

**EVOSTC FY17-FY21 INVITATION FOR PROPOSALS  
FY18 CONTINUING PROJECT PROPOSAL SUMMARY PAGE**

*Proposals requesting FY18 funding are due to [shihway.wang@alaska.gov](mailto:shihway.wang@alaska.gov) and [elise.hsieh@alaska.gov](mailto:elise.hsieh@alaska.gov) by August 23, 2017. Please note that the information in your proposal and budget form will be used for funding review. Late proposals, revisions or corrections may not be accepted.*

**Project Number and Title**

18160111-B - 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 23, 2017

**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. During spring 2017 we tagged 125 herring at Port Gravina in northeast Prince William Sound. For FY18 we will expand our efforts to two tagging sites and tag a total of 210 herring.

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

FY17	FY18	FY19	FY20	FY21	TOTAL
381.9	379.5	268.3	201.4	0	1231.0

**Non-EVOSTC Funds to be used, please include source and amount per source:**

FY17	FY18	FY19	FY20	FY21	TOTAL
15.0	415.0 (in-kind PWSSC 63.0, OTN 337.0; AOOS 15.0)	15.0	15.0		

## 1. EXECUTIVE SUMMARY

Please provide a summary of the project including key hypotheses and overall goals, as submitted in your original proposal. If there are highlights that you would like to include from your FY17 work, please include them here. Also, please list any publications that have been submitted and/or accepted since you submitted your last proposal.

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.aos.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 press*).

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, during February 2017 we deployed 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, during April 2017 we deployed an acoustic receiver array at Port Gravina, the site of all known spawning by PWS herring during 2017. We then acoustic tagged 125 herring at Port Gravina with acoustic tags with an estimated tag life of 768 d. Our expanded array at the entrances to PWS, as well as the new array at Port Gravina and the extended transmitter tag life 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<sub>1</sub>:** 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<sub>2</sub>:** 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.

**H<sub>3</sub>** Survival is related to age and body condition.

**H<sub>4</sub>:** Fine-scale spatial use patterns are associated with individual biological characteristics and vary seasonally.

### ***Recent Publications***

Bishop, M.A. and J. H. Eiler. *in press*. Migration patterns of post-spawning Pacific herring in a subarctic sound. *Deep-Sea Research Part II*. <http://dx.doi.org/10.1016/j.dsr2.2017.04.016>

## **2. COORDINATION AND COLLABORATION**

### ***A. Within an EVOTC-Funded Program***

Provide a list and clearly describe the functional and operational relationships with any EVOTC-funded Program (Herring Research and Monitoring, Long-Term Research and Monitoring or Data Management Programs). 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.).

### ***B. With Other EVOTC-funded Projects***

Indicate how your proposed project relates to, complements or includes collaborative efforts with other proposed or existing projects funded by the EVOTC that are not part of a EVOTC-funded program.

### ***C. With Trustee or Management Agencies***

Please discuss if there are any areas which may support EVOTC trust or other agency work or which have received EVOTC 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 EVOTC 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, note this and explain why.

### ***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. 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.s Moffit/Haught) we will receive and supply when available information from Alaska Department of Fish and Game on timing and location of herring spawn. We will also be provided seined herring opportunistically from the *RV Solstice* for tagging. 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:

<b><i>EVOS Gulf Watch Alaska</i></b>	
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 Stormy Haught 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, Executive Director). 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.

### **3. PROJECT DESIGN – PLAN FOR FY18**

#### **A. Objectives for FY18**

Identify the primary objectives for your project for FY18 as submitted in your original proposal.

#### **B. Changes to Project Design**

If the project design has changed from your original proposal, please identify any substantive changes and the reason for the changes. Include any information on problems encountered with the research or methods, if any. This may include logistic or weather challenges, budget problems, personnel issues, etc. Please also include information as to how any problem has been or will be resolved. This may also include new insights or hypotheses that develop and prompt adjustment to the project.

### ***Objectives for FY18***

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 press). As part of the Herring Research and Monitoring program, during FY18 this acoustic tagging project will contribute to the HRM program objective #2 *Provide inputs to the stock assessment model*, and objective #3 *Examine the connection between herring condition or recruitment to physical and biological oceanographic factors*.

Our acoustic-tagging project objectives for FY18 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.

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.

### ***Changes to Project Design***

There are no substantive changes to the project design for FY2018.

#### **4. SCHEDULE**

##### **A. Program Milestones for FY18**

For each project objective listed, specify when critical project tasks will be completed, as submitted in your original proposal. Please identify any substantive changes and the reason for the changes.

##### **B. Measurable Project Tasks for FY18**

Specify, by each quarter of each fiscal year, when critical project tasks (for example, sample collection, data analysis, manuscript submittal, etc.) will be completed, as submitted in your original proposal. Please identify any substantive changes and the reason for the changes.

### ***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 Project Tasks for FY18***

<u>FY 18, 1<sup>st</sup> 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, 2<sup>nd</sup> quarter</u>	(May 1, 2018 - July 31, 2018)
May-Jul	Data analyses
<u>FY 18, 3<sup>rd</sup> quarter</u>	(August 1, 2018 - October 31, 2018)
Aug	Annual work plan
Sep-Oct	Data analyses
<u>FY 18, 4<sup>th</sup> quarter</u>	(November 1, 2018 - January 31, 2019)
Nov	Herring Research & Monitoring P.I. meeting
Jan	Data analyses
Jan	Alaska Marine Science Symposium

**5. PROJECT PERSONNEL – CHANGES AND UPDATES**

If there are any staffing changes to Primary Investigators or other senior personnel please provide CV's for any new personnel and describe their role on the project.

**6. Budget**

**A. Budget Forms (Attached)**

Provide completed budget forms.

**B. Changes from Original Proposal**

If your FY18 funding request differs from your original proposal, provide a detailed list of the changes and discuss the reason for each change.

**C. 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.

**A. Budget Forms**

See attached for detail.

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	\$ 33.3
Travel	\$1.2	\$1.2	\$1.2	\$1.2	\$0.0	\$4.6	\$ 0.1
Contractual	\$23.6	\$46.3	\$47.6	\$2.8	\$0.0	\$120.3	\$ 16.1
Commodities	\$118.7	\$80.5	\$5.0	\$0.1	\$0.0	\$204.3	\$ 0.1
Equipment	\$5.9	\$0.0	\$0.0	\$0.0	\$0.0	\$5.9	\$ -
Indirect Costs ( <i>will vary by proposer</i> )	\$ 79.5	\$ 80.3	\$ 56.8	\$ 42.6	\$0.0	\$259.3	\$ 14.9
<b>SUBTOTAL</b>	<b>\$350.3</b>	<b>\$348.1</b>	<b>\$246.2</b>	<b>\$184.7</b>	<b>\$0.0</b>	<b>\$1,129.4</b>	<b>\$64.5</b>
General Administration (9% of subtotal)	\$31.5	\$31.3	\$22.2	\$16.6	\$0.0	\$101.6	N/A
<b>PROJECT TOTAL</b>	<b>\$381.9</b>	<b>\$379.5</b>	<b>\$268.3</b>	<b>\$201.4</b>	<b>\$0.0</b>	<b>\$1,231.0</b>	
Other Resources (Cost Share Funds)	\$15.0	\$15.0	\$15.0	\$15.0		\$60.0	



**B. Changes from Original Proposal**

No changes in budget are requested

**C. 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. 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.