1. Project Number:

19120111-G

2. Project Title:

Herring Program – Adult Pacific Herring Acoustic Surveys in PWS

3. Principal Investigator(s) Names:

Peter S. Rand, Prince William Sound Science Center

4. Time Period Covered by the Report:

February 1, 2019-January 31, 2020

5. Date of Report:

March 2020

6. Project Website (if applicable):

https://pwssc.org/herring/

7. Summary of Work Performed:

ABSTRACT

We successfully completed acoustic surveys in April 2019 to continue a long-term data set on biomass estimates of the spawning population of Pacific herring in Prince William Sound. We completed eleven separate surveys during 1-9 April within four regions in Prince William Sound: 1) Port Gravina near Knowles Head, 2) Hinchinbrook Island near Double Bay, 3) Rocky Bay, Zaikof Bay, and Stockdale Harbor in the northeast region of Montague Island, and 4) Hawkins Island near Canoe Pass. All surveys were conducted off a chartered vessel (M/V *Auklet*). The greatest biomass was observed along the coast of Hawkins Island during the night of 7-8 April (2,472 MT over a survey area of 11.6 km^2). In Port Gravina, which in recent years has supported the greatest biomass of spawners, we estimated herring biomass at 1,662 MT. Our survey, however, occurred one day following aerial observations of a major herring spawning event at Knowles Head in Port Gravina, thus our survey may have missed the peak herring biomass at that site. While absent from recent years' surveys, we documented presence of a herring spawning aggregation near Double Bay on Hinchinbrook Island (1,174 MT over a survey area of 8.3 km^2). By summing the largest biomass estimates from each site, we arrived at a total biomass of 7,992 MT, a higher biomass than that documented in 2018 (3,646 MT) but lower than that estimated in 2017 (9,896 MT). We provided

these estimates to Herring Research and Monitoring (HRM) principal investigators (PIs) for input in the age structured analysis (ASA) and Bayesian stock assessment models to meet the objective of supporting on-going stock assessment work.

SURVEY 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 and have been demonstrated to be both accurate and precise (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 2019.

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. Our spring 2019 survey included some daytime transects to provide some contrast with our observations at night or to take advantage of opportunities during the cruise. Calibration was carried out with a tungsten carbide sphere in Wind Bay, Hawkins Island (methods described in Foote et al. 1987). When feasible, the surveys were repeated several times to develop multiple estimates of the biomass of specific fish aggregations. After the acoustic surveys, the herring schools are sampled by the Alaska Department of Fish and Game (ADF&G) to provide biological information. During the spring 2019 survey, the crew of the *R/V Solstice* captured adult herring with a purse seine.

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:

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

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 the seine net collections described above, we used the following mean standard lengths (weighted by age composition) to represent mean target strengths for herring in our analyses: 18.2 cm (Gravina), 15.9 cm (Hawkins), 16.6 cm (Double Bay), and 16.6 cm (Rocky Bay, Stockdale Harbor, and Zaikof Bay).

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 2019 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 and whether surveys were conducted during day or night for each survey site are provided in Table 1.

The acoustic survey in 2019 consisted of two separate cruises on the M/V *Auklet.* During 1-3 April we completed three separate surveys (two in Port Gravina near Knowles Head, and one near Double Bay on Hinchinbrook Island, Table 1, Fig. 1). Following a port call in Cordova, eight additional surveys were carried out during 5-9 April (Rocky Bay, Zaikof Bay, Stockdale Harbor, and Hawkins, Table 1, Fig. 1). 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).

Table 1. Biomass estimates of adult Pacific herring during the 2019 spring cruise. Shaded rows are the survey results used to estimate total herring biomass that appears in the bottom row (described more fully in the text).

Location	Date	Time of Survey	Survey Area (km^2)	Biomass Estimate (mt)
Gravina	1 April	Day	16.3	1,662
Gravina	1-2 April	Night	7.2	151
Double Bay	2-3 April	Night	8.3	1,174
Zaikof Bay	5 April	Day	12.4	136
Zaikof Bay	5-6 April	Night	13.0	575
Rocky Bay	6 April	Day	3.3	1,424
Rocky Bay	7 April	Night	3.4	603
Stockdale Harbor	6-7 April	Night	6.9	306
Zaikof Bay	7 April	Night	13.2	884
Hawkins	7-8 April	Night	11.6	2,472
Hawkins	8-9 April	Night	9.9	481
Total:				**7,992**

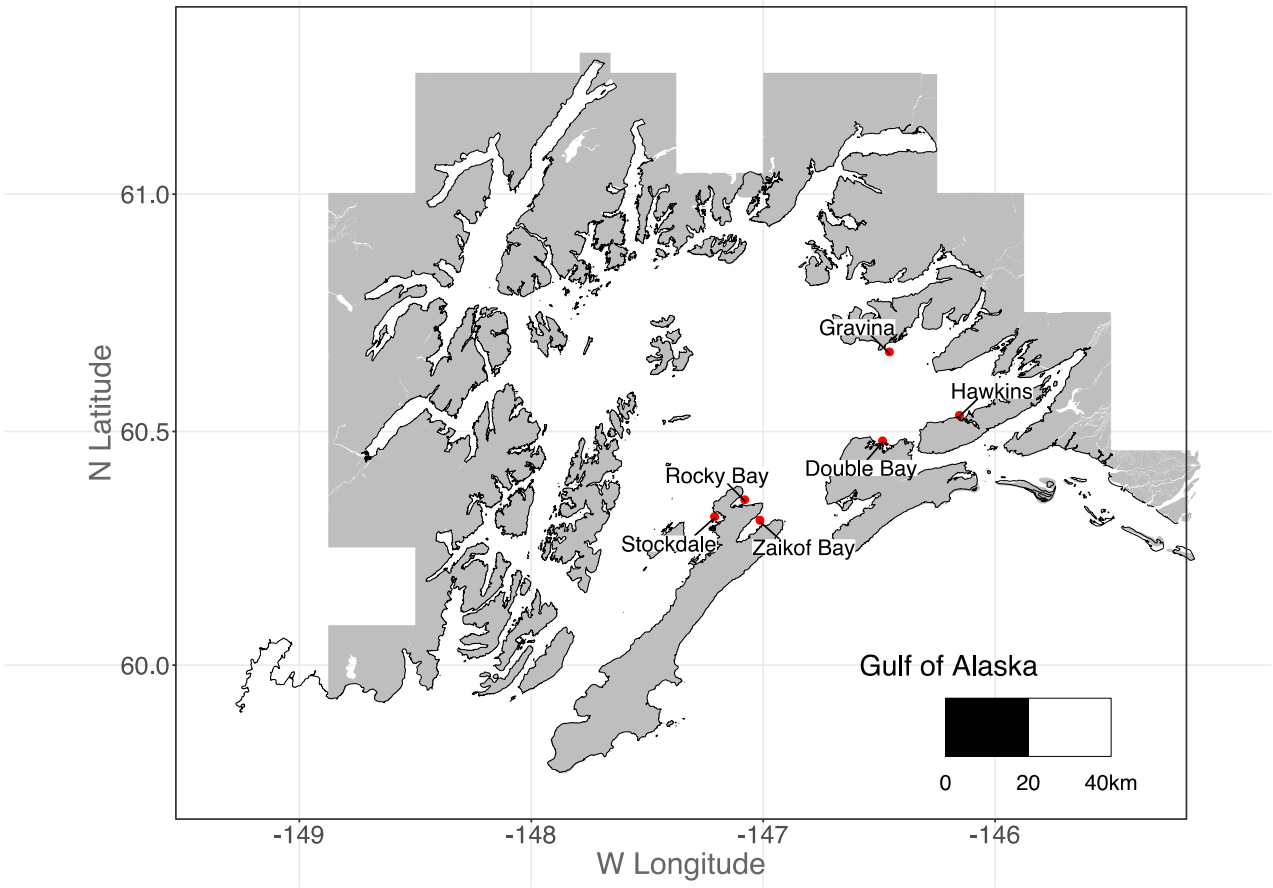

Figure 1. Location of acoustic surveys conducted during April 2019 in Prince William Sound, Alaska.

RESULTS

We successfully surveyed six different sites during the 2019 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 aggregation. Evidence of early spawning near Knowles Head in Port Gravina was reported by ADF&G based on milt observations during an aerial survey on March 31. We arrived at Port Gravina during the afternoon of 1 April and noted the presence of milt and predators (specifically sea lions and gulls) close to Knowles Head. We carried out a day survey there that produced a biomass estimate of 1,662 MT. The aggregation was observed to be close to shore and restricted to a small area just east of Knowles Head in ~ 10 m of water (Figs. 2a, 3a). We suspected at the time that this survey would likely underestimate the total biomass given the earlier observation of spawn. Our survey that night revealed a more dispersed distribution within the survey area (Fig. 2b), and this survey produced a markedly lower biomass estimate (151 MT).

We concluded this first leg of the cruise by sampling the coastline near Double Bay and Andersen Bay on Hinchinbrook Island, an area where herring aggregations were noted in early aerial surveys by ADF&G. This area has not been acoustically surveyed in recent years. The aggregation surveyed there was occupying slightly deeper water (~ 20 m) and was much less concentrated than the herring observed during the day survey in Port Gravina (Figs. 2c, 3b).

Following a port call, acoustic surveys were carried out, in chronological order, at Zaikof Bay (2 surveys), Rocky Bay (2 surveys), Stockdale Harbor (1 survey), Zaikof Bay (1 survey), and Hawkins Island near Canoe Pass (2 surveys). While the latter area has been noted to support herring spawning in recent years, this was the first year we surveyed and produced herring biomass estimates there.

Most of the herring biomass in the northeast region of Montague Island appeared to be located at the head of Rocky Bay in relatively shallow water (10 m), a pattern we have observed in other Rocky Bay surveys in the past few years (Figs. 2f,g, 3c). The biomass estimate we produced in Rocky Bay (1,424 MT) was markedly higher than that estimated in either neighboring Zaikof Bay or Stockdale Harbor (Table 1).

We concluded the cruise with two surveys along the coast of Hawkins Island, near Canoe Pass. The aggregation appeared to be centered just to the west of Canoe Pass (Fig. 2j,k), along the 10-20 m isobath (Fig. 3d). The largest aggregation was documented there during the night of 7-8 April, and this survey yielded the largest biomass estimate of the season (2,472 MT).

As in past years, observations indicated that herring aggregations were ephemeral, forming and breaking up over a relatively brief period of time. As a result, we were not confident that the multiple surveys that we conducted at some of our sites could be considered survey replicates of a single, discrete aggregation. Therefore, we were unable to provide a measure of precision of the survey.

Based on the largest estimates produced at each survey site, we produced a total biomass estimate in 2019 of 7,992 MT. This estimate is larger than that produced in 2018 (3,646 MT) but lower than that estimated in 2017 (9,896 MT, Figure 4). The survey year 2019 was notable given a substantial percentage of the total herring biomass was from two regions that have not been included in surveys in recent years (near Double Bay on Hinchinbrook Island and near Canoe Pass on Hawkins Island).

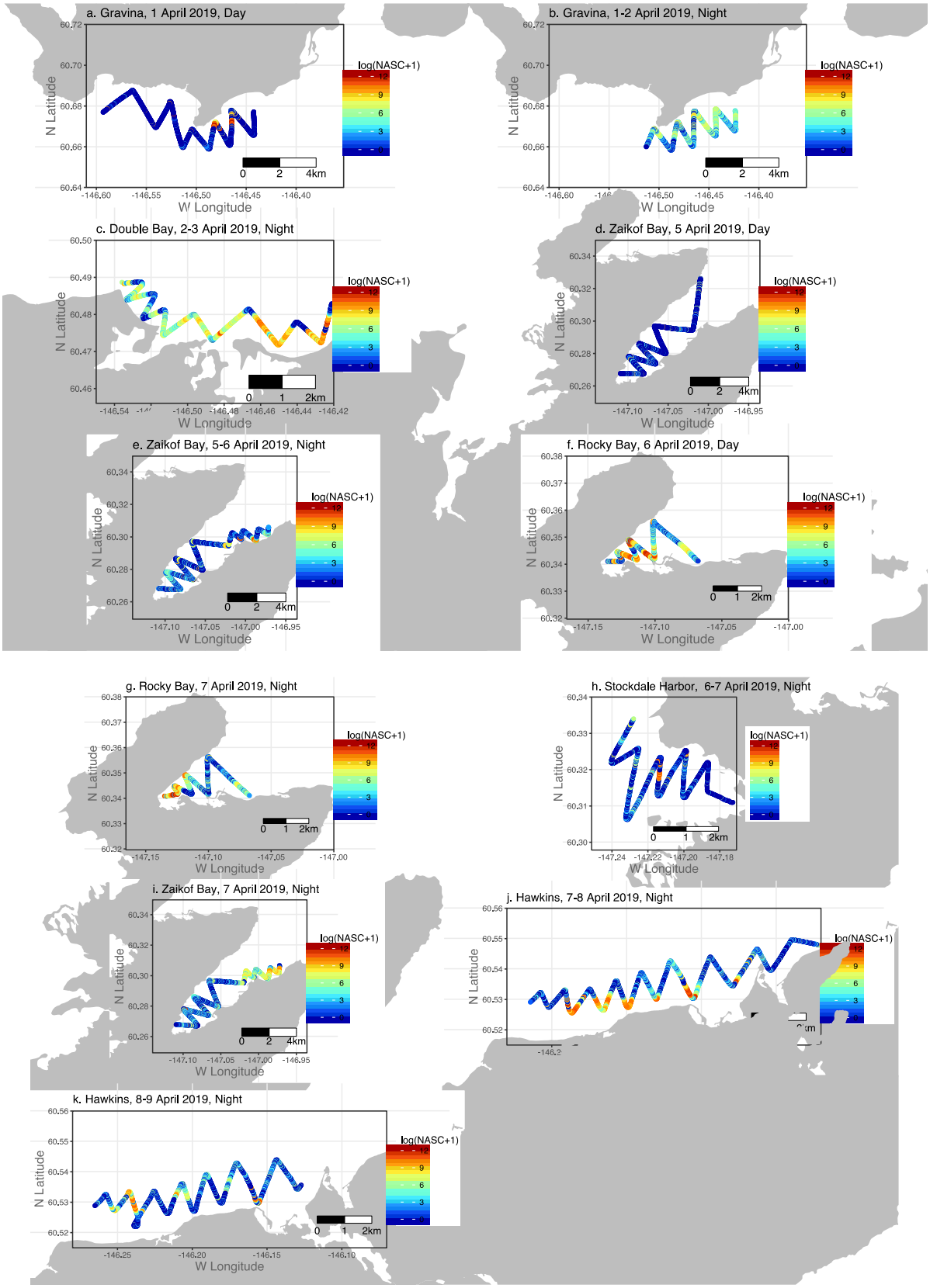

Figure 2. Transect configurations for each survey (a-k) with a false color spectrum indicating acoustic backscatter strength (logarithm of the nautical area scattering coefficient, or NASC, units m^2 nm^{-2}) at each point along the transect during the 2019 field season.

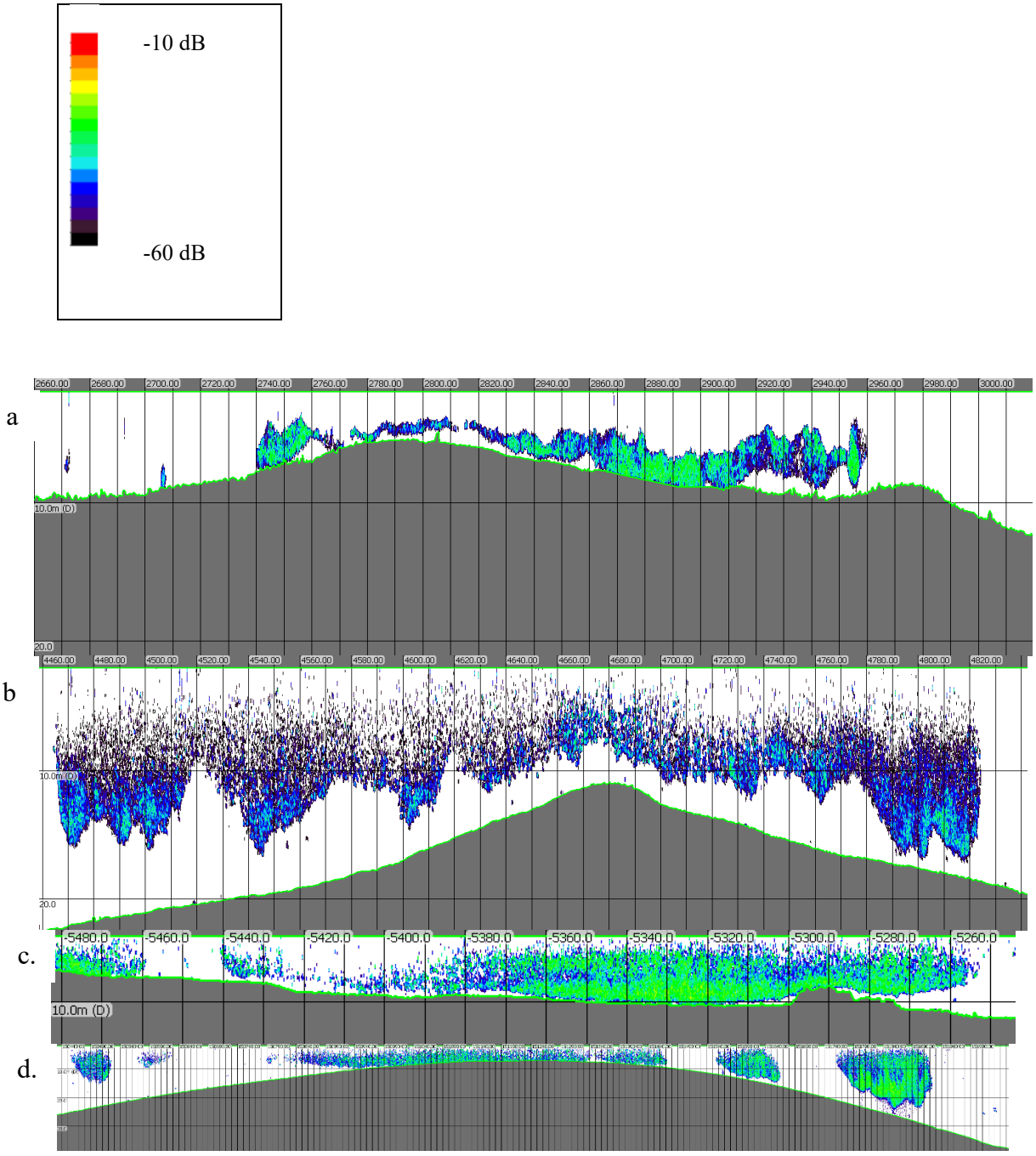

Figure 3a-d. Echograms (a. Gravina during day survey on 1 April, b. Double Bay on Hinchinbrook during night of 2 April 2019, c. the head of Rocky Bay on 7 April 2019, and d. Canoe Pass on Hawkins on the night of 7 April 2019) recorded at sites where the majority of herring occurred during the spring 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.

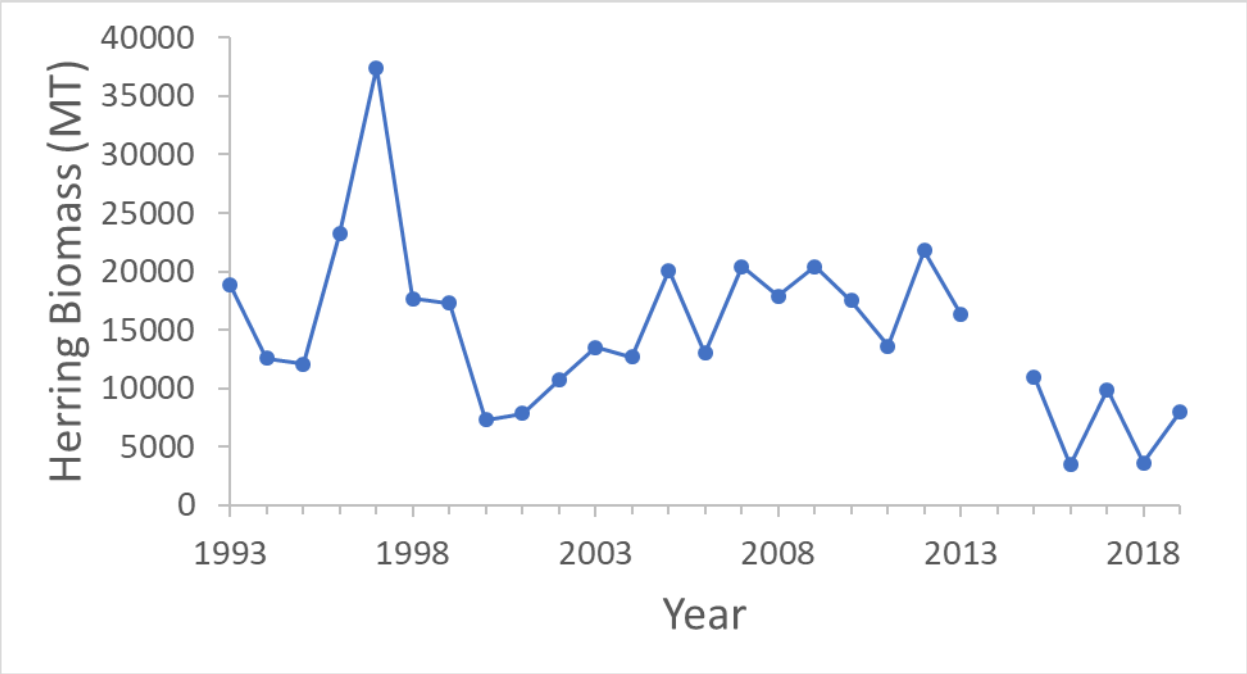

Figure 4. Time series of acoustic biomass estimates (MT, metric tonnes) of Pacific herring in Prince William Sound. The survey conducted during 2014 did not yield a biomass estimate due to adult herring occupying water too shallow to survey effectively with acoustics.

8. Coordination/Collaboration:

A. Long-term Monitoring and Research Program Projects

1. Within the Program

We primarily coordinated and collaborated with HRM Project 19160111-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 captured by purse seine for use in generating biomass estimates from our acoustic data. We also provide data to the population modeling effort (project 19120111-C).

2. Across Programs

a. Gulf Watch Alaska

No collaboration at this time.

b. Data Management

We work with the data management program to ensure our data and metadata are provided in a timely manner.

B. Individual Projects

No collaboration with individual *Exxon Valdez* Oil Spill Trustee Council projects at this time.

C. With Trustee or Management Agencies

This project collaborates with ADF&G in identifying areas for acoustic surveys and the collection of fish in survey regions to be used in the analysis of the acoustics data.

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. 2019. Adult Pacific Herring Acoustic Surveys in PWS. FY18 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 18120111-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 2019 survey were uploaded to the Research Workspace following the research cruise. Intermediary acoustic summary files were uploaded on 17 February 2020 (by Pete Rand), and the final biomass estimate was added to the time series and made public on 17 February 2020 (by Pete Rand). Preliminary biomass estimates were shared with HRM PIs during the November 2019 PI meeting.

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:

EVOSTC Science Panel Comment. The Science Panel understands that both competition and cooperation for vessel time can occur. We further understand that results from acoustic surveys have an immediate impact on biomass assessments and other understanding of herring distribution and

biology in PWS. Therefore, we have questions and concerns about the spatial and temporal consistency of herring distributions in PWS and the adequacy of the present acoustic surveys to detect change. This is not a criticism. Instead, it is a question about the adequacy of the spatial coverage of the surveys. We observe broad environmental changes that could impact herring distributions and we are concerned that potential changes in herring distributions could go undetected. Shifts in Pacific herring spawning distributions have been observed in other regions (e.g., SE AK, British Columbia). Thus, we support the request for additional funding to continue simultaneous surveys. We would also like to know what is the extent to which aerial surveys can be used to inform the acoustic surveys? Does the timing of each survey allow this?

PI Response (10/31/18). Thanks for clarifying your concerns about the acoustic survey. It is important to note that each survey we conduct relies on information from the following sources:

1) Aerial surveys conducted by ADF&G. This helps us in terms of timing and in identifying what areas to focus on in our survey. Observations of particular interest are the presence and distribution of predators (particularly sea lions and whales). Based on my experience in recent years, we receive information from 2-3 aerial surveys just prior to and during our acoustic survey, and we have found them very helpful to help us focus our field effort.
2) Some early, reconnaissance surveys by a vessel charter in the eastern sound (particularly in Fidalgo and Gravina, and along Hawkins Island, beginning in mid-March). These surveys (both visual surveys for predators and evidence of herring aggregations from ship-board sonar) provides additional information early in the season.
3) During a typical vessel charter day during our survey, we run long transects during the day to observe predators and roughly map out the area that contains any herring schools (based on ship-board sonar). This is done at a higher speed (compared to our night time transects with our tow fin deployed) to enable us to cover a relatively large area and determine the rough boundaries of our survey area.
4) To maximize spatial coverage over the night, we use a sawtooth transect design and adjust the length of each transect leg based on our observations leading up to the time of the survey so we can be assured we are covering a large enough area.
5) In addition, we do visit some bays where herring predators were noted in the ADF&G aerial survey (outside our traditional focal areas in Gravina/Fidalgo and NE Montague Island region). To date, none of these bays have yielded evidence of herring aggregations.

In short, I am confident that our survey coverage has been adequate to capture any changes that might be occurring in the distribution of spawning herring in PWS. Maintaining the amount of ship time we have used in past survey years will allow us to continue this level of survey coverage into the future.

11. Budget:

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	$ 86.1
Travel	$0.6	$0.6	$0.6	$0.6	$0.6	$2.8	$ 1.2
Contractual	$10.8	$10.8	$10.8	$10.8	$10.8	$54.0	$ 27.8
Commodities	$1.5	$0.0	$0.0	$0.0	$0.0	$1.5	$ 0.1
Equipment	$0.0	$0.0	$0.0	$0.0	$1.2	$1.2	$ -
Indirect Costs (*will vary by proposer*)	$15.7	$15.6	$16.0	$16.4	$17.1	$80.8	$ 34.6
SUBTOTAL	$68.1	$67.7	$69.3	$70.9	$74.1	$350.1	$149.8
General Administration (9% of subtotal)	$6.1	$6.1	$6.2	$6.4	$6.7	$31.5	N/A
PROJECT TOTAL	$74.2	$73.8	$75.5	$77.3	$80.8	$381.6	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

LITERATURE CITED

Cochran, W.G. 1977. *Sampling Techniques*. John Wiley & Sons, New York, 428p.

Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan, and E.J. Simmonds. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. Cooperative Research Reports of the International Council for the Exploration of the Sea. Volume 144, 69p.

MacLennan, D.N., and E.J. Simmonds. 1992. *Fisheries Acoustics*. Chapman and Hall, London, 325p.

Rand, P.S. 2019. Description of Acoustic Survey Design and Analysis. Report requested by HRM Oversight Group, June 2019.

Simmonds, J., and D. MacLennon. 2005. Fisheries Acoustics: theory and practice, 2nd Ed.. Blackwell Science, 429 p.

Thomas, G.L., E.V. Patrick, J. Kirsch, and J.R. Allen. 1997. Development have and ecosystem model for managing the fisheries resources of Prince William Sound, Alaska. Proceedings of the 2nd World Fisheries Congress. Ed (D.A. Hancock, D.C. Smith, A. Grant, and J.P Beumer. CSIRO. Collingwood. Pages 606-614.

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.

Thorne, R.E. 1971. Investigations into the relationship between integrated echo voltage and fish density. Journal of the Fisheries Research Board of Canada 28:1265-1274.

Thorne, R.E. 1977a. Acoustic assessment of hake and herring stocks in Puget Sound, Washington and southeastern Alaska. Pp. 265-278 in A.R. Margets (ed), *Hydroacoustics in Fisheries Research*. ICES Rapp. Et P.-v., Vol 170.

Thorne, R.E. 1977b. A new digital hydroacoustic data processor and some observations on herring in Alaska. Journal of the Fisheries Research Board of Canada 34:2288-2294.

Thorne, R.E. 1983a. Hydroacoustics. *In* Fisheries Techniques, pp. 239-259. Ed. by L. Nielson and D. Johnson. American Fisheries Society, Bethesda, MD.

Thorne, R.E. 1983b. Assessment of population abundance by echo integration. In. Proceedings of the Symposium on Assessment of Micronekton. Biological Oceanography Journal. 2:253-262.

Thorne, R.E., and G.L. Thomas. 2008. Herring and the "*Exxon Valdez*" oil spill: an investigation into historical data conflicts. ICES Journal of Marine Science 65(1):44-50.

Trumble, R., R.E. Thorne, and Lemberg. 1983. The Strait of Georgia herring fishery: A case history of timely management aided by hydroacoustic surveys. Fisheries Bulletin 80:381-388.