FY14 PROGRAM PROJECT
PROPOSAL FORM

Project Title: PWS Herring: Aerial Survey Support

Project Period: 1 February 2014 to 31 January 2016

Primary Investigator(s): W. Scott Pegau, Prince William Sound Science Center

Abstract:

This project is for providing aerial survey support to the EVOSTC sponsored Herring Research and Monitoring (HRM) and Gulf Watch Alaska (GWA) programs. For the HRM program the aerial support will be used to help collect herring samples for the genetics project and to provide an aerial index of age-1 herring abundance. For the GWA program the aerial support will be used by the forage fish project. The desire is to provide an aerial index of forage fish abundance and guide the capture efforts of the vessel. In turn the vessel will be providing ground truth of fish types and size of schools for better interpretation of the aerial based forage fish information. This proposal request is strictly for aerial support, all analysis and vessel funding will come from the existing projects. Funding for this project will be managed as a supplement to the HRM Coordination and Logistics project (12120111-O) led by Dr. Pegau.

Estimated Budget:
EVOSTC Funding Requested: $130,000
(breakdown by fiscal year and must include 9% GA)

FY 12	FY13	FY14	FY15	FY16
$ 0	$ 0	$65,000	$65,000	$ 0

Non-EVOSTC Funds to be used:
(breakdown by fiscal year)

Date:
August 30, 2013

PROJECT PLAN

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.

There are several needs for aerial support for the EVOSTC funded Herring Research and Monitoring (HRM) and Gulf Watch Alaska (GWA) programs. We need a capability to rapidly respond to remote locations in PWS for the collection of required samples that have been difficult to obtain using ships. The age-structure-analysis (ASA) model results can be improved by better knowledge of the expected incoming recruit class. Prediction of the recruiting class strength requires information that currently is not available. The aerial surveys provide one mechanism to address that need. The forage fish project in the GWA program also requires a better idea of the distribution of forage fish schools to help ensure their sampling program provides the best estimate of forage fish population. Additional aerial surveys will complement and improve the ongoing GWA forage fish research.

II. PROJECT DESIGN

A. Objectives

This project's objectives are:

1) Provide aerial support for collection of samples for the genetics project.
2) Provide an index of abundance of age-1 herring.
3) Provide aerial support to the forage fish project of the GWA program:
    a. Test the efficiency of adaptive vs. conventional sampling methods to optimize survey design for estimating stock size with an accurate estimate of the associated variance
    b. Validate aerial observations for species, age class, average biomass and school density.

B. Procedural and Scientific Methods

The herring genetics project is dependent on collecting samples from multiple spawning locations. In recent years there have been limited spawn events in areas outside of the Port Gravina and Port Fildago areas. This makes it difficult to ensure we can get a vessel to the spawning locations in time to collect fish. In 2013 we were able to use a plane to collect a herring sample from Kayak Island. The ability to rapidly access the spawning event allowed us

an opportunity to get a rare sample of fish from that location. The fish were turned over to ADF&G for their analysis and then to be shared with the genetics project of the HRM program. We intend to use a plane to access regions with active spawn for capture using cast nets, jigs, or gill nets. Four days of survey effort is requested for this purpose each of the next two years.

Aerial surveys led by Dr. Evelyn Brown during the Sound Ecosystem Assessment, Apex Predator Experiment, and PWS Herring Survey program provided an indication of the potential for using aerial surveys to provide an index of age-1 herring. This index has the potential for greatly improving the estimate of the number of age-3 herring to recruit to the spawning stock. The estimation of recruitment is critical to the ability for the age-structure-analysis model to be used to forecast herring biomass.

In the past, the aerial surveys were used to provide a measure of the density of age-1 herring in either June or July. In the last year of the aerial surveys for the PWS Herring Survey program Dr. Brown set up a survey approach that could be transitioned to a single spotter pilot. The approach divides PWS into several regions (Figure 1) and the pilot then surveys the region recording the number and size of schools and the assumed species/age. Size is split into three categories (small, medium, and large) based on the number of grid cells covered using the sighting tube used in previous surveys. Species and age is based on appearance of the school, with herring divided into age-0, age-1, and age-2+. Additional verification of aerial observations using vessel-based methods (i.e., hook and line, net collection methods, and hydroacoustics) will improve the reliability of the aerial schools index. Based on the previous surveys it was determined that June was the ideal month for surveying age-1 herring. This is due to no age-0 herring being present and eulachon and capelin tending to be in separate areas due to spawning. The simplified method proposed here is not used to estimate total density, but is used to provide a total number of schools per region. This simplified approach was used successfully in 2013.

Each survey region represents about one day of effort. By splitting the Sound into regions we can prioritize the regions in case the entire Sound cannot be surveyed due to weather. This will be done to maximize consistency between years. We expect to refine the survey regions this fall based on analysis of the previous data. Enough location information was collected in 2013 to allow us to reanalyze existing data if the boundaries of sampling regions are changed. The most likely changes will be in discontinuing surveys on the Gulf of Alaska side of Montague and Hinchinbrook islands and region 13. These are areas that traditionally do not have age-1 herring and are riskier to fly. Regions 2 and 3 will likely be combined.

Data from the previous years of surveys is currently being converted into the number of schools per region to determine how well the approach provides a prediction of incoming recruitment levels. We only have one measure of recruitment from the last four years of surveys. The age data from the 2013 spawning population needed to assess the recruitment will become available in the fall of 2013. There has been over an order of magnitude difference in the numbers of schools of age-1 herring observed in June in the recent years. From 2010 through 2013 the numbers of schools observed were 595, 150, 131, and 1,980 respectively. We still need to assess the number of schools observed during the Sound Ecosystem Assessment program, but the years of the observations were generally associated with small recruitment classes.

Dr. Pegau will be responsible for ensuring that proper data collection and analysis is conducted for the aerial data collected in support of the HRM program. His funding is included in the HRM coordination and logistics project. Eight days of survey effort are requested each year for this purpose.

The forage fish component of the GWA program identified the desire for aerial observations to provide another index of forage fish distribution and to help guide vessel-based sampling efforts. As originally proposed, the objectives of this work are to: 1) identify robust indices for monitoring forage fish populations over time and devise a sampling strategy for long term monitoring of those indices, 2) assess the current distribution, abundance, species composition, and body condition of forage fishes (other than herring) in selected areas of Prince William Sound at selected times of the year, and 3) relate abundance and distribution of forage species to abiotic characteristics of the marine environment. We originally designed a stratified systematic survey design for sampling forage fish. After testing this design in 2012-2013, and exploring the potential for using aerial surveys to locate schools in 2013, we believe a more efficient approach will incorporate larger scale aerial surveys to identify high density areas in the Sound, coupled with finer scale vessel-based hydroacoustic surveys to quantify forage schools.

In 2013 we worked with an experienced spotter pilot to find schools of herring, sand lance and capelin. The pilot was skilled at directing the boat to schools, and we were successful in quantifying the species and size composition of the schools. We also quantified small and medium herring schools with split beam dual frequency hydroacoustics, and we are working on those data to estimate biomass and density during fall 2013. Hydroacoustic validation of aerial observations will improve the schools/region index by increasing certainty in allocation of schools to species and age class, and may facilitate the quantification of biomass and fish density over time.

This project is designed as a supplement to the Herring Research and Monitoring (HRM) and Gulf Watch Alaska (GWA) programs. Oversight and reporting regarding this funding will be incorporated into the HRM coordination and logistics project.

Because both programs need similar survey information we are trying to determine if a single set of surveys can serve both programs. This would allow us to stretch the funding to cover the remaining three years of the programs instead of the two we expect the funding to cover. What we are balancing is the logistical constraints of the forage fish surveys that may not have access to the vessel in June and the quality of observations of age-1 herring in June. Both groups are looking for opportunities to ensure the highest quality data is provided and collaborate in the most effective manner.

C. Data Analysis and Statistical Methods

For the HRM program the initial analysis will be by the number of schools per region (Figure 1). The assumption is that the relative proportion of small, medium, and large schools remains constant through time. We will be testing that assumption using an ANOVA analysis using the data collected to determine if significant differences exist. The number of years of data to include remains small (seven), which limits the ability to discern differences. If there are

significant differences in school composition then we will shift from number of schools in our analysis to the area covered by the schools. Each school size is associated with an approximate area that will allow us to make the conversion.

As the recruitment information becomes available we will regress the number of schools observed against the estimated number of age-3 fish recruiting to the spawning stock. We will examine if a subset of the regions can be used to provide an accurate predictor of the total number of schools. This will be used to determine if reduced survey effort can be used in the future and to help prioritize survey efforts.

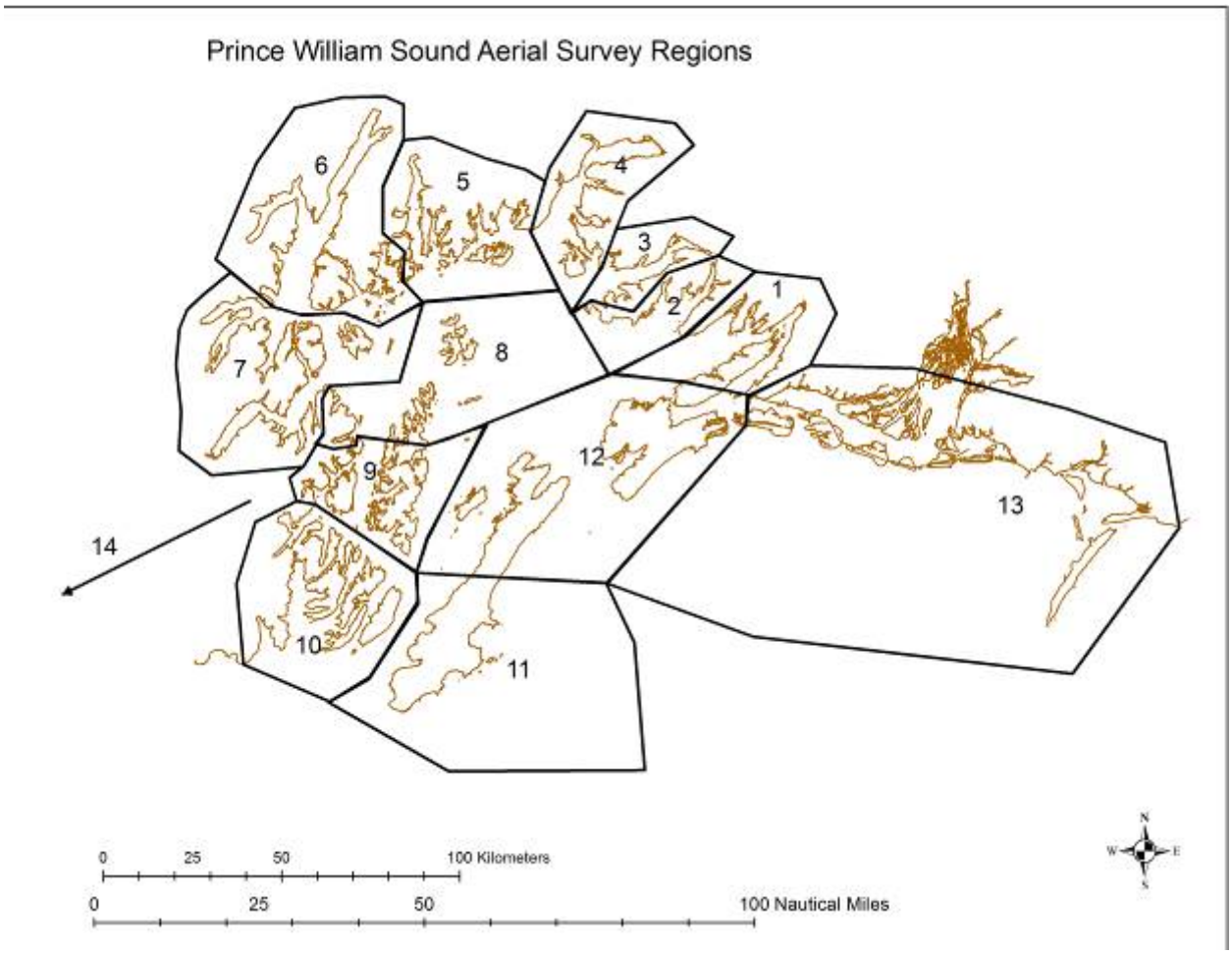

Figure 1. Survey regions as identified for the 2013 season. We expect to make refinements to regions 12 and 11 to remove the Gulf side of the islands and will probably drop region 13. These are not areas where age-1 herring tend to be found.

Work for the GWA forage fish program will require greater spatial resolution than proposed for the HRM program. In July 2013 the pilot made track lines using a handheld GPS, and recorded observations using a digital recorder. At the end of each flight day, the pilot handed off the data recorder and tracks so we could plot the locations of schools and rapidly assess high density areas for vessel-based work. This worked reasonably well (see Figure 2), and we would continue this level of effort at a minimum. Ideally we will have a near-real time large scale map of school

locations to aid in the allocation of hydroacoustic survey effort in the Sound. The validation of aerial observations will include 1) capture of fish in schools with jig, cast net, purse seine, midwater trawl, dip net, and underwater camera, and 2) hydroacoustic estimate of fish density and biomass for schools of different size and species classifications.

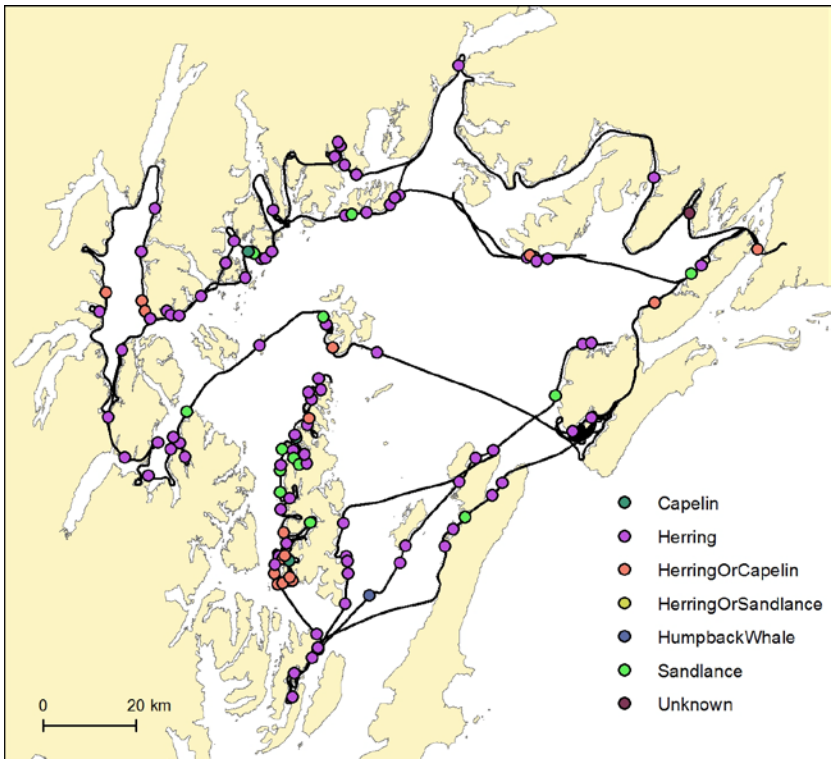

Figure 2. Aerial observations, including flight track (black line) and school locations (colored circles) during flights in July 2013.

D. Description of Study Area

The study area includes all of Prince William Sound (N, E, S, and W boundaries of respectively, ~ 61, -145.5. 60, and -149°). 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 2). 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 of bays sampled 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.

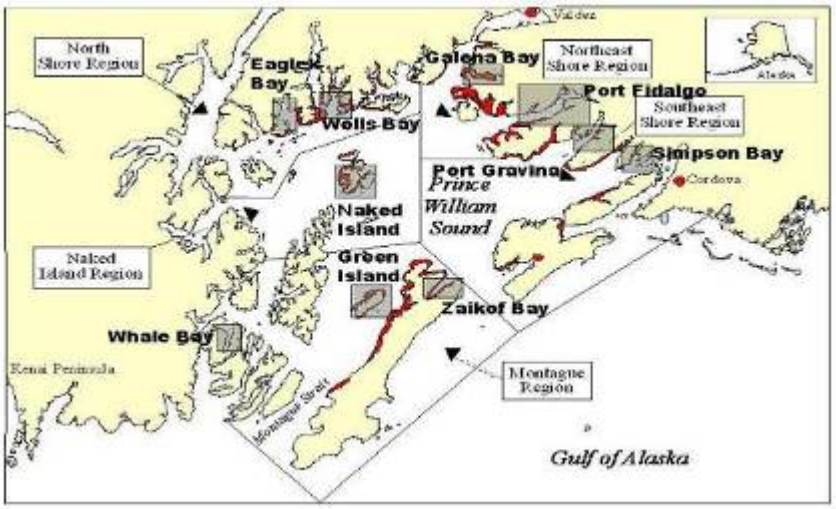

Figure 2. PWS study area, including the four SEA bays (Whale, Zaikof, Eaglek, and Simpson, as well as other bays historically important for juvenile herring.

E. Coordination and Collaboration with Other Efforts

This proposal will support projects in both the HRM and GWA programs. W. Scott Pegau will be responsible for ensuring the contracting of flights to support the two programs. He will also be responsible for ensuring the data related to the herring program is analyzed. He will coordinate with Mayumi Arimitsu to provide support for the forage fish project in the GWA program.

III. CV's/RESUMES

W. Scott Pegau
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Education:

1990 B.S., Physics, University of Alaska, Fairbanks
1996 Ph.D, Oceanography, Oregon State University

Professional Experience:

1987-1990 Research Assistant, University of Alaska, Fairbanks
1990-1996 Graduate Research Assistant, Oregon State University
1996-1997 Research Associate (Post Doc), Oregon State University
1997-1999 Faculty Research Associate, Oregon State University
1999-present Assistant Professor, Oregon State University
2002-2003 Senior Scientist, Kachemak Bay Research Reserve
2003-2007 Research Coordinator, Kachemak Bay Research Reserve
2007-present Research Program Manager, Oil Spill Recovery Institute

Research Interests:
To develop novel oil spill detection and tracking approaches. Understanding the fate and behavior of oil spilled in cold water environments. Development of response options for oceans with sea ice present. Circulation in Prince William Sound, Cook Inlet and the Gulf of Alaska and the associated larval transport. Relationship between oceanographic conditions and fisheries. Application of remote sensing for understanding coastal processes.

Publications
Selected publications

Pegau, W. Scott, Inherent optical properties of the central Arctic surface waters, *J. Geophys Res*, **107**, doi. 10.1029/2000JC000382, 2002.

Montes-Hugo, M. A., K. Carder, R. J. Foy, J. Cannizzaro, E. Brown, and S. Pegau, Estimating phytoplankton biomass in coastal waters of Alaska using airborne remote sensing, *Remote Sens. Environ.* **98**, 481-493, 2005.

Streever, B., R. Suydam, J.F. Payne, R. Shuchman, R.P. Angliss, G. Balogh, J. Brown, J. Grunblatt, S. Guyer, D.L. Kane, J.J. Kelley, G. Kofinas, D.R. Lassuy, W. Loya, P. Martin, S.E. Moore, W.S. Pegau, C. Rea, D.J. Reed, T. Sformo, M. Sturm, J.J. Taylor, T. Viavant, D. Williams, and D. Yokel, Environmental Change and Potential Impacts: Applied Research Priorities for Alaska's North Slope, *Arctic*, **64**, 390-397, 2011.

Moline, M.A., I. Robbins, B. Zelenke, W.S. Pegau, and H. Wijesekera, Evaluation of bio-optical inversion of spectral irradiance measured from an autonomous underwater vehicle, *J. Geophys. Res.*, **117**, 12pp., doi:10.1029/2001JC007352, 2012.

Musgrave, D.L., M.J. Halverson, and W.S. Pegau, Seasonal Surface Circulation, Temperature, and Salinity in Prince William Sound, Alaska, *Cont. Shelf Res.*, doi:10.1016/j.csr.2012.12.001, 2012

Collaborators

Mary Abercrombie (USF), Robyn Angliss (NOAA), Greg Balogh (USFWS), Mike Banner (UNSW), P. Bhandari (UM), Mary Anne Bishop (PWSSC), Rob Bochenek (Axiom consulting), Emmanuel Boss (U Maine), Kevin Boswell (FIU), Tim Boyd (SAM), Trevor Branch (UW), Evelyn Brown (Flying fish), John Brown, Michele Buckhorn (PWSSC), Lindsay Butters (PWSSC), Rob Cambell (PWSSC), L Carvalho (UCSB), Grace Chang (UCSB), Yi Chao (JPL), Paula Coble (USF), Robyn Conmy (EPA), Tim Cowles (OSU), Helen Czerski (U Southhampton), M. Darecki (PAS), Tommy Dickey (UCSB), C. Dong (IGGP), David Farmer (URI), Jim Farr (NOAA), Scott Freeman (NASA), J. Gemmrich (UVic), P. Gernez (U Nantes), Jess Grunblatt (UAF), Scott Guyer (BLM), Jeff Guyon (NOAA), B. Hagen (SAM), Nate Hall-Patch (IOS), Mark Halverson (PWSSC), Ron Heintz (NOAA), Paul Hershberger (USGS), Ben Holt (JPL), S. Jiang (UCSB), Mark Johnson (UAF), C. Jones (UCSB), Doug Kane (UAF), Lee Karp-Boss (U Maine), George Kattawar (TAMU), John Kelley (UAF), T. King (BIO), Tom Kline (PWSSC), Cory Koch (Wetlabs), Gary Kofinas (UAF), Kathy Kuletz (USFWS), J. Lacoste (Dalhousie), Denny Lassuy (DOI), D. LeBel (Lamont), Ken Lee (BIO), L. Lenain (SIO), Marlin Lewis (Satlantic), Y. Liu (MIT), L. Logan (UMiami), Wendy Loya (Wilderness org), Ted Maksym (WHOI), Darek Manov (UCSB) Phillip Martin (USFWS), W. Melville (SIO), Scott Miles (LSU), Steve Moffitt (ADF&G), Mark Moline (Cal Poly), Sue Moore (NOAA), Rue

Morison (UNSW), Dave Musgrave, F. Nencioli (MIO), Carter Ohlmann (UCSB), John Payne (DOI), Sean Powers (USA), Caryn Rea (Conoco), Dan Reed (ADFG), B. Reineman (SIO), Ian Robbins (Cal Poly), B. Robinson (BIO), Chris Roman (WHOI), R. Rottgers (HZG), Scott Ryan (BIO), H. Schultz (UMass), Li Shen (Johns Hopkins), M. Shinki (CRI), Matt Slivkoff(ISMO), M. Sokolski (PAS), Frank Spada (Sea Engineering), Nate Statom (SIO), Darius Stramski (SIO), Bill Streever (BP), Todd Sformo (NSB), Robert Shuchman (Mich Tech), Petere Sutherland (SIO), Hanumat Singh (WHOI), Matt Sturm (ACE), Robert Suydam (NSB), J. Taylor, Richard Thorne (PWSSC), Mike Twardowski (Wetlabs), S. Vagle (IOS), Ronnie Van Dommelen (Satlantic), Tim Viavant (ADFG), Johanna Vollenweider (NOAA), Ken Voss (UMiami), Ian Walsh (Wetlabs), Libe Washburn (UCSB), J. Wei (Dal), Hemantha Wijesekera (NRL), Dee Williams (BOEM), Sharon Wilde (NOAA), Amanda Whitmire (OSU), Jeremy Wilkinson (BAS), Michelle Wood (UO), O. Wurl (Old Domin), D. Yankg (John Hopkins), Dave Yokel (BLM), Dick Yue (MIT), Len Zabilansky (CRREL), Ron Zaneveld (Wetlabs), Chris Zappa (Lamont), Brian Zelenke (Cal Poly)

IV. SCHEDULE

A. Project Milestones

Objective 1. Provide aerial support for collection of samples for the genetics project.
This is an annual objective and will last through the two-year period.

Objective 2. Provide an index of abundance of age-1 herring.
This is an annual objective.

Objective 3 Provide aerial support to the forage fish project of the GWA program.
This is an annual objective and will last through the two-year period.

B. Measurable Project Tasks

FY14 1st Quarter (February 1, 2014 to May 30, 2014)

February	Establish finding
March	Contract pilot for survey efforts
May	Complete collection of fish for genetics research

FY14 2nd Quarter

June	Conduct aerial surveys for age-1 herring
July	Conduct aerial surveys for forage fish project

FY14 3rd Quarter

August	Complete annual processing of age-1 herring data.

FY14 4th Quarter

FY15 1st Quarter (February 1, 2014 to May 30, 2014)

February	Establish finding
March	Contract pilot for survey efforts
May	Complete collection of fish for genetics research

FY15 2nd Quarter

June	Conduct aerial surveys for age-1 herring
July	Conduct aerial surveys for forage fish project

FY15 3rd Quarter

August	Complete annual processing of age-1 herring data.

FY15 4th Quarter

V. BUDGET

Budget Form (Attached)

Budget Explanation

This budget includes a request for funding of aerial surveys. Twenty survey days are requested each year at a cost of $2,500 per day. Because the contracts are for a professional service and are actually three separate contracts the amount is subject to the PWSSC overhead rate of 30%.