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-D

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

PWS Herring Program- Non-lethal sampling

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

Kevin M. Bsowell

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).

Surveys on the cruise were conducted in Simpson and Beartrap Bays in the Prince William Sound. The DIDSON was deployed from a Seamor Marine ROV. Each site was surveyed at least in the morning and at night, encompassing crepuscular periods thought to be important in structuring herring schools. Surveys at this time were mostly exploratory and unequal search effort was expended towards school detections in each bay. Upon detecting a school in either the ROV camera or DIDSON, attempts were made to steady the ROV to enhance the quality and accuracy of the coupled video-DIDSON data to derive density and length distributions. Some schools which exhibited attraction behavior towards the ROV lights were surveyed for a disproportionately long period of time, in an attempt to lure individuals to the surface for capture. Post-processing of acoustic data were completed in the acoustic analysis software Echoview (Version 6; Myriax Ltd). School densities were derived from the estimated nominal beam volume approximated as a 14°x28° rectangular prism, and the number of single target detections per ping. Schools encountered with either ice or bottom present in the sonar data were excluded, as the DIDSON beam volume could not be estimated. Fish length as estimated by a DIDSON is dependent upon the orientation of a target to the sonar, and as such only targets that were orthogonal to the transducer face were measured for length. Though this excluded some portion of the herring school from length estimation, obtaining accurate estimations of length was deemed important enough to sample only the most appropriate targets in each school.

Beartrap Bay was surveyed in the afternoon, at night, and in the morning surrounding the crepuscular periods. Simpson Bay was surveyed at night upon arrival, and in the morning before departure. Average lengths were measured across all school events in each survey. Here we consider a schooling event to begin when five individuals or more are encountered simultaneously in the sonar data, and ends five seconds after no fish detection.

Average herring length in Beartrap Bay surveyed in the afternoon was 11.4 (± 2.3) cm, 10.4 (± 1.5) cm at night, and 11.5 (± 1.8) in the morning. Herring densities ranged from 1.172 fish/m^3 in the afternoon, dropping to 0.4067 fish/m^3 at night, and 0.4147 fish/m^3 in the morning. Densities in the afternoon at Beartrap were higher than subsequent survey times on station, however they were excluded from further analysis as there was no analog in Simpson Bay.

Simpson Bay herring lengths were measured at 12.2 (± 1.5) cm during the night survey, and 12.3 (± 1.9) during the morning survey. Densities in the bay were higher than those in Beartrap Bay, ranging from 2.566 fish/m^3 in the night survey, to 3.495 fish/m^3 in the morning survey.

Densities from the morning and night surveys at each bay were compared to each other to examine possible differences in habitat utilization. Histograms of each survey density were plotted against each other to visualize potential differences detected by the DIDSON (Figure 3). The histogram indicated that there may be differences in density estimates between each bay, and perhaps also between survey times. Each bay was individually examined for the role of survey time on the density estimates of individual schools. Beartrap Bay exhibited significant differences in density estimates based on time of day, with individual schooling events having higher densities in the morning than their night time counterparts (Time: $F_{1,23017} = 11.74$, $P = 0.0006$). Time was excluded as a factor when examining school densities in Simpson Bay as a result of too few observations. Our data show that density estimates among schools were significantly different in both Beartrap ($P < 0.0001$), and Simpson Bays (School_ID: $F_{9,3733} = 66.26$, $P < 0.0001$).

It was noted anecdotally that schools of potentially differing lengths were evident in the sonar data. Two representative schools were examined to test for the capabilities of the DIDSON to distinguish length. Though not significant, length differences were found between two schools encountered in the same survey, showing evidence to support discrimination of age classes by the DIDSON.

These preliminary and exploratory surveys have shown that a DIDSON deployed from a submersible ROV can not only find herring utilizing ice as cover, but can also measure the densities and lengths of schooling fishes. Recent trawl data show that YOY herring have a mean length of 8.28 (±1.64) cm, juvenile herring have a mean length of 14.39 (±2.14) cm, and adult herring have a mean length of 19.59 (±2.65) cm (Figure 1; PWSSC Validated Trawl Data, 2014). Although site means were homogenized by averaging across all schools and lengths, from the results we can see that a difference as small as 2 centimeters can potentially be distinguished by a DIDSON. Although differences between schools in this study were not significantly different, previous tests on estimating lengths of targets in a pool setting have proven effective in differentiating lengths that were different by only several centimeters (Zenone unpbl, 2014). It makes sense that since these length observations were extracted from fish that were potentially from the same cohort, significant length differences may simply not exist. Average length estimates of school events encountered were very close to the average length of a juvenile herring (14.39 ±2.14) that may be anticipated in these bays in the spring. These data show that a DIDSON could be a useful tool in non-lethally identifying and distinguishing herring in the Prince William Sound. The ability to characterize herring age classes could be further refined in the future by the use of the newest imaging sonar, the ARIS, which has an improvement in resolution over the DIDSON of approximately 30%.

Data collected as part of this cruise show that herring schools encountered in the morning are significantly denser than their afternoon and evening counterparts. This could be indicative of crepuscular and night time foraging behavior exhibited by the herring, resulting in a less dense aggregation as fish search for food items. We believe our data may have been skewed by unequal effort, particularly in Beartrap Bay Afternoon that is the sole exclusion from this density trend. It should also be noted that these preliminary analyses utilized single target detections in each ping to determine an average estimate of density over the entire school. This can lead to auto-correlation in our data as a result of individual fish contributing to density estimates multiple times within each school. To improve upon this, it would be useful to attempt enumeration of each individual in the DIDSON by using fish tracking algorithms that follow a single fish throughout its entire presence in the sonar beam. Future studies should also incorporate survey methodologies that allow for in depth examination of density differences among herring schools as a function of standardized time.

Although school encounter rates in Simpson Bay was low, herring densities were highest. This is in agreement with recent trawl data that show Simpson Bay to be the major contributor to herring biomass in sites targeted by the yearly herring intensive survey. This is also perhaps due to intentional targeting of a single large school for a length of time during our Simpson night survey. It was found that herring schools were attracted to the lights from our ROV, and in the interest of data validation we attempted to lure the school to the surface for capture by cast net. Other trends, though not significant, were witnessed in our exploratory data. It appeared to the analyst that fish of different size classes are utilizing disparate microhabitats in the fjords. Smaller herring seem to congregate directly under and near ice, while larger size classes appear to be more commonly encountered in deeper waters. To explore these trends, we recommend a survey design that includes an equal effort spent near ice, bottom, and in pelagic areas of a survey site. Future data collection and analysis is necessary to elucidate any potential habitat utilization patterns as a function of age class.

Further work to advance the non-lethal sampling of herring in the Prince William Sound can also aid in the systemic improvement of acoustic data collection during herring intensives. Previous efforts from the PWS Herring Survey Program have attempted to utilize nets and trawls in conjunction with acoustic surveys as a method of “ground-truthing” data output from acoustic systems, however problems with timely net deployment and mesh sizes which exclude a range of size classes still leave much to debate. The 2013 final report from the PWS Herring Survey Program recommended exploring better options for acoustic validation. We endorse the deployment of a DIDSON during herring intensive surveys to aid in the validation and identification of biomass as witnessed by a traditional acoustic survey. To this end, there exist new means besides the DIDSON to attempt to validate and improve acoustic data collection. Historically, target strength (TS) has been used as the principle parameter for discriminating among taxonomic groups detected acoustically. Target strength is a measure of the amount of energy backscattered from an ensonified target. In fish, greater than 90% of the TS response is attributable to the swimbladder, providing opportunities to exploit variance among species-specific swimbladder morphologies to facilitate discrimination (Horne, 2003). Given that TS of an individual fish is highly frequency-dependent, and scales with target size, we propose to integrate multiple frequencies to enhance the potential to classify among fishes. Specifically, we are interested in examining the relative frequency response across a continuous spectrum of frequencies to aid in guiding discrimination efforts at relevant taxonomic levels (Kang et al, 2002; Kornelieusen and Ona, 2003; Logerwell and Wilson, 2004; DeRobertis et al, 2010; Forland et al, 2014). Through the past year, the

Fisheries Ecology and Acoustics Laboratory has been evaluating the newest echosounder (Simrad EK80 Wideband Sonar) to determine the potential to collect highly-resolved acoustic data for age and species discrimination. When compared to the traditional single-frequency echosounder (i.e. nominal 120 kHz) the analogous wideband sonar will generate a 50 kHz spectrum (i.e. 100-150 kHz) across which scattering data can be collected. Previous studies have successfully implemented relative frequency response relationships for target discrimination and the wideband data shows promise for deriving an “acoustic fingerprint” for a specific target or age class (Reeder et al, 2004; Lundgren and Nielsen, 2008; Lavery et al, 2010). Along with further DIDSON surveys, we recommend the exploration of these wideband utilities for improvement of future acoustic surveys in the Prince William Sound.

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

a) Through the recent activities we have been able to complement the intensive juvenile herring surveys conducted as part of the herring monitoring plan through the deployment of the above described ROV and imaging sonar approach. Further activities will ensure enhanced coordination with the adult herring acoustic and energetic/condition surveys as well as the Gulfwatch humpback whale component to be conducted in Spring 2015.
b) No coordination with other EVOSTC funded projects.
c) No coordination with EVOS Trustee agencies.

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

Preliminary analyses have been presented at the PI meetings and we expect a contribution at the next upcoming AMSS meeting.

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

No comments provided for the non-lethal component

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	$16,500.0	$21,700.0	$0.0	$0.0	$38,200.0	$ 11,902
Travel	$0.0	$8,600.0	$8,600.0	$0.0	$0.0	$17,200.0	$ 9,887
Contractual	$0.0	$0.0	$7,000.0	$0.0	$0.0	$7,000.0	
Commodities	$0.0	$6,700.0	$0.0	$0.0	$0.0	$6,700.0	$ 7,825
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)		$8,270	$9,730			$18,000.0	$ 6,270
SUBTOTAL	$0.0	$40,070.0	$47,030.0	$0.0	$0.0	$87,100.0	$35,884.0
General Administration (9% of	$0.0	$3,606.3	$4,232.7	$0.0	$0.0	$7,839.0	
PROJECT TOTAL	$0.0	$43,676.3	$51,262.7	$0.0	$0.0	$94,939.0	
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.

See attached budget form