington). These results will be used to create a novel age-structured assessment model that incorporates herd immunity by herring age class.

With Other EVOSTC-Funded Programs and Projects

- Long Term Monitoring: Yumi Arimitsu (USGS – Alaska Science Center) and John Moran (NOAA Fisheries - Auke Bay Labs) continue to send samples of suspect sick herring and other forage fish to us for diagnosis.
- Long Term Monitoring: Zooplankton collections from throughout Prince William Sound will be provided by Dr. Rob Campbell (PWSSC). Subsamples from these collections will be assessed by qPCR and CISH to look for an *Ichthyophonus* invertebrate host.
- Lingering Oil: We have partnered with Dr. Andrew Whitehead on his proposal to investigate the effects of PAH exposure to genetic pathways that directly and indirectly influence immune-competence. In kind laboratory space and SPF herring for Dr. Whitehead's projects will be provided at the USGS - Marrowstone Marine Field Station.

With Trustee or Management Agencies

- We will continue to partner with Steve Moffit (ADF&G – Cordova) to collect herring infection and disease data onboard the ADF&G seining platform used to assess pre-spawn herring biomass in PWS.
- We will continue to partner with Eric Coonradt (AFF&G – Sitka) to collect herring infection and disease data from pre-spawn aggregations in Sitka Sound.

With Native and Local Communities

- Hershberger will provide a seminar with an updated description of Herring Disease Program in Cordova.

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6. Schedule
Program Milestones
Specify when critical program tasks will be completed. Reviewers will use this information in conjunction with annual program reports to assess whether the program is meeting its objectives and is suitable for continued funding.

Measurable Program Tasks
Specify, by each quarter of each fiscal year (February 1 – January 31), when critical program tasks will be completed.

6. Schedule
Program Milestones (By Objective)

i. Provide pathogen and disease prevalence data to inform the ASA model
Laboratory diagnostics for pre-spawn herring aggregations in PWS and Sitka Sound will be completed by June of each year.
ii. Rear Specific Pathogen-Free (SPF) Pacific herring
Annual rearing of SPF herring to juveniles will be completed by August of each year.
iii. Data Archive
Data and metadata will be submitted to the Ocean Workspace by Dec 31, each year.
iv. Process archived herring plasma samples for indications of prior VHSV exposure
Archived herring plasma samples, dating to 2012, will be processed by December 2017; thereafter, new plasma samples for each survey year will be processed by August of the same year.
v. Validate the novel plaque neutralization assay with wild herring
December 2021
vi. Contribute to novel disease modeling approaches
Preliminary data for the new models will be provided by December, 2017
vii. Determine the effects of temperature on VHSV shedding
December 2019
viii. Determine the susceptibility of Pacific herring to *Vibrio*
December 2017
ix. Investigate the possibility of a zooplankter intermediate host for *Ichthyophonus*
January 2022
x. Determine the causes for abnormally high *Ichthyophonus* prevalence among juvenile Pacific herring that establish temporary residency in Cordova Harbor
December 2020
xi. Determine the impacts of salinity on fish-to-fish transmission of *Ichthyophonus*
December 2018

Measurable Program Tasks
<u>**FY 2017**</u>

1st Quarter (Feb. 1 – Apr. 30)
- Project funding approved by TC
- Collect herring eggs for rearing SPF colonies
- Collect adult herring to assess annual infection and disease prevalence
- Collect zooplankton for investigation of possible *Ichthyophonus* intermediate host
- Initiate *Vibrio* challenge experiments

2nd Quarter (May 1 – Jul. 31)
- Finish processing spring adult herring to determine infection and disease prevalence.
- Collect herring from Cordova Harbor to assess *Ichthyophonus*-infected offal in the stomach bolus

Appendix C

- Begin studies to validate the plaque neutralization assay using wild herring
- Continue *Vibrio* challenge experiments

3rd Quarter (Aug. 1 - Oct. 31)
- Brood Year 2017 SPF herring metamorphosed to juveniles
- Continue *Vibrio* challenge experiments
- Complete analysis of 2017 plasma samples
- Continue studies to validate the plaque neutralization assay using wild herring

4th Quarter (Nov. 1 - Jan. 31)
- Annual PI meeting
- Complete *Vibrio* challenge experiments
- Complete analysis of archived plasma samples from 2012-2016 and share results with modelers.

<u>**FY 2018**</u>

1st Quarter (Feb. 1 – Apr. 30)
- Project funding approved by TC
- Collect herring eggs for rearing SPF colonies
- Collect adult herring to assess annual infection and disease prevalence
- Collect zooplankton for investigation of possible *Ichthyophonus* intermediate host
- Initiate experiments intended to assess the effects of salinity on fish-to-fish transmission of *Ichthyophonus*

2nd Quarter (May 1 – Jul. 31)
- Continue experiments intended to assess the effects of salinity on fish-to-fish transmission of *Ichthyophonus*
- Finish processing spring adult herring to determine infection and disease prevalence.
- Continue studies to validate the plaque neutralization assay using wild herring
- Collect herring from Cordova Harbor to assess *Ichthyophonus*-infected offal in the stomach bolus

3rd Quarter (Aug. 1 - Oct. 31)
- Continue experiments intended to assess the effects of salinity on fish-to-fish transmission of *Ichthyophonus*
- Brood Year 2018 SPF herring metamorphosed to juveniles
- Complete analysis of 2018 plasma samples
- Continue studies to validate the plaque neutralization assay using wild herring

4th Quarter (Nov. 1 - Jan. 31)
- Annual PI meeting
- Complete experiments intended to assess the effects of salinity on fish-to-fish transmission of *Ichthyophonus*

<u>**FY 2019**</u>

1st Quarter (Feb. 1 – Apr. 30)
- Project funding approved by TC
- Collect herring eggs for rearing SPF colonies
- Collect adult herring to assess annual infection and disease prevalence
- Collect zooplankton for investigation of possible *Ichthyophonus* intermediate host
- Initiate experiments to assess the effects of temperature on VHSV shedding

2nd Quarter (May 1 – Jul. 31)
- Continue experiments to assess the effects of temperature on VHSV shedding
- Finish processing spring adult herring to determine infection and disease prevalence
- Continue studies to validate the plaque neutralization assay using wild herring
- Collect herring from Cordova Harbor to assess *Ichthyophonus*-infected offal in the stomach bolus

Appendix C

3rd Quarter (Aug. 1 - Oct. 31)
- Continue experiments to assess the effects of temperature on VHSV shedding
- Brood Year 2019 SPF herring metamorphosed to juveniles
- Complete analysis of 2019 plasma samples
- Continue studies to validate the plaque neutralization assay using wild herring

4th Quarter (Nov. 1 - Jan. 31)
- Annual PI meeting
- Complete experiments to assess the effects of temperature on VHSV shedding

FY 2020

1st Quarter (Feb. 1 – Apr. 30)
- Project funding approved by TC
- Collect herring eggs for rearing SPF colonies
- Collect adult herring to assess annual infection and disease prevalence
- Collect zooplankton for investigation of possible *Ichthyophonus* intermediate host

2nd Quarter (May 1 – Jul. 31)
- Finish processing spring adult herring to determine infection and disease prevalence.
- Continue studies to validate the plaque neutralization assay using wild herring

3rd Quarter (Aug. 1 - Oct. 31)
- Brood Year 2020 SPF herring metamorphosed to juveniles
- Complete analysis of 2020 plasma samples
- Continue studies to validate the plaque neutralization assay using wild herring

4th Quarter (Nov. 1 - Jan. 31)
- Annual PI meeting
- Finish histological processing of herring from Cordova Harbor to assess *Ichthyophonus*-infected offal in the stomach bolus.

FY 2021

1st Quarter (Feb. 1 – Apr. 30)
- Project funding approved by TC
- Collect herring eggs for rearing SPF colonies
- Collect adult herring to assess annual infection and disease prevalence
- Collect zooplankton for investigation of possible *Ichthyophonus* intermediate host

2nd Quarter (May 1 – Jul. 31)
- Finish processing spring adult herring to determine infection and disease prevalence.
- Continue studies to validate the plaque neutralization assay using wild herring

3rd Quarter (Aug. 1 - Oct. 31)
- BY 2021 SPF herring metamorphosed to juveniles
- Complete analysis of 2021 plasma samples
- Complete PCR and CISH analyses of zooplankton samples for Ichthyophonus
- Complete studies to validate the plaque neutralization assay using wild herring
- Draft final report

4th Quarter (Nov. 1 - Jan. 31)
- Annual PI meeting
- Respond to peer review comments, acceptance and publication of final report

7. Budget

Appendix C

Budget Forms (Attached)
Please provide completed budget forms. Please note that the following items will not be considered for funding:

- Costs associated with international travel for meetings, symposia, or presentations.
- Costs associated with attendance at meetings, symposia, or presentations outside of those required to coordinate with project members.
- Costs associated with outreach or education efforts.

Sources of Additional Funding
Identify non-EVOSTC funds or in-kind contributions used as cost-share for the work in this proposal. List the amount of funds, the source of funds, and the purpose for which the funds will be used. Do not include funds that are not directly and specifically related to the work being proposed in this proposal.

Annual USGS in-kind contributions (personnel contributions include salary + benefits):

	FY 17	FY 18	FY 19	FY 20	FY 21	Total
P.K. Hershberger (PI) 20%	$29,404	$30,271	$30,271	$30,518	$31,535	$151,999
M.K Purcell (PI) 10%	$14,322	$14,794	$15,256	$15,719	$16,314	$76,405
J.L. Gregg (Fish Biol) 20%	$17,971	$18,485	$18,485	$18,998	$18,998	$92,937
Total	**$61,697**	**$63,550**	**$64,012**	**$65,235**	**$66,847**	**$321,341**

Budget Justification

Personnel Costs $676.8 K
Funding is requested each year to support a GS-9 laboratory technician ($67,200 - $81,600 / yr) at the Marrowstone Marine Field Station to perform laboratory studies, process samples from laboratory studies, perform predictive disease assays, and process herring survey samples. Funding is also requested to support a GS-7 laboratory technician ($55,200 - $67,200) to provide fish husbandry for the SPF herring and assist with controlled disease experiments in the wet laboratories. Both technicians will assist with annual herring collection trips to PWS and Sitka.

Travel Costs $100.5 K
Annual round trip travel costs from Nordland, WA are requested for two pathologists to perform field sampling in PWS ($7.6K) and perform Sitka field sampling ($3.2K K). Additional travel costs are included for the annual meeting with the other PI's from the HRM Program.

Contractual Costs $0 K

Commodities $195.0 K
Commodities include laboratory supplies for the Marrowstone Marine Station ($17.0 K/yr for fish food, live feed production, and herring diet enrichments; $22.0 K/ yr is requested for dry lab supplies (cell culture, molecular reagents, media, histology, etc.).

New Equipment / Existing Equipment Usage: $0
No new equipment with a life span of more than one year and a unit value greater than $1,000 is needed or requested for this project.

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$122.4	$128.4	$135.6	$141.6	$148.8	$676.8	
Travel	$20.1	$20.1	$20.1	$20.1	$20.1	$100.5	
Contractual	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Commodities	$39.0	$39.0	$39.0	$39.0	$39.0	$195.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
SUBTOTAL	$181.5	$187.5	$194.7	$200.7	$207.9	$972.3	
General Administration (9% of subtotal)	$16.3	$16.9	$17.5	$18.1	$18.7	$87.5	N/A
PROJECT TOTAL	$197.8	$204.4	$212.2	$218.8	$226.6	$1,059.8	
Other Resources (Cost Share Funds)	$61.7	$63.6	$64.0	$65.2	$66.9	$321.4	

COMMENTS:
This summary page provides an five-year overview of proposed project funding and actual cumulative spending. The column titled 'Actual Cumulative' must be updated each fiscal year as part of the annual reporting requirements. Provide information on the total amount actually spent for all completed years of the project. On the Project Annual Report Form, if any line item exceeds a 10% deviation from the originally-proposed amount; provide detail regarding the reason for the deviation.

FY17-21

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

TRUSTEE AGENCY SUMMARY PAGE

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Ashley MacKenzie (Technician)	Herring Disease Program	12.0	5.6		67.2
Mallory Wilmot (Technician)	Herring Disease Program	12.0	4.6		55.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	10.2	0.0	
				Personnel Total	$122.4

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Marrowstone - Cordova (PWS sampling)	1.2	2	28	0.3	10.8
Marrowstone - Sitka (sampling)	1.2	2	14	0.3	6.6
Marrowstone - Anchorage (PI meeting)	1.2	1	5	0.3	2.7
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$20.1

FY17

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
PERSONNEL & TRAVEL
DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Fish food, enrichments, and live feed production for SPF herring	17.0
Laboratory supplies (cell culture, histology, molecular biology, parasitology, virology, etc.)	22.0
Commodities Total	$39.0

FY17

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY17

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Ashley MacKenzie (Technician)	Herring Disease Program	12.0	5.9		70.8
Mallory Wilmot (Technician)	Herring Disease Program	12.0	4.8		57.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	10.7	0.0	
				Personnel Total	$128.4

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Marrowstone - Cordova (PWS sampling)	1.2	2	28	0.3	10.8
Marrowstone - Sitka (sampling)	1.2	2	14	0.3	6.6
Marrowstone - Anchorage (PI meeting)	1.2	1	5	0.3	2.7
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$20.1

FY18

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Fish food, enrichments, and live feed production for SPF herring	17.0
Laboratory supplies (cell culture, histology, molecular biology, parasitology, virology, etc.)	22.0
Commodities Total	$39.0

FY18

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY18

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Ashley MacKenzie (Technician)	Herring Disease Program	12.0	6.2		74.4
Mallory Wilmot (Technician)	Herring Disease Program	12.0	5.1		61.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	11.3	0.0	
				Personnel Total	$135.6

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Marrowstone - Cordova (PWS sampling)	1.2	2	28	0.3	10.8
Marrowstone - Sitka (sampling)	1.2	2	14	0.3	6.6
Marrowstone - Anchorage (PI meeting)	1.2	1	5	0.3	2.7
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$20.1

FY19

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Fish food, enrichments, and live feed production for SPF herring	17.0
Laboratory supplies (cell culture, histology, molecular biology, parasitology, virology, etc.)	22.0
Commodities Total	$39.0

FY19

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY19

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Ashley MacKenzie (Technician)	Herring Disease Program	12.0	6.5		78.0
Mallory Wilmot (Technician)	Herring Disease Program	12.0	5.3		63.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	11.8	0.0	
				Personnel Total	$141.6

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Marrowstone - Cordova (PWS sampling)	1.2	2	28	0.3	10.8
Marrowstone - Sitka (sampling)	1.2	2	14	0.3	6.6
Marrowstone - Anchorage (PI meeting)	1.2	1	5	0.3	2.7
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$20.1

FY20

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Fish food, enrichments, and live feed production for SPF herring	17.0
Laboratory supplies (cell culture, histology, molecular biology, parasitology, virology, etc.)	22.0
Commodities Total	$39.0

FY20

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY20

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Ashley MacKenzie (Technician)	Herring Disease Program	12.0	6.8		81.6
Mallory Wilmot (Technician)	Herring Disease Program	12.0	5.6		67.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	12.4	0.0	
				Personnel Total	$148.8

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Marrowstone - Cordova (PWS sampling)	1.2	2	28	0.3	10.8
Marrowstone - Sitka (sampling)	1.2	2	14	0.3	6.6
Marrowstone - Anchorage (PI meeting)	1.2	1	5	0.3	2.7
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$20.1

FY21

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
PERSONNEL & TRAVEL
DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.0

Commodities Costs: Description	Commodities Sum
Fish food, enrichments, and live feed production for SPF herring	17.0
Laboratory supplies (cell culture, histology, molecular biology, parasitology, virology, etc.)	22.0
Commodities Total	$39.0

FY21

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY21

Project Title: Herring Disease Project
Primary Investigator: Paul Hershberger
Agency: USGS

FORM 4B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

THE STATE of ALASKA
GOVERNOR BILL WALKER

Department of Fish and Game

DIVISION OF COMMERCIAL FISHERIES
Cordova Office

401 Railroad Ave
Cordova, Alaska 99574-0669
Main: 907.424.3212
Fax: 907.424.3235

8-12-2016

Exxon Valdez Trustee Council
Anchorage, Alaska

Dear Sir or madam:

This letter will provide information relative to comments by the Exxon Valdez Trustee Science Panel related to Project 17120111-F (Herring Program – ASL Study & Aerial Milt Surveys) in the Draft Work Plan for Fiscal Year 2017 that was issued on May, 19, 2016. Science Panel comments are in italic font below followed by my response.

While supportive of all of these tasks the Science Panel has the following comments on several topic items (underlined below).

1) *Distribution and abundance of sea lions, other marine mammals, and birds. The Panel strongly endorses this line of inquiry and notes that evaluation of the potential impacts of pinniped predation on herring is an active area of research in other parts of the northeast Pacific. The proposers should familiarize themselves with current research.*

Response: I agree that evaluations of potential impacts of predators on spawning aggregations are worth monitoring and the interactions are of importance to both the populations of both prey and the predators. Reviews, e.g., Willson and Womble (2006), are what led to the Alaska Department of Fish and Game staff in Cordova to put more effort toward documenting the predator distribution and abundance during the spring spawning season of Pacific herring. Aggregations of predators have historically been used by fishermen (subsistence and commercial) and researchers to help locate herring and other forage fish schools. This proposal would continue the collection of distribution and abundance data, but does not propose to evaluate the potential impacts of the predator on Pacific herring. However, the monitoring data may be used in other studies to help evaluate the impacts.

2) *Aerial surveys. The Panel is aware of the discrepancy between results of past aerial surveys of milt and estimates made from SCUBA diver surveys, as discussed in the paper by Hulson et al (2008). Further, as explained in the Hulson paper, there was a substantial difference between aerial survey estimates of milt and estimates based on dive surveys.*

   In view of the importance of estimates of milt, and/or egg deposition for herring assessments, the Panel strongly recommends that some effort be made to 'ground-truth' the aerial surveys. Specifically, at least some of the aerial survey data should be checked by visits to the site to confirm the geographic distribution of eggs. This does not necessarily require quantitative SCUBA surveys to estimate total egg *counts (as was done by Willette et al. 1999). Simpler, less expensive approaches could be considered, such as site visits on small vessels, and use of grappling hooks to look for presence/absence of eggs. Regardless, some effort must be made to calibrate the aerial survey data on milt distribution.*

Ideally, this effort such an effort at ground-truthing could even provide opportunities to provide some retrospective calibration of past milt surveys.

Response: I agree that a boat based survey to check the aerial survey documentation of miles of milt would be valuable. In the absence of a SCUBA spawn deposition survey, a small boat survey with underwater video or grappling hooks could provide this information. The Alaska Department of Fish and Game does not have a small boat appropriate for this type of survey and the R/V Solstice will be dedicated to other surveys. I would suggest a smaller research vessel that can range to Montague Island for this type of survey. Also, I would note that the ADF&G aerial surveys provide a documentation of the miles of milt rather than the miles of egg deposition. Large spawning events in some areas of the sound lead to milt drifting with the current for several kilometers from locations that historically contained egg deposition. As part of the aerial surveys protocol, milt is classified as active (light, medium, or heavy), drift, or dissipating. The drift is excluded from our kilometer-days of milt for use in our age-structured model.

3) *We note elsewhere (see comments on Gorman proposal) however, that an additional measurement of 'gonad weight' could provide very useful information related to 'age-at maturity'. Such an addition to the routine sampling would be relatively inexpensive.*

Although it was not included in the draft proposal, ADF&G has been collecting gonad weights (both sexes) from a subsample of prespawning fish since 1994. Currently we have approximately 8,500 gonad weights. ADF&G also collects gonad maturity index data from all fish, but gonad weights are only collected from a subsample of prespawning fish. Additional information about our gonad weight collections and methods are in the updated proposal.

4) *Acoustics surveys. The Panel notes the pivotal role of acoustics survey data in the assessment methodology. However, we also note that this is the only time-series data that have not been systematically examined to account or any variation attributable to varying survey designs or modification of equipment – which could include vessel types. Of course we are aware of the 2008 paper by Thorne et al. (written as a companion paper to the Hulson paper in the same journal). However, unlike aerial survey data (from which there is a large and readily accessible data base), and also unlike the ASL (age-sex-length) databases, there is no readily accessible database on the historical acoustics data. However, there should be such a database, especially if such data are used in support of vital biomass assessments. Therefore a recommendation from the Panel is for the development of a report on the acoustics data, as it is used, and has been used for herring assessments. Such a report should point out the strengths and limitations of such data, with emphasis on any methodological factors that might affect temporal trends in the data. Finally, to conform to normal protocols for assessments, we advise that the data, as it is used in the assessments, should be made accessible.*

Response: The Exxon Valdez Trustee Council has provided funding to assemble all the ADF&G acoustics data for Pacific herring in Prince William Sound. The funding will be used to complete the tasks as follows:

Acoustics coverage and biomass estimates

1. Design GIS shapefile (fields, data types, metadata).
2. Gather all historical acoustics data into Excel.
3. Preliminary error checking and quality control of historical data in Excel.
4. Bring Excel data into ArcMap shapefile and conduct final error checking.
5. Generate metadata for acoustics coverage.
6. Provide historical shapefile and metadata to EVOS researchers.

These tasks will be complete by 31 January 2017 and significant progress has been made to date. This will fall short of the Science Panel recommendation to have the data "...systematically examined to account or any variation attributable to varying survey designs or modification of equipment" and does not include the generation of a report documenting how the acoustics data has been used for herring assessments; however, it is a necessary first step before the other tasks can be completed.

Sincerely,

Steve Moffitt

PWS/CR Area Research Biologist
Alaska Department of Fish and Game
Commercial Fisheries Division
Cordova, Alaska.

Appendix C

EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
PROGRAM PROJECT PROPOSAL SUMMARY PAGE

Project Title

Surveys and age, sex, and size collection and processing.

Primary Investigator(s) and Affiliation(s)

Steve Moffitt, Alaska Department of Fish and Game

Date Proposal Submitted

12 August 2016

Project Abstract

This proposed project will conduct spring aerial surveys to document Pacific herring *Clupea pallasii* milt distribution and biomass as well as the distribution and abundance of sea lions, other marine mammals, and birds associated with herring schools or spawn. This proposed project will also provide a research platform (R/V Solstice) for an adult herring acoustics survey and disease sample collection and processing. Finally, this proposed project will collect and process age, sex, and size samples of herring collected by the acoustics survey, spawning surveys, and the PWS Herring Research and Monitoring Program disease sampling. Aerial survey and age, sex, and size data have collected since the early 1970s and are an essential part of the age-structured model used by the Alaska Department of Fish and Game to estimate the historical and future biomass for fisheries management. Acoustics surveys have been conducted consistently since 1995 and the age-structured model is also tuned to acoustics biomass estimates. This project will be help to meet the overall program goal to **improve predictive models of herring stocks through observations and research** by providing necessary inputs to the age-structured assessment models of the Alaska Department of Fish and Game and the *PWS Herring Research and Monitoring Program* Bayesian model.

EVOSTC Funding Requested *(must include 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
166.3	166.3	166.3	166.3	166.3	831.5

Non-EVOSTC Funding Available

FY17	FY18	FY19	FY20	FY21	TOTAL
54	54	54	54	54	270

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Please refer to the Invitation for the specific proposal requirements for each Focus Area. The information requested in this form is in addition to the information requested in each Focus Area and by the Invitation.

1. Executive Summary
Identify the hypotheses the project is designed to address. Describe the background and history of the problem. Include a scientific literature review that covers the most significant previous work history related to the project. Please provide a summary of the project including key hypotheses and overall goals.

This project will be help to meet the overall goal to **improve predictive models of herring stocks through observations and research** by providing necessary inputs to the age-structured assessment models of ADF&G and the *PWS Herring Research and Monitoring Program – Population Modeling.*

There are no proposed hypotheses to be tested directly from this project; however, this project will continue long-term monitoring programs to 1) conduct aerial surveys to collect data associated with spring Pacific herring *Clupea pallasii* spawning events, 2) collect and process age, sex, and size (ASL) samples from prespawn and spawning aggregations of Pacific herring, and 3) provide vessel support for spring acoustics surveys, disease sampling, and collection and processing of age, sex, and size samples for target strength assessment.

Spring aerial survey data have been collected since 1972 (Funk 1994), and spring acoustics surveys have been consistently conducted since 1995 (Willette et al. 1999). ASL data are available since 1973 (Sandone 1988); however, collections of both data sets have been more extensive since the early 1980s. Herring age data were collected in 1971 and 1972 also, but only published frequency plots (no individual fish data) are available (Pirtle et al. 1973).

Aerial surveys were used to document spring herring biomass and were the primary management tool prior to the development of the first statistical catch-at-age model or age structured assessment model (ASA) in 1988 (Brady 1987, Funk and Sandone 1990). Biomass is estimated as school surface area converted to biomass from a few paired observations of aerial observers and vessel harvests (Brady 1987, Fried 1983, Funk and Sandone 1990). Surface area and biomass conversion methods are as described in Brady (1987) and Lebida and Whitmore (1985). Prior to 1988, the aerial survey program's primary objectives were to collect biomass data for an annual index, document the distribution and linear extent of milt, document herring temporal movements, and document the distribution of commercial fishing boats, fishing tender boats, and processor boats (Brady 1987). Additionally, the locations of large aggregations of Stellar sea lions *Eumetopias jubatus* and other marine mammals were often noted on paper maps.

Brady (1987) described how herring arrive on the spawning grounds over time and may be available to document on multiple aerial surveys. Therefore, the biomass over several days of surveys cannot be summed to estimate the total or peak biomass. Consequently, peak biomass was calculated as the largest biomass observed in all areas on a single survey (Brady 1987). Additional biomass with a discrete time separation would also be added, but these conservative methods were required to estimate the peak biomass because the amount of time herring were available to observation by aerial surveys was unknown and likely variable (Funk and Sandone 1990).

Brady (1987) also detailed how the variable bathymetry of herring spawning areas in Prince William Sound has a large influence on the observer's ability to see herring schools. Herring may spawn in shallow bays (e.g., Rocky Bay, Montague Island), shallow beaches (e.g. Hells Hole beach), or deep bays (e.g., Fairmont Bay on the North Shore). The influence of bathymetry on observer efficiency suggests a biomass index will probably not be comparable across years. Although Funk and Sandone (1990) indicated that peak biomass values may be a useful relative abundance, issues with biomass observations described by Brady (1987) and Funk and Sandone (1990) caused the department to investigate the use of an index of spawn from observations of milt.

Two indices considered for spawn documented from aerial surveys were 1) discrete miles of milt over the season and 2) the sum of miles of milt for all survey days (mile-days of milt). The advantages of milt observations compared to school biomass observations are 1) herring schools likely spawn a single time e.g., a single day, but a herring school may be observed for several days prior to, or after spawning, 2) milt is relatively easy to observe from the air and observation efficiency is generally not influenced by ocean bathymetry (Brady 1987).

Discrete miles of milt do not account for multiple spawning events in the same area, so are unlikely to be a good index of total abundance in areas with multiple days of spawning on the same beach (Brady 1987). Mile-days of milt probably provide a better index to abundance because they account for multiple spawning days on the same beach, but may be biased if the number of surveys varies significantly across years (Funk 1994). Additionally, although bathymetry probably will not influence observation of milt, it is likely one factor that will influence the biomass of spawning fish for each linear mile of milt observed. Willette et al. (1999) collected paired spawn deposition survey estimates from dive surveys and aerial survey estimates of miles of milt; the short tons (dive survey) per mile of milt (aerial survey) were much larger on Montague Island beaches when compared to short tons per mile of milt in northern or northeastern PWS beaches. Montague Island shoreline typically has large shallow, subtidal areas with complex kelp structure while the northern and northwestern beaches tend to have a steeper gradient to deep waters and less complex kelp structure.

Funk (1994) used the discrete miles of milt index in his ASA model rather than the mile-days of milt index because there were fewer surveys flown in the early years (1970s). However, subsequent runs of the ASA model have excluded the earlier years and use of the mile-days of mile index.

In 2008 the department began using a tablet computer and a geographic information system (GIS) application to collect aerial survey data (Bochenek 2010). Because digital maps are scalable and allow much more data to be added to a small area (contrast with the 25 paper maps used prior to 2008), and because of interest in herring predators distribution and abundance, additional effort was employed in documenting numbers and locations of predators such as Stellar sea lions, humpback whales *Megaptera novaeangliae*, killer whales *Orcinus orca*, Dall's porpoises *Phocoenoides dalli*, and bird aggregations (mostly gulls) associated with herring schools or spawn.

Age, sex, and size data from Pacific herring have been collected from commercial fisheries and fishery independent research projects since the early 1970s. The department currently has an archive containing approximately 210,000 scales paired with size and sex data (most of the archive has been collected since 1979). Summaries of many of these data have been published (e.g., Sandone 1987, Funk and Sandone

1990, Willette et al. 1999). Processing methods are similar those described by Baker et al. (1991); however, electronic fish measuring boards have been used to enter sample summary data and individual fish data (standard length in mm, whole body weight in grams, and sex) at the time of processing since 1989. Gonad weights have been collected from prespawning fish (both sexes) in most years since 1994 (n = 8,500).

Scales are used to estimate age for PWS collections rather than otoliths because they are much easier to collect and prepare for examination. Additionally, Chilton and Stocker (1987) reported that Chi-square tests of age compositions from paired otoliths and scales collected off the British Columbia coast could not refute the null hypothesis that they were from the same population. Interpretation of age from otoliths indicated that there were older fish than interpreted from scales; however, few fish older than age 10 are found in PWS, so fish interpreted at age 9 and older are combined into an age category 9+. No age validation or tests of paired age structures have been completed for PWS herring.

Aerial survey, acoustics estimates, and ASL data sets are essential parts of the current ASA model the Alaska Department of Fish and Game (ADF&G) uses to estimate the historical biomass and project pre-fishery run biomass a year ahead for management (e.g., Hulson et al. 2008). Additionally, the mile-days of milt and ASL data are part of the Bayesian formulation of the ASA model (Muridan 2015), and the scales collected from this archive were used in an EVOS funded project titled “PWS Herring Program - Scales as growth history records”.

This project will conduct aerial surveys to collect data related to spring herring spawning events, provide vessel support for acoustics surveys and disease sample collections; and capture and process herring to generate age, sex, and size summaries and mean target strength. The overall goal of the aerial survey, acoustics survey, and ASL project components is meet the overall program goal to **improve predictive models of herring stocks through observations and research**.

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2. Relevance to the Invitation for Proposals

Discuss how the project addresses the projects of interest listed in the Invitation and the overall Program goals and objectives. Describe the results you expect to achieve during the project, the benefits of success as they relate to the topic under which the proposal was submitted, and the potential recipients of these benefits.

This project will help address 3 areas of interest in the invitation for proposals as follows:

1) The aerial survey and acoustics survey support portions of this proposed project will address area of interest number 4. "A project for a comprehensive spawn assessment to be conducted at a minimum interval of every two years". The current ADF&G age-structured stock assessment model uses mile-days of milt from aerial surveys and acoustics biomass estimates to tune the model (Hulson et al. 2008), and will be conducted annually.
2) The acoustics survey support part of this proposed project will address area of interest number 6 "The continuation of the work to study the role of disease in herring recovery and the potential for developing tools to aid management agencies in the detection and management of disease outbreaks". This proposed project will provide the research platform (R/V Solstice) to capture fish and for the Disease Studies staff to process fish. Additionally, this proposed project will assist in collecting and processing Pacific herring scales so age data can be paired with the disease data.
3) The age, sex, and size part of this proposed project will address area of interest number 9 "A study to estimate and corroborate herring age at maturity with ASA model estimates". This proposed project would assist collecting and interpreting Pacific herring scales for age.

Data collected in this proposed project will help meet the overall *Herring Research and Monitoring Program* goal to **improve predictive models of herring stocks through observation and research** and would also address overall *Herring Research and Monitoring Program* objective number 2) Provide inputs to the stock assessment model. The overall goal and program objective 2 would be addressed by providing necessary inputs to the age-structured assessment models of ADF&G and the *PWS Herring Research and Monitoring Program – Population modeling.* These inputs would include the mile-days of spawn, target strength values used in the acoustics echo integration, and age, sex, and size of prespawn and spawning Pacific herring.

3. Project Personnel

The CV's of all principal investigators and other senior personnel involved in the proposal must be provided. Each resume is limited to two consecutively numbered pages and must include the following information:

- A list of professional and academic credentials, mailing address, and other contact information (including e-mail address)

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- A list of up your most recent publications most closely related to the proposed project and up to five other significant publications. Do not include additional lists of publications, lectures, etc.
- A list of all persons (including their organizational affiliations) in alphabetical order with whom you have collaborated on a project or publication within the last four years. If there have been no collaborators, this should be indicated.

Steven D. Moffitt

P.O. Box 669
Cordova, Alaska 99574

Work: (907) 424-3212
FAX: (907) 424-3235
steve.moffitt@alaska.gov

Professional Background:

Prince William Sound/Copper River Research Project Leader, Alaska Department of Fish and Game, August 2000–2014. Duties: Develop, implement, and evaluate research projects on Pacific herring, Pacific salmon, and eulachon in Prince William Sound and the Copper River. Specific duties include directing salmon otolith laboratory, setting spawning escapement goals, preseason forecasts, evaluation of harvest policies, assessment of runs inseason, and local area network supervision (2000–2010). Directly supervised one full time Fishery Biologist II, two seasonal Fishery Biologist I positions, and two seasonal Fisheries Technician crew leaders (2000–2014). Currently supervise one seasonal Fishery Biologist I and two seasonal Fisheries Technician Crew leaders. Current supervisor: Dr. Jack Erickson, Regional Research Biologist.

Prince William Sound/Copper River Assistant Research Project Leader, Fishery Biologist II, Alaska Department of Fish and Game, November 1991 to August 2000. Duties: Responsible for sampling, compilation, and analysis of age, sex, size, and stock composition data; and salmon catch and escapement reporting. Responsible for assisting with inseason assessment of Pacific salmon and Pacific herring abundance. Supervised five seasonal employees and responsible for five project budgets. Supervisors: Mr. John Wilcock and Mr. Mark Willette, Area Research Biologists

Assistant Project Leader, Fishery Biologist II, Alaska Department of Fish and Game, July 1991 to November 1991. Planned work and supervised five employees in collecting and compiling pink and chum salmon fry/egg abundance and mortality data. Assisted with data analysis and damage assessment report writing. Supervisor: Mr. Sam Sharr, Area Research Biologist

Education:

B.S. Wildlife Management, University of Alaska Fairbanks, 1989.

Selected Publications:

Batten, S.D., S. Moffitt, W.S. Pegau, and R. Campbell. Plankton indices explain interannual variability in first year Prince William Sound herring growth. Fisheries Oceanography. *In press*.

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Recent collaborators:

Paul Hershberger – U.S. Geological Survey, Marrowstone Marine Laboratory
Peter-John Hulson – University of Alaska Fairbanks
Dr. Gary Marty – University of California Davis
Melissa Muradian – University of Washington
Scott Pegau – Oil Spill Recovery Institute and Prince William Sound Science Center
Dr. Terry Quinn – University of Alaska Fairbanks

4. Project Design

A. Objectives

List the objectives of the proposed research and briefly state why the intended research is important. If your proposed project builds on recent work, provide detail on why the data set needs to be continued and whether any changes are proposed. If the proposed project is for new work, explain why the new data is needed. Describe the anticipated final product.

These data will be collected to meet the overall goal to **improve predictive models of herring stocks through observations and research** by providing necessary inputs to the age-structured assessment models of ADF&G and the *PWS Herring Research and Monitoring Program – Population Modeling.* These data will add to data collected since 1972 (aerial surveys) and 1973 (age, sex, and size data).There are no proposed hypotheses to be tested directly from this project.

Objectives of this proposed project are as follows:

1.) Conduct spring aerial surveys to collect data on survey routes, location and linear extent of herring milt, classification of herring milt, herring school biomass; distribution and abundance of sea lions, other marine mammals and bird aggregations associated with herring or herring spawn; and other relevant environmental or anthropogenic observations.

2.) Collect, process, summarize, and distribute age, sex, and size data from herring collected during acoustics surveys, spawning grounds surveys, *PWS Herring Research and Monitoring Program* disease surveys, or other relevant collections.

   a. Estimate age composition in each fishery and spawning escapements by gear type for time and area strata with sample sizes sufficient to simultaneously estimate all age proportions to within ± 5% at the 90% level of precision.

   b. Estimate mean standard length and whole body weight for each fishery and spawning escapements by gear type for time and area strata with sample sizes such that the relative error is ±5% at the 95% level of precision.

   c. Estimate the mean gonad weight of prespawning fish for time and area strata with sample sizes such that the relative error is ±5% at the 95% level of precision.

   d. Estimate sex composition of each fishery and spawning escapements by gear type for time and area strata with sample sizes sufficient to estimate proportions to within ±5% at the 95% level of precision.

3.) Provide a vessel (R/V Solstice) as a research platform for an adult acoustics survey, disease sampling, and collection of pre-spawn and spawning Pacific herring samples. Mean length from pre-spawn samples will be used to estimate Pacific herring target strength for the acoustics work.

B. Procedural and Scientific Methods

For each objective listed in A. above, identify the specific methods that will be used to meet the objective. In describing the methodologies for collection and analysis, identify measurements to be made and the anticipated precision and accuracy of each measurement and describe the sampling equipment in a manner that permits an assessment of the anticipated raw-data quality.

If applicable, discuss alternative methodologies considered, and explain why the proposed methods were chosen. In addition, projects that will involve the lethal collection of birds or mammals must comply with the EVOSTC's policy on collections, available on our website www.evostc.state.ak.us

I. Objective 1: Aerial surveys

Aerial surveys generally begin in mid to late March or earlier if there are reports of herring aggregations, spawn, or large predator aggregations. The first survey usually covers the eastern side of Prince William Sound because the spawn timing is generally earlier on the east side (Port Gravina and Port Fidalgo). However, the first survey may be expanded based on boat or pilot reports from other areas. Surveys then continue once or twice a week until herring schools or spawn are detected by a survey flight or reported by other pilots or boats. Once spawning begins, surveys will be conducted daily in the area where spawn was detected if weather conditions are appropriate. Surveys will be expanded to other portions of the Prince William Sound area (North shore, Naked Island, Montague Island, and Kayak Island) in April or based on pilot or boat reports. Survey interval, duration, and area are adjusted inseason to allow available funding to last until approximately mid-May.

Aerial survey methods are similar to those described in Brady (1987), Baker et al. (1991), and Lebida and Whitmore (1985), but many aspects have been updated with newer technology. Surveys are generally conducted in a float equipped, fixed-wing aircraft flying at a standard elevation of ~1,200 feet if possible with existing weather conditions. Two observers will be used if possible for each flight. The primary observer sits in the back seat and uses a Tablet computer to enter survey metadata in a spreadsheet and georeferenced survey data in an ESRI ArcPad application connected to a Bluetooth GPS (Bochenek 2010). The primary observer also attaches a GoPro camera on the back window (inside) to collect either video or a still image every 1 or 2 seconds (either video or still images work…images are higher quality, but take more processing time to create a time lapse movie). A sighting tube described by Lebida and Whitmore (1985; Appendix III) is used to calibrate the surface area for a few schools at the beginning of each survey, but it usually is not possible to use it on each herring school observation.

The secondary observer sits in the front passenger seat and reports observations to the primary observer, collects observations on paper maps, deploys a handheld GPS as a backup to the Bluetooth capable GPS, and takes photos with a Digital Single Lens Reflex (DSLR) camera and fast lens (F2.8) of spawning events, large biomass aggregations, and large sea lion groups. Photos are georeferenced to the GPS track using software to match up the time-date stamps. This requires a photo of the GPS with the date and time on the GPS screen. During large spawning events, several passes are necessary to map all of the observation data.

After each survey, Arcpad data are transferred from the tablet to the local ADF&G network for processing with ESRI ArcMap and DSLR photos are transferred to the local network and edited with Adobe photo editing software. Observations on paper maps are examined for complete survey information and stored for use in post-season processing.

The handheld GPS is downloaded with DNRGarmin software, videos or images are downloaded from the GoPro camera, and DSLR images are georeferenced with the GPS data. At the end of the survey season, the milt locations and lengths are adjusted by comparing data collected on the GIS application to the GoPro imagery. The wide angle format that makes the imagery so useful for documenting milt locations makes the imagery much less useful for school observations or sea lion pod counts.

Aerial Survey Measurements

Measurements made during the survey include 1) estimating the linear extent of milt, 2) estimating the biomass of herring schools from surface area, 3) estimating the number of sea lions, and 4) estimating the number of birds at a location.

Estimates of the linear extent of milt with the GIS application on the tablet computer are probably ± 20% although this has not been tested. Estimates of linear extent of milt adjusted with synoptic imagery are probably ±10%. Biggs and Funk (1988) found that skiff measurements of spawn were often larger than the aerial estimates of milt, but they attributed this to additional spawn after the survey or multiple days between surveys (full citation in Executive Summary).

Estimates of individual herring school biomass in short tons are likely at ±50%. Biomass is estimated in the field from a surface area to short tons conversion based on a limited number of observations that were captured by seine vessels. A sighting tube is used to calibrate the primary observer on a few schools at the beginning of each survey. However, the sighting tube is difficult to use on a fixed-wing plane and larger schools fill the field of view. Also the depth of schools is difficult to estimate from plane. Photos with known focal length, elevation, and angle may be used to check surface areas after the survey; however, this assessment has not been evaluated. Very few tests of observer estimates have been completed by capturing a school with purse seine gear after an aerial estimate (Fried 1983, Lebida and Whitmore 1985; ADF&G unpublished). ADF&G has less confidence in our ability to estimate school size in short tons than the linear extent of milt along a beach.

Estimates of sea lion pod counts are likely ±5% if the pod is <50 animals. An examination of paired observer estimates and photo counts from a few large pods (>50 animals) indicated most observers underestimated by 100%, i.e., photo counts of sea lion pods of 150 animals were estimated during a survey at 75 animals. Other studies have also documented that observer counts estimate a smaller proportion of the total count as abundance increases (e.g., Jones et al. 1998). However, these data are not used as part of our current herring assessment model, so all counts in our GIS data files are currently unadjusted survey estimates.

Estimates of whales are likely ±100% or more given the duration of dives by foraging humpback whales described by Dolphin, 1988. Estimates of harbor seals at haul outs are most likely ±30% although there are a few locations with groups of ~100 individuals and the estimates are probably larger. Some paired photos and aerial observer estimates are available to examine, but these data are not used as part of our current herring assessment model, so all counts in our GIS data files are unadjusted survey estimates.

Given the size of many of the bird aggregations (gulls mostly), the uncertainty in our survey estimates is likely ±100% or more. Similar to sea lions and harbor seals, we have paired survey photos and survey observer estimates for comparison, but these data are not used as part of our current herring assessment model, so all counts in our GIS data files are unadjusted survey estimates.

ADF&G considered conducting helicopter surveys because a more stable platform would allow longer duration, fixed location observations of areas with many herring schools and predator aggregations; however, there is no helicopter service in Cordova and the cost for chartering a helicopter out of Valdez or Girdwood would be almost double the current fixed-wing charter costs.

II. Objective 2: Age, sex, and size sampling

Methods are mostly outlined in Baker et al. (1991). The overall goal of the ASL sampling program in the PWS areas is to provide the age, sex, and size composition of the herring catches and spawning escapements. To design a sampling program to provide this information, two questions should be addressed as follows:

Appendix C

1) Do we need to be concerned about temporal or spatial changes in the age, sex, or size composition, and if so, how should the samples be stratified to detect them?

2) How many samples are necessary to achieve desired levels of precision and accuracy?

The question of whether temporal or spatial changes occur in the age, sex, or size composition of a population is area specific. However, because the PWS herring fisheries and spawning escapements have varied greatly on temporal and spatial scales (e.g., Biggs et al. 1992), criteria applied have been as follows:

1) Spatially separated spawning populations should be sampled separately and, unless there are no demonstrable differences in the age composition among catches in management units within an area, those units should be sampled separately;

2) The duration of the sampling effort should cover the times when approximately 75%–85% of the catches are made or escapements occur;

3) The more rapidly the age composition changes the more time strata are necessary.

These criteria help ensure that time and area specific trends are represented in manageable portions of a population within an area, and at the same time help to minimize the variance around estimates of the age, sex, and size composition of the population as a whole.

Because PWS herring fisheries and spawn timing varies greatly on both temporal and spatial scales and because other areas have found changes in age composition through time (Ware and Tanasichuk, 1989), general sampling guidelines are followed rather than a fixed stratified sampling scheme. Samples are collected from as many spatially discrete prespawn and spawning aggregations as possible. Additionally, if spawning activity extends over multiple days in a single location, multiple samples are collected if possible.

Random samples from each fishery type or spawning escapements are stratified by area, time, and gear. Sample size (n=450) is set to simultaneously estimate the proportion of each age class to within ±5% of the true proportion 90% of the time (Thompson 1992). This sample size represents the worst case where there are 3 age classes of equal proportions; no more than 10% of the scales are unreadable, and no finite population correction is necessary because n is small relative to N. This sample size is also sufficient to estimate the overall proportion of each sex to within ±5% of the true proportion at >95% of the time (Thompson 1992). Additionally, this sample size is sufficient to estimate the mean standard length and mean whole body and gonad weights to within a relative error of ±5% of the true proportion at >95% of the time (Cochran 1977, Thompson 1992). The sample size to evaluate the mean standard length and weight was evaluated by examining the coefficient of variation (CV) of all spatially and temporally stratified samples collected in 2010–2015. The CV of 79 whole body weight samples was normally distributed with a mean of 0.27. Only 1 sample in 79 had a large enough CV such that a sample size of 450 would be insufficient to provide an estimate within a relative error of ±5% of the true proportion 95% of the time (Cochran 1977).

Samples of whole fish are collected in the field and frozen in large 6 mm plastic bags with labels inside the bag that document date, time, location, gear, samplers, and the number of bags. Other information including the approximate coordinates of the sample location are collected and added to a sample log.

Often more than 450 fish are collected such that an equal number of fish are randomly selected from each bag prior to processing to meet the sample goal of 450. From the fish selected for processing, 10 fish are place on a tray and their standard length measured to the nearest mm (standard length, tip of snout to hypural plate), whole weight to the nearest gram and gonad weight to the nearest 0.01 grams (both sexes) are measured with an electronic balance; sex determined from examination of the gonads (1=male, 2=female, 3= unknown), and gonad maturity estimated from examination of the gonads. Gonad maturity is determined according to the maturity scale of ICES (Anonymous 1962; scale of 1, undeveloped, to 8, recovering from spawning). This maturity scale covers the complete development cycle and is somewhat subjective; however, because most of our collections are in the spring, only a few of the categories are used consistently. All data are entered or captured with an electronic fish measuring board. The precision of length measurements collected on our previous electronic fish measuring boards were tested and were within ±1 mm; the new boards have not been tested yet. Whole body and gonad weights are collected with an electronic balance that is checked with calibration weights (and recalibrated if necessary) prior to each sampling event.

A scale is collected from the left side of the fish from a preferred area if possible. The preferred area is above the lateral line and 3-4 rows of scales back from the operculum. This area generally has symmetrical growth patterns and distinct annuli. Scales are cleaned and placed on a pre-labeled glass microscope slide after dipping in a solution of 1:10 mucilage glue to water. A single scale from each of 10 fish is placed as two rows of 5 scales on each slide. Scales are viewed on a microfiche to ensure they are readable for age (not regenerated or illegible for other reasons) and useable for measuring growth increments. If they are not useable to interpret age or measure growth increments, another scale is collected and examined. After all scales are placed on a glass slide and checked they are covered with a second slide and taped together at the label end of the slide. All slides are stored in a labeled box or cabinet tray until examination to interpret the age.

Once a sample is complete, data are downloaded from the electronic fish measuring board into an MS Excel spreadsheet. Scales are examined to interpret the age on a microfiche by 2 or 3 readers. Ages are interpreted independently and then the committee discusses any differences before agreeing on an age by consensus. The crew leader spot checks all samples to reduce the chance of reader drift in age interpretation.

Overall age compositions in PWS are in general agreement with observations from large recruitments, i.e., proportions from a large recruitment event can be tracked across years; however, Kimura et al. (1992) found that when readers were aware of the strong year class they tend to make the strong year class more predominate by assigning ages to the strong year class. Because there are no known-age scales in our collection, our readers cannot be tested for accuracy; however, readers can be tested for reader agreement with tests of symmetry (Bowker 1948) or Cohen's Kappa (Cohen 1960). With sufficient training and experience, readers of Pacific herring scales are likely very precise with interpreting age of scales up to age 9. Growth increments are much smaller after age 9 and variability in age assignments probably increases.

ADF&G has considered using structures other than scales for age interpretation (e.g., otoliths, fin rays, or vertebrae), but the increased difficulty in collection and processing does not appear to be an efficient use of available resources. Additionally, as mentioned earlier, Chilton and Stocker (1987) examined paired herring scales and otolith ages and could not reject the hypothesis that they produced age compositions from the same population.

III. Objective 3: Provide research platform for acoustics, pre-spawn ASL, disease sampling, and spawning escapement sampling for ASL.

This objective will be met using the Alaska Department of Fish and Game vessel R/V Solstice. The Solstice will deploy in late March or early April depending on the weather and pilot or boat reports. Onboard will be ADF&G staff to collect ASL samples, assist with processing disease samples (scale collections), and assist with the acoustics survey. Herring Research and Monitoring staff from the Prince William Sound Science Center (PWSSC) and United States Geological Survey Division will also be onboard to direct the adult acoustics survey and process disease samples.

During the acoustics data collection portion of the survey, a 20 m or 35-m deep anchovy purse seine (stretch mesh 1.5 cm) will be the primary herring capture gear. Onboard the R/V Solstice will be additional gear types to allow the capture of fish if necessary. These will include various sized cast nets, a variable mesh gillnet, and fishing rods with herring jigs. Generally, the anchovy purse seine gear will be deployed at night just prior to beginning acoustics transects. Herring schools are usually too deep to capture during the day, but rise toward the surface at dusk. Herring schools will be located with the vessel sounder and search light sonar. Marine mammal avoidance protocols will used for the spring survey prior to any purse seine deployment as follows:

A. Pre-survey information gathering and research staff briefing:
    1. Research staff will make a concerted attempt to contact local persons in specific areas they anticipate sampling. Air taxi pilots who have recently flown over those areas should be contacted. This information can be used to determine if there have been marine mammals in anticipated sampling areas.
    2. Research staff and vessel crew will familiarize themselves with the Marine Mammal Interaction handbook before or shortly after departure. Anyone onboard not familiar with the survey will be instructed in marine mammal avoidance protocol while deploying and hauling back the seine.

B. On site:
    1. If at all possible the vessel will arrive at the area to be sampled during daylight hours. This will allow time to transit the survey area and quantify marine mammal presence. All available persons on board must be looking and listening for marine mammals, especially whales during these transits. A hydrophone (a device used to detect sounds transmitted through the water) will potentially be used prior to making sets if available.

    2. Because these sets are made at night when the target species, Pacific herring, are closer to the surface, restricted visibility is an issue. After a possible herring school has been targeted acoustically, mark the position and carefully survey the surrounding area at a slow speed. During this survey all crew/staff should be looking and listening for marine mammal activity. One person should be on the bow as far forward from vessel noise as

possible, 1 person should be looking on the forward looking infrared (FLIR) camera, and 1 people should be aft on the main deck. An additional person will be placed in the seine skiff as a lookout. All persons serving as lookouts must have a radio or suitable communication device, capable of contacting the vessel operator. Ten to twenty minutes should be allowed for this marine mammal assessment and all lookouts must be focused on looking and listening. If any marine mammal activity is detected or suspected in the area where the set is to be made this information must be relayed to the vessel captain. If there is any possibility of conflict with marine mammals, especially whales, after the initial assessment has been made the seine will not be deployed.

3. Environmental conditions:
   Inclement weather conditions, e.g., wind, rain, snow, or fog that restrict visibility and auditory conditions, as well as sea state (sea & swell) should be subject to careful evaluation. If you can't see or hear, it will make it especially difficult to detect marine mammals in the sampling area. A decision to set the seine must be made jointly by both the vessel captain and the project leader, if either objects the net should not be deployed.

4. Electronic devices:
   All available equipment on board the vessel, except lights (lights may cause herring to dive), will be used to detect marine mammals in the sampling area. The vessel sonar if not tracking fish can be adjusted to detect targets near the surface. A forward looking infrared camera (FLIR) was installed on the Solstice in late 2007. Except in heavy rain or fog, the unit displays a clear picture of the shoreline, mountain tops, low lying rocks and islands in total darkness. Also visible are logs, sea ducks, gulls, otters, and whales out to about 0.5 miles. Whale spouts show up clearly, but for a short amount of time.

When the net is set, a waypoint is captured on a handheld GPS to collect the location, time, and date. After the net pursed sufficiently to concentrate the fish, dip nets are used to collect a random sample of sufficient numbers of fish for an ASL sample (450+) and also for disease sampling (60+). Several totes will be filled with sea water for the disease sample prior to bringing fish onboard. After sufficient numbers of fish are randomly selected, the end of the purse seine is released and pushed away from the vessel to allow the remaining fish to escape. The ASL sample is then placed in 6 mm plastic bags (6 or 7 for each 450 fish sample) and grease pencils are used to labeled each bag with vessel name, date, time, nearest headland, and bag number (e.g., 1 of 6). The bags are placed in freezer for storage and the deck is cleaned to prepare for the next set. If a disease sample is collected, ADF&G staff will help to organize the sample for processing and prepare labeled slides for scale collection. ADF&G staff will also help prepare for deploying the acoustics gear. After each set, a spreadsheet log is updated with information about the sample matching that on the bag labels and captured on the GPS.

The vessel will also be used to access areas with spawning Pacific herring. When an area with active spawn is located, a raft with 2 crew members will be deployed to capture fish for an ASL sample. Required gear will include fuel tank, tool kit, oars, rain gear and gloves, personal floatation devices, a VHF radio, a handheld GPS, 2 or 3 cast nets, 6 each 4 gallon buckets, and a 20 gallon fish tote. Cast nets will be thrown from the raft or shore into the milt to capture fish. This will often require an hour or more of cast net throws to capture a full sample. The mean time and approximate centroid of the area covered are used to describe the time and location of capture. Once a full sample is assured or another location must be evaluated, the sample is returned to the R/V Solstice and bagged, labeled, and logged as described for purse seine samples.

A trawl net has also been considered for capture of fish on pre-spawn surveys. A trawl net can be fished deeper such that captures could be made if herring were not rising to shallow enough depths (10–15 fathoms of the surface) to capture with the anchovy seine. However, the disadvantages are that we have 20 years of samples from an anchovy seine, it would be more difficult to limit the amount of capture mortality, and marine mammal interactions would be even more difficult to avoid.

We have also considered alternative gear to capture spawning herring (other than cast nets). These could include variable mesh gillnets or a small half purse that could be deployed from a skiff. Both of these gears were used in the early to mid-1990s, but each had disadvantages that caused us to begin using cast nets. Gillnets caused significant scale loss such that we were collecting scales that were asymmetrical and difficult to interpret for age. The skiff and half purse required a shallow draft skiff, so our seine skiff could not be used and at least 3 crew members to operate.

C. Data Analysis and Statistical Methods

Describe the process for analyzing data. Discuss the means by which the measurements to be taken could be compared with historical observations or with regions that are thought to have similar ecosystems. Describe the statistical power of the proposed sampling program for detecting a significant change in numbers. To the extent that the variation to be expected in the response variable(s) is known or can be approximated, proposals should demonstrate that the sample sizes and sampling times (for dynamic processes) are of sufficient power or robustness to adequately test the hypotheses. For environmental measurements, what is the measurement error associated with the devices and approaches to be used?

Aerial survey estimates of linear extent of Pacific herring milt, herring school biomass, sea lion counts, other marine mammal counts, and sea bird counts are saved directly in GIS shape files and a MS Excel spreadsheet is used to capture survey metadata. Once a survey is complete, shape files, the Excel metadata log file, GPS route files, GoPro video/image files, and DSLR photos are copied to the ADF&G Cordova file server. Survey metadata are entered into a yearly log file, and shape files, GPS route files, photos and videos are saved into an aerial survey subdirectory by survey date. Shape file data are viewed in ArcMap and attribute tables are examined for errors and adjusted as necessary.

After all surveys are complete, copies of the GIS miles of milt files will be compared to GoPro video or still images and the location and classification of milt will be adjusted if necessary. This is the highest priority as these data are used to tune the ASA model. If possible, biomass, sea lion counts and bird estimates will be compared against available georeferenced images.

After adjustments are complete, the individual survey GIS data will be combined into shape files for the year and then added to the historical GIS shape files. These historical shape files will allow comparison across all years for milt observations (1973–2015), survey routes (1997–2015), sea lion location and abundance (currently 2008–2015), other marine mammals (currently 2008–2015), and birds (currently 2008–2015). These data could be compared to other areas if they have similar data sets.

The ability to detect a change in mile-days of milt among years depends on the frequency of surveys and the completeness of the survey coverage. Similar to most years since 1973, this project will begin surveys in mid to late March on the east side of PWS to examine fish and sea lion distribution and fly daily surveys once spawning begins in the areas with significant fish, sea lion, or whale counts. Surveys will be extended to the Kayak Island area, North Shore, Naked Island, and Montague Island areas. Additionally, pilot reports of herring or spawn from other areas will be considered in flight route planning.

Standard length, weight, and sex data are collected directly into an electronic fish measuring board. At the completion of a sampling event, data are downloaded from the fish measuring board to the ADF&G Cordova file server. Data are reformatted into an Excel spreadsheet using a VBA application. Age is interpreted from scales and keyed into the Excel spreadsheet. A VBA application is used to generate age, sex, and size composition summaries that include sample size and percentage by age class and sex, mean and standard deviation by age class and sex for weight and standard length. Currently, historical data (1973–present) are summarized in an Excel spreadsheet; however, data are in the process of being organized for inclusion in a database that could be used by other herring research efforts.

Detecting a change in the sex, age, or size composition among spatial or temporal strata will depend on sample size; however, sample sizes of 450 should allow the use of Chi-square methods to detect difference in age composition. Age interpretations have been compared across areas in past, e.g., Brannian (1988).

D. Description of Study Area

Where will the project be undertaken? Describe the study area, including, if applicable, decimally-coded latitude and longitude readings of sampling locations or the bounding coordinates of the sampling region (e.g., 60.8233, -147.1029, 60.4739, -147.7309 for the north, east, south and west bounding coordinates).

The study area will include all of Prince William Sound and Copper River/Bering River coastal areas between Cape Suckling to the east and Cape Puget to the west. The bounding coordinates are 61.300 N, -144.00 W and 59.750 N, -148.760 W.

5. Coordination and Collaboration

Within the Program

Provide a list and clearly describe the functional and operational relationships with the other program projects. This includes any coordination that has taken or will take place and what form the coordination will take (shared field sites or researchers, research platforms, sample collection, data management, equipment purchases, etc.).

1) *PWS Herring Research and Monitoring Program –Acoustics Survey.*
This proposed project will share the R/V Solstice vessel research platform with a Prince William Sound Science Center staff member to conduct the adult acoustics survey. ADF&G acoustics equipment will be shared with the Acoustics Survey project if necessary. This proposed project will also capture and process age, sex, and size samples to calculate mean target strength by time or area strata for use in acoustics echo integration. Aerial surveys conducted by this proposed project will provide additional location information on herring aggregation for acoustics surveys.

2) *PWS Herring Research and Monitoring Program – Outreach and Education.*

This proposed project will assist public outreach through public presentations of methods and results.

3) *PWS Herring Research and Monitoring Program – Herring Disease Studies*
This proposed project will provide research platform vessel support (R/V Solstice) for Herring Disease Studies staff to capture and process adult herring for disease sampling similar to past years. Additionally, this project will help collect scales for fish age and interpret the scales for age.

4) *PWS Herring Research and Monitoring Program – Age at Maturity*
This proposed project will assist with collection and processing of herring scales for the proposed age at maturity project.

5) *PWS Herring Research and Monitoring Program – Population modeling*
This proposed project will collect mile-days of milt, provide vessel support for the acoustics survey, and provide age, sex, and size data to update the time series of data required for the Bayesian population dynamics model.

With Other EVOSTC-funded Programs and Projects
Indicate how your proposed program relates to, complements or includes collaborative efforts with other proposed or existing programs or projects funded by the EVOSTC.

Data Management Program
This proposed project will provide additional herring aerial survey and herring age, sex, and size data for use by other PWS Herring Program projects. Past funding and ADF&G funding has allowed us to provide aerial survey GIS data files for linear extent of spawn (1973–2015), survey routes (1997–2015), sea lion distribution and abundance (2008–2015), other marine mammals distribution and abundance (2008–2015), and bird aggregations (2008–2015).

With Trustee or Management Agencies
Please discuss if there are any areas which may support EVOSTC trust or other agency work or which have received EVOSTC trust or other agency feedback or direction, including the contact name of the agency staff. Please include specific information as to how the subject area may assist EVOSTC trust or other agency work.

If the proposed project requires or includes collaboration with other agencies, organizations or scientists to accomplish the work, such arrangements should be fully explained and the names of agency or organization representatives involved in the project should be provided. If your proposal is in conflict with another project or program, note this and explain why.

With Native and Local Communities
Provide a detailed plan for any local and native community involvement in the project.

Text

6. Schedule

Appendix C

Program Milestones

Specify when critical program tasks will be completed. Reviewers will use this information in conjunction with annual program reports to assess whether the program is meeting its objectives and is suitable for continued funding.

Objective 1.

Complete all aerial surveys of spring herring assessment.

To be met by June of each year 2017–2021

Summarize, edit, and combine all spring 2016 aerial survey shape files into yearly totals.

To be met by August each year 2017–2021

Provide all raw and summarized data and metadata to AOOS Workspace.

To be met by June of following year 2018–2021

Objective 2.

Finish processing all herring samples for age, sex, and size

To be met by August each year 2017–2021

Distribute final age data and summaries.

To be met by August each year 2017–2021

Provide all raw and summarized data and metadata to AOOS Workspace

To be met by June of following year 2018–2021

Objective 3.

Complete spring acoustics, disease vessel support trip

To be met by June each year 2017–2021

Complete spawning ASL collection trip

To be met by June each year 2017–2021

Distribute final age data and summaries for acoustics target strength and disease sampling

To be met by August each year 2017–2021

Provide all raw and summarized data and metadata to AOOS Workspace

To be met by June of following year 2018–2021

Measurable Program Tasks

Specify, by each quarter of each fiscal year (February 1 – January 31), when critical program tasks will be completed.

FY 17, 1st quarter (February 1, 2017 - April 31, 2017)

March: *Start Aerial surveys*
March or early April: *Start Acoustics and disease support survey*
April: *Start herring ASL sample processing*

FY 17, 2nd quarter (May 1, 2017-July 30, 2017)

May: *Finish Aerial surveys*
June: *Provide previous years data and metadata to workspace*
June: *Quality control work on ASL data*
July: *Quality control and editing of aerial shape files.*

FY 17, 3rd quarter (August 1, 2017 – October 31, 2017)

Appendix C

August:	*Finish analysis of aerial survey data.*
August:	*Combine aerial survey shape files into historical version*
August:	*Finish herring ASL sample processing*
August:	*Finish ASL analysis and distribute ASL sample summaries*
1 September:	*Submit proposal Request for FY18*

FY 17, 4th quarter (November 1, 2017- January 31, 2018)

November:	*PIs meeting with Gulf Watch Alaska*
January:	*Write summary reports.*

FY 18, 1st quarter (February 1, 2018 - April 31, 2018)

1 March:	*Annual Report due*
March:	*Start Aerial surveys*
March or early April:	*Start Acoustics and disease support survey*
April:	*Start herring ASL sample processing*

FY 18, 2nd quarter (May 1, 2018-July 30, 2018)

May:	*Finish Aerial surveys*
June:	*Provide previous years data and metadata to workspace*
June:	*Quality control work on ASL data*
July:	*Quality control and editing of aerial shape files*

FY 18, 3rd quarter (August 1, 2018 – October 31, 2018)

August:	*Finish analysis of aerial survey data.*
August:	*Combine aerial survey shape files into historical version*
August:	*Finish herring ASL sample processing*
August:	*Finish ASL analysis and distribute ASL sample summaries*
1 September:	*Submit proposal Request for FY18*

FY 18, 4th quarter (November 1, 2018- January 31, 2019)

November:	*PIs meeting with Gulf Watch Alaska*
January:	*Write summary reports.*

FY 19, 1st quarter (February 1, 2019 - April 31, 2019)

1 March:	*Annual Report due*
March:	*Start Aerial surveys*
March or early April:	*Start Acoustics and disease support survey*
April:	*Start herring ASL sample processing*

FY 19, 2nd quarter (May 1, 2019-July 30, 2019)

May:	*Finish Aerial surveys*
June:	*Provide previous years data and metadata to workspace*
June:	*Quality control work on ASL data*
July:	*Quality control and editing of aerial shape files*

FY 19, 3rd quarter (August 1, 2019 – October 31, 2019)

August:	*Finish analysis of aerial survey data.*
August:	*Combine aerial survey shape files into historical version*
August:	*Finish herring ASL sample processing*

August: *Finish ASL analysis and distribute ASL sample summaries*
1 September: *Submit proposal Request for FY18*

FY 19, 4th quarter (November 1, 2019- January 31, 2020)
November: *PIs meeting with Gulf Watch Alaska*
January: *Write summary reports.*

FY 20, 1st quarter (February 1, 2020 - April 31, 2020)
1 March: *Annual Report due*
March: *Start Aerial surveys*
March or early April: *Start Acoustics and disease support survey*
April: *Start herring ASL sample processing*

FY 19, 2nd quarter (May 1, 2020-July 30, 2020)
May: *Finish Aerial surveys*
June: *Provide previous years data and metadata to workspace*
June: *Quality control work on ASL data*
July: *Quality control and editing of aerial shape files*

FY 19, 3rd quarter (August 1, 2020 – October 31, 2020)
August: *Finish analysis of aerial survey data*
August: *Combine aerial survey shape files into historical version*
August: *Finish herring ASL sample processing*
August: *Finish ASL analysis and distribute ASL sample summaries*
1 September: *Submit proposal Request for FY18*

FY 19, 4th quarter (November 1, 2020- January 31, 2021)
November: *PIs meeting with Gulf Watch Alaska*
January: *Write summary reports.*

FY 21, 1st quarter (February 1, 2021 - April 31, 2021)
1 March: *Annual Report due*
March: *Start Aerial surveys*
March or early April: *Start Acoustics and disease support survey*
April: *Start herring ASL sample processing*

FY 21, 2nd quarter (May 1, 2021-July 30, 2021)
May: *Finish Aerial surveys*
June: *Provide previous years data and metadata to workspace*
June: *Quality control work on ASL data*
July: *Quality control and editing of aerial shape files*

FY 21, 3rd quarter (August 1, 2021 – October 31, 2021)
August: *Finish analysis of aerial survey data*
August: *Combine aerial survey shape files into historical version*
August: *Finish herring ASL sample processing*
August: *Finish ASL analysis and distribute ASL sample summaries*
1 September: *Submit proposal Request for FY18*

FY 21, 4th quarter (November 1, 2021- January 31, 2022)
November: *PIs meeting with Gulf Watch Alaska*
January: *Write summary reports; provide final data to workspace*

7. Budget
Budget Forms (Attached)
Please provide completed budget forms. Please note that the following items will not be considered for funding:

- Costs associated with international travel for meetings, symposia, or presentations.
- Costs associated with attendance at meetings, symposia, or presentations outside of those required to coordinate with project members.
- Costs associated with outreach or education efforts.

Sources of Additional Funding
Identify non-EVOSTC funds or in-kind contributions used as cost-share for the work in this proposal. List the amount of funds, the source of funds, and the purpose for which the funds will be used. Do not include funds that are not directly and specifically related to the work being proposed in this proposal.

IV. BUDGET JUSTIFICATION: Fiscal Year: 2017–2021

Personnel:

Funds are requested ($6.8 K) to support an ADF&G Fishery Biologist (FB) III in Prince William Sound. This will cover premium pay (sea duty and hazard pay) for boat and aerial surveys (*Objectives 1 –3*).

Funds are requested ($3.9 K) to support an ADF&G Fishery Biologist (FB) II in Prince William Sound. This will cover premium pay (sea duty and hazard pay) for boat and aerial surveys (*Objectives 1 –3*).

Funds are requested ($32.4 K) to support an ADF&G Fishery Biologist (FB) I position in Prince William Sound (4.5 months or 0.375 FTE). The FB I will complete preseason preparation for herring surveys (equipment setup and testing), schedule and collect data on many of the aerial surveys, process aerial survey data after each survey, combine data into historical GIS coverage, and assist with report writing (*Objectives 1*). The FB I will also assist with processing herring for age, sex, and size related data and summarizing the data (*Objectives 2*).

Funds are requested ($6.0 K) to support an ADF&G Fish and Wildlife Technician (FWT) III position in Prince William Sound (1 months or 0.08 FTE). The technician will lead the setup, organization, processing, and summary of age, sex, size related data from herring collected on surveys (*Objective 2).*

Funds are requested ($5.4 K) to support an ADF&G Fish and Wildlife Technician (FWT) II position in Prince William Sound (1 months or 0.08 FTE). The technician will lead assist with the organization, processing, and summary of age, sex, size related data from herring collected on surveys (*Objective 2*).

ADF&G will provide an in-kind contribution of 2.4 months (0.17 FTE) of Fishery Biologist III time ($33.4 K) to provide overall supervision of the project, conduct boat and aerial surveys, analyze data, provide data to other program projects, and write reports. ADF&G will provide and in-kind contribution of 2.1 months (0.18 FTE) of Fishery Biologist II time ($20.7 K) to supervise FB I, FWT III, and FWT II, conduct boat and aerial survey, analyze data, provide data to other program projects, and write reports (*Objectives 1–3*).

Travel:

Funds are requested for 2 round trips and per diem ($1.4 K) to meet with Herring Research and Monitoring and Gulf Watch Alaska program principle investigators (*Objectives 1–3).*

Contractual:

Funds are requested to fund survey trips on the R/V Solstice including a 9 day ($37.4 K) acoustics and age, sex, size sampling trip and a 5 days ($20.8 K) trip to sample spawning Pacific herring for age, sex, and size. Funds are also requested to fund aerial survey charters ($35.6 K) to collect data on the distribution and amount of Pacific herring spring biomass, mile-days of milt, sea lions, other marine mammals, and birds. Additionally, funds are requested for hotel ($0.6 K) and rental car ($0.3 K) for 2 meetings (*Objectives 1–3*).

Commodities:

Funds are requested to purchase commodities for boat surveys including rain gear ($0.2 K); sample totes, dip nets, and sample gloves ($0.5 K); and cast nets and variable mesh gillnets ($0.5 K). Funds are also requested for age, sex, and size processing including glass slides, glue, and slide boxes ($0.5 K); and miscellaneous office or field supplies ($0.4 K) (*Objectives 1–3*).

Equipment: None

Indirect:

The indirect for the Trustee Agency costs were calculated at 9% ($13.7K).

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$54.5	$54.5	$54.5	$54.5	$54.5	$272.5	
Travel	$1.4	$1.4	$1.4	$1.4	$1.4	$6.8	
Contractual	$94.6	$94.6	$94.6	$94.6	$94.6	$473.0	
Commodities	$2.1	$2.1	$2.1	$2.1	$2.1	$10.5	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
SUBTOTAL	$152.6	$152.6	$152.6	$152.6	$152.6	$762.8	
General Administration (9% of subtotal)	$13.7	$13.7	$13.7	$13.7	$13.7	$68.7	N/A
PROJECT TOTAL	$166.3	$166.3	$166.3	$166.3	$166.3	$831.5	
Other Resources (Cost Share Funds)	$54.5	$54.5	$54.5	$54.5	$54.5	$272.5	

COMMENTS:
This summary page provides an five-year overview of proposed project funding and actual cumulative spending. The column titled 'Actual Cumulative' must be updated each fiscal year as part of the annual reporting requirements. Provide information on the total amount actually spent for all completed years of the project. On the Project Annual Report Form, if any line item exceeds a 10% deviation from the originally-proposed amount; provide detail regarding the reason for the deviation.

FY17-21

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

TRUSTEE AGENCY SUMMARY PAGE

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Vacant FB I	Surveys and age,sex, size collection and proce	4.5	7.2	0.0	32.4
Vacant FWT III	Surveys and age,sex, size collection and proce	1.0	6.0	0.0	6.0
Cheng Xiong	Surveys and age,sex, size collection and proce	1.0	5.4	0.0	5.4
Steve Moffitt (sea duty and harzard)	Surveys and age,sex, size collection and proce	0.5	13.6	0.0	6.8
Stormy Haught (sea duty and hazard)	Surveys and age,sex, size collection and proce	0.5	7.8	0.0	3.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	40.0	0.0	
				Personnel Total	$54.5

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Meeting with HRMP PI's and GWA PI's	0.5	2	6	0.1	1.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.4

FY17

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description		Contract Sum
Acoustics survey - R/V Solstice @ $4,150/day (9 days)		37.4
Age, sex, size collections of spawning herring @ $4,150/day (5 days)		20.8
Air Charters for spring surveys (66 hours at $540)		35.6
Hotel for meetings (6 days at $100)		0.6
Rental car for meeting (6 days at $50)		0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required.	**Contractual Total**	$94.6

Commodities Costs: Description		Commodities Sum
Rain gear for surveys (2 @ $100)		0.2
Sample totes, nets, gloves ($500)		0.5
Age, sex, size processing supplies (glass slides, glue, slide boxes)		0.5
Cast nets and variable mesh gillnets		0.5
Misc supplies		0.4
	Commodities Total	$2.1

FY17

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY17

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs: Name	Project Title	Months Budgeted	Monthly Costs	Overtime	Personnel Sum
Vacant FB I	Surveys and age,sex, size collection and proce	4.5	7.2	0.0	32.4
Vacant FWT III	Surveys and age,sex, size collection and proce	1.0	6.0	0.0	6.0
Cheng Xiong	Surveys and age,sex, size collection and proce	1.0	5.4	0.0	5.4
Steve Moffitt (sea duty and harzard)	Surveys and age,sex, size collection and proce	0.5	13.6	0.0	6.8
Stormy Haught (sea duty and hazard)	Surveys and age,sex, size collection and proce	0.5	7.8	0.0	3.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	40.0	0.0	
				Personnel Total	$54.5

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Travel Sum
Meeting with HRMP PI's and GWA PI's	0.5	2	6	0.1	1.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.4

FY18

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

Contractual Costs: Description	Contract Sum
Acoustics survey - R/V Solstice @ $4,150/day (9 days)	37.4
Age, sex, size collections of spawning herring @ $4,150/day (5 days)	20.8
Air Charters for spring surveys (66 hours at $540)	35.6
Hotel for meetings (6 days at $100)	0.6
Rental car for meeting (6 days at $50)	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$94.6

Commodities Costs: Description	Commodities Sum
Rain gear for surveys (2 @ $100)	0.2
Sample totes, nets, gloves ($500)	0.5
Age, sex, size processing supplies (glass slides, glue, slide boxes)	0.5
Cast nets and variable mesh gillnets	0.5
Misc supplies	0.4
Commodities Total	$2.1

FY18

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B CONTRACTUAL & COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY18

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs: Name	Project Title	Months Budgeted	Monthly Costs	Overtime	Personnel Sum
Vacant FB I	Surveys and age,sex, size collection and proce	4.5	7.2	0.0	32.4
Vacant FWT III	Surveys and age,sex, size collection and proce	1.0	6.0	0.0	6.0
Cheng Xiong	Surveys and age,sex, size collection and proce	1.0	5.4	0.0	5.4
Steve Moffitt (sea duty and harzard)	Surveys and age,sex, size collection and proce	0.5	13.6	0.0	6.8
Stormy Haught (sea duty and hazard)	Surveys and age,sex, size collection and proce	0.5	7.8	0.0	3.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	40.0	0.0	
				Personnel Total	$54.5

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Travel Sum
Meeting with HRMP PI's and GWA PI's	0.5	2	6	0.1	1.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.4

FY19

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
Acoustics survey - R/V Solstice @ $4,150/day (9 days)	37.4
Age, sex, size collections of spawning herring @ $4,150/day (5 days)	20.8
Air Charters for spring surveys (66 hours at $540)	35.6
Hotel for meetings (6 days at $100)	0.6
Rental car for meeting (6 days at $50)	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$94.6

Commodities Costs: Description	Commodities Sum
Rain gear for surveys (2 @ $100)	0.2
Sample totes, nets, gloves ($500)	0.5
Age, sex, size processing supplies (glass slides, glue, slide boxes)	0.5
Cast nets and variable mesh gillnets	0.5
Misc supplies	0.4
Commodities Total	$2.1

FY19

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY19

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Vacant FB I	Surveys and age,sex, size collection and proce	4.5	7.2	0.0	32.4
Vacant FWT III	Surveys and age,sex, size collection and proce	1.0	6.0	0.0	6.0
Cheng Xiong	Surveys and age,sex, size collection and proce	1.0	5.4	0.0	5.4
Steve Moffitt (sea duty and harzard)	Surveys and age,sex, size collection and proce	0.5	13.6	0.0	6.8
Stormy Haught (sea duty and hazard)	Surveys and age,sex, size collection and proce	0.5	7.8	0.0	3.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	40.0	0.0	
				Personnel Total	$54.5

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Meeting with HRMP PI's and GWA PI's	0.5	2	6	0.1	1.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.4

FY20

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
Acoustics survey - R/V Solstice @ $4,150/day (9 days)	37.4
Age, sex, size collections of spawning herring @ $4,150/day (5 days)	20.8
Air Charters for spring surveys (66 hours at $540)	35.6
Hotel for meetings (6 days at $100)	0.6
Rental car for meeting (6 days at $50)	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$94.6

Commodities Costs: Description	Commodities Sum
Rain gear for surveys (2 @ $100)	0.2
Sample totes, nets, gloves ($500)	0.5
Age, sex, size processing supplies (glass slides, glue, slide boxes)	0.5
Cast nets and variable mesh gillnets	0.5
Misc supplies	0.4
Commodities Total	$2.1

FY20

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B CONTRACTUAL & COMMODITIES DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY20

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Vacant FB I	Surveys and age,sex, size collection and proce	4.5	7.2	0.0	32.4
Vacant FWT III	Surveys and age,sex, size collection and proce	1.0	6.0	0.0	6.0
Cheng Xiong	Surveys and age,sex, size collection and proce	1.0	5.4	0.0	5.4
Steve Moffitt (sea duty and harzard)	Surveys and age,sex, size collection and proce	0.5	13.6	0.0	6.8
Stormy Haught (sea duty and hazard)	Surveys and age,sex, size collection and proce	0.5	7.8	0.0	3.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	40.0	0.0	
				Personnel Total	$54.5

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Meeting with HRMP PI's and GWA PI's	0.5	2	6	0.1	1.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.4

FY21

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
Acoustics survey - R/V Solstice @ $4,150/day (9 days)	37.4
Age, sex, size collections of spawning herring @ $4,150/day (5 days)	20.8
Air Charters for spring surveys (66 hours at $540)	35.6
Hotel for meetings (6 days at $100)	0.6
Rental car for meeting (6 days at $50)	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$94.6

Commodities Costs: Description	Commodities Sum
Rain gear for surveys (2 @ $100)	0.2
Sample totes, nets, gloves ($500)	0.5
Age, sex, size processing supplies (glass slides, glue, slide boxes)	0.5
Cast nets and variable mesh gillnets	0.5
Misc supplies	0.4
Commodities Total	$2.1

FY21

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY21

Project Title: Surveys and age, sex, and size collection and processing.
Primary Investigator: Steve Moffitt
Agency: Alaska Department of Fish and Game

FORM 4B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

Response to Reviewers: 17120111-G Adult Pacific Herring Acoustic Surveys, P.I. Rand

This proposal was well-written and the objectives are very clearly stated: "to continue a long term data set of biomass estimates of the spawning population of Pacific herring in Prince William Sound." This proposal primarily addresses Objectives 1 (expanding and testing the herring ASA model) and 2 (providing input to the ASA model). Since 1993, the Prince William Sound Science Center (PWSSC) has been carrying out acoustic surveys as a cost-effective approach to estimate the biomass of adult Pacific herring just prior to the spawning period. The stated goal is to "produce a reliable estimate of adult biomass of the spawning population of Pacific herring for each year during 2017-2021 in support of the age-structured assessment (ASA) model".

The Panel notes that this work provides essential information for the herring assessment model, and for this reason the work should continue as proposed. We also note and commend the PI for ensuring that the continuity of this work will continue as it has been conducted in the past.

The Panel has several concerns and comments, however, one of which was mentioned in the response to the Moffitt proposal. That is, there is not a readily accessible database of the past acoustic surveys. Ideally there should have been annual reports showing dates and time and location of surveys, and locations where herring were, and were not, found. As much as possible these last surveys should also have commented on any issues (technical, methodological or biological) related to species identification and other factors that might have affected that validity of the data. In lieu of this and in recognition of the vital importance of these past acoustics data to the herring assessment process, the Panel recommends that a quantitative synopsis of past work be prepared, as an essential element in the assessment process.

****

PI Response:

I definitely recognized the value of documenting past observations. Much has been documented in annual reports submitted by the PI in the past (Dick Thorne at the PWSSC); however, I do acknowledge the difficulty of extracting insight into interannual trends and patterns by reviewing these reports. I have received a draft manuscript authored by Dick Thorne that summarizes the acoustic monitoring efforts in Prince William Sound from 1993-2015. In annual reports during this grant cycle, I will provide a brief summary of the current year's data as well as some historic context in the form of trends in annual biomass. Any notable changes from year to year in the herring distribution based on the acoustic survey will also be highlighted. I added a few sentences at the end of the executive summary in the revised proposal highlighting these efforts at better reporting. The PI has also been working with Axiom to make sure all the raw, digital files of acoustic data are now available on the AOOS HRM data portal (starting with year 2000).

****

Further, the Panel appreciated the comments on target strength of herring but also notes that there have been changes in size-at-age, and perhaps condition of PWS herring during the past several decades. Could such changes affect target strength? Perhaps there have been other changes? Therefore we wonder how such changes in the physical and biotic environment would have affected estimates of herring biomass. Clearly there may be other concerns about acoustic work as reliable indicators of herring biomass. In view of such uncertainties, the Panel encourages the PI to take a more rigorous and critical approach to acoustic assessments. We suggest that such an approach would be, in the longer term, the most valuable information that could be provided, regardless of whether it supported, or challenged the historical time-series of acoustics data. The PI of this project, more than anyone else, is in a position to put many assumptions to the test – while still providing the necessary data that will provide a time-series input to the assessment model.

****

PI Response:

Fish size can clearly affect target strength. Through the years, it has been imperative to capture pre-spawn herring at the time of the acoustic survey to determine average size in the population. This has been a routine part of the survey effort over the years. Some years obtaining samples has been difficult (e.g. 2015) and we have had to rely on data collected in previous years. In our original proposal, we noted that we will estimate mean size based on catches each year by ADF&G (typically a combination of purse seine and opportunistic cast net samples). Thus, we feel our monitoring effort effectively tracks changes in herring sizes to minimize any bias from interannual trends in growth and age structure of the population. We expect condition of the fish to have a relatively small effect on target strength. The size of the swimbladder is the dominant factor in defining the strength of echo returns. Depth of herring is a critical factor, but work by Thorne in the past has resulted in a sigma-correction that accounts for changes in target strength as a function of depth.

We feel the most challenging part of this survey effort is identifying the location of the fish each spring to help us plan our survey cruise. Having sufficient shiptime to accomplish this is critical, including time prior to the spawning season to look for early signs of spawning aggregations. That is why in our original proposal we included a modest number of days (5) to our field survey (this in addition to 12-14 days budgeted on the R/V Solstice in the allied proposal by Moffitt*) during the first two years of the project to assure we can meet our objectives. Due to budget limitations, we were unable to extend this during years 3-5, and thus may need to rely on other funds to support it.*

No changes were made regarding this in the revised proposal.

Appendix C

EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
PROGRAM PROJECT PROPOSAL SUMMARY PAGE

Project Title

Adult Pacific Herring Acoustic Surveys in Prince William Sound

Primary Investigator(s) and Affiliation(s)

Peter S. Rand, PWSSC

Date Proposal Submitted

12 August 2016

Project Abstract

We propose to continue a long term data set of biomass estimates of the spawning population of Pacific herring in Prince William Sound. This proposal primarily addresses Objectives 1 (expanding and testing the herring ASA model) and 2 (providing input to the ASA model). Since 1993, the Prince William Sound Science Center (PWSSC) has been carrying out acoustic surveys as a cost-effective approach to estimate the biomass of adult Pacific herring just prior to the spawning period. Here we propose to continue this sampling for the next 5 years. **Our main goal for this proposed project is to produce a reliable estimate of adult biomass of the spawning population of Pacific herring for each year during 2017-2021 in support of the age-structured assessment (ASA) model**

Prince William Sound herring stock biomass estimates from hydroacoustic surveys provide a measure of the stock abundance for use in the ASA model that is the forecasting tool used for management. Prior to 2001, the hydroacoustic surveys were conducted exclusively by the Prince William Sound Science Center (PWSSC). Since 2001, the effort has been shared between PWSSC and the Cordova office of Alaska Department of Fish and Game (ADF&G). While the ADF&G considers the hydroacoustic surveys to be critical (Steve Moffitt, pers. comm.) the lack of a commercial herring fishery in PWS since 1998 has reduced management priorities for herring. Thus the PWSSC contribution has become critically important for the long-term, especially if a future fishery appears only a remote possibility. With the level of effort available over the past several years, PWSSC and ADF&G individually have achieved herring biomass estimates with a precision of about ±30%. As in recent years, we intend to continue to survey the two main spawning aggregation regions (Port Gravina and Fidalgo, and along the northeast coast of Montague Island). This will allow us to continue generating accurate estimates of the total herring spawning biomass in PWS and provide an alert to changes in biomass in these two different regions. Beginning in FY2017 and continuing through 2021, hydroacoustic surveys will be conducted in spring (March-April) to assess adult spawning biomass. This project will use the ADF&G data from direct sampling for age, sex and length in the estimates of biomass. The estimate will then be provided to the modeling project.

EVOSTC Funding Requested ***(must include 9% GA)***

FY17	FY18	FY19	FY20	FY21	TOTAL
$74.2	**$73.8**	**$61.3**	**$63.1**	**$64.9**	**$337.4**

Non-EVOSTC Funding Available

FY17	FY18	FY19	FY20	FY21	TOTAL

Appendix C

Please refer to the Invitation for the specific proposal requirements for each Focus Area. The information requested in this form is in addition to the information requested in each Focus Area and by the Invitation.

1. Executive Summary
Identify the hypotheses the project is designed to address. Describe the background and history of the problem. Include a scientific literature review that covers the most significant previous work history related to the project. Please provide a summary of the project including key hypotheses and overall goals.

Robust Pacific herring (*Clupea pallasii*) populations, suitable for exploitation by commercial fisheries, are typically sustained by periodic recruitment of strong year classes into the adult spawning population. However, the Prince William Sound (PWS) 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). The current proposal will extend a long term data set on adult herring biomass which serves as a leading indicator of species recovery in PWS.

The current management of the Prince William Sound (PWS) herring stock by the Alaska Department of Fish and Game (ADF&G) includes information from hydroacoustic surveys. Biomass estimates from these surveys provide a measure of the stock abundance and serves as input into the age-structured assessment (ASA) model that is the primary forecasting tool. The hydroacoustic surveys were initiated in 1993 when fishers were unable to locate concentrations of herring despite a forecast for high abundance. Over time the hydroacoustic survey has shown to be an early and relatively precise measure of the herring stock abundance and compares well with the recent ASA model estimates that now can incorporate hydroacoustic survey information.

Prior to 2001, the hydroacoustic surveys were conducted exclusively by the Prince William Sound Science Center (PWSSC). Since 2001, the effort has been shared between PWSSC and the Cordova office of Alaska Department of Fish and Game. Over the past 5 years, the PWSSC effort has been supported by EVOS TC. The cooperative effort has been critical since both PWSSC and ADF&G have limited resources for this effort. While ADF&G considers the hydroacoustic surveys to be critical (Steve Moffitt, personal communication) the lack of a commercial herring fishery in PWS since 1998 has reduced management priorities for herring during a time of overall limited funding for the state agency. Thus the PWSSC contribution has become critically important for the long-term, especially if a future fishery appears only a remote possibility. With the level of effort available over the past several years, PWSSC has achieved herring biomass estimates with a precision of about ±30%.

Here we propose to extend this monitoring effort for 5 years (2017-2021). Our main goal is to estimate biomass of the spawning population of Pacific herring in Prince William Sound. Through an integrated program involving hydroacoustics and direct capture of herring, we will produce a reliable estimate of biomass to be used in the ASA model. We will maintain a similar level of survey effort relative to the combined surveys of PWSSC and ADF&G conducted in the past. The inter-annual trend in our biomass estimate will be compared to miles-spawn (see ADF&G proposal) to help determine the degree of coherence between these two measures of the size of the spawning population in Prince William Sound. Having two concurrent efforts at monitoring the spawning population can provide assurance that we will be able to detect marked changes in the status of this population given the uncertainties associated with field work in this region. After each survey, we will provide detailed summaries of the cruise and results of our survey, including a biomass estimate and any indications of interannual trends in spatial distribution of herring. Annual reports from past years will also be available through the AOOS data portal.

2. Relevance to the Invitation for Proposals
Discuss how the project addresses the projects of interest listed in the Invitation and the overall Program goals and objectives. Describe the results you expect to achieve during the project, the benefits of success as they relate to the topic under which the proposal was submitted, and the potential recipients of these benefits.

Appendix C

The present proposal directly addresses objective #3 of the EVOS HRM: 3) Provide input into the stock assessment model. Biomass estimates of the spawning population is a critical input into the model. This proposed work will generate estimates for the adult spawning biomass during each year of the grant period (2017-2021).

We expect to produce a robust times series (5 years) of spawning population biomass that will extend a time series begun in the 1990s. Through our efforts we will also be able to monitor significant spatial shifts in the spawning habitat, and this may provide insight into how these fish are coping with climate change and related oceanographic conditions.

If we detect a significant recovery of this species, fishers in this region would clearly benefit if the status of herring improves to the point that it could sustain some level of exploitation. Our work could also provide important insight into food web and ecosystem dynamics of the Prince William Sound region. Pacific herring play a critical role in this ecosystem, both as predator and prey, and better understanding their dynamics can help understand how the ecosystem may change in the future.

3. Project Personnel

The CV's of all principal investigators and other senior personnel involved in the proposal must be provided. Each resume is limited to two consecutively numbered pages and must include the following information:

- A list of professional and academic credentials, mailing address, and other contact information (including e-mail address)
- A list of up your most recent publications most closely related to the proposed project and up to five other significant publications. Do not include additional lists of publications, lectures, etc.
- A list of all persons (including their organizational affiliations) in alphabetical order with whom you have collaborated on a project or publication within the last four years. If there have been no collaborators, this should be indicated.

Appendix C

Peter S. Rand, Ph.D.

Prince William Sound Science Center

300 Breakwater Avenue, P.O. Box 705

Cordova, Alaska 99574

Office: 907-424-5800 (X233); Mobile: 971-409-0232; Email: prand@pwssc.org

Education

Colgate University, Biology, B.A., 1987

SUNY College of Environmental Science and Forestry, Ecology, M.S., 1990

SUNY College of Environmental Science and Forestry, Ecology, Ph.D., 1994

University of British Columbia, Fisheries Science, Postdoctoral Fellow, 1995-1997

Professional Positions

Research Ecologist, Prince William Sound Science Center (2015-present)

Senior Conservation Biologist (2003-2015), Wild Salmon Center.

Assistant Professor (1997–2003), Department of Zoology, North Carolina State University.

Research Interests

Ecological studies of freshwater, anadromous and marine fishes. Modeling studies of migration, energetics, survival and population dynamics. Novel field applications involving sonar and video methods to increase understanding of abundance, distribution, foraging, swimming behavior and predator-prey interactions.

Select Publications

Rand, P.S., and M. Fukushima. 2014. Estimating the size of the spawning population and evaluating environmental controls on migration for a critically endangered Asian salmonid, Sakhalin taimen. Global Ecology and Conservation 2:214-225.

Taylor, J.C., **P.S. Rand**, and J. Jenkins. 2007. Swimming behavior of juvenile anchovies (*Anchoa* spp.) in an episodically hypoxic estuary: implications for individual energetics and trophic dynamics. Mar. Biol. 152(4):939-957.

Rand, P.S., J.C. Taylor, and D.B. Eggleston. 2006. A stereo-video method for quantifying size distribution, density and three-dimensional spatial structure of reef fish spawning aggregations. National Marine Fisheries Service Professional Paper Series 5: 4-9.

Taylor, J.C., D.B. Eggleston, and **P.S. Rand**. 2006. Nassau grouper (Epinephelus striatus) spawning aggregations: hydroacoustic surveys and geostatistical analysis. National Marine Fisheries Service Professional Paper Series 5: 18-25.

Taylor, J.C., J.S. Thompson, **P.S. Rand**, and M. Fuentes. 2005. Sampling and statistical considerations for hydroacoustic surveys used in estimating abundance of forage fishes in reservoirs. North Am. J. Fish. Mgmt. 25: 73-85.

Taylor, J.C., and **P.S. Rand**. 2003. Spatial overlap and distribution of anchovies (*Anchoa* spp.) and copepods in a shallow stratified estuary. Aquat. Living Resour. (Elsevier, France) - Special ICES Volume 16: 191-196.

Rand, P.S. and S.G. Hinch. 1998. Spatial patterns of zooplankton biomass in the Northeast Pacific Ocean. Mar. Ecol. Prog. Ser. 171:181-186.

Rand, P.S., D.J. Stewart, B.F. Lantry, L. Rudstam, O.E. Johannsson, A. Goyke, S.B. Brandt, R. O'Gorman, G.W. Eck. 1995. Effect of lake-wide planktivory by pelagic prey fishes in Lakes Michigan and Ontario. Can. J. Fish. Aquat. Sci. 52:1546-1563.

Other Publications

Rand, P.S., B.A. Berejikian, T.N. Pearsons, and D.L.G. Noakes. 2012. Ecological interactions between wild and hatchery salmonids: an introduction to the special issue. Environmental Biology of Fishes. DOI 10.1007/s10641-012-9987-3

Rand, P.S., M. Goslin, M.R. Gross, J.R. Irvine, X. Augerot, et al. 2012. Global assessment of extinction risk to populations of sockeye salmon Oncorhynchus nerka. PLoS ONE 7(4): e34065. doi:10.1371/journal.pone.0034065

Zimmerman, C.E., **P.S. Rand**, M. Fukushima, and S.F. Zolotukhin. 2011. Reconstructing migratory and growth histories of Sakhalin taimen (*Parahucho perryi*). Environmental Biology of Fishes DOI 10.1007/s10641-011-9908-x

Rand, P.S., S.G. Hinch, J. Morrison, M.G.G. Foreman, M.J. MacNutt, J.S. Macdonald, M.C. Healey, A.P. Farrell, and D.A. Higgs. 2006. Effects of changes to river discharge, temperature and future climate on energetics and mortality of adult migrating Fraser River sockeye salmon. Transactions of the American Fisheries Society. 135:655-667.

Rand, P.S. 2002. Modeling stomach fullness and growth potential of sockeye salmon in the Gulf of Alaska: Implications for high seas distribution and migration. Mar. Ecol. Prog. Ser. 234:265-280.

Collaborators

Hitoshi Araki (Hokkaido University), Barry Berijikian (NOAA), K. Boswell (FIU), S. Cooke (CarletonU), Michio Fukushima (NIES), K. Gorman (PWSSC), Mart Gross (UToronto), Jim Irvine (DFO), E. Knudsen (Independent Contractor), David Noakes (Oregon State University), Dmitry Pavlov (Moscow State University), Todd Pearsons (Grant County PUD), Richard Thorne (PWSSC), Lev Zhivotovsky (Russia Academy of Sciences), Christian Zimmerman (USGS), Sergei Zolotukhin (TINRO)

4. Project Design

A. Objectives

List the objectives of the proposed research and briefly state why the intended research is important. If your proposed project builds on recent work, provide detail on why the data set needs to be continued and whether any changes are proposed. If the proposed project is for new work, explain why the new data is needed. Describe the anticipated final product.

B. Procedural and Scientific Methods

For each objective listed in A. above, identify the specific methods that will be used to meet the objective. In describing the methodologies for collection and analysis, identify measurements to be made and the anticipated precision and accuracy of each measurement and describe the sampling equipment in a manner that permits an assessment of the anticipated raw-data quality.

If applicable, discuss alternative methodologies considered, and explain why the proposed methods were chosen. In addition, projects that will involve the lethal collection of birds or mammals must comply with the EVOSTC's policy on collections, available on our website www.evostc.state.ak.us

C. Data Analysis and Statistical Methods

Describe the process for analyzing data. Discuss the means by which the measurements to be taken could be compared with historical observations or with regions that are thought to have similar ecosystems. Describe the statistical power of the proposed sampling program for detecting a significant change in numbers. To the extent that the variation to be expected in the response variable(s) is known or can be approximated, proposals should demonstrate that the sample sizes and sampling times (for dynamic processes) are of sufficient power or robustness to adequately test the hypotheses. For environmental measurements, what is the measurement error associated with the devices and approaches to be used?

D. Description of Study Area

Where will the project be undertaken? Describe the study area, including, if applicable, decimally-coded latitude and longitude readings of sampling locations or the bounding coordinates of the sampling region (e.g., 60.8233, -147.1029, 60.4739, -147.7309 for the north, east, south and west bounding coordinates).

Objectives

Our main goal for this proposed project is to produce a reliable estimate of adult biomass of the spawning population of Pacific herring for each year during 2017-2021 in support of the age-structured assessment (ASA) model. In support of this goal, we identify the following objectives:

1) Carry out a hydroacoustic survey prior to the herring spawning season as a means to quantify the total biomass of adult herring in regions within Prince William Sound that have historically been important for spawning. This survey includes validation of targets by direct capture of fish with various gear types.
2) Each year conduct repeated hydroacoustic sampling over transects to quantify precision of our biomass estimates.
3) Carry out reconnaissance by air or ship to assure our survey design is adapting to any changes in the spawning distribution of Pacific herring in PWS.

Procedural and Scientific Methods

The general use of acoustic methods for fisheries assessment is described in several publications including Simmonds and MacLennan (2005), Taylor et al. (2005), and Rudstam et al. (2013). Applications to Pacific herring are well documented (Thorne 1977a,b; Trumble et al. 1983).

The major difference in the Prince William Sound surveys compared to typical acoustic assessment surveys is the use of a three-stage adaptive sampling methodology rather than systematic transects. Adult herring during the extended winter period in PWS are typically located in a few select bays and inlets and are distributed primarily in large mid-water schools or dense layers at night. The surveys are conducted during the late winter/early spring pre-spawning distribution when the herring are most concentrated. The initial survey stage focuses on the location of these adult herring aggregations within PWS. Approaches include aerial surveys of foraging marine mammals, especially Steller sea lions and humpback whales, sonar surveys and observations from fishers, hunters and others transiting PWS, as well as a database of historic locations. After the herring are located, the second stage consists of multiple echo integration surveys over the areas occupied by the herring schools. These surveys are generally conducted at night with a dark vessel since herring are further removed from bottom at night, but are very light sensitive. The multiple surveys are used to determine the precision of the biomass estimates. The focus on pre-spawning herring also simplifies species composition problems as the concentrations are virtually all adult herring.

Currently the PWSSC has digital echosounder systems that are well-matched to our needs. Our echosounders are DTX BioSonics systems (www.biosonicsinc.com/product-dtx-portable-echosounder.asp). We have two digital transducers that are capable of meeting our survey needs: a single-beam 70 kHz transducer, and a split-beam 120 kHz transducer. While the former is not capable of determining position of targets off the axis beam, it can be used to produce reliable biomass estimates through echointegration. This is the unit that has been used in the PWS surveys since 2002 (R. Thorne, pers. comm.). In 2012 the PWSSC acquired a split-beam 120 kHz DTX system, and we propose that this unit will be our primary echosounder for this survey. This system assures a more accurate calibration in the field, and can be used to track individuals through the beam, providing an opportunity for some additional insight into fish movement and behavior. We propose to run them simultaneously to compare their performance and assure consistency in this long-term data series. Further, having two systems allows us to conduct independent surveys off two separate vessels.

Figure 1. Examples of typical, zig-zag transects in Fidalgo and Gravina Bays in eastern Prince William Sound. The locations of these transects in any given year are based on plane and ship reconnaissance to determine the distribution of the spawning population.

After the echo integration surveys, the herring schools are sub-sampled for biological information, primarily with a commercial purse seine (see ADF&G proposal). To augment this, we will opportunistically sample herring with other gear, including multi-panel gillnets and castnets. The size composition of the herring in the net catches is used to estimate target strengths for converting backscatter to biomass (see below for specific methods). While the acoustic surveys were initiated by PWSSC, the survey effort has been conducted in cooperation with Alaska Department of Fish & Game (ADFG) for most of its history. ADFG has conducted most of the direct capture sampling for age/weight/length. ADFG began to conduct acoustic surveys as well in 2001. From 2001-2004 both institutions collected acoustic data, all of which were analyzed by PWSSC. Since 2005, ADFG acoustic surveys have been conducted independently. For the proposed grant period, we intend to conduct the survey in cooperation with ADF&G (14 days, budgeted in the ADF&G proposal), in addition to 5 additional days we have budgeted in Years 1 & 2. This extra shiptime will allow us to charter a separate vessel for reconnaissance and additional survey work to help us evaluate any shifts in the spawning distribution relative to historical surveys. This level of effort is comparable to the combined survey effort in the past from PWSSC and ADF&G.

Data analysis and statistical methods

The methods used in PWS are detailed in several publications, including Thomas et al. (1997), Thomas and Thorne (2003) and Thorne and Thomas (2008). They are similar to standard methods in most regards: a single frequency system, down-looking transducer orientation, towed vehicle, echo integration signal processing, biological sampling for species and size information and calibration with standard targets. The transect design has been a zig-zag pattern along the shoreline. The target strength relationship that is used to scale echo integration was derived from many years of experience that culminated in the ex-situ target strength measurements described in Thomas et al. (2002). We propose to continue the survey as described. The PI of the current proposal has been working closely with Richard Thorne to assure the methods and overall approach will remain consistent with past surveys. We propose to carry out analyses using the Biosonics echointegration software used by R. Thorne to assure consistency. In addition, we propose to analyze data with a newer software program, Echoview (Version 5.4), and determine if there are advantages and efficiencies to be gained by using this newer software for our biomass estimation. Below we describe the analytical steps in arriving at a biomass estimate.

Target strengths measured by the echosounder need to be converted to biomass. Here we propose to follow the approach described in Thorne (1981). A number of studies have concluded that the function is non-linear, and reflects the fact that smaller fish reflect slightly more energy per unit of biomass compared to larger fish. Thorne (1981) incorporated multiple data sources into a single length-dependent relationship as follows:

$$TS_w = -5.98 \mathrm{Log}(L) - 24.23$$

where TS_w is the target strength (decibels) per unit weight, w is weight in kg and L is standard length of herring in cm. Lengths of fish will be determined by direct capture (see ADF&G proposal).

Ex situ target strength measurements were conducted on herring in Prince William Sound (Thomas et al 2002). The research verified the relationship described from Thorne (1981), but added depth and seasonal effects that resulted from swim bladder compression and gonad development. The Thorne (1981) relationship was found to be accurate for spring (prespawning) herring at 40 m depth, a reasonable depth assumption for night herring distributions. However, day distributions are much deeper, often over 100 m. Consequently, a depth correction for the target strengths has been applied to PWS herring surveys beginning in 2008 when daytime surveys began to be included in the survey effort. While we do not intend to survey during the day during this grant period, we will make adjustment in the analysis to account for changes in depth across the survey area (see below for additional details).

It is important to quantify the precision of our biomass estimates, and identify sources of error. The variance associated with the estimate has been approximated using the Delta Method (Oehlert 1992; Casella and Berger 2002). For purposes of the calculation, each series is divided into two estimates of herring biomass by separating the zigs from the zags in the transect survey to assure independence, thus producing two parallel series. These are combined with multiple surveys on the same population producing *n* values that can range from 2 to 8 biomass estimates depending on the opportunity for repeated surveys. Data from the estimates are not transformed. Variance of the total population is the sum of variances of the individual areas.

Based on previous sampling involving replicate sampling of transects during the spring survey, it was estimated that error in biomass estimates is ~30% (R. Thorne, pers. comm.). Assuming a 30% coefficient of variation, we determined the relationship between the number of years of acoustic sampling and the effect size (i.e. proportional changes in biomass) we can discern over time (at $\alpha = \beta = 0.05$, after Gerrodette 1987). After 5 years of sampling, we would be able to discern ~34% change in biomass (Fig. 2). We feel this level of power to detect trends is adequate to achieve our overall goal of detecting a recovery of herring in PWS and providing reliable annual data as input into the ASA model. By repeatedly sampling the same transects during our cruises each year, we will be able to quantify changes in precision in our sampling. Our objective is to maintain this level of sampling precision during this grant period.

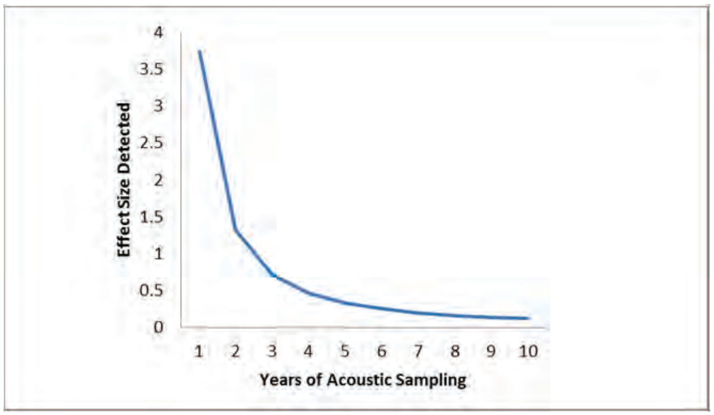

Figure 1. The effect size (i.e. the magnitude of interannual changes in abundance of adult Pacific herring) we can discern given the error associated in the hydroacoustic survey estimates.

It is important to document important sources of error in our biomass estimation. There are limitations in the habitat that can be effectively sampled using hydroacoustics. There is a blind spot near field (approximately 1 m away from the face of the transducer) and far field (approximately 1 m off bottom) that may contribute to an underestimate of biomass along a sampled transect. Herring generally are not surface oriented, so we do not believe lack of sampling at the surface is a significant source of error. Further, we minimize the error associated with missing fish on the bottom by sampling at night, a period where fish generally migrate off the bottom.

The accuracy of echointegration is a function of the school density of herring in the water column. In conditions of tightly packed schools, fish that are located near the bottom of the school may be in an acoustic shadow and thus their contribution to total backscatter may be reduced. We reduce this error by conducting our acoustic surveys at night, a period when fish are more dispersed in the water column.

The parameters used in our echointegration (particularly σ_{bs}, the acoustic backscattering cross section for a single target, in units m^2, as in McLennan et al. 2002) are associated with some error. We intend to account for two factors that are known to affect this parameter, specifically depth and season. Thomas et al. (2002) documents how σ_{bs} changes as a function of depth and season. As in previous years, we intend to account for this in the analysis of our survey data, following the current protocol (R. Thorne, pers. comm.). For each region sampled, we will adjust the σ_{bs} to best match the depth distribution of fish, and we will apply the appropriate parameter for sampling in the spring. Fish orientation in the water column can also affect σ_{bs}, but sampling primarily along the dorsal aspect of the fish, with the transducer downlooking into the water column, is known to reduce this error.

While we will be conducting routine species validation of our acoustic surveys, another source of error is the inclusion of other species along our sampling transects. Based on past experience, we have high confidence that the schools we sample are comprised entirely of Pacific herring. Our direct capture effort will continue to serve as a check on this assumption, but, in general, we feel this is a negligible source of error in our biomass estimates.

A key assumption in the power analysis described above is that our acoustic surveys are covering the habitat occupied by spawning herring during the spring. As described in our methods, we will endeavor to distribute sampling effort to adequately sample the entire PWS spawning population. Climate change can profoundly change the Prince William Sound ecosystem. We expect that herring life history may show some dramatic change in the coming years. This monitoring effort is intended to be adaptive given these changing environmental conditions. We have budgeted for additional shiptime support during the first two years of the project (in addition to the 14 days budgeted in the ADF&G proposal during 2017-2021) to enable some expanded sampling coverage and provide opportunities for simultaneous surveys (either in the same region to provide additional replicate sampling, or conducted independently in different regions). This will improve our ability to detect any temporal or spatial changes that may take place during the coming years and help us meet our broader goals and objectives.

Description of study area

We propose to sample along the north coast of Montague Island and the Port Gravina/Fidalgo area. Based on patterns we observe over the course of this monitoring effort, we may adapt the survey area to assure we conduct a comprehensive survey of the spawning population.

5. Coordination and Collaboration

Within the Program

Provide a list and clearly describe the functional and operational relationships with the other program projects. This includes any coordination that has taken or will take place and what form the coordination will take (shared field sites or researchers, research platforms, sample collection, data management, equipment purchases, etc.).

With Other EVOSTC-funded Programs and Projects

Indicate how your proposed program relates to, complements or includes collaborative efforts with other proposed or existing programs or projects funded by the EVOSTC.

With Trustee or Management Agencies

Please discuss if there are any areas which may support EVOSTC trust or other agency work or which have received EVOSTC trust or other agency feedback or direction, including the contact name of the agency staff. Please include specific information as to how the subject area may assist EVOSTC trust or other agency work.

If the proposed project requires or includes collaboration with other agencies, organizations or scientists to accomplish the work, such arrangements should be fully explained and the names of agency or organization representatives involved in the project should be provided. If your proposal is in conflict with another project or program, note this and explain why.

With Native and Local Communities

Provide a detailed plan for any local and native community involvement in the project.

Our proposal is closely aligned with the spring spawning survey proposal of ADF&G. The majority of the shiptime for our acoustic surveys is included in this allied proposal. Further, the ASL sampling (required to partition our total biomass estimate into separate age classes) is included in this allied proposal.

Data we generate in our proposed field work will also support the ASA model analyses in Trevor Branch's UW proposal.

Movements of herring determined by the proposed HRM tagging program may inform our survey planning during this grant period. Understanding movements of adult fish during the spring will help us address issues implicit in our survey design. Understanding residence time of adult herring in the spawning areas, and their migratory patterns between PWS and the Gulf of Alaska could help improve our ability to monitor the spawning population.

Appendix C

6. Schedule

Program Milestones

Specify when critical program tasks will be completed. Reviewers will use this information in conjunction with annual program reports to assess whether the program is meeting its objectives and is suitable for continued funding.

Measurable Program Tasks

Specify, by each quarter of each fiscal year (February 1 – January 31), when critical program tasks will be completed.

Task	FY17				FY18				FY19				FY20				FY21			
	EVOSTC FY Quarter (beginning Feb. 1)																			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Task 1 admin & logistics																				
Contracting for shiptime	X				X															
permitting	X				X				X				X				X			
Task 2 data acquisition & processing																				
Research Cruise	X				X				X				X				X			
Post processing			X				X				X				X			X	X	
Task 3 data management																				
database mgmt./QAQC			X				X				X				X				X	
metadata (HRM)			X				X				X				X				X	
workspace upload			X				X				X				X				X	
Task 4 analysis & reporting																				
Analysis and summary				X				X				X				X				X
Annual Reports					X				X				X				X			X
Annual PI meeting				X				X				X				X				X
Permit reports				X				X				X				X				X

7. Budget

Budget Forms (Attached)

Please provide completed budget forms. Please note that the following items will not be considered for funding:

- Costs associated with international travel for meetings, symposia, or presentations.
- Costs associated with attendance at meetings, symposia, or presentations outside of those required to coordinate with project members.
- Costs associated with outreach or education efforts.

Sources of Additional Funding

Identify non-EVOSTC funds or in-kind contributions used as cost-share for the work in this proposal. List the amount of funds, the source of funds, and the purpose for which the funds will be used. Do not include funds that are not directly and specifically related to the work being proposed in this proposal.

References

Appendix C

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Appendix C

Budget Justification

1. **Personnel.** We request support for 3 mo/yr for the PI to lead the project, including managing grant funds, arranging contracts, participating in field work, analyzing data and reporting results into reports and scientific manuscripts. We request support for a research technician at 0.5 mo/yr to assist in preparing and carrying out the field work during the spring cruise.
2. **Travel.** Travel funds are requested for the PI to attend annual PI meeting. Include is 1 round trip air fare or ferry service to meeting venue, and 2 days lodging and per diem.
3. **Contractual.** We request support during Years 1 & 2 for shiptime for additional reconnaissance and acoustic sampling. This additional shiptime (above the amount included in the allied proposal of ADF&G) provides an opportunity to survey a broader region and provide more opportunities for replicate transect sampling. In addition, we budget for communications at PWSSC for phone and email services, and use of PWSSC vehicles for transport of people and gear in Cordova.
4. **Commodities.** We request support during Year 1 for one PC for acoustic data analysis.
5. **Indirect Rate.** We apply the PWSSC indirect rate of 30%.

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$39.5	$40.7	$41.9	$43.2	$44.5	$209.9	
Travel	$0.6	$0.6	$0.6	$0.6	$0.6	$2.8	
Contractual	$10.8	$10.8	$0.8	$0.8	$0.8	$24.0	
Commodities	$1.5	$0.0	$0.0	$0.0	$0.0	$1.5	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)	$15.7	$15.6	$13.0	$13.4	$13.8	$71.4	
SUBTOTAL	$68.1	$67.7	$56.3	$57.9	$59.6	$309.5	
General Administration (9% of	$6.1	$6.1	$5.1	$5.2	$5.4	$27.9	N/A
PROJECT TOTAL	$74.2	$73.8	$61.3	$63.1	$64.9	$337.4	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

COMMENTS:
This summary page provides an five-year overview of proposed project funding and actual cumulative spending. The column titled 'Actual Cumulative' must be updated each fiscal year as part of the annual reporting requirements. Provide information on the total amount actually spent for all completed years of the project. On the Project Annual Report Form, if any line item exceeds a 10% deviation from the originally-proposed amount; provide detail regarding the reason for the deviation.

FY17-21

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

NON-TRUSTEE AGENCY SUMMARY PAGE

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Peter S. Rand	Adult Pacific Herring Acoustic Surveys	3.0	12.3		36.9
Research Assistant	Adult Pacific Herring Acoustic Surveys	0.5	5.3		2.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	17.6	0.0	
				Personnel Total	$39.5

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Trip to annual PI meeting	0.3	1	2	0.2	0.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.6

FY17

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
Shiptime (5 days @$2000/day)	10.0
PWSSC communications (3.5 person-months @ $140/month)	0.5
Vehicle and fuel	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$10.8

Commodities Costs: Description	Commodities Sum
PC for Acoustic Analysis	1.5
Commodities Total	$1.5

FY17	**Project Title: Adult Pacific Herring Acoustic Surveys** **Primary Investigator: Peter S. Rand**	**FORM 3B** **CONTRACTUAL &** **COMMODITIES DETAIL**

Date Prepared: 08/24/2016

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY17

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Peter S. Rand	Adult Pacific Herring Acoustic Surveys	3.0	12.7		38.0
Research Assistant	Adult Pacific Herring Acoustic Surveys	0.5	5.4		2.7
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	18.1	0.0	
				Personnel Total	$40.7

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Trip to annual PI meeting	0.3	1	2	0.2	0.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.6

FY18

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
Shiptime (5 days @$2000/day)	10.0
PWSSC communications (3.5 person-months @ $140/month)	0.5
Vehicle and fuel	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$10.8

Commodities Costs: Description	Commodities Sum
Commodities Total	$0.0

FY18

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY18

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Peter S. Rand	Adult Pacific Herring Acoustic Surveys	3.0	13.1		39.2
Research Assistant	Adult Pacific Herring Acoustic Surveys	0.5	5.6		2.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	18.6	0.0	
				Personnel Total	$41.9

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Trip to annual PI meeting	0.3	1	2	0.2	0.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.6

FY19

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
PWSSC communications (3.5 person-months @ $140/month)	0.5
Vehicle and fuel	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.8

Commodities Costs: Description	Commodities Sum
Commodities Total	$0.0

FY19

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
CONTRACTUAL & COMMODITIES DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY19

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Peter S. Rand	Adult Pacific Herring Acoustic Surveys	3.0	13.4		40.3
Research Assistant	Adult Pacific Herring Acoustic Surveys	0.5	5.7		2.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	19.2	0.0	
				Personnel Total	$43.2

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Trip to annual PI meeting	0.3	1	2	0.2	0.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.6

FY20

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
PWSSC communications (3.5 person-months @ $140/month)	0.5
Vehicle and fuel	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.8

Commodities Costs: Description	Commodities Sum
Commodities Total	$0.0

FY20

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY20

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Peter S. Rand	Adult Pacific Herring Acoustic Surveys	3.0	13.8		41.5
Research Assistant	Adult Pacific Herring Acoustic Surveys	0.5	5.9		3.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	19.8	0.0	
				Personnel Total	$44.5

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Trip to annual PI meeting	0.3	1	2	0.2	0.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.6

FY21

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
PERSONNEL & TRAVEL DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Contractual Costs: Description	Contract Sum
PWSSC communications (3.5 person-months @ $140/month)	0.5
Vehicle and fuel	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$0.8

Commodities Costs: Description	Commodities Sum
Commodities Total	$0.0

FY21

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

Date Prepared: 08/24/2016

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency

FY21

Project Title: Adult Pacific Herring Acoustic Surveys
Primary Investigator: Peter S. Rand

FORM 3B
EQUIPMENT DETAIL

Date Prepared: 08/24/2016