ATTACHMENT D ***EVOSTC Annual Program Status Summary Form***

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111

2. Program Title: *See*, Reporting Policy at III (D) (2).

Herring Research and Monitoring Program

3. Program Lead Name(s): *See*, Reporting Policy at III (D) (3).

W. Scott Pegau

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

1 February 2015 to 31 January 2016

5. Date of Summary: *See*, Reporting Policy at III (D) (5).

February 2016

6. Program Website (if applicable): *See*, Reporting Policy at III (D) (6).

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

7. Overview of Work Performed during the Reporting Period: *See*, Reporting Policy at III (D) (7).

This report covers the third year of work associated with the Herring Research and Monitoring (HRM) program. A detailed discussion of the findings of the program can be found in the synthesis titled, "Pacific herring in Prince William Sound: A synthesis of recent findings" that was submitted to the *Exxon Valdez* Oil Spill Trustee Council and available at http://pwssc.org/wp-content/uploads/2014/12/HRM-synthesis.pdf.

The goal and objectives of the HRM program are as follows.

Goal: Improve predictive models of herring stocks through observations and research.

Objectives

1) *Provide information to improve input to the age-structure-analysis (ASA) model, or test assumptions within the ASA model.*

2) *Inform the required synthesis effort.*

3) *Address assumptions in the current measurements.*

4) *Develop new approaches to monitoring.*

Program highlights

1) *Provide information to improve input to the age-structure-analysis (ASA) model, or test assumptions within the ASA model.*

- Disease prevalence consistent with other areas.

- Acoustic survey indicated a possible sharp decline in the adult population, but the spring spawn was broken up and late.
- Spawning was observed off Montague Island and fish were collected.
- Aerial surveys indicate a moderate age-1 class in 2015. This is consistent with the fall 2014 observations.
- The presence of a large age-3 year class is inconclusive. Not enough samples were collected in PWS, but one of four was almost all age-3 and large age-3 year classes were reported on either side of PWS.
- The population model indicated importance of previous egg deposition and disease surveys.
- A meta-analysis of herring stock variability has started.
- Condition of age-0 fish in the spring was similar to other years in spite of record warm temperatures.
- Trawl surveys show inter-annual differences in juvenile herring distribution.
- There was a change in P.I. for the acoustic survey projects.

2) *Inform the required synthesis effort.*

- A synthesis was presented to the EVOSTC Science Panel.
- Historic scale growth has been connected to environmental conditions in the Gulf of Alaska.
- A synthesis of *Ichthyophonus* in herring was published.

3) *Address assumptions in the current measurements.*

- There was a change in P.I. for the acoustic survey projects resulting in a reanalysis of the data.

4) *Develop new approaches to monitoring.*

- A chromogenic in situ hybridization (CISH) assay capable of detecting *Ichthyophonus has* been developed.

Program summary

To address the first objective by improving inputs to the ASA model we continued to monitor for disease prevalence, expanded the acoustic surveys for adult biomass, surveyed for juvenile herring using acoustic and aerial surveys, and monitored the condition of age-0 herring. The disease prevalence is consistent with other regions where similar monitoring is taking place. Acoustic surveys of adult herring found that the fish were spread out and in unusually small schools. This led to an estimated spawning biomass of 9-12 metric tons. This represents a large decline in the estimated spawning population. We are investigating how the record warm water temperatures may have affected the population. The program had been predicting a large age-3 recruitment to the spawning population. That was expected to lead to spawning late and in unusual areas. ADF&G and our surveys of the spawning population were too early to observe the primary spawning so we cannot say if the age-3 year class did join, but the spawning was late, there was an unusually large spawn event on Montague Island, and large age-3 year classes were reported in Kodiak and Sitka.

The aerial surveys for providing an index of age-1 herring continued. This year there were over 1300 schools of age-1 herring observed in June. This is nearly double the median numbers of schools observed in the past six years. This was a little unexpected because the warm winter temperatures were expected to lead to greater starvation. The project worked with the forage fish project of the Gulf Watch Alaska program to continue providing aerial surveys of forage fish. A stratified-random sampling designed was used in July in conjunction with the forage fish surveys. This year there was more directed effort on fish identification from the aircraft and repeated surveys of one location to help define observation variability. There were little to no capelin observed in the aerial surveys this year.

The condition of age-0 herring in March 2015 was similar to slightly better than in many of the previous years even though the water temperatures were unusually high through the winter (Figure 1). Our working hypothesis has been that warm water temperatures leads to higher winter metabolism and hence a greater energy loss should be expected during a warm winter. That hypothesis may be incorrect, or this is an indication of the importance of winter feeding.

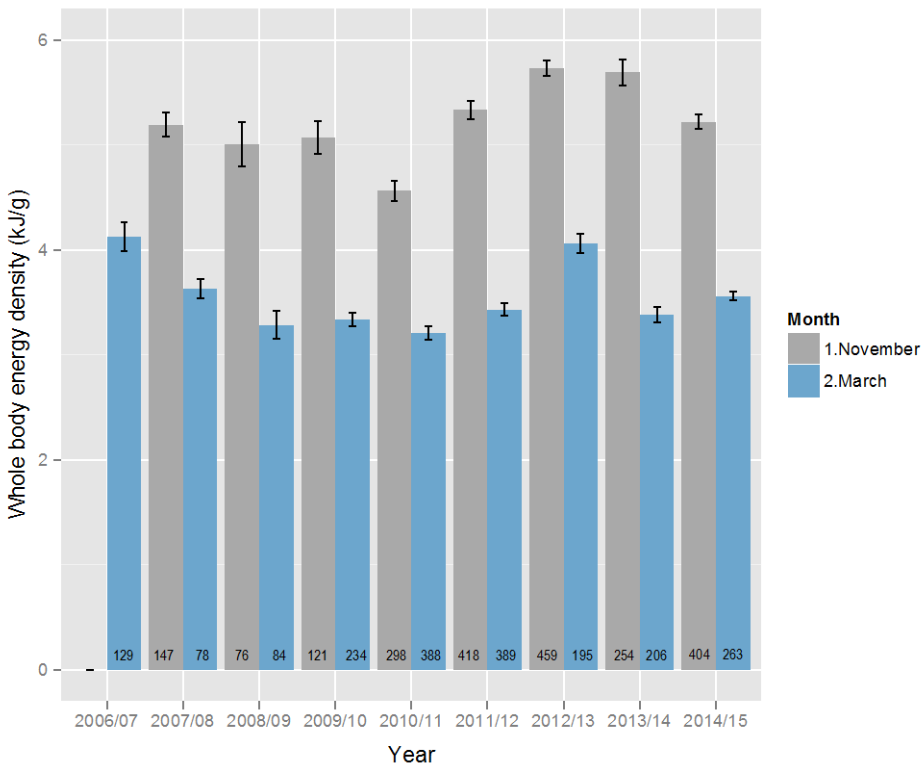


Figure 1. Whole body energy density of age-0 herring over time. In spite of the warm water temperatures during the winter of 2014-2015 the energy density of fish in March was similar to other years.

The Bayesian version of the ASA model was modified to accept inputs from the age-0 and age-1 surveys. It was also used to examine the most informative and cost effective inputs to the model. The disease prevalence was needed to match the collapse of the herring population in 1992-1993. The cost of disease prevalence measurements was low, so it ranked highest for benefit to cost. The egg deposition data was assumed to be the most accurate population estimate and found to be important in the past. The high cost of the data caused it to rank low for benefit to cost.

Of continued interest is the determination of age of first maturity. Preliminary analysis indicates that we were unable to determine age of first spawn from scale growth patterns, but histology proved to work.

The second objective deals providing information for the synthesis that has now been submitted to EVOSTC. More details about our understanding of herring can be found in that synthesis. We have continued to work with data from the herring scale analysis, which was used to examine the relationship between growth in the first year and environmental conditions. There is a strong correlation between growth in the first year and diatom abundance and weaker relationships to water temperature and zooplankton abundance in the Gulf of Alaska (Figure 2). It appears that fish need to be > 85 mm to be likely to reach an age that the fish can spawn this length corresponds to a change in energetic allocation from growth to lipid storage. This suggests that herring must reach a size where they can increase lipid storage if they are to live to a spawning age.

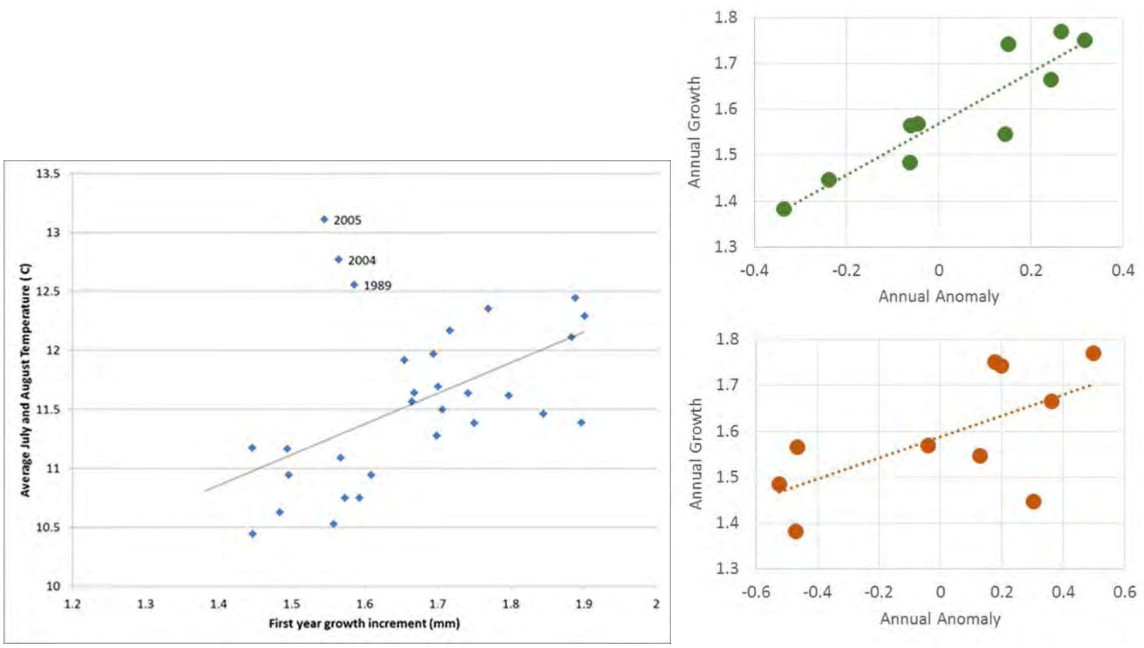


Figure 2 Age-0 growth versus temperature (left), diatom abundance anomaly from the CPR (upper right), and zooplankton abundance anomaly from the CPR (lower right). The 2004 and 2005 years that are anomalies in the temperature relationship are included in the diatom and zooplankton data.

In addressing the assumptions in measurements objective, the herring energetics intensive, acoustics intensive, and fatty acid projects are completing analysis and are working on final reports. The energetics information is being combined with information from the fatty acids project to determine minimum energetic and lipid levels exist in living herring to help understand minimum survivable conditions. The information is also showing that there are spatial differences in diets that affect the condition of the herring. It also shows that feeding occurs during the winter and the smaller, lipid-poor herring are feeding the most.

A study of the external signs of *Ichthyophonus* showed that they were not a precursor to mortality or a reliable metric for determining the date of exposure. However, the long term persistence of external signs of *Ichthyophonus* may still be useful in determining population-level impacts of the disease.

During the November juvenile herring surveys we deployed an autonomous surface vessel (ASV) to survey waters inshore of the normal acoustic surveys. The ASV detected much higher fish densities in the nearshore waters than are observed along the traditional acoustic survey tracks. This demonstrates the potential for large fluctuations in acoustic estimates of juvenile herring abundance depending on how the fish are distributed within a bay. The results are also consistent with the hypothesis that age-0 herring prefer to be in shallower waters.

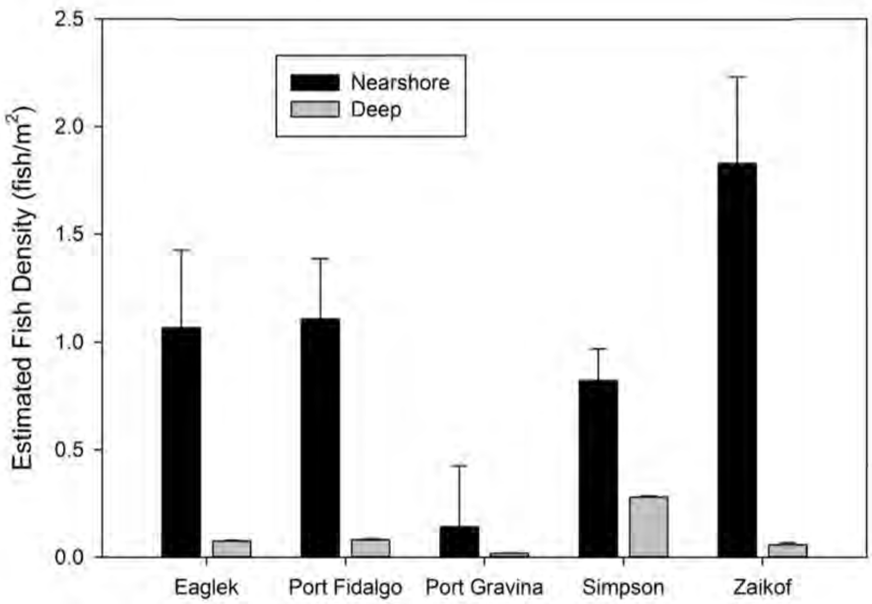


Figure 3. Acoustic density estimates during the November 2015 cruise. Dark bars are estimates derived from ASV sampling, and grey bars are from the traditional acoustic survey tracts.

In addressing the new approaches to monitoring most of the recent effort has been in analyzing results of previous testing. A new approach to detecting the presence of *Ichthyophonus* was developed. It uses a chromogenic in situ hybridization (CISH) assay to detect *Ichthyophonus* nucleic acid in standard histology sections. This provides greater ability to detect the presence of *Ichthyophonus* in archival samples and non-piscine intermediate hosts.

Community and Resource Managers

Results from the acoustic surveys of adult spawning biomass and disease prevalence work were provided to ADF&G for use in their ASA model.

We involved the fishing community in collection of juvenile herring in March instead of a dedicated scientific cruise to collect the fish necessary for the over wintering condition studies. Results of the program were presented to members of Cordova District Fishermen United. Working with both pilots and fishermen has improved communication between the scientists and the community and we are benefiting from more rapid reports of observations. It is through these communication lines that we are getting more reports about the summer distributions of fish and reports of herring spawn in a timely enough manner to allow ADF&G to collect the information they need. We continue to work with ADF&G and pilots in the area that are interested in making spawn observations to test protocols for data collection and reporting that can provide greater coverage of the spawn season.

Problems

Dr. Buckhorn was replaced by Dr. Rand this year. We arranged to contract with Dr. Boswell to provide technical support for the acoustics projects.

The expanded adult herring survey was unable to survey the main herring population in 2015 due to the fish not being aggregated during the cruise dates. We continue to explore means to increase flexibility in cruise dates to optimize our search effort. We are investigating means of determining the locations of staging grounds for fish spawning on Montague Island.

We expect that the ADF&G budget will not include funding to continue the surveys that they normally complete. These are critical inputs to the ASA model and for our understanding of the status of herring in Prince William Sound. We will need to find a way to cover these surveys if the state is unable to conduct them.

Other Significant Information

We found that age-0 herring from the Cordova Harbor have an usually high prevalence of *Ichthyophonus* and that the prevalence rapidly increases in May and June.

We have two positive indications for a moderately strong 2014 year class in spite of record winter water temperatures.

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

a) Publications

Batten, S.D., S. Moffitt, W.S. Pegau, and R. Campbell *In Press*. Plankton indices explain interannual variability in Prince William Sound herring first year growth. Fisheries Oceanography.

Conway, C.M., M.K. Purcell, D.G. Elliott, P.K. Hershberger. 2015. Detection of *Ichthyophonus* by chromogenic *in situ* hybridization. Journal of Fish Diseases 38: 853-857.

Hart, L.M., C.M. Conway, D.G. Elliott, P.K. Hershberger. *In Press*. Persistence of external signs in Pacific herring *Clupea pallasii* with ichthyophoniasis. Journal of Fish Diseases.

Hershberger, P.K., J.L. Gregg, L.M. Hart, S. Moffitt, R. Brenner, K. Stick, E. Coonradt, T. Otis, J. J. Vollenweider,K. A. Garver, J. Lovy, T.R. Meyers. *In Press*. The parasite *Ichthyophonus* sp. in Pacific herring. Journal of Fish Diseases.

Hershberger P.K., L.M. Hart, A.H. MacKenzie, M.L. Yanney, C. Conway, D. Elliott 2015. Infecting Pacific herring with *Ichthyophonus* sp. in the laboratory. Journal of Aquatic Animal Health 27: 217-221.

Muradian, M.L. 2015. Modeling the population dynamics of herring in the Prince William Sound, Alaska. MS thesis. School of Aquatic and Fishery Sciences, University of Washington, Seattle.

Muradian, M.L., T.A. Branch, S.D. Moffitt, and P-J. F. Hulson. *In review* Bayesian Stock assessment of Prince William Sound herring, Alaska. Fisheries Research.

Six articles were published in the Delta-Sound Connections.

b) Conferences: At the 2016 Alaska Marine Science Symposium there were eight posters and one oral presentation. Presentations on the herring disease program occurred at five venues. The modeling effort presented at the herring summit in B.C. Several investigators reported results at the Cordova community lecture series.

c) Data and information products: Disease prevalence numbers and acoustic estimates of adult herring biomass were provided to Alaska department of Fish and Game. Two Field Notes radio broadcasts were produced.

d) Data sets and metadata uploaded to data portal: We worked with Axiom to restructure the herring workspace and ensure that data on the workspace is up to date. Nearly 600 gigabytes of data was added to the workspace. A majority of that were raw acoustic files from the juvenile herring surveys and intensive. Updated data was provided by the energetics and conditions projects, herring scale analysis, aerial surveys, age at first spawn, disease, acoustic validation, and tracking projects.

9. Coordination and Collaboration: *See,* Reporting Policy at III (D) (9).

a) Within the HRM program fish captured by the validation project is provided to the acoustics, genetics, energetics, and disease projects. Data from the direct capture efforts are also used by the non-lethal sampling project. The energetics project processes juvenile herring for the disease project. They are also captured and processed fish from the Cordova harbor to provide a time series of disease prevalence and the energetic content of those fish. The disease project is working with the population modeling project to evaluate the best methods to incorporate disease prevalence data and how to bridge the change in methodology that occurred in 2007. The aerial survey project assists in collection of fish for the genetics project. The herring scale project provided hundreds of scale images to the age at first spawn project for their analysis. The coordination, outreach, and data management projects work with all other projects.

   Vessels were shared between the HRM and Gulf Watch Alaska (GWA) programs for collection of acoustics data during a humpback whale cruise, and bird observations during the November herring cruises. The aerial survey project is a collaboration between the herring program and the forage fish project in GWA. Aircraft time, survey methods, and results are shared between the projects. The HRM program has begun using data and expertise from the environmental drivers projects, particularly the continuous plankton recorder and PWS oceanography study to examine how environmental conditions affect growth of herring and to explain the migration patterns of tagged herring and the spatial patterns in stable isotopes and fatty acids. The disease component is receiving zooplankton from Dr. Campbell to determine if zooplankton may be a source of the ichthyophonus disease. We continue to follow the research of the bird and mammal projects to understand how to best incorporate their observations for understanding the predation pressure on herring.

b) We do not have direct collaboration with other EVOSTC funded projects.

c) There are investigators from US Geological Service and the National Oceanic and Atmospheric Administration that provide a link to those trustee agencies. Most of the collaboration is with Alaska Department of Fish and Game through Steve Moffitt at the Cordova office and Sherri Dressel as the statewide herring coordinator. ADF&G supports sampling for disease prevalence in adult herring, provides samples for the genetics projects, and provides several datasets and model results used for management. Data from the acoustic surveys of adult populations and disease prevalence data is provided to ADF&G for use in their age-structure-analysis (ASA) model. Adult herring collected from locations not sampled by ADF&G are provided to them for age-sex-length analysis. We provide information about findings to ADF&G and seek input on their needs.

10. Response to EVOSTC Review, Recommendations and Comments: *See,* Reporting Policy at III (D) (10).

See review, recommendations, and responses below. Responses are in italics.

FY15 comments

Next year, the Panel would like to see improvements in:

Inclusion of fundamental information

The Panel would like to see the inclusion in proposals of information regarding the 1) approach, design and analysis of studies and 2) explicit statements of how analyses are answering major questions. This key information is essential to evaluating proposals, and we expect to see brief descriptions included in the next set of proposals. We are not requesting that detailed descriptions be provided to the degree exhibited in original proposals or publications; PIs should use their expertise to identify and include essential, fundamental information that should be included to facilitate review. Good examples of the level expected detail include the GulfWatch proposals by Carls, Jones, and Piatt and the Marine Debris Removal proposal by Pallister (available on the EVOSTC website).

> *This message was sent to each of the P.I.s as they developed year 5 proposals.*

The Science Panel would also appreciate having more detail about how the herring programs contribute to the existing and proposed herring assessment process and model. In particular it would be useful to have a short paragraph on each of the tuners used in the model: spawn assessments and acoustic data.

> *Descriptions of the ADF&G and Bayesian models were provided to the EVOSTC staff for distribution to the Science Panel prior to the synthesis meeting.*

The Panel appreciates that any additional requests for information in proposals can be perceived as onerous and that the Panel had indicated in prior years that they did not want the entire original proposal text included every year. However, the minimal, essential information requested should not take long to incorporate and could remain in subsequent proposals. From a Panel perspective, proposals cannot be evaluated without key, fundamental information on major hypothesis and models, in part so changes to the design can be placed in proper context. We appreciate your efforts in refining your multi-year proposal submissions.

Planning Succession Necessitated by Attrition of Experienced Personnel

This continues to be an area of concern for the Panel. The departure of Michele Buckhorn, who serves as the lead PI for three of the twelve submitted projects, could have a large impact on the overall success of the Program. We understand from our discussion with Scott that they are working to address the issue but feel that this highlights the issue of a need for junior scientists to be trained within the projects so smooth transitions in scientific personnel.

The Panel continues to support efforts to increase future capacity with regard to PIs turnover and continues to encourage that post-docs be integrated into the programs.

> *We are trying to ensure we have a means to replace personnel if they leave the program. For each project a person has been identified to cover for a PI if they depart. There are impacts during the transitions, but we feel we can ensure critical components continue while a new PI is brought on. Dr. Buckhorn was a junior scientist that was under the tutelage of Dr. Thorne. Unfortunately, the junior scientists are most likely to move as they find other opportunities. We were able to bring on Dr. Rand to replace Dr. Buckhorn with minimal interruption. At this point the post-docs are funded through NCEAS and we don't have the ability to influence their projects to provide benefit to our program.*

Improved data submission by Herring Program PIs

We understand that many PIs in the Herring program are behind in providing metadata and data to the central data repository. With the new forms that have been developed, and the availability of assistance from Axiom staff, it is important for each PI to comply with the data submission requirements set forth as a condition of their funding.

> *Data submission to the Ocean Workspace is up to date and the PIs are getting better at ensuring data is updated on a regular basis. At this point we need to work on the metadata submission. Almost all of the PIs have met with Axiom staff to get training on data and metadata submission.*

Coordination & Collaboration/Synthesis
The Panel appreciated the programs' explicit statements recognizing the synergisms among project efforts. It is clear that most projects are already working together where it is practical or advantageous to the achieving the goals of individual projects. We also appreciated that the programs recognized the need to integrate data across projects to arrive at a synthetic view of the status and trends of herring populations in PWS. However progress in these areas will need to be more explicit and fully developed. Details provided to the Panel were too limited to be able to truly evaluate progress in this area. Discussion on the conference call with the PI was encouraging in that details of the stock models will be provided to the panel in advance of the February synthesis meeting.

> *The details on the stock models were provided as requested. Hopefully the level of detail provided in the synthesis, during the science review, and in this report helps to make the collaborations more obvious. There have always been close ties between the two programs at the administrative level, but we are gaining connections between individual projects. The requirement of the synthesis as a deliverable this past year was a great driver for developing those connections.*

FY16 comments
The Science Panel was pleased with the progress of the individual projects and the overall Program. The Panel is gratified to see several new and younger scientists with fine and promising records of past preparation and accomplishments. For example, the progress made already by Dr. Gorman to work through the backlog of samples left after the departure of Tom Kline is impressive. Dr. Pegau's active leadership is critical to the study's success and especially to achieving important syntheses among separate projects.

We hope this comment reflects the effort we made to address earlier concerns of the Science Panel.

11. Budget: *See,* Reporting Policy at III (D) (11).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$201,500.0	$377,300.0	$535,700.0	$506,700.0	$518,000.0	$2,139,200.0	$1,191,307.0
Travel	$26,800.0	$31,500.0	$47,000.0	$47,300.0	$46,600.0	$199,200.0	$101,234.0
Contractual	$336,960.0	$544,799.0	$456,188.0	$435,116.0	$362,757.0	$2,135,820.0	$1,684,652.0
Commodities	$81,600.0	$33,700.0	$104,100.0	$102,700.0	$67,100.0	$389,200.0	$255,570.0
Equipment	$187,200.0	$0.0	$0.0	$0.0	$0.0	$187,200.0	$221,569.0
Indirect Costs (*will vary by proposer*)	$108,500.0	$173,030.0	$168,200.0	$161,100.0	$144,370.0	$755,200.0	$510,385.0
SUBTOTAL	$942,560.0	$1,160,329.0	$1,311,188.0	$1,252,916.0	$1,138,827.0	$5,805,820.0	$3,964,717.0
General Administration (9% of subtotal)	$84,830.4	$104,429.6	$118,006.9	$112,762.4	$102,494.4	$522,523.8	
PROJECT TOTAL	$1,027,390.4	$1,264,758.6	$1,429,194.9	$1,365,678.4	$1,241,321.4	$6,328,343.8	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	N/A

Most of the discrepancy in spending can be traced to projects with personnel changes that led to reduced spending during the transition. All investigators are aware that spending must be completed this fiscal year and have plans to use any remaining funds to increase analysis efforts.

We appreciate your prompt submission
and thank you for your participation.

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.

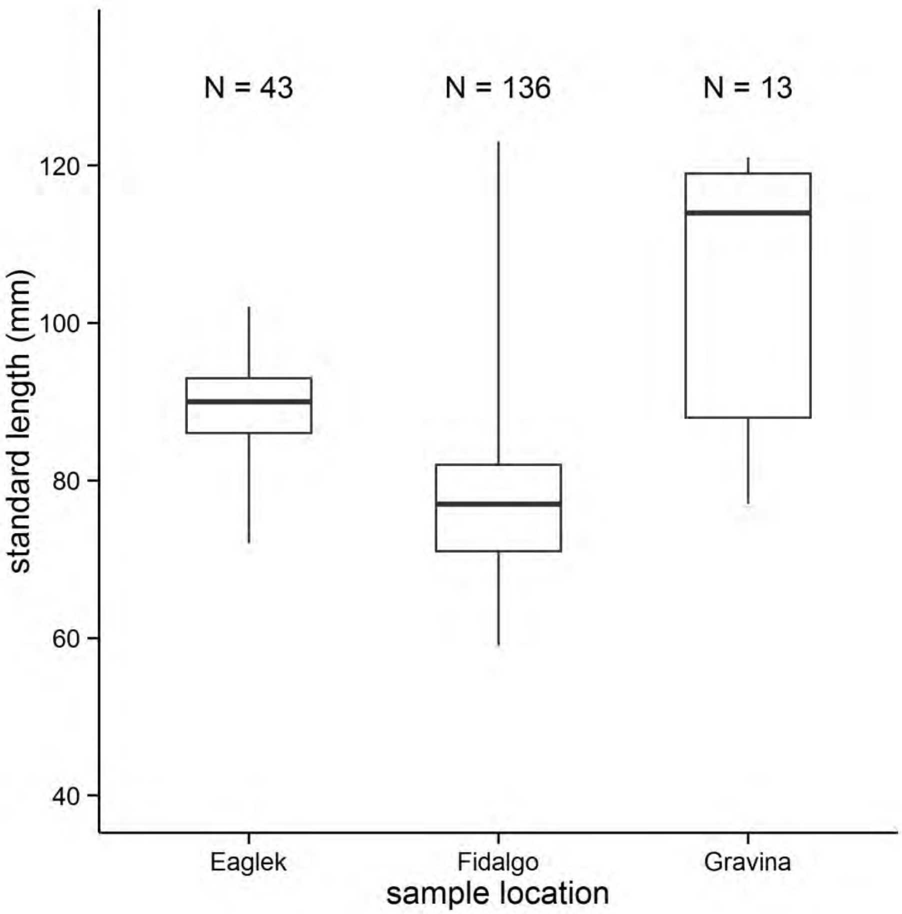
Project	**Agency**
Acoustic Validation	PWS Science Center
Condition Index	PWS Science Center
Genetic Stock Structure	NOAA / ADF&G
Disease	USGS
Growth RNA/DNA	NOAA Auke Bay
Age at First Spawn	NOAA Auke Bay

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, 25^{th} percentile, median, 75^{th} 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.

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

Popular Press:

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.

Meetings:

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.

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

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111-C

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

Data Management Support for the EVOSTC Herring Program

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

Rob Bochenek, Alaska Ocean Observing System (AOOS)

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

February 1, 2015 – January 31, 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).

AOOS Workspace Herring Research and Monitoring Program group: https://workspace.aoos.org/group/3503/projects

AOOS Gulf of Alaska Data Portal: http://portal.aoos.org/gulf-of-alaska.php#

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

The core focus of the data management effort for the EVOS Herring Research and Monitoring program has been on establishing protocols for data transfer, metadata requirements and initiating the data salvage effort. The data management team (henceforth 'Axiom') has participated in several Herring Program PI meetings and coordination activities between the Herring and Gulf Watch Alaska (GWA) programs, including the November 2015 and January 2016 PI meetings.

In coordination with Herring Program management, data management project PIs determined the need for additional staff time beyond that currently funded for the effort the project that would be dedicated to Herring Program data management needs. Based on feedback acquired from the EVOSTC Science Panel and staff, the project team applied for and received funding for this new position. In FY2015 Axiom recruited and hired the data coordinator, Ms. Stacey Buckelew, who began work on the project in June 1, 2015.

In addition, the AOOS Ocean Workspace has been in use by Herring Program PIs since 2013 for staging, organizing, and sharing their datasets. Software engineers at Axiom have worked throughout FY2015 to support the Workspace, resolving bugs and implementing new functionality in response to user feedback. Datasets from the HRM program have been visualized through the AOOS Gulf of Alaska data portal to provide researchers with a streamlined visual environment for data selection, filtering, and exploration.

In this reporting period, data management support continued to be provided through the Ocean Workspace. The emphasis was on facilitating the transfer of data to the Workspace by the various projects. All prior data from the Herring Data Portal have been transferred into the AOOS Gulf of Alaska Ocean Data Explorer. Work began on reorganizing the Workspace to encourage greater use and the inclusion of more metadata. Additionally in-person meetings occurred with HRM PIs to support data submissions and metadata authoring.

Table 1. Project milestones status

Deliverable/Milestone	**Status**
Objective 1. GoA Data Portal showcasing Herring data sets	*Completed* ● GoA Data Portal interface and herring data updated in 2015, larger updates begun.
Objective 2. Continue to support the transfer and documentation of Herring data sets. Auditing and restructuring/reorganizing	*Ongoing* ● Data coordinator Stacey Buckelew was recruited and hired in June 2015 to support the EVOS Herring Program and GWA.
Objective 3. Continue to cultivate and support the functional capabilities of the AOOS Ocean Workspace to address Herring researcher needs	*Ongoing* ● Restructure of the HRM Workspace occurred in fall 2015. ● One-on-one PI meetings held with PIs in December 2015 and January 2016 to implement best practices for metadata record creation
Objective 4. Improved Herring Portal project profile by exposing underlying file level metadata	*Completed*

Objective 1 & 4

The Gulf of Alaska Data Portal was originally launched in September of 2013 and made available for public access. At that time, all of the data that had been in the dedicated Herring Portal was migrated to the Gulf of Alaska portal where it benefits from the additional context of more than 400 other data layers describing other observed and modeled parameters in the Gulf of Alaska. The Gulf of Alaska Data Portal leverages the cyber infrastructure behind the AOOS Ocean Data Explorer, which was developed using other funding and has these additional features: an integrated search catalog which allows users to search by category or keyword, ability to preview data before downloading files, and advanced visualization tools.

During 2015, a number of updates were made to the AOOS data system, the benefits of which are available to be shared by the EVOS Herring Program and the other research groups supported by or working with AOOS. These improvements are separated below into work completed in 2015, and work begun in 2016 and still underway.

Work Completed

The Herring Research and Monitoring program has been added to the Gulf of Alaska's data portal splash page (Fig 1). Historical data from a quarter century of monitoring studies conducted by the Herring program are available. Data and metadata records from the more recent herring investigations will be published from the Workspace to the portal when they are complete. Data published through the portal is available for public access.

In this reporting period, a new search feature was added the portal to enhance data discovery by the user. When searching data in the catalog, the user can now opt to search for content using a manifest view. This tabular list of data allows more information to be viewed on the page at one time, and it will expedite access time for users seeking specific datasets (Fig 2).

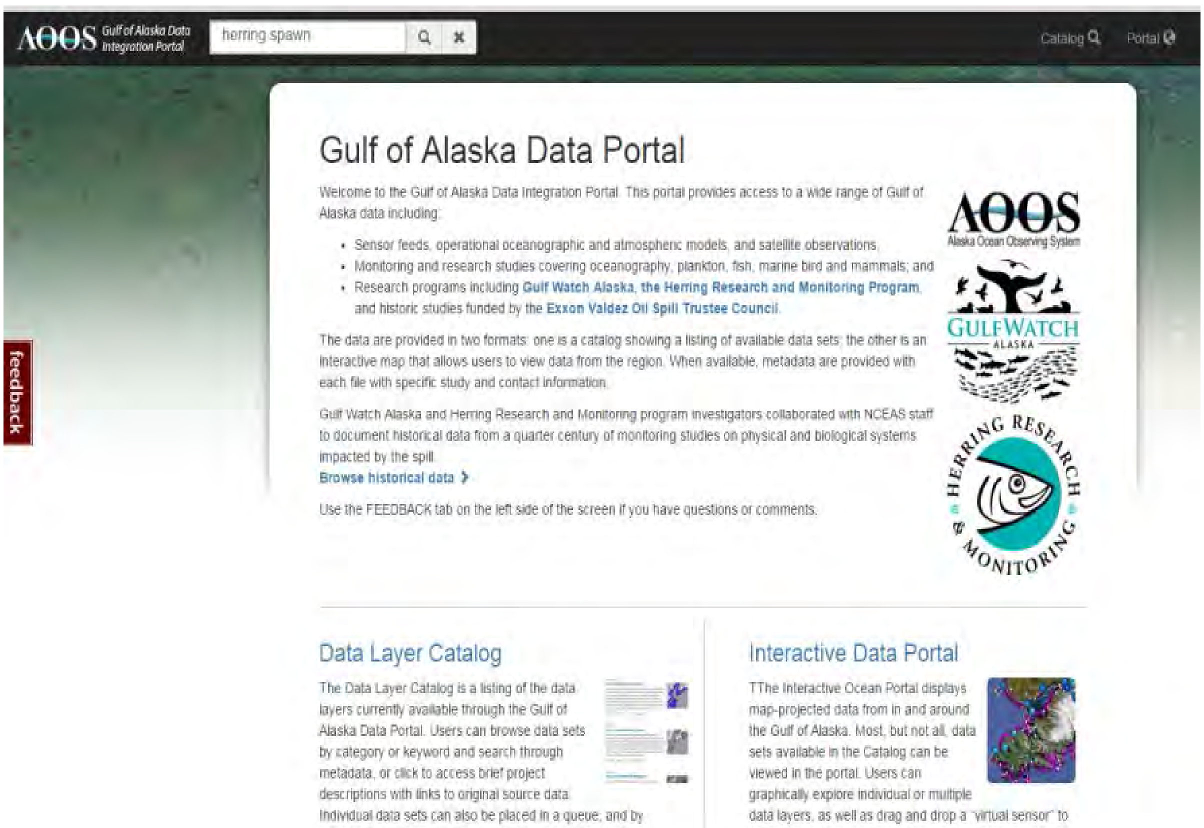


Figure 1. The overview page (e.g. splash page) to the Gulf of Alaska data portal highlights the recent and historical availability of information from both the EVOSTC-funded GWA and HRM programs.

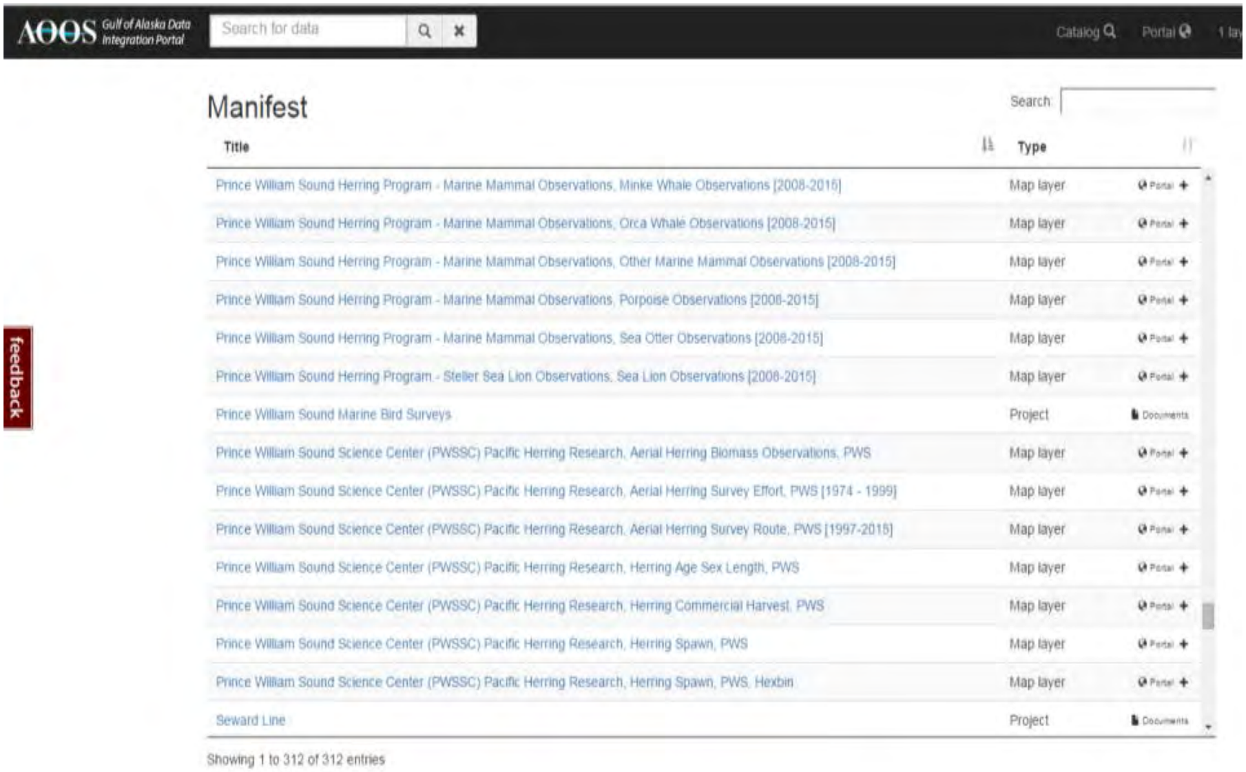


Figure 2. A manifest view of data available in the Gulf of Alaska data portal. This new search feature enhances data discovery by the user by allowing more information to be viewed on the page, thus expediting access time for users seeking specific datasets.

Axiom software engineers redesigned the display in the Gulf of Alaska Data Portal for metadata created in the Ocean Workspace and imported into the portal. Upon initial release of the portal, project metadata created in the Workspace was visible as an HTML webpage and file-level metadata from the Workspace was available in the portal as raw, unstyled JSON documents. In the time since the launch of the portal, the metadata editors in the Ocean Workspace have been harmonized to provide the same interface and fields for project and file metadata, and have expanded to provide new metadata fields. This year, Axiom's interface designer created a new style sheet to display both the project and file level metadata from the Workspace in a much more human-readable form. The design of the metadata pages in the portal underwent several design iterations based on user feedback before settling into their current form (Fig 3).

Axiom software architects and engineers have worked throughout 2015 to improve the Gulf of Alaska Data Portal's data catalog user interface and portal visualization capabilities. Improvements completed in 2015 include rebuilding the search tool to improve the precision and relevancy of search results, and to allow search results to be added to the mapping portal from the portal search bar. Additional improvements include indexing the spatial and temporal metadata associated with a dataset to allow searches to be constrained both spatially and temporally. These upgrades to the data system were motivated by feedback received from GWA managers as well as external sources. Improvements to the catalog search tool have expanded the range of material indexed for search to include file-level metadata and the text content of files imported into the Gulf of Alaska data portal from the Workspace. Indexing spatial and temporal metadata will allow users to limit the results of their searches to show only the data in the area selected during the time span indicated. Portal users are able to set these limits by drawing a polygon on a map, inputting a spatial bounding box, and/or using a time slider to set a time range.

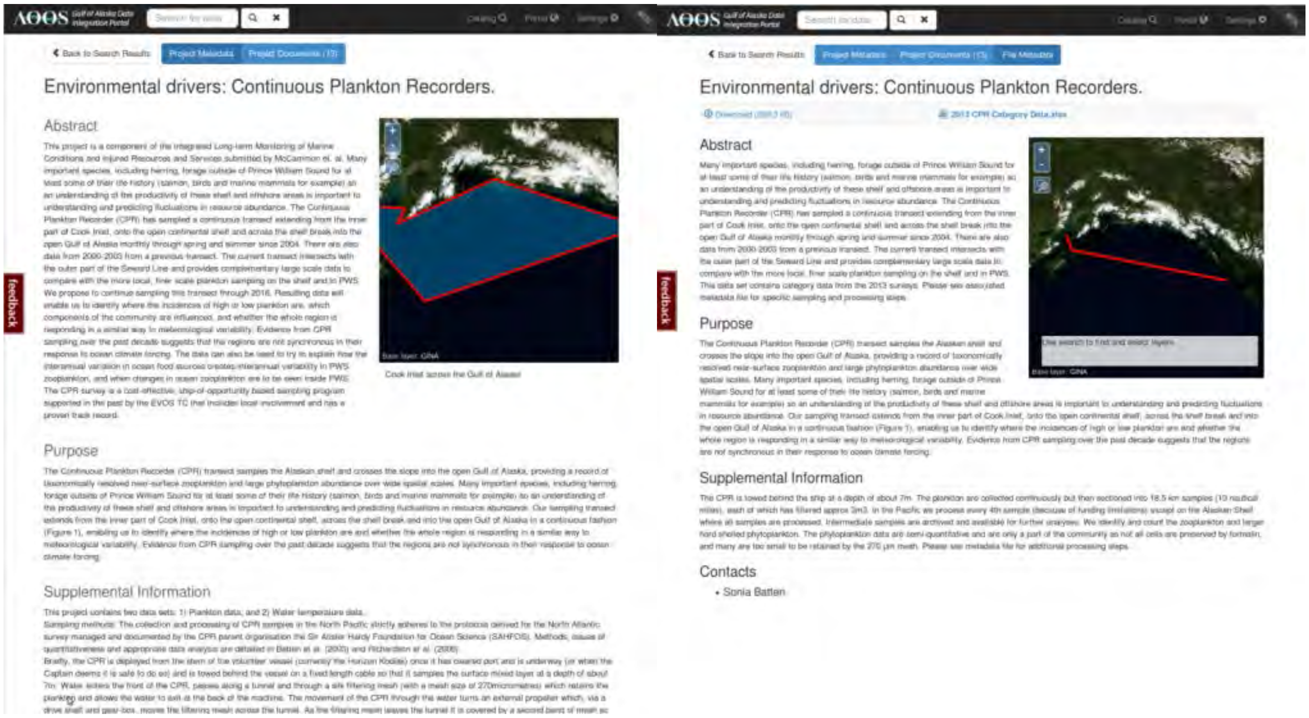


Figure 3. Screenshots of metadata imported from the Ocean Workspace into the Gulf of Alaska Data Portal. From left to right: project metadata for the Continuous Plankton Recorder (CPR) project, metadata for a single data file within the CPR project.

Work Underway

In addition to continually revising the display of project and file metadata in the portal, in FY2015 Axiom staff began work on an improved version of the metadata editor. This new editor will provide the fields and flexibility necessary to more robustly describe projects, the datasets they generate, and relationships between projects and resources. By enabling better, more precise and nuanced descriptions of data and projects, this improved editor will lead directly to better discoverability of data within the Gulf of Alaska Portal, and eventually within the DataONE system. This new web-based editor will initially create xml records for ISO 19115 metadata, with the ability to create 19115-1 and EML records developed after release. This new editor will be released in early spring 2016.

To integrate data into the Gulf of Alaska portal and enhance its use by GWA and HRM PIs and the public, data visualizations were completed for several EVOSTC long-term monitoring datasets. The goal of visualizations is to provide a clear and efficient visual communication of data by making complex or long-term information more accessible, understandable and usable. Additionally, visualizations help researchers to easily reason about data and make comparisons to other related or environmental datasets.

In this reporting period, the herring spawn survey data from the Alaska Department of Fish and Game through spring 2015 was updated in the data portal (Fig 4). The location and total length of herring spawn activity have been visualized for this entire dataset (1973 to 2015). The herring spawn data can be displayed as either as a plotted survey line or hexed heat map to represent the area when herring spawn activity was observed. This data set can be co-visualized (or ‘stacked’) together with humpback whale data collected during 2006 to 2014 as part of the GWA program (refer to 14120114D 2015 annual report). These stacked data layers allow for the visual exploration of how changes in humpback whale distributions may coincide both spatially and temporarily with aggregations of spawning herring (refer to 14120114D 2015 annual report).

Additional data can be co-visualized with the herring spawn survey data to help explore possible relationships among multiple data sources. During this reporting period, the incidental marine mammal observations during aerial herring surveys conducted 2008 to 2015 were visualized. The location, time, and number of marine mammals observed by species were mapped. The view can be filtered by the user to observe all or only select groups of species. Additionally, a time slider can be applied to view the change in marine mammal distributions over time. To aid the user in generating summary statistics about these observations, a polygon tool has been integrated into the data portal. With the tool, a user can draw a polygon around a spatial area to generate a summary chart of the number of animals by species observed over time within that area (Fig 5).

To summarize data over large spatial extents, a hexed heat map is generated when the user zooms out. The heat map displays the areas where marine mammals were most frequently observed (or’ hotspots’) in Prince William Sound (Fig 6). Using a time slider or seasonal filter to the heat map, the change in humpback whale distribution can also be explored.

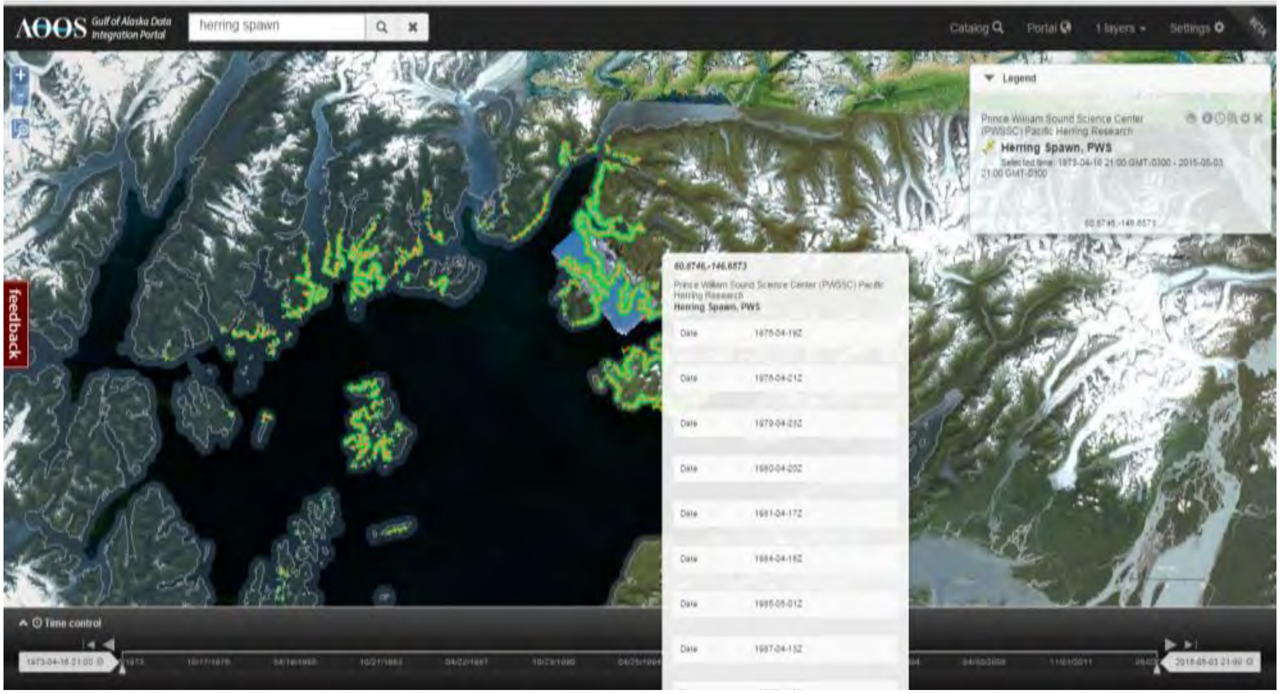


Figure 4a. Linear display of herring spawn lengths

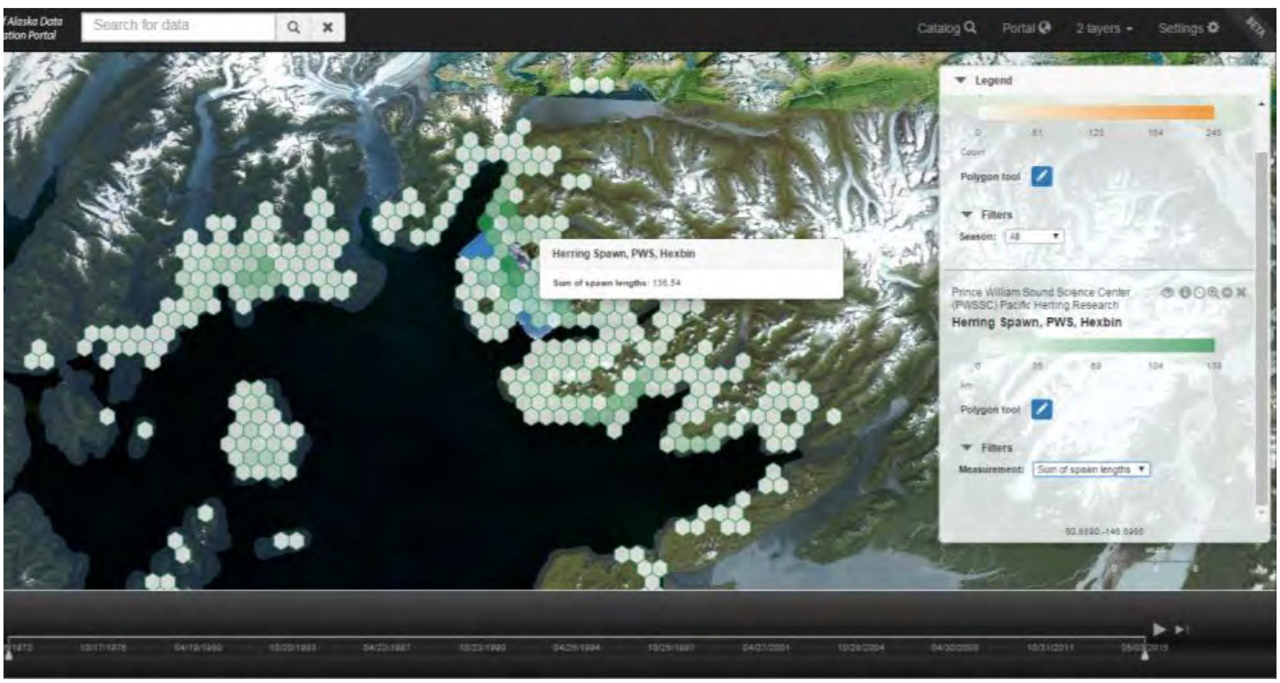


Figure 4b. Hex heat map display of the frequency and total length of herring spawn activity.

Figures 4 a & b, above. Screenshots of AOOS Gulf of Alaska Data Portal showing two different graphical displays of herring spawn observations in Prince William Sound from surveys conducted 1973 to 2015. The upper figure shows the length (km) of observed spawning area, whereas the heat map show the sum of observed spawning lengths within a given area. The darker the color, the greater the length of total spawning activity that was observed in that area. Using the time slider (at the bottom), the change in herring spawn activity can also be explored over time.

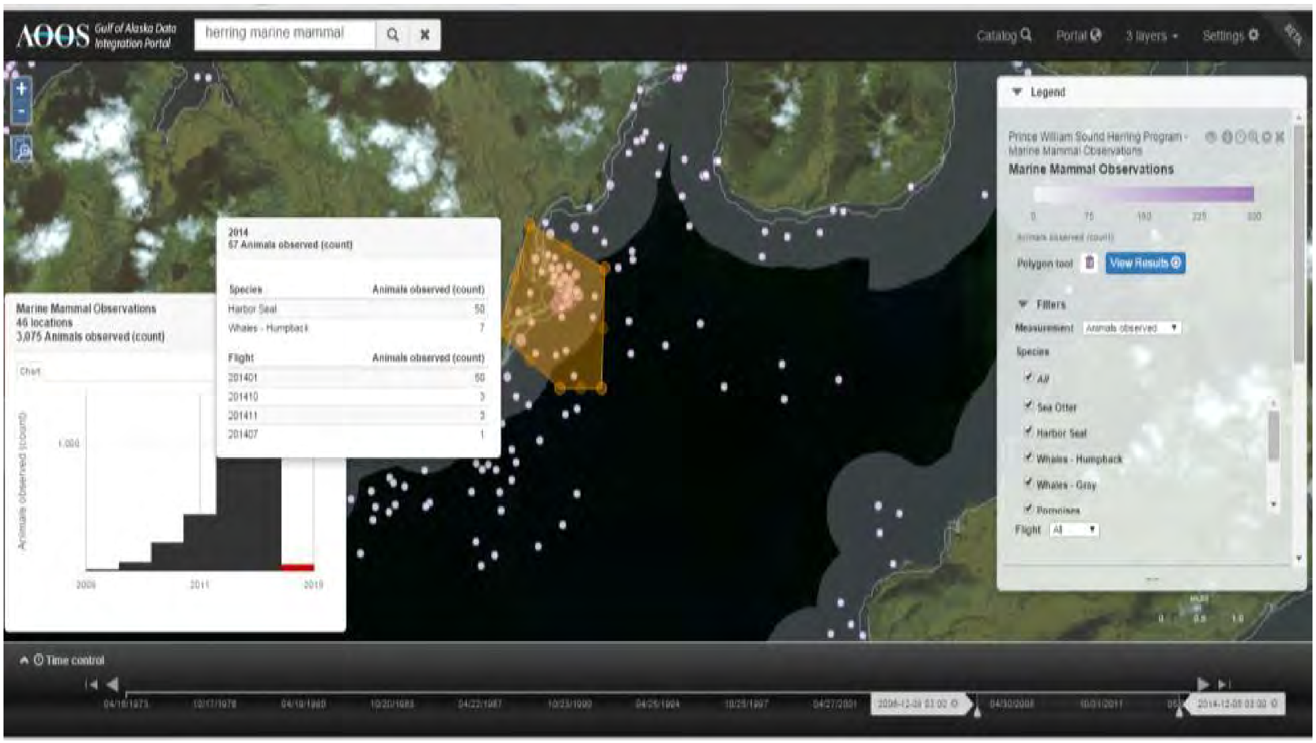


Figure 5. Screenshot of AOOS Gulf of Alaska Data Portal showing a polygon tool that automates summary statistics within user-defined spatial areas. A histogram of the number of marine mammals observed by species during aerial herring survey is shown over time from 2006 to 2015.

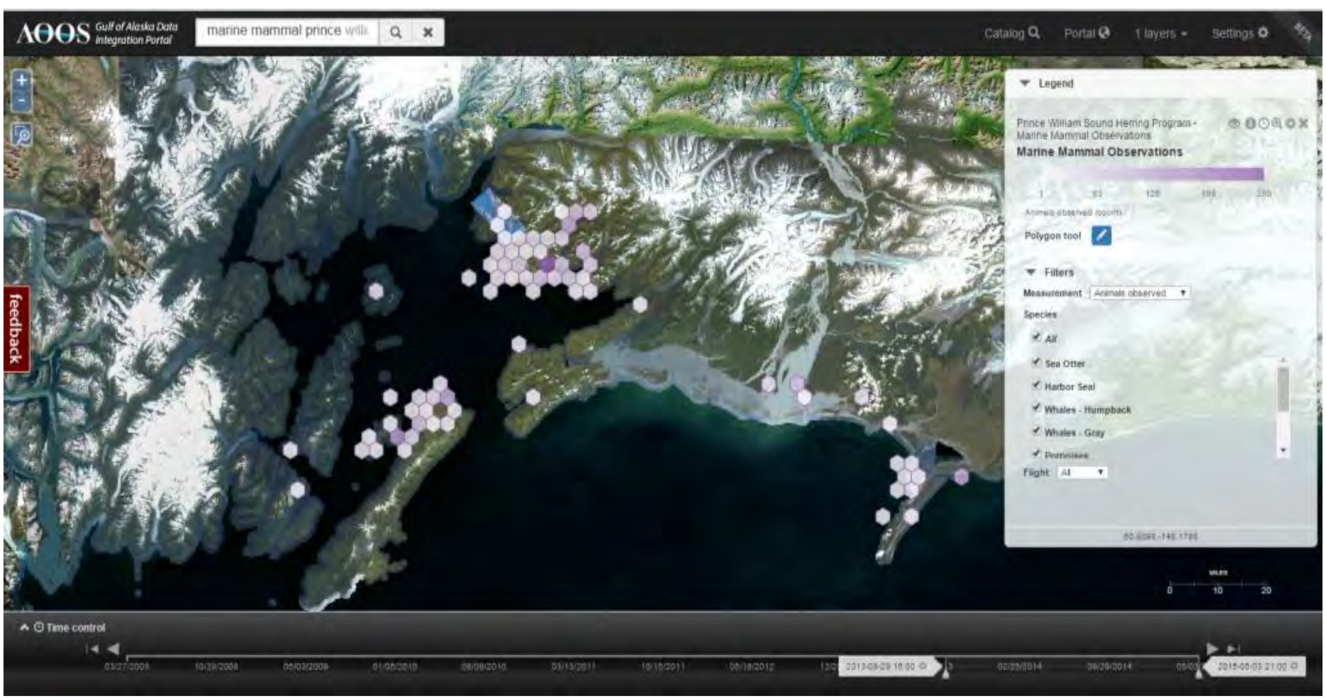


Figure 6. Screenshot of AOOS Gulf of Alaska Data Portal showing a hexed heat map of incidental marine mammal observation during aerial herring surveys conducted 2006 to 2015. The darker areas represent areas where marine mammals were most frequently observed (or' hotspots') in Prince William Sound . Using a time slider or seasonal filter to the heat map, the change in humpback whale distribution can also be explored.

Available in the Gulf of Alaska data portal are hundreds of additional data sets that allow for simplified, visual integration. As additional data is added from the GWA and HRM programs, the portal will continue to provide researchers with a streamlined visual environment for data selection, filtering, and exploration from multiple sources (including environmental, atmospheric, and numeric models). For example, the changes in marine mammal distribution by species could be observed relative to changes in ocean temperature using NASA's Multiscale Ultrahigh Resolution (MUR) Sea Surface Temperature analysis and herring spawn activity (Fig 7). This tool allows rapid discovery of other datasets that can be used to give context to and provide comparisons study data, evaluate initial study hypotheses, inform further experimentation and experimental design, and generate additional hypotheses or notice potential "hot spots" related to drivers of environmental change in Prince William Sound.

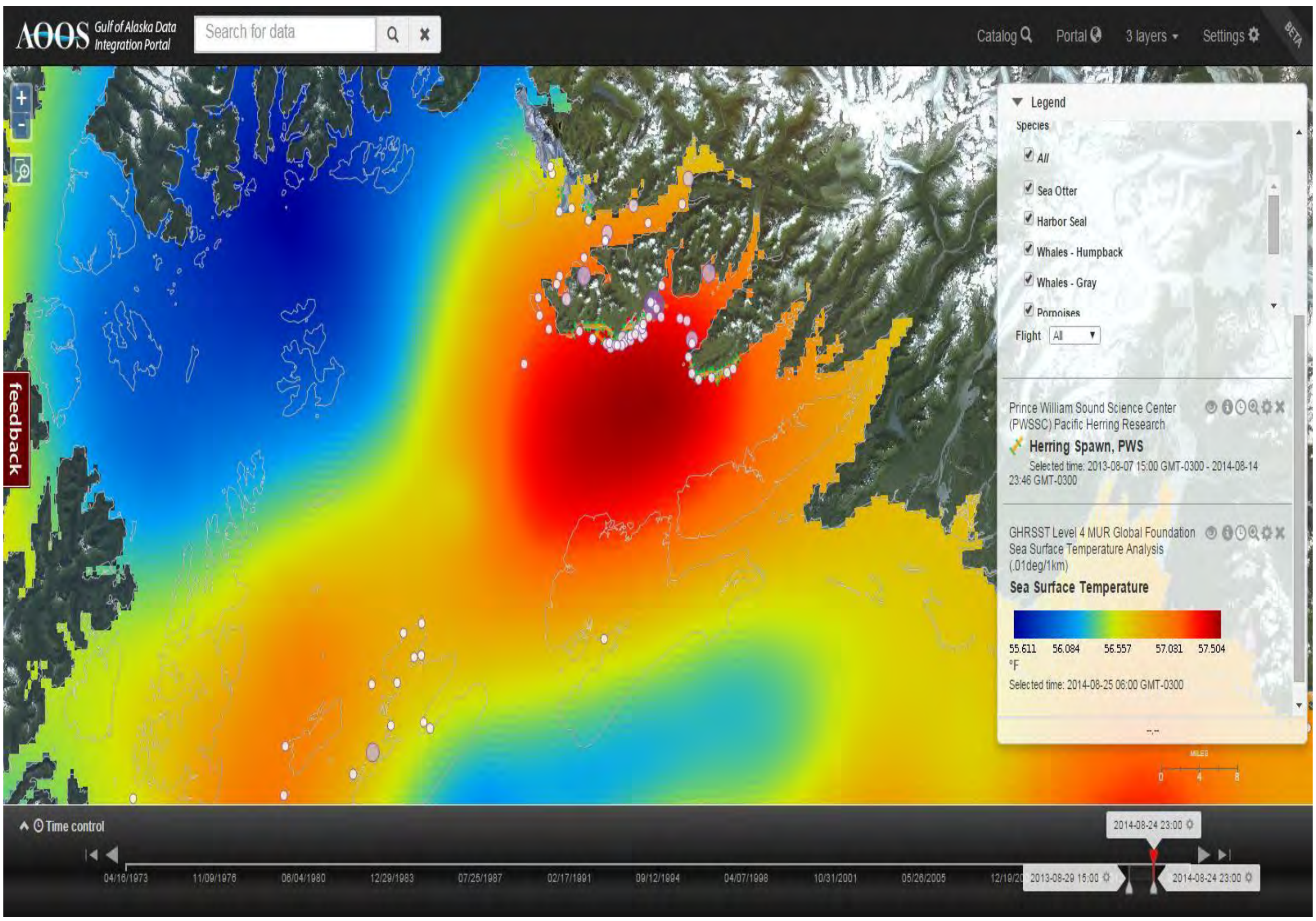


Figure 7. Screenshot of AOOS Gulf of Alaska Data Portal showing the number of marine mammal species (round circle) and herring spawning activity(green and orange lines along the coast) observed during herring survey in 2014. The underlay in the map reflects sea surface temperature from the NASA MUR Sea Surface Temperature Analysis. The change in species distribution and spawning aggregations relative to ocean temperature change can be explored across time using the time slider feature.

Objective 2 & 3

The primary results produced by this project include the acquisition and documentation of EVOS Herring Program PI-produced data sets and the aggregation of ancillary environmental data sets for integration into the AOOS Gulf of Alaska Data Portal. To facilitate the acquisition and documentation of Herring Program data, the project team provides Herring Program PIs with access to the Ocean Workspace, a web-based collaborative data management environment. The project team has supported the use of the Ocean Workspace for data ingestion and documentation through webinars, email support, and by making functional improvements to the Ocean Workspace based on user feedback.

The project team and the Herring Program management decided that the Herring Program required more active data management and facilitation than was possible using the Ocean Workspace. This would also require leveraging work done with other research groups to develop data lifecycle and management plans. In 2014, the project team applied for additional funding from the EVOSTC to partially fund a full time data coordinator position at the Axiom Data Science office to provide dedicated one-on-one work with EVOS Herring Program and GWA PIs. In June 2015, AOOS, through its technical arm at Axiom, responded to this need by hiring Ms. Stacey Buckelew as the data coordinator to lead the PWS Herring program data ingestion effort.

The data coordinator responsibilities have targeted improving metadata quality and best practices. As such, the AOOS Herring Research and Monitoring Program Workspace group was reorganized in fall 2015 to create a cohesive organizational structure to the GWA Workspace group. Additionally, one-on-one meetings were scheduled with individual PIs from the LTM and PWS Herring programs during fall 2016 and winter 2016 to provide guidance and support on data submission and metadata authoring. From December 2015 to February 2016, 24 meetings were held with over 30 program PIs or researchers to discuss data submissions and metadata authoring. PIs also received individual instruction in the use of the AOOS Workspace and exploration of data available in the Gulf of Alaska data portal. A metadata process was established to ease the authoring process by PIs and to help standardize the metadata formats across programs. For full details on these activities refer to the 2015 Supplemental Data Management project annual report.

Investigators continue to improve the Ocean Workspace in response to user feedback. The AOOS Herring Research and Monitoring Program Workspace group was reorganized in fall 2015 to create a cohesive organizational structure to the GWA Workspace group. Several meetings were held with Scott Pegau to discuss an agreed-to organizational structure. Workspace folders were then reorganized and retitled according to individuals projects in order to clearly establish the association of PIs to project and enhance their sense of 'ownership'. Additionally, data sets were reorganized by projects and tags added by current status, herring age class, and survey type to ease Workspace access by all PIs.

In concert with the Workspace restructure, a data file and metadata inventory by project was completed. The inventory was cross-referenced with project proposals and progress reports to determine which data files had not been submitted to the Workspace (Fig 1). At the PI meeting in November, the data coordinator presented the inventory and discussed a process for meeting the submission benchmarks with the PIs. The process was agreed-to by all PIs present at the meeting to include the PIs collecting content for the metadata record followed by one-on-one meetings to provide guidance and support on data submission and metadata authoring.

As a result, the Ocean Workspace has become more useful and easier to use by PIs. The increase in use by Herring Program PIs is represented in the Figures 8-10 below, followed by a description of the Ocean Workspace.

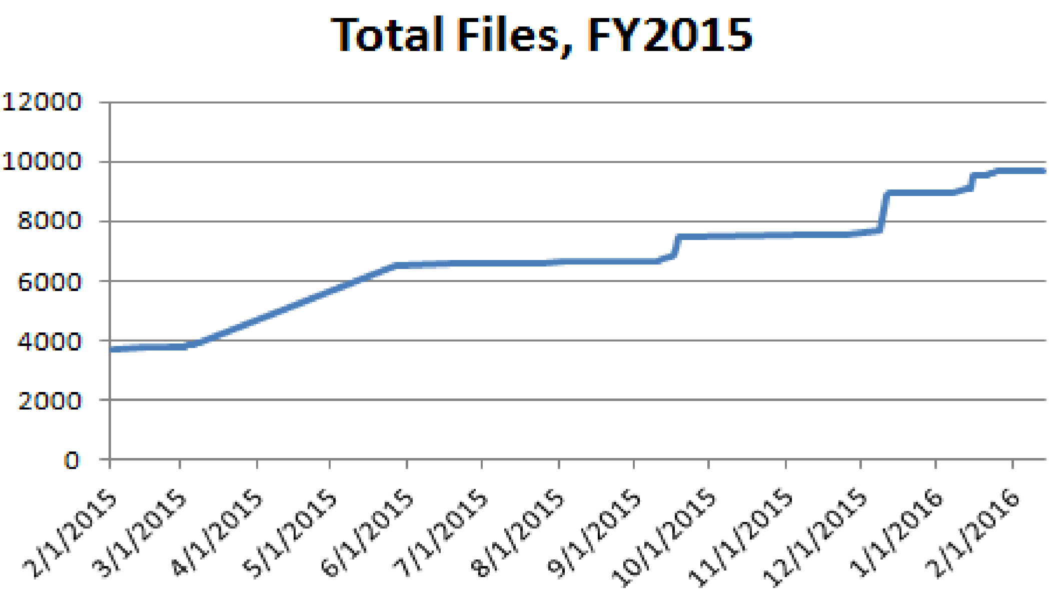


Figure 8. The number of files uploaded by HRM team members in FY 2015.

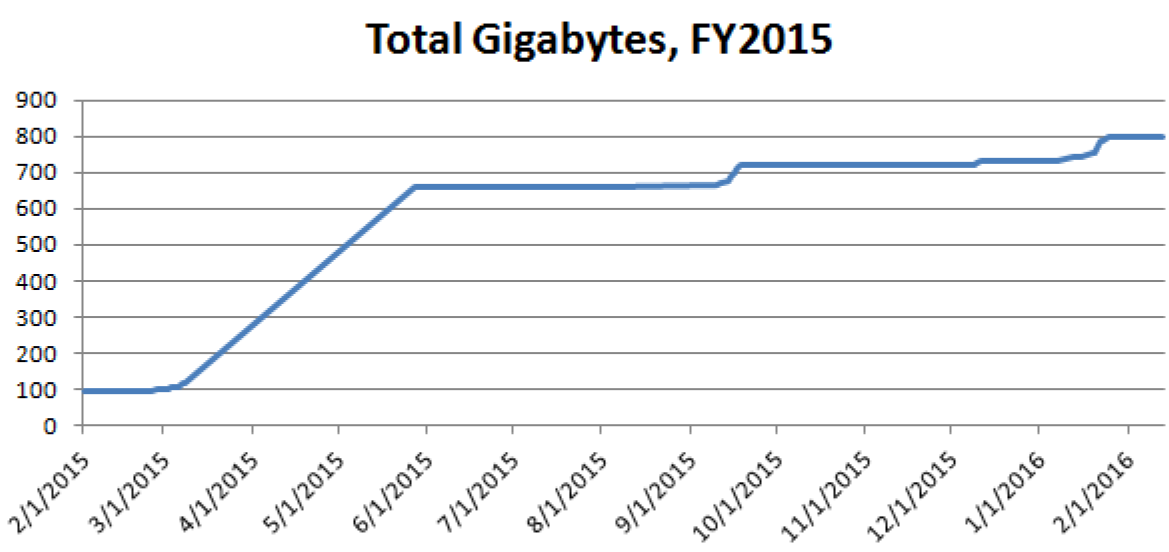


Figure 9. The amount of total storage in Gb used by HRM team members in FY 2015.

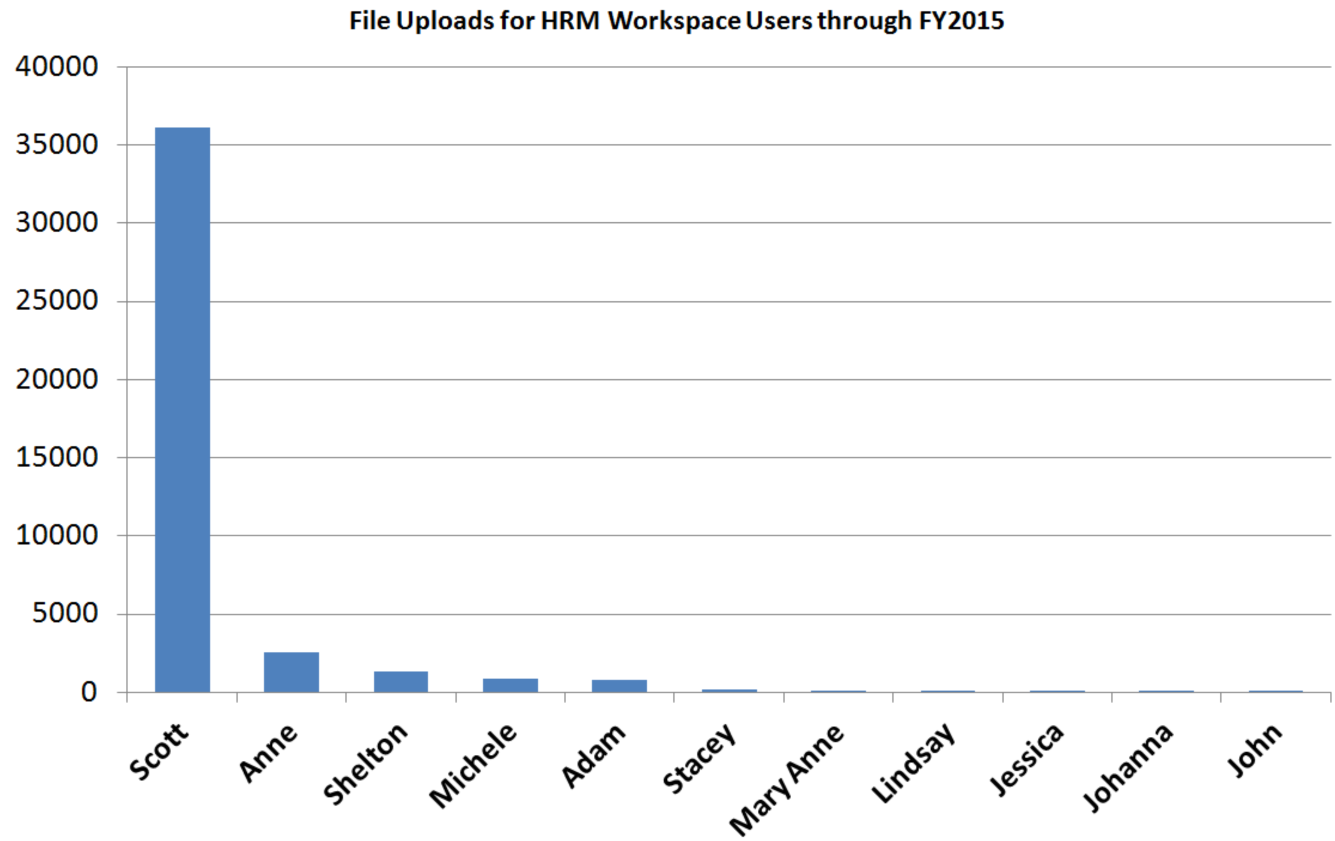


Figure 10. The distribution of file upload effort across individual HRM users through FY2015

The Ocean Workspace

The Ocean Workspace is a web-based data management application built specifically for storing and sharing data among members of scientific communities. GWA PIs and their teams use the Workspace as an internal staging area prior to public release of data through the AOOS Gulf of Alaska Data Portal. In addition to the GWA program, 36 other distinct regional, national, and private research efforts currently use the Workspace, which has more than 480 active individuals sharing more than 800,000 digital files across more than 1300 distinct projects. The Workspace provides users with an intuitive, web-based interface that allows scientists to create projects, which may represent scientific studies or particular focuses of research within a larger effort. Within each project, users create topical groupings of data using folders and upload data and contextual resources (e.g., documents, images and any other type of digital resource) to their project by simply dragging and dropping files from their desktop into their web-browser. Standard, ISO 19115-2 compliant metadata can be generated for both projects and individual files. Users of the Workspace are organized into campaigns, and everyone within a campaign can view the projects, folders and files accessible to that campaign. This allows preliminary results and interpretations to be shared by geographically or scientifically diverse individuals working together on a project or program before the data is shared with the public. It also gives program managers, research coordinators and others a transparent and front-row view of how users have structured and described projects and how their programs are progressing through time. The Workspace has the following capabilities:

Secure group, user, and project profiles — Users of the Workspace have a password protected user profile that is associated with one or more disciplinary groups or research programs. The interface allows users to navigate between groups in which they are involved through a simple drop down control. Transfer of data and information occur over Secure Socket Layer (SSL) encryption for all interactions with the Workspace. The Workspace supports authentication through Google accounts, so if users are already logged into their Google account (e.g., Gmail, Google Docs, etc.), they can use the Workspace without creating a separate username and password.

Metadata authoring — Because the Workspace is a cloud-based service, researchers can move between computers during the metadata generation process in addition to allowing team members and administrators to simultaneously review and edit metadata in real time.

Metadata elements currently available to researchers in the Workspace are common to the Federal Geographic Data Committee (FGDC) designed Content Standard for Digital Geospatial Metadata (CSDGM) and the ISO 19115 standards for geospatial metadata, extended with the biological profiles of those standards. Axiom also developed an integrated FGDC biological profile extension editor that allows users to search the ~625,000 taxonomic entities of the Integrated Taxonomic Information System (ITIS) and rapidly generate taxonomic metadata.

To support the multidisciplinary approach of many projects in the Gulf Watch Alaska program, PIs can author metadata records at both a project and individual file level (Fig 11-12). File level allows the PI to provide metadata fields that define the attributes of the data file in a standards-compliant format.

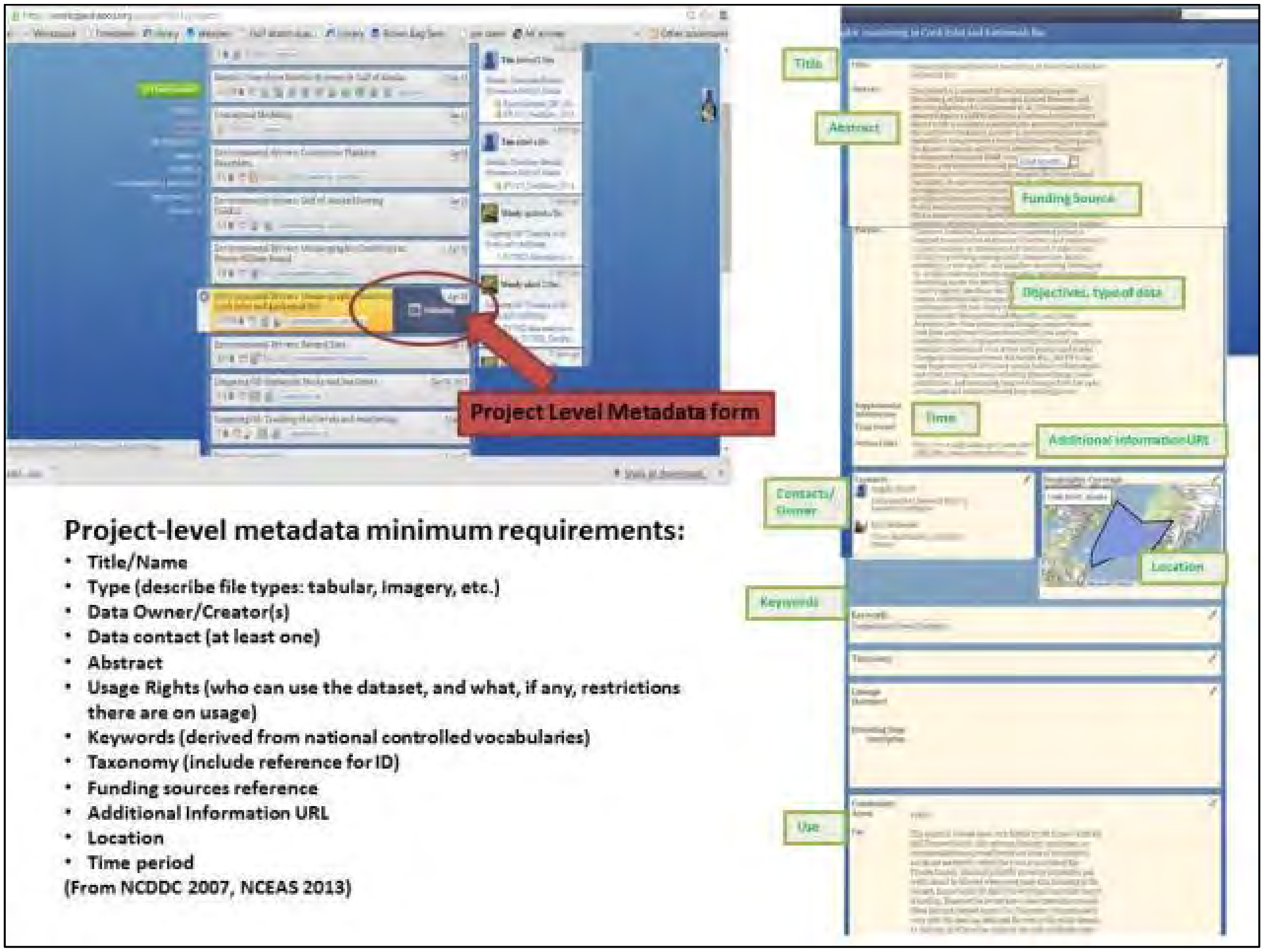


Figure 11. A screenshot of the Workspace project-level metadata interface. The interface allows the authoring of standards-compliant metadata content, including basic descriptive and citation metadata fields, description of the project's geographic extent, keywords, taxonomic information and data constraints. The suggested minimum metadata content for usefully descriptive metadata is included as a reference.

Figure 12. Screenshots of the Workspace interface for file-level metadata. The interface allows the authoring of standards-compliant metadata content, including basic descriptive and citation metadata fields, description of the project's geographic extent, keywords, taxonomic information, data constraints, and descriptive information about the attributes of the data set. The suggested minimum metadata content for usefully descriptive metadata is included as a reference. Additionally, included in the lower figure is a screenshot of the interface for editing attributes in tabular data files.

Advanced and secure file management — A core functionality of the Workspace is the ability to securely manage and share project-level digital resources in real-time with version control among researchers and study teams. Users of the Workspace are provided with tools that allow them to bulk upload files, organize those documents into folders or collections, create, contextualize, and sort projects with predefined and user-created tags, and control read and write permissions on files within projects (Fig 13). The Workspace also has the ability to track file versions: if a user re-uploads a file of the same name, the most current version of the file is displayed, but access is provided to past versions as well.

Figure 13. Screenshots of project and file management in the Workspace. The first screenshot shows a list of projects to which the example user has access rights. The second screenshot displays the interface a researcher would use to organize independent files into folders, and the way two versions of the same file are tracked by the Workspace.

Work Underway

As is described in a prior section of this report, Axiom began with in FY2015 on an improved web-based metadata editor. In FY2016, this new editor will entirely replace current Workspace metadata editor shown in the Figures 11 & 12, above.

The data management process will continue through the end of 2016 as additional data sets are submitted. The data coordinator, together with the data management team, will review submitted metadata records for completeness and accuracy. Once metadata records have been validated, they will be published to the portal. Metadata disseminated through the portal will improve the discoverability, access, and reuse of the data by a broader audience. One-on-one meetings with PIs will be scheduled again in fall 2016 to revise the metadata records by reviewing them for clarity and omissions. This quality control of the metadata from PIs will ensure records are both understandable and meet standards requirements. Validation will also involve comparing the metadata output to the FGDC/ISO standard for the DataOne portal to ensure the record conforms with the standardized format structure.

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

Collaboration and coordination both within your program and between the two programs:
This project is focused on increasing the data management support for both LTM and PWS Herring programs by establishing a data coordinator position to improve metadata quality and best practices. Furthermore, this project also develops a mechanism to transfer and integrate LTM and PWS

Herring program data products into DataONE. As such, the data management tools and services provided to the EVOSTC LTM and Herring programs are coordinated and collaborative by their very nature. As users of a central data management system, both programs provide useful feedback that informs the features Axiom develops and implements for the Ocean Workspace and the Gulf of Alaska Data Portal. A data management and metadata authoring process are being implemented uniformly across both programs to create a clear organizational structure and standard format. Additionally, by ingesting, synthesizing, and prioritizing feedback and feature requests from both programs, the project team coordinates the needs of each program into a set of tools useful to both. Similarly, by making data from each program available in the Gulf of Alaska Data Portal, the project team helps the two programs collaborate to provide a comprehensive, holistic portrait of the conditions monitored in the Gulf of Alaska by both programs.

Coordination with other EVOSTC funded projects:
Based on feedback acquired from the EVOSTC Science Panel and staff, this project was implemented as a supplemental data management effort to execute on major tasks that have been deemed of high importance but are not being addressed by existing data management projects supporting EVOSTC programs (Projects 1412011D and 1412011C). Therefore, all tasks associated with this project are by nature aligned with tasks from the coordinated projects.

Coordination with our trust agencies:
The project team provides data management visualization, and preservation services, including providing access to and facilitating the use of the Ocean Workspace, to a number of other programs that receive funding from or are administered or are overseen by representatives from the trustee agencies. Some of these programs and their associated trustee agencies are given in Table 2 below.

Table 2. Collaborating projects and trust agencies

Arctic Marine Biological Observation Network (AMBON)	BOEM
Arctic Ecosystem Integrated Synthesis (Arctic EIS)	BOEM
Marine Arctic Ecosystem Study (MARES)	BOEM
IOOS Systems Integration	NOAA
Beluga Sightings Database Visualization	NMFS
Alaska Ocean Observing System (AOOS) Data Management	NOAA
Central and Northern California Ocean Observing System (CeNCOOS) Data Management	NOAA

Gulf of Alaska Integrated Ecological Research Program (GOAIERP)	NMFS
Russian-American Long-term Census of the Arctic (RUSALCA)	NOAA
Spatial Tools for Arctic Mapping and Planning (STAMP)	NOAA
Alaska Data Integration working group (ADIwg)	USGS

9. Information and Data Transfer: *See,* Reporting Policy at III (C) (9).

A. **Publications produced during the reporting period**: None completed.

B. **Conference and workshop presentations and attendance during the reporting period**:

The AOOS data team at Axiom Data Science attended the GWA and HRM PI meetings in November 2015, and the team meetings in January 2016 at the Alaska Marine Science Symposium (AMSS). Presentations were given to PIs at both meeting regarding use of the Workspace, Workspace reorganization, data submission, and metadata authoring process. Additionally, the data coordinator team met with individual PIs of the GWA and HRM programs in Anchorage, Homer, Cordova, and Juneau during December and January 2016. Hands-on demonstrations of the AOOS Workspace and Gulf of Alaska data portal were given at this time. Throughout the year, the project team keeps in contact with the GWA program management team with regular email and phone calls.

10. Response to EVOSTC Review, Recommendations and Comments: *See,* Reporting Policy at III (C) (10).

Science Panel Comments, September 2014

It was encouraging for the Science Panel to hear via a conference call with Program Science Leads that the standardized forms for metadata submission had been recently modified, and a more refined version is now available to investigators. However, it was discouraging to learn that not all investigators were compliant on submission of both metadata and data in a timely manner (within one year of collection) as agreed upon when accepting funding from EVOSTC. In the future we see submission of required data and metadata as a condition of funding renewal.

Data Management Team Response

With the award for Supplemental Data Management Support and the addition of Ms. Stacey Buckelew to the data management team, these concerns have been addressed. One-on-one meetings have been been held with each PI funded through the HRM program to assess which expected data had not been uploaded into the Workspace, the existence and quality of metadata, and to identify responsibilities for uploading and documenting other data. For the majority of projects, data submissions are complete through 2014 and project metadata has been created. The exception is for projects that are experimental in nature and laboratory studies are underway. For these projects, a clear process for data submission and metadata creation has been created and will be tracked by the Data Coordinator. For the acoustic projects with data amounting to hundreds of gigabytes (Gb), these files have been manually transferred to Axiom on a hard drive at the Jan 2016 AMSS meeting. Processing to the Workspace is underway and these files should be updated in March 2016.

11. Budget: *See,* Reporting Policy at III (C) (11).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$94,400.0	$93,700.0	$16,700.0	$17,300.0	$17,900.0	$240,000.0	$ 225,726
Travel	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Contractual	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Commodities	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Equipment	$3,900.0	$4,800.0	$0.0	$0.0	$0.0	$8,700.0	
Indirect Costs (*23%*)	$21,700	$21,500	$3,800	$4,000	$4,100	$55,100.0	$ 48,728
SUBTOTAL	$120,000.0	$120,000.0	$20,500.0	$21,300.0	$22,000.0	$303,800.0	$274,454.0
General Administration (9% of	$10,800.0	$10,800.0	$1,845.0	$1,917.0	$1,980.0	$27,342.0	
PROJECT TOTAL	$130,800.0	$130,800.0	$22,345.0	$23,217.0	$23,980.0	$331,142.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Spending is in line with the budget.

We appreciate your prompt submission
and thank you for your participation.

ATTACHMENT C *EVOSTC Annual Project Report Form*

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111-E

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

PWS Herring Program – Expanded Herring Surveys

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

Richard Thorne, Pete Rand, PWSSC

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).

Project Summary – Overview

Introduction

Hydroacoustic surveys of Pacific herring in Prince William Sound were initiated in fall 1993 after indications that the stock had collapsed. The surveys have now been conducted by the Prince William Sound Science Center for 23 consecutive years. The survey in 2015 consisted of two cruises. The first cruise departed Cordova late afternoon on March 26 and returned March 30. The second cruise extended from April 7 to 12. The survey vessel was the Auklet, captained by David Janka. The first cruise covered Gravina Point, Port Gravina, Port Fidalgo, Tatitlek Narrows, Galena Bay, Glacier Island, Naked Island and the north edge of Hawkins Island (Fig. 1). The second cruise focused on Port Fidalgo and Port Gravina (Fig. 2).

Methods

Hydroacoustic survey methods are well documented and well established in fisheries (Thorne 1983; Simmonds and MacLennon 2005). They have been applied to Pacific herring for nearly forty years (Thorne 1977a,b; Trumble et al 1983). The specific methods used in PWS are well documented and have been demonstrated to be precise (Thomas et al. 1997, Thomas et al. 2002, Thomas and Thorne 2003, Thorne and Thomas 2008).

A three-stage sampling design (Cochran 1977) is used for the acoustic surveys in PWS rather than the systematic design more typically used in hydroacoustic surveys (MacLennan and Simmonds 1992; Simmonds and MacLennon 2005). 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 location of these adult herring aggregations within PWS. Approaches include aerial surveys of foraging marine mammals, especially Steller sea lions and humpback whales, sonar surveys and observations from fishers, hunters and others transiting PWS, as well as a detailed database of historic locations. 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). These surveys are generally conducted at night with a dark vessel since herring are further removed from bottom and surface boundaries at night, but are very light sensitive. The surveys are repeated several times to develop multiple, independent estimates of the biomass of specific fish aggregations. The repeated estimates are used to determine the precision of the biomass estimates (Scheaffer et al. 1986). After the echointegration surveys, the herring schools are subsampled for biological information, primarily with a commercial purse seine (McClatchie et al. 2000). The direct capture effort is conducted by the Alaska Department of Fish and Game.

Two separate echosounder systems operated during this cruise. We describe the systems and the analytical methodology applied to data generated by each system below. For both methodologies, we assume all targets are Pacific herring. Our objective during the spring 2015 cruise was to compare the measurements from these two systems so future work conducted by our contractor (FIU) could be calibrated to on-going survey efforts with the PWSSC system.

Biosonics 70 kHz Single Beam (PWSSC system)

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

$TS_w = -5.98 Log(L) - 24.23$

Where TS_w is the target strength (decibels) per unit weight, w is weight in kg and L is standard length in cm.

This equation applies to the typical night-time depths of herring during the late winter/early spring period (specifically 40 m). Alterations are made for different depths and seasons based on Thomas et al. (2002). Hydroacoustic systems initially were BioSonics analog scientific echosounders (models 101. 102 and 105). However, for most years digital echosounders have been used (BioSonics DT and DX). System frequencies have usually been either 70 kHz or 120 kHz, although multi-frequency systems including 38 kHz have been applied. All the hydroacoustic systems are calibrated with standard targets following procedures of Foote et al. (1987). Calibration was not conducted during this cruise, however. The 2015 sampling during both 2015 cruises was done with the PWSSC BioSonics 70 kHz single beam system.

Additional sampling was conducted with other systems and other frequencies by Aubree Zenone from the Fisheries Ecology and Acoustics Laboratory at Florida International University. A full array of frequencies were deployed including an SIMRAD EK60 38 and 120 kHz split-beam transducer, and a SIMRAD EK80 70 kHz split-beam transducer operating through a wide-band transceiver. Due to transducer interference, the PWSSC BioSonics system and the FEAL system were used on alternating transects. Initial analyses with both data sets were concerned with ensuring consistency in results between the PWSSC systems and the new FEAL equipment.

There were insufficient direct capture samples during 2015 to accurately determine the mean size of the herring. Consequently, the historical average target strength (-32 db/kg) was used for the 2015 estimation. This corresponds to an acoustic cross section (sigma) of 0.00063 and a mean length of 20 cm.

SIMRAD EK60 & EK80 Echosounder (FIU)

In alternating transects, data were collected using the FEAL's SIMRAD EK60 38 and 120 kHz split-beam transducer, and a SIMRAD EK80 70 kHz split-beam transducer operating through a wide-band transceiver. This latter system emits and receives across a broad band of frequencies to allow for potential target discrimination, but when making direct comparisons we used data only from a single frequency (70 kHz) to make it directly comparable to the PWSSC system described above.

Acoustic data from the FIU echosounder were manually inspected and post-processed in Echoview 7.1 (Sonar Data Pty., Ltd.). An analysis threshold of -60.00 dB was applied to the volume backscattering (S_V) data in addition to a bottom detection algorithm to remove reverberation and unwanted acoustic backscatter (eg. benthic habitat, air bubbles, etc.). Additional manual inspections removed any remaining undesired data and the echograms were binned into 10m horizontal by 5m depth analysis cells.

Acoustic fish density estimates were calculated by using the backscattering cross-section ($\sigma_{bs;}$ MacLennan *et al.*, 2002) and Target Strength (TS) as calculated using standard linear regression equations for TS derived using average length of herring caught by trawling in each bay (Thomas *et al*, 2002). The area backscattering coefficient, s_a [$s_a = \int_{z1}^{z2} \mathrm{Sv} * dz$], was then used to calculate fish densities (fish m^{-2}) in a transect as described in MacLennan *et al.,* 2002 (Eq.2).

$\sigma_{bs} = 10^{\wedge(TS/10)}$ (Eq. 1)

Fish $m^{-2} = s_a / \sigma_{bs}$ (Eq. 2)

Once density was derived, average herring length determined by average ADF&G trawl catch data was used to estimate herring weights as derived from a standard L/W relationship (Ostrand *et al*, 1998). Densities were then multiplied by average fish weight to obtain a biomass estimate for each analysis cell. Cells were then summed across a survey to result in total estimated acoustic biomass along the transect in each survey. Here we make the assumption that all backscatter in surveys were herring, as the threshold applied removes targets that lack a swimbladder, and schools likely to be herring were manually identified. Finally, we extrapolated out the results from the transects to the surface area of each bay. We did this by multiplying our estimates of density by the estimated surface area of the bay. We acknowledge this is a crude method of extrapolation. This simply represents a first step toward a more robust method accounting for other variables, particularly each bay's bathymetry.

Results

During the first cruise, the only appreciable abundance of adult herring was found in Port Fidalgo, and these were relatively small schools scattered primarily in deeper water from off Whalen Bay to off Two Moon Bay and Landlocked Bay. There were about 7 humpback whales within Port Fidalgo along with scattered groups of Steller sea lions. A single series of acoustic transects was run over this abundance the night of March 29 (Fig. 3). The survey covered a relatively large area (31.4 km^2) and encountered about 30 herring schools (Fig. 4). These fish were deep in the water column (40-130 m) and the acoustic cross section (sigma) was adjusted for depth (depth-corrected sigma values were calculated for each transect). The estimate of total biomass derived from the Biosonics echosounder was 9,240 metric tons (Table 1).

Five acoustic surveys were conducted during the second cruise. Two were in Port Fidalgo: one in an area off Two Moon Bay, the second in the vicinity of Whalen Bay. Three surveys were conducted in Port Gravina, all between Red Head and St. Mathews Bay (Fig. 5). The survey off Two Moon Bay was conducted at night in a limited area (5 km^2). Schools were similar to typical herring prespawning aggregations, although smaller in school size than normally observed in April. The estimated biomass with the Biosonics echosounder was 2,130 tons. The survey of the fish in the vicinity of Whalen Bay was conducted during the daytime. The fish were atypical both in location (upper Port Fidalgo) and distribution (small, deep schools-Fig. 6). They were clearly herring, and subject to predation by several humpback whales. The survey covered about 10 km^2 and the estimated biomass from the Biosonics echosounder was 1,380 tons.

Fish abundance in Port Gravina varied dramatically during the short interval of the cruise. Herring were distributed near shore between Red Head and St. Mathews Bay the first night of the cruise (April 7) but weather conditions precluded a survey. The next morning the fish (and associated marine mammals) had vanished. The night survey on April 10 encountered herring near shore, but primarily just off Red Head (Fig. 7). More fish had clearly entered the area on April 11 and the distribution had shifted slightly northward. Most of the herring were very near shore (Fig 8). The estimated fish biomass from the Biosonics echosounder was about 3,120 tons on April 10 and 5,850 tons on April 11 (Table 2). The fish were near surface (8-14 m), so the depth-corrected sigma was almost twice that of the normally assumed 40 m.

Additional fish were observed off Landlocked Bay during the second cruise, but not surveyed. It is unlikely these would amount to more than 2,000 tons. In summary, the first cruise could account for slightly over 9,000 tons using data from the Biosonics echosounder. The second cruise could similarly account for between 9 and 12 thousand tons. Additional fish were probably still entering Port Gravina at the time of the last survey. Nevertheless, the amount of fish detected during the 2015 appears to be considerably less than anticipated. Variances and confidence intervals were not calculated for the 2015 surveys because of the relatively small sample size and limited replications.

Acoustic density and biomass estimates from the SIMRAD echosounder were markedly lower than that generated from the Biosonics echosounder. The difference was particularly pronounced during three of the five days examined (Figure 9). The differences between the two systems appear to be related to differences in measures of acoustic backscatter (reflected here in our measures of acoustic density), but do not appear to be systematic given that on some days (e.g. 4 & 10 April 2015) the estimates from the two systems closely converged. One of the simplest explanations for the differences observed on those days was heterogeneity in the fish distribution across the transects. Because the two systems sampled alternating transects, it is conceivable that the transects run using the Biosonics echosounder on the days the estimates diverged were associated with a greater quantity of fish. Differences in post-processing between the systems may also have resulted in variable estimates of biomass. Biosonics data were analyzed with an automated program to detect potential fish targets. SIMRAD data were processed through Echoview, a program that can be used to manually excise unwanted data unlikely to be fish targets. It is possible this manual inspection and removal of non-herring targets resulted in lower estimates.

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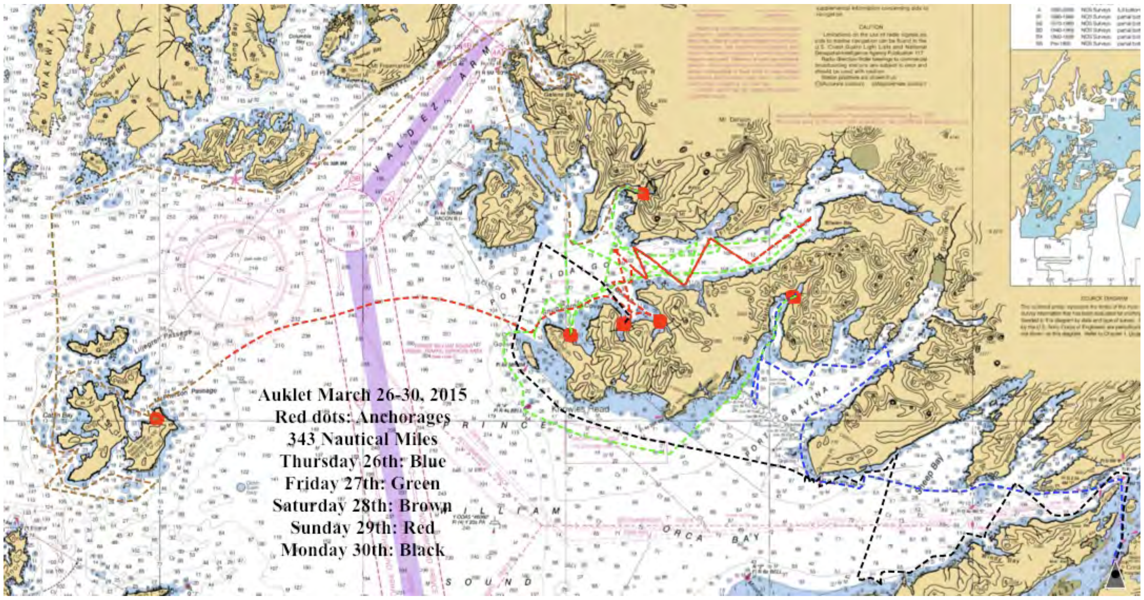


Fig. 1. Auklet vessel track for cruise #1, courtesy of David Janka

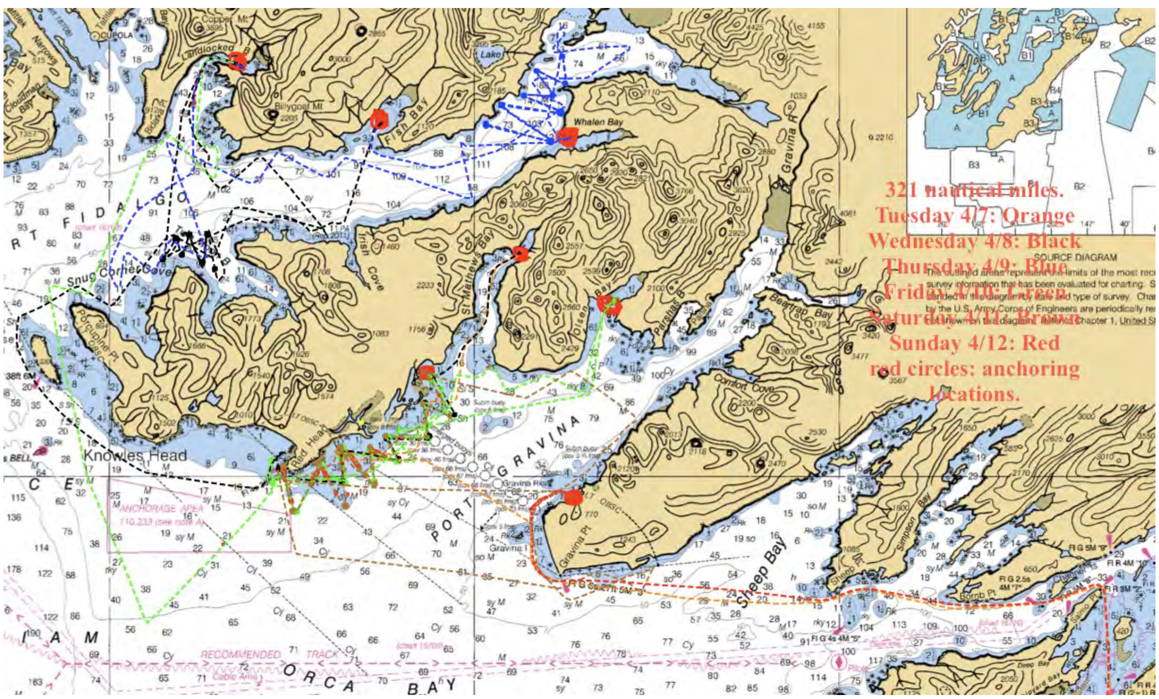


Fig. 2. Auklet vessel track for cruise #2, courtesy of David Ja

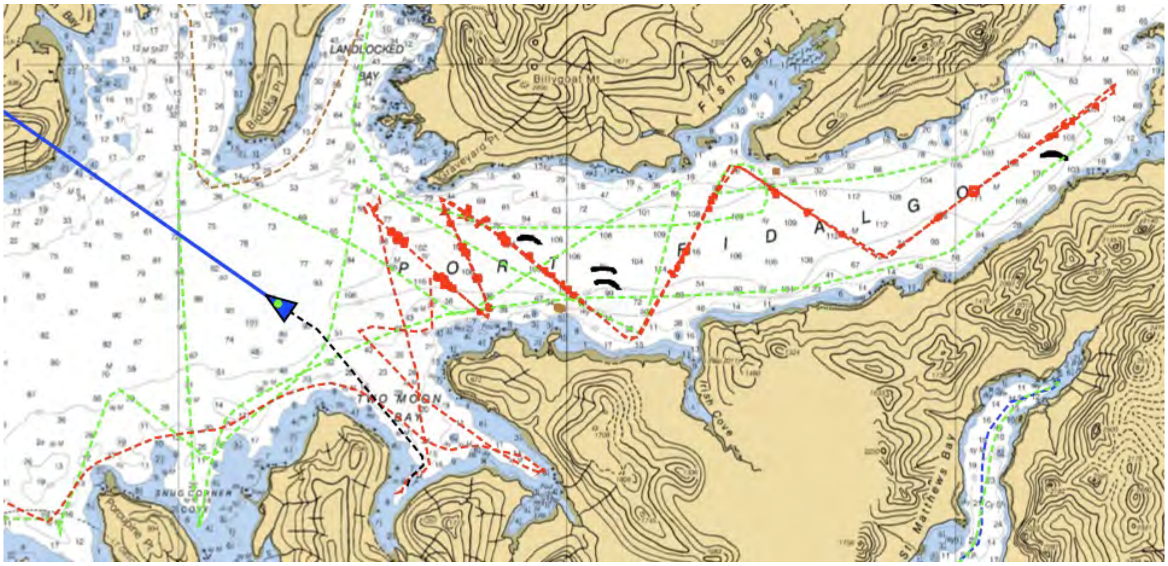


Fig. 3. Six-transect acoustic series conducted March 29, 2015. courtesy of David Janka.

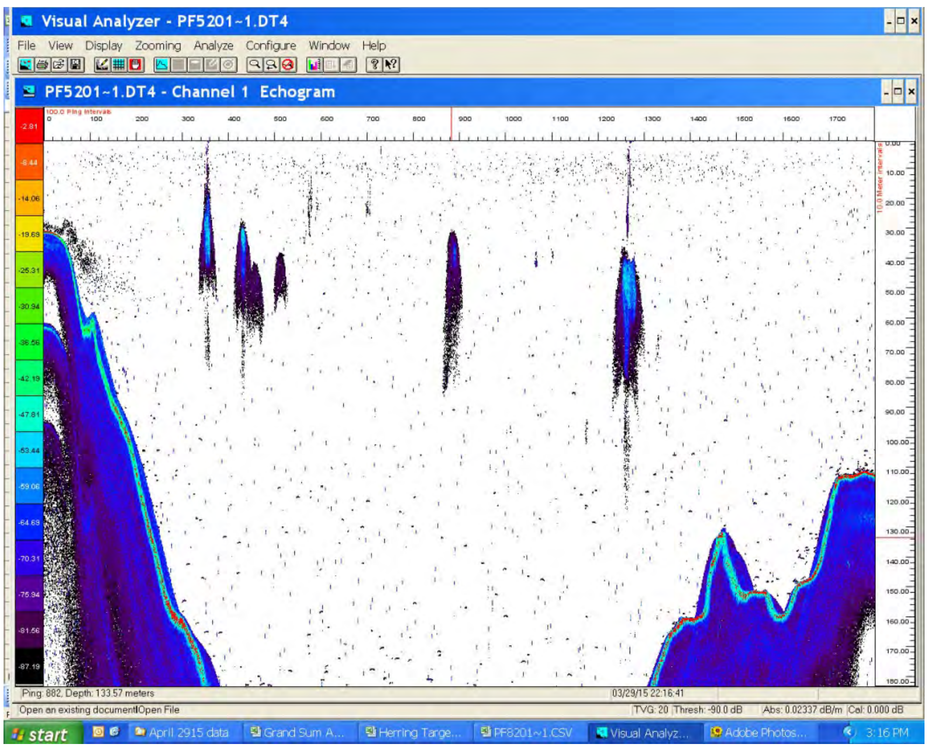


Fig. 4. Echogram from first 30 minutes of transect 3 from Fish Bay toward Irish Cove.

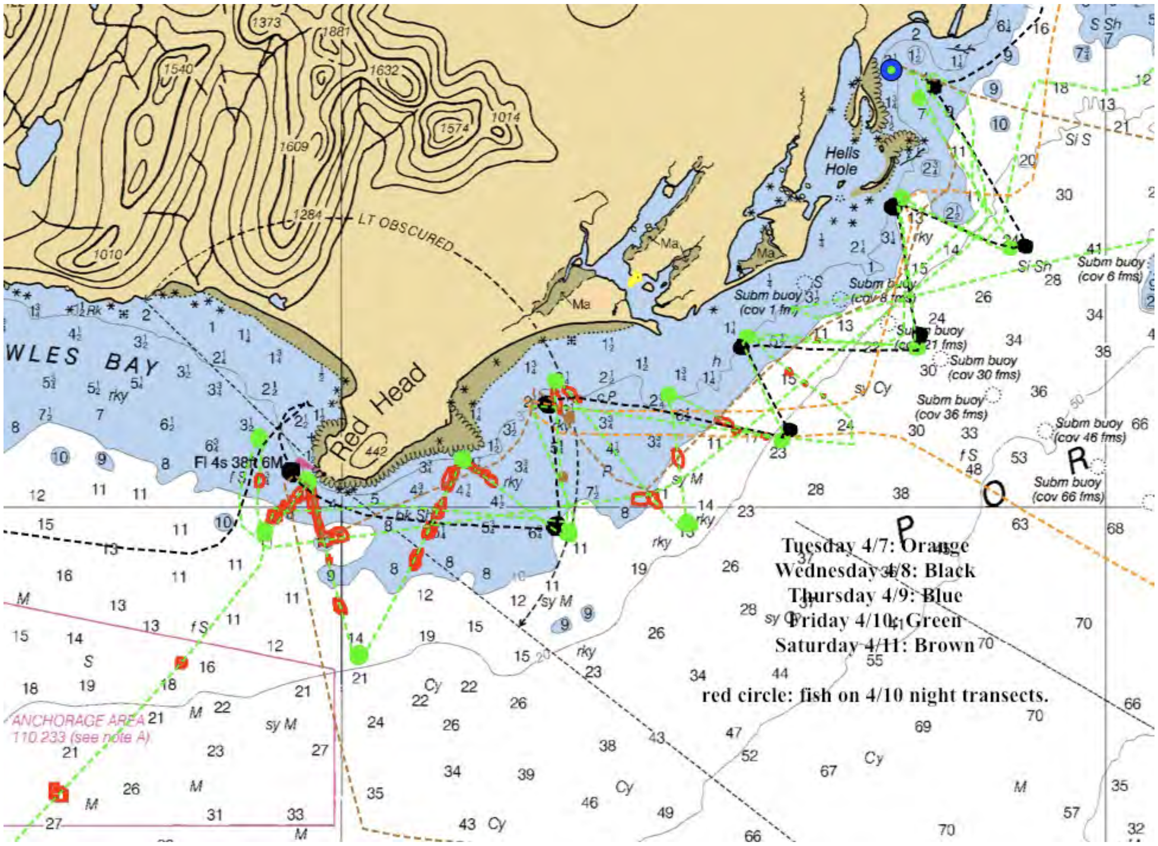


Figure 5. Surveyed area of Port Gravina, April 8, 10 and 11, 2015.

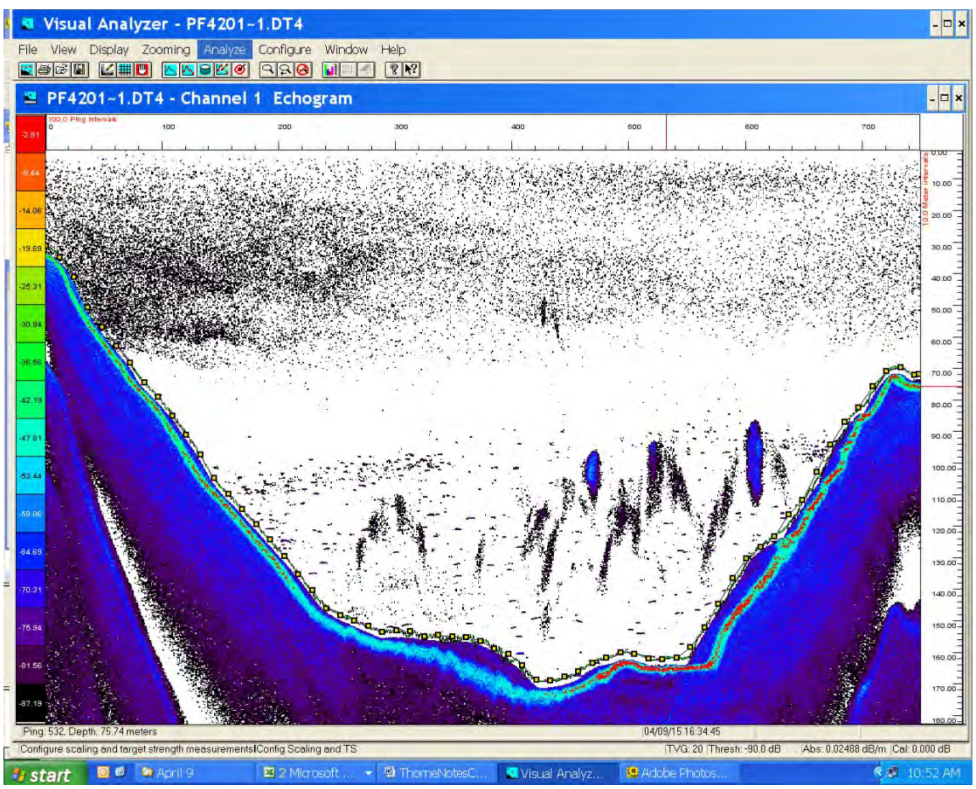


Fig. 6. Echogram from transect off Whalen Bay, Port Fidalgo, April 9, 2015.

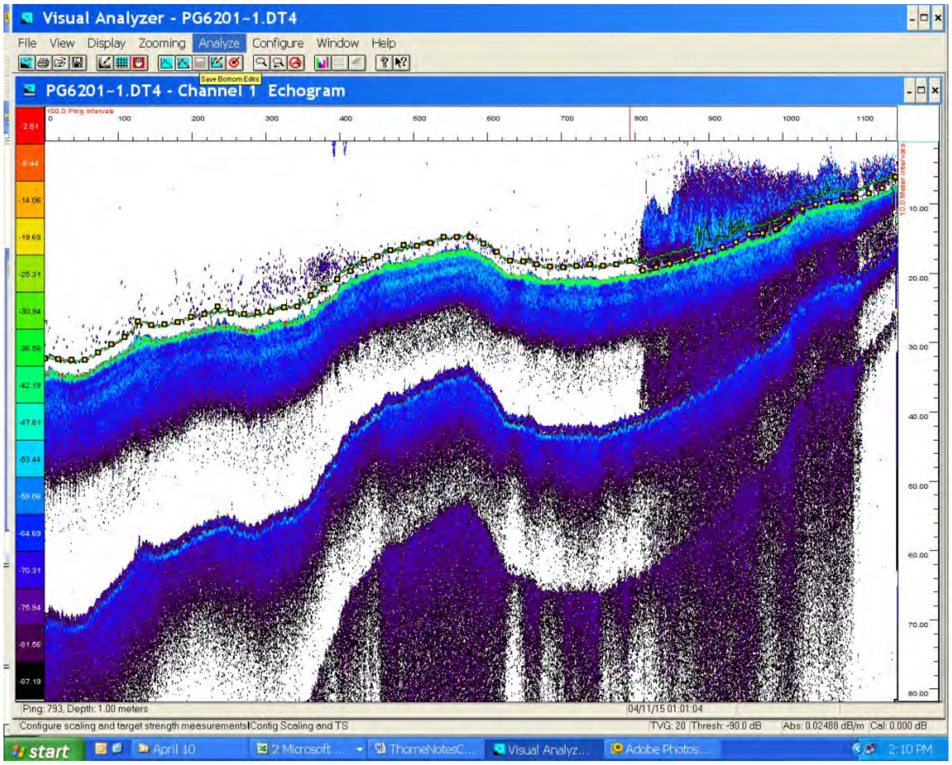


Fig. 7. Echogram of fish distribution just off Red Head

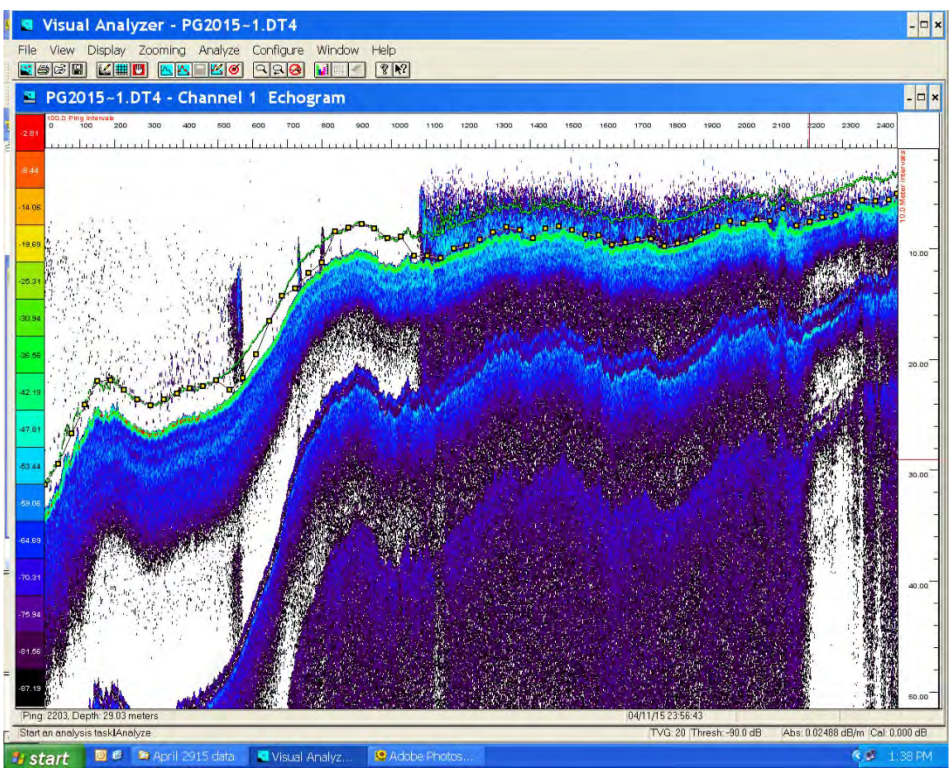


Fig. 8. Echogram from April 10 survey of Port Gravina showing inshore distribution

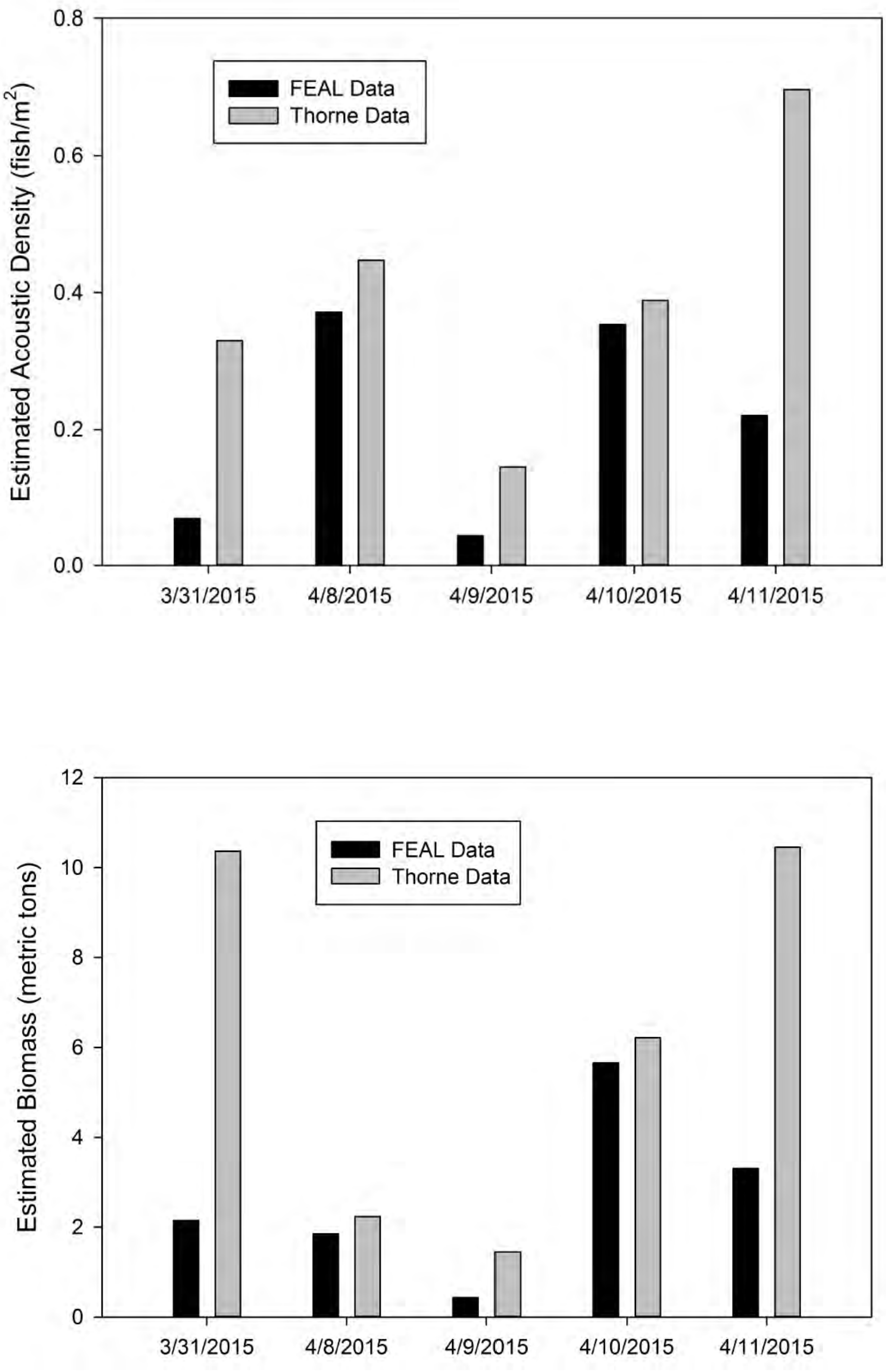


Figure 9. Estimates of acoustic density (fish/m2, upper panel) and biomass (MT, lower panel) for FIU SIMRAD systems (dark bars) and the PWSSC Biosonics echosounder (gray bars).

Table 1. Biomass Estimated from the PWSSC Biosonics echosounder from the March 29, 2015 Survey

Transect	Area (km^2)	Density (Kg/m^2)	Biomass (1000 mt)
1	8.96	0.097	0.87
2	5.12	0.051	0.26
3	5.76	0.573	3.30
4	7.68	0.489	3.75
5+6	3.84	0.275	1.06
Total	31.36		9.24

Table 2. Herring Biomass Estimates over the entire survey area during Spring 2015 from the PWSSC Biosonics echosounder

		Density	Area	Biomass
Location	**Date**	**kg/m^2**	**km^2**	**1000 mt**
Port Fidalgo	**29-Mar**	**0.29**	**31.4**	**9.24**
	8-Apr	**0.43**	**5**	**2.13**
	9-Apr	**0.14**	**10**	**1.38**
Port Gravina	**10-Apr**	**0.19**	**16**	**3.12**
	11-Apr	**0.39**	**15**	**5.85**
Total For Port Gravina				**9.4**

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

The inter-system comparison of density and biomass would not have been possible without the involvement of Aubree Zenone of FIU. This work was conducted through a contract to Kevin Boswell at FIU.

This project uses the size information collected by ADF&G during their spring surveys. Biomass estimates from the surveys are then provided to Steve Moffitt with ADF&G.

9. Information and Data Transfer: *See,* Reporting Policy at III (C) (9).

Data from these cruises have been uploaded to the AOOS website.

10. Response to EVOSTC Review, Recommendations and Comments: *See,* Reporting Policy at III (C) (10).

We were unable to address the issue of precision of the acoustic sampling brought up by the Science Panel in 2014. More ship time would be required to replicate transects to a sufficient degree to quantify the error associated with this sampling methodology. We are planning on doing this, at least for part of the survey area, during the Spring 2016 cruise. In addition, during this cruise we hope to generate estimates of herring size distribution and density using a multi-beam, imaging sonar system (DIDSON) mounted on an ROV. We hope this will provide another, independent measure of fish density to which we can compare with the more traditional, down-looking echosounders used in the present program.

11. Budget: *See,* Reporting Policy at III (C) (11).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$0.0	$49,900.0	$40,900.0	$55,300.0	$55,900.0	$202,000.0	$ 55,969
Travel	$0.0	$3,600.0	$3,600.0	$3,600.0	$3,600.0	$14,400.0	$ 11,532
Contractual	$0.0	$2,000.0	$3,600.0	$3,000.0	$0.0	$8,600.0	$ 12,184
Commodities	$0.0	$4,000.0	$0.0	$2,000.0	$0.0	$6,000.0	$ 531
Equipment	$6,000.0	$0.0	$0.0	$0.0	$0.0	$6,000.0	$ 6,000
Indirect Costs (*will vary by proposer*)	$0	$17,900	$14,400	$19,200	$17,900	$69,400.0	$ 24,065
SUBTOTAL	$6,000.0	$77,400.0	$62,500.0	$83,100.0	$77,400.0	$306,400.0	$110,281.0
General Administration (9% of	$540.0	$6,966.0	$5,625.0	$7,479.0	$6,966.0	$27,576.0	
PROJECT TOTAL	$6,540.0	$84,366.0	$68,125.0	$90,579.0	$84,366.0	$333,976.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Spending on personnel is behind because of a change in P.I. in 2015. Funding is being shifted from personnel to contractual to allow for contracting with Kevin Boswell at Florida International University to assist in data collection and processing.

We appreciate your prompt submission and thank you for your participation.

ATTACHMENT C *EVOSTC Annual Project Report Form*

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111-F

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

PWS Herring Program – Juvenile Herring Abundance Index

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

Pete Rand

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).

Project Summary – Overview

This project is intended to establish a monitoring effort on juvenile herring to help better understand recruitment dynamics. If successful, this information could be incorporated into the ASA model of ADF&G to help track herring recruitment as an alternative, more empirical, method compared to relying on theoretical, stock-recruitment models.

The current project has now included three years of surveys (FY2013-2015) of 8 bays; four of which are the Sound Ecosystem Assessment bays. The additional 4 bays were selected based upon the survey results of the current EVOSTC FY10 Herring Survey Project (# 10100132). This project, and the related expanded adult herring survey project, is now being led by a new PI at the PWSSC, Pete Rand. Dr. Rand joined the PWSSC staff in June 2015. Acoustic data for the fall juvenile surveys from all three years of this project (2013-2015) have now been uploaded to the AOOS workspace. Results reported here is the first effort to derive estimates of densities and biomass from these surveys. We focus here on some initial analyses from data collected during the November 2015 cruise. Trawl catch analysis to derive herring size and weight information from midwater trawls in 3 of the bays is, as of the time of this report, incomplete. Subsequently, we only report here results for the initial five completed surveys. It is our intention to establish an analytical protocol to which we can apply to all years of this survey effort, to be described in the final project report.

In addition to the standard survey, in November 2015 we augmented our sampling to include nearshore waters (to approximately the 5 m depth contour) using a SIMRAD 120 kHz split-beam echosounder mounted on an autonomous surface vehicle (or ASV, see Figure 1). This work was conducted as part of a contract with Florida International University (Kevin Boswell, PI). The objective of this effort was to better understand the distribution and abundance of herring in waters too shallow to be included as part of the surveys on the R/V Montague. Aggregations of herring were noted frequently in areas too shallow for deep water trawling, or Montague transects. It is apparent that large numbers of herring may be unrepresented in current survey methodology and shallow survey methodology should be applied in future survey design.

Figure 1. The autonomous surface vehicle (ASV) was deployed during our November 2015 cruise in all 8 bays to acoustically survey near shore waters to compare with observations in the main bay transects.

Below we describe some details on our analytical methodology and some preliminary results of our research cruise in November 2015.

Acoustic Analysis Methods

Juvenile herring were surveyed acoustically, as in previous years of this project, along cross-bay transects (hereafter referred to as the main bay survey) (Figure 2). Samples were obtained with a Biosonics 120 kHz split-beam hydroacoustic transducer (Biosonics DT-X system) fixed to a towfin towed alongside the R/V Montague. Midwater trawl and gill net surveys were conducted synoptically to provide information on species and size structure of acoustic targets. Results of this work are reported under a separate project (see Bishop). CTD casts were also conducted at the head and mouth of each bay in our survey to characterize the environmental conditions in the water column. Nearshore acoustic data were collected on the ASV using a calibrated SIMRAD EK60 multi-frequency echosounder system operating a 120 kHz split-beam transducer interfaced to an onboard computer running the EK80 software (SIMRAD, v1.0). Vessel position was recorded using a WASS-enabled USB Garmin GPS unit that was corrected for positional offsets from the face of the transducer. We refer to this survey as the near shore survey (Figure 2).

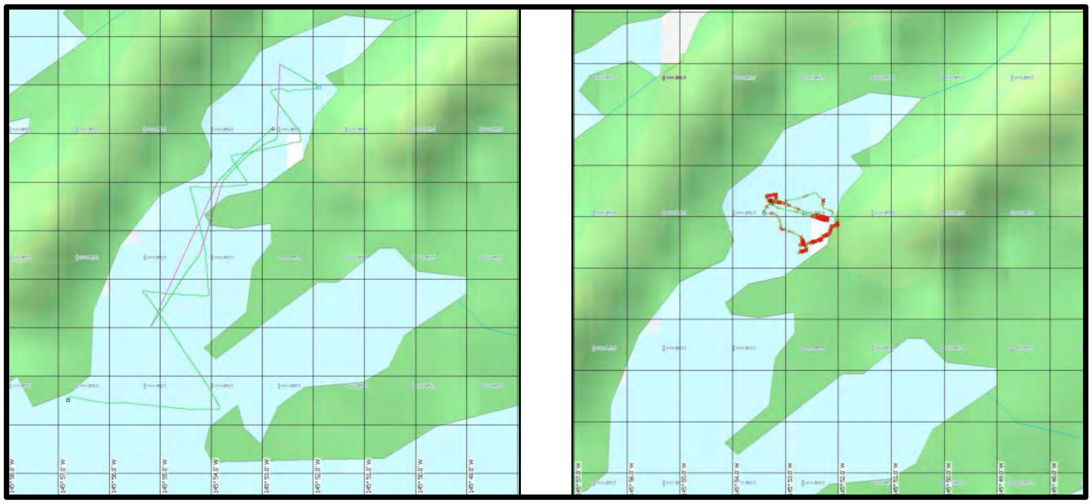


Figure 2. GPS data for main bay surveys (left) and nearshore acoustic surveys (right)

Acoustic data for both surveys were manually inspected and post-processed in Echoview 7.1 (Sonar Data Pty., Ltd.). An analysis threshold of -60.00 dB was applied to the volume backscattering (S_V) data in addition to a bottom detection algorithm to remove reverberation and unwanted acoustic backscatter (eg. benthic habitat, air bubbles, etc.). Additional manual inspections removed any remaining undesired data and the echograms were binned into 10m horizontal by 5m depth analysis cells. For deep surveys, we apportioned the Area Backscattering Coefficient (ABC), which is approximately proportional to biomass, to species based on the composition observed in each bay in the mid-water trawl catches (see Bishop for additional details on trawl results).

Acoustic fish density estimates for nearshore schools were calculated by using the backscattering cross-section ($\sigma_{bs;}$ MacLennan et al., 2002) and Target Strength (TS) as calculated using standard linear regression equations for TS derived by Thomas and Ona (Thomas et al, 2002 ; Ona, 2003). To fit the equation, the average length of herring caught by trawling in each bay was used. Multiple TS equations were used to obtain an estimate of the variability in acoustic biomass estimations. The area backscattering coefficient, s_a [$s_a = \int_{z1}^{z2} \mathrm{Sv} * dz$], was then used to calculate fish densities (fish m^{-2}) in a transect as described in MacLennan et al., 2002 (Eq.2).

$\sigma_{bs} = 10^{\wedge(TS/10)}$ (Eq. 1)

Fish $m^{-2} = s_a / \sigma_{bs}$ (Eq. 2)

For density comparisons between deep surveys and nearshore surveys, we assumed all targets and backscatter were herring.

Preliminary results

We successfully completed a cruise onboard the R/V Montague during 6-14 November 2015. We successfully sampled all 8 bays. Based on CTD casts conducted in each of the bays (see examples in Figure 3), where we observed relatively mixed water column conditions, with an average water temperature of 9.8 C and salinities of 30.2 ppt.

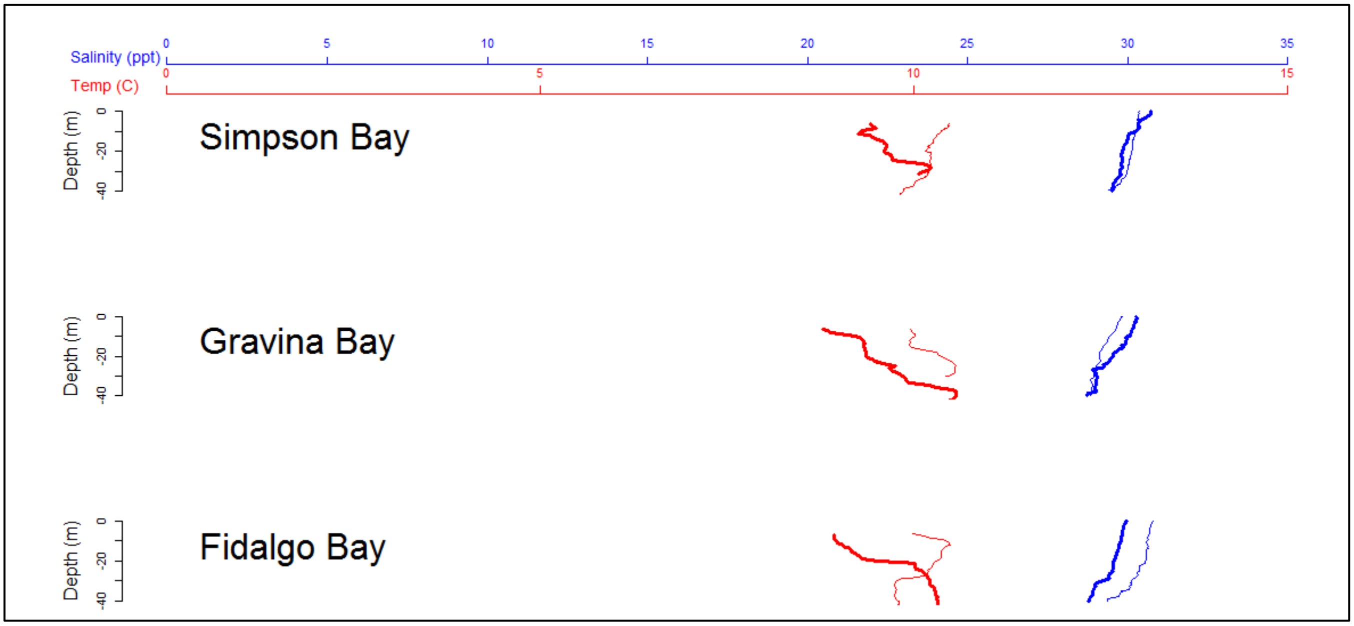


Figure 3. Example of data from CTD casts (temperature and salinity) in the eastern bays surveyed in November 2015 in Prince William Sound. Upper and lower bay cast locations are indicated by thin and bold lines, respectively.

As in previous years' surveys, most of the targets encountered, based on the size frequency of fish captured in mid-water trawls, were likely age 0 and age 1 herring (Figure 4).

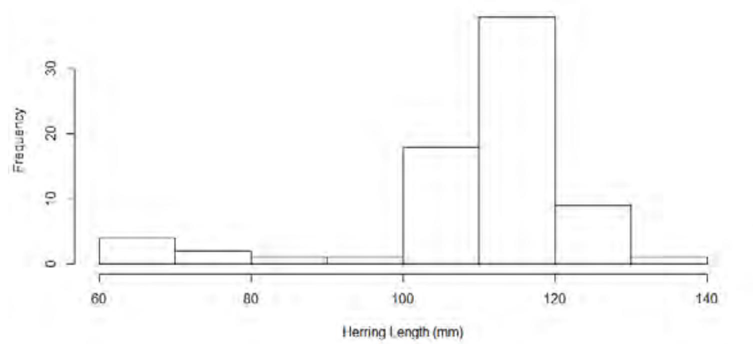


Figure 4. Length frequency of Pacific herring (standard lengths, in mm) collected in Simpson Bay on 6 November 2015 using a mid-water trawl.

Total acoustic fish biomass was apportioned into each of 5 taxonomic groups observed in the trawl catches (herring, Walleye Pollock, capelin, sculpin, and sandlance). Herring was the dominant species in all bays examined for this report (Table 1). Among the bays analyzed, the vast majority of the herring were observed in mid-bay in Simpson Bay at approximately 50 m depth extending across a ~4 km length of transect (Figure 5). This pattern of high biomass in Simpson Bay was corroborated by CPUE estimates from the synoptic trawl survey (see report by Bishop).

	Area Backscattering Coefficient by Bay				
	Eaglek	**Fidalgo**	**Gravina**	**Simpson**	**Zaikof**
Herring	3.3883e-7	5.4476e-7	1.0046e-7	4.9054e-6	3.8469e-7
Walleye Pollock	1.5717e-7	1.3244e-8	1.2429e-8	1.8643e-7	0
Capelin	0	0	2.0714e-9	5.6238e-8	1.3129e-9
Sandlance	0	0	5.9036e-8	2.4385e-7	0
Sculpin	0	0	0	6.8052e-8	0

Table 1. Biomass apportionment of acoustic backscatter based on species composition of trawl catches in each of five bays in Prince William Sound. Note, estimates describe only the water column ensonified during the survey; values were not extrapolated to entire bay volume. Individual figures for each bay may be found in the attached Appendix.

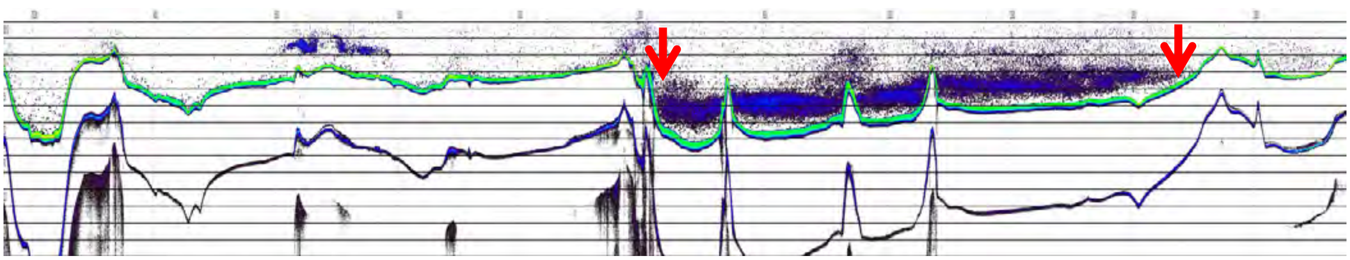


Figure 5. Echogram from the main bay transect in Simpson Bay on 6 November 2015. The majority of backscatter (bracketed by the red arrows) was observed in the deeper waters (~50 m) in the middle portion of the bay. The gridded horizontal lines represent 10 m depth intervals, and the vertical lines represent 1 km distance along the transect.

The depths occupied by fish in the bays appeared to be highly variable. In some bays (e.g. Gravina) most of the backscatter was observed at shallow depths, while in others (e.g. Simpson Bay) most of the backscatter was in deeper water (Figure 6).

We compared fish densities measured in the main bay transects with more shallow habitat in the near shore survey. Densities in the near shore survey were markedly higher, in some cases an order of magnitude higher, compared to densities observed in the main bays (Figure 7). It should be kept in mind that deep survey densities operated on the unlikely assumption that all backscatter was derived from herring. During this sampling we made multiple observations of birds (primarily kittiwakes, mew gulls and common murrs; A. Shaeffer, PWSSC, pers. comm.) feeding intensively on small fishes (presumably juvenile herring) near surface during early morning hours. These feeding events appeared to be ephemeral, lasting only 10-15 minutes.

To consider uncertainty in densities estimated acoustically, multiple Target Strength/Length equations were employed in estimating herring density. Results from Thomas et al. (2002) and Ona (2003) were used to examine variance in acoustic estimates, with values calculated using Ona (2003) more closely matching trawl weight values.

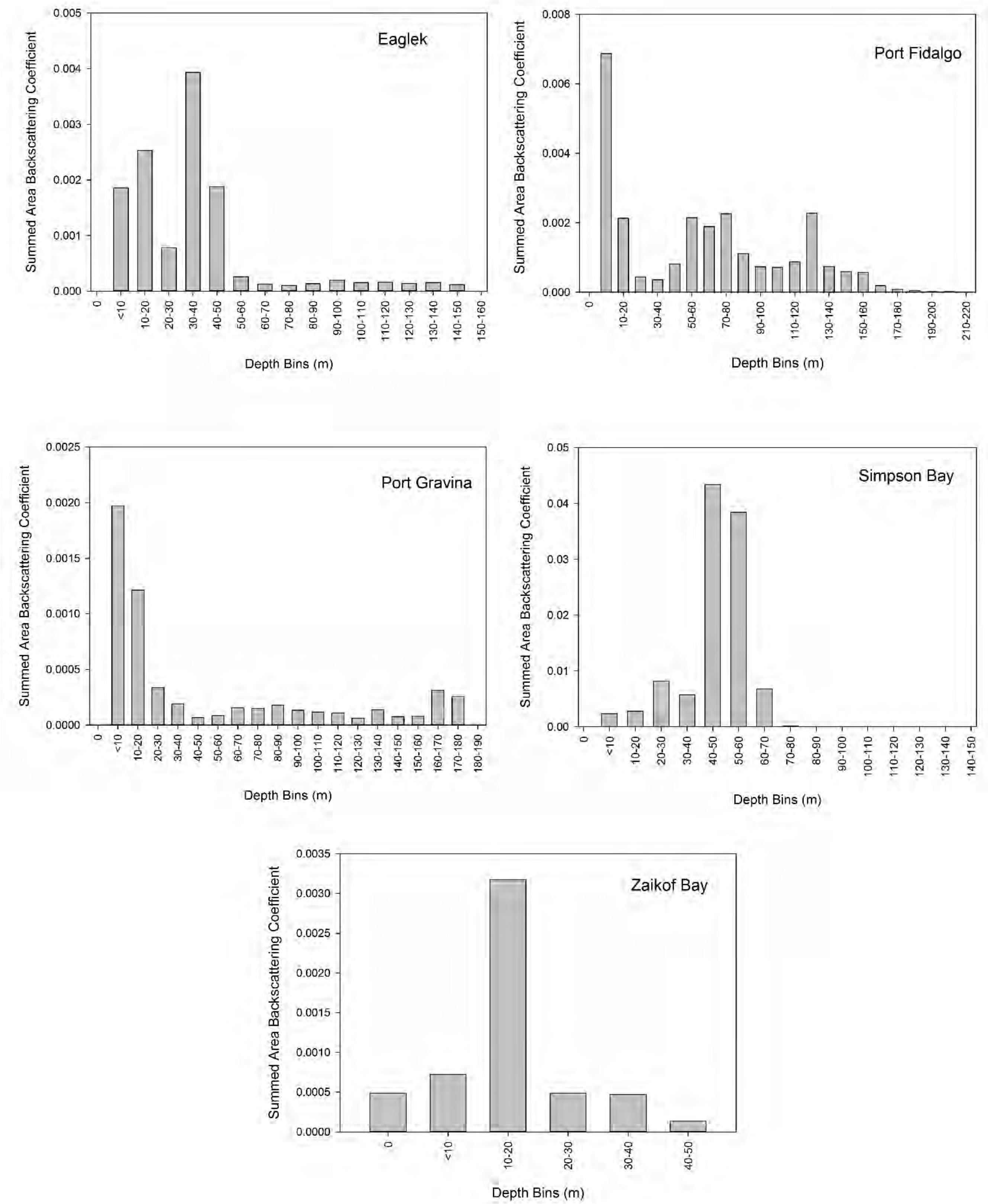


Figure 6. Distribution of acoustic backscatter across depth in five bays in Prince William Sound.

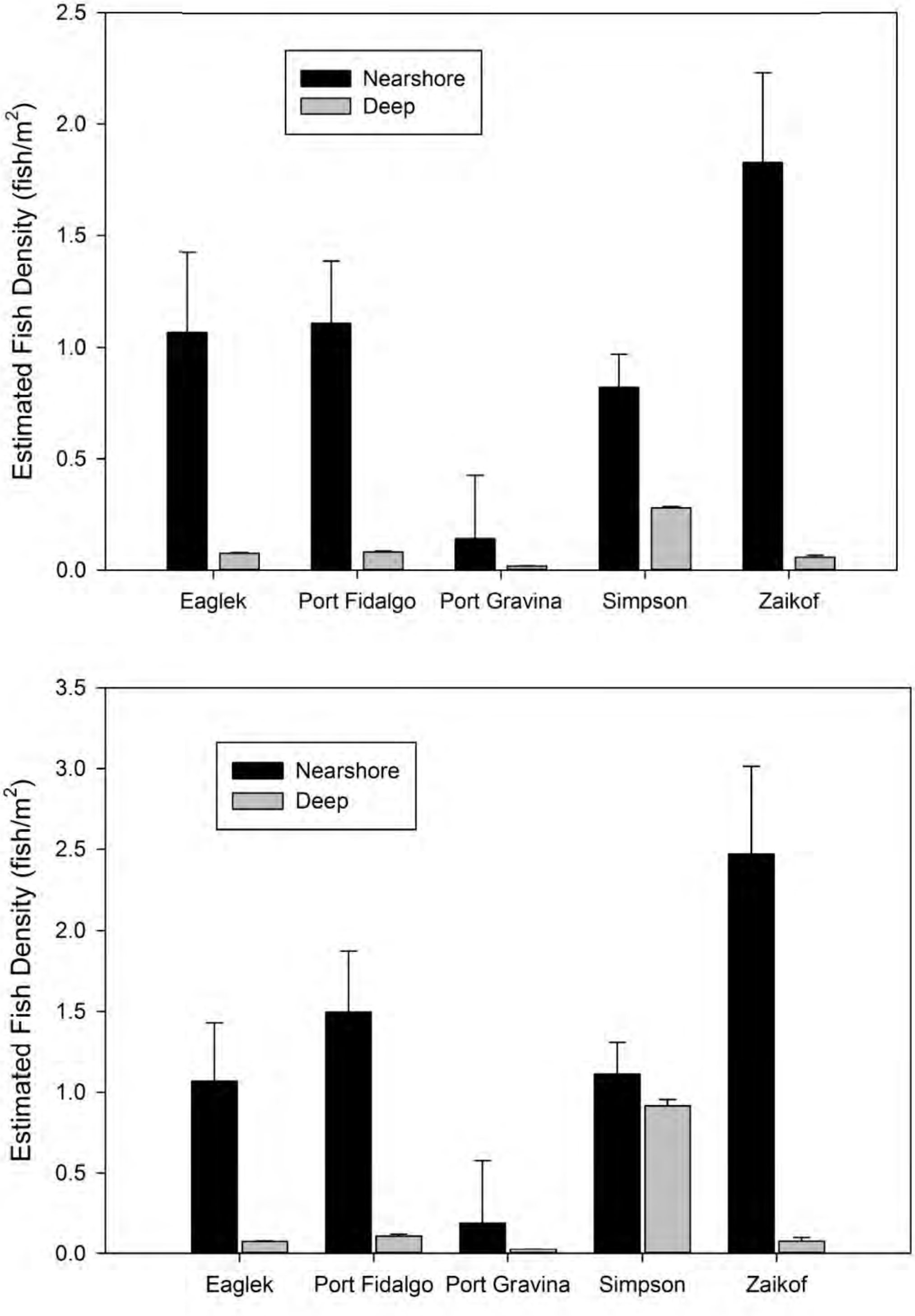


Figure 7. Acoustic density estimates for five bays during the November 2015 cruise. Top panel are density values using the TS relationship of Thomas et al. (2002); bottom panel are density values using the TS relationship of Ona (2003). Dark bars are estimates derived from ASV sampling, and gray bars depict densities in the main bay transects.

Appendix

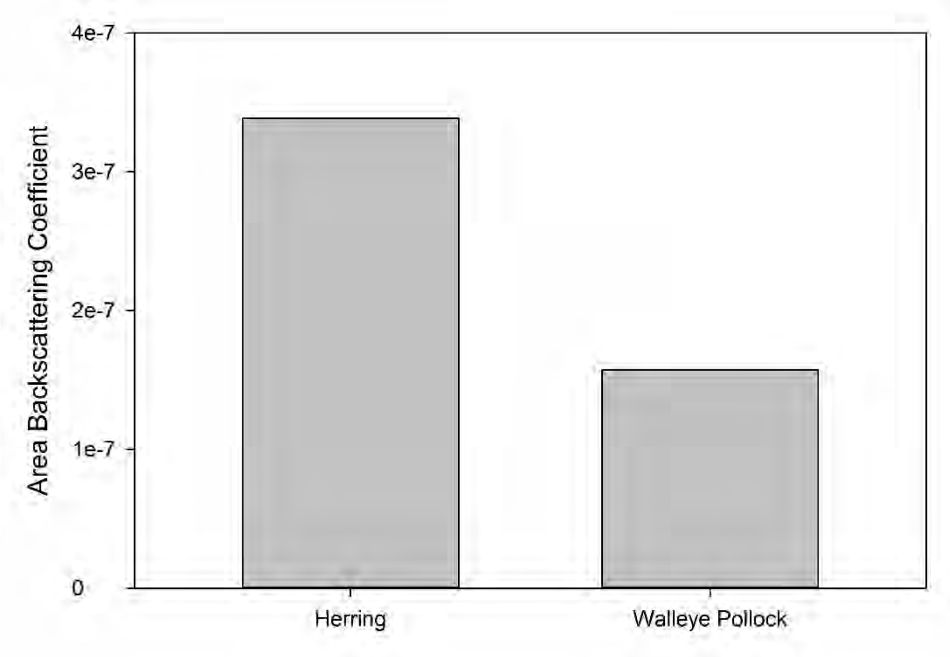


Figure A1. Acoustically estimated backscatter apportioned by trawl caught species in Eaglek Bay.

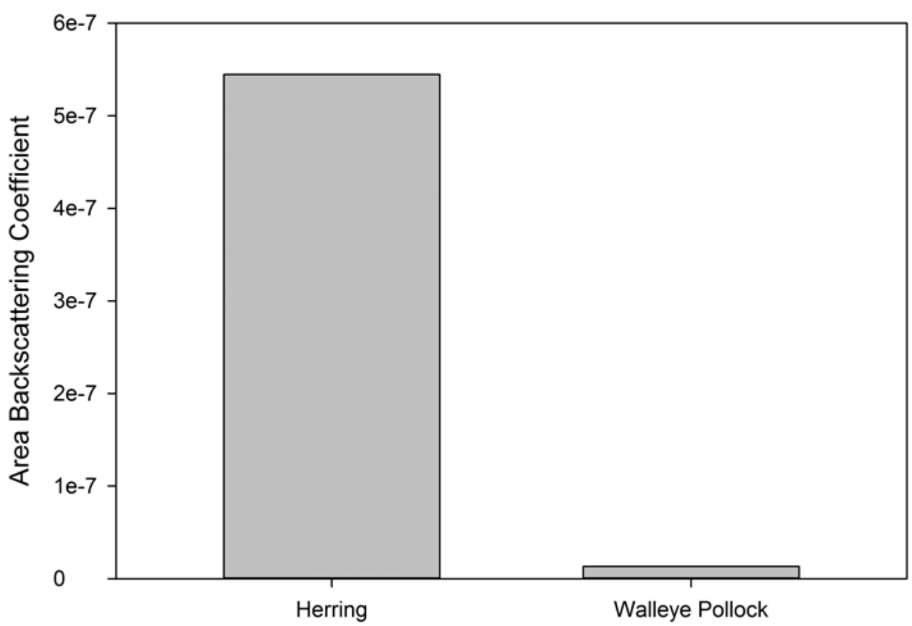


Figure A2. Acoustically estimated backscatter apportioned by trawl caught species in Port Fidalgo.

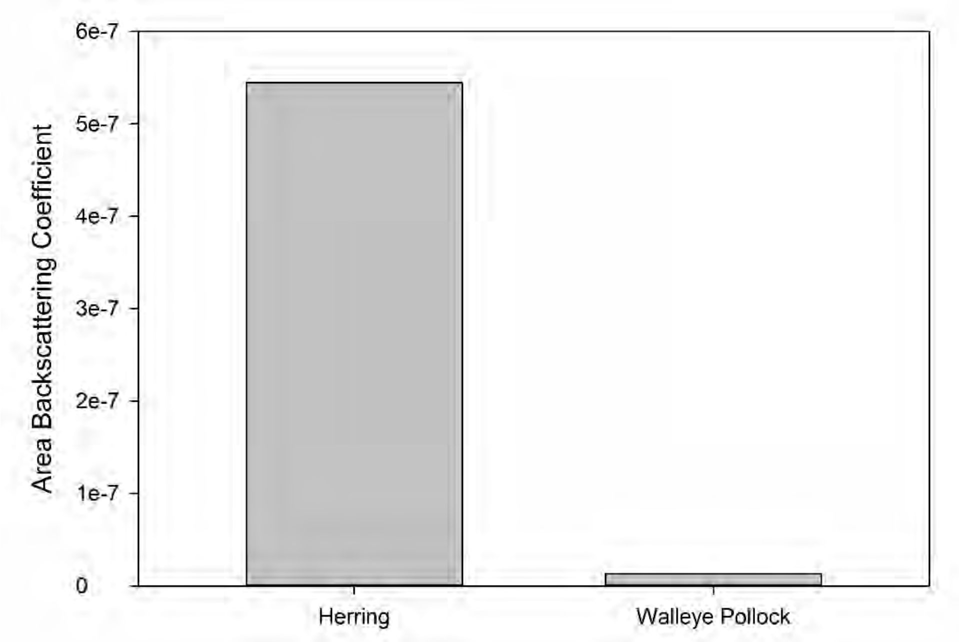


Figure A3. Acoustically estimated backscatter apportioned by trawl caught species in Port Gravina.

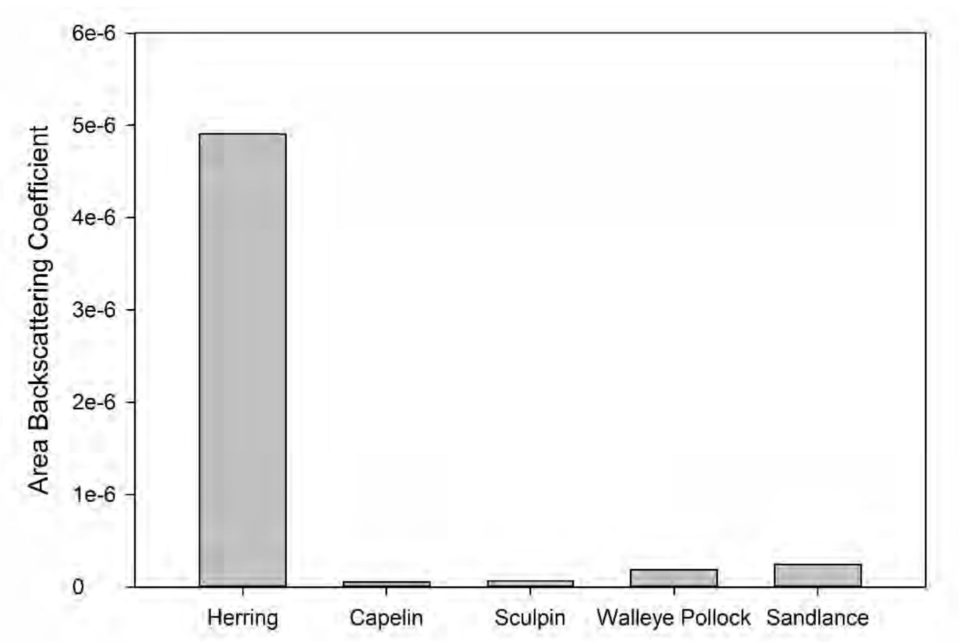


Figure A4. Acoustically estimated backscatter apportioned by trawl caught species in Simpson Bay.

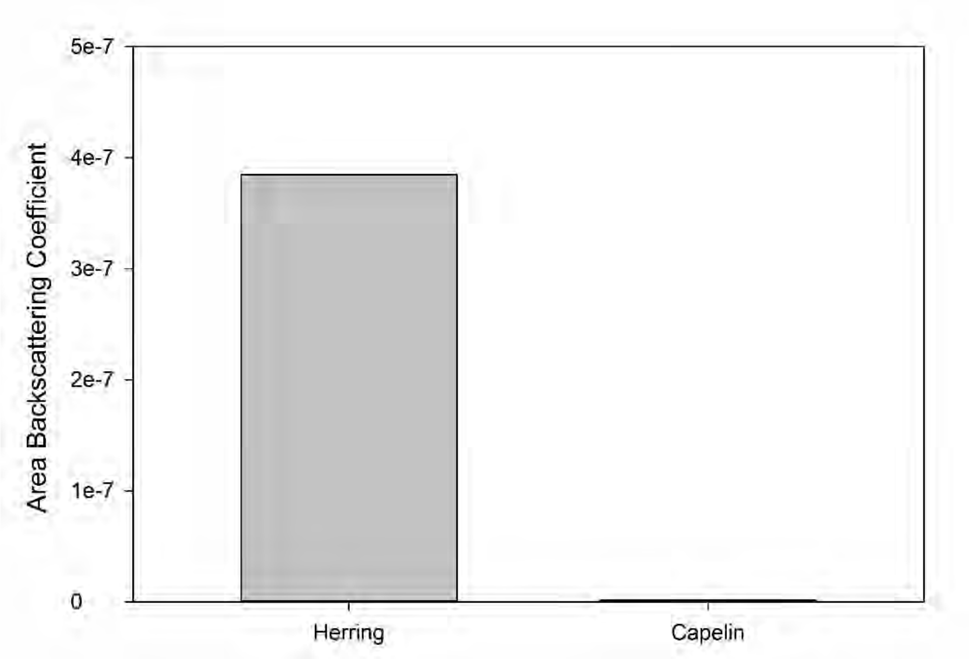


Figure A5. Acoustically estimated backscatter apportioned by trawl caught species in Zaikof Bay.

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

We collaborated with FIU (Kevin Boswell and Aubree Zenone) for this project. We coordinated our cruise with several other EVOS HRM PIs, including Mary Anne Bishop and Kristen Gorman. Bishop led the midwater trawl and gillnet surveys for acoustic validation, and subsamples of herring were measured, preserved on the vessel, and transferred to Gorman for energetic and isotope analyses. During this cruise we also deployed a hydrophone at each anchorage to monitor for the presence of acoustically tagged herring (the HRM tagging program of Bishop).

9. Information and Data Transfer: *See*, Reporting Policy at III (C) (9).

All acoustic data collected as part of this project has been uploaded to the AOOS website.

10. Response to EVOSTC Review, Recommendations and Comments: *See*, Reporting Policy at III (C) (10).

The Science Panel commented on the need to establish a method of surveying juvenile herring as an alternative to estimating recruitment using a stock-recruitment model. The panel reacted to a lack of clarity and context in previous reports. This report is the first effort to use acoustic data and synoptic trawl catches to derive species-specific biomass estimates in each of the bays. We endeavor to complete analyses on all three years of data (and perhaps earlier surveys) and determine if these biomass estimates correlate with recruitment of age-3 herring into the spawning population.

In addition, results of our ASV survey indicated high densities of fish in near shore waters, suggesting the standard main bay surveys may not be capable of providing a robust estimate of juvenile herring biomass. Sampling in the near shore was limited in space and time during our November 2015 cruise, so it is not yet possible to determine how much shallow water habitat contributes to overall biomass in each of the bays. We propose to expand these ASV surveys, perhaps in a limited set of bays, to evaluate the relative importance of this habitat in supporting juvenile herring during the fall period.

Finally, we intend to bootstrap the acoustic data to determine error bounds on biomass estimates – this will provide a measure of uncertainty in our estimates of juvenile herring biomass.

We see value in continuing fall juvenile surveys as an important effort to better understand recruitment dynamics of herring in Prince William Sound.

11. Budget: *See*, Reporting Policy at III (C) (11).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$16,200.0	$49,900.0	$40,900.0	$55,300.0	$55,900.0	$218,200.0	$ 92,947
Travel	$0.0	$2,600.0	$2,600.0	$2,600.0	$2,600.0	$10,400.0	$ 8,055
Contractual	$500.0	$4,000.0	$1,600.0	$2,000.0	$0.0	$8,100.0	$ 16,215
Commodities	$1,500.0	$0.0	$1,500.0	$0.0	$0.0	$3,000.0	$ 2,393
Equipment	$59,000.0	$0.0	$0.0	$0.0	$0.0	$59,000.0	$ 57,261
Indirect Costs (*will vary by proposer*)	$5,500	$17,000	$14,000	$18,000	$17,600	$72,100.0	$ 35,872
SUBTOTAL	$82,700.0	$73,500.0	$60,600.0	$77,900.0	$76,100.0	$370,800.0	$212,743.0
General Administration (9% of	$7,443.0	$6,615.0	$5,454.0	$7,011.0	$6,849.0	$33,372.0	
PROJECT TOTAL	$90,143.0	$80,115.0	$66,054.0	$84,911.0	$82,949.0	$404,172.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Spending on personnel is behind because of a change in P.I. in 2015. Funding is being shifted from personnel to contractual to allow for contracting with Kevin Boswell at Florida International University to assist in data collection and processing.

We appreciate your prompt submission
and thank you for your participation.

ATTACHMENT C *EVOSTC Annual Project Report Form*

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111-G

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

PWS Herring Program – Juvenile Herring Intensive Surveys

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

Pete Rand

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)

Project Summary – Overview

The overall objective of this project was to conduct repeated acoustic and midwater trawl surveys to characterize the distribution, abundance and habitat utilization of juvenile Pacific herring during the fall and winter periods in Simpson Bay and Windy Bay in eastern Prince William Sound. Sampling years included 2013 and 2014.

As a first step in exploring this data set (no previous annual reports have been submitted for this project), we examined the relationship between trawl captures and fish densities derived from acoustic data collected along a transect. We provide below a brief description of the analytical methods used and some preliminary results and discussion.

Acoustic Analysis Methods

Juvenile herring were surveyed acoustically along cross-bay transects. Samples were obtained with a Biosonics 120 kHz split-beam hydroacoustic transducer (Biosonics DT-X system) fixed to a towfin towed alongside the *R/V Montague*. Midwater trawls were conducted synoptically to provide information on total catch, species and size structure of acoustic targets. Depths that the trawl sampled were measured using pressure sensors (Star Oddi) fixed to the headrope of the trawl.

Acoustic data for these surveys were manually inspected and post-processed in Echoview 7.1 (Sonar Data Pty., Ltd.). An analysis threshold of -60.00 dB was applied to the volume backscattering (S_V) data in addition to a bottom detection algorithm to remove reverberation and unwanted acoustic backscatter (eg. benthic habitat, air bubbles, etc.). Additional manual inspections removed any remaining undesired

data and the echograms were binned into 10m horizontal by 5m depth analysis cells. For this analysis, we limited the depth bins to those corresponding to the volume sampled by the midwater trawl as measured by the pressure sensors on the trawl (Figure 1). By following this protocol, we assume all remaining backscatter in the acoustic data set was from Pacific herring in the water column.
Acoustic fish density estimates were calculated by using the backscattering cross-section ($\sigma_{bs;}$ MacLennan *et al.*, 2002) and Target Strength (TS) as calculated using standard linear regression equations for TS derived for Pacific herring by Thomas (Thomas *et al*, 2002). To fit the equation, the average length of herring caught by trawling in each bay was used. The area backscattering coefficient, s_a [$s_a = \int_{z1}^{z2} Sv * dz$], was then used to calculate fish densities (fish m^{-2}) in a transect as described in MacLennan *et al.*, 2002 (Eq.2).

$\sigma_{bs} = 10^{\wedge(TS/10)}$ (Eq. 1)

Fish $m^{-2} = s_a / \sigma_{bs}$ (Eq. 2)

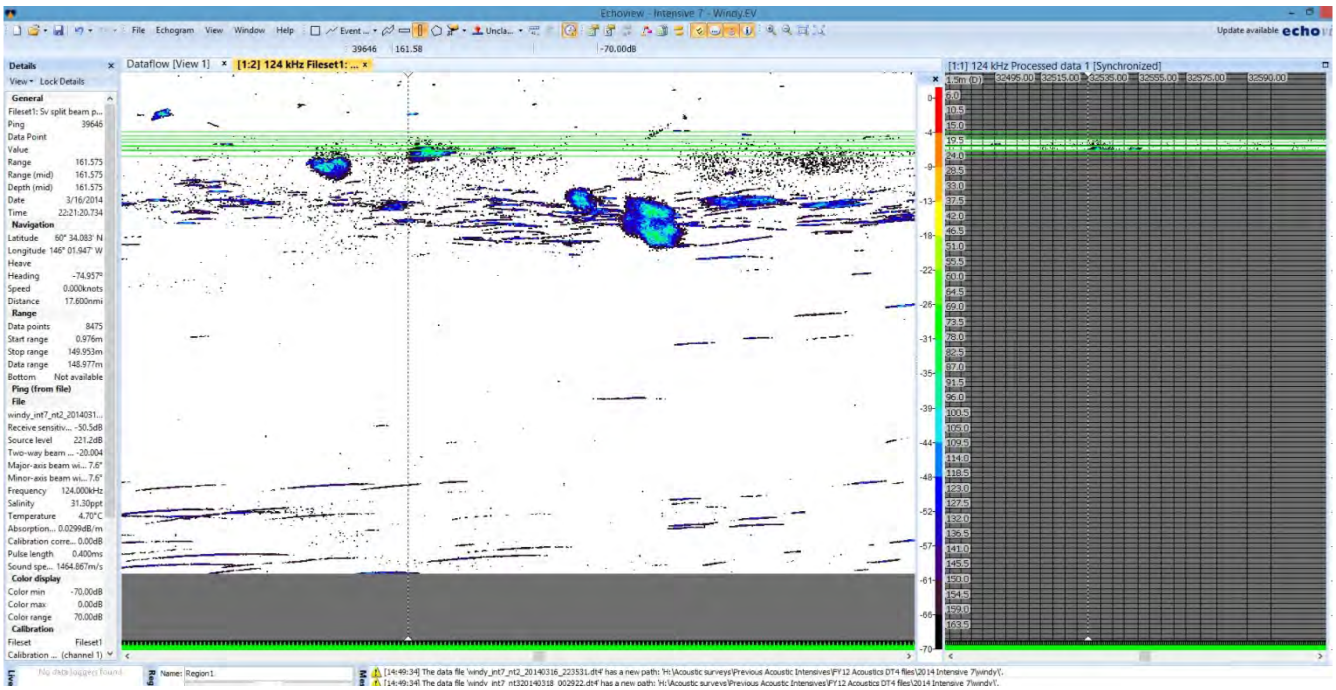


Figure 1. A screen shot of Echoview 7.1 to illustrate the process of subsetting the acoustic data to include only the backscatter from the depths sampled by our midwater trawl. The green horizontal bars envelope the acoustic data included in our estimates of fish density.

Preliminary results & discussion

We present results of acoustic density and trawl captures for the two years for which we had coupled data. We found a weak but statistically significant ($p<.05$) correlation between the number of herring captured in the trawl and the measure of acoustic fish density along the transect. We present results graphically for Simpson Bay (Figure 2). It is not surprising the correlation is weak considering in some cases the trawl was sampling near the top edge of the fish schools encountered and parsing the acoustic data to include only the volume of water swept by the trawl is highly uncertain (see Figure 1).

The slope of the regression (4304 herring captured along a transect for each increment in acoustic fish density) appears to roughly conform to expectations. Given a trawl opening of approximately 10 m, a tow speed of approximately 1 meter per second (2 knots), and a trawl duration of 10 minutes, the area swept by the trawl would be approximately 6000 m^2. Given some level of trawl avoidance by herring, our estimated slope appears reasonable, and thus this provides some assurance that these two survey methods corroborate each other.

We are now in the process of deriving density and biomass estimates using acoustic data from the entire water column. Results from this analysis will be produced for the final report in April 2016.

Table 1. Summary of coupled acoustic and trawl capture data from intensive surveys during the fall-winter periods of 2013 (Intensives #1-4) and 2014 (Intensives #5-8). Data set excludes transects with zero herring catch.

Intensive	Event	Bay	Density (fish/m^2)	Acoustic Catch (g)	Trawl Mass (g)	Trawl Herring Caught
1	6	Simpson	0.04750	21.726	8.25	3
1	9	Simpson	0.03104	73.654	44.5	5
1	3	Windy	0.00895	40.880	87	6
1	12	Windy	0.00380	32.234	23.25	1
2	3	Simpson	0.00070	2.084	11	2
2	5	Simpson	0.00587	49.908	47.25	9
2	18	Simpson	0.00187	5.225	63.25	7
2	20	Simpson	0.00138	2.722	52.75	13
2	28	Simpson	0.00857	65.741	58.25	7
2	30	Simpson	0.00292	11.410	40	9
2	8	Windy	0.00106	2.133	5.25	1
2	10	Windy	0.00116	17.574	25	1
3	3	Simpson	0.03460	326.699	4376	559
3	5	Simpson	0.10072	1090.201	3376.8	417
3	17	Simpson	0.18010	673.125	5399.55	1038
3	19	Simpson	0.16083	197.857	4110	549
3	22	Simpson	0.02626	260.870	40.25	7
3	24	Simpson	0.13347	750.013	771.25	125
3	8	Windy	0.00151	3.917	26.5	4
3	12	Windy	0.00098	5.021	6.75	1
3	14	Windy	0.00038	1.703	15.75	2
3	27	Windy	0.00810	64.438	10.75	2
3	29	Windy	0.00717	73.970	27	5
4	3	Simpson	0.00090	12.905	309.5	17
4	5	Simpson	0.00224	47.818	166	6
4	21	Simpson	0.00122	16.743	377	20
4	36	Simpson	0.00089	13.816	148.75	11
4	38	Simpson	0.00108	14.409	21	2
4	8	Windy	0.00044	1.739	7	1
4	15	Windy	0.00259	80.581	329	5
4	19	Windy	0.00081	1.766	4.25	1
4	29	Windy	0.17741	144.128	11.75	2
4	31	Windy	0.00821	42.245	3.5	1
5	3	Simpson	0.00023	7.187	935.25	23
5	5	Simpson	0.00069	3.677	373.75	19
5	13	Simpson	0.00004	3.094	69	1
5	15	Simpson	0.00061	1.396	5.5	1
5	34	Simpson	0.00024	1.255	141	13
5	36	Simpson	0.00107	24.508	966	18
6	3	Simpson	0.00072	26.321	25126	479
6	5	Simpson	0.00155	42.628	18.75	1
6	15	Simpson	0.00024	1.682	451.75	29
6	17	Simpson	0.00094	19.641	863	36
6	19	Simpson	0.00192	34.667	2804	55

6	34	Simpson	0.00463	46.677	7484	305
6	8	Windy	0.00007	11.999	1211	9
6	22	Windy	0.00011	18.168	47	1
6	24	Windy	0.00003	2.062	180	1
7	3	Simpson	0.00075	4.365	183.5	17
7	5	Simpson	0.02930	130.420	80.75	7
7	7	Simpson	0.01677	58.747	2063	118
7	21	Simpson	0.00288	9.885	2090	151
7	23	Simpson	0.00347	15.792	164.25	9
7	25	Simpson	0.00007	1.185	42.5	3
7	10	Windy	0.00022	2.559	16.5	1
7	15	Windy	0.00056	43.060	198261	1917
8	3	Simpson	0.00223	22.677	304	81
8	7	Simpson	0.00985	124.601	5981	324
8	24	Simpson	0.00176	13.495	1637	85
8	26	Simpson	0.00190	18.851	5122.6	211
8	31	Simpson	0.02432	26.600	3547.9	1124
8	33	Simpson	0.00883	41.245	244.8	51
8	35	Simpson	0.07407	27.356	4722.5	1457
8	10	Windy	0.00271	82.318	905.6	9
8	17	Windy	0.00046	19.137	4413.5	36
8	21	Windy	0.00071	18.468	47.6	1

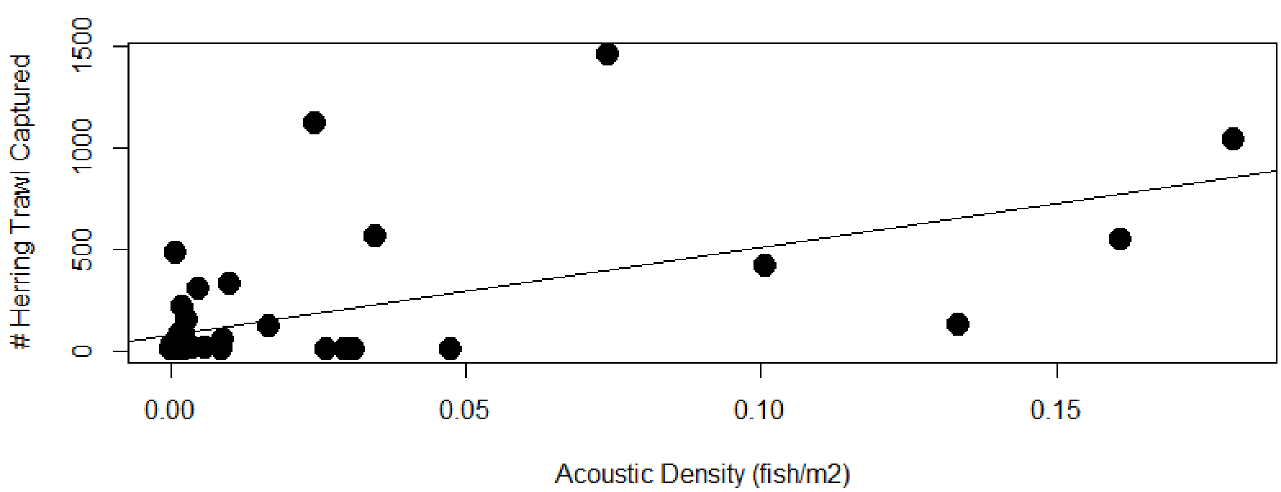


Figure 2. Relationship between the number of juvenile herring captured along a transect and the average fish density derived from acoustic data for transects in Simpson Bay. The cruises were conducted during November-December 2013 and February-April 2014.

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

We collaborated with FIU (Kevin Boswell and Aubree Zenone) for this project. These cruises were coordinated with several other EVOS HRM PIs, including Mary Anne Bishop and Kristen Gorman. Bishop led the midwater trawl surveys for acoustic validation, and subsamples of herring were measured, preserved on the vessel, and transferred to Gorman for energetic and isotope analyses.

9. Information and Data Transfer: *See*, Reporting Policy at III (C) (9).

All acoustic data collected as part of this project has been uploaded to the AOOS website.

10. Response to EVOSTC Review, Recommendations and Comments: *See*, Reporting Policy at III (C) (10).

This represents the first report on this project submitted to EVOSTC.

11. Budget: *See*, Reporting Policy at III (C) (11).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$0.0	$21,000.0	$30,100.0	$4,700.0	$0.0	$55,800.0	$ 38,574
Travel	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$ 9
Contractual	$0.0	$0.0	$1,000.0	$100.0	$0.0	$1,100.0	$ 10,301
Commodities	$0.0	$0.0	$2,000.0	$0.0	$0.0	$2,000.0	$ 1,376
Equipment	$46,000.0	$0.0	$0.0	$0.0	$0.0	$46,000.0	$ 45,886
Indirect Costs (*will vary by proposer*)	$0	$6,300	$9,600	$1,400		$17,300.0	$ 14,780
SUBTOTAL	$46,000.0	$27,300.0	$42,700.0	$6,200.0	$0.0	$122,200.0	$110,926.0
General Administration (9% of	$4,140.0	$2,457.0	$3,843.0	$558.0	$0.0	$10,998.0	
PROJECT TOTAL	$50,140.0	$29,757.0	$46,543.0	$6,758.0	$0.0	$133,198.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Spending on personnel is behind because of a change in P.I. in 2015. Funding is being shifted from personnel to contractual to allow for contracting with Kevin Boswell at Florida International University to assist in data collection and processing.

We appreciate your prompt submission
and thank you for your participation.

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

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111-H

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

PWS Herring Program – Outreach and Education

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

Hayley Hoover

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).

During the summer of 2013 the PWSSC made a major revision to its website. This required us to put effort to rebuilding the herring portion of the website. This effort continued through January 2015. All empty links that were on the HRM page have been filled. Keeping the web site up to date is of great importance because it connects the project's findings to a wide audience. Another way to widen our reach is to stay contemporary with outreach material produced. In an effort to stay current a DJI drone was purchased to enhance outreach materials. Videos produced with this new equipment will be put on the HRM page to compliment the existing information as well as on PWSSC's social media outlets. The PWSSC also reviewed their approach and format for the *Field Notes* radio programs. It is now in an interview format instead of a narrative format. *Field Notes* interviews were conducted at the PI meeting in November and will be edited and on the air by the end of the March.

In July 2015 a new education coordinator was hired. This new hire is now the lead for herring lessons in the Discovery Room programs taught at the local elementary school. Hayley Hoover will continue to be the lead for HRM outreach material.

Table 1. Status of project deliverables for this reporting period

Deliverable/Milestone	**Status**
Develop/update *Project Profiles* based on surveys & herring data analysis	Three *Project Profiles* completed, June 2015
Participate in Principal Investigator update and outreach meeting	Meeting held in Anchorage, November 2015
Evaluate oceanography and herring *Discovery Room* program	*Discovery Room* sessions held and evaluated March 2015
Delivery of *Community Lectures* and *Field Notes* complete for FY15	Two *Community Lecture* were given. One lecture was given at CDFU.
	Two *Field Notes* were completed.
Written outreach materials complete for FY15	Five articles in *Delta Sound Connections*, May 2015.
Deliver *Summer Field Program*	Summer programs were not delivered.
Submit semi-annual report	Completed August 2015
Continue implementing *Discovery Room*	Herring components have continued to be implemented in *Discovery Room* activities.
Develop *Field Notes* program based on fall surveys	This has not yet occurred.
Attend Alaska Marine Science Symposium	Completed

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

This project coordinates with the other projects within the HRM program to get materials for the various education and outreach projects. There is also coordination with the outreach projects of the Gulf Watch Alaska program. The investigator that is the lead for HRM outreach assists with aspects of GWA outreach and coordinates with the GWA outreach lead investigator.

9. Information and Data Transfer: *See*, Reporting Policy at III (C) (9).

Revised the HRM web page on the PWSSC website with articles in the *Delta Sounds Connections,* and *Breakwater*.

10. Response to EVOSTC Review, Recommendations and Comments: *See,* Reporting Policy at III (C) (10).

Science Panel Comments Hoover & Pegau. Outreach 14120111-H

"The Science panel appreciates the progress made on local outreach. One of the simplest ways to do this is to keep the website updated, because it is the portal to the outside world. However, we also recommend that investigators work with the outreach program to craft presentations that could be delivered at various venues (e.g., schools, Science Pubs). There was a comment in the proposal that there has been some difficulty getting PI's to commit to outreach efforts due to logistics. The location of the PI's should have little impact on their ability to participate in outreach efforts. Involvement of PI's in outreach activities can extend the reach of the program and improve the publics appreciation of what is being accomplished. We also encourage the outreach program to call and interview PI's to get information that would be beneficial to the outreach efforts."

In regards to the web page, many updates have been made and will continue to be made into the future. Staff agrees that this is a widely accessible tool that should be kept up to date at all times. A drone was purchased this fall to enhance the outreach material put on the web page. As Cordova is a very small town there are no specific 'Science pubs' at staff's disposal. However the Tuesday Night Community Lecture Series hosted by the USFS serves as an alternative to share the programs findings with the local community. A lecture was held at CDFU (Cordova District Fishermen United) to inform local herring permit holders about HRM program. Staff will continue to look for new avenues to present findings. Logistics no longer seem to be an issue. Staff will continue to pursue PI's diligently. Sharon Wildes made a trip to Cordova this winter to give a guest lecture, recordings for Field Notes were conducted at the November PI meeting in Anchorage, and two guest lectures are scheduled for April.

11. Budget: *See,* Reporting Policy at III (C) (11).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$2,800.0	$16,300.0	$16,800.0	$18,900.0	$22,900.0	$77,700.0	$ 48,957
Travel	$1,400.0	$1,800.0	$3,600.0	$2,500.0	$2,000.0	$11,300.0	$ 6,557
Contractual	$400.0	$2,000.0	$800.0	$2,100.0	$1,000.0	$6,300.0	$ 6,377
Commodities	$7,000.0	$1,400.0	$1,900.0	$1,900.0	$1,100.0	$13,300.0	$ 7,932
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0
Indirect Costs (*will vary by proposer*)	$3,500	$6,500	$6,900	$7,600	$8,100	$32,600.0	$ 20,947
SUBTOTAL	$15,100.0	$28,000.0	$30,000.0	$33,000.0	$35,100.0	$141,200.0	$90,770.0
General Administration (9% of	$1,359.0	$2,520.0	$2,700.0	$2,970.0	$3,159.0	$12,708.0	
PROJECT TOTAL	$16,459.0	$30,520.0	$32,700.0	$35,970.0	$38,259.0	$153,908.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Spending is currently consistent with the budget to date.

We appreciate your prompt submission and thank you for your participation.

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

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

PWS Herring Program #12120111-K

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

Herring Disease Program

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

Paul K. Hershberger

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

Feb 1, 2015 – January 31, 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).

Field Findings:

A. One sample of adult Pacific herring was collected from Prince William Sound (n=60) during the spring pre-spawn period on April 3, 2015:

	VHSV Prevalence	*Ichthyophonus* Prevalence	VEN prevalence
Gravina Point	0% (n=60)	25% (15/60)	0% (n=60)

B. Three samples of adult Pacific herring were collected from Sitka Sound Sound (n=60 / collection) during the spring pre-spawn period from March 20 – 22, 2015:

	VHSV Prevalence	*Ichthyophonus* Prevalence	VEN prevalence
Bieli Rock (May 20)	0%	10% (6/60)	0% (n=60)
Bieli Rock (May 22)	0%	13% (8/60)	0% (n=60)
Bieli Rock (May 22)	0%	20% (12/60)	0% (n=60)

C. One sample of adult Pacific herring was collected on April 27 by Ted Otis and Joe Loboy from Kamishak Bay; tissues were submitted to the ADF&G Anchorage Fish Pathology Laboratory for diagnostic testing (Courtesy J. Ferguson).

VHSV Prevalence	*Ichthyophonus* Prevalence	VEN prevalence
0% (n=60)	2% (1/60)	0% (n=60)

D. Juvenile herring were collected from PWS cruises in collaboration with the PWSSC surveys:

	Date	Sample Size	VHSV Prevalence	VEN Prevalence	*Ichthyophonus* Prevalence
Simpson Bay*	Nov 6	46	0%	Results Pending	2%
Lower Herring	Nov 11	54	0%	Results Pending	2%
Whale Bay	Nov 12	60	0%	Results Pending	3%

*During the culturing of samples for VHSV, one sample from Simpson Bay produced questionable cytopathic effect (cell clumping) on EPC cells. The CPE was not indicative of VHSV or other viruses that typically cause plaques. The sample is currently under further investigation using molecular tools to determine whether a different agent was present and can be identified. Additionally, the sample was inoculated into SPF herring in an effort to perpetuate any live agent that may have caused the CPE.

E. Samples from the Craig herring fishery were submitted by Eric Coonradt (ADF&G – Sitka). A low proportion (approximately 1/100) of pre-spawn adult herring reportedly demonstrated external hemorrhages, possibly indicative of a pathogen, predator wounds, abrasion, or other wound. A random sample of 52 wild herring and a high-graded sample containing 8 affected herring (see image below) were frozen at -20C and shipped to the USGS – Marrowstone Marine Field Station for VHSV assessment using cell culture. VHSV was not detected in any of these fish (either the 8 high-graded samples or the 52 random samples). Although the samples were previously frozen at -20 ^{o}C prior to processing (not optimal for VHSV recovery), no CPE was detected in any of the samples, indicating that the lesions were not likely caused by high titers of VHSV. The lesions were possibly caused by predator- or net-induced injuries.

Laboratory Findings:

A. Hart, L.M., C.M. Conway, D.G. Elliott, P.K. Hershberger. *In Press*. Persistence of external signs in Pacific herring *Clupea pallasii* with ichthyophoniasis. Journal of Fish Diseases.

The progression of external signs of *Ichthyophonus* infection in Pacific herring *Clupea pallasii* Valenciennes was highly variable and asynchronous after intraperitoneal injection with pure parasite preparations; however, external signs generally persisted through the end of the study (429 d post-exposure). Observed signs included 'sandpaper skin,' open lesions, pigmented ulcers and / or bleeding ulcers. The prevalence of external signs plateaued 35 d post-exposure and persisted in 73-79% of exposed individuals through the end of the first experiment (147 d post-exposure). Among a second group of infected herring, external signs completely resolved in only 10% of the fish after 429 d. The onset of mortality preceded the appearance of external signs. Histological examination of infected skin and skeletal muscle tissues indicated an apparent affinity of the parasite for host red muscle. Host responses consisted primarily of granulomatous inflammation, fibrosis, and necrosis in the skeletal muscle and other tissues. The persistence and asynchrony of external signs and host response indicated that they were neither a precursor to host mortality nor did they provide reliable metrics for hind-casting the date of exposure. However, the long-term persistence of clinical signs in Pacific herring may be useful in ascertaining the population-level impacts of ichthyophoniasis in regularly observed populations.

B. Hershberger, P.K., J.L. Gregg, L.M. Hart, S. Moffitt, R. Brenner, K. Stick, E. Coonradt, T. Otis, J. J. Vollenweider,K. A. Garver, J. Lovy, T.R. Meyers. *In Press*. The parasite *Ichthyophonus* sp. in Pacific herring. Journal of Fish Diseases.

The protistan parasite *Ichthyophonus* occurred in populations of Pacific herring *Clupea pallasii* throughout coastal areas of the NE Pacific, ranging from Puget Sound, WA north to the Gulf of Alaska, AK. Infection prevalence in local Pacific herring stocks varied seasonally and annually, and a general pattern of increasing prevalence with host size and/or age persisted throughout the NE Pacific. An exception to this zoographic pattern occurred among a group of juvenile, age 1+ year Pacific herring from Cordova Harbor, AK in June 2010, which demonstrated an unusually high infection prevalence of 35%. Reasons for this anomaly were hypothesized to involve anthropogenic influences that resulted in locally elevated infection pressures. Inter-annual declines in infection prevalence from some populations (e.g. Lower Cook Inlet, AK; from 20-32% in 2007 to 0-3% during 2009-2013) or from the largest size cohorts of other populations (e.g. Sitka Sound, AK; from 62.5% in 2007 to 19.6% in 2013) was likely a reflection of selective mortality among the infected cohorts. All available information for *Ichthyophonus* in the NE Pacific, including broad geographic range, low host specificity, and presence in archived Pacific herring tissue samples dating to the 1980's, indicate a long-standing host-pathogen relationship.

C. Hershberger, P.K., L.M. Hart, A.H. MacKenzie, M.L. Yanney, C. Conway, D. Elliott 2015. Infecting Pacific herring with *Ichthyophonus* sp. in the laboratory. Journal of Aquatic Animal Health 27: 217-221.

The protistan parasite *Ichthyophonus* sp. occurs in Pacific Herring *Clupea pallasii* populations in coastal areas throughout the northeast Pacific region, but the route(s) whereby these planktivorous fishes become infected is unknown. Several methods for establishing *Ichthyophonus* infections in laboratory challenges were examined. *Ichthyophonus* sp. infections were most effectively established after intraperitoneal injections with suspended parasite isolates from culture or after repeated feedings with infected fish tissues. Among groups that were offered infected fish tissues, infection prevalence was greater after multiple feedings (65%) than after a single feeding (5%). Additionally, among groups that were exposed to parasite suspensions prepared from culture isolates, infection prevalence was greater by intraperitoneal injection (74%) than by gastric intubation (12%); infections were not established in any experimental herring by flushing parasite suspensions over the gills. Although the consumption of infected fish tissues is not likely the primary route of *Ichthyophonus* sp. transmission in populations of wild Pacific Herring, this route may contribute to abnormally high infection prevalence in areas where juvenile herring have access to infected offal.

D. Conway, C.M., M.K. Purcell, D.G. Elliott, P.K. Hershberger. 2015. Detection of *Ichthyophonus* by chromogenic *in situ* hybridization. Journal of Fish Diseases 38: 853-857.

We developed a chromogenic in situ hybridization (CISH) assay capable of detecting *Ichthyophonus* nucleic acid in standard histology sections. The assay has utility for both diagnostic and research applications. The CISH assay can be used to confirm histological diagnosis of *Ichthyophonus* or be readily applied to archival material. There remain many unanswered questions regarding the *Ichthyophonus* life cycle and transmission routes. For example, although *Ichthyophonus* is typically observed as 50-250 µm diameter schizonts in tissues of live fishes, the parasitic life stages can be extremely pleomorphic in vitro and additional life stages have been reported in vivo, raising the possibility that small cryptic stages of the parasite have been overlooked when non-specific histological stains are used. If this is the case, the CISH assay may be useful for tracking sequential dissemination of *Ichthyophonus* throughout fish tissues following laboratory exposure. Additionally, the CISH assay may prove beneficial in ongoing studies intended to identify non-piscine intermediate hosts for the parasite.

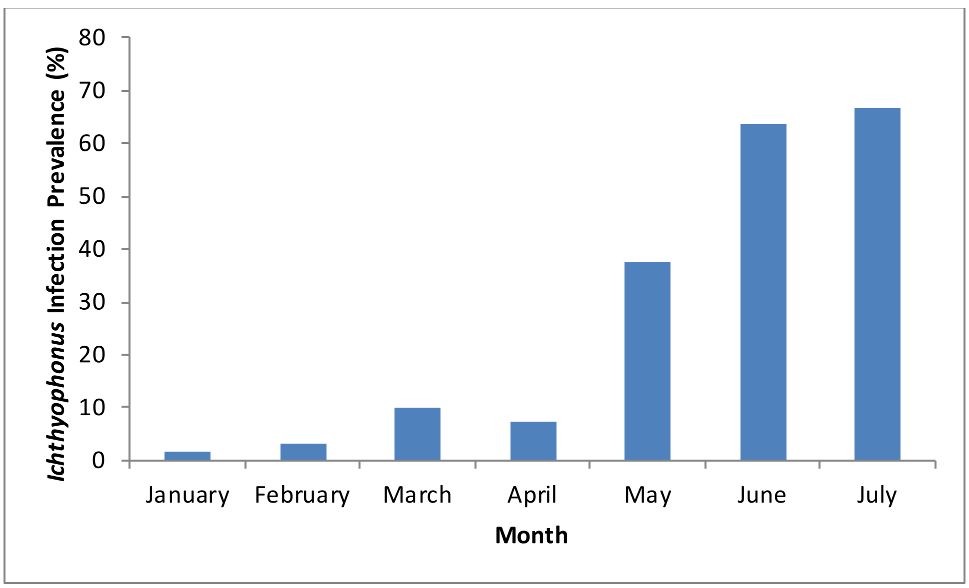
8. Coordination/Collaboration: *See*, Reporting Policy at III (C) (8).

Ongoing collaborations with partners within the PWS Herring Program include:

- Collection of shared zooplankton samples with Dr. Rob Campbell. These samples will be assessed for possible intermediate hosts for *Ichthyophonus*.

- Collection of juvenile herring samples from Cordova Harbor (monthly collections of juvenile herring, plankton collections, stomach samples, and bioenergetics samples) with Drs. Kristin Gorman and Scott Pegau.

2015 Monthly Prevalence of *Ichthyophonus* in Juvenile Herring from Cordova Harbor



- Discussions and planned meetings with Trevor Branch regarding best approaches for the integration of herring infection and disease data into the ASA or other herring population models.

9. Information and Data Transfer: *See*, Reporting Policy at III (C) (9).

In addition to the manuscripts listed above (Section 7), the following presentations were delivered during the current reporting period:

Scientific Presentations

Gregg, J.L., R.L. Thompson, M.K. Purcell, C.S. Friedman, P.K. Hershberger. November 5-8, 2015. Phylogeny of *Ichthyophonus* parasites indicates majority of global impacts can be attributed to a single ubiquitous marine species. Western Society of Naturalists – 96th Annual Meeting. Sacramento, CA.

Elliott, D.G., C.L. McKibben, C.M. Conway, A. MacKenzie, P.K. Hershberger. September 7-11, 2015. Platform. Differential susceptibility of Yukon River and Salish Sea Chinook salmon (*Oncorhynchus tshawytscha*) stocks to *Ichthyophonus*. 17th International conference of Diseases of Fish and Shellfish. Las Palmas de Gran Canaria, Spain.

Hart, L.M., P.K. Hershberger. August 16-20, 2015. Platform. Integration of disease information into population assessments: the case of VHS and Pacific herring. American Fisheries Society 145th Annual Meeting. Portland, OR.

Chen, M., B. Stewart, P. Hershberger, K. Snekvik. May 27-29, 2015. Platform. *Nanophyetus salmincola* in outmigrating Puget Sound Steelhead. 2015 Salmon Recovery Conference. Vancouver, WA.

Hershberger, P.K., J.L. Gregg, A.H. MacKenzie, M.L. Yanney, C. Conway, D.Elliott. June 2-4, 2015. Poster. Infecting Pacific herring (*Clupea pallasii*) with *Ichthyophonus* in the laboratory. 56th Annual Western fish Disease Workshop. Steamboat Springs, CO.

10. Response to EVOSTC Review, Recommendations and Comments: *See,* Reporting Policy at III (C) (10).

N/A

11. Budget: *See,* Reporting Policy at III (C) (11).

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$0.0	$0.0	$170.4	$186.6	$190.8	$547.8	$ 258,069
Travel	$0.0	$0.0	$17.0	$17.0	$18.4	$52.4	$ 22,776
Contractual	$0.0	$0.0	$12.0	$12.0	$12.0	$36.0	$ 49,933
Commodities	$0.0	$0.0	$59.2	$52.2	$52.2	$163.6	$ 79,096
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$ -
Indirect Costs (*will vary by proposer*)							
SUBTOTAL	$0.0	$0.0	$258.6	$267.8	$273.4	$799.8	$ 409,874
General Administration (9% of	$0.0	$0.0	$23.3	$24.1	$24.6	$72.0	$47,400.0
PROJECT TOTAL	$0.0	$0.0	$281.9	$291.9	$298.0	$871.8	$457,274.0
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

COMMENTS:
This summary page provides an five-year overview of proposed funding and actual cumulative spending. The column titled 'Actual Cumulative' should be updated each fiscal year to provide information on the total amount actually spent for all completed years of the project. On the Project Annual Report Form, if any line item exceeds a 10% deviation from the originally-proposed amount; provide detail regarding the reason for the deviation..

We appreciate your prompt submission and thank you for your participation.

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

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111-L

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

PWS Herring Research and Monitoring Program – Juvenile Herring Condition Monitoring

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

Kristen Gorman (PWSSC); Ron Heintz, Fletcher Sewall (NOAA/Auke Bay Labs)

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).

Project Summary - Overview

The juvenile herring condition monitoring (HCM) project is a collaborative effort between the Prince William Sound Science Center (PWSSC) and the Auke Bay Laboratory (ABL). This is the fourth year of sampling within EVOSTC's Herring Research and Monitoring (HRM) program although the work is an extension of similar efforts of the Prince William Sound (PWS) Herring Survey program. The core of this project involves the collection of age-0 Pacific herring (*Clupea pallasii*, hereafter juvenile herring) at two time periods during winter, November and March, to assess energetic strategies that might influence over-winter survival throughout PWS. Specific objectives of the HCM project follow:

Objective 1. Monitor juvenile herring condition by sampling in November.

Objective 2. Monitor juvenile herring condition by sampling in March.

Objective 3. Apply resultant observations from Objectives 1 and 2 to continue refining an overwintering mortality model with the addition of physiological indicators.

Objective 4. Monitor seasonal changes in juvenile herring diets (November vs. March) and examine relationship between diet and herring condition (objective not specifically defined in earlier proposals).

Project Summary – Samples Collected 2015 for both PWSSC and ABL

During 2015, juvenile herring were successfully collected during the core sampling events in March and November 2015 (Fig. 1). In addition, juvenile herring were collected monthly between February and July for disease and condition monitoring in Cordova Harbor (Fig. 1) in collaboration with Dr. Paul Hershberger's work as part of the HRM.

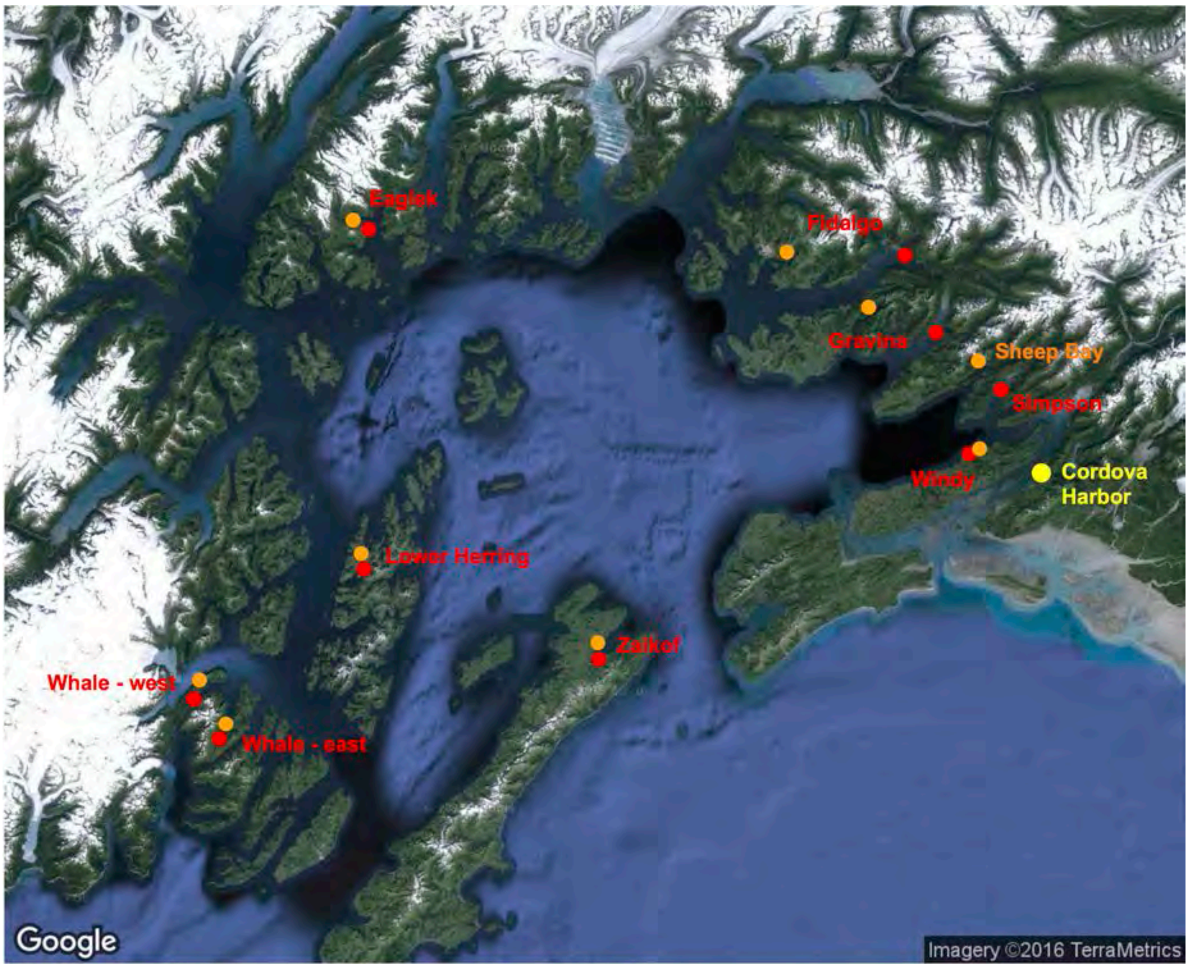


Figure 1. Sampling locations for juvenile herring condition monitoring throughout Prince William Sound during 2015. Locations sampled by Cordova fisherman in March 2015 are noted in orange, areas sampled by PWSSC staff in November 2015 are noted in red. Monthly disease sampling occurred February – July in Cordova Harbor, noted in yellow.

March sampling was conducted in collaboration with members of Cordova Fisherman United (CDFU) who used cast and gill nets to collect juvenile herring from several study sites located throughout PWS (Fig. 1, orange points). These data compare with similar data collected in November 2014 (not shown in Fig. 1) to assess over-winter changes in energy content of fish. The following samples were collected in the field during March 2015 for energetics analysis at PWSSC and ABL:

Date	*Location*	*Sample Size (n)*	*Collector*
3/21-22/2015	Whale Bay-West	129	Victor Jones, F/V Chelsea Dawn
3/22-23/2015	Whale Bay-East	162	Victor Jones, F/V Chelsea Dawn
3/23-24/2015	Zaikof Bay	140	Victor Jones, F/V Chelsea Dawn
3/19-20/2015	Lower Herring Bay	155	Kory Blake, F/V Crystal Falls
3/20-21/2015	Eaglek	9	Kory Blake, F/V Crystal Falls
3/21/2015	Windy Bay	65	Kory Blake, F/V Crystal Falls
3/20/2015	Fidalgo	150	Carl Burton, F/V Mandy La Nae
3/21/2015	Gravina	0	Carl Burton, F/V Mandy La Nae
3/22/2015	Sheep Bay	0	Carl Burton, F/V Mandy La Nae

In November, PWSSC staff completed a successful cruise of PWS collecting juvenile herring from eight bays. Sampling was conducted aboard a charter vessel primarily using trawl equipment, although other types of gear were sometimes used such as cast and gill nets in order to compare the size selectivity of gear types. Fish collected during this cruise were shared between PWSSC energetics projects, ABL projects, and Dr. Paul Hershberger's projects with HRM. The following sample sizes were collected in the field during November 2015 for energetics analysis at PWSSC and ABL:

Date	*Location*	*Sample Size (n)*	*Collector*
11/6-7/2015	Simpson Bay	342	PWSSC
11/7-8/2015	Gravina	13	PWSSC
11/8-9/2015	Fidalgo	145	PWSSC
11/9-10/2015	Eaglek	68	PWSSC
11/10-11/2015	Lower Herring Bay	227	PWSSC
11/12/2015	Whale Bay-East	225	PWSSC
11/12-13/2015	Whale Bay-West	33	PWSSC
11/13-14/2015	Zaikof Bay	82	PWSSC
11/14/2015	Windy Bay	12	PWSSC

Monthly winter sampling to obtain disease and energetic data was conducted during 2015 in Cordova Harbor. Cast nets were used to catch juvenile herring that were processed for disease in collaboration with Dr. Paul Hershberger's lab (n = 60). An additional set of samples (n = 20) was collected and processed for coupled disease and energetics data where the energy analysis is performed at PWSSC using bomb calorimetry. The following samples were collected for this project in the 2015 fiscal year:

Date	*Location*	*Sample Size (n)*	*Collector*
2/3/2015	Cordova Harbor	60	Megan Roberts, Darren Roberts, Kristen Gorman
3/4/2015	Cordova Harbor	80	Megan Roberts, Darren Roberts, Kristen Gorman, Julia McMahon
4/3, 4/9, 4/10/2015	Cordova Harbor	81	Kristen Gorman, Julia McMahon
5/5, 5/6, 5/11/2015	Cordova Harbor	80	Kristen Gorman, Julia McMahon
6/1, 6/2, 6/4/2015	Cordova Harbor	80	Kristen Gorman, Julia McMahon, Vivian Gonzalez, Austin Potter
7/8/2015	Cordova Harbor	6	Kristen Gorman, Julia McMahon, Austin Potter

Project Summary – Previously Collected Samples Processed in 2015, Data Management, Analysis Updates for PWSSC

The laboratory work by both PWSSC and ABL for this project is fairly extensive and results in previously collected samples being processed in the lab during the current fiscal year, which are described in more detail below. The general approach for the PWSSC component has been to conduct proximate analysis to estimate juvenile herring energy density using C/N atomic ratios and dry/wet mass ratios. C/N ratios are based on stable isotope analyses conducted at the University of Alaska Fairbanks – Alaska Stable Isotope Facility (http://ine.uaf.edu/werc/asif/). The relationship is formalized as:

Whole Body Energy Density (kJ/g wet mass) = -2.90242 + 32.585 x (dry/wet mass ratio) + 0.103514 x C/N after Paul et al. (2001).

Bomb calorimetric (BC) analysis, conducted at PWSSC, is then subsequently performed on ~10% of these same samples to ground-truth the energy density estimates from proximate analysis. In 2015, PWSSC made great progress in processing the backlog of BC samples collected since the start of HRM in 2012. This backlog of samples was a result from the change in PIs during this program from Kline to Gorman. In 2015, PWSSC processed samples for BC analysis from juvenile herring collected in the field during 2012, 2013, 2014, spring 2015. The following are numbers of samples analyzed for carbon and nitrogen stable isotopes and BC over the course of the current HRM program with the majority of the BC data produced in the last fiscal year.

Year	*Isotope Sample Size (n)*	*BC Sample Size (n)*	*Percent of Isotope Samples Analyzed by BC*
2012	852	91	10.7%
2013	449	53	11.8%
2014	682	69	10.1%
2015 spring only	263	28	10.6%
Totals	**2,246**	**241**	

The BC work is critical to understanding the accuracy of proximate analysis for inferring energy density of juvenile herring. The backlog of BC samples was a major delay in completing further ecological analyses of herring energy density, as we had no understanding of the accuracy of the proximate data until the BC work was completed. Our BC work over the last fiscal year suggests that energy density estimates of juvenile herring based on proximate and BC analyses accord well, with an error of 0.17 kJ/g wet mass (Fig. 2). Kline (2013) observed a similar level of error in energy estimation between the two methods (i.e, <0.10 kJ/g wet mass). An error of 0.17 kJ/g is very close to the margin of error for multiple BC instruments (0.15 kJ/g wet mass, F. Sewall, pers. comm). Further, because the difference in energy estimates between BC and proximate analysis is small (0.17 kJ/g) in comparison with the differences in energy estimates of interest in an ecological context, i.e., Fig. 3 below (~1.5 kJ/g wet mass), we do not intend to apply a correction factor to proximate analysis values in future analyses.

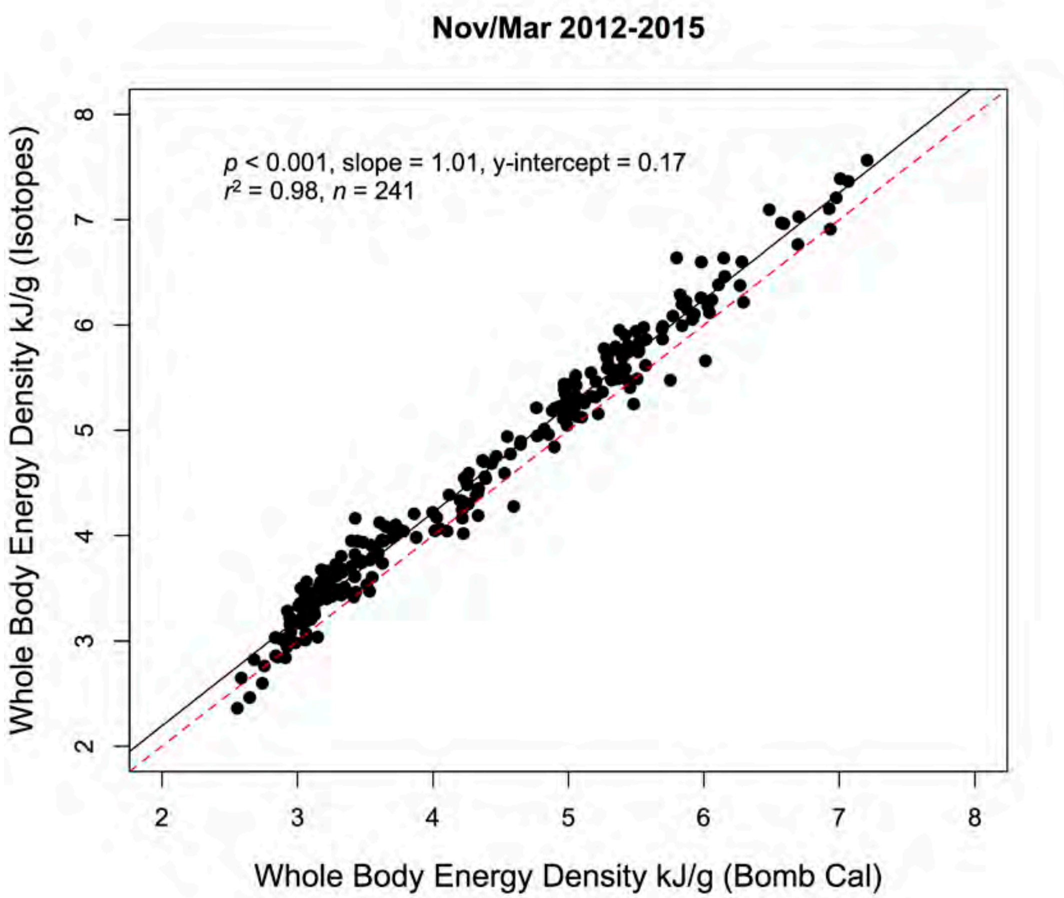


Figure 2. A comparison of energy density estimates of juvenile herring from the November and March time series between 2012 - 2015 using coupled proximate and bomb calorimetric techniques. Bomb calorimetry data were produced in 2015. The red dashed line indicates a 1:1 relationship.

New proximate analysis data for fall 2014 and spring 2015 continue to confirm our understanding that juvenile herring in March have a reduced energetic state in comparison with fish collected in November. March 2015 data are interesting because these fish were collected following a record breaking warm winter in the Gulf of Alaska and Prince William Sound, yet the energy density of these fish was similar to that of previous years. One possible explanation is that these fish are essentially at an energy threshold, below which would result in death, and therefore, little variation exists in energy density even among drastically different years in terms of ocean conditions (Fig. 3).

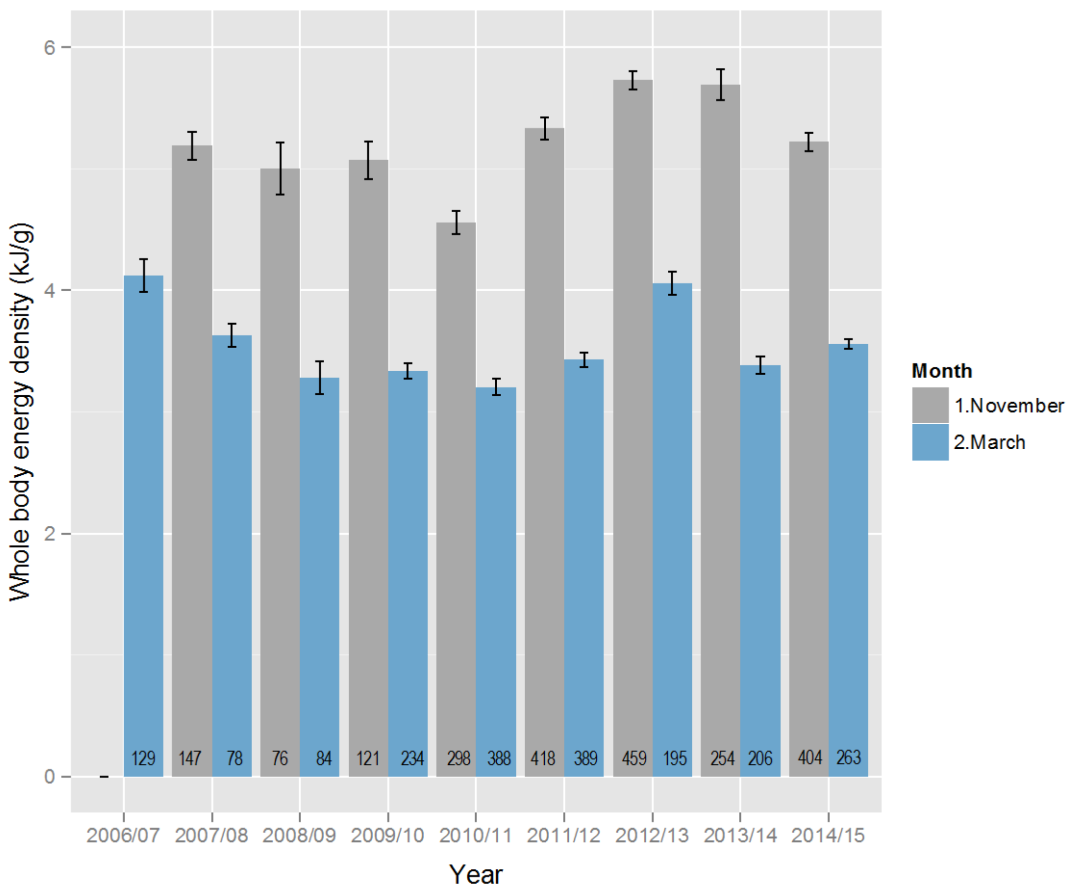


Figure 3. November and March time series of energy variation among juvenile herring collected from Prince William Sound. Sample sizes are noted at the bottom of each bar. Error bars are 95% confidence intervals.

Samples collected for disease (ichthyophonus, ICH) and BC analysis from Cordova Harbor were also all processed in 2015 – disease prevalence was determined by Dr. Paul Hershberger's lab, while BC analysis was performed at PWSSC. Our work suggests that ICH prevalence increases in Cordova Harbor later in the season, where more than 50% of fish are infected by June (Fig. 4).

Data for July are not shown in Fig. 4 due to small sample sizes (*n* = 6), however, the results were similar for June as 4/6 fish were ICH+, a 66.7% infection rate. During July 2015, Gulf Watch Alaska crews working on forage fish also caught juvenile herring outside Cordova Harbor. Interestingly, these fish had a comparatively low infection rate, 7.7% (*n* = 39, 3/39 fish ICH+). These results suggest that the higher ICH prevalence by early summer appears to be specific to Cordova Harbor, suggesting a possible local source associated with disease exposure. Within months, we found no difference in the energy density of infected and non-infected fish (Fig. 4), suggesting that body condition is not a factor associated with ICH infection. We do note that fish sampled later in the season in Cordova Harbor were less energy dense than fish caught earlier in the season, which may indicate some role for susceptibility to infection mediated by a general decline in body condition. We are hoping to continue these studies in 2016, however, currently there are no juvenile herring available to sample in Cordova Harbor.

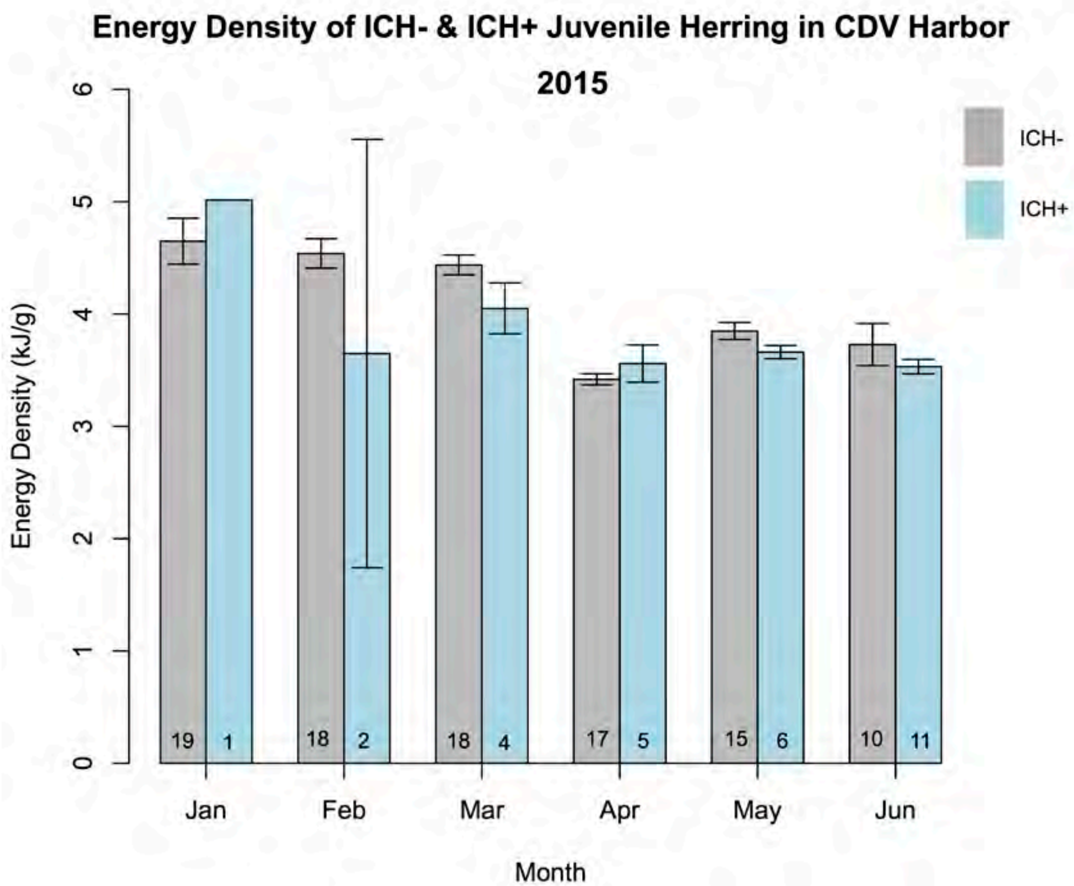


Figure 4. Monthly time series of energy density and ICH prevalence in juvenile herring samples collected from Cordova Harbor in 2015. Grey bars note ICH negative fish, blue bars note ICH positive fish. Error bars are 1 standard error of the mean. Sample sizes noted at the bottom of each bar.

One ecological aspect of the work that we are currently examining is relationships between carbon gradients from either the Gulf of Alaska or PWS and energy density of juvenile herring. These ideas were presented recently as part of a larger talk at the Alaska Marine Science Symposium, January 2016 by Heinz. We are learning that fish collected from different regions of Prince William Sound appear to have different carbon sources that also correlate with energy density - fish collected from the west side of PWS are more depleted in their lipid-corrected $\delta^{13}C$ values reflecting a Gulf of Alaska carbon source (Kline 1999) and these fish tend to be more energy dense, which compares with fish collected from eastern PWS (Fig. 5).

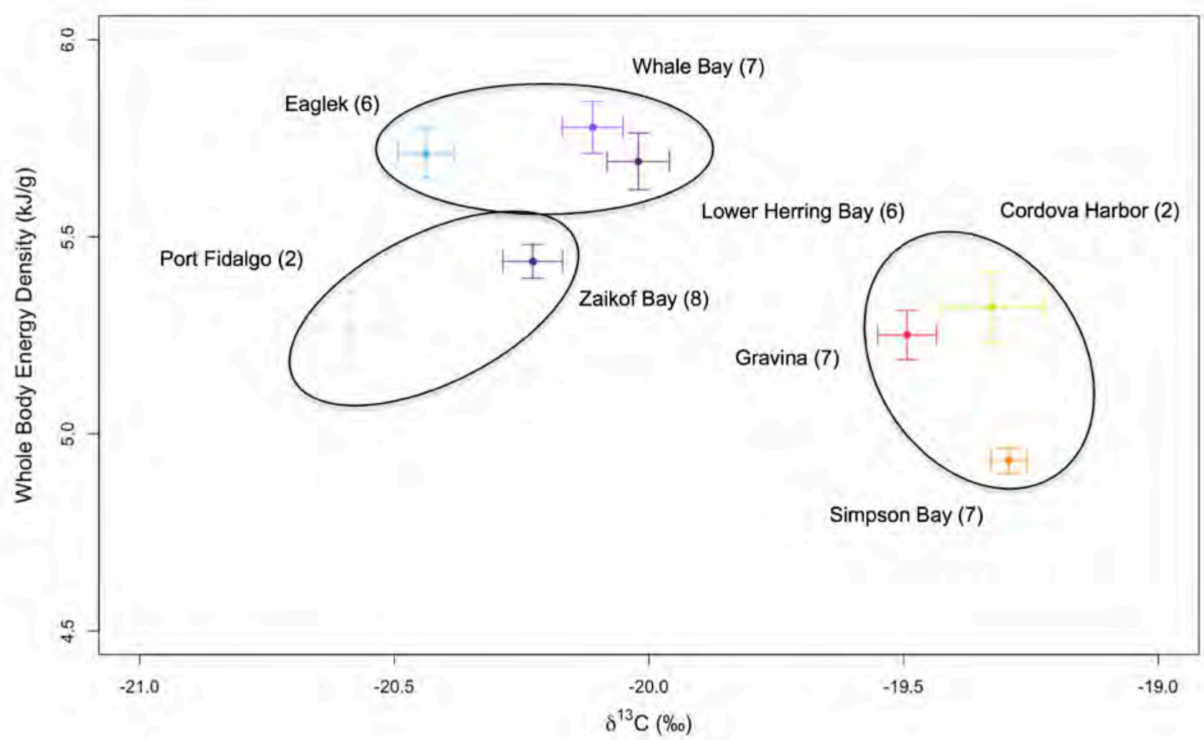


Figure 5. Spatial variability in PWS juvenile herring carbon stable carbon isotope signatures (lipid-corrected) and energy density based on proximate analysis. Numbers in parentheses are years of data for each site. Data include years prior to the current EVOSTC HRM program. Colors simply reflect the different sampling locations.

Our ability to start ecological analyses of our data has been greatly facilitated by an extensive effort during 2015 to develop an Access database for the juvenile herring energetics work at PWSSC. The database was designed in collaboration with a contractor skilled in database development and data were completely proofed this fall by a PWSSC technician. The efficiency for managing data with the new Access database, which now holds 12,444 sample entries, is excellent and will greatly facilitate the writing of several manuscripts.

Project Summary – Previously Collected Samples Processed in 2015, Analysis Updates for ABL

Lipid and RNA/DNA analyses as indicators of fish condition and growth were conducted at ABL on the following samples in 2015:

Date of sampling	*Location*	*Sample Size (n)*
Nov-2014	Eaglek	20
	Lower Herring	20
	Simpson	20
	Whale	20
	Zaikof	19
Mar-2015	Eaglek	6
	Lower Herring	18
	Whale	20
	Zaikof	20
	Total Nov + Mar	163

Processing of stomach content samples for identification and enumeration of prey taxa was also completed for these fish in 2015. Compilation and proofing of the diet data is in progress.

Preliminary results from ABL work indicate that November juvenile herring fat content (% lipid on wet tissue mass basis) increases with body size (fork length). A generalized additive model (GAM) fit to the data pooled across six years for November 2009 - 2014 suggests % lipid increases at a faster rate for larger fish (Fig. 6). A piecewise regression model fit to the data indicates that a shift in lipid allocation rate occurs at approximately 78 mm fork length (95% CI: 64 – 91 mm, Fig. 7).

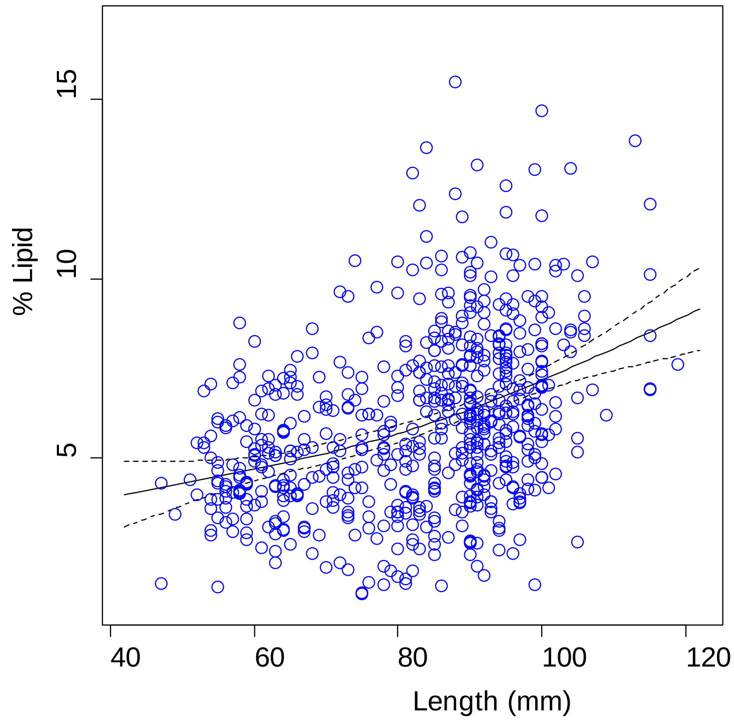


Figure 6. Lipid content (% wet tissue mass) as a function of fork length (mm) with GAM fit (dashed lines show 95% CI) for juvenile herring collected in PWS in November 2009 – 2014 (n = 629).

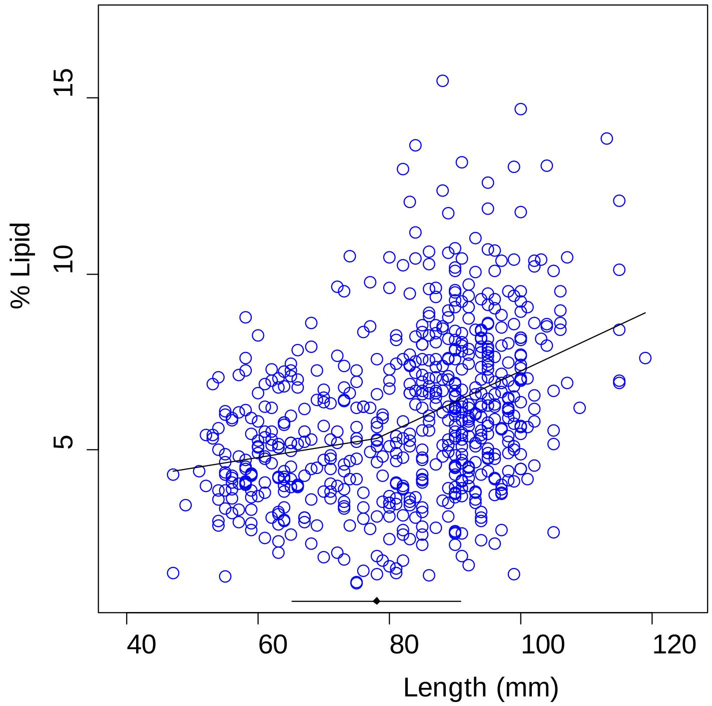


Figure 7. Lipid content (% wet tissue mass) as a function of fork length with piecewise regression line (bar at bottom shows breakpoint and 95% CI) for juvenile herring collected in PWS in November 2009 – 2014 (*n* = 629).

In contrast, juvenile herring growth effort (RNA/DNA ratio) decreases with body size. The GAM fit suggests a high RNA/DNA ratio for small herring, followed by a decline to minimum levels associated with no growth (Fig. 8). A piecewise regression model fit to the data indicates that a shift in growth effort occurs at approximately 73 mm fork length (95% CI: 69 – 78 mm), with minimum RNA/DNA shown for herring at 85 mm (95% CI: 82 – 88 mm) and larger (Fig. 9).

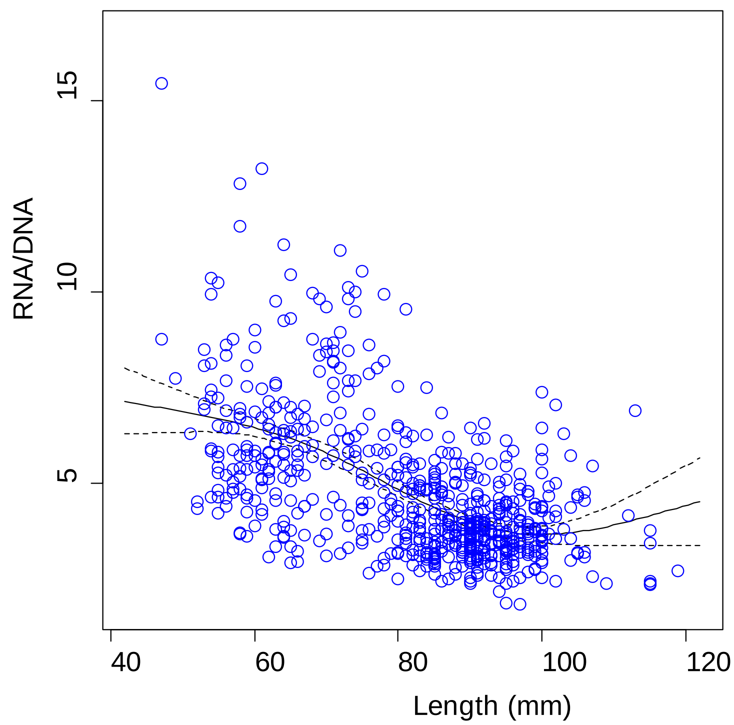


Figure 8. RNA/DNA as a function of fork length with GAM fit (dashed lines show 95% CI) for juvenile herring collected in PWS in November 2009 – 2014 (*n* = 668).

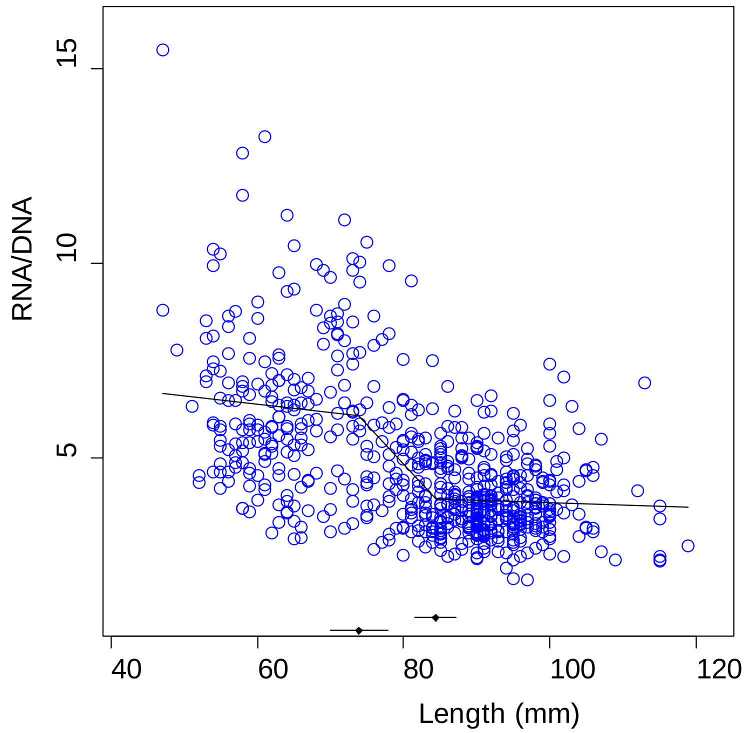


Figure 9. RNA/DNA as a function of fork length with piecewise regression line (bars at bottom show breakpoints and 95% CIs) for juvenile herring collected in PWS in November 2009 – 2014 (n = 668).

These size-based patterns in energy storage and growth are similar to those described for November juvenile herring from PWS as part of the Herring Survey program in 2009 – 2012.

To compare relative condition and growth of YOY herring across years and bays in PWS from November of 2009 to 2014, it is necessary to compare residuals from these regression models to account for the effects of different sizes of fish captured among sampling events. Comparison of lipid and RNA/DNA residuals indicates juvenile herring in 2012 were clearly above average in % lipid and RNA/DNA over the 6-year period studied (Fig. 10). 2012 was also the year in the study period with the lowest annual average water temperatures (Fig. 11), suggesting that temperature influences juvenile herring condition and growth.

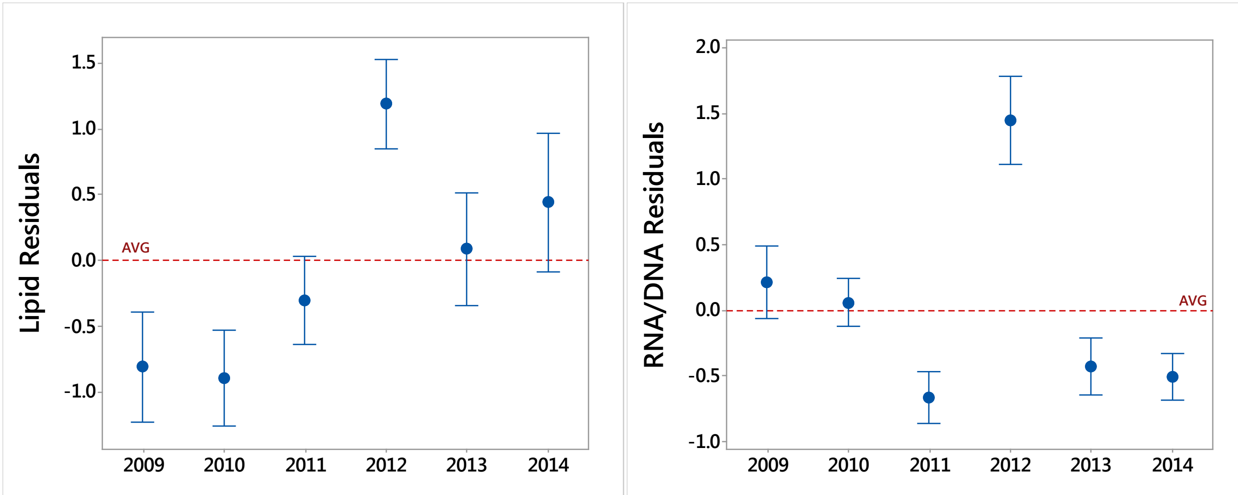


Figure 10. Residuals from the piecewise regression of lipid (left panel) and RNA/DNA (right panel) versus length of juvenile herring collected in PWS in November 2009 – 2014. Means and 95 % confidence intervals shown.

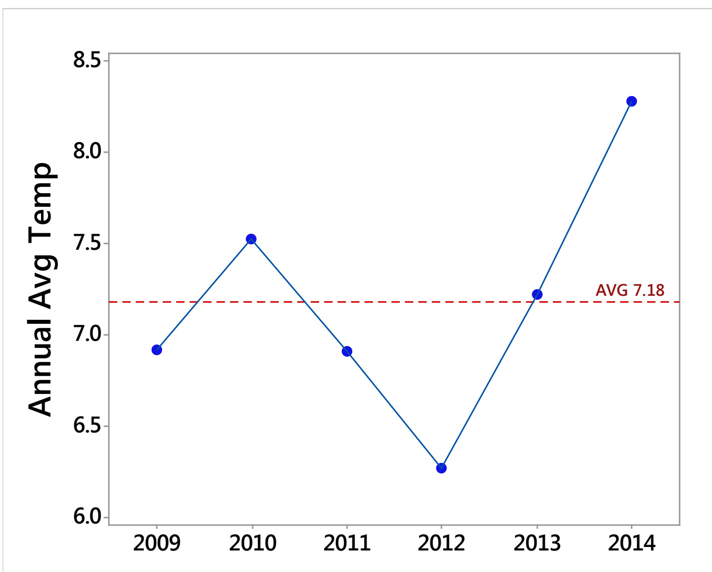


Figure 11. Average annual water temperature in PWS in 2009 – 2014, as measured at NOAA Cordova tide station, ~6 ft. below mean lower low water. (Data downloaded 10/9/15 from: https://tidesandcurrents.noaa.gov/stationhome.html?id=9454050.)

The lipid stores and growth of juvenile herring in autumn varied among bays across years, such that no specific bay consistently produced herring in the best condition. Eaglek and Simpson bays tended to be below average in lipid and growth across years, while Whale and Zaikof herring tended to be above average across years (Figs. 12 and 13).

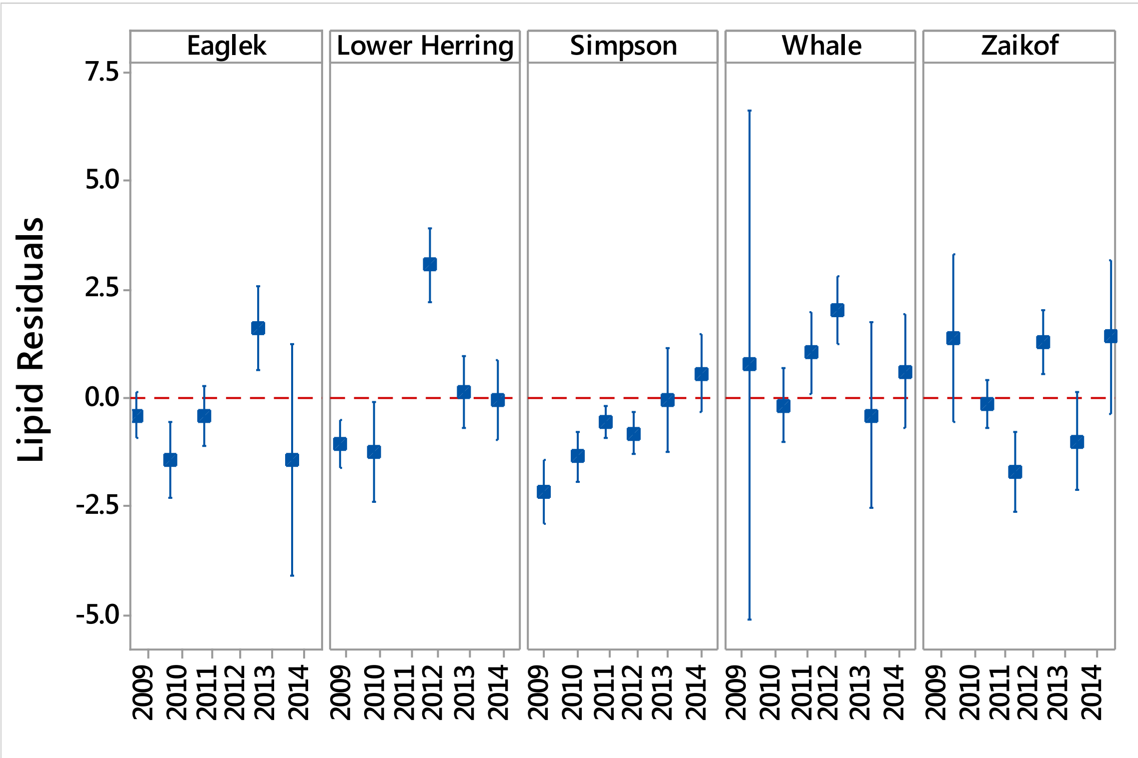


Figure 12. Residuals from the piecewise regression of lipid versus fork length of juvenile herring collected in PWS in November 2009 – 2014. Means and 95 % confidence intervals shown.

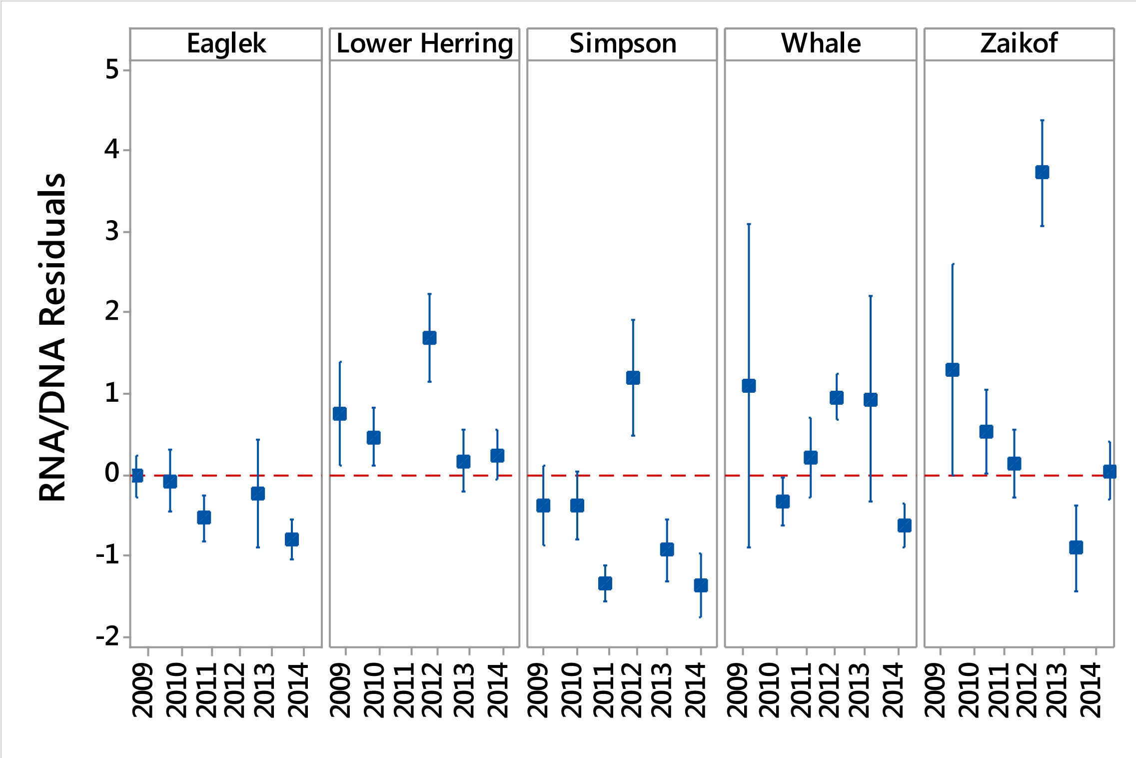


Figure 13. Residuals from the piecewise regression of RNA/DNA versus fork length of juvenile herring collected in PWS in November 2009 – 2014. Means and 95 % confidence intervals shown.

Juvenile herring that had above-average growth rates tended to also have greater fat stores in November (Fig. 14).

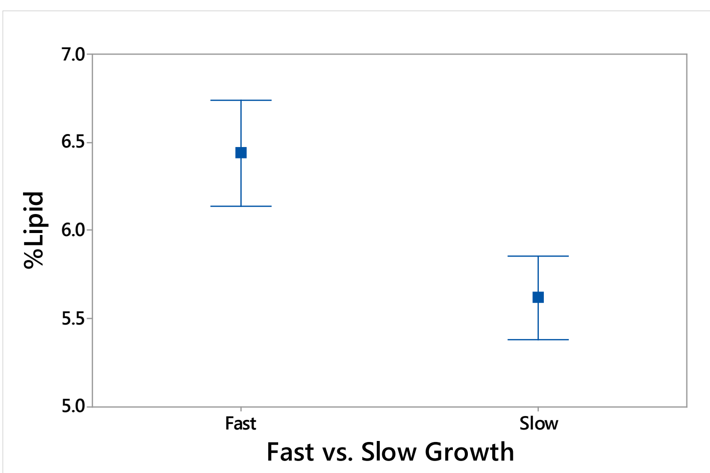


Figure 14. Comparison of lipid content (% wet tissue mass) for juvenile herring collected in PWS in November 2009 – 2014 with above average growth rate versus below average growth rate. "Fast" growth group (*n* = 262) is defined as individuals with positive residuals from the piecewise regression of RNA/DNA vs. length. "Slow" growth individuals (*n* = 349) had negative residuals. Means and 95 % confidence intervals shown.

By late winter (March), juvenile herring that were close to exhausting their fat stores were compelled to forage, as indicated by the higher stomach content masses (as % body weight) for herring with low % lipid (Fig. 15).

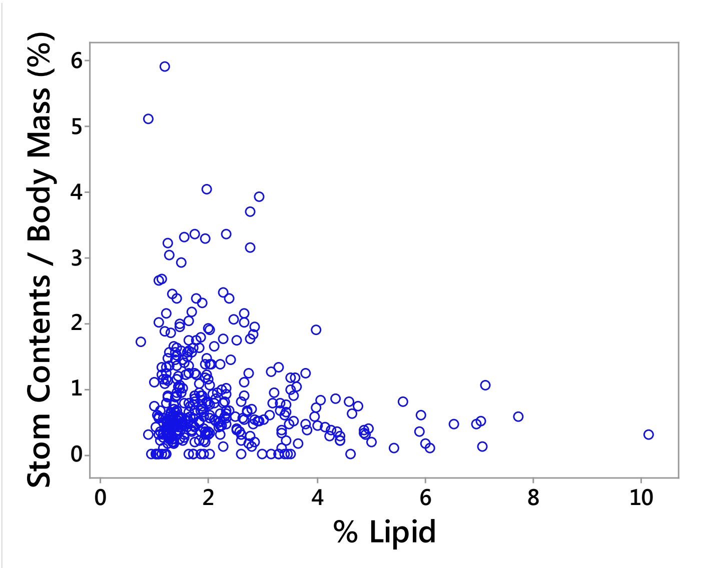


Figure 15. Stomach contents mass as a percentage of body mass, relative to lipid content (% wet tissue mass) for juvenile herring collected from PWS in March of 2010 – 2015 (n = 382).

Diet analysis across the 6 years of available data showed that juvenile herring in fall of 2011 had consumed the most food, as indicated by higher stomach contents masses relative to body mass (Fig. 16). Detailed prey identification and enumeration conducted since November 2011 showed that the energy density of prey in fall herring diets was highest in 2011 (Fig. 17), driven by the high proportion of euphausiids in diets that year (Fig. 18). However, the high quantity and quality of diets in fall 2011 did not appear to result in high lipid levels or growth rates for herring in fall 2011, suggesting that water temperature may moderate the effects of diet.

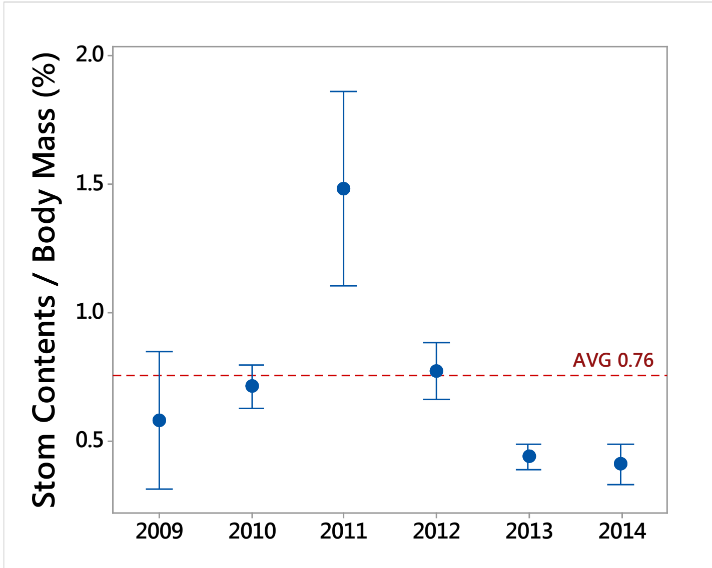


Figure 16. Stomach contents mass as a percentage of body mass for juvenile herring collected from PWS in November of 2009 – 2014.

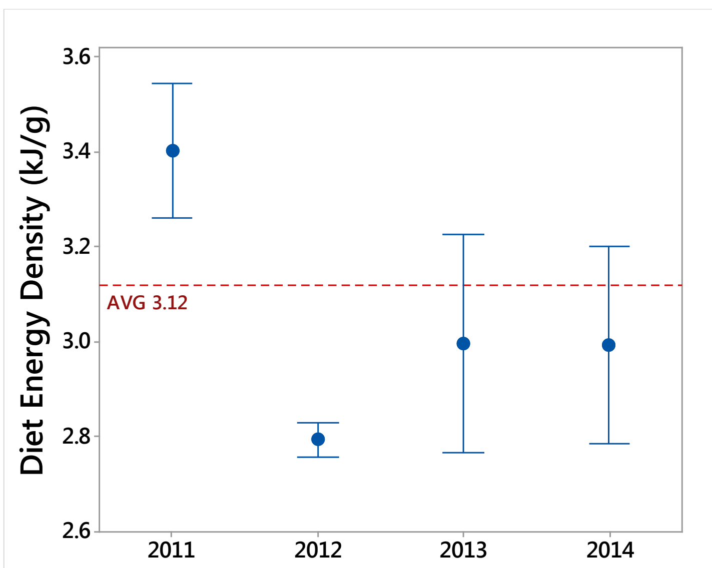


Figure 17. Diet energy density for juvenile herring collected from PWS in November of 2011 – 2014.

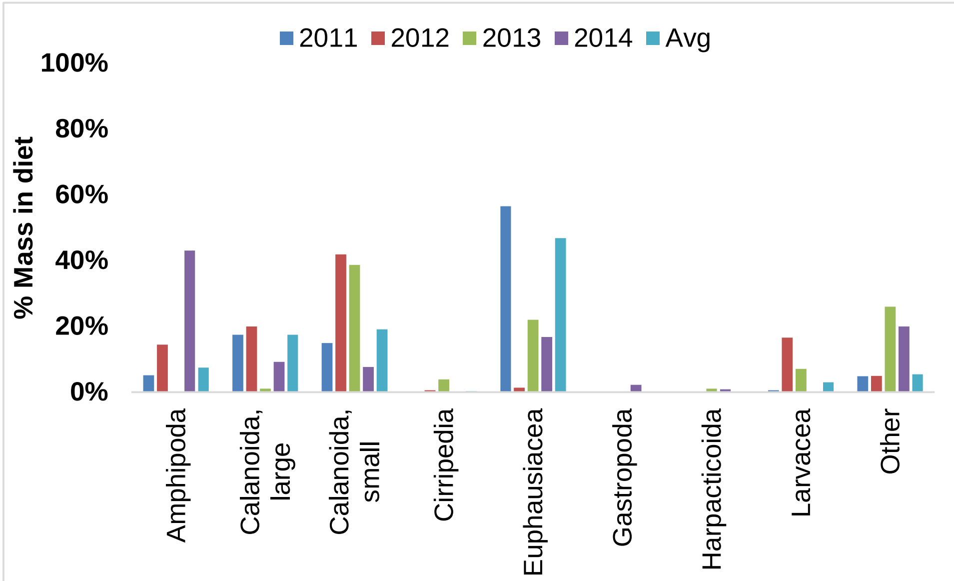


Figure 18. Diet proportion (% of total mass consumed) of prey identified in stomach contents of juvenile herring collected from PWS in November of 2011 – 2014.

Project deliverables for this reporting period

Annual PI Meeting: A PI meeting was held in Anchorage (February 2015) along with the EVOSTC Science Panel Meeting. Both Heintz and Gorman attended this meeting and Heintz presented a synthesis of the HRM juvenile energetics herring work completed to date. A second PI meeting was held in Anchorage in November 2015 and was attended by Gorman. Heintz attended a joint meeting between Gulf Watch Alaska and HRM at this time. Sewall was unable to attend the November 2015 meetings.

Outreach contributions: News articles were submitted to Delta Sound Connections by Gorman and Heintz/Sewall (Feb 2015).

March Juvenile Herring Collections: Completed March 2015. Samples sent to Auke Bay Labs in April 2015.

Student Interns: Two summer interns were supported to assist laboratory work by the PWSSC energetics project. Vivian Gonzalez's internship helped fulfill an undergraduate requirement for her degree in Biology at Bryan College. Austin Potter, a Chugiak High School student, also completed a summer internship.

American Fisheries Society annual meeting: Fletcher Sewall presented a poster on this project at the 2015 AFS annual meeting held in Portland, Oregon.

November Juvenile Herring Collections: Completed November 2015. Samples sent to Auke Bay Labs in mid-December 2015.

Reporting: A mid-year report was submitted to EVOSTC in August 2015. A semi-annual project report was submitted to NOAA in August 2015.

Submit FY2016 Work Plan for Review: Work Plan was submitted in August 2015 to match the current EVOSTC reporting dates.

Alaska Marine Science Symposium: Gorman, Heintz and Sewall attended AMSS in January 2016. Heintz delivered an oral presentation and Sewall presented a poster on this project at AMSS in 2016.

Literature Cited

Kline, T.C., Jr. 1999. Temporal and spatial variability of $^{13}C/^{12}C$ and $^{15}N/^{14}N$ in pelagic biota of Prince William Sound, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 56(Suppl. 1):94–117.

Kline, T.C., Jr. 2013. PWS Herring Survey: Pacific Herring Energetic Recruitment Factors, *Exxon Valdez* Oil Spill Restoration Project Final Report. (Project 10100132-C). Prince William Sound Science Center, P.O. Box 705, Cordova, AK 99574.

Paul, A.J., J.M. Paul, and T.C. Kline Jr. 2001. Estimating whole body energy content for juvenile Pacific herring from condition factor, dry weight, and carbon/nitrogen ratio. *In:* F. Funk, J. Blackburn, D. Hay, A.J. Paul, R. Stephenson, R. Toresen, and D. Witherell (eds.), Herring: Expectations for a New Millenium. University of Alaska Sea Grant, AK-SG-01-04, Fairbanks. Pp. 121-133.

Summary of Future Work to be Performed

Work efforts for FY2016 are expected to be the same as proposed. We plan to continue with March sampling and subsequent laboratory analysis. Since the program ends in January 2017, we anticipate not conducted the fall 2016 sampling as we have in the past since we would not be collecting coupled data in March 2017. The activities for fall 2016 have yet to be determined, but will be decided upon in consultation with the program lead, Scott Pegau, and other PIs.

We would like to continue the coupled disease and energy density sampling in Cordova Harbor in FY2016, however, currently there are no juvenile herring in the harbor to sample. This likely reflects the poor forage fish conditions evident by mass seabird die-offs in the region this winter.

Gorman, Heintz and Sewall plan to submit several manuscripts to the Gulf Watch/HRM special edition of Deep-Sea Research that is planned in 2016. Thus, we foresee considerable synthesis and writing occurring over the next year.

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

a) Within a Trustee Council-Funded Program.
The HCM project primarily requires coordination of PIs at PWSSC and ABL. Gorman, Heintz and Sewall were in good communication in 2015 to complete project goals.

In 2015 we continued a winter monthly study of disease and energetics in collaboration with Dr. Hershberger's lab at Marrowstone Marine Field Station/USGS whose work is a separate project within the HRM Program.

Manuscripts planned for 2016 will likely include working with Gulf Watch Alaska PIs (R. Campbell) to couple data with HCM.

b) With other Trustee Council-Funded Projects.
None in 2015.

c) With Trustee or Management Agencies.
None in 2015.

9. Information and Data Transfer: *See,* Reporting Policy at III (C) (9).

a) Publications produced during the reporting period.
None

b) Conference and workshop presentations and attendance during the reporting period.

PI meetings: Gorman and Heintz attended the EVOSTC science panel meeting in early 2015, and PI meetings in fall 2015.

AMSS: Heintz, Gorman and Sewall attended in Jan 2016. Heintz delivered an oral presentation and Sewall presented a poster on this project at AMSS in 2016.

c) Data and/or information products developed during the reporting period, if applicable.
New data were produced this year for all components of the project.

d) Data sets and associated metadata that have been uploaded to the program's data portal.
Data/metadata through summer 2015 will be uploaded to the AOOS workspace by the end of February 2016. This will be an important effort for the PWSSC component that will be facilitated by the new Access database as data are now much more efficiently managed.

10. Response to EVOSTC Review, Recommendations and Comments: *See,* Reporting Policy at III (C) (10).

Comment by EVOSTC fall 2016

None, no response required.

Comment by EVOSTC September 2015

Parts of this expensive proposal/project are vague. In particular the 'new' work looking at juvenile scales is not clear. (1) Is the plan to take scales from juvenile fish? If so, this could be difficult because, depending on the time of year and fish size, scales may be incompletely developed and very fragile. (2) Have the investigators done any 'preliminary work' to examine the feasibility of their approach? (3) The project refers to 'predictive models' but is there a hypothesis? (4) Will this project build on previous 2012 EVOSTC-supported projects on scales by Moffitt?

PWSSC Response
The plan for this new project was to measure scales from age-0 fish. This project was completed in 2014 (see 2014 EVOS Annual Report, Figure 14). In terms of hypotheses, we are testing the hypotheses that 1) increased growth in age-0 fish is associated with increased energy density based on juvenile data and that 2) larger scale growth at age-0 is associated with successful spawning based on scale data from older recruited fish where age-0 scale growth has been measured. The work builds off of previously supported EVOSTC projects.

11. Budget: *See,* Reporting Policy at III (C) (11).

PWSSC component budget:

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$0.0	$64,700.0	$67,300.0	$70,000.0	$72,800.0	$274,800.0	$ 111,587
Travel	$0.0	$3,000.0	$5,900.0	$5,900.0	$6,100.0	$20,900.0	$ 5,259
Contractual	$0.0	$24,800.0	$25,600.0	$26,300.0	$28,900.0	$105,600.0	$ 46,753
Commodities	$0.0	$7,500.0	$5,000.0	$8,300.0	$6,700.0	$27,500.0	$ 4,029
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)	$0	$30,000	$31,200	$33,200	$34,400	$128,800.0	$ 50,289
SUBTOTAL	$0.0	$130,000.0	$135,000.0	$143,700.0	$148,900.0	$557,600.0	$217,917.0
General Administration (9% of	$0.0	$11,700.0	$12,150.0	$12,933.0	$13,401.0	$50,184.0	N/A
PROJECT TOTAL	$0.0	$141,700.0	$147,150.0	$156,633.0	$162,301.0	$607,784.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

$190,733 will be carried forward into FY2016. Of this, $90,413 is allocated for salary. One main reason there is such a large carry-over for salary is due to the change in PIs during the course of this program (2012-2016) from Kline to Gorman. Kline was a senior PI and Gorman a new PI, therefore, they had significantly different salary rates that resulted in a considerable portion of salary not used by the current PI. However, the project in FY2015 did spend $111,588 in salaries, which was mainly driven by technician time to complete the backlog of BC analysis. FY2016 will be final year of the project during which manuscript writing will take place. PI Gorman may use more than 6 months of salary funding in FY2016, likely closer to 8-9 months, in order to complete several manuscripts on the project. $9,541 will be carried forward for travel. Meetings in the last year have all been in Alaska and therefore did not require as much funding. In FY2016, PI Gorman plans to attend 2-week professional development course at Colorado State University on Bayesian modeling, which will help facilitate analysis during this final year of the program. Some of the carry-over for travel funds will be used to attend the Bayesian short course. A total of $46,718 will be carried over for supplies and contractual in FY2016. It is expected that half of this money will be used for stable isotope analysis of sampling collected in November 2015 and March 2016.

ABL component budget:

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Travel	$0.0	$0.0	$3,900.0	$7,100.0	$4,000.0	$15,000.0	$5,474.0
Contractual	$0.0	$75,000.0	$75,000.0	$75,000.0	$75,000.0	$300,000.0	$220,494.0
Commodities	$0.0	$6,000.0	$5,000.0	$5,000.0	$5,000.0	$21,000.0	$13,538.0
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
SUBTOTAL	$0.0	$81,000.0	$83,900.0	$87,100.0	$84,000.0	$336,000.0	$239,506.0
General Administration (9% of	$0.0	$7,290.0	$7,551.0	$7,839.0	$7,560.0	$30,240.0	N/A
PROJECT TOTAL	$0.0	$88,290.0	$91,451.0	$94,939.0	$91,560.0	$366,240.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Commodities and travel spending is slightly low, but overall the spending is on target. Travel expenses in FY15 were lower than expected due to no travel for PI meeting, AMSS 2016 travel on the FY16 budget, and only Heintz traveling to the synthesis meeting. ~$12k will be carryover into FY16.

We appreciate your prompt submission and thank you for your participation.

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

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111-O

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

PWS Herring Program – Coordination and Logistics

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

W. Scott Pegau

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

February 2015 through 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).

The year began with the presentation of the synthesis completed in 2014 to the EVOS Science Panel. A principal investigator (PI) meeting was held in November in conjunction with the Gulf Watch Alaska PI meeting. A meeting also occurred during the Alaska Marine Science Symposium to allow investigators another opportunity to touch base with each other.

The synthesis pulls together results from the various projects and from the Gulf Watch Alaska program to examine our current knowledge of herring in Prince William Sound (PWS). The most surprising result was the correlation between the diatom abundance anomaly measured by the continuous plankton recorder and the growth of age-0 herring in PWS. A strong positive correlation was found and a manuscript was accepted that discuss the findings. Other important findings include the spatial and temporal patterns associated with herring condition, the evidence of overwinter feeding by age-0 herring, the importance of different inputs to the age-structure-analysis model, and the ability to track acoustically tagged adult herring. For complete findings please see the synthesis titled, "Pacific herring in Prince William Sound: A synthesis of recent findings" that was submitted to the *Exxon Valdez* Oil Spill Trustee Council.

The logistical support and reporting tasks were completed as scheduled. CDFU fishermen were trained and assigned areas for fish capture in March. Two cruises were contracted to support the expanded adult herring surveys. We worked with local researchers to collect herring at Montague Island for ADF&G and the genetics project. We deployed the satellite transmitting cameras on Kayak Island as a means to detect spawn without requiring daily aerial surveys. It was difficult to detect spawn in the camera images. We did observe spawn when we went to retrieve the cameras so we know of at least one spawn event that should have been captured. Examining the images revealed that there was a change in bird behavior that may indicate that there had been one spawning event earlier in the year.

A plane was contracted to support the aerial surveys for the age-1 herring index and to support the forage fish project. We worked closely with the forage fish project to survey in their areas of interest and provide validation. Several days of overlap of the aircraft and the sampling vessel allowed for validation of the aerial observations. A collaboration with a University of Oregon journalism class was established. The class provided people to maintain the paper logs while getting the opportunity to see more of PWS. Students have also been brought on for short periods to assist with analysis of the aerial survey data.

This project continues to support investigators in uploading their data to the ocean workspace. Updated energetics, disease prevalence, acoustic survey, aerial survey, and tagging data were submitted. Presentations from PI meetings and other meetings are also uploaded to the workspace.

We often meet with Steve Moffitt, the local herring fisheries manager. It is through these meetings that we keep track of the needs of the resource managers. We were also able to meet with Sherri Dressler of ADF&G to discuss our findings and how they might be informed by herring research in other parts of the state. We also meet with the Cordova District Fishermen United to ensure research results make it back to the fishermen.

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

a) This project is responsible for coordination among all of the HRM projects. In the past year there have been several meeting of the investigators to coordinate work, present a synthesis of our understanding of herring in Prince William Sound, and examine future research needs.

   There is coordination among the HRM and GWA programs in reporting, and PI meeting attendance.

   This project shares responsibility with the GWA forage fish project for analysis of the aerial survey data.

b) We follow the progress of the two other projects funded in Cordova. We use the harbor for testing herring and contribute when possible particularly to the Cordova Clean Harbor group.

c) This project works with Steve Moffitt and Sherri Dressel of Alaska Department of Fish and Game to transfer new findings to ADF&G and for guidance about the needs of the department. Investigators from the National Oceanic and Amospheric Administration and the US Geological Survey are participating in the program.

9. Information and Data Transfer: *See,* Reporting Policy at III (C) (9).

a) Publications – Batten, S.D., Moffitt, S., Pegau, W.S., and Campbell, R. (submitted) Plankton indices explain interannual variability in Prince William Sound herring first year growth. *Fisheries Oceanography*
b) Presentations – Presented an overview of the HRM program at a Cordova Community lecture, to the Cordova District Fishermen United, Prince William Sound Regional Citizens' Advisory Council, and various EVOS groups. A poster was presented at the Alaska Marine Science Symposium.
c) Data products – This project does not generate data.
d) Information archive - Presentations from the PI meetings are loaded on the Ocean Workspace.

10. Response to EVOSTC Review, Recommendations and Comments: *See,* Reporting Policy at III (C) (10).

There were no project specific comments.

11. Budget: *See,* Reporting Policy at III (C) (11).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$19,100.0	$27,900.0	$28,700.0	$20,900.0	$21,700.0	$118,300.0	$ 72,944
Travel	$9,500.0	$4,100.0	$5,000.0	$4,000.0	$8,700.0	$31,300.0	$ 21,296
Contractual	$216,960.0	$375,999.0	$282,288.0	$244,916.0	$243,657.0	$1,363,820.0	$ 995,892
Commodities	$2,300.0	$4,000.0	$2,300.0	$4,400.0	$1,000.0	$14,000.0	$ 10,425
Equipment	$50,500.0	$0.0	$0.0	$0.0	$0.0	$50,500.0	$ 79,851
Indirect Costs (*will vary by proposer*)	$35,700	$56,130	$37,800	$36,800	$35,570	$202,000.0	$ 159,275
SUBTOTAL	$334,060.0	$468,129.0	$356,088.0	$311,016.0	$310,627.0	$1,779,920.0	$1,339,683.0
General Administration (9% of	$30,065.4	$42,131.6	$32,047.9	$27,991.4	$27,956.4	$160,192.8	
PROJECT TOTAL	$364,125.4	$510,260.6	$388,135.9	$339,007.4	$338,583.4	$1,940,112.8	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$60,000.0

Total expenditures are very close to the proposed budget at this stage. The project is overspent on Equipment due to repairs to the Remotely Operated Vehicle and the purchase of remote cameras. Funds from Personnel and Contractual Services will be used to cover the equipment expenses.

We appreciate your prompt submission and thank you for your participation.

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

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111-P

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

Genetic Stock Structure of Herring in PWS

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

Sharon Wildes and Dr. Jeff Guyon

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

February 2015-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).

Pacific herring (*Clupea pallasi*) stocks have remained depressed in Prince William Sound (PWS) for the majority of the last 20 years and the reasons for their lack of recovery are unknown. The purpose of our study is to examine the genetic stock structure of herring within PWS using nuclear and mtDNA markers, and connections to stocks outside PWS.

Samples of herring were collected from eastern PWS, northern Montague Island, and several locations adjacent to PWS, including Kayak Island. Genetic information was examined from fifteen microsatellite loci and mtDNA sequences.

Analyses of the microsatellite loci show that allele frequencies of PWS herring are similar over time, and between year classes. However, one Montague Island collection of spring spawners and a winter collection from Evans Island produced a weak signal of differentiation from other PWS collections. Results also indicate PWS herring are genetically similar to herring east of PWS (Kayak Island, Yakutat), but are significantly different than herring west of the sound (Kodiak, Cook Inlet) (Figure 1). These findings suggest that PWS herring have connected with adjacent stocks to the east, either continually or episodically, but are not likely departing PWS and traveling westward in the Alaska Coastal Current around the Gulf of Alaska.

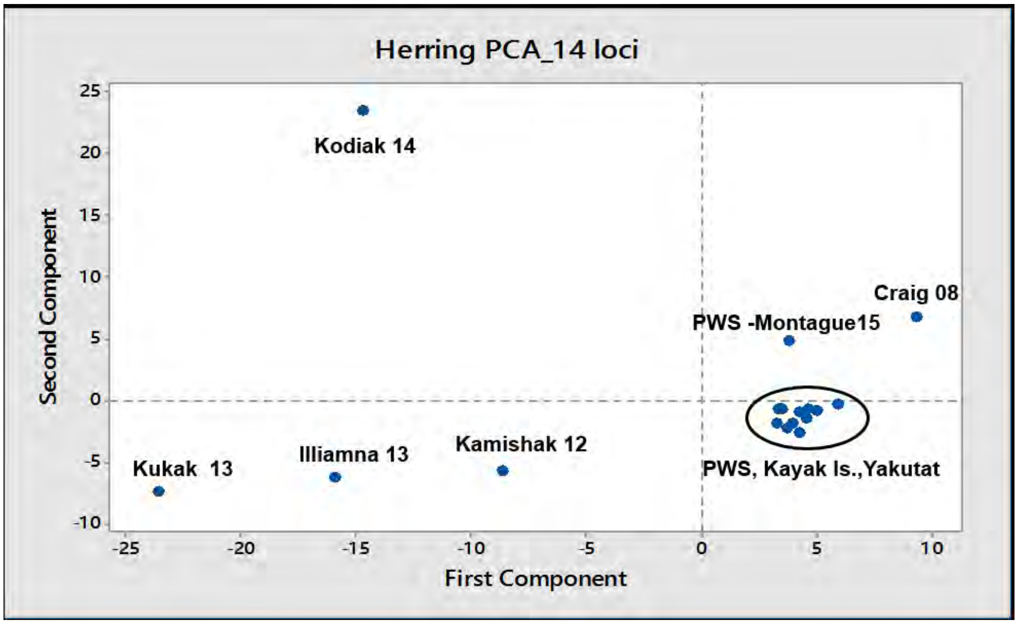


Figure 1. First and second principle components of the microsatellites showing how PWS and those to the east are similar, but very different from fish collected at locations west of PWS.

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

We collaborated with other researchers in the HRM program and ADF&G offices for collection of samples from around PWS and the Gulf of Alaska.

9. Information and Data Transfer: *See*, Reporting Policy at III (C) (9).

Data is just now becoming available and is still in a preliminary state, but we are beginning to transfer data and information into the AOOS website. A poster with preliminary results was presented at AMSS. A presentation was given at the Cordova community lecture series.

10. Response to EVOSTC Review, Recommendations and Comments: *See*, Reporting Policy at III (C) (10).

NA

11. Budget: *See*, Reporting Policy at III (C) (11).

$30K remaining to complete 2015 collection samples.

We appreciate your prompt submission and thank you for your participation.

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

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111-Q

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

PWS Herring Program: Modeling the population dynamics of Prince William Sound herring.

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

Trevor A. Branch

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).

15 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).

Over the past year, the first MS student employed on this grant, Melissa Muradian, graduated from the University of Washington, and the second MS student, John Trochta completed his coursework and started research on the project. The status of the four projects is as follows: (1) Bayesian model completed and submitted for publication (in review); the annual update to the Bayesian model was completed and the model revised to include ages 0-2 which were not previously included by any of the assessment models; (2) value of survey information completed in thesis format and in prep. for publication; (3) meta-analysis of herring populations is underway with data collected and preliminary analyses conducted, with completion anticipated in 2016-17; (4) examining hypotheses for the decline and lack of recovery of PWS herring has been started and a coauthored paper is in preparation looking at broader issues and will be completed in 2016-17.

Bayesian stock assessment model: the completed Bayesian stock assessment model was written up for publication and submitted to *Fisheries Research*. Reviews have been received, and are being addressed. An updated version of the model with the most recent data has been run and returns results that are consistent with the ADF&G assessment using the ASA model. The Bayesian framework employed allows for consistent weighting of different data sources and allows uncertainty to be automatically calculated from the Bayesian posteriors. This model now allows ADF&G managers, should they choose to do so, to choose management rules that directly include uncertainty in deciding on how conservative they should be in opening the herring fishery in the future. In the past six months the Bayesian model, which started at age 3 to mimic the ASA model, has been rewritten to start at age 0. This allows for the future incorporation of data such as the age-1 aerial survey, and over-winter survival estimates, in addition to other sources of data that are relevant for ages 0, 1, and 2. In addition, this revision to the model also allows a wider range of hypotheses about stock decline and recovery to be modeled and tested, which is important for the fourth part of this project.

Key results of the Bayesian model: the 2015 Bayesian model continues to provide good fits to the time series of data (Fig.1). Estimated pre-fishery biomass in 2014 was 17,000 metric tonnes (Fig. 2), just below the the threshold for opening the fishery (22,000 short tons = 19,958 mt). The 95% probability interval was 10,300-41,700 mt, and there was an estimated 80% probability of biomass being below the threshold for opening the fishery. The last year of medium recruitment was in 2002, since then, recruitment at age-3 has been between 9 and 103 million fish, compared to recruitment of 117 to 1234 million fish in every year from 1980 to 1988. Taken as a whole, the model differs little from last year's results: it confirms the ADF&G assessment that the fishery should not be reopened, and that biomass and recruitment have been low for more than a decade.

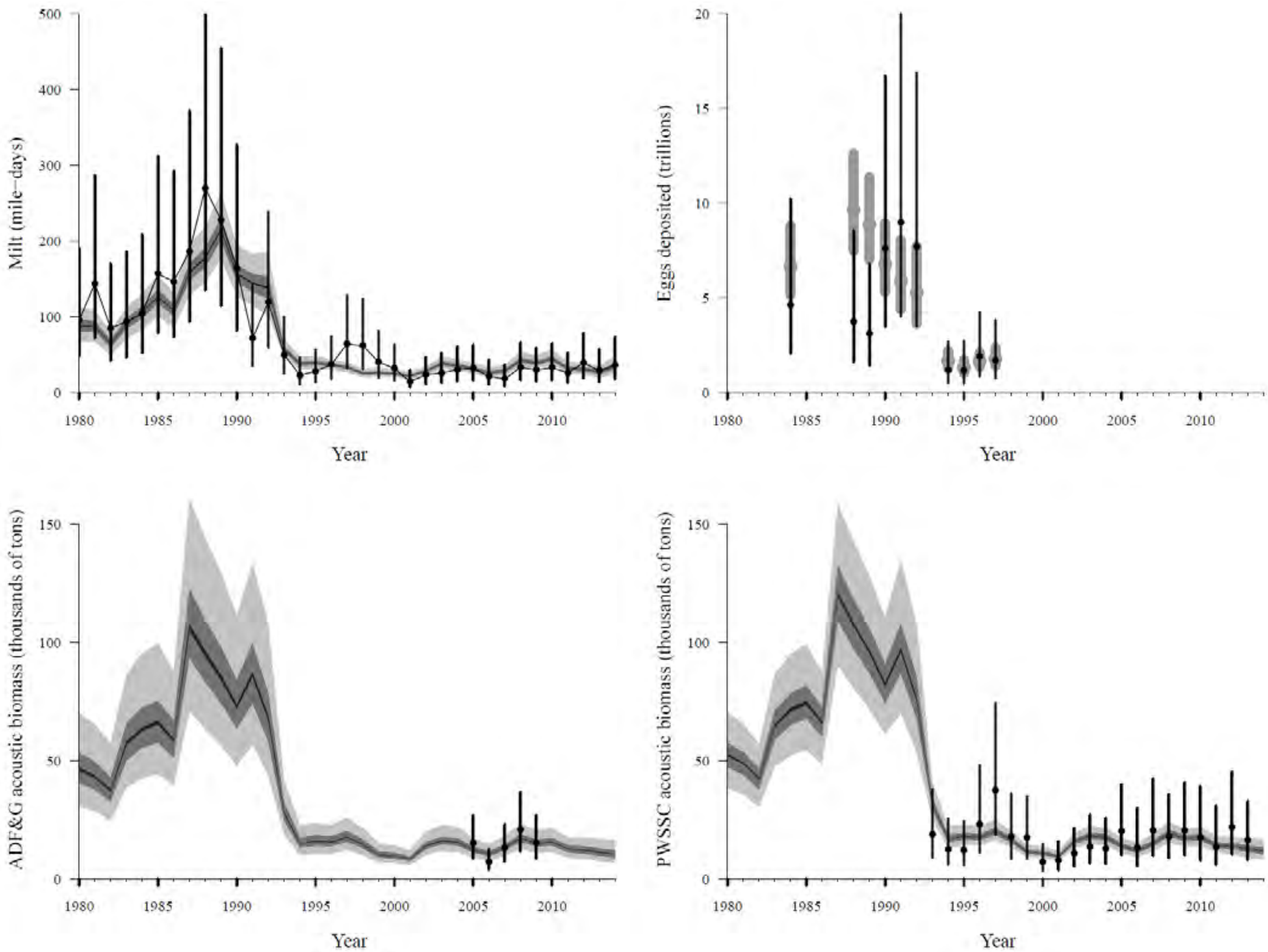


Fig. 1. Model estimates fitted to the four time series of abundance estimates (1980–2012): (A) mile-days of milt, (B) egg deposition surveys, (C) ADF&G hydroacoustic estimates, and (D) PWSSC hydroacoustic estimates. The solid circles and lines represent the mean and 95% confidence intervals of the data (plus additional variance estimated by the model); the shaded polygons represent the respective posterior intervals (light gray = 95% interval, darker gray = 50% interval, black = 5% interval). Source: J. Trochta.

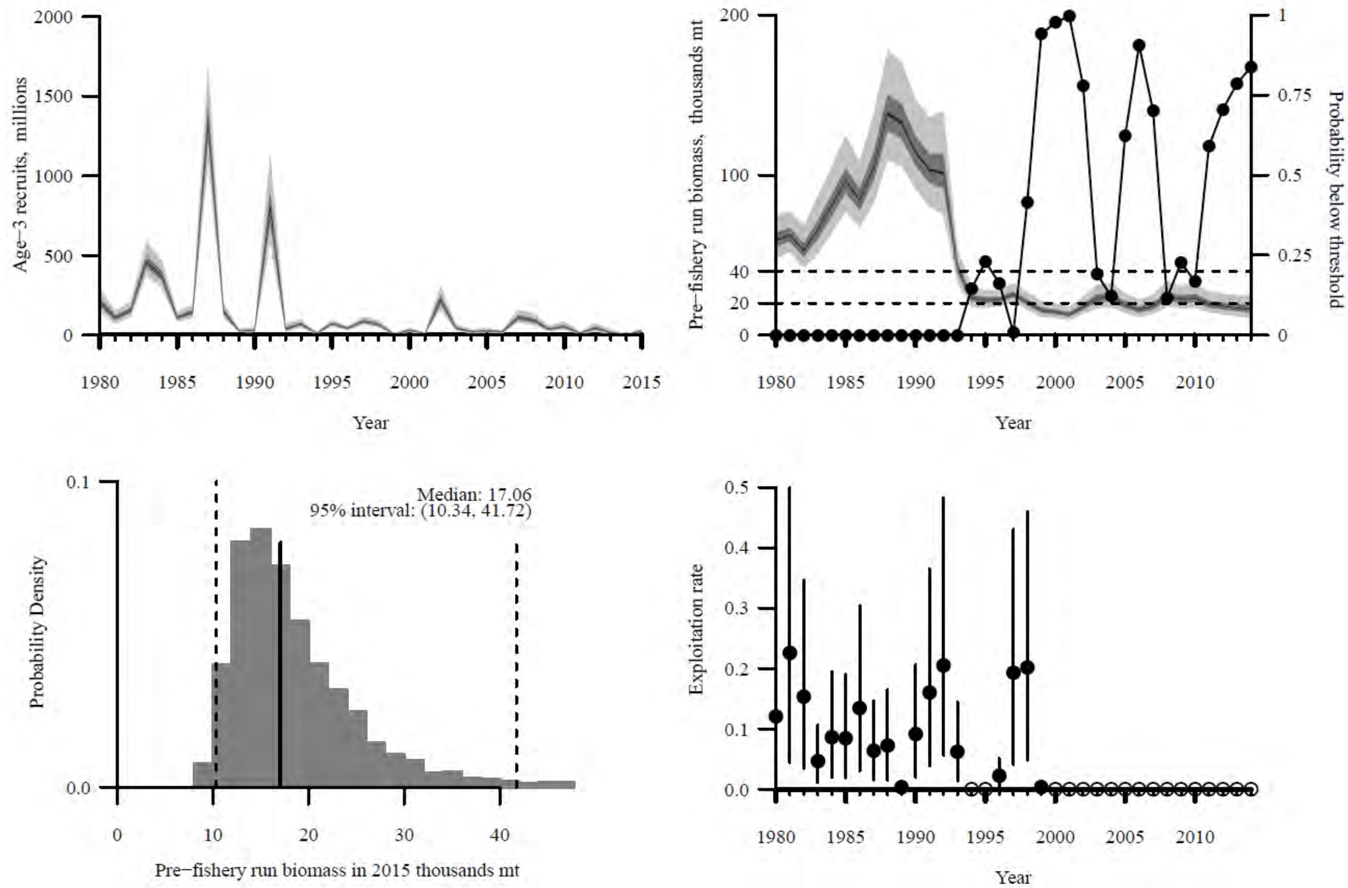


Fig. 2. (A) estimated recruitment at age-3 (posterior intervals; light gray = 95% interval, darker gray = 50% interval, black = 5% interval), (B) estimated pre-fishery biomass (posterior intervals; light gray = 95% interval, darker gray = 50% interval, black = 5% interval) and the probability that pre-fishery biomass is below the lower regulatory threshold (LRT) of 22,000 short tons (19,958 mt) (connected black points) with the upper regulatory threshold (URT: 42,500 short tons ≈ 38,555 mt) shown for reference, (C) posterior distribution of estimated pre-fishery biomass for 2013 with the 95% credible interval (light grey) and the median (black) shown, and (D) posterior median exploitation rates (black points) with 95% posterior intervals (segments) – open points show fishery closures. Source: J. Trochta.

Value of surveys: the Bayesian model was used to determine with surveys in the past were most valuable in obtaining precise estimates of abundance. The model is run with multiple iterations (in each iteration a different set of data are simulated and then fit with the model), for six scenarios. In the base scenario, all data are included in the assessment, while for the other scenarios, data from a particular survey or method of data collection are omitted. The results are reported in the MS thesis of Melissa Muradian, University of Washington, and are being prepared for submission to ICES Journal of Marine Science. The analysis shows, as, expected, that excluding data results in broader uncertainty intervals and greater bias in the abundance estimates. Quoting from the thesis results (Muradian 2015), the trade-off between survey cost and precision and bias revealed that the disease survey (which is relatively cheap and collects an index of additional mortality due to disease) and the egg-deposition diver survey (which is relatively expensive and collects an absolute index of abundance) were the most valuable sampling programs in the past. For $10,000 a year the disease survey reduces bias and imprecision in the forecast by 34% on average, increases model reliability by 22%, and decreases by 31% the probability of a false management conclusion when regulating the fishery. For $350,000 a year the diver survey reduces bias and imprecision in the forecast by 12% on average, increases model reliability by 6%, and decreases the probability of a false management conclusion by 23% (Fig. 3).

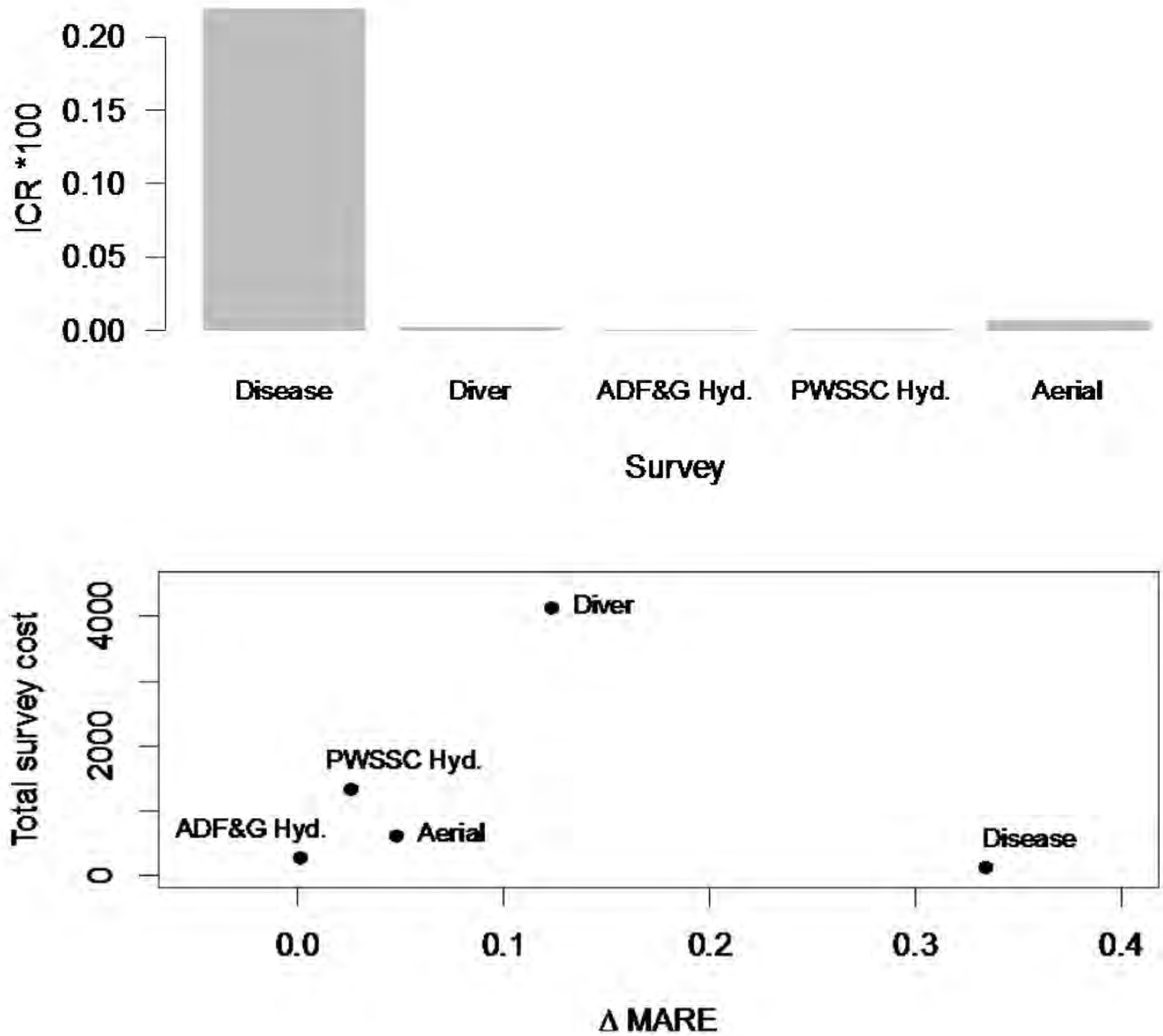


Fig. 3. The top panel shows the information to cost ratio (ICR) for each survey relating to the estimate of the forecast biomass in 2013. The bottom panel shows the estimated total cost of each survey program compared to the improvement in median absolute relative error (MARE) in the forecast biomass due to the addition of that survey's data.

Meta-analysis of herring populations: in this project we address whether it is an unusually long period of time over which PWS herring have collapsed and failed to recover, compared to other herring populations. We have now compiled spawning biomass time series for 32 herring populations, catches for 48 populations, and time series of recruitment for 39 populations (Fig. 4). Initial analyses suggest that there are many herring populations that are at low levels in recent years, suggesting a global trend towards decline, and that while the long period of time PWS herring has spent at low levels is unusual, it is not unique. A predictive model is being developed that takes into account other factors that might influence collapses and recovery, to make a quantitative prediction relevant to PWS herring.

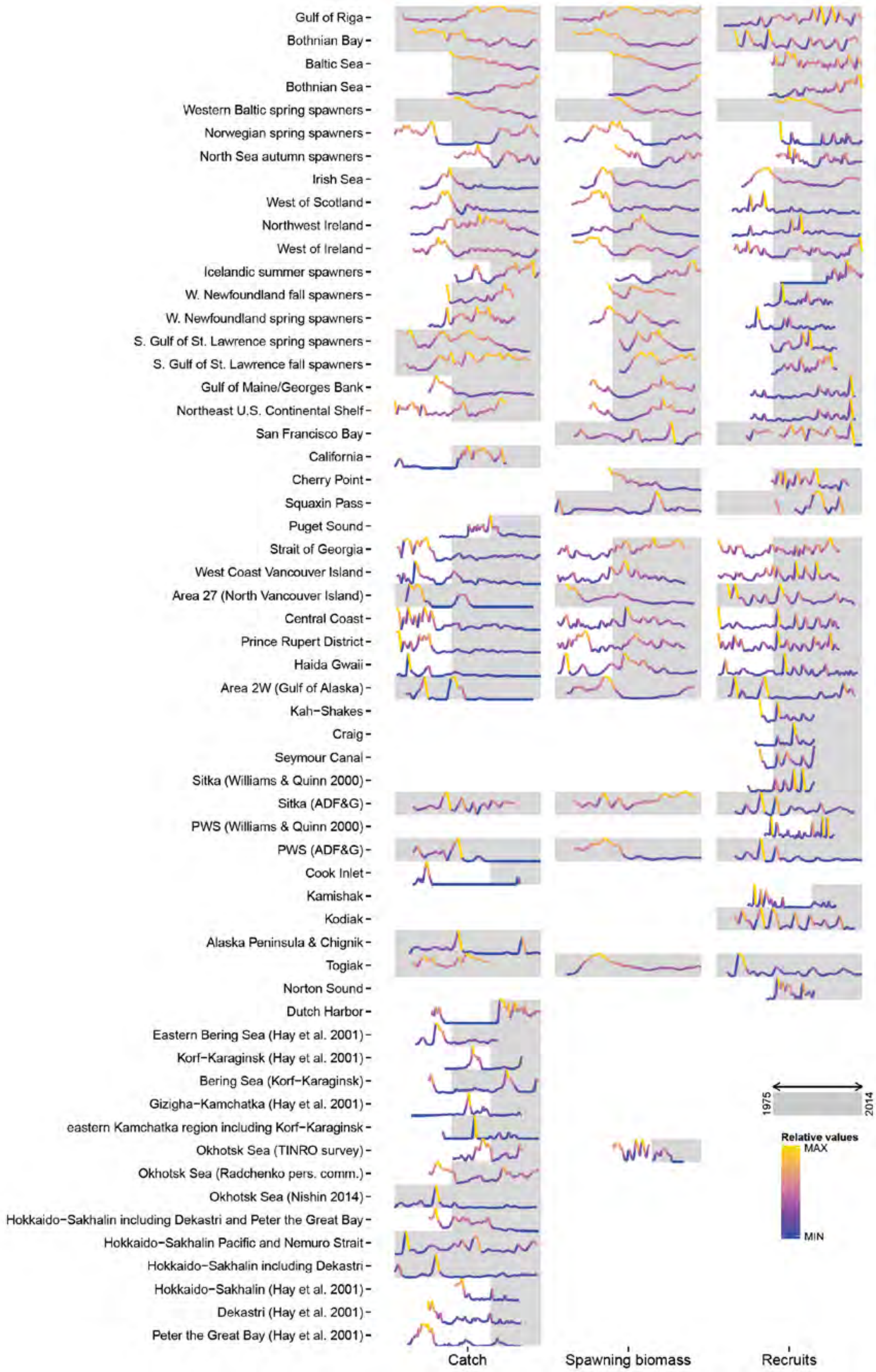


Fig. 4. Time series for catch, spawning biomass, and recruitment that have been collated for the meta-analysis of herring collapse and recovery. Gray shading represents the time period 1975-2014, thus sections with a short gray bar represent very long time series of data. Blue color shows low values and yellow high values within each time series.

Alternative hypotheses for PWS herring decline: work on this section of the project is scheduled for 2016-17, although the assessment model has been rewritten to allow for hypotheses affecting ages 0-2 to be modelled. This will assist in modeling hypotheses about over-winter survival, and correlates between environmental covariates and subsequent recruitment. In addition, this will allow for explicit fitting to the new time series of aerial surveys of juvenile herring conducted by Scott Pegau.

Personnel: Melissa Muradian defended her MS in 2015. John Trochta joined the project and is working on annual updates to the Bayesian stock assessment, the herring meta-analysis, and in examining hypotheses for the decline of PWS herring.

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

Close coordination with Steven Moffitt of ADF&G to include the data collected by ADF&G for the ASA Model, sharing of model code and results of the Bayesian model.

Coordination with Scott Pegau for data interpretation and oceanographic hypotheses.

Close coordination with Moffitt and Paul Hershberger to revise the indices of disease incorporated in the model.

It is intended that John Trochta will participate in the hydroacoustic surveys.

Inclusion of weight-at-age, sex ratios, hydroacoustic surveys (ADF&G and PWSSC), mile-days of milt survey, spawner-egg survey, and other data collected during the herring program, involving too many people to name individually.

Regular PI meetings, including at the AMSS meeting.

9. Information and Data Transfer: *See,* Reporting Policy at III (C) (9).

Theses/dissertations: Muradian, M. L. 2015. Modeling the population dynamics of herring in the Prince William Sound, Alaska. MS thesis, School of Aquatic and Fishery Sciences, University of Washington, Seattle.

Popular articles: by Melissa Muradian for Delta Sound Connections in 2014: "Herring: How much information does a population model need?"

Peer-reviewed publications coauthored by PI Branch, or graduate students Muradian and Trochta on broader issues related to recruitment, fisheries status, or fisheries stock assessment simulation methods, although none focused solely on Prince William Sound herring:

Branch, T. A. 2015. Fishing impacts on food webs: multiple working hypotheses. Fisheries 40:373-375

Hilborn, R., D. J. Hively, O. P. Jensen, and T. A. Branch*. 2014. The dynamics of fish populations at low abundance and prospects for rebuilding and recovery. ICES Journal of Marine Science 71:2141-2151.

Hurtado-Ferro, F., C. S. Szuwalski, J. L. Valero, S. C. Anderson, C. J. Cunningham, K. F. Johnson, R. Licandeo, C. R. McGilliard, C. C. Monnahan, M. L. Muradian*, K. Ono, K. A. Vert-Pre, A. R. Whitten, and A. E. Punt. 2015. Looking in the rear-view mirror: bias and retrospective patterns in integrated, age-structured stock assessment models. ICES Journal of Marine Science 72:99-110.

Johnson, K. F., C. C. Monnahan, C. R. McGilliard, K. A. Vert-pre, S. C. Anderson, C. J. Cunningham, F. Hurtado-Ferro, R. R. Licandeo, M. L. Muradian*, K. Ono, C. S. Szuwalski, J. L. Valero, A. R. Whitten, and A. E. Punt. 2015. Time-varying natural mortality in fisheries stock assessment models: identifying a default approach. ICES Journal of Marine Science 72:137-150.

Ono, K., R. Licandeo, M. L. Muradian*, C. J. Cunningham, S. C. Anderson, F. Hurtado-Ferro, K. F. Johnson, C. R. McGilliard, C. C. Monnahan, C. S. Szuwalski, J. Valero, K. A. Vert-Pre, A. R. Whitten, and A. E. Punt. 2015. The importance of length and age composition data in statistical age-structured models for marine species. ICES Journal of Marine Science 72: 31-43.

Stachura, M. M., T. E. Essington, N. J. Mantua, A. B. Hollowed, M. A. Haltuch, P. D. Spencer, T. A. Branch*, and M. J. Doyle. 2014. Linking Northeast Pacific recruitment synchrony to environmental variability. Fisheries Oceanography 23:389-408

Stawitz, C. C., T. E. Essington, T. A. Branch, M. A. Haltuch, A. B. Hollowed, and P. D. Spencer. 2015. A state-space approach for detecting growth variation and application to North Pacific groundfish. Canadian Journal of Fisheries and Aquatic Sciences 72:1316-1328.

Szuwalski, C. S., K. A. Vert-pre, A. E. Punt, T. A. Branch, and R. Hilborn. 2015. Examining common assumptions about recruitment: a meta-analysis of recruitment dynamics for worldwide marine fisheries. Fish and Fisheries 16:633-648

Publications in review: Muradian, M. L., Branch, T. A., Moffitt, S. D., and Hulson, P-J. F. Bayesian stock assessment of Prince William Sound herring, Alaska. Fisheries Research.

Publications in prep: Ward, E. J., Adkinson, M., Couture, J., Dressel, S., Litzow, M., Moffitt, S., Neher, T. H., Trochta, J., and Brenner, R. (in prep.). Evaluating signals of climates, oil spill impacts, and interspecific interactions on salmon and herring populations in Prince William Sound, Alaska.

Muradian, M. L., Branch, T. A., and Punt, A. E. (in prep.) A framework for assessing which sampling programs provide the best trade-off between accuracy and cost of data in stock assessments. ICES Journal of Marine Science.

Presentations: Trochta, J. 2015. The Highs and Lows of Herring: Characteristics of Collapse and Recovery.Poster, Alaska Marine Science Symposium, Anchorage, AK, January 25-29, 2015

Trochta, J. 2015 Transitioning toward a Bayesian assessment model of the Pacific herring in Prince William Sound, Alaska. Talk, Ocean Modeling Forum-Pacific Herring Summit, Richmond, BC, June 8-10, 2015

Data transfer: The current code for the Bayesian model is available for review and use by ADF&G, and final data inputs and AD Model Builder code have been uploaded to the herring portion of the Ocean Workspace, together with the MS thesis of Melissa Muradian.

10. Response to EVOSTC Review, Recommendations and Comments: *See,* Reporting Policy at III (C) (10).

Review requests were in line with what is being accomplished on this program, which was rated as the top priority for funding in the next five-year cycle for PWS herring.

11. Budget: *See,* Reporting Policy at III (C) (11).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$20,734.0	$34,445.7	$35,823.5	$37,256.4	$38,746.7	$167,006.3	$ 126,621
Travel	$982.0	$3,636.0	$8,194.0	$7,812.0	$8,508.0	$29,132.0	$ 15,005
Contractual	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$ 35,136
Commodities	$200.0	$16,884.0	$20,552.4	$21,286.5	$22,050.0	$80,972.9	$ 1,072
Equipment	$0.0	$4,000.0	$0.0	$0.0	$0.0	$4,000.0	$ 7,470
Indirect Costs (*will vary by proposer*)	$11,944	$20,863	$25,188	$25,761	$26,952	$110,708.0	$ 72,388
SUBTOTAL	$33,860.0	$79,828.7	$89,757.9	$92,115.9	$96,256.7	$391,819.2	$257,692.0
General Administration (9% of	$3,047.4	$7,184.6	$8,078.2	$8,290.4	$8,663.1	$35,263.7	
PROJECT TOTAL	$36,907.4	$87,013.3	$97,836.1	$100,406.4	$104,919.8	$427,082.9	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Spending on this budget has been close to budgeted amounts for salary, tuition, and travel. The difference in contractual and commodities is due to how the various organizations budget tuition.

In addition to the expenses charged against the budget, in 2014-15 the current graduate student Melissa Muradian and new graduate student John Trochta have overlapped for two quarters while Muradian was finishing. In the original project it was envisaged that a single PhD student would complete the entire project. As a result, salary and tuition for Muradian came from her being a Teaching Assistant for a course Oct-Dec

2014, and she was funded as a Research Assistant on the PI's own funds Jan-March 2015. These expenses were not charged to the EVOSTC grant.

We appreciate your prompt submission
and thank you for your participation.

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

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

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

15120111-R

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

PWS Herring Program – Aerial Survey Support

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

W. Scott Pegau

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

February 2015 through 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).

Flights were conducted in late March through mid-April to observe herring spawn, install remote cameras to detect spawn, and to support the collection of fish for the genetics project.

In June there were 12 flights designed to follow the coastline in Prince William Sound (PWS) and enumerate the number of schools of age-1 herring and other forage fish. The estimated number of schools observed during recent surveys are provided in table 1.

Table 1. The number of schools of age-1 herring observed during aerial surveys conducted in June.

	Number of schools				
Year	**Small**	**Medium**	**Large**	**Xlarge**	**Total**
2010	291	181	95	12	579
2011					75*
2012	143	104	28	4	279
2013	1904	187	27	0	2118
2014	151	19	0	0	170
2015	995	256	53	0	1304

* A significant portion of Eastern Prince William Sound was not flown. About 50 schools are normally observed in that area.

The proportion of small schools observed increased starting in 2013 when there was a change in one of the two observers. We are using a sighting tube to ensure this reflects a change in the school structure and not an observation error. Since we use the number of schools as the index instead of area or volume estimates a misclassification in size will not impact the results.

We flew 12 days in July to support the forage fish project and to work with them on validation. The sampling design was based on a stratified-random selection of survey sites (Figure 1) instead of the systematic sampling designed used to provide an index of age-1 herring. A 5' by 5'grid was placed over PWS and the aerial observations from 2010-2012 used to establish areas with high, medium, and low numbers of fish observations. Blocks were then selected to minimize the variance of the population mean.

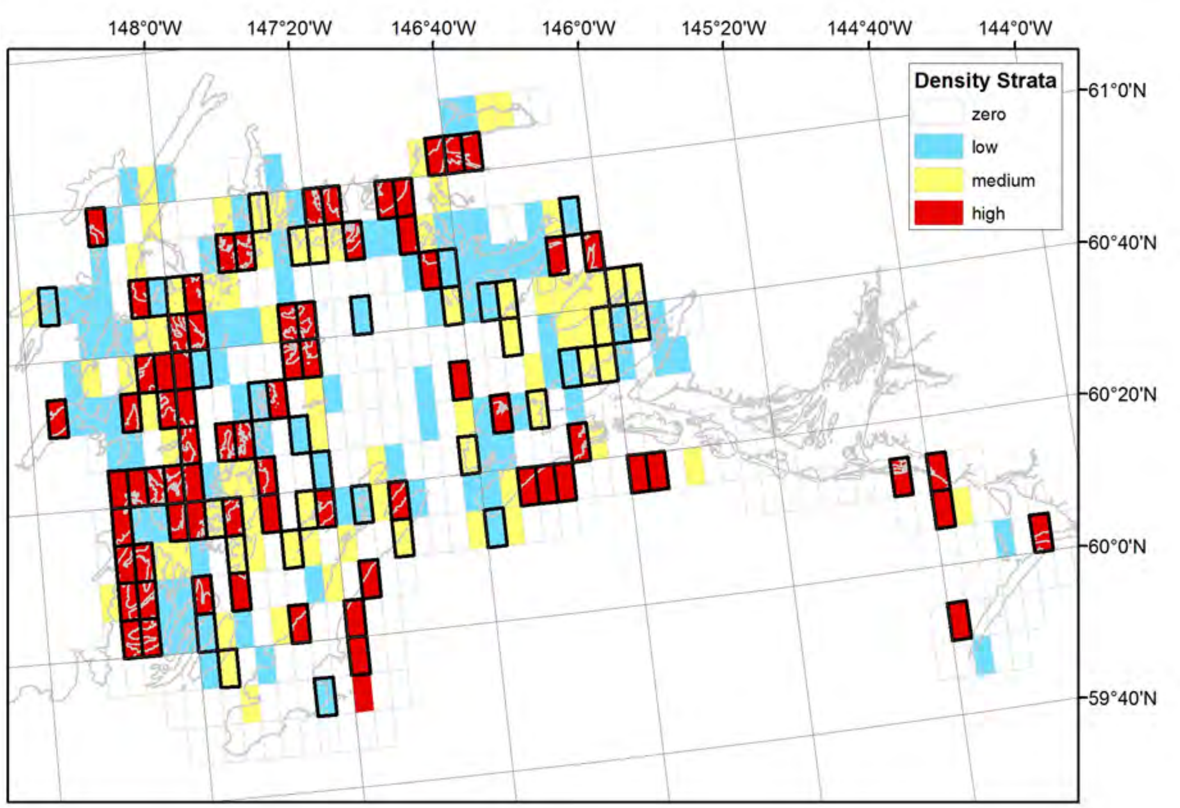


Figure 1. Blocks selected for surveying are marked with bold outlines. The school density as calculated using number of schools per kilometer of flight multiplied by a persistence factor is shown in the colors.

Block 371 (Windy Bay) was surveyed on each trip west of Cordova. When the forage fish vessel was at sea the aerial project would identify schools near the vessel for validation of the identification and to establish acoustic biomass estimates associated with the school size categories. Preliminary analysis of the identification indicates very good classification of age-2+ herring. Validation of age-1 herring classification was limited. We continue to put more effort will need to be placed on validation to get a large enough sample to determine observer identification accuracy. A difficulty is that typically only one or two schools can be validated during a day because of the distance between schools the boat must travel.

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

a) This project is a close collaboration between the Herring Research and Monitoring coordination project and the forage fish project in the Gulf Watch Alaska program. Logistics and surveys are conducted by the HRM coordination project. The forage fish project provides field computers and other recording devices. They also provide ground truth of the aerial identifications. The projects work together to determine sampling priorities and protocols. Both projects also share data analysis.

   Flights were also used to guide sample collection of fish used in the genetics project and deployment of remote cameras to watch for spawn on Kayak Island.

b) No collaboration with other Trustee Council funded projects

c) All herring spawn information was shared with Steve Moffitt at the Alaska Department of Fish and Game (ADF&G) office in Cordova. We have been working with Steve to identify what information is needed for non-ADF&G observations to be of value to ADF&G. The fish collected at Kayak Island were provided to ADF&G for age-sex-length analysis.

9. Information and Data Transfer: *See,* Reporting Policy at III (C) (9).

a) Publications – none
b) Presentations - none
c) Data products – The number of age-1 herring schools observed in June was determined. This number is the index that we are testing as a predictor of age-3 recruitment to the spawning population.
d) The raw data collected during the flights as recorded on the Recon hand-held computer and the paper logs of observations have been loaded on the Ocean Workspace. The index of age-1 herring schools was updated to include the 2015 observations. A file with that data has been uploaded to the workspace. The sampling protocols and initial analysis of survey effort for the July work with the forage fish project have been uploaded. We worked with Axiom on establishing the metadata necessary.

10. Response to EVOSTC Review, Recommendations and Comments: *See,* Reporting Policy at III (C) (10).

No comments require a response.

11. Budget: *See,* Reporting Policy at III (C) (11).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Travel	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Contractual	$0.0	$0.0	$50,000.0	$50,000.0	$0.0	$100,000.0	$ 100,000
Commodities	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)	$0.0	$0.0	$15,000	$15,000	$0	$30,000.0	$ 30,000
SUBTOTAL	$0.0	$0.0	$65,000.0	$65,000.0	$0.0	$130,000.0	$130,000.0
General Administration (9% of	$0.0	$0.0	$5,850.0	$5,850.0	$0.0	$11,700.0	
PROJECT TOTAL	$0.0	$0.0	$70,850.0	$70,850.0	$0.0	$141,700.0	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Spending is consistent with the budget.

We appreciate your prompt submission
and thank you for your participation.