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

Project Number and Title

21120111-G Adult Pacific Herring Acoustic Surveys in Prince William Sound

Primary Investigator(s) and Affiliation(s)

Peter S. Rand, Prince William Sound Science Center

Date Proposal Submitted

14 August 2020

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 conducted 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 2021. **Our main goal for this proposed project is to produce a reliable estimate of pre-spawning biomass of the population of Pacific herring during 2021 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 PWS, we assume 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 results from aerial surveys 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 in-season results 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 for Pacific herring in Port Gravina, Hawkins Island (Windy Bay and Canoe Pass), Double Bay, Rocky Bay, and Stockdale Harbor during the spring of 2020 (24 March - 3 April 2020). Because of some scheduling complications related to the coronavirus pandemic, our survey occurred a bit earlier than in the past few years. Aerial surveys by Alaska Department of Fish and Game (ADF&G) helped inform our surveys in eastern Prince William Sound (PWS), but there was little indication of spawning herring aggregations in the northeast region of Montague Island during our scheduled ship time, and our acoustic surveys occurred before aggregations formed there, and thus our estimates of herring biomass in western PWS will likely be biased low. We were able to survey most of the sites that were surveyed in 2019, with the exception of Zaikof Bay – very little evidence of aggregations were observed there in early April and we did not conduct any acoustic surveys there. 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 2020. Preliminary exploration of the acoustic survey data indicated most of the herring biomass was centered in Port Gravina during spring 2020, and there was a modest increase in herring biomass there compared to the past several years. Biomass estimates produced from this survey during 1993-2019 are presented in Fig. 1. **Our main goal for this proposed project is to produce a reliable estimate of pre-spawning biomass of Pacific herring during 2021 in support of the Bayesian Age Structured Assessment (BASA) model.**

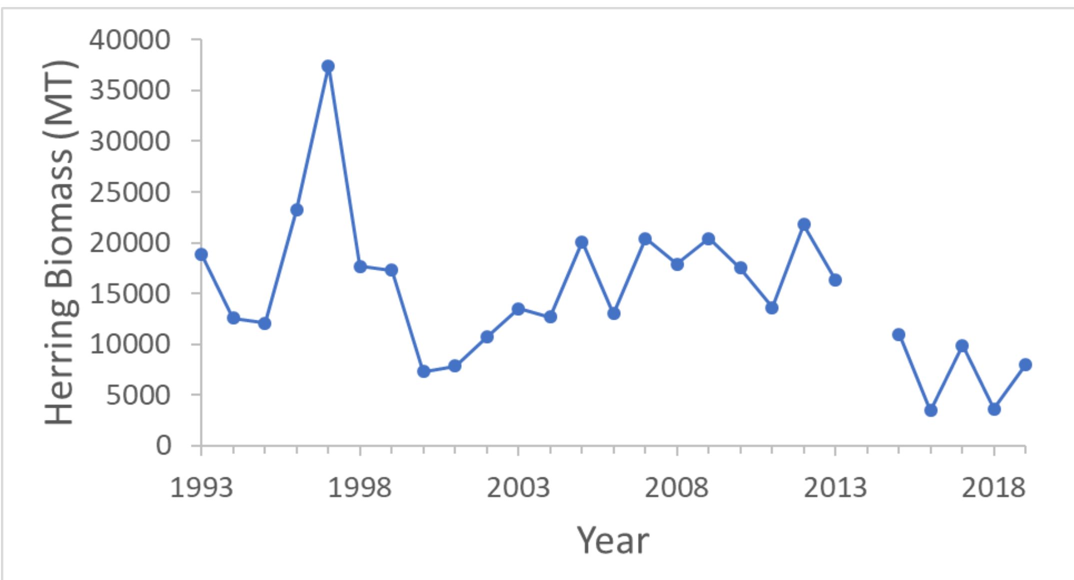

Figure 1. Time series of acoustic biomass estimates (MT, metric tonnes) of Pacific herring in Prince William Sound. The survey conducted during 2014 did not yield a biomass estimate due to adult herring occupying water too shallow to survey effectively with acoustics.

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. C = completed, X = planned or not completed. 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				C				C				X			
Permitting	C				C				C				C				X			
Data Acquisition & Processing																				
Research cruise	C				C				C				C				X			
Post Processing Data			C				C				C				X				X	
Data Management																				
Database mgmt./QAQC			C				C				C				X				X	
Metadata (HRM)			C				C				C				X				X	
Raw Data Upload		C				C				C				C				X		
Intermediate and Final Data Products Upload				C				C				C				X			X	
Analysis & Reporting																				
Analysis and summary				C				C				C				X				X
Annual Report				C				C				C				X				X
FY17-21 Final Report																				X
Conferences and Meetings																				
Annual PI meeting				C				C				C				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 FY20.

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

Gulf Watch Alaska

Data collected under this project are available for use by Gulf Watch Alaska pelagic component projects. Data from our annual acoustic surveys were included in a Gulf Watch Alaska science synthesis report chapter (lead author: Mayumi Arimitsu).

Herring Research and Monitoring

Our project relies on data on aerial surveys and mean lengths of pre-spawning herring collected in an allied project (21170111-F, Stormy Haught, ADF&G, principal investigator).

Data we generate in our proposed field work provides a primary data input to the BASA model in Trevor Branch's University of Washington proposal (21120111-C).

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. Timing of these data uploads are identified in our milestones 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 PWS.

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 pre-spawning 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 rely on several sources of herring distribution information 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 schools 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 Figure 2 as an example). The echo intensity is binned in cells by depth. These calculations are performed within Echoview and the backscatter measures (area backscatter coefficient, sa (units m2 m-2), or nautical area backscatter coefficient (sa, NASC, units m2 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.

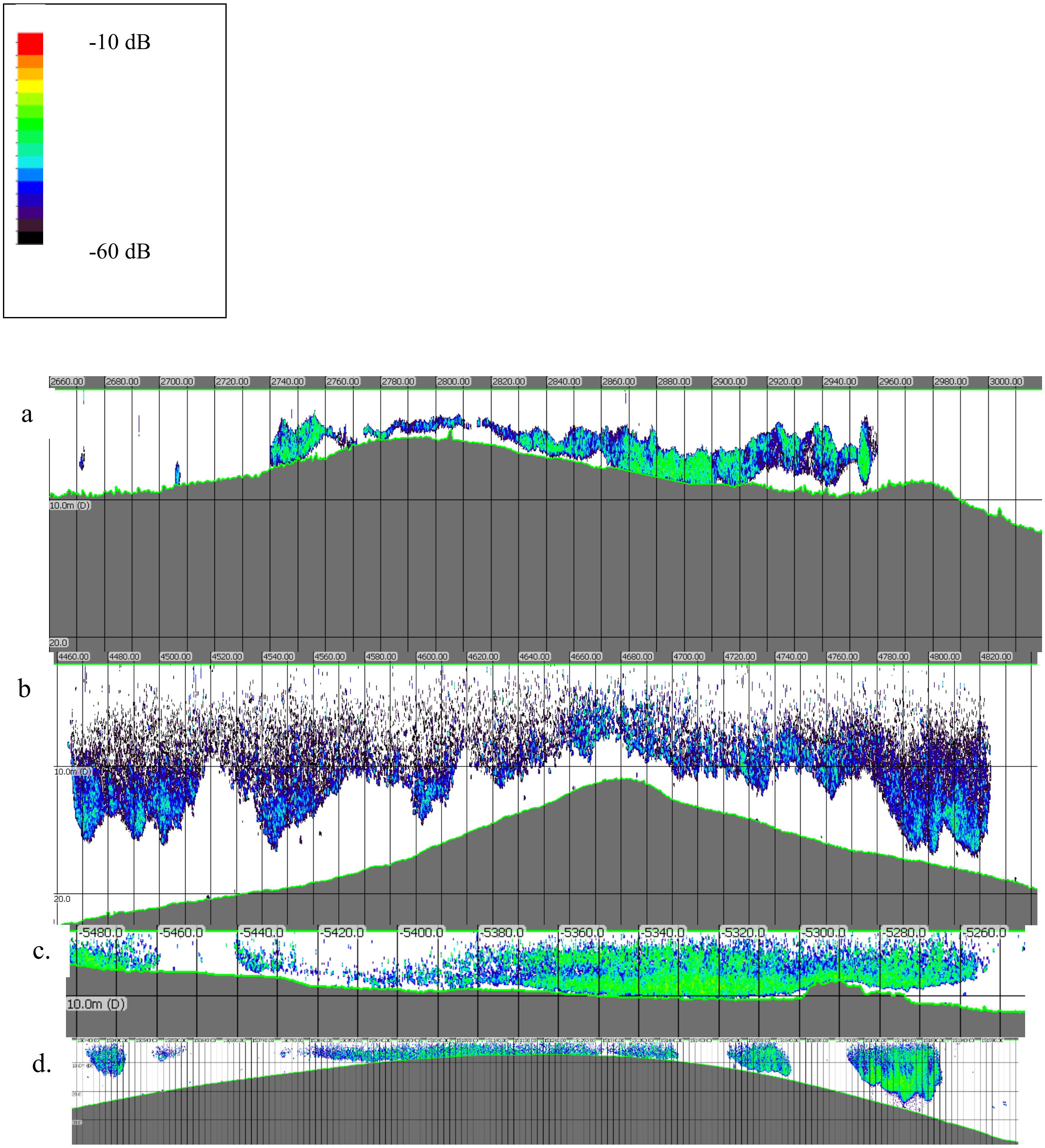

Figure 2a-d. Echograms (a. Gravina during day survey on 1 April, b. Double Bay on Hinchinbrook during night of 2 April 2019, c. the head of Rocky Bay on 7 April 2019, and d. Canoe Pass on Hawkins on the night of 7 April 2019) recorded at sites where the majority of herring occurred during the spring survey of 2019. Grid lines represent 10 m distance intervals along transect (vertical), and 10 m depth intervals (horizontal). 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 3). 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:

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

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

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

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. Our observation suggest aggregations are ephemeral (not lasting more than on or two days) which makes it difficult to complete replicate surveys at the aggregation sites. 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. We were able to carry out four separate surveys over the same area in Port Gravina during spring 2020, so it may be possible to derive an estimate of precision from this year's survey.

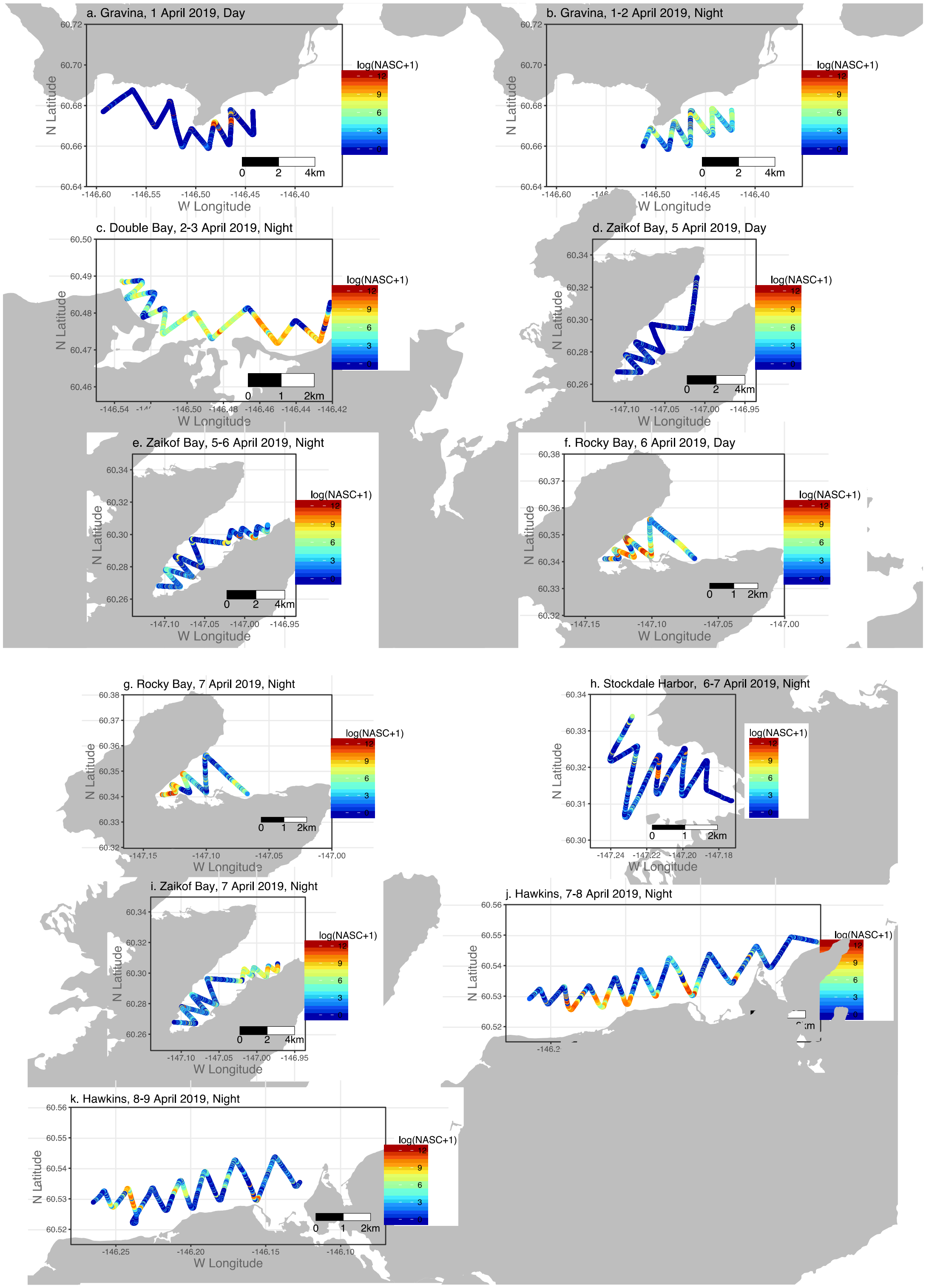

Figure 3. Transect configurations for each survey (a-k) with a false color spectrum indicating acoustic backscatter strength (logarithm of the nautical area scattering coefficient, or NASC, units m^2 nm^{-2}) at each point along the transect during the 2019 field season.

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 FY21 Budget Workbook)

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 2017-2019 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 respond 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 FY20 that allowed us to conduct an extensive survey, and I would like to request the same amount of support in FY21.

C. Sources of Additional Project Funding

N/A

7. FY17-20 PROJECT PUBLICATIONS AND PRODUCTS

Publications

Rand, P.S. 2018 Herring Program – Adult Pacific Herring Acoustic Surveys in PWS. *Exxon Valdez* Oil Spill Trustee Council Final Report (Restoration Project 16120111-G), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK.

Rand, P.S. 2018. Herring Program – Adult Pacific Herring Acoustic Surveys in PWS. FY17 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 17120111-G.

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

Rand, P.S. 2019. Herring Program – Adult Pacific Herring Acoustic Surveys in PWS. FY18 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 18120111-G.

Rand, P.S. 2020. Herring Program – Adult Pacific Herring Acoustic Surveys in PWS. FY19 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 19120111-G.

Published and updated datasets

Raw data from adult acoustic biomass survey uploaded to Herring Research and Monitoring Research Workspace during July 2020.

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

I provided data to Mayumi Arimitsu for a chapter in the synthesis volume, entitled "Reduced quality and synchronous collapse of forage species disrupts trophic transfer during a prolonged marine heatwave".

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".

I was interviewed and provided information and preliminary observations to Haley Hoover and Teal Barmore for PWSSC social media posts following the spring 2020 research cruise.

8. 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.