EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY20 (YEAR 9) CONTINUING PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

20160111-B - PWS Herring Research & Monitoring: Annual Herring Migration Cycle

Primary Investigator(s) and Affiliation(s)

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Date Proposal Submitted

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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 (OTN) 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 movement direction and if herring were seasonally leaving PWS and migrating into the GoA. With funding from the *Exxon Valdez* Oil Spill Trustee Council in FY16, we improved our ability to distinguish direction of movements between PWS and the GoA by deploying additional acoustic receivers at the OTN 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 GoA. During spring 2017 we tagged 124 herring in northeast PWS at Port Gravina and detected 59 tagged herring at entrances to the GoA. Nine fish were detected returning to the spawning grounds the following winter/spring. In April 2018, we tagged 202 herring at Port Gravina and at Hawkins Island (Canoe Pass) and to date have detected 136 at entrances to GoA. During FY19 we tagged 165 herring on the spawning grounds during April and will tag an additional 55 in fall 2019. For FY20 we will tag 210 herring on the spawning grounds in spring.

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

FY17	FY18	FY19	FY20	FY21	TOTAL
Auth: $381,900	Auth: $379,500	Auth: $275,800	$434,200	$272,800	$1,744,200

Non-EVOSTC Funds to be used, please include source and amount per source: (see Section 6C for details)

FY17	FY18	FY19	FY20	FY21	TOTAL
$15,000	$15,000	$15,000	$15,000	15,000	$75,000

1. PROJECT EXECUTIVE SUMMARY

Conservation concerns about the Pacific herring (*Clupea pallasii*) population in Prince William Sound (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 Gulf of Alaska (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 Elrington and LaTouche. These observations suggest that PWS herring are regularly migrating in and out of PWS and onto the shelf.

For FY20, we will continue to utilize acoustic telemetry to investigate seasonal movement patterns of Pacific herring. Post-spawn feeding, winter movements, 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 positioned at the entrances to PWS, the spawning grounds, and at other select locations in PWS. 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 adult herring migration.

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

The overall program goal of the Herring Research and Monitoring (HRM) program is the continued development and testing of an updated age-structured assessment (ASA) model in collaboration with the Alaska Department of Fish and Game (ADF&G). To address this goal, our tagging study will gather data to clarify the annual migration cycle of PWS adult herring. From 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 GoA.

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 PWS herring population is composed of migrant and resident individuals.

a) Resident individuals remain within the confines of PWS.
b) Resident herring are associated with specific spawning grounds.
c) Migrant individuals exit PWS by mid-June and return to the Sound in either fall or spring.

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.

Background and FY 2019 Update

Our project builds on the previous HRM project 14120111-B, a pilot project of Principal Investigator (PI) M.A. Bishop and collaborator J. Eiler (National Oceanic and Atmospheric Administration [NOAA]). During 2012 our pilot project developed handling and tagging methods designed to minimize physical injuries and stress to wild Pacific herring (Eiler and Bishop 2016). Subsequently, the February 2013 installation of the Ocean Tracking Network's (OTN's) six acoustic receiver arrays across the entrances to the GoA provided the first opportunity to detect movements from the spawning grounds to the GoA entrances. In April 2013, we tagged and released 69 adult herring from the Port Gravina spawning area. Tags had an expected life of 263 days. Post-release we detected 93% of the tagged herring (64 of 69 individuals) either at Port Gravina and/or the OTN arrays (Eiler and Bishop 2016, Bishop and Eiler 2018). With funding from the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) in FY 2016 (Project 16160111-S), 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).

In 2019, we uploaded data from the OTN arrays at the entrances to the GoA during February and March, and from receivers at the Port Gravina array and at Hawkins Island in late May and mid-June. Of the 124 fish tagged in 2017, all but one fish were detected post tagging at one or more arrays. Fifty-nine fish (48%) were detected at one or more of the OTN arrays (Table 1). In all, 9 of the 124 fish (7%) were detected > one year post tagging, including two herring detected in May 2019 shortly before tags expired.

In April 2018, we tagged 202 fish including 60 fish with smaller V8 tags. In all, 185 fish (92%) were detected at one or more arrays post tagging, including 136 (67%) at one or more of the OTN arrays. Compared with 2013 when tagged fish were larger, heavier and were primarily detected at the Montague Strait array (Bishop and Eiler 2018), tagged fish in both 2017 and 2018 were primarily detected at the Hinchinbrook Entrance array (Table 1).

Table 1. Patterns of movement by acoustic-tagged individual herring by the total number of arrays a fish was detected. HE = Hinchinbrook Entrance; MS = Montague Strait; SWP = Southwest Passages (LaTouche, Elrington, Prince of Wales, Bainbridge); All 3 OTN = Hinchinbrook Entrance, Montague Strait, and Southwest Passages.

		Total Arrays Detected							
Tag Yr/ Tag Type	No detection	Spawn area	HE	HE & MS	HE & SWP	MS	MS & SWP	SWP	HE, MS & SWP
2017									
V9 n = 124	1	64	26	11	0	3	7	0	12
2018									
V8 n = 60	6	18	22	5	1	0	0	1	7
V9 n = 142	11	31	42	14	2	7	13	2	20

We examined monthly detections by major array for fish tagged in 2018 (Fig. 1). At the entrances to the GoA, detections at Hinchinbrook Entrance and Montague Strait were observed in every month up to when data was last uploaded. In contrast, the Southwest Passages were used almost exclusively between May and August. Around the Port Gravina and Hawkins Island spawning areas, fish began returning to these areas in October. The array at Red Head, located just outside of Port Gravina (Fig. 2), was deployed for the first time in June 2018 and data was most recently uploaded in February 2019. Fish were recorded at this 2-receiver array in all months, suggesting this area may be used year-round by herring schools.

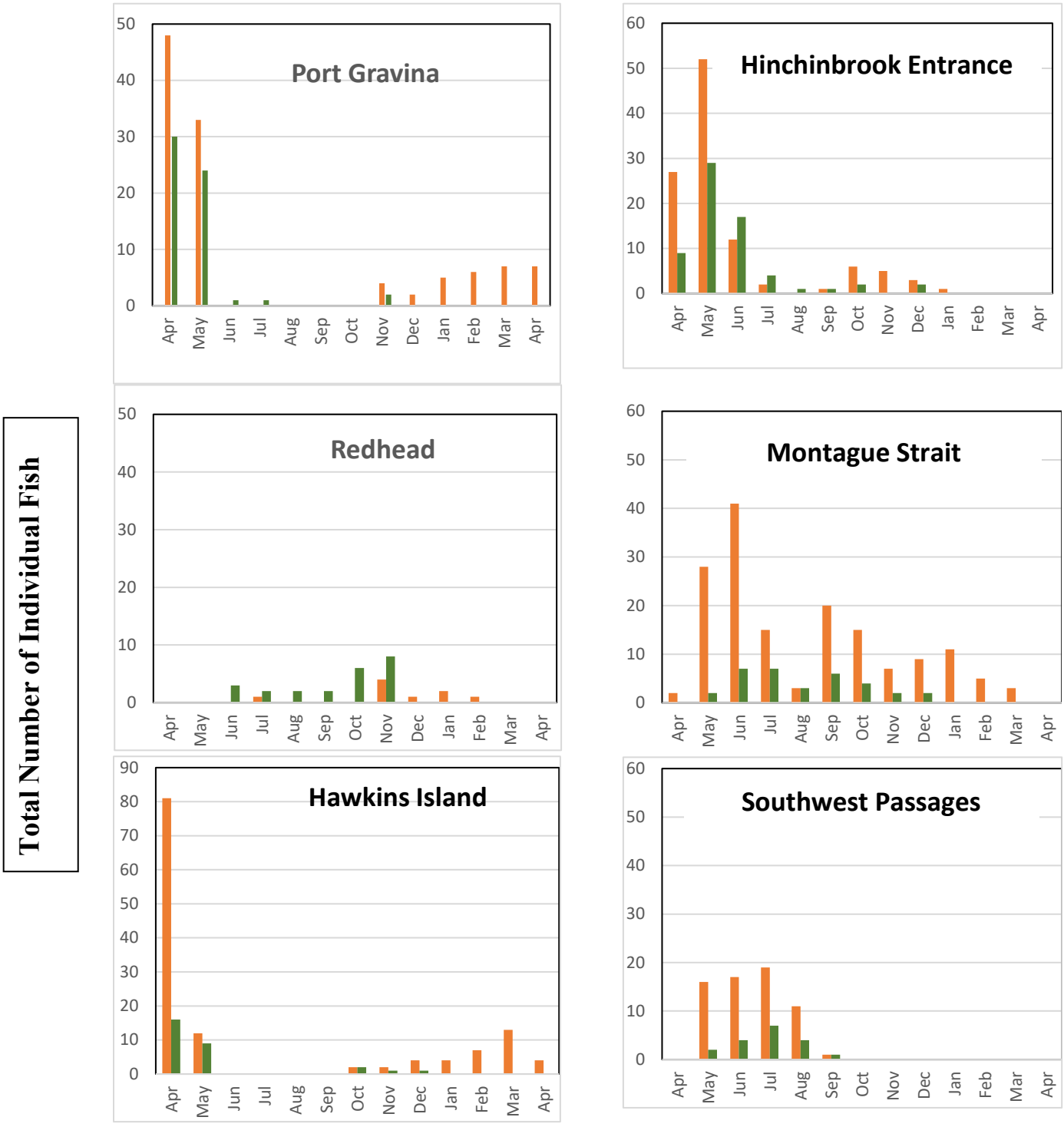

Figure 1. Number of individual herring tagged in Apr 2018 and subsequently detected by tag type, array location, and month, Apr 2018 - Apr 2019. Orange = V9 tag (25.1 month life), Green = V8 tag (8.2 month life, expired mid-Dec 2018). Left column: spawning ground areas; right column: OTN arrays at entrances to the Gulf of Alaska. Note that Jan-Apr 2019 data is incomplete for some areas. Data from Hinchinbrook Entrance, Southwest Passages, and Redhead was uploaded early Feb 2019; Montague Strait data was uploaded mid- Mar 2019.

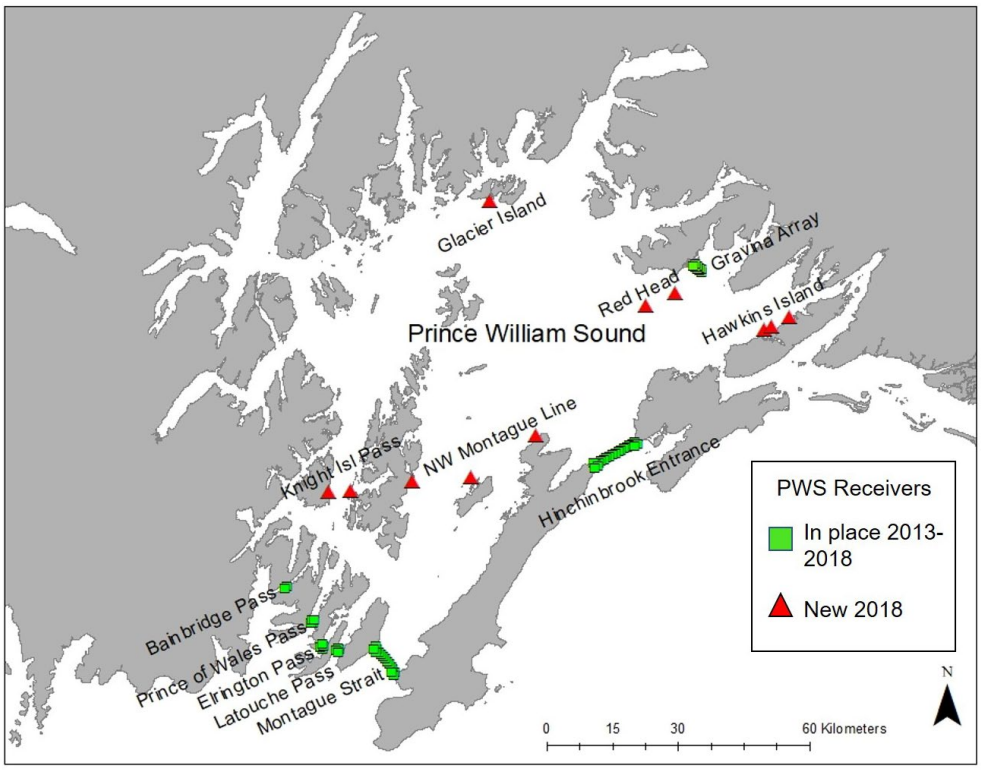

Figure 2. Location of underwater receivers in Prince William Sound.

Of the other new receivers deployed (Knight Island Passage n = 2; Northern Montague Strait (n = 3), and Glacier Island (n = 1), no fish were detected at the Knight Island Passage (deployed August 2018, data uploaded February 2019). At Glacier Island, the receiver at Chamberlin Bay recorded only 1 fish during a 12 month deployment (July 2018-June 2019). Of the three receivers across northern Montague Strait, the easternmost receiver at Montague Point had the most individual fish detections (n = 16 fish) with fish recorded in all months except August and a pronounced peak occurring in September (n = 6).

2019 Tagging

In 2019, spawning started > 1 week earlier than the past 7 years. ADF&G aerial surveys noted active herring spawn around Port Gravina on Sunday, 31 March. By the time we arrived to Port Gravina on 2 April, spawning was almost over for this area, making our capture efforts challenging since we aim to tag pre-spawning fish. We spent 2-10 April fishing at a variety of locations where ADF&G aerial surveys had observed schools, including Knowles Bay (Port Gravina area), Canoe Pass (west Hawkins Island), Double Bay (north Hinchinbrook Island) and Rocky Bay (north Montague Island). As in 2018, we used two types of acoustic tags: the V8 and V9. The V8 tag weighs 2g in air, and has an estimated tag life of 246 days, or 8.2 months. The V9 tag weighs 4.7 g and has an estimated tag life of 755 days, or 25.2 months. For the V8 tags, our target herring weight for tag implantation was 80-100 g. In all, we tagged 165 herring during spring 2019 (Table 2) for a total of 491 fish over three seasons (2017: n = 125; 2018: n = 202).

Table 2. Mean SL (mm), mass (g), and age (yr) of Pacific herring by tagged April 2019 by tag type. A scale was plucked from each herring for aging. Age was not able to be determined for 7/40 and 14/125 herring implanted with V8 and v9 tags, respectively.

	V-8 n = 40		V-9 n = 125	
	x + sd	min, max	x + sd	min, max
SL (mm)	199.1 ± 5.2	189, 211	213.1 ± 9.3	198, 240
Mass (g)	91.0 ± 5.6	80, 99	117.3 ± 18.1	97, 180
Age (yr)	3.6 ± 0.9	3, 6	4.6 ± 1.2	3, 9

2. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

A. Project Milestones and Tasks

Table 3. Project milestones and task progress by fiscal year and quarter, beginning February 1, 2017. Additional milestones and/or tasks have been added in red. Yellow highlight indicates proposed fiscal year workplan. C = completed, X = not completed or planned. Fiscal year quarters: 1 = Feb 1 – April 30; 2 = May 1 – July 31; 3 = Aug. 1 – Oct. 31; 4 = Nov. 1 – Jan. 31.

	FY17				FY18				FY19				FY20				FY21			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestone 1: Data Collection																				
Herring capture/tagging	C				C				C		X									
Upload data from arrays			C		C				C				X							
Milestone 2: Data Processing/Mgmt																				
Data summary/analysis			C	C	C	C	C	C	C	C	X	X	X	X	X	X				
Upload data workspace					C				C				X							
Metadata/data published																X				
Milestone 3: Reporting																				
Annual reports					C				C				X				X			
Annual PI meeting				C			C				X					X				X
FY work plan (DPD)			C				C				C				X				X	
5-Year Final Report																				X
Journal Publications												X								X
New Milestone: Data collection																				
Herring capture/tagging													X							
Upload data from arrays																	X			

B. Explanation for not completing any planned milestones and tasks

We have completed all planned milestones and tasks on schedule.

C. Justification for new milestones/tasks

In our original 2016 proposal, 2019 was scheduled to be the third, and final year for tagging. However, the EVOSTC Science Panel and Chief Scientist showed support for adding a fourth year to increase our sample size. Therefore, we plan to tag an additional 210 herring in April 2020. Further information is provided in Section 4.B. Changes to Project Design and Objectives.

3. PROJECT COORDINATION AND COLLABORATION

A. Within an EVOSTC-funded Program

Within the Herring Research and Monitoring (HRM) program

Our study, PWS Herring Annual Migration Cycle, is an ongoing component of the larger, EVOSTC-funded HRM program. We continue to coordinate and collaborate with, inform, and contribute data to the other HRM projects. Our tagging work informs the *Herring disease* studies (Project 20120111-E; PI Herschberger) by establishing the migration and feeding locations of herring. Our data contributes to 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* (Project 20120111-G; PI Rand) we receive data on adult school locations and provide data to them on return timing of tagged fish. We also investigate methods to track acoustic tagged fish concurrently during hydroacoustic surveys for adults. Our project informs and contributes data to *Herring condition connection to environmental factors* (20120111-A; postdoc position) through identifying where the adult herring are at different times of year. Our project contributes movement and survival rate data to the project *Modeling and stock assessment* (Project 20120111-C; PI Branch). For the *Herring age at reproductive* maturity (Project 20170111-D; PI Gorman) we share vessel space and will provide samples opportunistically. For the *Herring age, sex, and size collection* (Project 20160111-F; PI Haught) we receive from and supply available information to ADF&G on timing and location of herring spawn and obtain opportunistically seined herring for tagging from the ADF&G *RV Solstice*. We also receive and utilize the ADF&G age, weight, and length data. We. Finally, we are in constant collaboration and coordination with our 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 informs, receives data from and contributes data to the GWA programs. The GWA Pelagic component's Integrated Predator-Prey surveys are co-conducted by three existing GWA Pelagic projects:

- Forage fish distribution, abundance, and body condition in PWS, U.S. Geological Survey (Project 20120114-C; USGS)
- Humpback whale predation, NOAA and University of Alaska Southeast (Project 20120114-O)
- Fall and winter seabird abundance and distribution, PWS Science Center (Project 20120114-E PWSSC)

Understanding movements by adult herring throughout the annual cycle provides valuable data on trophic interactions between herring and piscivorous waterbirds (in particular loons and common murres, the major avian consumers of adult herring), humpback whales, and other forage fish competitors.

The GWA Environmental Drivers Program also provides valuable data for our project. The availability of oceanographic data from PWS collected at approximately monthly intervals from April-November (Project 20120114-G; PI Campbell), as well as the oceanographic and biological data made available from the GoA (Projects 20120114-D, I, and L; PIs Batten, Danielson, and Hopcroft) allow this project to explore how seasonal changes in herring distribution are associated with environmental drivers. In addition, the GAK1 monitoring project (20120114-I; PI Danielson) has deployed VR2W receivers on two of their moorings in the GoA, providing us with an opportunity to determine if tagged herring are using these areas in the GoA. Finally, we receive temperature data from the GWA nearshore project 20120114-H.

With Data Management

This project coordinates with the data management program by submitting data and preparing metadata for publication on the Alaska Ocean Observing System (AOOS) Gulf of Alaska Data Portal and DataONE within the timeframes required.

B. With Other EVOSTC-funded Projects

Except for the HRM and GWA programs, there are no other EVOSTC-funded collaborations.

C. With Trustee or Management Agencies

With Trustee or Management Agencies

Our project relies on information from ADF&G to locate adult herring schools in spring for acoustic surveys and sampling (HRM project 20160111-F). To that extent, we work closely with Stormy Haught at the Cordova office of ADF&G. Information learned about herring migrations is shared with ADF&G and the USGS herring disease project (HRM project 20120111-E; PI Herschberger). We also receive information on adult herring schools observed during summer and fall from the GWA Pelagic components - in particular the forage fish monitoring project (USGS; GWA project 20120114-C) and the humpback whale monitoring project (NOAA; GWA project 20120114-O).

Collaborations With Other Organizations

This project synergizes with efforts of the OTN (Fred Whoriskey, PhD. Executive Director, Dalhousie University) and with the AOOS (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 Wales, and Bainbridge. Since then, OTN has replaced lost receivers, and in February 2018 provided 18 VR2AR receivers to replace VR4 receivers that are tilting due to biofouling. With FY16 EVOSTC funding, the PWSSC expanded the OTN array in February 2017. Equipment is assembled and configured by PWSSC personnel in Cordova. Currently PWSSC maintains the array for OTN/AOOS on an annual basis. OTN maintains a database with detections from their worldwide network. Our data are archived in the OTN databases, as per their guidelines. In 2017, PWSSC received funding from AOOS to cover the costs of annual, regular maintenance of the OTN arrays. Funding will be for five years.

4. PROJECT DESIGN

A. Overall Project Objectives

Our previous tagging efforts suggest that herring are emigrating from PWS into the GoA and then returning (Eiler and Bishop 2016, Bishop and Eiler 2018). As part of the HRM program, during FY20 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 are:

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.
3) Determine seasonal residency time within PWS, at the entrances to PWS, and in the GoA.

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. Changes to Project Design and Objectives

In our original 2016 proposal, 2019 was scheduled to be the third, and final year for tagging. However, the EVOSTC Science Panel and Chief Scientist showed support for adding a fourth year to increase our sample size. To date we have tagged 491 fish, including 165 fish tagged in April 2019 for which no data is yet available. Of the 326 fish tagged the first two years, we have detected 195 herring (60%) at the OTN arrays including 48% (59/124) of the 2017 tag cohort and 67% (136/202) of the 2018 tag cohort.

This project catches fish right before spawning (many are milting when we tag them). Because of the reduced biomass of the PWS herring population and predominance of younger and smaller age classes, we have had to search long and hard to locate, catch, and tag over 200 fish during the short pre-spawning window. We expect an additional year of tagging would boost our sample size of fish that move to the entrances to between 400 and 500 fish. By 2020, the dominant age class may be larger, and, if so, it will be easier to find and tag larger herring.

The additional receivers installed in 2018 in parts of the Sound (Knight Island, northern Montague Strait, Hawkins Island, Red Head, and Glacier Island) will continue to provide new information on residency within PWS. At the same time, the partial, second line of receivers at the OTN arrays will continue to provide an opportunity to determine if and when fish return to PWS from the GoA.

5. PROJECT PERSONNEL – CHANGES AND UPDATES

The fisheries biologist on this project left PWSSC in spring 2019. We are currently in the process of interviewing candidates for a postdoctoral position that would work with the PI to complete the 5-year project. Other field staff, including the tagging crew, remain the same.

6. PROJECT BUDGET

A. Budget Forms (See HRM FY20 Budget Workbook)

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	$153.9	$157.9	$708.8	
Travel	$1.2	$1.2	$1.2	$3.1	$1.6	$8.1	
Contractual	$23.6	$46.3	$52.9	$50.3	$31.1	$204.2	
Commodities	$118.7	$80.5	$5.0	$99.1	$2.0	$305.3	
Equipment	$5.9	$0.0	$0.0	$0.0	$0.0	$5.9	
Indirect Costs (*will vary by proposer*)	$79.5	$80.3	$58.4	$91.9	$57.8	$367.9	
SUBTOTAL	$350.3	$348.1	$253.0	$398.3	$250.3	$1,600.2	$0.0
General Administration (9% of subtotal)	$31.5	$31.3	$22.8	$35.8	$22.5	$144.0	N/A
PROJECT TOTAL	$381.9	$379.5	$275.8	$434.2	$272.8	$1,744.2	
Other Resources (Cost Share Funds)	$15.0	$15.0	$15.0	$15.0		$60.0	

B. Changes from Original Project Proposal

The FY20 budget adds a fourth tagging year.

Personnel: a postdoctoral research associate will replace the fisheries biologist who left the project.

Travel: includes the cost for the postdoc and the PI to attend the EVOSTC Science Panel review and the annual PI meeting.

Contractual: includes the cost for vessel time for fish tagging and for uploading data from arrays that are not part of the OTN arrays as well as for a mid-year data upload from the OTN arrays.

Commodities: includes the cost of 210 tags, tagging supplies, 5 replacement receivers (to replace lost receivers)

C. Sources of Additional Project Funding

This project uses Dalhousie University's OTN, 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 OTN acoustic arrays is estimated at $337,200. This project also piggy backs on the annual OTN maintenance cruise (funded by AOOS starting in FY 17) which includes 6d@$3/k day. PWSSC will also provide in-kind equipment (9 VR2W acoustic receivers, 9 acoustic releases, and 9 floats) for an array that will be deployed at the tagging site as well as 9 VR3 refurbished receivers. The value of this equipment is estimated at $108k.

7. FY17-19 PROJECT PUBLICATIONS AND PRODUCTS

Publications

Bishop, M.A. and J. H. Eiler. 2018. Migration patterns of post-spawning Pacific herring in a subarctic sound. *Deep-Sea Research Part II.* 147: 108-115. https://doi.org/10.1016/j.dsr2.2017.04.016

Bishop, M.A. 2018. Tracking Seasonal Movements of Adult Pacific Herring in Prince William Sound. *Exxon Valdez* Oil Spill Restoration Project Final Report (Project 14120111-B), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Bishop, M.A. 2018. Annual Herring Migration Cycle: Expanding Acoustic Array Infrastructure. Exxon Valdez Oil Spill Restoration Project Final Report (Project 16160111-S), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Gray, B., M.A. Bishop, and S.P. Powers. 2019. Structure of winter groundfish feeding guilds in Pacific herring *Clupea pallasii* and walleye pollock *Gadus chalcogrammus* nursery fjords. *Journal of Fish Biology* 95(2):527-539. https://doi.org/10.1111/jfb.13984

Gray, B., M.A. Bishop, and S.P. Powers. In prep. Winter variability in the diets of groundfish predators of Pacific Herring and Walleye Pollock in a subarctic sound.

Published and updated datasets

Bishop, M.A. 2017. Tracking seasonal movements of adult Pacific Herring in Prince William Sound, 2012-2014, EVOS Herring Program. Axiom Data Science. https://doi.org/10.24431/rw1k1x

http://portal.aoos.org/gulf-of-alaska.php#metadata/c1e401be-8d52-477b-a76b-acf5cd817686/project

Presentations

Bishop, M.A. and B. Gray. 2019. How to tag a herring and where do they go afterwards? PWSSC Tuesday Night Science Lecture Series. January 2019, Cordova.

Bishop, M.A. 2018. Annual herring migration cycle. Herring Research and Monitoring Program, annual meeting. November 2018, Anchorage.

Bishop, M.A. 2017. Annual herring migration cycle. Herring Research and Monitoring Program, annual meeting. November 2017, Cordova.

Gray, B. P., M.A. Bishop, S.P. Powers. 2018. Identifying key piscine predators of Pacific herring (*Clupea pallasii*) and walleye pollock (*Gadus chalcogrammus*) during winter months in bays of Prince William Sound, Alaska through multivariate analysis of stomach contents. Poster presentation. Alaska Marine Science Symposium. January 2018, Anchorage.

Outreach

Bishop, M.A. 2019. Time to spawn! *Delta Sound Connections*

Bishop, M.A. 2018. How to tag a herring. *Delta Sound Connections*

Bishop, M.A. Pacific herring: Once done spawning – Where to next? *Delta Sound Connections*

Gray, B. 2019. Ping! Tracking fish using passive acoustic technology. *Delta Sound Connections*

Gray, B. 2018. Herring on the menu. *Delta Sound Connections*

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Brown, E.D., Seitz, J., Norcross, B.L., Huntington, H.P., 2002. Ecology of herring and other forage fish as recorded by resource users of Prince William Sound and the outer Kenai Peninsula, Alaska. Alaska Fisheries Research Bulletin 9:75–101.

Corten, A. 2002. The role of` 'conservatism'' in herring migrations. Reviews in Fish Biology and Fisheries 11: 339-361.

Eiler, J.H., Bishop, M.A., 2016. Determining the post-spawning movements of Pacific herring, a small pelagic forage fish sensitive to handling, with acoustic telemetry. Transactions of the American Fisheries Society 145:427–439.

Hay, D.E., McCarter, P.B., 1997. Continental shelf area, distribution, abundance and habitat of herring in the North Pacific. Wakefield Fisheries Symposium, Alaska Sea Grant College Program 97-01, pp. 559–572.

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