



CIMEC

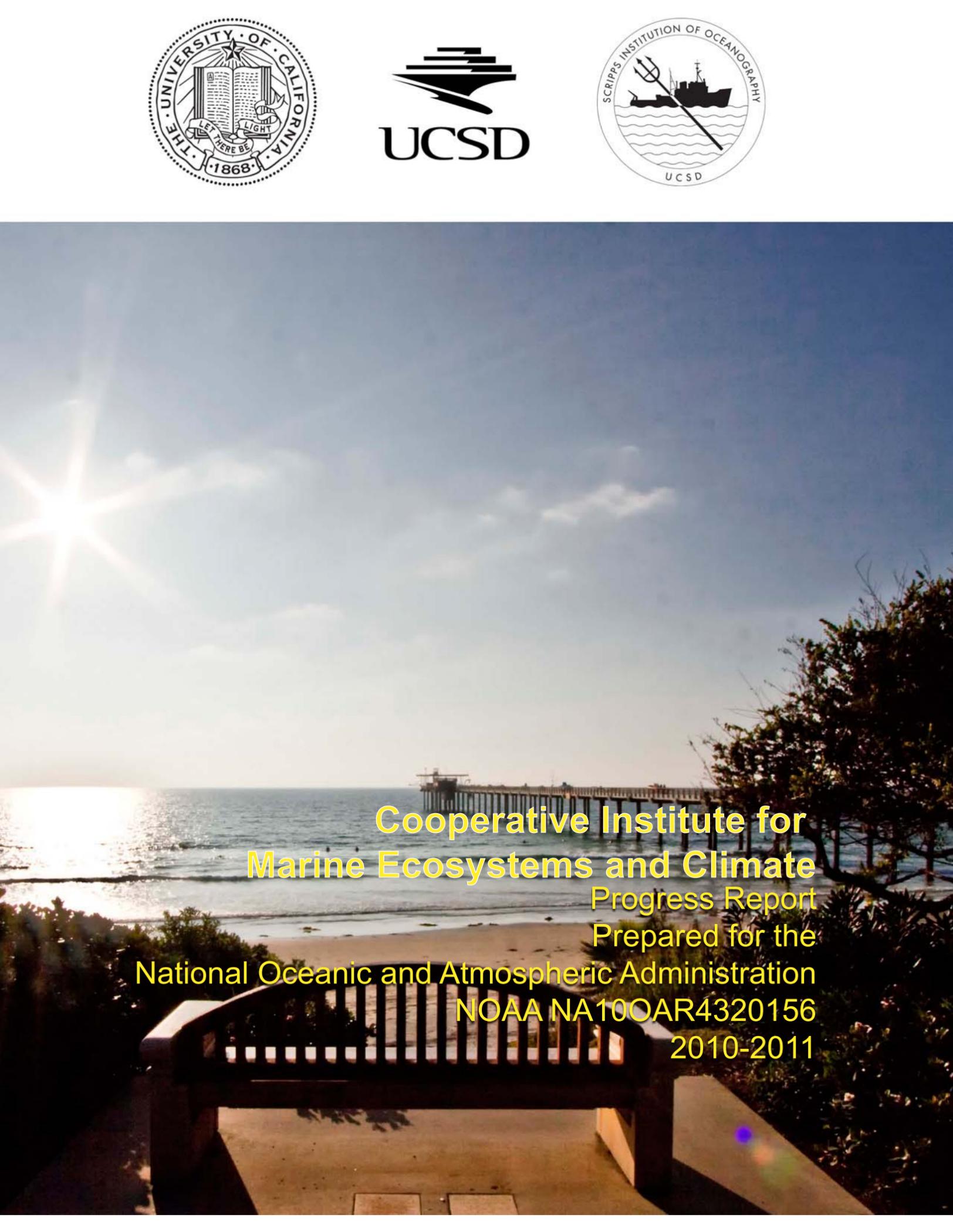
Cooperative Institute for Marine Ecosystems and Climate

Scripps Institution of Oceanography, UCSD
California State University Los Angeles
Humboldt State University
University of California Davis
University of California Los Angeles
University of California Santa Barbara
University of California Santa Cruz

PROGRESS REPORT

2010-2011





**Cooperative Institute for
Marine Ecosystems and Climate**
Progress Report
Prepared for the
National Oceanic and Atmospheric Administration
NOAA NA10OAR4320156
2010-2011



CIMEC

Cooperative Institute for Marine Ecosystems and Climate (CIMEC)

Scripps Institution of Oceanography

University of California, San Diego

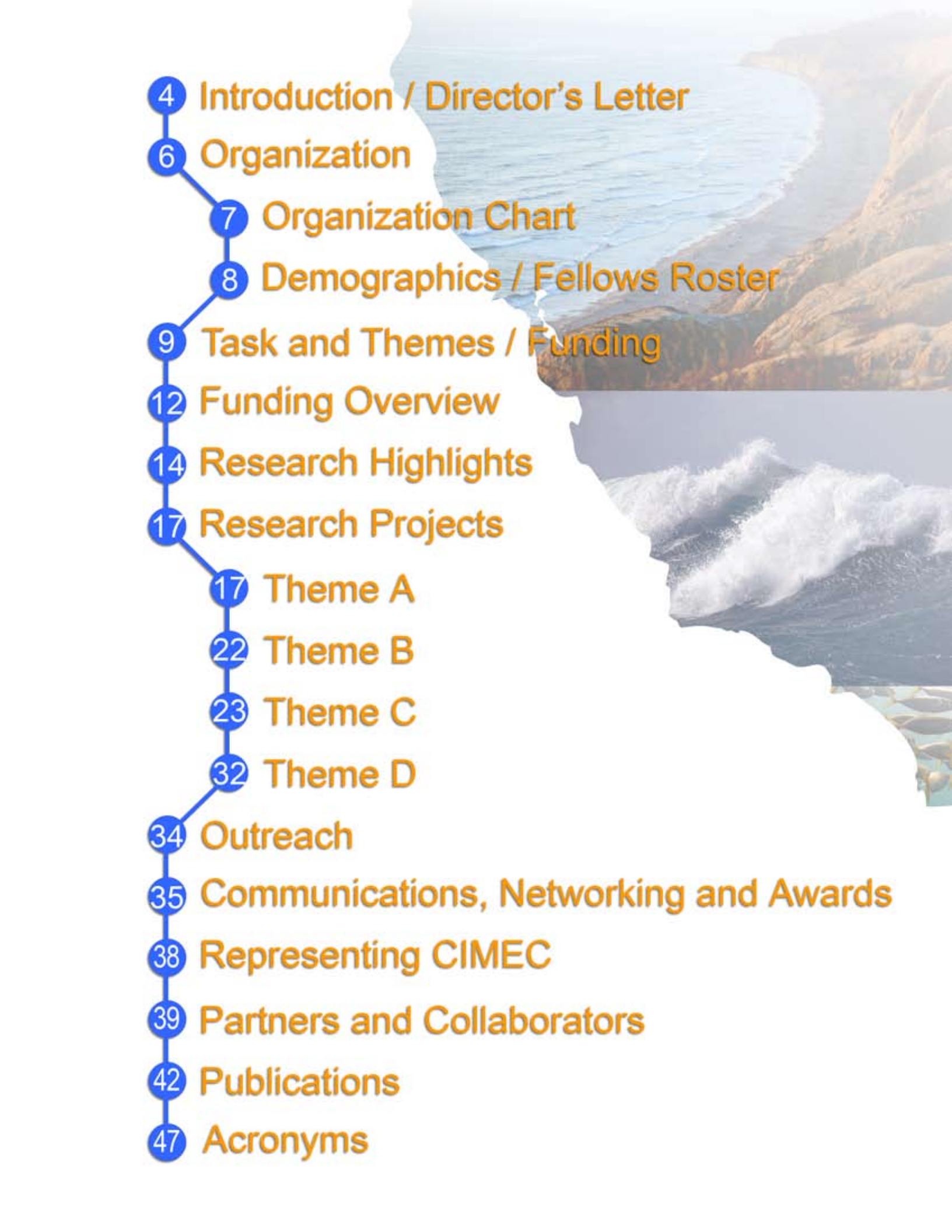
291 Rosecrans Street

San Diego, California 92106

Phone: (858) 534-1795

Fax: (858) 822-0665

<http://www.cimec.ucsd.edu>



4	Introduction / Director's Letter
6	Organization
7	Organization Chart
8	Demographics / Fellows Roster
9	Task and Themes / Funding
12	Funding Overview
14	Research Highlights
17	Research Projects
17	Theme A
22	Theme B
23	Theme C
32	Theme D
34	Outreach
35	Communications, Networking and Awards
38	Representing CIMEC
39	Partners and Collaborators
42	Publications
47	Acronyms



INTRODUCTION

The Cooperative Institute for Marine Ecosystems and Climate (CI-MEC) research and program activities for the first year (2010-2011) of the **National Oceanic and Atmospheric Administration** (NOAA) grant **NA10OAR4320156** are outlined in this report. CI-MEC is affiliated with the **Scripps Institution of Oceanography** (SIO), a multi-disciplinary Institution for ocean, climate, earth and environmental research as part of the University of California, San Diego (UCSD) campus and greater University of California (UC) system. Included in this report are the individual projects, activities and accomplishments of CI-MEC researchers and partners at SIO, UC and Cal State, as well as other collaborating organizations associated with CI-MEC.

CI-MEC's purpose is to facilitate and enhance research cooperation between NOAA entities and SIO, in particular, and the University of California (UC) and California State Universities (Cal State), in general, pertinent to the mission of NOAA.

During the July 1, 2010 to March 31, 2011 period, the NOAA research entities listed below were engaged with SIO as part of CI-MEC in marine, atmospheric and climate research, education and outreach efforts, data collection, and collaborative activities:

- Office of Oceanic and Atmospheric Research (OAR)
- Climate Program Office (CPO)
- Pacific Marine Environmental Laboratory (PMEL)
- National Weather Service (NWS)
- National Data Buoy Center (NDBC)
- National Marine Fisheries Service (NMFS)
- National Ocean Service (NOS)
- Integrated Ocean Observing System (IOOS)
- Southwest Fisheries Science Center (SWFSC)



DIRECTOR'S LETTER

CIMEC began on July 1, 2010. The collective expertise of the seven CIMEC academic member institutions has much to offer NOAA to meet its goals. The subsequent nine months have been a period of growth. CIMEC follows and builds on the highly successful JIMO with an increased emphasis on marine ecosystems and climate, consistent with NOAA's mission. Success of the CIMEC proposal was due to the efforts of Ken Melville, past director of JIMO, and his staff, Anne Footer, Rose Keuler, and Garrett Eaton.

CIMEC presently receives approximately \$3.7 million from NOAA for 9 projects. These include support of CIMEC administration, new faculty positions in marine population dynamics and fisheries, observing the inorganic carbon and oxygen cycles, data management for the National HF radar network, training quantitative fisheries scientists, investigations of both marine and freshwater fish ecology, and continuation of the world's longest time series of a pelagic marine ecosystem. Of note are CSTAR and CalCOFI, which contribute, respectively, to NOAA's workforce needs in fisheries management NOAA's goal of ecosystem-based management.

I anticipate that programs in JIMO will continue in CIMEC within the next two years. These include Argo, the Surface Drifter Program, CORC, the High-Resolution XBT program, and CNAP. Combined with its current programs, CIMEC will contribute valuably to NOAA's goals in marine ecosystems and climate.

As Director, I have attended a variety of NOAA national meetings and visited Headquarters. I have also met several times with the Francisco Werner, new head of the SWFSC, and his staff. Anne Footer and I attended the annual CI Director's Meeting. The CIMEC MOA is nearing completion. Thereafter, we will constitute our Executive Board and Council of Fellows, and schedule meetings of both.

A number of opportunities bode well for CIMEC's future. We look forward to working with the SWFSC, which has a new director, a new ship (the Reuben Lasker), and a new building. The NIST MESOM building is under construction and will soon house CIMEC programs, including CalCOFI. A challenge for CIMEC is to match our expertise with NOAA goals and, in particular, PIs with Line Office personnel.

While we acknowledge the difficult fiscal climate, we feel that CIMEC, like other CIs, has an important and growing role to play by enabling academic scientists help NOAA to meet its goals, particularly in regard to marine ecosystems and our changing climate.

A handwritten signature in black ink, appearing to read 'Dave Checkley'.

Dave Checkley
CIMEC Director



ORGANIZATION

Mission Statement

The mission of CIMEC is, in collaboration with NOAA, to develop and consolidate leading researching and educational programs across its member institutions in support of NOAA's mission "to understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social and environmental needs."

Vision Statement

CIMEC shares the fundamental mission and goals of NOAA research and strives to achieve several objectives based on the unique resources and character of the Scripps Institution of Oceanography (SIO) and the other partner institutions in California: (1) to foster collaborative research between NOAA and UC/Cal State scientists; (2) to facilitate participation of UC/Cal State and other academic scientists in NOAA programs; and (3) to use the educational strength of CIMEC both to train students for productive work in environmental activities and to educate the citizenry about the intellectual excitement and importance of studying and managing our environment.

CIMEC will build upon SIO's experience from nearly twenty years of management of the Joint Institute for Marine Observations, and work closely with NOAA line offices, goal teams and laboratories to assist in transitioning research and development into NOAA data products and services. NOAA leadership and researchers will be strongly represented on CIMEC's Executive Board and Council of Fellows. An annual meeting will be held to communicate progress on CIMEC's projects and to seek input on research directions and priorities from NOAA leadership and scientists and stakeholder groups. CIMEC institutions will work to ensure that wherever possible NOAA's needs are represented in their educational programs, from undergraduate to postdoctoral levels. The education and outreach program will also address ocean-literacy needs at the K-12 levels and in the broader community.

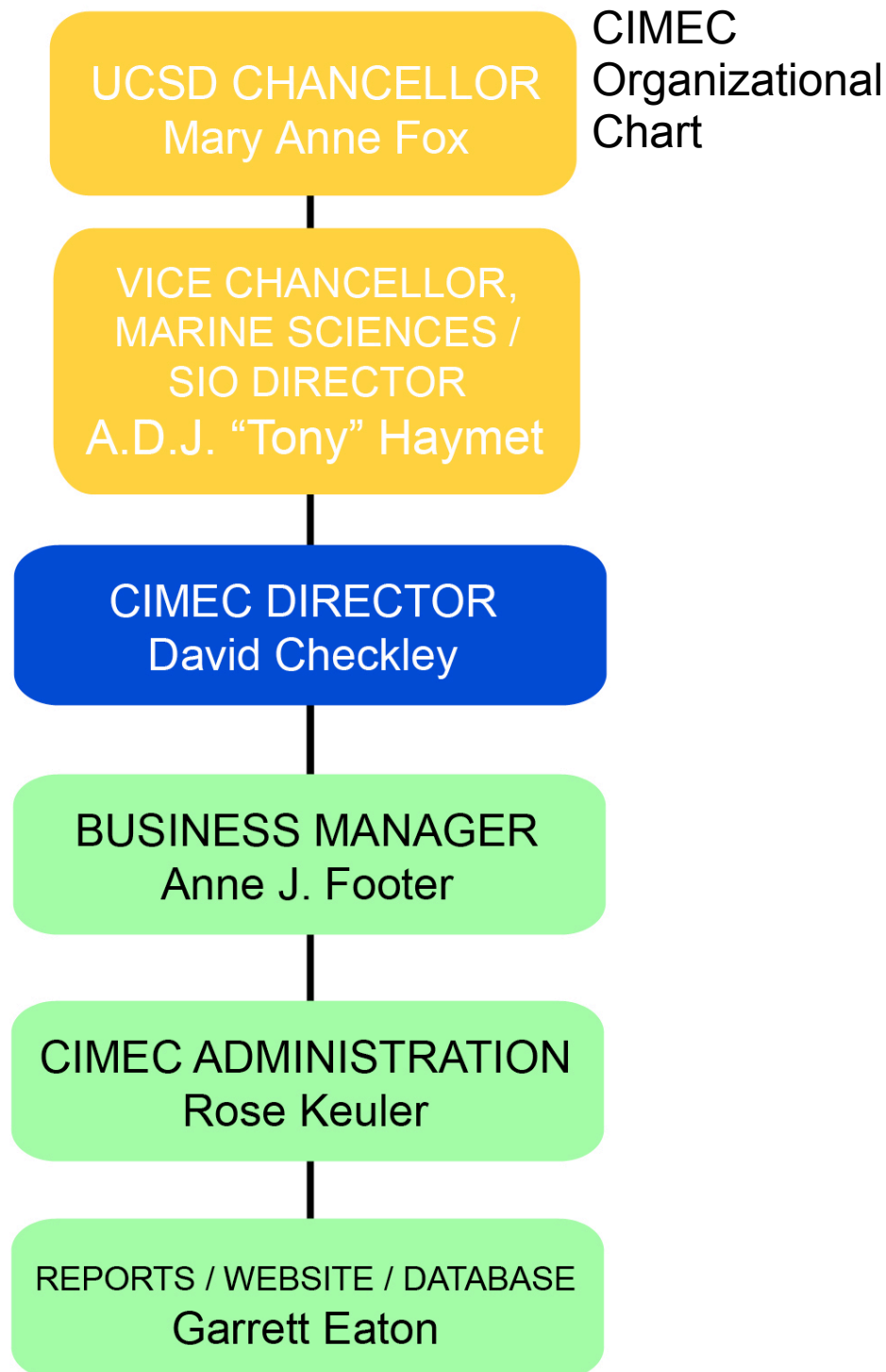
CIMEC LEADERSHIP

Director:

David Checkley is a professor at Scripps Institution of Oceanography, University of California, San Diego. His research interests are in the areas of long-term change in pelagic zooplankton and fish, including climate-biota interactions; role of zooplankton in the marine nitrogen cycle; effects of weather and air-sea interactions on plankton and fishes; ecology of marine zooplankton and fish; the biological pump, including the role of particles and plankton; ocean acidification; and instrument development. He holds a B.S. from the University of Washington and both an M.S. and Ph.D. from SIO.

Deputy Director:

Dean Roemmich is a professor at Scripps Institution of Oceanography, University of California, San Diego. His research interests are the role of the oceans in climate and climate variability, general circulation of the oceans, and the California Current system. He holds a B.S. from the Swarthmore University and a Ph.D. from the Massachusetts Institute of Technology—Woods Hole Oceanographic Institution.





CIMEC Employee Summary (July 1, 2010 – March 31, 2011)

Personnel Supported by NOAA/JIMO Funding				
Category	Number	B.S. / B.A.	M.S.	Ph.D.
Academic Specialist	1			1
Postdoctoral Fellow	4			4
Sr. Statistician				
Programmer/Analyst	1		1	
Staff Research Assoc/Asst	2	1	1	
Laboratory Asst	1		1	
Development Engineer				
Marine Technician				
Total (≥ 50% support)	9	1	3	5

Undergraduate Students				
Graduate Students	2			
Employees that receive < 50% NOAA Funding (not including students)	8			
Located at Lab (include name of lab)	5	NOAA/NMFS – Santa Cruz Laboratory		
Obtained NOAA employment within the last year				
Sub-awards				
Postdoctoral Fellow				
Graduate Students				
Undergrad Student				

CIMEC Fellows Roster (July 1, 2010 – March 31, 2011)

Andrew Dickson (SIO)	J. Anthony Koslow (SIO)
Douglas Bartlett (SIO)	Marc Mangel (UC Santa Cruz)
Gary Griggs (UC Santa Cruz)	Baldo Marinovic (UC Santa Cruz)
David Hankin (Humboldt State)	Eric Terrill (SIO)



RESEARCH TASKS AND THEMES

Research Tasks

Under the Cooperative Institutes' cooperative agreement, five tasks are outlined by CIMEC and agreed upon by NOAA, allowing CIMEC to group and account for research more easily. The tasks are defined as follows:

Task 1. Administration

Task 1 funding is for administration of the Institute and includes support for the CIMEC Director's office and minimal support for the staff. It includes costs associated with annual scientific meetings that are deemed important for the CIMEC Director to attend, workshops sponsored by CIMEC, web-site development and maintenance, funding for the Joint Institute Director's and executive board and fellows meetings.

Task 2. Joint NOAA Laboratory/CIMEC Collaboration

Collaborative proposals have NOAA and participating California University partners working together jointly on research themes. These proposals are divided by theme and include all research associated with funding including the funding of salaries, benefits, travel as well as instrumentation and computer time.

Task 3. Individual Science Projects

Cooperative research proposals are specific to the CIMEC theme areas, but submitted by individual scientists of CIMEC. The distinction here is that there is a loosely bound tie between individuals working on similar themes or topics. It is also seen that this may be a mechanism for developing collaborative proposals in the future, as well as encouraging new areas of research to develop. These proposals are divided by theme and include all research associated funding including the funding of salaries, benefits, travel and instrumentation and computer time.

Task 4. Education and Outreach

In support of NOAA's Mission and Strategic Plan, CIMEC's Task 4 was developed to strengthen and coordinate an education and outreach component to compliment and convey CIMEC research into the academic and public realms.

Task 5. CIMEC Research Infrastructure Proposals

Because proposals relevant to CIMEC will use a variety of observation platforms in order to carry out the research objectives, an infrastructure task by theme area was defined, which includes proposals for platform and specialized research facilities.

Research Themes

Four thematic areas form the basis for research performed in partnership with NOAA. Each of these areas are relevant to the NOAA mission elements, particularly those of environmental assessment and prediction and environmental stewardship.

A. Climate and Coastal Observations, Analysis and Prediction Research

The primary goals for this research theme are to understand the remote forcing functions that control fundamental ocean and atmosphere processes and to utilize this knowledge for prediction. For CIMEC the basis of interest is primarily the Pacific, although other areas may be studied as a model or to put the Pacific information in context (e.g., Indian, Arctic). These thrust areas include the following:

Oceanic roles in climate and global change

The oceans contain 96% of the Earth's free water. They are the source of 86% of all evaporation and the direct recipient of 78% of rainfall. The salinity of the ocean surface layer reflects the global pattern of evaporation minus precipitation, with salinity maxima in regions of excess evaporation and minima in regions of excess rainfall. The meridional transport of water vapor in the atmosphere is equal and opposite to the freshwater transport in the ocean. Long-term trends in salinity show the evaporative regions of the ocean



becoming saltier and the high precipitation areas fresher indicating an acceleration of the global hydrological cycle. Slow freshening of the oceans as a whole is a yardstick for the melting of glaciers, ice sheets, and sea ice. Past research in the hydrological cycle has been focused on the land and atmosphere, while the large role of the oceans has been poorly observed. It is increasingly clear that the complete global hydrological system, including the oceans, must be addressed.

Last, and very importantly among (physical) global change issues, is sea level rise. The present observing system includes satellite and in situ observations of total sea level, plus satellite measurements of changes in ocean mass and in situ observations of the ocean's steric height. While the majority of future sea level rise may come from melting Antarctic and Greenland ice sheets, the steric component of sea level is nonetheless significant, and the increasing heat content of the high latitude oceans is a key factor in understanding and predicting melting and precipitation (ice deposition) rates.

CIMEC projects contribute to datasets in an effort to build the models to address these important issues.

Coastal oceans and climate

The scientific community is faced with challenging issues across our coastal waters:

- How do human activities impact the coastal ocean?
- How do coastal ecosystems respond to climate change?
- How does climate change and sea level rise present itself at local scales?
- What role does the coastal ocean play in the global biogeochemical cycles?
- What processes determine community structure in coastal ecosystems?
- How can we predict and mitigate coastal hazards that impact human populations?

CIMEC has a myriad of tools within its partner institutions, including the long-running CalCOFI program with its 60-year time series of the California Current, at its disposal to help investigate these questions and find the solutions to the problems some of these questions pose.

B. Climate Research and Impacts

Observations and model simulations are crucial elements needed to guide decisions over the next several decades as global scale changes in climate, sea level and other environmental components such as aerosols and land surface changes continue to produce great impacts across the United States. Regions affected by these changes include the region of the western mountainous states, in particular, California and the adjacent coastal zone. CIMEC research will study climate and its impact on society to serve the nation's needs for climatic information with programs conducting applied climate research to assist decision makers prepare for and adapt to climate changes, both natural and (potentially) anthropogenic.

C. Marine Ecosystems

CIMEC will directly address NOAA's Ecosystem Mission Goal to "protect, restore, and manage the use of coastal and ocean resources through the ecosystem approach to management". Fisheries and protected species and their relation to the environment, including climate change, are broad areas of research and teaching within CIMEC, and will include participation from faculty, graduate students, postdocs, and NOAA colleagues.

Ecosystem characteristics of particular interest are marine population dynamics, biodiversity, and biogeochemistry. The means by which these will be investigated include observing, process studies, and modeling. Collectively, the results are used to assess and predict ecosystem productivity and health for decision makers. Fishing affects both the target species and their environment. Climate change will affect marine ecosystems through rising sea level, warming, ocean acidification, deoxygenation, and potential changes in productivity and circulation.

Primary regions of interest are the California Current Ecosystem (CCE), the Eastern Tropical Pacific (ETP), and the Southern Ocean (SO). Fisheries management research, such as the long-running 60-year time series of the California Current conducted under the CalCOFI program, provides policymakers and management officers with the information needed to manage the nation's marine resources.



D. Ecosystem-Based Management

Fisheries management has undergone a paradigm shift in recent years from an exclusive focus on individual assessments of commercially-exploited stocks to maximize sustainable yield (or comparable metric) to a precautionary, ecosystem-based approach. Ecosystem-based management (EBM) explicitly considers human impacts on key predator, prey and competitor species, on bycatch species and benthic habitat, as well as on directly targeted stocks. NOAA is mandated to manage US fisheries within an EBM framework and is implementing integrated ecosystem assessments (IEA) as a critical science-support tool.

The 60-year California Cooperative Oceanic Fisheries Investigations (CalCOFI) program is one of the longest running ocean observation programs in the world. A joint program of the Scripps Institution of Oceanography, the Southwest Fisheries Science Center (NMFS/NOAA), and the California Department of Fish and Game, CalCOFI is designed to provide data for stock assessment of key commercial species, as well as physical, chemical, and biological data on the state of the California Current ecosystem (CCE), including quantitative observations on ecologically critical species of krill, fish, seabirds and mammals. CalCOFI observations have provided the basis for much of our current understanding of the impact of climate variability (the El Niño, Pacific Decadal Oscillation, and the North Pacific Gyre Oscillation) on the CCE. In the future, CalCOFI will provide much of the observational 'backbone' for integrated ecosystem assessments (IEAs) and ecosystem-based management (EBM) of the CCE, as well as for modeling and understanding the impacts of long-term climate change.

Integration of Marine Protection Areas (MPAs) and Conventional Fishery Management

More than 15 percent of the coast of California will soon be in MPAs implemented under California's Marine Life Protection Act. Modeling of the effects of these for decision makers has been done by Partner labs, and will soon started in a Sea Grant project to develop models to use in the evaluation of ongoing monitoring efforts.

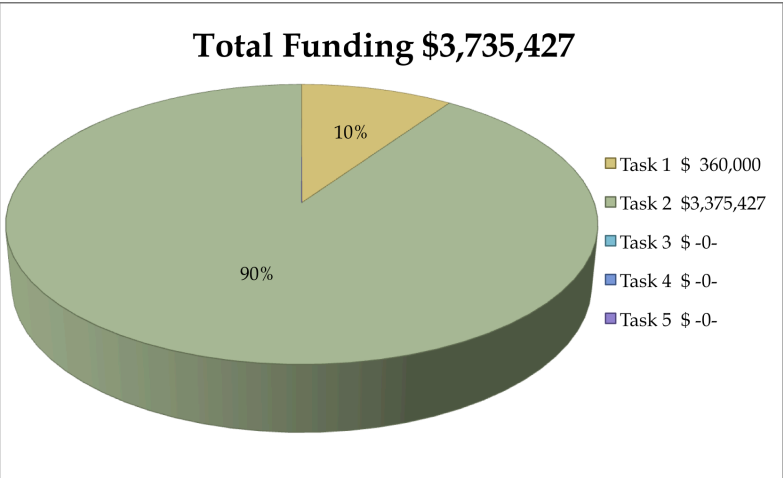
The Center for Stock Assessment Research (CSTAR)

CSTAR was formed in 2001, as a collaboration between the NMFS laboratories in Santa Cruz and Pacific Grove, with the objective of undergraduate, graduate and post-doctoral research and training associated with the problems of assessing the numerical abundance, spatial distribution, size distribution and reproductive status of commercially important fish species and thereby increasing the pool of quantitatively trained biologists available to be hired by NMFS. The program of research and training at CSTAR is science done in the national interest and moves in the direction outlined by the National Research Council in its report Recruiting Fishery Scientists.



Funding Summary

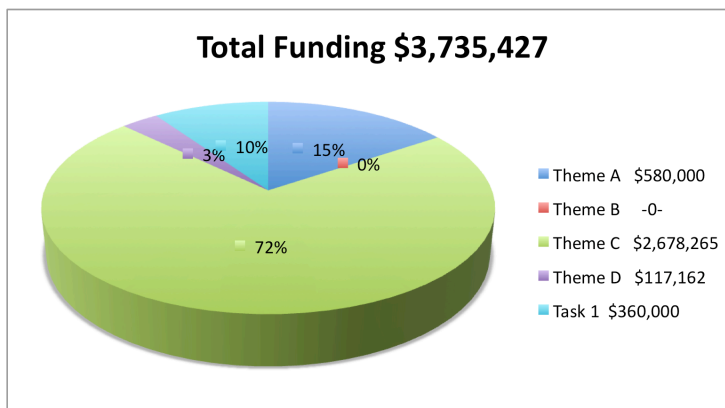
CIMEC: Cooperative Institute for Marine Ecosystems and Climate
Funding by Task
NA00AR4320156
July 1, 2010 - March 31, 2011



- Task 1: CIMEC Administration
- Task 2: Joint NOAA Lab/CIMEC collaboration
- Task 3: Individual Science Project
- Task 4: Education and Outreach
- Task 5: Shiptime



CIMEC: Cooperative Institute for Marine Ecosystems and Climate
Funding by Theme
NA00AR4320156
July 1, 2010 - March 31, 2011



Theme A: Climate and Coastal Observations, Analysis and Prediction Research
Theme B: Climate Research and Impacts
Theme C: Marine Ecosystems
Theme D: Ecosystem-Based Management



RESEARCH HIGHLIGHTS

CIMEC research activities are categorized by the following themes:

- A. Climate and Coastal Observations, Analysis and Prediction Research
- B. Climate Research and Impacts
- C. Marine Ecosystems
- D. Ecosystem-Based Management

Research highlights, or Executive Summaries, of the most recent individual research projects are summarized in the tables below and are more fully developed in the body of this report.

A. Climate and Coastal Observations, Analysis and Prediction Research

Collection and Analysis of Seawater Samples from the California Coast [Andrew G. Dickson, SIO]

- Collected samples on numerous CalCOFI expeditions in the Southern California Bight
- Collected samples on expeditions of the *RV Coral Sea* off Trinidad Head (N. California)
- Analyzed most of the samples that have been collected to date
- Calculated information about aragonite saturation state from the CalCOFI samples has been compared with values inferred from an algorithm calibrated using data from the NOAA 2007 NACP West Coast Cruise

HF Radar National Network Data Management Development [Eric Terrill, SIO]

- Updated and supported ten data portals, systems designed for collecting HF radar site data and transferring to within the network for the participating Universities: Scripps Institution of Oceanography; Rutgers University; University of Southern Mississippi; University of California, Santa Cruz; University of California, Santa Barbara; San Francisco State University; California Polytechnic State University; University of Southern California; Oregon State University, University of Maine, and University of Miami
- Three nodes, systems designed to act as data repositories and vector processing, have been maintained and upgraded for the participating Institutions: SIO, NDBC, and Rutgers University
- Migrated to HFRNet Development system to 64-bit platform
- Prototype of NetCDF-4 RTV's have been developed
- HFRNET code repository established for cleaner installations and maintenance
- Started repository for MATLAB toolbox based on recent updates; we have to be able to track what changes are HFRNet related to OI
- Installed the CODAROS software for radial metrics on SIO's San Elijo radar to continue evaluation
- Incorporated the HF Radar National Network (non-OI) into SAROPS through the ASA environmental data system (EDS)
- Supported temporary Alaska installations
- Started four new Hawaii sites with unconventional radial processing operated became available to National Nodes for RTV processing
- New Codar sites were made available to all Nodes for RTV processing



- Renamed Sites: Nantucket Island, MA is now NANT, instead of ERRA
- Decommissioned Sites: PPIN was decommissioned in August, 2010 and removed from National Nodes
- Supported Domains and available data: USEGC - US East and Gulf Coast - 2008-03 through present; USWC - US West Coast - 2008-03 through present; GAK - Gulf of Alaska - 2009-05 through 2009-07; PRVI - Puerto Rico and US Virgin Islands - 2010-01 through present
- The HF-Radar Network started as a prototype at SIO with a single portal and node and 4 sites in December 2003 that grew to an operational status produced by 112 sites from 30 participating institutions in 2007, is currently operating with 145 sites from 31 participating institutions.
<http://cordc.ucsd.edu/projects/mapping/maps/>

B. Climate Research and Impacts

No Theme B research funded for this time period

C. Marine Ecosystems

The Center for Stock Assessment Research (CSTAR)
[Marc Mangel, UC Santa Cruz]

- Continued the development of the Santa Cruz Fish Life History Simulator, with focused application to groundfish and salmon
- Wide range of collaborations with NMFS colleagues (SWFSC, NWFSC, PIFSC) and international colleagues (from Norway, Scotland, and Italy)
- The CSTAR seminar series continued to expose CSTAR students and post-docs to cutting edge research in applied ecology relevant to fisheries and allowed them to interact with leading scientists from around the country and the world
- Return visits to CSTAR by Prof Jarl Giske (University of Bergen) and Dr. Simone Vincenzi (University of Parma) for 6 month research stays and by Dr. Michael Bonsall (University of Oxford) for a 10 day research stay
- CSTAR post-doc William Satterthwaite received the Kendall Award for the best paper published in Transactions of the American Fisheries Society in 2009, for a paper on steelhead trout life history

Freshwater Fish Ecology
[David Hankin, Humboldt State]

- Hired Dr. Darren Ward at Humboldt State University for a collaborative research and teaching position in Freshwater Fish Ecology
- Executed a cooperative project to identify factors that limit overwinter survival of coho salmon started (graduate student Jennifer Hauer)

Shipboard Monitoring of the California Current System Off Central California
[Baldo Marinovic, UC Santa Cruz]
[Francisco Chavez, MBARI]
[Curtis Collins, Naval Postgrad School]

- Occupied CalCOFI lines 67 and 60 (n=20 hydrographic stations) with complete physical, chemical, phytoplankton, and zooplankton
- Occupied CalCOFI lines 67 and 60 (n=20 hydrographic stations) with complete physical, chemical, phytoplankton, and zooplankton
- Provided technical support for northern section of Winter NMFS CalCOFI cruise

Investigations in Fisheries Ecology
[Gary Griggs, UC Santa Cruz]

- Recruited and hired two technicians
- Aged over 3,000 widow rockfish
- Entered widow, blackgill, and greenspotted rockfish age information into data base



	<ul style="list-style-type: none"> ○ A recreational catch and effort database was constructed for partyboats operating in northern California waters, 1980-2003 ○ Version 2.1 of DCAC was released by the NMFS National Fisheries Toolbox on 2/18/2011 ○ Two UCSC graduate students were hired ○ We developed a bioenergetic model that predicts development, growth and reproduction of a Pacific salmon, from an egg to a reproducing female and its eggs, in a dynamic environment which reproduces the main life-history traits of five Pacific salmon species: Pink, Sockeye, Coho, Chum, and Chinook, which validates our approach to use generic DEB models for Pacific salmon
Freshwater Ecology Research Collaboration [Gary Griggs, UC Santa Cruz] Training the Next Generation of Marine Population Dynamics Scientists [Douglas Bartlett, SIO]	<ul style="list-style-type: none"> ○ Recruitment with outstanding candidates has been completed ○ Began recruitment process of new faculty in the area of marine population dynamics ○ Listed position in scholarly journals, such as <i>Science</i> and <i>Nature</i> ○ Held phone interviews between hiring committee and potential candidates ○ Held in-person interviews with three of the most promising applicants
D. Ecosystem-based Management	
California Cooperative Fisheries Investigations (CalCOFI), an Ocean Observation Program for the Southern California Current, FY 2011 [J. Anthony "Tony" Koslow, SIO] [Ralf Goericke, SIO]	<ul style="list-style-type: none"> ○ Continued to contribute to our understanding of acidification, declining oxygen levels, and plastic debris in the NE Pacific. Notably, mid-depth oxygen concentrations were shown to have declined by ca. 20% since the mid-1980s, but that oxygen levels were equally low in the 1950s. The abundance of many midwater fishes was found to be highly correlated with oxygen levels; these fishes have declined on average > 60% since the 1990s ○ Reconstructed time series of spiny lobster (<i>Panulirus interruptus</i>) spawning biomass based on phyllosoma abundance in CalCOFI ichthyoplankton samples. The time series, which is significantly correlated with SST, El Ninos, and the PDO, should contribute to spiny lobster stock assessment off California ○ Continued progress made on providing online web access to the combined NOAA, SIO, and ancillary data sets. ○ Carried out multi-frequency acoustic and trawl sampling of mid-trophic levels (krill, small pelagics, and midwater micronekton) for the first full year in 2010 ○ Showed that iron limitation of primary productivity plays an important role in the waters of the southern California Current beyond the coastal upwelling zone ○ Marine mammal census methods continue to improve with advances in localization software, acoustic species-identification and group size estimation. The cetacean database was developed and habitat modeling analysis expanded through integration of larger and more diverse sample of environmental variables with cetacean distribution data ○ Reported the abundance of market squid (<i>Doryteuthis opalescens</i>) to be significantly correlated with several variables indicative of primary and secondary productivity, as well as the ENSO cycle, based on analysis of the CalCOFI paralarvae time series



THEME A: CLIMATE AND COASTAL OBSERVATIONS ANALYSIS, AND PREDICTION RESEARCH



Collection and Analysis of Seawater Samples from the California Coast

Andrew G. Dickson (SIO)

NOAA Technical Contact: Joel Levy (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The goal of this work is to provide information that can be used to test an algorithm developed by Dr. Richard Feely (NOAA/PMEL) and his colleagues for predicting aragonite saturation state in the upper water column of waters off the California coast. This algorithm (which is specific to a particular geographic region) is based on measurements of salinity, temperature, depth, and oxygen concentration.

We thus collect water samples from cruises off the coast of California where the appropriate ancillary measurements (in particular oxygen concentrations) are also made. Examples of such cruises are the quarterly CalCOFI cruises (California Cooperative Oceanic Fisheries Investigations) and cruises off Northern California performed by Dr. Jeff Abell of Humboldt State University. These water samples are returned to the Scripps Institution of Oceanography, where they are analyzed for total dissolved inorganic carbon, total alkalinity, and salinity. Once the analyses are complete, and the data have been evaluated, they are reported to Drs. Feely & Alin at NOAA/PMEL where they are used to compare with the proposed algorithms.

Research Accomplishments

To date, 60 samples have been collected on each of the following CalCOFI cruises: July/August 2010; October 2010; January 2011; and April 2011. In addition, 20-40 samples were collected by Humboldt State University on cruises on the RV Coral Sea in August 2010; February 2011; and April 2011. We expect to collect additional samples as the year progresses. In addition, some samples were collected on trips to turn around the buoys operated as part of the California Current Ecosystem LTER

All but the most recent sets of samples have been analyzed. The CalCOFI data to the end of 2010 have been sent to Dr. Alin at NOAA/PMEL who has shown that, thus far, the algorithms that she had generated based on a calibration data set from the NOAA 2007 NACP West Coast Cruise imply values for the aragonite saturation state that are in excellent agreement with those inferred from the samples collected and analyzed as part of this project. This was true despite the fact that the newer data cover a wider range of seasons than the original calibration data set. This work was presented by Dr. Alin at the Fall AGU meeting in San Francisco in December 2010 in a poster entitled: "Predictive relationships for pH and carbonate saturation in the Southern California Current System using oxygen and temperature data."



HF Radar National Data Management Development

Eric Terrill (SIO)

NOAA Technical Contact: Jack Harlan (NOAA/IOOS) and Richard Crout (NOAA/NWS/NDBC)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

NOAA Goal 3: Serve Society's Needs for Weather and Water Information

NOAA Goal 4: Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

NOAA Goal 5: Provide Critical Support for NOAA's Mission

Research Objectives and Specific Plans to Achieve Them

Local, state, regional, and federal support for the Integrated Ocean Observing System (IOOS) have supported the installation, development, and operation of a network of surface current mapping systems for use by a broad range of end users. Central to the operational success of a large scale network is a scalable data management, storage, access, and delivery system. The objectives for this project are to continue the research, development, and implementation of the data management system for ocean surface current information derived from HF radar with a primary focus on preparing the data for integration into the United States Coast Guard (USCG) Search and Rescue Optimal Planning System (SAROPS).

The architecture of the HF-Radar Network lends itself well to a distributed real-time network and serves as a model for networking sensors on a national level. This joint university-NOAA partnership is focused on defining and meeting the expressed needs for an IT architecture supporting a national network of surface current mapping data systems. This proposal also includes development and prototype implementation of optimally interpolated near real-time surface currents for U.S. coastlines for integration into the USCG Search and Rescue Optimal Planning System (SAROPS). Implementation will occur in a phased approach in partnership with the United States Coast Guard (USCG), Applied Science Associates (ASA), the University of Connecticut, and Rutgers University. OI currents will be distributed based on the national HFRNet vector grid in a NetCDF file format that includes longitude, latitude, vector current components (u and v), uncertainty components (uu, vv, and uv), using the available grids used on the west coast. The OI data will be processed in parallel with the existing HF Radar national network and will be implemented as a proto-operational computational module, available and used within the national network architecture at both the NOAA NDBC DAC and the NOAA-funded servers at Scripps Institution of Oceanography.

Research Accomplishments

CORDC research and implementation efforts met expectations during this reporting period. Throughout this nine month reporting period, efforts focused on continued operations, maintenance, and expansion as well as incremental improvements to backend infrastructure in preparation for national HF radar network processing of optimally interpolated surface currents. As background, the HF-Radar Network architecture is comprised of two hardware building blocks, portals and nodes with distinct roles. Portals serve as 'point of entry' machines by acquiring and serving radial data from any number of HF-Radar sites. Nodes serve as data concentrators by collecting radial data from any number of portals (or nodes). This design minimizes data requests through sometimes unstable network connections to individual sites by serving data through portals while maintaining a high degree of network flexibility through selective data collection at nodes.

As the network of HF radar systems grows nationally, programmers continue to update and incorporate new data streams into the mapping system. A total of 17 new sites were added to the network during this period: 5 sites on the West coast, 4 sites on the East coast, 3 sites in Hawaii, and 3 temporary sites in the Gulf of Alaska.



In support of the transition to an optimally interpolated product, programmers migrated the HFRNet development system to a 64bit platform allowing for faster processing speeds and a new code base. The prototype of NetCDF4 real-time vectors (RTV) has been developed. This will significantly reduce the amount of storage space required for total vector fields increasing disk capacity and decreasing network traffic. An HFRNet code repository has been established for improved installations, reliability, and streamlining maintenance tasks. Initial implementation of ocean surface currents measured by the SCCOOS high frequency (HF) radar network are now accessible by the U.S. Coast Guard for search and rescue applications using their Environmental Data Server (EDS).

Efforts also continued on Direction of Arrival (DOA) metrics analysis. These metrics required a new radial file with expanded diagnostics to be produced from Codar Ocean Sensors. This new code has been evaluated and deployed at a local HF radar site: San Elijo. These metrics include, but are not limited to:

1. Signal to noise ratio (SNR) for each antenna
2. Cross spectra covariance matrix eigenvalues
3. Single and Dual angle Direction of Arrival

Following the Deepwater Horizon incident, personnel from the University of Southern Mississippi were able to deploy 3 HF radars along the Gulf of Mexico and staff at CORDC, were able to bring those online through the HF Radar National Network (HFRNet), providing the first data of surface currents near the site of the spill. IOOS Regional Associations and partners have worked to provide relevant ocean data, models, and products for the Gulf of Mexico Oil Spill Response. CORDC maintains and is supporting additional file formats of surface current measurements to ensure updates are available to the spill command center.

- British Petroleum (BP) Incident Command Center (ICC)
- Office of Response and Restoration (OR&R) Emergency Response Division (ERD) and Assessment and Restoration Division (ARD)
- Official NOAA forecasts for oil spill trajectories General NOAA Operational Modeling Environment (GNOME)
- Near real-time currents available in various formats (NetCDF, GNOME NetCDF, Shapefile, kml):
- Near real-time currents available via THREDDS at NDBC:
- Updated and supported ten data portals, systems designed for collecting HF radar site data and transferring to within the network for the participating Universities: Scripps Institution of Oceanography; Rutgers University; University of Southern Mississippi; University of California, Santa Cruz; University of California, Santa Barbara; San Francisco State University; California Polytechnic State University; University of Southern California; Oregon State University, University of Maine, and University of Miami.
- Three nodes, systems designed to act as data repositories and vector processing, have been maintained and upgraded for the participating Institutions: SIO, NDBC, and Rutgers University.
- Migrated to HFRNet Development system to 64-bit platform
- Prototype of NetCDF-4 RTV's have been developed
- HFRNET code repository established for cleaner installations and maintenance
- Started repository for MATLAB toolbox based on recent updates; we have to be able to track what changes are HFRNet related to OI.
- Installed the CODAROS software for radial metrics on SIO's San Elijo radar to continue evaluation.
- Incorporated the HF Radar National Network (non-OI) into SAROPS through the ASA environmental data system (EDS)

- Supported temporary Alaska installations
<http://cordc.ucsd.edu/projects/mapping/stats/?sta=BASC&aff=UAF>
<http://cordc.ucsd.edu/projects/mapping/stats/?sta=WAIN&aff=UAF>
<http://cordc.ucsd.edu/projects/mapping/stats/?sta=PTLY>

New Sites:

Four new Hawaii sites with unconventional radial processing operated became available to National Nodes for RTV processing;

- <http://cordc.ucsd.edu/projects/mapping/stats/?sta=KAK&aff=UH>
- <http://cordc.ucsd.edu/projects/mapping/stats/?sta=KOK&aff=UH>
- <http://cordc.ucsd.edu/projects/mapping/stats/?sta=KAL&aff=UH>

New Codar sites were made available to all Nodes for RTV processing:

- Point Conception, CA (Cal Poly)
<http://cordc.ucsd.edu/projects/mapping/stats/?sta=PTC1&aff=SLO>



Point Arguello, CA (Cal Poly)

<http://cordc.ucsd.edu/projects/mapping/stats/?sta=ARG1&aff=SLO>

<http://cordc.ucsd.edu/projects/mapping/stats/?sta=AGL1&aff=SLO>

Land's End, CA

<http://cordc.ucsd.edu/projects/mapping/stats/?sta=LEND>

Point Pinos, Pacific Grove, CA (Naval Post Graduate School)

<http://cordc.ucsd.edu/projects/mapping/stats/?sta=PPNS&aff=NPS>

Brant Beach, NJ

<http://cordc.ucsd.edu/projects/mapping/stats/?sta=BRNT>

Seaside Park, NJ (Rutgers)

<http://cordc.ucsd.edu/projects/mapping/stats/?sta=SPRK&aff=Rutgers>

Jekyll Island, GA

<http://cordc.ucsd.edu/projects/mapping/stats/?sta=JEK&aff=SKIO>

Martha's Vineyard, MA

<http://cordc.ucsd.edu/projects/mapping/stats/?sta=MVCO>

Renamed Sites:

Nantucket Island, MA is now NANT, instead of ERR.

<http://cordc.ucsd.edu/projects/mapping/stats/?sta=NANT&aff=Rutgers>

Decommissioned Sites:

- PPIN was decommissioned in August, 2010 and removed from National Nodes.

Supported Domains and available data:

- USEGC - US East and Gulf Coast - 2008-03 through present
- USWC - US West Coast - 2008-03 through present
- GAK - Gulf of Alaska - 2009-05 through 2009-07
- PRVI - Puerto Rico and US Virgin Islands - 2010-01 through present

- The HF-Radar Network started as a prototype at SIO with a single portal and node and 4 sites in December 2003 that grew to an operational status produced by 112 sites from 30 participating institutions in 2007, is currently operating with 145 sites from 31 participating institutions.

<http://cordc.ucsd.edu/projects/mapping/maps/>

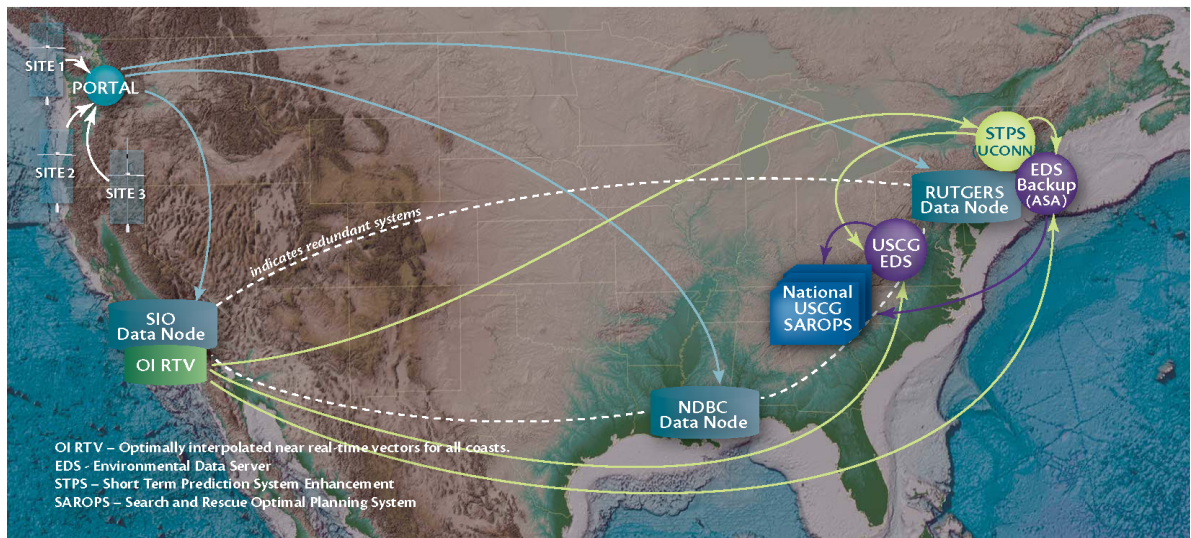


Fig. 1 HF radar national network configuration in support of integration into USCG SAROPS



US Coast Guard Search and Rescue: HF Radar Product

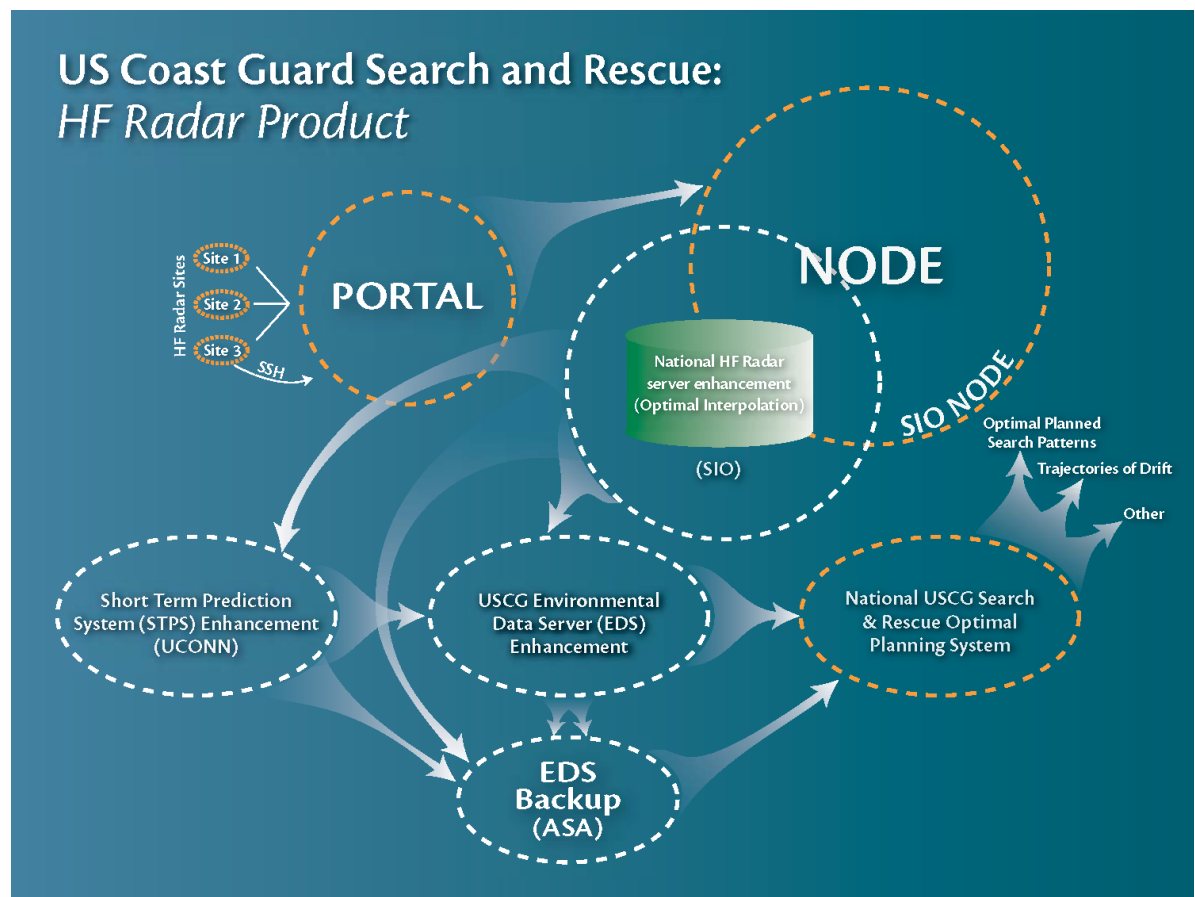


Fig. 2 HF radar national network configuration details of SAROPS data pathways



No research funded in this theme for this time period.



THEME C: MARINE ECOSYSTEMS



The Center for Stock Assessment Research (CSTAR)

Marc Mangel (UC Santa Cruz)

NOAA Technical Contact: Steve Ralston (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The objective of CSTAR is undergraduate, graduate, and post-graduate training in the science associated with the problems of assessing the numerical abundance, spatial distribution, size distribution and reproductive status of commercially important fish species. A broad and deep understanding of population processes is critical to the development and management of sustainable fisheries.

Finding means to conserve fish populations and to achieve sustainable fisheries requires understanding the effects of fishing on behavior, life history and population biology of exploited fishes. At CSTAR, work focuses on using mathematical, statistical, and computer models to solve important environmental and ecological problems. The work is grounded in data, and also seeks to expand the base of basic knowledge that supports rigorous application of science to real-world problems. Furthermore, research on marine fisheries conducted at CSTAR allows testing theoretical predictions via natural and human experiments on a scale that is appropriate for understanding the dynamics of ecosystems. Such large-scale experiments are rarely available to the scientific community.

The CSTAR grant provides a level of core support which is then leveraged by teaching assistantships and graduate research assistantships from other grants or contracts (with recent or current support from the CalFed Science Program, the Lenfest Ocean Program, and the National Science Foundation). This enables us to create a relatively large and interactively group of quantitative scientists working on a wide range of problems in fishery management.

Research Accomplishments

During the review period, we completed two large research projects. The first concerned life history variation in steelhead trout (*Oncorhynchus mykiss*) and water policy in California and was funded by the CalFed Science program. Collaborators on this project included colleagues from the Fisheries Ecology Division, Southwest Fisheries Science Center; from California Department of Fish and Game; and from Cramer Fish Sciences. The second concerned the implications of climate change for Antarctic krill (*Euphausia superba*), krill predators, and krill fisheries management. Collaborators on this project included colleagues from the NOAA Fisheries Antarctic Ecosystem Research Division, the Australian Antarctic Division, and the British Antarctic Survey.

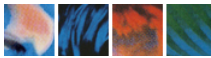
CSTAR graduate students Valerie Brown and Daniel Hively continued the development of the Santa Cruz Fish Life History Simulator (SCFLHS). The SCFLHS will allow the testing of various stock assessment tools that are proposed for fisheries differing in levels of data, from data poor fisheries to data rich fisheries. This tool will complement POPSIM in the NMFS Toolbox. Brown is focusing on salmonids and Hively on groundfish.



CSTAR post-doc Andrew Shelton developed Bayesian methods for filling in missing data in port sampling of groundfish catches. Shelton also developed methods for analyzing density dependent growth in fish population and the effect of density dependence on classic reference points.

CSTAR PI Marc Mangel continued his work on the reproductive biology of scombrids and the computation of steepness from first principles, in collaboration with Jon Brodziak and Gerard DiNardo, Pacific Islands Fisheries Science Center.

The CSTAR seminar series in applied theoretical ecology continued with talks by Nic Jonzen, Lund University (How should migratory birds respond to climate change? - Insights from evolutionary game theory); Jarl Giske, University of Bergen (Modeling behavior and diversity in fish populations with individual psychology); Simone Vincenzi, University of Parma (Selective Consequences of catastrophes on growth rates in a stream dwelling salmonid); Katie Lotterhos, Florida State University (Recruitment dynamics, population genetics, and reproductive success of black rockfish, *Sebastes melanops*); Jev Shelton, Juneau, Alaska (Salmon Science and Policy); and Tim Essington, University of Washington (Do catch shares programs produce ecological benefits).



Freshwater Fish Ecology

David Hankin (Humboldt State University)

NOAA Technical Contact: Churchill Grimes (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

This project provides support for the Department of Fisheries Biology at Humboldt State University (HSU) to establish long-term collaboration between HSU and NOAA/NMFS addressing salmon conservation and restoration in Northern California and the Klamath River basin. This objective is implemented through partial funding for a new faculty position at HSU to develop research projects focusing on evaluation of restoration effectiveness and assessment of issues related to restoration of salmon production in the Klamath River. Project funding allows this position to be 50% research and 50% teaching, as compared to typical 100% teaching appointments at HSU, to allow research efforts that complement NMFS efforts and fill needs for management and conservation planning.

Research Accomplishments

Dr. Darren Ward started at HSU in August 2010, teaching Principles of Fisheries Management and Freshwater Fish Ecology in Fall and Spring terms. In Fall 2010, Ward and new graduate student Jennifer Hauer started a new research project in collaboration with Seth Ricker (CA Department of Fish and Game). This project will identify factors that affect overwinter survival of juvenile coho salmon in a human-impacted coastal basin in Northern California. Ward collaborated with Dr. Adam Sepulveda (USGS) and Dr. Laurie Marczak (University of Montana) to secure funding for a new project addressing effects of invasive New Zealand mudsnails on juvenile salmon in Redwood National Park. Sampling for this project will start in June 2011 in cooperation with park biologists.



Shipboard Monitoring of the California Current System Off Central California

Baldo Marinovic (UC Santa Cruz), Francisco Chavez¹ and Curtis Collins²

1) Monterey Bay Aquarium Research Institute

2) Naval Postgraduate School

NOAA Technical Contact: Churchill Grimes (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

In cooperation with the NMFS, we will continue to conduct quarterly shipboard measurements along CalCOFI Lines 60 and 67 through July 2011. The R/V *Pt Sur* will be utilized to conduct measurements in the Fall of 2010 and the NOAA vessel *MacArthur II* will tentatively be scheduled to conduct measurements during the Summer of 2011. Measurements in Fall 2010 and Summer 2011 will consist of CTD/rosette casts, plankton tows, VMADCP current observations, and continuous underway measurements of sea surface and meteorological parameters. Seawater will be assayed for nutrients (nitrate, nitrite, phosphate and silicate). Water samples in the upper 200 m will also be assayed for chlorophyll-a, primary production, phytoplankton taxonomy and cell counts. Vertical and horizontal zooplankton sampling will include standard bongo oblique tows to 210 m depth. Samples will be preserved in 10% buffered formalin/seawater and processed post-cruise in the laboratory. Biovolume displacements will be initially determined and then samples will be archived at SIO where taxon specific processing will be conducted by various research groups. All data collected on the fall and summer cruises will be made available as soon as possible to other researchers via web based archives and technical reports.

In addition we will provide technical support to conduct CTD/water sampling on the northern leg of the scheduled NMFS 2011 Winter and Spring CalCOFI cruises.

Research Accomplishments

CalCOFI Lines 67 and 60 was successfully occupied in July of 2010 utilizing the NOAA Ship *MacArthur II*. All standard stations extending out to station 90 for both lines (n = 12) were occupied and sampled for physical/chemical parameters phytoplankton, and zooplankton.

CalCOFI Lines 67 and 60 was successfully occupied in the fall of 2010 utilizing the R/V *Pt. Sur*. All standard stations extending out to station 90 for both lines (n = 12) were occupied and sampled for physical/chemical parameters phytoplankton, and zooplankton.

Technical support to conduct CTD/water sampling was provided for the winter NMFS run CalCOFI cruises for the northern legs.

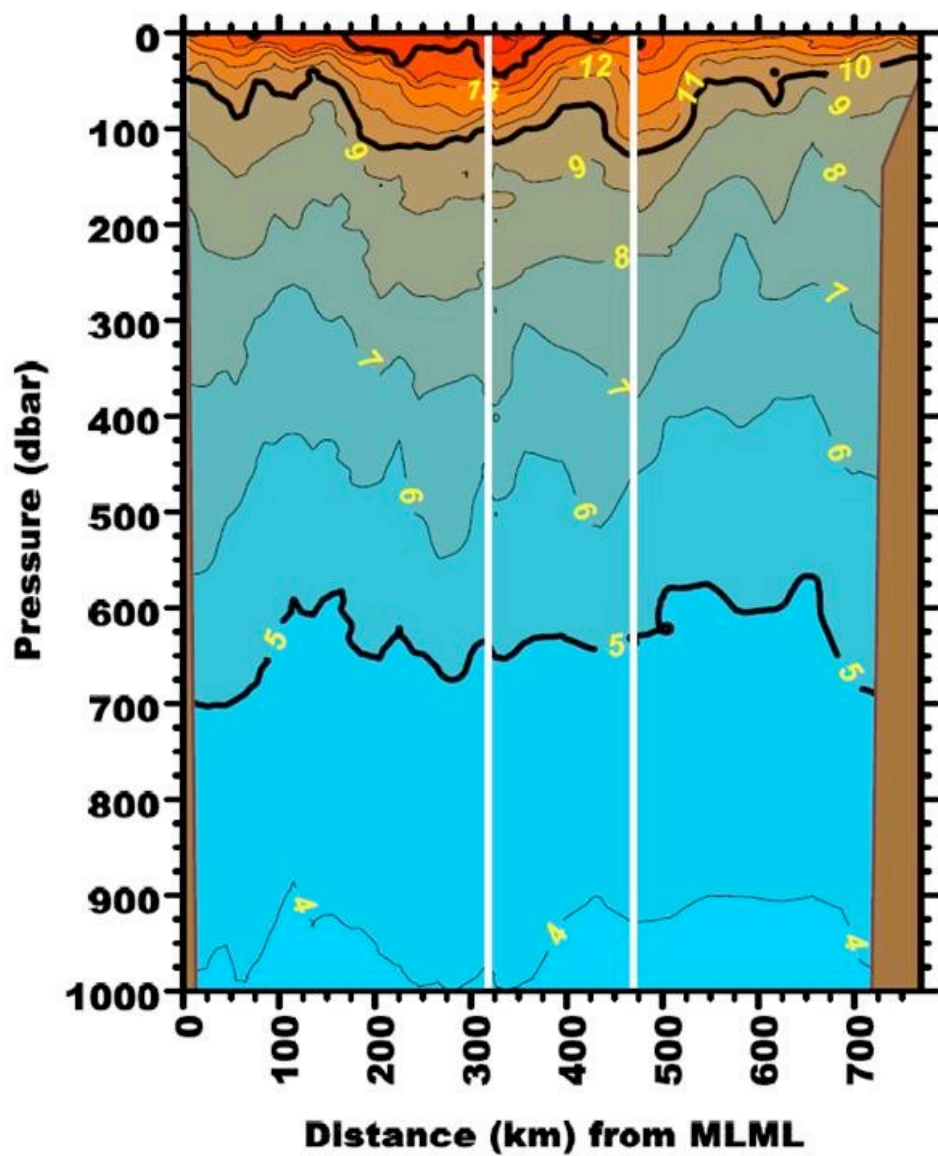


Fig. 1 Onshore/offshore temperature/depth contours for lines 67 (left side, running onshore-offshore) and 60 (right side running offshore-onshore) for the Fall 2010 R/V Pt Sur cruise. White lines represent the most offshore station for each transect (L67-90 & L60-90) with the middle region between them displaying the offshore transit between the two stations. Distance on the x axis refers to distance from the first station (L67-C1). 5,10, and 15 degree C isotherms are highlighted by bold lines

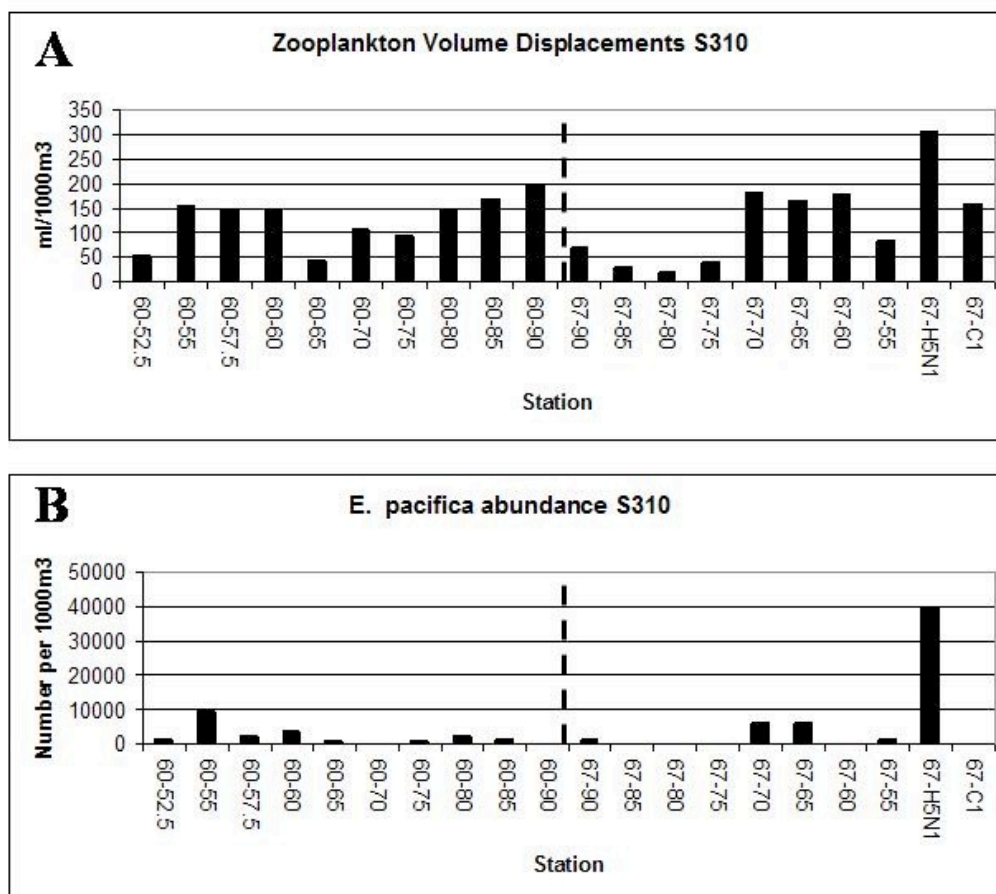


Fig. 2 Displacement volumes (A) and krill (*Euphausia pacifica*) abundance along L-60 and L-67 for July 2010. Dotted lines depict the break between L-60 and L-67 and represent a shift from onshore-offshore direction to offshore-onshore direction



Investigations in Fisheries Ecology

Gary Griggs (UC Santa Cruz)

NOAA Technical Contact: Churchill Grimes (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

1. Groundfish Research Support—The project is divided into three distinct sub-tasks: (1) spatial analysis of commercial catch data, (2) otolith archive modernization, and (3) historical catch reconstruction from recovered California Department of Fish and Game data sets. This first sub-task will hire a researcher to examine, describe, and analyze recovered catch data with the purpose of quantifying the spatial expansion of fishing activity in the California region over the last century. The second sub-task will hire a laboratory assistant and will better organize, classify, and document the Division's holdings of otoliths and will create a modern relational data base that can be used to access samples in an efficient manner. The third sub-task will continue efforts to digitize, edit, verify, analyze, and distribute catch reconstruction data for use in stock assessment.
2. Data-poor methods for fish stock assessment—The project is improving DCAC (Depletion-Corrected Average Catch) and is extending the DBSRA (Depletion-Based Stock Reduction Analysis) method to include information on abundance trends. One of the main sources of information on abundances is the RecFIN Database containing recreational fishery sample data since 1980. However the presently available database is not suitable for calculation of catch-per-unit-effort (a standard fishery index of abundance), requiring this project to re-construct a RecFIN-based database specifically for that purpose.
3. Dynamic Energy Budget models for central California salmon—To determine the response of Pacific salmon populations to environmental change, we need to understand impacts on all life stages. The objective of the research is to develop a Dynamic Energy Budget (DEB) model for Chinook salmon that links the available knowledge on all stages from eggs to mature adult, and opens the way to future modeling of the complex salmon dynamics in space and time. Dynamic Energy Budget (DEB) theory uses systems of differential equations to describe the rates at which individual organisms assimilate and utilize energy and elemental matter from food for maintenance, growth, reproduction and development. These rates depend on the state of the organism (age, size, sex, nutritional status) and on the state of its environment (food density, temperature, etc.). Characterization of the physical and biotic environments that determine the forcing functions for the model will come from models provided by other investigators. The primary product will be a prototype "full life cycle" DEB with parameters estimated from literature data. By the end of the one-year project, the model will be available for coupling different forcing functions (food, temperature).
4. Assess deep-sea coral communities—Research to determine the relationship between habitat forming corals such as the Christmas Tree Coral (*Antipathes dendrochristos*) and fishes. Also, data were collected on environmental conditions, including depth, temperature, salinity, dissolved O₂, and substratum type to help understand habitat factors that influence deepsea coral settlement and distribution. Researchers have also begun an assessment of the structure-forming invertebrates of the southern California Bight, utilizing videos created during fish surveys

Research Accomplishments

1. We have successfully hired a laboratory assistant and have made substantial progress in organizing the otolith inventory. The technician was trained in aging protocols for widow rockfish, including break-and-burn technique, sectioning, and cross-validation. Recruitment of a staff research assistant GIS analyst has been accomplished. This individual will conduct a spatial analysis of California groundfish catch statistics that have



been recovered from the period 1925-1969, allowing a better understanding of how today's fisheries developed over time.

2. Two graduate students have been hired and have been working on developing new models for catch-reconstruction data. Collaborators have run models to produce new analysis of population trends.

3. We developed a bioenergetic model that predicts development, growth and reproduction of a Pacific salmon, from an egg to a reproducing female and its eggs, in a dynamic food and temperature environment. This model was developed in the framework of the Dynamic Energy Budget (DEB) theory. To our knowledge, the standard DEB model is the simplest bioenergetic model that predicts the full life cycle of an organism in a dynamic environment.

4. Many hours of historical underwater videos have been organized, reviewed, analyzed and categorized. Additional dives, using both an ROV and AUV, have been scheduled.



Fig. 1 Laboratory Assistant Lyndsey Lefebvre removes a tray of rockfish otoliths from a small ceramic kiln. Baking the otoliths at a high temperature for a short period of time standardizes the preparation for age estimation using the “break-and-burn” method

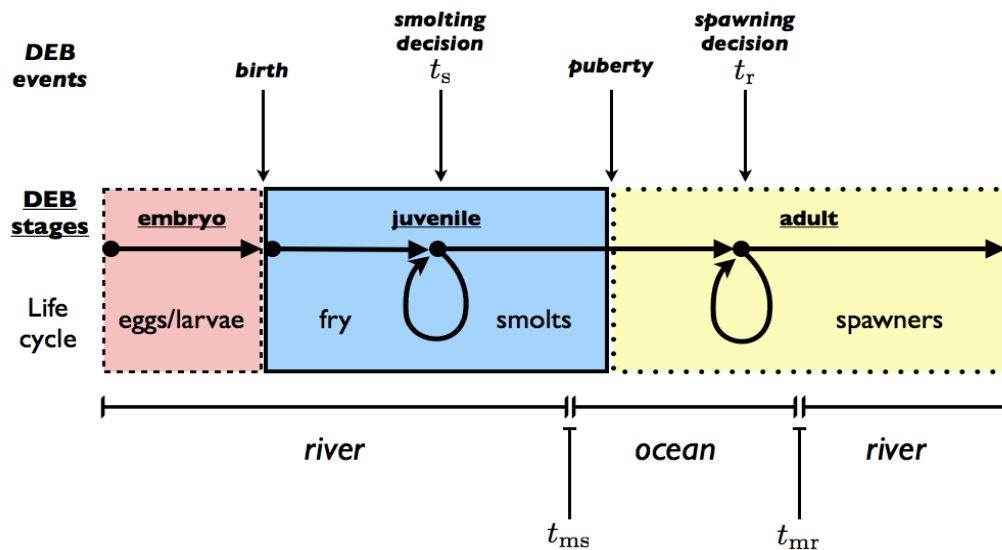
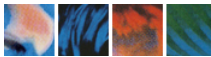


Fig. 2 Schematic representation of the life cycle of a Pacific salmon and link with DEB life stages and events. Time windows for smolting decision (t_s) and spawning decision (t_r) prior to smolt migration (t_{ms}) and spawning migration (t_{mr}) were added to a standard DEB model. If the individual does not reach the required maturity threshold at t_s , the individual stays in the river until the next time window in the year cycle for smolting, and then migrates and enters the ocean at t_{ms} . Once in the ocean, if the individual does not reach the reproduction buffer threshold at t_r the individual stays an extra year or more in the ocean and then migrates back to the river at t_{mr} and spawns



Freshwater Ecology Research Collaboration

Gary Griggs (UC Santa Cruz)

NOAA Technical Contact: Churchill Grimes (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

Provide instruction and research in freshwater ecology, with an emphasis in anadromous fish, by supporting the staffing of a faculty position at UC Santa Cruz. Freshwater ecology topics are integrated in the Dept of Ecological and Evolutionary Biology, and grad students assist on grants in which the Freshwater Ecology faculty is the lead researcher.

Research Accomplishments

The current Freshwater Ecology FTE relocated to another university, and some graduate students relocated with him. His grant projects have continued and some grad students are continuing their research projects. A national recruitment has been completed for a new FTE, who will be starting at UCSC in the fall.



Training the Next Generation of Marine Population Dynamics Scientists

Douglas Bartlett (SIO)

NOAA Technical Contact: Steven Murawski (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

The purpose of this project is to provide support for educational initiatives at SIO, including the set-up needs of a marine population dynamics new faculty hire. The faculty hire in question will have an interest in population dynamics and stock assessment, management strategy evaluation, climate effects, and ecosystem and food web modeling. This key appointment builds upon a long record of accomplishment and collaboration between Scripps Institution of Oceanography and NOAA Fisheries Service. The individual will play a major role in training future practitioners in the science of population assessment and development of enhanced assessment methods that incorporate environmental variability, food web linkages and spatial heterogeneity.

Research Accomplishments

This recruitment is moving forward and the PI is optimistic an offer will be made this spring. At this point in time the search committee has broadly advertised the position. This has included listing the position in journals such as Science and Nature and a large variety of on-line sources, and by personally contacting scientists working in this field. The committee will be holding phone interviews soon and bringing out three people for on-site interviews in April 2011.



THEME D: ECOSYSTEM-BASED MANAGEMENT



California Cooperative Fisheries Investigations (CalCOFI), an Ocean Observation Program for the Southern California Current, FY 2011

J. Anthony Koslow and Ralf Goericke (SIO)

NOAA Technical Contact: Roger Hewitt (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

CalCOFI's primary objectives are 1) to maintain its 60-year time-series of comprehensive, high-quality physical, chemical and biological observations of the California Current ecosystem, with an emphasis on the living marine resources, and 2) to contribute through its data and analyses to a scientific understanding of the human impacts and influence of climate variability and climate change on living resources of the California Current in support of an ecosystem approach to management.

CalCOFI successfully carried out its summer and fall, 2009 cruises aboard Scripps vessels and contributed to the winter and spring, 2010 cruises led by our NOAA partner, processing the hydrographic, chlorophyll and primary productivity data, exercising quality control, and making the data available. Good progress was made on combining Scripps and NOAA data holdings and making them publicly available through the web, maintaining ancillary observations and developing collaborative projects.

Collaboration with the NSF-funded California Current Ecosystem Long-Term Ecological Research (CCE-LTER) project continues successfully, as well as with a number of single-investigator projects. These projects include continued seabird and marine mammal observations on CalCOFI cruises, merging CalCOFI data sets at Scripps and the SWFSC/NMFS and improving their availability through the web, acoustic surveys of mid- to higher trophic levels on CalCOFI cruises, and developing time series of spiny lobster spawning stock using the historical CalCOFI samples.

Research Accomplishments

The four quarterly CalCOFI cruises were completed successfully. The cruises continue to be used as a platform for ancillary research programs that greatly contribute to our understanding of the system. The NSF-funded California Current Ecosystem Long-Term Ecological Research (CCE-LTER) group has participated on all four cruises, studying biogeochemical and lower trophic level processes. Marine mammal and seabird observations (independently funded) were carried out on three of the four cruises. Since January 2010, combined acoustic and trawl sampling were carried out for the first time on RV New Horizon cruises. This work, also independently funded, obtains data on krill, micronekton, and small pelagics. Preliminary results indicate that mesopelagic fishes, a previously neglected group, dominate the acoustic backscatter across most of the California Current (Fig. 1). Marine mammal survey methods also continue to improve through advances in localization software, acoustic species-identification and group size estimation. Online delivery of ancillary data sets from CCE-LTER, seabird and marine mammal observations continues to improve.



Time series for market squid (*Doryteuthis opalescens*) and spiny lobster (*Panulirus interruptus*), two key California invertebrate fisheries, were completed based on the historical CalCOFI zooplankton samples and analyzed in relation to ocean time series. Variability in the abundance of both species appears to be related to several regional and large-scale oceanographic variables in addition to the ENSO cycle. Because these species are not formally assessed, these results could contribute to sustainable fishery management.

The CalCOFI cruises and time series are contributing increasingly to our understanding of how key environmental issues, including plastic debris, declining oxygen concentrations, and acidification, are influencing the waters of the California Current. Plastic debris was found to be virtually ubiquitous in surface waters of the California Current at similar levels to the Bering Sea but lower than those found in the so-called 'Garbage Patch' of the central gyre.

Marine mammal monitoring on CalCOFI cruises has been conducted since 2004 to investigate cetacean distribution patterns relative to habitat, to make seasonal estimates of cetacean density and abundance, and to quantify differences in vocalizations between cetacean species. Over the last year, efforts to accomplish these objectives have expanded through incorporating novel analysis approaches, integrating new hardware/software tools, and developing collaborations with other experts in the field. Habitat modeling has improved through integration of a larger suite of environmental variables collected from CalCOFI cruises, satellite imagery, and autonomous gliders as well as the utilization of innovative GIS-based software tools. The development of density and abundance estimates for nine cetacean species in the CalCOFI study area are currently the focus of extensive line-transect analysis and spatio-temporal modeling, in collaboration with St. Andrews University. Acoustical census techniques have been improved through recently published advances in acoustic species-identification, localization software, and group size estimation.

Continuing investigations of iron limitation of primary production in the California Current, based on CCE-LTER ancillary sampling on CalCOFI cruises, indicates that iron limitation appears to be a significant factor limiting productivity in the waters beyond the coastal upwelling region.

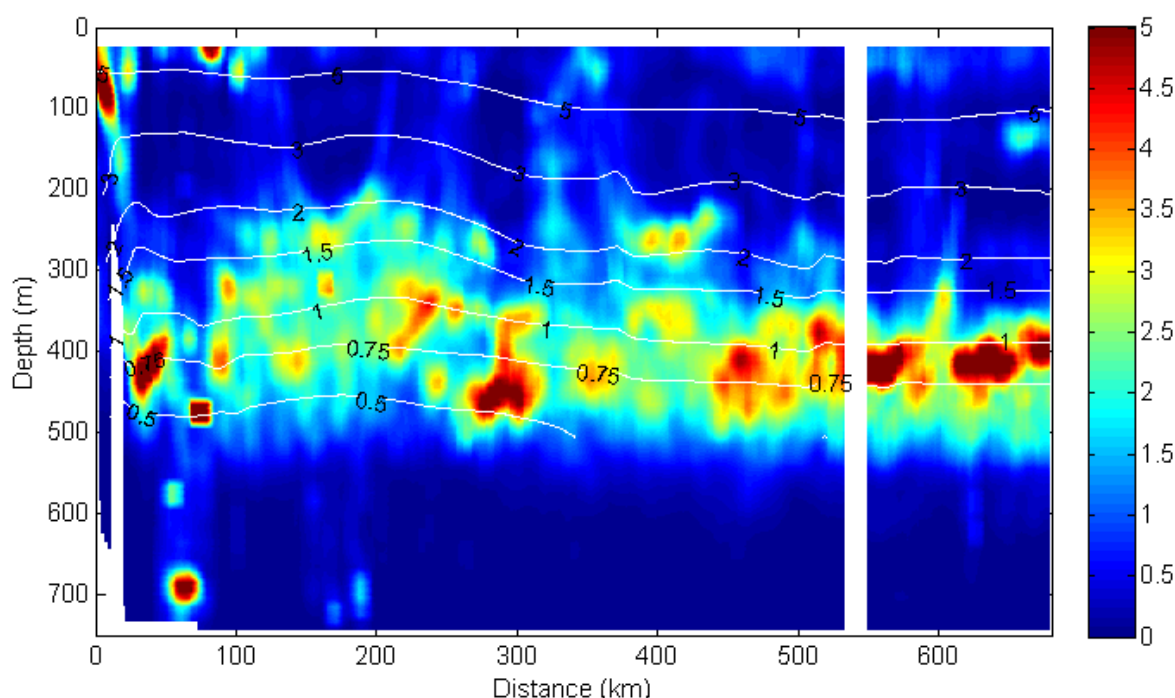


Fig 1. Color contours of the distribution of the daytime acoustic backscattering from the January 2009 CalCOFI cruise in relation to distance offshore and depth, showing isolines of oxygen concentration (ml O₂ L⁻¹). The acoustic backscattering, normalized to the maximum at each sampling interval, and oxygen data are averaged over the six core CalCOFI transects from the US-Mexico border to north of Pt Conception. Over most of the California Current, the backscattering is dominated by the deep-scattering layer, which is concentrated at the hypoxic boundary just above the oxygen minimum layer



OUTREACH

Shipboard survey data used in COSMOS-UC Santa Cruz

Designed specifically for talented and motivated high school students, the California State Summer School for Mathematics and Science (COSMOS) is a 4-week summer residential program for high school scholars with demonstrated interest and achievement in math and science. B. Marinovic distributed data from his shipboard studies project to the COSMOS program (UC Santa Cruz).

K-12 Education - SIO

T. Koslow and CalCOFI personnel trained San Diego area high school students in the lab for science fair projects on plastics in the ocean.

Marine Mammal Survey - SIO

Under T. Koslow's direction, CalCOFI associates gave K-12 students hands-on marine science and research experience via field trips, formal and informal education programs

Public outreach and education about research on Marine Debris in Deep water habitats - UCSC

P. Adams and his group partnered with NOAA Monterey Bay Sanctuary Foundation, UC Santa Barbara and others to give a series of talks, workshops and symposiums to the public about the effects of marine debris on deep water habitats.

Santa Cruz Science Fair - UCSC

J. Moore participated in the Santa Cruz County K-12 Science Fair as a professional organizations judge.

Salmon Biology and Conservation Outreach - UCSC

The Salmon Biology group and J. Moore at UC Santa Cruz gave numerous classroom presentations on Salmon biology and the importance of conservation to Westlake and Holy Cross Elementary Schools (Santa Cruz, CA) and Santa Catalina School (Monterey, CA); field trip presentations at Santa Catalina School, Monarch Elementary School and New Horizons School (Santa Cruz, CA); as well as a tour of the group's research lab to a local Girl Scout Troop.



COMMUNICATIONS, NETWORKING, ACADEMIC DEVELOPMENT and AWARDS

ACTIVITY TYPE	OBJECTIVE	PARTNERS
Communications		
CORDC Mapping Site http://cordc.ucsd.edu/projects/mapping/	Provide online access to surface current mapping sites, radial data, and diagnostics for participating sites	
Festival of Whales	K Merkens gave lecture on "Sperm whales of the western hemisphere: teeth, squid and oil"	Ocean Institute, Dana Point, CA March 2011
Birch Aquarium public lecture	T. Koslow: CalCOFI and ocean climate off California	Birch Aquarium, SIO, La Jolla, CA
Fisheries biology training for undergraduate and graduate students	D. Hankin and Fisheries Biology faculty at Humboldt State	Humboldt State University

ACTIVITY TYPE	OBJECTIVE	PARTNERS
Networking		
CalCOFI networking activities	Continuing collaborative relationships with other ocean observation programs on the west coast	Partner to CenCOOS, close collaboration with SCCOOS
	Provide CalCOFI input to end-to-end coupled biophysical California Current ecosystem model including pelagic fish and fisheries	Co-PIs in submission to renew CAMEO project (Curchitser et al)
	Provide CalCOFI data to global ocean time series data center	CalCOFI partnership with OceanSites
	Ongoing partnerships with to maintain ancillary observations of seabirds, marine mammals, and biogeochemistry and lower trophic levels	Collaborations with Farallon Institute, Hildebrand SIO laboratory and CCE-LTER program
	Provide CalCOFI input to integrated ecosystem assessment and ecosystem-based management of the California Current	Pacific Fisheries Environment Lab/SWFSC/NOAA
	Establish ocean acidification monitoring	Network with PMEL/NOAA
	Workshops and submission of proposal to expand CalCOFI to monitor California south coast MPAs	MPA Monitoring Enterprise, California Conservancy and Ocean Protection Council (OPC)



	Foster CalCOFI partnerships with North Pacific rim marine research	Active member of PICES, joined PICES Technical Committee on Data Exchange (TCODE)
	Foster collaboration with fisheries acoustics groups in ICES and globally	ICES Fisheries Acoustics Science and Technology Working Group (WGFAST)
Presented at Oil Spill Area Committee Meetings in San Diego	Provided updated information regarding HF radar surface current application to oil spill response	U.S. Coast Guard, Office of Spill Prevention and Response (OSPR), Marine Resources Advisory Committee (MRC), Chevron
Correspondence with Jordan Stout and Judd Muskat, OSPR	Support San Diego NPREP Planning Meeting March 29, 2011	NOAA OR & R and Office of Spill Prevention and Response
Hosted online Webinar	To educate community on use of HF radar RTV during Oil Spill response and drills	Various (80 participants)
ACTIVITY TYPE	OBJECTIVE	PARTNERS
Academic Development		
CSTAR Academic Development efforts	<u>M. Mangel</u> Member External Scientific Advisory Committee Meeting, Center for Complex Biological Systems, University of California, Irvine Member, Steering Committee, University of Florida IGERT in Spatial Ecology Member, Scientific Advisory Board, Florida State University Coastal and Marine Laboratory	
<u>Fellowships Programs / Internships</u>		
Graduate research fellowships:		
Kate Richerson	Provide mentoring to graduate student.	UC Santa Cruz
Valerie Brown		UC Santa Cruz
Proposed fellowship program at CalCOFI		SIO, UCSD
CalCOFI academic development	1 – 2 university students recruited for each cruise to volunteer and gain sea-going scientific experience	Universities throughout USA
	Laboratory training provided to graduate and undergraduate students with CalCOFI instrumentation	Mostly Scripps and UCSD
Participated in NOAA IOOS Data Management and Communications (DMAC) discussions	To provide guidance for HF radar real-time vector data formats and distribution	NOAA IOOS



Graduate student development: Shipboard Studies	Support graduate student education and research on shipboard studies	UC Santa Cruz, Marinovic lab
Undergraduate student development: Shipboard Studies	Support for 3 graduate students' education and research on shipboard studies – participated in data analysis	UC Santa Cruz, Marinovic lab
Guest lecture on CalCOFI, ocean climate and California fisheries by J.A. Koslow		SIO Center for Marine Biodiversity and Conservation (CMBC)
Listening for whales lecture by K. Merkens	Experiments in graduate school and marine biology.	School for Field Studies, July 2010, Turks and Caicos.
AWARD	RECIPIENT	YEAR
Awards and Honors		
Kendall Award for the Best Paper in Transactions of the American Fisheries Society in 2009	William Satterthwaite and Marc Mangel	2010



REPRESENTING CIMEC

EVENT	DATE / LOCATION	REPRESENTATIVE
35 th Climate Diagnostics and Prediction Workshop	October 4-7, 2010 / Raleigh, NC	S.Y. Kim (presentation)
AGU Fall meeting	December 2010 / San Francisco, CA	RE Todd, S. Alin
AGU Ocean Sciences meeting	February 2010 / Portland, OR	S Bograd, M Ohman, M Carter, J Powell
Annual CCE LTER Meeting	March, 2011, SIO / La Jolla, CA	Campbell, G.S., L.M. Munger, K.P. Merkens, D.L. Camacho, A.M. Havron and J.A. Hildebrand.
Bay Area Conservation Biology Symposium	Dec 2010	T. Levi
CalCOFI conference	November 9-12 / SIO-UCSC, La Jolla, CA-Santa Cruz, CA	JA Koslow, R Goericke, R Vetter, S McClatchie, C Allen, L Rogers-Bennett, B. Marinovic, V. Brown, D. Hively
Climate and fisheries symposium	April 2010 / Sendai, Japan	JA Koslow, A Suntsov
Dept Seminar, Environmental Science and Policy, UCB	Oct 2010	M. Mangel
Dept Seminar, Kellogg Biological Station	Oct 2010	M. Mangel
Dept Seminar, EEB Program, Michigan State University	Oct 2010	M. Mangel
Dept Seminar, Environmental Science and Policy, UCB	Nov 2010	W. Satterthwaite
Eastern Pacific Ocean Conference (EPOC)	September 22-25, 2010 / Mt. Hood, OR	S.Y. Kim
Exercise24 Planners Conference	August 9, 2010 / San Diego, CA	L. Hazard
HF Radar National Network Planning Meeting	October 22, 2010 / Con Call	L. Hazard, M. Otero, T. Cook
HF Radar Oil Spill Response Workshop	February 11, 2011 / Webinar	L. Hazard (presenter); All
HSU Ecoseries	Sep 23, 2010 / HSU, Arcata, CA	D. Ward
HSU Math Colloquium	Mar 3, 2011 / HSU, Arcata, CA	D. Ward
ICES Working Group on Fisheries Acoustics Science and Technology (FAST)	April, 2010 / San Diego, CA	A Lara-Lopez
Instream Flow Assessment Program Workshop	Dec 8, 2010 / UC Davis	R.M. Nisbet, L. Pecquerie (UCSB)
International Radiowave Oceanography Workshop	September 26-29, 2010 / Portland, OR	S.Y. Kim (poster)
National NMFS workshop on Annual Catch Limits	Feb 15-17, 2011 / Washington DC,	EJ Dick (NOAA)
NCEAS Working Group on Salmon, Climate and Plasticity	Oct 2010	W. Satterthwaite
NMFS/PRD Tech Tues	Oct 10, 2010 / Arcata field office	D. Ward
NOAA Workshop on the Biological Opinion Concerning Chinook Salmon	Dec 2010	W. Satterthwaite
Oil Spill Response Technology Workshop	February 15-17, 2011 / San Ramon, CA	E. Terrill (presenter), L. Hazard, M. Otero
PICES Conference	October 22-31, 2010 / Portland, OR	JA Koslow
San Diego Area Committee Meeting	July 15, 2010 / San Diego, CA	L. Hazard
San Diego Area Committee Meeting	September 2, 2010 / San Diego, CA	A. Dillon
Seminar, Center for Complex Biological Systems, UCI	Nov 2010	M. Mangel
Stanford-UCSC species interaction workshop	Nov 2010	T. Levi
Vietnamese Delegation Workshop	November 30 – December 9 / Vietnam	E. Terrill (presenter)
World Seabird Conference	Sept 2010	W. Satterthwaite



CIMEC PARTNERS AND COLLABORATORS

INTERAGENCY

Alaska Fisheries Science Center (AFSC)
Channel Islands National Marine Sanctuary
Monterey Bay National Marine Sanctuary
National Data Buoy Center (NDBC)
National Ocean Service (NOS)
National Parks Service (NPS)
National Science Foundation (NSF)
 NSF Division of Polar Programs (OPP)
National Weather Service (NWS)
Northeast Fisheries Science Center (NEFSC), NMFS
Northwest Fisheries Science Center (NWFSC), NMFS
Office of Naval Research (ONR)
Pacific Fisheries Management Council
Pacific Islands Fisheries Science Center (PIFSC)
Pacific Marine Environment Lab (PMEL)
Pacific States Fisheries Commission
Redwood National Park
Southeast Fisheries Science Center (SEFSC)
Southwest Fisheries Science Center (SWFSC)

PARTNERSHIPS

Australian Antarctic Division (AAD)
British Antarctic Survey (BAS)
CalFed Science Program
California Coastal Conservancy
California Department of Fish and Game (CDFG)
California Department of Forestry and Fire Prevention
California Department of Parks and Recreation
Centro Investigacion Cientifica y de Educacion Superior de Ensenada (CICSE), Mexico
Centro Regional de Investigacion Pesquera (CRIP), Instituto Nacional de la Pesca, Mexico
Commission for the Conservation of Antarctic Marine Living Resources (AMLR)
Commonwealth Scientific and Industrial Research Organisation (CSIRO)—Australia
Cramer Fish Sciences
East Bay Municipal District
Fisheries Centre, University of British Columbia
Georgia Institute of Technology
Humboldt State University, CA, USA



Investigaciones Mexicanas de la Corriente de California (IMECOCAL)
Lenfest Ocean Program
Lindquist Consulting Inc.
Los Angeles County Museum (LACM)
Monterey Bay Aquarium Research Institute (MBARI)
MRAG Americas
Ocean Protection Council
Oregon State University (OSU)
Pt. Reyes Bird Observatory (PRBO)
Rosenstiel Schools of Marine and Atmospheric Science
Rutgers University, Coastal Ocean Observation Lab (COOL)
St. Andrews University
San Jose State University, San Jose, CA
Save the Redwoods League
Scottish Association for Marine Science
Special Committee on Seals, UK
Spatial Ecosystems, Olympia, WA
Sustainable Fishery Advocates
Tenera Environmental, California
Texas A&M University, USA
University of California, Riverside (UCR)
University of California, Santa Barbara (UCSB)
University of California, Santa Cruz (UCSC)
University of Maine, USA
University of Miami, USA
University of Southern Mississippi, USA
University of Washington, Seattle, USA

COLLABORATORS

K. Anderson, University of California, Riverside
K. Aydin, NOAA/NMFS/NWFSC
K. Benson, National Park Service, Redwood National Park
S. Bograd, NOAA/SWFSC
M. Bonsall, Imperial College, London, UK
R. Brodeur, NOAA/NWFSC
J. Brodziak, NOAA/PIFSC
M. Burrows, Scottish Association for Marine Science
S. Carlson, UC Berkeley
E. Collins, CA Dept. of Fish and Game (CDFG)
T. Connors, San Diego Department of Public Works
A. Constable, AAD
J. Cope, NOAA/NWFSC
E. Curchitser, Rutgers University
A. Davis, California Department of Transportation



D. Demer, NOAA/SWFSC
E. di Lorenzo, Georgia Institute of Technology, Georgia
E. Dick, NOAA/NMFS/SWFSC
L. Emerson, AAD
T. Essington, University of Washington
N. Finnegan, UC Santa Cruz
L. Harrison, NOAA/NMFS/SWR
S. Hayes, NOAA
R. Hewitt, NOAA/SWFSC
M. Jones, NOAA/NEFSC-NFT
S. Kawaguchi, AAD
M. Key, CDFG
P. Levin, NWFSC
S. Lindley, NOAA/NMFS/SWFSC
A. MacCall, NOAA/NMFS/SWFSC
L. Marczak, University of Montana
S. McClatchie, NOAA/SWFSC
J. Merz, East Bay Municipal District
N. Metcalfe, Glasgow University
P. Monaghan, Glasgow University
S. Nicol, AAD
G. Ortuno, Centro Regional de Investigacion Pesquera, Mexico
D. Pearson, NOAA/NMFS/SWFSC
J. Phinney, NOAA/SWFSC
A. Punt, University of Washington, Seattle
S. Ralston, NOAA/NMFS/SCL
S. Ricker, CDFG
K. Rose, Louisiana State University
A. Rosenberg, University of New Hampshire
A. Sepulveda, USGS Northern Rocky Mountain Science Center
S. Sogard, UC Santa Cruz
C. Southwell, AAD
W. Sydeman, Farallon Institute for Advanced Ecosystem Research
G. Tarling, British Antarctic Survey
S. Thorpe, British Antarctic Survey
P. Trathan, BAS
A. Vega, Centro Regional de Investigacion Pesquera, Mexico
L. Washburn, UC Santa Barbara
W. Watson, NOAA/SWFSC
E. Weber, NOAA/SWFSC
C. Wetzel, NOAA/NWFSC
M. Yoklavich, NOAA/NMFS/SWFSC



PUBLICATIONS

Published Papers

- Ainsworth, C. H., I. C. Kaplan, P. S. Levin, and M. Mangel. A statistical approach for estimating fish diet compositions from multiple data sources: Gulf of California case study. *Ecol. Applic.* 20:2188-2202. (2010).
- Beakes, M. P., W. H. Satterthwaite, E. M. Collins, D. R. Swank, J. E. Merz, R. G. Titus, S. M. Sogard, and M. Mangel. Smolt transformation in two California steelhead populations: effects of temporal variability in growth. *Trans. Am. Fisheries Soc.* 139:1263-1275. (2010).
- Bjorkstedt, E., R. Goericke, S. McClatchie, E. Weber, W. Watson, N. Lo, B. Peterson, B. Emmett, J. Peterson, R. Durazo, G. Gaxiola-Castro, F. Chavez, J. T. Pennington, C. A. Collins, J. Field, R. Ralston, K. Sakuma, S. Bograd, F. Schwing, Y. Xue, W. Sydeman, S. A. Thompson, J. A. Santora, J. Largier, C. Halle, S. Morgan, S. Y. Kim, K. Merkens, J. Hildebrand, and L. Munger. State of the California Current 2009-2010: Regional variation persists through transition from La Nina to El Nino(and back). *CalCOFI Rep.* 51:39-69. (2010).
- Boyce, D. G., M. R. Lewis, and B. Worm. Global phytoplankton decline over the past century. *Nature.* 466:591-596. (2010).
- Decima, M., M. R. Landry, and R. R. Rykaczewski. Broad scale patterns in mesozooplankton biomass and grazing in the eastern equatorial Pacific. *Deep Sea Res. Part II: Topical Studies in Oceanography.* 58:387-399. (2010).
- Dorval, E., K. Piner, L. Robertson, C. S. Reiss, B. Javor, and R. Vetter. Temperature record in the oxygen stable isotopes of Pacific sardine otoliths: Experimental vs. wild stocks from the Southern California Bight. *J. Experimental Mar. Biol. and Ecol.* 397:136-143. (2011).
- Doyle, M. J., W. Watson, N. M. Bowlin, and S. B. Sheavly. Plastic particles in coastal pelagic ecosystems of the Northeast Pacific ocean. *Marine Environ. Res.* 71:41-52. (2011).
- Edwards, M., G. Beaugrand, G. C. Hays, J. A. Koslow, and A. J. Richardson. Multi-decadal oceanic ecological datasets and their application in marine policy and management. *Trends in Ecology and Evolution.* 25:602-610. (2010).
- Fuchs, H. L. and P. J. S. Franks. Plankton community properties determined by nutrients and size-selective feeding. *Mar. Ecol. Prog. Series.* 413:1-15. (2010).
- Gilbert, D., N. N. Rabalais, R. J. Diaz, and J. Zhang. Evidence for greater oxygen decline rates in the coastal ocean than in the open ocean. *Biogeosciences.* 7:2283-2296. (2010).
- Goebel, N. L., C. A. Edwards, J. P. Zehr, and M. J. Follows. An emergent community ecosystem model applied to the California Current System. *J. Mar. Syst.* 83:221-241. (2010).
- Goetze, E. and M. D. Ohman. Integrated molecular and morphological biogeography of the calanoid copepod family Eucalanidae. *Deep Sea Res. Part II: Topical Studies in Oceanography.* 57:2110-2129. (2010).
- Gorsky, G., M. D. Ohman, M. Picheral, S. Gasparini, L. Stemmann, J.-B. Romagnan, A. Cawood, S. Pesant, C. Garcia-Comas, and F. Prejger. Digital zooplankton image analysis using the ZooScan integrated system. *J. Plankton Res.* 32:285-303. (2010).
- Harlan, J., E. Terrill, L. Hazard, C. Keen, D. Barrick, C. Whelan, S. Howden, and J. Kohut. The Integrated Ocean Observing System High-Frequency Radar Network: Status and Local, Regional, and National Applications. *J. Mar. Technol. Soc.* 44 (6):122-132. (2010).
- Hinger, E. N., G. M. Santos, E. R. M. Druffel, and S. Griffin. Carbon isotope measurements of surface seawater from a time-series site off southern California. *Radiocarbon.* 52:69-89. (2010).
- Karl, D. M. Oceanic ecosystem time-series programs. *Oceanogr.* 23:104-125. (2010).
- Kim, S. Y. Observations of submesoscale eddies using high-frequency radar-derived kinematic and dynamic quantities. *Cont. Shelf Res.* (2010).
- Kim, S. Y., B. D. Cornuelle, and E. J. Terrill. Decomposing observations of high frequency radar derived surface currents by their forcing mechanisms: Decomposing techniques and spatial structures of decomposed surface currents. *J. Geophys. Res.* 115. (2010).
- Kim, S. Y., B. D. Cornuelle, and E. J. Terrill. Decomposing observations of high frequency radar derived surface currents by their forcing mechanisms: Decomposition Locally wind-driven surface currents. *J. Geophys. Res.* 115. (2010).
- King, A. L. and K. A. Barbeau. Dissolved iron and macronutrient distributions in the southern California Current System. *J. Geophys. Res.* 116. (2011).
- Lo, N. C. H., E. Dorval, R. Funes-Rodriguez, M. E. Hernandez-Rivas, Y. Huang, and Z. Fan. Utilities of larval densities of Pacific mackerel (*Scomber japonicus*) off California, USA and west coast of Mexico from 1951 to 2008, as spawning biomass indices. *Ciencia Pesquera.* 18:59-75. (2010).



- Ma, L., M. L. Stein, M. Wang, A. O. Shelton, C. A. Pfister, and K. J. Wilder. A method for unbiased estimation of population abundance along curvy margins. *Environmetrics*. (2010).
- McClatchie, S., R. Goericke, R. Cosgrove, G. Auad, and R. Vetter. Oxygen in the Southern California Bight: Multidecadal trends and implications for demersal fisheries. *Geophys. Res. Lett.* 37:L19602.19601-L19602.19605. (2010).
- Merl, D., L. R. Johnson, R. B. Gramacy, and M. Mangel. *amei*: An R package for the adaptive management of epidemiological interventions. *J. Statistical Software*. 32 ((6)):1-32. (2010).
- Moore, J. W., M. McClure, L. A. Rogers, and D. E. Schindler. Synchronization and portfolio performance of threatened salmon. *Cons. Lett.* 3:340-348. (2010).
- Moore, J. W. and D. E. Schindler. Spawning salmon and the phenology of emergence in stream insects. *Proc. Royal Soc. B* 277:1695-1703. (2010).
- Parnell, P. E., E. F. Miller, C. E. Lennert-Cody, P. K. Dayton, M. L. Carter, and T. D. Stebbins. The response of giant kelp (*Macrocystis pyrifera*) in southern California to low-frequency climate forcing. *Limnol. and Oceanogr.* 55:2686-2702. (2010).
- Roch, M. A., H. Klinck, S. Bauman-Pickering, D. K. Mellinger, S. Qui, M. S. Soldevilla, and J. A. Hildebrand. Classification of echolocation clicks from odontocetes in the Southern California Bight. *J. Acoust. Soc. Am.* 129 ((1)):467-475. (2011).
- Santoro, A. E., K. L. Casciotti, and C. A. Francis. Activity, abundance and diversity of nitrifying archaea and bacteria in the central California Current. *Environ. Microbiol.* 12:1989-2006. (2010).
- Satterthwaite, W. H. Competition for space can drive the evolution of dormancy in a temporally invariant environment. *Plant Ecol.* 208:167-185. (2010).
- Satterthwaite, W. H., M. P. Beakes, E. M. Collins, D. R. Swank, J. E. Merz, R. G. Titus, S. M. Sogard, and M. Mangel. State-dependent life history models in a changing (and regulated) environment: steelhead in the California Central Valley. *Evol. Applic.* 3:221-243. (2010).
- Satterthwaite, W. H., A. S. Kitaysky, S. A. Hatch, J. F. Piatt, and M. Mangel. Unifying quantitative life history theory and field endocrinology to assess prudent parenthood in a long-lived seabird. *Evol. Ecol. Res.* 12:779-792. (2010).
- Shelton, A. O. Environmental and community consequences of foundation species: surfgrass (*Phyllospadix* spp.) in tidepools. *J. Experimental Mar. Biol. and Ecol.* 391:35-42. (2010).
- Yu, D. W., T. Levi, and G. H. Shepard. Conservation in low governance environments. *Biotropica*. 42:569-571. (2010).

Conference Proceedings / Abstracts / Presented Papers / Reports

- Alin, S. R., R. A. Feely, A. G. Dickson, J. M. Hernandez-Ayon, L. W. Juranek, M. D. Ohman, and R. Goericke. Predictive relationships for pH and carbonate saturation in the southern California Current System using oxygen and temperature data *Am. Geophys. Un., Fall Mtg.* (2010).
- Baker, K., E. Weber, and J. A. Koslow. CalCOFI information management and data delivery. *PICES Conf. Portland, OR.* (2010).
- Bjorkstedt, E., R. Goericke, S. McClatchie, E. Weber, W. Watson, N. Lo, B. Peterson, B. Emmett, J. Peterson, R. Durazo, G. Gaxiola-Castro, F. Chavez, J. T. Pennington, C. A. Collins, J. Field, S. Ralston, K. Sakuma, S. Bograd, F. Schwing, Y. Xue, W. Sydeman, S. A. Thompson, J. A. Santora, J. L. Largier, C. Halle, S. Morgan, K. Merkens, J. Hildebrand, and L. Munger. State of the California Current 2009 - 2010: Regional variation persists through transition from La Nina to El Nino (and back?). *Fall 2010.* (2010).
- Bograd, S. J., C. G. Castro, F. Chavez, C. A. Collins, V. Combes, E. Lorenzo, and M. D. Ohman. The California Undercurrent, 1949-2008. *Proc. from the 2010 AGU Ocean Sci. Mtg. Portland, OR.* (2010).
- Campbell, G. S., K. Merkens, and J. Hildebrand. California Cooperative Fisheries Investigation (CalCOFI) Cruises 2009-2010. *Dept. of the Navy, U.S. Pacific Fleet, Annual.* 569-573. (2010).
- Campbell, G. S., K. Merkens, and J. Hildebrand. California Cooperative Fisheries Investigation (CalCOFI) Cruises 2009-2010. *Naval Postgraduate School NPS-OC-10.* (2010).
- Carter, M. and Z. Yin. Patterns of chlorophyll variability and phytoplankton community composition off southern California and the influence of macroscale and regional oceanographic processes. *Proc. from the 2010 AGU Ocean Sci. Mtg. Portland, OR.* (2010).
- Chekalyuk, A. M. and M. Hafez. Advanced Laser Fluorometry (ALF): New Technology, Field Observations and Findings. *Proc. from the 2010 AGU Ocean Sci. Mtg. Portland, OR.* (2010).
- Chenillat, F., P. C. Riviere, E. Lorenzo, S. J. Bograd, and M. D. Ohman. Low-frequency transport dynamics in the California Current *Proc. from the 2010 AGU Ocean Sci. Mtg. Portland, OR.* (2010).
- Davison, P., A. Lara-Lopez, and J. A. Koslow. Challenges in the application of acoustic survey methods to a complex aquatic community: the deep scattering layer of the California Current. *CalCOFI Conf. La Jolla, CA.* (2010).



- Dickson, A. Ocean Acidification Impacts on Shellfish Workshop: Findings and Recommendations Ocean Acidification Effects on Shellfish Workshop: Findings and Recommendations. Costa Mesa, CA. (2010).
- Hsieh, C., H. Kim, W. Watson, E. Lorenzo, and G. Sugihara. Climate-driven changes in abundance and distribution of larvae of oceanic fishes in the Southern California region. Proc. from the 2010 AGU Western Pacific Geophysics Mtg. Taipei, Taiwan. (2010).
- Kim, S. Y., B. D. Cornuelle, and E. J. Terrill, "Regression analysis of historical coastal observations off southern California Bight (presentation)," in 35th Climate Diagnostics and Prediction Workshop. Raleigh, NC, 2010.
- Kim, S. Y., E. J. Terrill, and B. D. Cornuelle. Observations of high-resolution surface circulation off the U.S. West Coast (poster). AGU Joint Assembly. Foz do Iguassu, Brazil. (2010).
- Kim, S. Y., E. J. Terrill, B. D. Cornuelle, B. Jones, L. Washburn, M. A. Moline, J. D. Paduan, N. Garfield, J. Largier, G. Crawford, and P. M. Kosro. Observations of high-resolution coastal surface circulation on the U.S. West Coast (poster). Eastern Pacific Ocean Conf. 2010. Portland, OR. (2010).
- Koslow, J. A. and C. Allen. The influence of the ocean environment on the abundance of market squid (*Doryteuthis opalescens*) paralarvae in the Southern California Bight. CalCOFI Conf. La Jolla, CA. (2010).
- Koslow, J. A., R. Goericke, A. Lara-Lopez, and W. Watson. Climate, the oxygen-minimum zone, and deepwater fishes of the southern California Current. CalCOFI Conf. La Jolla, CA. (2010).
- Koslow, J. A., R. Goericke, A. Suntsov, and W. Watson. Climate and larval fish assemblages in the southern California Current, 1951 - 2008. Climate and Fisheries Symposium. Sendai, Japan. (2010).
- Koslow, J. A., R. Goericke, and W. Watson. Climate and fish assemblages of the southern California Current, 1951 - 2008. PICES Conf. Portland, OR. (2010).
- Koslow, T., L. Rogers-Bennett, and D. Neilson. A time series for the phyllosoma of the California spiny lobster (*Panulirus interruptus*) off Southern California, 1951 - 2008: relationships with climate and the fishery. CalCOFI Conf. La Jolla, CA. (2010).
- Lara-Lopez, A., P. Davison, and J. A. Koslow. Methodological challenges to estimating abundance of mid-trophic organisms using multi-frequency acoustics and net sampling in contrasting hydrographic regimes off southern California ICES Working Group on Fisheries Acoustics Science and Technology (FAST). San Diego, CA. (2010).
- Lavigne, M., T. M. Hill, H. J. Spero, and T. P. Guilderson. Climate, productivity, and intermediate water nutrients: new records from bamboo coral Ba/Ca. Am. Geophys. Un., Fall Mtg. (2010).
- Lo, N. and B. Macewicz. Daily egg production method survey. Workshop on enhancing stock assessments of Pacific sardine in the California Current through cooperative surveys. La Jolla, CA. (2010).
- Lo, N. C. H., B. J. Macewicz, and D. A. Griffith. Spawning biomass of Pacific sardine (*Sardinops sagax*) off the U.S. in 2010. (2010).
- Mason, J. Review of the use of California Commercial Fisheries Landings and Recreational Catch Data in stock assessments. Managing Data-Poor Fisheries: Case Studies, Models & Solutions. (2010). 247-256.
- Munro, D. R. and P. Quay. Gross and net production estimates in the California Current System from oxygen triple isotopes and the O₂/Ar ratio. Am. Geophys. Un., Fall Mtg. (2010).
- Neal, A. C., M. Gonsior, M. Gassel, H. Coleman, N. Argyropoulos, C. Hume, R. Mielke, D. Steuerman, K. D. Knobelspiesse, and B. Balestra. Initial analysis of marine debris accumulation in the Subtropical Convergence Zone of the North Pacific Gyre. Proc. from the 2010 AGU Ocean Sciences Mtg., 2010. Portland, OR. (2010). 22-26.
- Nisbet, R. M., K. E. Anderson, L. Pecquerie, and L. Harrison. Integrating bioenergetics, spatial scales, and population dynamics for environmental flow assessment. California Energy Commission CEC-500-02-004. (2011).
- Nur, N., J. Jahncke, M. Herzog, J. Howar, J. A. Wiens, and D. Stralberg. Wildlife hotspots in the California Current System Petaluma, CA. (2010).
- Powell, J. R., M. D. Ohman, and R. E. Davis. Glider-based analysis of covariability of ocean fronts and zooplankton acoustic backscatter in the California Current System Proc. from the 2010 AGU Ocean Sci. Mtg. Portland, OR. (2010).
- Song, A. J. Miller, and B. D. Cornuelle. Estimating ocean states during the LTER CCE-P0605 cruise using ocean data assimilation analysis. Proc. from the 2010 AGU Ocean Sci. Mtg. Portland, OR. (2010).
- Sweetnam, D. Current management and fishery-dependent sampling of the U.S. Pacific Sardine Fishery Workshop on enhancing stock assessments of Pacific sardine in the California Current through cooperative surveys. La Jolla, CA. (2010).
- Todd, R. E., D. L. Rudnick, and R. E. Davis. Mesoscale and submesoscale thermohaline structure in the California Current System from glider observations. Am. Geophys. Un., Fall Mtg. 2010. (2010).
- Yu, H. Characterization of mysterious algal cultures from the California coast. Monterey Bay Aquarium Research Institute, Moss Landing, CA. (2010).
- Zeigler, L. A., J. Badger, J. P. McCrow, I. Paulsen, E. E. Allen, S. J. Williamson, and A. Allen. Microbial metagenomics across a southern California Current upwelling mosaic. Proc. from the 2010 AGU Ocean Sci. Mtg. Portland, OR. (2010).



Books / Book Sections / Edited Books

- Bograd, S. J., W. J. Sydeman, J. Barlow, A. Booth, R. D. Brodeur, J. Calambokidis, F. Chavez, W. R. Crawford, E. Di Lorenzo, R. Durazo, R. Emmett, J. Field, G. Gaxiola-Castro, W. Gilly, R. Goericke, J. Hildebrand, J. E. Irvine, M. Kahru, J. A. Koslow, B. Lavaniegos, M. Lowry, D. L. Mackas, M. Manzano-Sarabia, S. M. McKinnell, B. G. Mitchell, L. Munger, R. I. Perry, W. T. Peterson, S. Ralston, J. Schweigert, A. Suntsov, R. Tanasichuk, A. C. Thomas, and F. Whitney. Status and trends of the California Current region, 2003-2008. *Marine Ecosystems of the North Pacific Ocean 2003-2008*, S. M. McKinnell and M. J. Dagg, Eds. PICES, 2010), pp. 106-141.
- Bucklin, A., S. Nishida, S. B. Schnack-Schiel, P. H. Wiebe, D. Lindsay, R. J. Machida, and N. J. Copley. A Census of Zooplankton of the Global Ocean. *Life in the World's Oceans: Diversity, Distribution and Abundance*, E. A. D. McIntyre, Ed.: (Oxford, Wiley Blackwell, 2010), pp. 247-265.
- Creswell, K. R., W. H. Satterthwaite, and G. A. Sword. Understanding the evolution of migration through empirical examples. *Animal Migration: A Synthesis*, E. J. Millner-Gulland, J. Fryxell, and A. R. E. Sinclair, Eds.: (Oxford, U.K., Oxford University Press, 2011), pp. 7-16.
- Taylor, A. H. *The Dance of Air and Sea: How Oceans, Weather and Life Link Together*. Oxford University Press, New York, (2011).

Theses

- Henderson, E. *Cetaceans in the Southern California Bight: Behavioral, acoustical and spatio-temporal modeling*. Ph.D. University of California, San Diego. San Diego, CA. (2011).

In Press / Submitted / In Preparation

- Bednarek, A. T., A. B. Cooper, K. A. Cresswell, M. Mangel, W. H. Satterthwaite, C. A. Simpfendorfer, and J. R. Wiedenmann. Marine conservation in the 21st century: the certainty of uncertainty and what to do about it. *Bull. Mar. Sci.*
- Brown, V. and D. Hively. Assessing the Assessments: A Life History Simulator to Test Stock Assessment Models and Methods. *Natural Resource Modeling*.
- Carlson, S. M. and W. H. Satterthwaite. Weak portfolio effect in a collapsed fish population complex. *Can. J. Fisheries and Aqu. Sci.*
- Dick, E. J. and A. D. MacCall. Depletion-Based Stock Reduction Analysis: A catch-based method for determining sustainable yields for data-poor fish stocks. *Fisheries Res.*
- Gangopadhyay, A., P. F. Lermusiaux, L. Rosenfeld, A. R. Robinson, L. Calado, H. S. Kim, W. G. Leslie, and J. P. J. Haley. The California Current System: A multiscale overview and the development of a Feature-Oriented Regional Modeling System (FORMS). *Dynamics of Atmospheres and Oceans*. 65.
- Koslow, J. A., K. Brander, M. Fogarty, and F. Schwing. Integration of ocean observations into an ecosystem approach to resource management. *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society*. Venice, Italy. 1.
- Koslow, J. A., R. Goericke, S. McClatchie, R. Vetter, and L. Rogers-Bennett. The California Cooperative Oceanic Fisheries Investigations (CalCOFI): the continuing evolution and contributions of a 60-year ocean observation program. *Proc. of OceanObs'09: Sustained Ocean Observations and Information for Society*. Venice, Italy. 1.
- Koslow, J. A., R. Goericke, W. Watson, and A. Lara-Lopez. Impact of declining intermediate-water oxygen on deepwater fishes in the California Current. *Mar. Ecol. Prog. Series*.
- Levi, T., G. H. J. Shepard, J. Ohi-Schacherer, C. C. Wilmers, C. A. Peres, and D. W. Yu. Spatial tools for modeling the sustainability of subsistence hunting in tropical forests. *Ecol. Applic.*
- McQuatters-Gollop, A., P. C. Reid, M. Edwards, P. H. Burkill, C. Castellani, S. Batten, W. Gieskes, D. Beare, R. R. Bidgare, E. Head, R. Johnson, M. Kahru, J. A. Koslow, and A. Pena. Marine phytoplankton: decline - or not? *Nature*.
- Pecquerie, L., L. R. Johnson, S. A. L. M. Koojiman, and R. M. Nisbet. Analyzing variations in life-history traits of Pacific salmon in the context of Dynamic Energy Budget (DEB) theory. *J. Sea Res.*
- Satterthwaite, W. H., S. A. Hayes, J. E. Merz, S. M. Sogard, and M. Mangel. State dependent life history of *Oncorhynchus mykiss* in central California: model testing and extensions for systems with seasonally closed lagoonal estuaries. *Trans. Am. Fisheries Soc.*
- Satterthwaite, W. H., A. S. Kitaysky, and M. Mangel. Effects of climate variability on productivity, stress, and demography in a long-lived seabird. *Oikos*.



- Satterthwaite, W. H. and M. Mangel. Using behavioral models to predict impacts of climate change on seabirds and fur seals. *Deep Sea Res. II*.
- Send, U., P. Burkill, N. Gruber, G. C. Johnson, A. Kortzinger, J. A. Koslow, R. O'Dor, S. Rintoul, and D. Roemmich. Towards an integrated observing system: in-situ observations. *Proc. of OceanObs'09: Sustained Ocean Observations and Information for Society*. Venice, Italy. 1.
- Shelton, A. O., E. J. Dick, D. E. Pearson, R. Ralston, and M. Mangel. Estimating landings and quantifying uncertainty in multi-species fisheries: Hierarchical Bayesian models for stratified sampling protocols with missing data. *Can. J. Fisheries and Aqu. Sci.*
- Shelton, A. O. and M. Mangel. On the fluctuations of fish populations and the magnifying effects of fishing. *Proc. Natl. Acad. Sci.*
- Shelton, A. O. and M. Mangel. Sex differences in Pacific herring (*Clupea pallasii*) life-histories and their implications for fisheries. *Trans. Am. Fisheries Soc.*
- Suntsov, A., J. A. Koslow, and W. Watson. The spatial structure of coastal ichthyoplankton assemblages off central and southern California. *Estuarine, Coastal, and Shelf Sci.*
- Swope, S. M. and W. H. Satterthwaite. Variable effects of a generalist parasitoid on a biocontrol seed predator and its target weed. *Ecol. Applic.*
- Vincenzi, S., A. J. Crivelli, J. Giske, W. H. Satterthwaite, and M. Mangel. Selective consequences of catastrophes on growth rates in a stream-dwelling salmonid. *Oecologia*.
- Ward, D. M., K. H. Nislow, and C. L. Folt. Seasonal shift in the effect of predators on juvenile salmon energetics. *Functional Ecology*.
- Yovovich, V., K. Richerson, and Y. Wang. *Fisheries. Green Issues and Debates*. (Sage Publications).

PUBLICATION SUMMARY											
CIMEC Lead Author				NOAA Lead Author				Other Lead Author			
2010-11	2011-12	2012-13	2013-14	2010-11	2011-12	2012-13	2013-14	2010-11	2011-12	2012-13	2013-14
Peer Reviewed Non Peer Reviewed	22			24				11			
	19			14				7			
	41			38				18			

Total Publications for this period: 97



ACRONYMS

AMLR	Antarctic Marine Living Resources Program
AOML	NOAA/Atlantic Oceanographic and Meteorological Lab
BAS	Birch Aquarium at Scripps
BML	Bodega Marine Laboratory, UC Davis
CA COSEE	California Center for Ocean Science Excellence in Education
CalIT	California Institute of Technology
Cal State	California State University system
Caltrans	California Department of Transportation
CAP	California Applications Program
CBNMS	Cordell Banks National Marine Sanctuary
CDFG	California Department of Fish and Game
CEC	California Energy Commission
CEFA	Climate, Ecosystem and Fire Applications
CeNCOOS	Central and Northern California Ocean Observing System
CEOP	Coordinated Enhanced Observing Period
ChESS	Biogeography of Deep-Water Chemosynthetic Ecosystems / Census of Marine Life
CICAR	Cooperative Institute for Climate Applications and Research, Palisades, New York
CICOR	Cooperative Institute for Climate and Ocean Research, Woods Hole, Massachusetts
CICS	Cooperative Institute for Climate Science, Princeton, New Jersey
CIFAR	Cooperative Institute for Arctic Research, Fairbanks, Alaska
CILER	Cooperative Institute for Limnology and Ecosystems Research, Ann Arbor, Michigan
CIMAS	Cooperative Institute for Marine and Atmospheric Studies, Miami, Florida
CIMMS	Cooperative Institute for Mesoscale Meteorological Studies, Norman, Oklahoma
CIMRS	Cooperative Institute for Marine Resource Studies
CIMSS	Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin, Madison
CIOSS	Cooperative Institute for Oceanographic Satellite Studies
CIRA	Cooperative Institute for Research in the Atmosphere
CIRES	Cooperative Institute for Research in Environmental Sciences
CLIMAS	Climate Assessment for the Southwest
CLSA	California Land Surveyors Association
CMER	Cooperative Marine Education and Research
CNES	Centre National d'Etudes Spatiales



COML	Census of Marine Life
COP	NOAA/NOS/Center for Sponsored Coastal Ocean Research/Coastal Ocean Program
CPO	NOAA/Climate Programs Office (formerly, Office of Global Programs (OGP))
CRIP	Centro Regional de Investigacion Pesquera, Instituto Nacional de la Pesca, Ensenada/La Paz, Mexico
CRTN	California Real Time Network
CSIRO	Commonwealth Scientific and Industrial Research Organisation--Australia
CSRC	California Spatial Reference Center
CTD	Conductivity Temperature and Depth (as in, Underway CTD)
DBCP	Data Buoy Cooperation Panel, WMO-IOC
DOE	U.S. Department of Energy
DWR	California Department of Water Resources
ECCO	SIO's Estimating the Circulation and Climate of Oceans Consortium
ENSO	El Niño and Southern Oscillation
ESRL	NOAA/Earth System Research Laboratory
FKNMS	NOAA/Florida Keys National Marine Sanctuary
GACC	Geographic Area Coordination Centers
GEOSS	Global Earth Observation System of Systems
GEWEX	Global Energy and Water-cycle Experiment
GIS	Geographic Information Systems
GMD	NOAA/ESRL/Global Monitoring Division
GODAE	Global Ocean Data Assimilation Experiment
GPS	Global Positioning System
GSD	NOAA/ESRL/Global Systems Division
GTS	GNU Triangulated Surface
HRC	Hydrologic Research Center, San Diego, CA
HRX	Repeat high resolution expendable Bathythermograph
ICARTT	International Consortium for Atmospheric Research on Transport and Transformation
IOC	Intergovernmental Oceanographic Commission
IOOS	Integrated and Sustained Ocean Observations
IRD	Institut de Recherche pour le Développement
IRI	International Research Institute for Climate Prediction
JCOMM	Joint WMO-10C Technical Commission for Oceanography and Marine Meteorology
JIMAR	Joint Institute for Marine and Atmospheric Research
JIMO	Joint Institute for Marine Observations
JISAO	Joint Institute for the Study of Atmosphere and Ocean



JPL	Jet Propulsion Laboratory, NASA
MBARI	Monterey Bay Aquarium Research Institute
MIT	Massachusetts Institute of Technology, Harvard
MPI	Max Planck Institute, Germany
MPL	Marine Physical Laboratory, SIO, UCSD
NASA	National Aeronautics and Space Administration
NDBC	NOAA/NWS/National Data Buoy Center
NCAR	National Center for Atmospheric Research
NCEP	NOAA/National Centers for Environmental Predictions
NEFSC	NOAA/Northeast Fisheries Science Center
NESDIS	NOAA/National Environmental Satellite, Data, and Information Services
NGI	Northern Gulf Institute
NGS	NOAA/National Geodetic Survey
NIWA	National Institute of Water and Atmospheric Research, New Zealand
NMFS	NOAA/National Marine Fisheries Service
NMSP	National Marine Sanctuary Program
NOS	NOAA/National Ocean Service
NSF	National Science Foundation
NWFSC	NOAA/Northwest Fisheries Science Center, NMFS
NWS	NOAA/National Weather Service
OAR	NOAA/Ocean and Atmospheric Research
OE	NOAA/Office of Ocean Exploration
OGCM	Oceanic General Circulation Model
OGP	See CPO
ONR	Office of Naval Research
ORA	NOAA/Office of Research and Applications
PDO	Pacific Decadal Oscillation
PFEG	NOAA/NMFS/Pacific Fisheries Environmental Group
PIFSC	NOAA/NMFS/Pacific Islands Fisheries Science Center
PMEL	NOAA/Pacific Marine Environment Lab
R/V	Research Vessel
ROWG	Radio Operators Working Group
SAS	Simplified Arakawa-Schubert cumulus convection scheme
SCCWRP	Southern California Coastal Water Research Project
SDG&E	San Diego Gas & Electric



SEFSC	NOAA/Southeast Fisheries Science Center, Panama City, FL
SIO	Scripps Institution of Oceanography, UCSD
SOPAC	Scripps Orbit and Permanent Array Center
SST	Sea surface temperature
SVP	Surface Velocity Program
SWFSC	NOAA/Southwest Fisheries Science Center, NMFS
UC	University of California
UCD	University of California, Davis
UCLA	University of California, Los Angeles
UCSB	University of California, Santa Barbara
UCSC	University of California, Santa Cruz
UCSD	University of California, San Diego
UNAM	Universidad Nacional Autonoma de Mexico
USARP	U.S. Antarctic Research Program
USC	University of Southern California
USFS	U.S. Fire Service
USGS	U.S. Geological Survey
UW	University of Washington, Seattle
VAdm	Vice Admiral
VOS	Voluntary Observing Ship
WECC	Western Electricity Coordinating Council
WHOI	Woods Hole Oceanographic Institution
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
XBT	Expendable Bathythermograph
XCTD	Expendable Conductivity Temperature and Depth

Credits

Photography and illustrations courtesy of researchers and staff affiliated with the Cooperative Institute for Marine Ecosystems and Climate. Additional photography courtesy of Scripps Institution of Oceanography Archives, as well as the following individuals and groups:



Cooperative Institute for Marine Ecosystems and Climate
Scripps Institution of Oceanography
University of California, San Diego
291 Rosecrans Street
San Diego, California 92106

