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).

14120111-M

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

PWS Herring Program – Juvenile herring intensive monitoring

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

Ron Heintz and Fletcher Sewall (NOAA/Auke Bay Labs), Scott Pegau and Kristen Gorman (PWSSC)

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

1 February 2014 to 31 January 2015

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

February 2015

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 for this reporting period

The juvenile intensive HCM project is a collaborative effort between the Prince William Sound Science Center (PWSSC) and the Auke Bay Laboratory (ABL). This is the final year of this project within the Herring Research and Monitoring (HRM) program. The core of this project involved the collection of age-0 Pacific herring (*Clupea pallasii*, hereafter herring) from Simpson Bay (Fig. 1) at monthly intervals between fall and spring 2011/12. This intensive sampling was primarily designed to assess assumptions in the November - March monitoring of herring energetic that might influence over-winter survival throughout PWS.

Similar to other HRM juvenile energetic projects, this intensive project used both stable carbon and nitrogen isotope ratios, in addition to bomb calorimetry, to estimate energy density of age-0 herring. Samples for stable isotopes have been processed in previous FYs of this project. However, bomb calorimetry samples for this project were completed in 2014 and are reported here.

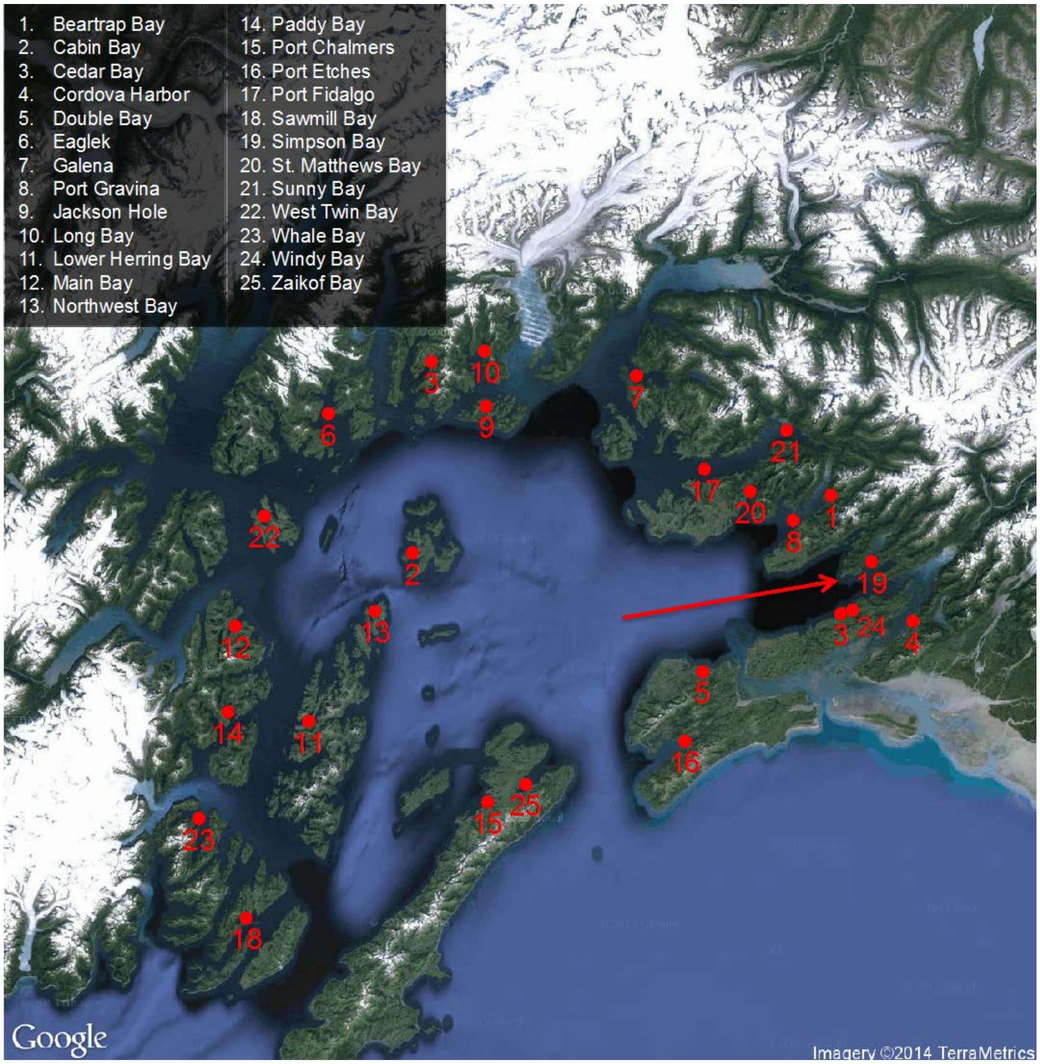

Figure 1. Sampling location in Simpson Bay for juvenile herring intensive condition monitoring noted by the red arrow. Other areas have been sampled for juvenile herring energetics as part of the PWS Herring Research and Monitoring program.

Project deliverables for this reporting period

Annual PI Meeting: A PI meeting was held in March 2014 attended by both Drs. Heinz and Pegau. Another PI meeting was held in Anchorage during November 2014 and was attended by both Drs. Pegau and Gorman. Dr. Ron Heinz and Fletcher Sewall were unable to attend the November 2014 PI meeting. However, Dr. Pegau presented results from this project at the EVOSTC Science Panel Meeting that took place in Anchorage during February 2015 in preparation for the next round of RFPs by EVOSTC.

Juvenile Herring Collections throughout winter 2011 and 2012: Completed with all samples previously sent to ABL.

Submit FY2015 Work Plan for Review: A work plan was not submitted as this project will not continue in FY2015.

Reporting: A semi-annual project report to NOAA was submitted in August 2014.

Submit synthesis to EVOS Science Council: The Synthesis Report was submitted to EVOSTC in November 2014, which included analyses of this dataset.

Alaska Marine Science Symposium: Drs. Scott Pegau, Kristen Gorman, Ron Heinz and Fletcher Sewell attended AMSS in January 2015. Dr. Gorman did not present on this project as when AMSS Abstracts were due, new analyses had not been finished at that time. However, new analyses were reported in the Synthesis Report that was submitted in November 2014. Dr. Heinz and Fletcher Sewell presented data from this project at AMSS in 2014.

Progress Update and Results

Data from this project were important for testing several assumptions of the November – March time series: 1) that the November – March sampling occurs when energy content is at its highest and lowest, 2) that feeding does not occur through the winter, and 3) that energy loss through the winter is constant (e.g., Kline et al. 2013). The intensive sampling of winter 2011/12 revealed that 1) November and March do capture early and late winter months of high and low energy density among age-0 herring (Fig. 2). However energy loss is not constant over winter, but appears to occur mostly between November and December with energy density of the late winter months being similar to that of December (Fig. 2).

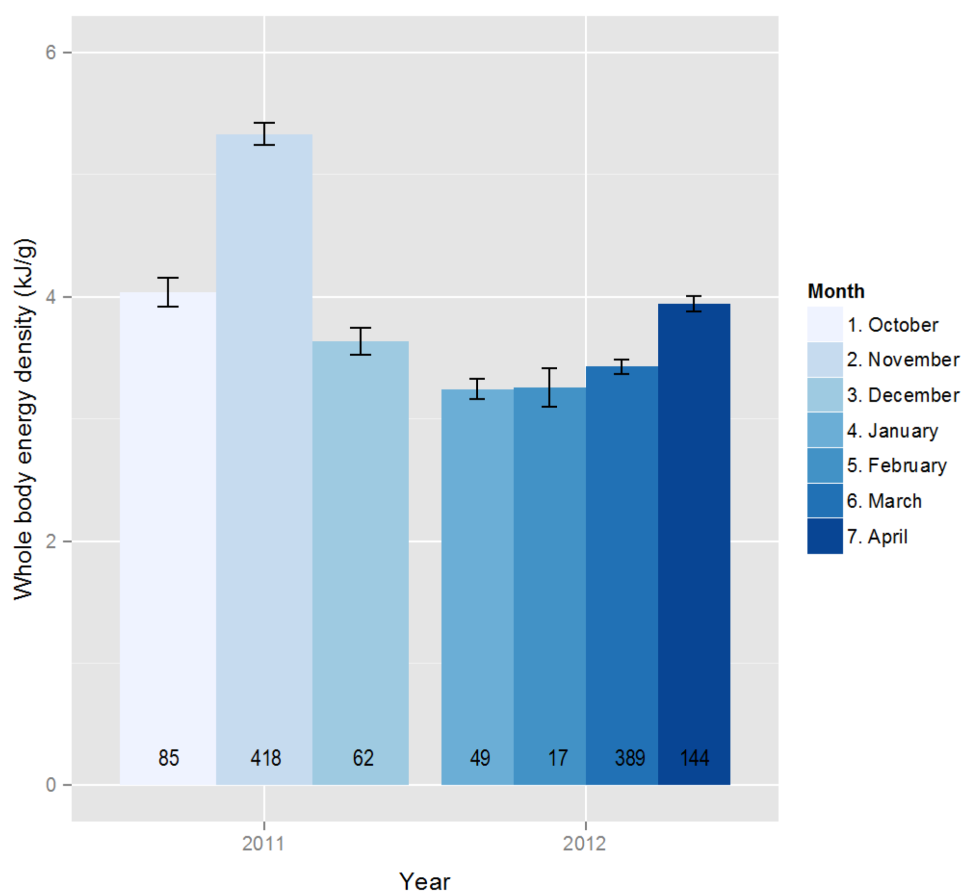

Figure 2. Monthly variation in energy density of age-0 herring during winter 2011 and 2012. Sample sizes for each month are noted at the bottom of bars. Error bars are 95% confidence intervals.

During 2014, we were able to make considerable progress in processing the backlog of bomb calorimetry samples from this dataset that serve as a comparative method for estimating energy density in comparison with stable isotope techniques. These data are presented in Fig. 3 and demonstrate a strong correlation between energy density estimates based on stable isotope and bomb calorimetry approaches, suggesting that isotope-derived values appear relatively accurate.

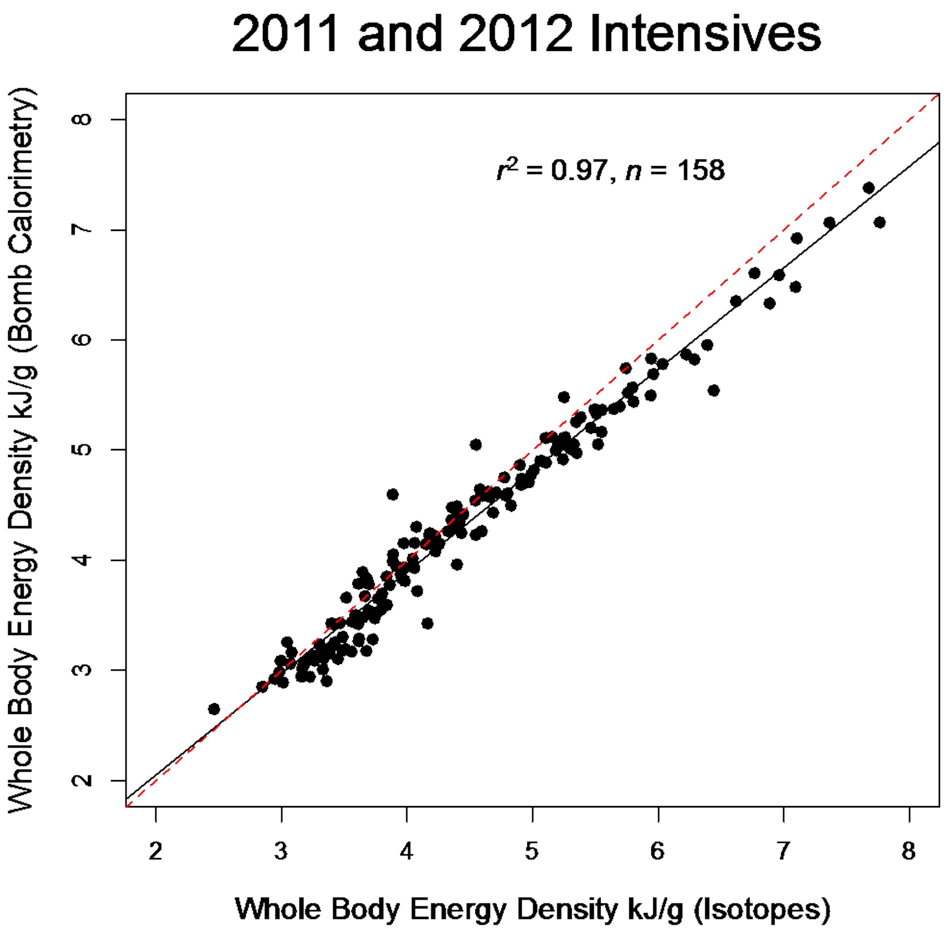

Figure 3. A comparison of energy density estimates of age-0 herring from the 2011 and 2012 intensive time series using coupled stable isotope and bomb calorimetry techniques. Bomb calorimetry data were produced in 2014. The red dashed line indicates a 1:1 relationship.

The mean size of herring captured over winter changed such that small herring were rare by March, while large herring persisted (Fig. 4), suggesting size-dependent winter mortality. The shift in sizes was unlikely due to growth, as indicated by low RNA/DNA ratios through winter (Fig. 5). Comparison of seasonal trends in RNA/DNA and lipid levels indicates a shift in energy allocation strategy prior to winter from growth to lipid storage. Herring lipid levels were largely consistent with trends in energy density, with a peak in November followed by a decline through March (Figs. 2 and 6). Larger herring captured in gillnets typically had higher lipid levels than the smaller individuals caught in cast nets, and metabolized more lipid over winter. The tradeoff between growth and energy storage is size-dependent, with smaller cast-net caught herring favoring growth more than larger gillnet-caught herring. This finding is consistent with previous data collected from multiple bays over three winters that showed smaller herring had higher RNA/DNA ratios and lower % lipid than larger herring (Sewall et al. 2013). This pattern is likely due to selective pressures favoring large size in juvenile fish (Sogard 1997).

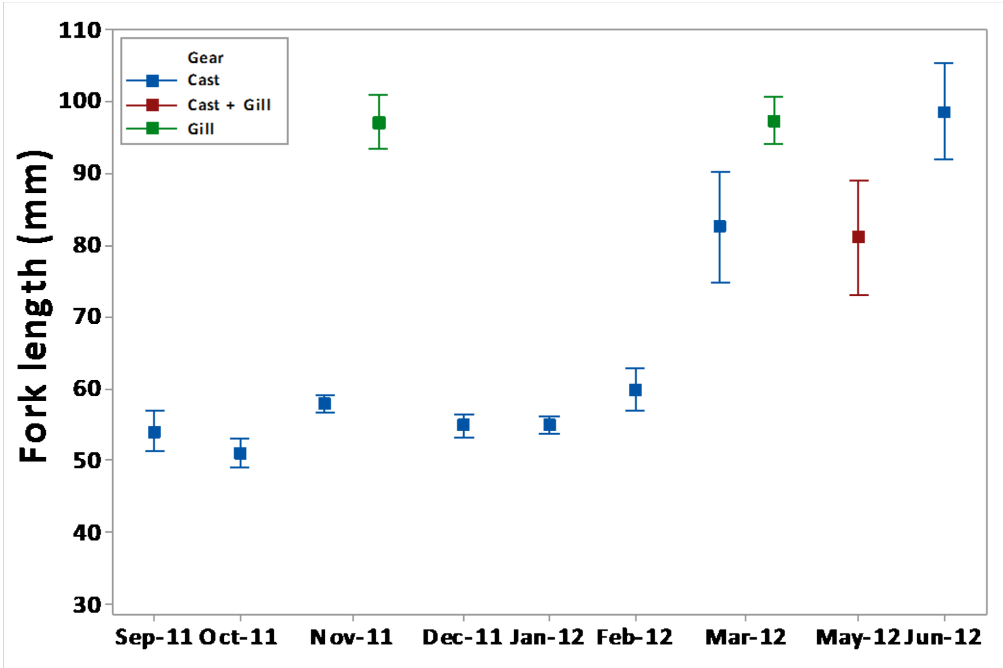

Figure 4. Fork length (mm) of age-0 herring captured in Simpson Bay, Prince William Sound, from September 2011 to June 2012, means and 95% confidence intervals. Separate cast net and gillnet samples were collected concurrently in November 2011 and March 2012. May 2012 samples by both gears were pooled.

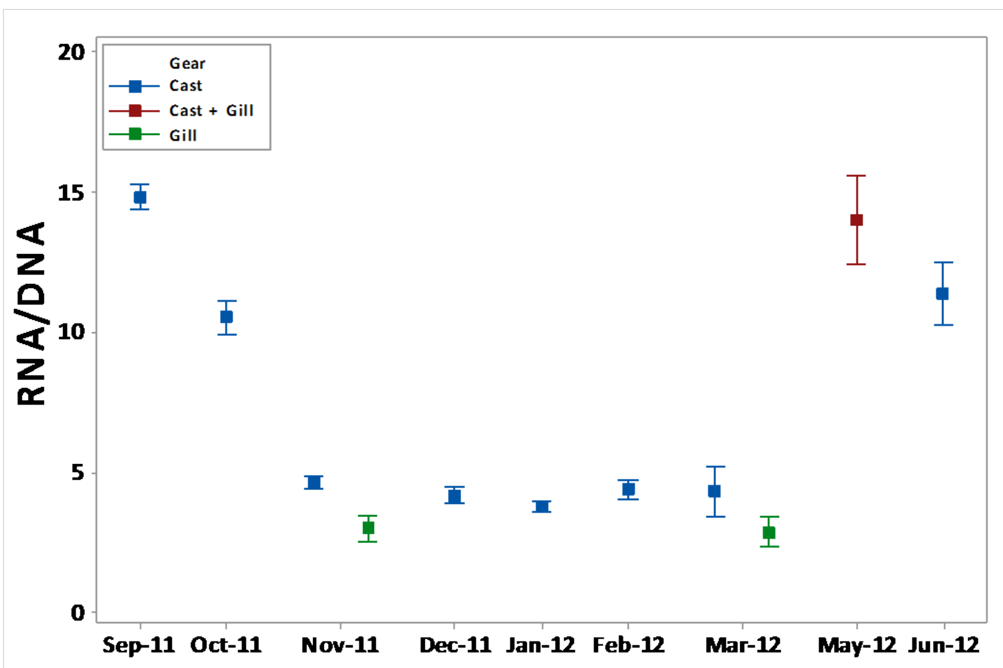

Figure 5. RNA/DNA ratio of age-0 herring from Simpson Bay, Prince William Sound, means and 95% confidence intervals. Separate cast net and gillnet samples were collected concurrently in November 2011 and March 2012. May 2012 samples by both gears were pooled.

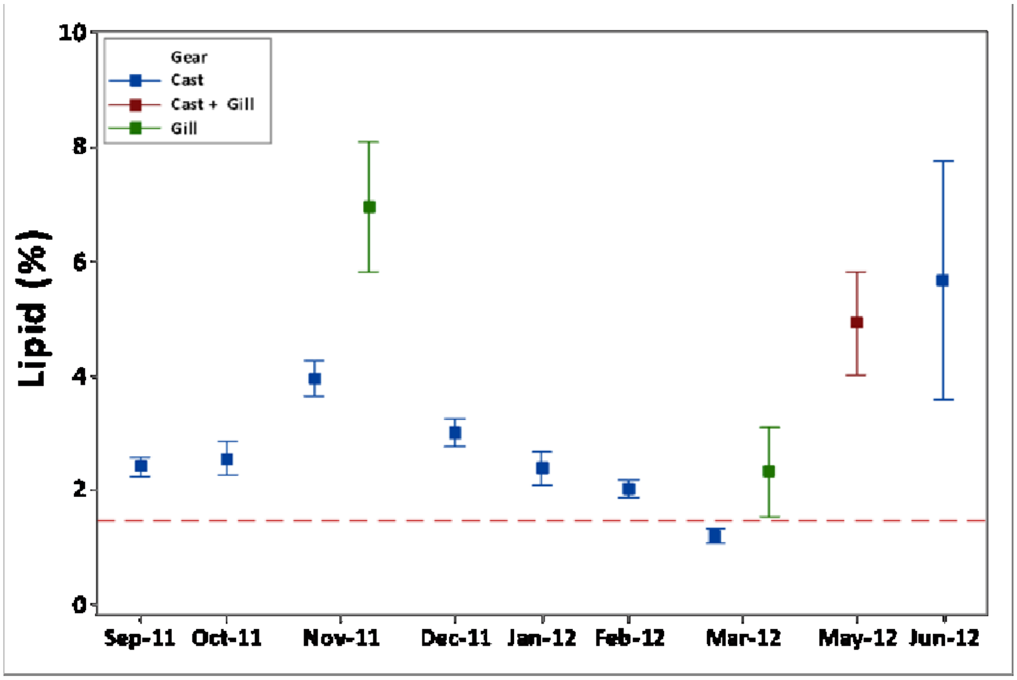

Figure 6. Lipid content (% wet mass) of age-0 herring from Simpson Bay, means and 95% confidence intervals. Separate cast net and gillnet samples were collected concurrently in November 2011 and March 2012. May 2012 samples by both gears were pooled. Red dashed line indicates minimum 1.49% lipid required for survival, as determined by previous lab study.

We examined trends in herring diets to assess the potential influence of variation in zooplankton prey quantity and quality on herring survival, and to test the assumption of no food intake for modeling winter energy loss. Interestingly, feeding was evident throughout the winter, with only 3% empty stomachs from December through March (Table 1). Stomach contents analysis showed that the level of feeding varied monthly over winter, and was influenced by fish size and condition. In autumn, all seven empty stomachs observed in November came from larger, fatter individuals captured in gill nets. Gillnet-captured herring that had eaten had lower mean stomach contents masses than castnet-captured herring (Fig. 7), reflecting the lower foraging need for large fish at that time. This pattern of higher foraging activity for small, low-lipid fish in Simpson Bay is consistent with previous reports of greater evidence of foraging among low-lipid individuals across multiple bays in PWS (Sewall et al. 2013). Mean stomach contents mass as a percentage of fish body mass tended to increase from December through February, which likely reflects greater reliance on dietary energy as lipid stores were decreasing. The sharp decline in March may indicate zooplankton had become scarce by this time, though we lack independent zooplankton density estimates as verification.

Table 1. Percent empty stomachs observed in age-0 herring captured in Simpson Bay, Prince William Sound, Alaska. *Herring caught by cast net and gillnet in May 2012 were pooled.

	Cast net		*Gillnet*	
Month	**% Empty**	**N**	**% Empty**	**N**
Sep 2011	0	60		
Oct 2011	0	20		
Nov 2011	0	30	70	10
Dec 2011	0	20		
Jan 2012	0	20		
Feb 2012	12.5	16		
Mar 2012	0	10	0	10
May 2012	25*	20*		
Jun 2012	0	20		
Total	5.93	236		

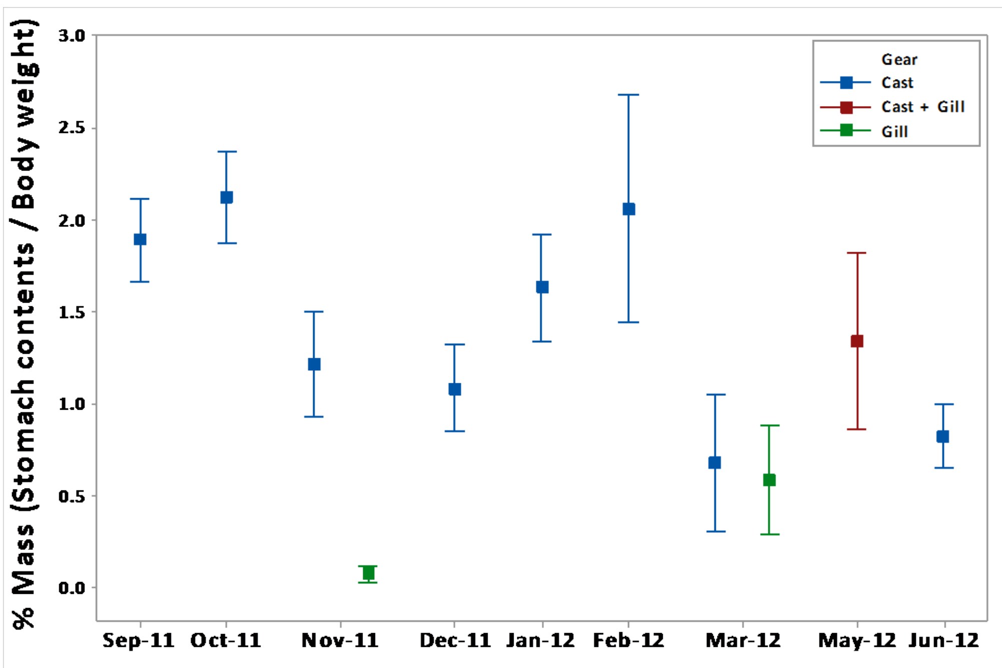

Figure 7. Stomach contents mass as a percentage of body mass for age-0 herring captured in Simpson Bay, Prince William Sound, from September 2011 to June 2012, means and 95% confidence intervals. Separate cast net and gillnet samples were collected concurrently in in November 2011 and March 2012. May 2012 samples by both gears were pooled.

The diet compositions of Simpson Bay herring were notable in the scarcity of high-energy prey such as euphausiids and mysids. Throughout the winter, relatively lower-energy prey such as larvaceans and small copepods made up the majority of herring diets, with increasing numbers of barnacle larvae (Cirripedia) in spring and summer (Fig. 8). This contrasts with the diet compositions of herring in other bays in PWS examined in November 2011, which had significant proportions of euphausiids (Sewall et al. 2013). As a result, the estimated energy density of diets for herring in Simpson Bay was the lowest among the five bays observed. This variability in diet energy among bays may be important in evaluating the relative significance of winter-feeding for herring survival.

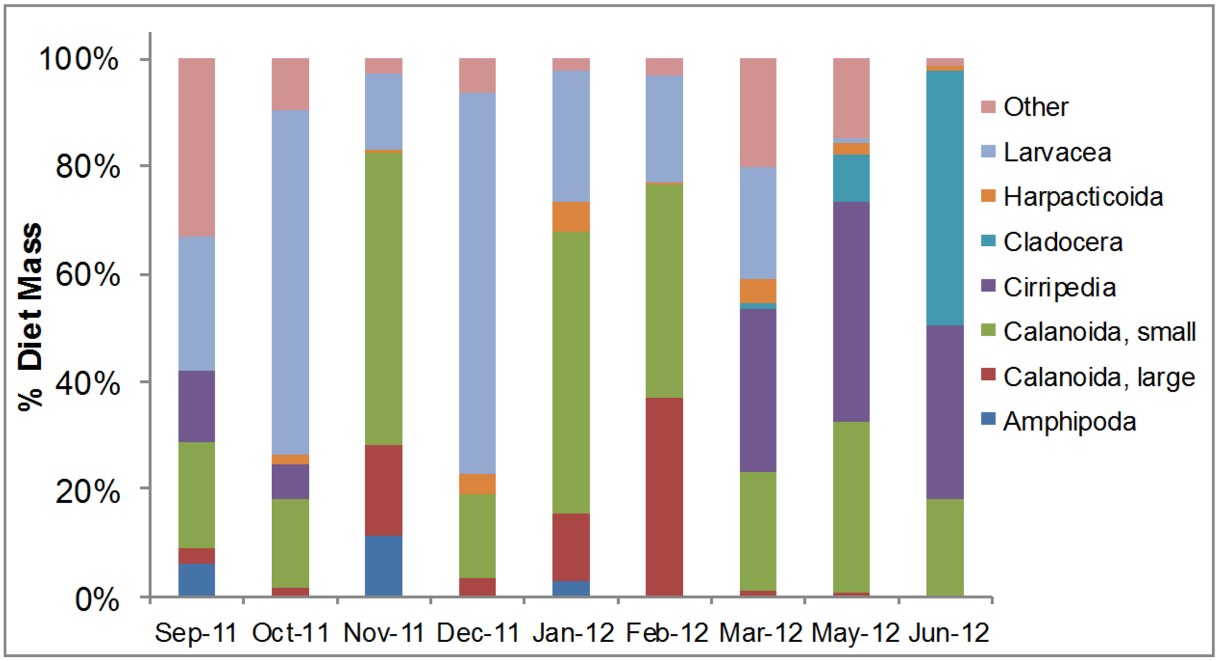

Figure 8. Diet composition (% of total mass consumed) for age-0 herring captured in Simpson Bay, Prince William Sound, from September 2011 to June 2012. Herring in November 2011, March 2012, and May 2012 were captured by cast net and gillnet; all other months were by cast net only.

Smaller fish captured in cast nets had exhausted their lipid stores by March and were reliant on diet energy for their survival. However, estimated diet energy content in March appeared insufficient to meet daily metabolic needs (Fig. 9). Assuming metabolic energy use of 23 J/g per day (Paul and Paul 1998), age-0 herring in March had less than one day of spare lipid stores and energy from consumed prey. Their actual energy use is likely higher due to foraging activity, which would further increase the risk of energy depletion. These findings suggest that smaller juvenile herring in Simpson Bay were unlikely to survive through this winter, due to a combination of low lipid stores and limited diet energy intake in March.

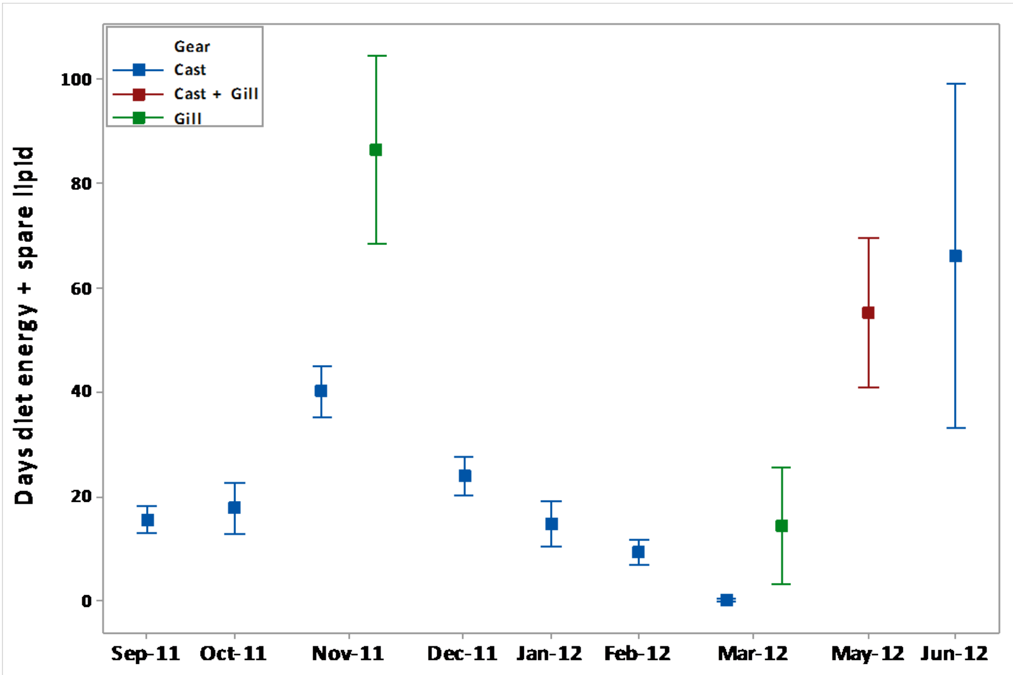

Figure 9. Days until depletion of energy from consumed prey (diet energy) and spare lipid stores (lipid stores in excess of minimum for survival) for age-0 herring captured in Simpson Bay, Prince William Sound, from September 2011 to June 2012, means and 95% confidence intervals. Separate cast net and gillnet samples were collected concurrently in November 2011 and March 2012. May 2012 samples by both gears were pooled.

Literature Cited

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. and J. M. Paul. 1998. Comparisons of whole body energy content of captive fasting age zero Alaskan Pacific Herring (*Clupea pallasi Valenciennes*) and cohorts over-wintering in nature. Journal of Experimental Marine Biology and Ecology. 226. 75-86.

Sewall, F. F., R. A. Heintz, and J. J. Vollenweider. 2013. Prince William Sound Herring Survey: Value of Growth and Energy Storage as Predictors of Winter Performance in Young-of-the-year Herring from Prince William Sound. National Marine Fisheries Service, Juneau, Alaska.

Sogard, S. M. 1997. Size-selective mortality in the juvenile stage of teleost fishes: a review. Bulletin of Marine Science **60**:1129-1157.

Summary of Future Work to be Performed
This project is ending after FY2014 and therefore no future work is planned.

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

a) Within a Trustee Council-Funded Program.
The juvenile intensive HCM project primarily requires coordination of PIs at PWSSC and ABL.

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

c) With Trustee or Management Agencies.
None.

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.
March PI meeting: Pegau and Heinz attended
November PI meeting: Pegau and Gorman attended
AMSS: Pegau, Heinz, Gorman and Sewell attended

c) Data and/or information products developed during the reporting period, if applicable.
Synthesis Report submitted in November 2014 including these data.

d) Data sets and associated metadata that have been uploaded to the program's data portal.
The long-term herring dataset, which includes these intensive data, is being updated in its current form (Excel) with new isotope and bomb calorimetry data obtained during fall 2014 and will be added to the AOOS workspace as soon as all newly available data are entered.

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

None as this project is ending after FY2014.

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	$64,800.0	$41,200.0	$13,700.0	$0.0	$0.0	$119,700.0	$ 119,328
Travel	$2,700.0	$2,700.0	$0.0	$0.0	$0.0	$5,400.0	$ 2,965
Contractual	$41,600.0	$8,500.0	$700.0	$0.0	$0.0	$50,800.0	$ 56,157
Commodities	$13,900.0	$2,200.0	$0.0	$0.0	$0.0	$16,100.0	$ 8,613
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)	$36,900	$16,300	$4,300			$57,500.0	$ 56,068
SUBTOTAL	$159,900.0	$70,900.0	$18,700.0	$0.0	$0.0	$249,500.0	$243,131.0
General Administration (9% of	$14,391.0	$6,381.0	$1,683.0	$0.0	$0.0	$22,455.0	
PROJECT TOTAL	$174,291.0	$77,281.0	$20,383.0	$0.0	$0.0	$271,955.0	
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.

None

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