U.S. GLOBEC: A Component of the U.S. Global Change Research Program

U.S. GLOBEC NEWS

Number 12 August 1997

Northeast Pacific Program Begins . . . Finally!

The NSF Ocean Sciences and NOAA Coastal Ocean Program selected thirteen projects to begin U.S. GLOBEC's scientific research program in the ecosystems of the Northeast Pacific (NEP). Thus begins U.S. GLOBEC studies in two regions (California Current System [CCS] and the Coastal Gulf of Alaska [CGOA]) that represent important ecosystem types—eastern boundary currents and buoyancy-driven coastal currents—identified in the Initial Science Plan (published February 1991), and for which numerous planning workshops were held and documents produced. Hence, the "Finally!" in the title above.

The Announcement of Opportunity for initial studies in U.S. GLOBEC's NEP program requested proposals for modeling, pilot monitoring, and retrospective data analysis in both the CCS and CGOA, and was released jointly with the NSF Coastal Ocean Program (CoOP), which requested proposals for modeling in the CCS. CoOP funded one modeling project (see box, page 2).

The principal investigators, institutional affiliations and project summaries of the successful U.S. GLOBEC proposals are provided below, prepared from information provided in the project summaries of the proposals.

Three modeling proposals were funded, two specifically directed to the CCS (Botsford et al.; Huntley et al.) and one for the CGOA (Haidvogel et al). These projects complement a recently NSF funded modeling project of Powell and Haidvogel (see box). Six retrospective data analysis projects were funded. Three of these (Brodeur et al.; Merick et al.; Strom) were specific to the CGOA; one (Ohman et al.) was specific to the CCS; and two (Berkeley et al.; Finney) consider both regions. Two pilot monitoring projects, one each in the CCS (Smith et al.) and the CGOA (Weingartner et al) were selected. One project (Schwing et al.) involves both retrospective data analysis and modeling; and one (Strub et al.) involves both retrospective data analysis and monitoring. This last project, using remote sensing to characterize basin- and meso-scale variability of the NEP is also partially funded by NASA, in addition to U.S. GLOBEC.

U.S. GLOBEC: Retrospective Analysis of Growth Rate and Recruitment for Sablefish, *Anoplopoma fimbria*, from the Gulf of Alaska and California Current System (Berkeley, S. A. [Oregon State Univ. (OSU)]; Chelton, D. B. [OSU]). The PI's will use the otoliths of the long-lived sablefish, which may live up to 70 years, to examine variability in growth from year to year. Sablefish are one of the most valuable groundfish species in the region. They have a widespread distribution in the Northeast Pacific, occurring in two discrete stocks in the two major oceanographic regimes (Gulf of Alaska and the California Current). During their first 6-9 months they reside in pelagic waters over the shelf and slope, broadly overlapping the temporal and spatial distribution of juvenile salmon. This proposal hypothesizes that growth of sablefish during their first year is modified by variability in the pelagic environment, that early juvenile growth influences subsequent recruitment success, and that a common juvenile environment results in correlative relationships between year class strength in salmon and

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sablefish. Previously collected and archived sablefish otoliths have the potential to establish a 50-60 year time series of juvenile growth, thus allowing extensive retrospective comparison of the influence of climatic factors on a key ecological parameter of fish populations.

The specific objectives of this study are 1) to establish a time series of juvenile sablefish growth beginning in the 1940s, using otoliths that have been collected from sablefish in the Gulf of Alaska and off the west coast since the early 1980s. 2) To evaluate the correspondence between juvenile growth and subsequent recruitment to the adult stocks of sablefish, and the relation of these factors to year class strength in west coast and Gulf of Alaska salmon stocks. 3) To compare and contrast growth rates and recruitment indices between the Gulf of Alaska and west coast stocks of sablefish. 4) To develop preliminary models of the interannual and interdecadal response in growth and recruitment to past environmental conditions. 5) To provide these data to other researchers to allow development of more comprehensive models and help refine subsequent process and monitoring studies. 6) To provide training for graduate students.

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Coastal Ocean Processes (CoOP) Begins West Coast Program

Circulation and Ecosystem Modeling for the Oregon Coast (Allen, J. [Oregon State University]) The general objective of this project is to understand and be able to model physical oceanographic circulation processes and accompanying ecosystem dynamics in the wind-forced continental shelf flow fields off the U.S. northwest Pacific coast. Immediate objectives include the application of high resolution numerical circulation and ecosystem models to both process studies and to direct simulations of continental shelf and slope flow fields for investigations of the physical and biological mechanisms involved in wind-forced across-shelf transport processes. A specific goal is to develop the capability to support future Coastal Ocean Processes (CoOP) program field experiments with application of a high resolution, limited-area, regional shelf circulation and ecosystem model. That model would be used to help understand the physical and biological processes in the observed flow fields by providing interpolation or extrapolation of necessarily incomplete measurements and by enabling directly relevant process studies.

The research plan involves application of a high resolution three-dimensional, numerical model for the hydrostatic primitive equations to studies of flow on the Oregon continental shelf and slope. The initial application will be with the Blumberg-Mellor (1987) finite difference, sigma coordinate model. The ecosystem model of Moisan and Hofmann (1996) will be parameterized for the Oregon shelf and coupled to the physical primitive equation model. Planned model domains will extend 300-400 km alongshore and 150-200 km offshore, with horizontal grid sizes of 1 km or less and 40 or more vertical sigma levels. The domain will thus cover most regions of coldest shelf mesoscale variability induced by alongshore topographic or wind stress irregularities and, correspondingly, will cover the regions of typical field experiments. Open boundary conditions for the circulation model will be formulated based on experience gained from work in progress on a model for the northern California shelf in the region of the Coastal Ocean Dynamics Experiment (CODE). The initial model domain will include a region of the continental shelf off Oregon from approximately 42°N to 45.5°N. This region includes ideal potential locations for future Coastal Ocean Process (CoOP) field experiments. In addition, previous and ongoing field experiments in this region provide both physical and biological measurements necessary for initial model comparisons.

Proposed research involves investigations of three-dimensional wind-forced circulation processes and ecosystem dynamics in both upwelling (summer) and downwelling (winter) regimes through numerical experiments involving process studies and direct simulations. Physical model results of the direct simulations will be compared to existing measurements through calculations of appropriate statistical and joint statistical functions. The initial objective is to find the requirements on the use of the models to properly represent the important physical and biological features observed in previous field experiments. Physical oceanographic investigations will focus on the time-dependent, three-dimensional dynamics of the following processes which potentially play major roles in the across-shelf circulation; upwelling and downwelling fronts, surface and bottom boundary layer behavior including the role of the turbulence parameterization schemes and the nature of bottom layer behavior including the role of downwelling conditions, and interactions of the wind forced flow field with variations in shelf topography and coastline geometry. Particular attention will be given to model studies of the flow near Cape Blanco (43°N) where separation of the southward coastal jet on the shelf has been observed during summer.

Ecosystem studies will focus initially on experiments in flows utilizing a two dimensional approximation (variation across-shelf and with depth; uniformity alongshore) as a desirable prerequisite to experiments in more complex dimensional flow fields and for calibration purposes, e.g., for determination of optimum representations for growth and death rates. Objectives include determination of the ecosystem response during both upwelling and downwelling under conditions of time varying wind forcing. Investigations of ecosystem dynamics in the three-dimensional shelf and slope flow experiments mentioned above will follow.

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The otoliths of more than 35,000 sablefish previously collected from both the Gulf of Alaska and California Current stocks are available for analysis. Representative samples from as complete a time series as possible will be analyzed for both stocks. The distance from the central core of the otolith to the first annulus will be measured and used as an estimate of the first year's growth. Recruitment indices have been developed for both stocks that extend back at least 20 years. A variety of comparative techniques will be applied to the growth and recruitment time series developed in this study and archived physical data to identify statistically significant links between the biological and environmental variability. Available data on salmon year class strength and results of similar studies likely to be undertaken on salmonid stocks will be contrasted with sablefish to determine whether growth and mortality of juvenile salmon and sablefish covary (in or out of phase).

U.S. GLOBEC: Physical Influences on Populations in the California Current (Botsford, L. [Univ. Calif. Davis (UCD)], Hastings, A. M. [UCD], Largier, J. [Scripps Institute of Oceanography]) We propose to formulate models spanning the individual level to the metapopulation level for two genera of interest to GLOBEC in the CCS: (1) the two CCS salmon species identified by GLOBEC, coho salmon (*Oncorhynchus kisutch)* and chinook salmon (O. *tshawytscha)* and (2) Dungeness crab (*Cancer magister),* a species which covaries with salmon, is a significant prey of both species, and is subject to similar mesoscale circulation patterns. The ultimate purpose of these models will be to link the different scales of variability and levels of ecological organization in the various retrospective, monitoring and process studies so that the effects of changes in the physical environment on populations can be projected. Also, we will answer a number of questions through modeling and analysis of existing data, that will allow better focus of field studies on critical issues.

While upwelling and the regime shift in the mid-1970s are believed to have affected survival through this period, results of field studies of the cause are equivocal. We will develop a model to evaluate the interaction of time of ocean entry, size at entry, varying growth rate, and size dependent mortality rate on the fraction surviving this phase, and use it to compare the various field results in a common context. The results will help to focus field studies, and the model will provide a framework for evaluation of those studies. Even though Core Hypothesis III focuses on the juvenile stage, ENSO events are known to have a dramatic effect on survival of pre-spawning adults. Because the behavior of random populations of semelparous, anadromous species is poorly understood, the relative effects of environmental variability on their persistence and productivity is unknown. We will formulate a population model to determine which variable life history stage has the greater effect so that the GLOBEC process studies can focus on the appropriate one. We will formulate a metapopulation model to evaluate whether covariability between the environmental influences on different subpopulations affect persistence, and if it does, whether more productive populations can "rescue" extinct less productive populations?

We will also model and analyze the Dungeness crab population because the dramatic fluctuations in their abundance along the coast may be caused by the same environmental factor(s) that cause the salmon populations to vary, and may also be a cause of that variability through predation. We will apply a new approach to population analysis that answers the question: which environmental forcing function can combine with known density-dependent recruitment mechanisms to produce the observed variability in crab catch?

U.S. GLOBEC: Analysis of Ichthyoplankton Abundance, Distribution, and Species Associations in the Western Gulf of Alaska (Brodeur, R. [NOAA Alaska Fisheries Science Center (AFSC)], Bailey, K. [AFSC], Doyle, M. [Pacific Marine Environmental Laboratory], Kiernan, A. [AFSC]) The coastal Gulf of Alaska supports large and economically valuable fisheries resources and provides nursery areas for many species, including all the dominant salmon species. Over the last few decades, there have been dramatic shifts in the abundance and species composition of many of these commercial species and concomitant changes in the marine ecosystem due to large-scale atmospheric forcing and changing ocean conditions. It is hypothesized that there are strong linkages between the spawning strategies of fishes and environment in which they occur in the northern Gulf of Alaska and that these fish species must continually adapt to new conditions as major regime shifts occur. It is further hypothesized that higher frequency but less dramatic changes in ocean conditions, such as those attributable to El Niño/Southern Oscillation (ENSO) events, lead to increased cross-shelf flux of fish larvae but do not dramatically alter the established spawning strategies of most fish species.

To test these hypotheses, a collaborative program of research will analyze an extensive set of ichthyoplankton data spanning 16 years (1981-1996) and encompassing much of the western Gulf of Alaska. Included are data from 51 U.S. and U.S.S.R. cruises and from *ca.* 5500 bongo and Tucker vertically-integrated net tows, as well as additional depth-discrete tows made with MOCNESS samplers. The PIs propose: to identify dominant species and multispecies assemblages in the ichthyoplankton and to describe their temporal/spatial distribution patterns in relation to local circulation processes.

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U.S. GLOBEC: Northeast Pacific Retrospective Study, Long Term Variability in Salmon Abundance in the Gulf of Alaska and California Current Systems (Finney, B. [Univ. Alaska, Fairbanks]) The main goals of this project are to reconstruct trends in salmon abundance in the California Current and Northern Gulf of Alaska systems over the past 500 to 2000 years, to compare trends in abundance between the systems, and to determine relationships between climate change and salmon abundance. This project will use newly developed techniques to reconstruct salmon abundance trends from stable isotopic analysis of lake sediment cores. Several sites will be studied in each of the California Current and Northern Gulf of Alaska systems to compare trends within and between regions. The records of salmon abundance will be compared with paleoclimatic data determined from studies of tree rings, glacial advances and other sources.

Long-term records of salmon abundance will be reconstructed by analyses of stable nitrogen isotopes in sediment cores. This new application of N stable isotopes is based on the observation that Pacific salmon supply measurable quantities of elements into freshwater systems when they return to spawn. Nitrogen derived from adult salmon is enriched in ^{15}N relative to terrestrially-derived N, and thus past changes in the number of returning adult salmon are reflected by down core changes in sedimentary delta^{15}N. The stable isotopes of sulfur also have potential to trace salmon-derived elements into freshwater ecosystems, because there is a large difference between marine and terrestrial signatures of delta^{34}S. Because N and S have different geochemical controls and different geochemical cycling processes, the use of both tracers should lead to a robust reconstruction of salmon abundance.

U.S. GLOBEC: Coupled Bio-physical Models for the Coastal Gulf of Alaska. (Haidvogel, D. [Rutgers Univ.], Herman, A. J. [NOAA Pacific Marine Environmental Laboratory (PMEL)], Stabeno, P. J. [PMEL], Hinckley, S. [NOAA Alaska Fisheries Science Center], M. Iskandarani [Rutgers], H. Arango [Rutgers]) A core hypothesis of the US GLOBEC Northeast Pacific Implementation Plan is that interannual to interdecadal variability in the circulation and hydrography of the Gulf of Alaska drives changes in productivity of zooplankton in the coastal zone, with consequent effects on the feeding success of salmonids and other species in the Gulf. Production regimes in the Coastal Gulf of Alaska (CGOA) and the California Current may covary on interannual to decadal scales, due to spatially correlated changes in physical forcing. To address these issues for the CGOA, a set of linked circulation models, coupled with a lower trophic level Nutrients-Phytoplankton-Zooplankton (NPZ) biological model, and an individual-based model (IBM) of salmon are used. Specific questions to be addressed by this set of models include: 1) How do the relative strengths of the offshore Alaska Current-Alaskan Stream and the Alaska Coastal Current (ACC) affect exchange between the shelf and slope, and hence the supply of nutrients and deep-sea zooplankton to the shelf area? 2) Can wind-driven Ekman flux account for most of the transport of oceanic zooplankton onto the shelf, or are more intricate cross-frontal processes involved? 3) How does interannual/decadal modulation of the seasonal pattern of the ACC affect secondary production and transfer to higher trophic levels on the shelf? Does a stronger ACC act to enhance or reduce productivity on the shelf? 4) Does tidal mixing significantly affect coastal production in the Gulf of Alaska? If so, can very low frequency modulation of tides account for some of the decadal change in the coastal dynamics, and hence production?

The proposed set of coupled (global/basin and regional/coastal) circulation models are forced by realistic wind and river runoff time series. Output from the coastal circulation model will be used to drive the NPZ model of the near-coastal area encompassing the shelf and shelf break. Circulation and prey fields produced in this manner will then be used as input to the spatially explicit IBM of juvenile salmon. This set of models will comprise a significant advance over past and existing models of the Gulf of Alaska, which have with few exceptions tended to use either coarse spatial grids or simplified physics, which exclude biologically relevant processes such as baroclinic instability in the coastal zone.

A Zooplankton Population Dynamics Model in the California Current Region. (Huntley, M. E. [Scripps Institute of Oceanography (SIO)], Zhou, M. [SIO]) We propose to construct a practical zooplankton population dynamics model based on novel advances in the biomass spectrum theory. Testing and application of the theory will use eddy-resolving Optical Plankton Counter data collected in the California Current region during June-July 1993 and September-October 1993. The novel advances in the biomass spectrum theory explicitly include population dynamics parameters such as rates of individual growth, birth, and mortality. We first developed a general biomass spectrum theory of size-structured zooplankton population dynamics and then demonstrated that this theory can be practically applied to estimate zooplankton population dynamics rates and productivity from observations of the biomass spectrum. In this theory, zooplankton, including all species and stages, are classified by weight. For estimating population dynamics rates from field observations and verifying modeling results, we further developed an objective interpolation method which removes the effects of advection from observations and calculates statistical properties of the spatiotemporal interpolation. This objective interpolation method will be applied to zooplankton data obtained in the California Current region. The results, together with the biomass

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Linked Biophysical Modeling in the California Current System:
The Influence of Circulation and Behavior on Prominent Mesozooplankton Species
T. Powell [Univ. of California, Berkeley] and D. Haidvogel [Rutgers Univ.]

Eastern Boundary Current Systems, such as the California Current System (CCS), owe their high phytoplankton productivities to circulation patterns that bring nutrient-rich deep waters to the surface. Further, the spatial patterns of high primary and secondary productivity appear to be closely linked to mesoscale physical structures *(e.g.* filaments, jets, and eddies) in the CCS. We hypothesize that both spatial distribution and demographic processes *(e.g.* growth, fecundity, mortality) of calanoid copepods *(e.g. Calanus pacificus* and *Metridia pacifica)* and euphausiids *(e.g. Euphausia pacifica),* are influenced by circulation patterns within the CCS. We also hypothesize that the vertical migration behavior of these zooplankton influences their spatial distribution and demographic processes through the interaction between vertical migration and the circulation field. Moreover, the bioenergetic and behavioral differences between species are hypothesized to influence differential population successes and spatial distributions.

To address these hypotheses, we will construct a series of linked physical-biological models of the CCS. We propose to use an individual-based bioenergetics model to simulate CCS zooplankton behavior and phenology, to simulate the CCS circulation field with SPEM5. 1, and to link the two via simulated Lagrangian drifters.

Using the linked models we intend to address the following questions:

- How does the circulation field *(e.g.,* upwelling, rapid offshore transport in filaments) impact the distribution and population success of major CCS zooplankton species such as *Calanus pacificus, Metridia pacifica* and *Euphausia pacifica?*

- How does the behavior *(e.g.,* vertical migration) of these species interact with the circulation field ? How does this interaction influence the distribution and population success of these species?

- How do bioenergetic differences *(e.g.,* in growth effficiency) and behavioral differences *(e.g.* in vertical migration excursion) affect the <u>relative</u> distribution and population success of C. *pacificus, M. pacifica* and *E. pacifica*?

In general, the models developed in this project represent a major advance in incorporating detailed zooplankton biology and ecology into realistic, three-dimensional circulation models. The method we have chosen, coupling a bioenergetics individual-based model, that includes behavior, with a detailed physical circulation model is generally applicable to populations in other ocean ecosystems.

The results of this proposal will:

- improve our understanding of how diel vertical migration and circulation interact to affect the spatial distribution and population success of important CCS zooplankton species.

- explore how three dominant CCS mesozooplankters, C. *pacificus, M. pacifica,* and *E. pacifica* respond <u>differentially</u> to the physically and biologically complex environment of the CCS. This is of particular interest because, although the two copepods are similar in size, they have distinct behavioral differences that should impact both their spatial distribution and population success in the CCS. Conversely, the contrast of the euphausiid with the two copepods will provide insights on how relative differences in both bioenergetics and behavior impact spatial distribution and population success.

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spectrum theory and individual-population growth models, will be used to estimate rates of population dynamics. These rates and zooplankton spatiotemporal distributions allow us realistically to construct and verify a population model. Then we will develop a numerical model based on the biomass spectrum theory and analyzed population dynamics rates, which takes the phytoplankton and physical fields from observations or modeling, and outputs zooplankton spatiotemporal distribution and productivity. This model provides the trophic link between models of phytoplankton and fish, and can be directly embedded into an existing hydrodynamic-ecosystem model for ecosystem study and

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A Coordinated Response to the ENSO 1997-98 with Emphasis on Ecological Impacts

Summary of a Meeting held July 11, 1997 in San Francisco

Below is the **Executive Summary** of a U.S. GLOBEC White Paper resulting from a one-day workshop to discuss options for coordinating more comprehensive physical and biological sampling along the west coast of North America during the El Niño that is forecast this year (see article on page 7). Adobe Acrobat and html versions of the complete white paper are available from the U.S. GLOBEC web site at:

http://www.usglobec.berkeley.edu/usglobec/enso/enso97rev01.html
http://www.usglobec.berkeley.edu/usglobec/enso/enso97rev01.pdf

Since the early 1980's, there has been marked improvement in remote sensing and modeling of El Niño's, such that it can be stated with some certainty that an El Niño will occur in 1997-1998. The evidence available to date suggests that it may be as strong or stronger than the 1982-83 El Niño. A group of oceanographers, representing a number of west coast programs, and variety of disciplines, met to develop a coordinated response of the research community to examine the propagation and impacts of this El Niño along the Pacific coast of the U.S. and Canada. The goal was to 1) provide a summary of ongoing and newly funded research/monitoring along the Pacific coast; 2) identify critical types of observations or specific regions where data are missing (gaps); and 3) provide guidance for filling those gaps. **Two major goals of an enhanced monitoring program on the west coast are 1) to document the alongshore response of ocean conditions as the El Niño propagates northward along the Pacific coast of North America; and 2) to document the impacts of the anomalous conditions associated with a major El Niño on the nearshore, coastal ecosystem of the Northeast Pacific.** Many of the research programs along the west coast are not directed specifically at El Niño; however, a major 1997-1998 El Niño would impact ocean conditions and ecological interactions along much of the west coast. Small changes in focus, perhaps accompanied by small, incremental enhancements of funds, could dramatically improve sampling at sites along the coast likely to be impacted by El Niño. However, in no respect should these changes be viewed as altering the fundamental long-term missions/goals of these established programs.

Four general needs of a coordinated ENSO monitoring effort are: 1) increased sampling of subsurface observations; 2) broader sampling of ocean chemistry and biology, including nutrients and multiple trophic levels; 3) sampling at many locations along the west coast, at as high a frequency as affordable; and, 4) establishment of a more effective communication network to coordinate the many sampling and monitoring activities that occur along the west coast.

Generally, we are much better placed presently to document the physical manifestation of El Niño conditions along the west coast than we are for biological aspects of the ecosystem. The network of observation sites, including moorings, NDBC buoys off California, tide gauges and shore temperature stations at a number of locations, and survey transects and grids in place now is nearly capable of documenting the physical manifestation of an El Niño as it propagates poleward along the North American west coast. If the network is supplemented in a few sites by a) beginning programs earlier than their intended starts, b) continuing existing programs beyond their scheduled completion, or c) augmenting existing programs, physical aspects of this prospective ENSO will be recorded satisfactorily. The coastwide sampling outlook is not as favorable for nutrient and biological variables. As for the physics, some improvement in chemical and biological sampling could be obtained by beginning projects prior to their official start dates. However, some regions do not have ongoing or planned sampling of biology at all, nor are there research cruises ongoing to which additional biological sampling could be added. In other regions it might be possible to obtain additional biological sampling for minimal cost, because research cruises are already taking place for other reasons. ΔΔΔ

Space-Based Observations of Anomalies in the Equatorial Pacific

by Timothy Liu and Wenqing Tang

From the start of the ocean observing mode on 15 September 1996, the NASA Scatterometer (NSCAT) has observed stronger than normal easterly winds (negative) in the tropical Pacific, which may have piled up surface warm-water in the western Pacific, as reflected in the anomalous high sea level and sea surface temperature observed by the Topex/Poseidon altimeter and the Advanced Very High Resolution Radiometer (AVHRR). At the same time, lower than normal values of the two parameters are observed in the central and eastern Pacific. NSCAT observes a number of episodes of strong westerly wind anomalies (positive). The first two wind anomalies, in the December/January and February/March periods, generate two downwelling Kelvin waves which propagate across the Pacific, as represented by positive sea level anomalies observed by the altimeter. Such strong waves have been absent for more than a year. The waves are followed by anomalous warming in the central and eastern equatorial Pacific and anomalous cooling in the west. Some of the observed conditions are known precursors of El Niño. The mechanism which relates intraseasonal wind anomalies and Kelvin waves to interannual El Niño episodes are not sufficiently known. However, by May of 1997, anomalous warming was experienced through the central and eastern equatorial Pacific. *(W. Timothy Liu and Wenqing Tang are scientists at the Jet Propulsion Laboratory of the California Institute of Technology).*

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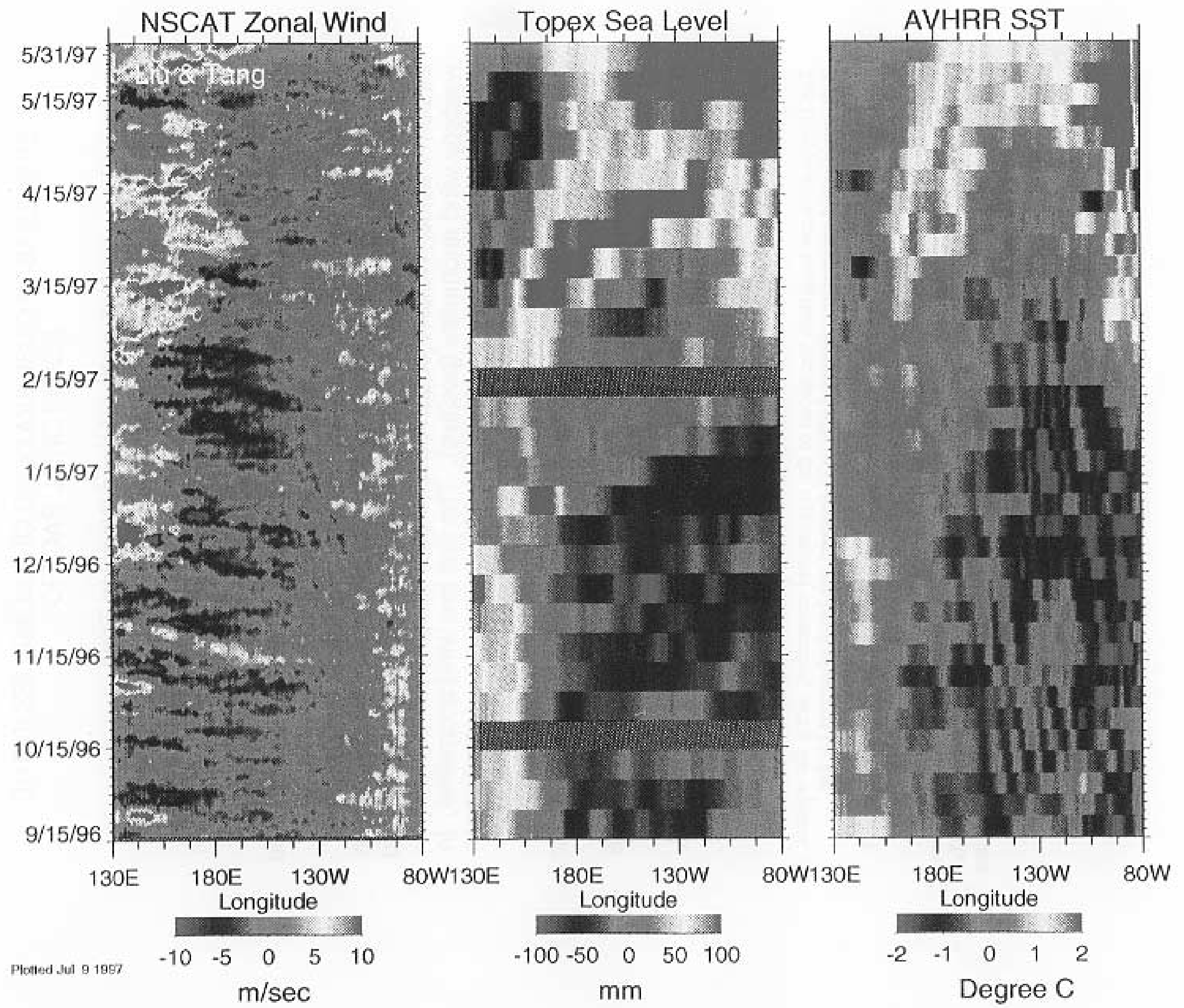

Figures are time-longitude variations of the anomalies, along the equator, of (left) zonal wind component observed by NSCAT, (center) sea level observed by the Topex/Poseidon altimeter, and (right) sea surface temperature observed by AVHRR, showing atmospheric forcing and oceanic responses. Climatological seasonal cycles have been subtracted. Longitude (horizontal axis) covers most of the Pacific from Indonesia to the Galapagos; time (vertical axis) starts when NSCAT data became available.

U.S. GLOBEC Calendar

1997

24-28 August: The 127th Annual Meeting of the American Fisheries Society, Monterey Convention Center, Monterey, California, USA. Contact: Paul Brouha, AFS; 5410 Grosvenor Lane, Suite 110, Bethesda, MD 20814-2199, USA (Phone: 301-897-8616; FAX: 301-897-8096; Internet: main@fisheries.org; Website: http://www.esd.ornl.gov/societies/AFS/)

31 August-19 September: The Summit of the Sea, St. John's, New-Foundland, Canada. Contact: Dave Finn, Summit of the Sea John Cabot 500th Anniversary Corporation, P.O. Box 1997, 1 Crosbie Place, St. John's, Newfoundland, Canada A1C 5R4 (Phone: 709-579-1997; FAX: 709-579-2067 Internet: david_finn@porthole.entnet.nf.ca; Website: http://www.newcomm.net/cabot500/summit/)

8-11 September: First International Symposium on Stock Enhancement and Sea Ranching, Bergen, Norway. Contact: PUSH, Bontelabo 2, N-5003 Bergen, Norway (FAX: +47-55-317395; Internet: borthen@telepost.no; Website: http://www.imr.no/sear/hav97.html)

16-19 September: 44th Annual Eastern Pacific Ocean Conference (EPOC), Stanford Sierra Camp, Fallen Leaf Lake, CA, USA. Contact: Jeff Paduan, Meeting Chairperson, Code OC/Pd, Naval Postgraduate School, Monterey, CA 93943 (Phone: 408-656-3350; FAX: 408-656-2712; Internet: paduan@nps.navy.mil) or Bill Peterson, EPOC Secretary, NMFS, Hatfield Marine Science Center, 2030 S. Marine Science Dr., Newport, OR (Phone: 541-867-0201; FAX: 541-867-0389; Internet: bpeterso@sable.hmsc.orst.edu)

22-24 September: ICES International Symposium: The Role of Physical and Biological Processes in the Dynamics of Marine Populations, Baltimore, MD, USA. Contact: ICES Secretariat, ICES, Palaegade 2-4, DK-1261, Copenhagen, Denmark (Phone: +45 33 15 42 25; FAX: +45 33 93 42 15; Internet: ices.info@ices.dk; Website: http://www.ices.dk/symposia/rp_symp.htm)

25 September - 3 October: ICES Annual Science Conference, The John Hopkins Univ., Baltimore, Maryland, USA. Contact: ICES Secretariat, ICES Palagade 2-4, DK-1261 Copenhagen, Denmark (Phone: +45 33 15 42 25; FAX: +43 33 93 42 15; Internet: ices.info@ices.dk; Website: http://www.ices.dk)

6-9 October: OCEANS'97 MTS/IEEE. Halifax World Trade and Convention Centre, Halifax, Nova Scotia, Canada. Contact: IEEE Travel and Conference Management Service, 445 Hoes Lane, Piscataway, NJ 08855-1331 USA. (Phone: (in USA) +800-810-4333, (outside USA) +908-562-5598 (collect); FAX: +908-981-1203; Internet: publications@sirius.ns.ca)

8-11 October: International Symposium on Fisheries Stock Assessment Models for the 21st Century: Combining Multiple Information Sources, 15th Lowell Wakefield Symposium, Anchorage, Alaska, USA. Contact: Brenda Baxter, Alaska Sea Grant College Program (Phone: 907-474-6701; FAX: 907-474-6285; Internet: fnbrb@aurora.alaska.edu)

9-10 October: U.S. GLOBEC Scientific Steering Committee meeting, Rutgers Univ., New Brunswick, NJ, USA. Contact: H. Batchelder, Department of Integrative Biology, University of California, Berkeley, CA 94720-3140 (Phone: 510-642-7452; FAX 510-643-1142; Internet: halbatch@socrates.berkeley.edu)

10-13 October: 3rd LOICZ Open Science Meeting on Global Change Science in the Coastal Zone, Leeuwenhorst Conference Centre, Noordwijkerhout, The Netherlands. Contact: LOICZ Core Project Office, Netherlands Institute for Sea Research, P.O. Box 59,1790 AB Den Burg, Texel The Netherlands; (Phone: +31-222-369404; FAX:+31-222-369430; Internet: loicz@nioz.nl; Website: http://www.nioz.nl/loicz/) or Julie Hall, NIWAR, Ecosystems, P.O.Box 11-115, Hamilton, New Zealand. (FAX: +64-7-856-0151; Internet: hall@hamilton.niwa.cri.nz)

17-26 October: PICES 6th Annual Meeting, Pusan, Korea. Contact: PICES Secretariat, c/o Inst. of Ocean Sciences, P.O. Box 6000, Sidney BC, Canada V8L 4B2 (Phone: 604-363-6366; FAX: 604-363-6827; Internet: pices@ios.bc.ca; Website: http://pices.ios.bc.ca)

27-31 October: NPAFC 5th Annual Meeting, Victoria BC, Canada. Contact: North Pacific Anadromous Fish Commission, 6640 Northwest Marine Drive, Vancouver BC, Canada V6T 1X2 (Phone: 604-228-1128; FAX: 604-228-1135)

28-30 October: California Cooperative Oceanic Fisheries Investigations (CalCOFI) Annual Meeting , Lake Arrowhead, California USA. Contact: Mary Olivarria or George Hemingway, MLRG, Scripps Inst. of Oceanogr., La Jolla, CA, USA 92093-0227 (Phone: 619-534-4236/2868; FAX: 619-534-6500; Internet: molivarria@ucsd.edu or ghemingway@ucsd.edu; Website: http://www-mlrg.ucsd.edu/calcofi/ccinfo.html). Symposium on squid organized by California Dept. of Fish & Game, plus contributed papers.

15-18 December: 1997 World Conference on Natural Resource Modelling, Spatial and Temporal Dynamics for Management of Natural Resource Systems, Hobart, Australia. Contact: Conference Secretary, Tanya Fisher (Phone: +61 3 6232 5482; FAX: +61 3 6232 5199; Internet: rma@marine.csiro.au; Website: http://www.cqs.washington.edu/~gordie/rma.html)

1998

9-13 February: 1998 Ocean Sciences Meeting, San Diego, CA, USA. Contact: AGU Meetings Department, 1998 Ocean Sciences Meeting, 2000 Florida Avenue, NW Washington, DC 20009 (Phone: 202-462-6900 (in D.C. or outside N.America) or 1-800-966-2481 (toll-free in N. America); FAX: 202-328-0566; Internet: meetinginfo@kosmos.agu.org; Website: http://www.agu.org/meetings)

17-20 March: First Open Science Meeting of GLOBEC International, Paris, FR. Contact: Dr. Roger Harris, Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, England (Phone: +44-1752-633 400, FAX: +44-1752-633 101, Internet: r.harris@pml.ac.uk)

16-17 April: U.S. GLOBEC Scientific Steering Committee meeting, Washington, DC, USA. Contact: H. Batchelder, Department of Integrative Biology, University of California, Berkeley, CA 94720-3140 (Phone: 510-642-7452; FAX 510-643-1142; Internet: halbatch@socrates.berkeley.edu)

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Taking Stock of Fisheries Management

by TIMOTHY R. PARSONS, Founding Editor of Fisheries Oceanography

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The term 'fisheries oceanography' first came to my attention when I listened to a series of *lectures* by Professor Uda of Japan, who visited our laboratory in 1958. I believe that he was largely responsible for founding the Japanese Society for Fisheries Oceanography in the 1940s. For some years I contemplated trying to start a similar society in North America but it seemed that the idea was of no interest to established fisheries scientists, a position that was partly maintained by the two totally different funding systems for fisheries science and oceanography. In the 1980s two happy events came together to change my direction of thinking more towards a journal. These were meetings with Professor Sugimoto at the Ocean Research Institute in Tokyo and with Simon Rallison of Blackwells, both of whom were sympathetic to the idea of starting an international journal on fisheries oceanography. It was their idea that I should start as Editor, which I did by formulating an editorial policy, designing a cover and contacting potential Editorial Board members together with an additional Associate Editor (the late Dr. John Gamble), all of whom were prepared to risk their names in this joint venture.

My scientific thoughts on starting a new journal remain much the same now as they were before we managed to get started. It is obvious to the public in general that in the latter part of the 20th Century, scientific advancements in outer space have given us moon landings and views of other planets; in medicine, organ transplants; in agriculture, 'miracle rice'; and in engineering, we have tunnelled under the English Channel. What accomplishments can we cite in fisheries? The public perception of fisheries science and management is that we don't know why cod stocks failed on the Grand Banks, why Pacific salmon started to surge in abundance in the late 1970s (or why they are now declining in Canadian waters since the 1990s), or whether there will be a recovery of the blue whale population in the Antarctic. These are but a few examples of a myriad of fishery resource uncertainties that are reflected daily in many newspapers around the world. Surely it is time to say that something has gone very wrong with the scientific process for commercial fisheries compared with other branches of science, including those in biology such as agriculture and medicine.

THE PROBLEMS WITH FISHERIES

Fisheries science has been based historically on the economic need to sustain the fish resources of the sea. The approach employed for most of the 20th Century was to focus on various commercial species of fish and to protect them, assuming a relationship between the number of parent fish (the stock) and the number of young fish achieving a size at which they could be caught (the recruits). This stock/recruitment relationship has been the subject of many learned writings by fisheries scientists, and was the basis for a well-known book published in 1957 by Beverton and Holt entitled *On the Dynamics of Exploited Fish Populations.* The application of this scientific approach has obviously been inadequate for management, but what is more surprising is to find that this textbook was reprinted in 1995, largely without change. Is there any other branch of science in which one could reprint a 40-year-old textbook and claim contemporary validity of the science?

Historically, the economic basis for fisheries has led to overcapitalization, followed by overfishing and subsequent population declines. There has still been virtually no attention given to environmental causation and multispecies interactions, including non-commercial species, in determining fish abundance. Regulations drafted by national governments and by international organizations such as FAO have failed due to a lack of a proper scientific understanding of processes governing fish abundance. The hypothesis of stock/recruitment has been widely applied (even to many small pelagic species for which it was not developed). No fisheries model forecast the rapid decline of the Peruvian anchovy in the early 1970s; nor did a fisheries model forecast the resurgence of this fishery to 11 million tonnes in 1994 - this was not for a lack of complexity in fisheries models, but because basic data and understanding of the marine ecosystem were lacking.

AN ANALOGY WITH MEDICINE

It is often claimed that the management of fisheries is so complex because it must satisfy the competing interests of scientists, fishermen, fishing companies and governments. It is this web of complexity that has been held responsible for creating a lack of predictive success in managing the ocean's renewable resources. The same might have been said of medicine in the 1930s. The field of medicine was very complex because it involved the genetic makeup of the individual, the environment in which she or he lived, the economic circumstances dictating whether a patient could afford a cure (e.g. TB sanatoriums), and the use of 'trained' physicians whose training was controlled by medical schools where novel practices were seldom part of the curriculum. The physician 'practised' on the 'patient' who generally

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NEP Begins—(Cont. from page 5)
prediction of secondary production.

U.S. GLOBEC: A Retrospective Study of Top Predator Trophic Positions, Productivity, and Growth in the Gulf of Alaska for 1960-75 and 1975-90. (Merrick, R. [Alaska Fisheries Science Center], K. Hobson [Canadian Wildlife Service], J. Piatt [Biological Resources Division, USGS]) Conditions in the Northeast Pacific Ocean began a shift in 1975-76 to a different oceanic regime which continued through at least the early 1990s, and appears to have resulted in increased productivity of Alaskan salmonids and groundfish. However, pinnipeds and sea birds, and some forage fish species exhibited sharp population declines (~50%). While trends of pinniped and sea bird populations have been suggested as related to changes in the availability or abundance of prey, the opposing trends of these predators and the major salmonid and groundfish stocks suggest that the relationships between marine predators and prey are more complex than are presently understood. Ocean ecosystem dynamics in the Northeast Pacific may affect salmonids and upper trophic level consumers in entirely different (and perhaps opposing) ways. The research proposed here will investigate through retrospective analysis whether changes in the oceanography and trophic structure of the Gulf of Alaska after 1975-76 decreased the Gulf's carrying capacity for marine mammals and birds.

This research will first involve a reconstruction of the trophic positions of a pinniped (Steller sea lion), piscivorous (common murre) and planktivorous (auklet) seabirds, and some of their major prey (juvenile and adult walleye pollock, juvenile and adult sockeye salmon, and adult herring) using analyses of changes in nitrogen isotope ratios for periods prior to and after the onset of the 1975-76 regime shift. Analyses will be performed using archival material (i.e., bones, teeth, feathers, otoliths, scales, and other tissue) obtained from animals collected during the two periods. Sea lion growth during the two periods will be assessed using the width of dental growth layer groups as an index. Age-specific sea lion trophic positions and growth indices will then be compared to assess relationships between the two. Finally, data on predator trophic positions, productivity, and sea lion growth will be compared to indices of oceanographic conditions (e.g., the Northeast Pacific Pressure Index) and prey productivity (e.g., year-class size) to assess the influence of bottom up processes on the carrying capacity for upper-trophic level species in the Gulf of Alaska. Results of this study will add to the understanding of the potential effects of climate variability and decadal climate change on top predator productivity in the eastern North Pacific. This study also adds to the ongoing exploration of the relationship between food web changes and the precipitous declines in Gulf of Alaska top predator populations being conducted by various agencies in the U. S., Canada, and Russian Commonwealth.

Long-term Changes in California Current Zooplankton—A Retrospective Analysis (Ohman, M. D. [Scripps Institute of Oceanography (SIO)], Checkley, D. [SIO]) Marine zooplankton are one of the primary pathways through which physical climate signals propagate to marine fish populations. Evidence now shows geographically extensive changes of zooplankton biomass in concert with variations in the atmospheric and oceanic circulation in the NE Pacific. However, such analyses of bulk zooplankton biomass do not distinguish among taxa with diverse life histories, some of which are important trophic links to planktivorous fishes and others of which are not. The species composition of the zooplankton can strongly influence the intensity of zooplankton-fish linkages, and consequently alter recruitment success. Mechanistic understanding — and quantitative modeling — of climate linkages to planktivorous fishes will depend upon specific knowledge of the zooplankton fauna and the differential responses of different zooplankton taxa to variations in circulation and productivity of the NE Pacific.

We propose a retrospective analysis of the past 4 1/2 decades of the California Current System (CCS). We will use the high quality CalCOFI zooplankton collection, together with associated hydrographic data and indices of atmospheric forcing, to understand the causes of changes in the zooplankton from 1951 to the present. Three aspects of the zooplankton composition will be investigated: changes in the high-level taxonomic composition of all holozooplankton taxa, including gelatinous and crustacean forms; changes in the species composition of copepods and selected other taxa; and changes in trophic structure and nitrogen economy as inferred from the N stable isotope composition of two species of particle grazing copepods.

We hypothesize that there have been differential, taxon-specific responses to: (1) decadal-scale changes in the climate of the NE Pacific, including the 1976-77 warming event; (2) El Niño and other interannual variations in flow from the equatorial region and from the Subarctic Pacific; (3) regional differences in the intensity of coastal upwelling and cross-shore transport.

Our studies will provide, for the first time, an understanding of multi-decadal zooplankton species changes in the Pacific. We will uncover the taxa responsible for the longterm 70% decline in CCS zooplankton biomass. We will establish the temporal coherence of population changes in the central and southern sectors of the CCS, with which to analyze the covariation with related zooplankton species in the Subarctic Pacific. These studies will form the foundation for the design of new GLOBEC field studies and the development of NE Pacific pelagic ecosystem models.

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NEP Begins—(Cont. from p.10)

U.S. GLOBEC: Patterns, Sources and Mechanisms of Decadal-Scale Environmental Variability in the Northeast Pacific: A Retrospective and Modeling Study (Schwing, F. B. [NOAA Southwest Fisheries Science Center (SWFSC)], Monterey, G. [SWFSC], Parrish, R. [SWFSC], Murphee, T. [Naval Post-graduate School]) To relate environmental variability to fluctuations in marine populations, we must be able to describe how the environment varies in time and space; especially the primary patterns, processes, sources, mechanisms, and scales of decadal variability. We propose to examine decadal ocean variability in the Northeast Pacific (NEP) using a state of the art numerical model, combined with a retrospective analysis of atmospheric and oceanic observations using statistical modeling techniques recently introduced to the area of climate research. Based on our previous and ongoing modeling and retrospective work, we expect that we will be able to identify the key environmental indicators that are likely to be dynamical links, rather than simply correlations between changes in the environment and fluctuations in marine populations. Although the principal species of interest are salmon, our analyses will be directly applicable to a number of other commercially important fish stocks, as well as ecologically significant primary and secondary producers. We will emphasize decadal variability, but will examine the relationship between decadal and interannual (e.g., ENSO) scale phenomena.

Our studies will focus on the following questions: (1) What are the major patterns of decadal change in oceanic fields and processes in the NEP?; (2) What are the mechanisms leading to decadal oceanic change, and where do these changes originate?; (3) How do basin-scale and local processes interact in the major regions of the NEP (e.g., those defined in US GLOBEC [1994, 1996]) to produce the oceanic responses observed in these regions?; (4) How do the seasonal cycles in the different regions of the NEP vary on decadal scales?; and, (5) How are the patterns, processes, and mechanisms of decadal change in the NEP similar to and different from those operating on shorter (e.g., one to three year) scales?

Pilot Monitoring off Oregon for Climate Change Studies in the Eastern North Pacific. (Smith, R. L., Huyer, A., Wheeler, P., Peterson, W., Kosro, M., Barth, J. A. [All at Oregon State Univ.]) To understand the effects of climate variability on marine life in the eastern North Pacific requires that we know what the oceanic environment is, how it is changing, and what the oceanic environment was in the past. There is evidence that the ecosystems over the continental margins of the eastern North Pacific have changed since a "climate shift" occurred about 1976. Salmon production is different since 1976, and interannual changes in the coastal ocean clearly affect the productivity and survival of biota. Subsurface oceanic conditions off central Oregon in the anomalously warm years of 1983 and 1992 were unique when compared with data from the 1960s; no years in the 1960s had as warm temperatures at depth (50 to 200 m) as those in 1983 and 1992. Seasonal monitoring had been conducted for the decade 1961-71, but with very limited hydrographic data since 1976, we aren't able to say whether the mean conditions for non-anomalous years since 1976—since the "climate shift"—are different than earlier years. Measurements are needed now to compare with the good data base that exists for the 1960s.

This proposal seeks to initiate a pilot monitoring program along two transects off the central Oregon coast (44.6° and 43.2°N) where regular hydrographic sampling programs have existed in the past. We plan five cruises per year to monitor the hydrography, nutrients, chlorophyll, and zooplankton species composition and abundance at biologically-important times of year: Winter (Dec-Feb) when winds are normally favorable for downwelling and shelf currents are normally northward, chlorophyll is low, and the copepod *Calanus* are in diapause or just emerging from diapause and have not begun their seasonal population increase; Early Spring (March/April), at or soon after the spring transition that marks the seasonal onset of upwelling, and before juvenile salmon enter the ocean; Late Spring (May/June), when the southward flow is fully established, the phytoplankton is likely to be in full bloom, euphausiid abundances normally begin their seasonal increase and salmonids are entering the ocean; Summer (July/August), near the height of the upwelling season and the peak of copepod abundance; and Autumn (Sept/Oct), when seasonal heating has ended, coastal convergence has begun, coastal copepods are still abundant, and *Calanus* species are preparing for diapause.

Retrospective Analysis of Northeast Pacific Microzooplankton: A Window on Physical Forcing of Food Web Structure. (Strom, S. [Western Washington Univ.]) A retrospective analysis of microzooplankton samples from the Gulf of Alaska is proposed as a means of relating changes in ocean physics to changes in abundance and distribution of taxa at higher trophic levels, particularly copepods. The mechanisms by which climate regime shifts translate into changes in copepod and fish production are unknown. Climate-driven variability in ocean physics may alter resource availability to primary producers, ultimately resulting in variation in prey availability to marine animals. Microzooplankton are known to be the major trophic link between primary producers and higher trophic levels in oceanic subarctic waters, and may play an equally important role in coastal ecosystems. We propose that retrospective analysis of this key trophic link, when combined with data on meteorol-

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NEP Begins—(Cont. from page 11)

ogy, ocean physics, and plankton biology, will provide a window onto the mechanisms by which climate shifts may alter food web structure and function.

The sample set consists of acid Lugol's-preserved 1-liter water samples collected during oceanographic cruises along Line P and at Station P (50°N, 145°W). Vertical profiles (~8 discrete depths sampled per profile) are in hand from cruises in 1987, 1988, and 1993-1997 (inclusive), with most sampling focused during winter (Feb.) and spring (May) months. Additional samples will be collected during 1998 and 1999. Thus a 13-year time period, with 7 continuous years, ultimately will be available for analysis. Abundance, biomass, size structure, and species composition of the microzooplankton community (primarily protozoa) will be determined. Because quantitative sampling techniques for microzooplankton came into consistent use fairly recently, the data set ultimately obtained will be a rare if not unique view of multi-year variation in this important planktonic group. Furthermore, all samples were collected during oceanographic research cruises, providing a detailed contextual framework for the microzooplankton data. Microzooplankton data will be compared to physical and biological parameters (e.g. meteorological conditions, ocean temperature, mixed layer depth, nutrient concentrations, phytoplankton biomass, size structure, and production, and copepod biomass). Analysis of microzooplankton samples in the context of related environmental data will increase our understanding of the mechanisms linking ocean physics and higher trophic level changes, as mediated through the microzooplankton. An understanding of how the food web responds to seasonal and interannual shifts in the environment is essential for the development and validation of predictive models, a major goal of U.S. GLOBEC.

U.S. GLOBEC: Remote Sensing of the NE Pacific: Retrospective and Concurrent Time Series Analysis Using Multiple Sensors on Multiple Scales (Strub, P. T. [Oregon State Univ. (OSU)], Abbott, M. [OSU], Thomas, A. C. [Univ. of Maine], Svejkovsky, J. [Ocean Imaging]) A significant number of physical and biological variables covary within and between the boundary currents of the subarctic and subtropical gyres in the NE Pacific Ocean. These include the strength of the transports, surface temperatures, zooplankton biomass and the catch of commercially important fishes. Time scales range from individual events to interdecadal regime shifts. The mechanisms by which these physical and biological fields covary are unknown, but it is postulated that the same mechanisms involved in interannual variability also affect long term climatic variability. Clarification and quantification of the mechanisms governing interannual variability will therefore help to "model" the biological and physical responses of these economically and ecologically important systems to future climate change. One of the principal strategies for addressing variability across these time and space scales and their potential linkages is to make effective use of historical and presently available multi-sensor satellite data sets.

The goal of this proposal is to process, archive and analyze environmental data from a number of satellite sensors and other sources in order to characterize and quantify the dominant modes of variability in surface transports, temperature and pigment concentrations in the NE Pacific Ocean. The analyses will cover multiple time/space scales, considering basin-scale connections, mesoscale circulation within specific regions of the boundary currents, and small-scale, nearshore circulation in two of the regions. In addition to the analysis carried out in this project, these data will be made available over Internet and on CDROM to other investigators.

On the basin-scale, the project will quantify the exchange between the West Wind Drift (WWD), the Coastal Gulf of Alaska (CGOA) and the California Current System (CCS), testing the hypothesis that the covariability in the two boundary currents is due to changes in the location of the WWD. The alternate large-scale hypothesis is that this is not the case—that these boundary currents are forced by the large-scale wind systems and that these atmospheric systems covary between the basins. Satellite altimeters and scatterometers provide the instruments to test this hypothesis for the first time. Consistently reanalyzed atmospheric model winds allow a test of the wind covariability over a longer period than possible with the satellite data. The large scale modes of transport variability will be quantified using EOF analysis and Canonical Correlation Analysis.

On the mesoscale, within each boundary current, the combination of AVHRR SST and/or satellite ocean color with altimeter data can resolve mesoscale circulation features with scales of 50-100 km or less. AVHRR and ocean color data, with 1 km resolution, will be collected and processed in ongoing fashion for the three years of the project (1998-2000). Historical 1 km AVHRR data over the CCS (25°-55°N) for the period 1981-1997 will also be processed in identical fashion. These data, will allow an examination of the mesoscale circulation (location and seasonality of jets and eddies) around the sites proposed for process studies in Phase II of the US GLOBEC/CoOP NEP study. The direct transport along the boundaries of British Columbia and the Northwest US will also be examined, to provide greater details about the large-scale connection between the gyres. Other areas of focus will be: the region around the Columbia River Plume, due to the impact on out-migrating coho salmon; the region west of Prince

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William Sound, where juvenile salmon encounter the Alaskan Stream; and details of the flow from the coastal ocean along central and southern Oregon into the core of the California Current of northern and central California. The analysis will test the hypothesis that much of the interannual variability seen off central California in the CalCOFI data set comes from the upwelling region off Oregon, rather than from the WWD. Combination of the satellite data with in situ data collected during monitoring studies (funded by GLOBEC or other sources) will be used to transform the satellite circulation fields into mass, heat and pigment surface transports. Timing of seasonal transitions will be another focus, due to possible mismatches of coastal ocean environmental conditions with salmon out-migrations.

Physical-Chemical Structures, Primary Production and Distribution of Zooplankton and Planktivorous Fish on the Gulf of Alaska Shelf: A GLOBEC Monitoring Proposal. (Weingartner, T. J., Haldorson, L., Paul, A. J., Coyle, K. [all at Univ. of Alaska, Fairbanks], T. Royer [Old Dominion Univ.], T. E. Whitledge [Univ. Texas]) The Gulf of Alaska (GOA) shelf sustains a number of commercially significant fisheries. Despite dramatic changes in many of these fisheries in the late 1970s, little is known of the factors linking fish populations to the physical and climatic environment. Nevertheless. the existing oceanographic and fisheries data indicate variability on the same time scales as climatic changes. We propose to initiate a monitoring program, which in conjunction with GLOBEC process studies will aid in elucidating the links between the various physical, biological and climatic factors.

The basic water properties and circulation pattern of the GOA are coupled closely to the Aleutian Low pressure system; the atmospheric wind stress and precipitation drive a cyclonic, coastally downwelling system and produce the Alaska Stream and the narrow, freshwater Alaska Coastal Current over the shelf. Most of the zooplankton biomass on the GOA shelf in the spring and early summer is composed of oceanic species, thus implicating cross-shelf transport in the interannual variability in zooplankton densities. However, there is little data on primary production and nutrient concentration on the shelf, additional factors which could strongly influence zooplankton densities. Since zooplankton are critical to the growth and survival of planktivorous fish, factors impacting their abundance, distribution and species composition will ultimately impact populations of salmon, pollock and other commercially important stocks.

Specifically, we propose to document seasonal and interannual variability in the cross-shelf distribution of physical properties; the concentrations of nutrients, dissolved oxygen and chlorophyll; primary production rates; and the density and species composition of zooplankton. We will occupy a cross-shelf transect from the mouth of Resurrection Bay to the outer edge of the shelf break during each of six cruises per year, timed to coincide with key periods in the seasonal cycles of physical and biological events. Acoustic data will be used to document fish populations, and the species composition and condition of fish will be determined during the summer and fall cruises using samples collected by trawler. Sampling will be optimized during each cruise by real-time data analysis.

We also propose to identify the significant elements required for effective long-term monitoring beyond the time period of this study, to aid in the design of cost-efficient monitoring programs in the future. The effective duration of our data set will be greatly enhanced by existing data from previous hydrographic sections along our transect line, using a 26-year time series at one of the transect stations, and by a number of other oceanographic and climatic data sets. Retrospective studies using this enhanced data set, climatic records and a hydrological model will examine the historical relationship between the various physical and biological variables, thus aiding in the identification and validation of links between climate and the biological and physical environment.

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At Sea—(Cont. from page 15)

My tallest tale of high adventure at sea is from our return journey during which we had 30-40 kts of wind across the deck with combined seas and swell reaching 20 ft. The ship is only 170 ft long. Have you ever noticed that no matter which way a ship is headed, it is always in the trough? We were taking some impressive rolls (30 degrees routinely and 35+ occasionally). It was impossible to sleep so I wedged myself into a corner of the bridge and hung-on. It was like riding a bucking bronco. Yeeha!

All-in-all, it was wonderful to get out on a research cruise again. Would I do it again? YES! Eventually. My comfy D.C. office is piled even higher with paperwork but I approach it with renewed enthusiasm. Many thanks to Ron Schlitz, Bill Strahle, my fellow scientists, and the Captain and crew of the OCEANUS.

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Taking Stock—(Cont. from page 9)
waited to get better; unscientifically justified operations such as tonsillectomies were commonly carried out. Medicine improved between the 1930s and the 1990s after it was invaded by other sciences - genetics, biochemistry, pharmacology, virology, physiology and so on - and today it is a predictive, if not always an exact science. It is necessary to invade the established schools of fisheries science with data on meteorology, physics, physiology, tropho-dynamic concepts and natural history studies of individual species (including non-commercial species, such as jellyfish). Many, but not all, of these sciences are included in the multidisciplinary science of oceanography - and hence the title of our journal, *Fisheries Oceanography.*

THE ECONOMIC AND ENVIRONMENTAL DAMAGE OF FISHERIES

In the absence of a predictive science, one can argue that the world's industrial fisheries do as much harm as good. Against the justified need for fish protein, one has to consider the following points.

1) There is no doubt that overfishing has occurred in just about every stock in the world, and this has reduced the abundance of fish while increasing the price of the increasingly scarce resource. In some cases, even the remaining refugia populations are threatened by the high prices offered for rare species.

2) Not only has the actual cost of the resource increased, but the cost to the taxpayer of a highly subsidized industry is now estimated worldwide to be about $16 billion annually. Fisheries lose money, but fishing companies prosper on the backs of the taxpayer.

3) In a recent survey of the British Columbian trawl fishery, it was shown that the fishery for turbot discarded over 50% of its total catch as bycatch (i.e. unprofitable species, or species that are not allowed to be caught). On a worldwide basis this discard of bycatch may range from 10% to 90% depending on species. A high percentage of the discarded bycatch may be assumed to be dead or dying (i.e. susceptible to disease from tissue damage or attacks from predators).

4) Fisheries make the largest single anthropogenic impact on the ocean environment. No form of pollution is equal to the removal of about 100 million tonnes of commercial fish from the ocean (and no one is ever charged with damaging fish as bycatch!). There has been no systematic study on how fish harvesting has affected ocean ecology, although many examples can be given of dramatic effects (e.g. changes from large to small species, replacement of mammal populations in the Antarctic, increased occurrence of jellyfish, etc.). Fishing companies have not been challenged on these effects, as have many companies that exploit terrestrial resources.

5) Fishing operations cause many types of habitat damage depending on the type of 'fishery' being carried out. Many of these have not been seriously challenged. They include the destruction of mangroves for shrimp farms, the destruction of benthic habitat by bottom trawls, the mining of coral reefs for building material, the capture of non-targeted species (turtles and dolphins have recently received some attention) and the use of dynamite and cyanide to collect shallow-water fish.

THE BEGINNINGS OF CHANGE IN THE 1970s

Following the collapse of a number of fisheries in the world, there was an effort in the 1970s to turn toward alternative management strategies. Statistical interpretations of data showed that some fish species appeared to fluctuate with climate. Unfortunately, these single-factor environmental models did not reveal the underlying cause for change. In many cases, relationships were autocorrelated, resulting in two or more parameters being linked although the causative agent was never in fact identified. The failure of such models, when tested over longer time periods, was a source of discouragement to environmentally-based fisheries management theories. However, these studies often served to open up the need for future changes in fisheries science.

Some future directions

"If we do not solve our problems, we are doomed."
- *Buckminster Fuller*

1) As in my earlier analogy to medicine in the 1930s, it is unlikely that fisheries science will change of its own accord. In fisheries science, the tendency to introduce more regulations and more complex mathematical theories is likely to dominate at least into the beginning of the next century. What is really needed is to be able to account for fish population fluctuations based on a scientific understanding of the ocean's ecology; this can then be used as a basis to establish a predictive science for fisheries management. To accomplish this, fisheries science must be invaded by new sciences and by new scientific techniques ranging from molecular biology to satellite imagery.

2) The actual fishing process should, in many cases, be based on the total tonnage of fish that can be taken from an area, regardless of species. Protecting single-species fisheries in areas where fish populations are multispecies has not worked. Conservation of fish resources can be more readily achieved by assigning fishing areas within a total ecosystem (e.g. a shelf area subject to a

(Cont. on page 15)

Taking Stock—(Cont. from page 14)

trawl fishery). Because in most cases nets are size-selective, this means moving away from species-selective fisheries, which may kill more fish than they catch, to size-selective fisheries in which (by law) all fish caught must be processed in some way by fishing companies. Such a policy would eliminate the wasteful discard of bycatch, while allowing the changing background of species shifts to determine the total allowable tonnage during any one oceanographic regime dominance. This type of fishery appears to have been inadvertently followed off the coast of Japan where the dominant fish species has changed over an 80-year period from herring to sardine, to various species of mackerel and saury, and back again to sardine. This occurred without the need to endlessly organize committee meetings and change fisheries theories to regulate any one particular species fishery. Size-selective fisheries would not be applicable to fisheries in which the target species is easily identified (e.g. migrating salmon, tuna), but would apply to fisheries that routinely capture a variety of species of similar size.

3) Changes in laws regarding the catching and processing of fish must accompany the change in (2) above.

4) Finally, there is a paramount need in the future science of fisheries for factual data on the environment of fish (including competing species such as jellyfish) and fewer theoretical assumptions derived by scientists working with computers, out of touch with Nature.

(Tim Parsons is a Professor in the Department of Earth and Ocean Science, University of British Columbia, Vancouver, BC *Canada V6T 1Z4)*

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NOAA's U.S. GLOBEC Project Coordinator Goes to Sea

by Judy Gray

It had been about eight years since my last ocean research cruise. I remember it fondly: February in the Gulf of Alaska. After several years of "riding a desk" in Washington, DC, I was starting to wonder if I was becoming a land-lubber, losing my saltiness. So, at a GLOBEC meeting last year I made the comment that it was a sin to have a program manager who never went to sea. Ron Schlitz of NOAA's Northeast Fisheries Science Center took up my challenge and asked me to stand a CTD watch on his January cruise out of Woods Hole aboard R/V OCEANUS. "It'll be a physics cruise." he said. "You won't have to get your hands all gooey or stare into a microscope on a rolling ship." My stomach gets queasy even thinking about that. I lobbied for a late spring or summer cruise but was destined to prove my mettle on Georges Bank in the winter.

Upon arrival at Woods Hole, I was surprised to see the ENDEAVOR tied up across the dock and ALBATROSS still docked at NOAA. Both ships were supposed to be out on Georges Bank already. Hmmm. We awoke on Friday morning to high winds, freezing temperatures, and a threatening sky. OCEANUS, too, delayed her departure.

I am happy to say we accomplished our objectives despite terrible weather. The ship arrived at the working area on Georges Bank on Monday morning and immediately began mooring deployments. Two moorings were deployed on Monday, two on Tuesday, and then the forecast for Thursday arrived. Gale Warnings. This would mean a rush to complete the deployments before bad weather set in. Wednesday's activities began at about 0600. Bill Strahle, his crew, and the ship's crew worked like maniacs until 2230 that night to get as much work done as possible before the storm set in. They deployed an amazing four moorings. Phew! And they were up again at 0600 on Thursday for the final mooring deployment. They were very lucky. It was the calmest seas of the week and the mooring was deployed without a hitch. I finished my CTD watch at noon and hit the rack.

When I awoke at about 1400, the ship was pitching and rolling. Rats! I really needed a shower. It is amazing what a person will endure for a shower with the ship going one way, the shower water going another, and myself going yet another. After several encounters with the freezing-cold shower walls and a near-miss with the toilet, I bagged it, dressed, and staggered up to the oceanography lab only to learn that our gale warnings had been upgraded to storm warnings and we were headed home.

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Powell Stepping Down as Chair

In January 1998, Zack Powell, Professor in the Department of Integrative Biology, Univ. of California, Berkeley, will be handing the U.S. GLOBEC tiller to a new chair. Dr. Powell has been chair of the U.S. GLOBEC Scientific Steering Committee since January 1992. During his period as chair, U.S. GLOBEC has accomplished many of the goals originally outlined for the Georges Bank/Northwest Atlantic program, and has begun research activities in the Northeast Pacific Program. Everyone involved in the U.S. GLOBEC leadership is sorry to see Zack relinquish the chair, but very thankful of the time and effort he put forth on behalf of the program. A new chairperson for U.S. GLOBEC will be elected by the Scientific Steering Committee at or just following the October SSC meeting. ΔΔΔ

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