REVISED WORK STATEMENT

1. *Project Title*: **CONTINUATION OF OBSERVATIONS ON THE BERING SEA SHELF: BIOPHYICAL MOORINGS AT SITE 2 and 4**

2. *Principle Investigators:*

Phyllis J. Stabeno
Pacific Marine Environmental Laboratory
7600 Sandpoint Way NE
Seattle, WA 98115-6349

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University of Alaska Fairbanks
Fairbanks, AK 99775-7220

Budget for PMEL
Requested funds for PMEL $277,376
Cost Sharing $621,169

3. *Revised Project Design*

This is a revision of proposal submitted January 2003, which was funded at a reduced level. The original submission proposed 2.7 years of monitoring in the southeastern Bering Sea shelf, with enhanced biological measurements and dissemination of data through World Wide Web. The reduced funding level permits only one year (September 2003 – September 2004) of monitoring, with a focus to maintaining two biophysical mooring sites on the southeastern Bering Sea shelf. Data have been collected at Site 2 nearly continuously since 1995, and at Site 4 more sporadically for five years. At each site, physical (temperature, salinity and currents), biological (fluorescence) and chemical (nutrients only at Site 2) will be collected by instruments on the moorings. The primary moorings will be at Site 2 where during the summer of 2004 a surface platform will be deployed on which the standard meteorological data will be collected. We will not be able to expand the instrumentation to include zooplankton counter on the mooring as originally proposed. We also will not be able to make net tows at and between the mooring sites, which will break a 9-year time series on the southeastern shelf. The reduced funding level will also not permit the creation of a web site to provide data on demand. Noting this, J. Overland and J. Napp are no longer funded PIs on this proposal. Data will continue to be provided to other scientists and stakeholders in as timely manner as possible.

We have modified the mooring deployment/recovery scheme that we have used for the last 9 years. Previously, we recovered/deployed moorings in September/October, then turned around the mooring at Site 2 in February, and finally turned around moorings at both sites in April/May. Under present funding, we have dropped the February cruise. This will decrease our ability to understand the spring phytoplankton bloom if ice should cover during the mooring in March or April. The mooring designs will be the same as presented in the original proposal, with the exception that there will be no nutrient meter at Site 4 nor will there be a zooplankton counter or water sampler at Site 2.

These moorings are critical to characterizing the changing ecosystem of the Bering Sea shelf. For the third year in a row, ice has not reached Site 2. Examining the sea-ice records back to 1972 (when reliable records became available) reveal that such a hiatus has not occurred previously. Whether this is an indicator of a marked change in the Bering Sea climate is not known, but these moorings are critical to understanding what is happening in the ocean and the bottom-up response of the ecosystem to this change. A marked warming over the southern shelf will directly impact the species composition over the shelf, including commercially valuable fish species.

Table 1. MILESTONES

Duration of proposal: July 1, 2003 - November 30, 2004

July 1, 2003	Begin mooring preparation
September 2003 [8 d]	Recover at Site 2: ADCP/ADP, SM w/ nitrate meter Recover at Site 4: SSM Deploy at Site 2: ADCP/ADP, SSM w/ nitrate meter Deploy at Site 4: SSM Collect CTDs, water samples at mooring sites
Apr/May 2004 [8 d]	Recover at Site 2: ADCP/ADP, SSM w/ nitrate meter Recover at Site 4: SSM Deploy at Site 2: ADCP/ADP, SM w/ nitrate meter Deploy at Site 4: SSM Collect CTDs, water samples at mooring sites
September 2004 [7 d]	Recover at Site 2: ADCP/ADP, SM w/ nitrate meter Recover at Site 4: SSM Collect CTDs, water samples at mooring sites

All times series data will be processed and available to other researchers 8 weeks after recovery of the moorings. Data from CTD stations will be also be available 90 days after completion of the cruise.

KEY: SM - Surface biophysical mooring
SSM - Subsurface biophysical mooring
ADCP/ADP - Moored acoustic Doppler current profiler.
[The number of ship days]

4. Revised Budget Justification

PMEL Budget: Personnel costs for Phyllis Stabeno are provided at no cost to this program. Support is for participation in the cruises, mooring preparation and deployment, data analysis, computer and graphics costs. Costs of mooring preparation and deployments are itemized. Truck and forklift rentals are for ship loading in Dutch Harbor (the probable port of embarkation), and are necessary for cruises on which deployment and recovery of the moorings will occur. Funds are requested to cover computer maintenance, software upgrades, connections charges, graphics (for publications and presentations), for the maintenance of web page presenting results from moorings and supplies.

Salaries for field operations personnel are to prepare equipment, cut moorings lines, and participate in cruises. Salary for processing/web are for processing the time series, placing figures on a web site for other researchers and disseminating data to stakeholders. Travel is requested to Dutch Harbor, where the cruises will likely originate.

NPRB BUDGET SUMMARY FORM

PROJECT TITLE: Continuation of Long-term Observations on the Bering Sea Shelf: Biophysical Moorings at Sites 2

PRINCIPAL INVESTIGATO Dr. Phyllis J. Stabeno

FUNDING SOURCE	YEAR 1	YEAR 2	YEAR 3	TOTAL
NPRB Funding	320,212	0	0	320,212
Match/In Kind				621,169
TOTAL	320,212	0	0	941,381

Cost Categories	NPRB Year 1	NPRB Year 2	NPRB Year 3	NPRB TOTAL	Match/In kind TOTAL (all years)
1. Personnel Salaries	88,826			88,826	26,962
2. Personnel Fringe Benefits	35,429			35,429	12,448
3. Travel (include 1 trip to review meeting in Anchorage)	17,268			17,268	6,759
4. Equipment				0	270,000
5. Supplies	67,135			67,135	5,000
6. Contractual/Consultants (UAF)				0	0
7. Other (Include $1500 for education and outreach)	42,836			42,836	300,000
Total Direct Costs	251,494			251,494	621,169
Indirect Costs	68,718			68,718	0
TOTAL PROJECT COSTS	320,212			320,212	621,169

NPRB Use Only
Reference No: ________________
Date Received: ________________

NPRB PROPOSAL SUMMARY PAGE

(To be filled in by applicant)

Project Title: Continuation of Long-term Observations on the Bering Sea Shelf: Biophysical Moorings at Sites 2 and 4

Project Period: From Date: July 1, 2003 to June 30, 2006

Name, Address, Telephone Number and Email Address of Applicant:
P. J. Stabeno, 7600 Sand Point Way NE
Pacific Marine Environmental Lab.,
Seattle, WA. 98115 206-526-6453 stabeno@pmel.noaa.gov

Principal Investigator(s): (Include full contact information here or in CVs, including email address)
P. J. Stabeno, NOAA, Pacific Marine Environmental Lab.
J. M Napp, NOAA Fisheries, Alaska Fisheries Science Center
J. E. Overland, NOAA, Pacific Marine Environmental Lab.,
T. E. Whitledge, School of Fish and Ocean Sciences, Univ. of Alaska, Fairbanks

Research Priorities Addressed:

Identify up to three priorities from list in RFP (a-g): a

Summary of Proposed Work (250 words or less):
The inherent nature of an ecosystem is change. Dramatic variations in the physical and biological environment of the southeastern Bering Sea have occurred recently. The most comprehensive oceanographic characterization of these changes was made using observations collected at, and in the vicinity of, biophysical moorings at Sites 2 and 4 (12 scientific articles including Stabeno, et al., 2001, 2002; Hunt et al., 2002; Napp et al., 2002). Syntheses using these data provide the foundation for a knowledgeable forecast of how future changes in climate may impact this ecosystem, its living marine resources and protected marine species. These data were used to track the biophysical conditions during the coccolithophorid blooms and are used in the annual NMFS ecosystem review. The objective of this proposal is to continue time series measurements of the ocean-ice-atmosphere coupled Bering Sea shelf ecosystem at these two sites from September 2003 through May 2006. At these sites, we propose to measure ocean temperature, salinity, currents, fluorescence, nutrients and zooplankton, and during summer standard meteorological variables. Historically, these moorings and the monitoring line between them were funded by a number of programs, most recently by North Pacific Research Board (winter of 2003). Continued monitoring will: 1) provide essential information during a period of change (data from 2002 show a remarkably warm southeastern shelf), 2) provide necessary data allowing researchers to address the influence of climate change on sustainable fisheries, threatened and endangered species, and the vitality of this ecosystem, and 3) continue this invaluable time series.

Funding: Total NPRB Funding Requested: $1.358M (PMEL:$833K; AFSC:$246K, UAF:$280K)

Total Matching Funds Used: $1.433M

Legally Binding Authorizing Signature and Affiliation:

(NOT TO EXCEED ONE PAGE)

STATEMENT OF WORK

1. ***Project Title:*** Continuation of Long-term Observations on the Bering Sea Shelf: Biophysical Moorings at Sites 2 and 4

2. Proposal Summary

We propose to continue biophysical measurements at two mooring sites (2 and 4) and along the Southeast Bering Sea hydrographic transect (Fig. 1). These observations were begun in 1995, partially in response to the National Research Council's (1996) call for studies to determine the roles of sea ice and top-down/bottom-up forcing in the Bering Sea ecosystem. Data and analyses from these observations were shared with the scientific community and form the basis for key papers in two recent journals addressing the Bering Sea ecosystem (Dagg et al., 2002; Macklin et al., 2002). By funding this proposal, NPRB would continue the flow of data from the southeastern Bering Sea shelf to the scientific community, invest in technological upgrades to the observing system, and obtain specific analyses of the data with respect to stated goals of the NPRB.

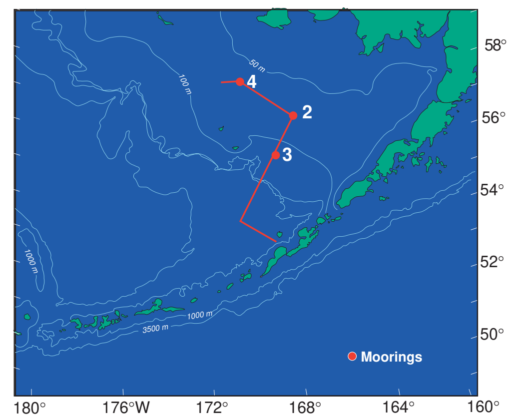


Fig. 1. Bathymetry of the southeastern Bering Sea showing the location of Sites 2 and 4 and the proposed monitoring line. A mooring is no longer maintained at Site 3, but hydrographic and plankton samples are still taken at this location.

Site 2 has been maintained almost continually since 1995, providing the longest near continuous time-series of biophysical variables on the Bering Sea shelf. In addition, a series of moorings have been deployed at Site 4, providing almost five years of more sporadic data. Water property measurements have been made along the transect between Sites 2 and 4 on >20 occasions since 1995. Long-term observations provide critical data that allow comparisons among habitats and years, characterizations of inter-annual variability, quantification of regime shifts and climate change, and the database necessary for model simulations of the shelf ecosystem. Data from the moorings and transects have provided fundamentally new insight into how the Bering Sea shelf functions (e.g. the Oscillating Control Hypothesis; Hunt, et. al, 2002), and have supported over a dozen publications (see vitae) and many more presentations to scientists and stakeholders.

This research is a continuation of a series of research programs that started in 1995. NPRB provided partial funding for the continuation of these moorings for the period September 2002 through May 2003. In October 2002, subsurface moorings were deployed at Sites 2 and 4. They are scheduled for recovery in April/May 2003. These moorings cannot be re-deployed in September 2003 without funding from NPRB. The objectives of our proposed project are three fold:

- continuously monitor the temporal variability of biophysical properties of the southeast Bering Sea ecosystem using moorings and shipboard measurements;
- use these data to calculate annual ecosystem metrics/indices recently developed by the Southeast Bering Sea Carrying Capacity (SEBSCC) program;
- make observations and results easily accessible to all end users (including scientists, managers, industry, educators, students and the general public) via the World-Wide Web (www).

3*. Responsiveness to NPRB Research Priorities*

This cooperative research is designed to provide critical information to enhance understanding of the Bering Sea marine ecosystem. One product for stakeholders is to use the time series together with the indices developed by SEBSCC (Schumacher et al., draft final report) to provided information to fisheries managers. Meeting the three objectives of this proposal supports three themes in NPRB's call for proposals "Marine ecosystem structure and processes"

a) "Factors affecting marine productivity, including nutrient transport and availability, water column stability and the role of sea ice."

b) "Influence of climate variability on physical, chemical and biological processes"

c) "Long term monitoring of biophysical parameters and phytoplankton and zooplankton."

Continuation of these moorings provides unique and critical data to address the above research themes. NOAA has been the only entity collecting extended time series data of this type in the Southeast Bering Sea ecosystem. During the last six years several research programs (i.e., NOAA's SEBSCC, NSF's Inner Front, IARC, NPMR) have focused their energies in the southeastern Bering Sea. Unfortunately, in 2002 there was no focused oceanographic research in this region, and without funding the same will be true of 2003. It is critical that these long-term measurements be continued, so that we can better understand and predict dynamics, especially the impacts of climate change on this ecosystem. The next couple of years are a critical period in this changing ecosystem. The Pacific Decadal Oscillation (PDO) shifted phase in 1998 from positive to negative. More recently it has shifted back to the positive phase, but whether this is a result of the on going El Nino or a genuine regime shift is not known. The Arctic Oscillation (AO) continues a long-term upward trend with increasing interannual variability (Overland et al, 2002). The biophysical time series must be continued to document the effect of these climate events on the productive Bering Sea ecosystem. We are requesting funding from NPRB to maintain a highly successful operation for the next three years. Without funding there will be a break in these valuable time series.

The continuation of these observations will improve:

- "our understanding of the dynamics of the North Pacific marine ecosystem," and
- "our ability to forecast and respond to effects of changes through integration of various research activities, including long-term monitoring",

which NPRB has recognized as necessary to carry out its mission (page 2 of the RFP).

Our observations permit the characterization of changes in the physics and biology of this ecosystem that is important to the economy of Alaska and the nation. In addition, the proposed observations will permit examination of the physical processes responsible for nutrient fluxes onto the shelf, as well as biological process that help convert the nutrients into harvestable resources. These long-term measurements are important in addressing the first of the overarching hypotheses found in the Bering Sea Ecosystem Research Plan (BSERP): "*Natural variability in the physical environment causes shifts in trophic structure and changes in the overall productivity of the Bering Sea."* Long-term observations of the physical and biological environment of the Bering Sea must be made to quantify the variability of the ecosystem. These moorings address most of the questions (1, 3, 4, 5, 6) in the "Variability and Mechanisms in the Physical Environment" section of the BSERP.

4. Project Design and Conceptual Approach

Our project design is based on eight years of successful mooring deployments and ship observations developed as part of BSFOCI and SEBSCC. Moorings at Sites 2 and 4 are presently in place, and will be turned around in April using other funding. Under this proposal, we will first recover those moorings (October, 2003) and then redeploy them to collect data over the winter. The moorings at Site 2 are turned around in February, April/May and September/October. Because of sea ice, which usually covers the northern mooring site in winter, Site 4 is only visited in April/May and September/October. Shipboard measurements will be made at three mooring sites (M2, M3, M4) and on transects between the moorings. While historically M3 has maintained moorings, changes in both ship traffic and fishing pressure make this site presently too risky for moorings. Our conceptual approach in determining ecosystem response to climate forcing is to relate these and other historical *in situ* observations (including fish, sea bird, and marine mammal abundance and distributions) to long-term climate variables such as PDO, AO and sea-ice distribution.

<u>Background and results to date</u>

The broad (>500km) southeastern Bering Sea shelf consists of three distinct domains characterized by contrasting summertime water column structure, currents and biota (Coachman 1986; Schumacher and Stabeno, 1998). They include the coastal domain (bottom depth (z) < 50 m with weakly stratified or well-mixed water), middle shelf domain (50 < z < 100 m with strongly stratified, 2-layer structure) and outer shelf domain (100 < z < 180 m with mixed upper and lower layers separated by gradually increasing density). The coastal and middle shelf domains are separated by the inner front, and the middle and outer domains by the middle transition zone. Each domain is also distinct in terms of amount and duration of sea ice cover, plankton community and carbon flux dynamics (e.g., Cooney and Coyle, 1982), distribution of horizontal kinetic energy (Coachman, 1986; Schumacher and Stabeno, 1998) and nutrient distribution (Whitledge et al., 1986). The cross shelf domains are further subdivided into northern, middle and southern habitats, which while less distinct than the across-shelf habitats still have unique biological-chemical-physical characteristics. (e.g. Stabeno et al., 2002). This along-shelf variability includes such features as number of storms, persistence of ice, tidal mixing, and the influence of currents in the cross-shelf transport of nutrients (Reed and Stabeno, 1996).

Sea ice is a dominant feature of the Bering Sea shelf. During summer and fall the shelf is usually ice-free; during winter strong, frigid winds from the northeast cause extensive ice formation along leeward coasts, and the southwestward advection of the sea ice. The leading edge of the ice is continuously melting, introducing cold, fresh water to the water column. Maximum ice extent typically occurs in late March (Stabeno *et al.,* 1999). Interannually, the location of the southernmost position of the ice varies over hundreds of kilometers, and in extreme years, ice covers the entire southeastern shelf. Sea ice arrives at this location as early as January and has remained as late as May. The time of arrival, persistence and departure of ice at Site 2 indicates that the most extensive ice years coincided with a strong negative PDO. Between 1979-1981, ice was largely absent from the middle shelf near Site 2. Beginning in the early 1990s, ice once again became more common in this region, although not to the extent that was observed in the early 1970s. Recent research has indicated that during the 1990s, an earlier spring transition, related to the AO, occurred over the Bering Sea (Stabeno and Overland, 2001).

A recent examination of jellyfish biomass and climate change shows that longer period (perhaps decadal) fluctuations in ice extent/persistence occur that may have resulted in marked increase in biomass (Brodeur *et al.,* 1999). The extent and persistence of the ice largely determine the temperature and horizontal extent of a cold pool that occurs in the lower layer of the middle shelf. The cold pool, which is 40-50 m thick, persists through the summer, warming only slightly (often <3 ^{o}C). Associated with the presence of ice is a phytoplankton bloom, which can begin as early as March (Stabeno *et al.*, 1998), and can account for a large fraction of the total annual phytoplankton production (Niebauer *et al.*, 1991, 1998). The coupled atmosphere-ocean-sea ice system and its attendant phenomena play an important role in the temporal and spatial characteristics of secondary production, the production of prey for larval fish, and help to determine the distribution of higher trophic level species (Napp *et al.*, 2000; Wyllie-Echeverria, 1995). The most reliable method of measuring the changes in water properties that occur under the ice is through the use of moored arrays.

Eight years of temperature records (Fig. 2) from the moorings at Site 2 reveal a large seasonal cycle, which is typical for the southeastern middle shelf. In January, the water column is well mixed. This condition persists until buoyancy is introduced to the water column either through ice melt or solar heating. The very cold temperatures (indicated by black in Fig. 2) that occurred in 1995, 1997 and 1998 resulted from the *in situ* melting of ice. Generally, stratification develops during April. The water column exhibits a well-defined two-layer structure throughout the summer consisting of a 15-25 m wind mixed layer and a 35-45 m tidally mixed bottom layer. Deepening of the mixed layer by strong winds and heat loss begins as early as mid August, and by early November the water column is again well mixed.

During any given year marked variations are superimposed on the mean springtime warming trend observed at Site 2 (Fig. 2b). The data from these moorings give valuable information on the dynamics of the Bering Sea shelf. During 1995 ice persisted for more than a month; however, the water column was mixed to the bottom only for a short period in March because advection of warmer, more saline water in the lower layer created a strong density gradient between the upper and lower layers. This effectively insulated the lower layer, limiting warming of the cold pool (<0.3^{o}C/month). The mixed layer was shallow (<20m), because of the weak summer winds. During 1996, since there was little buoyancy contributed by ice melt, the density gradient was weak and above average wind mixing resulted in a deeper surface layer than in 1995. Between April and August, the bottom temperature warmed by ~1^{o}C/month. During 1997, ice was less persistent than in 1995, and weak winds and strong heating resulted in a shallow warm mixed layer. A storm during late May mixed the water column to 50 m, reducing the density gradient between the upper and lower layer. As in 1996, there was substantial warming (~1^{o}C/month) of the cold pool. In contrast to 1995 and 1997, ice arrived early in February 1998, during a period of weak winds. Thus, while the ice quickly cooled the upper layer, it did not affect bottom temperatures. Only after the retreat of the ice in late February did wind energy become sufficient to completely mix the water column, which remained well mixed until late May. The warmer than usual bottom waters resulted in above average mean water column temperatures. The weak stratification permitted a steady warming of the bottom layer by ~0.8^{o}C/month from June through August. Each year, stratification from melting ice failed to persist through the summer, since strong mixing occurred during (or after) the ice melt. The results from Site 4, tell similar stories, but are less clear because the time series is shorter and not continuous. Site 4 provides a contrast to Site 2, since cross shelf advection is stronger at this location, thus providing important information on the replenishment of nutrients to this shelf.

(a)

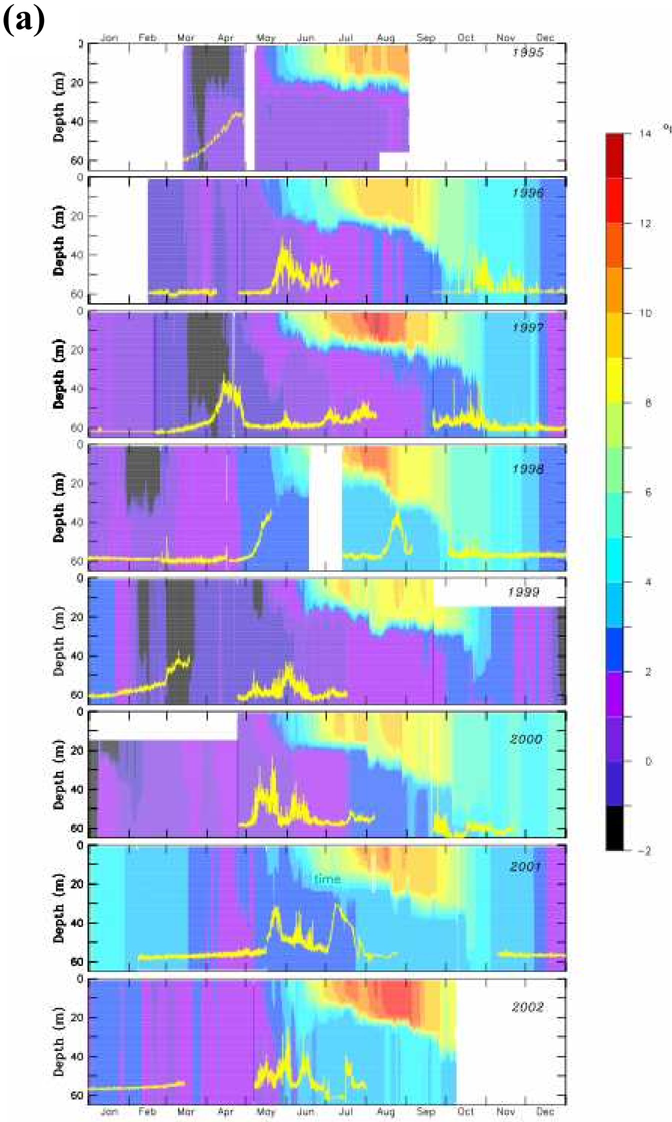
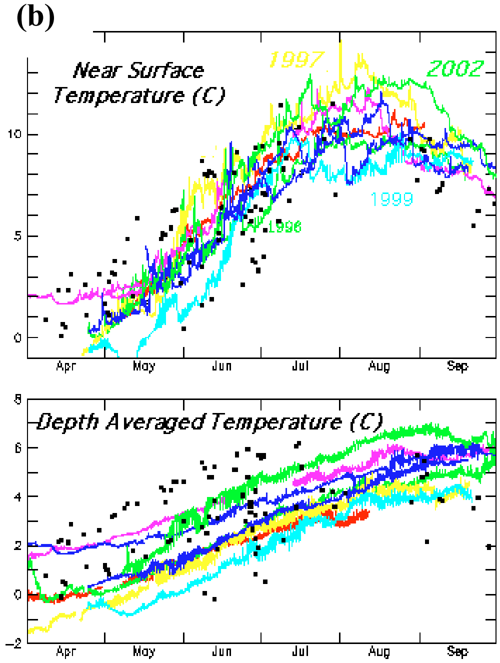


Fig. 2. (a) Contours of temperature measured at Site 2. The coldest temperatures (black) occurred when ice was over the mooring. The yellow line is fluorescence measured at ~11m. During the summer temperatures were recorded at 1m, during the winter the upper most instrument was at ~10m. Temperature was extrapolated to the surface. b) The depth averaged temperature at Site 2. The squares are from historical record temperature recorded in the vicinity of Site 2 (after Stabeno et al., 2001). The warmest temperatures are from the late 1970s and early 1980s. In 2002 not only was the surface temperature almost as warm as in 1997, but the average temperature was significantly warmer.

(b)



In addition to currents, temperature and salinity, chlorophyll fluorescence and nutrients are measured by the biophysical platforms. A phytoplankton bloom (Fig. 2, yellow lines) occurred in March/April during 1995 and 1997, associated with the arrival and melting of sea ice. In both years, the bloom began even though the water column was not yet stratified. In 1996 and 1998, when ice was present early in the year (February) and then retreated, the earliest bloom occurred during May after the water column became thermally stratified. This was also observed during PROBES (Sambrotto *et al.*, 1986). It is likely

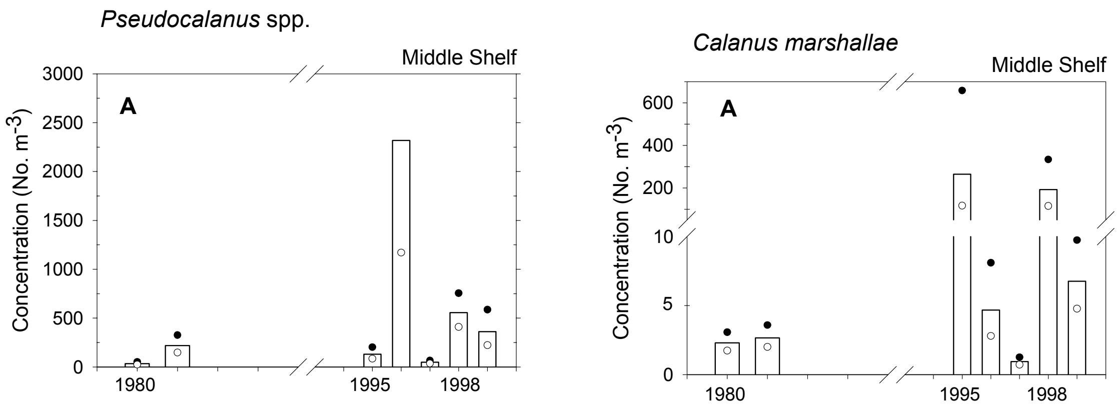


Fig. 3. Spring concentration of *Pseudocalanus* and *Calanus* around Site 2. Shown is the mean concentration and Standard Error (black and open circle). Note that the high values in zooplankton concentration began before the 1997 warming event and that concentrations in the late 1990s were generally higher than those of the early 1980s (from Napp et al., 2002).

that during 1996 and 1998, the ice was present too early in the year when insufficient sunlight was available to initiate an ice edge bloom. The timing of the blooms is important to the Bering Sea's sea food webs (e.g. the Oscillating Control Hypothesis; Hunt et al., 2002, Hunt and Stabeno, 2002). Conventional wisdom is that ice-edge blooms, being little-grazed (Coyle and Cooney, 1982), are especially important sources of food to the benthos. In addition, the cold-water temperatures associated with years in which ice penetrates far into the southeastern Bering Sea result in low plankton production (Coyle and Pinchuk, 2002). Shipboard measurements show that both the ice-associated bloom and the more typical spring bloom strip the upper water column of nutrients. In November, when the strong summer thermocline breaks down, a fall bloom is signaled by an increase in fluorescence.

In addition to observations from the moorings, we have examined zooplankton biomass, abundance and community composition in the spring and fall at five stations around each mooring since 1995. These measurements were crucial in determining whether or not the recent warm years (1997 and 1998) had a significant impact on the ecosystem (Napp and Hunt, 2001). These data and those of the Inner Front program (Stockwell *et al*., 2001) demonstrated that the abundance of key copepod species in recent years were significantly higher than abundances measured in the early 1980s during PROBES. It was the SEBSCC data, however, that documented that this increase began before the most recent El Niño (Fig. 3; Napp *et al*., 2002). The observed increase in zooplankton biomass was key evidence that the southeastern Bering Sea shelf may actually be more productive now than in recent decades (Hunt *et al*., 2002).

Measurements of nutrients at Site 2 reveal a seasonal cycle that contains significant annual variability depending on physical conditions and the timing of spring phytoplankton blooms (Fig. 4). The replenishment of nutrients occurs during the winter months after the breakdown of the shelf frontal systems (Fig. 4 in October) and the decrease in nutrients in 2001 is in response to the beginning phytoplankton bloom evident in fluorescence in Fig. 2a. The use of a moored nitrate meter provides critical information on the temporal scales of this replacement, of the level of winter replenishment and the physical mechanisms responsible for replenishment. The winter replenishment sets the annual level of new production in areas distant from the shelf edge.

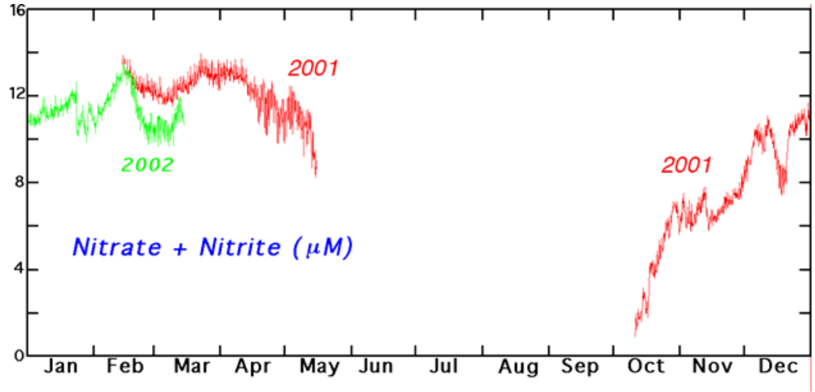


Fig. 4. Time series of nitrate concentration at ~15m measured with nutrient meters on moorings at Site 2. The red lines are from 2001 and the green line from 2002

Critical Testing and Adoption of New Technologies

Incorporation of new measurement technologies is an important way to advance knowledge and applicability of science. We propose to test and adopt two new technologies: autonomous underwater phytoplankton sampling and acoustical detection of zooplankton size and biomass. The former is to learn the origin of under ice phytoplankton blooms and the latter is to obtain continuous time series of zooplankton biomass and size structure (without having to capture, preserve, and count samples). The water sampler is a WS EnviroTech Aqua Monitor that enables the collection and storage of fifty discrete water samples in preservative for post-recovery analysis. Samples (200 to 500 ml depending on the season) will be collected every 2 to 4 days (depending on length of deployment) and stored in 1-liter medical bags containing preservatives..

The autonomous phytoplankton sampler is made by WS Ocean (http://www.wsevirotech.com/ AquaMoitor.htm). PMEL and UAF requests only instrument set-up costs as they each already own an instrument. If successful in getting data, PMEL will use matching funds to pay for the analysis of the samples. The underwater plankton sampler pumps a known quantity of water through a small fine mesh net on a carousel. This is the only way we can sample the phytoplankton community during under ice blooms as ship time is limited and the available ships do not have ice-strengthened hulls. Reproduction of important zooplankton species begins well before the bloom is detected by the fluorometers (Baier and Napp, submitted).

Autonomous acoustical detection of zooplankton will use multi-frequency acoustics to determine the total biomass and size distribution. It is a mature sampling technology (U.S. GLOBEC, 1991, 1993; Smith et al., 1992, Holliday and Pieper, 1995, http://www.gso.uri.edu/criticalscales/, http://www.aard.tracor.com/AARDDefault.html) that we are currently using in the Gulf of Alaska under GLOBEC sponsorship (Napp et al., 2003). The multi-frequency technique uses uni- or multi- scattering model inverse solution to resolve acoustic volume backscatter by zooplankton into biomass sorted by organism size (Holliday, 1977, 1996). Examples of other successful moored applications include work in northern Puget Sound (Holliday, 2001, Alldredge et al., 2002) and the Southern California Bight (Holliday and Pieper, 1995). This system measures backscattering at eight frequencies from 104 - 3000 kHz, suitable for size-abundance estimation of zooplankton from ca. 0.25mm to >25mm TL. Data from the TAPS-8 consist of mean integrated echo intensities and echo variance ratios at each of the eight frequencies, computed over 32 individual pings. Echo intensities are measured from a small (2 liter) sample volume at a range of ca. 1.5 m from the transducers. The system also estimates the abundance of

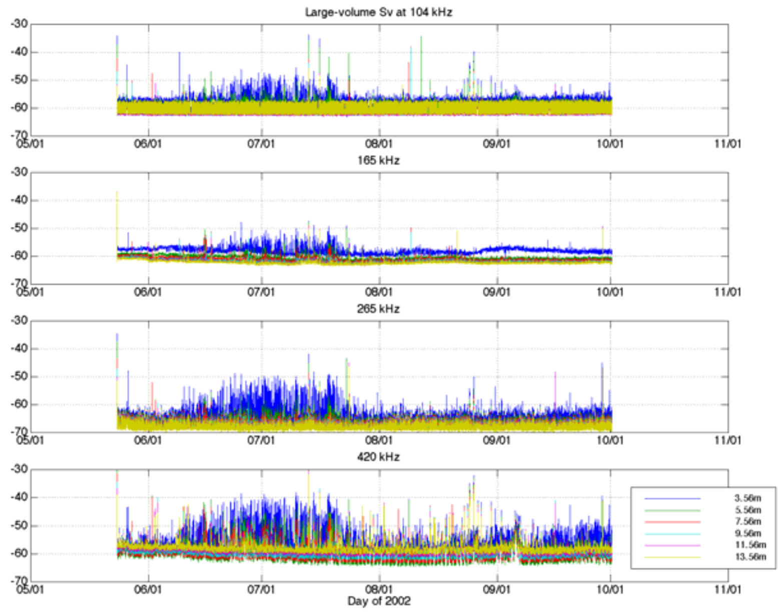


Fig. 5. Recent TAPS-8 results from the Gulf of Alaska. Backscatter volume at the four lowest TAPS-8 frequencies at 6 distance bins from the transducer. This deployment was from late May to the end of September 2002.

larger, less numerous scatterers such as euphausiids, ctenophores, pteropods, etc. using a longer transmit pulse and extended range (up to 20 m from instrument; Figure 5, http://es.ucsc.edu/~coestl/) We request funding in Years 1 and 2 to modify an instrument for dedicated Bering Sea use in Year 3. Ultimately, as satellite transmission bandwidth improves, we hope to telemeter the zooplankton data to the surface and then back to our laboratory through satellite uplinks.

Strategy

We propose to use the same mooring design that we have employed successfully for the last six years. Both moorings will be subsurface over the winter, with the upper float at ~10m. In spring, the mooring at Site 2 will be replaced with a surface mooring, and that at Site 4 with a subsurface mooring. Ocean temperature is measured approximately every 4-6m (the higher resolution is in the upper 30m), salinity at four depths on each mooring, and fluorescence at ~11m. At Site 2, a nitrate meter will be deployed at ~15m (adjacent to the fluorometer) in the photic zone to measure the drawdown of nutrients and ~15 m above the bottom to measure drawdown and renewal of nutrients in the bottom layer. Site 4 will have one nutrient meter at ~15m below the surface in the photic zone. In addition, a plankton pump sampler will be deployed in February (2004, 2005 and 2006) at Site 2 to collect water samples to examine the phytoplankton bloom below the ice. Historically, during most years there is ice over Site 2. Typically, maximum ice extent occurs in March, so the deployment in February of a water sampler should obtain samples of the phytoplankton community under the ice. At Site 4, currents will be measured using three current meters on the mooring, while at Site 2 a 600KHz ADCP will be deployed on a separate, nearby mooring. In addition, we propose to continue collecting shipboard observations (CTD, dissolved nutrients, chlorophyll, and zooplankton) at Sites 2, 3 and 4, two to three times (dependent upon ice cover) a year (Fig. 1), while continuously measure water properties (temperature, salinity, currents, chlorophyll fluorescence, and nitrate) from moorings. Hydrographic sections measuring T/S, nutrients and chlorophyll, will be occupied between Sites 2, 3 and 4, along the monitoring line (Fig. 1).

We plan to follow the successful deployment strategy for Sites 2 and 4 used since 1996, as specified in Table 1. In the future, we will seek funding to continue the moorings beyond May 2006 by making them part of a Coastal Alaska Observing System (CAOS).

During the fall, winter and spring cruises, personnel will visit the mooring to collect ground truth and time-series samples. Chlorophyll samples will be frozen at (-70^{o}C) and analyzed in Seattle. Samples for meso- and microzooplankton will be collected using double-oblique tows of paired bongo frames (60-cm frame with. 0.333 mm mesh and 20-cm frame with. 0.150 mm mesh) for mesozooplankton and vertical hauls (20-cm CalVET frame with. 0.053 mm mesh for microzooplankton). The preserved samples will be sent to the Polish Plankton Identification and Sorting Center for processing. Once the sorted samples are returned, identifications and counts from a subset of the samples will be verified.

Although the deployment of nutrient samplers on moorings is relatively new, we have had success with this instrumentation (Fig. 4). We use a W.S. Ocean Systems Model NAS-2EN that has a depth capability of 100m and duration of 4-6 months. This sensor utilizes the standard wet chemical analysis for nitrate, using the cadmium reduction methodology by Wood, Armstrong and Richards (1967). Quality control of the nitrate data will be checked in several ways. Prior to and after deployment, calibrations of the instruments will be checked with five standards that are in a concentration range that brackets the ambient concentrations. In addition, CTD/rosette casts with replicate samples will be collected before and after deployment to validate in situ concentrations. The shipboard nitrate concentrations will be analyzed on an Alpkem Model RFA 3000 using the same methodologies as those in PROBES, IISHTAR and SEBSCC.

The time-series measurements require shipboard samples for calibration and verification. Funding is requested as part of this proposal. Samples of nutrients will be collected in each October and each April/May to ground-truth the nutrient sampler. Calibration CTD casts will be done on deployment and recovery of each mooring. Areal hydrographic surveys will be done to place the moorings in regional context. Nutrients are collected on each of the cruises on the hydrographic line (Fig. 1), as is fluorescence and chlorophyll.

Table 1. MILESTONES

Duration of proposal: July 1, 2003 - June 30, 2006.

July 1	Begin mooring preparation Begin to build new TAPS-8
October, 2003, 2004, 2005 [10 days]	***R*** at Site 2: ADCP/ADP, SM ***R*** at Site 4: SSM ***D*** at Site 2: ADCP/ADP, SSM w/ 2 nitrate meters and TAPS [2005] ***D*** at Site 4: SSM, w/ nitrate meter Collect CTDs, water samples and plankton along the monitoring line and mooring sites
Apr/May 2004, 2005 [10 days]	***R***- at Site 2 and 4: SSM, and ADCP/ADP* (Site 2) ***D*** at Site 2: ADCP/ADP, SM w/ 2 nitrate meters and TAPS-8 [2005] ***D*** at Site 4: SSM, w/ nitrate meter Collect CTDs, water samples and plankton along the monitoring line and mooring sites
February 2003, 2004, 2005	***R***/***D*** at Site 2: SSM w/ water sampler, nitrate meters and TAPS [2005]
Apr/May 2006	***R*** all moorings

All times-series data will be processed and available to other researchers within 6 weeks after recovery of the moorings. Data from CTD transects will be also be available 90 days after completion of the cruise. Meso- and microzooplankton samples will be shipped to Poland for sorting and enumeration. The data are generally available in digital form one year later.

KEY: ***D*** – Deploy ***R***-Recover SM - Surface biophysical mooring
SSM - Subsurface biophysical mooring [The number of ship days]
ADCP/ADP - Moored acoustic Doppler current profilers.

It is our experience that monitoring from biophysical platforms provides essential observations of physical and biological parameters. These observations permitted a bi-yearly, comprehensive characterization of the changes in the ecosystem during 1997-2002 (e.g., Stabeno, 1997). Also, information from biophysical moorings provided the key component to new hypotheses of Bering Sea productivity, such as the Oscillating Control Hypothesis (Hunt *et al.*, 2002; Hunt and Stabeno, 2002). New ecosystem status metrics for the Bering Sea are under development as a result of the SEBSCC program and ongoing NPRB studies.

Outreach and Education through Access to Data and Information

We have found that broad availability of data is critical to the advancement of understanding of this or any ecosystem. Presently, there are time-series data from eight years at Site 2, and from 5 years at Site 4. In addition there are hundreds of CTD profiles that have been collected in the region, and ~100 satellite tracked drifter trajectories. While this data has been made available to other scientists, the process has been cumbersome. We propose to provide an information source modeled after the successful web pages that serve the TOGA/TAO equatorial data sets. The data will be available in near real time to all researchers, stakeholders, managers and interested persons in a complete and easily navigated web page. This information will be combined with retrospective data to provide an easily understood comparison to previous years. Such an information system provides full utility for the investment in the observational system.

The NPRB places a priority on enhanced data availability to support marine ecosystem information needs. Our objective is to provide a single-source, robust dissemination system for all relevant information including: historical and near real-time data from moored and drifting buoys, CTD and nutrient data, sea ice data, and weather data both from long-term stations and derived fields from the NCEP reanalysis. Value added information includes multiple customizable views, animations, historical comparisons, and multivariate presentations and overlays. This system will be designed so that it can easily become a node of other systems, e.g. a larger Alaska information system. It will foster involvement by a wide community by presenting easily understood information and readily accessible data that clearly explains science, and observing system concepts and methodologies to a broad audience of users.

Tasks include preparation and quality control of the observed data, extraction and development of the gridded data fields, development of web codes and back end graphics, controller scripts for comparison and user customized views of the data, and incorporation of comprehensive information and outreach materials. Automated scripts support near real-time updates of observed data and extraction of required gridded fields. The development effort is significantly reduced by our extensive leveraging of experienced personnel and software components from the TAO system. The highly successful TAO information system has resulted in more than 400 peer reviewed publications and over 2,000,000 accesses per month by a broad spectrum of users.

In addition to the dissemination through the web, we propose to visit communities in St. Paul Island and Kodiak Island. In the second year, T. Whitledge will present results from this research in St. Paul Island and in third year P. Stabeno will present results at Kodiak. Both outreach efforts will address schools and the larger community.

5. Project Management and Experience and Qualifications of Personnel

The PIs have worked together for the last decade in investigating variability in the Bering Sea and are leading researchers in the Bering Sea ecosystem. Stabeno has been the lead PI on a series of proposal that have maintained moorings at Sites 2 and 4, in addition to other mutli-disciplinary programs funded by GLOBEC, SEBSCC, NPMR, etc. She leads a group at PMEL that deploys ~80 moorings each year, many of which are similar in design to the ones proposed here. She publishes extensively in peer-reviewed journals. Napp has been working in the southeastern Bering Sea for the past 10 years to understand how climate and upper-ocean physics influences the flow of energy through the ecosystem. He has been a PI on several multi-disciplinary programs in the NE Pacific Ocean (FOCI, BS FOCI, SEBSCC, GLOBEC) and regularly publishes his results Recently, he together with Stabeno served as a Guest Editors on a PICES Bering Sea special issue (Progress in Oceanography, 55 (1/2). He and D. VanHolliday (BAESystems) have worked together since 1988. Napp, Holliday and Greenlaw are currently funded by GLOBEC to use TAPS-8 on a Gulf of Alaska mooring. Whitledge is an experienced and leading chemical/biological oceanographer. He is the leader in the introduction of nitrate meters to the Bering Sea, North Pacific and the Arctic Oceans. He has been investigating the nutrient/phyto-plankton cycles in various parts of the Bering Sea ecosystem for the past 25 years in the PROBES, ISHTAR. SEBSCC and Inner Front programs. Overland has conducted Bering Sea research for over 20 years and has authored over 60 journal articles. His current interest is in combining near real time and retrospective data in multivariate analyses to assess environmental changes. Overland provides a link to the regional and climate scale studies (PDO, AO, etc.)

We will present all cruise information on web pages (http://www.pmel.noaa.gov/foci/operations/index.htm) as follows: 90 days before the cruise, draft cruise plans will be available on the web; 30 days before the cruise, final cruise plans including mooring design, will be posted; 30 days after completion of a cruise, the cruise report will be available on the web; and 90 days after recovery of moorings, plots of updated time series will be available on a web site. In addition all data will be submitted to NODC in a timely manner, and metadata will be archived in the North Pacific Ecosystem Metadatabase (http://www.pmel.noaa.gov/bering/mdb/np).

PI Responsibilities:

Stabeno will be responsible for the mooring design, deployment and recovery, including calibration and processing of data from all moored equipment (except the nitrate meter and TAPS-8) and for the CTD data. Stabeno and Napp will jointly be responsible for the cruise plans and reports. Napp will be responsible for obtaining chlorophyll ground truth samples for the moored fluorometers, and for continuing the meso- and microzooplankton time series begun at Sites 2, 3 and 4 in 1995 (Site 3 no longer has a mooring, but continues to be sampled). He will be the COTR for the contract with BAESystems for the TAPS-8, and interface with BAE to ensure quality data from the acoustic zooplankton counter. Whitledge will take responsibility for preparation, calibration and operation of the *in situ* nitrate instrument and shipboard nitrate measurements. Overland will be responsible for the completion of the web dissemination system in a timely manner.

Stabeno, Napp, Overland and Whitledge will be jointly responsible for merging the results with output from other sources, analyzing the time series data in conjunction with shipboard hydrographic measurements of physical biological variables and larger scale studies, and for publication of the results. Together, the PIs will be responsible for collaboration with NPRB and interpretation of results, dispersal, outreach and education.

6. Coordination and Collaboration

We welcome continued coordination with other research components. We particularly welcome the addition of other appropriate equipment to the moorings, and other investigators are welcome to coordinate their studies with our mooring systems. We will collaborate with S. Henrichs on her proposal to NPPRB "Sinking Particles and Pelagic Food Webs in the SE Bering Sea: Continued Monitoring Using Sediment Traps". We will share ship time with several Steller Sea Lion Research Programs. Moorings will be deployed as part of a major mooring deployment cruise in the Bering Sea and Aleutian Islands. AFSC and UAF will continue their long-standing collaboration with scientists from the Faculty of Fisheries, Hokkaido University. Our invited participation on their annual summer cruise (T/V Oshoro Maru) to the southeastern Bering Sea has allowed us access to longer time series.

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Research Associate; Oregon State Univ., Corvallis OR, 1985-1987
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Guest Editor on Special Issue for Progress in Oceanography "Variability in the Bering Sea Ecosystem" (2002)
Invited Contributor on the Bering Sea PICES (1997-2002)
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PI or Co-PI on numerous research programs including:

1997-2000: Inner Front Program, NSF, (Hunt et al.)
1995-2001: Monitoring on the Bering Sea Shelf, SEBSCC Coastal Ocean Prog. (Stabeno et al.)
2000-2002: Ecosystems trends of SE Bering Sea, SEBSCC Coastal Ocean Prog. (Schumacher et al.)
2001-present: OAR Steller Sea Lion Research: Investigating Relationships between North Pacific Ocean Climate and Steller Sea Lions (Stabeno et al.)
2002-2003: Biophysical Moorings at Site 2, NPMR (Stabeno and Whitledge)
2001-2005: Shelf Transport, NP GLOBEC (Stabeno et al.)
2001-2005: Modeling the GOA, NP GLOBEC (Haidvogel et al.)

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NOAA/NMFS, Recruitment Processes Program Leader, and Principal Investigator for the Fisheries Oceanography Coordinated Investigations (FOCI), 2001-Present.

NOAA/NMFS, Oceanographer and Principal Investigator for FOCI, 1990-2001.

University of Washington, School of Oceanography, Affiliate Assistant Professor, 1991-Present.

Executive Committee, Bering Sea FOCI. A NOAA Coastal Ocean Program sponsored research partnership between NOAA and Academia, 1993-present

University of Miami, Rosenstiel School of Marine and Atmospheric Science, Research Assistant Professor, 1989-1990.

RECENT PUBLICATIONS

Brodeur, R.D., M.T. Wilson, L. Ciannelli, M. Doyle, and J.M. Napp (2002). Interannual and regional variability in distribution and ecology of juvenile pollock and their prey in frontal structures of the Bering Sea. Deep-Sea Res. II, 49: 6051-6067.

Hunt, G.L., Jr., P. Stabeno, G. Walters, E. Sinclair, R.D. Brodeur, J.M. Napp, and N.A. Bond (2002). Climate change and control of the southeastern Bering Sea pelagic ecosystem. Deep-Sea Res. II, 49: 5821-5853.

Napp, J.M., C.T. Baier, R.D. Brodeur, K.O. Coyle, N. Shiga, and K. Mier (2002). Interannual and decadal variability in zooplankton communities of the southeast Bering Sea shelf. *Deep Sea Res. II*, 49: 5991-6008.

Stabeno, P.J., R.K. Reed, and J.M. Napp (2002). Transport through Unimak Pass, Alaska. Deep-Sea Res. II, 49: 5919-5930.

Weingartner, T.J., K. Coyle, B. Finney, R. Hopcroft, T. Whitledge, R. Brodeur, M. Dagg, E. Farley, D. Haidvogel, L. Haldorson, A. Hermann, S. Hinckley, J. Napp, P. Stabeno, T. Kline, C. Lee, E. Lessard, T. Royer, and S. Strom (2002). The Northeast Pacific GLOBEC Program: Coastal Gulf of Alaska. Oceanography 15:48 - 63.

Hermann, A.J., S. Hinckley, B.A. Megrey, and J.M. Napp (2001). Applied and theoretical considerations for constructing spatially explicit individual-based models of marine larval fish that include multiple trophic levels. ICES J. Mar. Sci., 58: 1030-1041.

Napp, J.M. and G.L. Hunt, Jr. (2001). Anomalous conditions in the southeastern Bering Sea, 1997: Linkages among climate, weather, ocean, and biology. *Fish. Oceanogr.* 10:61-68.

Stockwell, D.A., T.E. Whitledge, S.I. Zeeman, K.O. Coyle, J.M. Napp, R.D. Broduer, and A.I. Pinchuk (2001). Anomalous conditions in the southeastern Bering Sea, 1997: Nutrients, phytoplankton, and zooplankton. *Fish. Oceanogr.* 10:99-116.

OTHER RELEVANT PUBLICATIONS

Napp, J.M., A.W. Kendall, Jr., and J.D. Schumacher (2000). A synthesis of biological and physical processes affecting the feeding environment of larval walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea. *Fish. Oceanogr*., 9:147-162.

Schabetsberger, R., R.D. Brodeur, L. Ciannelli, J.M. Napp, and G.L. Swartzman (2000). Diel vertical migration and interaction of zooplankton and juvenile walleye pollock *(Theragra chalcogramma*) at a frontal region near Pribilof Islands, Bering Sea. *ICES J. Mar. Sci.* 57:1283-1295.

Napp, J.M., K. Mier, and M.K. Cohen (1999). Estimation of larval fish prey volume: Mensuration formulae for copepod nauplii. *J. Plankton Res*., 21:1633-1642.

Stabeno, P.J., J.D. Schumacher, R.F. Davis, and J.M. Napp (1998). Under-ice observations of water column temperature, salinity and spring phytoplankton dynamics: Eastern Bering Sea shelf. J. Mar. Res., 56:239-255.

Sugisaki, H., R. Brodeur, and J. Napp (1998). Summer distribution and abundance of macrozooplankton in the western Gulf of Alaska and southeastern Bering Sea. Mem. Fac. Fish. Hokkaido Univ., XXXXV(1):96-112.

Napp, J.M., L.S. Incze, P.B. Ortner, D.L.W. Siefert, and L. Britt (1996). The plankton of Shelikof Strait, Alaska: standing stock, production, mesoscale variability and their relevance to larval fish survival. Fish. Oceanogr. 5 (Suppl. 1):19-38.

RECENT COLLABORATORS

R. Brodeur	K. Coyle	M. Dagg
M. Flint	C. Greenlaw	D.V. Holliday
G. Hunt, Jr	E. Lessard	W.T. Peterson
R. Schabetsberger	J. Schumacher	P. Stabeno
D. Stockwell	S. Strom	G. Swartzman
T. Whitledge		

James E. Overland
Pacific Marine Environmental Laboratory/NOAA
Seattle, Washington 98115
overland@pmel.noaa.gov
December 2002

ACADEMIC TRAINING:

Ph.D.	New York University, Physical Oceanography and Meteorology, 1973
M.S.	University of Washington, Physical Oceanography, 1971
B.S.	University of Washington, Physical Oceanography, 1970

PROFESSIONAL EXPERIENCE:

1997-present	GS-15 Research Oceanographer, Pacific Marine Environmental Laboratory, NOAA
1991-present	Affiliate Professor, Department of Atmospheric Sciences, University of Washington
1979-1997	GM-15 Division Leader, Coastal and Arctic Research Division, PMEL
1973-76	Physical Scientist, National Meteorological Center, National Weather Service

SELECTED SOCIETIES, COMMITTEES, AWARDS and JOURNAL ACTIVITIES:

NOAA Administrator's Award (Leadership in Arctic Science) 2002
Committee on the Coastal Ocean, National Academy of Sciences, 1990-1996
Panel on Marine Meteorology, National Academy of Sciences 1993-1994
Panel on Coastal Meteorology, National Academy of Sciences, 1990-1991
Editor, *JGR-OCEANS*, 1990-1994
Co-Editor, of six journal special issues

SELECTED JOURNAL PUBLICATIONS:

Overland, J.E., N.A. Bond, and J.M. Adams, 2002: The relation of surface forcing of the Bering Sea to large-scale climate patterns. *Deep-Sea Res. II, 49,* 5855-5868.
Overland, J.E., M. Wang, and N.A. Bond, 2002: Recent temperature changes in the western Arctic during Spring, *J. Climate 15*, 1702-1716.
Overland, J.E., J.M. Adams, 2001: On the temporal character and regionality of the Arctic Oscillation. *Geophys. Res. Lett. 8*, 2811-2814.
Percival, D.B., J.E. Overland, and H.O. Mofjeld, 2001: Interpretation of North Pacific variability as a long-memory process. *J. Climate*, 14, 4545-4559.
Stabeno, P.J. and J.E. Overland, 2001: The Bering Sea shifts toward an earlier spring transition, *EOS, Trans. , AGU, 82*, 317, 321.
Overland, J.E., N.A. Bond and J.M. Adams, 2001: North Pacific atmospheric and SST anomalies in 1997: Links to ENSO. *Fish. Oceanogr.*, 10, 69-80.
Adams, J.M., N.A. Bond, and J.E. Overland, 2000: Regional variability of the Arctic heat budget in fall and winter. *J. Climate, 13,* 3500-3510.
Overland, J.E., J.M. Adams and H.J. Mofjeld, 2000: Chaos in the North Pacific: Spatial modes and temporal irregularity. *Progr. Oceanogr. 47*, 337-354.
Overland, J.E., J.M. Adams and N.A. Bond, 1999: Decadal variability in the Aleutian low and its relation to high latitude circulation. *J. Climate 12*, 1542-1548.
Overland, J.E., S. Salo and J.M. Adams, 1999: Salinity signature of the Pacific Decadal Oscillation. *Geophys. Res. Lett.*, *26,* 1337-1340.
Overland, J.E., S.A. Salo, C.A. Clayton and L.H. Kantha, 1999: Thermal stratification and mixing on the Bering Sea shelf. IN: *Dynamics of the Bering Sea*, PICES, 129-146.
Overland, J.E., J.M. Adams and N.A. Bond, 1997: Regional variation of winter temperatures in the Arctic. *J. Climate, 10*, 821-837.

Overland, J.E., A.H. Oort, and P. Turet, 1996: Regional variations of moist static energy flux into the Arctic. *J. Climate*, 9, 54-65.
Overland, J.E., P.J. Stabeno, and S.A. Salo, 1996: Direct evidence for northward flow on the northwestern Bering Sea Shelf. *J. Geophys. Res.*, *101*, 8971-8976.
Overland, J.E. and N.A. Bond, 1995: Observations and scale analysis of coastal wind jets. *Mon. Weather Rev. 123*, 2934-2941.
Bond, N.A., J.E. Overland, and P. Turet, 1994: Spatial and temporal characteristics of the wind forcing of the Bering Sea. *J. Climate, 7*, 1119-1130.
Overland, J.E., M.C. Spillane, H.E. Hurlburt, and A.J. Wallcraft, 1994: A numerical study of the circulation of the Bering Sea basin and exchange with the North Pacific Ocean. *J. Phys. Oceanogr., 24*, 736-758.
Stabeno, P.J., R.K. Reed, and J.E. Overland, 1994: Lagrangian Measurements in the Kamchatka Current and Oyashio. *J. Oceanogr., 50*, 653-662.
Overland, J.E. and P.S. Guest, 1991: The Arctic snow and air temperature budget over sea ice during winter. *J. Geophys. Res., 96*, 4651-4662.
Overland, J.E., 1990: Prediction of vessel icing at near-freezing sea temperatures. *Weather and Forecasting, 5,* 62-77.
Overland, J.E., and C.H. Pease, 1988: Modeling ice dynamics of coastal seas. *J. Geophys. Res., 93,* 15619-15637.
Overland, J.E., and A.T. Roach, 1987: On northward flow in the Bering and Chukchi Seas. *J. Geophys. Res., 92*, 7097-7105.
Overland, J.E., 1985: Atmospheric boundary layer structure and drag coefficients over sea ice. *J. Geophys. Res., 90*, 9029-9049.
Overland, J.E., H.O. Mofjeld, and C.H. Pease, 1984: Wind-driven ice drift in a shallow sea. *J. Geophys. Res., 89*, 6525-6531.
Overland, J.E., H.O. Mofjeld, and C.H. Pease, 1984: Wind-driven ice drift in a shallow sea. *J. Geophys. Res., 89*, 6525-6531.
Overland, J.E., and J.G. Wilson, 1984: Mesoscale variability in marine winds at mid-latitude. *J. Geophys. Res., 89*, 10599-10614.
Cavalieri, D.J., J.E. Overland, C.H. Pease, R.M. Reynolds, J.D. Schumacher, *et al.,* 1983: MIZEX-West Bering Sea marginal ice zone experiment. *EOS Trans., AGU, 64*, 578-579.
Overland, J.E., R.M. Reynolds, and C.H. Pease, 1983: A model of the atmospheric boundary layer over the marginal ice zone. *J. Geophys. Res., 88*, 2836-2840.
Overland, J.E., and C.H. Pease, 1982: Cyclone climatology of the Bering Sea and its relation to sea ice extent. *Mon. Weather Rev., 110*, 5-13.
Overland, J.E., and R.W. Preisendorfer, 1982: A significance test for principal components applied to a cyclone climatology. *Mon. Weather Rev., 110*, 1-4.
Schumacher, J.D., C.A. Pearson, and J.E. Overland, 1982: On exchange of water between the Gulf of Alaska and Bering Sea through Unimak Pass, Alaska. *J. Geophys. Res., 87*, 5785-5795.
Overland, J.E. and T.R. Hiester, 1980: Development of a synoptic climatology for the northeast Gulf of Alaska. *J. Appl. Meteor., 19*, 1-14.

CURRICULUM VITAE

TERRY E. WHITLEDGE

Education:

Ph.D., Oceanography, University of Washington, 1972
M.S., Chemistry, Western Illinois University, 1966
B.S., Chemistry, Western Illinois University, 1964

Professional Experience:

1998-, Professor, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks
1993-1996, Acting Director, Marine Science Institute, The University of Texas at Austin
1992-1998, Professor, Department of Marine Science, The University of Texas at Austin
1990-1992, Associate Professor, Department of Marine Science, The University of Texas at Austin
1986-1998, Senior Research Scientist, Marine Science Institute, The Univ. of Texas at Austin
1980-1986, Guest Investigator, Woods Hole Oceanographic Institution
1977-1986, Oceanographer, Brookhaven National Laboratory
1975-1977, Associate Oceanographer, Brookhaven National Laboratory
1972-1975, Research Associate, Department of Oceanography, University of Washington

Research Interests:

Automated nutrient chemistry of seawater
Nutrient cycles associated with uptake and regeneration processes in the marine environment
Moored chemical and biological instrument arrays
Interaction of biological populations with the chemical and physical dynamics in marine ecosystems

Other Significant Experience and Awards:

National Science Foundation Arctic Service Award, August 2000
Science Advisory Committee, Submarine Arctic Science Ice Expeditions (SCICEX)
Co-Chair, Steering Committee, OAII/ARCSS Biological Initiative in the Arctic: Western Arctic Shelf-Basin Interactions (SBI)
Fleet Improvement Committee (FIC), University-National Oceanographic Laboratory System (UNOLS), 2000-2003.
Arctic Icebreaker Coordinator Committee (AICC), University-National Oceanographic Laboratory System (UNOLS), 1998-2004
Steering Committee, Ocean-Atmosphere-Ice Interactions, Arctic System Science (ARCSS), National Science Foundation, 1993-1997.
Harmful Algal Blooms in Coastal Waters Assessment Panel: Options for Prevention, Control and Mitigation, National Fish and Wildlife Foundation, 1995-1997.
Bering Sea Working Group, North Pacific Marine Science Organization (PICES) for Canada, Japan, Korea, The Peoples Republic of China, Russia and the United States, (U.S. Department of State), 1992-1996
Program for Long-term Ecological Research of Ecosystems of the Bering and Chukchi Seas and the Pacific Ocean (BERPAC). U.S. Fish and Wildlife Service and USSR Committee for Hydrometeorology and Natural Environment, 1988-1993.

Recent Publications:

Weingartner, T.J., K. Coyle, B. Finney, R. Hopcroft, T.E. Whitledge, R. Brodeur, M. Dagg, E. Farley, D. Haidvogel, L. Haldorson, A. Herman, S. Hinckley, J. Napp, P. Stabeno, T. Kline, C. Lee, E. Lessard, T. Royer and S. Strom. 2002. The Northeast Pacific GLOBEC Program: Coastal Gulf of Alaska. Oceanography. 15:48-63.

Dunton, K.H., B. Hardegree, and T.E. Whitledge. 2001. Response of estuarine marsh vegetation to interannual variations in precipitation. Estuaries 24:851-861.
Stockwell, D.A., T.E. Whitledge, S.I Zeeman, K.O. Coyle, J.M. Napp, R.D. Brodeur, A.I. Pinchuk and G.H. Hunt, Jr. 2001. Anomalous conditions in the southeastern Bering Sea, 1997: nutrients, phytoplankton and zooplankton. Fish. Oceanogr. 10:99-116.
Guay, C.K., G.P. Klinkhammer, K.K. Falkner, R. Benner, P.G. Coble, T.E. Whitledge, B. Black, F.J. Bussell and T.A. Wagner. 1999. High-resolution measurements of dissolved organic carbon in the Arctic Ocean by in-situ fiber optic spectrometry. Geophys. Res. Lett. 26:1007-1010.
Cooper, L.W., G.F. Cota, L.R. Pomeroy, J.M. Grebmeier and T.E. Whitledge.m 1999. Modification of NO, PO and NO/PO during flow across the Bering and Chukchi shelves:Implications for use as Arctic water mass tracers. J. Geophys. Res. 104:7827-7836.
Coachman, L.K., T.E. Whitledge and J.J. Goering. 1999. Silica in Bering Sea deep and bottom water. In: T.R. Loughlin and K. Ohtani (editors), The Bering Sea: Physical, Chemical and Biological Dynamics, Univ. Of Alaska Sea Grant, Fairbanks, Alaska, pp. 285-309.
Whitledge T.E. and V.A. Luchin. 1999. Summary of chemical distributions and dynamics in the Bering Sea. In: T.R. Loughlin and K. Ohtani (editors), The Bering Sea: Physical, Chemical and Biological Dynamics, Univ. Of Alaska Sea Grant, Fairbanks, Alaska, pp. 217-249.

Other Significant Publications:

Walsh, J.J., D.A. Dieterle, F.E. Muller-Karger, K. Aagaard, A.T. Roach, T.E. Whitledge and D.A. Stockwell. 1997. CO_2 cycling in the coastal ocean. II. Seasonal organic loading of the Arctic Ocean from source waters in the Bering Sea. *Cont. Shelf Res.* 17:1-36.
Cooper, L.W., T.E. Whitledge, J.G. Grebmeier and T. Weingartner. 1997. Nutrient, salinity and stable oxygen isotope composition of Bering and Chukchi Sea waters in and near the Bering Strait. J. Geophys. Res. 102: 12563-12574.
Hansell, D.A., T.E. Whitledge and J.J. Goering. 1993. Patterns of nitrate utilization and new production over the Bering/Chukchi Shelf. *Cont. Shelf Res*. 13:601-627.
Whitledge, T.E., R.E. Bidigare, S.I. Zeeman, R.N. Sambrotto, P.F. Roscigno, P.R. Jensen, J.M. Brooks, C. Trees and D.M. Veidt. 1988. Biological measurements and related chemical features in Soviet and U.S. regions of the Bering Sea. *Cont. Shelf Res.* 8:1299-1319.
Whitledge, T.E., W.S. Reeburgh, and J.J. Walsh. 1986. Seasonal inorganic nitrogen distributions and dynamics in the southeastern Bering Sea. *Cont. Shelf Res.* 5:109-132.
Hansell, D.A., J.J. Goering, J.J. Walsh, C.P. McRoy, L.K. Coachman and T.E. Whitledge. 1989. Summer phytoplankton production and transport along the shelf break in the Bering Sea. *Cont. Shelf Res.* 9:1085-1104.
Whitledge, T.E. and C.D. Wirick. 1986. Development of a moored in situ fluorometer for phytoplankton studies. In: Tidal Mixing and Plankton Dynamics, Bowman, Yentsch and Petersen (eds.), Springer-Verlag, pp. 449-462.
Whitledge, T.E. and C.D. Wirick. 1983. Observations of chlorophyll concentrations in Long Island shelf waters using a moored in situ fluorometer. Deep-Sea Res. 30:297-309.

Graduate/Post Doctoral Advisors:

Dr. Richard C. Dugdale, Tiburon / Dr. James C. Kelly, San Francisco State University

Collaborators not listed in publications:

Dr. R. Benner	Dr. S. Okkonen	Dr. J. Schumacher
Dr. W. Maslowski	Dr. T. Royer	Dr. P. Stabeno
Dr. K. Faulkner	Dr. M. Dagg	Dr. S. Hendrichs
Dr. D. Musgrave		

D.V. Holliday

Principal Scientist and Director of Analysis and Applied Research

Applied Technologies, Electronic Systems Division
BAE SYSTEMS

Education: B.S. (1961) & M.A. (1965) in Physics, Univ. of Texas, Austin
Ph.D. (1972) in Applied Physics, Univ. of California, San Diego
Employment: BAE SYSTEMS (formerly Tracor and Marconi) 1962-present.
Address: BAE SYSTEMS, 4669 Murphy Canyon Road, Suite 102, San Diego, CA 92123

Technical Experience and Related Activities

Dr. Holliday is a physicist with formal training and extensive experience in several fields of oceanography. While maintaining an active research program in pure and applied acoustics, e.g., reverberation, ambient noise, propagation and signal processing, he has also used his background to develop new, innovative high technology instrumentation to measure, study and monitor life at several trophic levels in the marine ecosystem. He has pioneered several acoustical methods used internationally to assess and study oceanic plankton, nekton and marine mammals. He has worked in both Arctic and temperate ocean environments.

He maintains an active program of research in ambient noise, small scale ocean physics, and in the development and application of new technology to measurements of oceanic, estuarine and limnological phenomena. In addition to his management responsibilities, he personally participates in sea-going research such as that on thin layers and experiments on the effects of endo- and epibenthic organisms on acoustic properties of sediments. Under his direction, BAE SYSTEMS provides TAPS high frequency zooplankton sensors and the advanced data processing algorithms to allow zooplankton size - biomass data to be integrated into the field research of fisheries and biological oceanographers in North America, the UK, Australia and France.

He is a senior member of the US ICES delegation and has served on the ICES Fisheries Technology Committee and its Fisheries Acoustics Science and Technology (FAST) working group since 1987. He served on the US GLOBEC Scientific Steering Committee for several years and chaired its Technology Subcommittee during the formulation of the GLOBEC plan for acoustical and optical technology. He is a member of ASLO, and serves on the Editorial Board of the new ASLO: Methods journal. He is a charter member of TOS, and is the representative for technology on the TOS Executive Council. He is also a Fellow of the Acoustical Society of America. In the summer of 2002, for his work in bioacoustics and it's impact on naval sysems, the Chief of Naval Research presented Dr. Holliday the third highest honor given to civilians by the DoD, the Meritorious Public Service Award.

Related Publications

"Acoustic applications in fisheries science: the ICES contribution", Fernandes, P.G., Gerlotto, F., Holliday, D.V., Nakken, O. and Simmonds, E.J. ICES J. Mar. Sci. 215: 483-492, 2002.

"Occurrence and mechanisms of formation of a dramatic thin layer of marine snow in a shallow Pacific fjord", .Alldredge, A.L., T.J. Cowles, S. MacIntyre, J.E.B. Rines, P.L. Donaghay, C.F. Greenlaw, D.V. Holliday, M.M. Dekshenieks, J.L. Sullivan and J.R.V. Zaneveld., Mar. Ecol. Prog. Ser. 233: 1-12, 2002.

"Acoustical sensing of biology in the sea", D.V. Holliday, in Acoustical Oceanography, T.G. Leighton, G.J. Heald, H.D. Griffiths and G. Griffiths, eds., Proc. Institute of Acoustics (UK) 23(2): 172-180, 2001.

"Multifrequency acoustical volume backscattering patterns in the Arabian Sea - 265 kHz to 3 MHz", D.E. McGehee, C.F. Greenlaw, D.V. Holliday and R.E. Pieper. J. Acoust. Soc. Am. 107: 193 - 200, 2000.

"Acoustical Sensing of Small Scale Vertical Structures in Zooplankton Assemblages", Holliday, D.V., R.E. Pieper, C.F. Greenlaw and J.K. Dawson. Oceanography 11(1): 18-23, 1998.

"Fisheries and Plankton Acoustics: Past, Present and Future", D.N. MacLennan and D.V. Holliday, ICES J. mar. Sci. 53: 513-516, 1996.

"Bioacoustical oceanography at high frequencies", D.V. Holliday and R.E. Pieper, ICES Journal of Marine Science 53: 279-296, 1995.

Recent and Current Collaborators

W. Au (UHI); A. Alldredge (UCSB); C. Barans (SC, W&F); M. Berman (NMFS); D. Bibee (NRL, Stennis); K Bird (UHI); W. Boicourt (UMD); S. Brandt (NOAA); K. Briggs (NRL, Stennis); M. Buckingam (UCSD); N. Chotiros (ARL/UT); K. Commander (CSS Panama City); T. Cowles (OSU); K. Coyle (UAK); J. Dawson (USC); M. Deksheniks (URI); P. Donaghay (URI); G. Fogel (CEEC); J. Green (NMFS); G. Heald (DERA/UK); E. Houde (UMD); D. Houser (Sonoma State); D. Jackson (UW); J. Jaffe (UCSD); P. Jumars (UME); K. Kringel (UW); S. Kuczaj (USM); A. Lebourges (ORSTOM); T. Leighton (U. of Southampton);.E. Levine (USN/NUWC); J. Lopes (CSS Panama City); S. MacIntyre (UCSB); D. MacLennan (U. Aberdeen); R. Mitson (Acoustec); J. Napp (NMFS); T. Osborn (JHU); M. J. Perry (UW); R. Pieper (USC); M. Richardson (NRL, Stennis); J. Rines (URI); A. Robinson (Harvard); M. Roman (UMD); B. Rothschild (UMass); G.Schwartzman (UW); K. Sherman (NMFS); P. Stabeno (PMEL); B. Stender (SC, W&F); D.J. Tang; (UW); E. Thorsos (UW); K. Williams (UW); R. Wheatcroft (OSU); R. Zanefeld (OSU).

Graduate Advisors

MA: U. of Texas at Austin, W. Millett; PhD Supervisor: UC San Diego, V.C. Anderson

Graduate Students Advised

Carol Burkhart, Nova U; David Demer, UC San Diego; Christen Herren, UC Santa Barbara; Denise McKelvey, U. of Washington.

7. Possible Peer Reviewers

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PMEL Budget:

An itemized break down of costs are given. Personnel costs for Phyllis Stabeno and Jim Overland are provided at no cost to this program. Support is for participation in the cruises, mooring preparation and deployment, data analysis, computer and graphics costs. Costs of mooring preparation and deployments are itemized. NOAA/PMEL equipment (releases, floats, ADP and MTRs), valued at ~$270,000 per year, will be used on the moorings. Truck and forklift rentals are for ship loading in Dutch Harbor (the probable port of embarkation), and are necessary for cruises on which deployment and recovery of the moorings will occur. Funds are requested to cover computer maintenance, software upgrades, connections charges, graphics (for publications and presentations), for the maintenance of web page presenting results from moorings and supplies.

Salaries for field operations personnel are to prepare equipment, cut moorings lines, and participate in cruises. Salary for the information system is for a programmer to modify the TOGA/TAO scripts to applicable for the Bering Sea data sets and for placing data, figures and other information on a web site for other researchers. Salary for processing are for the mooring instruments, and CTDs.

Travel is requested for four round trips to Dutch Harbor. Round-trip airfare for one person is estimated at $2000, and per diem costs and ground transportation at $250. Cost of six additional round trips for mooring deployment/recovery will be covered from other funded research.

AFSC Budget:

Personnel: We only request funds to cover overtime for two technicians for 45 sea days. As matching, NOAA will contribute one month salary each of J. Napp (Principal Investigator) and Colleen Harpold (Oceanographer). We will also contribute the base pay and benefits for the 2 technicians while at sea.

Supplies: We request all necessary expendable supplies to collect and process the zooplankton and chlorophyll samples collected each year. This includes bottles, preservatives, sample labels, filters, acetone, etc.

Capital Equipment: We request funds in the first year to buy backup net frames as our research group often stages more than one cruise at a time and it is necessary to have backup equipment on all vessels. We will contribute as matching all other collection equipment from our pool that is used on these cruises.

Travel: We request 4 round trips @ $2,000 each for cruise participants. Dr. Stabeno will represent the project at PI meetings and has included funds for travel to these meetings.

Contracts: We request funds to contract with BAE Systems for collaboration on the zooplankton acoustics portion of this project (see attached letter). They will build, test, and calibrate a TAPS-8 during Years ! & II. Delivery will occur at the end of Year II and deployment of the instrument will occur in September of Year III. Several deployment, recovery, calibration cycles will occur in Year III. The instrument could be built in the first year and deployed in Years II & III, if additional funding were available. We will contribute as matching the zooplankton verification contract that pays to spot check the samples processed by the Polish Plankton Sorting and Identification Center.

Other Costs: Grants -- We request funds to process the samples at the Polish Plankton Sorting and Identification Center in Szczecin, Poland (Yr. I - $10,000; Yr. II - $11,000; Yr. III - $12,000). The Center does excellent work and returns both the sample sort and a digital record of the results. NOAA/NMFS has been using this Center for 29 years. We will contribute, as matching, the costs of maintaining the Grant, including, but not limited to, the cost of attending the annual Advisory Committee meeting.

Other Costs (Shipping) -- We request funds to ship samples (by surface) to and from Poland (Yr. I - $500; Yr. II - $1,000; Yr. III - $1,000).

Other Costs (Publications) -- In Year III, we request funds ($2,000) to prepare our research results for distribution. These charges include, but are not limited to, costs of laminating posters, journal color plate charges, and reprint charges.

Other Costs (Education and Outreach) -- The lead Principal Investigator, Dr. P. Stabeno, will be in charge of education and outreach. She has included funds in her budget to cover these costs.

Other Costs (Indirect Costs) -- We are required to recover NOAA, NMFS, and AFSC Management Fund fees and GSA rent from extramurally funded salaries. The current rate is 50.01% of requested base salary. We (AFSC) will contribute funds to pay for these expenses on all matching salary.

***UAF Budget**:*

Two months of a technician (S. Thornton) salary is requested ($3999) and in addition $1500 for sea time. Two round trip tickets from Fairbanks to Dutch Harbor with per diem are requested at $1350. In addition $300 is requested to attend the NPRB Anchorage PI meeting. Supplies include chemicals, sampling bottles, tubing, etc. necessary to conduct the field operations. We request $3000 for maintenance and prep of the moored nitrate meter and $500 for education and interpretation conducted with NPRB. This includes placing data on a web page.