EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY20 CONTINUING PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

20120111-G

Adult Pacific Herring Acoustic Surveys in Prince William Sound

Primary Investigator(s) and Affiliation(s)

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Date Proposal Submitted

August 29, 2019

Project Abstract

We are continuing to conduct hydroacoustic surveys and calculate biomass estimates of pre-spawning biomass of Pacific herring in Prince William Sound (PWS), providing a long-term relative abundance index for the Bayesian age-structured assessment model (BASA) . This work primarily addresses Objectives 1 (expanding and testing the BASA model) and 2 (providing input to the BASA model). Since 1993, the Prince William Sound Science Center (PWSSC) has been carrying out acoustic surveys as a cost-effective approach to estimate pre-spawning biomass of adult Pacific herring just prior to the spawning period. Here we propose to continue this sampling during 2020. **Our main goal for this proposed project is to produce a reliable estimate of pre-spawning biomass of the population of Pacific herring during 2020 in support of the BASA model.**

As in recent years, we intend to continue to survey the two main spawning aggregation regions (Port Gravina and Fidalgo, and along the northeast coast of Montague Island). This will allow us to continue generating estimates of the pre-spawning herring biomass in PWS and provide an alert to changes in biomass in these two different regions. While our survey does not include the full extent of spawning habitat in the PWS, we assume here that surveys in these two regions account for the majority of spawning activity that occurs each spring. We feel this is a reasonable assumption given the aerial survey results that monitor herring aggregations, predators, and distribution of milt. While we have focused on these two regions in recent years, other regions may also be surveyed depending on result of aerial surveys and other indicators. We propose to carry out this assessment in spring (March-April). This project will use the Alaska Department of Fish and Game data from direct sampling for age, sex and length in the estimates of biomass. The estimate will then be provided to the modeling project.

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

FY17	FY18	FY19	FY20	FY21	TOTAL
74,200	73,800	75,500	77,300	79,100	379,900

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

FY17	FY18	FY19	FY20	FY21	TOTAL
$0	$0	$0	$0	$0	$0

1. PROJECT EXECUTIVE SUMMARY

We completed acoustic surveys in Port Gravina, Windy Bay, Double Bay, Rocky Bay, Stockdale Harbor, Zaikof Bay, and Canoe Pass during the spring of 2019 (1-9 April 2019). The survey area was informed by the results of aerial milt surveys conducted this spring by the Alaska Department of Fish and Game (ADF&G). In particular, we included some additional sites in eastern PWS (Windy Bay, Double Bay, and Canoe Pass) based on aerial observations of milt and predators in those locations. This expanded survey coverage compared to recent years was possible given additional funds provided for ship-time on this project. We also conducted an acoustic calibration exercise in Windy Bay during the cruise. Raw acoustic data have now been uploaded to the Alaska Ocean Observing System (AOOS) Research Workspace, but we have not yet conducted the analysis to estimate biomass. We expect to have estimates completed by the third quarter and have the annual report completed in the final quarter of 2019. Results from ongoing surveys in recent years indicate persistent, very low biomass estimates of pre-spawning herring (Figure 1). A shift has occurred over the time series, with a greater proportion of the biomass observed in the eastern part of Prince William Sound over the recent decade. **Our main goal for this proposed project is to produce a reliable estimate of pre-spawning biomass of Pacific herring during 2020 in support of the ASA and BASA models.**

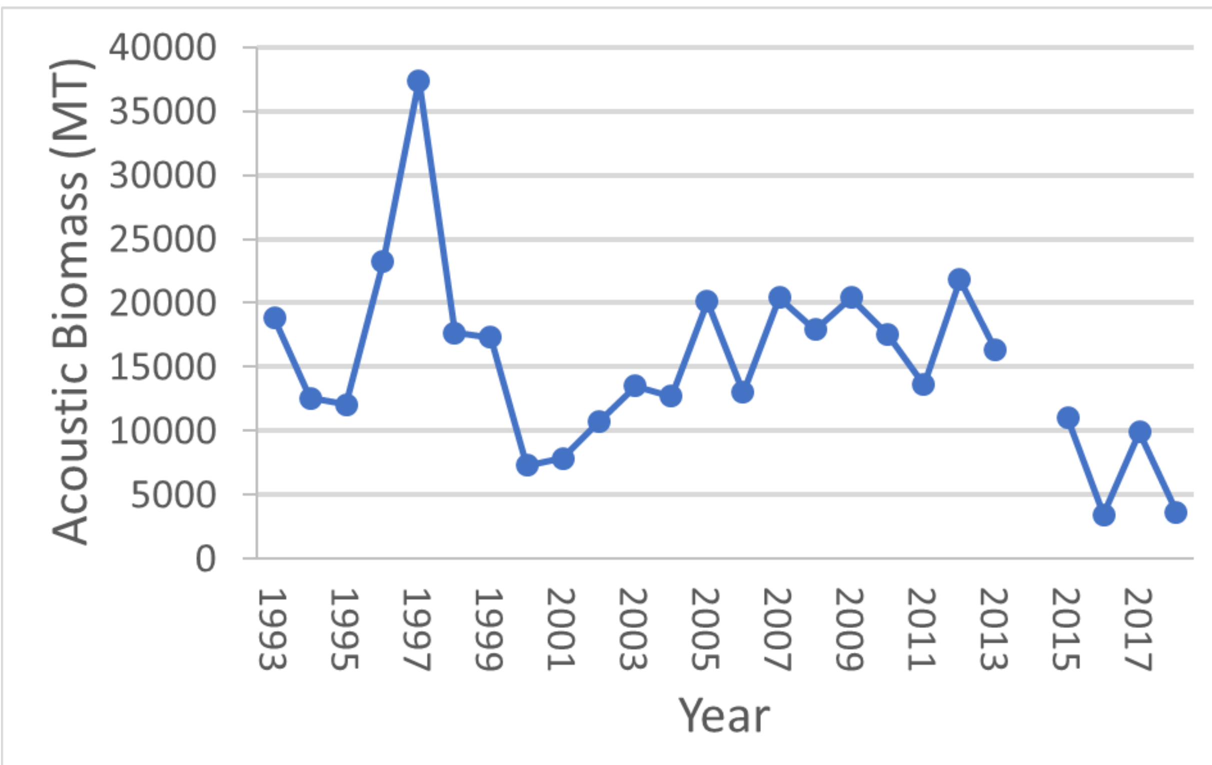

Figure 1. Time series of acoustic biomass estimates in metric tonnes (mt) of pre-spawning Pacific herring in Prince William Sound during 1993-2018. The survey conducted during 2014 did not yield a biomass estimate due to adult herring occupying water too shallow to survey effectively with hydroacoustics.

2. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

A. Project Milestones and Tasks

Table 1. Project milestones and task progress by fiscal year and quarter, beginning February 1, 2017. 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
Administration & Logistics																				
Contracting for ship time	C				C															
Permitting	C				C				C				X				X			
Data Acquisition & Processing																				
Research cruise	C				C				C				X				X			
Post processing			C				C				X				X			X	X	
Data Management																				
Database mgmt./QAQC			C				C				X				X				X	
Metadata (HRM)			C				C				X				X				X	
Workspace upload			C				C				X				X				X	
Analysis & Reporting																				
Analysis and summary				C				C				X				X			X	X
Annual reports					C				C				X				X			
Permit reports				C				C				X				X				
FY work plan (DPD)			C				C				C				X					
FY17-21 Final Report																				X
Conferences and Meetings																				
Annual PI meeting				C				C				X				X				X
Publications																				
Manuscript							C													

B. Explanation for not completing any planned milestones and tasks

I am on track with milestones and tasks planned in FY19.

C. Justification for new milestones/tasks

No new milestones or tasks have been added.

3. PROJECT COORDINATION AND COLLABORATION

A. Within an EVOSTC-funded Program

Herring Research and Monitoring

Our project relies on data on mean lengths of pre-spawning herring collected in an allied project (Stormy Haught, ADF&G, PI).

Data we generate in our proposed field work will also support the BASA model analyses in Trevor Branch's University of Washington proposal (20120111-C).

Gulf Watch Alaska

Data collected under this project are available for use by Gulf Watch Alaska pelagic projects.

Data Management

We upload data in three different formats to the AOOS Research Workspace: raw acoustic data, intermediary summaries following echointegration, and final biomass by region and a summed index value for use in the ASA and BASA models. These data uploads are preformed according out milestones identified in 2A above.

B. With Other EVOSTC-funded Projects

N/A

C. With Trustee or Management Agencies

Results of our project are provided to ADF&G for use in their ASA model to help track trends and recovery of herring in Prince William Sound.

4. PROJECT DESIGN

A. Overall Project Objectives

Our main goal for this proposed project is to produce a reliable estimate of pre-spawning biomass of Pacific herring for each year during 2017-2021 in support of the ASA and BASA models. In support of this goal, we identify the following objectives:

1) Carry out a hydroacoustic survey prior to the herring spawning season to quantify biomass of adult herring in regions within PWS that have historically been important for spawning. Mean length of herring captured by direct methods (typically by purse seine) in an allied project allow us to estimate biomass.
2) When possible conduct repeated hydroacoustic sampling over transects to quantify precision of our biomass estimates.
3) Rely on reconnaissance by air or ship to assure our survey design is adapting to any changes in the spawning distribution of Pacific herring in PWS.

Overall Survey Design

A three-stage survey design has been established, and is described in a number of publications (e.g. Thomas and Thorne 2003). Given the interannual dynamics of herring aggregations, a fixed survey design would only be effective if it included a very large survey area to account for heterogeneity in distribution of herring from year to year. The amount of resources required given the very large sampling frame would be prohibitive. An approach that can be adapted each year to focus on regions that contain significant aggregations provides a more efficient and cost-effective solution to index the population. We describe each of the stages in detail below:

1. *Locate aggregation(s)*. We have been relying on several sources of information on distribution of herring to decide which regions to focus on. Traditionally there have been western and eastern spawning aggregations, with the former located mostly near the northeast coast of Montague Island (including Zaikof Bay, Rocky Bay, and Stockdale Harbor), and the latter located in Fidalgo Bay and Gravina Bay. Smaller aggregations have been observed in other parts of PWS, but have not been consistently surveyed, and we assume they are (collectively) a small contributor to the PWS spawning population. We rely on a combination of observations from aerial surveys conducted by ADF&G, early-season ship surveys contracted through PWSSC (visual observations and ship-board sonar), and more anecdotal observations from other flights, vessels, or observations by residents of coastal communities (e.g. Tatitlek). Indicators of pre-spawn herring include direct observations of schools and foraging activity of herring predators, including whales, sea lions, and seabirds.
2. *Conduct systematic survey within the spatial sampling frame.* Once evidence of aggregations exist, cruises are planned to those regions with scientific echosounder equipment (we currently use 70 kHz and 120 kHz echosounder systems produced by Biosonics). While the surveys are conducted at night, daytime observations (visual, as well as ship-board sonar) are gathered to provide additional information on distribution of schools, although many herring are close to the seabed during the day and may not be detectable by sonar. The sample frame is defined to encompass the aggregation and a series of parallel zigs and parallel zags (approximately 2 km separation) are charted to serve as the survey transects. The sampling frame is informed, in part, on spatial patterns of milt observed in previous years in addition the spatial patterns in herring schools and predators just prior to our acoustic survey as described above. The largest aggregation, typically observed in Port Gravina in recent years, encompasses approximately 8 km of shoreline (from mouth of St. Matthews Bay to Red Head), and transects extend just beyond the 60 m isobath (some transects pass over depths > 80 m). In Gravina we have included 8 separate transects (4 zigs and 4 zags) that add up to a total transect length of approximately 12-15 km. This is equivalent to a systematic survey with evenly spaced transects within the established sampling frame. We begin the survey at dark (typically about 10-11 PM), and the survey takes approximately 4-5 hours to complete. Conducting acoustic surveys at night is advantageous as schools are generally higher in the water column and individuals are more dispersed which decreases the likelihood of acoustic shadowing which tends to produce bias in acoustic surveys. Our transducer is fixed down-looking on a towfin, and the towfin is towed about 1 m below the surface. Vessel speed is approximately 2-3 knots, and all ship-board lights are turned off. Sonar pulse width is set at 0.4 ms, with a ping rate of 1 per second. Similar survey designs are established in other regions to accomplish our main objective. An effort is made to repeat the survey over consecutive nights to provide an estimate of precision on our biomass estimate, although this has been difficult in recent years as herring distribution is more ephemeral and the “staging period” prior to spawning appears to now be very brief. As a result, we have not been able to obtain estimates of precision in recent years.
3. *Estimate mean target size in the surveyed aggregation.* We coordinate with another vessel (ADF&G vessel, *R/V Solstice*) to carry out the third stage involving direct capture of herring to estimate mean target size. We use an established relationship between target strength and backscatter (dB re m^{-2}, Thomas et al. 2002) that requires an unbiased estimate of the mean herring length in the surveyed aggregation, ideally collected in each region during the same night of the acoustic survey. In past surveys (particularly one conducted during daylight hours when school are generally deeper), target strengths are adjusted to account for gas bladder compression at depth (Thomas et al. 2002). This has not been required in recent years as the mean depth of aggregations in nighttime surveys have not diverged from the depths at which the relationship was established (herring at ~ 40 m depth). ADF&G summarizes length at age and age composition of the net-captured individuals. We compute a mean length (SL) weighted by the age composition. The preference is to rely on purse seine catches, as this

gear is the most effective at sampling aggregations (generally deeper, and less selective than other gear). In past years, data on sizes were obtained from other capture gear when purse-seines were not deployed or were not effective (including cast nets and multi-mesh gill nets).

Data Collection, Processing, and Analysis

Acoustic data and GPS coordinates are saved during the survey as *.DT4 files on a laptop networked to the Biosonics DTX echosounder. Since 2016 I have collected calibration data. This involves recording target strength (dB) of a tungsten carbide sphere suspending by monofilament at 5-10 m below the face of the transducer (at least 300 echos are recorded, recording lasts about 5 minutes). This is typically done once a season at a location near the survey area just prior to a night's survey. These calibration data are also saved in a separate *.DT4 file. Calibration results have been stable over time and no adjustments to results have been needed.

Data from each night survey is first processed using Echoview (v. 5.0) to perform vertical echointegration. This software automatically detects bottom and creates a line. Some errors in bottom detection occur, so each echogram is visually inspected and the bottom line is adjusted accordingly. The data are filtered (-60 dB threshold) to remove smaller, non-fish targets. An image file (PNG) for each night's transect is produced from the software for use in the annual report (see example, Figure 1). The echo intensity is binned in cells by depth. These calculations are performed within Echoview and the backscatter measures (area backscatter coefficient, s_a (units m^2 m^{-2}), or nautical area backscatter coefficient ($s_{A,}$ NASC, units m^2 nm^{-2})) are exported in a comma delimited file. We limit the echointegration to the top 60 m of the water column. It should also be noted that the transducer is suspended approximately 1 m below the surface when the ship is underway on a transect, and we exclude data 1 m below the transducer face, the so-called blind zone due to transducer ringing and limited sampling volume. Thus, the ensonified survey area extends from ~ 2 m below the surface down to 62 m below the surface. If deeper aggregations are encountered (particularly if any surveys are conducted during the day, we adjust the lower depth threshold to extend the survey area into deeper water.

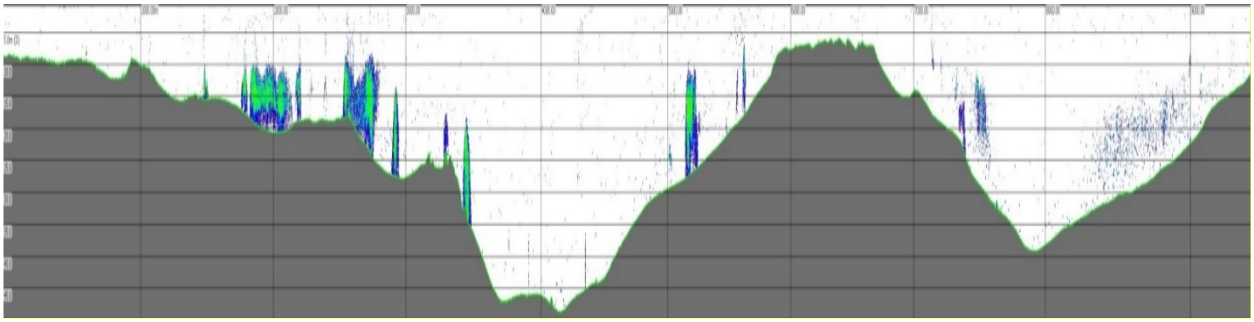

Figure 1. *Example echogram from transects conducted off of Hell's Hole in Gravina Bay, Prince William sound during 2 April 2016. Horizontal bars represent 10 m depth strata, and vertical bars represent 1 km intervals determined from GPS tracking of the vessel during the survey. Acoustic data shown are filtered by applying a minimum threshold of -60 dB.*

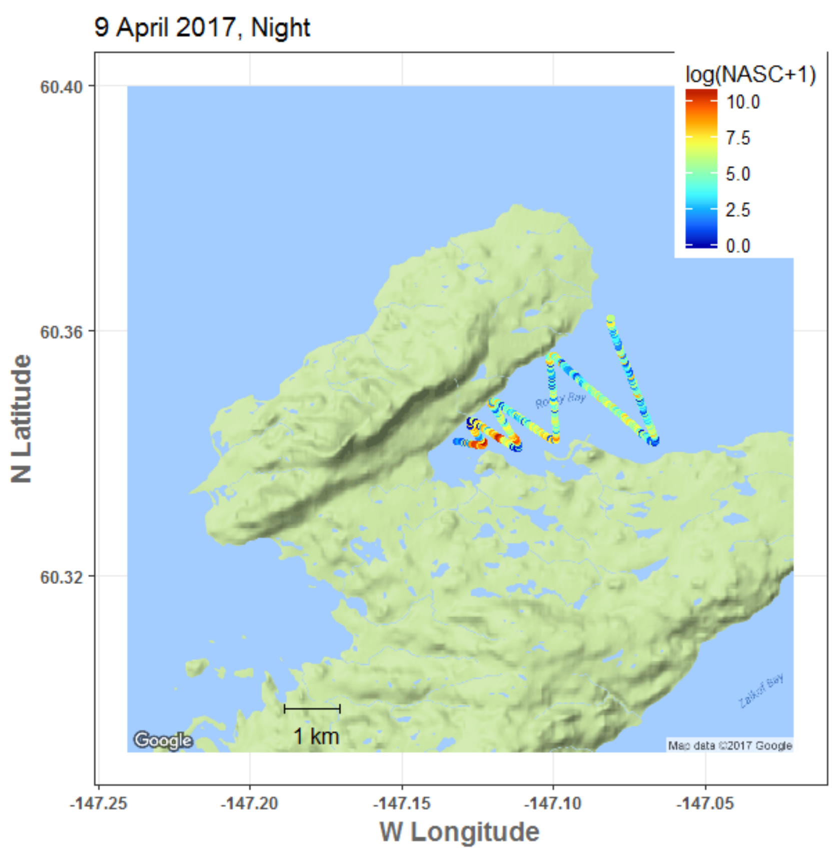

Figure 2. *Example transect conducted in Rocky Bay in Prince William Sound in on 9 April 2017. Colors along transect reflect backscatter (NASC, defined in text) integrated from the surface to 60 m depth. Acoustic data shown are filtered by applying a minimum threshold of -60 dB.*

The second and final analysis step involved uploading the output from Echoview in R statistical software to estimate the echo intensity of an individual herring target, estimate the biomass of herring along the transect, and extrapolate to the sampling frame to estimate herring biomass in the survey area. We first produce a map with the cruise track with backscatter measures represented using a false-color spectrum (see Figure 2). This provides a plan view that highlights locations along the transect where herring schools were encountered. The R code estimates the average biomass estimate for each ping along the entire transect, and this average is applied over the spatial extent of the sampling frame described above. The computation is as follows:

$$TS_w = -5.98\, log_{10}\,(L) - 24.23$$

where TS_w = target strength (dB re 1 kg herring) and L = standard length of herring (in cm). A backscatter scaler is computed as:

$$\sigma_{bs} = 10^{TS_w/10}$$

which represents the backscatter relative to 1 kg of herring (units $m^2\ kg^{-1}$).

The value of this may be adjusted in cases where herring depth distribution diverges from ~ 40 m. We then estimate average total backscatter per ping along the entire transect as:

$$\overline{s_a} = \sum_0^n s_{a,n}/n$$

where $\overline{s_a}$ is the backscatter per ping ($m^2\ m^{-2}$), and n is the number of pings along the transect. Biomass is calculated as:

$$Biomass = \overline{s_a}/\sigma_{bs} * SA * 1000$$

where SA is the total survey area estimated by computing the subset of points that lie on the convex hull (chull routine in R, in m^2), and 1000 converts kg to mt. We report biomass separately for each region surveyed in our annual reports, along with a summed index value for use in the ASA and BASA models.

In cases where precision of the estimate is calculated, we produce two estimates per survey-night (1 estimate derived from the transect zigs, and the other from the transect zags) and, when conducted over multiple nights, we estimate the mean and variance of biomass by considering each estimate as independent and drawn from a normal distribution. This has not been possible in recent years given the lack of evidence that the population is closed (no immigration or emigration from the survey area) over consecutive nights. Precision of the survey has been estimated during a period of overall higher abundance (CV range of 4.5-13.3% during 1993-2001, Thomas and Thorne 2003). It appears fish behavior has changed since these earlier surveys with fish likely moving in and out of the study area over multiple days, and this has frustrated efforts to estimate survey precision.

B. Changes to Project Design and Objectives

No changes.

5. PROJECT PERSONNEL – CHANGES AND UPDATES

No changes.

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	$39.5	$40.7	$41.9	$43.2	$44.5	$209.9	
Travel	$0.6	$0.6	$0.6	$0.6	$0.6	$2.8	$ -
Contractual	$10.8	$10.8	$10.8	$10.8	$10.8	$54.0	$ -
Commodities	$1.5	$0.0	$0.0	$0.0	$0.0	$1.5	$ -
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$ -
Indirect Costs (*will vary by proposer*)	$15.7	$15.6	$16.0	$16.4	$16.8	$80.4	
SUBTOTAL	$68.1	$67.7	$69.3	$70.9	$72.6	$348.5	$0.0
General Administration (9% of subtotal)	$6.1	$6.1	$6.2	$6.4	$6.5	$31.4	N/A
PROJECT TOTAL	$74.2	$73.8	$75.5	$77.3	$79.1	$379.9	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

B. Changes from Original Project Proposal

The budget for years 2019-2021 in our original proposal only included ship-time on the *R/V Solstice*. This shared ship-time scheme resulted in compromises in surveys resulting from competing project tasks. Having ship-time budgeted on a separate, chartered vessel for the project during years 2017 and 2018 allowed us to conduct a more extensive survey (often in regions separate from regions where the *R/V Solstice* was located) and we were able to response more quickly to observations of herring aggregations and predators. Because of the likelihood of compressed field seasons in the future (given recent patterns in fish distribution and behavior) and multiple, competing objectives among projects relying on the *R/V Solstice* as the sampling platform, compromises would need to be made that would ultimately limit the scope of the acoustic survey. Having two vessels operating simultaneously also provides an opportunity to observe, sample and survey simultaneously in both the eastern and western regions of the herring spawning range in PWS. I was granted additional ship-time support for acoustic surveys ($10K/yr) during FY19 that allowed us to conduct an extensive survey, and I would like to request the same amount of support in FY20.

C. Sources of Additional Project Funding

N/A

7. FY17-19 PROJECT PUBLICATIONS AND PRODUCTS

Publications

Rand, P.S. 2016. Final Report: Herring Program – Adult Pacific Herring Acoustic Surveys in PWS. Project 16120111-G

Rand, P.S. 2017. Annual Report: Herring Program – Adult Pacific Herring Acoustic Surveys in PWS. Project 17120111-G

Rand, P.S. 2018. Annual Report: Herring Program – Adult Pacific Herring Acoustic Surveys in PWS. Project 18120111-G

Rand, P.S. 2018. Pacific herring response to surface predators in Prince William Sound, Alaska, USA. Marine Ecology Progress Series 600:239-244.

Published and updated datasets

Raw data from adult acoustic biomass survey uploaded to HRM Research Workspace.

Summary of our survey design and analytical approach was produced at the request of Sherri Dressel at ADF&G during 2019.

Outreach

I provided information and was interviewed by Haley Hoover for a new Field Notes episode for HRM in 2019. It can be found here (https://pwssc.org/education/field-notes/) under "Acoustic Sampling of Herring".

LITERATURE CITED

Thomas, G.L, J. Kirsch and R.E. Thorne 2002. Ex situ target strength measurements of Pacific herring and Pacific sand lance, North American Journal of Fisheries Management **22**:1136-1145.

Thomas, G. L. and Thorne, R.E. 2003. Acoustical-optical assessment of Pacific herring and their predator assemblage in Prince William Sound, Alaska. *Aquatic Living Resources* 16:247-253.