PROJECT TITLE: Physical Oceanographic Factors Affecting Productivity in Juvenile Pacific Herring Nursery Habitats, submitted under the BAA

Project Number: 070817

Interim Progress Report

July 2007

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Affiliations: Prince William Sound Science Center and Texas A&M University

Project Overview

The objectives of the study of physical oceanographic factors affecting productivity in juvenile herring nursery habitats are to build upon the data base within Prince William Sound (PWS) fjords started under Sound Ecosystem Assessment (SEA) to provide a more objective description of the seasonal dynamics of physical factors affecting productivity of nursery fjords and potential coupling of high recruitment of juvenile herring to broad-scale advection of Gulf of Alaska (GOA) water into PWS. It is also intended to address the limitations inherent in the SEA study, by providing a more comprehensive set of physical data that can be tested with advanced statistical methods used to discern the dominant mechanisms forcing the circulation within fjords and hence advection and/or retention of plankton and larval herring within nursery fjords. Understanding how these mechanisms vary between productive and marginally productive habitats is crucial in accessing the feasibility of restoring Pacific herring by remote rearing of juveniles within specific nurseries. In addition, temporal variation in the physical properties of these sites is important to ascertain the strength of these patterns over time in response to interannual (high frequency) and interdecadal (low frequency) climatic shifts brought about respectively by the El Nino Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO), as well as gradual background changes heat flux due to Global Warming.

To meet these objectives the study has three major goals:1) to continue a time series of basic physical and biological parameters measured during the SEA project within four nursery fjords used by juvenile Pacific herring (Fig. 1), and to compare these results with similar data being collected at oceanographic moorings at Hinchinbrook Entrance (HE) and Montague Strait (MS) and during high spatial resolution hydrographic cruises conducted as part of the PWS (Ocean) Observing System (PWSOS); 2) To quantify conditions that influence advection of nutrients and plankton into two experimental nursery fjords by measuring features of hydrography and circulation pertaining to exchange of water near the mouth.; and 3) to provide descriptions of the general circulation within two nursery fjords (one per year) by obtaining high resolution physical data on the flow field and its affects on the spatial distribution of physical properties.

Results to Date

Broadscale Hydrography

The first component of this research involves the seasonal collection of hydrography data from the four fjords surveyed during SEA and stations within PWS. The data, including temperature and salinity (T/S), fluorescence, and turbidity, are being obtained through coordination with other ongoing research programs including Oil Spill Recovery Institute (OSRI) and Alaska Ocean Observing System (AOOS) sponsored oceanographic moorings, thermosalinograph (TSG) cruises within PWS, and two EVOS funded research projects: (Trends in adult and juvenile herring distribution and abundance in PWS - R. Thorne, PWSSC and Prince William Sound Herring Forage Contingency - T. Klein, PWSSC). Results of the AOOS moorings deployments are still under evaluation, but hydrography data within the four SEA fjords were collected in March and June, and additional conductivity/temperature/depth (CTD) data in Simpson were collected in June and July (Table 1). A TSG cruise planned for early August will

Table 1. Research Log for Factors Affecting Productivity in Herring Nurseries (2007)

Month	*Dates*	*Cruise, Locations & P.I.*	*Types Data Collected or Service Performed*
March	19-24	Juvenile Herring Cruise - D. Thorne	Broad scale hydrography; CTDs at 6 stations in each fjord
May	8-20	Zooplankton Cruise - T. Kline	Hydrography (Hydrobios CTDF) at discrete depths in above fjords
June	2	Trip to Simpson - S.Gay	Hydrography (6 CTDs) & wire-walker test deployment at SB
June	13-14	Cruise to Simpson - S. Gay	CTD Moorings deployed at SB (inner basin and mouth)
June	16	Trip to Simpson in Whaler - S. Gay	Checked moorings & placed kill cells on CT in N. Arm
June	20-22	Cruise to Simpson Bay (KD706)	Intensive ADCP/Hyrography transects
June	26	Trip to Simpson in Whaler - S. Gay	Collected water samples (A.Q.) & CTDs at 4 stns (20 m max.)
June	28	Trip to Simpson in Whaler - S. Gay	Download met data; zoop tows at mouth & delta (N.Arm); CTD's
July	1-5	TSG Cruise to EGB, WB, ZB	Broad scale hydrography; tsg & CTDs at 6 stations in each fjord
July	7	Trip to Simpson in Whaler - S. Gay	Download met data & attempted to deploy 2nd weather stn
July	13	Trip to Simpson in Whaler - S. Gay	setup shore met station on an island on east side of Simpson
July	15-17	Cruise to Simpson Bay (OC707)- S.Gay	Intensive ADCP/Hyrography transects
July	21	Trip to Simpson in Whaler - S. Gay	Download met data from buoy & shore stations (note-unable to establish comm. w/ buoy met station)

collect CTD data throughout PWS and at the mooring sites in Hinchinbrook Entrance and Montague Strait. This cruise will also survey the four SEA fjords as well as the outer portions of two tidewater glacial fjords also investigated during SEA (Unakwik Inlet and Icy Bay). The intent here is to determine the extent of subsurface glacial water potentially emanating from the glacial basins. During the SEA project, water advected from these fjords was found to enter Eaglek Bay and Whale Bay and produce fronts (i.e. differing fish habitat) within the main basins (Gay and Vaughan, 2001).

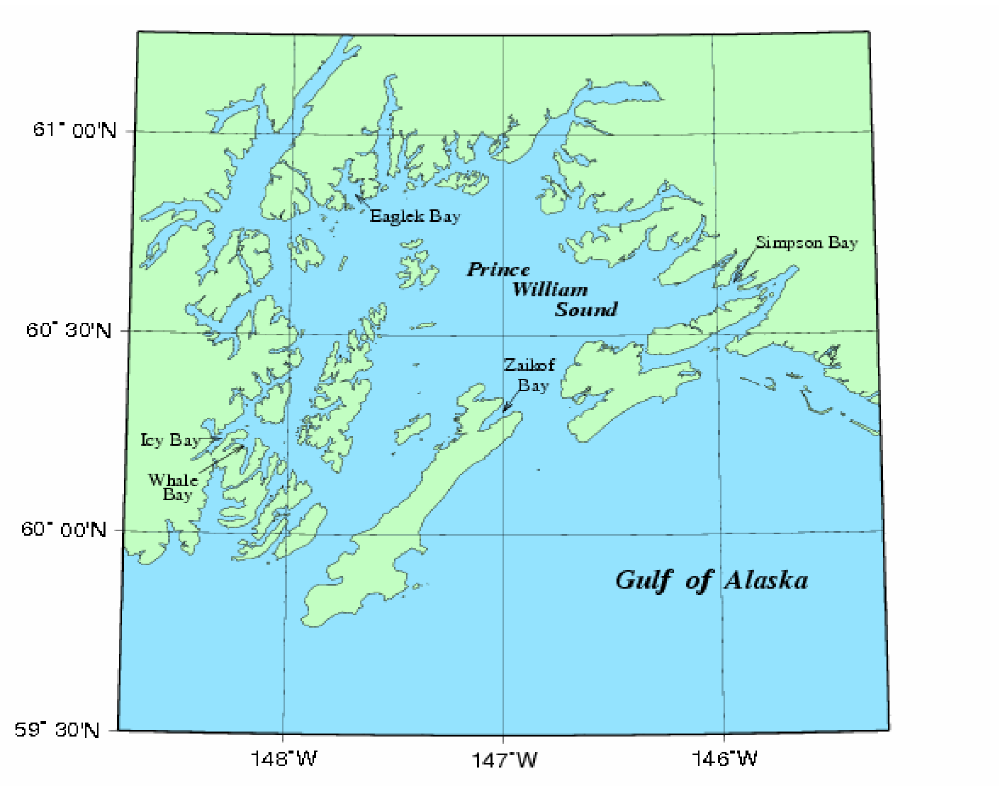

Fig. 1. Locations of four fjords surveyed during the SEA herring research project conducted from 1995 to early 1998.

Results from March 2007 Cruise

The physical properties of the four SEA fjords surveyed in March 2007 are shown in Figure 2. The conditions observed in 1996 are shown in Figure 3 to provide a comparison over 10+ years. From these data it is quite evident that local spatial variation in late winter is greater among these four sites in 2007 in comparison to 1996. Note, however, that the plots for 2007 go only to 100*m* depth whereas the 1996 data show nearly the entire water column. Comparing the T/S data to this depth limit shows profiles in 2007 to be generally colder and saltier in comparison to 1996. This is expected on the basis of the extreme weather conditions that occurred in March 2007 in comparison to 1996. For example mean air temperatures over PWS in March 1996 were ~ 2^{o}C (Gay and Vaughan, 2001) whereas in March 2007 high pressure over the continent created strong seaward katabatic winds and air temperatures fell to -17 ^{o}C (Dick Thorne, personal comm.).

One interesting difference between these years, however, is the marked spatial heterogeneity that occurred in 2007 despite the strong mixing processes that prevailed that year. This appears to reflect both local variation in winter climatic conditions and differences in water mass conditions between the inner and outer regions of these fjords, particularly at stations located at the mouths. The fjord exhibiting the most consistent vertical pattern in mixing of heat and freshwater is Whale. The depth of upper layer mixing in 2007 is much greater (40-50m) in comparison to all other fjords as well as to conditions within Whale in 1996 (Fig. 3b). In fact, 1996 exhibited the coldest winter water conditions during the SEA years (1996-1998), and yet in 2007 the entire upper 50m layer is significantly colder and fresher by comparison. This suggests that 2007 is an anomaly, and illustrates the need for long-term data collection if highly variable interannual events are to be distinguished from low frequency changes occurring in the background, such as ENSO and PDO.

Exprimental Bay

The second component of this project involves intensive collection of physical data in Simpson Bay (Fig. 1b), an experimental nursery fjord selected for 2007. Whale Bay will be surveyed in 2008. The various cruises and trips (non-chartered) made to Simpson since the beginning of June are listed in Table 1. These trips have involved both intensive acoustic Doppler current meter (ADCP)/hydrography cruises conducted in June and July and various half-day trips in my personal skiff to download weather data (described below) and collect water and plankton samples. Additional data collected during the intensive cruise in July include water for nutrient and chlorophyll analyses and zooplankton net-tows. The water samples will be analyzed by Antonietta Quigg, who is concurrently investigating phytoplankton production in Simpson Bay, whereas the zooplankton samples will be processed qualitatively for species composition by Dr. Robert Campbell (PWSSC).

Currents. Examples of ADCP data collected during the intensive cruise in June are given in Figures 4 to 6. Figure 4 shows a vertical section of the *u* velocity component during the first flood tide and Figure 5 shows the near surface (2*m*) current vectors for the same set of transects. Note that during this tide phase strong currents occur in the upper 10*m* over the entire main basin. These flows appear to force a flow reversal along the eastern side of the fjord thus forming an eddy at the mouth (Fig. 5). These results are consistent with ADCP data collected later in July 2007 and during a flood tide in 1996 (see Fig. 5 in Revised DPD). In contrast, the Northern Arm (inner basin) has very limited flows during the flood tide. However, during ebb tide (Fig. 6) the outflows increase in strength apparently due to the topographic obstruction caused by the reef (sill) guarding the entrance to this basin. This reef also causes a topographic obstruction to deep flows and hence appears to set up a subsurface reversal (Fig. 6), which was also observed within the N. Arm during the SEA project.

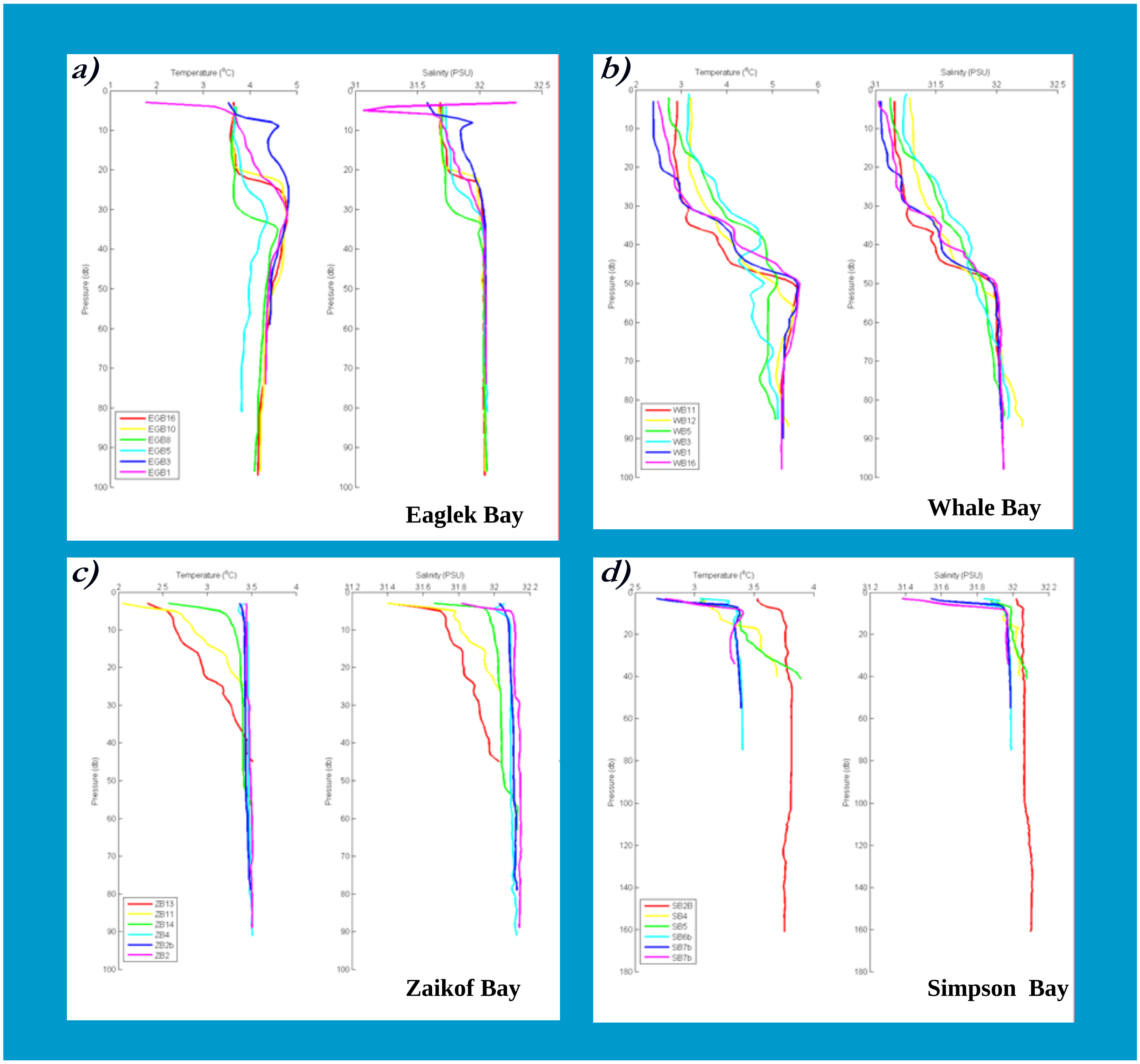

Fig. 2. Spatial variation in hydrography within the four SEA nursery fjords in March 2007. (*Plots courtesy of Rob Campbell, PWSSC.*)

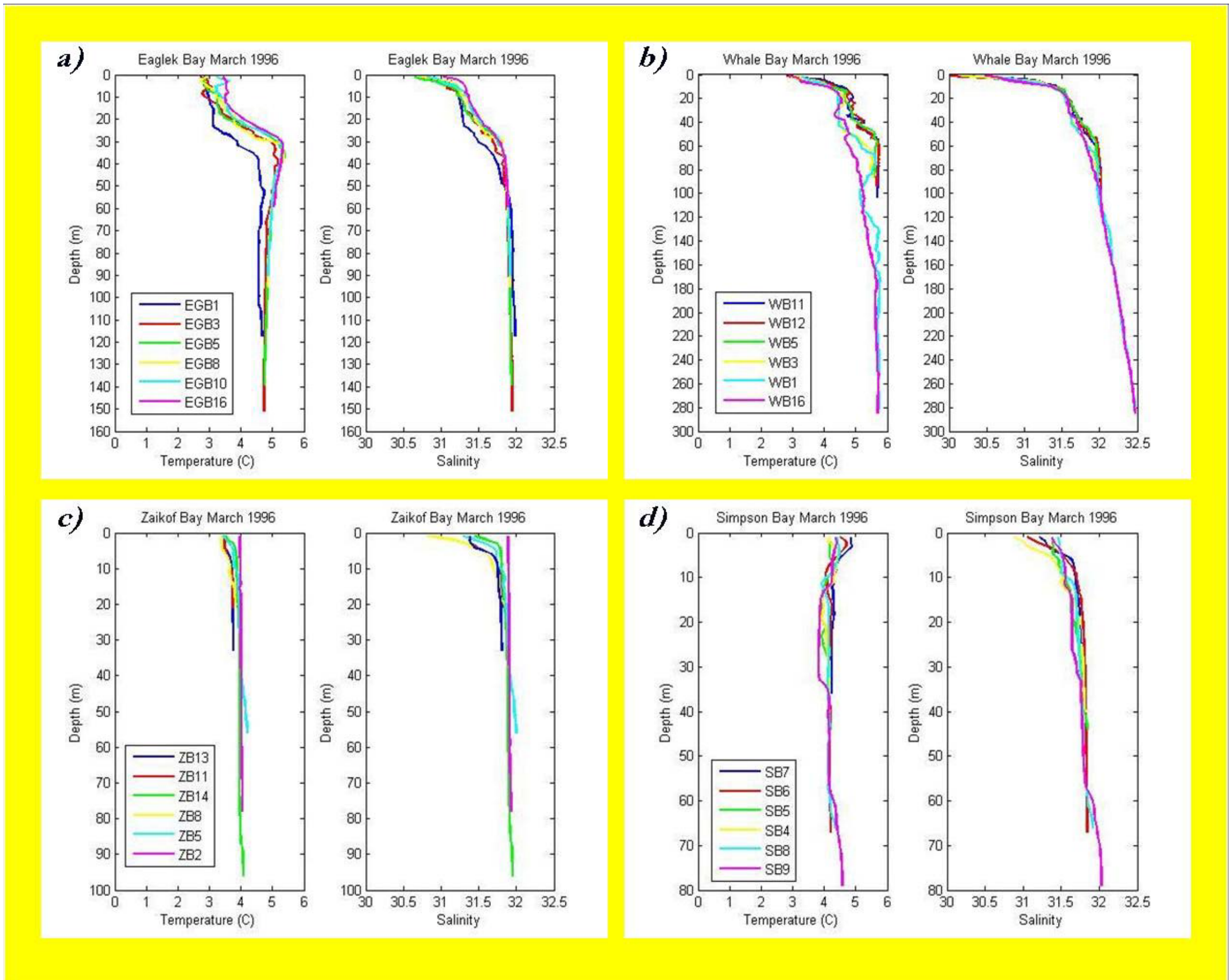

Fig. 3. Spatial variation in hydrography within the four SEA nursery fjords in March 1996.

Ancillary data collected in Simpson Bay include a time series of meteorological data consisting of winds and air temperatures (Fig. 7). These data are being collected by a weather station placed on the mooring buoy at the mouth and also by a second station, which has been set up on shore on an island located on the eastern side of the mouth (Fig. 8).

Figure 7 shows a subset of the total time series for the period covering the first intensive cruise (June 20-22). The shaded area of the plot indicates the period over which transects were surveyed in Figures 4 to 6. Note that the although the winds were generally low during this period there is a burst of winds from the west-southwest exceeding 5*m/s* (~ 10*kts*) during the flood tide. Many of these westerly wind bursts have been evident in the wind data this summer. They are typically generated by high barometric pressure to the west and intensify in the afternoon due to sea-breeze effects. These winds probably enhanced the inflowing currents during the first flood tide slightly. However, the primary forcing of these flows was due to the tidal prism and effects of bathymetry. The same pattern was observed during the first flood tide in July, which had a similar tidal height change (~ 3*m*). In contrast to June, however, the winds from the west were stronger (~8-10*mps*) and this appeared to enhance the surface inflow and the eddy formation at the mouth. These observations tend to confirm a supposition made during the SEA project regarding surface transport from central PWS into Simpson Bay.

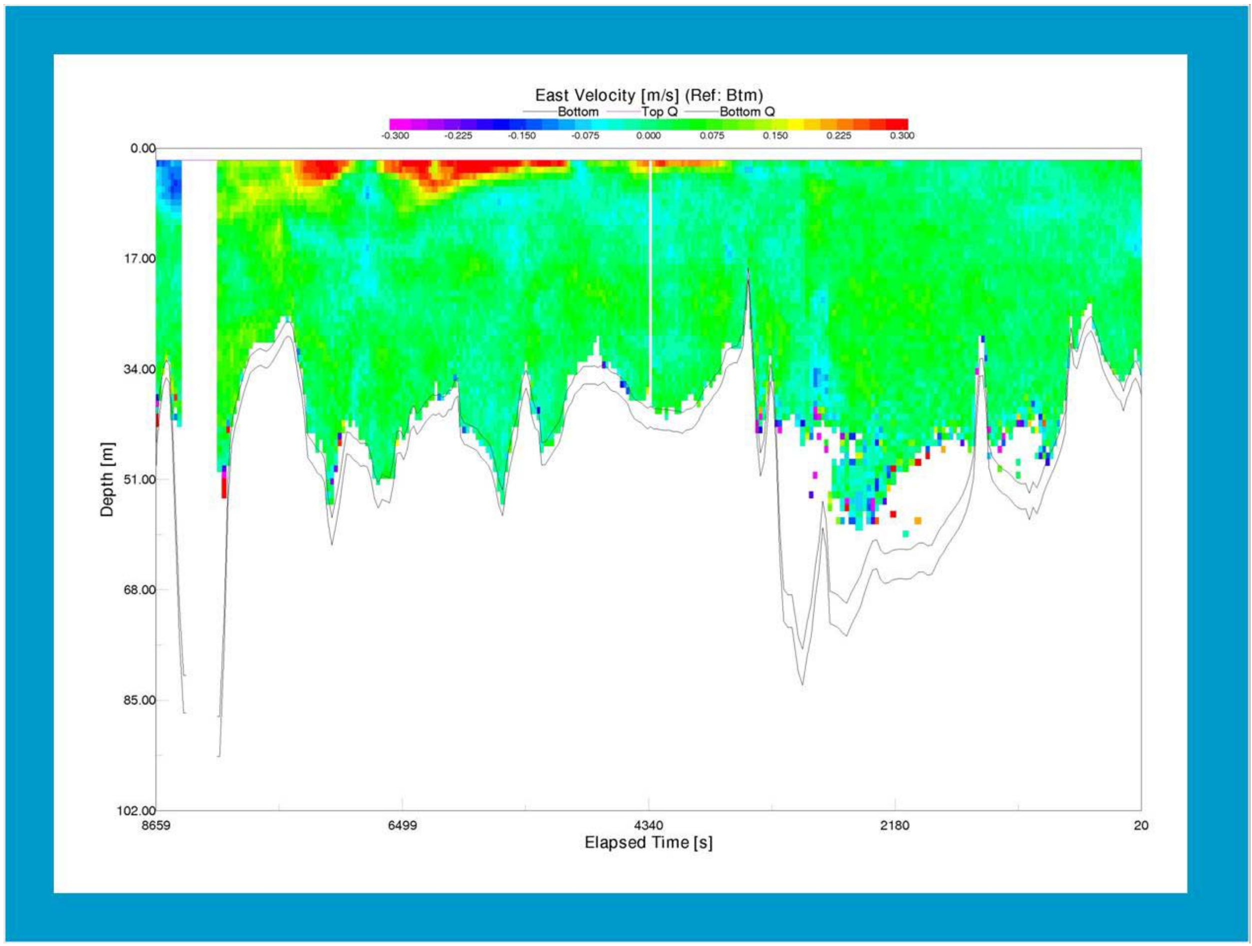

Fig. 4. East velocity (*u*) component of currents during the first flood tide in Simpson Bay, June 21, 2007.

Hydrography. During the first intensive cruise in June hydrography data were collected initially with an undulating tow-body. Because of a problem with the Chelsea Instruments (CI) Aquapack these data were collected with an SBE911 CTD mounted to a tow-sled. This instrument was providing very high resolution T/S data, but unfortunately the sled struck bottom in the deep channel on the eastern side of the mouth. The impact sheered off the power bulkhead connector and disabled the instrument for the remainder of the cruise. To compensate for this loss, CTD casts were repeated at standard stations from the N. Arm to the main basin and a series of 5 stations were surveyed across the mouth. The repeated casts were performed on every other set of transects, thus allowing uninterrupted current data collection on every other set. This same protocol was followed during the July cruise, as the vessel used for the survey was not capable of operating the hydraulic winch required for the undulating CTD. At present, the minimum size vessel for collecting these data is a 15*m* (50*ft*) seine type vessel equipped with 220 VAC 3-phase power. Due to the escalation in fuel and charter costs it is anticipated that only one more cruise of this type may be feasible this summer due to budgetary constraints.

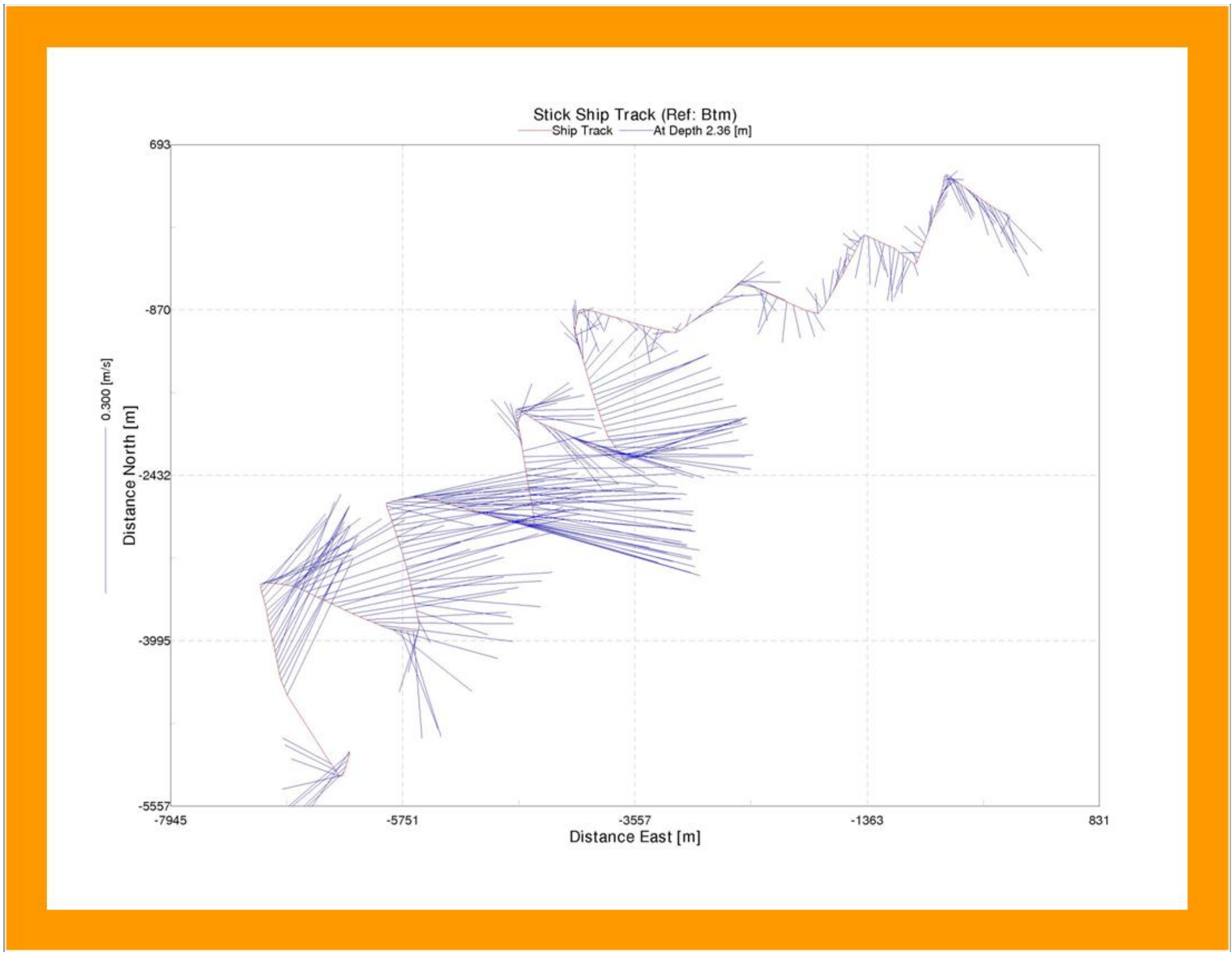

Fig. 5. Surface (2m) currents during the first flood tide in Simpson Bay, June 21, 2007.

An example of T/S data collected at the standard stations just prior to the intensive transects surveyed in June is shown in Figure 9. These CTD casts span between the N. Arm and the mouth (SB7b to Sb2b), and include two stations in the SE Arm (SB8 and 9). The data were collected during a flood tide on June 20. Although there is some spatial variation evident in the subsurface physical properties, the main feature that stands out is the progressive increase in salinity from the inner basin (N. Arm) and the outer basin and mouth. The surface water is warmest within the upper main basin (SB5) and coolest within the inner basins (at both SB7b and SB8). The conditions within the N. Arm remained the same during the ebb tides with the exception that station 7 exhibited low surface salinity (<10) due to discharge from the river moving southward.

This water also tended to be significantly cooler during the ebb since it primarily originates from glacial melting in the watershed. Station SB8 and 9 also exhibited cooler surface conditions, but the water was also saltier in comparison to the other arm. This appears to be the result of both surface mixing in this region of the fjord and less freshwater input. For example the westerly winds that affect the main basin continue unhindered into the SE Arm where the long fetch produces breaking and mixing far up into the arm.

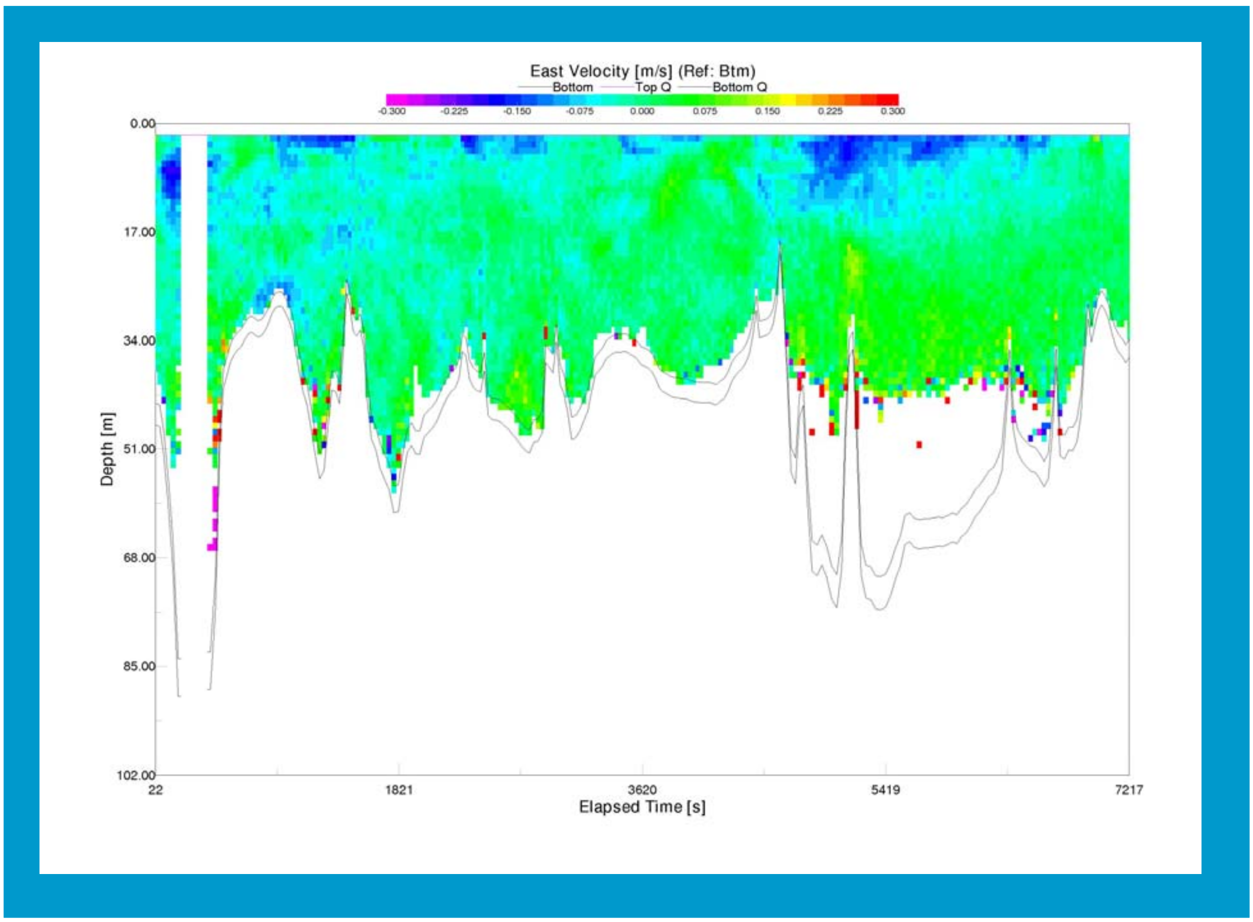

Fig. 6. East velocity (*u*) component of currents during the first ebb tide in Simpson Bay, June 21, 2007.

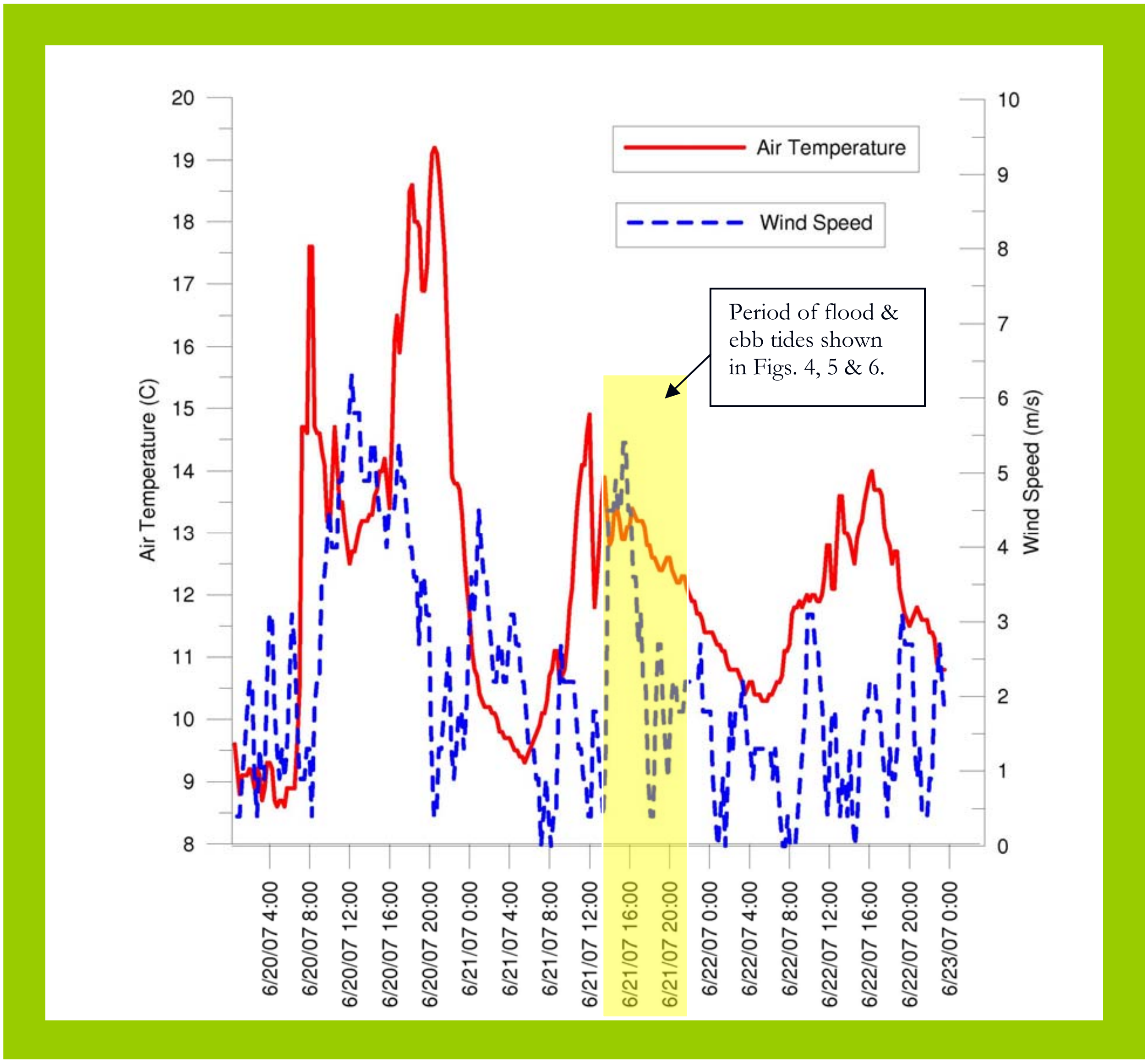

Fig. 7. Air temperatures and wind speeds during the first intensive ADCP/hydrography cruise from June 20-22, 2007. Shaded area shows period during the first flood and ebb tide for data shown in Figures 4 to 6.

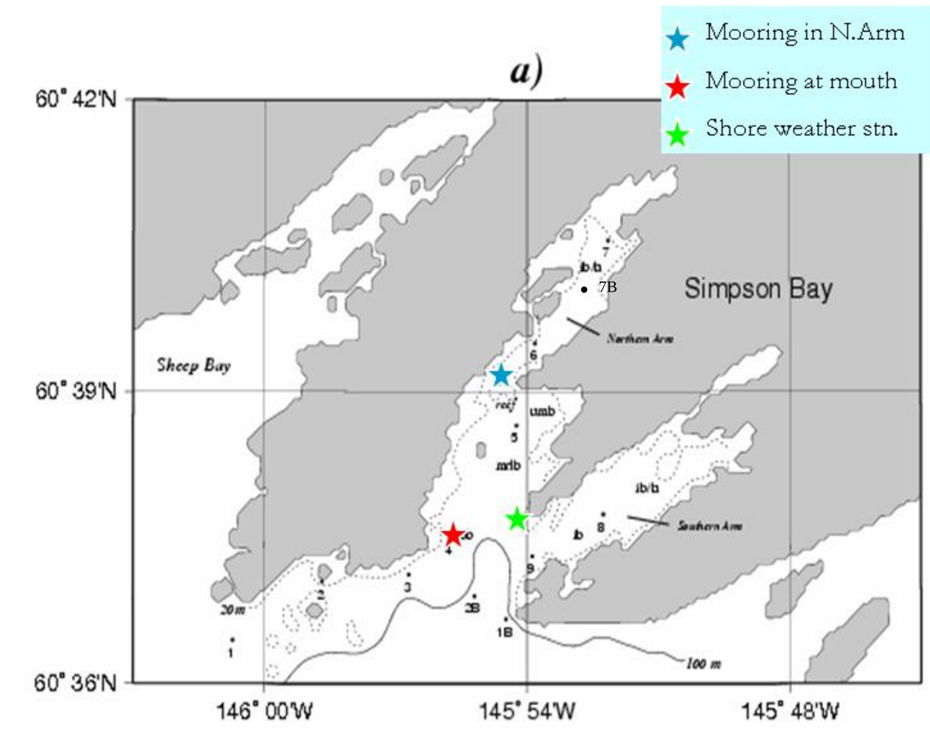

Fig. 8 Locations of oceanographic stations, CT moorings and shore weather station in Simpson Bay in 2007. Note that station 6 is close to 6b in Fig. 9.

CTD Moorings

The final component of the experimental fjord is comprised of time series of heat and freshwater flux obtained from two moorings equipped with near-surface (2-3*m*) and deep (40-70*m*) CTs. These moorings are deployed in the deep (70-80*m*) portion of the N. Arm (i.e. north of the sill) and near the mouth (40-50*m*) respectively (Fig. 8). The moorings were deployed in mid June, prior to the first cruise on June 20-22, and will be retrieved in the early fall. Calibrations of the CTs were performed by SBE Inc. prior to deployment to determine offset and drift in the sensors.

A schematic of the mooring located near the mouth is shown in Figure 10. Pictures of the various components of these moorings are also shown in this Figure. The basic design of the moorings includes subsurface flotation located at the top of the thermistor array. This functions to both minimize the dip in the mooring line during ebb tides and serve as a potential recovery safeguard if the surface buoys were to be lost or sunk for some reason. To reduce the lean of the mast under high winds the spar buoy at the mouth was designed with a tether (Fig. 10d). This was done to prevent an excessive vertical angle for the anemometer on the weather station. The clamping point for this tether is located at the approximate center of pressure given a 1.0 *m/s* current and a 10 *m/s* wind. The latter parameters fall well within the range of water currents and winds expected during the summer at Simpson. Note that the console and battery for operating the weather station is located inside a waterproof Pelican case attached to the buoy mast (Fig. 10b,d,e). Instead of heavy solid weights, the anchor system utilizes large Danforth style anchors with long (10m) runs of chain and a series of heavy links on the ends. This was done to ensure that minimal drag occurs under high current and wind loads and also for ease of deployment. As of this report both moorings are performing well and have remained in place.

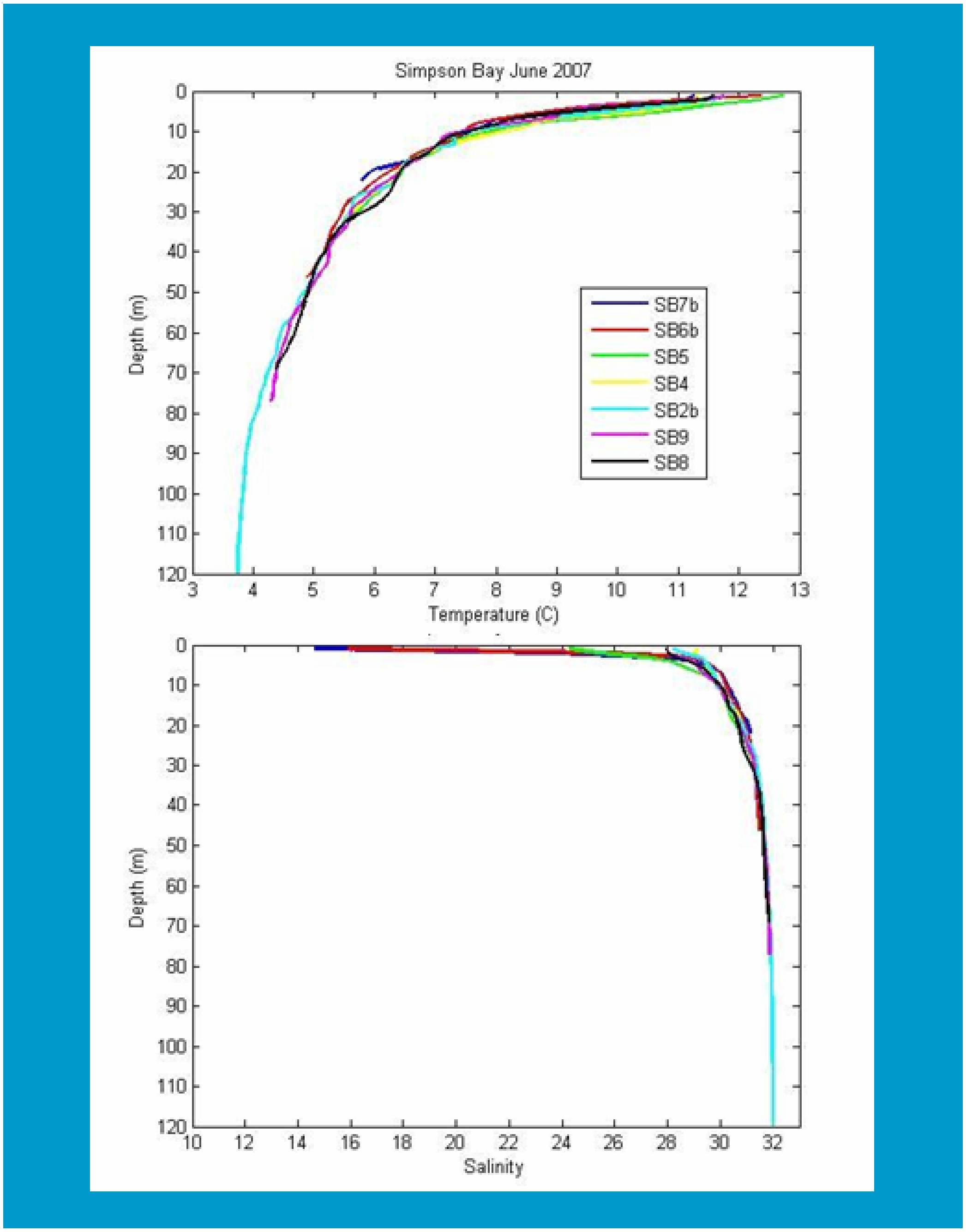

Fig. 9. Temperature and salinity profiles during a flood tide on June 20, 2007 prior to ADCP transects on June 21-22.

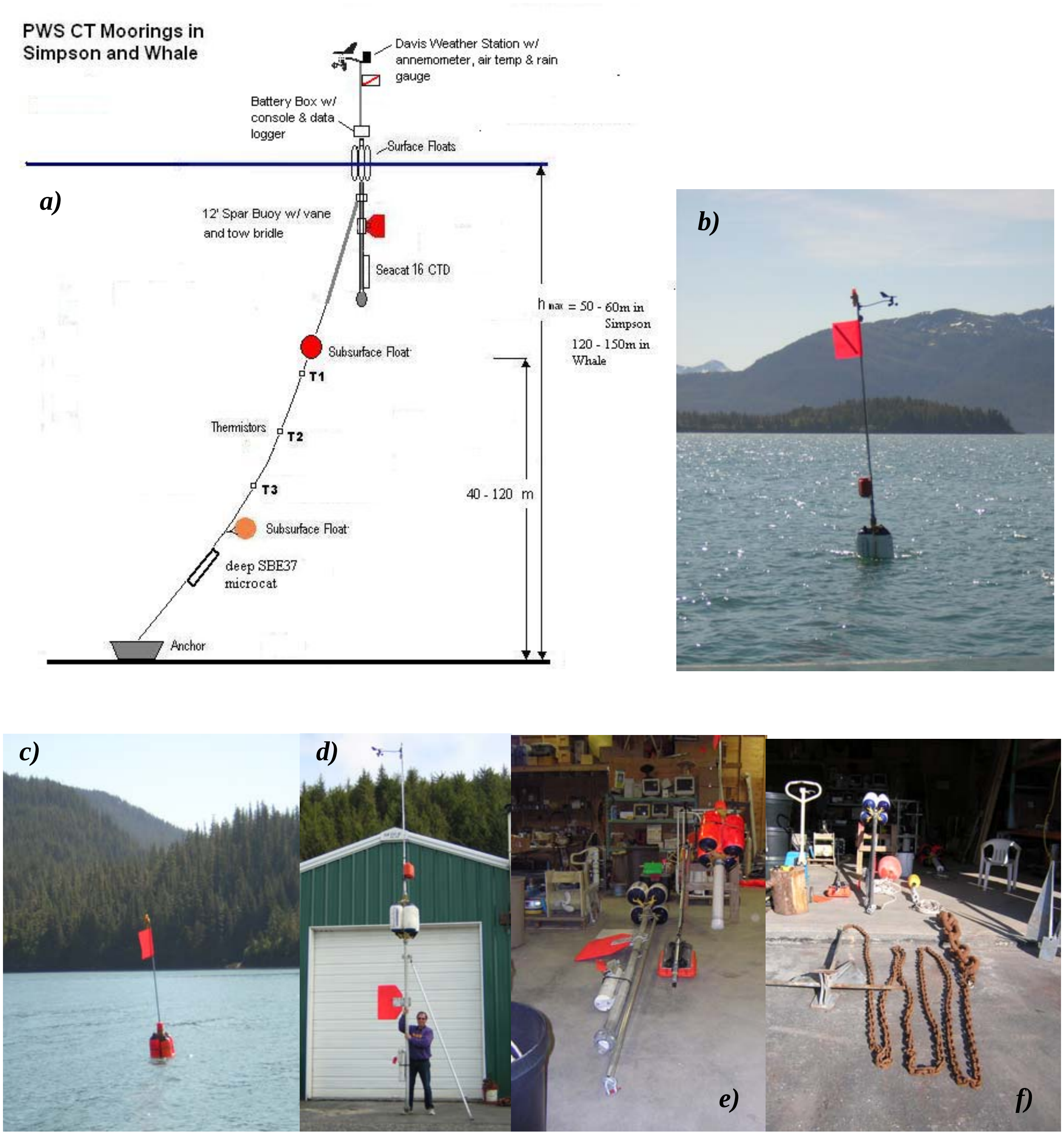

Fig. 10. Schematic and components of moorings deployed in Simpson Bay. a) schematic showing placement of CTs and thermistors; b and c) surface buoys deployed at the mouth and N. Arm respectively; d) spar buoy with weather station and tether; e and f) surface buoy components and anchor set-up. Note that anchors are 23 kg (50 lb). Danforth type weighted with ~ 10m of 3/8 in. chain and heavy chain links located at the beginning of the Spectra mooring line. The 1st CT is located 10m above this juncture.

Summary

The project investigating factors affecting productivity of juvenile herring nursery habitats has three major objectives described in the introduction. The first of these, which involves collection of hydrography data within the four SEA fjords, has been mostly successful and thus far two sets of data (March and June) have been obtained. Cast data in May were not obtained, however. This was due in part to the project just beginning and attempting to direct the initial work from Texas. After arriving in Cordova, however, these cruises are being coordinated, and a more intensive cruise is planned for early August in which all of the fjords and TSG stations will be surveyed within one week. This cruise will also include casts at HE and MS to calibrate the AOOS moorings. The last cruise to obtain CTD data from the four SEA fjords this year will likely occur when Dick Thorne's project commences to sample juvenile herring in the late fall.

The second and third objectives of the project involve intensive surveys of the physical oceanography of Simpson Bay. This work has been fairly successful thus far with two cruises completed, two sets of CT moorings deployed and two weather stations set up. At least one more intensive cruise is scheduled before the end of August. Unfortunately, the damage to the undulating tow-sled incurred during the first cruise and the lack of suitable vessels during the summer to operate the CTD winch have constrained the use of this equipment. In addition, there have been equipment problems with the Aquapack, and this instrument has also not been functional since its return. Another limitation involving logistics has been the high cost of fuel and charters. This has created significant constraints this season and is addressed further under the proposed changes to next year's budget.

Despite various set-backs this project has encountered, I believe that a comprehensive picture of the factors forcing circulation within Simpson bay are beginning to emerge from the data being collected. The number of ADCP transects obtained during the last cruise are adequate to perform the statistical analyses described in the proposal to determine the flushing rates and water exchange within the main basin and N. Arm. The hydrography from repeated casts should indicate how water masses are circulating in general with the tide stages, but I will only be able to obtain one full set of these data in late August using an undulating CTD. The next intensive cruise may focus sampling at the mouth of the main basin and SE Arm over several tide cycles to obtain a high frequency record of the currents and hydrography to pinpoint water exchange into the fjord. The water and plankton samples collected during the various cruises will be analyzed to determine the relative importance of locally derived versus allochthonous sources of nutrients and plankton to the productivity of this nursery fjord. These data along with circulation and water exchange should also indicate whether the N. Arm (the primary habitat of age-0 herring) is semi-isolated from flushing that appears to occur regularly in the main basin of the fjord.

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July 27, 2007

To: Michael Baffrey, Executive Director
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Anchorage, AK 99501-2340
Phone: 907-278-8012

Subject: Cover sheet listing changes in project components and budget items for project #070817 Factors Affecting Productivity in Juvenile Pacific Herring Nursery Habitats.

Included with this cover letter are three attachments: a revised Detailed Project Description (DPD), a revised budget and an interim progress report.

Changes to DPD:

In general there are very few changes made to the original DPD. The main exceptions include the following: 1) the total number of oceanographic stations to be surveyed within the four SEA fjords during juvenile herring surveys (R. Thorne's project) and thermosalinograph (TSG) cruises; 2) the placement of a second weather station on shore; and 3) the use of a paired ADCP system to obtain full measurements of currents over deep regions. As described in the interim report, the use of the undulating CTD was limited by equipment problems, damage during the first cruise and, in particular, budget constraints in use of a seine type vessel due to availability and fuel costs. I am requesting a small increase in the budget to cover the rise in cruise expenses due to fuel cost increases; without this budget increase, I may be unable to keep the high resolution hydrography as part of next year's DPD. The loss of these data will make tracking the development of fronts (convergences of different water masses) more difficult.

The following is a list of changes to the original DPD:

Page 5, ¶ 1

Original:

During the highly productive period from spring to early fall, however, the hydrographic data will be collected on a monthly basis during cruises sponsored by PWSOS by a separate vessel, which will be collecting synoptic thermosalinograph (TSG) data in the surface (1m) layer. At this time certain stations may be relocated outside the mouths of the fjords to overlap with current TSG work and with past *surveys of the large primary basins conducted during the SEA project (Vaughan et al., 2001) and OSRI sponsored cruises (Vaughan and Gay, 2002). During TSG surveys hydrographic profiles will also be collected at stations located along the standard route through PWS (Fig. 2).*

Replaced with:

During the highly productive period from spring to early fall, however, the hydrographic data are being collected on a quasi-monthly basis during cruises sponsored by the Alaska Ocean Observing System (AOOS) by a separate vessel, which is collecting synoptic thermosalinograph (TSG) data in the surface (1m) layer. During the TSG surveys hydrographic profiles are also collected at stations located along the standard route through PWS (Fig. 2). In August 2007 additional stations will be surveyed near the mouths of two tidewater glacial fjords to compare the T/S profiles of water emanating from these fjords with past surveys during SEA (Gay and Vaughan 2001). The TSG surveys will also provide an interannual comparison of the hydrography of the large primary basins conducted during the SEA project (Vaughan et al., 2001) and cruises sponsored by OSRI (Vaughan and Gay, 2002).

Page 5, ¶ 2

Original:

From late spring to early fall, all stations will be occupied whenever possible, but in the late fall and late winter/spring (March-early April) the number of stations will be reduced to a 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 3. They were located to obtain either grids covering the larger basins or lines of stations within long narrow arms. Station distances range from 0.5 to 1.0km.

Replaced with:

During these cruises oceanographic stations are occupied to determine the general hydrography within each fjord. The locations and number of stations are shown below for each fjord in Figure 3. These stations follow the sampling regimen used during the SEA project by Gay and Vaughan (2001) and are located so as to obtain a line of stations extending between the head and mouth. Station distances range from 0.5 to 1.0*km*. Although hydrographic conditions are more uniform spatially in the late fall to late winter/spring (March-early April) (Muench and Schmidt, 1975; Gay and Vaughan, 2001; Vaughan et al., 2001), the same stations are being surveyed during each cruise in order to fully compare seasonal T/S conditions among the four fjords.

Page 6, ¶ 3 **Changed** to reflect that R Crawfords Study was not funded.

Page 7, ¶ 2 **Changed** to reflect that spatial variation in hydrography at Simpson is being measured with either repeated CTD casts or an undulating tow-body. In the same paragraph the statement is made regarding calibration casts prior to and after moorings have been deployed. This is changed in the revised DPD to reflect that the instruments were calibrated by SBE prior deployment and will be calibrated again next year.

Page 9, ¶ 2 **Changed** to reflect the limitations found in using the 600 kHz ADCP alone at Simpson and the need for a paired system during future surveys.

Original:

Due to the greater basin depths at Whale Bay (~300m) it will be necessary to use the 150kHz ADCP in this fjord to obtain bottom tracking (i.e. measure absolute vs. relative flow). The inner basins are much shallower (~120m), however, and these regions should be amenable to surveying with the 600kHz unit. The total number of depth bins in the main fjord will range from 20 to 30, but the spatial resolution will be relatively coarse since vessel speeds can not be reduced, as this would prohibit obtaining an adequate number of repeated transects. It may be possible to reduce ensemble averages from 120s to 60s, which would affectively double the resolution of that shown. This will depend on the limit of error based on the ADCP settings.

Replaced with:

The initial surveys at Simpson show that valid water current data with the 600*kHz* unit are limited to about 60*m* due to a threshold in backscatter and echo intensity at greater depths. For this reason future surveys will include either a 300 or a 150*kHz* ADCP in order to obtain flows in the two deep areas located on the eastern side of the mouth (120*m*) and just inside the Northern Arm (80-90*m*). The greater basin depths at Whale Bay (~300*m*) will require the use of the 150*kHz* ADCP to obtain bottom tracking (i.e. measure absolute vs. relative flow). The Southern Arm (inner basin) is much shallower (< 100*m*) and should be amenable to bottom-tracking with the 600*kHz* unit. However, the current profiles will be limited to the upper (60*m*) layer. The total number of 4*m* depth bins using the 150 *kHz* ADCP will range from < 20 to 75, but the spatial resolution will be relatively coarse since vessel speeds can not be reduced, as this would prohibit obtaining an adequate number of repeated transects. It may be possible to reduce ensemble averages from 120*s* which would affectively increase the resolution of that shown (Fig. 5a,b). This will depend on the limit of error based on the ADCP settings. Past experience has shown that high variability in the flows (and hence the Doppler shift) necessitate greater ensemble averaging.

Page 10, ¶ 2 **Changed** to reflect the use of an SB911 CTD if needed

Original:

High Resolution Hydrography. In addition to the ADCP measurements, a synoptic data set consisting of high spatial resolution hydrography will be collected with a Chelsea Instruments (CI) Aquashuttle equipped with an Aquapack CTDF. The Aquapack sensors have the following accuracies: T = 0.005 ^{o}C; Cond. = 0.001 S/m and p = 0.2m, and a fluorometer accurate to 0.01μg/l. Due to low vessel speeds, the Aquashuttle will be manually lowered and raised via a deck-winch while the vessel is underway. Thus a series of oblique profiles of temperature, salinity and fluorescence within the upper 50 to 100m of the water column will be obtained.

Replaced with:

High Resolution Hydrography. In addition to the ADCP measurements, a synoptic data set consisting of high spatial resolution hydrography is being collected when possible with a tow-body equipped with either an Aquapack CTDF or an SBE 911 CTD. The Aquapack sensors have a temporal resolution of 1 *Hz* and the following accuracies: T = 0.05 ^{o}C; Cond. = 0.001 *S/m* and p = 0.2*m*, and a fluorometer accurate to 0.01 *g/l*. In contrast, the SBE 911 has a much higher sampling frequency (25 *Hz*) and has T/C sensors accurate to 0.001 ^{o}C and 0.001 *S/m* respectively. Due to low vessel speeds, the tow-body is manually lowered and raised via a deck-winch while the vessel is underway. Thus a series of oblique profiles of temperature, salinity and fluorescence within the upper 50 to 100*m* of the water column are obtained.

Page 11, ¶ 2 **Changed** to reflect the use of Davis Instruments Weather Stations instead of the RCAC portable station, which was not available. This same paragraph describes the use of a tether on the spar buoy tow line instead of a gimbel for the anemometer as well as the need for a shore met. station.

Changes to Budget:

The primary change requested for next year's budget is an increase for fuel and charter costs. The total time required for work at Whale using a seine type vessel will range from 10 to 12 days due to the additional transit time required. The original costs were calculated at $1250 per day, which was actually on the low side. Given a 25-30% increase in charter expenses brings this total per day to about $1600. Therefore, the funds needed to cover these cruises would range between $16K to $19K. I have requested $18K for the intensive cruises and $6K for the TSG work in the revised budget.

Another addition involves $300.00 for purchase of a GPS with an electronic compass and RS232 output for directly measuring wind direction on the spar buoy using the Davis Instruments weather station. The reason for this is that the inexpensive stations lack an internal compass and are designed for a stationary placement. At present the general wind directions are being determined from a shore station. If a compass is installed, however, then the actual wind at the buoy can be deduced by accounting for the rotation angle of the system relative to the direction the anemometer was set to.

Other minor changes to the budget involve additional funds of $250.00 under field supplies for the mooring CTs and the weather station components. This includes batteries and spare parts for maintenance of the weather stations and possible overhaul of the wind sensors after this field season. The costs of CTD calibration will also increase since a third SB16 CT has been used on the moorings. The total I have requested is $2000.

PROPOSAL SIGNATURE FORM

By submission of this proposal, I agree to abide by the Trustee Council's data policy (*Trustee Council Data Policy**, adopted July 9, 2002) and reporting requirements (*Procedures for the Preparation and Distribution of Reports***, adopted July 9, 2002).

PROJECT TITLE: Physical Oceanographic Factors Affecting Productivity in Juvenile Pacific Herring Nursery Habitats, submitted under the BAA

Printed Name of P.I. Shelton M. Gay, III

Signature of P.I. ______________________________ Date _____________

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PROPOSAL SUMMARY PAGE

Project Title - Physical Oceanographic Factors Affecting Productivity in Juvenile Pacific Herring Nursery Habitats, submitted under the BAA

Project Period: October 1, 2007 - September 30, 2008

Proposer: Shelton M. Gay III (PhD Dissertation Research Project)
Prince William Sound Science Center
(Committee advisors include Drs. Tim Dellapenna, Ayal Anis and Steve DiMarco of Texas A&M University and Dr. Steve Okonnen of University of Alaska, Fairbanks.)

Study Location: Prince William Sound

Abstract

Past research of juvenile Pacific herring in PWS has shown that recruitment is highly influenced by conditions within nursery sites affecting survival within the first year. 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. The proposed study will build upon past research by continuing a hydrographic time series within nursery fjords and collect high resolution data on currents and hydrography to determine the dominant mechanisms of water exchange and circulation within two experimental fjords; one located in a highly productive sub-region (Simpson Bay) and one located in less productive sub-region influenced by tidewater glacial outflow (Whale Bay). Also, this project will provide a physical context for a suite of biological sampling proposed for these sites.

Funding:	EVOS Funding Requested:	FY 07	$ 71.4	
		FY 08	$ 70.1	
		FY09	$ 26.3	TOTAL: $167.9

Date: July 27, 2007

PROJECT PLAN

NEED FOR THE PROJECT

Statement of the Problem

The importance of Pacific herring (*Clupea pallasi*) to the Prince William Sound (PWS) ecosystem has been shown from various studies of the diet of marine mammals and birds (Agler et al. 1999; Matkin et al. 1999; Irons et al. 2000). This coupling is particularly strong for Steller sea lions. For example, research in 2000 revealed intensive night-time foraging of sea lions on over-wintering herring schools (Thomas and Thorne 2001), and subsequent studies have shown strong correlations between herring abundance and sea lion abundance in PWS, including a collapse of both populations following the Exxon Valdez Oil Spill (EVOS) (Thomas and Thorne 2003). Since EVOS, herring populations in PWS have generally remained at low levels, and the commercial fishery has essentially remained closed for more than a decade. Any effort to restore herring to stock levels of the 1980's will require knowledge of the distribution of early life stages and the factors primarily affecting survival and recruitment (Norcross et al., 2001).

In 1995 the Sound Ecosystem Assessment (SEA) project began research focusing on ecological factors affecting recruitment of Pacific herring. This study 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). Variation in growth rates of juvenile herring occurs both spatially and temporally (Paul and Paul, 1999), suggesting that herring differ in ability to forage successfully in different regions of PWS. Larval and juvenile herring survival is therefore highly influenced by habitat conditions within individual inlets (Norcross et al., 2001; Foy and Norcross 2001.)

One of the hypotheses generated by SEA is that survival of age-0 herring through the first winter is a key factor determining recruitment (Norcross and Brown, 2001), and that survival of this age class is contingent upon forage availability during the first year. In this regard, Kline (1999, 2001) has found from trophic structure analysis using stable isotope abundance that the relative contribution of oceanic subsidies to the zooplankton population plays a major role in interannual variation in age-0 survival and recruitment. For example, during 1995, a year of high juvenile herring survival, the $^{13}C/^{12}C$ ratios of age-0 herring indicate that late season zooplankton subsidies were mainly from oceanic sources of carbon advected into PWS. Interestingly, this pulse of oceanic carbon also occurred in juvenile Pollock and many other forage taxa, including diapausing *Neocalanus spp.* in the deep regions of PWS (Kline, 1999), thus pointing to the relative importance of advective processes, such as deep water exchange, between the Sound and the Gulf of Alaska in determining forage quality as opposed to merely quantity.

Physical Oceanographic Studies of Juvenile Herring Nurseries during SEA

During SEA a series of oceanographic surveys was undertaken to study the physical properties of various nursery fjords and bays in Prince William Sound. The initial cruises were in the spring and summer of 1994 and focused on the hydrography of inlets within western PWS (Gay and

Vaughan, 1998). In 1995, this research was extended to other regions of the Sound, and included both oceanographic and biological characteristics believed to affect the growth and survival of juvenile herring. At this time, nursery habitats within four principal regions of PWS were selected by the University of Alaska at Fairbanks (UAF) for intensive study over the period from fall of 1995 to spring of 1998. These sites included Whale Bay, Eaglek Bay, Simpson Bay and Zaikof Bay (Fig. 1).

The primary objective of the initial physical oceanographic surveys of juvenile herring habitat was to quantify the seasonal changes in water temperature, salinity and density within the four bays representing 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 temperature directly affects larval growth rates in the summer and metabolism and feeding behavior of juveniles during the winter (Foy and Paul, 2000; Foy and Norcross, 1999a). Juvenile (age-0) herring were also found to frequently occupy the heads of various inlets, particularly in winter (Stokesbury et al., 2000). These inner regions tended to exhibit higher stratification relative to the main fjord basins (Gay and Vaughan, 2001), and the seasonal hydrography and circulation in these sites may therefore be important in producing zooplankton locally and/or retaining plankton advected into the fjord over time. Freshwater input also tends to be relatively high in the inner basins as most have small rivers entering at the heads, and their protected nature allows sea-ice to develop during the winter. Sea-ice may provide a dual advantage to over-wintering age-0 herring by providing both a refuge from avian predators and relatively cold water temperatures (Gay and Vaughan, 2001) enhancing winter survival by reducing metabolism, and hence starvation (Paul and Paul, 1998).

A secondary objective of this research was to identify regions of convergence, divergence, 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. This research was only partly successful, however, as the scale of many of these processes is extremely small and their nature too dynamic in time and space to be easily resolved or predicted given the limitations of the study design. In three of the nursery fjords some persistent (and ephemeral) features were identified as possible transport mechanisms. These included broad scale fronts due to advection of water derived from tidewater glaciers, subsurface flow reversals caused by baroclinc tides, and large eddies formed at the mouths of fjords by lateral variation in the flow field and entrainment caused by relatively strong currents moving across (i.e. perpendicular) to the mouth.

The proposed research will build upon the data base within PWS fjords started under SEA to provide a more objective description of the seasonal dynamics of physical factors affecting productivity of nursery fjords and potential coupling of high recruitment of juvenile herring to broad-scale advection from the GOA into PWS. It is also intended to address the limitations inherent in the SEA study, by providing a more comprehensive set of physical data that can be tested with advanced statistical methods used to discern the dominant mechanisms forcing the circulation within fjords and hence advection and/or retention of plankton and larval herring within nursery fjords.

PROJECT DESIGN

A. Objectives

This study is part of a PhD dissertation designed to build upon the past results of surveys conducted during SEA. 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 within four nursery fjords used by juvenile Pacific herring, and to compare these results with similar data being collected at oceanographic moorings and high spatial resolution hydrographic cruises conducted as part of the PWS (Ocean) Observing System (PWSOS).

2. To quantify conditions that influence advection of nutrients and plankton into two experimental nursery fjords by measuring features of hydrography and circulation pertaining to exchange of water near the mouth. These data should provide evidence of a direct linkage between the seasonal phytoplankton and zooplankton biomasses in these small tertiary basins to broad-scale features of circulation within PWS.

3. To provide descriptions of the general circulation within two nursery fjords (one per year) by obtaining high resolution physical data on the flow field and its affects on the spatial distribution of physical properties. These data will provide a basis for determining the nature of transient mechanisms affecting both advection and retention of plankton and larval fish, as well as aggregations (or patches) of the planktonic food resources of juvenile herring.

B. Procedural and Scientific Methods

Four Nursery Fjords

This study continues a time series of basic seasonal physical and biological properties within four fjords previously surveyed in Prince William Sound, Alaska during the SEA project (Fig. 1). To accomplish this, oceanographic cruises are being carried out seasonally from late winter (late March or early April) to late fall (October to early November). During these cruises physical data comprised of temperature, salinity (T/S), pressure (p), fluorescence (a proxy for phytoplankton) and turbidity (primarily associated with glacial meltwater) are measured throughout the water column at stations pre-established during SEA (see below). In the late fall and winter the hydrography are being sampled during cruises conducted by R.Thorne and T. Kline to measure abundance of juvenile herring and zooplankton. During the highly productive period from spring to early fall, however, the hydrographic data are being collected on a quasi-monthly basis during cruises sponsored by the Alaska Ocean Observing System (AOOS) by a separate vessel, which is collecting synoptic thermosalinograph (TSG) data in the surface (1m) layer. During the TSG surveys hydrographic profiles are also collected at stations located along the standard route through PWS (Fig. 2). In August 2007 additional stations will be surveyed near the mouths of two tidewater glacial fjords to compare the T/S profiles of water emanating from these fjords with past surveys during SEA (Gay and Vaughan 2001). The TSG surveys will also provide an interannual comparison of the hydrography of the large primary basins conducted during the SEA project (Vaughan et al., 2001) and cruises sponsored by OSRI (Vaughan and Gay, 2002).

The temperature and salinity (T/S) data are currently being collected with either a SeaBird Electronics (SBE) 19*plus* or a 19.03 conductivity/temperature/depth meter (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[1]. The ancillary data (fluorescence and turbidity) are being collected with a WetLabs FLSTUB fluorimeter/turbidimeter. During these cruises oceanographic stations are occupied to determine the general hydrography within each fjord. The locations and number of stations are shown below for each fjord in Figure 3. These stations follow the sampling regimen used during the SEA project by Gay and Vaughan (2001) and are located so as to obtain a line of stations extending between the head and mouth. Station distances range from 0.5 to 1.0*km*. Although hydrographic conditions are more uniform spatially in the late fall to late winter/spring (March-early April) (Muench and Schmidt, 1975; Gay and Vaughan, 2001; Vaughan et al., 2001), the same stations are being surveyed during each cruise in order to fully compare seasonal T/S conditions among the four fjords.

The hydrography data will be collected in both 2007 and 2008 and should provide a basis for comparing interannual differences in physical processes, such as sub-regional heat and freshwater fluxes, stratification and turbulent mixing, with temporal and spatial variation in these same processes over PWS (SEA and OSRI) and the GOA shelf (GLOBEC). 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 (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 and Montague Strait should provide an indication of how exchange of surface and deep water from the GOA into PWS possibly extends into the small secondary and tertiary fjords. These advective processes typically interact with localized processes driven by variation in climate and freshwater runoff to produce large scale T/S gradients within nursery fjords (Gay and Vaughn, 2001).

Experimental Nursery Bay

This study is currently obtaining high spatial and temporal resolution data on the circulation and hydrography within Simpson Bay and proposes to do the same in Whale Bay in 2008. These data will provide a physical context for describing transient (i.e. tidal/meterological) mechanisms affecting the advection and exchange of water from PWS into a highly productive nursery habitat versus a potentially poor habitat influenced by glacial advection. To accomplish this objective high resolution acoustic Doppler current profiler (ADCP) surveys are being conducted monthly from June through August to provide estimates of: 1) the basin-scale flow-field; and 2) transport estimates at the mouth. In either case, the measurements will be made through at least one full diurnal tidal period (25-26hrs). Tides within PWS are principally semidiurnal (M_2) and current velocities range from 30 to *50cm* s^{-1} (Niebauer et al.,1994). However, currents in PWS fjords (Gay and Vaughan, 2001) have a much larger range (5 to 150 *cm* s^{-1}) and marked fluctuations in flow occur due to variation in tidal prisms (i.e. amplitudes) interacting with the bathymetry. The present study is therefore attempting to sample circulation and hydrography on both neap and spring tides in order to measure the extremes in the tidally forced flows.

Fig. 1. Locations of four fjords surveyed during the SEA herring research project conducted from 1995 to early 1998.

In addition to the ADCP data, hydrography data are being collected at Simpson Bay over the tidal cycles with either an undulating tow-body or via repeated CTD stations. Other ancillary data at Simpson include time series measurements of heat and freshwater fluxes obtained from two moorings each equipped with a near-surface and deep CT deployed in the deep (70-80*m*) portion of the Northern Arm (i.e. north of the sill) and near the mouth (40-50*m*) respectively (Fig. 4). The moorings were deployed in the early summer and will retrieved in the early fall. Meteorological data including wind speeds and air temperatures are being collected by a weather station placed on the mooring buoy at the mouth. A second shore station has also been set up on the eastern side of the mouth to obtain the general wind directions. Calibrations of the CTs have been performed by SBE Inc. prior to deployment to determine offset and drift in the sensors. The details of the sampling design for all instruments are addressed in the following sections.

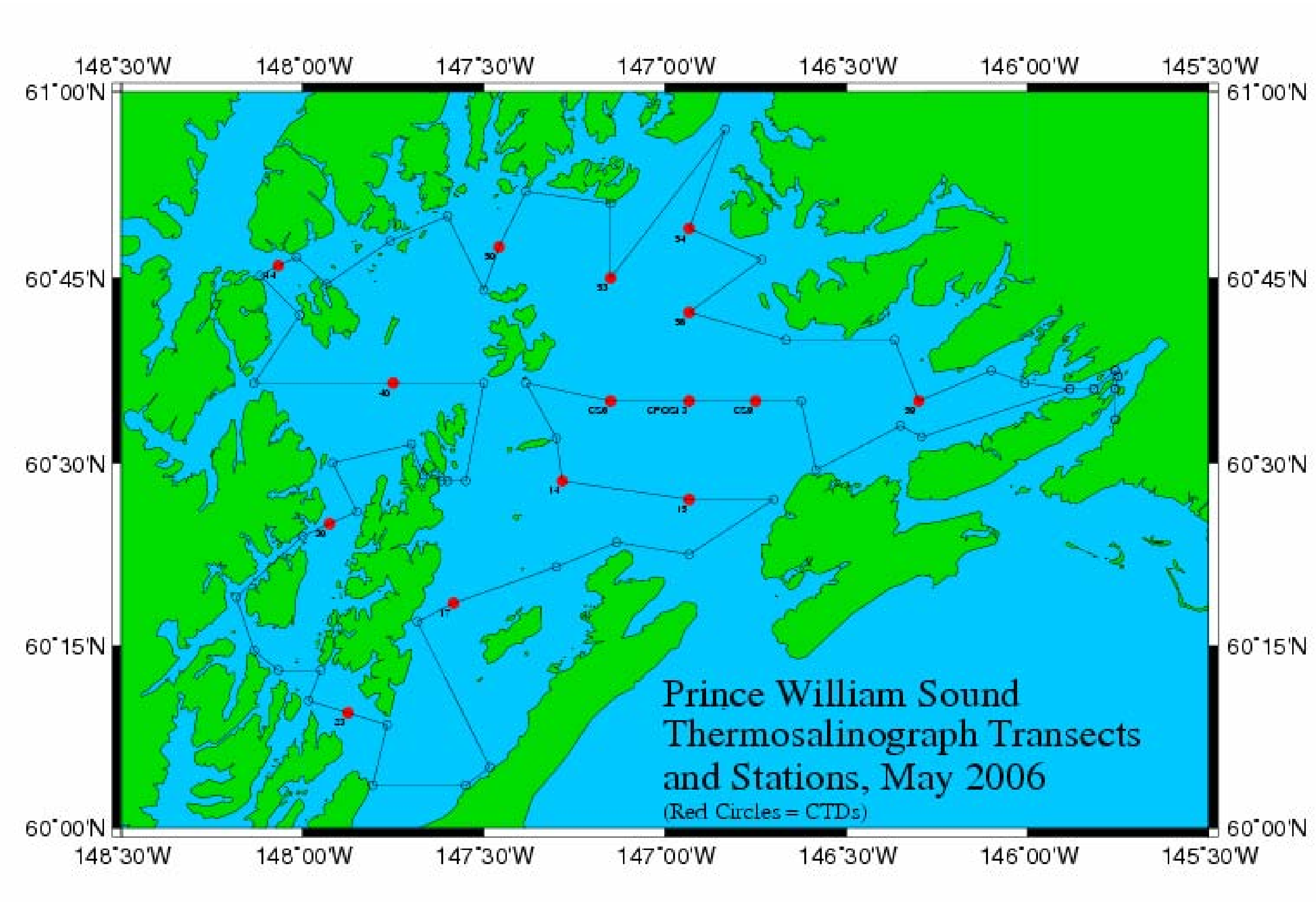

Fig. 2. Standard transects and oceanographic stations occupied during thermosalinograph cruises sponsored by the Alaska Ocean Observing System as part of the PWSOS.

<u>Circulation</u>. The objectives of measuring circulation within nursery fjords is to describe the general flow-field and to determine the dominant mechanisms of water exchange between small tertiary basins and PWS. Examples of ADCP transects conducted in Simpson Bay during SEA are shown in Figure 5. A similar series of transects are currently being surveyed in 2007. However, in contrast to SEA, which used a 150*kHz* instrument, data are being collected with a 600*kHz* ADCP. An example of currents obtained with this instrument is also shown in Figure 5. As can be seen, these data have a much higher spatial resolution (~40 vs. 6 vectors per km). These differences are due in part to the fact that no ensemble averaging was done to the data. The raw (un-averaged) data tend to be much cleaner in comparison to the 150*kHz* unit, and this a result of enhanced backscatter associated with the higher frequency, faster ping rate and relatively large depth bins. In addition, transects are being run continuously over at least one full diurnal tidal cycle (~25 hrs) and repeated to obtain a minimum of 6 cross-sections during each semidiurnal tide (i.e. one ebb and flood phase). Depending on vessel speed, sampling intervals for all transects currently range from 1.86 to 2*hrs* and frequencies range from 0.49 to 0.54*cph*.

The latter frequencies exceed the fundamental semidiurnal Nyquist frequency (~0.08*cph*) by a factor > 6. Therefore, the data should be amenable to harmonic analysis described below.

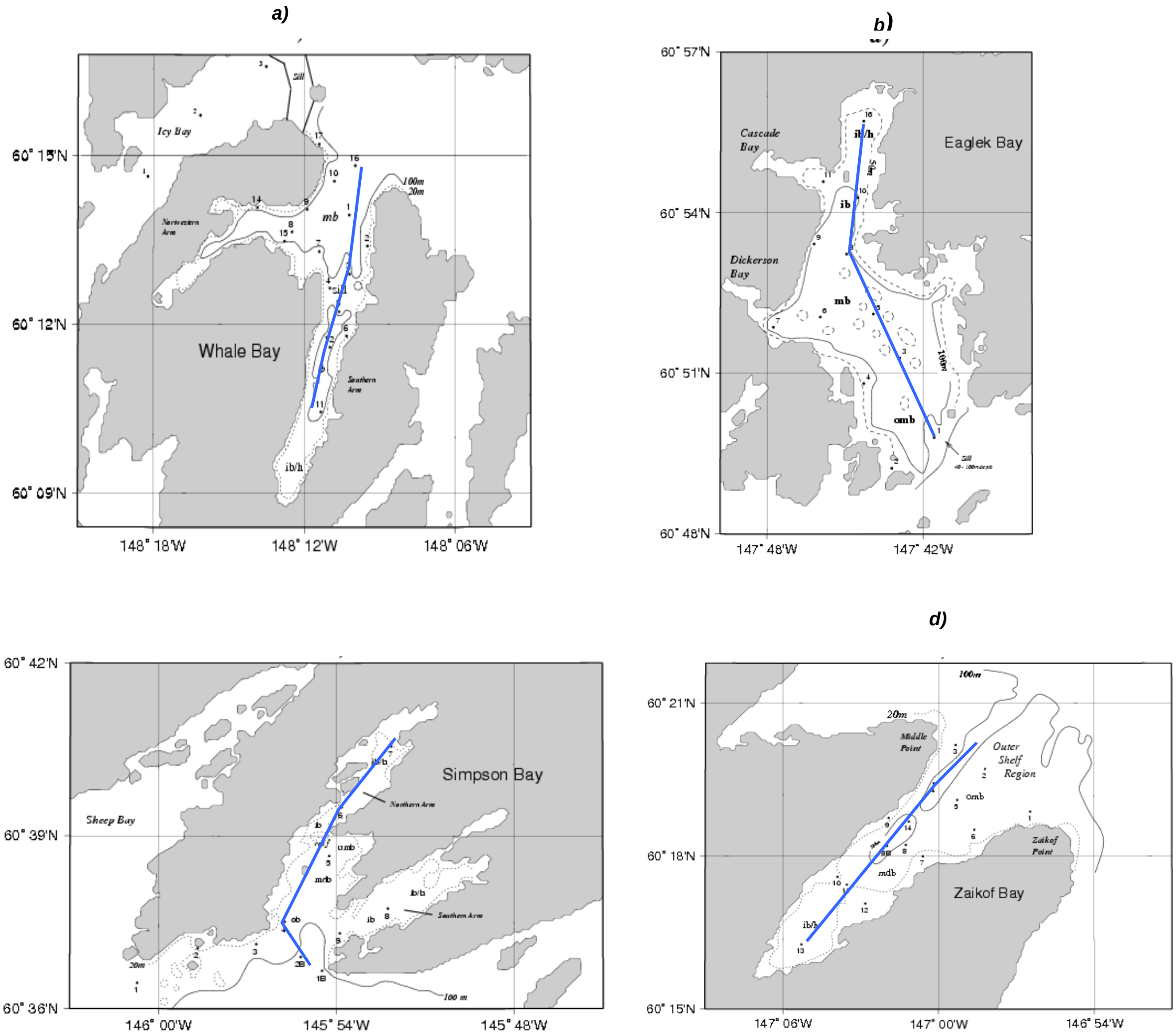

Fig. 3. Locations of oceanographic stations within the four fjords surveyed during the SEA herring project.

The initial surveys at Simpson show that valid water current data with the 600*kHz* unit are limited to about 60*m* due to a threshold in backscatter and echo intensity at greater depths. For this reason future surveys will include either a 300 or a 150*kHz* ADCP in order to obtain flows in the two deep areas located on the eastern side of the mouth (120*m*) and just inside the Northern

Arm (80-90*m*). The greater basin depths at Whale Bay (~300*m*) will require the use of the 150*kHz* ADCP to obtain bottom tracking (i.e. measure absolute vs. relative flow). The Southern Arm (inner basin) is much shallower (< 100*m*) and should be amenable to bottom-tracking with the 600*kHz* unit. However, the current profiles will be limited to the upper (60*m*) layer. The total number of 4*m* depth bins using the 150 *kHz* ADCP will range from < 20 to 75, but the spatial resolution will be relatively coarse since vessel speeds can not be reduced, as this would prohibit obtaining an adequate number of repeated transects. It may be possible to reduce ensemble averages from 120*s* which would affectively increase the resolution of that shown (Fig. 5a,b). This will depend on the limit of error based on the ADCP settings. Past experience has shown that high variability in the flows (and hence the Doppler shift) necessitate greater ensemble averaging.

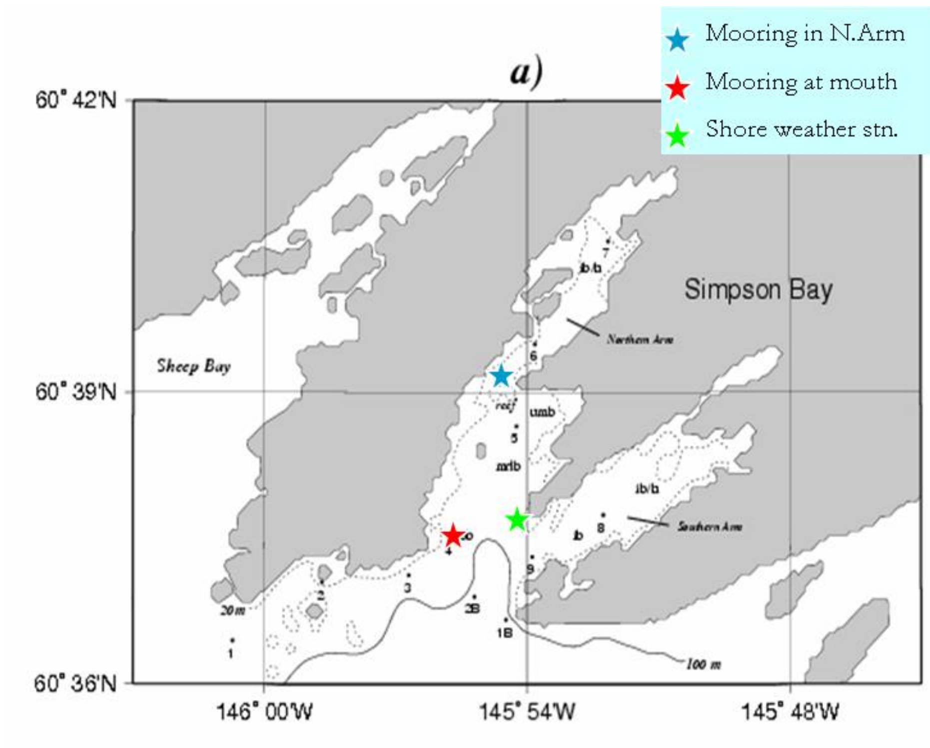

Fig. 4. Locations of CT moorings and shore weather station in Simpson Bay in 2007.

The 600 *kHz* ADCP is currently being towed beside the survey vessel on an aluminum Biosonics acoustic tow-sled, whereas the 300 and150 *kHz* units will be mounted to the side of either a 16*m* (52*ft*) or a 8.5*m* (28*ft*) fiberglass vessel. All instruments contain an internal compass, which allows velocities to be determined independently of ship navigational data. The transducers on these instruments will be immersed to a depth of ~ 0.6*m* and the vessel mounted ADCPs will be rotated 45^{o} to reduce ringing from the hull and to remove bias induced by having two on-axis beams measuring the ship velocity (Trump, 1989). Bottom tracking will be attainable during all surveys, and the depth of the first velocity bin (including a 1*m* blanking distance) will be ~ 2*m* for the 600*kHz* unit and 4*m* for the 150*kHz* ADCP. Vessel speeds will range from 2.5 to 3$m\ s^{-1}$. At these speeds turbulence around the transducers is negligible and should produce no bubbles to cause either beam loss or contamination of data (Gay and Vaughan, 2001). Air entrainment has caused problems in the past with vessel side-mount systems only when excessive ship-roll causes transducers to be lifted near the surface. In such cases, surveys were suspended and resumed later during calm conditions. Weather was not a problem at Whale since this fjord tends to be protected from winds. Nor should it be problematic for the towed instrument since the transducers are deeper in the water. Also, if a recoil system is set-up to allow the tow cable to free wheel then the problem of vessel roll due to swell can be minimized.

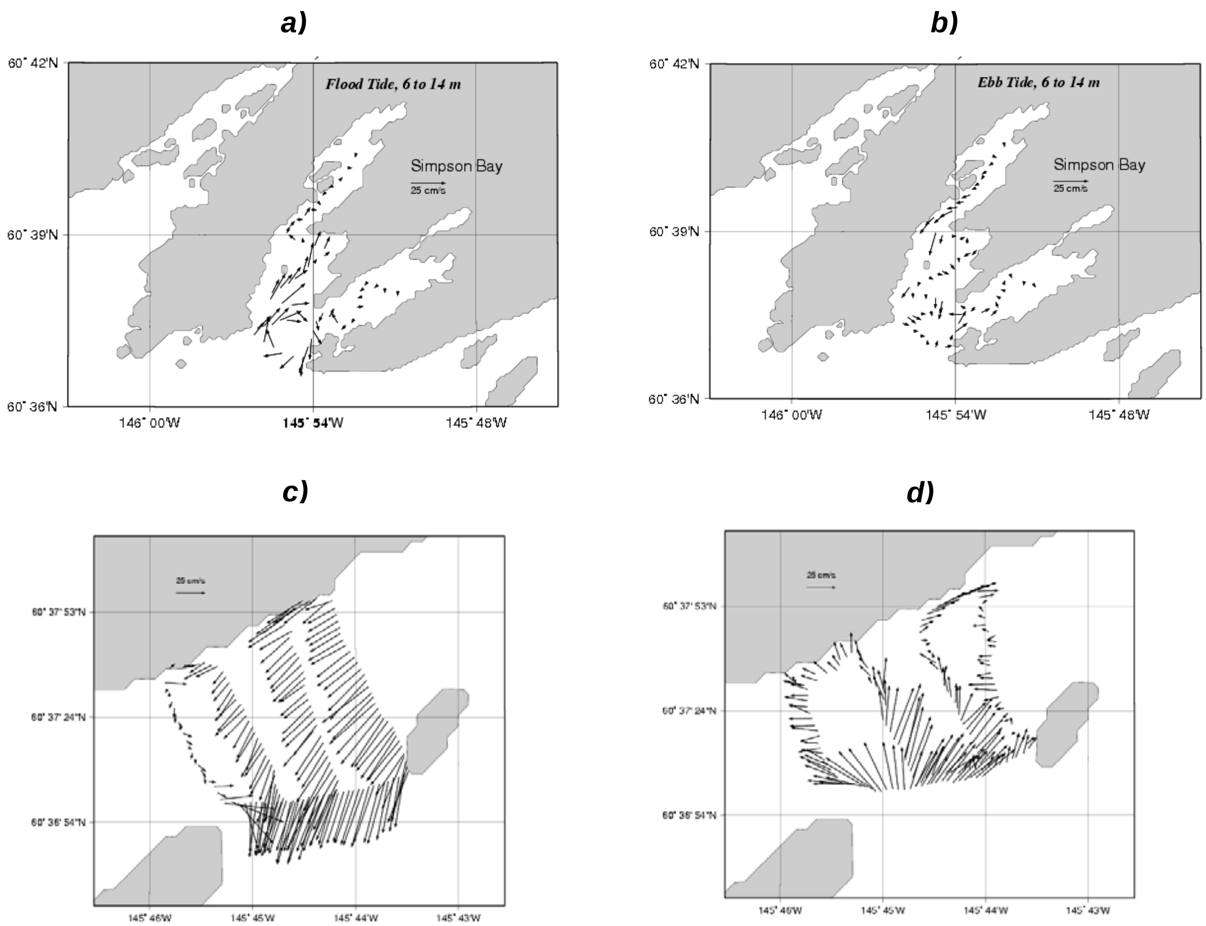

Fig. 5. Examples of currents measured at Simpson Bay with a 150 kHz ADCP: a and b) and at Salmo Point with a 600 kHz ADCP: c and d). Note that the spatial resolution of data collected with the 600 kHz instrument is nearly 7 times that of the 150 kHz unit.

<u>High Resolution Hydrography</u>. In addition to the ADCP measurements, a synoptic data set consisting of high spatial resolution hydrography is being collected when possible with a tow-

body equipped with either an Aquapack CTDF or an SBE 911 CTD. The Aquapack sensors have a temporal resolution of 1 *Hz* and the following accuracies: T = 0.05 ^{o}C; Cond. = 0.001 *S/m* and p = 0.2*m*, and a fluorometer accurate to 0.01μ*g/l*. In contrast, the SBE 911 has a much higher sampling frequency (25 *Hz*) and has T/C sensors accurate to 0.001 ^{o}C and 0.001 *S/m* respectively. Due to low vessel speeds, the tow-body is manually lowered and raised via a deck-winch while the vessel is underway. Thus a series of oblique profiles of temperature, salinity and fluorescence within the upper 50 to 100*m* of the water column are obtained. These measurements in combination with the ADCP data should indicate where features of circulation, such as eddies, convergences and divergences, may create fronts between water masses differing in both origin and T/S properties. These zones can also occur between regions of stratified water and regions of mixing caused by turbulence (Mann and Lazier 1991), and hence can cause concentrations (i.e. spatial patchiness) of plankton and larval fish.

An example of high resolution data collected in Simpson Bay during SEA is shown in Figure 6. In both plots spatial variation in the hydrography indicates the presence of fronts located in the near-surface layer at the mouth (Fig. 6a) and a deeper subsurface layer located between the main basin and northern arm of the fjord (Fig. 6b). The contours for the shallow (5-10*m*) layer contained 47 grid points, or an average spatial frequency of 2.3 casts km^{-1}, whereas the deeper layer (20-30*m*) contained slightly more than half this number, or a frequency of 1.5 casts km^{-1}. The current study is attempting to increase the cast frequency to > 3.0 km^{-1} (the actual number will vary depending on vessel speeds and cast depths). The high frequency of these data relative to individual CTD stations should have the capacity to resolve fine-scale features of hydrography as they develop and change during the tidal cycle due to tide rips associated with eddies, reversals and current shear (i.e. instabilities in the flow-field). The increased resolution should also provide better tracking of the broad scale features (such as the fronts shown in Fig. 5) produced by advection of water into the fjord with physical properties differing than those of water in the main and inner basins.

Temporal and Spatial Aliasing

Since water properties can not be measured simultaneously throughout the experimental bay, a certain amount of aliasing in the data will be unavoidable due to the time differences between transects. During SEA, the lack of repeatability in sampling transects created limitations in determining the exact phasing of currents with respect to the tide changes and in precisely tracking fronts associated with current shear. In the proposed research, however, transects will be sampled well above the Nyquist frequency, and least squares harmonic analysis can therefore be applied to the data to determine the phasing relative to the tides. Also, the aliasing for successive transects will be quite small as sampling times will range from 10 to 15*min*; at most < 1/20th of a typical tide stage.

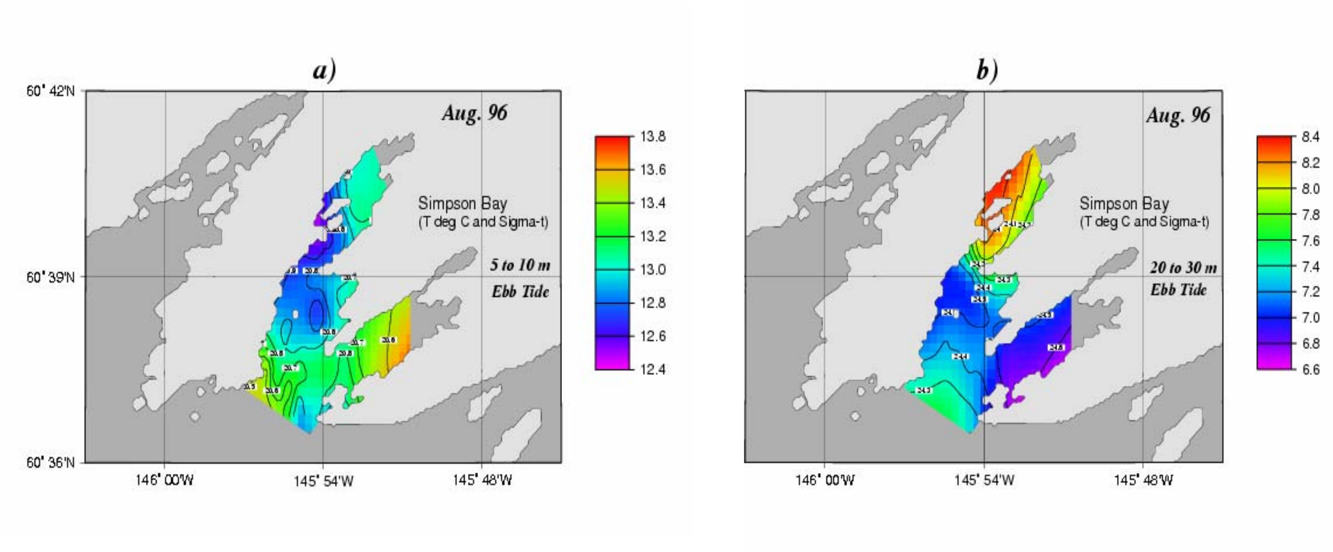

Fig. 6. Examples of high resolution hydrography data collected in Simpson Bay during SEA with a Chelsea Instruments Aquashuttle. Note the presence of fronts in the surface layer (a) and deep layer (b) and a deep reversed density gradient (b) extending from the mouth into the main basin.

Ancillary Data

As stated above, ancillary data comprised of time series of weather data and stationary (moored) temperature and salinity measurements are currently being collected during the summer within Simpson. The meteorological data consist of wind speed and direction, and air temperature measured with Davis Instruments Weather Wizard III stations. The T/S data are being collected by surface (2-3*m*) and a deep (50-70*m*) CTs (a SBE16.03 at the surface and a SBE37 microcat in the deep layer) mounted on oceanographic moorings. The moorings (Fig. 7a) consist of long (2-3*m*) surface spar buoys connected to a bottom anchor with 3/16 in. Spectra line. The surface CTs are directly attached to the base of the spar buoys and the deep CTs are attached to the line. Weather sensors, including an anemometer and thermometer, are attached to the mast of the buoy located at the mouth. The buoy platform has minimal shadowing of winds caused by topography. However, to prevent excessive tilting of the anemometer, caused by drag on the spar buoy from moderately strong winds and currents, the spar buoy has been tethered to the tow-line as shown in Figure 6a. The minimal affects of winds and current on this buoy (currently deployed in Simpson) can be seen in Figure 6b. Additional weather sensors on a shore station are mounted to a mast and tripod placed on an island approximately 200m offshore from the eastern side of the bay (Fig. 6c). This site has a clear view to the west and southwest (Fig. 6d), where the winds affecting Simpson in the summer predominately originate.

C. Data Analysis and Statistical Methods

The methods applied to the proposed research will follow standard procedures for obtaining descriptive physical oceanographic data. Details regarding the procurement and processing of these data are given in Gay and Vaughan (2001). A summary of data precision and limits on error are given below for each of the data sets described in the methods as well as types of advanced statistical tests applicable to the data.

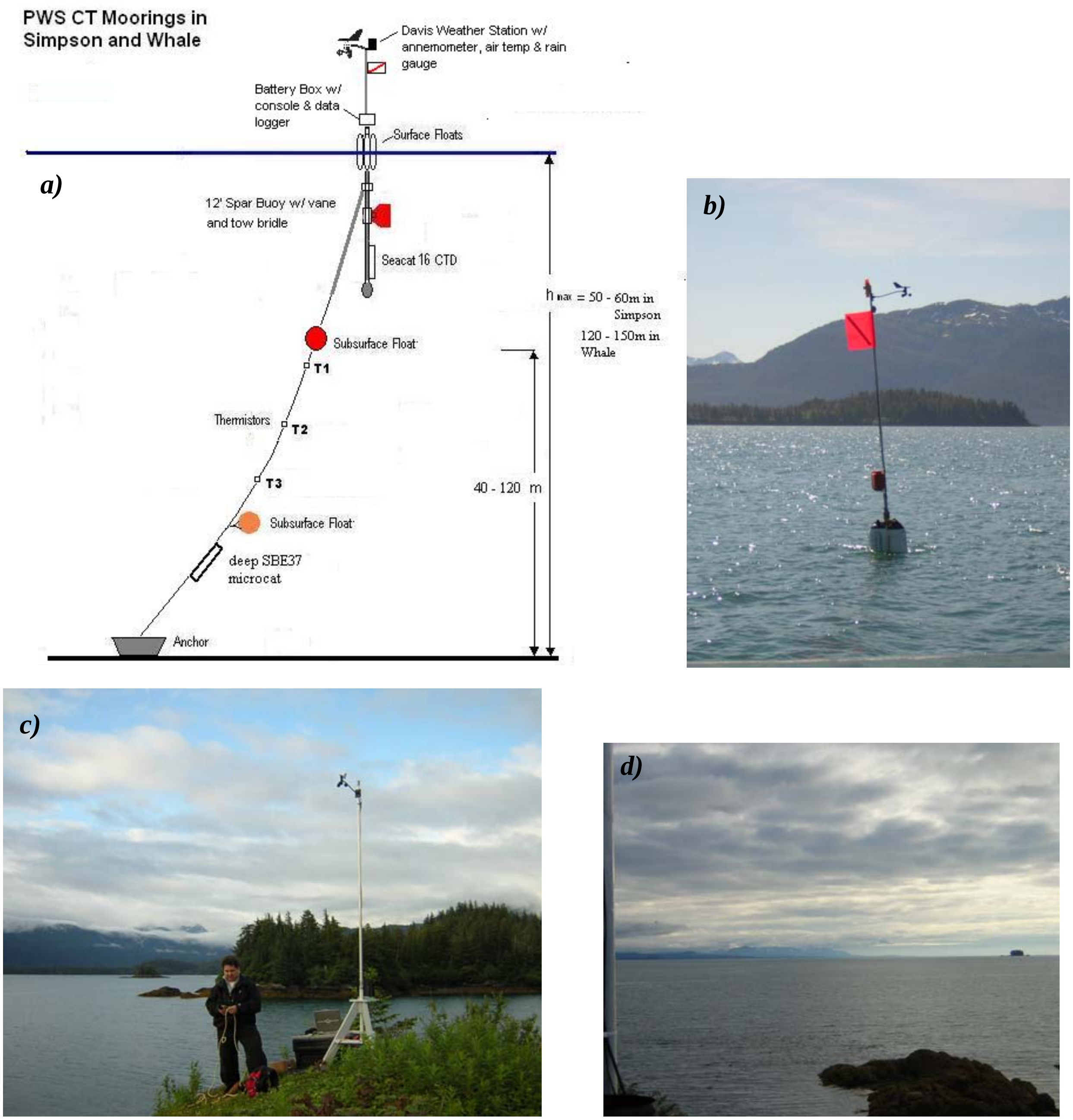

Fig. 7. a) Design of oceanographic mooring located at the mouth of Simpson Bay; b) surface buoy with weather sensors mounted to the top mast under moderate wind and tidal current; c) shore station on an island located on the eastern side of the mouth; and d) view from shore station to the southwest.

CTD Profiles and Moorings

The number and spacing of stations established during SEA was sufficient to minimize standard errors of temperature and salinity to ≤5% of the mean values over all depths within the four fjords (Appendix A). The scan rate of sensors on the SBE 911*plus* is 8*Hz*. Given a drop rate of 0.5 to 0.75*m/s* the data resolution will range from 10 to 16 *data points/m*. Data will be post processed using SeaBird's Seasoft programs, which allow low pass filtering, aligning sensor outputs in time, marking bad scans, removal of T/S spikes and averaging into 1*m* depth bins. Additional stations may be added depending upon the amount of variability observed among casts. However, spatial heterogeneity in the physical properties will be most effectively measured using the high resolution CTD data provided by the Aquashuttle. This instrument is described in more detail below. The CTD mooring data will require a minimum amount of post-processing (i.e. conversion to engineering units only). However, the data will be initially corrected by using calibration data obtained by making casts with the SBE19*plus* profiler.

ADCP Profiles

The 600 and 150*kHz* ADCP's will be in a towed and hull mounted configuration respectively. The data quality will be checked following procedures outlined by Trump (1989). Both of these instruments contain an internal flux-gate compass, which has a precision and accuracy of $\pm 0.5^{o}$ and $\pm 2^{o}$ respectively. They will require *insitu* calibration in order to check for magnetic effects induced by the vessel's engine's, generators, and pumps, etc. Calibration procedures for hull mounted ADCP's are given by Munchow et al. (1995) and similar methods can be applied to the towed instrument. The data for the 150*kHz* APCP will be collected vertically into 4*m* depth bins and temporally over 60*s* to produce averaged segments every 0.1-0.2*km*. Standard deviations of these data will range from 0.6 to 1.0*cm/s* depending upon water conditions. The statistical precision of these data can be increased, however, by averaging more pings and/or increasing the segment lengths. The data from the 600*kHz* ADCP will be collected into vertical depth bins of 2*m* (also depending upon water conditions affecting statistical precision). However, a total of 20 -30 pings per ensemble will provide a standard deviation of 0.5-0.6*cm/s*, and temporal averaging will further reduce this error significantly. For example, a 10*s* ensemble interval at a vessel speed of 2.5*m/s* (~5*kts*) will yield raw segments of currents every 0.03*km* with a precision of about ± 0.6*cm/s*. Post-processing of these data by ensemble averaging at 60*s* will yield average currents every 0.16*km* with a precision of ± 0.2*cm/s*.

High Spatial Resolution CTD Data

The high resolution hydrographic profiles (made with either a CI Aquapack or a SBE 19.03 CTD) will require additional post-processing other than conversion to engineering units. The sampling rate for either instrument when used on the Aquashuttle is 1*Hz* and the average data resolution will range from 0.2 to 0.35 *m/sample* vertically and 2.5 to 2.75 *m/sample* horizontally. This will yield a cast frequency of 1.2 to 6 *casts/km* depending upon maximum depth and vessel speed (e.g. given a maximum speed of 2.75*mps*, a transect length of 3*km*, and a cast depth of 50*m* a total of 6-7 casts would be taken). This should be sufficient to observe regions of varied hydrography across fronts caused by wind and tidal mixing. Post-processing of the Aqashuttle data will include vertical averaging into 1*m* depth bins (to minimize sampling bias caused by variation between ascent/descent rates) and georeferencing using GPS data collected during the ADCP transects.

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). Both the high resolution and moored CTD data will be amenable to the harmonic and integral scales analysis. However, the application of these tests will be directed by the student's graduate committee.

Historical Data Sets

The most comprehensive historical data set for the PWS region includes CTD profiles made in the 1970's and 80's by UAF (CFOS program), the mid to late 90's by PWSSC (SEA program), and from 2000 to present by PWSSC (OSRI Nowcast/Forecast monitoring program). Other data sets exist for the GOA shelf through various publications (Royer, Johnson, etc.) and more recently through the GLOBEC Northeast Pacific program. These results will be used in a synthesis to compare past and present physical oceanographic conditions within the PWS/GOA shelf region to the upper 100*m* and deep (>100*m*) layer conditions observed within nursery fjords to determine in what years broad-scale advection may have occurred.

D. Description of Study Area

The proposed study will take place in four fjords within PWS (Fig. 1). 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 are relatively deep (200-300*m*) and exhibit strong T/S stratification, which is not completely eroded in the winter (Gay and Vaughan, 2001). 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 and proximity to tidewater glacial fjords (affecting heat and freshwater content), basin morphometery and maximum depth (both affecting tidal currents and stratification) and proximity to the main entrances into PWS (affecting water exchange with the GOA).

E. Coordination and Collaboration with Other Efforts

This study will be conducted in coordination and collaboration with other ongoing research programs including OSRI and AOOS sponsored oceanographic moorings, TSG cruises and hydrographic profiles within PWS. Additional research projects supported either directly or indirectly by the proposed research include Trends in adult and juvenile herring distribution and abundance in PWS, (R. Thorne, PWSSC) and Prince William Sound Herring Forage

Contingency, (T. Klein, PWSSC). The data will also be used to help with validation of a Life-Stage Specific Ecosystem Model of PWS Pacific Herring (D. A. Kiefer, System Science Applications), and possibly in a non-EVOS sponsored model of PWS fjord-circulation (R. Hetland, TAMU).

SCHEDULE

A. Project Milestones

A schedule of cruises and the oceanographic stations and transects occupied 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 herring surveys (Thorne Proposal, 2006) and during TSG surveys. In contrast, the high resolution data will be collected on a monthly basis and if possible synoptically with surveys of juvenile herring and zooplankton distribution and abundance (Thorne and Klein Proposals, 2006).

Table 1. Schedule of Research Cruises for Physical Oceanographic Surveys in 2007 and 2008

	Calandar	Year
Month	2007	2008
Jan		
Feb		
Mar	*Adult,* **Juvenile herring , CTDs**	*Adult,* **Juvenile herring , CTDs**
Apr		
May	TSG Cruise	TSG Cruises & HR Data in Whale
Jun	TSG Cruises & HR Data in Simpson	TSG Cruises & HR Data in Whale
Jul	TSG Cruises & HR Data in Simpson	TSG Cruises & HR Data in Whale
Aug	TSG Cruises & (2) HR Data in Simpson	TSG Cruises & HR Data in Whale
Sep		
Oct	*Juvenile herring, CTDs*	*Juvenile herring, CTDs*
Nov		
Dec		

1 HR = high resolution data

B. Measurable Project Tasks

FY07 1st Quarter (October 1, 06 to December 31, 06)

October	Project funding approved by Trustee Council
	CTD profiles collected during Juvenile herring survey

FY07 2nd Quarter (January 1, 07 to March 31, 07)

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

FY07 3rd Quarter (April 1, 07 to June 30, 07)

May and June	Conduct first full CTD survey in the four fjords and first set of comprehensive (HR) surveys of Simpson Bay

FY07 4th Quarter (July 1, 07 to September 30, 07)

July and August	Conduct second two full CTD surveys in the four fjords and second set of comprehensive (HR) surveys of Simpson Bay Submit Annual Report

FY08 1st Quarter (October 1, 06 to December 31, 06)

October/November	CTD profiles collected during Juvenile herring survey

FY08 2nd Quarter (January 1, 08 to March 31, 08)

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

FY08 3rd Quarter (April 1, 08 to June 30, 08)

May and June	Conduct first two full CTD surveys in the four fjords and first set of comprehensive (HR) surveys of Whale Bay

FY08 4th Quarter (July 1, 08 to September 30, 08)

July and August	Conduct second two full CTD surveys in the four fjords and second set of comprehensive (HR) surveys of Whale Bay Submit Final Report

RESPONSIVENESS TO KEY TRUSTEE COUNCIL STRATEGIES

Community Involvement and Traditional Ecological Knowledge (TEK)

The proposed research will incorporate community involvement and traditional knowledge by using local fishermen for boat charters and anecdotal information on physical features observed while commercial fishing in the locations of interest. In past EVOS sponsored projects field demonstrations of the physical oceanographic sampling technology were provided to students involved with the Youth Area Watch, and at least one public seminar is given each year in Cordova. Articles on research are also routinely contributed to the Breakwater, PWSSC's newsletter (www.pwssc.gen.ak.us/breakwater).

Resource Management Applications

The proposed research is an extension of the SEA project, which was a cooperative effort with various state and federal agencies including ADF&G, UAF and USFS (Cooney, 2001). Physical oceanography influences marine ecosystems as a bottom-up process, and the information from this project should therefore support management models that are used to make decisions on herring fisheries management. This would occur via support of other models that predict primary and secondary production given changes in environmental conditions driven by the physics (e.g. NPZ models). This data will aid in the assessment of factors affecting juvenile herring age structure and condition used to provide a potential forecast of recruitment. I have also worked with ADF&G personnel in Cordova including Steve Moffitt and Bob Berceli either formally during workshops or informally in discussions of how scientific research at PWSSC can be utilized by resource managers.

PUBLICATIONS AND REPORTS

No costs for publications are specifically requested in this proposal beyond those for annual and final reports.

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BUDGET JUSTIFICATION - FY 08 Request = $70.1

1. Personnel (Total: $20.8K in FY07, $21.2K in FY08 and $16.5K in FY09)

Personnel costs will cover the salary of the Principal Investigator (PI) while employed by PWSSC in Cordova from May to September in FY07 and FY08; 3 months of support are requested in FY09. Costs while at TAMU in College Station, Texas will be covered by both a Teaching and Research Assistance Award.

2. Travel (Total: $1.5K in FY07, $1.7K in FY08 and $1.7K in FY09)

Travel costs include round-trip airfare in FY07 from College Station, Texas to Anchorage, Alaska for the PI to attend the Ocean Sciences meeting held annually in January. In FY08 and FY09 travel is from Galveston, Texas to Anchorage.

3. Contractual (Total: $20.1K in FY07, $26.6K in FY08 and $0.6K in FY09)

Contractual costs include chartering vessels for oceanographic surveys, fabrication of equipment necessary for deploying sampling gear, and repair/calibration of equipment, office 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 herring and requires no further funding. The second vessel will be engaged in TSG operations in 2007 and due to the extra time and fuel expenditures this project will require further assistance with costs. The third vessel will be chartered specifically for intensive work (diel surveys) in Simpson Bay. A seine type vessel is required to simultaneously deploy sampling gear, including a large oceanographic winch to operate the Aquashuttle. In 2008 funding for the TSG work is uncertain. Therefore the broadscale CTD data collection (i.e. within the four fjords) will be combined with the intensive surveys of Whale Bay.

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) Repair of CI Aquapack: Funds are required to ship this instrument back to the manufacturer for repair of the communication circuitry. The total cost is an approximation at this time (until CI inspects the problem).

4) Calibration Costs: Funds are necessary for shipping CTs back to SBE Inc. to check and calibrate the instruments. For FY07 only two Seacat 16.03 CTs will need calibration. In FY08, both the Seacats and Microcats will require calibration.

5) Fabrication Costs: The fabrication of a second spar-buoy for deployment of one CT mooring will be required. One of these buoys (shown schematically in Fig. 6) will also probably house meteorological instrumentation in addition to the near-surface CT .

4.Commodities ($1.3K in FY07, $1.8 in FY08, and $0.5K in FY09) – Request is for miscellaneous field and office supplies, batteries and maintenance supplies for some of the equipment, and lines and shackles for the moorings. FY08 budget includes a GPS with an electronic compass and RS232 output.

5.Equipment ($8.5K in FY07)
Request is for purchase of two Microcat CTDs at a cost of $4.3K each.

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 4, paragraph 5); and 2) transects conducted with towed or vessel mounted instruments collecting data on currents, including vector components (*u*,*v*, and *w*), magnitudes and directions, and ancillary data such as pitch, roll, heading, echo intensity, error velocity and percentage of good data returns, and high spatial resolution hydrography comprised of continuous CTD casts, measuring T, C, P and F (objectives 2 and 3, pages 4 and 5, paragraphs 5 and 2).

Data collection methods for the majority of the above instruments are given in Gay and Vaughan (2001), and are also summarized in this proposal (pages 4 to 10). 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). Similar procedures are done when deploying the Aquashuttle. However, the data require user specified algorithms for post-processing (see Data Analysis and Statistical Methods, page 13, paragraph 3).

Data management in the field is done by filling out field sample forms or logs of data that identify each CTD or transect 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 the towed or vessel mounted instruments depth is determined by either a pressure sensor (CI Aquapack), fixed depth below the surface by marks on the tow cable (towed ADCP), or immersion of the pressure housing (vessel side-mounted ADCP). Additional data management in the field will include uploading and checking data for instrument malfunctions as soon as feasible (i.e. following retrieval, or as data are streamed to the computer in the case of real-time output from towed 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[1]. With the exception of RDI, all of the equations used for converting data from the various instruments are provided by the manufacturers upon purchase. 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 either in real-time (Aquapack data) or 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 other instruments all have their own suite of meta data that is output along with the variables of interest.

Appendix A shows examples of metadata for SBE and RDI 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. Those used by RDI to convert Doppler shift and echo intensity data into current vectors are proprietary. For more details on all of the remaining instruments see online documentation at http//rdinstruments.com, and http//chelsea.co.uk. Note that the 150*kHz* ADCP is now only available as a custom order and the closest instrument shown on the web site to this ADCP is the 75*kHz* Long Ranger. The Continental Shelf 150 Broad Band ADCP that will be used in this project has a range of ~ 300m and typically collects data in 4 *m* to 8 *m* bins and ensemble temporal averaging of over 60*s*. The actual settings used during data collection depend on the standard deviation obtained for the Doppler shift given the number of water ping, depth bins and temporal averaging.

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.[2] Similar processing will be done with the hydrography data collected with the Aquashuttle using

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

Basic and Fortran programs written to perform temporal/spatial averaging and derivation of other oceanographic parameters using standard subroutines (Fofonoff and Millard, 1983).

The current data collected with the two RDI ADCPs will be post-processed by the following procedure: 1) conversion to ascii (engineering) units using RDI's software; 2) QC of the data by checking for data loss (i.e. bad bins) and unrealistic sudden changes in velocity, checking the ancillary data for beam loss, low percentage of good echoes, high error velocities (i.e. poor consistency in measurements among beams); 3) removal of bad bins or segments (ensemble averages); 4) interpolation/extrapolation to produce a final 'clean' data set. 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.

Data Storage and Handling

All quantitative physical data collected will be stored electronically on computers and back-up media such as CDs and DVDs. 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 (except RDI ADCPs) will be sent back to the manufacturer for post-cruise calibrations either annually (SBE16 Seacats) or biannually (SBE19*plus* , SBE37 Microcats and CI Auqapack). The SBE16s require more frequent calibrations since they have older style sensors and electronics.

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

APPENDIX A. Examples of Meta Data for SBE and RDI 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
```

2. Example of a meta data file collected with an RD Instruments ADCP

```
[RDI WinRiver Configuaration File]
Version=1.03.000

[Subsection]
Use All Ensembles=YES
First Ensemble=0
Last Ensemble=131071

[Offsets]
ADCP Transducer Depth [m]=1
Magnetic Variation [deg]=26
Heading Offset [deg]=0
One Cycle K=0
One Cycle Offset=0
Two Cycle K=0
Two Cycle Offset=0

[Processing]
Speed of Sound Correction=0
Salinity [ppt]=0
Fixed Speed Of Sound [m/s]=1500
Mark Below Botom Bad=YES
Backscatter Type=0
Intensity Scale [dB/cts]=0.43
Absorption [dB/m]=0.139
Projection Angle [deg]=0
Cross Area Type=0
```

```
Use 3 Beam Solution For BT=YES
Use 3 Beam Solution For WT=NO
BT Error Velocity Threshold [m/s]=0.1
WT Error Velocity Threshold [m/s]=1.5
BT Up Velocity Threshold [m/s]=10
WT Up Velocity Threshold [m/s]=10
Fish Intensity Threshold [counts]=50
Near Zone Distance=2.1

[Discharge]
Top Discharge Estimate=0
Bottom Discharge Estimate=0
Power Curve Coef=0.1667
Cut Top Bins=0
Cut Bins Above Sidelobe=0
River Left Edge Type=0
Left Edge Slope Coeff=0.5
River Right Edge Type=0
Right Edge Slope Coeff=0.5
Shore Pings Avg=10

[Edge Estimates]
Begin Shore Distance=100
Begin Left Bank=YES
End Shore Distance=100

[Depth Sounder]
Use Depth Sounder In Processing=NO
Depth Sounder Transducer Depth [m]=0
Depth Sounder Transducer Offset [m]=0
Depth Sounder Correct Speed of Sound=NO
Depth Sounder Scale Factor=1

[GPS]
GPS Time Delay [s]=0

[External Heading]
External Heading Offset=0

[Recording]
Filename Prefix=SALM
Output Directory=C:\My Documents\
GPS Recording=YES
DS Recording=NO
EH Recording=NO
Maximum File Size [MB]=0
Comment #1=
Comment #2=
Next Transect Number=0


[Commands]
BX1400
BA20
WS100
BP10
WP20
EA26
ES20
EZ1011101
ED10
EX00111
WD111100000
WS100
WN100
WE2000
WI0
WF100

[Wizard Commands]
```

```
[Wizard Info]
ADCP Type=1
Use Radio Modem=NO
Use GPS=NO
Use Depth Sounder=NO
Use External Heading=NO
Max Water Depth=50
Max Water Speed=1
Max Boat Speed=1
Material=0
Water Mode=1
Beam Angle [deg]=20

[Charts]
East Velocity Minimum=-0.5
East Velocity Maximum=0.5
North Velocity Minimum=-0.5
North Velocity Maximum=0.5
Up Velocity Minimum=-0.6096
Up Velocity Maximum=0.6096
Error Velocity Minimum=-0.6096
Error Velocity Maximum=0.6096
Velocity Magnitude Minimum=0
Velocity Magnitude Maximum=0.5
Velocity Direction Minimum=0
Velocity Direction Maximum=360
Projected Velocity Minimum=-0.5
Projected Velocity Maximum=0.5
Depth Minimum=0
Depth Maximum=70
East Displacement Minimum=-88.34080384
East Displacement Maximum=1855.15688064
North Displacement Minimum=-169.836100617
North Displacement Maximum=1886.569013696
Intensity Minimum=40
Intensity Maximum=255
Backscatter Minimum=0
Backscatter Maximum=255
Correlation Minimum=0
Correlation Maximum=255
Discharge Minimum=-1
Discharge Maximum=1
Heading Minimum=0
Heading Maximum=360
Pitch Roll Minimum=-10
Pitch Roll Maximum=10
Water Speed Minimum=0
Water Speed Maximum=0.5
Boat Speed Minimum=0
Boat Speed Maximum=5

[Fixed Commands]
CR1
CF11110
BA30
BC220
BE100
BP1
BR2
ES0
EX10111
TE00000000
TP000020
WA50
WE1500
WF50
WM1
WN50
WP1
WS50
WV170
```

2007 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2006 - September 30, 2007

Budget Category:		Authorized FY 2007	Proposed FY 2008	Proposed FY 2009				
Personnel		$ 20.8	$ 21.2	$ 16.5				
Travel		$ 1.5	$ 1.7	$ 1.7				
Contractual		$ 20.1	$ 26.6	$ 0.6				
Commodities		$ 1.3	$ 1.8	$ 0.5				
Equipment		$ 8.5	$ -	$ -				
Subtotal		$ 52.1	$ 51.3	$ 19.3				
Indirect at 25.57%		$ 13.3	$ 13.1	$ 4.9				
Project Total w/o G&A		$ 65.5	$ 64.4	$ 24.2	Approved FY 2007	Requesting FY 2008	Estimated FY 2009	Project Total
Trustee Agency GA (9% of Project Total)		$ 5.9	$ 5.8	$ 2.2				
Project Total w/G&A		$71.4	$70.1	$26.3	$71.4	$70.1	$26.3	$167.9
Full-time Equivalents (FTE)		0.3	0.3	0.3				
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 08 Notes: Added FY 08 PJ 080817; Hid FY 07 and FY 09 detail; Edited Proposal Summary sheet because PI didn't round to thousands; Budget Justification cost totals match the spreadsheet;

FY 07 Notes: Unauthorized travel in the amount of $3,200 was removed during the proposal review processes. This resulted in an additional reduction of $1,200 in Indirect and Agency G&A, The travel not funded was for your advisor, Tim Dellapenna from Texas A&M , Galveston campus, to attend the Annual Marine Science Symposium in FY 07 and FY 08. This project was funded for FY 07 only; FY 08 & FY 09 are pending.

CTD Surveys in late fall and late winter within the four nursery bays would be conducted on vessel charters provided by the following collaborative projects:
1) "Trends in adult and juvenile herring distribution and abundance in Prince William Sound" (Principal Investigator Richard Thorne, Prince William Sound Science Center) proposed for EVOS 07 funds
2) Stellar Sea Lion Winter Food Limitation study (Nov 07 only juvenile herring survey; Principal Investigator Richard

FY 08 Request for FY07 - FY 09

Project Number: 080817
Project Title: Physical Oceanographic Factors Affecting Productivity in Junvenile Pacific Herring Nursery habitats - Submitted under the BAA - NOAA
Name: Prince William Sound Science Center. Shelton M Gay III

FO RM 4A Non

Prepared:

Rev. 8/1/07

Personnel Costs:			Months Budgeted	Monthly Costs	Overtime	Proposed FY 2008
Name	Position Description					
Shelton M. Gay III	Principal Investigator		4.0	5.3		21.2
	Subtotal		4.0	5.3	0.0	
					Personnel Total	$21.2

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2008
Description					
Galveston, Texas to Anchorage for Alaska Marine Symposium	0.7	1	5	0.2	$1.7
				Travel Total	$1.7

FY08

Project Number: 080817
Project Title: Physical Oceanographic Factors Affecting Productivity in Junvenile Pacific Herring Nursery habitats - Submitted under the BAA - NOAA
Name: Prince William Sound Science Center. Shelton M Gay III

Rev. 8/1/07

Contractual Costs:	Proposed
Description	FY 2008
Vessel Charter - provided by collaborative proposal, P.I. Thorne	0
Vessel Charter - primarily provided by PWSOS TSG cruises - these funds include additional fuel and time cost	6.0
Vessel Charter - seine vessel for intensive surveys at Whale Bay	18.0
network costs (based on $100/mo x staff mo)	0.4
phone/fax/copying charges/mail/freight	0.2
calibration for 2 SBE16 Seacats	2.0
Contractual Total	26.6

Commodities Costs:	Proposed
Description	FY 2008
field & office supplies	0.5
batteries & maintenance supplies for Seacats & weather stations	0.5
lines, shackles etc. for moorings	0.5
GPS w/ electronic compass and serial output	0.3
Commodities Total	1.8

FY08

Project Number: 080817
Project Title: Project Physical Oceanographic Factors Affecting Productivity in Junvenile Pacific Herring Nursery habitats - Submitted under the BAA - NOAA
Name: Prince William Sound Science Center, Shelton Gay III

Rev. 8/1/07

2007 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2006 - September 30, 2007

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2008
Those purchases associated with replacement equipment should be indicated by placement of an R.			
		New Equipment Total	0.0

Existing Equipment Usage: Description	Number of Units	
600 kHz ADCP - Prince william sound Science Center (loaned from ADF&G)	1	
300 or 150kHz ADCP - PWSSC	1	
Chelsea Instr. Aquashuttle w/ Aquapack CTDF (includes winch w/ slip rings)	1	
SBE16 Seacat CT	2	
SBE19plus CTD w flourimeter & turbidity	1	
SBE 19 CTD	1	
surface mooring buoys and anchors	2	
Davis weather stations	2	
Safety equipment - Prince William Sound Science Center	1	
Desktop Computers and software (PWSSC)	1	
SUN Unix workstation	1	
laptop	1	

FY08

Project Number: 080817
Project Title: Project Physical Oceanographic Factors Affecting Productivity in Junvenile Pacific Herring Nursery habitats - Submitted under the BAA - NOAA
Name: Prince William Sound Science Center, Shelton Gay III

Rev. 8/1/07