ATTACHMENT B. Annual Project Report Form (Revised 11.21.19)

1. Project Number:

20120111-G

2. Project Title:

Herring Program – Adult Pacific Herring Acoustic Surveys in PWS

3. Principal Investigator(s) Names:

Peter S. Rand

4. Time Period Covered by the Report:

February 1, 2020-January 31, 2021

5. Date of Report:

March 2021

6. Project Website (if applicable):

https://pwssc.org/herring/

7. Summary of Work Performed:

ABSTRACT

We successfully completed acoustic surveys in March-April 2020 to continue a long-term data series on biomass estimates of the spawning population of Pacific herring in Prince William Sound. We completed twelve separate surveys during 24 March – 3 April within four regions in Prince William Sound: 1) Port Gravina, 2) Hinchinbrook Island near Double Bay, 3) Hawkins Island near Canoe Pass, and 4) Rocky Bay and Stockdale Harbor in the northeast region of Montague Island. All surveys were conducted off a chartered vessel (*M/V Auklet*). The greatest biomass was observed in Port Gravina during the evening of 29 March (11,808 MT over a survey area of 27.1 km^2). In addition, we quantified biomass at two other locations during night time hours on 27-28 March: 1) near Canoe Pass on Hawkins Island (4,906 MT), and 2) Double Bay on Hinchinbrook Island (1,326 MT). We conducted reduced acoustic surveys in the northeast region of Montague Island (Rocky Bay and Stockdale Harbor) during 1-3 April, but observed very little sign of herring in these locations. We suspect that our survey occurred prior to the formation of aggregations in the northeast region of Montague Island based on observations during aerial surveys. By summing the largest biomass estimates from each site, we arrived at a total biomass of 18,245 MT, representing the highest biomass recorded since 2012. We provided these estimates to Herring Research and

Management principal investigators for input in the age structured assessment and Bayesian stock assessment models to meet the objective of supporting on-going stock assessment work.

SURVEY and ANALYSIS METHODS

Hydroacoustic survey methods are well documented and well established in fisheries (Thorne 1983a,b; Simmonds and MacLennon 2005). They have been applied to Pacific herring for over forty years (Thorne 1977a,b; Trumble et al 1983). The specific methods used in Prince William Sound (PWS) are well documented (Thomas et al. 1997, Thomas et al. 2002, Thomas and Thorne 2003, Thorne and Thomas 2008). Below we provide a summary of the general methods applied for analysis of acoustic data collected during spring 2020.

A three-stage sampling design (Cochran 1977) is used for the acoustic surveys in PWS. Adult herring during the extended winter period in PWS are typically located in a few select bays and inlets and are distributed primarily in large, midwater schools or dense layers at night. Since 1995, survey efforts have focused on the late winter/early spring prespawning distribution when the herring are most concentrated. The initial survey stage focuses on locating adult herring aggregations within PWS. As in years past, we primarily relied on aerial surveys of foraging marine mammals, especially Steller sea lions and humpback whales, to determine general location of spawning aggregations.

After the herring are located, the second stage consists of echo integration surveys over the areas occupied by the herring schools (Thorne 1971, 1983a,b; MacLennan and Simmonds 1992; Simmonds and MacLennon 2005). To collect acoustic data, a BioSonics 120 kHz digital single-beam transducer was mounted down-looking on a 30 cm long aluminum towfin and deployed off the M/V *Auklet*. The echosounder was configured to transmit 1 ping s-1 with a pulse duration of 0.4 ms. Transects were conducted after sunset, and the deck lights were extinguished to avoid responses of herring to light. Tow speeds were maintained at approximately 2-3 knots and the transducer was positioned approximately 1-2 m below the surface. Position of the vessel along the transect was recorded with a Garmin 17x NMEA 0183 high-sensitivity GPS (accuracy rating under typical conditions < 10 m) connected via a power/data cable to the BioSonics DT-X top box so GPS coordinates were integrated as a cruise track into the *.DT4 data files. All surveys during spring 2020 were conducted during nighttime hours. Due to problems getting access to gear in Cordova due to COVID-19 health restrictions, we were unable to carry out a field calibration of the echosounder system during this survey. When feasible, the surveys were repeated several times to develop multiple estimates of the biomass of specific fish aggregations. We obtained herring size information from the Alaska Department of Fish and Game (ADF&G) for use in our biomass calculations.

The size composition of the herring in the net catches were used to estimate target strengths for converting backscatter to biomass. The general target strength equation used in PWS is:

$$TS_w = -5.98 \mathrm{Log}(L) - 24.23$$

Where TS_w is the target strength (decibels) per unit weight, w is weight in kg and L is standard length in cm. Based on data provided by ADF&G, we used the following mean standard lengths (weighted by age composition) to represent mean target strengths for herring in our analyses: 18.5 cm (Gravina, average of Hell's Hole and Redhead age, sex, and length [ASL] samples), and 18.0 cm (captures at Hawkins near Canoe Pass). We applied a mean of these two regions (18.2 cm) to apply to our other surveys at Double Bay on Hinchinbrook, Rocky Bay, and Stockdale Harbor.

This equation applies to the typical night-time depths of herring during the late winter/early spring period (specifically 40 m). No alterations were made for different depths in the 2020 data set (Thomas et al. 2002) – in some past years adjustments were made if herring occupied depths much greater than 40 m. We have not observed deep schools of herring in recent years. Dates of the surveys are provided in Table 1.

The acoustic survey in 2020 were carried out during one research cruise on the *M/V Auklet.* We focused on surveys in the eastern PWS during the initial part of the cruise (24 March – 2 April). We than transited to Montague Island to carry out surveys during the remainder of the cruise (3 April). Under our normal protocol, we would have returned to Cordova and waited later to conduct the survey in the northeast Montague Island region, but the scientific crew aboard the *M/V Auklet* were under COVID-19 quarantine and were unable to return to port. As a result, our Montague Island survey was timed early and we likely missed the aggregation there. We relied on reports from ADF&G aerial surveys to plan surveys. As in past years, we also relied on our own observations (visual or observations using the ship's sonar) to determine locations of surveys and configure transects to effectively survey the encountered aggregations. A more thorough description of the sampling approach used in these surveys can be found in Rand (2019).

We provide estimates of standard error (SE) and coefficients of variation (CV) on the surveys that yielded the greatest estimates of herring biomass by applying a non-parametric bootstrap method. We resampled with replacement the biomass estimated from echointegration data calculated over 1 km intervals over the entire cruise track separately in each region. We resampled 10,000 times to produce estimates of standard error for each survey. We used the 'boot' package in R (v. 1.3-26) to produce error estimates.

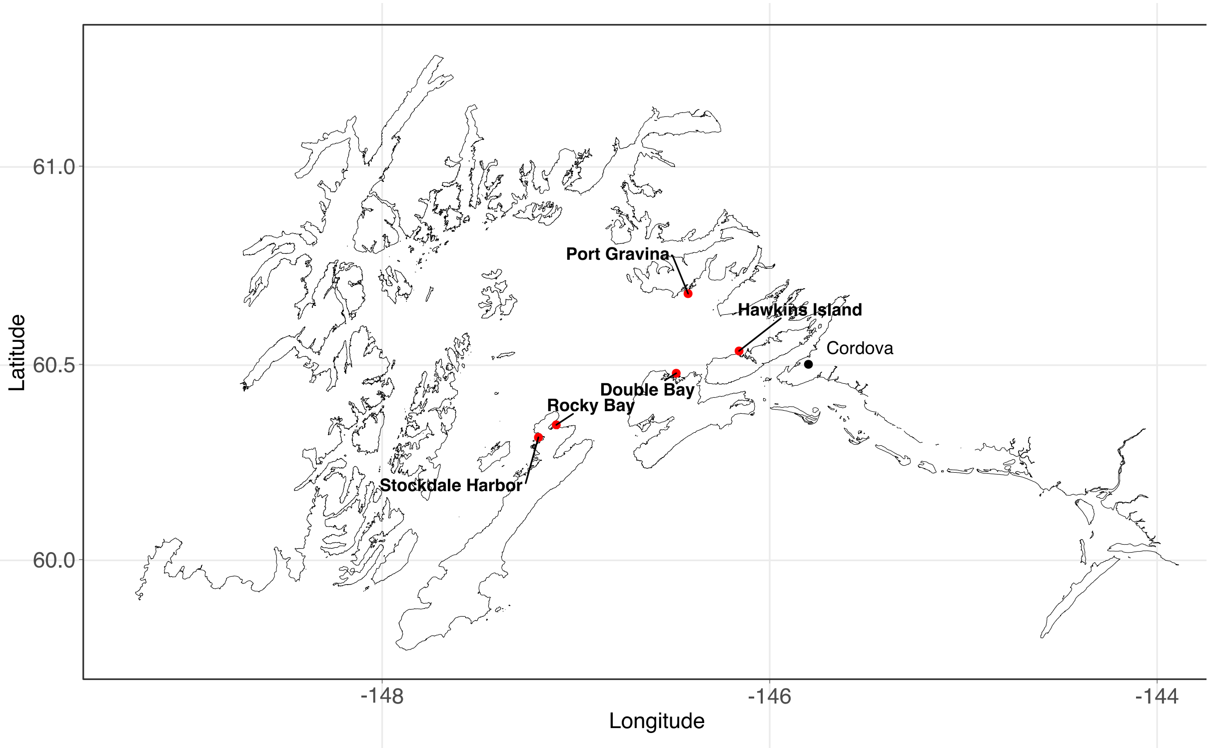

Figure 1. Location of acoustic surveys conducted during March-April 2020 in Prince William Sound, Alaska.

RESULTS

We successfully completed 12 acoustic surveys in five different locations during the 2020 spring survey season (Fig. 1). As in recent years, we observed an aggregation of herring in Port Gravina, a region which has typically supported the largest aggregations. We arrived at Port Gravina during the afternoon of 24 March. As in previous years the aggregation was observed to be close to shore and restricted to a small area just east of Knowles Head to Hell's Hole in 10-20 m of water (Figs. 2, 3). During this day, and in subsequent days, we noted a general lack of predators in the area, which we noted to be very different from previous years.

During 24 March – 2 April we conducted surveys across the three eastern sites (Gravina, Canoe Pass on Hawkins Island, and Double Bay on Hinchinbrook Island). We conducted a total of four separate surveys in Gravina (Figs. 2, 3), three surveys at Hawkins Island (Fig. 4), and two surveys at Double Bay. Our greatest estimate of herring biomass was obtained during the night survey on 29 March in Port Gravina (11,808 MT, Table 1) with the majority of herring occupying the middle to eastern end of the survey area (Figs. 2, 3). It appeared the herring aggregation moved eastward during the survey period.

Based on aerial observations, we added additional surveys at Hawkins and Hinchinbrook islands. Our greatest biomass at Hawkins Island (near Canoe Pass) was obtained during the night of 27 March (4,906 MT, Table 1), and herring appeared to be more abundant near shore compared the other surveys on 1-2 April. We observed less herring near Double Bay on Hinchinbrook Island. Of the two surveys we conducted there (27 and 31 March), we produced the highest biomass estimate on the first of the two surveys (1,326 MT, Table 1).

We visited Zaikof Bay, Rocky Bay, and Stockdale Harbor during 3 April. We made observations from the ship's sonar in Zaikof Bay and concluded no herring aggregations had formed there. We conducted two limited acoustic surveys in Rocky Bay and one in Stockdale Harbor, all conducted during nightime hours. All of these surveys produced minimal estimates of herring biomass (combined 205 MT, Table 1).

Based on the largest estimates produced at each survey site, we produced a total biomass estimate in 2020 of 18,245 MT (Table 1). This estimate is larger than that produced in any year since 2012 (Fig. 5). We noted in last year's report that the majority of biomass during 2019 was observed in regions outside of Port Gravina, an unusual result. Results from this year were more consistent with the general pattern of most spawners aggregating in Port Gravina. As noted earlier, this year was unusual with markedly fewer predators in all our survey areas, including relatively few humpback whales, sea lions, and sea birds.

As in past years, observations indicated that herring aggregations were ephemeral, forming and breaking up over intervening periods between acoustic surveys. As a result, we were not confident that the multiple surveys we conducted at some of our sites could be considered survey replicates of a single, discrete aggregation. We note here that over 4 replicate surveys conducted in Port Gravina, the biomass estimates ranged from a low of 1,472 MT to a high of 11,808 MT (Table 1). As in previous years we chose the surveys in each region that yielded the greatest biomass estimate to provide input into the age structured assessment and Baysian stock assessment models. We estimated variance for each of the surveys that contributed to our overall biomass estimate by applying a non-parametric bootstrap method. Estimates of the coefficient of variation (SE/mean) ranged from 26.0-59.6% across the surveys (Table 1). The range of variances was narrower if only the three regions that yielded the greatest amount of biomass were included (Gravina, Hawkins, and Double Bay, CVs of 26.0-38.6%, Table 1). It should be noted that this method of estimating variance differs from that estimated by Dick Thorne in earlier surveys. These early estimates of precision were based on estimating variance across separate surveys, not bootstrapping from a single survey as has been done here.

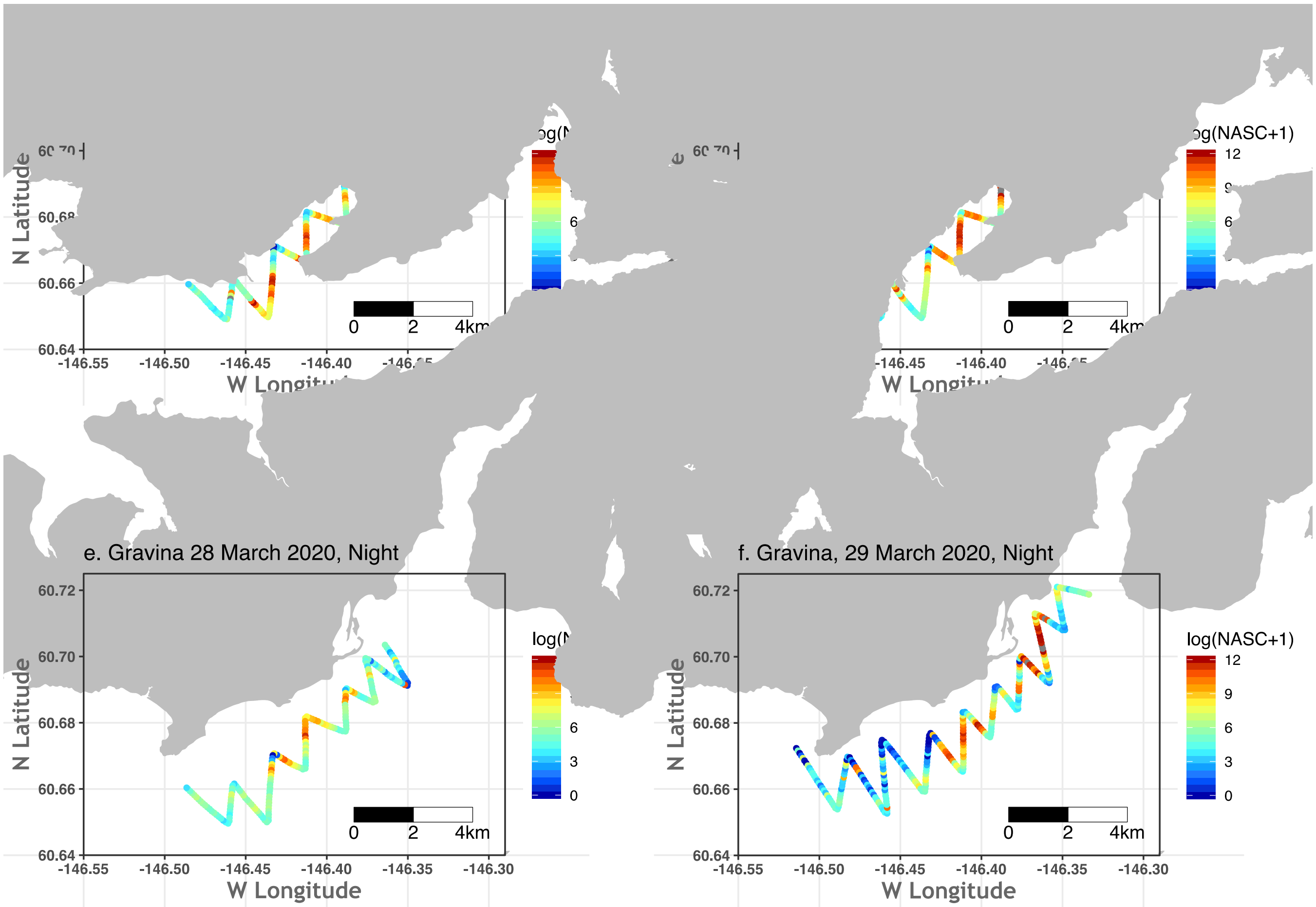

Figure 2. Transect configurations for Gravina surveys with a false color spectrum indicating acoustic backscatter strength (logarithm of the nautical area scattering coefficient [NASC], units m^2 nm^{-2}) at each point along the transect during the 2020 field season.

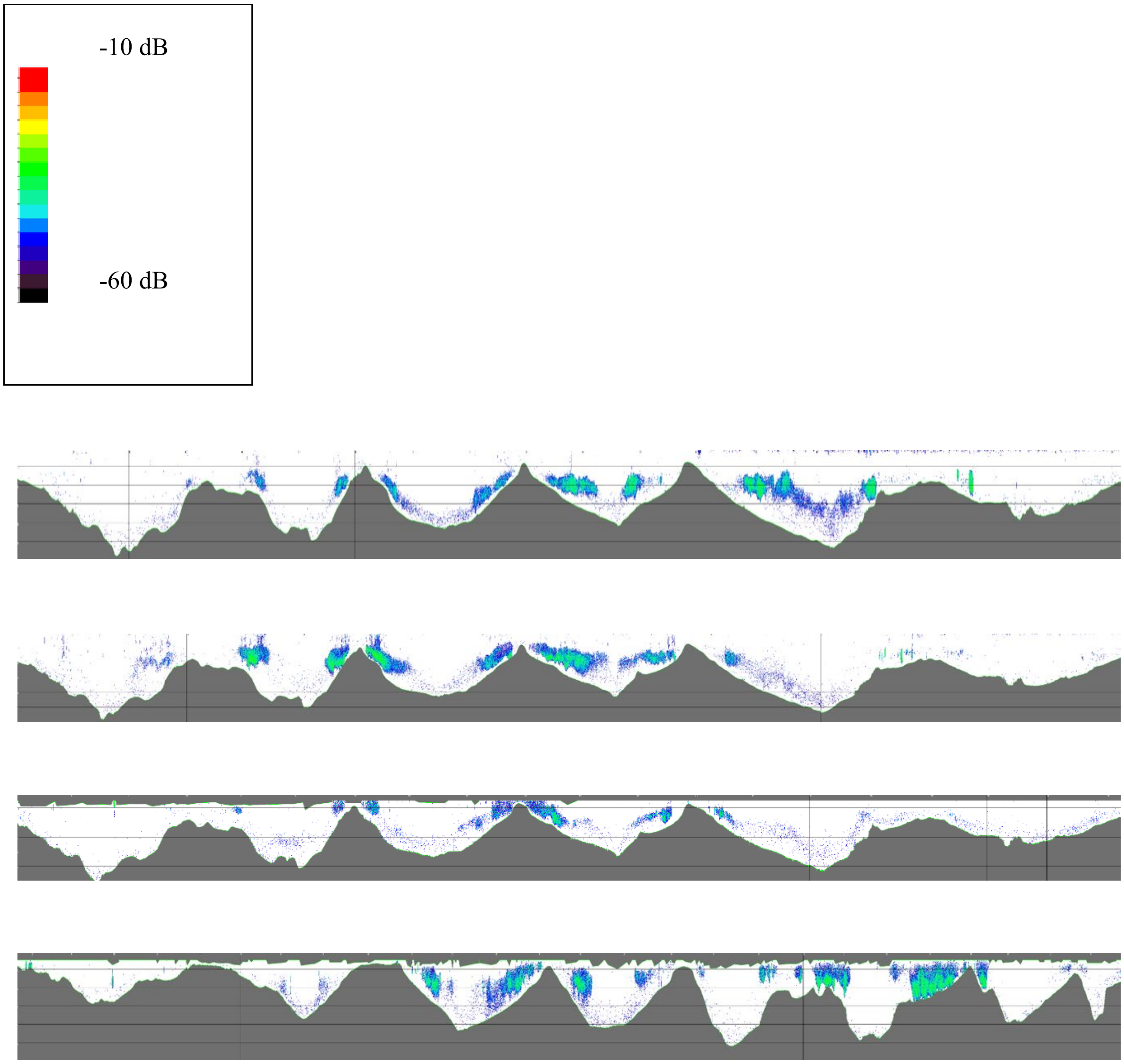

Figure 3. Echograms from night surveys in Gravina *(from top to bottom, 24 March 2020, 25 March 2020, 28 March 2020, 29 March 2020). Grid lines represent 1000 m distance intervals along transect (vertical), and 10 m depth intervals (horizontal). Acoustic data shown are filtered by applying a minimum threshold of -60 dB.*

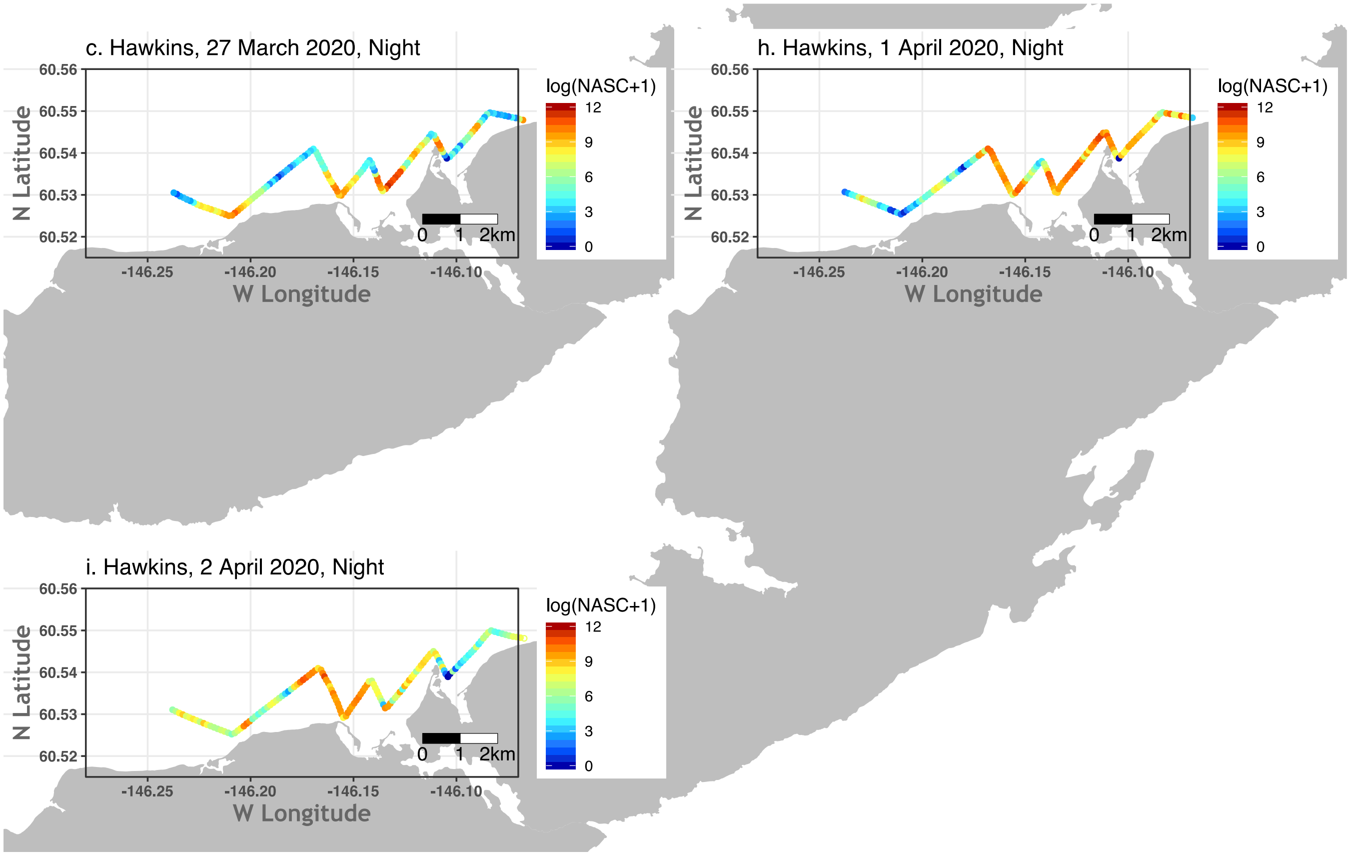

Figure 4. Transect configurations for Hawkins Island surveys with a false color spectrum indicating acoustic backscatter strength (logarithm of the nautical area scattering coefficient [NASC], units m^2 nm^{-2}) at each point along the transect during the 2020 field season.

Table 1. Biomass estimates of adult Pacific herring during the 2020 spring cruise. Shaded rows with bold font are the survey results used to estimate total herring biomass that appears in the bottom row. Standard errors (1SE) and coefficients of variation (CV) determined through bootstrap method for selected surveys. A more detailed description of sample methods and analysis is provided in the text.

Location	Date	Time of Survey	Survey Area (km^2)	Biomass Estimate (mt)	1SE	CV
Gravina	24 March	Night	13.2	3,746		
Gravina	25 March	Night	12.0	6,485		
Hawkins	**27 March**	**Night**	**16.0**	**4,906**	**1,277**	**26.0%**
Double Bay	**27 March**	**Night**	**4.9**	**1,326**	**512**	**38.6%**
Gravina	28 March	Night	14.2	1,472		
Gravina	**29 March**	**Night**	**27.1**	**11,808**	**3,621**	**30.7%**
Double Bay	31 March	Night	3.8	369		
Hawkins	1 April	Night	15.9	4,318		
Hawkins	2 April	Night	16.0	2,474		
Rocky Bay	**3 April**	**Night**	**0.2**	**111**	**51**	**46.0%**
Rocky Bay	3 April	Night	0.3	81		
Stockdale	**3 April**	**Night**	**3.2**	**94**	**56**	**59.6%**
Total:				**18,245**		

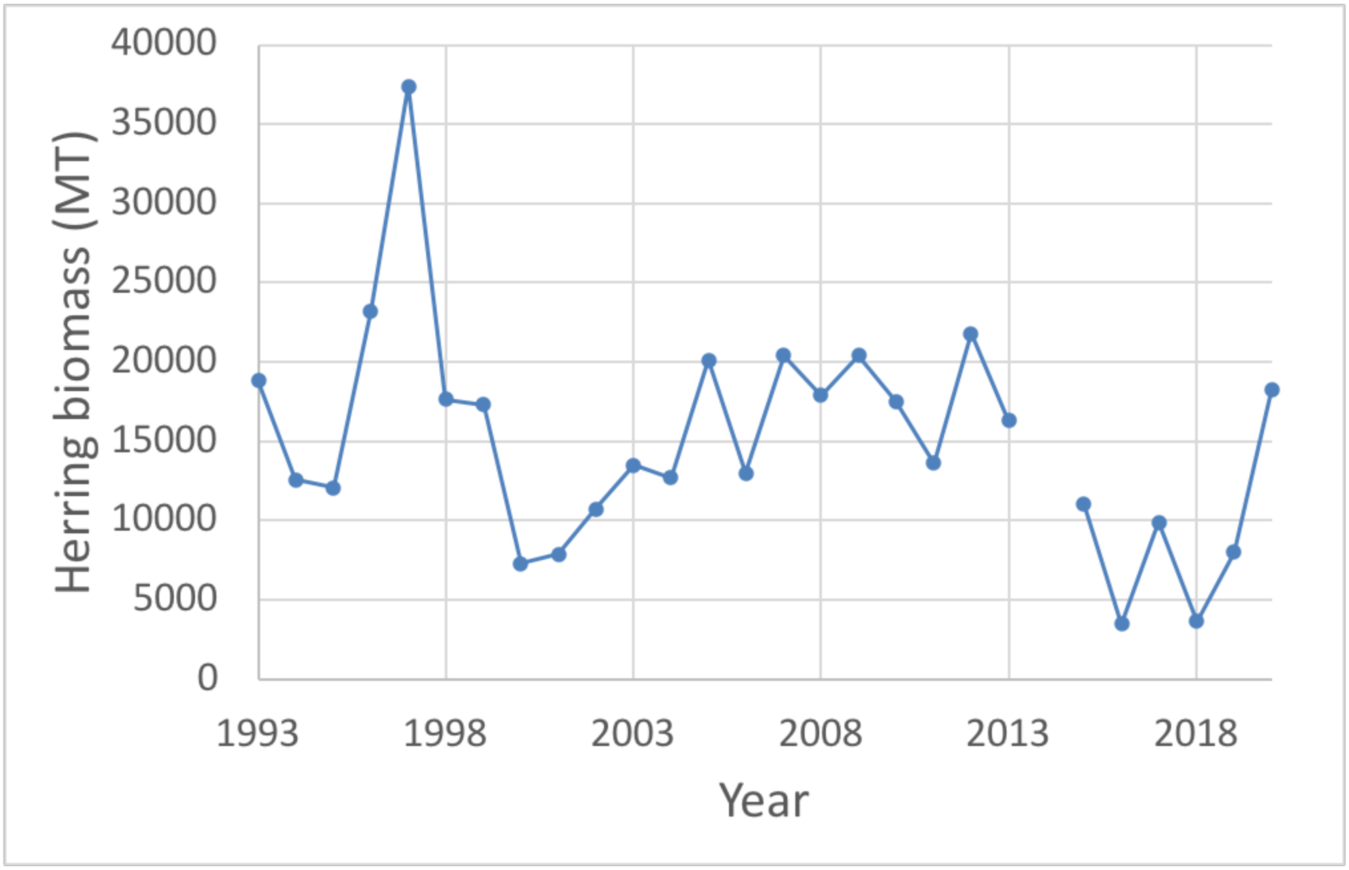

Figure 5. Time series of acoustic biomass estimates (MT, metric tonnes) of Pacific herring in Prince William Sound. The survey conducted during 2014 did not yield a biomass estimate due to adult herring occupying water too shallow to survey effectively with acoustics.

8. Coordination/Collaboration:

A. Long-term Monitoring and Research Program Projects

1. Within the Program

We primarily coordinated and collaborated with Herring Research and Monitoring (HRM) project 20160111-F (Herring Program – Surveys and age, sex and size collection and processing). We relied on this project to provide reports on distribution of herring from aerial surveys during the field component of our project and mean size of Pacific herring for use in generating biomass estimates from our acoustic data. We shared biomass estimates for use in stock assessment modeling with Trevor Branch and John Trochta at University of Washington. We presented preliminary results of survey during the November 2020 HRM PI meeting.

2. Across Programs

a. Gulf Watch Alaska

We provided acoustic estimates of herring biomass to Mayumi Arimitsu of USGS for use in a synthesis analysis and manuscript as part of the Gulf Watch Alaska program during 2020.

b. Data Management

Survey data and metadata were entered onto the Workspace.

B. Individual Projects

This project does not have connections with any of the projects outside the large programs.

C. With Trustee or Management Agencies

We work with ADF&G to coordinate surveys based on their aerial survey and age-sex-length sampling. We depend on the ADF&G data for final processing of the acoustics information.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

1. Peer-reviewed Publications

None during the reporting period.

2. Reports

Haught, S. W.S. Pegau, and P. Rand. 2019. Chapter 1 PWS herring survey designs. In, W.S. Pegau and D.R. Aderhold, editors. Herring Research and Monitoring Science Synthesis. Herring Research and Monitoring Synthesis Report, (*Exxon Valdez* Oil Spill Trustee Council Program 20120111). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

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

3. Popular articles

None during the reporting period.

B. Dates and Locations of any Conference or Workshop Presentations where EVOSTC-funded Work was Presented

1. Conferences and Workshops

None during the reporting period.

2. Public presentations

None during the reporting period.

C. Data and/or Information Products Developed During the Reporting Period, if Applicable

Raw acoustic data from the spring 2020 survey were uploaded to the AOOS Research Workspace data portal on 8 July 2020. Intermediary acoustic summary files were uploaded on 9 February 2021, and the final biomass estimate was added to the time series and made public on 9 February 2021. Preliminary acoustic biomass estimates were shared with HRM PIs during the November 2020 PI meeting during a presentation.

D. Data Sets and Associated Metadata that have been Uploaded to the Program's Data Portal

See C. above.

10. Response to EVOSTC Review, Recommendations and Comments:

Sept 2020: Science Panel Comment – FY21: For the short-term, the SP recommends approving the request for $10 K again (also see last year's SP comments) this coming year to support a second vessel for the reasons stated in the proposal. However, again the SP had an extensive discussion on the value of this project to the program. The SP recognizes the utility of the information provided from this project as a component of the stock assessment process. We also note that the EVOSTC has supported this work for decades but, relative to virtually all other projects, there has been a paucity of published scientific reports, published either in the grey literature or in peer-reviewed journals. This project has untapped opportunities to test hypotheses and to advance the understanding of the biology, life history and dynamics of Pacific herring in PWS. The perspective of the SP is that there is scope to address a number of important aspects of herring biology that could be presented in citable literature. In particular we note that the reliance of the project on reports that are now more than 30 years old does not inspire confidence that the work continues on the cutting edge with respect to the understanding the biology of herring in PWS or elsewhere. We note that the cited literature in the present and past proposals, and the annual reports, comments mainly on aspects of distribution and changes in distribution in time, and, especially, temporal changes in oceanographic conditions and temporal distribution changes in distribution and abundance of other species that might impact herring. There might also be scope to comment on the ways that schools are configured by depth and other hydrographic variations. Surely, there must be more that the proponents can do to synthesize results from past work. We strongly encourage the PI and their colleagues to consider how they might extract more useful information from past and recent work.

Moving forward this project will need integration, synthesis, and hypotheses testing to be considered for awards for the next Invitation. Also, future proposals should contrast the current acoustic survey with those performed by Dick Thorne and ADF&G and contemporary hydroacoustic surveys done elsewhere on herring to justify the proposed survey methods and sampling gear.

Rand response to Science Panel:

It is my understanding that the main objective of this project was to provide estimates of herring abundance during the spring, spawning period independent of the aerial milt survey. That has been my focus and has been articulated in my proposals. Along with my annual reporting of biomass estimates to EVOSTC and detailed descriptions of the monitoring results in different PWS regions, I did publish a manuscript during this period that focused specifically on some the key biological aspects of herring during their spawning period (Rand, P.S. 2018. Pacific herring response to surface predators in Prince William Sound, Alaska, USA. Marine Ecology Progress Series 600:239-244). These observations, using an uplooking transducer mounted on the seafloor, provided a detailed description of the temporal variability of schools, including density and depth dynamics. In addition, by use of split-beam technology, I was able to describe swim speeds of both predator and prey and how herring reacted in the presence of surface predators. I also contributed information on acoustic survey methods to a synthesis chapter in 2019.

I do understand the value of synthesizing some of the past acoustic survey data. Dick Thorne did share with me various drafts of incomplete manuscripts that were never submitted for publication. If this is a priority for the SP, I would be glad to pursue additional analyses of past data, but this would require additional PI time to accomplish. I would be glad to scope out what it might require in a future EVOSTC proposal.

In addition, I believe the technology I am currently using (split-beam, 120 kHz Biosonics system) is adequate to meet the basic objectives of monitoring. I am aware of other technologies (e.g. broadband) that have some advantages. This technology may be able to discriminate species, but I don't think this is a significant source of error in our current monitoring efforts. During the pring 2016 Kevin Boswell and Bree Zenone deployed a broadband system and collected data at aggregation sites, but I don't think those data were ever analyzed. At the time, I believe analytical methods were still under development.

There are other areas of research that I think are important and timely and may be amenable to hypothesis testing. Specifically, I have been discussing potential studies examining the importance of kelp (both as a spawning substrate, but also as important habitat for juvenile herring). Given the rising interest in kelp commercial production in Prince William Sound, I think focusing on this topic would be worthwhile. It has implications for herring reproductive success and recovery. I am aware of acoustic approaches to describing benthic habitat, and this might be a very cost-effective way of describing spawning habitat associated with past and current herring aggregation sites.

Regarding contingency plans, if I have any unused funds in my project in 2021, I can begin some work on compiling and analyzing past acoustic data as requested by SP. We were able to accomplish some field work this past spring, and I am hopeful we will be able to complete the field work next spring. I appreciate the extra funds provided by EVOSTC to support an extra vessel. Because the R/V Solstice was not available during this past spring, it was critical to have these funds available to charter a separate vessel to conduct field work.

Sept 2019: Science Panel Comment – FY20: The Science Panel had a discussion about the utility of adult acoustic surveys. It was noted that such data played an important role in resolving a data conflict previously in the BASA model. The BASA model could be used to evaluate the importance of acoustic versus aerial survey data to model results. The Science Panel also had a discussion about the Biosonics echosounder and wondered whether this is still the optimal tool for such assessments. However, the panel does not have adequate expertise in this area to answer this question.

While it is gratifying to see that this project is cognizant of the merit of expanding the areas ensonified, it is still worrisome to the panel that some portion of the herring population may now occur in areas that are not examined. We note, for instance that NOAA is capable of conducting large (massive) scale acoustic and fishing surveys of the Bering Sea using large vessels that are capable of working in adverse weather. A fundamental question is this: is the PWS herring population diminishing in abundance (and perhaps spatial distribution) or has the population shifted its distribution to locations they are not presently observed? This comment is not meant to be critical of the PI or this specific project (although it may be useful if this issue were addressed directly in this proposal). Rather we suggest that this may be a salient question directed to the collective research community working on herring and related species in PWS.

Rand response to Science Panel:

It is important to keep in mind that the acoustic survey effort is guided by results of a spatially-extensive aerial survey conducted by ADF&G each spring. We do, in fact, respond to aerial survey observations within season (i.e. presence of schools, milt, and/or herring predators) by adapting our survey effort spatially. For example, during the spring 2019 season we surveyed Canoe Pass and Double Bay, regions that have not historically been the focus of the PWS adult acoustic survey, but showed evidence of significant herring aggregations based on aerial observations. While Kayak Island is recognized as an important spawning site, surveying that site would require significantly more funding to cover ship time on a larger vessel. Expanding the survey to include this site would constitute a new survey approach that would produce a new time series. It would take many survey years for an expanded survey like this to generate insight into population dynamics across a broader survey region.

There are echosounders of higher quality in the marketplace (e.g., SIMRAD ES series), with certain advantages, including a much easier and more straightforward field calibration procedure, but it is hard to justify given the great expense of purchasing a new system. There have been some advances in these systems is the ability to discriminate species within schools based on backscatter resonance from swim bladders (e.g. Stanton et al. 2012). There are still relatively few applications of this technology, and I do not see the advantage of applying this technology to adult herring assessments in PWS given the aggregations are composed almost entirely of Pacific herring based on results of net captures at the locations we survey. I do see how this technology might improve our ability to survey juvenile herring, as they are often found in mixed species assemblages in PWS bays based on observations from trawling in PWS bays during the HRM juvenile herring surveys conducted during 2012-2016. Determining precise size distribution and maturity status of adult individuals is critical to monitoring the population, and, at this time, I do not see how acoustic survey technologies could offer any advantage over direct net capture. I intend to track the development of this technology to determine how we might improve our assessment approach in the future.

Stanton, T.K., C.J. Sellers, and J.M. Jech. 2012. Resonance classification of mixed assemblages of fish with swimbladders using a modified commercial broadband acoustic echosounder at 1-6 kHz. Can. J. Fish. Aquat. Sci. 69:854-868.

11. Budget:

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	$ 132.0
Travel	$0.6	$0.6	$0.6	$0.6	$0.6	$2.8	$ 2.3
Contractual	$10.8	$10.8	$10.8	$10.8	$10.8	$54.0	$ 41.6
Commodities	$1.5	$0.0	$0.0	$0.0	$0.0	$1.5	$ 0.1
Equipment	$0.0	$0.0	$0.0	$0.0	$2.3	$2.3	$ -
Indirect Costs (*will vary by proposer*)	$15.7	$15.6	$16.0	$16.4	$17.4	$81.1	$ 52.8
SUBTOTAL	$68.1	$67.7	$69.3	$70.9	$75.6	$351.5	$228.8
General Administration (9% of subtotal)	$6.1	$6.1	$6.2	$6.4	$6.8	$31.6	N/A
PROJECT TOTAL	$74.2	$73.8	$75.5	$77.3	$82.4	$383.1	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

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