NOAA FORM 56-48
(10-85)
PRES. BY NDM 06-18

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
OFFICE OF AIRCRAFT OPERATIONS

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Date Received	**REQUEST FOR OAO AIRCRAFT SUPPORT**	Program Manager

PART I - ORGANIZATIONAL DATA

INVESTIGATION TITLE

Coastal Alaska Marine Processes (CAMP)

PRINCIPAL INVESTIGATOR (Name, Organization, Agency/Code, Address, Telephone)	FUNDING AGENCY/SPONSOR (Name, Organization, Agency/Code, Address, Telephone)
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ABSTRACT OF PROPOSAL A NOAA WP-3D is requested to document marine atmospheric boundary layer (MABL) and upper ocean structures in coastal Alaska during Spring 2003. The results will constitute an important element of two major interdisciplinary programs examining how climate variability influences Steller sea lions in the Aleutians and salmon in the Gulf of Alaska.

PART II - REQUIREMENTS SUMMARY

BRIEF SUMMARY OF OBSERVATION SITES, FLIGHT DATES, TYPE AND NUMBER OF AIRCRAFT AND TOTAL FLIGHT HOURS.

There are two regions of interest: offshore of the Kenai Peninsula in the northern Gulf of Alaska and in the vicinity of the far eastern Aleutian Islands. Flight dates: a 4-week IOP during May 2003. One NOAA WP-3D is required for 95 research flight hours, from a base in Anchorage, Alaska, plus 24 ferry hours for a total of 119 hours.

PART III - RATIONALE FOR USE OF NOAA FACILITIES (NON-NOAA INVESTIGATORS)

STATE REASON FOR REQUESTING NOAA SUPPORT VS. CONTRACTING WITH PRIVATE INDUSTRY

Direct observations of the physical environment are required to better understand relationships of local atmospheric forcing to mesoscale ocean structure and primary productivity in the study area. The proposed program relates to NOAA's missions of Building Sustainable Fisheries and Recovering Protected Species.

PART IV - BACKGROUND AND OBJECTIVES

PROGRAM OBJECTIVES (Briefly describe the background and overall goals of the program that this flight request supports.)

This request addresses crucial elements of the Steller Sea Lion program in the eastern Aleutian Islands and the Global Ocean Ecosystems Dynamics (GLOBEC) program in the coastal Gulf of Alaska. These programs seek to better understand linkages between climate variability and the local atmosphere-ocean system, and ultimately the marine ecosystem. The specific goals of this project are to document MABL structures and processes and their impacts on the upper ocean, and subsequent effects on phytoplankton distributions.

RATIONALE FOR AIRCRAFT SUPPORT (Briefly summarize aircraft performance requirements. Specify role of aircraft in this investigation.)

A NOAA P-3 is the only platform available with the necessary duration and measurement capability to collect the required suite of atmospheric and oceanographic observations on a synoptic basis. The aircraft observations will be complemented by measurements from research ships and moored buoys.

PART V - SENSOR AND DATA REQUIREMENTS

OBSERVATIONS (Describe the characteristics of the physical features to be observed and the phenomena to be measured.)

The focus is on lower atmosphere and upper ocean properties offshore of the Kenai Peninsula, and near the far eastern islands of the Aleutians. The phenomena of interest are coastal MABL structures, surface heat and momentum fluxes, and upper ocean temperature, salinity and phytoplankton concentration (color).

SENSORS

STANDARD INSTRUMENTATION PACKAGE. The Standard Instrumentation Package as listed is routinely provided for all flights. Raw data are recorded at a once-per-second rate with most parameters being an average of 40 samples per second. NOTE: If higher data rates are required, the user is expected to provide or reimburse the cost of the additional data tapes used as well as other associated costs including hardware and software reconfigurations, special data processing, formatting, etc.

CHECK WHICH SENSORS/PARAMETERS ARE ESSENTIAL

- ☑ Time (GMT)
- ☑ Position (LAT/LON)
- ☑ Ground Speed
- ☑ Pitch
- ☑ Roll
- ☑ Heading
- ☑ Radar Altitude
- ☑ JW Water Content
- ☑ Dynamic Pressure
- ☑ Attack Pressure
- ☑ Slip Pressure
- ☑ Static Pressure
- ☑ Total Temperature
- ☑ Dew/Frost Point Temperature
- ☑ PRT-5 Surface Temp
- ☑ PRT-5 Side Temp (CO2)

CHECK WHICH DERIVED (COMPUTED) PARAMETERS ARE ESSENTIAL

- ☑ Attack Angle
- ☑ Slip Angle
- ☑ Pressure Altitude
- ☑ Geopotential Alt
- ☑ D-Value
- ☑ Vert Airspeed
- ☑ Vert Acceleration
- ☑ Vert Groundspeed
- ☑ Vert Wind
- ☑ Track Angle
- ☑ Drift Angle
- ☑ True Airspeed
- ☑ Horiz Wind
- ☑ True Temp
- ☑ Potential Temp
- ☑ Equiv Potential Temp
- ☑ Surface Pressure
- ☑ Std Surface Height
- ☑ Vapor Pressure
- ☑ Relative Humidity

CHECK IF A HIGH DATA RATE REQUIRED ☑ If so, underscore specific parameters desired for fast recording on the list above.

List other special recording or configuration requirements for the Standard Instrumentation Package. NOTE: The constraints of the system timing and the data tape volume will limit the total number of parameters available as well as the duration of the continuous high-speed recording time.

Fast data recorded as in TOGA/COARE

OPTIONAL AVAILABLE INSTRUMENTATION - In addition to the Standard Instrumentation Package, a number of other instruments and systems are available for use on the aircraft. As some of the systems are mutually exclusive due to space and weight limitations, certain combinations may not be feasible. Certain system configurations may also displace people and/or fuel. The user must, therefore, exercise care in specifying the requirements and selectively differentiate between the essential and the nice-to-have systems.

System reconfigurations after a program has started are discouraged. NOTE: If changes are essential, the user is expected to bear all costs, including labor and materials. Field installations and reconfigurations are normally not permitted due to engineering and safety considerations.

CHECK THE OPTIONAL INSTRUMENTATION/SYSTEM REQUIRED

METEOROLOGICAL RADAR SYSTEMS
NOTE: User is expected to provide and/or pay cost of tape used. Data processing is responsibility of user.

☐ Lower Fuselage C-Band Radar
(requires complete radar data system)
360 degree horizontal PPI
4 RPM continuous scan
200 nm range
(normally every other scan digitally recorded on dedicated Mag tape)

☑ Tail X-Band Radar
(requires complete radar data system)
360 degree vertical RHI
8 RPM continuous scan
50 nm range
(normally every other scan digitally recorded on same tape as above)

☑ Doppler Radial Velocity
(requires tail radar system listed above)
developmental pulse-pair processor system
available on one aircraft only
requires independent data system
data stored on different tape medium other than above

CHECK THE OPTIONAL INSTRUMENTATION/SYSTEMS REQUIRED (Continued)

16 mm TIME-LAPSE PHOTOGRAPHY
(0.5, 1, 2, and 5 frame/sec)
NOTE: Film types and quantities are limited. User is expected to pay all associated costs of materials and processing

- [x] Forward looking
- [ ] Left/Right Side Looking
- [x] Downward Looking (N43RF only)

SOLAR/SKY RADIATION

- [x] Up-looking Package (contains 3 Epply pyranometers and 1 Epply Pyrgeometer)
- [x] Down-looking Package (same as up-looking)
- [ ] Up-looking PRT-5 IR Radiometer (same as sea-surface temp unit)

DATA TRANSMISSIONS (Aircraft-Satellite Data Link-ASDL)

- [ ] Flight Level Data in Fixed Format (Time, Lat, Long, Pressure Alt, D-Value, Wind Direction/Speed, Temperature, Dew Point)
- [ ] Fixed Format Reconnaissance/Vortex Reports
- [ ] Variable Format Free Text
- [ ] Single Sweep Radar Image (requires full radar data system)

PROFILES
NOTE: The supply of sondes and other expendables are the responsibility of the user.

- [ ] Omega Dropsonde Windfinding System, ODW, (provides temperature, humidity, pressure and wind profiles from flight level to surface)
- [x] Aircraft Expendable Bathythermography-AXBT (provides temperature profiles from ocean surface to maximum depth of instrument)

CLOUD PHYSICS-Only 3 of the 4 PMS probes are available on an aircraft. Requires independent stand-alone data system.

- [x] PMS OAP 2D-P (200-6400 micron size range)
- [x] PMS OAP 2D-C (50-1600 micron with ice-phase discriminator)
- [x] PMS FSSP-100 (1-15, 2-30, or 3-45 micron)
- [ ] PMS ASASP-100X (0.12-3.12 micron)
- [ ] Rosemount Ice-Rate Detector
- [ ] Liquid Water Content (Development Nimbiometer. One aircraft only.)

LIST OTHER SPECIAL HARDWARE OR SOFTWARE REQUIREMENTS FOR OPTIONAL SENSORS AND INSTRUMENTATION.

1. Airborne Expendable Conductivity-Temperature-Depth (AXCTD) system.

The color sensor unit requires synchronous time/position information from the onboard instrumentation package.

USER SUPPLIED INSTRUMENTATION - OAO will assist users in the installation and integration of special purpose systems on the aircraft. The equipment must, however, conform to various engineering and airworthiness standards. Early definition of the system is strongly encouraged to ensure a timely installation. Systems and instrumentation will not be considered for installations without proper documentation.

CHECK IF USER SUPPLIED INSTRUMENTATION IS REQUIRED ☐ If so, list instrument(s) and provide mechanical and electrical particulars (i.e., size, weight, locations, power requirements, interfacing specifications, etc.).

I. Satlantic SeaWIFS Aircraft Simulator (SAS-II) radiometer as installed by Dalhousie University for Bering Sea FOCI in spring 1996 on NOAA-43. This instrumentation consists of the following components:

1) An upwelling radiance sensor that has mounting hardware compatible with the depth charge port on the wing.
2) One downwelling irradiance sensor mounted in a top port.
3) Approximately 10" of rack space.

NOTE: User is expected to bear all costs associated with any special installation efforts. All details MUST be supplied at time of program request. If aircraft structural modifications are required, all hardware must be at OAO 120 days prior to the program start date. Otherwise, hardware must be available and ready for installation, no later than 30 days prior to start date.

DATA (Specify data formats desired, housekeeping data requirements, sensor operation requirements, look angles, data processing requirements, etc.)

Standard AOC tapes of one second data are required. Radar data (tail-Doppler) and PMS probe data recorded in conventional manner. The onboard radiation instrumentation (the Epply radiometers and PRT-5's) are particularly important, and require calibration for sea surface temperatures ranging from 4 - 10 deg. C.

PART VI - LOCATION AND FLIGHT SCHEDULE

GEOGRAPHIC LOCATION (Attach map(s) showing flight requirements, or indicate regions of interest, key features, priorities, etc., and/or use PART VII worksheet to specify flight lines).

Mesoscale surveys in generally two different locations: in the Gulf of Alaska just offshore of the Kenai Peninsula, and in the vicinity of Unimak and Unalaska Islands (near 54 deg. N, 165 deg. W). A map of the study areas, and a sample flight track are included in an appendix to this request.

SCHEDULE (Indicate desired flight dates and tolerance for the program.)

Eleven (11) flights of approximately 9 hours duration between about 1 May and 27 May 2003. The exact dates are subject to change based on ship schedules. The period of the experiment cannot be changed more than a week, since it is tied to the "spring bloom" in the ocean.

CONSTRAINTS (Specify desired weather conditions, cloud cover, sea-state, sun angle, tidal cycles, ground conditions, maximum and minimum altitude, etc., for each flight.)

There is interest in both relatively windy (the region rarely experiences strong storms during May) and benign conditions. In general, conditions with low (IFR) ceilings will be avoided. Flights will generally consist of a ferry at altitude (~10-20K') to one of the two study areas, lawnmower patterns below cloud base (with some short vertical stacks) in the study area, and a return ferry at altitude. The flight time available on-station will typically be 6 hours offshore of Prince William Sound and 5 hours in the vicinity of Unimak and Unalaska Islands. The flights will almost always be scheduled for the daytime in order to collect ocean color measurements, but one or two nighttime flights may be tasked. To maximize the time on-station for the Aleutian Island work, we request the option of using Cold Bay or Dutch Harbor, AK as an overnight stopover between back-to-back flights.

PART VII - FLIGHT REQUIREMENTS WORKSHEET

(Complete a separate worksheet for each operational location.)

OBSERVATION SITE

FLIGHT DATE AND TOLERANCE

MEAN ALTITUDE ABOVE SEA LEVEL

DATE __________ ± __________ DAYS

FLIGHT NUMBER	FLIGHT ALTITUDE	FLIGHT LENGTH IN NAUTICAL MILES	TAKE OFF TIME OF DAY (LOCAL)	FLIGHT LINES (LAT. & LONG.)		REQUIRED SENSORS
				START	TURN POINT/ END	

COMMENTS:

Coastal Alaska Marine Processes (CAMP)

ABSTRACT

The objective of the proposed fieldwork is to examine how coastal processes modulate the effects of climate variability on marine ecosystems in coastal Alaska. This linkage involves three distinct stages: (1) the manifestation of climate-scale fluctuations in the coastal zone, (2) the influence of local atmospheric forcing on the coastal ocean, and (3) the impact of mesoscale ocean structures on primary productivity. Each of these aspects can be effectively addressed in a field program using a NOAA P-3 research aircraft, supplemented by shipboard and buoy measurements. This field activity has been designed as an element of two major, ongoing programs in coastal Alaska, the research program seeking to understand the decline in western populations of Steller sea lions, and the Global Ocean Ecosystem Dynamics Program (GLOBEC) in the Gulf of Alaska.

BACKGROUND

During the past several decades, changes have occurred in many components of the North Pacific Ocean/Bering Sea ecosystem. Hare and Mantua (2000) show that many of these are related to long-term climate variability, notably the Pacific Decadal Oscillation (PDO). The PDO is the first mode of the decadal variability of sea surface temperature in the North Pacific and is closely related to sea-level pressure (SLP), notably the strength of the Aleutian Low. In 1976, the PDO underwent a marked change from a negative to a positive state that persisted until 1998. This period of positive PDO included decline of Steller sea lion populations and prosperity for Gulf of Alaska salmon. It is unknown whether the change in the PDO that occurred in 1998 is a result of short-term variability or a long-term trend, nor is it possible to anticipate trends in sea lion or salmon abundance.

The Decline of the Steller Sea Lion

Steller sea lion populations have dropped precipitously since the 1970s in a region extending from Kodiak Island along the Alaskan Peninsula to the Aleutian Island arc. A variety of hypotheses have been formulated to explain this decline. One group of hypotheses focuses on the decline and/or change in the distribution of prey for sea lions. One example of these, the “junk food hypothesis”, states that the decline of Steller sea lions is due to their inability to find food of adequate nutritional value. A different hypothesis suggests that changes in large-scale climate can modify ecosystems and species they support. This is called the “climate change hypothesis”. This matter is of considerable urgency since this stock of Steller sea lions is now listed as an endangered species.

In general, the relative importance of climatic to anthropogenic effects on sea lion populations are unknown. A series of investigations began in 2001 to examine the impact of climate forcing on food webs and ultimately, the western stock of Steller sea lions. Because commercial fisheries may act as competitors for a significant fraction of the Steller sea lions' dietary requirements, management actions have been taken to mitigate the effects of the fisheries. These actions have had a severe impact on the commercial groundfish fishery. The role that natural variations in the ecosystem have on the Steller population, however, is not known, nor are the mechanisms by which changes in climate affect the ecosystem. In order to make knowledgeable management decisions regarding commercial fisheries, endangered species and resource conservation, there must be better understanding of how climate variations affect the whole ecosystem.

The Variability in Gulf of Alaska Salmon

The variability in Alaska salmon mortality is greatest at the juvenile stage. The ability of the shelf to provide sufficient forage fish for juvenile salmon appears to be marginal (Cooney 1985); salmon at this stage are therefore liable to respond to even modest changes in along-shelf transports and cross-shelf exchanges. The factors controlling these aspects of the flow in the coastal region are not well understood, but there are strong indications they are related to climate.

There is a remarkable correlation between Alaskan salmon stocks and North Pacific climate fluctuations. It is interesting that while the changes in parameters such as wind speed, sea-surface temperature (SST) and mixed layer depth are significant, they are not particularly large. Many fish stocks appear well-adapted to interannual variability, but sensitive to modest climate shifts on decadal scales (e.g., Hare and Mantua 2000). The regime concept is important in fisheries management because natural shifts in abundance can be large and sudden, and difficult to isolate from fishing effects (Beamish et al. 1999). Conceptual and numerical models are being employed increasingly for fisheries management; these models for Gulf of Alaska salmon are limited by our lack of knowledge of the processes through which physical and biological elements of the system are linked.

PROJECT RATIONALE

The operating hypothesis and central theme of the research programs to which this aircraft request is related are that changes in the basin-scale North Pacific climate have impacted the local biophysical environment. Pathways from climate change to marine biota have only been conceptualized; the exact mechanisms by which these pathways function in the North Pacific, Gulf of Alaska and Bering Sea are not well known.

Biophysical measurements are critical in order to monitor and develop an understanding of the connections between climate and the ocean ecosystem. The fluctuations in forcing provided by climate change is manifested on a basin scale throughout the North Pacific/Bering Sea and is also realized on both regional and local spatial scales. The regional studies are focusing on the subarctic gyre of the North Pacific, specifically the Alaskan Stream, a western boundary current along the shelf break of the southern Alaska coast. Early results indicate that the strength and position of the Stream influence onshelf fluxes that provide nutrient rich water to shelf communities. Local studies are investigating mechanisms in the coastal ecosystems that support sea lion rookeries (in the Aleutians) or juvenile salmon (in the Gulf of Alaska), and to determine how these mechanisms are perturbed by climate shifts. Figure 1 shows a map of the two study areas. To complement and augment the observational studies, modeling and retrospective analyses are being conducted to examine and relate historical ocean data to large-scale atmospheric forcing and to provide a more comprehensive spatial description of physical features.

This request for NOAA P-3 support relates directly to the local studies currently underway. Specific questions of interest, but which would be much more completely investigated with the aircraft as an observational platform, are itemized below.

1. Is there a systematic, predictable response in the mesoscale coastal weather to the large-scale atmospheric circulation?
2. Are the principal sources of errors in mesoscale numerical weather prediction (NWP) models in the coastal zone more related to specification of the large-scale flow or parameterization of sub-grid scale processes?
3. How much does the coastal ocean respond to basin-scale versus local forcing by the atmosphere?
4. Are vertical circulations in the coastal region (which are crucial for supplying nutrients to the euphotic zone) predominately due to local winds or to hydrodynamical effects internal to the ocean?
5. How does primary productivity in the coastal zone relate to horizontal and vertical advections?
6. What are the time scales of coupling between nutrient supply, primary production and cropping by zooplankton?

This list is not exhaustive in terms of the scope of the overall research program, but does represent the types of issues amenable to inquiry using P-3 observations as a primary resource. The great benefit of the P-3 towards these problems is its ability to collect a suite of meteorological and oceanographic observations over mesoscale domains in a short amount of time.

APPROACH

The measurements to be collected by the P-3 are of three basic types, as outlined below. Previous field campaigns using P-3 aircraft have been used in planning, and demonstrate the feasibility of the proposed work.

Coastal Meteorology

The first step in evaluation of the effects of climate variability on the coastal marine ecosystem of Alaska involves determining how the coastal weather relates to the large-scale properties of the atmospheric flow. The mesoscale effects of coastal terrain and land-sea contrasts has studied using research aircraft, as in the COAST project (Bond et al. 1997). But there remain outstanding issues associated with these effects related to the marine atmospheric boundary layer (MABL) structure.   The MABL acts as mediator of coastal effects in their expression on local air-sea interactions. In general, we have incomplete documentation of the response of the MABL to the large-scale flow in both strongly forced, e.g., during the passage of storms, and in relatively quiet weather conditions. Both kinds of situations occur during springtime in Alaska. Progress here requires detailed observations of mean and turbulent MABL structures and processes to evaluate current conceptual and numerical models.

A NOAA P-3 is well-suited to collect the necessary measurements. It would be tasked to fly lawnmower patterns, interspersed with vertical stacks or porpoise-type maneuvers, to map out the horizontal and vertical distributions of mean and turbulent properties in selected locations. Properties of particular interest are the basic state meteorological parameters of temperature, humidity, and wind, the turbulent fluxes of momentum, heat and moisture, the shortwave and longwave radiative fluxes, and cloud coverage and droplet concentrations. There are liable to be periods of widespread precipitation in which Doppler radar observations of radar reflectivity and winds would be available and useful, but for the most part, it is expected that the primary measurements will be the suite of flight-level observations collected from a P-3 in its standard configuration. Previous flight experiments at high-latitudes have had problems collecting accurate turbulent wind measurements because of icing of the radome; that is not expected to be a problem because the MABL in the study area in May is considerably warmer than freezing.

Coastal Oceanography and Air-Sea Interaction

One of the long-standing problems in coastal oceanography relates to the difficulty of collecting mesoscale observations of the ocean in sufficiently short periods of time. In general, it is difficult to isolate the effects of horizontal advection of mesoscale variability (notably in association with eddies embedded in the flow) from variability that is locally generated. Regarding local generation, it is often unclear how much can be attributed to intrinsic oceanographic processes (e.g., shear instabilities, bathymetric effects, tidal mixing) versus air-sea interactions (e.g., wind mixing, Ekman pumping, and surface heat fluxes). There are mesoscale numerical ocean models that have been developed for coastal applications (e.g., Hermann and Stabeno 1996), but relatively scant observations of a synoptic nature have been collected for evaluating their performance. Mesoscale surveys from ships are hampered by their inability to provide adequate coverage of the region of interest. The expense of moorings tends to limit the numbers to which they can be deployed.

Research aircraft such as the NOAA P-3 have shown their capability for upper ocean sampling, notably in the hurricane environment (e.g., Shay et al. 1998) but also for the just completed EPIC project. While the suite of possible oceanographic measurements from aircraft is limited, the speed of an aircraft, and the complementary meteorological measurements that can be made, make it an attractive observational platform. The physical oceanographic measurements planned for CAMP include SST from a downward-looking PRT-5, upper ocean temperature and salinity from AXBTs and AXCTDs for determining mixed layer structure, and as mentioned above, the near surface turbulent fluxes of heat and momentum. The regions of interest from the meteorological and oceanographic perspectives are coincident.

Ocean Color

Ocean color measurements have been made from aircraft, in particular a NOAA P-3, but most in the aircraft community are probably unfamiliar with this application. Because of this unfamiliarity, the proposed ocean color measurement component is discussed in some detail below. In brief, this component builds upon the study carried out in spring 1996 over the Bering Sea shelf using a NOAA P-3. The ocean color measurements are a crucial element of CAMP because they will show how the base of the food chain is responding to the physical state of the coastal system, as will be documented in the other two components. While ocean color can in principle be determined by satellite, good imaging of the coast in Alaska in spring is rare because of the persistent cloud cover. The aircraft generally can avoid this problem by flying below cloud base.

The primary instrument aboard the P-3 for measuring ocean color will be a Satlantic SeaWiFS Aircraft Simulator (SAS-II) radiometer. It measures downwelling irradiance and upwelling radiance in wavebands of the SeaWiFS satellite sensor. Data collection is during level flight at altitudes below cloud base. Periodically, data will be collected on the same track at three altitudes (e.g., 100, 300, and 600 m) to discern the atmospheric contribution to the observed spectra. Corrections for atmospheric contamination and sea-surface glitter will applied to estimate water-leaving radiance (Lazin et al. 1997). Then bio-optical algorithms will be applied to estimate surface chlorophyll a (Chl) and diffuse attenuation coefficients for visible irradiance. These algorithms will be based on existing data collected by J. Cullen and colleagues in the Bering Sea in 1996 and 1997, supplemented by sea-truth data collected aboard ship(s) during the study period. Upwelling radiance and downwelling solar irradiance will be measured in situ with a Tethered Spectral Radiometry Buoy (TSRB) outfitted to match the SAS II and the SeaWiFS satellite (Cullen et al. 1997). The attenuation of downwelling spectral irradiance will be measured with a Satlantic 13-channel profiling spectroradiometer. Chlorophyll concentration and the absorbance of particulate and dissolved organic material will be measured on surface samples collected during deployment of the TSRB. These in situ data will be used to refine bio-optical algorithms for chlorophyll and attenuation as functions of ocean color. Information on productivity per unit chlorophyll as a function of irradiance, maps of surface chlorophyll, and measurements of irradiance will be used to construct maps of primary production from aircraft and satellite-sensed ocean color. A full spectral model will be applied (Neale et al. 1997; without the UV component) and compared to one or more general chlorophyll-light models (e.g., Platt and Sathyendranath 1993; Behrenfeld and Falkowski 1997). The aircraft measurements and regional bio-optical algorithms will be complemented by satellite estimates of ocean color from SeaWIFS, and the data from moorings.

Preliminary results from a pilot field program in spring 1996 involving a NOAA P-3 research aircraft illustrate some of the issues regarding primary production in Alaskan waters. The aircraft observed a large (~100 by 200 km) patch of very green water over the Bering Sea shelf; estimated chlorophyll concentrations within this patch were at least three times greater than in surrounding waters. Most remarkable were the intense gradients along its northern and eastern boundaries where much of the change in color occurred over a horizontal scale of a kilometer or less. There were some moored buoy observations of physical and biological properties in the vicinity of the patch, and some thermal profiles from AXBT's deployed by the aircraft, in addition to the color mapping. But the mechanism(s) that formed the patch, and the processes that maintained the intense gradients at its edge against diffusion, are unknown. Patches of enhanced chlorophyll concentrations are also common in the areas of interest due to the high eddy activity (Thompson and Gower 1998) causing localized transport and/or isolation of enhanced concentrations of nutrients. The occurrence of eddies varies on intraseasonal to interannual time scales. It is unknown whether eddies are required for sustained production, or whether they merely redistribute the production engendered at regions of enhanced nutrient concentrations, such as at the shelf break. High-quality synoptic maps of phytoplankton distributions and the upper ocean flow can help resolve this question.

Our fieldwork will build upon the pilot study in 1996. The basic instrumentation has already been built and adapted for use aboard a P-3; it operated very reliably during 1996. The results from 1996 indicate that relatively closely-spaced legs, i.e., ~15-20 km apart, are required to resolve the features of interest. Relatively small-scale surveys are feasible because of the focus on particular areas, specifically in the northern Gulf of Alaska south of the Kenai Peninsula, and in the vicinity of the far eastern Aleutian Islands near the western end of the Alaska peninsula. These regions are also where the mesoscale meteorological and oceanographic surveys will be conducted. Therefore, a single type of survey (the lawnmower pattern) is suitable for all three of kinds of studies envisioned. A sample flight track for the Gulf of Alaska work is shown in Fig. 2.

EXPECTED RESULTS

A NOAA P-3 is capable of collecting mesoscale meteorology and oceanography observations in concert with ocean color estimates in key regions of the marine ecosystem of coastal Alaska. Analysis of these data sets will help illuminate the dominant physical mechanisms forcing the upper ocean and ultimately primary production, thereby providing guidance for development of ecosystem models for these regions. It bears emphasizing that the knowledge and insights gained will not just be specific to coastal Alaska, but will also be broadly applicable to other high-latitude and shelf-break ocean ecosystems.

It bears emphasizing that CAMP is a component of two programs involving climate variability; the specific contributions that CAMP will make towards these programs are itemized below. First, large-scale fluctuations in the climate are actually manifested substantially and in some cases primarily on the ocean in their effects on the forcing in the coastal zone. Accurate diagnosis of this forcing therefore requires proper account of local influences (e.g., coastal orography) on the large-scale flow. Considerable progress has been made on this issue, but site-specific documentation of these influences will be made by CAMP. These results will be used to determine a reliable and practical configuration for a high-resolution NWP model (the MM5) for the region. The MM5 will then be run for long integrations, using the NCEP/NCAR Reanalysis for boundary conditions. The results of these simulations will provide a high-quality synthetic data set for retrospective analysis of past climate variability and forcing a coastal oceanographic model. The second step in the linkage between climate forcing and ecosystem response relates to the response of the coastal ocean to coastal forcing. Progress in this area has been hampered by the difficulty of collecting synoptic meteorological and oceanographic observations. We simply do not know how much mesoscale ocean variability in the coastal region of Alaska relates to mesoscale variability in forcing versus intrinsic oceanographic processes (e.g., flow instabilities). The air-sea interaction measurements to be collected in CAMP will provide unprecedented detail for a number of forcing situations; the oceanographic measurements from aircraft, ships and buoys will indicate the physical oceanographic response. Finally, CAMP will show how the physical state of the upper ocean in coastal Alaska relates to primary productivity. Unlike the infrequent and or spotty ocean color estimates available from satellite, the aircraft-based color mapping will be suitable for documenting the evolution of chlorophyll concentrations on appropriate time scales, i.e., a few days. These results will form the basis for a validation study of productivity models of the region, and a major component of an interdisciplinary, synthesis-type study for the coastal ecosystem.

INVESTIGATORS

Nicholas Bond	NOAA/PMEL & Univ. WA	Meteorologist & Coordinator
John Cullen	Dalhousie University	Ocean Color
Al Hermann	NOAA/PMEL & Univ. WA	Oceanographic Modelling
George Hunt	Univ. California/Irvine	Marine Ecosystems
Jeff Napp	NOAA/AFSC	Biological Oceanographer
Peter Olsson	Univ. Alaska/Anchorage	Meteorologist
Phyllis Stabeno	NOAA/PMEL	Physical Oceanographer

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Figure 1 Map of study regions. The triangles refer to the locations of moored buoys.

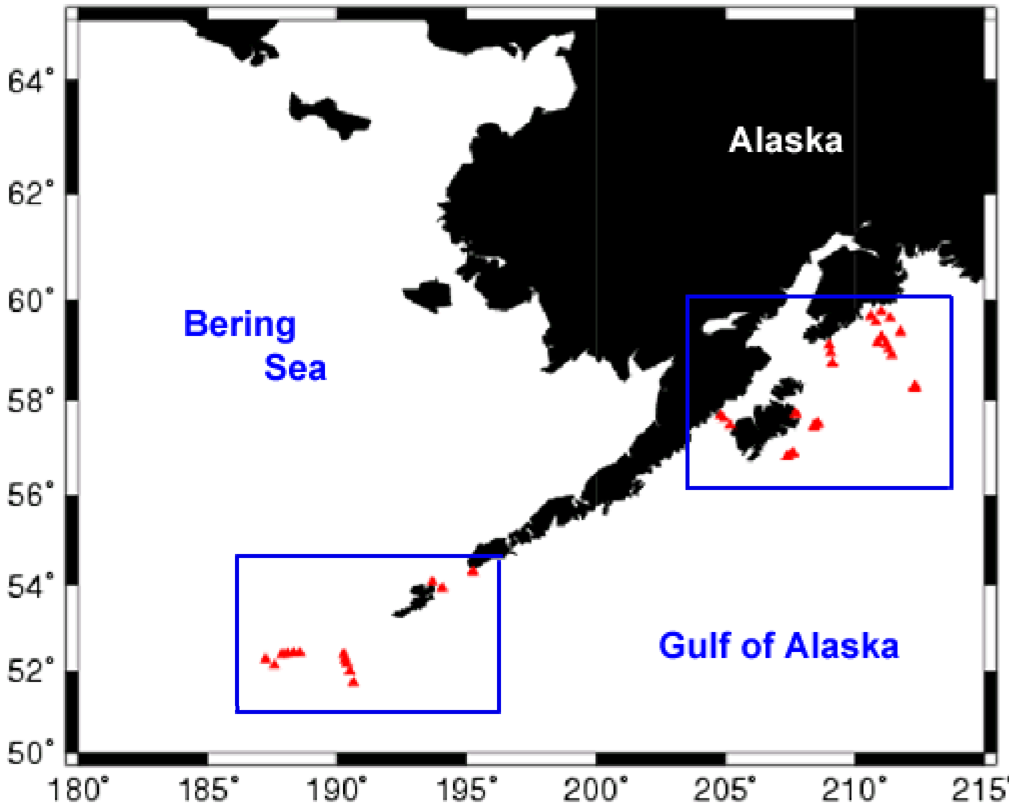

Figure 2   Sample flight track for the survey offshore of the Kenai Peninsula. The heavy lines refer to the locations of cross-shelf vertical stacks (nominally at 100, 300 and 600 m). The triangles refer to the locations of moored buoys.