

FROM WIND TO WHALES: USING AN INTEGRATED OCEAN OBSERVATION SYSTEM TO UNDERSTAND CALIFORNIA'S UPWELLING ECOSYSTEM



*A 60-month progress report submitted by the
Center for Integrated Marine Technologies
University of California, Santa Cruz
August 2007*

Award No. NA160C2936

PARTNERS:

University of California, Santa Cruz (UCSC)
NOAA Monterey Bay National Marine Sanctuary (MBNMS)
Monterey Bay Aquarium Research Institute (MBARI)
Naval Postgraduate School (NPS)
Moss Landing Marine Laboratories (MLML)
NOAA National Marine Fisheries Service Southwest Fisheries Science Center
Cornell University
Jet Propulsion Laboratory (JPL)
University of California, Davis Bodega Bay Marine Laboratory

PART 1

BACKGROUND

With increasing human populations, demands on coastal resources are increasing, leading to dramatic changes in coastal ecosystems. Because we rely on the ocean for food, commerce, mineral, and energy resources, as well as for recreation, it is critical that we develop conservation and management strategies that facilitate the sustainable use of marine resources while minimizing impacts on natural systems. A major impediment to achieving this has been a lack of an integrated understanding of the basic processes governing coastal ocean ecosystems.

In an effort to develop this understanding, the U.S. Commission on Ocean Policy recommended that the National Ocean Council make the development and implementation of a sustained, national Integrated Ocean Observing System (IOOS) a key element of its leadership and coordination role (recommendation 26-1). This system should be developed such that it is able to rapidly and systematically acquire and disseminate data and data products to serve the critical and expanding needs of environmental protection, public health, industry, education, research, and recreation.

The IOOS is a system that: 1) is based on sound science and modern technologies, 2) provides timely access to data, and 3) makes effective use of existing resources, knowledge, and expertise (Malone 2001). Malone (2001) proposed that an ICOOS initially develop through the establishment of regional proof-of-concept pilot projects that incorporate existing programs and new initiatives into a coordinated and integrated system. Starting in 2002, the Coastal Observation Technology System (COTS) project funded the Center for Integrated Marine Technologies (CIMT) to develop one of several model demonstrations of regional coastal ocean observing systems based on combined knowledge, expertise, and efforts. In 2003, a regional component of IOOS was initiated (Central and Northern California Ocean Observing System – CeNCOOS) and CIMT joined as a partner in this regional effort.

Table 1. Proposed core variables for the IOOS (U.S. Commission on Ocean Policy).		
Physical	Chemical	Biological
<i>Salinity</i>	Contaminants: water	Fish species
<i>Water temperature</i>	<i>Dissolved nutrients</i>	<i>Fish abundance/biomass</i>
<i>Bathymetry</i>	<i>Dissolved oxygen</i>	<i>Zooplankton species</i>
Sea level	<i>Carbon: total organic</i>	<i>Optical properties</i>
Directional wave spectra	Contaminants: sediments	<i>Ocean color</i>
<i>Vector currents</i>	<i>Suspended sediments</i>	<i>Pathogens: water</i>
Ice concentration	<i>pCO₂</i>	<i>Phytoplankton species</i>
Bottom characteristics	<i>Carbon: total inorganic</i>	Benthic abundance
Seafloor seismicity	<i>Total nitrogen: water</i>	Benthic species
Ice thickness		<i>Mammals: abundance</i>
Sea-surface height		<i>Mammals: mortality events</i>
		Bacterial biomass
		<i>Chlorophyll-a</i>
		Non-native species
		<i>Phytoplankton abundance</i>
		<i>Phytoplankton productivity</i>
		Wetlands: spatial extent
		<i>Bioacoustics</i>

Core variables measured by CIMT shown in italicized blue.

A well-integrated interdisciplinary approach offers the best prospect of providing predictions regarding present and future effects of human activities on marine ecosystems. We have assembled a group of physical, biological, and geochemical oceanographers, ecologists, resources managers, and remote sensing experts, together with instrumentation and networking engineers who are working synergistically to develop an integrated Regional Coastal Ocean Observation System (RCOOS). Our unified goal is to create a well-integrated pilot system that will provide novel insights and critical data about the functioning of the California coastal upwelling ecosystem.

In its final report, the U.S. Commission on Ocean Policy proposed a list of core variables to be measured by the national IOOS (Table 1). CIMT currently measures 23 of 36 relevant variables (excluding variables concerning ice). In addition, CIMT measures 13 of 19 provisional IOOS core variables that should be measured by the national backbone for detection or prediction of phenomena of interest. From its inception, the CIMT has sought to develop the resources and technologies needed to: 1) develop an integrated, sustainable system to measure core IOOS environmental variables over the long-term, 2) archive and access these data products using IOOS Data Management and Communication (DMAC) subcommittee data management guidelines, 3) use data products in the development of predictive models to facilitate prognostication of change in the coastal environment with time, 4) identify a broad community of users for measured data products, and 5) create integrated data products that are accessible and understandable to community users. CIMT seeks to explicitly link new technologies across disciplines of marine science to address key questions for environmental protection, public health, industry, education, research, and recreation. CIMT combines emerging technological and data integration approaches to determine the processes underlying the dynamics of coastal upwelling ecosystems, and to investigate the critical linkages between:

- *Physical oceanographic measurements of upwelling and surface currents with*
- *Assessment of the availability of critical nutrients, to determine the extent to which these may be used to predict*
- *The distribution, abundance and species composition of phytoplankton zooplankton, harmful algal species, and*
- *The distribution, abundance and species composition of top-level, commercially-important consumers including fish, sea lions, seabirds, sea turtles, and whales.*

By using a multi-disciplinary approach, CIMT promises to deliver relevant physical, chemical, and biological ocean information to a diverse array of stakeholders.

The CIMT efforts are focused on the Monterey Bay region of the Monterey Bay National Marine Sanctuary (MBNMS) – from Pt. Año Nuevo on the North to Pt. Lobos on the South out to 122°05' west longitude. This region roughly encompasses the effects of the Davenport/Año Nuevo upwelling region (Rosenfeld et al. 1994). Monterey Bay is an ideal location for the development of a pilot sub-regional OOS. Presently, there are more

than 20 federal, state, and private academic, research, and resource management agencies and institutions actively involved in studying, measuring, and monitoring the waters in and around Monterey Bay and the MBNMS on an ongoing basis. A number of these institutions have been collectively developing, maintaining, and operating a coastal observing system in Monterey Bay and the surrounding region, delivering data in near real-time, for almost 15 years, and these efforts are becoming increasingly interdisciplinary and multi-institutional.

The California Upwelling Ecosystem

California's National Marine Sanctuaries (Cordell Bank, Gulf of the Farallons, Monterey Bay and Channel Islands) are situated in one of four major coastal upwelling regions worldwide. Coastal marine ecosystems are the world's most productive - producing nearly 95% of the annual global production of marine biomass (Sherman 1991). While they represent only 0.1% of the ocean surface area, upwelling regions account for more than 21% of the world's fisheries landings (Parrish et al. 1983). In 1996, for example, the landings of commercial fisheries in the California upwelling region totaled 208,440 metric tons, with a wholesale value of \$183.7 million. Despite the ecological and economic importance of coastal upwelling centers, we have only a rudimentary understanding of how coastal upwelling fuels the engines of productivity associated with them. Progress in understanding the dynamics of upwelling centers and their associated ecological communities has been hindered as workers in disparate disciplines have failed to coordinate their use of new technologies in interdisciplinary studies of upwelling processes. Understanding the strength of these linkages and the factors that contribute to their variability provides us with the foundation of knowledge needed to predict the impacts of climatic change and human activities on coastal productivity. Developing and integrating the new technologies accomplish this and will serve as a model for ocean observing in all U.S. coastal regions. Coastal upwelling occurs along the eastern margins of ocean basins as winds moving from poles toward the equator act in combination with the Coriolis force to move surface waters offshore and draw cold, deep water to the surface (reviewed by Barber and Smith 1981, McGowan et al. 1996). Upwelled water infuses surface waters with essential plant macronutrients such as nitrate, phosphate, and silicic acid, and this often leads to blooms of phytoplankton, forming the foundation of food chains that support coastal fisheries, seabirds and marine mammals. Along the California coastline, upwelling occurs during periods of strong northwesterly winds and is most intense in late spring and early summer, producing a band of cold water along the coast. This band is typically tens of km wide and separated from offshore warmer water by a series of highly variable jets, plumes and eddies (Strub et al. 1991).

The Monterey Bay Upwelling Region

Monterey Bay oceanography is strongly influenced by this persistent upwelling plume (Pennington and Chavez, 2000; Rosenfeld et al., 1994). During the spring and summer upwelling period, satellite imagery indicates cold surface water originates north of Monterey Bay near Davenport and appears to advect southwards across the mouth of the Monterey Bay as an upwelling plume (herein termed the Davenport Upwelling Plume [DUP] [Pennington and Chavez, 2000]). Presence of the DUP is confirmed by shipboard surveys of both temperature and salinity and direction of flow by drifter releases (Chavez

et al., 1997). During active upwelling, drifters move southwards 20 cm/s. Such plumes are common features of upwelling systems, and typically appear 'anchored' to capes, headlands, or other features of coastal topography (Strub et al., 1991). During active upwelling, surface temperature is low and nitrate high in the DUP, but chlorophyll and total production values are typically low. Biomass-specific production rates are, however, high under these conditions (Chavez, unpublished). The low production and chlorophyll values found during active upwelling are apparently due to low phytoplankton biomass of water initially upwelled near Davenport (Service et al., 1998; Kudela and Chavez, 2000). In the northeast corner of Monterey Bay, a seasonal front forms between the DUP and older, upwelled water residing in the wind shadow behind the Santa Cruz Mountains (Graham et al. 1992, Graham 1993). In this portion of Monterey Bay, chlorophyll values are often high but productivity/ biomass ratios low (Pennington and Chavez, 2000; Chavez, unpublished), suggesting residence times (2-12 d) are sufficient to allow bloom formation in this area. Southeast Monterey Bay, which is not protected from northwest wind, is likely flushed more regularly by recently upwelled water (Pennington and Chavez, 2000), though temperature and phytoplankton biomass are often higher in this area (Waidelich 1976, Schrader 1981). Much of the productivity stimulated by DUP nutrients is probably advected offshore of Monterey Bay and the continental shelves, as has been found in other upwelling areas (Chavez et al., 1991; Hutchings et al., 1995).

During fall and winter, surface currents are northward both within Monterey Bay (Breaker and Broenkow 1994) and across its mouth (Paduan and Rosenfeld 1996). At this time the DUP is absent and the spatial distributions of surface temperature, salinity, primary production and chlorophyll are more uniform relative to the upwelling season. Recent studies have demonstrated that the supply of iron, a key micronutrient necessary for plant growth, plays a critical role in controlling phytoplankton. The major source of iron to the surface waters of California is iron rich coatings on sediments that are discharged from rivers during episodic winter storms. Paradoxically, there is a temporal mismatch between the *winter* delivery of iron-rich sediment and *spring/summer* upwelling. However, the continental shelf appears to act as a trap for the sediments delivered by winter floods. When coastal upwelling occurs in the spring, iron from the shelf sediments are entrained in upwelled water along with elevated concentrations of nitrate and silicic acid. Southerly currents result in the enormous productivity of this region being swept into Monterey Bay (Kudela and Dugdale 2000, Kudela and Chavez 2002). *Please refer to the 36 month progress report for a summary of findings during 2005.*

Climatic Impacts on Upwelling Centers

Adding further complexity to coastal productivity are the influences of climatic events occurring interannually (El Niño/La Niña) and interdecadally (climatic regime shifts). Declines in upwelling, potentially linked to human activities, led to changes in productivity along the West Coast of North America beginning in 1977 (McGowan et al. 1998). However, a strong reversal, associated with multidecadal changes, occurred in the late 1990s (Chavez et al., 2003), making it clear that we need to understand the natural system before we can assess human impacts. Unfortunately, our ability to predict the potential impacts of these events is poor. For example, during the 1997/98 El Niño event,

productivity was generally low in the Eastern Pacific. However, weak upwelling very close to the central California coastline fueled moderate levels of primary production (Kudela and Chavez 2000 & 2002, Chavez et al. 2002). Seabirds and marine mammals that normally range far offshore responded to this climate-induced inshore shift in productivity and were concentrated in very nearshore waters (Benson et al. 2002). In contrast, other animals that rely on the productivity of upwelling centers, such as squid, experienced dramatic declines and fishery collapse. Combined, these new insights indicate phytoplankton production and the distribution and abundance of animals from zooplankton to fish, squid, seabirds and whales may be determined by complex interactions among climatic events, riverine input of iron, and wind-driven coastal upwelling of nutrients.

INTEGRATION OF NEW AND EXISTING TECHNOLOGIES

The CIMT has initiated a new approach to interdisciplinary coastal research by simultaneously collecting and integrating data collected via remote sensing, coastal observation moorings, shipboard surveys, and apex predator tagging and tracking. By utilizing technology on these different platforms, we can examine temporal changes in the Monterey Bay coastal environment using (mooring-based measurements) within local (ship-based measurements) and regional (satellite-based measurements). Individually, each component measures physical, biological and chemical components of coastal processes at specific temporal and spatial scales. Integrated together, they provide the data to develop predictive models across multiple spatial and temporal scales of how marine resources respond to variability in coastal dynamics. CIMT is integrating the measurement of a range of key parameters for understanding coastal dynamics.

Program Management Evolution

It isn't possible to maintain a program of this scope and diversity without program management. In our initial three years of funding we developed a CIMT Governing Board, which consisted of a lead investigator for each of the major research components (refer to CIMT's 48th month progress report http://cimt.ucsc.edu/documents/CIMT_48mo_Progress_Report.pdf for past structure breakdown). It was the responsibility of these investigators to coordinate the research within each group, including ship time and sampling, data collection and processing, as well as preparing sections for Progress Reports and Proposals to NOAA.

Beginning in FY06 CIMT has an active seven member Steering Committee that meets monthly via conference calls and on an as needed basis. All CIMT Principal Investigators and participants also meet yearly to present results of their work such that all research teams were aware of the progress, data and conclusions being developed by each group. There is collaboration and integration occurring on an on-going basis. Many of the individuals meet regularly as well to integrate their results, plan for data integration and future data collections efforts (for example, HFR/CODAR and ocean current modeling efforts). The Advisory meetings are open (non-CIMT personnel are welcome to attend), and we have made an effort to ensure that regional representation from groups

(such as Center for Integrative Coastal Observation, Research and Education (CICORE), the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) and CeNCOOS) outside of CIMT attended these meetings. A *CIMT workroom* has also been built into the CIMT website. This is a password protected resource that allows for CIMT business and resources to be streamlined internally and provides a central location for posting and receiving information, creating ease in this collaborative environment.

Our existing governance structure (or visit 48th month report for history http://cimt.ucsc.edu/documents/CIMT_48mo_Progress_Report.pdf):

In FY06

CIMT Steering Committee:

Program Manager and Board Chair: Gary **Griggs**, UCSC

Ship Surveys/Bioacoustics: Don **Croll**, UCSC

Mooring: Francisco **Chavez**, MBARI

HF Radar: Jeff **Paduan**, NPS

Remote Sensing (including Apex Predator Tagging): Raphe **Kudela**, UCSC

Database: Raphe Kudela, UCSC

Modeling and Forecasting: Chris **Edwards**, UCSC

Outreach: Rondi **Robison**, UCSC

This governing board meets monthly via conference calls. Agenda is distributed CIMT wide prior to the meetings and notes are distributed CIMT wide after calls and posted in the *CIMT workroom*.

Advisory Meetings:

- TBD

CIMT Staff:

- Academic Coordinator: Rondi Robison
- Graphic Specialist: Laura Beach – half time

Other collaborations:

- Surfrider Foundation
- Central Coast Long-term Environmental Assessment Network (CCLEAN)
- Tagging of Pacific Pelagics (TOPP)
- California Department of Health Services
- NOAA CoastWatch
- Monterey Bay National Marine Sanctuary
- NMFS Southwest Center
- Naval Research Labs (NRL)
- California Department of Fish and Game
- California Program for Regional Enhanced Monitoring for PhytoToxins (CAL-PReEMPT)
- PISCO

Support provided to Brian Fulfrost of the Environmental Studies Department of UCSC to provide an integrated ArcIMS of CIMT data.

CIMT AND CENCOOS COORDINATION

CIMT is collaborating closely in the development of the CeNCOOS regional IOOS. Since 2003 CIMT has endeavored to provide cogent CeNCOOS committee support. The CIMT Outreach Coordinator was the chair of the End User Committee for CeNCOOS, and at least one CIMT member participated in each of the five CeNCOOS interim committees: Executive (G. Griggs), End Users (R. Robison), Data Management and Communications (J. King), Science (F. Chavez, R. Kudela, J. Paduan, L. Rosenfeld), and Governance and Business Plan Development (L. Rosenfeld, J. Paduan) committees. Many CIMT members participate in quarterly CeNCOOS organizational meetings (June 2004 - present) and provide review of CeNCOOS materials. The following CIMT PIs have or are members of the CeNCOOS Council: Jeff Paduan – served as President of the CeNCOOS Council from December 2005 to January 2007; Francisco Chavez – is acting Vice President of the CeNCOOS Council (December 2005 – present); and Gary Griggs—who has been instrumental in creating CeNCOOS and was elected to the CeNCOOS Council in March 2007.

CIMT has been involved with many aspects of CeNCOOS including attending meetings with Stephanie Watson the former CeNCOOS Coordinator (January 2004 - May 18, 2005) and helping with the transition to the new coordinator Heather Kerkering (August 8, 2005). Robison also provided interim support for CeNCOOS during the two and half months (May 18-August 8, 2005) without a coordinator. Robison acted as the Assistant to the CeNCOOS Coordinator (Heather Kerkering) during the past year (August 2005–August 2006). Robison, worked half time for CIMT and half for CeNCOOS, coordinated and/or participated in all CeNCOOS activities and meetings.

Robison still continues to actively participate in CeNCOOS providing time and expertise throughout the region (for highlights of CeNCOOS coordination over the last six-months please refer to the Part II of this progress report). CIMT text descriptions and metadata have been provided or entered and updated for several on-going data collection efforts occurring within ocean observing; including COTS, oceanObs (MBNMS/CeNCOOS) www.oceanobs.org, and the SIMoN/MBNMS InfoShare program www.mbnms-simon.org.

PART II

REGIONAL INTEGRATION MECHANISM

During the last six months (February 2007 – July 2007) of FY06, COTS funds provided the opportunity for the continuation of the long-term monitoring of Monterey Bay and the further CIMT support to the Regional Association, CeNCOOS.

CIMT AND CENCOOS COORDINATION

CIMT's Academic Coordinator, Rondi Robison, continues to collaborate and provide assistance to the CeNCOOS Coordinator (Heather Kerkering).

University of California Santa Cruz (UCSC) collaborators Gary Griggs, Robison, Kerkering, Paul Siri and Lora Lee Martin received a co-award with Communication Partnership for Science and the Sea (COMPASS) to host a January 30-31, 2008 California Current Ecosystem-Based Management (CCEBM) Workshop (funding provided by the David and Lucile Packard and the Gordon and Betty Moore Foundations). The above mentioned members of UCSC and COMPASS compose the Planning Committee along with the Program Manager, Sarah Lester. To date we have hired the Program Manager, created both a Steering Committee and Science Committee, built a website <http://ims.ucsc.edu/CCEBM/>, and are finalizing the invitation list which we expect to send out in September 2007. Through this workshop, we hope to integrate Ecosystem Based Management (EBM) approaches to our regional ocean observing community and to introduce the EBM community to IOOS.

The Institute of Marine Sciences at the University of California Santa Cruz continues to provide office space and administrative support to Kerkering, and UCSC also hosts the CeNCOOS OceanObs Database Manager, Tom Wadsworth, at the Long Marine Lab facility. OceanObs is a metadata inventory of ocean observing activities in the CeNCOOS region <http://www.oceanobs.org>. Wadsworth, Kerkering, Robison and SIMoN/MBNMS Coordinator Josh Pederson meet monthly to maintain and build up and expand OceanObs.

Kerkering and Robison continue to work directly with members of the CeNCOOS Council and the Ocean Sciences Applications Executive Director, Paul Siri, to coordinate with state ocean observing efforts and the state's Ocean Protection Council. California is unique in that the state has provided \$21M in funding for the Coastal Ocean Currents Monitoring Program (COCMP) to install a system of HF Radar instrumentation along the entire coast, using the Regional Associations (both CeNCOOS and Southern California Coastal Ocean Observation System (SCCOOS)) to aid in installation, maintenance, data collection and integration. Kerkering and Robison continue to work towards meeting the needs of ocean observing outreach in the region. Specifically efforts have been made to develop multi and single page fact sheets that highlight ocean observing activities and CeNCOOS "Success Stories".

The monthly outlines below include highlights of CIMT and CeNCOOS coordination over the past six-months (February 1, 2007 – July 31, 2007).

FEBRUARY 2007

- 5 February: CCEBM Planning Committee
- 12 February: MBNMS Currents Symposium - CeNCOOS Exhibit I - Krista Kamer (CICORE/COCMP), Kerkering, Beach, Wadsworth, and Robison
- 14 February: OceanObs Update - Wadsworth, Pederson, Kerkering, Robison
- 16 February: CCEBM Planning Committee
- 20 February: Kelly Newton and Robison work on completing CIMT's entries to OceanObs ship survey component
- 26 February: CCEBM Planning Committee
- 28 February: MBNMS Currents Symposium - CeNCOOS Exhibit II - Kamer, Kerkering, Beach, Wadsworth, and Robison

MARCH 2007

- 2 March: CeNCOOS Governing Council meeting at Moss Landing Marine Laboratories, Moss Landing, CA
- 12 March: OceanObs Update - Kerkering, Wadsworth, and Robison
- 23 March: Monterey Bay Crescent Ocean Research Consortium (MBCORC) sponsored meeting I to create a Report Card and Ecosystem Report for Monterey Bay – Francisco Chavez/MBARI/CIMT; Andrew DeVogelaere/MBNMS; Kerkering/CeNCOOS; Mike Clancy/ Fleet Numerical Meteorology and Oceanography Center (FNMOC); California Department of Fish and Game
- 29 March: Coordination Update - Kerkering and Robison

APRIL 2007

- 4 April: Real-time data conference call
- 6 April: Coastal States Organization Coastal (CSO) Managers Workshop (September 2007) -Josie Quentrell, Kerkering and Robison, MPAs and water quality in Monterey Bay
- 6 April: FNMOC Monterey, CA – CeNCOOS met with the Naval Research Lab (NRL) and FNMOC. COAMPS support and CeNCOOS data integration support: Robison, Kerkering, Chavez, Clancy, others from NRL and FNMOC. Jim Doyle/ NRL and Leslie Rosenfeld/NPS/CIMT wrote a proposal entitled, “Atmospheric Forecasts over the Monterey Bay in Support of CeNCOOS,” requesting CeNCOOS funds to continue and expand the COAMPS atmospheric model. The existing COAMPS model wind product created by NRL and JPL for CIMT/CeNCOOS can be found here: <http://cimt.jpl.nasa.gov/>. Additional COAMPS Real-Time Forecasts for Monterey Bay can be found here: <http://www.nrlmry.navy.mil/coamps-web/web/mbay> . In short, FNMOC is willing to provide the data storage and power capabilities to continue and expand the COAMPS model – but NRL still needs funds to successfully transfer the program to FNMOC. The interim ExCom agreed this was a valuable effort and is very interested in supporting it.

13 April: Coordination Update - Kerkering and Robison

Fact Sheets: Robison and Beach are developing two CeNCOOS fact sheets. The two fact sheets will focus on 1) Surface Currents and 2) Animals as Ocean Sensors. Outlines for the fact sheets began April 2007.

OceanObs Database Manager Position: CeNCOOS worked with UCSC to begin a recruiting process to continue the OceanObs database manager position. The position will be held at UCSC.

MAY 2007

- 7 May: CCEBM Update - Lester/CCEBM Project Manager and Robison
- 9 May: Outreach & Education Strategy - Kamer, Kerkering and Robison discussions about education and outreach partner possibilities with Centers for Ocean Sciences Education Excellence (COSEE) and institution in region.
- 10 May: OceanObs Update - Wadsworth, Kerkering, Robison, Pederson
- 11 May: OceanObs Database Manager position announcement posted.
- 15 May: CCEBM Planning Committee
- 22 May: Spencer Lindsay from Lindsay Digital with Robison and Kerkering in Monterey, CA discussions about contracting work to create outreach and education animations for CeNCOOS.
- 22 May: CCEBM Science Committee call: Robison & Karen McCloud, COMPASS representatives from Planning Committee
- 23 May: Kerkering, Griggs and Robison - Discuss how to get CeNCOOS Outreach and Education Strategy support from Governing Council
- 24 May: Coordination Update - Kerkering and Robison
- 24 May: Robison and Wadsworth CeNCOOS presentation to Monterey Bay Aquarium's Sea Otter Research and Conservation Program and meet with Chris Harold the Monterey Bay Aquarium's (MBA) Science Director to get support of MBA science programs to contribute to OceanObs.
- 25 May: CSO Coastal Managers Workshop - Robison, Kerkering and Chris Edwards, UCSC/CIMT and John Largier, UC Davis/CIMT for MPA discussions
- 30 May: Outreach Materials - Robison, Beach and Kerkering

CSO Coastal Zone Managers Workshop: CIMT asked to provide input to MPA and water quality discussions.

Outline 2 for Surface Current fact sheet completed and distributed for feedback from Coastal Oceans Current Monitoring Program (COCMP).

MBCORC Report Card and Ecosystem Report for Monterey Bay II – Francisco Chavez/MBARI/CIMT; Andrew Devogleare/MBNMS; Kerkering/CeNCOOS; Mike Clancy/FNMOC; California Department of Fish and Game

JUNE 2007

- 1 June: CeNCOOS Governing Council Meeting, NOAA National Marine Fisheries Building, Santa Cruz, CA.
- 5 June: OceanObs and CIMT - Wadsworth and Robison
- 5 June: Coordination Update - Kerkering and Robison
- 6 June: OceanObs Update - Wadsworth, Kerkering and Robison
- 8 June: CeNCOOS Executive Summary Working Group I: Kenneth Coale, Robison, Kerkering, Chavez, Kamer, Toby Garfield
- 12 June: Envisioning the Future of Coastal Management, NOAA CSO Workshop in San Francisco, CA – Kerkering, Robison, Kamer, Garfield
- 15 June: CeNCOOS Executive Summary Working Group II: Coale, Robison, Kerkering, Chavez, Kamer, Garfield
- 21 June: CeNCOOS presentation at the MBARI EARTH (Education and Research: Testing Hypotheses) workshop to teachers from across the nation interested in locating and incorporating real-time ocean data into their classroom, MBARI, Moss Landing, CA – Robison and Wadsworth
- 25 June: Sam Johnson, West Coastal Marine Geology Team Chief Scientist, United States Geological Survey (USGS) and Robison discuss CeNCOOS development and USGS involvement.
- 27 June: Coordination Update - Robison and Kerkering
- 27 June: Robison arranging logistics for Sarah Lester, CCEBM Program Manager office at UCSC

JULY 2007

- 11 July: CeNCOOS Outreach Strategy - A single page CeNCOOS “Success Story” template is being developed to capture the value of ocean observing to management needs.- Robison, Kerkering, Beach and Amber Szoboszlai (MBNMS)
- 18 July: CCEBM - Lester and Robison
- 18 July: OceanObs Update - Wadsworth, Kerkering, and Robison
- 22-27 July: Coastal Zone 07 Conference in Portland, OR. Kamer and Robison attending for CeNCOOS. CeNCOOS poster presentation and participation in a number of discussions with the other RAs, the state of California, and in the West Coast Governors Agreement on Ocean Health.

MBCORC Report Card and Ecosystem Report for Monterey Bay III – Francisco Chavez/MBARI/CIMT; Andrew Devogleare/MBNMS; Kerkering/CeNCOOS; Mike Clancy/FNMOC; California Department of Fish and Game

On behalf of CIMT Robison submitted comments to *NOAA 5 Year Research Plan* for 2007-2011 to CeNCOOS to incorporate into National Federation of Regional Associations response.

CIMT AND CICORE COLLABORATION

See *54 month progress report for meeting goals and outcome*
http://cimt.ucsc.edu/documents/CIMT_54mo_Progress_Report.pdf

CIMT COORDINATION

CIMT has been monitoring and collecting data in Monterey Bay since its inception in 2002, integrating and extending the existing oceanographic and environmental records for this region. This long-term monitoring is critical to our understanding of the state and health of the marine ecosystem, because it provides a baseline for comparison to more recent data. CIMT's efforts have allowed us to capture an apparent transition in this ecosystem which appears to have shifted in approximately 2005/2006. During Spring 2005, we documented a dramatic delay in the onset of normal, upwelling favorable winds (the spring transition). Because of the delayed wind forcing, there was a subsequent delay in coastal upwelling, primary production and krill recruitment. Because of the interconnected nature of the coastal ocean, this physical perturbation depressed the biological growth of algae (primary production), which resulted in nest failure of seabirds, a depressed abundance in whales, and (potentially) a shift in the oceanic phytoplankton in favor of dinoflagellate blooms. Since 2005, CIMT has documented new/different species of harmful algae blooms in the bay, dominated by dinoflagellates. Thus, our long term goal of connecting wind to whales has provided an important ability to document and evaluate this massive restructuring of the California Current System. *See Figure 1.*

Blooms of algae producing neurotoxin began in southern California, Spring 2007, causing marine animal sickness and casualties; resulting in an early (4-20-07) mussel quarantine and additional shellfish health advisories. CIMT researchers have monitored water quality and the presence of algae blooms for five years in Monterey Bay. During this Spring bloom, CIMT continued these ocean monitoring programs.

Satellite data from the 250-meter resolution MODIS ocean color sensor, MODIS Aqua, was acquired for 27 April, 2, 5, and 8 May, 2007. Images were processed for chlorophyll, sea surface temperature, and fluorescence line height (FLH). FLH is a good tool for studying phytoplankton blooms because it minimizes interference from runoff, sediment, and other non-biological signals (*Figure 2*).

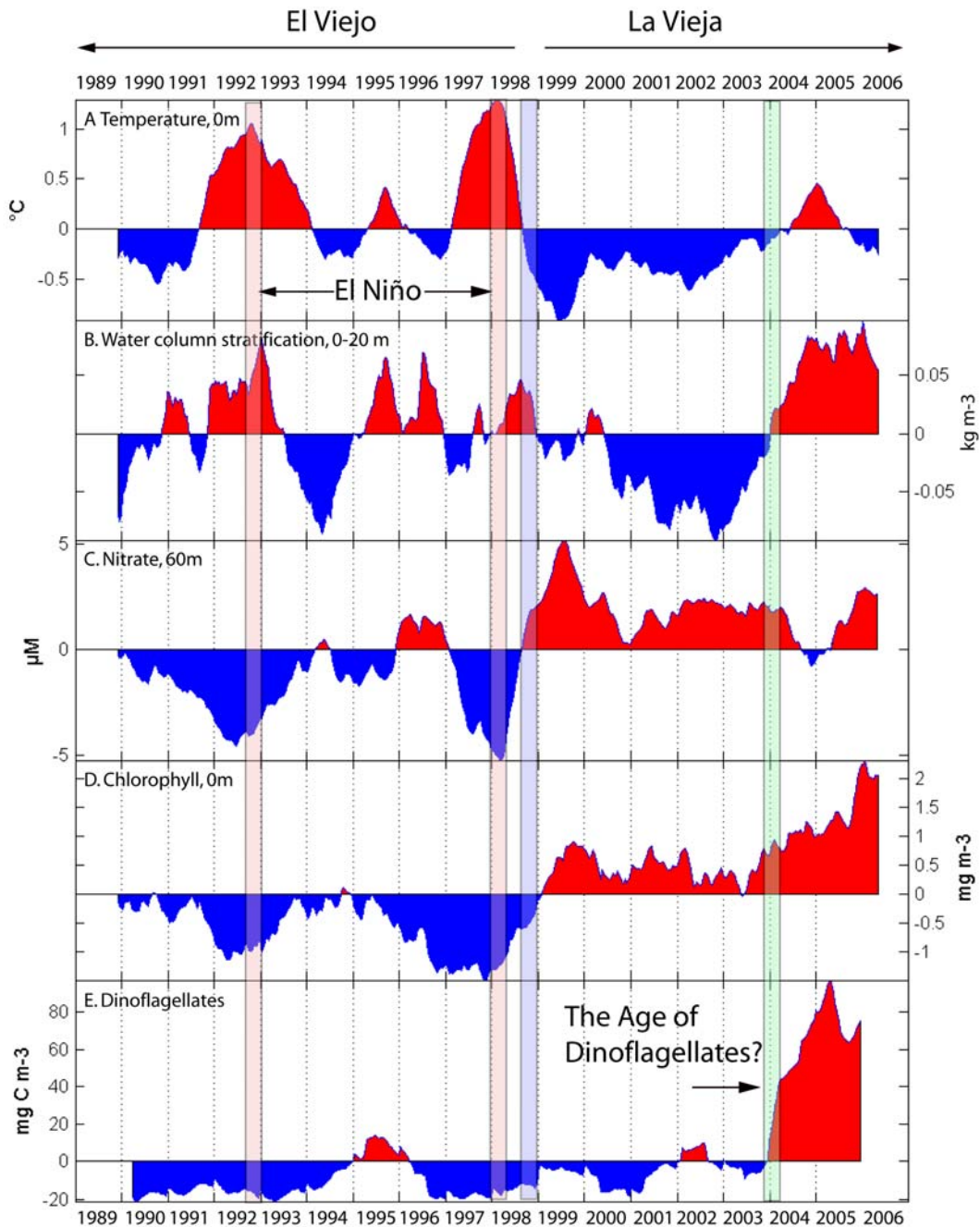


Figure 1: The ability to monitor the ocean over longer periods helps scientists to document oceanographic shifts because we have been monitoring before and after conditions change. Because of CIMT's efforts in Monterey Bay over the last five years in addition to data collections preserved through these efforts and the integration of physical, chemical and biological ocean conditions we have been able to begin to describe an oceanographic shift occurring during 2005/2006. The above figure shows (a) temperature, (b) water column stratification, (c) nitrate, (d) chlorophyll, and (e) dinoflagellate concentrations from pre-1990 to 2006. We can see El Niño's happening in 92-93 and 97-98 with evidence pointing to larger climate shifts from El Viejo (during 98-99) to a La Vieja.

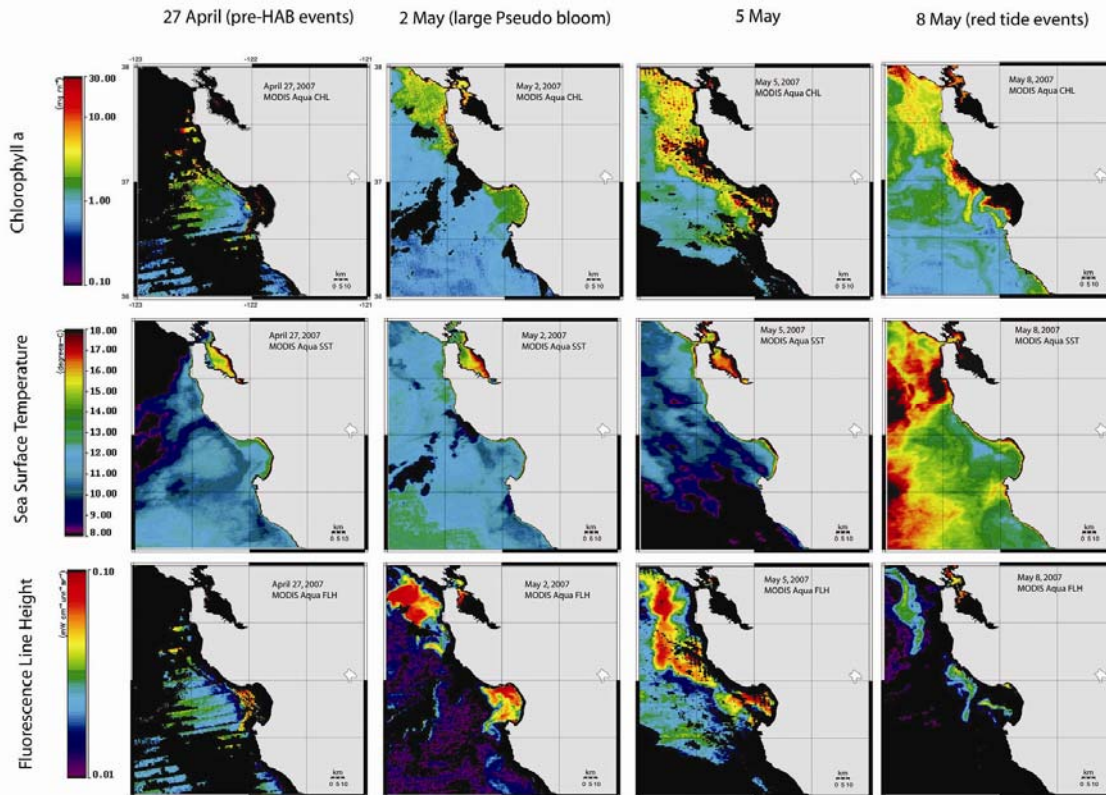


Figure 2: The sequential imagery shows a rapid warming of Monterey Bay and also suggests that the bloom occurred both within the northern part of Monterey Bay and more broadly between Monterey and San Francisco. The FLH images (bottom row) show the most intense parts of the bloom as bright red. Black regions for all images were either cloud-covered or had data that were not reliable.

In addition to our regular monitoring program, CIMT responded to the events by adding an extra cruise to track the bloom, increased offshore and onshore ocean monitoring, satellite imaging, analysis of water and tissue samples from mussels, and marine life surveys throughout Monterey Bay beaches.

Direct responses from this event included further active collaborations between several CeNCOOS member programs including CIMT and the California Program for Regional Enhancement Monitoring for PhycoToxins (Cal-PReEMPT), as well as through outreach to volunteer programs such as BeachCOMBERS and the public. Other CeNCOOS collaborators during this time included the California Department of Health Services, California Department of Fish and Game, and the Marine Mammal Stranding Network. Outreach efforts by CIMT and collaborators included a press release http://www.ucsc.edu/news_events/text.asp?pid=1292 and web-based access to related articles <http://cimt.ucsc.edu/outreach.htm>. The Harmful Algal Bloom fact sheet http://cimt.ucsc.edu/factsheets/2HaB_Factsheet.pdf was distributed at public venues, such as the Seymour Marine Discovery Center. NOAA used CIMT data for their web page and press releases http://www.cop.noaa.gov/stressors/extremeevents/hab/features/ca_pn_050807.html.

CIMT and Cal-PReEMPT researchers were also featured on Santa Cruz, Community TV programs to help inform and educate the local community on bloom events. A nice written summary of the event and collaborators can be found at <http://calpreempt.ucsc.edu/2007HABevent.htm>.

Next steps include further development of prediction capabilities and models of these events, as well as the development of an algal species library (*Image 1*) that will be made available on the web to help inform and educate.



Image 1: Phytoplankton on-line library prototype.

Center for Integrated Marine Technologies press release:

- Large blooms of toxic algae in Monterey Bay are affecting marine animals http://www.ucsc.edu/news_events/press_releases/text.asp?pid=1292
- Scientists investigate unusual ocean conditions along the U.S. West Coast http://www.ucsc.edu/news_events/press_releases/text.asp?pid=971
- Scientists concerned about potentially harmful algae persisting in Monterey Bay http://www.ucsc.edu/news_events/press_releases/text.asp?pid=646
- Expect more dead birds and sea lions to wash ashore <http://www.santacruzsentinel.com/archive/2007/May/17/local/stories/02local.htm>
- Harmful Algal Bloom in California: Pseudo-nitzschia Spreads Along Coast Causing Massive Mortalities of Marine Life http://www.cop.noaa.gov/stressors/extremeevents/hab/features/ca_pn_050807.html

Additional important result during this period was the quantification of HF radar failure modes based on site log statistics from ten HF radar sites over five years in the region around Monterey Bay. The results show that the most common failure mode is related to computer crashes at the field sites. The detailed results help to prioritize work that needs to be done to improve reliability of the real-time surface current mapping network.

Figure 3 shows the composite failure mode statistics from all sites.

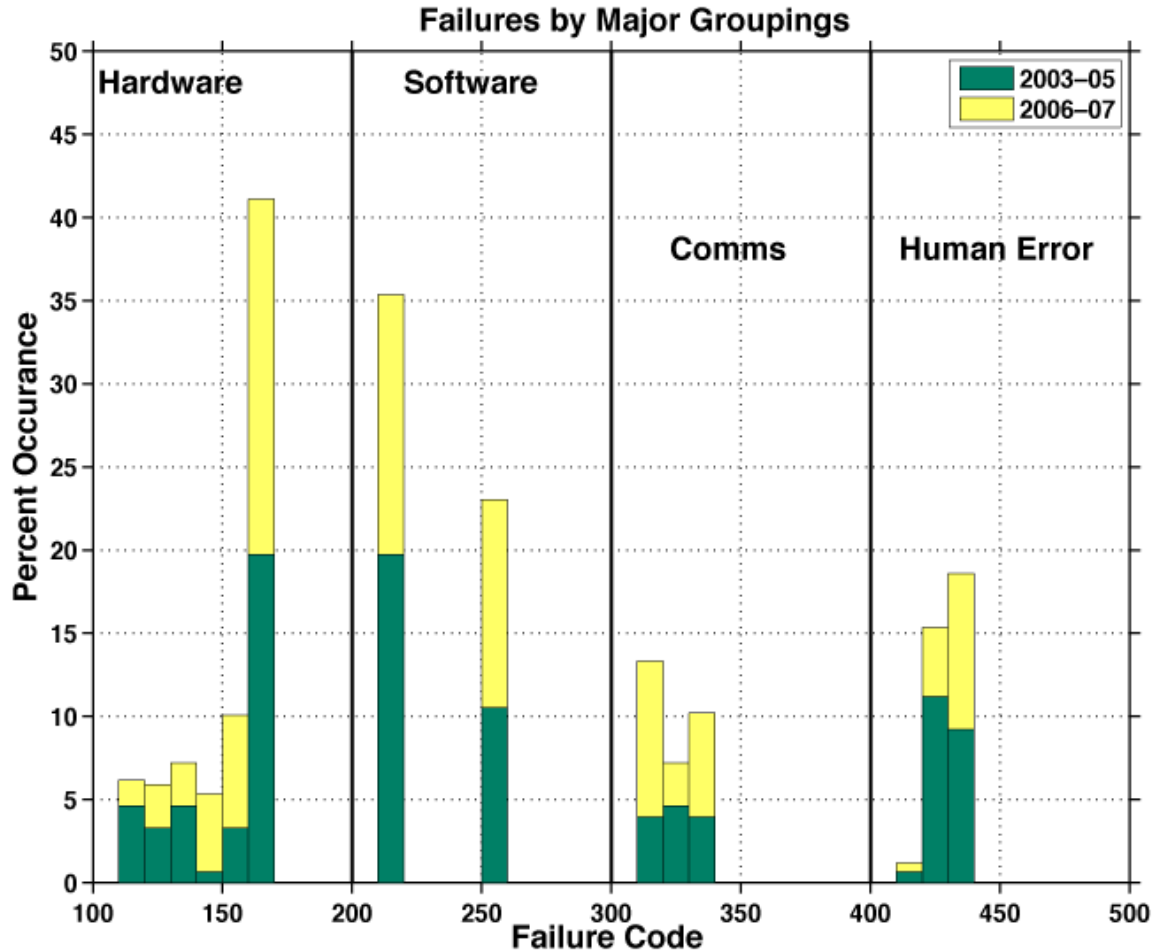


Figure 3: Failure mode statistics for ten individual HF radar sites for the area around Monterey Bay. The single largest category of failures in the Hardware grouping actually includes combined hardware and software problems that led to computer freezes or crashes.

CIMT MILESTONES

CIMT continues to meet milestones (below in **bold type** from page 31 of FY06 proposal) set out in the FY06 proposal in addition to moving ocean observing system efforts to the next level. Milestones met and additional efforts include:

- **CIMT web site revised** and hired half-time Graphic Specialist to help maintain site – 10/2006

- CIMT representatives Robison, Paduan, Chavez and Griggs continue to help the **governance within CeNCOOS** – on-going
- CIMT has developed two fact sheet **products** toward the education and outreach of ocean observing and ocean issues; CIMT fact sheets efforts have evolved into the creation of two CeNCOOS fact sheets that are currently in progress and a “Success Story” template design – on-going
 - CIMT 4 pager http://cimt.ucsc.edu/factsheets/1cimt_factsheet.pdf – 9/2006
 - HABs http://cimt.ucsc.edu/factsheets/2HaB_Factsheet.pdf -1/2007
 - Krill – in process (outline complete)
 - CeNCOOS Surface Currents – in process (outline complete, text provided)
 - CeNCOOS Animals as Ocean Sensors – in process (outline drafted)
 - CeNCOOS Success Stories – in review (initial mock ups complete)
- Talks, presentations and posters are listed in the section *Recent CIMT publications, talks & posters*. Further outreach and product development
 - EcoReview public TV show – 1/07
 - GIS static images of krill abundance 2003 – 2006
 - 2003 & 2004 completed expected available on the web in late 2007
 - 2005 & 2006 completed expected available on the web in late 2007
 - Animation of images expected available on web in late 2007
 - Progress made with ArcIMS online CIMT GIS. It will contain: (1) shipboard data from Croll lab; (2) SST images from Kudela (updated 4 times a day); and (3) points representing the moorings with links to the “real-time” online data reports. Prototype complete (*Image 2*). – in progress

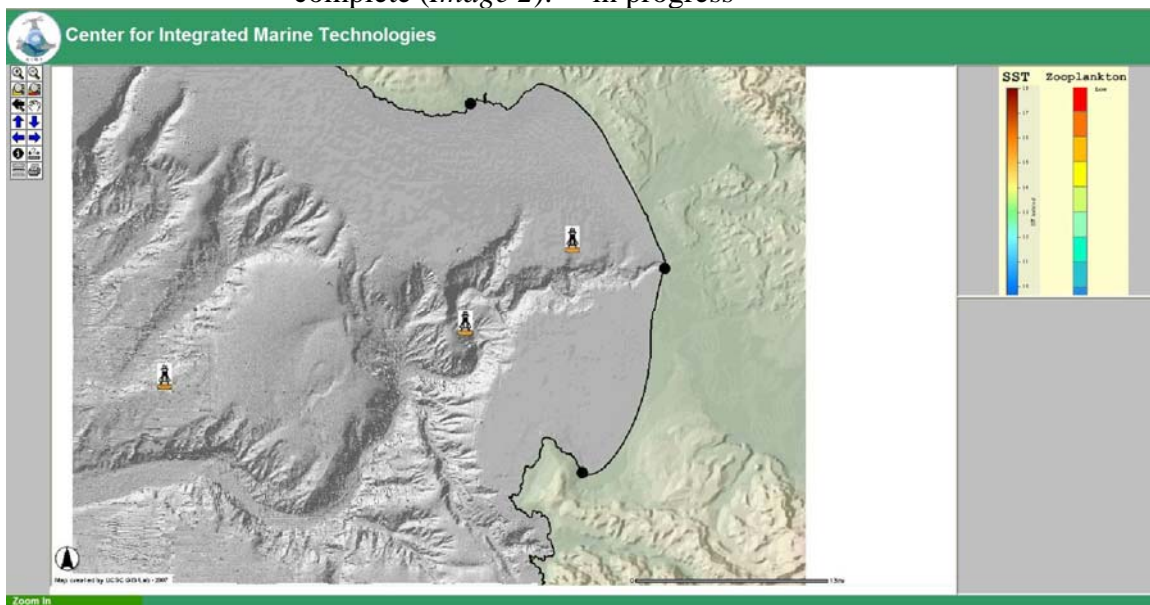


Image 2: CIMT ArcIMS online CIMT GIS Prototype. This GIS will contain SST (updated 4 times a day), Zooplankton abundance from cruises, and Mooring locations with links to real-time data.

- Hindcast animation of sealions as animal platforms (online http://cimt.ucsc.edu/oos_topp.htm)
- State of the Monterey Bay (expected completion late 2007 – mid 2008)
 - Report draft complete August 2006
 - Presentation at Sanctuary Currents Symposium March 2007
 - Product output design in process
- Toxic algal and non-harmful algal species photo library *See Image 1* (late 2007) – in progress
- Report to CCLEAN on water quality sampling integration
 - Draft report February 2007
- Press release on Red Tide events November 2006
- Press release on Spring Pseudo-nitzschia bloom event April and May 2007
See links on page 16 of this report and/or visit the CIMT website <http://cimt.ucsc.edu>.
- **Continue ship surveys:** Three CIMT cruises were completed: March 6, May 8-9, and July 10, 2007. Both observations and station work occurred on the same day in March and July with the observations from the R/V Fulmar and the hydrographic stations on the R/V John Martin. The March survey was the first time the Monterey Bay National Marine Sanctuary's vessel, the R/V Fulmar was used. *See 54 month progress report http://cimt.ucsc.edu/documents/CIMT_54mo_Progress_Report.pdf for rationale on changes to methodology.*
 - These data helped to identify a major harmful algal bloom event during the April/May, 2007 time period (*described under the CIMT COORDINATION section*). CIMT shipboard observations helped us to identify the spatial extent of this bloom. Following the May 2007 CIMT cruise, the Kudela group obtained an additional day of ship time on the R/V Fulmar to determine whether the bloom event was still occurring. CIMT coordinated closely with another NOAA-funded project, Cal-PreEMPT, to disseminate this information to the management community and public.
 - We continued to acquire data on phytoplankton community composition throughout Monterey Bay, and specifically cell densities, distribution and toxin analysis for toxin producing phytoplankton species of interest, namely *Pseudo-nitzschia australis* and *P.n. multiseriis*, producers of domoic acid, and the saxitoxin producing species *Alexandrium catanella*. *Figure 4* shows the abundance of *Pseudo-nitzschia* cells throughout Monterey Bay during the CIMT study period. As you will see there are bloom periods that occur throughout the bay, but there's no one station that consistently has higher cell densities.
 - Continuation of the databases, which are developing baseline data for toxin producing phytoplankton distribution throughout Monterey Bay, and phytoplankton community composition.
 - Nutrient data is available through the 7/2007 cruise. Particulate metal data is available through the 1/2007 cruise and available on the CIMT web site. Dissolved metal samples have been analyzed through the 7/2006 cruise.

Samples through 7/2007 were attempted on the ICP-MS but technical problems inhibited data acquisition, the samples will be re-run in the coming months.

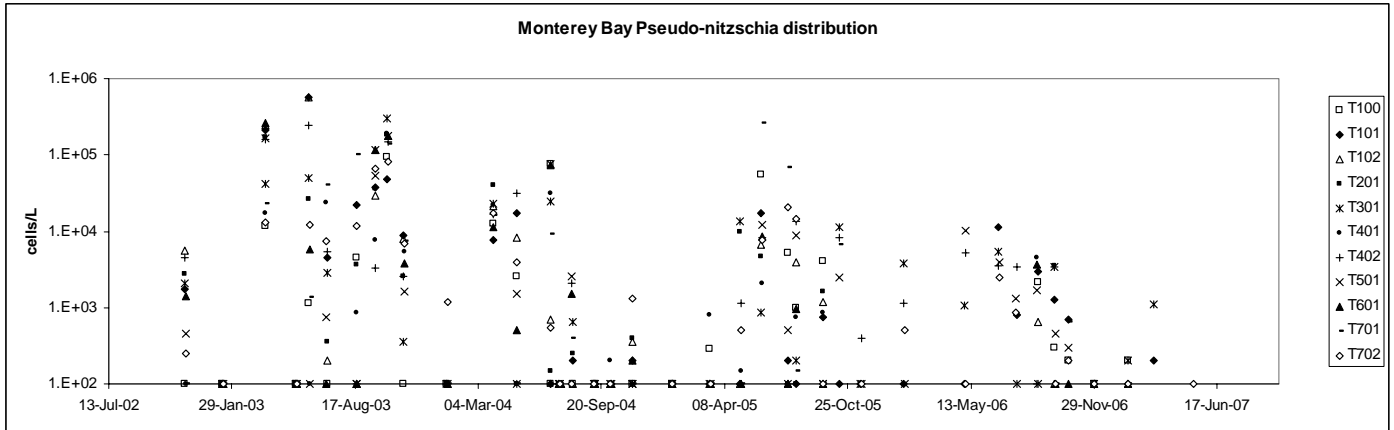


Figure 4: *Pseudo-nitzschia* distribution in Monterey Bay and CIMIT stations during entire study period.

- **Summarize multi-year HAB and plankton:** Multi-year HAB and plankton data have been summarized – 1/2007
- **Real-time composite images** have been established - 1/2007
- **Remote Sensing:** Our primary objective for the 2006 funding was to continue our successful collaborations with other regional partners, and to maintain distribution of the remote sensing data. During this 6 month time interval, one major milestone was the synthesis of the data from the COAST experiment, conducted in September 2006. The COAST project was designed to assess the need for hyperspectral remote sensing in the coastal ocean, and was funded separately by NOAA. Monterey Bay was chosen as a study site in large part because of the existing infrastructure, such as CIMIT, that would provide background context. The COAST field experiment was previously described in the 54 month progress report. Since then, we attended a COAST data workshop in Corvallis, OR, July 30-August 4, 2007. Several manuscripts were started, and data was QA/QC'd and distributed to participants.
- **Develop HAB warning algorithms:** Progress is being made on the development of HAB warning algorithms – on-going
- JPL/CIMIT is currently running the **real-time ocean model (ROM)** <http://ourocean.jpl.nasa.gov/MB06/> . – 8/2006 The remainder of this process is on-going and next steps include incorporating HF Radar assimilations development and implementation within the ROMS forecast system. We have demonstrated significant positive impact of the HF radar data in forecasting the upper ocean circulation in Monterey Bay. Further work is being done to transfer the real-time data to the CIMIT web site.
- **CIMIT has evaluated the physical model of 2003.** - 8/2006; Develop, implement, test and evaluate the Monterey Bay ROMS real-time nowcast and

forecast system that provides six hourly 3D fields of temperature, salinity and current over the Monterey Bay area.

- **Evaluate biological model:** through collaborations with Christine Peterson and Steve Ralston at NMFS the process studies of fish larval are underway and making progress with successful model runs of calculated larval dispersal statistics which can be used to help identify the export out of the region and the connectivity (average transport) from one region to another. Multi-year simulations were developed to look at the variability and work is currently being done to look at long-shore recruitment issues at a higher resolution. Further work is continuing on the model but summary statistics of what is happening in the region are available upon request. Results have been written up and are going through review for submission. Further wrap-up work on this effort will continue under PISCO funding. Findings are being directly shared with NOAA Fisheries, Steve Ralston.
- **CIMT wind model has been developed and displayed on CIMT web site** – 2006 and maintenance on-going; CIMT developers are working with CeNCOOS and CIMT coordinators to identify the best long-term home for the product. We have explored transitioning the wind page to a commercial partner (WeatherFlow) and presented that option to the CeNCOOS Governing Council, which was not ready to entertain the idea of partnering with industry. A paper has been drafted and submitted to EOS that describes the real-time wind page.
- **Complete MySQL CTD database & Establish LAS/OpenDAP access:** Database progress has been slowed due to losing our database manager during FY05. Every effort has been made to hire a replacement for this role. Database efforts have been maintained through CIMT PI (Kudela) including up-to-date data inventory of CIMT ship board surveys in a MySQL database, these data sets are available for download on-line at http://cimt.ucsc.edu/data_portal.htm . Further efforts have been made to maintain the current LAS at http://cimt.ucsc.edu/data_portal.htm through collaboration with Dave Foley at NOAA Coastwatch. This six-month interval was challenging for the database part of CIMT. We identified and hired a contractor (February 2007) to work on the CIMT project, but he subsequently declined to renew the contract, in large part because of inadequate funding. Despite these challenges, we completed a review of our hardware/software structure and database strategy, and are well positioned to improve the database if funds become available. We continue to upload shipboard data into our system, which is OPeNDAP compliant.
- **Maintain CIMT/M0:** CIMT's M0 mooring continues to be maintained and instruments updated – on-going
- **Maintenance continues to the Santa Cruz wharf CTD and fluorometer** collecting temperature, depth, salinity and fluorescence. The instrument was most recently redeployed on 8/1/07. However, we now are operating without the fluorometer, as data from water samples collected between 3/6 and 6/14/07 showed that fluorometer data were poor, likely due simply to rapid biofouling. Without a different instrument with better biofouling control, or much more frequent (probably 2 weeks or shorter) cleaning, this instrument will not provide a usable chlorophyll record. Another concern with chlorophyll measurements at this

site is the depth of the package – at 5m below the surface it may well ‘see’ a different story than that occurring in water closer to the surface. – on-going example of data collected is shown in *Figure 5*.

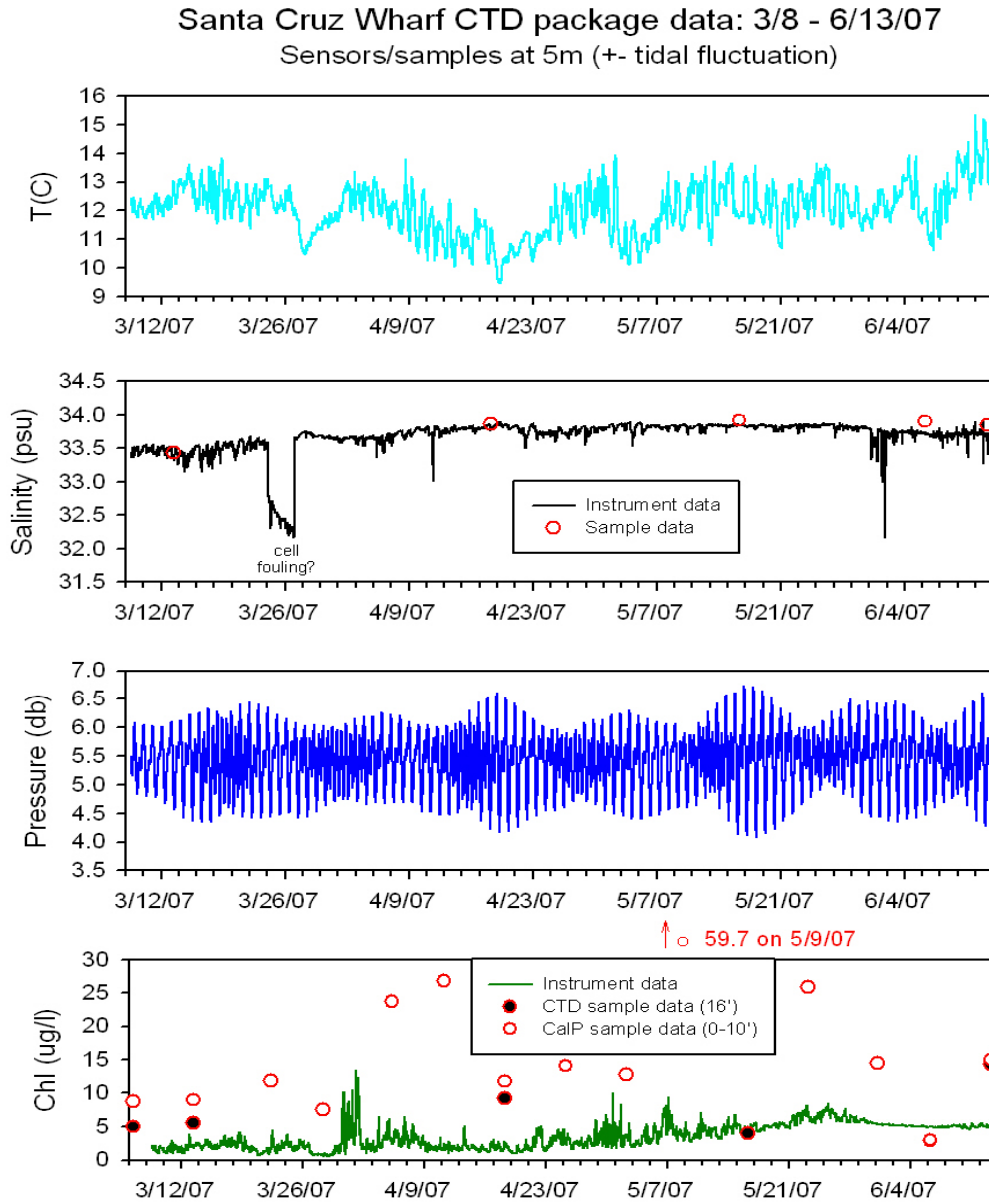


Figure 5: Santa Cruz Wharf CTD package data from March 8 to June 13, 2007. Temperature, salinity, pressure and chlorophyll are shown from top to bottom. Figure courtesy of PISCO/CIMT collaborations.

- **Install dual-freq. SeaSondes:** Dual-frequency SeaSonde was installed in Moss Landing but software for automated, 2-frequency processing is not complete.
- **Transition velocity mapping to COCMP:** This was done; basic hourly mapping is handled exclusively by COCMP technicians while CIMT programming time is being used to develop and test trajectory forecast models and other products based on the data.
- **Test 3-freq wind mapping & Test real-aperture SeaSonde:** Together with John Vesecky (UCSC) and the MCR radar at Long Marine Lab, we will be testing a 3-frequency version of their HF radar-based wind mapping algorithm after the 2-frequency radar in Moss Landing becomes operable. Hence, there has not been any progress on these items during 2006.
- **Test wave mapping & Convert to SeaSonde:** Extensive testing of the CODAR-based significant wave height, peak direction, and peak period detection algorithms is underway using data from 5 CODAR SeaSonde units in the CIMT region and validation data from offshore NOAA buoy 46042, from two shallow water wave moorings, and from wave refraction modeling based on the buoy 46042 observations. Preliminary multi-month wave time series have been produced and the quantitative assessment of the HF radar-derived wave parameters under various wind conditions is underway as part of the UCSC M.S. thesis of Daniel Atwater.
- **HF Radar Data** from 14 coastal sites along central California has been assembled and organized. Data are available online at <http://cencalcurrents.org/data.shtml> . Much of the data during the past year has been reprocessed to implement calibration changes or to correct problems with the real-time data processing. That organization is continuing. But an unprecedented amount and extent of surface current mapping data is available for analysis and for testing of short-term forecast methods that have been created to support hazardous spill response efforts. HF radar data from the central California coastal stations have been assembled on one server. Testing has begun on short-term forecast algorithms.
- **Establish real-time QC and data flows:** this part of the CIMT effort was finished up in FY05 with the no-cost extension funds. No further funds in FY06 were dedicated to this piece.
- **Real-time tracks of California sea lions and northern elephant seals with oceanography.** When tagging animal tracks will be shown in real-time on the CIMT and TOPP webpage.
- **8-day and 14-day animations of animal movements (real-time and hind casts).** Track animations of sea lion movement patterns for three years animals tagged: 2003-04, 2004-05, 2005-06. Animation was designed for display on CIMT website and for use in professional and public meetings. http://cimt.ucsc.edu/oos_topp.htm
- **Predator Considerations for Ecosystem-Based Management.** Finalize the processing, identification of all diet samples collected between 2001 and 2006. Preliminary data in press with the 2006 CalCOFI report 'State of the California Current' in 2005-06. Quantitative models to estimate annual sea lion consumption of commercially important prey species is completed for all diet data from 2001-

2006. Information on the at-sea distribution, movements, and foraging behaviors of sea lions ultimately will be used to create individual-based-models that can be used to forecast sea lion population distribution and habitat use along the California coast. Individual based models have been developed by Yann Tremblay working within the TOPP program and are currently being validated with GPS location data. We are currently evaluating and mapping sea lion distribution and movements in relation to commercial fisheries landings data using CDF&G spatial grids. Further we are evaluating sea lion data in relation to critical fish habitat, such as Marine Protected Areas and with commercial fisheries.

- **CIMT Integration**

- Kelly Newton, M.S. student with Croll has been integrating at-sea seabird abundance data with physical and biological data sets from CIMT researchers. Data sets include: sea surface temperature (M1 buoy), chlorophyll and primary productivity (Kudela), and zooplankton biovolume and krill abundance (Marinovic). She is using these and other data sets to answer questions: what drives seabird abundance in Monterey Bay and what are the oceanographic influences on seabird diversity in Monterey Bay?
- Maitreyi Ellison, undergraduate student with Edwards is working on a thesis correlating krill data (Croll, Marinovic, Newton) and local and remote measures of sea surface temperature (Kudela). Results expected August 2007.
- For the CIMT real-time wind page, M0 wind data is continually integrated with other wind measurements and COAMPS model predictions.
- For the CIMT biological modeling the M1 and M0 moorings are used for model evaluation.
- On-going efforts to update HF radar processing algorithms within CIMT and make them available to the CeNCOOS COCMP effort.
- Real-time *in-situ* water and salinity profiles: Working with Yi Chao from the NASA-AMES Jet Propulsion Laboratory to explore methods to incorporate animal-derived physical oceanographic data (temperature, salinity) into the Regional Oceanographic Model Systems (ROMS) model for the Monterey Bay region. Article on NASA Website featuring Dan Costa, Mike Weise, and Yi Chao: Satellites and Sea Lions: Working Together to Improve Ocean Models.
- Coordination of PISCO/NEOCO/CIMT wharf CTD data collection with Mary Silver and Raphe Kudela to maximize utility – CTD data is sent to Kudela, including historical NEOCO data, and have been coordinating water sampling with Jenny Quay (graduate student, Kudela), who gets an integrated 0 – 10m water sample every week from the other side of the wharf.
- CIMT data were used as part of the synthesis efforts for the COAST project.
- Many CIMT outreach efforts including the fact sheets and the ArcIMS GIS mentioned previously under this CIMT MILESTONES section are specific integration pieces that deliver products to users.

- Several integration surface contour maps have been created for visualizing CIMT data. The maps look at both the distribution of a given variable (e.g. dissolved iron) during a single cruise and possible correlations between variables over many cruises. An example is shown in the *Figure 6*. This is an example of preliminary analyses and intuitions that we are able to gain from looking at the CIMT datasets in this way.

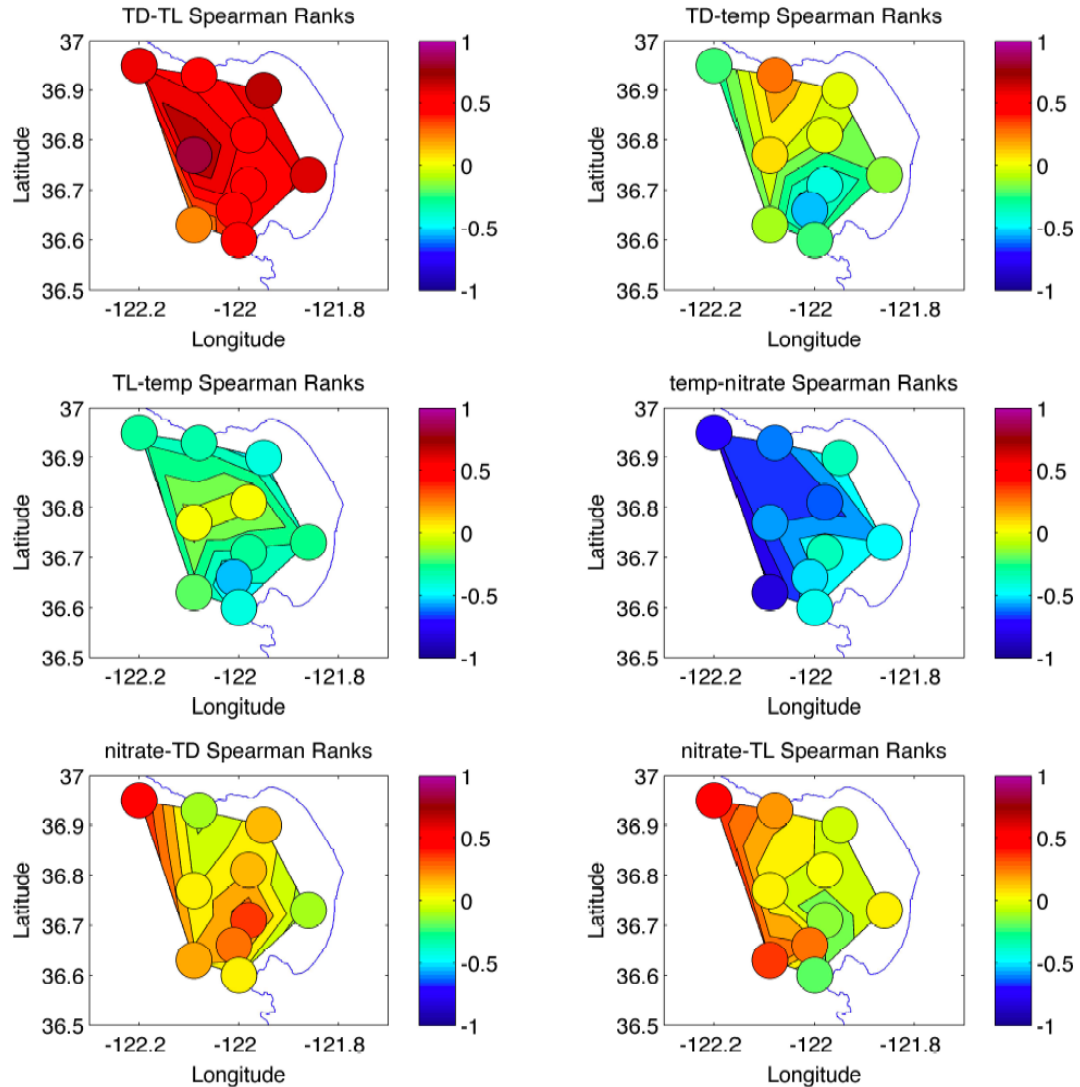


Figure 6: Contour maps of Spearman Rank correlation between the variables noted: TD- Total dissolved iron concentration; TL- Total leachable iron concentration; Temp- Temperature; Nitrate- Nitrate concentration. The large circles represent the stations and the area between stations has been interpolated from the station data. In these figures we have used a spearman rank correlation method to look at the degree of correlation between a series of different variables. Regions of the bay that show up either dark red/purple or deep blue have shown (over all cruises from 2003-2005) either a strongly positive or strongly negative correlation between the variables noted. The plot in the upper right, for example,

indicates that over the cruises during those three years T601 has had a stronger negative correlation between dissolved iron and temperature than have the stations in the middle of the bay (i.e. at T601 we have see higher iron concentrations with colder waters). The plot directly below indicates that nitrate and temperature are fairly strongly negatively correlated throughout the bay.

- **CIMT research contributions to management decisions or public outreach.**
 - **Fisheries Management:** CIMT data, in collaboration with Moss Landing Marine Labs, on the food habits of California sea lions has been used to model the impacts of pinnipeds on listed Salmon and rockfish stocks for federal management agencies. The Pacific Fisheries Management Council and the National Marine Fisheries Service are both using this information to better inform management decisions.
 - **Oceanographic Conditions:** Working with Yi Chao, of the NASA Jet Propulsion Lab, CIMT has validated the use of temperature profiles of the water column collecting during dives by instrumented adult male California sea lions. This environmental data will be fed into ocean climate models developed by Yi Chao to predict coastal oceanographic conditions.
 - Provided “rapid response” remote sensing products for the **HAB event** to UCSC, California Department of Public Health, NOAA, UC Santa Barbara, and University of Southern California.
 - Provided information relevant to the **HAB outbreak** in Spring 2007 to the California Department of Public Health, the MBNMS, and the California Department of Fish and Game. This was a joint effort with Cal-PReEMPT.
 - Co-hosted with Cal-PReEMPT the “**Algal Bloom Workshop**” California Water Boards Training Academy, Santa Cruz, CA. This was a hands-on workshop for local, regional, and state managers dealing with water quality issues in California, and was attended by about 40 people.
 - Pseudo-nitzschia distribution and abundance data was used in conjunction with marine mammal stranding and fecal data to produce a report working with The Marine Mammal Center in Sausalito, looking at the **effect of Pseudo-nitzschia on pelagic food webs**.
 - The biological model evaluations and statistics for the **larval dispersal model** are shared directly with Steve Ralston at NMFS. There is interest amongst MPA/MLPA community in California for these efforts.
 - Researchers participating in radio/NPR and community TV programs in addition to press releases and news articles. Visit <http://cimt.ucsc.edu/resources.htm> for links to these events.
 - **HF radar demonstration booth** CIMT in conjunction with COCMP at the “Teen Thrive” youth environmental outreach event at the UC MBEST Center, Marina, California.
 - The **CIMT real-time wind page** is part of the nationwide inventory of real-time environmental data and model products intended for internal U.S. Coast Guard use. These products are used by the U.S. Coast Guards

Search and Rescue Optimal Planning System as well as for operational planning

The monthly outlines below include CIMT specific highlights over the past six-months (February – July 2007).

FEBRUARY 2007

Robison and Beach meet individually will CIMT principles from 1/24 – 2/16/2007 to identify progress and next steps.

- 24 January: Raphe Kudela/UCSC
- 25 January: Dan Costa and Mike Weise – UCSC/TOPP
- 26 January: Chris Edwards/UCSC
- 26 January: Mark Carr and Dan Hoover – UCSC/PISCO
- 29 January: Baldo Marinovic/UCSC
- 1 February: Ken Bruland and Sherry Lippett -UCSC
- 5 February: Jeff Paduan/NPS/COCMP, David Kaplan/UCSC, Mike Cooke/NPS, and Jack Harlan/NOAA
- 8 February: Steve Lonhart/MBNMS
- 8 February: Mary Silver and Katie Roberts - UCSC
- 12 February: Jim Harvey/MLML
- 15 February: Don Croll and Kelly Newton - UCSC
- 16 February: Call with Yi Chao/JPL
- 16 February: Brian Fulfrost/UCSC
- Principles: Francisco Chavez/MBARI, Leslie Rosenfeld/NPS, Scott Benson/NMFS and John Largier/UC Davis provided written comment. Chris Clark/Cornell no update on progress.

- 1 February: Robison and Laura Beach, CIMT Poster for MBNMS Currents Symposium
- 12 February: CIMT Steering Committee Call; Focus: Progress Report and Funding Opportunities - Griggs, Chavez, Kudela, Croll, Edwards, Paduan and Robison
- 14 February: CIMT research photos submitted to SIMoN photo catalogue

MARCH 2007

- 13 March: Leslie Rosenfeld initiated a request to CeNCOOS to help fund continued operation of the Naval Research Lab's high resolution COAMPS runs for central California. This led to a decision by FNMOC to run COAMPS on its computers. At the Workshop for Environmental Modeling of the Central California Coast (August 15, 2007), numerous academic and government users who have used the high resolution COAMPS weather forecasts for central California praised this model. CIMT was instrumental in giving visibility to the model, and advocating for its continued operation.
- 14 March: CIMT Program Budget Overview - Robison and Michele Tashima (UCSC Accountant)
- 15 March: Program Review and Outlook - Robison and Griggs
- 19 March: CIMT Steering Committee call; Focus: NCTE request process; Sea Grant proposal- Griggs, Paduan, Chavez, Edwards, Croll, Kudela, Robison

23 March: Robison with Paul Siri: outlook of CIMT funding and potential for state support

APRIL 2007

Applied for NOAA BAA funding

A paper was drafted and submitted to EOS that describes the CIMT real-time wind page.

5 April: Sherry Lippet (Bruland Lab) with Robison; progress on nutrient analysis and integration with CIMT data *See Figure 6.*

29 April 2007: Paduan hosted a HF radar demonstration booth in conjunction with COCMP at the “Teen Thrive” youth environmental outreach event at the UC MBEST Center, Marina, California.

MAY 2007

Requested No Cost Time Extension with NOAA

Provided “rapid response” remote sensing products for the HAB event to UCSC, California Department of Public Health, NOAA, UC Santa Barbara, and University of Southern California.

*“Ocean scientists **Raphael Kudela** and **Mary Silver** were featured in coverage of the harmful algal bloom in Monterey Bay by the Santa Cruz Sentinel, Monterey County Herald, Salinas Californian, and local newscasts on KSBW and KPIX-TV. And Mary Silver was featured in a Santa Cruz Sentinel article about research on the oceans' ability to absorb and store excess carbon dioxide from the atmosphere. . . .” (UCSC News)*

4 May: Robison with Cindy Plasman (UCSC Grants Manager) – update

7 May: Outreach Update - Robison and Beach

10 May: Program Update - Griggs and Robison

10 May: Robison and Beach: Strategize outreach and response to DA event happening off California and focus on Monterey Bay

12 & 13 May: Raphe Kudela, Mary Silver and Jason Smith were seen on community television, Santa Cruz County Public Access discussing the health of the world's oceans, in particular responses to the recent HAB events in Monterey Bay and throughout California.

14 May: CIMT Steering Committee Call; Focus: Database contract; DA event response-Griggs, Kudela, Edwards, Chavez, Paduan, Robison, Croll

15 May: Outreach Update – Robison and Beach

15 May: Terri Sigeler and Robison discuss Marine Mammal Stranding Network response and findings during HAB event

16 May: Press Release for UCSC News on Large blooms of toxic algae in Monterey Bay are affecting marine animals. By Tim Stephens. CIMT featured scientists and collaborators include: Raphe Kudela, Mary Silver, Jim Harvey, Don Croll, Cal-PreEMPT, Department of Fish and Game, Monterey Bay National Marine Sanctuary's BeachCOMBERS program,

- 17 May: Santa Cruz Sentinel published the article: Expect more dead birds and sea lions to wash ashore. By Roger Sideman.
- 21 May: Julie Berett-Heffington, Director Seymour Marine Discovery Center and Wendellin Montciel, Enrichment Programs Manager Exhibits and Enrichment Seymour Marine Discovery Center
- 27-31 May: Paduan attended the 7th International Radiowave Oceanography Workshop in Cancün, México and presented results from the CIMT and COCMP effort to quantify HF radar failure modes. *The presentation citation is under recent publications, talks, posters below.*
- 29 May: Meredith Armstrong Howard PhD defense. CIMT data supported research, student of Kudela and Silver.
- 30 May: Wendelin of the Seymour Marine Discovery Center and Robison meet to identify CIMT visuals that could be used in educational exhibits
- 30 May: Amber Mace, CA Ocean Protection Council Science Director – state perspective

JUNE 2007

- 8 June: Outreach Update - Beach and Robison
- 13-14 June: Co-hosted with Cal-PReEMPT the “Algal Bloom Workshop” California Water Boards Training Academy, Santa Cruz, CA. This was a hands-on workshop for local, regional, and state managers dealing with water quality issues in California, and was attended by about 40 people.
- 28 June: MBCORC meeting at the Monterey Bay Aquarium - Robison

JULY 2007

- Presentation on the *Status of marine mortalities in central CA & Domoic Acid*. Monterey Bay National Marine Sanctuary Research Activity Panel, July 2007.
- 12 July: Program Update - Robison and Griggs
- 18 July: CIMT Steering Committee Meeting at Long Marine Lab, Santa Cruz, CA; Focus: NCTE FY07 - Paduan, Griggs, Chavez, Edwards, Croll, Robison, Kudela and Kerkering
- 22-26 July: Robison attends Coastal Zone, presents poster on CIMT, attends West Coast Governors Meeting on 25 July for CeNCOOS and CIMT.
- 30 July – August 4: COAST data workshop in Corvallis, OR. - Kudela

RECENT CIMT PUBLICATIONS, TALKS & POSTERS:

Howard, M.D.A., **Silver, M.**, and **Kudela, R.M.** Yessotoxin detected in mussel (*Mytilus californicus*) and phytoplankton samples from the U.S. west coast. *Harmful Algae* (in revision)

Kudela, R. M. *From Genomes to Satellites: An Integrated Approach to Improving Monitoring and Detection of Harmful Algae*, Monterey Bay National Marine Sanctuary Symposium, Sanctuary Currents 2007, *The Ocean Revealed: Observing Systems for Healthy Oceans*. Monterey, CA. 3 March 2007.

- Kudela, R. M.** *Ecology of Marine Phytoplankton Blooms in California: Factors Contributing to Blooms*. Understanding Algal Blooms Workshop, California Water Boards Training Academy, Santa Cruz, CA. 13-14 June 2007.
- Kudela, R. M.** *Status of marine mortalities in central CA & Domoic Acid*. Monterey Bay National Marine Sanctuary Research Activity Panel, July 2007.
- Kudela, R.M.,** Ryan, J.P. Blakely, M., Lane, J.Q., and Peterson, T.D. Linking the physiology and ecology of *Cochlodinium* to better understand harmful algal bloom events: a comparative approach. *Harmful Algae*. (revised, pending acceptance).
- Kudela, R.M.,** J.Q. Lane, and W.P. Cochlan. The Potential Role of Anthropogenically Derived Nitrogen in the Growth of Harmful Algae in California, USA. *Harmful Algae* (accepted).
- Newton, K.,** H. Nevins, **S. Benson, J. Harvey,** and **D. Croll.** At-Sea Mortality Patterns of Monterey Bay Seabirds. 34th Annual Meeting of the Pacific Seabird Group. Pacific Grove, CA. February 2007.
- Newton, K.,** H. Nevins, **S. Benson, J. Harvey,** and **D. Croll.** At-Sea Mortality Patterns of Monterey Bay Seabirds. Monterey Bay National Marine Sanctuary Currents Symposium. Monterey, CA. 3 March 2007.
- Paduan, J.D.,** J. Figueroa González, D.P. Atwater, **M.S. Cook,** S. Cosoli, and A. Mazzoldi, 2007: Multi-year HF radar network failure statistics plus a look at wind-induced noise. 7th International Radiowave Oceanography Workshop in Cancün, México.”
- Robison, R.J., L. Beach, R. Kudela, M. Silver, K. Roberts, D. Costa, M. Weise, C. Edwards, M. Carr, D. Hoover, L. Rosenfeld, Y. Chao, G. Griggs.** *The Center for Integrated Marine Technologies Observing Ocean Health in Monterey Bay*. Monterey Bay National Marine Sanctuary Currents Symposium; Theme: Ocean Observing. Monterey, CA. 3 March 2007.
- Robison, R.J., L. Beach, R. Kudela,** H. Kerkering, **G. Griggs.** *The Center for Integrated Marine Technologies: Long-term Ocean Observing System in Monterey Bay, Improving the Understanding of Ocean and Coastal Ecosystems*. Coastal Zone 07: Brewing Local Solutions to Your Coastal Issues. Portland, OR. 22-26 July 2007.
- Rosenfeld, L.K.,** I. Shulman, **M.S. Cook, J.D. Paduan,** and L. Shulman, 2006: Development of a tidal model for central California. *Deep-Sea Res.*, Submitted.
- Ryan, J.P., A.M. Fischer, **R.M. Kudela,** J.F.R. Gower, S.A. King, R.M. Marin III, and **F.P. Chavez.** Dinoflagellate red tide bloom dynamics of the upwelling shadow in Monterey Bay, California. (submitted to *Harmful Algae*, June 2007).

- Shadden, S.C., F. Lekien, **J.D. Paduan**, J.E. Marsden, and **F.P. Chavez**, 2006: Transport barriers in Monterey Bay. *Deep-Sea Res.*, Submitted.
- Shulman, I., K. Kindle, P. Martin, S. deRada, J. Doyle, B. Penta, S. Anderson, **F. Chavez**, **J. Paduan**, and S. Ramp, 2007: Modeling of upwelling/relaxation events with the Navy Coastal Ocean Model. *J. Geophys. Res.*, 112, doi: 10.1029/2006JC003946.
- Shulman, I., **J.D. Paduan**, 2006: Assimilation of HF radar-derived radials and total currents in the Monterey Bay area. *Deep-Sea Res.*, Special AOSN Issue, Submitted.
- Wang, X., **Y. Chao**, C. Dong, J. Farrara, Z. Li, J.C. McWilliams, **J.D. Paduan**, and **L.K. Rosenfeld**, 2007: Modeling Tides in Monterey Bay, California. *Deep-Sea Res.*, Submitted.
- Weise, M.J.**, and **D. P. Costa** (2007) *Individual-based foraging strategies in male California Sea Lions (Zalophus californianus)*. Society for Integrative and Comparative Biology Conference. Phoenix, Arizona.
- Weise, M.J.**, and **D. P. Costa** (2007) Tagging of Pacific Pelagics: From the bottom Up. Animal Tracking and Physiological Monitoring Workshop. Princeton University. Princeton, NJ.
- Weise, M.J.**, and **D. P. Costa**. 2007. Total Body Oxygen Stores and Physiological Diving Capacity of California Sea Lions as a Function of Sex and Age. *Journal of Experimental Biology*. 210:278-289.
- Weise, M.J.**, and **D. P. Costa**. Diving behavior and foraging strategies of the male California sea lion (*Zalophus californianus*). *Journal of Animal Ecology*. February 2007.

BUDGET EXPENDITURES

Table 2: Balance for the
 University of California, Santa Cruz
 Center for Integrated Marine Technologies
 1-Feb-07 to 31-July-07 period
 on award:
 NOAA NA16OC2936

	Balance 1- Feb-07	Total obligations & expenditures Aug-02-July- 07	Remaining Balance for NCTE
Staff Salaries	\$0.00	\$1,728,306.72	\$175,230.28
Retirement & Employee Benefits	\$58,909.49	\$319,738.20	\$34,882.80
Non-Capital Expenditure - Budget	\$49,476.82	\$402,425.70	-\$6,897.67
Capital Expenditure - Budget	-\$15,683.76	\$641,048.02	-\$11,107.02
Domestic Travel	\$13,612.20	\$40,057.14	\$21,292.86
Foreign Travel	-\$1,167.04	\$2,419.37	-\$2,419.37
General Assistance	\$321,410.13	\$0.00	\$0.00
Tuition & Fees	\$45,959.56	\$82,904.48	\$91,251.52
Subcontacts	\$0.00	\$2,975,611.00	-\$6,000.00
Participant Support	\$0.00	\$0.00	\$32,000.00
Indirect Costs	\$232,905.06	\$156,888.27	-\$26,203.90
Total	\$705,422.46	\$6,349,398.90	\$302,029.50

CIMT’s remaining balance for FY07 NCTE is \$302,029.50. Commentary on expenditures that differ from budget justification submitted with proposal FY06 follow.

- Graphic Specialist (Staff Research Associate II) has been supported 50% time for four months.
- Coordinator has used travel funds, in and around Monterey Bay for CIMT and CeNCOOS related meetings and outreach. Domestic travel was also used by staff and graduate students to attend conferences like Coastal Zone 2007 (July 2007).
- Production of CIMT’s printed outreach materials.
- Database manager position was offered as a staff position through the University of California, Santa Cruz. The position was advertised for approximately six months. Only one qualified applicant applied. The position was offered and the position turned down. We have moved forward with contracting out the work needed on the database system. The contractor was hired and worked through the first phase of three phases of the contract.
- All subcontract have been paid out.
- CIMT requested and received approval for a no-cost extension for FY07, we don't anticipate any major changes in goals, outcomes, or personnel *more detail below*.

CIMT will continue to operate in part under NCTE funds granted by NOAA, COTs beginning in August 2007. CIMT Steering Committee met on July 18, 2007 to discuss status of program and identify the best mechanism for completing the program prior to loss of total funds. We invited CeNCOOS Coordinator, Kerkering to take part in this discussion. During the NCTE:

- The M0 mooring will be supported through July 2008, at which time, unless funds are made available the mooring will be removed from the water and be offline.
- CIMT will only participate in two more ship surveys, August and October 2007. September and November cruises were cancelled. It was determined that the best time series would be kept by the August and October cruises.
- CIMT's Coordinator and Graphic Specialist will be supported as long as possible through 12/07 with the possibility of extension to 6/08, to finalize some publications, commitments to CeNCOOS, and a lessons learned piece, in addition to day to day operations of the program.
- Most CIMT researchers funds are gone or will be completely depleted in December of 2007. During the NCTE researchers plan to continue the valuable time series data collection if and when possible but efforts will be focused on the continued analysis of data and preparation of publications.
 - Weise, M.J., and D. P. Costa. Habitat associations of the California sea lion foraging in the California Current System. *Marine Ecology Progress Series*.
 - Newton, K. Thesis: *At-sea mortality of Monterey Bay seabirds*.
 - Harmful Algal Bloom Meeting in Woods Hole 10/2007; three posters containing CIMT data will be presented
 - Vigilant, V.L., V. Apkenas, and M.W. Silver. *The sediment as a potential long-term source of DA to an estuarine invertebrate in Elkhorn Slough, California*.
 - Vigilant, V.L. Thesis: *The Occurrence of the Harmful Algal Bloom Toxin, Domoic Acid, in Nearshore and Offshore Benthic Communities of Monterey Bay, California*.
 - Sutherland, C. Thesis: Title TBD
 - Curtiss, C. Thesis: Title TBD; using CIMT community composition data
- Real-time wind page efforts have no remaining funding, but researchers plan to finish the paper submitted to EOS (April 2007) and will continue to troubleshoot and keep the wind page going, if they can, aiming toward a transition to a more permanent home in the next few months.
- HF Radar funds have been completely expended. Collaborative work will continue with CeNCOOS via COCMP.
- ROMS: we are currently able to assimilate the remote sensing data from satellite observations in real-time. The HF radar data assimilation has been developed and tested. In the coming NCTE year we plan to implement the HF radar data assimilation in our real-time forecast system, and produce a multi-year re-analysis using the CIMT in-situ data.
- Continue normal operations of the CTD at the SC wharf.
- Remote Sensing efforts that will continue include QA/QC the existing shipboard data and get it into the database, participate in the remaining 2 (August & October

2007) cruises, and pay a programmer to continue working with the remote sensing data. We will continue (through CeNCOOS and Cal-PReEMPT) the Santa Cruz Wharf sampling for nutrients, HABs, and indicator bacteria.

- Several proposals and efforts have been made to several venues to try to identify additional support for CIMT operations.

REFERENCES

Barber RT, RL Smith. 1981. Coastal upwelling ecosystems. In: Longhurst A. (ed) Analysis of marine ecosystems, Academic Press, New York, pp. 31-68.

Benson SR, DA Croll, B Marinovic, FP Chavez and JT Harvey. 2002. Changes in the cetacean assemblage of a coastal upwelling ecosystem during El Niño 1997-98 and La Niña 1999. Progress in Oceanography.

Breaker LC and WW Broenkow. 1994. The circulation of Monterey Bay and related processes. Oceanography and Marine Biology: An Annual Review, 32: 1-64.

Chavez F, JT Pennington, R Herlien, H Jannasch, G Thurmond and GE Friederich. 1997. Moorings and drifters for real-time interdisciplinary oceanography. J. Atmos. Oceanic Tech. 14: 1199-1211.

Chavez FP, JT Pennington, CG Castro, JP Ryan, RP Michisaki, B Schlining, P Walz, KR Buck, A McFadyen and CA Collins. 2002. Biological and chemical consequences of the 1997-98 El Niño in central California waters. 54: 205-232.

Chavez FP, JP Ryan, S Lluch-Cota and M Niquen. 2003. From anchovies to sardines and back-Multidecadal change in the Pacific Ocean. Science. 299: 217-221.

Graham WM. 1993. Spatio-temporal scale assessment of an "upwelling shadow" in Monterey Bay, California. Estuaries 16:83-91.

Hutchings L, GC Probyn and TA Bailey. 1995. The chemical and biological consequences of coastal upwelling. In: Summerhayes CP, Emeis KC, Angel MV, Smith RL, and Zeitzschel B. (eds). Upwelling in the ocean: Modern processes and ancient records. Wiley and Sons, New York, pp. 64-81.

Kudela RM and FP Chavez. 2000. The impact of the 1992 El Niño on new production in Monterey Bay, California. Deep-Sea Res. II 47: 1055-1076.

Kudela RM and FP Chavez. 2002. Multi-platform remote sensing of new production in central California during the 1997-1998 El Niño. Progr. Oceanogr. 54: 233-249.

Kudela RM and RC Dugdale. 2000. Regulation of phytoplankton new production as determined by enclosure experiments with nutrient additions in Monterey Bay, California. Deep-Sea Res. II 47: 1023-1053.

- Kudela, R., G. Pitcher, T. Probyn, F. Figueiras, T. Moita, and V. Trainer. 2005. Harmful Algal Blooms in coastal upwelling systems. *Oceanography* 18(2): 184-197.
- Malone TS. 2001. The coastal component of the U.S. Integrated Ocean Observing System. Ocean.US. program document. <http://www.ocean.us/documents/EMAP-2001-paper.pdf>
- McGowan JA, CB Chelto, and A Coversi. 1996. Plankton patterns, climate and change in the California Current. *Cal COFI Rep.* 37: 45-68.
- McGowan JA, DR Cayan and LM Dorman. 1998. Climate-ocean variability and ecosystem response in the Northeast Pacific. *Science* 281: 210-217.
- Paduan JD, LK Rosenfeld. 1996. Remotely sensed surface currents in Monterey Bay from shore-based HF radar (Coastal Ocean Dynamics Application Radar), *Journal of Geophysical Research*, 101, 20669-20686.
- Parrish R, A Bakun, DM Husby and CS Nelson. 1983. Comparative climatology of selected environmental processes in relation to eastern boundary current pelagic fish reproduction. FAO report.
- Pennington JT and FP Chavez. 2000. Seasonal fluctuations of temperature, salinity, nitrate, chlorophyll and primary production at station H3/M1 over 1989-1996 in Monterey Bay, central California. *Deep-Sea Res. II* 47: 947-973.
- Rosenfeld LK, FB Schwing, N Garfield and DE Tracy. 1994. Bifurcated flow from an upwelling center: a cold water source for Monterey Bay. *Continental Shelf Research* 14:931-964.
- Schrader GC. 1981. Seasonal cycles of phytoplankton in relation to the hydrography of Monterey Bay. Moss Landing Marine Lab. Tech Publ. 81-2, 92 pp.
- Service SK, JA Rice and FP Chavez. 1998. Relationship between physical and biological variables during the upwelling period in Monterey Bay, CA. *Deep-Sea Research II*, 45, 1669-1685.
- Sherman K. 1991. Yields, Models, and Management of Large Marine Ecosystems. Pp. In: *Food Chains*. (eds) K Sherman, LM Alexander and BD Gold. Westview Press, Boulder, CO. pp 1-34.
- Strub PT, PM Kosro, A Huyer. 1991. The nature of the cold filaments in the California Current System. *JGR*. 92: 1507-1527.
- Waidelich R. 1976. Seasonal and spatial fluctuations of the phytoplankton in Monterey Bay. MS thesis. California State University at Hayward. 124 pp.