FY14 PROGRAM PROJECT
PROPOSAL FORM

Project Title: PWS Herring Research and Monitoring Validation of Acoustic Surveys for Pacific Herring Using Direct Capture

Project Period: February 1, 2014 – January 31, 2015

Primary Investigator(s): Mary Anne Bishop, Ph.D., Prince William Sound Science Center, Cordova
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Abstract:
Acoustic surveys provide a relatively low-cost, remote sensing tool to estimate species-specific fish biomass and abundance. Interpreting acoustic data requires accurate ground truthing of acoustic backscatter to confirm species and length frequency of insonified targets. Since November 2012, juvenile and adult herring acoustic surveys have been conducted in November and late March, respectively. Pelagic trawls are the recommended method for validating species composition and for obtaining relatively unbiased information on length frequency distribution, age, and other biological information. Here we propose to use a low-resistance, light-weight midwater sweeper trawl capable of towing speeds (up to 3 knots) as a method to ground truth acoustic surveys for juvenile herring. Our pelagic trawl surveys will take place in conjunction with and onboard the same vessel as three studies in the *PWS Herring Research and Monitoring* program: a) *Juvenile Herring Abundance Index* (years 2-5); b) *Acoustic Consistency: Intensive Surveys of Juvenile Herring* (year 3). Because of concerns of the Alaska Department of Fish and Game, for the March *Expanded Adult Herring Surveys* (years 2-5) we are being required to use gillnets and jigging for validation. Our project will provide data on species composition and length frequency to aid in the interpretation of current and historical acoustic surveys. In addition it will provide adult herring samples to Alaska Department of Fish and Game for the adult herring age-structure-analyses model and will provide juvenile herring samples to researchers investigating juvenile herring fitness and disease. Our trawls will also provide fishery-independent surveys for non-herring species, thus increasing our knowledge of pelagic fishes in Prince William Sound.

Estimated Budget:
EVOSTC Funding Requested:

FY12	FY13	FY14	FY15	FY16	TOTAL
68,000	90,600	148,000	141,100	145,300	593,000

(Funding requested must include 9% GA)

Non-EVOSTC Funds to be used:

FY12	FY13	FY14	FY15	FY16	TOTAL

Date: August 30, 2013

I. NEED FOR THE PROJECT

A. Statement of Problem

Robust Pacific herring (*Clupea pallasii*) populations, suitable for exploitation by commercial fisheries, are typically sustained by periodic recruitment of strong year classes into the adult spawning population. However, the Prince William Sound (PWS) herring population has not had a strong recruitment class since 1989, when the *Exxon Valdez* Oil Spill (EVOS) occurred. In the EVOS settlement, herring were identified as an injured resource and they remain listed as an unrecovered species by the EVOS Trustee Council (EVOSTC). Understanding why herring have not recovered in Prince William Sound requires understanding potential bottlenecks in the herring life cycle. The identification of the limiting conditions to herring recovery requires a series of focused process studies combined with monitoring of the natural conditions that affect herring survival. Described here is one project of a multi-project program that will enhance the current monitoring efforts of the Alaska Department of Fish and Game (ADF&G), and examine aspects of particular life stages to allow better modeling of herring populations. The long-term goal of the overall multi-project program is to improve predictive models of herring stocks through observations and research.

We recognize that a major deficit in the existing *PWS Herring Survey* program is the lack of an effective means of validating the acoustic signal. Fortunately, if we can establish through direct capture of insonified fish that certain patterns in echograms can be interpreted as different year classes of herring, then we may be able to reanalyze historical acoustic measurements to better understand changes in juvenile herring populations.

From November 2007 through March 2012, juvenile herring acoustic surveys were conducted at the beginning (November) and end (March) of each winter. A variety of methods were used with limited success to ground truth these surveys. Small mid-water trawls used during fall 2007 and fall 2009 cruises failed to catch fish. In most cases, these trawls were towed 1 day after the acoustic survey and always from a different vessel. Trawling speeds were typically 2-3 knots, producing a high level of net avoidance by the targeted fish. Variable mesh gill nets have also been used to validate acoustic surveys; however, gillnets select for faster swimming fish (Thorne et al. 1983) and in PWS, gillnet deployments have resulted in very small catch rates of juvenile herring.

Pelagic trawls are the recommended *in situ* method for validating species composition and for obtaining relatively unbiased information on length frequency distribution, age, and other biological information (Simmonds et al. 1992, McClatchie et al. 2000, Adams et al. 2006, NOAA 2009). In the proposed program we plan to use a low-resistance, light-weight mid-water sweeper trawl capable of towing speeds of 2-3 knots designed specifically to capture juvenile forge fish as a direct capture method for collecting the number of fish necessary to provide validation. These surveys will take place as part of two studies in the *PWS Herring Research and Monitoring*: These include: a) *Juvenile Herring Abundance Index* (years 2-5); b) *Acoustic Consistency: Intensive Surveys of Juvenile Herring* (year 3). A third study, *Expanded Adult Herring Surveys* (years 2-5) will use gillnets and cast nets to ground truth insonified fish, due to overfishing concerns of Alaska Department of Fish & Game.. Principal Investigators for these three studies are Buckhorn and Thorne. In addition to ground truthing acoustic surveys, in year 1 we will use the trawl along with cast nets to collect juvenile herring during the 9-month intensive A *High-Temporal & Spatial Resolution Study to Validate the Separate Herring Condition Monitoring Programs* (Principal Investigators Kline and Heintz).

B. Summary of Project to Date (if applicable)

All milestones are on track and scheduled to be completed by November 2015 (1 milestone), or in 2016 (4 milestones). The first direct capture study, *HRM: A High Temporal and Spatial Resolution Study to Validate the Separate Herring Condition Monitoring Program* (PI's Kline and Heintz) began in August

2011 (pre-award) and was completed in June 2012. Personnel from this study assisted with the monthly direct capture on several occasions, under the direction of HRM project leader Scott Pegau.
Our first multi-project direct capture effort was scheduled for November 2012 in conjunction with the *HRM study: Juvenile Herring Abundance Index*. Prior to that juvenile herring survey and to ensure that our validation methods would be appropriate for our study area and goals, Megan McKinzie, the project's fisheries biologist, participated in the EVOS Gulfwatch study: *Monitoring long-term changes in forage fish distribution, abundance, and body condition in Prince William Sound* (USGS Alaska Science Center, PI's Piatt and Armitsu). From July 20-26, 2012 McKinzie was onboard the *R/V* Alaskan Gyre with other scientists assisting with data collection. In addition to acquiring experience fishing the mid-water trawl, McKinzie acquired critical information to determine the appropriate net and mesh size required for our herring validation surveys.

When we wrote the original proposal for this project we planned to use a trawl that was part of the PWS Science Center's inventory. Unfortunately, this trawl was lost during field work on another project, forcing us to purchase a new trawl. Due to hydraulic compatibility issues between our reel/winches and the charter vessel during the initial November 2012 survey we were unable to obtain sufficient power to successfully deploy and haul our mid-water sweeper trawl, despite several attempts at system modifications and replumbing. Therefore, within each survey bay variable mesh adult and juvenile herring gillnets were deployed and allowed to soak overnight in areas of high acoustic signature as an alternative validation method. To provide samples to the juvenile herring and disease projects conducted concurrently with the acoustic surveys we supplemented our validation efforts with a small mesh gillnet and cast nets. All fish captured were identified to species, separated and measured for total length and weight.

The first expanded adult herring acoustic survey began late March through early April 2013 aboard the *R/V Auklet.* We collected fish for Herring and Research Monitoring acoustic validation and genetics studies primarily using jigs and gillnets, and to a lesser extent castnets. We did not utilize the mid-water trawl for the adult survey validation component because of ADFG concerns that too many adult herring would be captured.

To prepare for the upcoming fall 2013 juvenile herring survey, we made equipment adjustments to our trawl winches and our hydraulics. On 15 March 2013 we successfully tested the trawl to ensure it is fully functional and that we have the necessary power to deploy and retrieve the net. From October 2013-December 2013 we participate in the biweekly *Juvenile Herring Intensive Acoustic & Validation Surveys*. In addition, in November 2013 we will conduct the validation surveys for the annual *Juvenile herring abundance index* acoustic surveys.

II. PROJECT DESIGN

A. Objectives

This study, *Validation of Acoustic Surveys for Pacific Herring Using Direct Capture*, is a process study that addresses **objective 3** of the *PWS Herring Research and Monitoring**: to address assumptions in the current measurements***. Our study will provide the ability to rapidly improve our understanding of the herring population in PWS. This effort will allow the design of the most accurate and efficient monitoring program.

Objectives specific to the *Direct Capture* study include:

1) Improve capture methods used for ground truthing 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.

In addition, to providing better information on acoustic targets. this study will bolster the current understanding of pelagic species composition and abundance in PWS.

B. Procedural and Scientific Methods

Field Collections and Laboratory Methods

To provide accurate data on insonified fish, the trawl will be towed simultaneous with acoustic surveys for juvenile herring and from the same research vessel. Based on our sampling objectives, desired species and age classes it was determined that a mid-water sweeper trawl would be the most effective net design. The net has an approximately 154 m^2 mouth (14 m x 11m) and is 22 m long. Mesh size diminishes from 38 mm at the mouth to 12 mm at the cod end (Innovative Net Systems, Inc.). The net is held open by two 0.4 m^2, series 2000 steel mid-water trawl doors (Nor 'Eastern, Inc.); each weighing approximately 76 lbs. The net and doors are deployed via dual winches with enough 3/8" dynema line to fish to a maximum depth of about 70 m. Target depth for juvenile herring capture is 15-25 m. Until a trawl master can be obtained, trawl depth and water temperature will be recorded every second using a DST centi-TD temperature depth recorder (Star-Oddi). To analyzed trawl performance and net orientation the trawl will also be equipped with as DST-tilt sensor (Star-Oddi). Data will be downloaded and reviewed between trawls. Average trawling speeds will be 2-3 kts.

Validation of acoustic echograms relies on ground trothing acoustic backscatter to confirm species composition and length frequency distribution of insonified fish (McClatchie et al. 2000). In each survey bay, we will conduct three 1-km tows in areas and depths with the strongest acoustic signature, as designated by the lead acoustician. For each haul, all catch items will be collected, broken down by species, then weighed and measured. In the case of large hauls, a random sub-sample of the catch will be collected and measured. For all non-herring species, 60 individuals/species will be randomly selected along with 200 herring for the collection of morphometric data.

Species composition and length frequency will be characterized by identifying all fish to species and measuring individual total length, fork length, standard length and weight. Juvenile herring of age 0+ and 1+ can be reliably aged based on length (Norcross et al. 2000, Kline unpubl. data), however, herring >150 mm will be aged using scale conventions developed by Alaska Department of Fish and Game (ADF&G). Adult herring captured during expanded spring surveys will be measured, sexed, aged, and assessed for spawning condition. Adult herring samples will be processed in collaboration with the Cordova office of ADF&G so that data can be incorporated into the ADFG herring age-structure-analysis model. All herring scales will be archived with ADF&G.

C. Data Analysis and Statistical Methods

Acoustic-based estimates of fish abundance rely on unique target strengths obtained for each fish species according to fishes' behaviors, physiologies, anatomies and morphologies, in addition to physical characteristics of the surveyed environment (Hazen and Horne, 2003). In most cases, the target strength obtained from hydroacoustic surveys is best described by the equation:

$$TS = m \log L + b + \mathcal{E}$$

where TS is the target strength, m and b are species specific coefficients, Ɛ is an error term and L is the mean fish length for the school (McClatchie et al., 1996, Stokesbury et al. 2000). Thus in order to validate acoustic signals, the aforementioned trawls will provide requisite species and length data necessary to obtain values of m, b and L. Trawl data will be compiled for such validation analysis by Dr. Buckhorn. See Buckhorn and Thorne proposal for details on echo integration and acoustic surveys. In addition to facilitating the validation of acoustic survey data, the proposed trawls will provide valuable fishery independent data on non-herring species and size composition (length and weight) for multiple bays throughout Prince William Sound. For a subset of non-herring species, otoliths will be collected, providing additional age data. These data will improve upon a scarce body of knowledge of pelagic fishes and populations, providing novel baseline data.

D. Description of Study Area

The study area includes all of Prince William Sound. However, most of the projects will focus on the four bays (Zaikof, Whale, Eaglek, and Simpson) that were extensively studied during the Sound Ecosystem Assessment study and PWS Herring Survey program (Figure 1). This allows the work to build upon the historical research completed in those bays. These bays also cover four different quadrants of the Sound. We anticipate a potential build out to include other bays or contraction based on the results from the synthesis. As part of the synthesis effort we will be reviewing the question "What is the appropriate sampling distribution?" as applied to the questions of juvenile herring condition and providing an index of juvenile abundance.

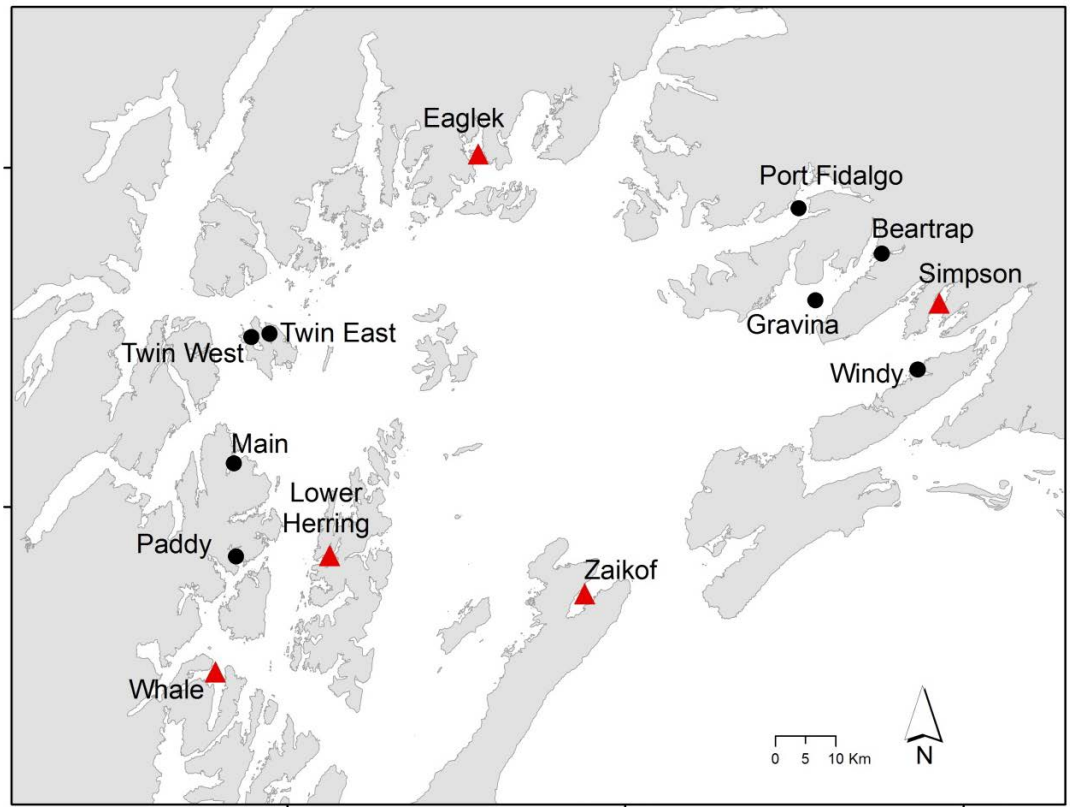

Figure 1. Map of Prince William Sound indicating bays surveyed for juvenile herring between November 2009 and March 2012. Primary bays indicated with red triangles.

E. Coordination and Collaboration with the Program

This proposal is part of the integrated "*PWS Herring Research and Monitoring*" proposal submitted by the Prince William Sound Science Center to the Exxon Valdez Oil Spill Trustee Council. It includes the collaboration and coordination described there for work within the herring research group and with the *Gulfwatch Long-Term Monitoring* proposal submitted by the Alaska Ocean Observing System. This proposal is structured to be a collaborative effort being led by the Prince William Sound Science Center. Program coordination will primarily be through e-mail and phone communications. Annual meetings are planned in Cordova, tentatively in May, for all investigators to share information between themselves and with the community. These in-person meetings are vital to ensure proper communication among programs.

Dr. Pegau will act as the team leader and be responsible for ensuring a coordinated and focused research program that leverages other assets whenever possible. He will be responsible for ensuring proper scientific oversight of individual projects and reporting to the EVOSTC. He will lead the development of annual work plans and the synthesis of findings from these programs. He will be responsible for coordinating the efforts of the herring research program with those of the Long-term Monitoring program. He will also be responsible for outreach and public input efforts.

Dr. Pegau currently is the coordinator of the existing EVOSTC funding PWS Herring Survey program. This program consists of ten individual projects that provide a coordinated examination of juvenile herring in Prince William Sound. This proposal is heavily influenced by the early findings from that effort. Dr. Pegau also serves as the Research Program Manager for the Oil Spill Recovery Institute (OSRI). In that capacity he is responsible for developing annual work plans, ensuring proper reporting, making reports available, developing partnerships to leverage funding, and to ensure outreach of OSRI activities. All activities that provide experience delivering the team leader duties outline in the request for proposals.

One of his duties is to ensure proper scientific oversight of the research programs. To accomplish this we will be setting up a four-person scientific oversight panel that will help guide the program and ensure the research is relevant to the long-term goal. The team will consist of people representing Alaska Department of Fish and Game, the National Oceanic and Atmospheric Administration, academia, and the local fishing community. There will be annual Principal Investigator meetings in Cordova each year to provide updates to the oversight panel, improve coordination between projects, and provide outreach and public input opportunities. This meeting will be in the spring so that there is opportunity to provide input on the development of the next year's work plan. In an effort to be proactive in the scientific oversight we sought input on the development of this proposal from ADF&G, NOAA, Cordova District Fishermens United (CDFU), and others. Team development and input on research direction was also sought at the 2011 Alaska Marine Science Symposium.

Coordination with the EVOSTC Long-term Monitoring program is critical to the success of the herring program. The ability to develop a predictive tool using the juvenile condition component requires an understanding of when feeding may occur and hence the need to coordinate with the oceanographic monitoring component. Predation by whales, fish, and birds are also considered potential factors inhibiting the recovery of herring. In that regard we will be looking to the monitoring program for information on the changes in the predator population base. That information will be critical if the herring program chooses to focus on predation during future efforts. The forage fish component and our efforts to develop an index of juvenile herring populations must inform each other. We expect that our hydroacoustic surveys and direct capture efforts will help provide measures of total fish biomass as well as forage fish populations. We will also work together to identify historical data that both programs would benefit from as part of the data management efforts. Throughout the proposal writing effort, the

herring and long-term monitoring efforts led by Kris Holderied have been working together to identify how the two programs can inform and complement each other.

Dr. Mary Anne Bishop (PWSSC) will lead the direct capture efforts needed for validation of hydroacoustic measurements and disease and condition studies. Bishop will oversee the project and coordinate with other studies that are part of the *PWS Herring Research & Monitoring* program. Specifically, the *Validation of Acoustic Surveys for Pacific Herring Using Direct Capture* project will be providing samples for projects by Drs. Kline and Heintz (herring condition) Dr. Hershberger (herring disease), Moffitt (herring scales), and Drs. Buckhorn and Thorne (juvenile herring index and intensive surveys; expanded adult herring surveys). In addition, Bishop will have primary responsibility for field work (fish capture), data integration, and completion of final products for *PWS Herring Research & Monitoring* synthesis. She will supervise her research assistant. Megan McKinzie. She will be responsible for project design, statistical analyses and data interpretation and preparation of a manuscript and contributing to the *PWS Herring Research & Monitoring* synthesis.

III. CV's/RESUMES

Curriculum Vitae

MARY ANNE BISHOP, Ph.D.
Research Ecologist,
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EDUCATION

Ph.D. Department of Wildlife and Range Sciences, University of Florida, Gainesville, 1988.
M.S. Wildlife and Fisheries Sciences, Department of Wildlife and Fisheries Sciences, Texas A & M University, College Station, 1984.
B.B.A. School of Business, University of Wisconsin, Madison, 1974.

RECENT PROFESSIONAL EXPERIENCE

Research Ecologist, Prince William Sound Science Center, Cordova, Alaska, Jun 1999-present
Research Wildlife Biologist, Copper River Delta Institute, Pacific Northwest Research Station, U.S. Forest Service, Cordova, Alaska, 1990-1994 and 1997- May1999
Research Wildlife Biologist, Center for Streamside Studies and Dept. Fisheries, University of Washington, assigned to Copper River Delta Institute, Cordova, Alaska, 1994-1997
Acting Manager, Copper River Delta Institute, Pacific Northwest Research Station, U.S. Forest Service, Cordova, Alaska, 1992-1993.

SELECTED SCIENTIFIC PUBLICATIONS (10 of 53)

*= publication resulting from herring research

***Bishop, M.A.,** J.T. Watson, K. Kuletz, T. Morgan. Pacific herring consumption by marine birds during winter in Prince William Sound, Alaska. *Fisheries Oceanography*. (accepted pending revisions).

Bishop, M.A., B.F. Reynolds, S.P. Powers. 2010. An *in situ*, individual-based approach to quantify connectivity of marine fish: ontogenetic movements and residency of lingcod. *PLoS ONE* 5(12): e14267

***Bishop, M.A.** and S.P. Green. 2001. Predation on Pacific herring (*Clupea pallasi*) spawn by birds in Prince William Sound, Alaska. *Fisheries Oceanography* 10 (1): 149-158.

*Cooney, R.T., J.R. Allen, **M.A. Bishop**, D.L. Eslinger, T. Kline, B.L. Norcross, *et al*. 2001. Ecosystem control of pink salmon (*Oncorhynchus gorbuscha*) and Pacific herring (*Clupea pallasi*) populations in Prince William Sound. *Fisheries Oceanography* 10(1): 1-13.

*Dawson, N.M., **M.A. Bishop**, K.J. Kuletz, A.F. Zuur.. Using ships of opportunity to assess winter habitat associations of seabirds in subarctic coastal Alaska. *Arctic*. *(accepted pending revisions)*.

Powers, S.P., **M.A. Bishop**, S. Moffitt, and G.H. Reeves. 2007. Variability in Freshwater, Estuarine and Marine Residence of Sockeye Salmon (*Oncorhynchus nerka*) within the Copper and Bering River Deltas, Alaska. Pages 87-99 in C. A. Woody (ed) *Sockeye salmon evolution, ecology and management*. American Fisheries Society, Symposium 54, Bethesda, MD.

Powers, S.P., **M.A. Bishop**, J.H. Grabowski, and C.H. Peterson. 2002. Intertidal benthic resources of the Copper River Delta, Alaska, USA. *Journal Sea Research* 47: 13-23.

Reynolds, B.F., S.P. Powers, **M.A. Bishop.** 2010. Application of Acoustic Biotelemetry to Assess Quality of Created Habitats for Rockfish and Lingcod in Prince William Sound, Alaska. *PLoS One* 5(8): e12130.

*Watson, J.T., **M.A. Bishop**, and S.P. Powers. Pacific cod predation on pacific herring during winter in Prince William Sound. *Fisheries Oceanography*. (in press).

*Zuur, A.F., N. Dawson, **M.A. Bishop**, K. Kuletz, A.A Saveliev and E.N. Ieno. 2012. Two-stage GAMM applied on zero inflated Common Murre density data. Pages 155-188 *in* A.F. Zuur, A.A.Saveliev, E.N. Ieno (eds). *Zero Inflated and Generalized Linear Mixed Models with R.* Highland Statistics Ltd, Newburgh, United Kingdom.

PROFESSIONAL COLLABORATIONS

M. Buckhorn (PWSSC), K. Carpenter (CRWP), N. Dawson (PWSSC), J. Eiler (NOAA), R. Federer (PWSSC), R. Heintz (NOAA), N. Hill (MIT), E.N. Ieno (Highland Statistics), K. Kuletz (USFWS), A. Lang (Memorial Univ.), F. Li (Intl. Crane Foundation), J. Moran (NOAA), T. Morgan (PWSSC), E. Nol (Trent Univ.), W.S. Pegau (OSRI), S. Powers (U. S. Alabama), B. Reynolds (PWSSC), G. Robertson (CA), D. Roby (OSU), J. Runstadler (MIT), A Saveliev (Highland Statistics), S. Senner (Audubon), Y. Suzuki (OSU), A. Taylor (UAA), R. Thorne (PWSSC), D. Tsamchu (Tibet Plateau Institute of Biology, PR China), J. Vollenweider (NOAA), J. Watson (PWSSC), M. Wille (Memorial Univ.), Z. Zuur (Highland Statistics)

IV. SCHEDULE

A. Project Milestones

Objective 1. Improve capture methods used for ground truthing acoustic surveys.
Field work completed April 2016. Synthesis evaluating techniques, August 2016.

Objective 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.
Completed April 2016.

Objective 3. Provide data on species composition and length frequency to aid in the interpretation of current and historical acoustic surveys.
Sampling completed April 2016. Data synthesis completed August 2016.

Objective 4. Provide adult herring samples to Alaska Department of Fish and Game for the adult herring age-structure-analyses model.
Completed April 2016.

Objective 5. Provide juvenile herring samples to researchers investigating juvenile herring fitness and disease.
Completed November 2015.

B. Measurable Project Tasks

FY 14, 1st quarter (Feb 1 – Apr 30, 2014)

Feb-Mar Biweekly Field Cruises: *Juvenile Herring Intensive Acoustic & Validation Surveys*
late Mar Field cruise: *Expanded Adult Herring Survey* with hydroacoustic & validation surveys

FY 14, 2nd quarter (May 1, 2014-Jul 31, 2014)

May-Jul Process fish & analyze data
Jul Prepare mid-year report & FY15 work plan

FY 14, 3rd quarter (Aug 1, 2014- Oct 31, 2014)

Aug Submit report & FY 15 work plan
Aug-Oct Analyze data

FY 14, 4th quarter (Nov 1, 2014 – January 31, 2015)

Nov Field cruise: *Juvenile herring abundance index* with hydroacoustic & validation surveys; disease & energetics collections
Dec Process fish samples
Jan Alaska Marine Symposium

V. BUDGET

Budget Form (Attached)