August 24, 2016

Elise Hsieh, Executive Director
Exxon Valdez Oil Spill Trustee Council
4210 University Drive
Anchorage, AK 99508-4626

Dear Elise:

Final FY 2017-2021 Proposal Submittal for Long-term Monitoring

17120114-G. Long-term Monitoring of Oceanographic Conditions in Prince William Sound

Gulf Watch Alaska, the long-term monitoring program of the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC), has finalized our program and project proposals for fiscal years 2017-2021 funding based on comments received from EVOSTC's Science Panel on May 19, 2016. Below is the final budget summary and response to Science Panel comments for the Oceanographic Conditions in Prince William Sound project.

EVOSTC Funding Requested *(including 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
$218,700	$223,430	$228,310	$233,330	$238,530	$1,142,300

Non-EVOSTC Funding Available

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

Science Panel comment: *The Panel acknowledges the value of continued time series of physical, chemical, and biological primary production data to provide the basis for analyses of how changing environmental conditions are affecting the higher trophic level animals of the PWS and other spill-affected regions of the Northern Gulf of Alaska.*

PI Response:

- Thank you for the comment. The proposal was not revised.

Sincerely,

Mandy Lindeberg
Gulf Watch Alaska Program Lead designate

Attachment: Gulf Watch Alaska: Environmental Drivers Component Project Proposal: 17120114-G—Long-term Monitoring of Oceanographic Conditions in Prince William Sound

EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
PROGRAM PROJECT PROPOSAL SUMMARY PAGE

Project Title

Gulf Watch Alaska: Environmental Drivers Component Project:

17120114-G—Long-term monitoring of oceanographic conditions in Prince William Sound

Primary Investigator(s) and Affiliation(s)

Robert W. Campbell

Date Proposal Submitted

24 August 2016

Project Abstract

This project will continue physical and biological measurements that may be used 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 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: in central PWS, at the entrances (Hinchinbrook Entrance and Montague Strait), and at four priority bays that were part of the *Exxon Valdez* Oil Spill Trustee Council-funded Sound Ecosystem Assessment project in the 1990s and the ongoing Herring Research and Monitoring program.

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-development *in situ* plankton camera will also enumerate zooplankton, large phytoplankton and other particles, with some taxonomic discrimination.

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

FY17	FY18	FY19	FY20	FY21	TOTAL
$218.7	**$223.4**	**$228.3**	**$233.3**	**$238.5**	**$1,142.3**

Non-EVOSTC Funding Available

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

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 upwards to the mid and upper trophic level consumers. As in the first 5 years of GWA, this observation network consists of 5 separate, but often interconnected components distributed across the spill-impacted Gulf of Alaska (GOA):

- Oceanographic station GAK-1 at the mouth of Resurrection Bay that has over 45 years of nominally monthly repeat observations (Danielson)
- The multidisciplinary Seward Line surveys stretching 250 km from GAK-1 into offshore waters, and covering the deep passages of PWS for nearly 2 decades (Hopcroft)
- The Lower Cook Inlet Oceanographic surveys of the past decade (Doroff/Holderied)
- The oceanographic surveys of PWS bays and entrances that builds upon 4 decades of prior work (Campbell)
- The Continuous Plankton Recorder surveys that connect several of these surveys with the broader domain of GOA for the past 15 years (Batten)

Combined with measurements and analyses that incorporate other broad-scale ocean, atmosphere and cryosphere datasets, the Ecosystem Drivers component positions itself to understand the ramifications of environmental perturbations such as El Nino, the recent North Pacific warm water anomalies, longer-term trends of a warming climate, and altered species distributions and interactions.

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 been assembled (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 2016 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. As well as the more traditional vessel-based surveys that will return information on spatial variability, a state of the art autonomous profiling mooring will be used to observe the evolution of the annual cycle in physical, biogeochemical, and biological parameters in central PWS at very high frequency.

A marine pelagic ecosystem is a complicated network of constantly changing trophic and biogeochemical pathways, embedded within a 3-dimensional moving fluid that evolves in both space and time. The GOA ecosystem is of medium complexity (Fautin et al. 2010) but large spatial extent (order of 1.5×10^6 km^2) and is connected to PWS through the several large entrances, providing an upstream influence that is then modified within PWS in numerous ways (Cooney et al. 2001). In the Prince William Sound (PWS) region, there is a ~40-year time series of hydrographic, biogeochemical and biological observations, with the bulk of the data collected since the 1989 *Exxon Valdez* oil spill (EVOS); there is ongoing ecosystem monitoring work being done in the region, from ocean climate through top predators.

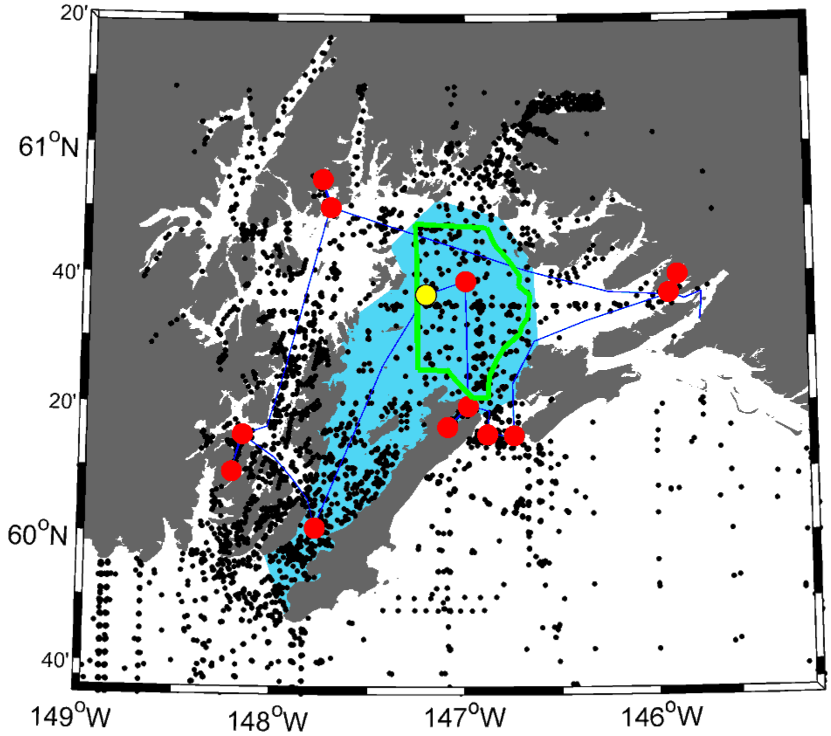

Figure 1: Prince William Sound. Black dots indicate the position of CTD casts done 1974-2016. Red dots indicate the stations visited during vessel surveys (this study), and the blue line indicates the standard vessel track. The yellow dot indicates the position of the autonomous profiling mooring. The 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 pixels were averaged (see Figure 3).

A great deal of research has been done on the relative importance of various forcing factors, such as "top down" vs "bottom up" (e.g., Megrey et al. 2009) or climate (Francis et al. 1998). Forcings are moving targets (Jochum et al. 2012) and it is not instructive to pick a single one (Rice 2001). That said, given the conservation of mass and energy, one can expect that the amount of material and energy entering at the bottom of a food web will constrain overall ecosystem productivity. Long term observations of biogeochemical cycling and lower trophic level dynamics are thus of considerable value to the understanding of the long term dynamics of the pelagic ecosystem in PWS.

Primary productivity in the GOA and PWS is highly seasonal, and thought to be mediated by the availability of light and water column stability (Henson, 2007). There is usually a large bloom each spring that depletes surface nutrients, a period of relatively low productivity through the summer months, and potentially a smaller autumn bloom as stability breaks down. The canonical mechanism for spring bloom formation is the Critical Depth Hypothesis (CDH; Sverdrup 1953), whereby bloom initiation occurs after stability reaches a critical depth and growth exceeds losses. Recent work elsewhere has suggested that the CDH does not necessarily hold, and that bloom formation may occur in winter, leading to the Dilution-Recoupling Hypothesis of Behrenfeld (2010), which explicitly includes zooplankton grazing. Neither hypothesis has been tested empirically in the GOA, likely due to lack of the necessary data.

Within PWS, variations in annual productivity have been posited to vary based on the variations 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 is 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).

There are any number of additional hypotheses for mechanisms structuring annual productivity that are more specific to the region that might be put forward, given appropriate observations. For instance, there is the role of turbidity: the waters of the margin of the GOA are quite turbid, the result of freshwater runoff containing particulates of glacial origin. 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.

Identifying interannual trends in a system that is strongly seasonal is challenging: as well as absolute differences (e.g., warmer vs. colder, less vs. more), there can be changes in timing (i.e., earlier vs later). For a system with irregular and infrequent sampling instances, it is often difficult to tell the difference. The PWS region has arguably one of the better time series in the GOA, particularly since EVOS. However, work

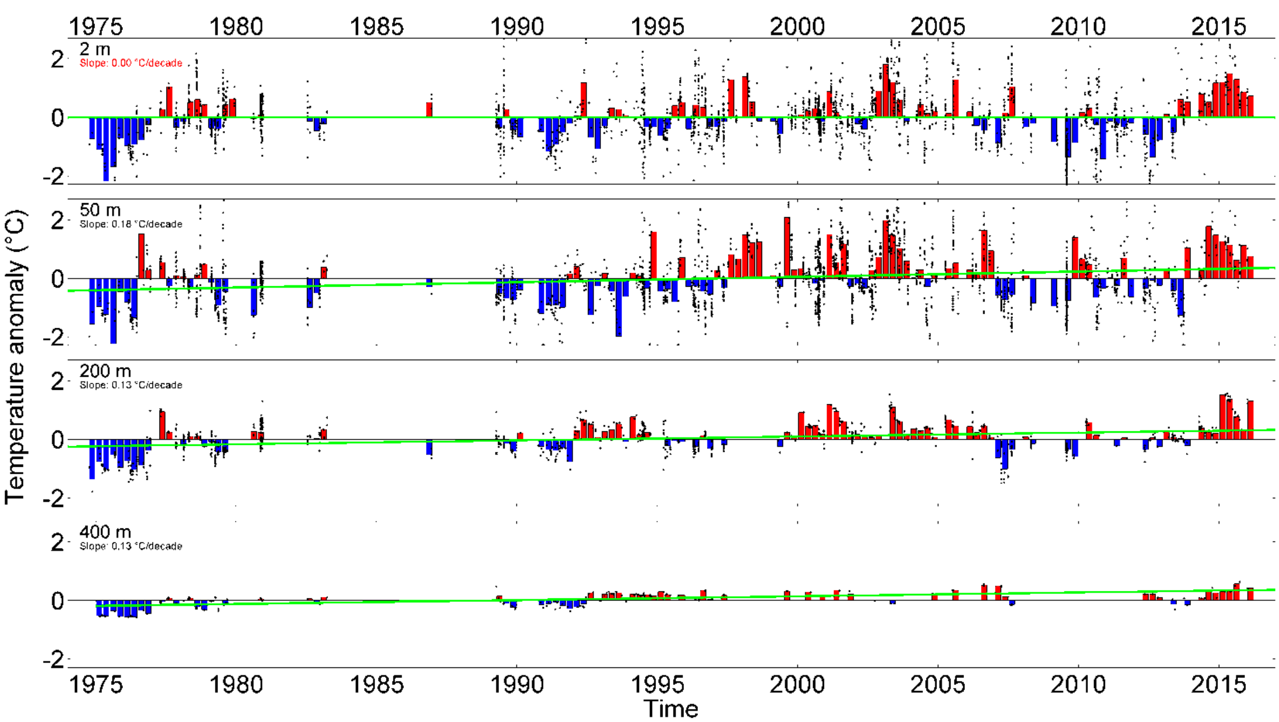

Figure 2: Temperature anomalies at four selected depths in central PWS (the blue-shaded area in Figure 1). Anomalies were calculated as the residual to a second order cosine curve fit to all years data (to remove seasonality). Black points are observations, bars are quarterly averages, and the green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

in the area has been done by several different projects, often with differing priorities, and inter- and even intra-annual coverage can be limited.

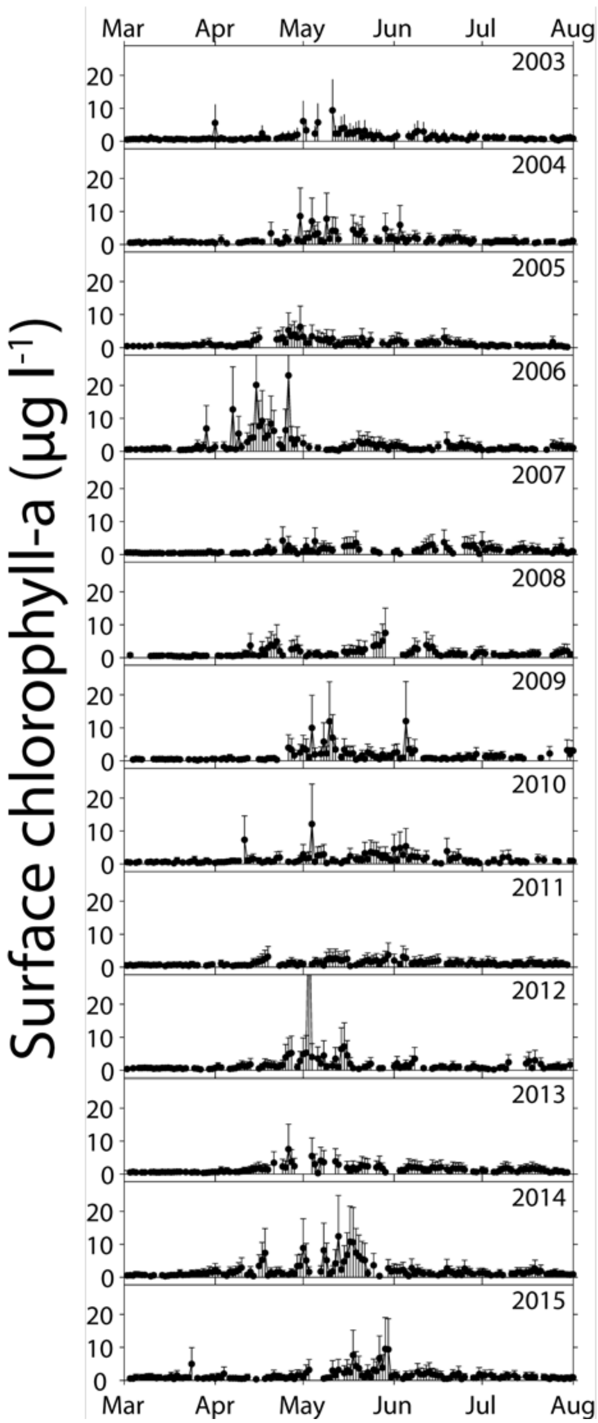

Figure 3: Annual time series of chlorophyll-a concentration in central PWS. Time series were produced from MODIS L3SMI composites (NOAA ERDDAP product erdMH1chla1day); daily averages (± SD) were calculated for all non cloud-masked pixels within the polygon in Figure 1.

As part of the ongoing GWA project (project 12120114-E) that precedes this proposal, an exhaustive effort to compile all historical CTD casts in the region has been conducted. Those efforts produced a database of casts dating back to 1974. That database has been continually combined with the data collected by the GWA program and as of January 2016 contains 23150 unique profiles throughout the region (Figure 1). The resulting dataset is temporally patchy and spatially variable: projects have come and gone over time, and the station locations have also varied. Some spatial aggregation is necessary to make use of the dataset (e.g., looking at "central PWS" as a single area). 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 (and not significantly different from zero), presumably due to enhanced inputs of cold meltwater at the surface along the margin of the GOA. In the northwestern portion of PWS (not shown), the trend at the surface is one of cooling and freshening.

In late 2013, temperature anomalies shifted to primarily positive (Figure 2), which echoes a pattern of warm anomalies observed GOA-wide (Bond et al., 2015). That anomaly (colloquially referred to as "The Blob") is hypothesized to have arisen as a result of a strong atmospheric ridge creating a persistent high pressure of the GOA, which in turn altered storm tracks and resulted in less than average winter cooling (Bond et al. 2015). Estimates of heat flux at buoys in PWS suggest that the same mechanism occurred within the PWS region (Campbell, 2016). 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. The winter of 2015/2016 is also reported to be one of the strongest El Niños on record. At the time this proposal was submitted (August 2016) sea surface temperatures measured by buoys in PWS remained ~1-1.5 °C above average.

Biological and biogeochemical observations in PWS are much sparser than temperature and salinity, and it is difficult to describe trends without a long time series. The best record currently is satellite chlorophyll (which is confounded by the high degree of cloudiness in the region, as well as by turbidity artifacts). Examination of satellite chlorophyll records from central PWS (Figure 3) shows that phytoplankton abundance varies considerably over the course of each year, with many episodic blooms (both during the major spring bloom, and earlier and later in the year). The spring bloom in 2014 ("Blob" year #1) was much earlier and stronger than average, while in 2015 it was comparatively small and late. Observations made by ongoing GWA projects also support that idea. Preliminary analysis of observations made in 2016 by the central PWS profiler suggest that this year's spring bloom was also smaller and earlier than average.

2. Relevance to the Invitation for Proposals

This project addresses both of the areas of interest under the Environmental Drivers component. It proposes to continue the monitoring of oceanographic conditions, including water temperature, salinity, and turbidity (as well as oxygen, chlorophyll-a fluorescence and zooplankton concentrations) throughout the spill-affected area, and in the area most heavily impacted by the spill. As well as the biological studies done by this project, the data collected is of use and interest to several of the other sub-components of the project, including other Environmental Drivers projects, as well as Nearshore and Pelagic projects, and the Herring Research and Monitoring program (Campbell is already actively collaborating with several members of those projects).

This project also includes numerous measurements of macronutrients (nitrate, phosphate and silicate) both from water samples collected during vessel surveys, and from the profiling mooring (which has a nitrate sensor on board) that may in part be used to assess the transport of nutrients into PWS. Estimates of inflows/outflows to the system are required to estimate nutrient budgets, but were not included in this proposal to keep costs reasonable; interannual changes in nutrient concentrations in deep waters may provide clues about the year to year changes in inputs attributable to deepwater renewal.

3. Project Personnel

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Prince William Sound Science Center
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(907)424-5800 x241(office)
rcampbell@pwssc.org

Please see 2-page CV at end of this document

4. Project Design

A. Objectives

The goal of this program is to deliver a monitoring program that will return useful information on temporal and spatial changes in the marine environment in PWS, at a reasonable cost. The data will be depth-specific (because water column stability is important to ecosystem productivity), of sufficient frequency to capture timing changes (changes that occur on order of weeks), and give an idea of spatial variability in the region. As well, given that PWS herring will remain a funding priority of the *Exxon Valdez* Oil Spill Trustee Council

(EVOSTC) in the next 20 years, any long term monitoring efforts will be integrated with future herring studies as well as building upon ongoing work funded by the EVOSTC. 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 Sound Ecosystem Assessment project 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.

B. Procedural and Scientific Methods

Vessel surveys will be conducted 6 times per year, and will visit the four Sound Ecosystem Assessment project bays (Eaglek, Simpson, Whale, and Zaikof) that have been a focus of prior EVOSTC funded research, as well as Hinchinbrook Entrance, Montague Strait, and central PWS (Figure 1). Each station will include a CTD cast, water samples for nutrient and chlorophyll-a analysis, and a zooplankton tow (a 202 µm mesh, 60 cm diameter bongo net). Two stations will be sampled in each of the bays, one near the head where juvenile herring are more frequently encountered, and one in more open waters at the mouth of the bay where older age classes are more common. The timing of the surveys will be structured around the "productivity season" to attempt to capture the spring and autumn blooms (i.e., pre-bloom, bloom and post-bloom). The data collected during the surveys (particularly phytoplankton abundance and nutrient concentrations) will be compared to the high frequency record in the central sound, in order to assess how the timing and magnitude of production events in the bays differs from the open waters of PWS. Stage composition of the copepod species collected by the plankton net will also give information on annual changes in phenology.

The Seabird SBE25plus CTD used in the surveys has in initial accuracy of ±0.001 °C and ±0.0003 S/m for temperature and salinity; and drift between annual calibrations has been on order of 0.0002 °C/year and 0.0003 PSU/month, respectively. The Wetlabs FLNTU fluorometer/turbidometer has a resolution of 0.01 µg l^{-1} chl-a and 0.01 NTU, and the Seabird SBE43 oxygen sensor has an accuracy of ±2% of saturation and a drift of ~3% per year. Extracted chlorophyll-a has a detection limit of 0.05µg/l. Nutrients will be measured on a Seal Analytical AA3 autoanalyzer, and detection limits for nitrate, phosphate and silicate are 0.015 µM, 0.03 µM, and 0.29 µg/l, respectively.

The autonomous profiling mooring is deployed in central PWS near Naked Island (Figure 1). The site is the same location occupied by a surface buoy deployed during the SEA project (Eslinger et al. 2001) and co-located with a sampling site occupied during Seward Line cruises (see Hopcroft's Seward Line proposal). The mooring is an Autonomous Moored Profiler (AMP; WetLabs, Inc.). The AMP is a self-contained positively buoyant float that is capable of profiling from ~60 m to the surface, via an onboard winch that pays out and retrieves a thin (4mm UHMWPE) tether. The system is powered by an onboard 1.5 kWh battery, which allows ~45 profiles from 60 m to the surface per charge (i.e. 6 weeks of daily profiles). The instrument payload on the AMP includes a Seabird SBE16 CTD (0.01 °C, 0.001 S/m resolution), a Wetlabs FLNTU fluorometer/turbidometer (0.01 µg l-1 chl-a and 0.01 NTU resolution), and a UV nitrate analyzer (a Satlantic SUNA: 2 µM resolution). The profiler underwent significant upgrades in early 2016, including new controller electronics and new communications hardware. An in situ camera system was developed in collaboration with researchers at the Scripps Institution of Oceanography, it is expected to sample ~700 ml of water at 4 Hz, with a pixel resolution of ~15 µm. As of mid-July 2016, the camera had taken over one million images of individual plankters, totaling over 26 gigabytes.

C. Data analysis and statistical methods

The patchiness of the long term dataset in space and time (e.g., see Figures 1 & 2) confounds standard time series analysis, and some spatial binning is required to produce time series that are dense enough to analyze. At present, spatially binned data (such as the blue area in Figure 1) are seasonally detrended with a second order cosine function, anomalies determined from the residuals, and used to detect long term trends (Figure 2). Trends have been examined with standard linear regression and more complicated nonlinear models to incorporate cyclical variations (such as the 18.6-year nodal tidal signal that arises in many geophysical datasets). Power analysis has not yet been conducted on this series of methods, and will likely require a Monte Carlo simulation approach to be developed.

Plankton distributions will be analyzed with a set of common multivariate approaches. Species-by- station matrices will be assigned into clusters by various similarity metrics (Bray-Curtis being the most common). Following clustering, indicator species analysis (ISA) applied to the clusters returns information on the species that define the cluster groups (Legendre and Gallagher 2001). The impact of environmental parameters on species assemblages will be analyzed with Canonical Correlation Analysis, which permits reducing dimensionality and determining which environmental axes most closely relate to different zooplankton taxa. Multivariate approaches such as these are better described as descriptive (versus inferential), and power analysis is not usually applied.

The data collected by the profiling mooring results in an impressive record of the seasonal cycle of all of the parameters being measured. The onset of seasonal stratification is captured in the temperature and salinity records, and the effect of wind events on stratification is evident. The uptake of nutrients and increased fluorescence that accompanies the growth of phytoplankton is also apparent. To better understand how the physical environment is forcing lower trophic level productivity in that area, the one-dimensional physical-biological model developed by Allen and Wolfe (2013) will be adapted to Prince William Sound (the model code is available online from Susan Allen). The model framework allows the impacts of various physical and biogeochemical variables to be parsed out and examined separately.

D. Description of study area

This study will be conducted throughout PWS; the stations occupied are shown in Figure 1 and Table 1.

Table 1: Station locations

Station	Latitude	Longitude
Simpson Bay head	60.67	-145.87
Simpson Bay mouth	60.61	-145.93
Hinchinbrook Entrance East	60.25	-146.73
Hinchinbrook Entrance West	60.25	-146.89
Zaikof Bay head	60.27	-147.09
Zaikof Bay mouth	60.34	-146.96
Montague Strait	60.01	-147.77
Whale Bay head	60.15	-148.21
Whale Bay mouth	60.23	-148.17
Eaglek Bay head	60.93	-147.74
Eaglek Bay mouth	60.85	-147.71
Central PWS	60.58	-146.93
Profiling Mooring	60.61	-147.20

5. Coordination and Collaboration

WITHIN THE PROGRAM

This project links materially with the Lower Cook Inlet/Kachemak Bay long term monitoring effort: plankton samples collected under that program will be 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) and the Pelagic component by providing climatic context to their studies. During the predecessor project to this proposal, Campbell has collaborated with the other GWA program team members on publications, by providing data, and by making room on cruises for other researchers. In collaboration with the Matkin group (long-term monitoring of killer whales in PWS/Kenai Fjords), a pilot hydrophone was deployed on the profiling mooring in 2016 to listen for marine mammal vocalizations (early results show several good detections of vocalizations). Pending results of the pilot study, it is expected that it will continue be deployed for the duration of this project.

WITH OTHER EVOSTC-FUNDED PROGRAMS AND PROJECTS

This project links directly with the Herring Research and Monitoring program submitted separately to the EVOSTC. This project provides a bottom up context for the proposed work on herring in PWS. Plankton samples have been sent to Hershberger group for herring disease studies for several years, and those activities will continue.

WITH TRUSTEE OR MANAGEMENT ACTIVITIES

Plankton samples have been regularly sent to the U.S. Geological Survey Marrowstone group for tests for the presence of Ichthyophonus life stages, and that sampling will continue under this project. Discussions with John Crusius (U.S. Geological Survey, University of Washington) began in 2016 about adding a low drift oxygen sensor to the moored profiler, which may be used to infer primary productivity from oxygen generation.

WITH NATIVE AND LOCAL COMMUNITIES

Water samples for measurement of carbonate chemistry will be taken during the vessel surveys and sent to the analysis facility at the Alutiiq Pride Shellfish Hatchery in Seward (owned and operated by the Chugach

Regional Resource Division, a coalition of several Native villages in the Chugach region). Their observations will assist other researchers in tracking the impacts of Ocean Acidification in PWS. This collaboration began in 2016 on the predecessor project to this proposal.

Campbell has given several public lectures in the region on the "State of the Sound" to local residents, and will continue to do so, and to participate in media outreach (radio, TV, podcasts).

6. Schedule

PROJECT MILESTONES

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 mass at the end of each year. Data will be made available via the online workspace and publically-available GWA 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). In the event of breakdowns, the profiler will be repaired as soon as possible and returned to service.

MEASUREABLE PROGRAM TASKS

Measurable project tasks are presented by fiscal year and quarter graphically in Table 2 and descriptively below.

Table 2. Schedule of Measurable Project Tasks

Task	FY17				FY18				FY19				FY20				FY21			
	Quarter (EVOSTC FY beginning Feb. 1)																			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Task 1 Surveys																				
Vessel surveys	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sample analysis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Data available online					X				X				X				X			
Task 2 Profiling mooring																				
Mooring deployed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Service/calibration				X	X			X	X			X	X			X	X			
Task 3 Reporting																				
Annual Reports					X				X				X				X			
Annual PI meeting				X				X				X				X				X
FY Work Plan (DPD)			X				X				X				X					

FY 2017 (Year 6)

FY 17, 1st quarter (February 1, 2017 - April 30, 2017)
March: *PWS survey, install mooring*

FY 17, 2nd quarter (May 1, 2017 - July 31, 2017)
May: *PWS Survey, service mooring*
June: *PWS Survey, service mooring*
July: *Service mooring*

FY 17, 3rd quarter (August 1, 2017 - October 31, 2018)
August: *PWS Survey, service mooring*
October: *PWS Survey, service mooring*

FY 17, 4th quarter (November 1, 2017 - January 31, 2018)
November: *PWS survey, remove mooring*
January: *Sample analysis completed*

FY 18 (Year 7)

FY 18, 1st quarter (February 1, 2018 - April 30, 2018)
March *PWS survey, install mooring, submit annual report*

FY 18, 2nd quarter (May 1, 2018 - July 31, 2018)
May: *PWS survey, service mooring*
June: *PWS survey, service mooring*
July: *Service mooring*

FY 18, 3rd quarter (August 1, 2018 - October 31, 2019)
August: *PWS survey, service mooring*
October: *PWS survey, service mooring*

FY 18, 4th quarter (November 1, 2018 - January 31, 2019)
November: *PWS survey, remove mooring*
January: *Sample analysis completed*

FY 19 (Year 8)

FY 19, 1st quarter (February 1, 2019 - April 30, 2019)
March: *PWS survey, install mooring, submit annual report*
February-April : *Analysis ongoing*

FY 19, 2nd quarter (May 1, 2019 - July 31, 2019)
May: *PWS survey, service mooring*
June: *PWS survey, service mooring*
July: *Service mooring*

FY 19, 3rd quarter (August 1, 2019 - October 31, 2019)
August: *PWS survey, service mooring*
October: *PWS survey, service mooring*

FY 19, 4th quarter (November 1, 2019 - January 31, 2020)
November: *PWS survey, remove mooring*

January: *Sample analysis completed*

FY 20 (Year 9)

FY 20, 1st quarter (February 1, 2020 - April 30, 2020)
March: *PWS survey, install mooring, submit annual report*

FY 20, 2nd quarter (May 1, 2020 - July 31, 2020)
May: *PWS survey, service mooring*
June: *PWS survey, service mooring*
July: *Service mooring*

FY 19, 3rd quarter (August 1, 2020 - October 31, 2020)
August: *PWS survey, service mooring*
October: *PWS survey, service mooring*

FY 20, 4th quarter (November 1, 2020 - January 31, 2021)
November: *PWS survey, remove mooring*
January: *Sample analysis completed*

FY 21 (Year 10)

FY 21, 1st quarter (February 1, 2021 - April 30, 2021)
March: *PWS survey, install mooring, submit annual report*

FY 21, 2nd quarter (May 1, 2021 - July 31, 2021)
May: *PWS survey, service mooring*
June: *PWS survey, service mooring*
July: *Service mooring*

FY 19, 3rd quarter (August 1, 2020 - October 31, 2020)
August: *PWS survey, service mooring*
October: *PWS survey, service mooring*

FY 21, 4th quarter (November 1, 2021 - January 31, 2022)
November: *PWS survey, remove mooring*
January: *Sample analysis completed, submit manuscript*

7. Budget

BUDGET FORMS (ATTACHED)

Completed budget forms are attached.

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.

As well, 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), and will allow additional opportunities for service visits at the mooring (as well as expanding the suite of measurements available at the site).

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 PWSSC, 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.

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PROJECT DATA ONLINE

http://portal.aoos.org/gulf-of-alaska.php#metadata/fc5b0956-ef7c-49df-b261-c8e2713887fc/project

http://portal.aoos.org/gulf-of-alaska.php#metadata/fc5b0956-ef7c-49df-b261-c8e2713887fc/project/files

Robert William Campbell
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EDUCATION

Doctor of Philosophy, University of Victoria, School of Earth and Ocean Sciences (1999-2003)
Thesis: "Overwintering ecology of Neocalanus plumchrus"
Master of Science, Biology, Dalhousie University (1996-1998)
Thesis: "Reproduction of Calanus finmarchicus in the western North Atlantic: fecundity and hatching success"
Bachelor of Science (Hons), Biology, University of Toronto (1991-1996)
Thesis: "Simulation and bioenergetic modeling of Walleye (Stizostedion v. vitreum) populations"

APPOINTMENTS

2007 – present Oceanographer, Prince William Sound Science Center
2010 – present Affiliate faculty, University of Alaska Anchorage
2004-2006 Post-doctoral researcher, University of Hamburg, Germany

PROFESSIONAL SOCIETY MEMBERSHIP/PROFESSIONAL SERVICE

Member, American Society of Limnology and Oceanography (1998-present)
2007: Member-at-large, Education and Human Resource Image Library Subcommittee
Member, International Council for the Exploration of the Sea
Member, Exxon Valdez Trustee Council Integrated Herring Restoration Plan Working Group.
Proposal Reviewer: NPRB, National Science Foundation, Deutsche Forschungsgemeinschaft.
Report Reviewer: Exxon Valdez Trustee Council
Manuscript Reviewer: Canadian Journal of Fisheries and Aquatic Sciences, ICES Journal of Marine Science, Journal of Marine Systems, Journal of Plankton Research, Marine Biology, Marine Ecology Progress Series, Progress in Oceanography

RECENT RELEVANT PUBLICATIONS

Batten, S.D., Moffitt, S., Pegau, W.S. and R. Campbell. 2016. Plankton indices explain interannual variability in Prince William Sound herring first year growth. Fisheries Oceanography. 25:420-432.
Schroth, A.W., Crusius, J., Hoyer, I. and R. Campbell. 2013. Estuarine removal of glacial iron and implications for iron fluxes to the ocean. Geophysical Research Letters.
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OTHER PUBLICATIONS

Campbell, R.W. and J.F. Dower. 2003. The role of lipids in the regulation of buoyancy by zooplankton. Mar. Ecol. Prog. Ser. 263:93-99.
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RECENT COLLABORATORS (EXCLUSIVE OF CO-AUTHORS ABOVE)

Batten, Sonia; Bishop, Mary Anne; Causey, Doug; Doroff, Angela; Gassó , Santiago; Gorman, Kristin; Heintz, Ron; Holderied, Kris; Hopcroft, Russ; Matkin, Craig; Mayumi, Arimitzu; Moran, John; Pegau, Scott; Rand, Pete; Sewall, Fletcher; Sorum, Alan; Thomas, Andrew; Welker, Jeff.

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$145.0	$149.3	$153.8	$158.4	$163.2	$769.7	
Travel	$1.0	$1.0	$1.0	$1.0	$1.0	$5.0	
Contractual	$43.7	$43.7	$43.7	$43.7	$43.7	$218.3	
Commodities	$11.0	$11.0	$11.0	$11.0	$11.0	$55.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*waived*)							
SUBTOTAL	$200.6	$205.0	$209.5	$214.1	$218.8	$1,048.0	
General Administration (9% of subtotal)	$18.1	$18.4	$18.9	$19.3	$19.7	$94.3	N/A
PROJECT TOTAL	$218.7	$223.4	$228.3	$233.3	$238.5	$1,142.3	
Other Resources (Cost Share Funds)	$300.0	$300.0	$275.0	$275.0	$275.0	$1,425.0	

COMMENTS:
PWSSC waives the indirect cost on this proposal due to its administration of the overall proposal. This project is part of the Long-Term Monitoring of Marine Conditions and Injured Resources and Services (LTM), Environmental Drivers Monitoring Component.

FY17-21

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

NON-TRUSTEE AGENCY SUMMARY PAGE

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Robert Campbell	Principal Investigator	5.0	10.3		51.7
Robert Campbell - at sea rate	Principal Investigator	0.5	11.4		5.7
Caitlin McKinstry	Technician	12.0	7.3		87.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	29.0	0.0	
				Personnel Total	$145.0

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting	0.4	1	3	0.2	1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.0

FY17

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
PERSONNEL & TRAVEL DETAIL

Contractual Costs: Description	Contract Sum
Instrument calibration	3.0
Vessel Charter	37.8
Network and Telephone	2.6
Printing	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$43.7

Commodities Costs: Description	Commodities Sum
Reagents and Lab Supplies	5.0
Mooring supplies	5.0
Sampling harware	1.0
Commodities Total	$11.0

FY17

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Seabird Conductivity Temperature Depth (CTD) meter	2	PWSSC
WETlabs fluorometer	2	PWSSC
Satlantic SUNA	2	PWSSC
Mooring releases	2	PWSSC
Mooring flotation	4	PWSSC
Seal AA3 nutrient autoanalyzer	1	PWSSC
Turner Designs fluorometer	1	PWSSC

FY17

Project Title: Long-term monitoring of the oceanographic conditions of PWS
Primary Investigator: Robert W. Campbell

FORM 3B
EQUIPMENT DETAIL

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Robert Campbell	Principal Investigator	5.0	10.7		53.3
Robert Campbell - at sea rate	Principal Investigator	0.5	11.7		5.9
Caitlin McKinstry	Technician	12.0	7.5		90.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	29.9	0.0	
				Personnel Total	$149.3

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting	0.4	1	3	0.2	1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.0

FY18

Project Title: Long-term monitoring of oceanographic conditions of PWS
Primary Investigator: Robert W. Campbell

FORM 3B
PERSONNEL & TRAVEL DETAIL

Contractual Costs: Description	Contract Sum
Instrument calibration	3.0
Vessel Charter	37.8
Network and Telephone	2.6
Printing	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$43.7

Commodities Costs: Description	Commodities Sum
Reagents and Lab Supplies	5.0
Mooring supplies	5.0
Sampling harware	1.0
Commodities Total	$11.0

FY18

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Seabird Conductivity Temperature Depth (CTD) meter	2	PWSSC
WETlabs fluorometer	2	PWSSC
Satlantic SUNA	2	PWSSC
Mooring releases	2	PWSSC
Mooring flotation	4	PWSSC
Seal AA3 nutrient autoanalyzer	1	PWSSC
Turner Designs fluorometer	1	PWSSC

FY18

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
EQUIPMENT DETAIL

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Robert Campbell	Principal Investigator	5.0	11.0		54.8
Robert Campbell - at sea rate	Principal Investigator	0.5	12.1		6.0
Caitlin McKinstry	Technician	12.0	7.7		92.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	30.8	0.0	
				Personnel Total	$153.8

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting	0.4	1	3	0.2	1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.0

FY19

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
PERSONNEL & TRAVEL DETAIL

Contractual Costs: Description	Contract Sum
Instrument calibration	3.0
Vessel Charter	37.8
Network and Telephone	2.6
Printing	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$43.7

Commodities Costs: Description	Commodities Sum
Reagents and Lab Supplies	5.0
Mooring supplies	5.0
Sampling harware	1.0
Commodities Total	$11.0

FY19

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B CONTRACTUAL & COMMODITIES DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Seabird Conductivity Temperature Depth (CTD) meter	2	PWSSC
WETlabs fluorometer	2	PWSSC
Satlantic SUNA	2	PWSSC
Mooring releases	2	PWSSC
Mooring flotation	4	PWSSC
Seal AA3 nutrient autoanalyzer	1	PWSSC
Turner Designs fluorometer	1	PWSSC

FY19

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
EQUIPMENT DETAIL

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Robert Campbell	Principal Investigator	5.0	11.3		56.5
Robert Campbell - at sea rate	Principal Investigator	0.5	12.4		6.2
Caitlin McKinstry	Technician	12.0	8.0		95.7
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	31.7	0.0	
				Personnel Total	$158.4

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting	0.4	1	3	0.2	1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.0

FY20

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
PERSONNEL & TRAVEL DETAIL

Contractual Costs: Description	Contract Sum
Instrument calibration	3.0
Vessel Charter	37.8
Network and Telephone	2.6
Printing	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$43.7

Commodities Costs: Description	Commodities Sum
Reagents and Lab Supplies	5.0
Mooring supplies	5.0
Sampling harware	1.0
Commodities Total	$11.0

FY20

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Seabird Conductivity Temperature Depth (CTD) meter	2	PWSSC
WETlabs fluorometer	2	PWSSC
Satlantic SUNA	2	PWSSC
Mooring releases	2	PWSSC
Mooring flotation	4	PWSSC
Seal AA3 nutrient autoanalyzer	1	PWSSC
Turner Designs fluorometer	1	PWSSC

FY20

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
EQUIPMENT DETAIL

Personnel Costs:		Months	Monthly		Personnel
Name	Project Title	Budgeted	Costs	Overtime	Sum
Robert Campbell	Principal Investigator	5.0	11.6		58.2
Robert Campbell - at sea rate	Principal Investigator	0.5	12.8		6.4
Caitlin McKinstry	Technician	12.0	8.2		98.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
		Subtotal	32.7	0.0	
				Personnel Total	$163.2

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
PI Meeting	0.4	1	3	0.2	1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.0

FY21

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
PERSONNEL & TRAVEL DETAIL

Contractual Costs: Description	Contract Sum
Instrument calibration	3.0
Vessel Charter	37.8
Network and Telephone	2.6
Printing	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$43.7

Commodities Costs: Description	Commodities Sum
Reagents and Lab Supplies	5.0
Mooring supplies	5.0
Sampling harware	1.0
Commodities Total	$11.0

FY21

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
CONTRACTUAL &
COMMODITIES DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Seabird Conductivity Temperature Depth (CTD) meter	2	PWSSC
WETlabs fluorometer	2	PWSSC
Satlantic SUNA	2	PWSSC
Mooring releases	2	PWSSC
Mooring flotation	4	PWSSC
Seal AA3 nutrient autoanalyzer	1	PWSSC
Turner Designs fluorometer	1	PWSSC

FY21

Project Title: Long-term monitoring of oceanographic conditions in PWS
Primary Investigator: Robert W. Campbell

FORM 3B
EQUIPMENT DETAIL