PROPOSAL SIGNATURE FORM

THIS FORM MUST BE SIGNED BY THE PROPOSED PRINCIPAL INVESTIGATOR AND SUBMITTED ALONG WITH THE PROPOSAL. If the proposal has more than one investigator, this form must be signed by at least one of the investigators, and that investigator will ensure that Trustee Council requirements are followed. Proposals will not be reviewed until this signed form is received by the Trustee Council Office.

By submission of this proposal, I agree to abide by the Trustee Council's data policy (Trustee Council Data Policy*, adopted March 17, 2008) and reporting requirements (Procedures for the Preparation and Distribution of Reports**, adopted June 27, 2007).

PROJECT TITLE: **PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring, submitted under the BAA AB133F-09-RP-0059**

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* www.evostc.state.ak.us/Policies/data.cfm
** www.evostc.state.ak.us/Policies/reporting.cfm

FY10 INVITATION
PROPOSAL SUMMARY PAGE

Project Title: PWS herring survey: Physical Oceanographic Factors of Nursery Habitats of Juvenile Pacific Herring, submitted under the BAA AB133F-09-RP-0059

Project Period: October 1, 2009 to September 30, 2013

Primary Investigator(s): Shelton M. Gay III –Prince William Sound Science Center and Texas A&M University, Cordova, Alaska and College Station, Texas

Study Location: Prince William Sound

Abstract:

The objectives of this research are to build upon a physical oceanographic data base started during the SEA project and continued under a recent EVOS funded project: *Physical Oceanographic Factors Affecting Productivity in Juvenile Pacific Herring Nursery Habitats*. The rationale of this project is based upon past research of juvenile Pacific herring in PWS, which has shown that recruitment is highly influenced by conditions within nursery sites affecting survival within the first year. Important among these conditions is the pre-winter condition of juvenile (age-0) herring and the effects of water temperatures on metabolism and hence over-winter survival. Past studies of the physical oceanography of nursery fjords has indicated that each site has a unique set of hydrographic conditions that are influenced by both local processes and water exchange between the GOA and PWS. These factors vary significantly depending on geographic location, basin morphometry, watershed topography and proximity to tidewater glacial fjords. The proposed study will continue monitoring the physical properties within the four SEA nursery fjords and additional sites as determined by future herring surveys, and collect time-series data on temperature, salinity and fluorescence to determine the variation among nurseries in factors such as ocean climate, stratification, mixing, phytoplankton biomass, and energy constraints imposed on juvenile herring by seasonal changes in water temperatures. The data will also assist in evaluating potential sites for future supplementation efforts in restoring the herring population.

Estimated Budget:
EVOS Funding Requested *(must include 9% GA)*

FY10	FY11	FY12	FY13	Total
$88.4K	$83.1K	$90.0K	$91.5K	$353.0K

Non-EVOS Funds to be used:

FY10	FY11	FY12	FY13	Total

PROJECT PLAN

I. NEED FOR THE PROJECT

A. Statement of Problem

The importance of Pacific herring (*Clupea pallasi*) to the Prince William Sound (PWS) ecosystem has been well documented from past studies of the diet of marine mammals and birds (Agler et al. 1999; Matkin et al. 1999; Irons et al. 2000). This coupling has been found to be particularly strong for Steller sea lions (Thomas and Thorne 2001), and subsequent research has shown strong correlations between herring abundance and sea lion abundance in PWS including a collapse of both populations following the 1989 Exxon Valdez Oil Spill (EVOS) (Thomas and Thorne 2003). Although herring in PWS increased slightly in population size from 1994 to 1997, the adult population has been depressed for nearly two decades, with a biomass generally below 20,000 mt since 1998. The reasons for the collapse are both uncertain and controversial. However, due to the continued decline over the years the commercial fishery has essentially remained closed for more than a decade, and as a consequence the EVOS Trustee Council has classified Pacific herring in PWS as a resource not yet recovered from the effects of the oil spill.

The failure of PWS herring to recover since the spill constitutes a difficult problem since many of the reasons for a lack of recovery are still conjectural. For example, since 1989 the annual recruitment of age-3 cohorts has remained far below the historical maximum of 1 billion fish, a threshold associated with strong year-classes in the past (Funk 2007). This consistently low recruitment has, therefore, created a gap in our understanding of the actual factors that produced such strong historical year classes in the first place. In response to the lack of knowledge of the problem and public comments about the continuing impacts to communities and the commercial fishermen from herring losses, the Trustee Council sponsored a herring workshop in Anchorage in April 2006. An important outcome of this meeting was the formation of a Herring Steering Committee in November 2006. Tasked with identifying strategies pertaining to the recovery and restoration of herring, the committee focused on a program with an ecological perspective that considered herring population dynamics and life history attributes.

The main objective of the restoration program is to determine if any remedial efforts can be made to successfully restore Pacific herring in PWS back to stock levels of the 1980's. Any effort to accomplish this task, however, requires first determining what factors are limiting the recovery of herring in PWS. This, in of itself, requires knowledge of the population distribution and habitats used by juveniles, and what factors primarily affect their survival and recruitment.

The current proposal is intended to provide ancillary oceanographic data in support of three other proposed studies being submitted by R.Thorne, T. Kline and R. Campbell (see Section B below) that will together accomplish the primary task by monitoring the distribution, abundance and habitats used by juvenile herring in PWS, and by determining the effects of food quality (i.e. origin) and availability on the whole body energy density of age-0 fish from summer through winter. Knowledge of the physical oceanography of habitats used by juvenile herring is vital to both understanding why certain sites exhibit consistently high recruitment and selecting potential sites for future remedial efforts in supplementation.

Background of Physical Studies of PWS Herring Nurseries

In 1995 the Sound Ecosystem Assessment (SEA) project (Cooney et al., 2001) began the initial research addressing ecological factors affecting recruitment of juvenile herring in Prince William Sound (PWS), Alaska (Fig. 1). The initial oceanographic cruises during SEA actually began in the spring and summer of 1994 and focused on the larger passes and small inlets within the western Sound (Gay and Vaughan 1998, Vaughan et al. 2001). In 1995 this research was extended to other regions of PWS, and it included both oceanographic and biological characteristics believed to affect the growth and survival of juvenile herring. The results of this research found that many of the small fjords and bays within PWS comprise the nursery habitat during the early life stages of this species and that the juveniles remain within nursery sites for up to two years (Stokesbury et al. 2000). Survival and recruitment of young herring is therefore highly influenced by habitat conditions within individual inlets (Foy and Norcross 2001; Gay and Vaughan 2001; Norcross et al. 2001;).

Hydrography

1995-1998. One of the main objectives of the oceanographic surveys conducted during SEA was to quantify the seasonal changes in water temperature and salinity within four sub-regional habitats over a period of several years. These features of hydrography potentially impact the survival of young herring in two ways: first, annual variation in stratification from heat and freshwater input influences the local production and availability of plankton food sources (Foy and Norcross 1999b and 2001), and second, water temperatures directly affect larval growth rates in the summer, and metabolism and feeding behavior of juveniles during the winter (Foy and Paul 2000; Foy and Norcross 1999a). To accomplish this goal, four nursery habitats located within the principal regions of PWS were selected in 1995 by the University of Alaska at Fairbanks (UAF) for intensive study over a period extending from the fall of that year to the spring of 1998. These sites included two deep fjords, Whale Bay and Eaglek Bay, and two shallow inlets, Simpson Bay and Zaikof Bay (Fig. 1).

One of the salient results of the SEA project was that young (age-0) herring were found to mostly occupy the heads of various inlets, particularly in winter (Stokesbury et al. 2000). Oceanographic surveys of these basins, however, indicate that they exhibit significant variation in physical properties. For example, Figure 2 shows time series of the hydrography within the inner basins of the four SEA fjords from October 1995 to March 1998. From these plots it can be seen that although all of these basins exhibit some degree of thermal and haline stratification in the summer, in the two shallow sites (Simpson and Zaikof) these conditions were short-lived and existed mainly in late summer when sufficient amounts of freshwater had entered the basins to stabilize the water columns from mixing. In contrast, the deep fjords (Whale and Eaglek) exhibited stratification over the entire basins, and the effects of minor freshwater input appear to extend throughout the winter.

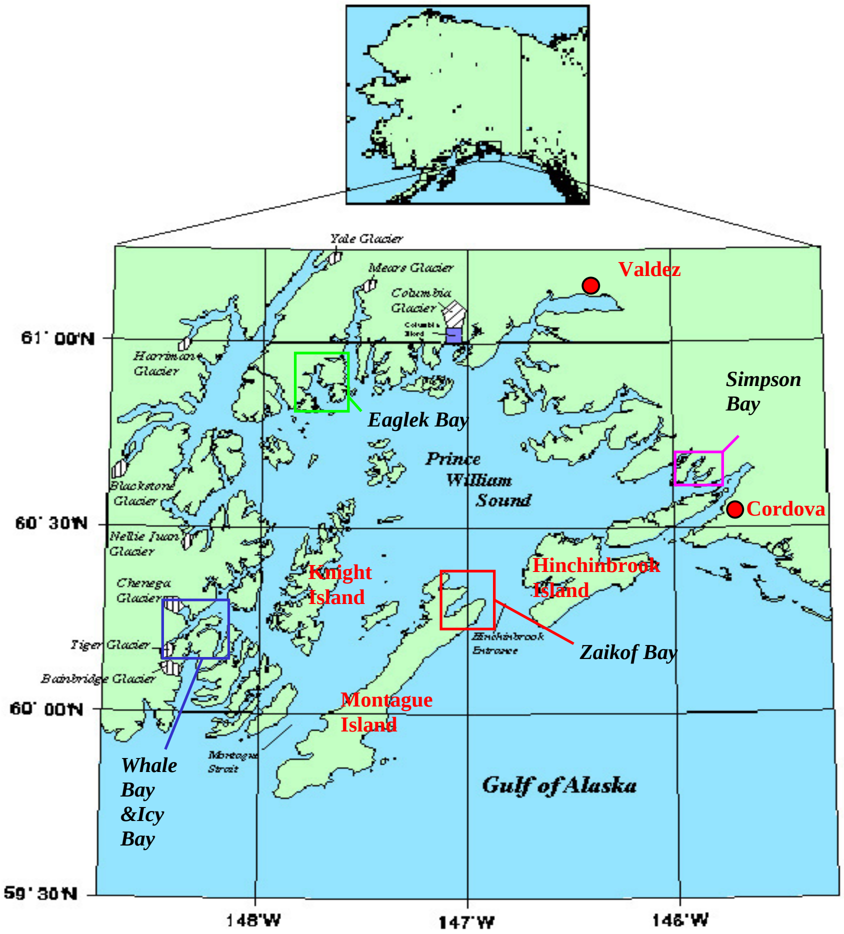
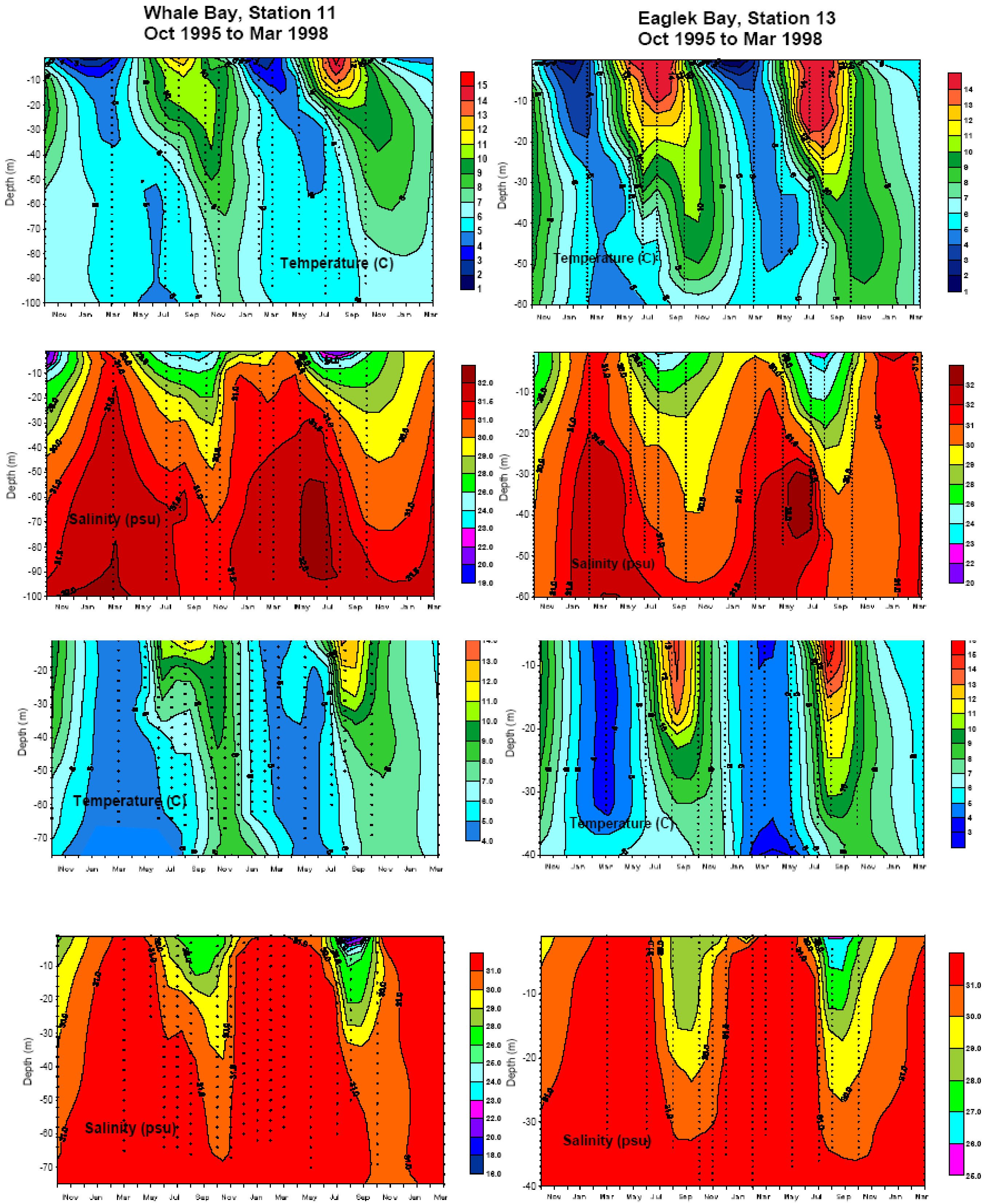


Fig 1. Locations of fjords surveyed during Sound Ecosystem Assessment Program and during the current project that is investigating juvenile Pacific herring nursery habitats.

The persistence of stratified conditions within the deeper fjords is apparently due to two factors: 1) they tend to have much slower currents and hence have a lower eddy viscosity in relation to the shallow systems, and 2) they are located in sub-regions with more consistent sources of allochthonous freshwater coming from large, adjacent fjords that contain tidewater glaciers (Gay and Vaughan 2001). One of the indices that reflect the latter factor is percent freshwater content (%fwc = the vertical integral of relative salinity, normalized by layer depth). At both of the deep fjords for example, the mean surface salinity and %fwc were consistently lower and higher respectively ($p < 0.05$) in comparison to the two shallow sites, despite the fact that they all have relatively small, localized watersheds (Gay and Vaughan 2001). This feature of the hydrography was especially true at Whale Bay, which exhibited a consistently higher %fwc in comparison to Eaglek Bay, even though the watershed at Eaglek is twice as large (114 km^2 vs. 54 km^2) and much higher in elevation (1200m vs. 900m). This advected glacial water was typically observed in the form of frontal regions within the main fjord basins in both the 1990's (Gay and Vaughan 2001) and more recently during surveys of Whale in 2008 (Fig. 3).



Whale Bay, Station 11
Oct 1995 to Mar 1998

Eaglek Bay, Station 13
Oct 1995 to Mar 1998

Fig. 2. Time series of temperature and salinity within the inner basins of Whale Bay, Eaglek Bay, Simpson Bay and Zaikof Bay during the SEA project (from Gay and Vaughan, 2001).

2007-2008. The results of recent hydrographic surveys conducted within Simpson Bay and Whale Bay under the project *Physical Oceanographic Factors Affecting Productivity in Juvenile Pacific Herring Nursery Habitats*, confirm a hypothesis formed during the SEA project; that is the physical properties within individual fjords reflect both interannual variation in sub-regional climate and local factors that are unique to each site (Gay, 2009). For example, both of the above locations exhibited much cooler upper water column conditions in 2008 in comparison to 2007, and this is consonant with the variation in climate between the two years (*see attached pfd file from* Gay, 2009). However, density stratification was much higher at Whale in both years due to relatively high freshwater input and limited mixing by the currents. In contrast, Simpson exhibited a marked difference in stratification between the two years primarily due to higher heat input in 2007 and a lower buoyancy flux in comparison to 2008. The latter year was marked by much cooler and fresher conditions in the upper water column due to a higher frequency of storms, and as a consequence deeper pycnoclines formed at both sites from the additional freshwater input (*see pfd* Gay 2009). At Simpson Bay, however, vertical mixing of this water caused the pycnocline to extend 10 to 15 m deeper in 2008 in comparison to 2007, creating conditions more consistent with observations made in the 1990's.

The high stratification within Whale Bay was expected since similar conditions were observed in the 1990's (Fig. 2). However, freshwater input in 2007 and 2008 was exceptional by comparison, and in both years low salinity water (18-20) was well dispersed throughout the fjord basin within the upper 10 m (*see pfd* Gay, 2009). Such deep, widespread freshening was not consistently observed in the 1990's and it indicates that in 2007 and 2008 relatively high amounts of freshwater entered the fjord from both local sources and from allochthonous glacial water advected from Icy Bay (Fig. 1). In 2008 runoff was late in the spring due to the cooler climate but it was also more intense than 2007 due to high amounts of snow within the watershed. Also,

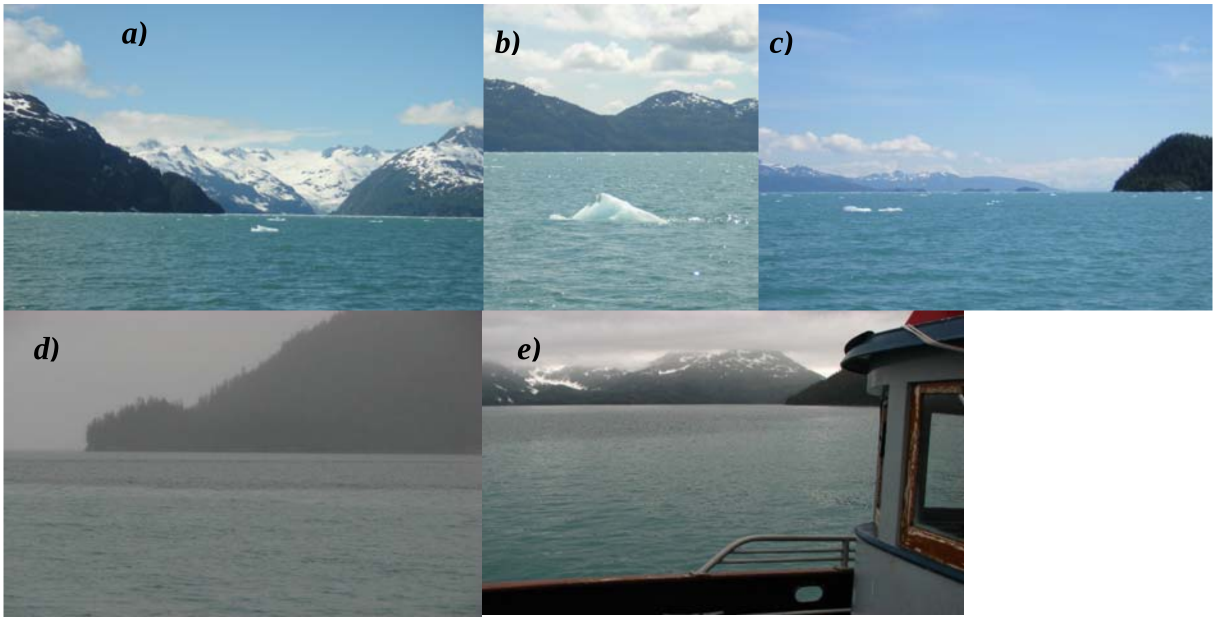


Fig. 3. Outflow of icebergs and glacial water from Icy Bay observed in the summer of 2008. a to c) small icebergs emanating from Icy Bay and down Dangerous Pass towards Whale; d and e) fronts of glacial water observed entering Whale on an ebb tide. *photos d and e courtesy of Dave Janka*

in 2008 the fronts of glacial water observed entering Whale Bay during ebb tides (Fig. 3) appeared to do so as surface flows. The turbidity of the water in the main basin of Whale appeared to also confirm this, as the highest turbidity occurred primarily in the nearsurface layer in association with the advected glacial water (*see pfd* Gay, 2009). In contrast, intrusions of this water during the previous decade appeared to be dispersed deeper in the water column (Gay and Vaughan 2001), and at a limit determined by the depth of Icy Bay's outer sill (i.e. moraine).

Circulation

A secondary objective of the research conducted during the SEA project was to identify regions of convergence, divergence, current shear and ephemeral fronts associated primarily with the tidal currents. Larval herring and zooplankton are advected to various nursery sites by the general circulation within PWS (Wang et al. 2001). The role of the currents in causing either drift or retention within nursery sites had not been determined, thus measuring these features of circulation was deemed of value in identifying potential transport mechanisms.

The surveys made during the 1990's indicated that the currents at all fjords were strongest near the mouth, but varied considerably in pattern and magnitude within the main basins (Gay and Vaughan 2001). At Whale for example, the flows in the outer basin exhibited reversed (i.e. inflow) patterns in the near-surface layer during ebb tides (Fig. 4a). This type of flow resulted in marked convergence with water trying to exit the southern arm, thus creating the fronts of glacial water observed inside the main basin (Fig. 3). During the flood tides (Fig. 4b), both convergence and cross-channel shear occurred due to water entering the east side of the mouth and exiting on the west side. At Simpson the patterns were highly variable within the main (lower) basin, but on a cruise in August 1996 (Fig. 4c,d) an inflowing tidal jet was seen during a flood tide along with an anticyclonic eddy that formed across the eastern side of the mouth (Fig. 4c). During the subsequent ebb tide (Fig. 4d) a strong current initially flowed southward from the northern arm around the shallow reef that separates the two basins (see Fig 5c below). These same patterns were also consistently observed during various portions of the flood and ebb tides at Simpson in 2007 and 2008 (*see pfd* Gay 2009). The only regions within both fjords that exhibited any strong correlation of flow velocities with the tidal phases were the inner basins. There the surface flows generally follow the ebb and flood tides with subsurface flow reversals occurring beneath the pycnocline (Gay and Vaughan 2001; *see pfd* Gay 2009).

In 2008 the surveys of currents at Whale showed this fjord to have relatively low flow velocities (< 0.15 m/s) within the upper 100m, and hence a limited flushing rate (*see pfd* Gay 2009). This pattern differed considerably from the 1990's when flows at the mouth were nearly double the above magnitude, and resulted in mid-basin convergence. The high glacial silt load and longer residence time of surface water entering the fjord in 2008 appears to have allowed more turbid water to persist within the main basin, and this may have potentially inhibited phytoplankton growth both inside and outside the fjord. These conditions were reflected by a relatively low fluorescence over the entire middle to outer regions of the fjord from June to August in both years (*see pfd* Gay, 2009). In contrast to Whale, Simpson Bay exhibited significant advection of water from Orca Bay during flood tides (*see pfd* Gay, 2009) due to relatively high currents (> 0.3 m/s) and a much lower volume relative to Whale. Various factors apparently influence transport into this fjord, however, including diurnal winds from the southwest, inflowing tidal jets within the main basin, and re-circulation of water by eddies at both the mouth and at a reef separating the inner (northern) basin from the lower basin (*see pfd* Gay, 2009). Glacial silt within the upper water column was also much more limited at Simpson and for all of the above reasons fluorescence values were 3 to 7 times higher comparison to Whale (4-7 ug/l vs.1.0- 1.5 ug/l).

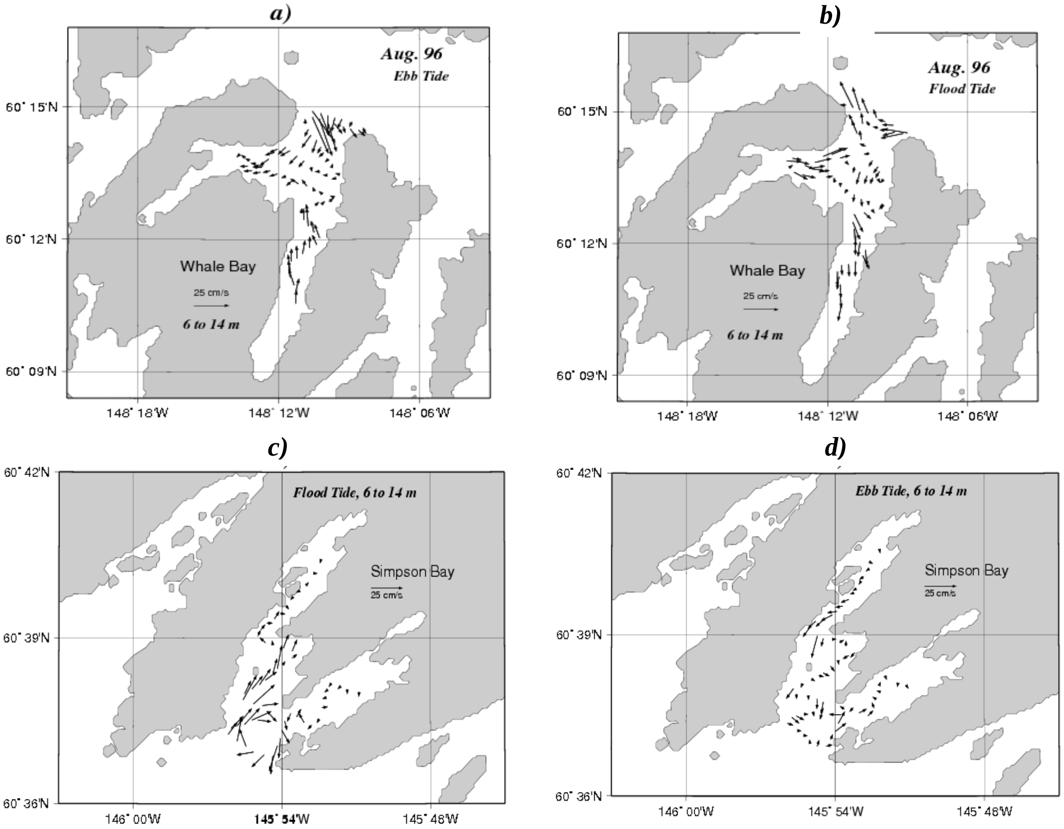


Fig. 4. Currents at Simpson Bay measured in Aug. 1996 during: a) flood tide

From the above synthesis it is quite evident that juvenile herring nurseries differ significantly in the various factors that affect their physical oceanographic properties, and hence their habitat characteristics. Some of the more prominent factors in addition to basin morphometry and circulation include geographic location within PWS (i.e. local climate), watershed topography, and proximity to tidewater glacial fjords. As a result of this diversity of conditions, monitoring the ocean climatology within these habitats requires that individual basins have instrument arrays moored inside them. The proposed research is intended to accomplish this, and thereby continue the hydrography database within PWS fjords started under SEA and re-commenced in 2007.

B. Relevance to 1994 Restoration Plan Goals and Scientific Priorities

The proposed project is part of a comprehensive program that addresses the goals and priorities outlined in the 1994 Restoration Plan. In particular it addresses ‘Herring Surveys’, item #2 in the FY2010 Invitation. The objectives of the proposed comprehensive program are given in the coordination proposal submitted by W. Pegau (2009). These include identifying areas of important habitat and gathering information that leads to the development of new tools to improve herring management. The proposed study will help meet these goals by providing ancillary physical oceanographic data needed to develop and test biological and physical models of herring growth and recruitment. The data will also be used to support two other proposed studies (R.Thorne and T. Kline) and will be collected in collaboration with another proposed study by R.Campbell.

The study by Campbell proposes to monitor physical properties, nutrients and zooplankton within the four nursery bays surveyed extensively during the SEA program. The hydrography time series collected by moored instruments will therefore provide a basis for comparing the CTD data collected by the Campbell project with long-term processes occurring at various frequencies within each fjord. Together, all of these studies will accomplish the primary task of the restoration program by monitoring the distribution, abundance and habitats used by juvenile herring in PWS, and by determining the effects of water temperatures, and food quality (i.e. origin) and availability on the whole body energy density of age-0 fish from summer through winter.

II. PROJECT DESIGN

A. Objectives

The proposed study is part of a concerted effort to determine juvenile herring nursery habitat characteristics and energetics affecting over-winter survival. It is intended to monitor the ocean climate of nurseries over time. This will be accomplished by meeting the following objectives.

1. To continue a time series of basic physical and biological parameters including temperature (T), salinity (S), density (sigma-t), fluorescence (F) and turbidity (Tb) measured during the SEA project and more recently in 2007 and 2008 within four nursery fjords used by juvenile Pacific herring. These results will be compared with similar data being collected at oceanographic stations and high spatial resolution hydrography collected with a thermosalinograph (TSG) during cruises conducted as part of the project proposed by R. Campbell.

2. To quantify physical properties over time that influence habitat conditions within individual nurseries by placing moored instruments in a configuration similar to those deployed in Simpson Bay and Whale Bay respectively in 2007 and 2008 (Gay 2008; 2009). These data will be used to track changes in interannual ocean climate within nurseries and to assist in evaluating interannual variation in plankton production. They will also provide data necessary to determine the energy changes in the water column in terms of degree-days which will assist the studies of the age-0 herring energy content in the late fall through winter and the effects on survival within specific nurseries.

3. To compare physical oceanographic data collected in various nurseries with similar data collected at permanently established meteorological and oceanographic stations in PWS. These comparisons will determine to what extent data collected at the permanent sites can be used to assess conditions within individual nurseries.

B. Procedural and Scientific Methods

Hydrography Time Series

This study proposes to continue a time series of basic seasonal physical properties within four fjords previously surveyed in Prince William Sound, Alaska during the SEA project and more recently under a study titled *Physical Oceanographic Factors Affecting Productivity in Juvenile Pacific Herring Nursery Habitats* (Fig. 1). In general, this will be accomplished by collecting oceanographic data during cruises monitoring the juvenile herring population to be carried out seasonally in late winter (late March or early April), summer and late fall (October to early November) (see accompanying proposals by R. Thorne and T. Kline). During these cruises physical data comprised of temperature, salinity, fluorescence -a proxy for phytoplankton, and turbidity will be measured throughout the water column at certain stations pre-established during SEA (Fig. 5). During the highly productive period from spring to early fall, however, hydrographic data will also be collected on a monthly basis during cruises conducted by R. Campbell. These cruises will also be collecting synoptic thermosalinograph (TSG) data in the surface (1m) layer (see R. Campbell's proposal for proposed cruise tracks).

The physical data, including temperature and salinity (T/S) will be collected using either a SeaBird Electronics (SBE) 19*plus* or a 19.03 conductivity/temperature/depth (CTD). These instruments are accurate to 0.01^{o} *C,* 0.001 Siemens/*m* and 0.25% of full-scale pressure range of 50 to 1000 psia. The ancillary data (F and Tb) will be collected with a WetLabs FLSTUB fluorometer/turbidimeter. The number of stations surveyed within each nursery fjord during the summer will be similar to sampling conducted under the more recent physical study (Gay 2007 and 2008), in which a line of approximately 6 stations were occupied in each fjord with a distance of 0.5 to 1.0*km* per station. In the late fall and winter the number of stations may be reduced to a small core set since hydrographic conditions are more uniform spatially at that time of the year (Muench and Schmidt, 1975; Gay and Vaughan, 2001; Vaughan et al., 2001). The locations and number of stations occupied during the summer will essentially follow the sampling regimen used during the SEA project by Gay and Vaughan (2001). These stations are shown below for each fjord in Figure 5.

The proposed hydrography data will be collected from late fall 2009 to mid summer 2012 and should provide a basis for comparing interannual differences in physical processes, such as sub-regional heat and freshwater fluxes, stratification, mixing, changes in turbidity due to variation in glacial runoff, and phytoplankton abundance. These data can also be compared with temporal and spatial variation in the same processes over PWS during the past decade (from SEA), more recently (from TSG data from 2006 to 2009) and possibly in the future (TSG cruises will continue under Campbell's project). The broad-scale advection of GOA water into PWS is believed to be potentially important in enhancing productivity within herring nursery habitats during certain years (Gay and Vaughan 2001; Kline 1999). The direct comparisons of physical properties within fjords to conditions across PWS (determined from the TSG cruises) and indirect comparisons with physical data from current meter/CTD moorings currently placed in Hinchinbrook Entrance (HE) and Montague Strait (MS) should therefore provide some indication of how exchange of surface and deep water from the GOA into PWS possibly extends into the small secondary and tertiary fjords, and how these advective processes interact with localized processes driven by variation in climate and freshwater runoff within each site.

CTD Moorings

As stated above in objective 2, moored instruments comprised of CTs, CTDs, and thermistors are proposed for deployment throughout the year to measure temperature and salinity within the four SEA bays. It should be noted here that in the spring of 2010, OSRI equipment being used in HE and MS will become available for additional moorings as the PWSOOS pilot program comes to an end. The OSRI equipment also includes fluorometers, and these will be added to the four SEA bay moorings in the spring of 2010. In addition to CTD casts these data will provide a more thorough description of the seasonal changes in T/S and fluorescence, and hence the dynamics of both the physical factors and phytoplankton standing stocks within various nursery fjords. The project will also provide ancillary data supporting both empirical and modeling studies of over-winter herring energetics, used to predict survival and recruitment. Finally, the physical data from within individual sites can be used to determine if meteorological and oceanographic data

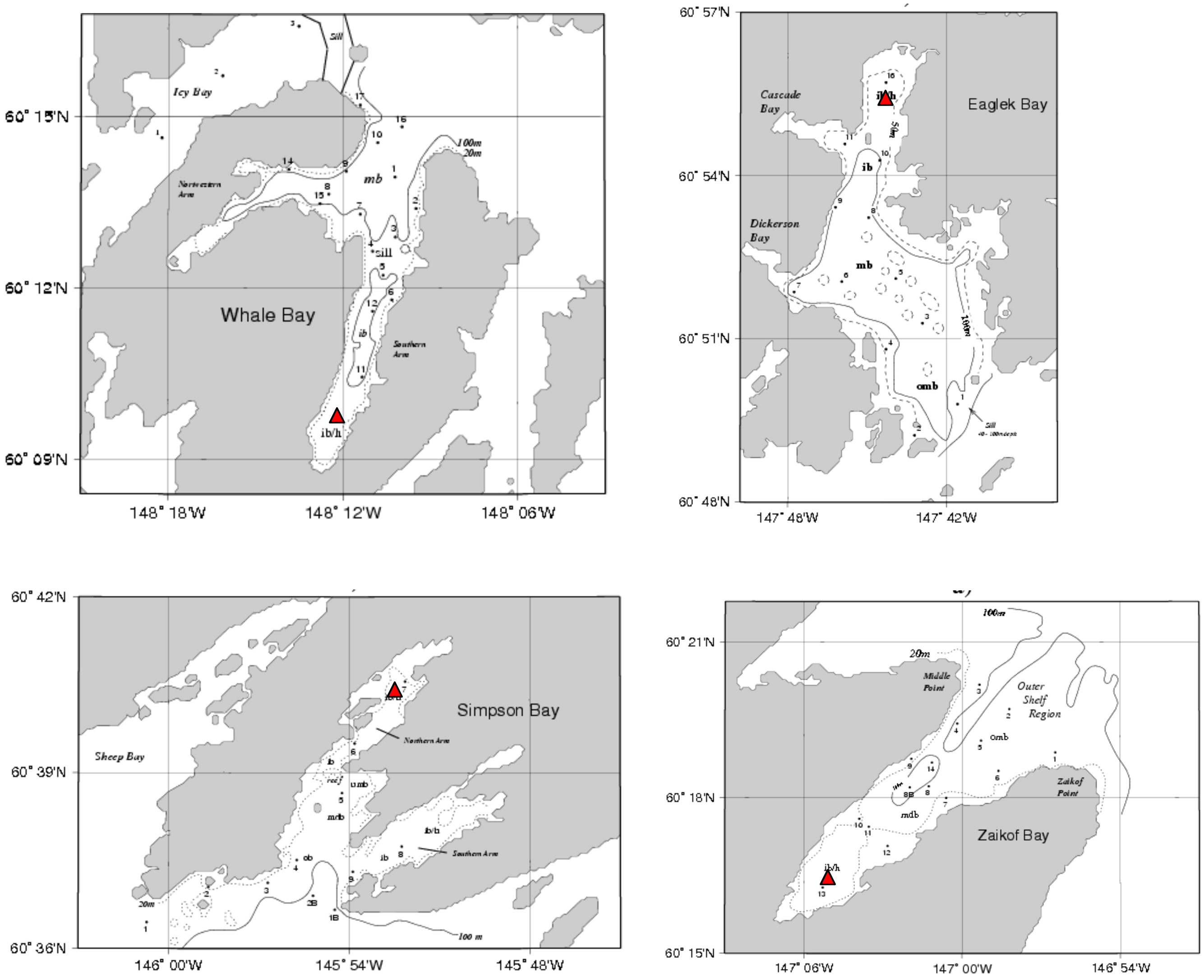


Fig. 5. Locations of oceanographic stations within the four fjords surveyed during the SEA herring project, and likely locations for moored instruments.

collected at permanently established NOAA NDBC[1] moorings and stations at PWSAC hatcheries[1] can be used as proxies of environmental conditions within various nursery bays.
In order to track the physical and biological properties within habitats used by age-0 herring, instruments will be located within the inner basins of each site as indicated in Figure 5. The exact mooring locations will be determined after consulting R. Thorne, who has been tracking juvenile herring distributions by acoustics within the four bays over the past 3 years. The locations of any additional instrument arrays within new nurseries will be based upon the findings of the juvenile and larval herring surveys (see proposal by R. Thorne). The moorings will be deployed and serviced, and hydrography data (i.e. CTD profiles) will be collected during these cruises (see schedule below). Therefore no ship time is anticipated for this project.

Mooring Designs. The design of the proposed moorings (Fig. 6) follows the same instrument configurations used in 2007 and 2008. The CTD data will be collected by SBE16.03 seacats and SBE37 microcats to be deployed in a near-surface layer (2-3*m*) and a deep layer (50-150*m*); the exact depth of the deep layer will depend on the total depth of the site. In addition to the main instruments, the moorings will have thermistors attached to the lines at about every 10 to 15 m, depending on the total water depth. Fluorescence will be also measured from the spring through late fall. With the exception of thermistors, there are enough Seabird CT and CTD sensors on hand to initially deploy one mooring array in each bay without purchasing new instruments.

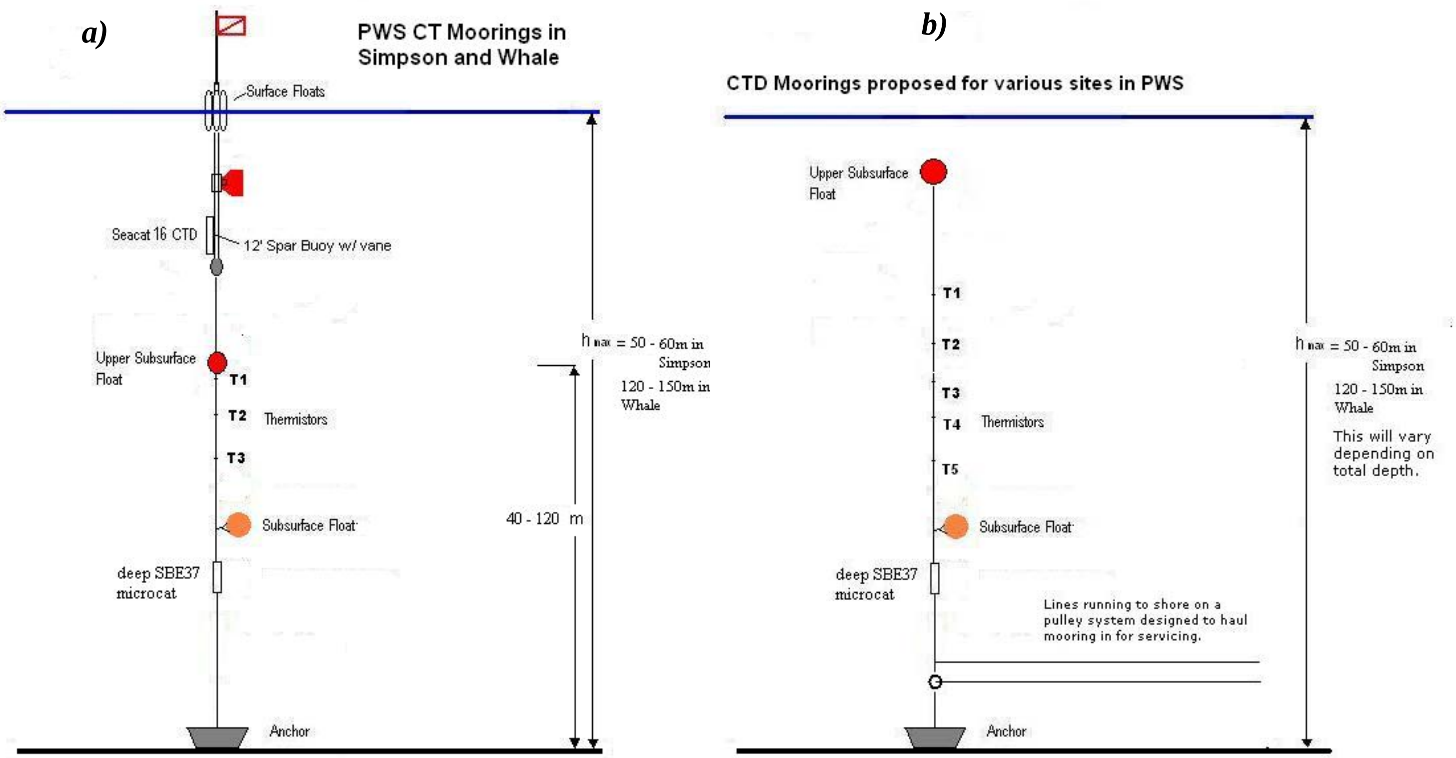


Fig. 6. Design of oceanographic moorings equipped with SBE Seacat 16.03s and SBE37 Microcats: a) w/ surface buoy; b) sub-surface buoys.

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1 National Oceanographic and Atmospheric Administration – National Data Buoy Center weather and oceanographic moorings
Prince William Sound Aquaculture Corporation salmon hatchery weather stations, main office based in Cordova Alaska

Certain sites may require a surface buoy for visibility due to boat traffic. In such cases the moorings will consist of either long (3*m*) surface spar buoys connected to bottom anchors with 3/16 in. Spectra line (Fig. 6a), or they will simply be marked with fluorescent orange crab-pot buoys. However, in sites where the threat of winter sheet ice exists the moorings will need to be sub-surface in configuration (Fig. 6b). Some locations possibly requiring this are already known from experience in past winter deployments within the four SEA fjords in1996/97. In the cases where surface spar buoys are used, the surface CT will be directly attached to the base of the buoy and the deep CT will be attached in-line. For the sub-surface configurations all CTs and CTDs will be attached in-line, and the moorings will be configured with a pulley system similar to that used to shore anchor small boats (Fig. 6b). This will allow them to be pulled ashore for servicing and vice versa for re-deployment.

The initial deployments will consist of a combination of two SBE 16 Seacats and four SBE37 Microcats. In the fall of 2010, however, the Seacats will be removed and receive a final pos-cruise calibration. These instruments will be replaced with Microcats made available from the OSRI moorings, and unless they are needed for additional moorings they will not be redeployed. The reason being that the Microcat circuitry is more stable over time and less prone to sensor drift. This will allow these instruments to remain deployed for at least two years before a calibration is required (SeaBird Inc., pers. comm.). Final calibrations will be performed on all sensors at the end of the project.

C. Data Analysis and Statistical Methods

Statistical Analysis

In addition to basic descriptive statistics (derived by programs written in Basic and Fortran) the data will be further tested with more advanced statistics (Emmory and Thompson, 2004) used to determine the integral time and spatial scales (to assess the dominant scales of variation and adequacy of sampling resolution), Eigenvector analysis (to determine the dominant modes of variation by a group of factors), and Harmonic Analysis (to determine the dominant frequencies of cyclical processes such as tides and storm events). The moored CTD data are amenable to all of the above analyses, and the cast data are amenable to analysis by Emperical Orthogonal Functions (i.e. Eigenvector analysis). Comparisons of the initial results should also indicate if more data types are required to fully characterize the physical oceanography important to herring recruitment. For example, it may be found that the addition of moored ADCPs to measure currents over time may be necessary to resolve temporal differences in T/S structure between nursery sites. In this case, such instruments will be available after the spring of 2010 from the termination of the OSRI mooring program. The deployment of these instruments will require some modification to the budget for that year, however.

D. Description of Study Area

The proposed study will initially take place in the four fjords within PWS studied intensively during SEA (Fig. 1). The variation in physical properties among all sites and the circulation within two of the locations were described above under the section on background. To summarize, two of these sites (Simpson and Zaikof) are relatively shallow (50-70*m*) and the main basins tend to exhibit relatively uniform T/S conditions due to turbulent mixing from a combination of wind and tidal forcing. In contrast, the other two fjords (Whale and Eaglek) are relatively deep (200-300*m*) and exhibit strong T/S stratification, which is not completely eroded in the winter (Fig. 2). Each site has a set of factors that produce hydrographic conditions unique to that location. These factors include differences in local climate (affecting heat flux), watershed topography (affecting runoff), proximity to tidewater glacial fjords (affecting both heat and freshwater content), basin morphometery and maximum depth (both affecting tidal currents and stratification), and proximity to the main entrances into PWS (affecting GOA water exchange).

The results of the SEA project (Gay and Vaughan, 2001) and more recent studies of Simpson Bay and Whale Bay (Gay, 2008 and 2009) indicate that differences in the seasonal hydrography and circulation within the nursery sites may have important indirect effects in the local production of zooplankton and/or possibly retain plankton advected into the fjord over time. The protected nature of these basins and the colder sub-regional climate in the northern and western Sound also allows sea-ice to develop during the winter particularly within the deep fjords. This ice likely provides a refuge from avian predators, and the low water temperatures may generally enhance winter survival by reducing metabolism, and hence starvation (Paul and Paul, 1998). Small basins in the eastern Sound may also develop sea-ice in the winter, but since the sub-regional climate tends to be warmer than the western Sound, ice may be an ephemeral occurrence there and any persistence would only occur during exceptionally cold winters.

E. Coordination and Collaboration with Other Efforts

The proposed study will be conducted in coordination and collaboration with other proposed research programs submitted under *PWS herring surveys.*. These include *Assessment of Juvenile Herring Abundance and Habitat Utilization* by Richard Thorne, *Pacific Herring Energetic Recruitment Factors* by Tom Kline, and *Plankton and oceanic observations in PWS* by Robert Campbell. Additional research projects under *PWS herring surveys* supported indirectly by the proposed research include *Growth and energy allocation in overwintering herring* by Ron Heintz (NOAA) and *Herring disease program* by Paul Hershberger (USGS). The data will also be used to help with continued validation of a Life-Stage Specific Ecosystem Model of PWS Pacific Herring (D. A. Kiefer, System Science Applications).

III. SCHEDULE

A. Project Milestones

A proposed schedule of cruises and mooring deployments/servicing is given in Table 1. As listed, the surveys to determine general hydrography (CTD casts) will be done on a seasonal basis, in accordance with sampling scheme for the juvenile and larval herring surveys (Thorne Proposal, 2009) and during plankton/oceanography/TSG surveys (Campbell Proposal, 2009).

B. Measurable Project Tasks

FY10 1st Quarter (October 1, 2009 to December 31, 2009)

October	Project funding approved by Trustee Council Initial deployment of CTD moorings CTD profiles collected during juvenile herring survey

FY10 2nd Quarter (January 1, 2010 to March 31, 2010)

January	Annual Marine Science Symposium
March	CTD profiles collected during juvenile herring survey

FY10 3rd Quarter (April 1, 2010 to June 30, 2010)

May	Perform first data retrieval and servicing of moorings CTD profiles collected during larval herring survey

FY10 4th Quarter (July 1, 2010 to September 30, 2010)

August	CTD profiles collected during juvenile herring survey Submit Annual Report

FY11 1st Quarter (October 1, 2010 to December 31, 2010)

October/November	CTD profiles collected during Juvenile herring survey Perform second data retrieval and servicing of moorings

FY11 2nd Quarter (January 1, 2011 to March 31, 2011)

January	Annual Marine Science Symposium
March	CTD profiles collected during Juvenile herring survey

FY11 3rd Quarter (April 1, 2011 to June 30, 2011)

May	Perform third data retrieval and servicing of moorings CTD profiles collected during larval herring survey

FY11 4th Quarter (July 1, 2011 to September 30, 2011)

August	CTD profiles collected during juvenile herring survey; Submit Annual Report

FY12 1st Quarter (October 1, 2011 to December 31, 2011)

October/November	CTD profiles collected during Juvenile herring survey Perform fourth data retrieval and servicing of moorings

FY12 2nd Quarter (January 1, 2012 to March 31, 2012)

January	Annual Marine Science Symposium
March	CTD profiles collected during Juvenile herring survey Final retrieval of CTD moorings and data retrieval

FY12 3rd Quarter (April 1, 2012 to June 30, 2012)

May	Data analysis/synthesis

FY12 4th Quarter (July 1, 2012 to September 30, 2012)

August	Data analysis/synthesis; Submit Annual Report

FY13 1st Quarter (October 1, 2012 to December 31, 2012)

October/November	Data analysis and report/paper writing

FY13 2nd Quarter (January 1, 2013 to March 31, 2013)

January	Annual Marine Science Symposium

FY13 3rd Quarter (April 1, 2013 to June 30, 2013)

April	Submit Draft Final Report
June	Submit Revised Final Report after peer review

Table 1. Schedule of Mooring and Hydrography Work in Coordination with Juvenile/Larval Herring Surveys and Plankton Surveys

Fiscal Year 2010

Month	**Juvenile Survey**	**Larval Survey**	**Plankton Survey**	**CTD Moorings**	**CTD Hydrogr.**
October					
November	X		X	X	X
December			X		
January			X		
February			X		
March	X		X		X
April			X		
May		X	X	X	X
June			X		
July			X		
August	X		X		X
September			X		

Fiscal Year 2012

	Juvenile Survey	**Larval Survey**	**Plankton Survey**	**CTD Moorings**	**CTD Hydrogr.**
October			X		
November	X		X	X	X
December			X		
January			X		
February			X		
March	X		X		X
April			X		
May		X	X	X	X
June			X		
July			X		
August	X		X		X
September			X		

Fiscal Year 2011

October			X		
November	X		X	X	X
December			X		
January			X		
February			X		
March	X		X		X
April			X		
May		X	X	X	X
June			X		
July			X		
August	X		X		X
September			X		

Fiscal Year 2013

October					
November	?		?	?	?
December					
January					
February					
March	?				?
April					
May		?		?	?
June					
July					
August	?			?	?
September					

Fiscal Year 2014	April	**FINAL REPORT DUE**

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CURRICULUM VITAE

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Experience:

Prince William Sound Science Center,	2007 – Present: Physical Oceanographer and PI
Cordova, Alaska	1994- 2007: Researcher and Marine Technician
University of Alaska, Fairbanks, Alaska	1991 – 1994: Research Technician
P&M Cedar Products, Stockton, CA	1987 – 1991: Quality Control Analyst and Forester

1984 – 1987: Seasonal positions as Game Range Manager and Forestry Technician with the Arizona Game and Fish Department, Flagstaff Arizona, U.S. Forest Service, Jacob Lake, Arizona, and Huallpai Tribal Forestry Department, Peach Springs, Arizona

Education:

Ph.D. work 2006-Present: Physical Oceanography Texas A&M University, College Station, Texas (Advisors: Steve Dr. DiMarco and Dr. David Brooks)
MS Degree 1984: Biology Northern Arizona University, Flagstaff, Arizona
Graduate coursework 1979 – 1980: Forestry Northern Arizona University, Flagstaff, Arizona
Graduate coursework 1978 – 1979: Wildlife Ecol. West Virginia University, Morgantown, WV
BS Degree 1976: Biology Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Publications:

Gay, S.M. III and S.L. Vaughan (2001) *Seasonal hydrography and tidal circulation of bays and fjords in Prince William Sound, Alaska.* Fisheries Oceanography pp. 159-193.

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Vaughan, S.L., C.N.K. Mooers, and S.M. Gay III (2001) *Physical variability in Prince William Sound during the SEA study (1994-1998).* Fisheries Oceanography pp.58-80.

Recent and Future Collaborations:

Dellapenna, T.	Texas A&M University, Galveston Texas
Noll, C.	Texas A&M University, Galveston Texas
Thorne, R.	Prince William Sound Science Center
Kline, T.	Prince William Sound Science Center
Campbell, R.	Prince William Sound Science Center

Research Interests:

Factors influencing variation in hydrography and circulation within Prince William Sound, Alaska and its large and small fjord systems. These include variation in local climate, watersheds, glacial runoff and water exchange processes that effect nutrient/plankton advection. Research interests naturally extend to circulation processes along the Gulf of Alaska continental shelf downstream of PWS.

Relevant Experience:

1994 to 1998- During Sound Ecosystem Assessment (SEA) I served as lead marine technician for oceanographic surveys of Prince William Sound (PWS). At that time I was also lead physical oceanographer investigating tidal circulation (currents) and hydrography of fjord nursery habitats of juvenile Pacific herring. This work resulted in a peer reviewed paper published in 2001 (see above). I also contributed to a joint study with the Alaska Dept. of Fish and Game (ADFG) and the University of Alaska at Fairbanks (UAF) regarding the effects of wave energy on losses of herring spawn in intertidal and subtidal locations along the shoreline of Montague Island, PWS Alaska. June to Sept 1998 - Conducted hydrographic surveys of Kenai Fjords, Alaska in collaboration with Dr. Peter Armato of the U.S. Park Service.

1998 to 2004 – I was in charge of Oil Spill Recovery Institute (OSRI) and EVOS Trustee Council sponsored research cruises to validate a Princeton Ocean Model (POM), and to further investigate water exchange processes between the Gulf of Alaska and PWS. Project involved measuring currents within the central basin of PWS and at Hinchinbrook Entrance (HE) using a towed ADCP, collecting CTD data, and deploying an ADCP mooring annually at HE (through 2002). Additional OSRI sponsored work included planning and implementing shallow and deep oceanographic moorings at HE and Montague Strait, and participating in a circulation study in the central basin of PWS utilizing surface and subsurface (10m) drifters.

2004 and 2007 I led a study of the tidal circulation and hydrography in locations near Cordova, Alaska, proposed as alternative sites for the disposal of fish offal from Cordova's Seafood Processors, and from 2005 to 2006 I was responsible for designing, planning and deploying five ADCP moorings in PWS for the Alaska Ocean Observing System.

2007 – Present: Most recently I've been a lead P.I. of an EVOS funded research project titled: *Physical Oceanographic Factors Affecting Productivity in Juvenile Pacific Herring Nursery Habitats*. This project involved cruises to measure currents and hydrography over semidiurnal tidal cycles and also to deploy moored instruments to measure hydrography over time.

BUDGET JUSTIFICATION

1. Personnel (Total: $40.2K in FY10, $41.4K in FY11, $53K in FY12, and $54.6 in FY13)

Personnel costs will cover the salary of the Principal Investigator (PI) while employed by PWSSC in Cordova and for approximately two months per year while at TAMU in College Station, Texas. The lower rate will apply for fiscal years 2010 and 11, and starting in 2012 the PI expects to be permanently in Cordova. For those two years a higher salary rate applies since the PI will be receiving full benefits. However, this rate may need some adjustment depending on the PI's graduation status. The additional money covers two months per year for a technician to assist in purchasing supplies, set-up and deployment of moorings, and collecting CTD data.

2. Travel (Total: $7K in FY10, $1.8K in FY11, $1.2K in FY12, and $1.2 in FY13)

Travel costs in FY10 include round-trip airfares from College Station, TX and per diem for one trip to Anchorage, Alaska to attend the annual marine symposium and two trips to Cordova, Alaska for mooring cruises (one in the fall to deploy and one in the spring to service and retrieve data. In FY11 costs cover a round-trip airfare from College Station, TX and per diem to attend the annual marine symposium in Anchorage, Alaska. The costs in all remaining years are for travel from Cordova to Anchorage to attend the annual marine symposium.

3. Contractual (Total: $11.3K in FY10, $10.3K in FY11, $14.3K in FY12, and $9.3 in FY13)

Contractual costs include covering additional costs for chartering vessels for oceanographic surveys under R. Campbell's project, repair/calibration of equipment, network costs, etc.

1) Vessel Charters: Two vessels of opportunity will be used to collect CTD data. One will be in operation to conduct surveys of juvenile and larval herring and requires no further funding. The second vessel will be engaged in plankton surveys and will sometimes have a TSG installed. The additional money is for extra time and fuel expenditures this project will incur when collecting extra CTD data.

2) Network & Office Costs: Funds to cover basic costs of office work including (but not limited to) computer network, phone, fax, copying, mail and freight.

3) Calibration Costs: Funds are necessary for shipping CTs back to SBE Inc. to check and calibrate the instruments. For FY10 two Seacat 16.03 CTs and six Microcat CTDs will need calibration. In FY11 six Microcats will require calibration in order to replace the two SBE 16s and expand mooring operations to two more sites. Final post-cruise calibration of the SBE 16s will occur in FY12. A final postcruise calibration will be performed in FY13 on all 12 SBE37s after the final retrieval in March 2012.

4.Commodities (Total: $3K in FY10, $4.1K in FY11, $3.5K in FY12, and $0.5 in FY13) – Request is for miscellaneous field and office supplies, batteries and maintenance supplies for some of the equipment, and lines, shackles and miscellaneous hardware for the moorings.

5.Equipment (Total: $3.5K in FY10, $2K in FY11) Request is for purchase of 20 Tidbit® thermistor data loggers for use on CTD moorings in FY10 and an additional 20 loggers in FY 11 to cover new moorings and replace any loggers that may have defective batteries. An additional $1.5K is requested to purchase a new laptop for the project.

DATA MANAGEMENT AND QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) STATEMENT

The design of the proposed research is given in the section above on Procedural and Scientific Methods. The study will generate two basic types of data that are routinely collected by physical oceanographers: 1) hydrography data collected by CTD casts at oceanographic stations, including measurements of temperature (T), conductivity (C), pressure (P), fluorescence (F) and turbidity (objective 1, page 10, paragraph 3); and 2) moored instruments that will collect CTD data and water temperatures at discrete depths over time (objective 2, page 10, paragraph 4).

Data collection methods for the above instruments are summarized in this proposal (pages 11 to 13). The first level of data management and quality assurance for physical oceanographic data is in standardizing the procedures used to deploy the various instruments. For example, using a standard cast procedure for CTDs ensures quality control so that instruments: a) properly equilibrate to the water conditions prior to down-casts, b) do not exceed the maximum drop rates (limited by pump speeds) and c) expedite the post-processing of the data (QC of the data).

Data management in the field is done by filling out field sample forms or logs of data that identify each CTD cast with its times (local and GMT), locations (i.e. geo-referencing), maximum depth, depth or length of line paid out, etc. In the cases of moored instruments depth is either predetermined by measuring the cable lengths for specific basin depths or measured by a pressure sensor on the instrument (e.g. Seacat 16s or Microcat 37s). Additional data management in the field will include uploading and checking data for instrument malfunctions as soon as feasible (i.e. following retrieval for moored instruments), and making back-up copies of the raw data during the cruises.

Metadata and Conversion Algorithms

The conversion of physical data into engineering units (i.e. ascii data) is typically done by applying instrument counts to polynomial equations using specific calibration coefficients[2]. For all the CTDs, the equations used for converting data are provided by the manufacturer (i.e. SeaBird Inc.). These come in the form of calibration data sheets and software files containing the coefficients and the equations. These files are an integral part the manufacturer's software and are used to produce the ascii data in post-processing (SBE and Wetlabs data). Each of the instruments typically generates a list of meta data describing the sensor serial numbers, programming set-up, status (battery voltage, data buffer capacity), etc. In the case of the Wetlabs instrument, however, the data are integrated with the SBE 19*plus* sensor output and therefore the meta data are part of the SBE data files. The thermistors have their own suite of meta data that is output along with the variables of interest.

Appendix A shows examples of metadata for SBE data files. In each case there are identifiers used to clarify the fields, and in the example for the CTD data the calibration coefficients used for conversion are included. The electronic version of this proposal contains pdf files listing the specifications, precisions and accuracies for most of the instruments to be used. The methods and algorithms used by SBE and Wetlabs for data measurements are given in various publications listed on their web sites http://seabird.com, and http://wetlabs.com.

Data Processing and Analysis

All data processing and analysis will be accomplished with a combination of software provided by the manufacturers and algorithms written in Basic, Fortran and Matlab by the PI (or other oceanographers). Post-processing of CTD data will include data QC to remove spurious values and spikes caused by misalignment of sensors in time/space and reversals due to ship roll, low-pass filtering, bin averaging and derivation of additional oceanographic parameters such as depth (m) density (sigma-t), specific volume anomaly, potential temperature, sound velocity, etc.[3]

Similar processing will be done with the hydrography data collected with the Aquashuttle using Basic and Fortran programs written to perform temporal/spatial averaging and derivation of other oceanographic parameters using standard subroutines (Fofonoff and Millard, 1983). The moored data requires minimal post-processing other than calibrations since the instruments are fixed and not being lowered into the water column. Further data reduction for the purpose of reporting will include layer averaging (accomplished by programs written in either Basic, Fortran or Matlab) and gridding (using algorithms such as Krieging, Minimum Curvature, Inverse Distance, etc.) written as part of graphics representation software such as Generic Mapping Tool (University of Hawaii), Grapher and Surfer (Golden Graphics, Boulder CO). Advanced statistical tests such as harmonic analysis, auto and cross-correlation/covariance, Eigenvalues, etc. will be run with programs written in Matlab.

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[2] Sea-Bird Electronics, Inc. (2005) specifications and application note no.31. 1808 136th Place N.E., Bellevue, WA 98005.

[3] Sea-Bird Electronics, Inc. (2005) data processing user manual software v. 5.34a. 1808 136th Place N.E., Bellevue, WA 98005.

Data Storage and Handling

All quantitative physical data collected will be stored electronically on computers and back-up media such as CDs and portable data drives. Data will be backed-up in the field following uploading from instruments or completion of file writing in the case of real-time data. All processing steps will be documented and intermediate files saved and backed-up along with the final processed and analyzed data.

Instrument Calibrations

Aside from performing calibration casts for the CT moorings, all instruments will be sent back to the manufacturer for post-cruise calibrations either annually (SBE16 Seacats) or biannually (SBE19*plus* and SBE37 Microcats). The SBE16s require more frequent calibrations since they have older style sensors and electronics. These will therefore be replaced with SBE 37s after the first year.

APPENDIX A. Examples of Meta Data for SBE Data Files

1. Example of meta data for an SBE CTD data file

Instrument serial number, upload datafile, set-up and status:

```
* Sea-Bird SBE19plus Data File:
* FileName = C:\My Documents\ak606tsgc048.hex
* Software Version 1.50
* Temperature SN =  4773
* Conductivity SN =  4773
* System UpLoad Time = Jun 24 2006 14:06:59
* F/V Alena K
* AK606
* ds
* SeacatPlus V 1.6  SERIAL NO. 4773    24 Jun 2006  22:06:26
* vbatt = 12.4, vlith =  8.3, ioper =  65.1 ma, ipump =  39.8 ma,
* wait four seconds for biowiper to close, iext01 =  55.4 ma
*
* status = not logging
* number of scans to average = 1
* samples = 72990, free = 486250, casts = 62
* mode = profile, minimum cond freq = 2800, pump delay = 30 sec
* autorun = no, ignore magnetic switch = no
* battery type = alkaline, battery cutoff =  7.3 volts
* pressure sensor = strain gauge, range = 870.0
* SBE 38 = no, Gas Tension Device = no
* Ext Volt 0 = yes, Ext Volt 1 = yes, Ext Volt 2 = no, Ext Volt 3 = no
* echo commands = yes
* output format = raw HEX
* S>
```

Calibration coefficients for converting raw data to engineering units:

```
 * SeacatPlus V 1.6  SERIAL NO. 4773    24 Jun 2006  22:06:55
* temperature:  08-mar-06
*     TA0 = 1.252114e-03
*     TA1 = 2.627939e-04
*     TA2 = -1.320481e-07
*     TA3 = 1.524150e-07
```

```
*     TOFFSET = 0.000000e+00
*     conductivity:  08-mar-06
*     G = -1.020485e+00
*     H = 1.337537e-01
*     I = -2.227477e-04
*     J = 3.432042e-05
*     CF0 = 2.766116e+03
*     CPCOR = -9.570000e-08
*     CTCOR = 3.250000e-06
*     CSLOPE = 1.000000e+00
*     pressure S/N = 7193, range = 870 psia:  30-jan-06
*     PA0 = -1.286078e-01
*     PA1 = 2.645991e-03
*     PA2 = -6.415912e-12
*     PTCA0 = 5.190734e+05
*     PTCA1 = -1.119338e+01
*     PTCA2 = 4.218478e-01
*     PTCB0 = 2.475413e+01
*     PTCB1 = -5.750000e-04
*     PTCB2 = 0.000000e+00
*     PTEMPA0 = -7.274188e+01
*     PTEMPA1 = 4.916496e+01
*     PTEMPA2 = -3.066672e-01
*     POFFSET = 0.000000e+00
* volt 0: offset = -4.686526e-02, slope = 1.248314e+00
* volt 1: offset = -4.645158e-02, slope = 1.249373e+00
* volt 2: offset = -4.679053e-02, slope = 1.249253e+00
* volt 3: offset = -4.638842e-02, slope = 1.249655e+00
*     EXTFREQSF = 1.000003e+00
* dh
```

Cast meta data identifying date, time and number of scans, etc:

```
* cast  48 22 Jun 2006 18:48:52 samples 49280 to 50953, avg = 1, stop = mag switch
* S>
```

List of variables to be initially converted and derived:

```
# nquan = 12
# nvalues = 134
# units = specified
# name 0 = scan: Scan Count
# name 1 = timeS: Time, Elapsed [seconds]
# name 2 = prdM: Pressure, Strain Gauge [db]
# name 3 = tv290C: Temperature [ITS-90, deg C]
# name 4 = c0mS/cm: Conductivity [mS/cm]
# name 5 = flECO-AFL: Fluorescence, Wetlab ECO-AFL/FL [mg/m^3]
# name 6 = upoly0: Upoly 0, Turbidimeter
# name 7 = nbin: number of scans per bin
# name 8 = depSM: Depth [salt water, m], lat = 60
# name 9 = sal00: Salinity [PSU]
# name 10 = sigma-t00: Density [sigma-t, Kg/m^3 ]
# name 11 = flag: flag
# span 0 =        459,       1045
# span 1 =    114.497,    261.055
# span 2 =      1.000,    134.000
# span 3 =     5.0527,    12.2755
# span 4 =  30.764489,  33.029437
# span 5 =     9.8855,    11.4881
# span 6 =  24.261663,  24.285019
# span 7 =          3,         17
# span 8 =      0.991,    132.694
# span 9 =    26.4293,    32.0688
# span 10 =    19.8948,    25.3170
# span 11 = 0.0000e+00, 0.0000e+00
# interval = decibars: 1
# start_time = Jun 22 2006 18:48:52
# bad_flag = -9.990e-29
# sensor 0 = Frequency 0  temperature, 4773, 08-Mar-06
# sensor 1 = Frequency 1  conductivity, 4773, 08-Mar-06, cpcor = -9.5700e-08
# sensor 2 = Pressure Number
# sensor 3 = Extrnl Volt  0  WET Labs, ECO_AFL
```

```
# sensor 4 = Extrnl Volt  1  userpoly 0, 0281, 11-Jan-06
# datcnv_date = Jun 30 2006 13:21:25, 5.34a
# datcnv_in = C:\SBE4223\2006\pwstsgJun06_ctd\ak606tsgc048.hex
```

Calibration file used for data conversion and list of standard post-processing steps using SBE algorithms in the Data Processing software

```
C:\SBE4223\2006\pwstsgJun06_ctd\4773_Mar06.con
# datcnv_skipover = 240
# filter_date = Jun 30 2006 13:34:59, 5.34a
# filter_in = C:\SBE4223\2006\pwstsgJun06_ctd\ak606tsgc048.cnv
# filter_low_pass_tc_A = 0.500
# filter_low_pass_tc_B = 1.000
# filter_low_pass_A_vars = tv290C c0mS/cm
# filter_low_pass_B_vars = prdM
# alignctd_date = Jun 30 2006 13:35:34, 5.34a
# alignctd_in = C:\SBE4223\2006\pwstsgJun06_ctd\ak606tsgc048.cnv
# alignctd_adv = tv290C 0.500
# binavg_date = Jun 30 2006 13:36:01, 5.34a
# binavg_in = C:\SBE4223\2006\pwstsgJun06_ctd\ak606tsgc048.cnv
# binavg_bintype = decibars
# binavg_binsize = 1
# binavg_excl_bad_scans = yes
# binavg_skipover = 0
# binavg_surface_bin = no, min = 0.000, max = 0.000, value = 0.000
# Derive_date = Jun 30 2006 13:36:26, 5.34a
# Derive_in = C:\SBE4223\2006\pwstsgJun06_ctd\ak606tsgc048.cnv
C:\SBE4223\2006\pwstsgJun06_ctd\4773_Mar06.con
# file_type = ascii
```

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

Budget Category:	Proposed FY 10	Proposed FY 11	Proposed FY 12	Proposed FY 13	TOTAL PROPOSED
Personnel	$40.2	$41.4	$53.0	$54.6	$189.1
Travel	$5.4	$1.8	$1.2	$1.2	$9.6
Contractual	$11.3	$10.3	$6.8	$9.3	$37.7
Commodities	$5.0	$6.1	$3.5	$0.5	$15.1
Equipment	$1.5	$0.0	$0.0	$0.0	$1.5
Subtotal	$63.4	$59.6	$64.5	$65.6	$253.0
Indirect at 28%	$ 17.7	$ 16.7	$ 18.1	$ 18.4	$70.8
SUBTOTAL	$81.1	$76.2	$82.6	$84.0	$323.9
General Administration (9% of subtotal)	$7.3	$6.9	$7.4	$7.6	$29.1
PROJECT TOTAL	$88.4	$83.1	$90.0	$91.5	$353.0
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0

COMMENTS: In this box, identify non-EVOS funds or in-kind contributions used as cost-share for the work in this proposal. List the amount of funds, the source of funds, and the purpose for which the funds will be used. Do not include funds that are not directly and specifically related to the work being proposed in this proposal.

FY10 - 13

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4A
NON-TRUSTEE
AGENCY SUMMARY

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

Personnel Costs:		GS/Range/	Months	Monthly		Personnel
Name	Project Title	Step	Budgeted	Costs	Overtime	Sum
Shelton M. Gay III	Principal Investigator		6.0	5.0		30.2
T.B.D	Technician		2.0	5.0		10.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		8.0	10.0	0.0	
					Personnel Total	$40.2

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
College Station, TX to Cordova for mooring deployment cruise in Fall	0.8	1	5	0.2	1.8
College Station, TX to Anchorage for Alaska Marine Sympoisum	0.8	1	5	0.2	1.8
College Station, TX to Cordova for mooring servicing cruise in Spring	0.8	1	5	0.2	1.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$5.4

FY10

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B
PERSONNEL &
TRAVEL DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

Contractual Costs: Description	Contract Sum
Vessel Charter - provided by collaborative proposal, P.I. Thorne	
Vessel Charter - provided by TSG cruises under collaborative proposal, P.I. Campbell - these funds include additional fuel and time co	5.0
calibration for 2 SBE16 Seacats and 6 SBE 37 microcats	6.0
network costs (based on $50/mo x staff mo)	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$11.3

Commodities Costs: Description	Commodities Sum
field & office supplies	0.5
batteries & maintenance supplies for Seacats	0.5
lines, shackles etc. for moorings	1.5
anchors for two more moorings	0.3
hard trawl floats (subsurface buoys for moorings)	0.2
HOBO Tidbit thermistors (20)	2.0
Commodities Total	$5.0

FY10

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B
CONTRACTUAL & COMMODITIES DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
new laptop	1.0	1.5	1.5
			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	$1.5

Existing Equipment Usage: Descriptior	Number of Units	Inventory Agency
SBE16 Seacat CTs (moorings)	2	PWSSC
SBE37 microcat CTDs (moorings)	6	PWSSC
SBE19plus CTD Profiler w/ fluorometer & turbidity sensors	1	PWSSC
SBE 19 CTD Profiler	1	PWSSC
Spar buoys (for moorings)	2	PWSSC
Fender floats (for moorings)	6	PWSSC
Hard Trawl floats (for mooring subsurface buoys)	6	PWSSC
anchors (60-70 lb Danforth)	2	PWSSC

FY10

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B
EQUIPMENT
DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

Personnel Costs:		GS/Range/	Months	Monthly		Personnel
Name	Project Title	Step	Budgeted	Costs	Overtime	Sum
Shelton M. Gay III	Principal Investigator		6.0	5.2		31.1
T.B.D	Technician		2.0	5.2		10.3
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		8.0	10.3	0.0	
					Personnel Total	$41.4

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
College Station, TX to Anchorage for Alaska Marine Sympoisum	0.8	1	5	0.2	1.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.8

FY11

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B
PERSONNEL &
TRAVEL DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

Contractual Costs: Description	Contract Sum
Vessel Charter - provided by collaborative proposal, P.I. Thorne	
Vessel Charter - provided by TSG cruises under collaborative proposal, P.I. Campbell - these funds include additional fuel and time co	5.0
calibration for 6 SBE 37 microcats (incl. 4 extra for 2 new moorings)	5.0
network costs (based on $50/mo x staff mo)	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$10.3

Commodities Costs: Description	Commodities Sum
field & office supplies	0.5
batteries & maintenance supplies for Seacats	1.0
lines, shackles etc. for moorings	2.0
anchors for two extra moorings for delpoyment in new nursery bays	0.3
surface buoys and subsurface trawl floats for two extra moorings	0.3
HOBO Tidbit thermistors (20)	2.0
Note - The increase in some costs reflects extra moorings possibly to be deployed in new nursery bays	
Commodities Total	$6.1

FY11	**Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring** **Lead PI:Gay (PWSSC/TAMU)**	**FORM 4B CONTRACTUAL & COMMODITIES DETAIL**

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

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: Descriptior	Number of Units	Inventory Agency
SBE16 Seacat CTs (moorings)	2	PWSSC
SBE37 microcat CTDs (moorings)	2	PWSSC
SBE19plus CTD Profiler w/ fluorometer & turbidity sensors	1	PWSSC
SBE 19 CTD Profiler	1	PWSSC
Spar buoys (for moorings)	2	PWSSC
Fender floats or crab-pot buoys (for moorings)	6	PWSSC
Hard Trawl floats (for mooring subsurface buoys)	8	PWSSC
anchors (60-70 lb Danforth)	4	PWSSC

FY11

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B
EQUIPMENT
DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

Personnel Costs:		GS/Range/	Months	Monthly		Personnel
Name	Project Title	Step	Budgeted	Costs	Overtime	Sum
Shelton M. Gay III	Principal Investigator		6.0	7.1		42.4
T.B.D.	Technician		2.0	5.3		10.6
Note the PI's salary rate increased due to						0.0
receiving benefits as becoming a						0.0
full-time employee						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		8.0	12.4	0.0	
					Personnel Total	$53.0

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
Cordova to Anchorage for Alaska Marine Sympoisum	0.2	1	5	0.2	1.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.2

FY12

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B
PERSONNEL &
TRAVEL DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

Contractual Costs: Description	Contract Sum
Vessel Charter - provided by collaborative proposal, P.I. Thorne	
Vessel Charter - provided by TSG cruises under collaborative proposal, P.I. Campbell - these funds include additional fuel and time co	5.0
final calibration for 2 SBE16 Seacats	1.5
network costs (based on $50/mo x staff mo)	0.3
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$6.8

Commodities Costs: Description	Commodities Sum
field & office supplies	0.5
batteries & maintenance supplies for Seacats	1.0
lines, shackles etc. for moorings	2.0
Commodities Total	$3.5

FY12

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B
CONTRACTUAL &
COMMODITIES
DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

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: Descriptior	Number of Units	Inventory Agency
SBE16 Seacat CTs (moorings)	2	PWSSC
SBE37 microcat CTDs (moorings)	2	PWSSC
SBE19plus CTD Profiler w/ fluorometer & turbidity sensors	1	PWSSC
SBE 19 CTD Profiler	1	PWSSC
Spar buoys (for moorings)	2	PWSSC
Fender or crab-pot floats (for surface buoys)	8	PWSSC
Hard Trawl floats (for mooring subsurface buoys)	12	PWSSC
anchors (60-70 lb Danforth)	6	PWSSC

FY12

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B
EQUIPMENT
DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Personnel Sum
Name	Project Title					
Shelton M. Gay III	Principal Investigator		6.0	7.3		43.7
T.B.D.	Technician		2.0	5.5		10.9
Note the PI's salary rate increased due to						0.0
receiving benefits as becoming a						0.0
full-time employee						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		8.0	12.7	0.0	
					Personnel Total	$54.6

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Travel Sum
Cordova to Anchorage for Alaska Marine Sympoisum	0.2	1	5	0.2	1.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.2

FY13

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B
PERSONNEL &
TRAVEL DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

Contractual Costs: Description	Contract Sum
Vessel Charter - provided by collaborative proposal, P.I. Thorne	0.0
Vessel Charter - provided by TSG cruises under collaborative proposal, P.I. Campbell - these funds include additional fuel and time co	0.0
network costs (based on $50/mo x staff mo)	0.3
final post-deployment calibration for 12 SBE 37 microcats	9.0
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$9.3

Commodities Costs: Description	Commodities Sum
field & office supplies	0.5
Commodities Total	$0.5

FY13

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B CONTRACTUAL & COMMODITIES DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

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: Descriptior	Number of Units	Inventory Agency

FY13

Project Title:PWS herring survey: Physical Oceanographic Characteristics of Nursery Habitats of Juvenile Pacific Herring
Lead PI:Gay (PWSSC/TAMU)

FORM 4B
EQUIPMENT
DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

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DETAILED BUDGET FORM FY 10- FY 12

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DETAILED BUDGET FORM FY 10- FY 12

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

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DETAILED BUDGET FORM FY 10- FY 12

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 10- FY 12