

**EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY19 CONTINUING PROJECT PROPOSAL SUMMARY PAGE**

Project Number and Title

19120111-A
Herring Research Program – Program Coordination

Primary Investigator(s) and Affiliation(s)

Scott Pegau, Prince William Sound Science Center

Date Proposal Submitted

September 28, 2018

Project Abstract

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

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

Coordination is primarily through e-mail and teleconference. The management team of GWA and the lead of DM are included in the emails to HRM PIs to ensure they are aware of our activities. We also plan joint PI meetings and community involvement activities.

The postdoctoral researcher, Dr. Maya Groner, was hired during year one and is focusing her research on understanding the combined impacts of environmental conditions and disease on herring population dynamics using a field collected data, experiments and population models.

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

EVOSTC Funding Requested* (must include 9% GA)

FY17	FY18	FY19	FY20	FY21	TOTAL
Auth:\$138,400	Auth:\$270,200	\$302,500	\$256,100	\$90,700	\$1,057,800

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

FY17	FY18	FY19	FY20	FY21	TOTAL
\$26,000	\$26,600	\$27,200	\$28,000	\$28,300	\$136,100

1. PROJECT EXECUTIVE SUMMARY

Provide a summary of the program including key hypotheses and overall goals, as submitted in your original proposal. Please include a summary and highlights since your last annual report: preliminary results with figures and tables. If there are no preliminary results to present, please explain why (i.e., lab analysis is still in progress). List any publications that have been submitted and/or accepted since you submitted your last proposal and other products in *Section 7*. Prior annual reports will be appended to remind reviewers of progress in previous years.

The **goal of this proposal is to provide the coordination necessary to continue integrating the research and monitoring projects** to achieve the program goals. The objectives of the project are:

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

This project provides a program lead who works with the Council's staff to ensure the Council's objectives and requirements are met. The coordinator facilitates the most cost-effective and scientifically-supportive stream of funding, supports a program science panel to provide program oversight, and other duties as identified in the invitation for proposals.

Coordination since the annual report has focused on the spring and summer sampling activities. These include the aerial and acoustic surveys of herring biomass, age-sex-length sampling of the herring biomass, acoustic tagging of herring and age at maturity sampling in the spring and summer. In support of the summer sampling for age at maturity, we conducted aerial surveys to identify locations of potentially mature herring and other forage fish. We are currently in negotiations with the Prince William Sound Regional Citizens' Advisory Council for funding to support aerial forage fish surveys that support the age at maturity program and the GWA forage fish program.

Additional coordination includes work with the EVOSTC staff to complete reviews of the final reports for the first five-year program and revision of the EVOS annual proposal forms. We participated in the GWA teleconferences and with the Data Management program to make more data available through the AOOS data portal.

An intern was supported who worked on identifying potential relationships between spawn timing and location and environmental conditions. They found that there was no relationship between water temperature in March and the start of spawn timing. The timing of spawn was found to differ depending on location. Spawn occurs earlier in eastern locations and later on Montague Island (Fig. 1). That work was passed to Dave McGowan who is working with Trevor Branch on similar issues.

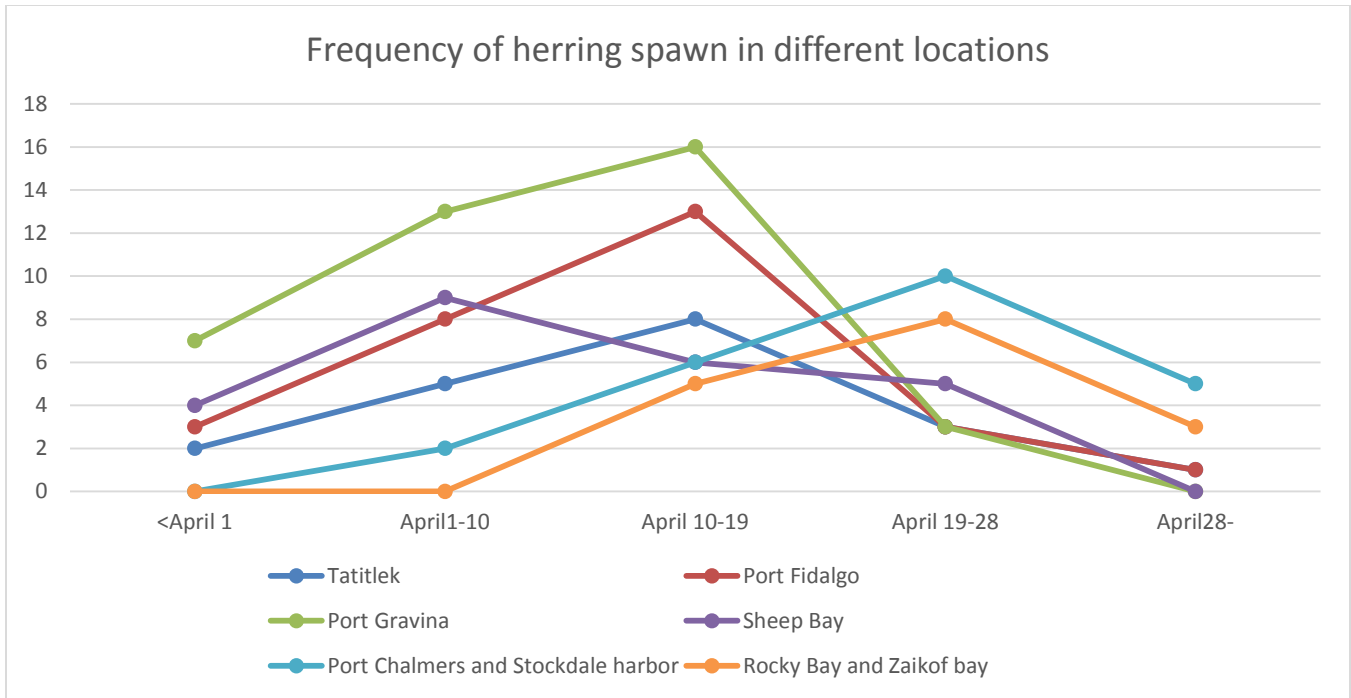


Figure 1. The number of years that spawn was observed to occur within date ranges at different locations.

Work within the project also includes support for outreach activities. We completed updates to the website (<http://pwssc.org/research/>) for all ongoing projects within the HRM program and made significant progress in updating past projects to include more findings. We worked with the PWSSC web developers to add a search tool that allows a quick identification of on-going versus completed projects. We completed podcasts describing the herring modeling, acoustic sampling, disease research, overwintering energetics, and HRM program coordination. The podcasts can be found at <http://pwssc.org/education/field-notes/> and linked within the individual project posts. Dr. Groner participated in the listening session held at Port Graham along with several GWA researchers.

Finally, the project supported a post-doctoral researcher examining the relationship between herring diseases and environmental conditions. Dr. Maya Groner started at the beginning of the second year of funding and is primarily collaborating with Drs. Hershberger and Purcell in Washington. Research conducted to date has been focused on two topics. First is experimentally quantifying the relationship between *Ichthyophonus* sp. pathogen load and mortality using specific pathogen free herring at the U. S. Geological Survey Marrowstone Laboratory. Replicate tanks (3) of age 1 herring were exposed to *Ichthyophonus* via consumption of offal from ground up infected conspecifics. Mortality, infection status, size and cardiac tissue samples were collected from all tanks. Pathogen load will be quantified in moribund, dead and subsamples of live fish by through quantitative image analysis of histologically sectioned cardiac tissue. A pilot experiment was completed with age 1 herring and a second experiment is underway with age 4 herring. These experiments will serve to parameterize models estimating mortality due to this disease in both Sitka Sound and Prince William Sound between 2009 until now.

The second ongoing project an experimental infection trial to examine interactions between age and susceptibility to viral erythrocytic necrosis (VEN) in herring. Replicate tanks (3) of mixed aged herring (age 0, 1, 2, or 4) have been exposed to erythrocytic necrosis virus (ENV) or a sham control. Herring are tagged with elastomer tags to identify them to cohort. Mortality and water quality will be monitored for the following month

and kidney samples will be collected in morts and at the end of the experiment to determine infection status. Ultimately these data will aid in modeling population level effects of VEN.

In addition, Dr. Groner has participated in several publications that are tangentially related to this project including collaborations on (1) a book chapter on marine disease modeling and (2) a manuscript reviewing how management of marine resources (i.e. fisheries, marine protected areas and rehabilitation) can indirectly alter host-pathogen interactions. The book chapter will be published in a textbook on marine diseases. Dr. Groner’s contribution is focused on how to infer epidemiological processes by examining and modeling distributions of parasites within hosts. The theory in this chapter underlies her current work being applied to quantifying and interpreting Ichthyophonus intensities in herring hearts. The manuscript uses several examples of Pacific herring diseases to illustrate how fishing practices may alter diseases processes, including size-selective harvests that may inadvertently target herring infected with Ichthyophonus and the spawn-on-kelp fishery which has been associated with shedding of viral hemorrhagic septicemia. Both publications are targeted for summer 2019.

2. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

A. Project Milestones and Tasks

Milestones are annual steps to meet overall project objectives. For each milestone listed, specify the status (completed, not completed) when each was completed and if they are on schedule, as submitted in your most current proposal.

Tasks are annual steps to meet milestones. Specify, by each quarter of each fiscal year, when critical tasks (for example, sample collection, data analysis, manuscript submittal, etc.) were and will be completed.

Please identify any substantive changes and the reason for the changes. *Reviewers will use this information in conjunction with annual program reports to assess whether the program is meeting its objectives and is suitable for continued funding.*

B. Explanation for not completing any planned milestones and tasks

Please identify any substantive changes and the reason for the changes. If tasks were not completed as scheduled or delayed, please explain why and the anticipated completion date.

C. Justification for new milestones and tasks

Please identify any new milestones and tasks and the reason why they have been added.

A. Project Milestones and Tasks

Project milestone and task progress by fiscal year and quarter, beginning February 1, 2017. Yellow highlight indicates proposed fiscal year Work Plan. Additional milestones and tasks may be added. 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.

Milestone/Task	FY17				FY18				FY19				FY20				FY21			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Postdoctoral Researcher																				
Request proposals for postdoctoral researchers	C																			
Select project to include in FY18 proposal submission		C																		
Hire postdocs				C																

(10) Examine relationships between food quality and disease susceptibility (bioenergetic-disease hypothesis) for Ichthyophonus, VHS and VEN											X	X						
(11) Publish on bioenergetics disease hypothesis													X	X				
(12) If data is sufficient, analyze relationships between environmental factors and prevalence of Ichthyophonus and VHS in PWS and Sitka											X	X	X					
(13) Publish on environmental correlates of disease analysis																X		

B. Explanation for not completing any planned milestones and tasks

All tasks were completed as planned. The milestone of hiring of the postdoctoral researcher has been completed. The tasks associated with Dr. Groner’s work have been added under a new milestone.

C. Justification for new milestones and tasks

New milestones have been added to correspond with tasks that will be conducted by Dr. Groner. These milestones have been modified from her original submitted proposal to have more detail. In addition, the timeline has been altered from the original proposal so that experiments will be conducted analyses on field data. These changes were made due to availability of lab space and herring at the Marrowstone Lab and because experimental results should further inform hypotheses about field-collected data. These milestones are described in more detail below.

Milestone 1 is in conjunction with Paul Hershberger. We are continuing on-going sampling of 180 wild herring in both Sitka and PWS and testing them for Ichthyophonus, VEN and VHS.

Milestones 2-4 are focused on quantifying the basic epidemiological dynamics of VEN. This disease, caused by an intracellular virus (erythrocytic necrosis virus), can cause severe anemia and mortality in infected herring. Knowledge gaps prevent us from predicting when or why this disease will outbreak. Field-based studies of VEN are challenging as epidemics can be acute and are easily missed during yearly sampling. Not enough is known about the disease to design a targeted surveillance sampling design. In fall 2018 and winter 2019 we will conduct two experiments focused on parameterizing the effects of two probable drivers of epidemiological patterns VEN: herring age and seawater temperatures. (The first of these experiments is underway and summarized in more detail in the executive summary.) Experiments will be conducted at the U.S. Geological Survey Marrowstone Laboratory using Specific Pathogen Free (SPF) herring. By quantifying the impacts of herring age and temperature on VEN, we may begin to understand the set of conditions that lead to pathogen outbreaks in Prince William Sound.

Milestones 5-9 are focused on understanding effects of *Ichthyophonus* sp. infections on Pacific herring population dynamics. This common protistan parasite has been detected in Pacific herring from PWS and Sitka Sounds with varying prevalence over the past 10 years. Recent trends in an endemic disease of herring, ichthyophoniasis, indicate that this disease may have shifted to a more lethal ‘acute’ phase in Sitka Sound, where herring populations have declined in recent years. Infection prevalence has decreased in older fish, yet infection intensity has increased overall. Because herring do not recover from infection, the most parsimonious

explanation for these trends is an increase in disease mortality. We are using data from the *Ichthyophonus* experiments (described in the executive study) to estimate the lethal infectious dose. We are then comparing these data with cardiac infection intensities in wild herring collected from Prince William Sound and Sitka Sounds between 2009 and now (n~900 infected herring). We will use the distribution of infection intensities across age class, site and year to 1) determine if the hypothesis of increasing mortality is consistent with patterns of infection intensity in Sitka Sound and 2) parameterize a disease model to quantify the impacts of acute and chronic infection on Pacific herring populations (figure 2).

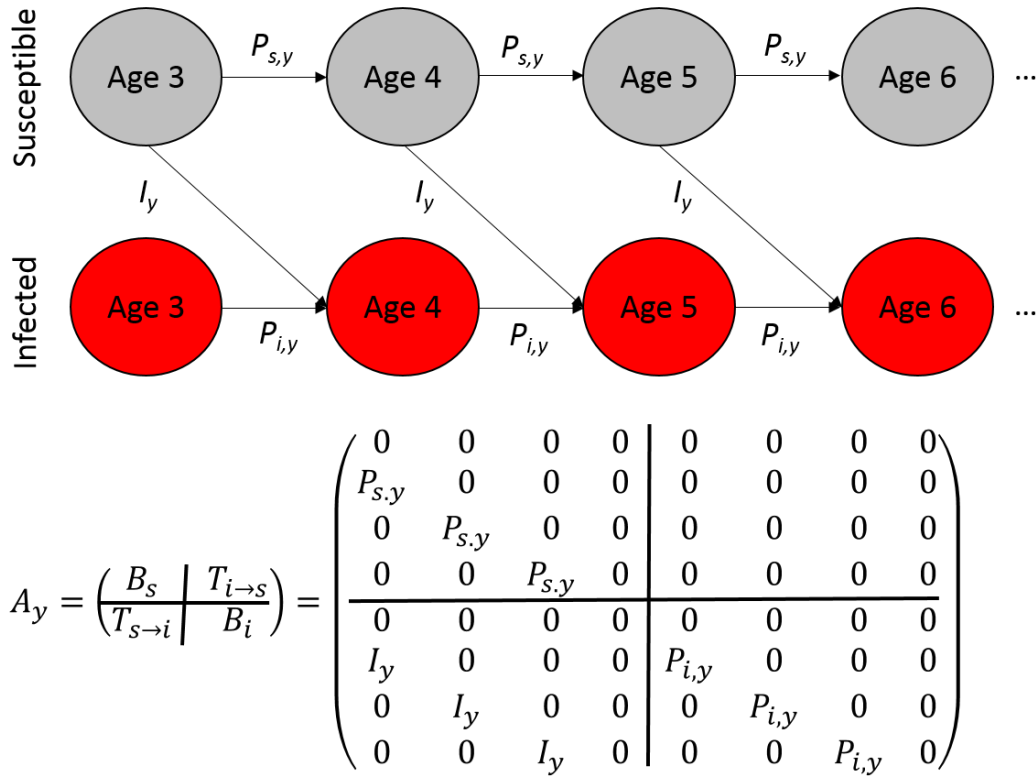


Figure 2. Conceptual and mathematical depictions of parameter terms to be estimated using an age-structure SI (susceptible- infected) model. Survival of healthy and infected herring will be determined for fish that have recruited into the spawning populations (age 3 and older). Once recruited, fish will transition to the next age class each year and, if they are healthy (in grey), they have some probability (I_y) of becoming infected (in red). In the mathematic formulation, submatrices B_s and B_i contain survival rates of healthy and infected herring from ages three through six. Submatrix $T_{s \rightarrow i}$ consists of estimates of transitions from susceptible to infected, while submatrix $T_{i \rightarrow s}$ consists of parameters for recovery, which is assumed not to occur in Pacific herring. In the example above, estimates for survival and incidence are assumed to be constant across ages, but vary through years (y). Matrices with different assumptions can also be tested.

Milestones 10 and 11 are focused on investigating the relationship between herring bioenergetics and disease susceptibility. Specifically, we will run experiments in the USGS Marrowstone Lab to test the hypotheses that susceptibility of age 0 herring to VHS, VEN and *Ichthyophonus* increases with decreasing plankton quality, and warmer winter temperatures.

Milestones 12 and 13 are focused on using time series analyses to investigate the hypothesis that: *Ichthyophonus* and VHS in wild-collected Pacific herring are correlated with environmental conditions that alter condition factor (fall plankton, winter temperature).

3. PROJECT COORDINATION AND COLLABORATION

A. Within an EVOTC-Funded Program

Provide a list and clearly describe the functional and operational relationships with any EVOSTC-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 EVOSTC-funded Projects

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

C. With Trustee or Management Agencies

Please discuss if there are any areas which may support EVOSTC trust or other agency work or which have received EVOSTC trust or other agency feedback or direction, including the contact name of the agency staff. Please include specific information as to how the subject area may assist EVOSTC trust or other agency work. If the proposed project requires or includes collaboration with other agencies, organizations or scientists to accomplish the work, such arrangements should be fully explained and the names of agency or organization representatives involved in the project should be provided. If your proposal is in conflict with another project, note this and explain why.

Within an EVOSTC-Funded Program

This project provides the overall coordination between all projects within the program, therefore is directly linked to each project. Dr. Pegau is the program team leader responsible for ensuring a coordinated and focused research program that leverages other assets whenever possible. Within program coordination is primarily through e-mail and phone communications. In-person meetings of participants occur in the fall of each year for exchange of information and to encourage collaboration between projects.

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

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

With Other EVOSTC-funded Projects

The lingering oil project led by Dr. Whitehead is the project of primary interest to the HRM program. Dr. Whitehead has been added to the HRM PI mailing list and participated in the HRM PI meeting by teleconference. We continue to explore means to further include Dr. Whitehead in the HRM activities and ensure the HRM investigators are aware of his results.

With Trustee or Management Agencies

Alaska Department of Fish and Game is the primary trustee and management agency that the HRM program aims to serve. The success of the program is highly dependent on the information collected by ADF&G so it is

imperative that we work with the agency. We will continue to have an ADF&G employee (Sherri Dressel) on our scientific oversight group.

Drs. Groner and Hershberger have partnered with ADF&G – Sitka to assess whether temporal changes in the severity of *Ichthyophonus* infections may be responsible for recent declines in the spawning herring biomass and age structure. Data and archived samples from the past 10 years of this EVOS-funded project were leveraged to obtain supplemental funding from the North Pacific Research Board (# 1807: *Ichthyophonus* in Pacific Herring).

4. PROJECT DESIGN

A. Overall Project Objectives

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

B. Changes to Project Design and Objectives

If the project design and objectives have changed from your original proposal, please identify any substantive changes and the reason for the changes. Please include the revised objectives in this section. 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.

The original goals and objectives of the project are as follows. The **goal of this proposal is to provide the coordination necessary to continue integrating the research and monitoring projects** to achieve the program goals. The objectives of the project are:

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

The objectives have been modified to include the following that represent the work of the postdoctoral researcher that was selected.

- 1) *To quantify the role of VEN, VHS and Ichthyophonus in low recruitment of Pacific herring*
- 2) *To evaluate the contribution of environmental and biotic drivers of disease, particularly as they relate to decreased condition factor and disease susceptibility of juvenile herring*
- 3) *To provide estimates of the environmentally-dependent estimates of the effects of disease on Pacific herring recruitment to inform the Bayesian ASA model for Pacific herring assessment in PWS (Muradian et al. 2017)*
- 4) *Parameterize an age-structured disease model for Ichthyophonus sp. in Pacific herring.*

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.

The addition of Dr. Maya Groner as the postdoctoral researcher occurred at the beginning of the FY18 funding year and her CV was included at that time. Dr. Groner is primarily focused on examining the connections between herring diseases and environmental conditions, but she also supports Dr. Pegau in evaluation of reports and annual proposals being submitted to the EVOSTC.

Revision 9.28.18

We are requesting the addition of Donna Aderhold to provide an additional level of review of documents that the HRM program is submitting to the EVOSTC. Donna will coordinate primarily with the HRM program lead, W. Scott Pegau, and with individual project principal investigators (PIs) as needed to complete document editorial reviews. For FY19, editorial support will include FY18 annual reports, FY20 work plans, and the draft synthesis report.

6. PROJECT BUDGET FOR FY19

A. Budget Forms (Attached)

Provide completed budget forms.

B. Changes from Original Proposal

If your FY19 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.

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

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	\$57.0	\$153.3	\$177.4	\$161.9	\$51.7	\$601.2	
Travel	\$6.4	\$9.9	\$6.4	\$6.4	\$6.4	\$35.5	
Contractual	\$24.7	\$26.0	\$26.2	\$11.0	\$4.4	\$92.3	
Commodities	\$3.8	\$1.5	\$3.5	\$1.4	\$1.5	\$11.7	
Equipment	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	
Indirect Costs (will vary by proposer)	\$35.1	\$57.20	\$64.0	\$54.2	\$19.2	\$229.7	
SUBTOTAL	\$127.0	\$247.8	\$277.5	\$234.9	\$83.2	\$970.4	
General Administration (9% of subtotal)	\$11.4	\$22.3	\$25.0	\$21.1	\$7.5	\$87.3	N/A
PROJECT TOTAL	\$138.4	\$270.2	\$302.5	\$256.1	\$90.7	\$1,057.8	
Other Resources (Cost Share Funds)	\$26.0	\$26.6	\$27.2	\$28.0	\$28.3	\$136.1	

COMMENTS:

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

B. Revision 9.28.18

We are requesting an additional \$13,000 in salaries in FY19 to hire Donna Aderhold to provide an additional level of review of documents that the HRM program is submitting to the EVOSTC. Donna will coordinate primarily with the HRM program lead, W. Scott Pegau, and with individual project principal investigators (PIs) as needed to complete document editorial reviews. For FY19, editorial support will include FY18 annual reports, FY20 work plans, and the draft synthesis report.

C. The Oil Spill Recovery Institute provides up to two months of salary for Dr. Pegau to complete his coordination activities. The Herring Disease Program was leveraged to obtain NPRB funding (Groner and Hershberger) to evaluate the possible involvement of *Ichthyophonus* in the recent herring population trends occurring in Sitka Sound.

7. FY18 PUBLICATIONS AND PRODUCTS

Products include publications (include *in prep* and *in review*), published and updated datasets, presentations, and outreach during FY18.

The following manuscripts have now been published.

Aderhold, D. G. R., M. R. Lindeberg, K. Holderied, and W. S. Pegau, Spatial and temporal ecological variability in the northern Gulf of Alaska: What have we learned since the *Exxon Valdez* oil spill? *Deep Sea Research II*. **147**, 3-8. DOI 10.1016/j.dsr2.2017.11.015

Gorman, K. B., T. C. Kline, M. E. Roberts, F. F. Sewall, R. A. Heintz, and W. S. Pegau, Spatio-temporal variation in stable carbon and nitrogen isotope signatures and condition of juvenile herring (*Clupea pallasii*) in Prince William Sound, Alaska: teleconnections with the Gulf of Alaska. *Deep Sea Research II*. **147**, 116-126. DOI 10.1016/j.dsr2.2017.10.010

Shore-Maggio, A., Groner, M. L., Burge, C. A., Carnegie, R., Hershberger, P. *in prep*. Disease transmission in managed marine systems.

Ben-Horin, T., Groner, M. L., Bidegain, G., McCallum, H., Powell, E., Hofmann, E. *in prep*. Modeling and forecasting disease dynamics in the sea. *Marine disease ecology*. Ed. Lafferty, K.

We completed updates to the website (<http://pwssc.org/research/>) for all of the ongoing projects within the HRM program and made significant progress in updating past projects to include more findings. We worked with the PWSSC web developers to add a search tool that allows a quick identification of on-going versus completed projects. We completed podcasts describing the herring modeling, acoustic sampling, disease research, overwintering energetics, and HRM program coordination. The podcasts can be found at <http://pwssc.org/education/field-notes/> and linked within the individual project posts. Dr. Groner participated in the listening session held at Port Graham with along with GWA researchers.

The forage fish aerial survey data collecting in 2017 was amended to the forage fish data available from the AOS data portal.