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-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) Names: *See,* Reporting Policy at III (C) (3).

Mary Anne Bishop, Ph.D., Prince William Sound Science Center
Report Prepared by: Sean Lewandoski and Megan McKinzie

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

February 1, 2014 – January 31, 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).

Fiscal year 2014 marked the completion of the third year of the five-year *Validation of Acoustic Surveys for Pacific Herring Using Direct Capture*, a component of the *Prince William Sound Herring Research and Monitoring* (HRM) program sponsored by the EVOS Trustee Council. This project collects the data needed to estimate useful population level parameters for PWS Pacific herring obtained 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 EVOS HRM program, including: condition index, energetics, growth, disease, and age at first spawn (Table 1).

Field work in FY14 was extensive and included direct capture efforts associated with the following acoustic survey projects: annual juvenile herring abundance index surveys (Nov), annual expanded adult herring surveys (Mar and Apr), juvenile herring intensive surveys (Feb-Apr), and a pilot, integrated marine bird/whale/forage fish survey at Montague Strait in collaboration with the EVOS Gulf Watch Pelagic component (Sep). In addition, we collected and provided samples to the HRM projects. Here we report on work performed in FY2014 and our preliminary results.

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

Project	**Agency**	**Species provided**
Acoustic Validation	PWS Science Ctr	All species – measurements only
Condition Index	PWS Science Ctr	Juvenile herring
Genetic stock structure	ADFG	Adult herring
Disease	USGS	Juvenile herring

1) Improve capture methods used to validate acoustic surveys.

2) Increase the sample size for identification, quantification, and measurement of juvenile (0+, 1+, 2+) and adult (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.

Sampling Methods

Juvenile Herring Surveys. During FY14 two sampling programs were implemented that target juvenile herring: 1) the annual HRM Juvenile Herring Abundance Index, which includes 8 bays in PWS (Simpson, Port Gravina, Fidalgo, Eaglek, Lower Herring, Whale (East and West), Zaikof and Windy bays; Fig. 1); and, 2) the second half of the HRM Juvenile Herring Intensive Surveys, a project designed to investigate

Table 1. Prince William Sound Herring Research and Monitoring projects that this validation project collects and provides samples to.

Energetics	NOAA Auke Bay	Juvenile herring/walleye pollock
Growth RNA/DNA	NOAA Auke Bay	Juvenile herring
Age at First Spawn	NOAA Auke Bay	Adult Herring

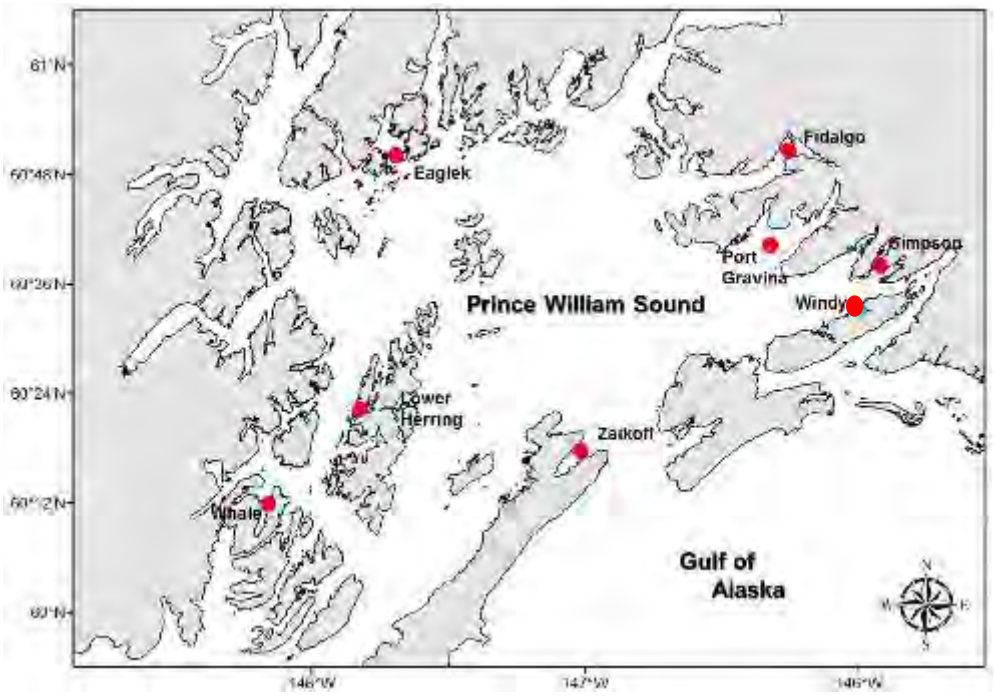

Figure 1. Location of acoustic surveys and corresponding validation efforts (red circles) conducted as part of the juvenile herring abundance index surveys, 15-24 Nov 2014. Windy and Simpson Bays were also sampled from Oct 2013 through Apr 2014 as part of the juvenile herring intensive study.

temporal changes across one winter (2013/2014) in the number and size distribution of herring in two PWS bays: Simpson and Windy. For both programs, acoustic surveys were conducted across the sampling area. Based on the acoustic surveys, "targets" were identified and returned to for short-distance (0.1-1.6 km) trawls concomitant with acoustic surveys. We used a mid-water 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 that collected conductivity, temperature, and depth data to the head-rope of the trawl. Additionally, a sensor tag that collected temperature and depth data was attached to the foot-rope of the trawl. In this report we use environmental data collected with the head-rope tag.

The annual juvenile herring abundance index survey was conducted from 15-24 Nov 2014. During each annual survey 2-4 transects were conducted in each study bay. The eight juvenile intensive surveys at Windy and Simpson Bays were conducted between early Oct 2013 and the first week in Apr 2014. Each survey was conducted over a three night period and consisted of nocturnal acoustic transects followed by three combined trawl and acoustic transects. All juvenile herring surveys and trawls were conducted aboard the R*/V Montague*.

At sampling bays, additional fish were collected with juvenile herring gillnets (60'X 16'; 1/4, 5/16, 3/8" mesh) and castnets (6', 3/16" mesh) to provide samples for other herring research projects. Nets were deployed opportunistically while at anchor. Data collection from captured fish consisted of measuring (SL, FL, TL; mm) and weighing (g) up to 200 fish per species. Total count and batch weight were calculated if more than 200 of a species were captured. Measured herring were grouped into three age categories based on standard length: young-of-year (YOY; <116 mm), juvenile (116-159 mm), and adults (>159 mm). Fish samples were later sent to the various HRM project for additional analysis (Table 1).

Expanded Adult Herring Survey. The 2014 expanded adult herring acoustic survey consisted of two cruises conducted between 25 Mar and 25 Apr aboard the *M/V Auklet*. The objective of this expanded survey was to locate schools of adult herring in PWS in areas that were not sampled during previous adult herring acoustic surveys. Our sampling protocol consisted of first, during the daytime, using the depth sounder to locate areas with acoustic noise. After target sampling areas were located, nighttime acoustic transects were conducted and large mesh (0.75", 1.00", 1.25", 1.50") gillnets (60' x 16') were deployed. During the first survey (25-28 Mar 2014) acoustic data were collected but no direct capture validation efforts were conducted.

Integrated Surveys with Gulf Watch at Montague Strait. An analysis of the previous seven winters of marine bird surveys (2007/08 through 2013/2014) showed that Montague Strait is a "hotspot" for marine birds. Similarly, the Gulf Watch NOAA Humpback Whale project identified this area as a "hotspot" for whales and the Herring Research Management (HRM) Post-spawn movements of Herring project previously has recorded acoustic-tagged herring reappearing in Montague Strait from Sep through Dec (M. Bishop unpubl. data). Based on these results, in Sep 2014 we collaborated with three other EVOS-funded projects (Gulf Watch NOAA

Humpback Whale, Gulf Watch PWSSC fall and winter marine bird surveys, Gulf Watch USGS forage fish) to investigate multispecies predator-prey aggregations, specifically interactions between humpback whales, forage fish, and forage flocks of seabirds, in Montague Strait. For this project, we deployed the midwater trawl during the day and at the direction of the Gulf Watch forage fish PI M. Armitsu.

Data Analysis

Juvenile herring surveys. For the juvenile herring abundance index analysis we assumed that transects within the same bay were correlated and not independent samples. Following, we included sample bay as a random effect in our modeling to address the spatial correlation in our dataset. Additionally, we were interested if environmental and geographic variables, including water temperature, salinity, and trawl depth, were associated with YOY herring catch data. To analyze these data, first catch was standardized to account for differences in trawl distance to obtain the rate YOY/km. We assumed that the log of YOY/km followed a negative binomial distribution and modeled YOY/km as a function of the environmental predictor variables using a Genera Linear Mixed Model (GLMM). This model was fit in R using the glmmADMB package.

Using a random intercept and slope mixed-model, our data could not support more than two predictor variables due to limited degrees of freedom. To select predictor variables we first fit a model for each variable and then selected the two variables that had the strongest relationship with YOY/km. Of the single-variable models, water temperature had the strongest relationship with YOY/km ($p= 0.03$), trawl depth ($p=0.12$) was weakly associated, and salinity was likely not associated with YOY/km ($p=0.73$). Based on these results, our estimation model contained trawl depth and water temperature as predictor variables.

For the intensive surveys, we investigated trends in adult herring, juvenile herring, and YOY herring catch per unit effort (CPUE) over time and between bays (Simpson and Windy). Additionally, the biomass of each herring age category as a proportion of total captured biomass was calculated to investigate temporal trends in catch composition. Finally, we were interested if the presence of an ice edge influenced CPUE or catch composition. Ice was present in Simpson bay during all trawls conducted in Feb and Mar and two of three sampling nights in Apr (number of trawls = 24) and no ice was present from Oct through Dec and one night in Apr (number of trawls = 25). Size structure was investigated by categorizing all catch data as either from “ice” or “open” periods and generating length frequency histograms for each group.

Expanded adult herring survey and Montague Strait pilot study. Catches and capture efforts were summarized by date, capture location, and gear type. Additionally, herring length data were plotted against weight to examine the relationship between these two metrics and a regression model was fit to the data. Total effort and herring catch for the Montague Strait pilot study was summarized.

Results

Juvenile Herring Surveys. Data from the 2014 Juvenile Index survey indicated that median YOY/km in the nine bays sampled in PWS was strongly related to water temperature ($p=0.03$) and trawl depth ($p=0.06$). A 0.1 degree Celsius increase in water temperature was associated with a 20% increase (95% CI: 2-42% increase) in median YOY/km, and a 1-m increase in trawl depth was associated with 12% decrease in median YOY/km (95% CI: 0-23% decrease).

Because of the spatial correlation in our data, we need to consider the relationship between these predictor variables and sample bay to interpret the biological significance of these results. We investigated these relationships graphically and determined that trawl depth covered a wide gradient in most bays and was not strongly related to sample bay (Figure 2). However, water temperature was similar for transects occurring in the same bay and was higher in bays with high YOY/km (Figure 3). Thus, the positive association between YOY/km and water temperature could be due to confounding with other unmeasured variables related to sample bay. Sampling a wide gradient of temperatures within each bay and further analysis of other environmental and geographic variables and their covariance with water temperature could help determine if the association between water temperature and YOY/km found in this analysis is due to the ecology of herring in PWS or is a result of confounding with other variables. For the juvenile intensive surveys, we calculated YOY, juvenile, and adult catch per km (Figures 4-6). Further analysis is needed to investigate possible associations between CPUE and environmental and geographic variables.

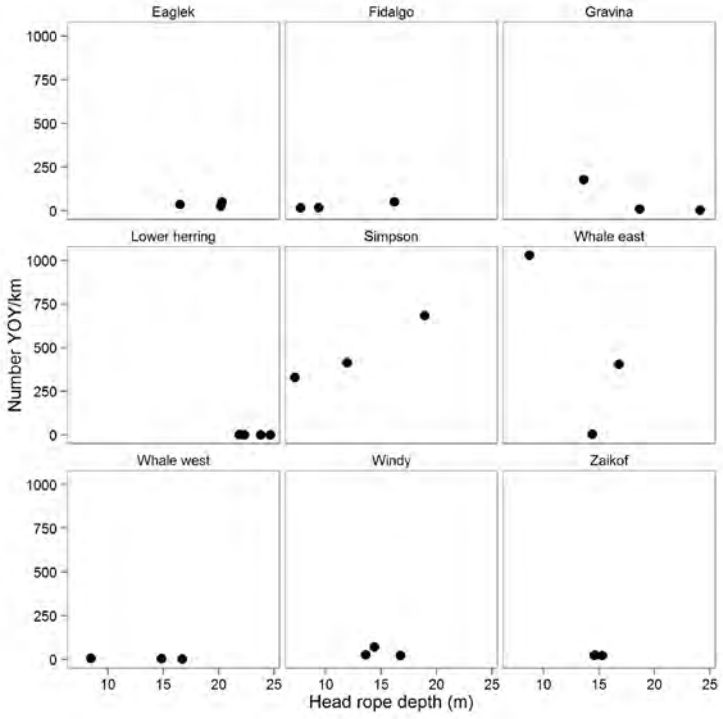

Figure 2. YOY herring (SL <116 mm) catch per km plotted against trawl head-rope depth faceted by sampling bay. Data are from the juvenile herring abundance index survey, Nov 2014.

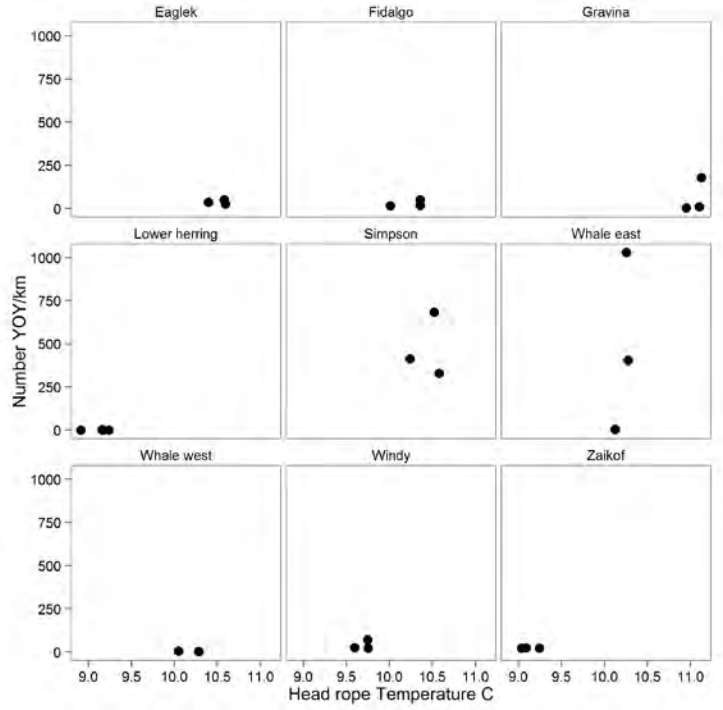

Figure 3. YOY herring (SL <116 mm) catch per km plotted against water temperature (C) faceted by sampling bay. Data are from the juvenile herring abundance index survey, Nov 2014.

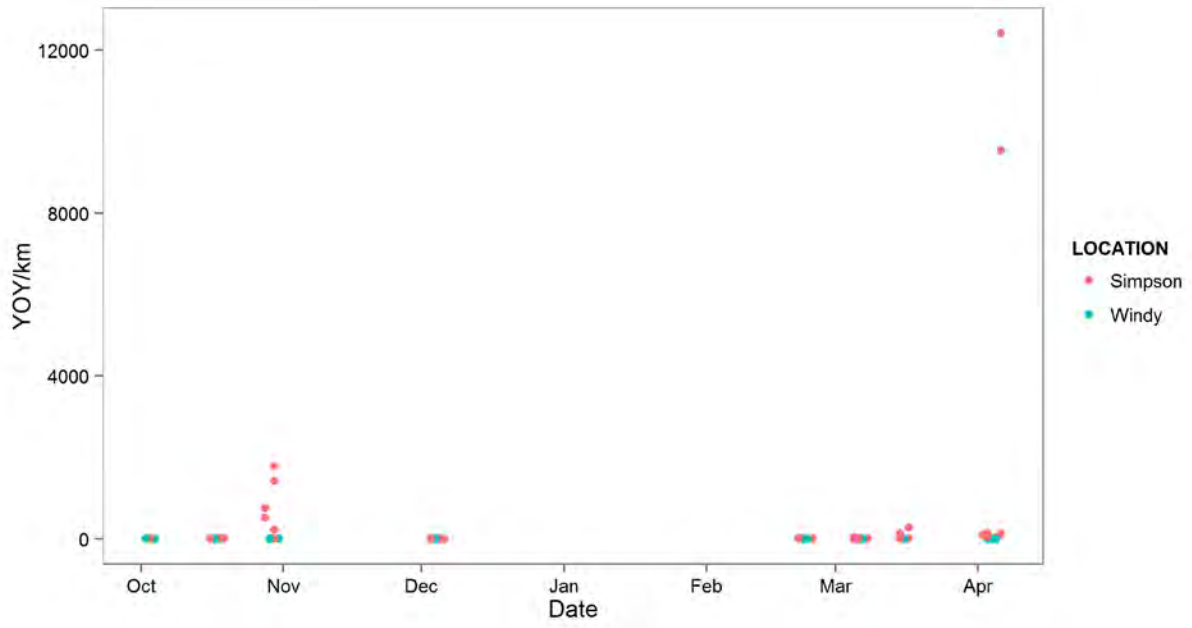

Figure 4. YOY Pacific herring (SL <116 mm) catch per km plotted against capture date. Data are from the juvenile herring intensive surveys, Oct 2013 – Apr 2014.

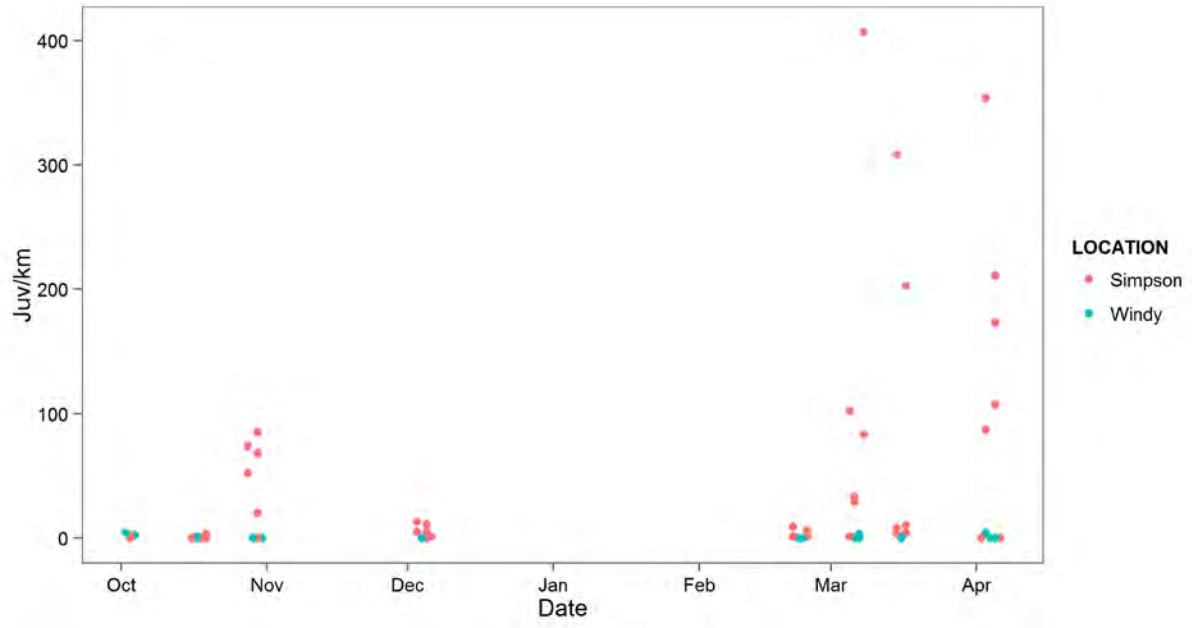

Figure 5. Juvenile Pacific herring (SL 116-159 mm) catch per km plotted against capture date. Data are from the juvenile herring intensive surveys, Oct 2013 – Apr 2014.

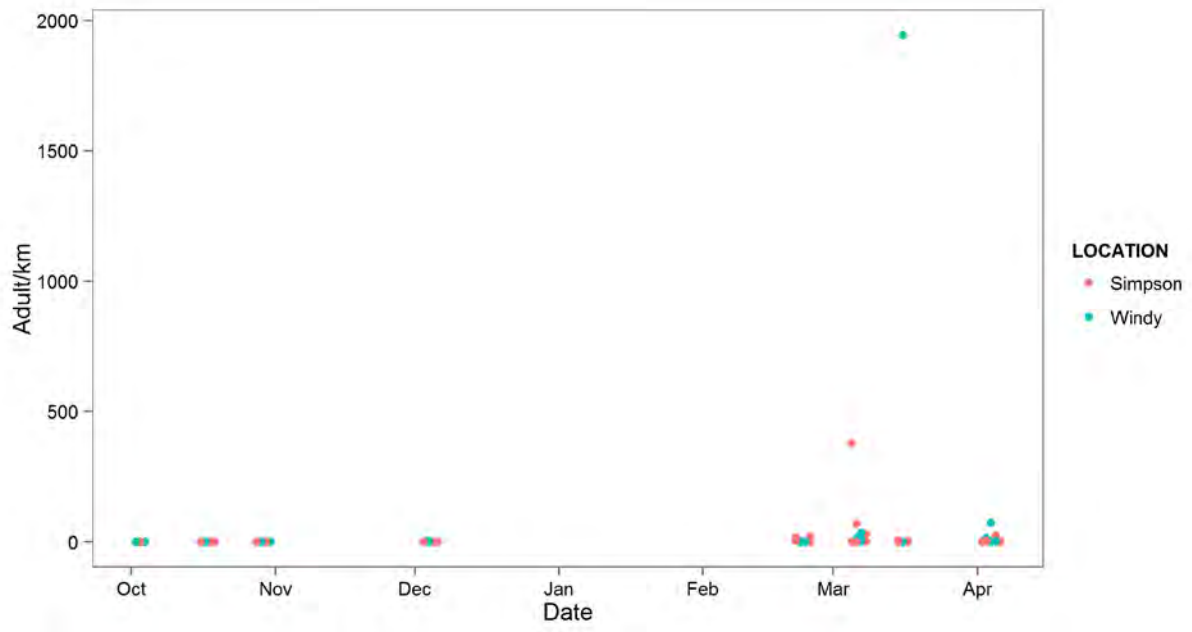

Figure 6. Adult Pacific herring (SL >159 mm) catch per km plotted against capture date. Data are from the juvenile herring intensive surveys, Oct 2013 – Apr 2014.

The number and size structure of captured herring in Simpson Bay during the intensive surveys was hypothesized to be related to the presence of an ice edge in Simpson Bay. An ice edge was present during all trawls conducted in Feb and Mar and two of three sampling nights in Apr (number of trawls = 24) and no ice was present from Oct through Dec and one night in Apr (number of trawls = 25). Size structure was investigated by categorizing all catch data as either from "ice" or "open" periods and generating length frequency histograms. During open periods YOY herring were captured in the highest proportion, fewer juvenile fish were captured, and adults were captured infrequently (Figure 7). Catches from periods with ice cover were dominated by juvenile herring, while both adult and YOY age classes were present in lower proportions (Figure 7).

During the final sampling period (2-6 Apr), ice was present the first two nights of sampling but retreated during the final night of sampling. As a result, the Apr sampling period included six tows conducted while ice was present and three when the bay was open. This allowed for a comparison of size distribution based on ice cover with data from the same time period. During the two sampling nights with ice, catches were dominated by juvenile and adult herring and contained a low proportion of YOY herring (Figure 8). However, during the final sampling night without ice, catches contained only YOY herring (Figure 8). Finally, the size distribution of herring caught during the open, no-ice sampling night in Apr 2014 was compared to the size distribution of herring caught in previous months. The size distribution is different than distributions from open periods, but is similar to the Oct 2013 distribution. From these data it appears that the proportion of YOY herring in trawl samples is higher during open water (no-ice) periods in Simpson Bay.

Finally, we calculated the proportion biomass of each trawl that was YOY, juvenile, and adult herring (Figures 9-11). Herring made up a low proportion of capture biomass during the Oct, Nov, and Dec intensive surveys, with the exception of one transect in Windy Bay in Dec (Figures 9-11). The proportion of YOY and juvenile biomass in Windy Bay catch remained low throughout the sampling period, but

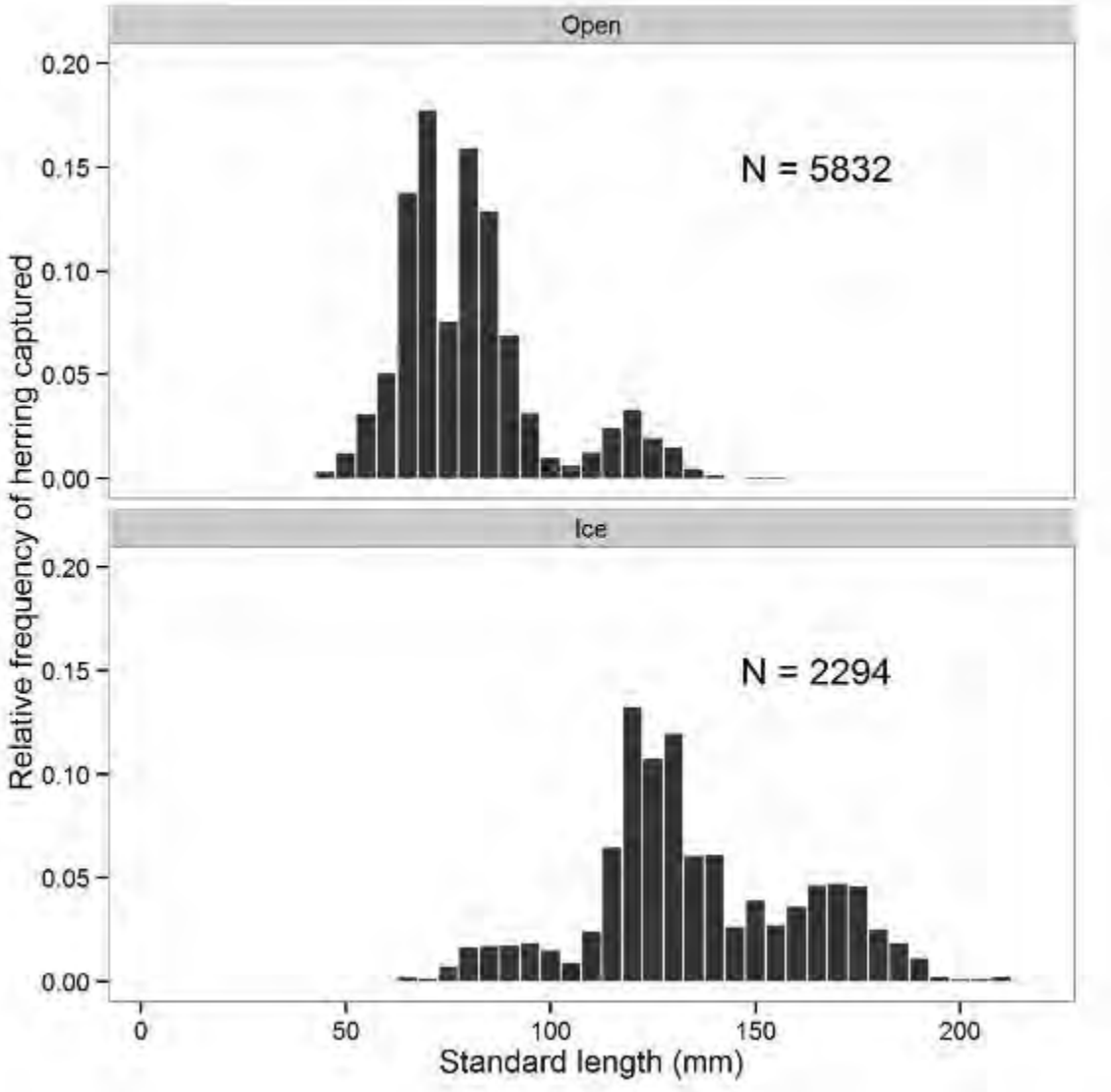

Figure 7. Length frequency histograms of the number of Pacific Herring caught by trawling in Simpson Bay, Oct 2013 – Apr 2014. Catch data are grouped in 5-mm bins by ice conditions at time of capture. Simpson Bay had ice during Feb and Mar sampling events and for three of nine tows in Apr.

the proportion of adult herring biomass increased substantially during Mar and Apr. In Simpson Bay, YOY and juvenile herring biomass made up a large proportion of catch in Mar and Apr, while adult herring biomass was a large proportion of catch in Mar but was low in Apr (Figure 9-11).

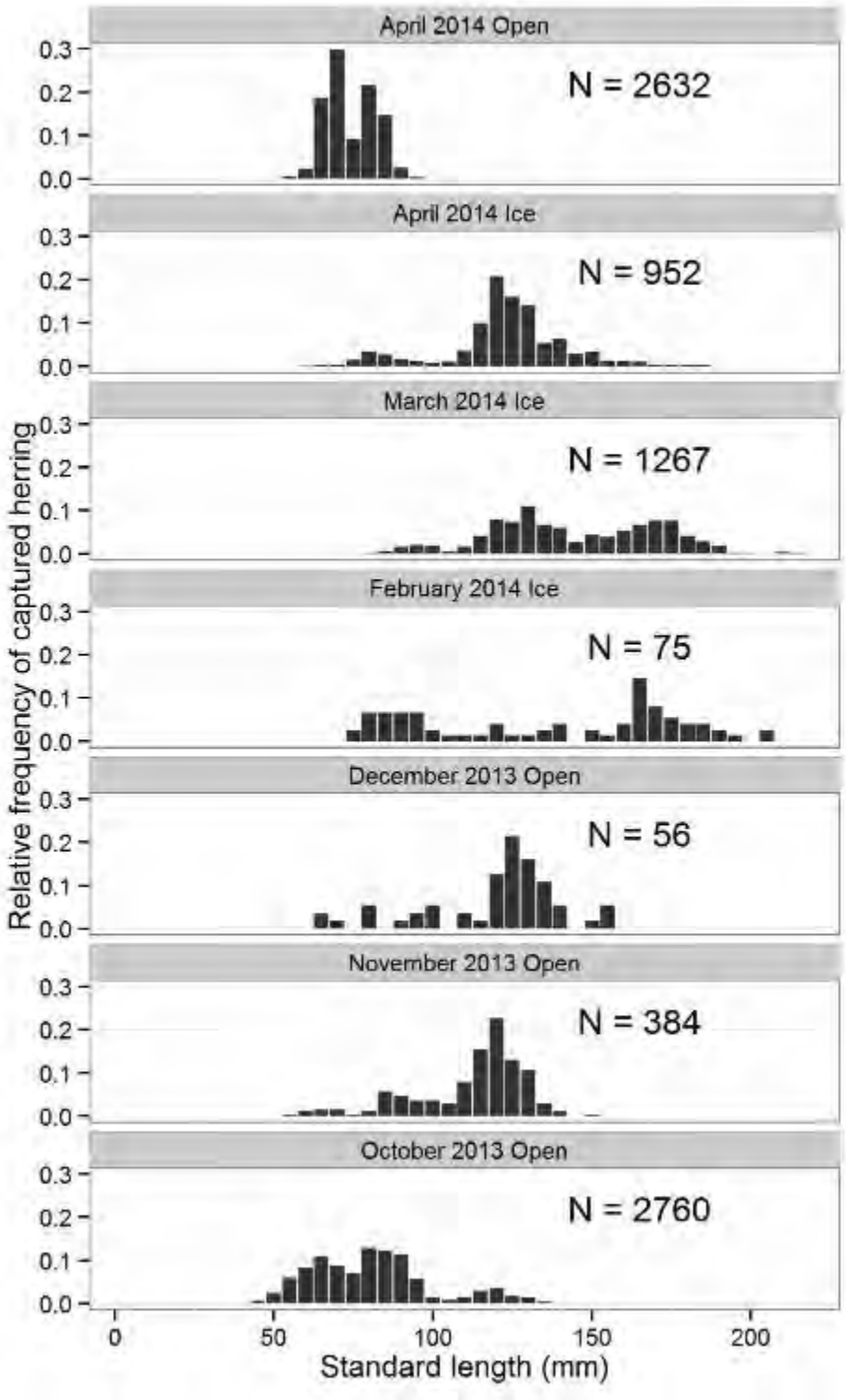

Figure 8. Length frequency histograms of herring caught in Simpson Bay from Oct 2013 through Apr 2014 with 5-mm bins.

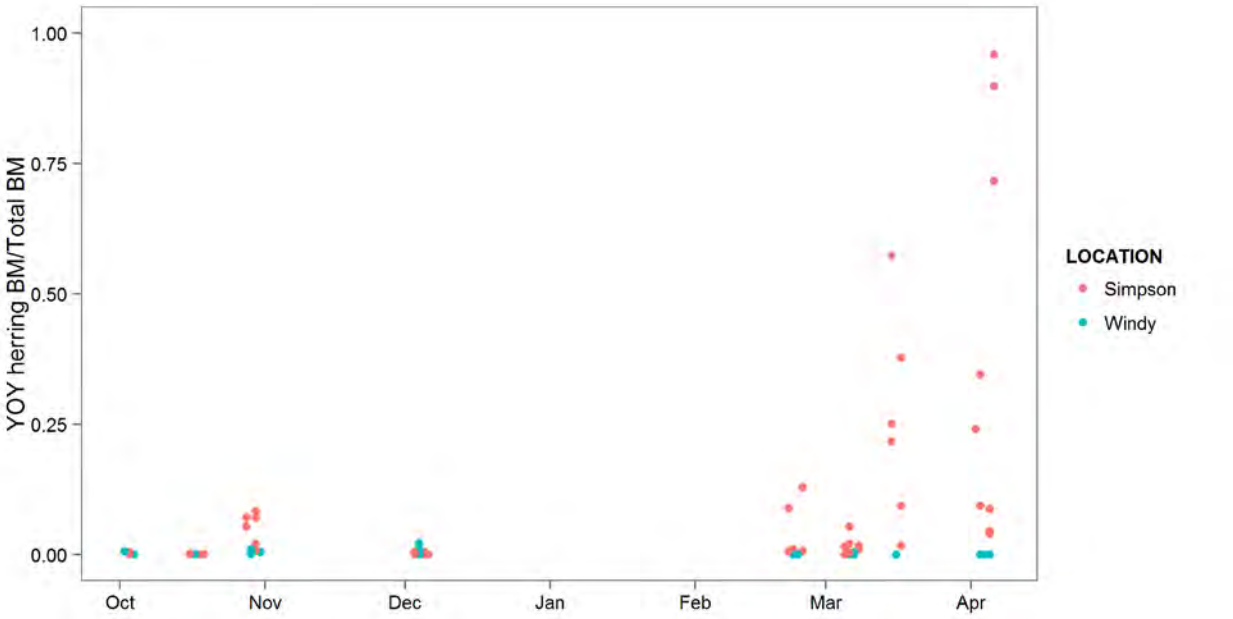

Figure 9. Proportion of YOY herring (SL <116 mm) biomass in trawl catch from the juvenile herring intensive surveys, Oct 2013 – Apr 2014.

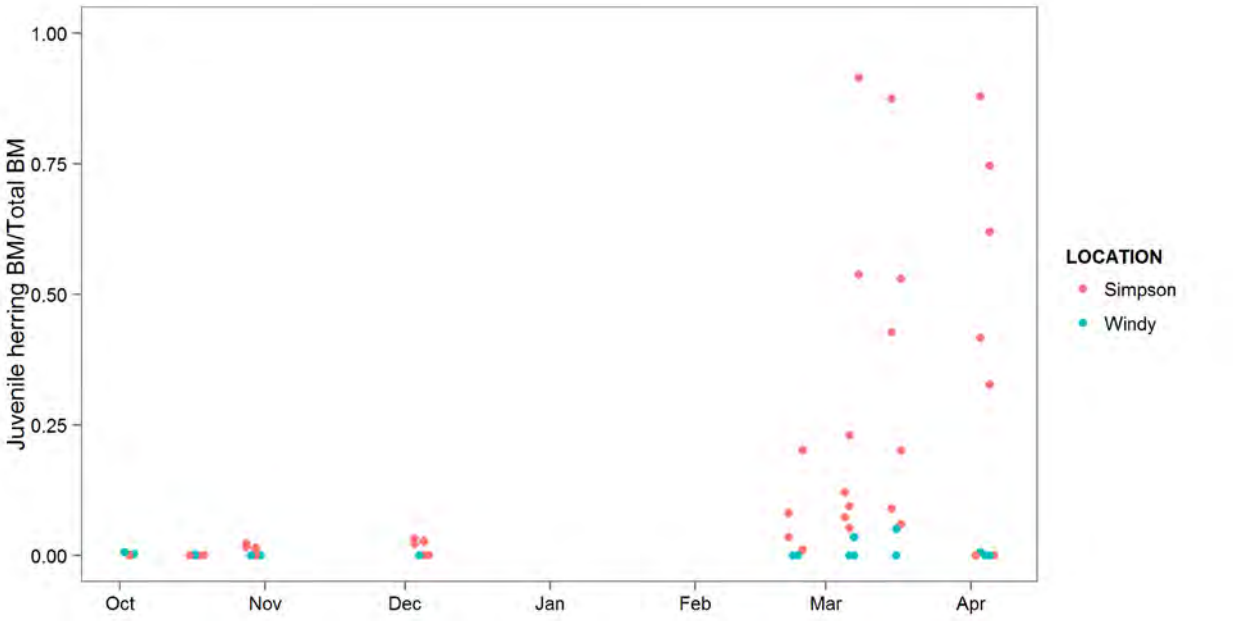

Figure 10. Proportion of juvenile herring (SL 116-159 mm) biomass in trawl catch from the juvenile herring intensive surveys, Oct 2013 – Apr 2014.

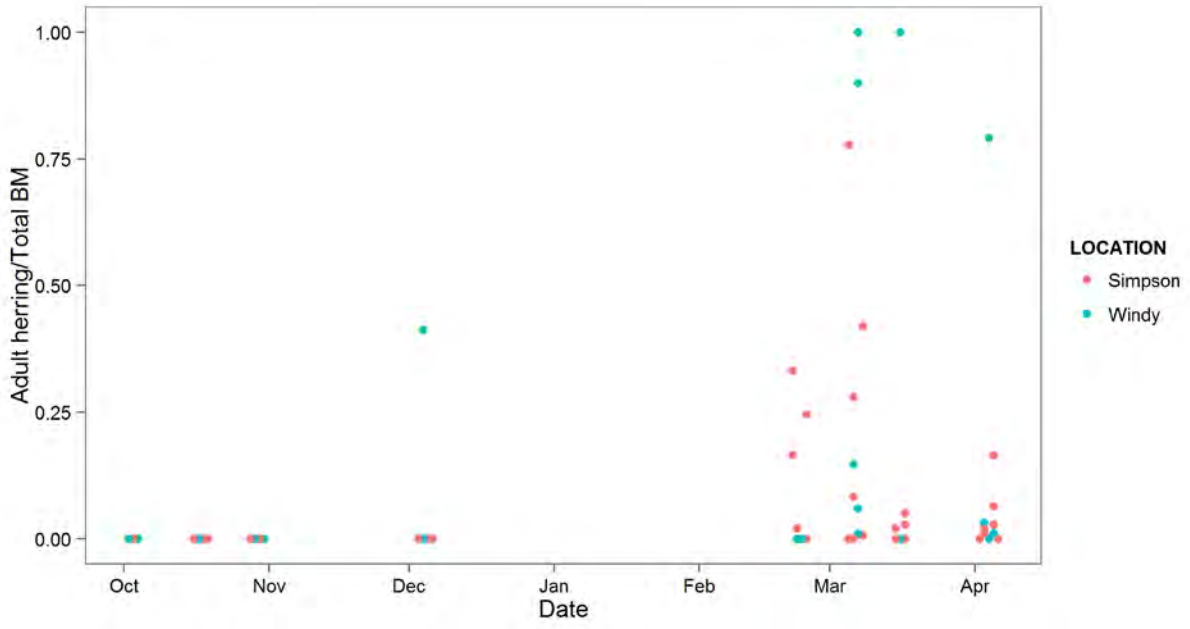

Figure 11. Proportion of adult herring (SL >159 mm) biomass in trawl catch from the juvenile herring intensive surveys, Oct 2013 – Apr 2014.

Expanded Adult Herring Surveys. During 2014 expanded adult survey 95% of the 97 captured fish were adult herring (Table 3). The majority of adult herring (85) were caught in a single large-mesh gillnet set. The mean standard length of captured adult herring was 221.9 mm (95% CI: 242.1–201.7 mm) and the mean weight was 137.6 g (95% CI: 175.3–99.9 g). The relationship between length and weight of captured adult herring was approximately linear (Figure 12). Following, we fit a linear regression model to the data and determined that the association between standard length (SL) and weight of adult herring was strong ($p < 0.001$) and SL accounted for much of the variation in weight ($R^2=0.929$).

Table 3. Summary of catch and capture effort for the expanded adult survey, spring 2014.

Date	Location	Gear Type	Species	No. Collected
4/4/2014	Sheep	Midwater Trawl	NA	0
4/22/2014	Port Chalmers	Gillnet	kelp greenling	1
			Pacific cod	1
			Pacific herring	6

			saffron cod	1
4/23/2014	Stockdale	Jig	NA	0
4/24/2014	Stockdale	Gillnet	great sculpin	2
			Pacific herring	1
4/24/2014	Stockdale	Gillnet	Pacific herring	85

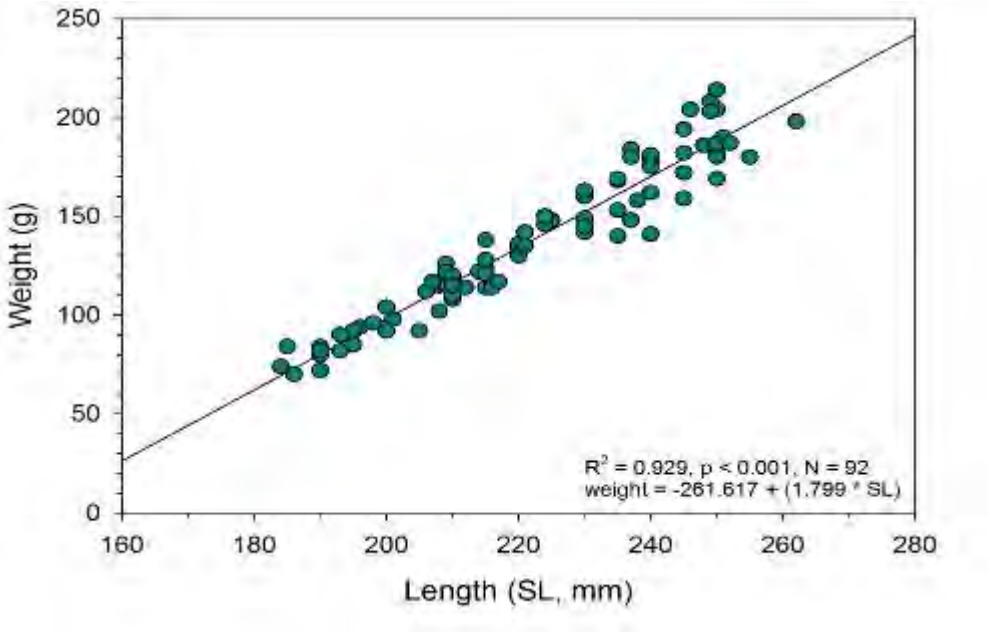

Figure 12. Length/weight regression of herring captured during the expanded adult herring cruise, Apr 2014.

Montague Strait pilot study. Multiple gear types were used during the Montague Strait pilot study and a total of 250 herring were captured (Table 4).

Table 4. Summary of the gear type and associated number of captured herring per deployment for the Montague Strait pilot study.

Date	Gear Type	Number of Herring Captured
9/24/2014	Jigging	39
9/25/2014	Mid-water trawl	0
9/25/2014	Aluette trawl	0
9/26/2014	Tucker trawl	0
9/26/2014	Tucker trawl	0
9/27/2014	Aluette trawl	17

9/28/2014	Jigging	0
9/28/2014	Dip net	104
9/28/2014	Aluette trawl	90

Milestones/Deliverables

No milestones were scheduled to be completed in FY 2014. Table 5 summarizes field work activities for this project in FY14.

Table 5. Status of project deliverables for this reporting period.

Deliverable/Milestone	**Status**
Mar/Apr *Expanded Adult Herring Survey* with validation & collections for genetics & age at first spawn	Completed, 25 Mar—25 Apr 2014
Feb through Apr *Juvenile Herring Intensive Acoustic & Validation Surveys;* collections for multiple herring projects	Completed, Intensive # 5: 21 Feb—24 Feb 2014 Intensive # 6: 5 Mar—8 Mar 2014 Intensive # 7: 15 Mar— 18 Mar 2014 Intensive # 8: 2 Apr—6 Apr 2014
Nov *Juvenile herring abundance index* with hydroacoustic & validation surveys; disease, condition index & energetics collections	Completed 15-24 Nov 2014
Pilot *Montague Strait Hotspot Integrated Study* with GulfWatch projects	Completed 23-29 Sep 2014

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

a) Coordination and collaboration is critical to this project as <u>all</u> our surveys are associated with other projects. During FY14 we conducted validation trawls or gillnets on EVOS-sponsored HRM juvenile herring abundance index, HRM juvenile herring intensive surveys, HRM expanded adult herring surveys, and the integrated Montague Strait study. The pilot Sep2014 surveys around Montague Strait and the southwest passages marked the first attempt to integrate Gulf Watch marine bird surveys (PWSSC), Gulf Watch forage fish acoustic surveys (USGS), Gulf Watch humpback whale (NOAA) and our and our acoustic validation project. In addition, as noted in Table 1, we collect and provide samples to several HRM projects.
b) No collaboration with other Trustee Council funded projects
c) Adult herring collected off Montague Island were provided to Steve Moffitt with Alaska Department of Fish and Game in Cordova for age-sex-length analysis.

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

<u>Data:</u>

Datasets and associated metadata through May 2014 have been uploaded to the HRM portal.

Popular Press:

Bishop, M.A. 2014. Age-0+ herring: only trawls and time will tell. *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 and gave presentations at the HRM meeting for Principal Investigators in Mar 2014 (Cordova) and Nov 2014 (Anchorage).

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

No issues were raised by the most recent EVOSTC review. The Science panel stated: *There is evidence of substantial, well-executed field work, and excellent support and integration with other projects (pg. 87)*

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	$32,500.0	$58,300.0	$98,100.0	$95,000.0	$98,000.0	$381,900.0	$ 137,924
Travel	$1,000.0	$1,000.0	$2,000.0	$1,200.0	$1,200.0	$6,400.0	$ 2,804
Contractual	$900.0	$1,800.0	$2,600.0	$2,200.0	$2,200.0	$9,700.0	$ 10,154
Commodities	$5,400.0	$2,800.0	$1,800.0	$1,100.0	$1,100.0	$12,200.0	$ 12,658
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	$ 49,062
SUBTOTAL	$62,400.0	$83,100.0	$135,800.0	$129,400.0	$133,300.0	$544,000.0	$229,673.0
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	

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 purchased a trailer for transporting and storing the trawl reel as well as a temperature/depth tag, putting us slightly over on our equipment budget.