EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY18 CONTINUING PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

Gulf Watch Alaska: Environmental Drivers Component Project

18120114-G—Long-term monitoring of oceanographic conditions in Prince William Sound

Primary Investigator(s) and Affiliation(s)

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Project Abstract

This project will continue physical and biological measurements to assess trends in the marine environment and bottom-up impacts on the marine ecosystems of Prince William Sound (PWS). Regular (~6 per year) vessel-based surveys of PWS will be conducted to maintain ongoing time series observations of physical (temperature, salinity, turbidity), biogeochemical (nitrate, phosphate, silicate, dissolved oxygen), and biological (chlorophyll-a concentration, zooplankton abundance and composition) parameters in several parts of PWS. Sampling sites include central PWS, the entrances (Hinchinbrook Entrance and Montague Strait), and four priority bays that were part of the *Exxon Valdez* Oil Spill Trustee Council- (EVOSTC)-funded Sound Ecosystem Assessment (SEA) project in the 1990s and the ongoing Herring Research and Monitoring project.

Additionally, an autonomous profiling mooring will be deployed each year in central PWS to provide high frequency (at least daily) depth-specific measurements of the surface layer that will be telemetered out in near real-time. The profiler will include measurements that complement the survey activities (temperature, salinity, oxygen, nitrate, chlorophyll-a, turbidity). An *in situ* plankton camera is under development and will be used to enumerate zooplankton, large phytoplankton and other particles, with some taxonomic discrimination.

FY17 spring and early summer observations in PWS indicate the spring bloom was about on time, the surface layer water temperature was 1-2 °C above average, but still showing negative anomalies below the surface layer. Some warm water zooplankton (southern species) are still present. We are not proposing any major changes to this project for FY18.

EVOSTC Funding Requested* *(must include 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
$218,700	$223,400	$228,300	$233,300	$238,500	$1,142,300

Non-EVOSTC Funds to be used, please include source and amount per source: (see Section 6C for details)

FY17	FY18	FY19	FY20	FY21	TOTAL
$300,000	$300,000	$275,000	$275,000	$275,000	$1,425,000

1. EXECUTIVE SUMMARY

The Ecosystem Drivers component of the Gulf Watch Alaska (GWA) program provides the spatial and temporal context for understanding change in the physical and chemical environment. Abiotic environmental changes will mediate lower trophic level (phytoplankton and zooplankton) productivity changes and subsequently propagate to mid and upper trophic level consumers. As in the first 5 years of GWA, this observation network consists of five interconnected projects distributed across the spill-impacted Gulf of Alaska (GOA). The focus of my project is oceanographic surveys of Prince William Sound (PWS) bays and entrances that builds upon 4 decades of prior work.

Within PWS, variations in annual productivity have been posited to vary with changes in upwelling/downwelling and the track of the Alaska Coastal Current (ACC; the River-Lake hypothesis of Cooney 2001). Some support was found for the hypothesis for some years (1981-1991), but not in others (Eslinger et al. 2001). The hypothesis has not been revisited since 2001. In the greater GOA, it has been suggested that salmon returns are mechanistically linked to zooplankton and phytoplankton productivity via large scale atmospheric and oceanographic processes (the Optimal Stability Window hypothesis of Gargett 1997). It has been suggested that retrospective data are lacking to test the hypothesis, but that long time series of hydrographic profiles and biological observations are one way to move forward (Gargett et al. 1998). Additional hypotheses include assessing the role of turbidity. The southern coast of Alaska is currently losing ice mass at some of the highest rates on earth (Jacob et al. 2012), which may be accompanied by increases in surface layer turbidity, which could then retard phytoplankton growth rates. Similarly, increases in freshwater inputs can be expected to have an impact on the timing of springtime stability, and the depth of the annual mixed layer where productivity occurs.

The goal of this project is to continue the time series of oceanographic observations in PWS that began in 2009 under the GWA program and to continue to put that new data into context with a 40-year conductivity-temperature-depth (CTD) database that has was assembled during the first five years of GWA (Figure 1). These data will be used to observe and describe how the region changes in response to the 2013-2016 warm anomaly and very strong El Niño event over the next few years, and to begin to address the many hypotheses for the mechanisms that are driving productivity in the region. In addition to more traditional vessel-based surveys to assess spatial

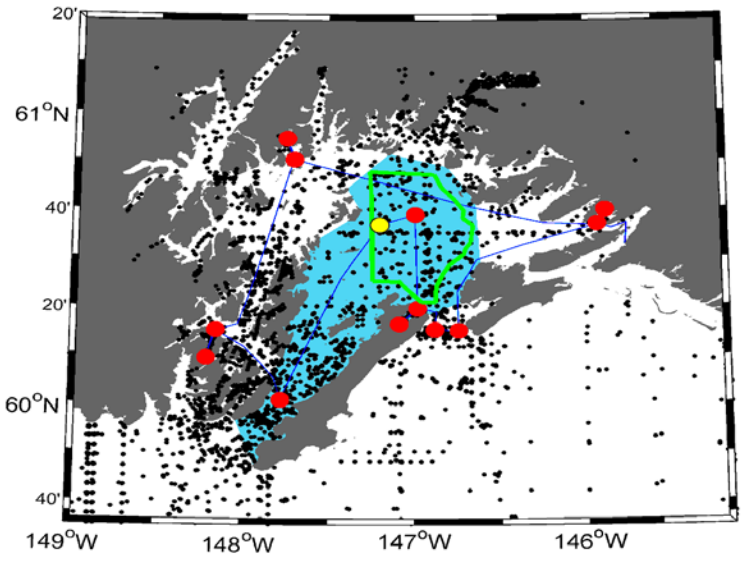

Figure 1: Prince William Sound. Black dots indicate the position of CTD casts done 1974-2016. Red dots indicate the stations visited during vessel surveys (this study), and the blue line indicates the standard vessel track. The yellow dot indicates the position of the autonomous profiling mooring. The blue area is the "central PWS" region, and was used for the determination of anomalies (see Figure 2). The green polygon is the area within which MODIS chlorophyll data are extracted.

variability of environmental drivers, a state of the art autonomous profiling mooring will be used to observe the annual cycle of physical, biogeochemical, and biological metrics in central PWS at very high frequency.

During the first 5 years of this project (16120114-E), an exhaustive effort to compile all historical CTD casts in the region was conducted. That database has been continually combined with the data collected by the GWA program and contains 23,150 unique profiles dating back to 1974 (Figure 1). Analysis of the anomalies in temperature shows a warming trend over the last 40 years at most depths (Figure 2). The temperature trend at the surface is flat, presumably due to enhanced inputs of cold meltwater at the surface along the margin of the GOA.

In late 2013, temperature anomalies shifted to primarily positive (Figure 2), like those observed throughout the Gulf of Alaska (Bond et al. 2015). Anomalies within PWS in 2015 were as much as 4 °C above average, which appears to be causing numerous changes in the marine ecosystem, including observations of rare southern species; mortality events in birds, mammals and starfish; and larger than average blooms of toxin producing phytoplankton. Examination of satellite chlorophyll records from central PWS shows that the spring phytoplankton bloom in 2014 was much earlier and stronger than average, 2015 was small and late, and 2016 was smaller and earlier.

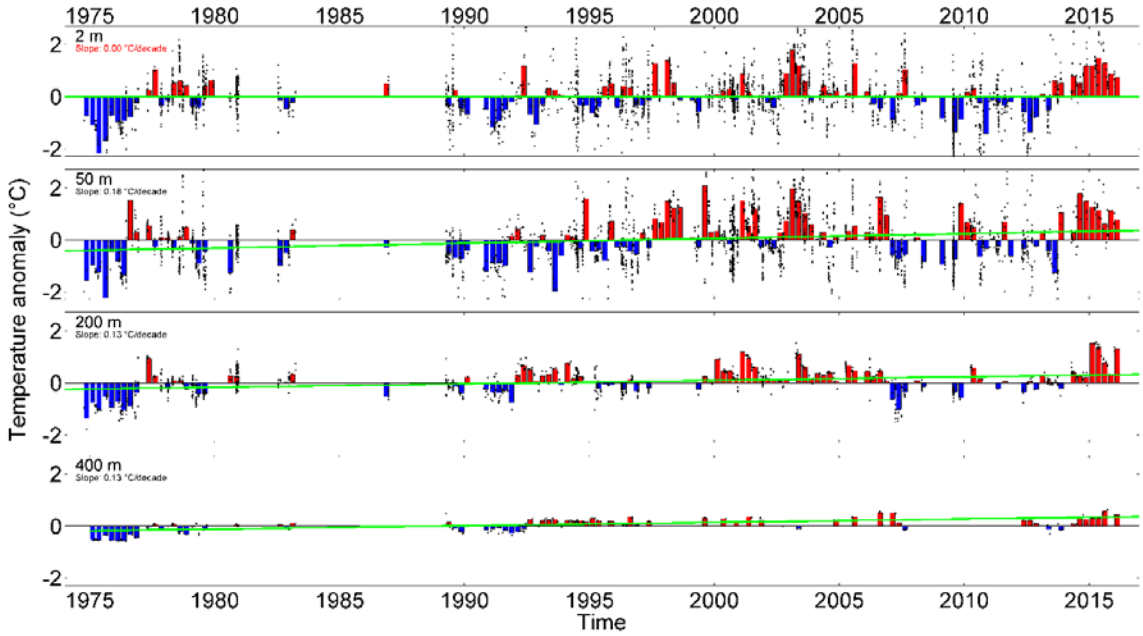

Figure 2: Temperature anomalies at four selected depths in central PWS (the blue-shaded area in Figure 1). Anomalies were calculated as the residual to a second order cosine curve fit to all years data (to remove seasonality). Black points are observations, bars are quarterly averages, and the green line indicates the linear trend. Slopes with text in black are significantly different from zero ($p<0.05$).

Observations so far in FY17 indicate that the spring bloom timing is near average, water temperatures show positive anomalies at the surface and negative anomalies below, and some warm water zooplankton (southern species) are still present. There are no major changes to sampling for this project in FY18, other than we will begin extracting data from the plankton imaging camera.

2. COORDINATION AND COLLABORATION

A. Within an EVOSTC-funded Program

Gulf Watch Alaska

This project links with the Lower Cook Inlet/Kachemak Bay long term monitoring effort: plankton samples collected in Lower Cook Inlet/Kachemak Bay are analyzed at the Prince William Sound Science Center by this project. The data collected will also be of use to projects under the Nearshore component (particularly in areas of overlap, such as Whale Bay), marine bird surveys, and the pelagic component by providing climatic context to their studies. The PI for this project has provided data and collaborated with other GWA PIs on publications and provided platforms of opportunity for other GWA investigators. For example, a hydrophone has been deployed on the profiling mooring since 2016 to listen for marine mammal vocalizations for the GWA long-term killer whale monitoring project (Project 18120114-N).

Herring Research and Monitoring

This project links directly with the Herring Research and Monitoring program by providing a bottom up context for the work on herring in PWS. Plankton samples will continue to be sent to P. Hershberger for herring disease studies.

Data Management

This project coordinates with the data management program by submitting data and preparing metadata for publication on the Gulf of Alaska Data Portal and DataONE within the timeframes required.

B. With Other EVOSTC-funded Projects

This project will coordinate with other EVOSTC-funded projects as appropriate by providing data, discussing the relevance and interpretation of data, and collaborating on reports and publications.

C. With Trustee or Management Agencies

Plankton samples have been regularly sent to Paul Hershberger of the U.S. Geological Survey Marrowstone Marine Field Station to test for the presence of Ichthyophonus life stages, and that sampling will continue under this project. With John Crusius (U.S. Geological Survey, University of Washington), we are discussing the addition of a low drift oxygen sensor to the moored profiler, which may be used to infer primary productivity from oxygen generation.

3. PROJECT DESIGN – PLAN FOR FY18

A. Objectives for FY18

The goal of this project is to provide environmental driver data to assess temporal and spatial changes in the marine environment in PWS. The data will be depth-specific (water column stability is important to ecosystem productivity), of sufficient frequency to capture timing changes (weeks), and give an idea of spatial variability in the region. Long term environmental monitoring data will be integrated with future herring studies as well as building upon ongoing work funded by the trustee council. We will maintain all sampling depicted in Figure 1. Specific objectives include:

1. Conduct regular surveys in PWS and its entrances to continue the ongoing time series of physical, biogeochemical, and biological parameters while also supporting continued herring research by

maintaining the existing time series (hydrography, plankton and nutrients) at the four SEA bays.

2. Install and maintain an autonomous profiling mooring in PWS that will conduct frequent (at least daily) profiles of the same physical, biogeochemical and biological parameters as the surveys, plus in situ observations of zooplankton, large phytoplankton and other particles (Figure 3).

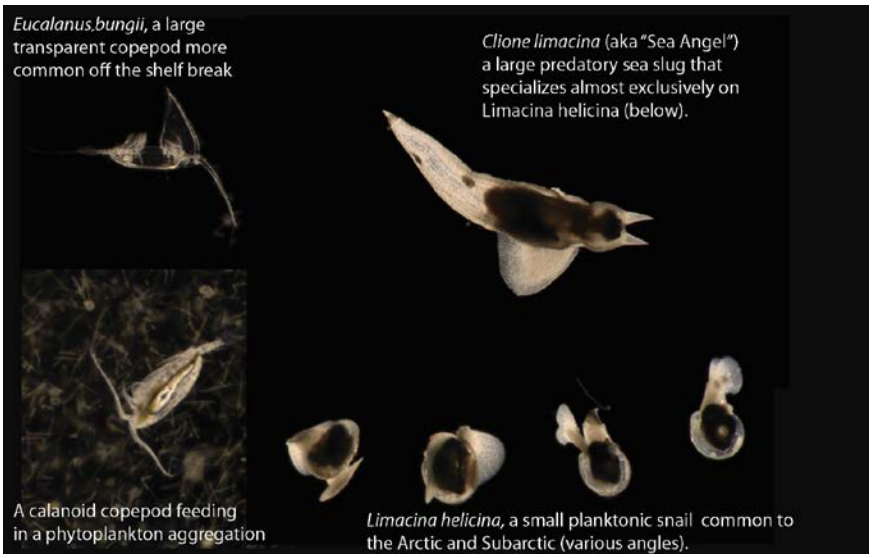

Figure 3: A selection of images from the plankton imaging camera in FY17.

B. Changes to Project Design

None

4. SCHEDULE

A. Project Milestones for FY18

Objective 1: 6 vessel-based surveys will be conducted each year between March and November. Samples will for the most part be analyzed as they come in. Nutrient samples (which are filtered and frozen) will be stockpiled and analyzed en masse at the end of each year. Data will be made available to GWA and HRM scientists via the Research Workspace and publicly-available on the Gulf of Alaska data portal within one year of collection.

Objective 2: The autonomous profiling mooring will be installed during the first survey of the year (late March, as weather allows), and will remain in place operationally until the final cruise of the year (~November).

B. Measurable Project Tasks for FY18

FY 2018 (Year 7)

FY 18, 1st quarter (February 1, 2018 - April 31, 2018)

February: *Prior year datasets available to public*

***March 1**:* *Submit annual report*

March: *PWS survey, install mooring, submit annual report*

April: *Attend quarterly PI teleconference*

FY 18, 2nd quarter (May 1, 2018-July 31, 2018)

May: *PWS survey, service mooring*
June: *PWS survey, service mooring*
July: *Attend quarterly PI teleconference*
July: *PWS survey, service mooring*

FY 18, 3rd quarter (August 1, 2018 – October 31, 2018)

August: *PWS survey, service mooring*
***August 23**:* *Submit annual program work plan*
September: *data compliance on Research Workspace*
October: *PWS survey, service mooring*

FY 18, 4th quarter (November 1, 2018- January 31, 2019)

November: *Attend annual PI meeting*
November: *PWS survey, service mooring*
January: *Attend quarterly PI teleconference or in person at AMSS*
January: *Sample analysis completed*

5. PROJECT PERSONNEL – CHANGES AND UPDATES

No changes.

6. BUDGET

A. Budget Forms (See GWA FY18 Budget Workbook)

Please see project budget forms compiled for the program.

B. Changes from Original Proposal

No changes from original proposal.

C. Sources of Additional Funding

A major refit of the profiling mooring (new communications and electronics, development of an in situ plankton camera) began in 2016 with support from the North Pacific Research Board ($400K from 2015-2018), and that project will also support higher than average frequency sampling and maintenance visits. In addition, a surface weather buoy that will be deployed adjacent to the mooring site is in development with support from the PWS Regional Citizen's Advisory Council ($125K from 2015-2018), which will expand the suite of measurements available at the site and support additional service visits at the mooring.

In-kind contributions include the instruments used on the vessel surveys (~$100K), mooring equipment used for the profiling mooring (releases, floats, ADCP current meters and CT recorders: ~$100K), laboratory equipment used for the nutrient, extracted chlorophyll-a, and zooplankton analyses (nutrient autoanalyzer, fluorometer, and microscopes: ~$75K). The vessel used for the surveys is owned by Prince William Sound Science Center, which allows the timing of the cruises to be very flexible, and to avoid the standby and mobilization/demobilization fees that are standard with a charter vessel.

7. RECENT PUBLICATIONS AND PRODUCTS

Publications

Campbell, R. W. 2017. Long term monitoring of oceanographic conditions in Prince William Sound. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 16120114-E), Prince William Sound Science Center, Cordova, Alaska.

Campbell, R. W. In press. Hydrographic trends in Prince William Sound, Alaska: 1960-2016. Deep Sea Research Part II: Topical Studies in Oceanography, Spatial and temporal ecological variability in the northern Gulf of Alaska: what have we learned since the *Exxon Valdez* oil spill?

McKinstry, C., and R. W. Campbell. In press. Seasonal variation in zooplankton abundance and communities in Prince William Sound, Alaska, 2009-2016. Deep Sea Research Part II: Topical Studies in Oceanography, Spatial and temporal ecological variability in the northern Gulf of Alaska: what have we learned since the *Exxon Valdez* oil spill?

Published datasets

Campbell, R. W. 2017. Oceanographic Conditions in Prince William Sound, CTD, Chlorophyll-a, and Zooplankton Data: 2013-2016, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k19.

Presentations

Campbell, R.W. 2017. Effects of the 2013-2016 warm anomaly in Prince William Sound, Alaska. Alaska Marine Science symposium, Anchorage.

Campbell, R.W. 2016. Surface layer and bloom dynamics observed with the Prince William Sound Autonomous Profiler. ASLO/AGO Ocean Sciences Meeting, New Orleans.

Campbell, R.W. 2016. Surface layer and bloom dynamics in Prince William Sound. Alaska Marine Science Symposium, Anchorage.

Campbell, R.W. 2016. Effects of the 2013-2015 warm anomaly in Prince William Sound, Alaska. Pacific Anomalies Workshop 2, Seattle.

Outreach

The profiler and camera system were profiled on the PWSSC Facebook page on July 17th.

Campbell, R.W. 2017. Say cheese, plankton! Delta Sound Connections. 2017-18, 16 pp. (http://pwssc.org/wp-content/uploads/2017/06/DSC-2017-web2.pdf).

LITERATURE CITED

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Cooney, R. T., K. O. Coyle, E. Stockmar, and C. Stark. 2001b. Seasonality in surface-layer net zooplankton communities in Prince William Sound, Alaska. Fisheries Oceanography. 10(Suppl. 1):97-109.

Eslinger, D. L., R. T. Cooney, C. P. McRoy, A. Ward, T. C. Kline, E. P. Simpson, J. Wang, and J. R. Allen. 2001. Plankton dynamics: observed and modeled responses to physical conditions in Prince William Sound, Alaska. Fisheries Oceanography 10(Suppl. 1):81-96.

Gargett AE. 1997. The optimal stability “window”: a mechanism underlying decadal fluctuations in North Pacific salmon stocks? Fish. Oceanogr. 6(2):109-117.

Gargett AE, Li M, Brown R. 1998. Testing the Concept of an Optimal Stability 'Window'. In: Holloway, G., P. Muller and D. Henderson (ed.) 'Aha Huliko'a: Biotic Impacts of Extratropical Climate Variability in the Pacific. Univ. Hawaii SOEST special publ.