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:

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& Research Wildlife Biologist, Copper River Delta Institute, Pacific Northwest Research
4/97-5/99 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

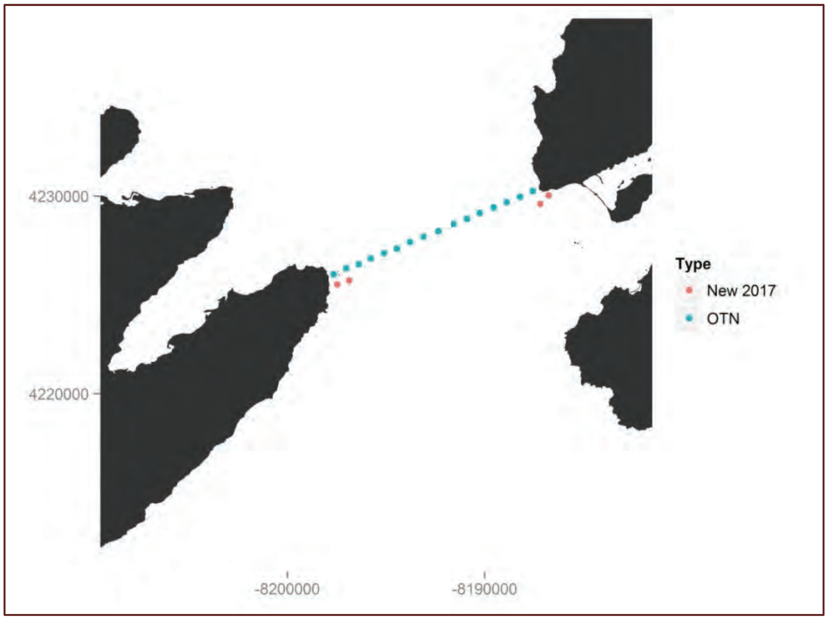

Figure 1. Location of the OTN acoustic array in Hinchinbrook Entrance (blue circles) and locations for receivers to be deployed in January 2017 (red circles).

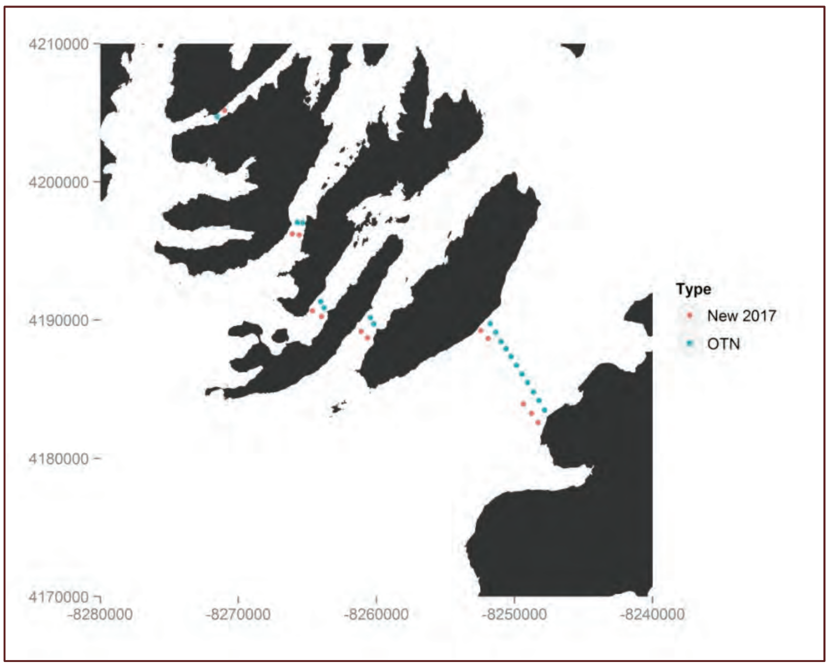

Figure 2. Location of the OTN acoustic array in Montague Strait and the four southwest passages (blue circles) and locations for receivers to be deployed in January 2017 (red circles.

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).

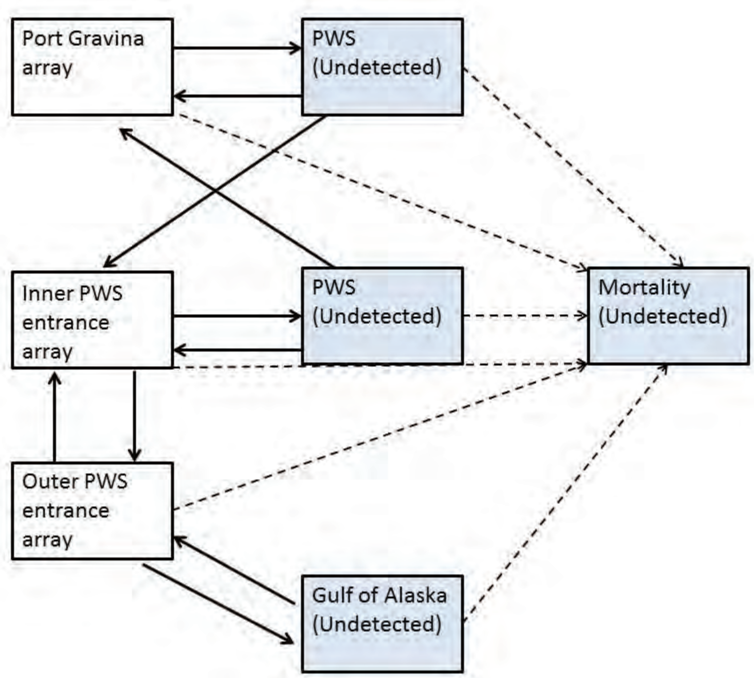

Figure 3. Schematic of the multistate model used to describe herring movements between acoustic arrays (solid line= movement; broken line= mortality) for the 2017 tagging data with a single monitored spawning area.

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).

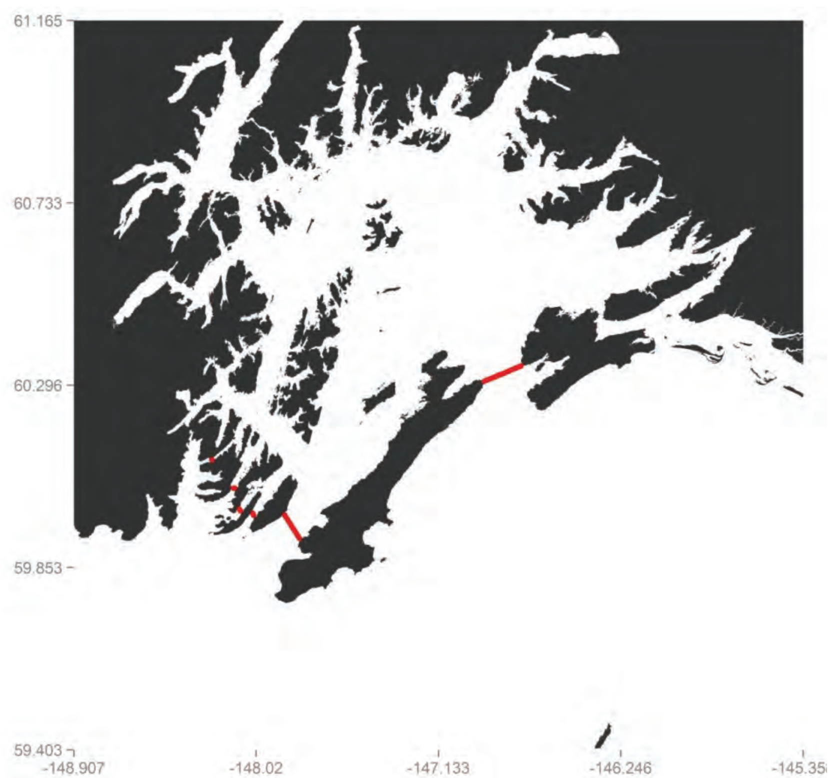

Fig. 4. Prince William Sound, Alaska. Our study will take place around spawning sites in northeast Prince William Sound and northern Montague Island and the Ocean Tracking Network acoustic arrays (noted in red).

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

	FY17				FY18				FY19				FY20				FY21			
Task	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.

7. Literature Cited

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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

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

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

***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

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: Name	Project Title	Months Budgeted	Monthly Costs	Overtime	Personnel 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: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Travel 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: Name	Project Title	Months Budgeted	Monthly Costs	Overtime	Personnel 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: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Travel 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

***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

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:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	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:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	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