ATTACHMENT C ***EVOSTC Annual Project Report Form***

Form Rev. 1.17.14

*Please refer to the Reporting Policy for all reporting, due date and technical submission requirements.

1. Project Number: *See,* Reporting Policy at III (C) (1).

15120111-A

2. Project Title: *See,* Reporting Policy at III (C) (2).

PWS Herring Program: Validation of Acoustic Surveys for Pacific Herring

3. Principal Investigator(s): *See,* Reporting Policy at III (C) (3).

Mary Anne Bishop, Ph.D., Prince William Sound Science Center

4. Time Period Covered by the Report: *See,* Reporting Policy at III (C) (4).

1 February 2015 to 31 January 2016

5. Date of Report: *See,* Reporting Policy at III (C) (5).

February 2016

6. Project Website (if applicable): *See,* Reporting Policy at III (C) (6).

http://pwssc.org/research/fish/pacific-herring/

7. Summary of Work Performed: *See,* Reporting Policy at III (C) (7).

Acoustic surveys offer a cost effective, remote sensing method for estimating Pacific herring biomass, abundance, and distribution. However, concurrent direct-capture sampling is required for interpreting these acoustic data and producing reliable estimates. We collected the data needed to estimate useful population level parameters for PWS Pacific herring from acoustic surveys by coupling acoustic transects with direct-capture sampling efforts. Additionally, the validation project collects juvenile and adult herring samples for other projects within the Prince William Sound Herring Research and Monitoring program, including: condition index, energetics, genetics, growth, disease, and age at first spawn.

The primary objectives for the Validation of Acoustic Surveys for Pacific Herring Using Direct Capture project include:

1) Improve capture methods used to validate acoustic surveys.
2) Increase the sample size for identification, quantification, and measurement of juvenile (age-0, age-1, age-2) and adult (age-3 and older) herring schools as well as other fish schools in survey areas.
3) Provide data on species composition and length frequency to aid in the interpretation of current and historical acoustic surveys.
4) Provide adult herring samples to Alaska Department of Fish and Game for the adult herring age-structure-analyses model.
5) Provide juvenile herring samples to researchers investigating juvenile herring fitness and disease.

2015 Field Work and Preliminary analyses

Sampling Methods

The annual HRM Juvenile Herring Abundance Index survey was conducted in nine PWS bays from November 6-14, 2015 onboard the R/V *Montague*. Each survey consisted of acoustic transects and direct capture using a midwater trawl (14 X 11 X 22 m with 38-mm mesh size dropping down to 12-mm mesh at the codend). Environmental data were collected during trawl transects by attaching a Star Oddi sensor tag to the head-rope of the trawl that collected salinity, temperature, and depth data. Additionally, a sensor tag that collected temperature and depth data was attached to the foot-rope of the trawl.

In each bay, an initial acoustic survey was conducted to identify target areas with relatively strong acoustic signal. After this initial survey, we returned to target areas to conduct short acoustic/trawl transects (2-4 transects were conducted in each study bay). Within each sampling bay, additional fish were collected with juvenile herring gillnets (60'X 16'; 1/4, 5/16, 3/8" mesh) to provide samples for other herring research projects. Nets were deployed opportunistically while at anchor.

While in the field we obtained total counts and batch weights for each species and capture gear deployment. Up to 200 fish per species from each capture event were frozen for future analyses at the PWSSC laboratory where individual measurements including length (SL, FL, TL; mm) and weight (g) were collected. Additional samples were frozen and sent to NOAA and USGS laboratories for additional analyses.

The primary objectives of the expanded adult survey in FY15 were to conduct acoustic surveys for adult herring aggregations in areas that were not sampled during previous adult herring acoustic surveys, collect multifrequency and single-frequency acoustic data, and compare acoustic datasets collected during the same sampling events. As the focus was on comparing two acoustic datasets, direct capture gear was not deployed during the adult survey in FY15.

Data Analysis

Analyses of frozen fish samples are ongoing at the PWSSC laboratory. To date, 366 herring samples have been processed, including all samples from Port Gravina (n= 13), Port Fidalgo (n=136), and Eaglek (n=43). We summarized length data from those three sample locations and present the median, interquartile range, minimum, and maximum graphically as box plots.

We examined trawl catch data from the 2013-2015 November juvenile intensive surveys. We calculated mean, minimum, and maximum catch per unit effort (CPUE; number of fish captured per km towed) by capture location and species. Within this multiyear dataset, 98% of the catch was Pacific herring and walleye pollock. Therefore, we focused further analyses on these two species. Spatial and temporal patterns were examined visually by calculating mean CPUE per bay for each survey year and plotting these data on a map of PWS. Mean bay CPUE was plotted against survey year to examine bay-specific interannual variability in detail.

Additionally, we were interested in investigating possible associations between CPUE and environmental data (depth, water temperature, and salinity data collected concurrently with each trawl) and detecting interannual variation after accounting for sampling variability. Our analytical approach was to develop models with environmental and temporal covariates using the generalized linear model (GLM) framework. Catch data were assumed to follow a negative binomial distribution. Due to the spatial clustering of our study design, we included a random intercept for sampling bay in all models. Additionally, we accounted for variable towing distances by assuming that catch was proportional to towing distance and including an offset for towing distance in the model. Towing depth, salinity, and temperature were not strongly correlated ($-0.030 < r < -0.003$); therefore, we included all environmental parameters (df=3) in the fully parameterized model. Models including interannual variability were considered by including a categorical covariate for survey year (df=2). All possible reduced fixed-effect models were considered and model selection was conducted by ranking models using Akaike's information criterion (AIC) corrected for small sample size (AIC*c*).

Trawl catch data and concurrent environmental data from FY13- FY15 provide insight into distribution patterns of Pacific herring and walleye pollock in PWS. We present one approach for analyzing these data, but alternative methods are being considered and analyses are ongoing.

Results

Collected fish from the FY15 juvenile herring survey were sent for further analyses to six HRM research programs representing four agencies (Table 1). Over 90% of the fish captured during the FY15 juvenile herring survey were Pacific herring (Table 2). Pacific sand lance, walleye pollock, and capelin were also captured, though collectively these three species made up only 9.1% of the total catch. Pacific herring were effectively captured in both the midwater trawl tows and juvenile gillnet sets, whereas Pacific sand lance were only captured in gillnet sets and walleye pollock and capelin were captured almost exclusively in midwater trawl tows (Table 2).

Table 1. Herring Research and Monitoring programs that were provided samples from validation capture efforts.

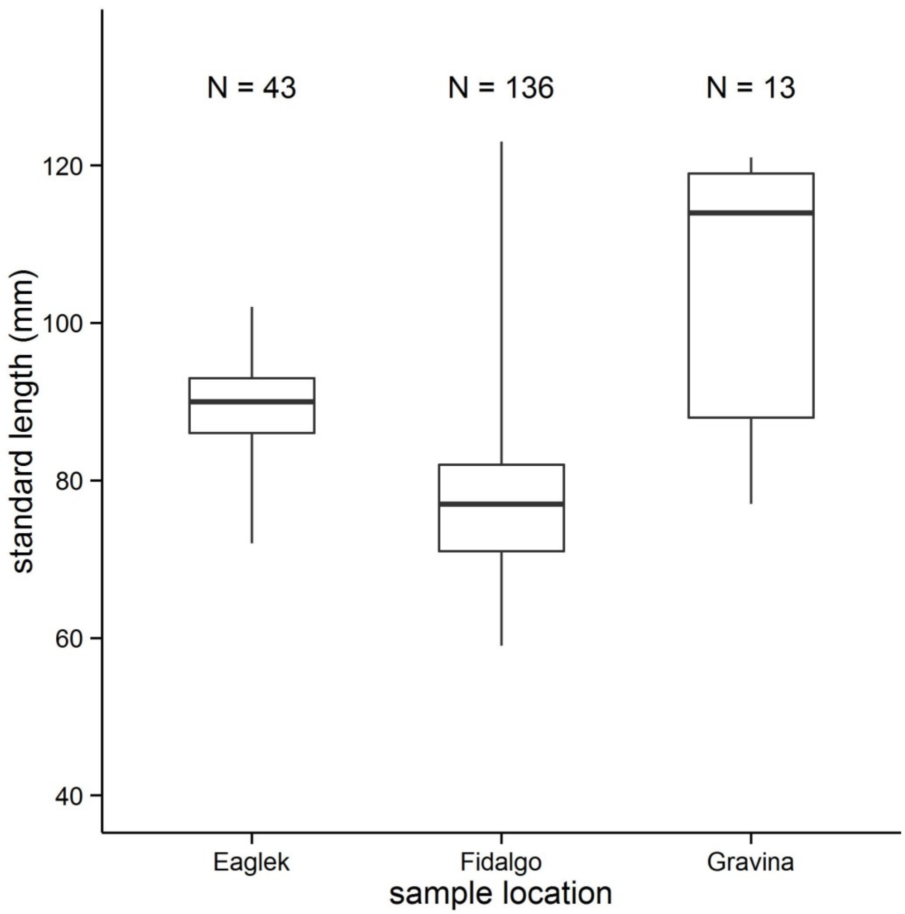
Project	**Agency**
Acoustic Validation	PWS Science Center
Condition Index	PWS Science Center
Genetic Stock Structure	NOAA / ADF&G
Disease	USGS
Growth RNA/DNA	NOAA Auke Bay
Age at First Spawn	NOAA Auke Bay

Table 2. Number of fish captured during the FY15 juvenile index survey. JGN= juvenile gill net; TWL= midwater trawl.

	Gear type		
Species	JGN	TWL	Total
Pacific herring	1062	2116	3178
Pacific sand lance	133	0	133
walleye pollock	0	123	123
capelin	3	61	64
crescent gunnel	2	0	2
Pacific staghorn sculpin	0	2	2

Of the three sample locations that have completely processed herring samples (Eaglek, Port Gravina, and Port Fidalgo), median standard length was highest in Port Gravina and lowest in Port Fidalgo, though the range of lengths within each sample location was considerable (Fig. 1). The maximum standard length in this dataset was 132 mm. This indicates that, similar to the 2013 and 2014 juvenile index surveys, the majority of herring captured during the 2015 survey were age-0 and age-1.

Figure 1. Boxplots depicting the minimum, 25th percentile, median, 75th percentile, and the maximum standard length of herring captured in three bays in PWS during the 2015 juvenile index cruise.



A total of 79 midwater trawl tows were conducted during the three years (2013-2015) of November, juvenile herring index surveys. From this aggregate dataset, the highest mean CPUE (number of fish/km) of Pacific herring occurred in east Whale Bay, though Simpson Bay also had high CPUE (Table 3). Interestingly, the lowest CPUE occurred in west Whale Bay, which suggests considerable variability in Pacific herring habitat suitability at a relatively small spatial scale (Table 3). The highest mean walleye pollock CPUE rates occurred in Eaglek Bay and Windy Bay. Similar to Pacific herring, the highest mean capelin CPUE rates occurred in Simpson Bay and east Whale Bay.

Table 3. Mean catch per unit effort (CPUE; number of captured fish per km towed) of each fish species by for each location. Minimum and maximum values are presented in brackets.

	Species					
Location	capelin	Pacific herring	Pacific sandfish	Pacific staghorn sculpin	surf smelt	walleye pollock
Eaglek	1.1	20.8	0	0	0	16.5
	(0,7.3)	(0,51.1)	(0,0)	(0,0)	(0,0)	(0,46.9)
Fidalgo	1.4	20.3	0	0	0	3
	(0,6.8)	(0,49.7)	(0,0)	(0,0)	(0,0)	(0,10.3)
Gravina	3.1	42.0	0	0	0	2.2
	(0,16)	(0,178.6)	(0,0)	(0,0)	(0,0)	(0,6.8)
Lower	0.3	8.9	0	0	0	2.3
Herring	(0,1.9)	(0,56)	(0,0)	(0,0)	(0,0)	(0,13.3)
Simpson	11.0	**358.6**	0	0.3	0	4.9
	(0,31.1)	(0,699.6)	(0,0)	(0,1.2)	(0,0)	(0,17.5)
Whale-East	8.8	**686.5**	0	0	0	0
	(0,42.6)	(0,3363.9)	(0,0)	(0,0)	(0,0)	(0,0)
Whale-West	0.5	2.2	0	0	0	0
	(0,3.1)	(0,5.2)	(0,0)	(0,0)	(0,0)	(0,0)
Windy	0.8	10.9	0	0	0	11.3
	(0,5.6)	(0,34.7)	(0,0)	(0,0)	(0,0)	(0,47.9)
Zaikof	0.1	18.1	0.1	0	0.2	7.7
	(0,1)	(0,54)	(0,1)	(0,0)	(0,1.5)	(0,29.5)

In November 2013 the highest Pacific herring mean CPUE occurred in Simpson Bay and CPUE was low in all other locations except for Port Gravina and Lower Herring Bay (Fig. 2). Mean CPUE increased in all locations in 2014 except for Lower Herring Bay (CPUE decreased), and Port Gravina and west Whale Bay where mean CPUE was similar between years. East Whale Bay had the highest mean CPUE in 2015 and mean CPUE in Lower Herring and west Whale Bay remained low. Additionally, mean CPUE decreased in Windy Bay, Port Gravina, Eaglek Bay, and Zaikof Bay.

In 2013 the highest mean walleye pollock CPUE rates occurred in Eaglek Bay, Windy Bay and Lower Herring Bay (Fig. 2). Zero walleye pollock were captured in east and west Whale bay and Port Gravina. Mean CPUE remained high in Eaglek Bay in 2014. Additionally, mean CPUE increased in Port Fidalgo, Port Gravina, Simpson Bay, and Zaikof Bay compared to 2013 levels. In 2015 the highest walleye pollock mean CPUE occurred in Eaglek Bay and Windy Bay and zero walleye pollock were captured in east and west Whale Bay, Lower Herring Bay, and Zaikof Bay.

Figure 2. Distribution of Pacific herring and walleye pollock mean CPUE (number of captured fish per km towed) in 2013, 2014, and 2015. The column labeled (A) depicts Pacific herring CPUE data and the column labeled (B) depicts walleye pollock CPUE data.

The most supported model for Pacific herring CPUE contained towing depth and salinity parameters (Table 4). Models containing parameters for interannual variability in CPUE were not well supported by the data. Pacific herring CPUE was negatively associated with trawl depth (p-value=0.004; β=-0.089; SE=0.031) and salinity (p-value=0.0352; β=-0.457; SE=0.217). After accounting for salinity, an increase of 1 m in towing depth was associated with an 8.5% decrease in CPUE (95% CI: 2.9-13.8). After accounting for depth, an increase of 1 PSU (g/kg) in salinity was associated with a 36.6% decrease in CPUE (95% CI: 3.1-58.6). For walleye pollock CPUE, the most supported model contained a water temperature parameter (Table 5). Similar to Pacific herring CPUE, models including interannual variability were not well supported by the data. Walleye pollock CPUE was positively associated with water temperature (p-value= 0.032; β=1.317; SE=0.613). A 0.1 degree C increase was associated with a 14.1% increase in walleye pollock CPUE (95% CI: 1.2-28.6).

Table 4. Model section results for Pacific herring catch data. All models include a random intercept for location (N=9) to account for spatial clustering in the study design and an offset term for distance trawled.

fixed effects	df	logLik	AIC*c*	ΔAIC*c*	weight
β_0 + depth + salinity	5	-301.85	614.52	0.00	0.40
β_0 + year + depth	6	-301.73	616.63	2.11	0.14
β_0 + depth + salinity + temp	6	-301.78	616.73	2.21	0.13
β_0 + depth	4	-304.47	617.47	2.95	0.09
β_0 + year + depth + salinity	7	-301.06	617.70	3.17	0.08
β_0 + year + depth + temp	7	-301.69	618.95	4.43	0.04
β_0 + depth + temp	5	-304.47	619.75	5.23	0.03
β_0 + year + depth + salinity + temp	8	-300.94	619.93	5.41	0.03
β_0 + salinity	4	-305.88	620.30	5.78	0.02
β_0 + salinity + temp	5	-305.28	621.37	6.85	0.01
β_0 + year + salinity	6	-304.66	622.49	7.97	0.01
β_0	3	-308.54	623.39	8.87	0.00
β_0 + year + salinity + temp	7	-304.65	624.88	10.36	0.00
β_0 + year	5	-307.13	625.09	10.57	0.00
β_0 + temp	4	-308.33	625.19	10.67	0.00
β_0 + year + temp	6	-307.03	627.23	12.71	0.00

Table 5. Model section results for walleye pollock catch data. All models include a random intercept for location (N=9) to account for spatial clustering in the study design and an offset term for distance trawled.

fixed effects	df	logLik	AIC*c*	ΔAIC*c*	weight
β_0 + temp	4	-173.00	354.54	0.00	0.29
β_0 + salinity + temp	5	-172.93	356.69	2.14	0.10
β_0 + depth + temp	5	-172.98	356.78	2.23	0.09
β_0	3	-175.23	356.78	2.24	0.09
β_0 + year + temp	6	-172.00	357.16	2.62	0.08
β_0 + year + depth + temp	7	-171.00	357.57	3.03	0.06
β_0 + year	5	-173.68	358.19	3.64	0.05
β_0 + year + depth	6	-172.54	358.25	3.71	0.04
β_0 + year + salinity + temp	7	-171.67	358.91	4.37	0.03
β_0 + depth + salinity + temp	6	-172.87	358.91	4.37	0.03
β_0 + depth	4	-175.19	358.92	4.38	0.03
β_0 + salinity	4	-175.23	359.00	4.46	0.03
β_0 + year + depth + salinity + temp	8	-170.59	359.23	4.68	0.03
β_0 + year + salinity	6	-173.68	360.52	5.97	0.01
β_0 + year + depth + salinity	7	-172.52	360.62	6.07	0.01
β_0 + depth + salinity	5	-175.19	361.20	6.66	0.01

***Milestones/Deliverables*:**

Provide juvenile herring samples to researchers investigating juvenile herring fitness and disease: Completed November 2015.

8. Coordination/Collaboration: *See*, Reporting Policy at III (C) (8).

a) Coordination and collaboration is critical to this project. As noted in Table 1, we collect and provide samples to several HRM projects.

b) No collaboration with other Trustee Council funded projects

c) We shared fish collected from Montague Island and Port Gravina with Steve Moffitt at ADF&G for age structure analysis.

d) Information and Data Transfer: *See*, Reporting Policy at III (C) (8).

<u>Popular Press:</u>

Lewandoski, S. Herring survival 101: hide under the ice. *Delta Sound Connections* (circulation ~15,000). This annual newspaper published about the natural history of PWS and the Copper River Delta is distributed each May to airports and tourist areas in southcentral Alaska.

<u>Meetings:</u>

Bishop participated in the HRM/GulfWatch synthesis meeting in Anchorage during February 2015. Bishop also participated in the HRM and the joint HRM/GulfWatch meeting for Principal Investigators in November 2015 in Anchorage.

Data:

Datasets and associated metadata through October 2015 have been uploaded to the HRM portal. Data from November 2015 will be uploaded as soon as laboratory measurements are completed.

In January 2016 we met with Stacey Buckelew of Axiom Consulting to discuss project metadata and address changes or additions that were needed.

e) Response to EVOSTC Review, Recommendations and Comments: *See*, Reporting Policy at III (C) (9).

No issues were raised by the most recent EVOSTC review

f) Budget: *See*, Reporting Policy at III (C) (10).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$32,500.0	$58,300.0	$98,100.0	$95,000.0	$98,000.0	$381,900.0	$ 269,676
Travel	$1,000.0	$1,000.0	$2,000.0	$1,200.0	$1,200.0	$6,400.0	$ 3,430
Contractual	$900.0	$1,800.0	$2,600.0	$2,200.0	$2,200.0	$9,700.0	$ 12,837
Commodities	$5,400.0	$2,800.0	$1,800.0	$1,100.0	$1,100.0	$12,200.0	$ 14,944
Equipment	$10,700.0	$0.0	$0.0	$0.0	$0.0	$10,700.0	$ 17,071
Indirect Costs (*will vary by proposer*)	$11,900	$19,200	$31,300	$29,900	$30,800	$123,100.0	$ 97,005
SUBTOTAL	$62,400.0	$83,100.0	$135,800.0	$129,400.0	$133,300.0	$544,000.0	$414,963.0
General Administration (9% of	$5,616.0	$7,479.0	$12,222.0	$11,646.0	$11,997.0	$48,960.0	
PROJECT TOTAL	$68,016.0	$90,579.0	$148,022.0	$141,046.0	$145,297.0	$592,960.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Overall spending matches the funding to date. There are slight overruns in equipment, supplies, and contractual that are being covered by funds in personnel.