

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

2013-2014





**Cooperative Institute for
Marine Ecosystems and Climate**
Progress Report
Prepared for the
National Oceanic and Atmospheric Administration
NOAA NA10OAR4320156
2013-2014



CIMEC

Cooperative Institute for Marine Ecosystems and Climate (CIMEC)

Scripps Institution of Oceanography

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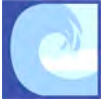
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INTRODUCTION

The Cooperative Institute for Marine Ecosystems and Climate (CIMEC) research and program activities for the year (2013-2014) of the **National Oceanic and Atmospheric Administration** (NOAA) grant **NA10OAR4320156** are outlined in this report. CIMEC is affiliated with the **Scripps Institution of Oceanography** (SIO), and is 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 CIMEC researchers and partners at SIO, UC and Cal State, as well as other collaborating organizations associated with CIMEC.

CIMEC'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 April 1, 2013 to March 31, 2014 period, the NOAA research entities listed below were engaged with SIO as part of CIMEC 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)
- Earth System Research Laboratory (ESRL)
- Integrated Ocean Observing System (IOOS)
- National Data Buoy Center (NDBC)
- National Integrated Drought Information System (NIDIS)
- National Marine Fisheries Service (NMFS)
- National Ocean Service (NOS)
- Marine Ecosystems Division (MED)
- Ocean Assessment Program (OAP)
- Office of Habitat Conservation (OHC)
- Pacific Island Fisheries Science Center (PIFSC)
- Pacific Marine Environmental Laboratory (PMEL)
- Southeast Fisheries Science Center (SEFSC)
- Southwest Fisheries Science Center (SWFSC)



DIRECTOR'S LETTER

The Cooperative Institute of Marine Ecosystems and Climate continues to serve NOAA and the Nation through research and observing conducted by scientists at its constituent academic institutions. CIMEC's reach extends from the atmosphere to the deep ocean. CIMEC's products are used for near-term forecasts of the ocean and atmosphere and for the assessment and prediction of long-term change. CIMEC plays a critical role in sustaining marine fisheries and ecosystems. CIMEC contributes importantly to the training the next generation of scientists. Since its start on July 1, 2010, CIMEC has received more than \$54 million dollars from NOAA. CIMEC is proud to contribute valuably to NOAA's mission.

CIMEC continues to be active in a wide variety of areas of concern to NOAA. Fisheries research and training occurs at the UCSC, UCSD, and HSU. The Center for Stock Assessment Research has been joined by the Center for the Advancement of Population Methodology to contribute to NOAA's needs in fisheries management. The California Cooperative Oceanic Fisheries Investigations (CalCOFI) remains the longest ship-based physical/biological time-series program. Passive acoustics are being used to sense marine mammals and anthropogenic noise. The Global Drifter Program provides observations critical for weather and hurricane forecasting. The Argo Project characterizes the state of the upper ocean. Deep Argo floats continue to be tested. Standard Argo floats measure temperature in the upper two kilometers of the ocean. A complete energy budget requires temperature measurements to full ocean depth. Deep Argo measures temperature and salinity to six kilometers, enabling assessment of the heat and freshwater content of the ocean. The Consortium on the Ocean's Role in Climate is designing and implementing boundary current observing systems. Two moorings in the California Current provide real-time observations of ocean physics, chemistry, and biology. Ocean acidification is a focus of both CalCOFI and moorings.

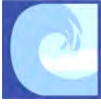
Two workshops are notable. The international TPOS 2020 Workshop in January 2014 addressed modernization of the tropical Pacific observing system. The California Current and Climate workshop in April 2014 focused on coordinated, coastwide observing in support of ecosystem-based management.

The La Jolla Laboratory of NOAA's Southwest Fisheries Science Center and SIO's Marine Ecosystem Sensing, Observation, and Modeling Laboratory at SIO are now in full use. NOAA's FSV Reuben Lasker was commissioned on May 2, 2014 and SIO's global-class R/V Sally Ride, funded by the US Navy, will be christened on August 9, 2014.

CIMEC received the highest ("outstanding") rating during its fourth-year review in February 2014. We look forward to five more years of service to NOAA and the Nation.

I continue to appreciate the expert administrative support provided to CIMEC by Rose Keuler, Anne Footer, and Garrett Eaton.

David M. Checkley, Jr.
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 builds upon SIO's experience from nearly twenty years of management of the Joint Institute for Marine Observations, and works 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 Organizational Chart

UCSD CHANCELLOR
Pradeep Khosla

VICE CHANCELLOR,
MARINE SCIENCES /
SIO DIRECTOR
Margaret Leinen

CIMEC DIRECTOR
David Checkley

BUSINESS MANAGER
Anne J. Footer

CIMEC ADMINISTRATION
Rose Keuler

REPORTS / WEBSITE / DATABASE
Garrett Eaton



CIMEC Employee Summary (April 1, 2013 – March 31, 2014)

Personnel Supported by NOAA/JIMO Funding				
Category	Number	B.S. / B.A.	M.S.	Ph.D.
Associate Professor	1			1
Assistant Professor				
Project Scientist	8			8
Postdoctoral Fellow	3			3
Research Specialist	3			3
Programmer Analyst	8	2	6	
Staff Research Assoc/Asst	11	9	2	
Assoc. Development Engr.	1	1		
Laboratory Asst	16	14		
Marine Technician	2	2		
Admin. Analyst	1	1		

Total (≥ 50% support)	54	29	8	15
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Undergraduate Students	24			
Graduate Students	19			
Employees that receive < 50% NOAA Funding (not including students)	73			
Located at Lab (include name of lab)	38	NOAA FED SWFSC		
Obtained NOAA employment within the last year	1	Arliss Winship (NOS/NCCOS/CCMA)		
Sub-awards				
Postdoctoral Fellow	-			
Graduate Students	-			
Undergrad Student	-			

CIMEC Fellows Roster (April 1, 2013 – March 31, 2014)

Jeffrey Abell (Humboldt State)	Timothy Mulligan (Humboldt State)
Bruce Appelgate (SIO)	Eric Palkovacs (UC Santa Cruz)
Simone Baumann-Pickering (SIO)	Marty Ralph (SIO)
Yehuda Bock (SIO)	V. Ramanathan (SIO)
Dan Cayan (SIO)	Dean Roemmich (SIO)
Luca Centurioni (SIO)	Brice Semmens (SIO)
Andrew Dickson (SIO)	Uwe Send (SIO)
Tracey Goldstein (UC Davis)	Ana Sirovic (SIO)
John Hildebrand (SIO)	George Sugihara (SIO)
Mark Jacobsen (UCSD)	James Swift (SIO)
Ralph Keeling (SIO)	Eric Terrill (SIO)
J. Anthony Koslow (SIO)	Aaron Thode (SIO)
Marc Mangel (UC Santa Cruz)	Darren Ward (Humboldt State)
Baldo Marinovic (UC Santa Cruz)	



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 be started in a Sea Grant project to develop models to use in the evaluation of ongoing monitoring efforts.

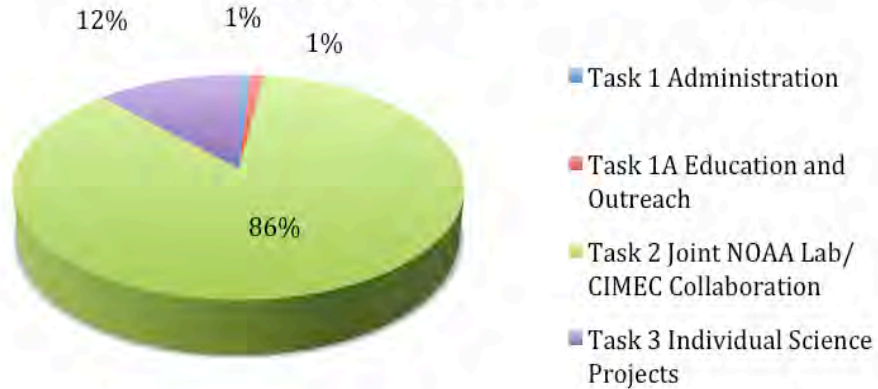
The Center for Stock Assessment Research (CSTAR)

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."



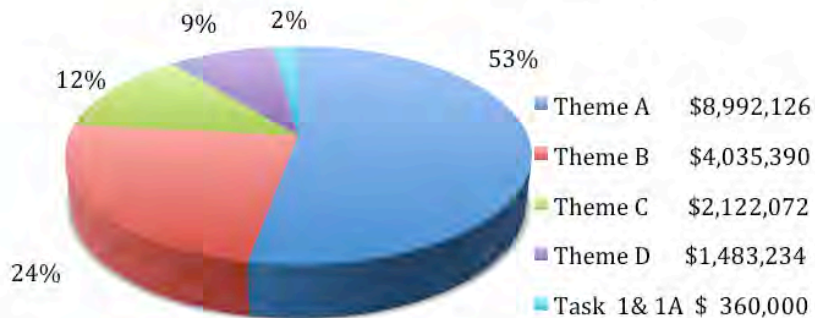
Funding Summary

CIMEC Funding by Task \$16,992,822



Task 1: CIMEC Administration - \$160,000
Task 1A: Education and Outreach - \$200,000
Task 2: Joint NOAA Lab/CIMEC Collaboration - \$14,580,457
Task 3: Individual Science Projects - \$2,052,365

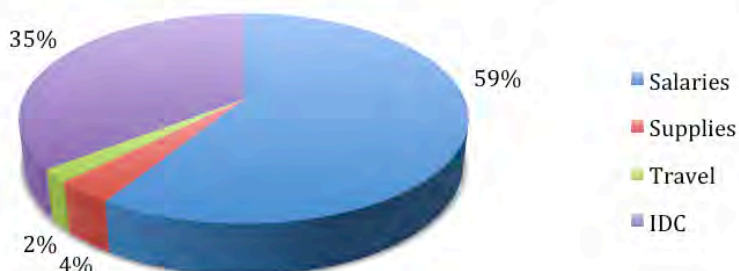
CIMEC Funding by Theme \$16,992,822 April 1, 2013 - March 31, 2014



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



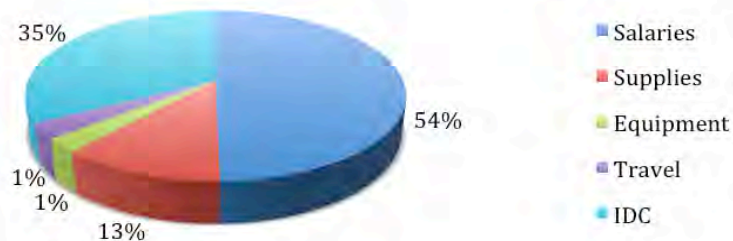
CIMEC Task 1 Administration Expenditures \$197,754



Category	Awarded	Expensed
Salary and Benefits	\$96,793	\$116,421
Supplies	\$3,563	\$7,157
Travel	\$2,870	\$4,005
IDC	\$56,774	\$70,171
	\$160,000	\$197,754

Salary and Benefit expenditures are comprised of support for the CIMEC Director and Administrative staff. Supply expenditures comprise NGN costs (network support), project specific supply costs and meeting costs. Travel expenses were for costs associated with the CIMEC Formal Review which was held in February 2014 and for the CIMEC Director in 2013.

CIMEC Task 1A Education and Outreach Expenditures \$217,866



Category	Awarded	Expensed
Salary and Benefits	\$119,393	\$108,275
Equipment	-	\$5,800
Supplies	\$9,639	\$25,746
Travel	-	6,603
IDC	\$70,968	\$71,442
	\$200,000	\$217,866



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

NOAA Ocean Acidification Program: Monitoring, Small Sample Analysis and AQ/AC Analytical Support [Andrew G. Dickson, SIO]

- We continue to submit our data from high-quality measurements of total alkalinity and total dissolved inorganic carbon from CalCOFI samples to the CalCOFI database, and to Dr. Alin at NOAA/PMEL
- The inter-laboratory study of CO₂ measurements included over 50 labs and demonstrates the current level of skill of the various NOAA labs
- There are still problems with labs both in measuring pH, and in measuring DIC, particularly for samples with high CO₂ levels

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

- Implemented and upgraded 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.
- Installed new nodes, systems designed to act as data repositories and vector processing, have been purchased for the participating Institutions: SIO, NDBC, and Rutgers University.
- Added one new region to HFRNet – Mexico
- Enabled International totals for three regions: Taiwan, Australia, and Spain
- Completed reports on Radial Metrics and Optimal Interpolation
- Maintained THREDDS server for near real-time RTV's
- Maintained and updated HFRNET code repository
- New Codar sites were made available to all Nodes for RTV processing:
 - Kaena, HI (KNA) University of Hawaii
 - <http://cordc.ucsd.edu/projects/mapping/stats/?sta=KNA&aff=UH>
 - Point Barrow, AK (PBRW), AK University of Alaska Fairbanks
 - <http://cordc.ucsd.edu/projects/mapping/stats/?sta=PB&aff=UAF>
 - Cape Simpson, AK (SIMP) University of Alaska



	<ul style="list-style-type: none">- Fairbanks http://cordc.ucsd.edu/projects/mapping/stats/?sta=SI MP- Point Lookout, NY (LOOK) Rutgers University http://cordc.ucsd.edu/projects/mapping/stats/?sta=LO OK- Sandy Hook, NJ (HOMR) Rutgers University http://cordc.ucsd.edu/projects/mapping/stats/?sta=HO MR- Quinta, MX (QTA) Autonomous University of Baja California http://cordc.ucsd.edu/projects/mapping/stats/?sta=QT A- Villarino, MX (VIL) Autonomous University of Baja California http://cordc.ucsd.edu/projects/mapping/stats/?sta=VIL- Conalep, MX (CONA) Autonomous University of Baja California http://cordc.ucsd.edu/projects/mapping/stats/?sta=CO NA <ul style="list-style-type: none">o Decommissioned Sites:<ul style="list-style-type: none">- Barrow, AK (BASC) University of Alaska Fairbanks – 8/12/2013- 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 present (when available)- PRVI - Puerto Rico and US Virgin Islands - 2010-01 through present
Collaborative Scientific and Technical Support to the NOAA Earth System Research Laboratory [Yehuda Bock, SIO] [Peng Fang, SIO]	<ul style="list-style-type: none">o Maintained high reliability orbit solutions in terms of two global sub-networks in parallel with an automatic failover system.o Continued using the latest global gravity model and most recent global reference frame, updated absolute antenna phase center model, most recent ocean tidal loading model, updated differential phase bias correction, and improved ambiguity resolution for long baselines.o Continued comprehensive orbit quality control procedure to reduce the risk of contaminating the IPW estimates in the GPS/Met solutions.
Develop Forecast Methods and an “AR Portal” for Atmospheric River Data Tools [Dan Cayan, SIO] [Marty Ralph, SIO]	<ul style="list-style-type: none">o New AR Portal web page developed and is now online at http://cw3e.ucsd.eduo New automated IVT and IWV forecasts derived from real-time GFS products were developedo Analysis of Feb 2014 dropsonde measurements reveals atmospheric river event with water transport of $8 \times 10^8 \text{ kg sec}^{-1}$o 75% of total IVT occurred below about 650 hPa during Feb 2014 AR events



An Atmospheric River Case Study on the Russian River and a Vision for Western US Observing Systems
[Dan Cayan, SIO]
[Marty Ralph, SIO]

- Condensed the Western Observing System Vision informal document into a peer-reviewed journal submission.
- Published paper in April 2014 (Ralph et al. 2014)
- Presented at an interagency meeting on hydroclimate monitoring networks for the western U.S.
- Continuing analysis of the March 2012 landfalling atmospheric river case and comparison with an event in 2007, both affecting the Russian River

B. Climate Research and Impacts

NOAA Support for CLIVAR and Hydrographic Data Office
[Bruce Appelgate, SIO]
[James Swift, SIO]

- Continued increase of US and non-US CTD profiles, both public and non-public, available for Argo reference data
- Continued reconciliation of EXPOCODE expedition identifiers among US data centers
- Progress on the Applications Programming Interface will soon enable large data users (e.g., modelers) to directly download any/all data of interest
- On-going harmonization of disparate data centers and the data from various large-scale hydrographic surveys has led to a better "capture percentage" of all data (US-HYDRO, GO-SHIP, DIMES). Because the CCHDO carries out data curation for these programs, their data interoperability is improved as the metadata and discovery information. NOAA/NODC benefits because it obtains all curated data from the CCHDO
- NOAA funded observations are captured by the CCHDO through the GO-SHIP, Argo and OceanSITES programs and are provided in a uniform format with consistent content. The importance of this work and its potential impact was recognized last year by IODE, who asked the CCHDO to become an Associated Data Unit (ADU), a class of IODE members created last year specifically to include organizations such as BCO-DMO, CDIAC and the CCHDO, on par with each member nation's NODC
- The CCHDO's involvement in IODE, SOOS, Argo, OceanSITES, GO-SHIP, DIMES and related organizations leads to continued improvement in the areas of NOAA interest funded by the award

Global Drifter Program
[Luca Centurioni, SIO]
[Bruce Cornuelle, SIO]

- GDP array completed with 1,326 drifter in the array at the time of writing
- SIO is now posting drifter data to the GTS
- Significant increase in the number of drifters in the Indian Ocean
- Coordinated GDP Activities Between Partners and Support of other science programs
- Enhanced the GDP Array with Matching Contributions
- Monitored and Advised the Drifter Manufacturers to Ensure Drifter are Built According to Specifications
- Updated and Maintain the Enhanced GDP dataset/GDP data distribution
- Maintained Statistics of Drifter Performances
- Reported GDP activities and research at several meetings and conferences
- Scientific Analysis of GDP data

Integrated Boundary Current Observations in the Global Climate System (CORG III)
[Uwe Send, SIO]

- Continuous occupation of two CC sections with gliders and one SS section with gliders, with 100% data return
- Occupation of one cross-shore and one along-shore CC section with moorings/PIES, and one SS section
- Extended and improved transport timeseries through the SS, and validation with the endpoint moorings/PIES



	<ul style="list-style-type: none"> ○ Merging of HR-XBT, ARGO, and altimetry for optimal estimates of EAC transport ○ Long-term and short-term state estimates generating indices for the CC
Meridional Overturning Variability Experiment (MOVE) [Uwe Send, SIO]	<ul style="list-style-type: none"> ○ Moorings recovered, fresh moorings/PIES deployed, additional data downloaded acoustically, 13-1/2 years of data in hand now ○ Detailed analyses of origins of the changes under way, including joint analyses with RAPID community and modellers
Moored Climate, Carbon, Biogeochemical, and Ecosystem Observations in the Southern California Current (CCE) [Uwe Send, SIO]	<ul style="list-style-type: none"> ○ Recovery and re-deployment of two equivalent highly instrumented realtime moorings across the California Current ecosystem with physical, chemical, carbon, and ecosystem sensors ○ Improved indices for upwelling variability ○ Quantitative relation between nutrient deficit and chlorophyll concentration ○ Demonstration of using attenuation of solar radiation to determine integrated chlorophyll
Measurements of Atmospheric O₂/N₂, Ar/N₂ and CO₂ Abundances in Relation to Carbon Cycling, Ocean Biochemistry and Global Change [Ralph Keeling, SIO]	<ul style="list-style-type: none"> ○ O₂ and CO₂ records from the Scripps O₂ program continue to provide estimates of the global uptake of CO₂ by the oceans and land biosphere. The data suggest that the land and ocean carbon sinks have both continued to grow over the past two decades ○ The data provide a new estimate of net community production in the Southern Ocean
The Argo Project – Global Observations for Understanding and Prediction of Climate Variability [Dean Roemmich, SIO]	<ul style="list-style-type: none"> ○ The first prototype Deep SOLO float, capable of profiling to 6000 m depth, was successfully recovered in October 2013 after about 75 cycles in 4000 m water depth. ○ This Deep SOLO and one other will be deployed in the Southwest Pacific in June 2014, in 5600 m water depth, where they will profile to the ocean bottom. ○ 1584 research publications since 1998 have used Argo data (http://www.argo.ucsd.edu/Bibliography.html) ○ The Argo Program is obtaining over 10,000 Temperature/Salinity/Pressure profiles per month. ○ The Argo Program has sustained its global coverage of more than 3000 active floats since 2007. ○ N. Zilberman published an estimate of basin-wide transport in the Pacific's shallow meridional overturning circulation using Argo data.
SIO High Resolution XBT/XCTD Transects [Dean Roemmich, SIO] [Bruce Cornuelle, SIO] [Janet Sprintall, SIO]	<ul style="list-style-type: none"> ○ A case study on combining High Resolution XBT, Argo, and satellite altimetry data for estimation of western boundary current mean and time-varying volume transport was carried out by N. Zilberman and colleagues in the East Australian Current. ○ Characteristics and mechanisms responsible for Southern Ocean upper ocean heat content variability were examined by SIO graduate student Gordon Stephenson using XBT transects and remotely sensed data. ○ High Resolution XBT data provide the near-surface and subsurface temperature structure and the geostrophic current, 0-800m, flowing across the sampled routes, on a quarterly basis and with spatial resolution as fine as 10-15 km in boundary current regions. ○ Data from Scripps High Resolution XBT transects have been used in 10 PhD dissertations.
Modernizing the tropical ocean/atmosphere observing system [Dean Roemmich, SIO] [Bruce Cornuelle, SIO] [John Gilson, SIO]	<ul style="list-style-type: none"> ○ SV Investigator, a commercially operated sailboat, deployed 41 SIO SOLO-II Argo floats along the Pacific equator from 100°W to 160°E. ○ The first Spray glider transects of temperature, salinity, pressure, and chlorophyll fluorescence along 95°W from 2°S to 2°N were obtained.



Intraseasonal to Interannual Variability in the Intra-Americas Sea in Climate Models [Shang-Ping Xie, SIO]

- Improved estimates of the spatial statistics of variability in the tropical Pacific, by F. Gasparin based on earlier Argo data, have allowed more accurate mapping of new observations.
- A major eastward propagating event in the equatorial thermocline (7°C temperature anomalies) was observed in float and glider data in early 2014.
- We contributed to a *Journal of Climate* special collection on North American climate in CMIP5 models, including two overview papers examining CMIP5 projections of North American climate
- We developed several successful process-oriented model diagnostics that can distinguish between models with good and poor intraseasonal variability, and applied these diagnostics to several versions of the GFDL AM2 and AM3, and the NCAR CAM and SP-CAM. This analysis extended to the tropical Americas. These metrics should help inform model development
- We have attributed the recent global warming hiatus to recent processes related to east Pacific cooling
- We have diagnosed reasons for CMIP5 model bias in the ITCZ and cold tongue regions of the Pacific, helping to inform model development

C. Marine Ecosystems

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

- CSTAR sponsored a month-long visit by colleagues Mark Bravington and Marinelle Basson, from the CSIRO lab in Hobart, to work with CSTAR member Eric Andersen and visitor Hans Skaug on close-kin methods for estimating population size. Bravington gave two seminars and Basson one. CSTAR also sponsored seminars (that complemented the regular weekly seminar at NOAA Fisheries) by Dr. Matt Bouro (UC Berkeley), Dr. Andrew Hein (Princeton University), and Dr. Anieke van Leeuwen (University of Amsterdam).
- CSTAR sponsored a two week visit by colleague Chris Wilcox, from the CSIRO lab in Hobart, to discuss state space models for animal movement, and application to IUU fishing.
- CSTAR PhD student Kate Richerson participated in the AMLR winter cruise. Richerson also co-authored a PLoS biology editorial on interdisciplinary graduate education.
- CSTAR PhD student Duran Fiack worked as science adviser to the Watsonville Area Teens Conserving Habitat and began collaborations with the members of the economics team on the effects of fracking on salmon habitat.
- CSTAR students Juan Lopez and Daniel Ladd completed MS. Degrees in Statistics and Applied Mathematics.
- CSTAR post-doc Melissa Monk developed new methodologies to analyze the recreational fisheries catch data from California and Oregon. The resulting indices of abundance were used for the first time to inform stock assessments in 2013. Monk also participated in the stock assessments of eight data-moderate fish stocks. In addition, Monk, working with Director Mangel and USGS colleague Tim Tinker is developing a population dynamics model for southeast Alaskan sea otters. The U.S. Fish and Wildlife Service will use the model for management of the population and to predict future population sizes
- CSTAR post-doc Carl Boettiger was offered the position of Assistant Professor of Ecoinformatics at UC Berkeley.
- CSTAR post-doc Santiago Salinas participated in an invitation only meeting on transgenerational plasticity, in Amsterdam.
- CSTAR post-doc Vanessa Labrada Martagon completed her



	<p>year-long UCMEXUS-CONACyT fellowship, developing models for the life history of green sea turtles, and is lead author on a major review of non-lethal methods for determining reproductive status in marine vertebrates.</p> <ul style="list-style-type: none">○ Dr. Jarrod Santora joined CSTAR as Assistant Researcher at UCSC. Santora published 11 peer-reviewed papers, received an NSF award from the Office of Polar Programs to conduct 3 research cruises to the Antarctic Peninsula, participated on the second U.S. Antarctic Marine Living Resources winter survey of sea ice conditions and predator-prey interactions, and presented papers at the annual North Pacific Marine Science Organization (PICES) meeting and at the CalCOFI conference.○ Dr. Valerie Poynor joined CSTAR as a post-doc, to work with NOAA Fisheries colleague Stephan Munch on Bayesian non-parametric descriptions of population dynamics and fishery management.○ CSTAR EU International Outgoing Marie Curie Fellow Simone Vincenzi was invited to present his research on the consequences of extreme events on population dynamics at the EURAEXESS event at Columbia University in March 2014.○ CSTAR Director Marc Mangel served as the independent scientific expert witness in the case in the International Court of Justice "Whaling in the Antarctic: Australia v. Japan. New Zealand Intervening" and received the degree of DSc. <i>honoris causa</i> from the University of Guelph
Shipboard Monitoring of the California Current System Off Central California [Baldo Marinovic, UCSC]	<ul style="list-style-type: none">○ Provided support personnel for data collection/analysis during Northern Legs of the Winter and Spring CalCOFI surveys conducting by the NMFS La Jolla Lab
Investigations in Fisheries Ecology [Eric Palkovacs, UC Santa Cruz]	<ul style="list-style-type: none">○ Conducted 21 collaborative research trips with California commercial and party boat operators to collect fisheries data in support of life history studies and groundfish stock assessments.○ Collected 1,170 rockfish (25 <i>Sebastes</i> species) for an ongoing assessment to develop size-dependent relative fecundity relationships for stock assessment and correlation of condition factors with reproductive output in respect to variable oceanographic conditions.○ Initiated a laboratory study to better understand interannual and spatial variation in the production of multiple broods in certain species of rockfish.○ Developed models for estimating stock-specific harvest and ocean distribution of Chinook salmon using genetic tags and quantifying uncertainty of the estimates.○ Developed sample size requirements for estimating stock proportions from genetic data and estimating age structure from scale collection and reading.○ Developed alternative forecast methods for Sacramento River fall Chinook salmon. One of the alternative models evaluated was adopted by the Pacific Fishery Management Council for management of ocean fisheries.○ Developed, tested, and began documenting code to estimate temporal variability in salmon vital rates using a "separable model".○ Completed a study on the reproductive biology study on the commercially important Blackgill rockfish.○ Completed field and aquarium studies on the reproductive biology and fecundity of Pacific sanddab; preliminary results were included in the stock assessment.○ Completed a study of the spatial development of California groundfish fishery over time (1930-2010) that revealed patterns



of fishing activity occurring in deeper depths, at greater distances from ports, and in increasingly inclement weather conditions.

- Completed report sections on climate drivers, top predator risk, marine mammal indicators, and coastal pelagic species (CPS) risk for the 2013 California Current Integrated Ecosystem Assessment.
- Completed comparative GIS analysis of VMS and logbook data for the California groundfish trawl fishery. This was an important milestone toward development of models to better understand how spatial fishery regulations affect fleet behavior.
- Developed and applied models to estimate agricultural employment impacts associated with the contentious 2009 reductions in water deliveries to California's San Joaquin Valley.
- Prepared data sets with over 280,000 records of fish species, counts, effort, size, location, and associated habitat variables from visual surveys of seafloor communities off central and southern California.
- Developed derived indices of seafloor characteristics from available bathymetric data off California, to be used in mapping predicted abundance and distribution of demersal marine species.
- Continued development of models and maps of predicted rockfish distribution and abundance to quantify habitat capacity, prioritize habitat conservation, improve stock assessments, and evaluate potential risks of various activities to rockfish populations over broad spatial scales.
- Developed an empirical method that differentiates between two sardine populations in the Pacific coast of Mexico and California, which provides a more accurate statistical assessment of the sardine population that is primarily fish within US waters.
- Proposed a novel method that accounts for international fishing pressure on the northern sardine stock. The method allows for adjusting the US fishing pressure in order to maximize the long term sustainability of the stock in the absence of tri-national (USA, Mexico and Canada) agreements.
- Completed the 2013 spring and summer acoustic-trawl method (ATM) surveys of the forage fish assemblage in the California Current. These surveys have been conducted since 2006, and provide data that improve the understanding of the population dynamics of the Pacific sardine and other coastal pelagic species (CPS) in the California Current.
- Expanded studies on juvenile Chinook salmon mortality associated with predation in the Sacramento and San Joaquin rivers in the Central Valley.
- Continued and expanded a basin-wide study of survival of hatchery and wild Chinook salmon smolts in the Sacramento River using an extensive array of >100 JSAT acoustic receivers.
- Completed summer ocean surveys to determine salmon distributions, diets, and age composition off the coast of central Oregon to central California and to tag adult Chinook salmon with acoustic telemetry tags to track movements in the coastal ocean and during spawning migrations.
- Completed extensive literature review and search for existing biological and environmental data to assemble a database for use in developing life-cycle models for Central Valley Chinook salmon runs; documented and compiled data into 82 tables of cleaned and quality-controlled datasets.
- Developed framework for Chinook salmon life cycle models for Central Valley runs, and developed underlying relationships and submodels for specific life-cycle events and stages (for example:



	<p>survival and timing of juvenile and smolt migrations, adult spawning migrations, habitat associations and habitat-specific survival) and ,</p> <ul style="list-style-type: none"> o Developed hydrologic and hydrodynamic models to assess river flow and temperature conditions, both in the past and also for future climate and development scenarios; these models will be used in conjunction with microhabitat preferences for salmon to predict overall habitat suitability of the river and floodplain over time.
Freshwater Ecology Research Collaboration [Eric Palkovacs, UC Santa Cruz]	<ul style="list-style-type: none"> o Eric Palkovacs organized a special session at the Joint Aquatic Sciences Meeting in Portland on Eco-evolutionary Dynamics in Aquatic Systems o Eric Palkovacs published lead author papers in Evolutionary Applications and Freshwater Biology o Eric Palkovacs submitted a paper to Freshwater Biology o Eric Palkovacs accepted an incoming PhD student (Ben Wasserman) through the Dept. of Ecology and Evolutionary Biology o Eric Palkovacs is working with the Seymour Marine Discovery Center to build the 'Evolution Around Us' program for K-12 education and outreach to the public including minority and underrepresented groups o Dan Hasselman (postdoc) published a lead author paper in Molecular Ecology o Gina Contolini (PhD student) obtained a Myers Ocean Trust Graduate Award for her work on the eco-evolutionary dynamics of marine ecosystems
Freshwater Fish Ecology Research Collaboration [Darren Ward, Humboldt State University]	<ul style="list-style-type: none"> o Showed that strontium isotope analysis can distinguish Chinook salmon born in each of the two primary spawning areas on the Shasta River, providing a new tool for assessment and monitoring of this important Klamath Basin Chinook population o Demonstrated that habitat enhancement projects on tributaries of the Klamath River support both summer and winter growth and residence of juvenile coho salmon comparable to natural habitats o Used juvenile and adult recaptures of tagged coho salmon to evaluate scale-based growth analysis, uncovering substantial bias in standard scale analyses of growth o Showed that substantial differences in Chinook salmon life history between rearing locations in the Shasta River are strongly plastic; individuals originating from either location can express either life history type if they encounter the appropriate habitat
Ocean Observing and Fisheries Oceanography Research of the Coastal Ocean off Northern California [Jeffrey Abell, Humboldt State University]	<ul style="list-style-type: none"> o 17 successful ocean observing cruises along the THL, including successful collaborations with OPC funded OA research. o Observations from coastal waters off Northern California contributed to State of the California Current Report (Wells et al 2013, Leising et al, in prep), and to quarterly and annual PaCOOS reports. o Preliminary analysis of causes of krill stranding presented at 2013 Eastern Pacific Ocean Conference: Joe Tyburczy¹, B. Peterson², J. Abell³, and Eric Bjorkstedt "Big Krill Kill: investigating a mass mortality of euphausiids in Oregon and Northern California"
Collaborative Studies of Cetaceans with the Southeast Fisheries Science Center [John Hildebrand, SIO]	<ul style="list-style-type: none"> o Collected broadband sound data at two sites in the southeast Gulf of Mexico using HARP's o Acoustic data collected at these sites provide information on the presence of marine mammals including beaked whales



SOAR Acoustic Ecology Project [John Hildebrand, SIO]	<ul style="list-style-type: none"> ○ Bowhead whale acoustic presence analysis completed ○ Beluga acoustic presence analysis completed ○ Bowhead manuscript submitted by Chris Clark (lead author, Cornell)
Measurements of North Atlantic Ambient Noise [John Hildebrand, SIO]	<ul style="list-style-type: none"> ○ Deployed High-frequency Acoustic Recording Package south of Bermuda ○ Obtained ambient noise data from June 2013 to March 2014 ○ Low frequency ambient noise levels at this site were comparable to those measured in 1966
Passive Acoustic Studies in the Central and Western Pacific Ocean [Ana Sirovic, SIO] [Simone Baumann-Pickering, SIO]	<ul style="list-style-type: none"> ○ Described detailed presence of calling baleen whale and anthropogenic noise sources at three locations: Hawai'i, Kauai, and Saipan. ○ Developed transmission loss models for Saipan and Tinian in support of study on seasonal presence of baleen whales ○ Determined year-round presence of three beaked whale signal types off Saipan and Tinian ○ Described two delphinid echolocation click types, which have been presented at scientific meetings and included in one article submitted for publication
Using Combined Video Acoustic Recordings of Marine Mammals/Fishing Gear Interactions to Evaluate Utility of Passive Acoustic Monitoring [Aaron Thode, SIO]	<ul style="list-style-type: none"> ○ Twenty camera systems built with acoustic recording capability demonstrated ○ 11 Deployments conducted off Sitka, AK, five provided useable footage (100% of the four most recent deployments), but no depredation activity to date
Evaluation of exposure to and infection with Phocine Distemper Virus to the eastern Distinct Population Segment of Steller sea lions (<i>Eumetopias jubatus</i>) and continued monitoring of the western Distinct Population Segment [Tracey Goldstein, UC Davis]	<ul style="list-style-type: none"> ○ Over three hundred Steller sea lion serum samples tested for antibodies against Phocine Distemper virus to examine exposure in the previously untested eastern Distinct Population segment for comparison with results from animals in the western Distinct Population segment off Alaska and Russia ○ Preliminary results from the CIMEC funded study show that an additional 22% of animals tested in Russia, 60% in the central Gulf of Alaska and 64% in southeast Alaska were positive for antibodies. Additionally, 41% of animals sampled in the Aleutians from 2011 to 2013 were also positive for antibodies against the virus ○ Preliminary results to date thus indicate that exposure to Phocine Distemper virus is more widespread than previously thought in Steller sea lions and appears to be circulating in the populations across Alaska and Russia ○ Complementary PCR testing to detect virus to evaluate the current status of Phocine Distemper virus infection in Steller sea lions is ongoing
Ocean Observing Systems [Timothy Mulligan, Humboldt State University]	<ul style="list-style-type: none"> ○ Project work has not yet begun – no accomplishments to report
D. Ecosystem-based Management	
California Cooperative Fisheries Investigations (CalCOFI), an Ocean Observation Program for the Southern California Current [David M. Checkley, SIO] [Ralf Goericke, SIO]	<ul style="list-style-type: none"> ○ Adoption of CalCOFI temperature index in the harvest guideline for the Pacific sardine fishery. ○ Improved understanding of climate effects on anchovy, sardine, and other populations of exploited fish, including rockfish, in the California Current System. ○ Characterization of coastal circulation, including off northern Baja California and southern California, and of the California Undercurrent



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- Estimation of net community production from oxygen isotopes and the ratio of O_2/Ar , nutrient enrichment below the thermocline, and dynamics of the deep chlorophyll maximum
 - Carbon flux due to migrating midwater fish inferred to be increasingly important going from coastal, eutrophic to offshore, oligotrophic waters
 - Carbon flux due to sinking aggregates of phytoplankton and related particles has been characterized using an autonomous profiling float, the SOLOPC
 - Separating the effects of climate and fishing on anchovy and sardine; concluded that the crash of the Pacific sardine in the 1940s was due primarily to climate and thus unavoidable, but with the rate of decline and low abundance period exacerbated by fishing
 - Development of a multivariate ocean-climate indicator (MOCI) of the environment
 - Use of a range of models, from statistical to size-based to earth system to end-to-end, to infer about the fisheries and the marine ecosystem of the California Current System
 - Lipid biomarkers in samples collected on CalCOFI help provide the means to infer about past ocean conditions from lipids in anoxic sediments below CalCOFI stations
 - Climate effects on mesopelagic fish have been observed by analysis of CalCOFI hydrographic and ichthyoplankton data, lending insight into variation of an important part of the forage fish assemblage and the effects of climate variability and change on unexploited fish
 - The SWFSC launched a new ERDDAP server (<http://calcofi.org/data/x-btldata/596-erddap.html>) of CalCOFI data, facilitating its availability to a wide range of users
 - Scripps CalCOFI enhanced its website (<http://www.calcofi.org>)
 - Near-real-time data, as well as historical data to 1998, on the distribution and abundance of eggs of anchovy, sardine, and jack mackerel are posted on the SWFSC website and updated daily during quarterly cruise; comparable acoustic-trawl data are posted as they become available; collectively, these data provide information on the distribution and abundance of these species more rapidly than ever before
 - Time series of fish and related data as collected in CalCOFI was the focus of a Perspectives piece in *Nature*
 - Autonomous measurements continue to be made and enhanced by the use of moorings, floats, and gliders with funding from NOAA as well as other sources, enhancing the capability of CalCOFI
 - The California Current Ecosystem Long Term Ecological Research Program, funded by NSF and augmenting CalCOFI, successfully passed its mid-cycle review, ensuring continued augmentation of and collaboration with CalCOFI
 - Testimony was made by Checkley, and two others from SIO, to the California Fish and Game Commission on CalCOFI
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Studies in Anadromous Fisheries
[Darren Ward, Humboldt State]

- Graduate student Meiling Roddam trained in laser ablation analysis of otolith stable isotopes
- Completed preparation and stable isotope analysis for 80 juvenile Chinook salmon otoliths from the Shasta River

Center for the Advancement of Population Assessment Methodologies (CAPAM)
[Brice Semmens, SIO]

- Published 22 articles in a special issue of *Fisheries Research* on the topic of Selectivity (in press)
- Published 6 additional peer reviewed articles, 1 report, and 1 workshop series proceeding
- CAPAM PI Mark Maunder presented keynote speech at the World Conference on Stock Assessment Methods (WCSAM) in 2013. Six other CAPAM affiliated talks were presented at WCSAM 2013.
- CAPAM obtained a contract to conduct a white seabass stock assessment. CAPAM research scientist, Dr. Juan Valero will mentor Scripps Institution of Oceanography (SIO) graduate student Lynn Waterhouse throughout stock assessment process.
- CAPAM researchers taught 5 courses on stock assessment methods and modeling techniques. Additionally, Brice Semmens taught a graduate level Bayesian Population Analysis course and an undergraduate Statistical Methods in Marine Biology course; both of which were held at UCSD.
- Visiting scientists Chris Francis and David Sampson conducted "Selectivity" research at SWFSC

Training the Next Generation of Marine Population Dynamics Scientists
[Brice Semmens, SIO]

- Authored or co-authored 4 peer-reviewed manuscripts, 2 in press, and 1 report
- Developed MixSIAR graphic user interface (GUI) software and user manual
- Presented 5 conferences, including two invited presentations (Manatoba, CA, and Vienna, Austria)
- Taught a 'Statistical Methods in Marine Biology' undergraduate course
- Taught a graduate level Bayesian Population Analysis course
- Organized and implemented a CAPAM Introduction to Stock Assessment short course
- Began the formation of new California Acoustic Tracking Network (CATN) collaboration
- Floy tagged >10,000 *Paralabrax* spp. and acoustically tagged 50 *Paralabrax* spp. An additional 8 soupfin sharks tagged as part of a collaborating project.
- Engaged hundreds of volunteer anglers aboard 25 tagging charters conducted in partnership with the San Diego sport fishing fleet and an additional 3 charters with the commercial fleet.
- Completed the public outreach website for the La Jolla Acoustic Array Project (www.lajollaarray.org) Reporter™ program and assist with day to day lab operations
- Initiated the development of a citizen science program "Catch Reporter™" allowing recreational anglers to participate research by reporting their catches to a SIO database

Workshop on Application of Non-Linear Time Series Analysis
[George Sugihara, SIO]

- Explained and promoted nonlinear state-space reconstruction techniques for time series forecasting
 - Introduced NMFS scientists to tools for nonlinear time series analysis with a series of hands-on examples
 - Discussed differences between the nonlinear time series
-



	<ul style="list-style-type: none">analysis approach and conventional biomass-based models○ Examined successfully specific case studies where classical fisheries methods failed with NLTS○ Recruitment dynamics of atlantic menhaden and pacific hake were found not to be random, but were amenable to forecasting with SSR/NLTS methods.○ Presented applications and extensions of the method for identifying causal interactions, comparing ecosystem structure, optimizing fisheries yield, and ecosystem-based management
Deep-Ocean Industrialization : A New Stewardship Frontier [Lisa Levin, SIO]	<ul style="list-style-type: none">○ Significant awareness raising ensued as a result of the presentations
Frontiers of Marine Resources Course [Mark Jacobsen, UCSD]	<ul style="list-style-type: none">○ Offered short course on deep sea resources in Spring 2014○ Focus on deep sea ecosystems, current policy, dynamic resource economics, and fisheries economics○ Exceeded enrollment expectations and generated considerable interest in the topic among economics PhD students



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



NOAA Ocean Acidification Program: Monitoring, Small Sample Analysis and AQ/AC Analytic Support

Andrew G. Dickson (SIO)

NOAA Technical Contact: L. Jewett (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management;

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

Amendment No.: 44, 76

Research Objectives and Specific Plans to Achieve Them

This project comprises three independent activities:

- (1) Collection and Analysis of Samples from the California Coast;

The primary goal of this work is to provide information that can be used to test algorithms 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. Such algorithms are based (for a particular region) on measurements of salinity, temperature, depth, and oxygen concentration.

It is thus necessary to collect water samples from cruises such as those of the California Cooperative Oceanic Fisheries Investigations (CalCOFI) where these data are measured routinely, and to analyze these water samples for carbon system parameters so as to allow an independent assessment of the aragonite saturation state for that location and time.

- (2) Evaluation of Measurement Quality for Analysis of Small Samples

The goal of this activity is to assess just what the uncertainty will be when using state of the art analysis techniques on small seawater samples (e.g., 50 mL for measurement of both total alkalinity and total dissolved inorganic carbon).

- (3) QA/QC for CO₂-Related Measurements in NOAA OA Laboratories

The goal of this activity is to provide advice to various NOAA OA laboratories that will enable them to improve their ability to make effective CO₂-related measurements in support of NOAA's Ocean Acidification program..

Research Accomplishments

Activity 1: Samples were collected on the following CalCOFI cruises: CalCOFI 1304SH (6 Apr 13 – 30 Apr 13); CalCOFI 1307NH (6 Jul 13 – 22 Jul 2013); CalCOFI 1311NH (9 Nov 13 - 26 Nov 13); 1402SH (28 Jan 13 – 6 Feb 13), note: this cruise was halted part way for major engine repairs.

The analyses have been completed and finalized for all 2013 cruises, analyses for the 2014 cruise still need to be finalized.

Activity 2: Dr. Dickson reported the results for NOAA laboratories at a NOAA PI meeting in Silver Spring (Sep 2013). A full report of the inter-laboratory comparison of CO₂ measurements, including many other labs around the world, has been completed and submitted for publication in *Marine Chemistry*.

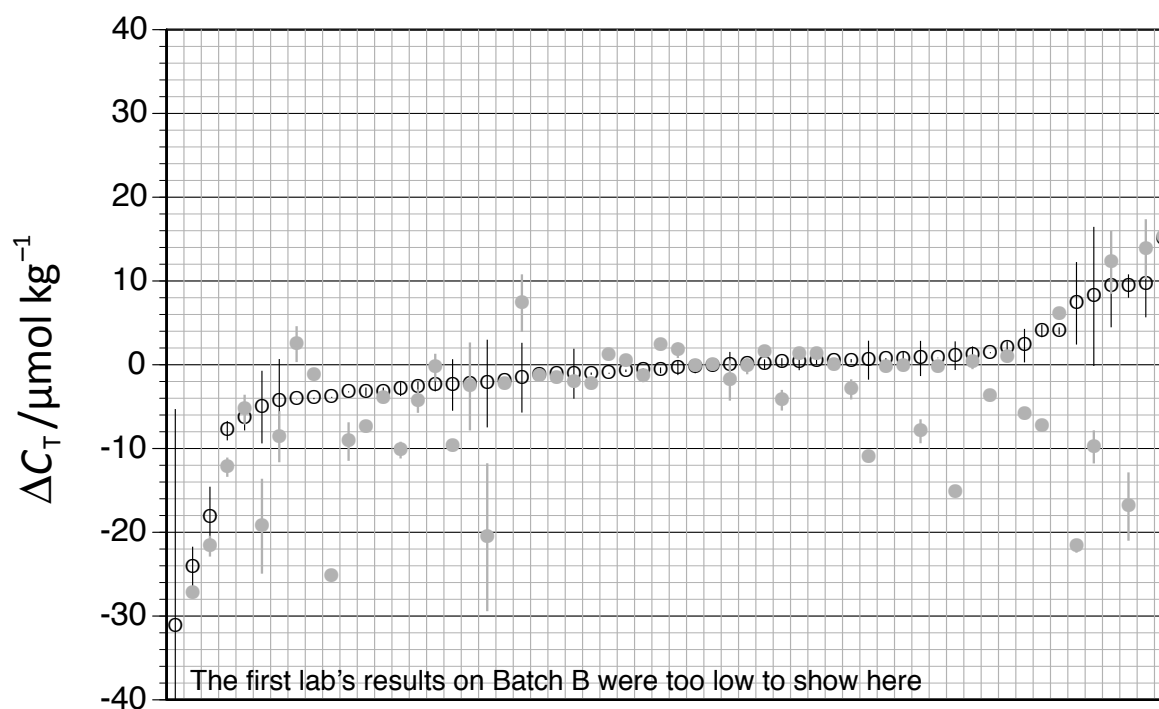


Fig 1. Differences between the total dissolved inorganic carbon values reported by the participating laboratories and the assigned values for the test samples (Table 1). The open circles indicate the average difference for Batch A, the corresponding black lines the range of such differences; the filled grey circles indicate the average difference for Batch B, the corresponding grey lines the range

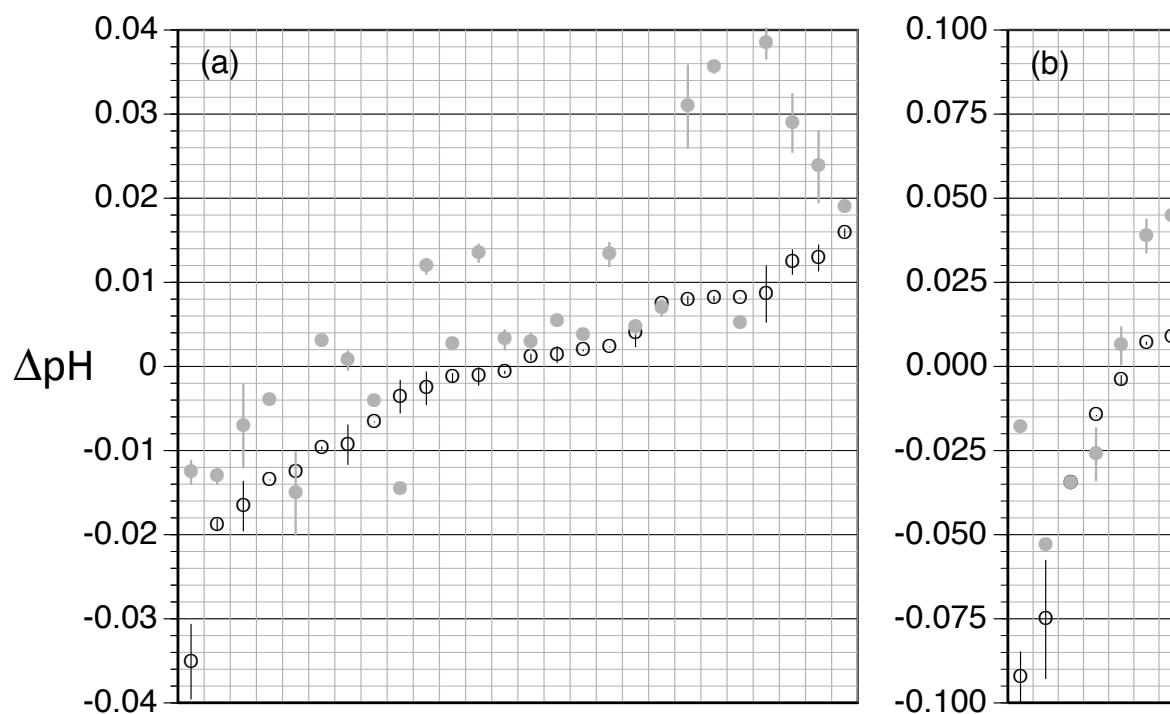




Fig 2. Differences between the pH values (25 °C; total scale) reported by the participating laboratories and the assigned values for the test samples (Table 1). The open circles indicate the average difference for Batch A, the corresponding black lines the range of such differences; the filled grey circles indicate the average difference for Batch B, the corresponding grey lines the range. The laboratories grouped in panel (a) used spectrophotometric techniques to measure pH; those grouped in panel (b) used electrometric techniques



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

Amendment No.: 2, 23, 39, 89

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 proposal concentrates on development activities critical for network growth and sustainability. Programming staff will improve processing code to optimize network growth and ensure total vector processing is maintained in near real-time. Programmers will evaluate the existing data acquisition and delivery system with a look towards global partnership and improve diagnostic utilities. Additionally, evaluation of DOA metrics will continue. Programmers will assimilate near real-time vectors from the Republic of Korea coordinate with partners. Archiving at level 2 (RTV's through THREDDS) will be initiated with a plan for next steps. As the national network continues to grow, support and maintenance requires increase time and dedication.

Research Accomplishments

Research and implementation efforts for this project met expectations during this reporting period. Throughout this reporting period, efforts focused on continued operations, maintenance, and expansion as well as evaluation of optimal interpolation output and the Direction of Arrival (DOA) metric. As background, the HF-Radar Network architecture is comprised of two hardware building blocks, aggregators and nodes with distinct roles. Aggregators 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 6 new sites were added to the network during this period 3 sites on the West coast and 3 sites on the East coast.

The optimal interpolation (OI) method is a biased estimator and assumes a (continuous) spatial covariance function, derived from the observed spatial scale and structure. It improves both baseline consistency and the uncertainty definition in the estimates [e.g., Kim et al. "Mapping surface currents from HF radar radial velocity measurements using optimal interpolation" (2008), Kim(2010)]. Optimal Interpolation (OI) was implemented on the national network for both U.S. West Coast (USWC) and U.S. East and Gulf Coast (USEGC). Following implementation of OI programmers determined additional quality control of the data output was necessary based on anomalies and differences with un-weighted least-squares fitting (UWLS). CORDC programmers hope to continue this evaluation in FY15.

HF Radar radial metrics were collected from three sites within the SIO network (Border Field State Park; Point Loma; and Coronado Island). The goal was to research possible performance enhancements of system baseline vectors by filtering out data outliers in the distributions of these 6 radial metrics:

- Signal Power of the Response (Signal Power)
- Direction of Arrival Function Maximum (DOA)
- Direction of Arrival Function Width (DOA Width)
- Signal-to-Noise Ratio Antenna 1 (SNR1)
- Signal-to-Noise Ratio Antenna 2 (SNR2)
- Signal-to-Noise Ratio Antenna 3 (SNR3)

Results included:

1. Bad radial vectors, often large in magnitude and going in the opposite direction, were eliminated
2. Variance decreased, making a more consistent set of baseline vectors
3. Variance along baseline decreased by up to 5 cm/s

Programmers implemented a program called 'db2sql' which monitors the database for all relevant changes and translates the data to a MySQL server on the SIO node. This allows web applications for metadata to rely on the more familiar, widespread, and sometimes faster MySQL database for serving the collected near real-time radial data and metadata. Future diagnostic features will utilize this database for web queries

CORDC programmers maintained a THREDDS server for hosting the near real-time vectors (RTV). Radar derived surface currents are now available through the following protocols:

- [Data Access via CORDC THREDDS Server](#)
- [Data Access via FTP \(3 day rolling archive\)](#)
- [Shapefile Access \(California\) via FTP \(3 day rolling archive\)](#)
- [Shapefile Access \(Gulf Coast\) via FTP \(3 day rolling archive\)](#)

And operationally support the following organizations:

- University of Connecticut Short Term Prediction System (STPS)
- Applied Science Associates (ASA) Environmental Data Server (EDS)
- U.S. Coast Guard Search and Rescue Optimal Planning System (SAROPS)
- 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)
- Office of Spill Prevention and Response (OSPR), California Department of Fish and Wildlife

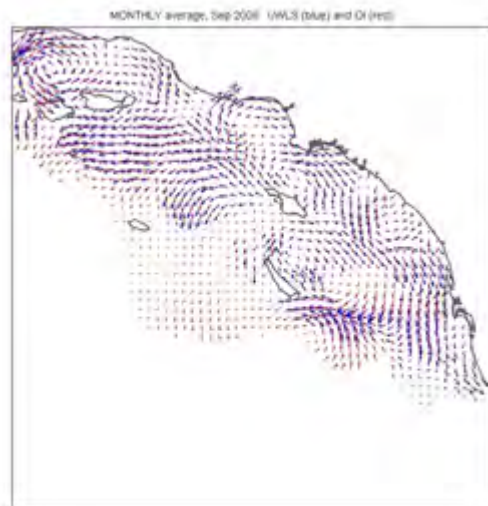


Fig. 1 Santa Barbara to San Diego. Mean surface currents from UWLS (blue) and OI (red) algorithms September 2008

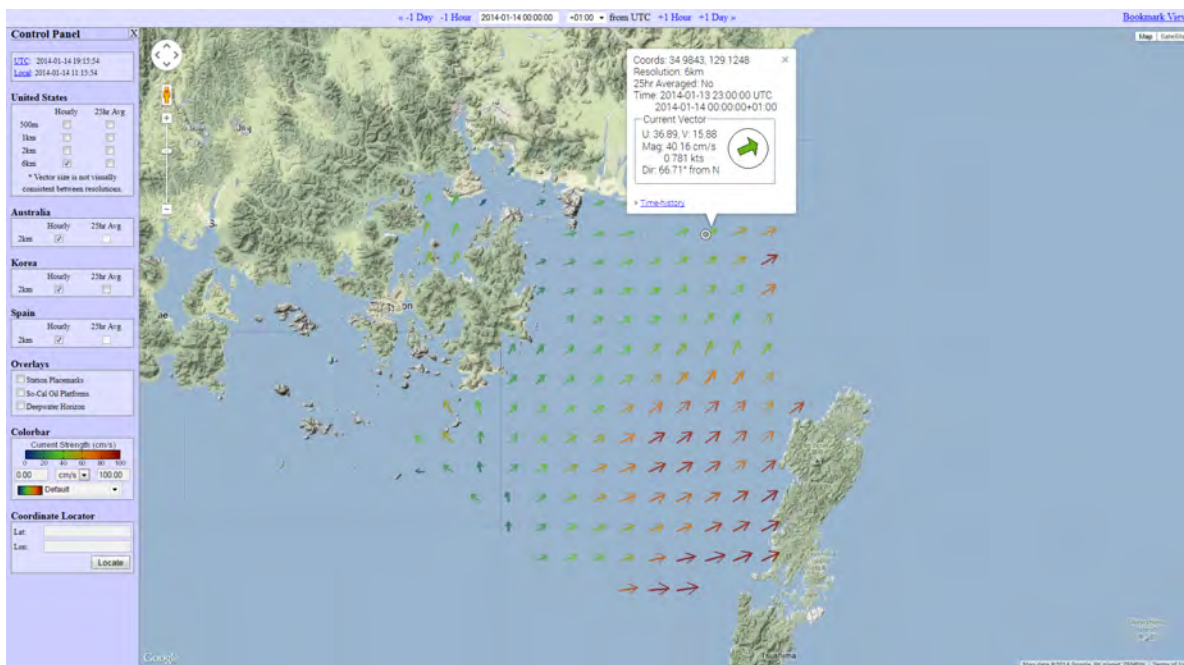


Fig. 2 South Korea HF radar network surface currents



Collaborative Scientific and Technical Support to the NOAA Earth System Research Laboratory

Yehuda Bock and Peng Fang (SIO)

NOAA Technical Contact: Seth Gutman (ESRL/GRD)

Links to NOAA Strategic Plan:

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

Amendment No.: 10, 56, 95

Research Objectives and Specific Plans to Achieve Them

To reliably estimate the absolute integrated precipitable water (IPW) at 30-minute temporal resolution with an accuracy of 1.5mm or better in near real-time using data collected from continuous GPS receivers covering the continental U.S. as a way of supplementing and improving numerical weather prediction models, i.e., short-term weather forecasting. At NOAA's Earth Systems Research Laboratory, a ground-based GPS meteorology system, capable of simultaneously processing sub-networks, has been implemented, with continued scientific input, oversight, and refinement from the Scripps Orbit and Permanent Array Center (SOPAC). The major effort has been focused on various sophisticated quality control elements of an automated data processing system, generating precise GPS orbits and Earth orientation parameters at SOPAC, using a 24-hour sliding window in an hourly update cycle.

The precision of the orbits is approximately 3 cm within the observed session and below 7 cm in the 12-hour predicted segment. We constantly introduce the latest error modeling techniques in order to provide more robust and timely GPS satellite orbits. These include realizing the latest global gravity mode and global reference frame, incorporating the absolute antenna phase center model, applying improved tidal loading model and differential code bias correction, adding more evenly distributed raw data from global GPS tracking stations, and developing redundant and more robust quality control mechanisms. The Co-PI (Peng Fang) interacted closely with our sponsor at NOAA (Seth Gutman, his staff, and their international contacts) to enhance their systems for GPS Meteorology, providing scientific and technical consultations. In addition, he computed, upon requests, numerous special solutions for the Northern America region as well as places of global interest.

Research Accomplishments

High quality orbits are now delivered hourly with better than 98.6% (5 interruptions over a 365 day period, most of them due to internal or external Internet or centralized archive system related problems) reliability with a precision of about 3 cm, and a predictive capability of 7 cm. An automated text message alert generation mechanism was implemented in order to promptly bring attention to the operator so that the system issues could be handled as quickly as possible after system failure. A few improved error modeling schemes have been incorporated into the data processing system. This research directly contributes to atmospheric sounding research in general and directly contributes to operational weather forecasting by NOAA in the U.S. Techniques developed for this system can support other applications in geodynamics and surveying/navigation.



Develop Forecast Methods and an “AR Portal” for Atmospheric River Data Tools

Dan Cayan and Marty Ralph (SIO)

NOAA Technical Contact: A. White (ESRL/GRD)

Links to NOAA Strategic Plan:

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

Amendment No.: NA13OAR4830231 (Completed)

Research Objectives and Specific Plans to Achieve Them

Our research is aimed at developing products related to forecasting and climate projections of atmospheric rivers (ARs). In conjunction we will design and implement an AR website to disseminate information using working tools. We will adopt and implement real-time offshore AR detection based on recently developed AR Detection Tool (ARDT) in addition to real-time monitoring of AR conditions using observations from Atmospheric River Observatories (AROs). We will examine relationship between 3-day time-integrated Integrated Vapor Transport (IVT) and precipitation to quantify causal linkage between IVT and extreme rainfall. New methods of quantifying the probability of AR conditions as a function of location will also be developed together with studying the potential for global and regional climate anomalies to modulate the frequency and strength of ARs in a particular region.

Research Accomplishments

We have developed a beta version of an automated integrated water vapor transport (IVT) diagnostic and predictive tool based on NOAA global numerical weather forecast products. Forecast maps of IVT are produced linked to our AR website for viewing and inspection. These are produced using real-time Global Forecast System (GFS) model products and we currently produce IVT maps for 00 (analysis), 24 hr, 48 hr, and 72 hr forecasts. These forecasts maps are updated every 6 hours.

We are currently exploring the Madden-Julian Oscillation (MJO) tropical Pacific phase and amplitude as a possible predictor of West Coast AR activity. The current winter, 2013-14 was marked by relatively muted MJO amplitude, and we are investigating this as a potential causal mechanism for the extreme lack of storm activity along the West Coast U.S. during the winter period. Early work is also considering the phase and amplitude of ENSO as a possible indicator of AR structure.

We are providing diagnostic analysis of dropsonde data obtained from several research flights during CALWATER in February 2014. Vertically Integrated Water Vapor (IWV) calculated from the dropsonde measurements compare well with co-located SSM/I satellite-derived estimates. We are also using the dropsonde data to compute the integrated vapor transport along the path of each flight. Atmospheric rivers are denoted when the IVT $> 250 \text{ kg m}^{-1} \text{ s}^{-1}$. Using this criteria we found total water transport of up to $8 \times 10^8 \text{ kg sec}^{-1}$ in atmospheric rivers up to nearly 1400 km wide during these flights. Cross-sections of IVT across atmospheric rivers on several of the flights were also produced. These cross-sectional views show how water vapor transport varies in the vertical direction. The results indicate that 75% of the total IVT occurred below about 650 hPa for most of the atmospheric rivers observed during the February 2014 flights. We have also started analyzing the sensitivity of horizontal resolution of dropsondes on the total measured AR water transport. The results of this sensitivity analysis will be useful for planning future dropsonde deploying research flights.

We have produced a beta-version of the new AR web page. This provides background and links to relevant data. More development will be undertaken as new tools and data become available. Ultimately, this will serve as the AR Portal that is called out in the Project Deliverables. The website is currently featuring a special section contains data and links relevant to the ongoing California drought.

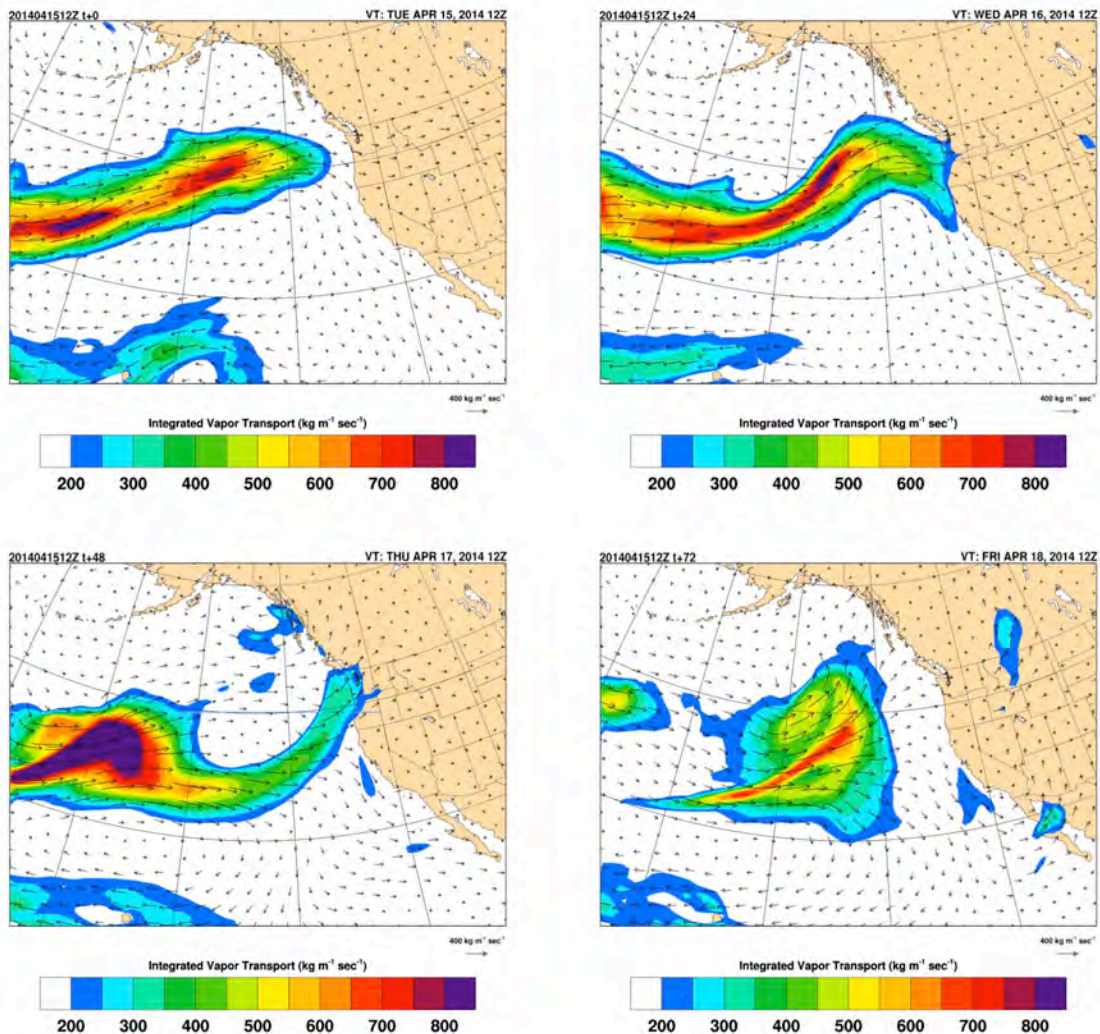


Fig 1. Integrated vapor transport (IVT) based on Global Forecast System (GFS) model products. Individual panels show IVT at analysis time of 12Z 15 Apr 2014 (upper left), 24-hour forecast (upper right), 48-hour forecast (lower left), and 72-hour forecast (lower right)

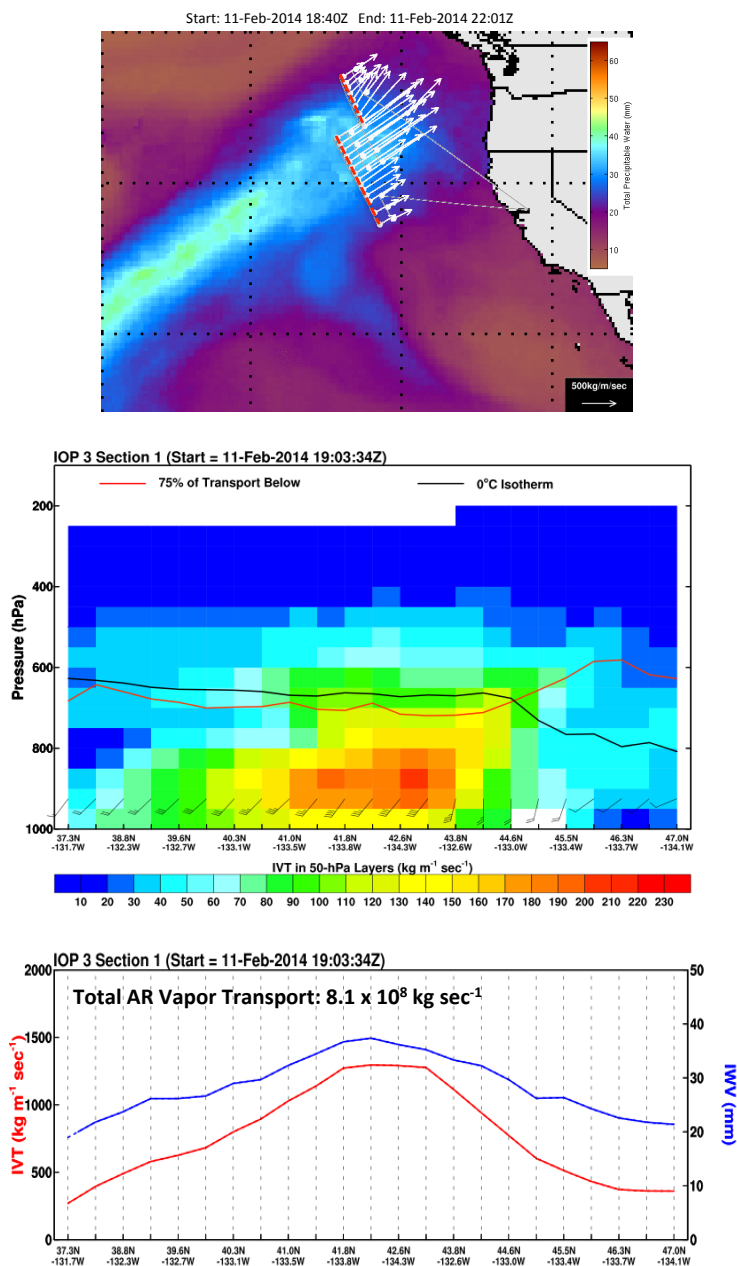


Fig 2. Integrated vapor transport (IVT) and Integrated Water Content (IWC) during 11-Feb-2014 CALWATER research flight. The top panel shows the flight path with dropsonde locations denoted by the white dots and white arrows showing direction and magnitude of IVT superimposed on contemporaneous SSM/I derived IWC. The middle panel shows IVT integrated in 50 hPa bins along a cross-section (red dashed lines in top) across the main AR axis. The bottom panel contains the vertically integrated IVT (red line) and IWC (blue line). The total vapor transport across the AR was $8.1 \times 10^8 \text{ kg sec}^{-1}$.



An Atmospheric River Case Study on the Russian River and a Vision for Western US Observing Systems

Dan Cayan and Marty Ralph (SIO)

NOAA Technical Contact: W. Neff (ESRL/GRD)

Links to NOAA Strategic Plan:

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

Amendment No.: 94

Research Objectives and Specific Plans to Achieve Them

Research over the last 10 years, including NOAA's Hydrometeorological Testbed (HMT; Ralph et al. 2013), has identified the role of atmospheric rivers in many of California's flooding events (Ralph et al. 2006), which has led to the design and implementation of a state-of-the-art network of observations (roughly 100 sites) in California (White et al. 2013). Based on these findings and associated observing network design, the Western States Water Council requested development of a vision of next generation observations for extreme events across the west. This informal vision document incorporated input from 26 experts from federal, state and local agencies, and universities across the West. The AR findings also led the Sonoma County Water Agency to request analysis of a particularly important AR event that affected the Russian River watershed in March 2012. This proposal will carry out two tasks focused on these issues: Task A: Document the role of an atmospheric river in an extreme event on the Russian River of California in March 2012, and its role in providing beneficial water supply later in the year, and compare this event with one in 2007. Task B: Submit a formal journal article presenting the Vision of Western Observing Systems that was created for and presented to western Stakeholders.

Research Accomplishments

The Western Observing System Vision informal document was condensed into a peer-reviewed journal submission. The paper published in April 2014 (Ralph et al. 2014) and was then presented at an interagency meeting on hydroclimate monitoring networks for the western U.S. sponsored by the Western States Water Council.

The analysis of the March 2012 landfalling atmospheric river case and comparison with an event in 2007, both affecting the Russian River, is underway. This effort now includes a strong Atmosphere river that hit in February 2014 and was observed offshore using NOAA G-IV aircraft and dropsondes. This case produced over 250 mm (10 inches) of rain in 2 days in the Russian River area.



THEME B: Climate Research and Impacts



NOAA Support for CLIVAR and Hydrographic Data Office

Bruce Appelgate and James Swift (SIO)

NOAA Technical Contact: David Legler (CPO)

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

Amendment No.: 65, 77

Research Objectives and Specific Plans to Achieve Them

(a) In the CCHDO activities as a CTD/hydrographic/tracer/ocean-carbon data assembly center, the CCHDO will [and does] provide data from specific cruises that are of special interest to NOAA. (b) The CCHDO will [and does] work with NODC to improve transfer of data and integration with related data centers. (c) The CCHDO will [and did] make its holdings more query-able and accessible through modern data management standards and practices (including those that NOAA and the international oceanographic community recommend). All CCHDO deliverables are expressed as new and revised data and documentation entries on the CCHDO web site <http://cchdo.ucsd.edu>.

Research Accomplishments

a. There is a substantial amount of CTD data of value to the Argo and ocean research/modeling communities. The CCHDO continues to work with NOAA to assemble and incorporate into NOAA-related holdings select cruise data sets. This includes continued addition of HOT and BATS profiles and submitting them to OceanSITES, and new profiles added to the Argo reference CTD data set. Also, Steve Diggs (CCHDO) assumed the role of Chair for the SOOS Data Management Subcommittee for the next three years.

b. The NOAA/NODC works with several data assembly centers, including CCHDO, to bring data into NODC. CCHDO continues to improve their relationship with NODC in the following areas:

- i. Continued data assembly of cruise hydrographic data and metadata, particularly those from the GO-SHIP program.
 1. The CCHDO became the official global DAC for GO-SHIP.
 2. JCOMMOPS hired a technical coordinator for the GO-SHIP program, Martin Kramp. Martin visited the CCHDO to evaluate and adopt methods similar to the CCHDO's for use in GO-SHIP coordination.
- ii. Working with NODC to improve efficiency of transfer of data and to make CCHDO data more "archive ready". The CCHDO and NODC have been actively implementing incremental technological enhancements which have improved the efficiency of the data transfer. These technological improvements include:
 - o Construction of a custom Application Programming Interface (API), for use by external entities such as US-NODC, for a stable and deterministic method of file transfer, and
 - o Evaluating NOAA's ERDDAP server to make file transfer more customizable by the end-user.



iii. Improved CCHDO participation in discussions towards enhancing integration of the related Data Assembly Centers (specifically CDIAC and BCO-DMO), to reduce ambiguity and redundancy in data archiving.

- The CCHDO led a session on Digital Object Identifiers (DOI) at the February 2014 Ocean Sciences Meeting. The attendees provided information on their actual or planned use for these identifiers for both data and scientific publications.
- Initial discussions regarding the harmonization of the CCHDO/BCO-DMO data holdings including persistent identifiers and fully interoperable data files.

c. CCHDO holdings are of great value to a wide audience of climate researchers and other users (e.g. modelers). The CCHDO is making continued progress on changes to make their holdings more query-able and accessible through modern data management standards and practices (including those that NOAA and the international oceanographic community recommend), for example via an Application Programming Interface. [Data search based on available parameters now available and can be combined with other search features; "OR" function available in data searches; data cart now enables bulk download of selected files.

CCHDO
CLIVAR & Carbon Hydrographic Data Office

SEARCH DATA

HOME BROWSE DATA SEARCH DATA SUBMIT DATA CONTACT INFORMATION

Welcome to the CCHDO

The CCHDO's primary mission is to deliver the highest possible quality global CTD and hydrographic data to users. These data are a product of decades of observations related to the physical characteristics of ocean waters carried out during WOCE, CLIVAR and numerous other oceanographic research programs. Whenever possible we provide these data in three easy-to-use formats: [WHP-Exchange](#) (which we recommend for data submissions to the CCHDO), [WOCE](#), and [netCDF](#).

The CCHDO also manages public and non-public CTD data to be used for the global Argo and OceanSITES programs.

This site is funded by the [National Science Foundation](#) and the National Oceanic and Atmospheric Administration's [Climate Observations Division](#).

Recent Updates

[ACT2013 316N20130213](#)
KNORR
Cruise Date: 2013-02-13
Updated: 2014-04-30

[EQPAC 33MW19920224](#)
MALCOLM BALDRIGE
Cruise Date: 1992-02-24
Updated: 2014-04-29

[A02 06MT20010507](#)
METEOR
Cruise Date: 2001-05-07
Updated: 2014-04-28

[AR04 35A3200304](#)
L'ATALANTE
Cruise Date: 2003-04-12
Updated: 2014-04-25

[WBEX 316N19860424](#)
KNORR
Cruise Date: 1986-04-24
Updated: 2014-04-24

[A16S 33RO20131223](#)
DONALD L. BROWN

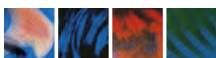
Search for Data Geographically

Click on a basin

Use our interactive map tool

This site is funded by the [National Science Foundation](#) and the [National Oceanic and Atmospheric Administration](#).
This web site and all other CCHDO activities are supported by the National Science Foundation and the National Oceanic and Atmospheric Administration. Any opinions, findings, and conclusions or recommendations expressed in this web site are those of the PI, James Swift, and the CCHDO and do not necessarily reflect the views of the supporting Federal agencies.

Fig. 1 Front page of the CCHDO web site <http://cchdo.ucsd.edu>



The Global Drifter Program

Luca Centurioni (SIO) and Bruce Cornuelle (SIO)

NOAA Technical Contact: Candyce Clarke (CPO)

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

Amendment No.: 19, 27, 59, 79

Research Objectives and Specific Plans to Achieve Them

1) Provide to the Global Telecommunication System (GTS) a near-operational, near-real time data stream of drifter position, SST, Sea Level Air Pressure (SLAP). 2) observe the 15m depth velocity on a global basis with a nominal 5.0° resolution and, jointly with satellite altimeter data, produce circulation charts of the world ocean at 0.5° resolution that can be used to trace pollution laden particles or turbulent dispersion of vorticity and thermal energy due to the tropical eddy field; 3) develop and implement drifter's technological advances in sensors, electronics, power, methods of assembly and deployment packaging. 4) provide enhanced research quality data sets of ocean circulation that include drifter data from individual research programs.

All the research objectives were met or exceeded. All drifters' derived data of location, SST and SLAP were posted on the GTS. GTS compatible data of winds, subsurface temperature (Tz) and SSS were also provided basis when these sensors are mounted on the drifters. In collaboration with AOML we maintained an array of 1100 drifters (average) to chart the circulation of the world ocean. In the past two years, these technological advances have introduced new drifter wind sensors integration, drogue-on sensors (strain gauges), improved air pressure ports and improved drogue construction technology; Gridded, global data sets of SST, near surface circulation and dynamic topography, or absolute sea level, are available on line for assimilation into and use in the verification of the processes, such as wind-driven Ekman currents and spatial patterns of the seasonal circulation in ocean climate models.

Research Accomplishments

Since September 2005 the fully implemented global drifter array has consisted of between 1100-1400 drifters. This 'required' global drifter array size is based on the need to return instrumental observations of daily average SST ($\pm 0.10^\circ\text{C}$) over the global ocean at a 5° resolution, or the spatial scale of the error covariance function of operational NOAA satellite infrared SST sensors, sufficient to keep the potential SST satellite bias error smaller than 0.5°C. Surface pressure sensors are also supported by national meteorological agencies based on regional needs. The status of the GDP array is updated weekly can be seen at the AOML website: <http://www.aoml.noaa.gov/phod/dac/index.php>. The present drifter array is 6% bigger than its nominal size. Over 40 salinity drifters were deployed in the tropical Atlantic in support of NASA's SPURS experiment. The experiment is now concluded and data analysis is in process. See also <http://spurs.jpl.nasa.gov/SPURS/>. Ongoing targeted drifter deployments are underway in the Bay of Bengal, in the South China Sea and in the Arabian Sea.

Significant capacity building efforts by the PI at DBCP/WMO/UNESCO meetings (Fourth In-Region Western Indian Ocean Capacity Building Workshop, 29 April - 3 May 2013, Zanzibar, Tanzania, and Fifth In-Region Western Indian Ocean Capacity Building Workshop, 12 - 15 May 2014, Port Elizabeth, South Africa) has resulted in a significant increase of drifters in the Western Indian Ocean.

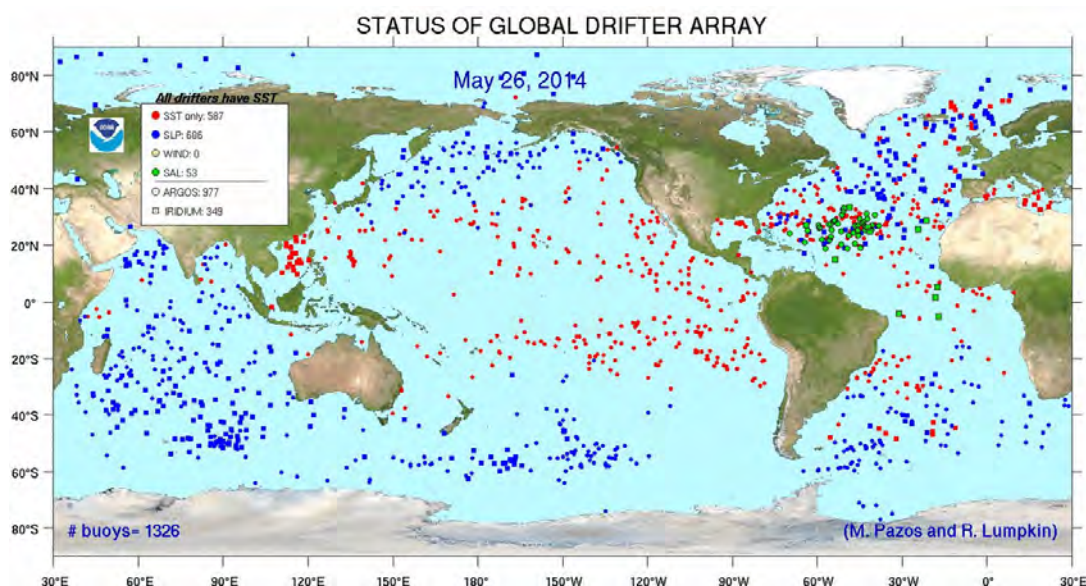
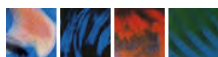


Fig 1 Global drifter population as of May 26, 2014



Integrated Boundary Current Observations in the Global Climate System (CORC III)

Uwe Send (SIO)

NOAA Technical Contact: Diane Stanitski (CPO)

Links to NOAA Strategic Plan:

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

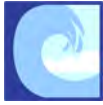
Amendment No.: 24, 64, 85

Research Objectives and Specific Plans to Achieve Them

For over 20 years the Consortium on the Ocean's Role in Climate (CORC) has focused on implementing new ocean observing technologies and systems. After identifying inadequately measured properties of the ocean circulation that are important to understanding and predicting climate variability, CORC investigators have developed cost-effective technology, methodology and infrastructure to implement observing systems to measure them. These systems have been put into operation to refine and demonstrate their abilities. Examples of past and ongoing projects are the High-Resolution Expendable Bathythermograph network operating from commercial ships, the Surface Velocity Program, the Argo network of profiling floats, the array of California Current glider transects, and moorings to capture high-frequency processes.

Motivated by national and international planning efforts, CORC is now focused on methods to observe boundary currents, both western boundary currents whose powerful circulation signatures affect global climate fluctuations and eastern boundary currents where the circulation affects local weather, ocean acidification, and valuable fisheries. The boundary current data streams are intended primarily for scientists developing societally valuable analyses and prediction products that are influenced by persistent ocean conditions i.e. ocean climate. Examples are developing models to predict seasonal temperature or precipitation anomalies over land, assessing and predicting trends in ocean productivity and fisheries, or planning coastal development in a changing climate.

More specifically, CORC is now developing regional observing systems in the California Current and the Solomon Sea and developing methods to merge these observations with global ocean climate observations like



altimetry, winds, Argo profiles and the Surface Velocity Program. In and inshore of the California Current, changes in processes like alongshore currents from the north and south, upwelling, changes in stratification and mixing, and the frequency and strength of near-surface fronts have been implicated in large changes in the abundance of fish and their prey. CORC data is being used to look for relations between ecosystem properties and coastal circulation. The Western Boundary Current in the Solomon Sea is the main source of the Pacific's Equatorial Undercurrent. This makes it a central part of the shallow overturning circulation that influences central Pacific surface temperatures that drive the El Niño – Southern Oscillation (ENSO) fluctuations with global temperature and precipitation consequences. CORC observing systems are delivering data to test and improve methods of predicting ENSO and its decadal-variability relatives as well as ecosystems and local weather along the California coast. This delivery is done primarily through public web sites where data can be plotted or downloaded. CORC does not intend to operate these observing systems indefinitely and hopes to transition them to a program better suited to sustaining them.

CORC has identified circulation in mid-latitude western boundary currents (WBCs) as another type of inadequately observed components of the ocean climate system and is planning to address them with new methods. We are therefore exploring new ways of observing the transport processes of such WBCs with an eye toward sustaining measurements at a reasonable cost.

Research Accomplishments

CORC supports gliders in the California Current (CC) on line 90 off Dana Point, and line 66.7 off Monterey. We produce data products consisting of profiles of temperature, salinity, density, velocity, chlorophyll fluorescence, and acoustic backscatter on uniform grids for each glider transit along all lines. The resulting sections allow calculation of the transport of such quantities as heat, salt, phytoplankton, and zooplankton, directly addressing the Climate Program Office deliverables of Ocean Heat Content and Transport, and Ocean Carbon Uptake and Content. We continue to produce and publish a glider-based SoCal Niño Index, which is remarkably correlated with the Oceanic Niño Index (Nino 3.4 filtered with a 3-month running mean). The CORC moorings and PIES (inverted echosounders with bottom pressure) on line 90 were reconfigured in September 2012 to capture more fully the cross-shelf circulation on shorter timescales. We have now replaced the CORC3 mooring with a stationary glider co-located with a PIES, and also now routinely operate a glider next to the CCE1 mooring (co-located with a PIES) and between there and the coast. The prior 2009-2012 CORC mooring/PIES data are currently being used to construct an altimeter-based index of the offshore CC transport (figure 1).

We continued the time series of Solomon Sea (SS) transport above 700 m begun in 2007. An additional 12 transects of the southern SS were completed with 100% data return. These observations are the only repeated indicator of the subsurface western boundary current in the tropical South Pacific. The 7 year glider and Argo time series show transport variability in the interior and the WBC to be well correlated to each other and to equatorial SST on ENSO scales. The 2009 El Niño is clearest in the relative transport because this is dominated by the upper layer that is well correlated with ENSO. Transport to the EUC occurs in the lower layer and the $O(10)$ Sv difference between the absolute and relative-geostrophic transports reflects a flow of $O(4)$ cm/s at the relative flow's reference level, which is in the lower layer. This is why direct velocity measurements are important in the Solomon Sea boundary current. The end-point component across the Solomon Sea (moorings and PIES) has become an important complement now, confirming and resolving very rapid transport changes by 10-15 Sv over 10-20 days, and providing flow fluctuations at the reference level.

The spatial sampling characteristics of High Resolution XBT and Argo data in the East Australian Current (EAC) region near Brisbane were merged in a study whose results are illustrated in figure 2. While Argo is efficient at broadscale areal coverage, it does not provide sufficiently dense sampling to resolve the energetic, temporally and spatially varying EAC. The HR-XBT network provides the necessary spatial resolution along the sampled routes, and is thus strongly complementary to Argo. Argo trajectory data also provide a reference velocity for absolute transport estimation. In turn, the boundary current region is combined with the ocean interior for basin-wide estimation of mean and time-varying volume and heat transport and meridional overturning circulations. The line-mode (HR-XBT) and the area-mode (Argo) of sampling are both essential for the integrated ocean observing system, with these and satellite altimetric height each providing complementary coverage of spatial, depth, and temporal domains.

The long-term state estimate produces estimates of air-sea interaction every two days throughout the 4-year duration, including heat, momentum, freshwater, and now CO₂ fluxes. The reanalysis is a complete ocean state, providing estimates of surface temperature and velocity, heat content, isotherm and isopycnal displacement, sea surface height (SSH), and subsurface pressure gradients. Indices are being generated for



upwelling strength, undercurrent variability/surfacing, and heat content. In parallel to the long-term state estimate (LTSE) effort, short-term state estimates (STSE) of one month duration have been made, both overlapping with the LTSE for comparison. Tests of the state estimate against independent observation shows that it performs well.

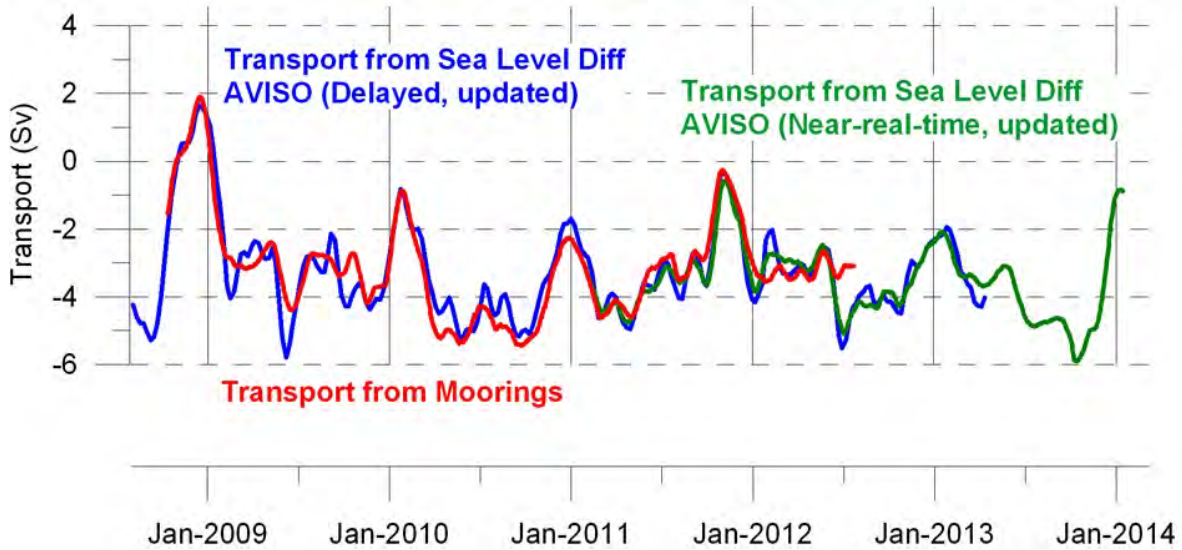


Fig. 1 Transport of the offshore (beyond shelf break) part of the California Current, measured by the CORC moorings from the 2009-2012 phase (red), delayed-mode AVISO satellite altimetry sea surface height (SSH) differences (blue) with scaling determined by the moorings, and the same SSH difference quantity from AVISO near-realtime data (green). The near-realtime AVISO data can now be used to construct estimators for the California Current transport

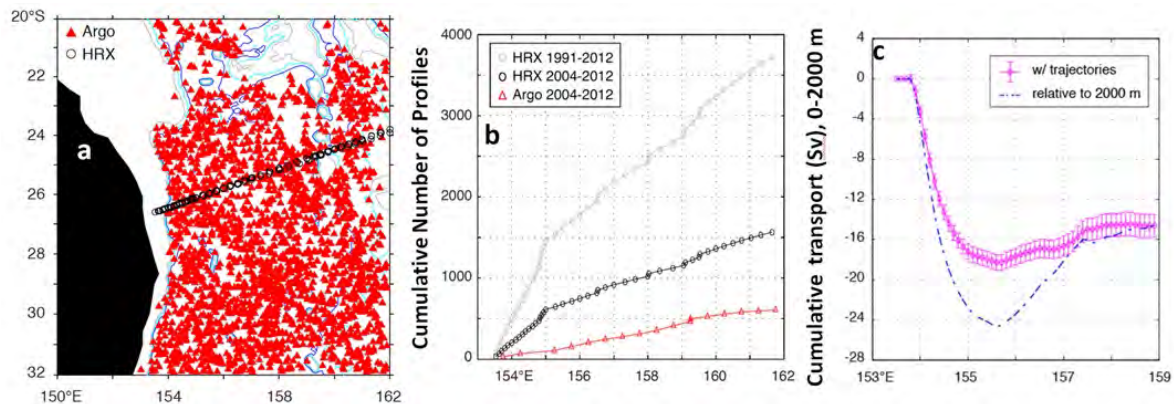


Fig. 2 (a) Location of all Argo profiles in the EAC region, 2004-2012, compared with profiles from a single year (2010) with 4 HR-XBT transects. (b) Cumulative number of HR-XBT profiles for 2004-2012 (black), and for 1991-2012 (gray), compared with Argo profiles within 1.5-degrees of latitude of the HR-XBT track. (c) Cumulative geostrophic transport, 0-2000 m with standard error, for the combined HR-XBT and Argo data (including trajectory-based reference velocity)



Meridional Overturning Variability Experiment (MOVE)

Uwe Send (SIO)

NOAA Technical Contact: Diane Stanitski (CPO)

Links to NOAA Strategic Plan:

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

Amendment No.: 25, 68, 75

Research Objectives and Specific Plans to Achieve Them

A present gap in the sustained ocean climate observing system are techniques and programs for monitoring the circulation and mass/heat/freshwater transports of major current systems, sometimes called "transport reference sites". For broad-scale and deep-reaching circulations, an accurate and cost-effective method for this consists of fixed-point installations with moored and bottom-mounted instruments to obtain horizontally and vertically integrated measurements throughout the watercolumn. The MOVE project applies this approach to obtain sustained observations of a component of the AMOC (Atlantic Meridional Overturning Circulation) which is a national ocean observing priority. This effort had been initiated via the German CLIVAR programme from 2000 to 2006 in the subtropical west Atlantic along 16N, in order to observe the transport fluctuations in the North Atlantic Deep Water layer. Since 2006 it has been operated with NOAA funding, now providing the longest record of direct AMOC observations.

Within the current NOAA MOVE project, SIO/CIMEC/NOAA operates the two geostrophic endpoint moorings and bottom pressure recorders (PIES) between the western boundary and the Midatlantic Ridge (yielding dynamic height and bottom pressure differences), plus a small current meter mooring on the slope. This is complemented on the eastern side of the Atlantic with a German-funded and operated mooring (near the Cape Verde islands). Routine operation is now achieved with two-year long deployments, and routine delivery of indicators about the state of the thermohaline overturning circulation at this latitude will be enabled. The moorings and PIES have recently been equipped with acoustic modems, allowing data retrieval from research vessels or via gliders.

Research Accomplishments

A major MOVE array service was then carried out in May 2013 from the German RV "Meteor" cruise where the MOVE team had the opportunity to participate in the leg from Guadeloupe to the Cape Verde Islands. During this cruise, all three moorings were recovered, serviced, and redeployed, and two additional PIES were added to the existing ones in order to finally reach the staggered 4-year deployments with 2-year overlaps at each site. All new moorings and PIES now carry acoustic modems, using the technology developed under CORC, to allow data retrieval with gliders. In October 2013, a member from the SIO MOVE team participated in the NTAS/MOVE cruise led by WHOI and retrieved data from all MOVE moorings and PIES, extending the data record in hand to nearly 14 years now.

The new longer data set now reveals a reversal of the weakening trend which we had found with the first 9-1/2 years of data. The new timeseries shows the decrease in transport in the first 6-8 years, but in the last 4-6 years a clear increase emerges (see figure 1). This is the first such observation, and we are in the process of analyzing relations with changes in water mass formation and exports at higher latitudes.

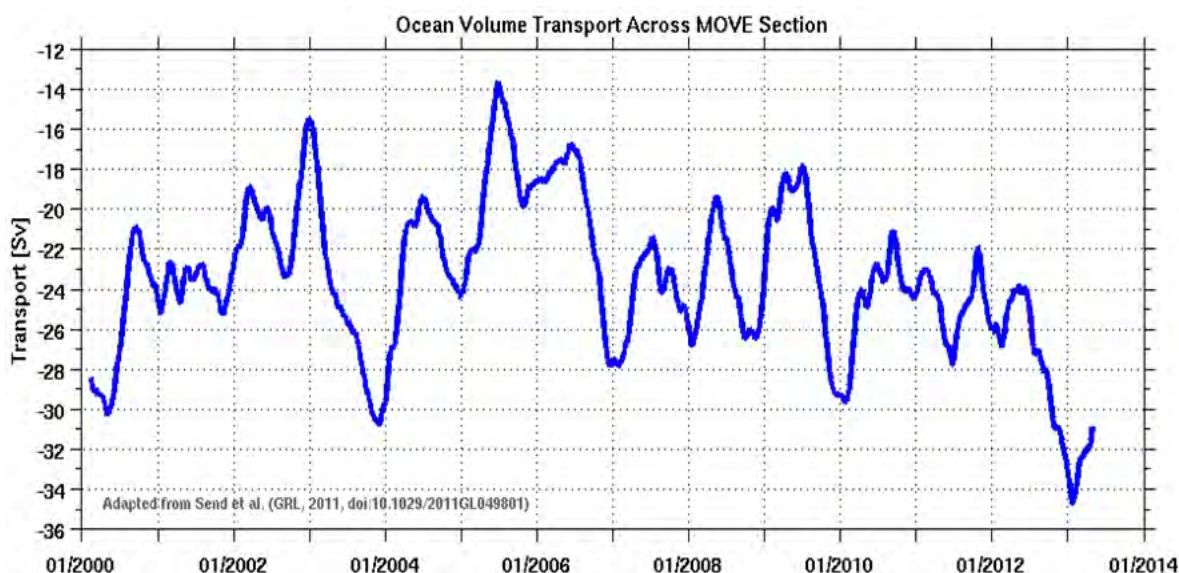


Fig. 1 Thirteen years of quality-controlled North Atlantic Deep Water MOC transport (southward therefore negative), showing first a weakening and then a strengthening trend



Moored Climate, Carbon, Biogeochemical, and Ecosystem Observations in the Southern California Current (CCE)

Uwe Send (SIO)

NOAA Technical Contact: Diane Stanitski (CPO)

Links to NOAA Strategic Plan:

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

Amendment No.: 28, 58, 98

Research Objectives and Specific Plans to Achieve Them

The California Current is a region of large ecological significance and known sensitivity to climate forcing. Climate processes, complex physical systems, carbon and nutrient chemistry, and ecosystem dynamics all interact to create a rich, societally important, and scientifically fascinating ocean environment off the west coast of the US. This project will establish a unique highly multidisciplinary mooring presence in the southern California Current, to complement the flow and transport monitoring system that has been initiated under CORC, and to start building a comprehensive continuous real-time monitoring system for this region.

Two moorings, called CCE(California Current Ecosystems)-1 and -2 are located in the core of the California Current and in the upwelling regime on the continental slope, respectively, along CalCOFI line 80, and measure

- **atmospheric conditions** ($x(\text{CO}_2)$, wind, temperature, humidity, precipitation, irradiance),
- **surface ocean conditions** (temperature, salinity, $p(\text{CO}_2)$, O_2 , pH, currents, point and integrated measures of phytoplankton chlorophyll content over the euphotic zone, and nitrate supply), and mixed-layer depth,
- **multi-frequency active-acoustic observations** of zooplankton and fish biomass over the upper 300m.

The data will be telemetered in real-time and made available via websites to other researchers and agencies. The moorings contribute unique timeseries for the US ocean acidification and carbon observing programs, and add a time dimension to regular ship surveys under CalCOFI, CCE-LTER, and fisheries stock assessment programs.



Research Accomplishments

The field work consisted of recovery and redeployment of two nearly identical moorings CCE1 and CCE2 along CalCOFI line 80 in September March 2013 and March 2014, in the offshore and the upwelling regimes off Pt. Conception. Both moorings now measure: meteorological parameters, incoming solar radiation in 7 wavelengths, air and water pCO₂, surface T/S and pH/oxygen, mixed-layer (15m or 40m) chlorophyll fluorescence/turbidity, pH/oxygen and nitrate, and the bottom of the euphotic zone (40m or 80m) the downwelling irradiance in the same 7 wavelengths as at the surface. In addition, both moorings have T/S sensor through the upper layer, a longranger ADCP covering the upper 500m, and at 150m depth an acoustic zooplankton/fish sonar from D.Demer/SWFSC which covers the 0-300m layer of the water column. All data are telemetered inductively within the mooring and via Iridium internet connections to shore.

The continuous observations with oxygen and pH data allow the characterization of periods, events, and processes that are believed to have an impact on the ecosystem. For the upwelling events, we have found a better wind-driven index that describes density and nutrient variability, than the traditionally used Bakun index (figure 1). We also are able to estimate the nutrient deficit by comparing the expected upwelled nutrient concentration (from temperature) with the observed nutrients at the CCE2 mooring – these deficits compare well with chlorophyll concentrations on the event time scale. The optical absorption method for determining vertically integrated chlorophyll from the change in solar irradiance between surface and depth (i.e. the attenuation) is also giving very encouraging results (figure 2). We also continue to analyze semidiurnal processes, carbon budgets, and undercurrent variability.

Data from both CCE moorings are being displayed in real-time on the website <http://mooring.ucsd.edu/CCE>.

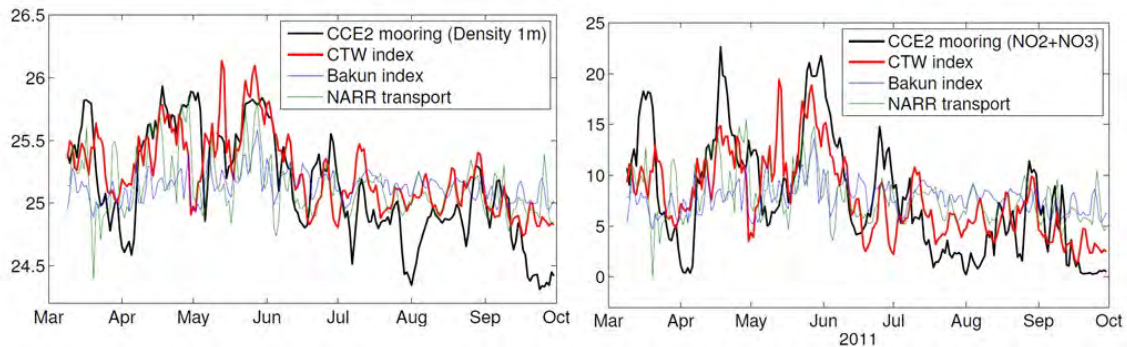


Fig. 1 Timeseries at CCE2 of 1m density (left) and 15m nitrate (right) in black. Thin blue and green lines show the Bakun upwelling index at the nearest grid point, and the Ekman transport (essentially wind stress) from NCEP regional reanalysis winds. The “coastally trapped wave” index we derived from accumulated wind stress forcing to the south (red) has much better correlation with both density and nutrient concentration

CCE2-2

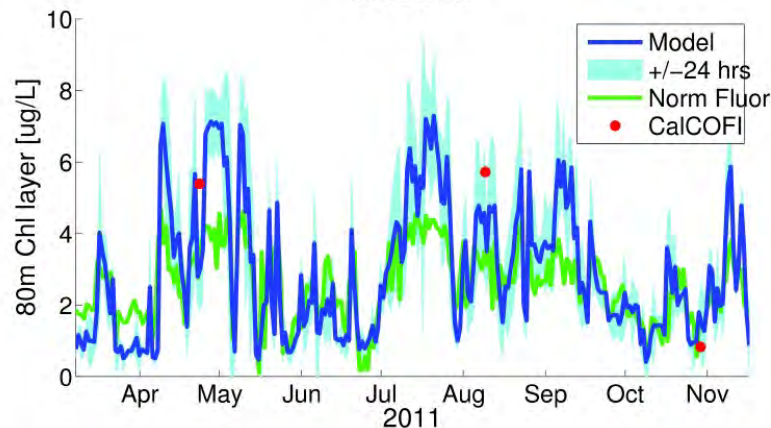


Fig. 2 Daily averages of total chlorophyll from inverse model applied to irradiance attenuation between the surface and 40m depth at CCE2, deployment 5 (blue). These are compared to normalized fluorescence at a single depth (green) and CalCOFI hydrographic measurements of the total chlorophyll over 0-40m (red)



Measurements of Atmospheric O₂/N₂, Ar/N₂ and CO₂ Abundances in Relation to Carbon Cycling, Ocean Biochemistry and Global Change

Ralph Keeling (SIO)

NOAA Technical Contact: Ken Mooney (CPO)

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

Amendment No.: 16, 40, 71

Research Objectives and Specific Plans to Achieve Them

This project continues and expands time series measurements of O₂/N₂ and Ar/N₂ ratios and CO₂ concentration at background air stations by the Scripps O₂ project (Figure 1). These measurements enable refined estimates to be made of land and ocean carbon sinks and provide benchmark tests for models depicting the response of ocean biogeochemistry to changing climate on a range of time scales, extending from seasonal, El Niño, to multi-decadal. The measurements are also relevant for quantifying the global loss of O₂ from the oceans, or “deoxygenation” and for detecting changes in ocean ventilation and production associated with warming-induced stratification that may influence future deoxygenation. The measurement may enable improved atmospheric inversions that take account of processes internal to the ocean influencing carbon dioxide. The measurements have strong synergistic relationship to measurements by the carbon cycle group of the NOAA Global Monitoring Division, the Argo float program, to measurements made as part of the HIAPER Pole-to-Pole (HIPPO) mission to survey the distribution of long-lived atmospheric tracers related to carbon dioxide, and to the Scripps CO₂ program.

The primary proposed activity involves sustaining ongoing time series at a global array of nine stations extending from the Arctic to the Antarctic along a (mostly) Pacific transect. One new site, Barrow, Alaska, has been added to the flask network during this three-year grant period in order to sustain the Barrow time series initiated by the Princeton atmospheric O₂ program (Figure 2).

An integrally related activity involves the assessment and reduction of systematic errors which may impact the ongoing measurements or the merging with these measurements with measurements of other programs. The project supports interpretive activities related to detecting and reporting such errors. It support activities to reduce errors, and it enables the Scripps O₂ program to continue its central role in an international intercalibration effort for O₂ measurements, as endorsed by the World Meteorological Organization.

The proposal support collaborative interpretive activities with investigators at other institutions to develop methods for incorporating O₂/N₂ measurements into atmosphere/ocean inversions for detecting trends in land and ocean sinks on decadal time scales.

Research Accomplishments

Flask collections and analyses have proceeded without major incident at the nine long-term stations in the Scripps O₂ network, as well as at recently Barrow station. Last year's report mentioned difficulties at Cold Bay. These were resolved as described last year, and further measurements appear to be normal.



Further research was done to examine the potential for improving the stability of the O_2/N_2 and Ar/N_2 ratios delivered from high pressure cylinders by placing a ball in the cylinder and rocking the cylinder to force the ball to role. The approach has the potential to reduce thermal and gravitational fractionation in the cylinders.

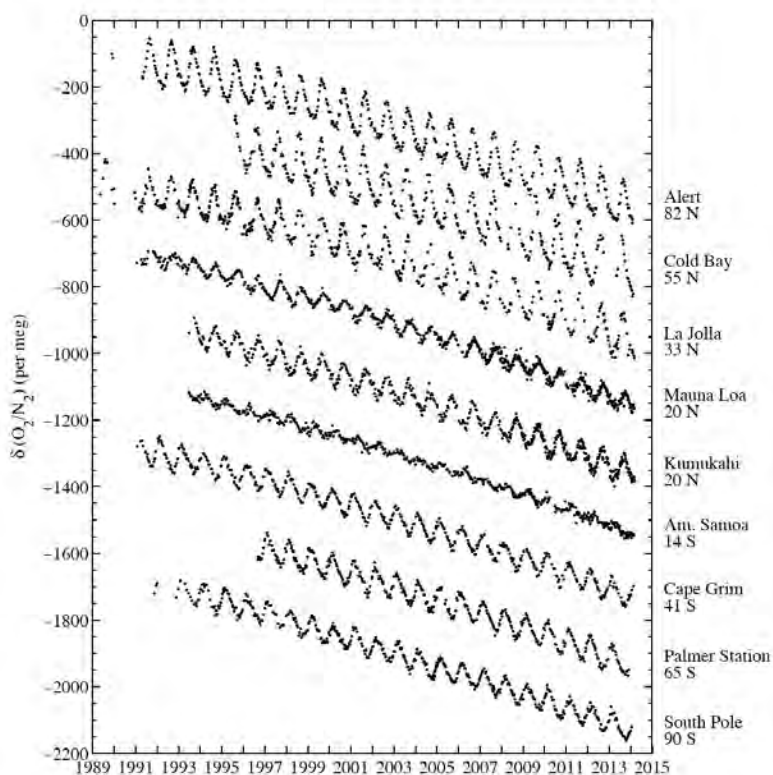
A key publication this year is by the PI and Dr. Andrew Manning of U. East Anglia summarizing the main value of atmospheric O_2 measurements to global change research. Entitled, "Studies of recent changes in atmospheric O_2 concentration", the paper describes motivation and methods for measuring changes in O_2/N_2 abundance, the relation to atmospheric oxygen, an overview of basic phenomena, including seasonal cycles, secular and interannual trends, and provides updated estimated of global land and ocean carbon sinks, as summarized in Table 1 below.

A draft is in preparation by the PI in collaboration with Manfredi Manizza (of Scripps) and Cindy Nevison (of CU Boulder) to compare observed cycles in Ar/N_2 and APO with results from a high resolution biological ocean model. The ratio of the amplitudes of the seasonal cycles of APO and Ar/N_2 appear to be well measured, and provides a measure of the seasonal biological response of the ocean biota (via APO) to the seasonal physical forcing of the upper ocean (via Ar/N_2). A correct depiction of the processes influencing the seasonal exchange of O_2 is critical also for accurate depiction of the seasonal controls on surface water pCO_2 . The purpose of the paper is to illustrate the power of the Ar/N_2 and APO constraints for challenging ocean models used for assessing ocean biological and carbon cycle processes.

The data from the Scripps O_2 program from Palmer Station have been used in a publication by Kieth Rodgers at Princeton entitled "Strong sensitivity of Southern Ocean carbon uptake and nutrient cycling to wind stirring" which has been submitted to the journal "Biogeosciences".

The data from the Scripps O_2 program indirectly informed a new synthesis of global carbon sources and sinks by LeQuere et al. (see below).

Fig. 1 Time series of O_2/N_2 ratio at sites in the Scripps O_2 program. Data from Alert are shown on the Scripps Institution of Oceanography reference scale. The scales of all other stations are offset from the station above by -200 per meg.





The Argo Project – Global Observations for Understanding and Prediction of Climate Variability

Dean Roemmich (SIO)

NOAA Technical Contact: Steve Piotrowicz (CPO)

Links to NOAA Strategic Plan:

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

Amendment No.: 15, 42, 74

Research Objectives and Specific Plans to Achieve Them

Argo is an international collaboration providing a global array of profiling CTD floats for a broad range of operational and scientific applications (<http://www.argo.ucsd.edu>). The Argo array, now including about 3500 active floats, is providing unprecedented real-time views of the evolving physical state of the ocean. These measurements reveal the physical processes that balance the large-scale mass, heat, and freshwater budgets of the ocean on basin-to-global scale. Argo is a large initiative for oceanography, merging research and operational objectives to provide a uniquely valuable global dataset for climate science, ocean state estimation, seasonal-to-decadal forecasting, and other applications. All Argo data are freely available in near-real time.

SIO plays a number of key roles within U.S. and international Argo. The U.S. provides over 50% of the international Argo array, including instrumentation development, float production and deployment, communications and data management, and scientific analyses to demonstrate the value of Argo data. SIO produces and deploys one-fourth of the U.S. floats, carries out float technology development, participates in delayed-mode quality control, coordinates the U.S. Argo partnership, and provides leadership for international Argo through the Argo Steering Team.

Research Accomplishments

During the 12 months covered by this report (04/2013 – 03/2014), 69 SIO Argo floats were built, shipped, and deployed, and an additional 6 have been shipped. Deployments included 45 floats by RV Kaharoa in the S/W Pacific, 7 floats by S/V Investigator west of Mexico, and 7 floats by R/V Shokalskiy in the Southern Ocean. In addition to these Argo-funded floats, our lab also built 41 Argo floats for the project "Modernizing the Tropical Pacific Observing System". These were deployed by S/V Investigator in the equatorial Pacific, and their data are provided gratis to the Argo Program.

The total number of active Argo floats produced in our lab is now 486. For all active floats, profile and engineering data are regularly monitored to identify any technical problems with the instrument or sensor. Technology development continues to focus on further improvements in reliability and capability of profiling floats. Deployments of the newly designed SOLO-II float have been successful, including both SOLO-II floats built at Scripps and SOLO-II floats produced under commercial license by MRV Systems LLC. The SOLO-II design provides greater buoyancy adjustment, more robust operation, and increased lifetime relative to all existing Argo floats. During the present reporting period a new float CPU and new firmware were developed and installed.

During this reporting period the design and development of Deep SOLO floats, capable of more than 100 cycles to full ocean depth (6000 m), was continued. The first prototype Deep SOLO float was successfully recovered off Central California in October, 2013. This instrument has been reconditioned and, along with a second prototype Deep SOLO float, will be deployed in June 2014 in the Southwest Pacific in water depth of 5600 m.

Scientific quality control of all SIO Argo profile data has been carried out by J. Gilson and M. Scanderbeg according to protocols set by the international Argo Data Management Team. All eligible delayed-mode profiles (i.e. > 12 months old) have been reviewed. SIO Argo data are available from either of the two Argo Global Data Assembly Centers.



D. Roemmich has been Chairman of the international Argo Steering Team since its inception in 1998. The AST, which is responsible for coordinating the international Argo partnership, was hosted by New Zealand's National Institute of Water and Atmospheric Research (NIWA) in its March 2013 meeting. The meeting report for AST-14 is available from http://www.argo.ucsd.edu/FrMeeting_reports.html. M. Scanderbeg provides support for a wide variety of AST functions, including Steering Team and Data Management Team meeting planning, reporting, and inter-session activities, and is responsible for designing and updating of the Argo web site, <http://www.argo.ucsd.edu>.



SIO High Resolution XBT/XCTD Transects

Dean Roemmich, Bruce Cornuelle and Janet Sprintall (SIO)

NOAA Technical Contact: Candyce Clark (CPO)

Links to NOAA Strategic Plan:

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

Amendment No.: 20, 47, 78

Research Objectives and Specific Plans to Achieve Them

The SIO High Resolution XBT Network is a set of basin-spanning shipping routes (<http://www-hrx.ucsd.edu>) along which eddy-resolving temperature transects are collected four times per year. The HRX Network was initiated in 1986 along a commercial shipping route between New Zealand, Fiji, and Hawaii. It was subsequently expanded during the 1990's to include basin-spanning temperature transects in all of the oceans. Major partners in the HRX network include Scripps (Pacific and Indian Ocean), NOAA/AOML (Atlantic), and CSIRO (SW Pacific, Indian). Typically, each transect is repeated on a quarterly basis to resolve variability in temperature, geostrophic circulation and transport on annual and longer periods. Scientific objectives of the HRX Network are:

- Measure the seasonal and interannual fluctuations in the transport of mass, heat, and freshwater across ocean-wide transects spanning the ocean's boundary currents and interior circulations.
- Determine the long-term mean, annual cycle and interannual fluctuations of temperature, geostrophic velocity and large-scale ocean circulation in the top 800 m of the ocean.
- Obtain long time-series of temperature profiles at precisely repeating locations in order to unambiguously separate temporal from spatial variability.
- Determine the space-time statistics of variability of the temperature and geostrophic shear fields.
- Provide appropriate *in situ* data (together with Argo profiling floats, tropical moorings, air-sea flux measurements, sea level etc.) for testing ocean and ocean-atmosphere models.
- Determine the synergy between HRX transects, satellite altimetry, Argo, and models of the general circulation. What are the minimal sampling requirements for *in situ* data?
- Identify permanent boundary currents and fronts, describe their persistence and recurrence and their relation to large-scale transports.
- Estimate the significance of baroclinic eddy heat fluxes.

Research Accomplishments

HRX transects, quarterly in most cases, have been maintained along routes (Fig 1) that include:

- PX37/40 (North Pacific – Los Angeles to Hawaii to Yokohama)
- PX38 (North Pacific – Hawaii to Alaska)
- PX05 (Western Pacific – Brisbane to Yokohama)
- PX06/31 (Central Pacific – Auckland to Fiji to San Francisco)
- PX30 (South Pacific – Brisbane to Fiji, joint with CSIRO Australia)
- IX15/21 (South Indian – Durban to Mauritius to Fremantle)



Logistical assistance or XBT probes are provided collaboratively for:

- PX34 (South Pacific – Wellington to Sydney, CSIRO Australia)
- IX28 (Southern Ocean – Hobart to Antarctica, CSIRO Australia)
- AX22 (Southern Ocean - Drake Passage)

During each cruise, XBT temperature profiles (0-800 m) were collected at spatial intervals from 10 km near ocean boundaries and the equator, to 50 km in interior regions – resolving boundary currents and interior eddies for calculation of ocean-wide integrals of geostrophic transport. A web site for the project, with downloadable data, is maintained at <http://www-hrx.ucsd.edu>. HRX data are transmitted on the GTS immediately after collection for real-time applications. Due to the rapidly evolving nature of the present-day commercial shipping industry, a strong focus of the work has been to maintain sampling along routes as ships and shipping companies change.

Scientific analysis of the HRX dataset is progressing both on a stand-alone basis and in the context of ocean data assimilation (ODA) modeling. The HRX Network is observing the volume transport and variability of all the world's subtropical western boundary currents: with a total of 10 repeating transects across the Gulf Stream, Kuroshio, Agulhas, Brazil Current, and East Australian Current. Other boundary current sampling includes the California Current and the Antarctic Circumpolar Current. Absolute geostrophic transports for the upper 800 m are estimated using Argo profile and trajectory data in conjunction with HRX transects.

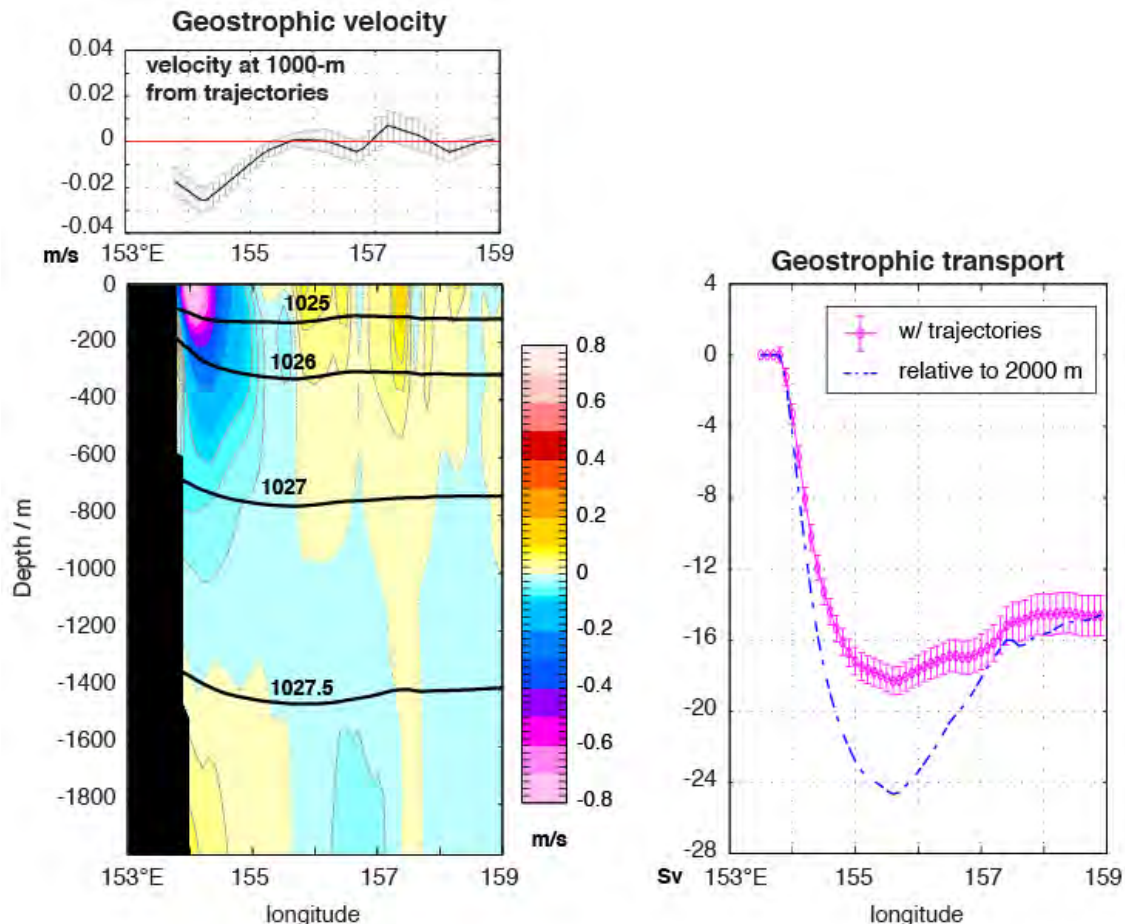
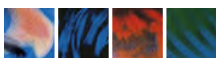


Fig. 1 The velocity (m/s, colors in lower left) and transport ($10^6 \text{ m}^3/\text{s}$, lower right) of the East Australian Current (EAC) off Brisbane is estimated from combining High Resolution XBT and Argo data. Use of Argo trajectory data at 1000 m (upper left, m/s) results in improved transport estimates compared with calculations using a 2000 m reference level. The mean southward transport of the EAC at this location is estimated to be $18 \times 10^6 \text{ m}^3/\text{s}$, with a flow reversal below 1350 m, consistent with previous moored current meter observations



Modernizing the tropical ocean/atmosphere observing system

Dean Roemmich, Bruce Cornuelle and John Gilson (SIO)

NOAA Technical Contact: D. Legler (OAR/COD)

Links to NOAA Strategic Plan:

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

Amendment No.: NA13OAR4830216 (Competed)

Research Objectives and Specific Plans to Achieve Them

The project is composed of three distinct but coordinated elements. The overall goal is to demonstrate the scientific potential and cost-effectiveness of modern autonomous instrumentation (floats and underwater gliders) for modernizing the Tropical Pacific Observing System, and the value of Ocean Data Assimilation Modeling in synthesizing these observations. Objectives and plans for each element are:

a) Enhanced coverage of Argo profiling floats. The objective is to provide enhanced spatial resolution of Pacific equatorial variability in relation to El Niño/Southern Oscillation evolution, using Argo profiling floats (Temperature/Salinity/Pressure, 0-2000 m). Production and deployment of 41 SIO SOLO-II Argo floats along the equator between 100°W and 160°E will double the Argo coverage along the equatorial waveguide.

b) Underwater glider missions in the eastern equatorial Pacific. The objective is to demonstrate the utility of underwater gliders to deliver time series of vertical profiles as a replacement of TAO moorings. Two glider years are to be obtained between 2°N and 2°S at 95°W, which is an active location for equatorial upwelling and where mooring survival rates are very low due to vandalism and fishing damage. The glider operations will be based in the Galapagos and done in collaboration with INOCAR (the oceanographic institution of the Ecuadorian Navy).

c) System evaluation using high resolution ocean state estimation. The goal of this work is improved estimation of the physical state of the tropical Pacific for resolving intra-seasonal to interannual variability and possibly enabling predictions of ENSO and other air-sea interactions. The benefits of the capabilities enabled by the new observation systems (Argo, gliders, and satellites) will be explored. The synthesis of these observations will be compared to the information available from moorings, which provide high temporal sampling, but only at a limited number of locations and depths.

Research Accomplishments

a) Enhanced coverage of Argo profiling floats. The 41 SIO SOLO-II Argo floats have been produced and were deployed along the equator between 100°W (23 January, 2014) and 160°E (26 March, 2014). Each float returns a temperature/salinity/pressure profile from the sea surface to 2000 m depth every 7 days. These floats are providing unprecedented coverage of the equatorial Pacific, including a major intraseasonal wind-driven Kelvin wave that crossed the Pacific during February-April. This is a possible El Niño precursor, and NOAA models that assimilate these data are predicting warm (El Niño) conditions as likely later this year. All Argo data are publicly available in near real-time via <http://www.argo.net>

b) Underwater glider missions in the eastern equatorial Pacific. A new SIO Spray glider was produced, and along with other gliders in the SIO glider pool will support the present mission. The initial glider deployment along 95°W between 2°N and 2°S was carried out in the first week of April, 2014, using a Spray glider equipped with sensors for pressure, temperature, salinity, and chlorophyll fluorescence. The glider transects along 95°W are coordinated with a separate NSF-funded project obtaining glider transects along 93°W. These data showed the eastward propagating event in early 2014, with very high meridional resolution, as it arrived in the eastern Pacific.

c) System evaluation using high resolution ocean state estimation. The state estimation began with a 1/3 degree resolution model spanning the entire tropical Pacific Ocean, using all observation systems now available: Argo, CTDs, XBTs, gliders, and satellite SST and SSH. The state estimation progressed from testing periods in 2007, to 2010 and we are now refining the estimation weights and evaluating the fit to Argo and altimeter observations. Observations, atmospheric forcing, and boundary conditions are in the final stages of assembly and quality control for 2010-present in preparation for more up-to-date state estimates and comparison with the TAO observations.

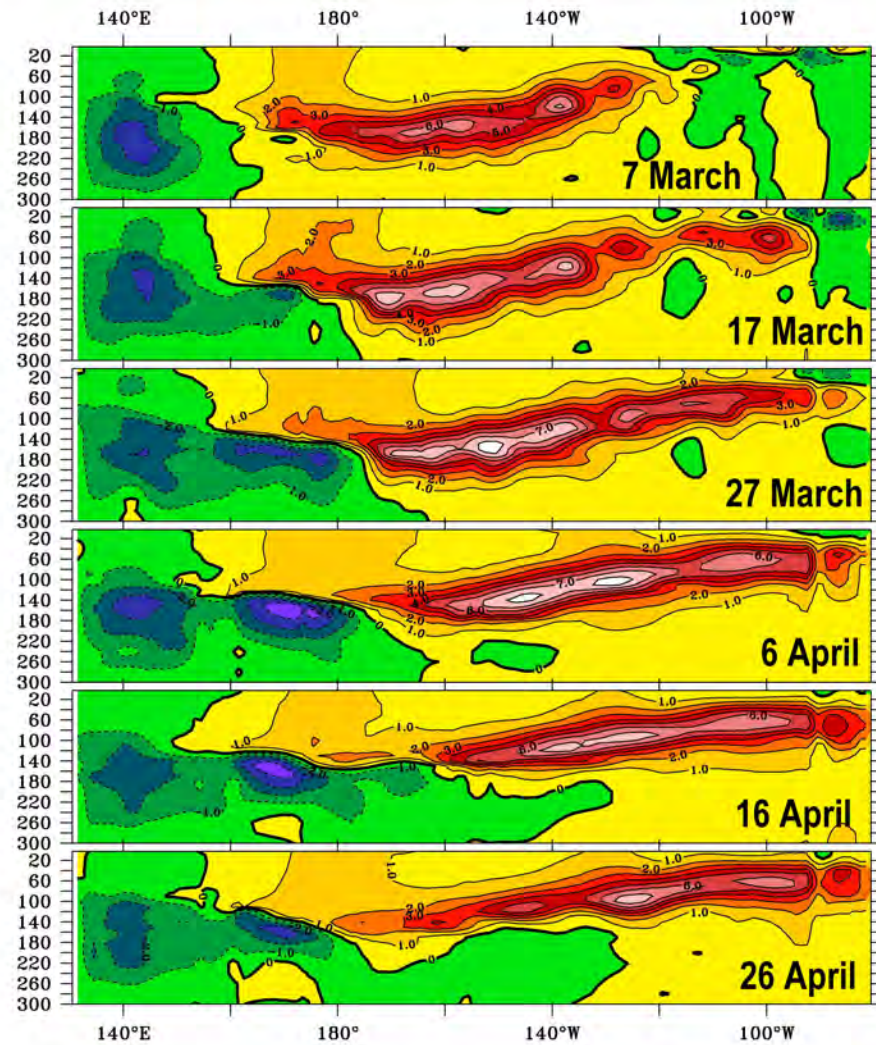
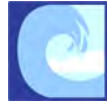


Fig. 1 Vertical sections along the equator, 0-300 m, of temperature anomaly at 10-day intervals in early 2014, from profiling float data, including previous Argo floats plus the 41 Argo floats deployed by this project. In January 2014 a strong burst of westerly wind in the western equatorial Pacific, caused a pulse of warm temperature anomaly (downwelling of the thermocline) that propagated across the Pacific in February to April. On arriving at shallow depths in the eastern equatorial Pacific, the warm anomaly spreads into the surface layer. These floats are now the dominant source of subsurface information for ocean analysis and forecasting

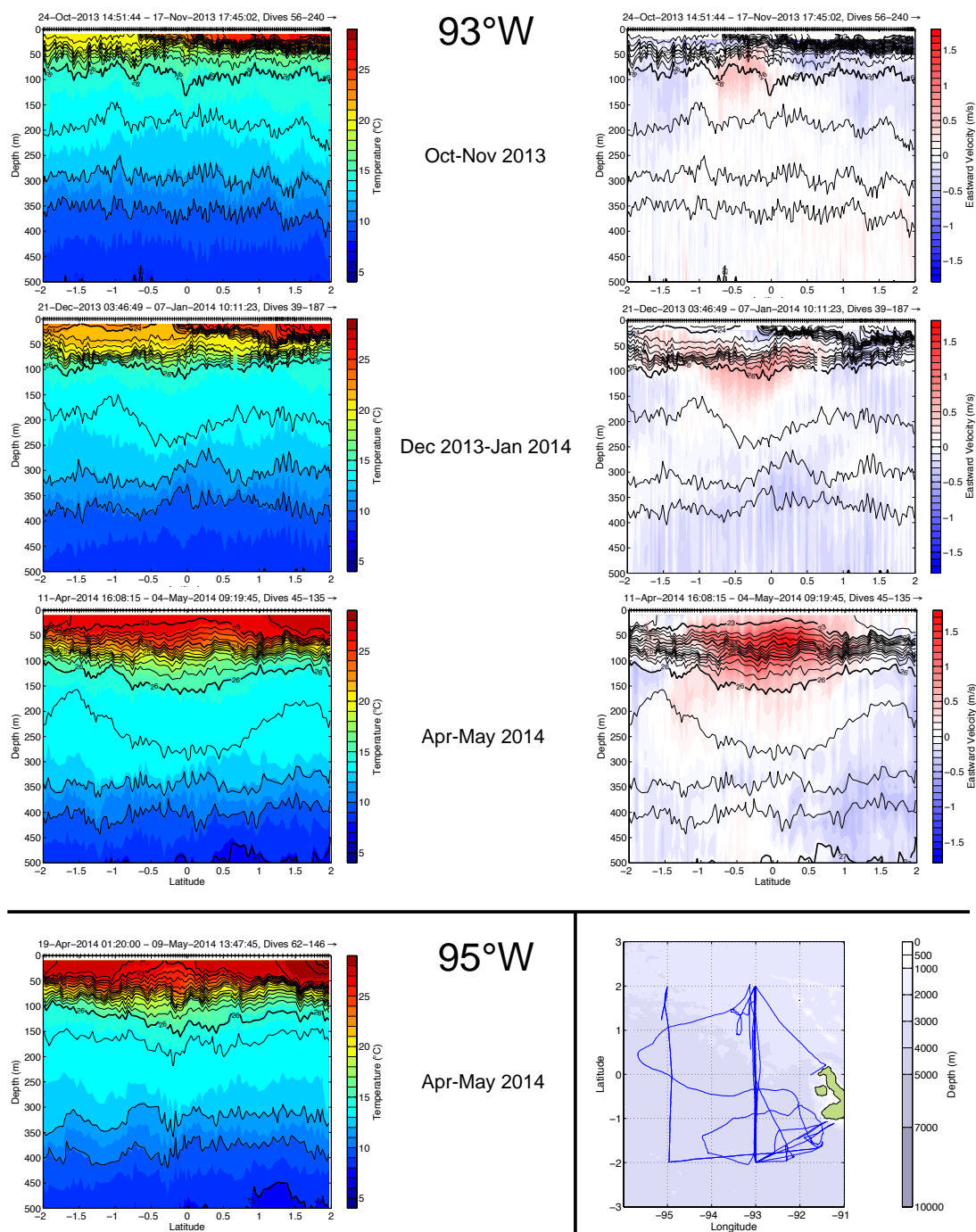


Fig. 2 Sections of temperature (left) and eastward velocity (right) from Spray underwater gliders crossing the equator between 2°N and 2°S at 93°W (top) and 95°W (bottom). Black lines are isopycnals. Gliders have been patrolling along 93°W since October 2013, while 95°W was first occupied in April 2014. The sections in April/May 2014 show warming, a deepening pycnocline, and a swifter and broader equatorial undercurrent. All gliders were deployed from the Galapagos Islands (lower right corner), with 4 missions completed and 4 currently underway. The gliders have collected 3000 profiles to as deep as 1000 m in 390 glider-days, covering 8900 km in track length



Intraseasonal to Interannual Variability in the Intra-Americas Sea in Climate Models

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NOAA Technical Contact: D. Barrie (CPO)

Links to NOAA Strategic Plan:

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

Amendment No.: NA13OAR4310092 (Competed)

Research Objectives and Specific Plans to Achieve Them

To assess the ability of CMIP models to produce realistic intraseasonal to interannual variability (IAV to ISV) in the Atlantic warm pool (AWP) region and the implications for hurricanes, the ability of parameterization modifications in the GFDL AM3 to improve the simulation of AWP ISV, and how mean state biases in CMIP models develop and the implications for forecast biases in ISV and IAV.

Research Accomplishments

Cause of the pause of global temperature rise

Despite the continued increase in atmospheric greenhouse gas concentrations, the annual-mean global temperature has not risen in the twenty-first century, challenging the prevailing view that anthropogenic forcing causes climate warming. Various mechanisms have been proposed for this hiatus in global warming, but their relative importance has not been quantified, hampering observational estimates of climate sensitivity. Here we show that accounting for recent cooling in the eastern equatorial Pacific reconciles climate simulations and observations. We present a novel method of uncovering mechanisms for global temperature change by prescribing, in addition to radiative forcing, the observed history of sea surface temperature over the central to eastern tropical Pacific in a climate model. Although the surface temperature prescription is limited to only 8.2% of the global surface, our model reproduces the annual-mean global temperature remarkably well with correlation coefficient $r = 0.97$ for 1970–2012 (which includes the current hiatus and a period of accelerated global warming). Moreover, our simulation captures major seasonal and regional characteristics of the hiatus, including the intensified Walker circulation, the winter cooling in northwestern North America and the prolonged drought in the southern USA.

Climate model evaluation

Errors of coupled general circulation models (CGCMs) limit their utility for climate prediction and projection. Origins of and feedback for tropical biases are investigated in the historical climate simulations from the Coupled Model Intercomparison Project phase 5 (CMIP5), together with the available Atmospheric Model Intercomparison Project (AMIP) simulations. The excessive equatorial Pacific cold tongue and double intertropical convergence zone (ITCZ) stand out as the most prominent errors of the current generation of CGCMs. The comparison of CMIP-AMIP pairs enables us to identify whether a given type of errors originates from atmospheric models. The equatorial Pacific cold tongue bias is associated with deficient precipitation and surface easterly wind bias in the western half of the basin in CGCMs, but these errors are absent in atmosphere-only models, indicating that the errors arise from the interaction with the ocean via Bjerknes feedback. For the double ITCZ problem, excessive precipitation south of the equator correlates well with excessive downward solar radiation in the Southern Hemisphere midlatitudes, an error traced back to atmospheric model simulations of cloud during austral spring and summer. This extratropical forcing of the ITCZ displacements is mediated by tropical ocean-atmosphere interaction, and is consistent with recent studies of ocean-atmospheric energy transport balance.

NOAA MAPP CMIP5 Task Force

Eric Maloney is a co-chair, and Shang-Ping Xie is a member, of the NOAA MAPP CMIP5 Task Force. Accomplishments have included generation of a *Journal of Climate* special collection on North American Climate in CMIP5 Models, which includes the three overview assessment papers. The NOAA CMIP5 task force will end its activities this coming Fall.

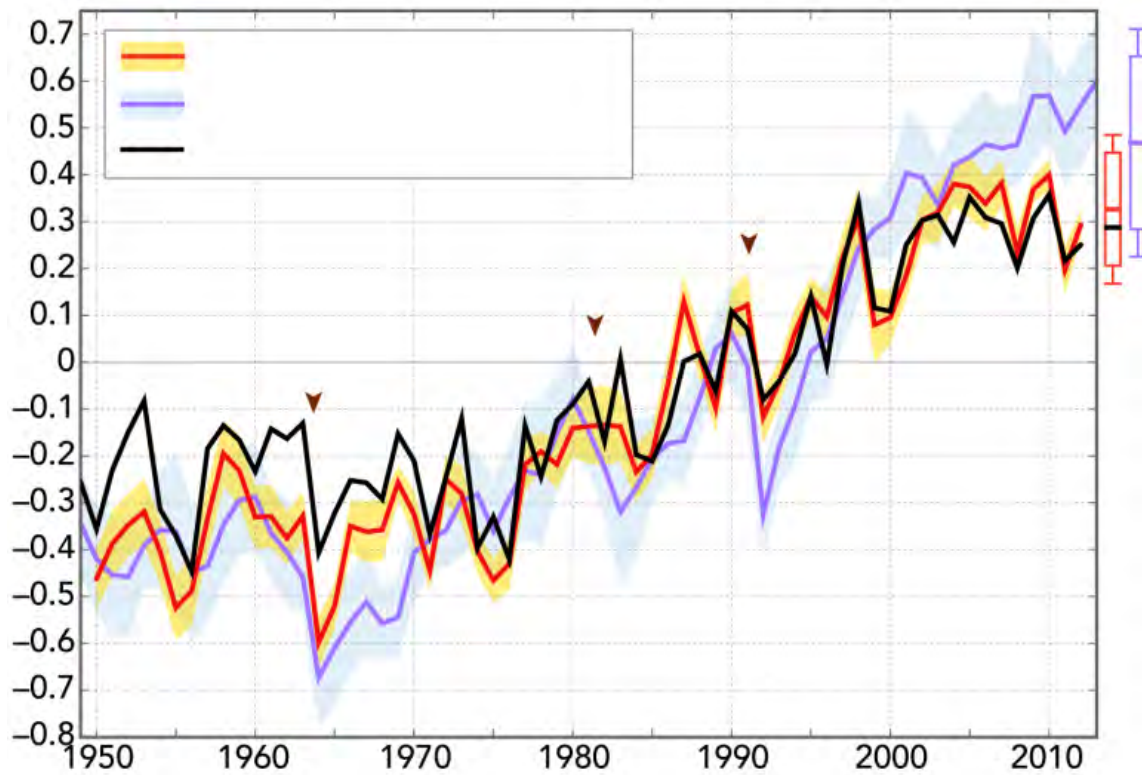


Fig. 1 Observed and simulated global temperature trends. Annual mean time series based on observations, HIST (climate simulation forced with radiative forcing) and POGA-H (climate simulation forced with radiative forcing and observed sea surface temperature over the eastern tropical Pacific). Anomalies are deviations from the 1980–1999 averages, except for HIST, for which the reference is the 1980–1999 average of POGA-H. SAT anomalies over the restoring region are plotted in b, with the axis on the right. Major volcanic eruptions are indicated. Shading represents 95% confidence interval of ensemble means. Bars on the right of a show the ranges of ensemble spreads of the 2002–2012 averages.



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

Amendment No.: 1, 35, 54, 87

Research Objectives and Specific Plans to Achieve Them

CSTAR was formed in 2001 with the goal of 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. 2013-14 was another successful year for CSTAR.

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 level of core support which is then leveraged by teaching assistantships and graduate research assistantships or post-doctoral scholar support from other grants or contracts. This enables us to create a relatively large and interactively group of quantitative scientists working on a wide range of problems in fishery management.

During the review period, members of CSTAR were
 Eric Anderson (Staff Member, NMFS Santa Cruz Laboratory)
 Carl Boettiger (Postdoctoral Scholar)
 Mariah Boyle (Assistant Project Director, FishWise)
 Valerie Brown (Assistant Specialist, UCSC)
 Edward (EJ) Dick (Staff member, NMFS Santa Cruz Laboratory)
 John Field (Staff Member, NMFS Santa Cruz Laboratory, co-Director)
 Michelle Gorbaty (Undergraduate Research Assistant)
 Xi He (Staff member, NMFS Santa Cruz Laboratory)
 Meisha Key (Staff member, California Department of Fish and Wildlife)
 Thanassis Kottas (Faculty, UCSC)
 Daniel Ladd (MSc Student, Statistics and Applied Mathematics)
 Juan Lopez (PhD student, Applied Mathematics)
 Alec MacCall (Staff member, NMFS Santa Cruz Laboratory)



Marc Mangel (Faculty UCSC, Co-director)
Vanessa Labrada Martagon (UC-MEXUS/CONACyT Post-doctoral scholar)
Melissa Hedges Monk (Postdoctoral Scholar)
Steve Munch (Staff member, NMFS Santa Cruz Laboratory)
Valerie Poynor (Postdoctoral scholar)
Kate Richerson (PhD student, Ecology and Evolutionary Biology)
Santiago Salinas (Postdoctoral Scholar)
Jarrod Santora (Independent AMLR contractor)
Hans Skaug (sabbatical visitor from the Department of Mathematics, University of Bergen, 2012-13)
Braden Soper (PhD student, Applied Mathematics)
Will Satterthwaite (Staff member, NMFS Santa Cruz Laboratory)
Simone Vincenzi (Research scientist, MRAG Americas and EU Marie Curie Outgoing Fellow)
Brian Wells (Staff member, NMFS Santa Cruz Laboratory)

Research Accomplishments

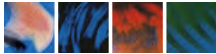
CSTAR continues its work of training students and post-docs in quantitative population biology relevant to the mission of NOAA Fisheries and placing them in positions in NOAA Fisheries and beyond. At the current time, CSTAR Representation in the Fisheries Ecology Division Teams are:

- Groundfish Analysis (CSTAR Alum EJ Dick, CSTAR Post-doc Melissa Monk)
- Salmon Assessment (CSTAR Alum Will Satterthwaite)
- Landscape Ecology (CSTAR student Juan Lopez, CSTAR Alum Valerie Brown,
- CSTAR Researcher Jarrod Sant)
- Fisheries Economics (CSTAR student Duran Fiack)
- Early Life History (CSTAR Alum Steve Munch, CSTAR Post-doc Carl Boettiger,
- Valerie Poynor, Santiago Salinas)
- Molecular Ecology (CSTAR Alum and Visiting EU Marie Curie Fellow Simone Vincenzi)
- and a bit further afield
- US AMLR (CSTAR Student Kate Richerson)

During the review period, CSTAR students and post-docs continued to do novel and important work in quantitative population biology as it pertains to sustainable fisheries. PhD student Kate Richerson participated in the AMLR winter cruise. PhD students Juan Lopez and Daniel Ladd completed MS. Degrees in Statistics and Applied Mathematics. Lopez's thesis included a chapter on using fishing vessel behavior to achieve conservation objectives and a chapter on the thermal ecology of steelhead in the Santa Ynez mountains. Ladd's thesis included a chapter on water policy for salmonid conservation and the effect on labor in California. Post-doc Melissa Monk developed new methodologies to analyze the recreational fisheries catch data from California and Oregon. The resulting indices of abundance were used for the first time to inform stock assessments in 2013. In addition, Monk, working with Director Mangel and USGS colleague Tim Tinker is developing a population dynamics model for southeast Alaskan sea otters. The U.S. Fish and Wildlife Service will use the model for management of the population and to predict future population sizes. Post-doc Carl Boettiger was offered the position of Assistant Professor of Ecoinformatics at UC Berkeley. Post-doc Vanessa Labrada Martagon completed her year-long UCMEXUS-CONACyT fellowship, developing models for the life history of green sea turtles, and is lead author on a major review of non-lethal methods for determining reproductive status in marine vertebrates. Dr. Jarrod Santora joined CSTAR as Assistant Researcher at UCSC. Santora published 11 peer-reviewed papers, received an NSF award from the Office of Polar Programs to conduct 3 research cruises to the Antarctic Peninsula, participated on the second U.S. Antarctic Marine Living Resources winter survey of sea ice conditions and predator-prey interactions, and presented papers at the annual North Pacific Marine Science Organization (PICES) meeting and at the CalCOFI conference. EU International Outgoing Marie Curie Fellow Simone Vincenzi was invited to present his research on the consequences of extreme events on population dynamics at the EURAEXESS event at Columbia University in March 2014. The other speakers were from Harvard (2), the University of Michigan, and UC Berkeley. Director Marc Mangel served as the independent scientific expert witness in the case in the International Court of Justice "Whaling in the Antarctic: Australia v. Japan. New Zealand Intervening"



Fig. 1 CSTAR post-doc Vanessa Labrada Martagon in the field, collecting data on green sea turtles to parametrize and test her model of their life histories, as related to stock assessment, conservation, and management of human effects on them



Shipboard Monitoring of the California Current System Off Central California

Baldo Marinovic (UC Santa Cruz)

NOAA Technical Contact: Steve Miller (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

Amendment No.: 4, 32, 50

Research Objectives and Specific Plans to Achieve Them

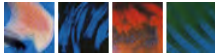
In cooperation with the NMFS, we propose to continue shipboard measurements off central California through September 2013. Personnel will be provided to assist in the collection of hydrographic data during the NMFS run Winter and Spring cruises of 2013. Seawater will be assayed for nutrients (nitrate, 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. All data collected will be made available as soon as possible to other



researchers via web based archives and technical reports, e.g. Rago et al., 2012. Note: CIMEC funding for this project was terminated on Sep 30, 2013.

Research Accomplishments

Personnel participated in hydrographic sampling on the northern legs of the 2014 Winter and Spring CalCOFI surveys conducting by NMFS.



Investigations in Fisheries Ecology

Eric Palkovacs (UC Santa Cruz)

NOAA Technical Contact: Steve Miller (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

Amendment No.: 6, 22, 63, 72, 97, 99

Research Objectives and Specific Plans to Achieve Them

This cooperative research program encompasses a large number of individual studies conducted by scientists from the University of California Santa Cruz (UCSC), the National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecology Division (FED) and Environmental Research Division (ERD), and many collaborators at other institutions and agencies. The overall objectives are to conduct research needed to support (1) management and recovery planning for Pacific salmonids and sturgeon listed under the Endangered Species Act; (2) stock and ecosystems assessments and harvest management for West Coast groundfish and Pacific salmon fisheries; and (3) economic assessment of fisheries and fishing communities in California.

Specific research projects addressed 10 objectives: (1) examine intrinsic and extrinsic factors influencing the fecundity of rockfishes; (2) develop mathematical and statistical tools to improve salmon stock assessments, abundance forecast methods, and population dynamics models; (3) develop improved historical catch statistics and demographic data for commercially important groundfish to support stock assessments; (4) assess climate-ecosystem linkages at interannual to decadal time scales in the North Pacific Ocean and disseminate satellite-derived oceanographic data; (5) evaluate the economic effects of salmon restoration activities in the Central Valley, the Klamath Basin, and coastal rivers in California and of groundfish regulatory actions on commercial and recreational fisheries and fishing communities; (6) develop habitat-based spatial models of the distribution and abundance of demersal fishes in untrawlable habitats; (7) develop improved methods for using acoustic trawl and acoustic optical surveys to estimate the distribution and abundance of fish and zooplankton in the North Pacific Ocean; (8) conduct comparative studies of salmon ecology and life history across salmon habitats and life stages in small and large rivers, estuaries, and the near shore coastal ocean; (9) evaluate and improve physical-biological ecosystem models to support the California Current Integrated Ecosystem Assessment; and (10) develop a life cycle model and decision support tools for Central Valley Chinook salmon based on integrated physical and biological models.

Project scientists used a wide range of methods to address these research questions, including field sampling, laboratory experiments, physical and biological modeling, spatial analysis and modeling using GIS and remote sensing, and economic data collection and analysis.

Research Accomplishments

Project scientists met research goals and milestones for each of the 10 projects described above, which addressed a wide range of topics on biology, analytical methods, and economics related to the management of groundfish, salmon, and the California Current ecosystem. Accomplishments included final completion of a number of major projects resulting in publication of papers and reports; completion of several large field and laboratory data collection efforts, data analyses, and modeling projects; and initiation of a number of new studies through hiring of research staff, developing research plans and protocols, and beginning data collection



or model development. Results were published in 25 journal articles and 12 reports or book chapters, and an additional 12 articles were in press or submitted. Project scientists engaged in more than 25 conferences, workshops, symposia, and outreach events to present research, network and collaborate with other scientists, contribute to training and professional development within the field, and provide information to the public. Academic development was provided to undergraduate and graduate students and post-doctoral scholars through employment and support of thesis and dissertation research.

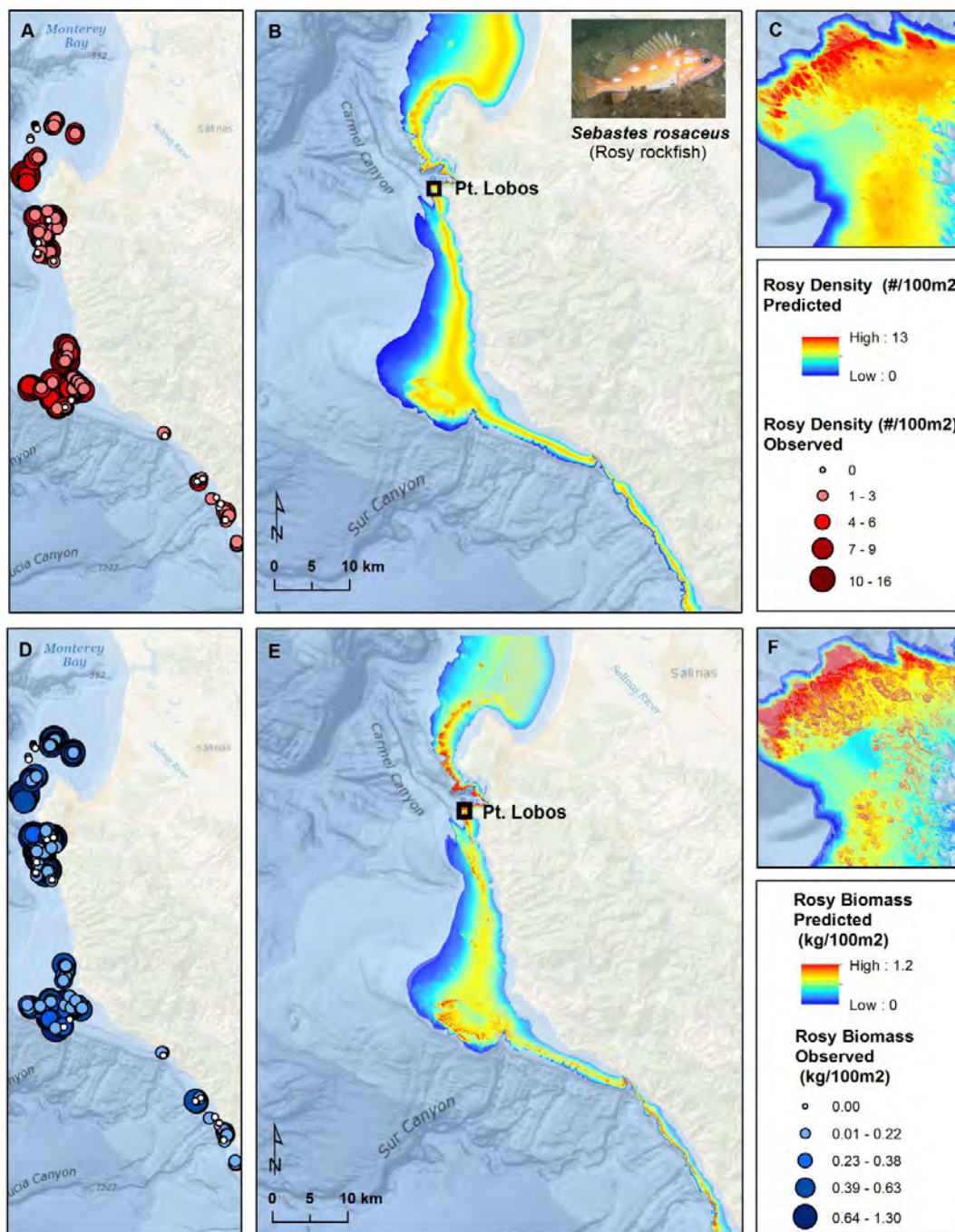


Fig. 1 Density and biomass for rosy rockfish *Sebastes rosaceus* off central California: (A) graduated dots of observed density; (B) predicted density throughout study area; (C) predicted density in enlarged map of area off Pt. Lobos; (D) graduated dots of observed biomass; (E) predicted biomass throughout study area; and (F) predicted biomass in enlarged map of area off Pt. Lobos



Fig. 2 NOAA/CIMEC researchers prepare to release an acoustically-tagged adult Chinook salmon caught during an ocean survey. A tissue sample was taken from the salmon for DNA analysis to determine its river of origin, and the acoustic tag will track its movements at sea and during its up-river spawning migration



Freshwater Ecology Research Collaboration

Eric Palkovacs (UC Santa Cruz)

NOAA Technical Contact: Steve Miller (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

Amendment No.: 9, 21, 52, 88

Research Objectives and Specific Plans to Achieve Them

Primary objectives were 1) continue to build the Palkovacs Laboratory at UCSC, 2) continue to make progress on existing projects, and 3) establish and fund new projects and collaborations in California. To accomplish these goals, I extended the appointment for a postdoc (Dr. Daniel Hasselman), hired a research technician (Travis Apgar), continued to support a PhD student (David Fryxell), and took on a new PhD student (Gina Contolini). All have been extremely productive. This year, the Palkovacs Lab has published 3 peer-reviewed



papers, 1 book review, currently has 1 in review, and a book chapter in press. I have organized and contributed to several working groups, established new research collaborations.

Research Accomplishments

- 1) River herring population genetic structure and demography – paper published in *Evolutionary Applications* (EP Palkovacs first author)
- 2) Genetic stock identification of bycatch – manuscript preparation underway involving Dan Hasselman (Postdoc) and Eric Anderson (NMFS SWFSC)
- 3) Alewife landlocking and rate of evolution – paper published in *Freshwater Biology* (EP Palkovacs first author)
- 4) Alewife and blueback herring hybridization – paper published in *Molecular Ecology* (Dan Hasselman first author)
- 5) Ecological effects of temperature adaptation in *Gambusia* – Dave Fryxell (PhD Student) continued work in California and New Zealand in with Kevin Simon (University of Auckland).
- 6) Ecological causes and consequences of chromosome 5 variation in Steelhead Trout – analyzing existing chromosome 5 data in the context of environmental variables with Devon Pearce (NMFS SWFSC).
- 7) Trait variation among coastal populations of threespine stockpileback – began sampling of coastal estuaries with Andrew Hendry (McGill University)
- 8) Tidewater goby extinction risk due to climate change – began collecting data for extinction modeling with Barry Sinervo (UCSC) and Andrew Kinziger (Humboldt State).
- 9) Testing eco-evolutionary trophic cascades in aquatic ecosystems – submitted NSF proposal with Mike Kinnison (University of Maine)
- 10) Ecological and evolutionary consequences of secondary contact between anadromous and landlocked alewife populations – submitted NSF proposal with David Post (Yale University)
- 11) Selection on anadromous fishes driven by fishways – began analysis of Connecticut River fishway selectivity on size and body shape variation in American Shad (with Ted Castro-Santos, USGS).



Fig. 1 Alewives at Damariscotta Mills, Maine (Photo by Keith Ellenbogen). Population genetic analysis of anadromous alewife (*Alosa pseudoharengus*) indicates three distinct genetic stocks (Northern New England, Southern New England, Mid-Atlantic). Analysis of demographic trends show that all stocks have declined, but that the Southern New England Stock has declined most dramatically over recent decades



Freshwater Fish Ecology Research Collaboration

Darren Ward (Humboldt State University)

NOAA Technical Contact: Steve Miller (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

Amendment No.: 3, 29, 49, 81

Research Objectives and Specific Plans to Achieve Them

This project provides support for the Department of Fisheries Biology at Humboldt State University (HSU) to maintain a 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 faculty position held by Dr. Darren Ward 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 continue as a 50% research and 50% teaching appointment, 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

Research activities for this project are primarily carried out through increased time investment in mentoring graduate students and developing funding proposals. In the 2013-2014 project period, two graduate students from the Ward laboratory at Humboldt State successfully defended Master's theses. Shari Witmore, a NOAA Advanced Studies student, completed an intensive field study to compare growth and life history of ESA-listed juvenile coho salmon in natural off-channel habitats and ponds constructed for habitat enhancement in tributaries of the Klamath River. Meiling Roddam completed a study that combined mark-recapture and otolith microchemistry to evaluate Chinook salmon smolt production from discrete spawning and rearing areas in the Shasta River, an important Klamath River tributary. Five continuing graduate students are conducting related research projects:

- Sean Cochran (expected completion Fall 2014) is using monitoring data and archived scale samples from coho salmon monitoring projects all along the California coast to identify links between freshwater growth, early marine growth, and marine survival.
- Molly Gorman (expected completion Fall 2015) is comparing the fate of juvenile coho salmon that rear in natal habitat in the upper Shasta River and those that emigrate from the lower Shasta River into the main stem Klamath River.
- Michelle Krall (expected completion Fall 2015) is evaluating growth and abundance of juvenile coho salmon occupying habitat enhancement sites in Klamath River tributaries to identify site features associated with increased coho production.
- Gabe Scheer (expected completion Spring 2016) is constructing a life-history based population model for coastal coho salmon populations in order to predict the relative population effects of different conservation approaches.
- Justin Alvarez (expected completion Fall 2016) will measure predation on native salmon by non-native brown trout in the upper Trinity River.



Fig. 1 Humboldt State University students seining for juvenile salmonids as part of a habitat assessment study in Jacoby Creek, Humboldt County, CA

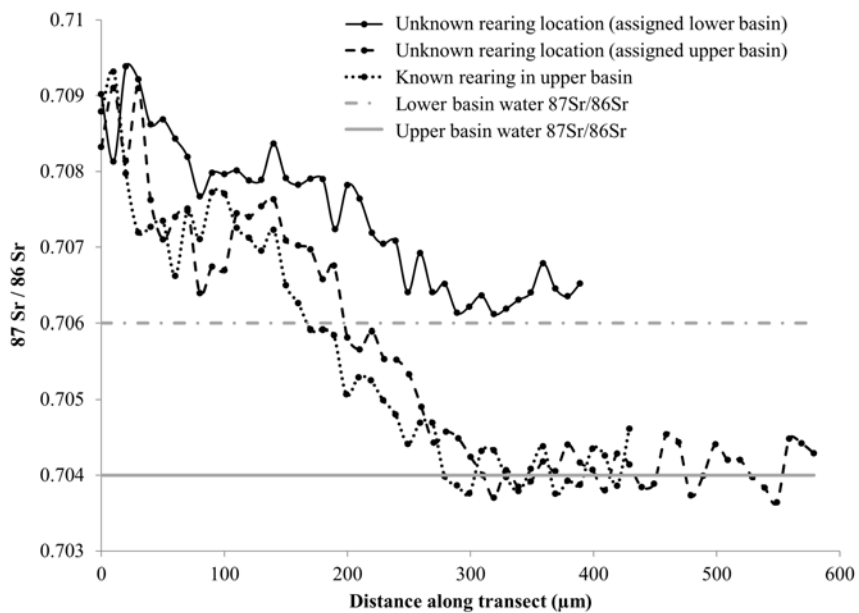
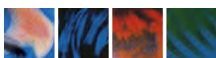


Fig. 2 Strontium isotope composition from laser ablation of juvenile Chinook salmon otoliths along a transect from the primordium (0 μm, marine strontium signal from maternal influence) to the outer edge, showing individuals classified to different rearing locations and the strontium isotope composition of the water at the two locations



Ocean Observing and Fisheries Oceanography Research of the Coastal Ocean off Northern California

Jeffrey Abell (Humboldt State University)

NOAA Technical Contact: Steve Miller (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

Amendment No.: 34

Research Objectives and Specific Plans to Achieve Them

The goals of this project are (1) to facilitate ongoing ocean observation cruises along the Trinidad Head Line, and to prepare hydrographic and biological data for analysis and inclusion in coastal observation networks, and (2) to support focused research in fisheries oceanography and recruitment dynamics off northern California. The primary strategy for achieving these goals is to support a research technician tasked with the day-to-day operations associated with planning, executing, and demobilizing from observation cruises and assisting with coordination of post-cruise laboratory analysis and data synthesis. This work is based out of Humboldt State University, and represents a collaborative effort between HSU and the Fisheries Ecology Division of NMFS' Southwest Fisheries Science Center.

Research Accomplishments

Roxanne Robertson continued to serve as lead technician and to be a tremendous asset to the program. She has coordinated and in many cases led hydrographic and biological sampling on 17 successful cruises along the Trinidad Head Line (including several collaborative cruises focused on ocean acidification), processed hydrographic data, overseen laboratory efforts to catch up on analysis of archived specimens (technical support for plankton sorting augmented by funding from the Ocean Protection Council), and ensured timely calibration and maintenance of instrumentation. Results from this work include observations of intense upwelling in early 2013 that appears to have brought low DO/low pH water on to the shelf on several occasions, and in one case contributed to an unusual stranding of krill (primarily *Thysaonessa spinifera*) along beaches in northern California and Oregon (see Figure 1).

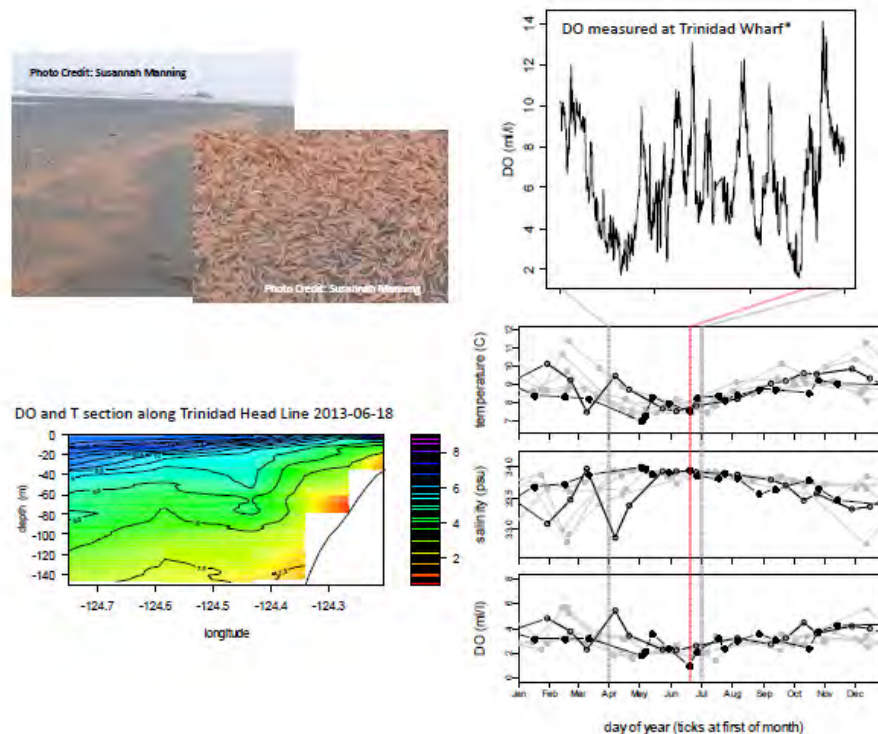


Fig. 1 Upper left color photos: example of mass stranding of euphausiids observed from northern California and Oregon in June 2013. Lower left color plot: Cross shelf section of dissolved oxygen (color) and temperature (contours) observed along the Trinidad Head Line 18 June 2013 showing low DO water over the shelf. Upper right panel: DO measured at Trinidad Head Wharf (data courtesy Frank Shaughnessy and CeNCOOS). Lower right panel: Annual time series of temperature, salinity and DO at 60 m at station TH02 (approximately mid-shelf) along the Trinidad Head line. Solid symbols indicate observations for 2013, open symbols are for 2012, and grey symbols are for previous years (2007-2011).



Collaborative Studies of Cetaceans with the Southeast Fisheries Science

John Hildebrand (SIO)

NOAA Technical Contact: L. Garrison (NMFS/SEFSC)

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

Amendment No.: 13, 55, 82

Research Objectives and Specific Plans to Achieve Them

The goal of this project is to conduct acoustic observations of cetaceans during the Gulf of Mexico Sperm Whale Cruise (GMSWC) on the NOAA Ship Gordon Gunter and using High-frequency Acoustic Recording Packages (HARPs) deployed in the southeastern Gulf of Mexico. A broadband towed hydrophone array was sent to the Gulf of Mexico, along with personnel to operate the array, during a three leg cruise (total 55 days at sea). Recordings of cetacean sounds were collected to aid in characterization of sounds by species. Two



HARPs were deployed in the southeastern Gulf of Mexico, and their acoustic data analyzed for marine mammal sounds to better understand the distribution of marine mammal populations in the Gulf of Mexico.

Research Accomplishments

Passive acoustic monitoring was conducted in the southeastern Gulf of Mexico at two sites, designated as Dry Tortugas and Howell Hook. Both sites were along the Florida Escarpment, approximately 145 nm from the western Florida coastline on the shelf break. The Howell Hook deployments were at a water depth of 1000 m, (25° 31.9 N, 84° 38.0 W), from May 2012 to April 2013, for a combined continuous 310 days. The Dry Tortugas deployments were 34 nm to the northwest of the Howell Hook site, at a water depth of 1200 m (25° 01.7 N, 84° 23.8 W), from May 2012 to August 2013, for a combined continuous 448 days. High-frequency Acoustic Recording Packages (HARPs) recorded sounds continuously between 10 Hz and 100 kHz. The data were analyzed by scans of long-term spectral averages and spectrograms.

Acoustic data collected at these sites provide information on the presence of marine mammals and anthropogenic sound sources. Several different toothed whale species were monitored: Blainville's, Cuvier's, and Gervais' beaked whales, unidentified beaked whale (BWG), killer whales, pygmy or dwarf sperm whales (*Kogia* spp.), Risso's dolphins, sperm whales, and unidentified odontocetes. Cuvier's and Gervais' beaked whales were detected at both sites over the entire deployment time. The unidentified beaked whale (BWG) was detected from June-November at both sites and had a diel pattern. Risso's dolphins were present at both sites with a distinct diel pattern, but were more dominant at Howell Hook. *Kogia* species were present at both Howell Hook and Dry Tortugas although Howell Hook had more detections. Sperm whales were detected throughout the entire deployment period at both sites. Unidentified odontocetes (not including clicks separated into the seven click types, see below) were the most common odontocete present at both sites. Neither Blainville's beaked whales nor killer whales were detected at either site.

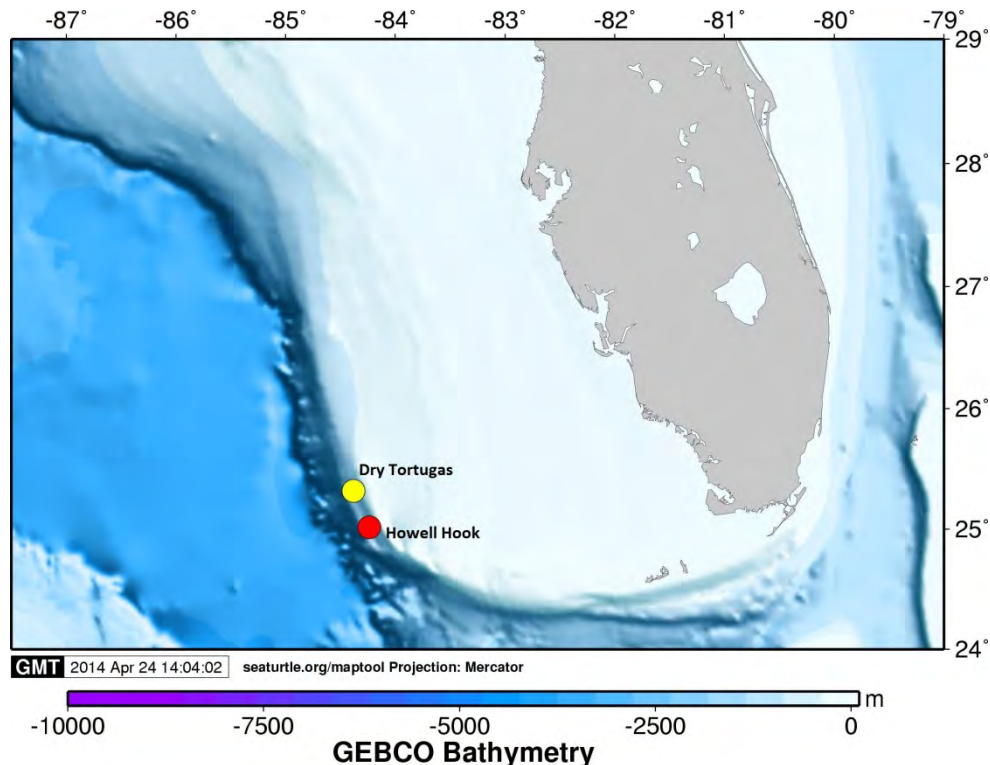


Fig. 1 HARP deployment locations.



SOAR Acoustic Ecology Project

John Hildebrand (SIO)

NOAA Technical Contact: L. Guy (PMEL)

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

Amendment No.: 73

Research Objectives and Specific Plans to Achieve Them

Project 1: *Ambient noise and bowhead whales in the Beaufort and Chukchi Seas*

The objective of this project is to map the spatial and temporal variability of the acoustic environment encountered by bowhead whales in the Beaufort and Chukchi Seas. Acousticians from six organizations will compile analyses and prepare a manuscript for publication.

Project 2: *Beluga whales, Arctic cod, and oceanographic conditions*

The goal of this project is to develop a better understanding of how and why beluga whales use Barrow Canyon and the shelf break areas of the western Beaufort Sea by combining varied data sets including: aerial surveys, satellite tracking and dive data from tagged belugas of the eastern Chukchi Sea, fish trawls, passive acoustic monitoring, and oceanographic conditions.

Research Accomplishments

SIO staff completed analyses of acoustic data from two High-frequency Acoustic Recording Packages (HARPs) deployed in the Chukchi Sea from 2009-2011. Detections of beluga and bowhead whale calls were provided to project collaborators and included in two manuscripts. The manuscript entitled, *A year in the acoustic world of Western Arctic bowhead whales* was submitted to Progress in Oceanography in April, 2014.



Measurements of North Atlantic Ambient Noise

John Hildebrand (SIO)

NOAA Technical Contact: J. Gedamke (MED)

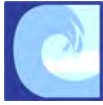
Links to NOAA Strategic Plan:

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

Amendment No.: 53

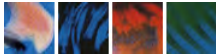
Research Objectives and Specific Plans to Achieve Them

This project will examine changes in North Atlantic ocean ambient noise by comparing measurements conducted south of Bermuda in 1966 with current noise levels. An autonomous acoustic recorder will be deployed at a previously studied location south of Bermuda. Data will be compared for shipping and other anthropogenic noise sources as well as environmental contributions (wind and waves). A year-long study of ambient noise was conducted during 1966 southwest of Bermuda. We propose to place an autonomous seafloor recorder at the site of the 1966 recordings so that direct comparison can be made without the need to correct for site dependency. The bandwidth of the new recordings (100 kHz) will be greater than the bandwidth used in 1966 (400 Hz), allowing a baseline to be established for mid-frequency as well as low-frequency noise. We expect to find an increase (3 dB/decade) in shipping noise at the Bermuda site.



Research Accomplishments

Calibrated passive acoustic recordings were collected from June 2013 to March 2014 on the south side of Bermuda in the North Atlantic, at a location where ambient noise data were collected in 1966. Monthly and hourly mean power spectra (15-1,000 Hz) were calculated, in addition to skewness, kurtosis, and percentile distributions. Average spectrum levels at 40 Hz, representing shipping noise, ranged from 78-80 dB re: 1 $\mu\text{Pa}^2/\text{Hz}$, with a peak in March and minimum in July and August. Values recorded during this recent period were similar to those recorded during 1966. This trend is different from what has been observed in the Northern Pacific, where ocean ambient noise has been increasing; however, the location of this monitoring site was not exposed to major shipping lanes in the North Atlantic. At frequencies dominated by wind and waves (500 Hz), noise levels ranged from 55-66 dB re: 1 $\mu\text{Pa}^2/\text{Hz}$, indicating low sea states (2-3) prevailed during the summer, and higher sea states (4-5) during the winter. Seasonally important contribution to ambient sound also came from marine mammals, such as blue and fin whales.



Passive Acoustic Studies in the Central and Western Pacific Ocean

Ana Sirovic and Simone Baumann-Pickering (SIO)

NOAA Technical Contact: Erin Oleson (NMFS/PIFSC)

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

Amendment No.: 86

Research Objectives and Specific Plans to Achieve Them

The goal of the project is to conduct passive acoustic monitoring focusing on cetaceans in the central and western Pacific Ocean in collaboration with the NOAA Pacific Island Fisheries Science Center (PIFSC). We are focusing on four tasks: (1) investigate response of cetaceans to anthropogenic noise around Hawaiian and Northern Mariana Islands; (2) study the seasonal presence of baleen and beaked whale signals off Northern Mariana Islands; (3) provide technical support for continued data collection; and (4) work on the discrimination of echolocation click types for species common in the region.

Research Accomplishments

We identified the occurrence of transient anthropogenic (boats and sonar) noise events at three locations with relatively high incidence of these sounds: Kauai, Hawaii-Kona, and Saipan. We also evaluated the occurrence of baleen whales most commonly detected in these areas: blue whales, fin whales, humpback whales, and minke whales. Hawaii-Kona had the most blue whale calls, totaling over 1,000 detected calls over four deployments. The calls were detected year-round. Kauai site had just 10 blue whale calls, while none were detected at Saipan. Fin whale calls occurred from late fall into mid spring at all sites. Again, Hawaii-Kona had the most fin whale calls, just less than 1,000 detected from mid October 2010 to early January 2011. Kauai's 600 fin whale calls were detected from mid December 2009 to late February 2010. At Saipan, 400 fin calls were detected in April 2010 and March 2013. Minke whale boings were common in the winter and spring; most of the detections occurred in Kauai and Hawaii-Kona, and very few boings were detected off Saipan. The broadband shipping noise was found at all three sites year round, with a diel trend of increased boat activity during the daylight hours. Mid frequency active (MFA) sonar was detected at all sites, with the longest total duration in Hawaii-Kona and the shortest total duration in Kauai. At Hawaii-Kona and Kauai, MFA occurred intermittently through most of the data (Figure 1). The MFA off Saipan was concentrated to a period from summer 2012 to the winter 2013.

Three beaked whale echolocation signal types were encountered at both sites: frequency modulated (FM) pulses from Blainville's and Cuvier's beaked whale and a signal of unknown origin (called BWC). Blainville's beaked whale FM pulses were the dominant beaked whale signal detected at Saipan and Tinian, and were consistently present throughout the deployment periods at both sites. Cuvier's beaked whales were



consistently detected throughout the Saipan deployment, while there were very few acoustic encounters of Cuvier's beaked whales at Tinian. There were no discernable diel patterns in the occurrence of Blainville's or Cuvier's beaked whales at either site. There were few detections of the BWC signal of unknown origin at Tinian, all of which occurred at nighttime. There were more BWC detections at Saipan, and a strong nocturnal cycle was again observed.

To improve the efficacy of passive acoustic monitoring of marine ecosystems, unique characteristics of biological and anthropogenic acoustic signals need to be described. The echolocation clicks of pygmy killer whales (*Feresa attenuate*) were described based on recordings that were collected at times when satellite tagged animals were near bottom-anchored acoustic recorders. Unique features were identified to distinguish pygmy killer whales from other sympatric odontocetes. The echolocation click properties of rough-toothed dolphins (*Steno bredanensis*) were determined based on acoustic recordings collected from ship-based hydrophones with concurrent visual observations.

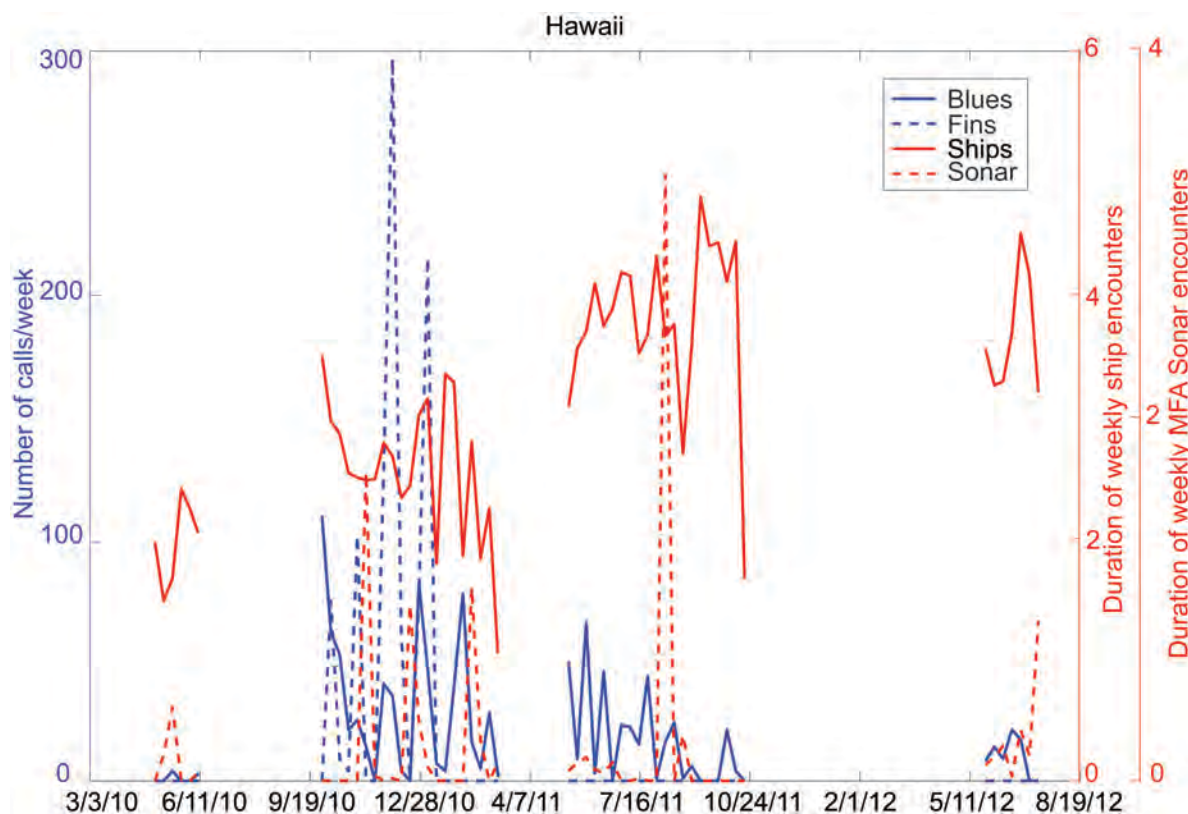


Fig. 1 Weekly number of calls detected from blue and fin whales (full and dotted blue lines, respectively) and total duration of encounter periods with ship noise and mid-frequency active (MFA) sonar (full and dotted red lines, respectively) during the same week recorded off Hawaii-Kona from 2010 to 2012

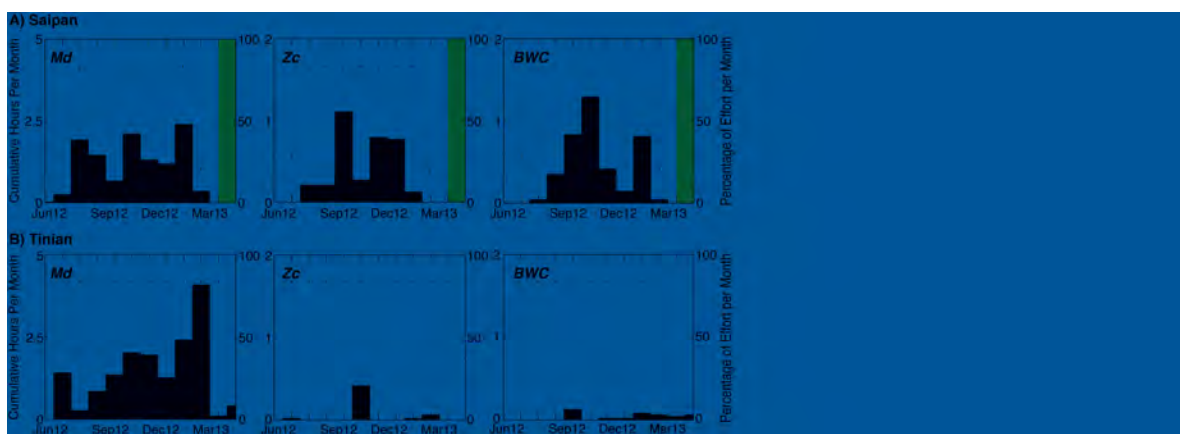


Fig. 2 Monthly presence in cumulative hours of Blainville's (Md), Cuvier's (Zc), and one unidentified beaked whale (BWC) FM pulse type at A) Saipan and B) Tinian recording sites. Grey dots represent monthly percentage of recording effort (recorders were set on a schedule)



Using Combined Video Acoustic Recordings of Marine Mammals/Fishing Gear Interactions to Evaluate Utility of Passive Acoustic Monitoring

Aaron Thode (SIO)

NOAA Technical Contact: D. Orner (NMFS/OHC)

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

Amendment No.: NA12NMF472053 (Competed)

Research Objectives and Specific Plans to Achieve Them

The overriding objective is to simultaneously deploy cameras and acoustic recorders from fishing gear, to determine whether visually-documented interactions of killer and false killer whales are accompanied by distinctive acoustic cues, such as echolocation sounds by the species of interest.

Specific subobjectives include the following:

- (1) Expanding two existing autonomous acoustic recorders to incorporate a long-endurance natural-lighting camera capability (between 24 hours to 7 day coverage, depending on picture frame acquisition rate);
- (2) Testing the system on sperm and killer whales in Alaska and false killer whales in Hawaii.
- (3) Using visually-documented encounters to determine the probability that killer and false killer whales generate sounds during fishing gear interaction during daylight hours, as a function of gear depth.
- (4) Exploiting opportunistic visual records of other bycatch events to determine whether acoustic cues are generated by entanglement with the fishing gear.

Research Accomplishments

As discussed in a previous progress report, the project has settled on the use of a GoPro Hero 3 camera as the basis for video collection. The resulting unit has been dubbed a "TadPro" (Figs. 1-3). The Tadpro combines GoPro™ cameras, a triggering circuit board, and one of the smallest camer timers/intervalometers available on market, the "Michron" (www.invivolabs.com), developed through Kickstarter.com), and a rectangular pressure case with glass lenses, pressure tested at Scripps in a pressure bomb to the equivalent of 1000 m depth. Photos of the current TadPro design can be reviewed at <http://scripps.ucsd.edu/labs/athode/some-photos-of->



[tadpro-assembly/](#) (password: SEASWAP). At present the 128 Gb system can record video and sound continuously for over five hours—longer if a duty cycle is used. As it turns out, the GoPro accepts a crude programming language that allows various functions to be entered into the camera once it is powered on by the intervalometer. The project has built a prototype that feeds an external hydrophone signal into the camera system via the camera's USB port.

Another item of progress is that the British Broadcasting Corporation (BBC) has provided support to build 19 additional "TadPro" units (pictured below), along with underwater lights to permit the cameras to gather video at depths where natural lighting is not available. The lights have a timer circuit to allow them to turn on just before hauling begins. In April the BBC agreed to let the project continue to use ten of these cameras past June 2014 for BREP research purposes.



Evaluation of exposure to and infection with Phocine Distemper Virus to the eastern Distinct Population Segment of Steller sea lions (*Eumetopias jubatus*) and continued monitoring of the western Distinct Population Segment

Tracey Goldstein (UC Davis)

NOAA Technical Contact: K. Rivera (NMFS/AKR)

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

Amendment No.: 84

Research Objectives and Specific Plans to Achieve Them

The purpose of the project is to evaluate the extent of infection and exposure to the potentially deadly virus, phocine distemper, in the Steller sea lion population off Alaska. The presence of phocine distemper virus was detected in Northern sea otters off the coast of Alaska in 2004, the first confirmation of this virus in marine mammals in the Pacific. Sequence analysis confirmed the viral fragment was identical to that from the 2002 phocine distemper outbreak that caused large-scale mortality in harbor seals in Europe and serological surveys prior to 2000 revealed that marine mammals in Alaska had not been exposed to Phocine Distemper Virus. Thus we hypothesized that the virus may have been transmitted through the Arctic to the North Pacific after the 2002 epidemic by vector species as sea ice reduction may have altered seal haul-out and migration patterns, resulting in contact between Atlantic, Arctic, and Pacific Ocean species that was not possible in 1988, after the previous outbreak in Europe. Through our recent work, funded by the Morris Animal Foundation, we were able to document that the virus is present and circulating in most Arctic and Subarctic seals, sea lions and sea otters off Alaska. Results also supported our hypothesis as they indicated that the virus moved into the Pacific from the Atlantic after 2002 after the outbreak in Europe that killed 30,000 seals.

To date limited testing has been performed on samples from Steller sea lions from the eastern Distinct Population Segment, thus to evaluate how widespread this viral infection is in Steller sea lions across their range, additional testing is needed. The goals of this work are to test for evidence of infection and measure exposure to phocine distemper virus in the samples from the eastern Distinct Population Segment of Steller sea lions, in animals from the western Distinct Population Segment in Russia, and to complete testing of samples collected from the animals from the western Distinct Population Segment in Alaska from 2011 to present to evaluate their current exposure and infection status.

Research Accomplishments

This is the first year of a two-year project. The first stage of this work was to further evaluate exposure in Steller sea lions in the western Distinct Population Segment in both Alaska and Russia, and also in the eastern Distinct



Population Segment off Alaska, Washington, Oregon and California. Archived serum samples ($n = 334$) were identified for serologic testing to examine for the presence of antibodies to Phocine Distemper virus and shipped to our collaborating lab at Belfast University in the UK. Nasal swab and tissue samples ($n = 235$) for PCR testing to examine for presence of infection were identified and shipped to our laboratory at UC Davis for testing. Our previous serologic analysis, focused primarily on animals from the central and eastern Aleutians and western and central Gulf of Alaska, and indicated that exposure to the virus likely first occurred in 2003 in Steller sea lions and antibodies could be detected in animals tested through 2010. This current work focused on testing animals from areas not previously examined in the eastern Gulf of Alaska, southeast Alaska and Russia; as well as from animals sampled in the central and eastern Aleutians since 2010 to better understand the current status of exposure in these animals.

Results to date from the CIMEC funded work show that an additional 22% of animals tested in Russia, 60% in the central Gulf of Alaska and 64% in southeast Alaska were positive for antibodies. Additionally, 41% of animals sampled in the Aleutians from 2011 to 2013 were also positive for antibodies against the virus. Figure 1 shows the proportion of animals that tested positive by location through our previous Morris Animal Foundation funded work (blue dots), as well as the proportion that tested positive by location funded in this current CIMEC funded work (red dots). Positive antibody titers ranged from 1:40 to 1:640 (the cut off for positive is greater than 1:32). Thus results indicate that exposure to the virus appears to be more widespread than previously thought, as animals as far east as Hazy Island, near Petersburg, in southeast Alaska, and as far west as Iony Island (Sea of Okhotsk) in Russia, tested positive. Additionally, results indicate that the virus may still be circulating as positive animals were detected in 2013. PCR testing, that will complement serology results to examine for the presence of current infections, is planned for the summer of 2014.

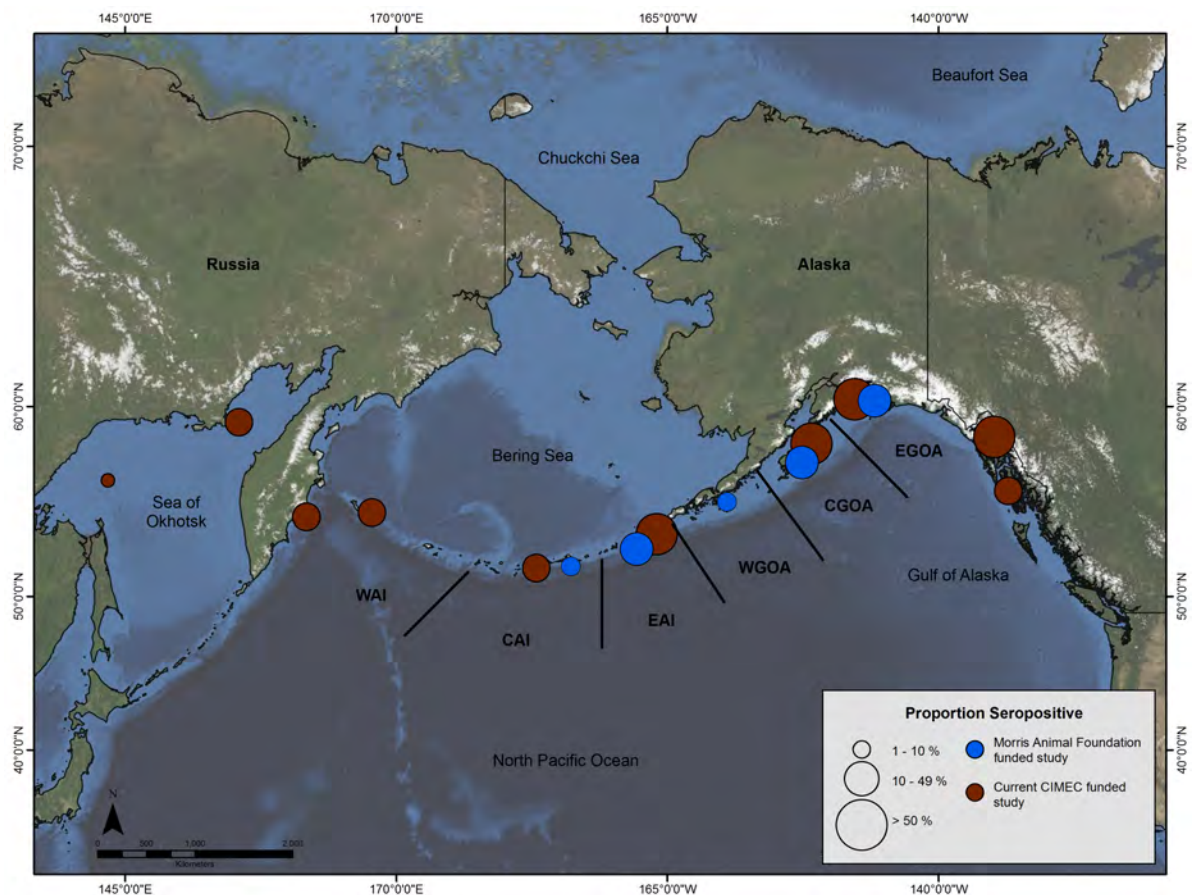


Fig. 1 The geographic distribution and proportion of positive Steller sea lions with antibodies against Phocine Distemper virus in Alaska and Russia. Circles in blue indicate samples that were tested in the previous Morris Animal Foundation funded study, those in red indicate samples tested through this current CIMEC funded work.



Ocean Observing Systems

Timothy Mulligan (Humboldt State University)

NOAA Technical Contact: S. Miller (NMFS/SWFSC)

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

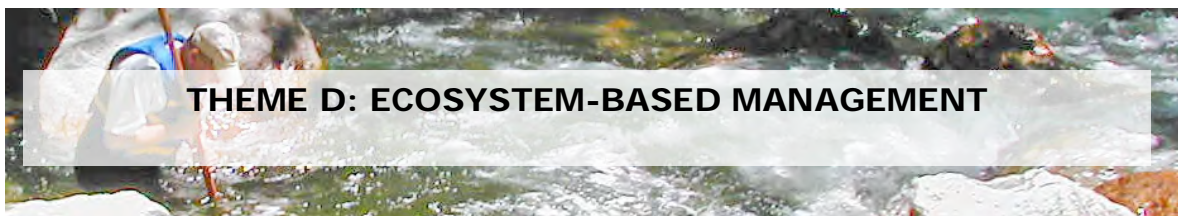
Amendment No.: 57

Research Objectives and Specific Plans to Achieve Them

The reduction of bycatch of deep-sea corals and sponges in federally managed trawl fisheries is a high priority for NOAA's Deep Sea Coral Program. Areas of high bycatch of corals, including large catches of bamboo and black corals, have been identified off northern California in the vicinity of the Mendocino Ridge and off southern Oregon. No exploration of these sites has occurred to determine the extent of these coral colonies. The project will allow exploration of these sites with support from the UNOLS Research Vessel Point Sur. This substantial research effort significantly compliments NOAA's long term interests in Northern California.

Research Accomplishments

Project work has not yet begun – no accomplishments to report



THEME D: ECOSYSTEM-BASED MANAGEMENT



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

David M. Checkley 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

Amendment No.: 28, 58, 90

Research Objectives and Specific Plans to Achieve Them

CalCOFI's primary objectives are 1) to continue 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 the living resources of the California Current in support of an ecosystem approach to management.

Our specific plan to achieve these objectives is, in collaboration with NOAA's SWFSC, to conduct quarterly cruises in the CCS, analyze the resultant data and samples, make the resultant data available to users, and analyze those and other data and present those results in the peer-reviewed literature and at meetings, including the annual CalCOFI Conference. We also work closely with ancillary programs, including the NSF-sponsored CCE-LTER study, marine mammal observers, and seabird observers.

Research Accomplishments

The four quarterly CalCOFI cruises were completed as planned, save for only partial completion of the winter 2014 cruise due to ship malfunctions. Collaborations with CCE-LTER and observing programs for marine mammals and birds continued as planned. Sampling was increased for dissolved inorganic carbon (to investigate ocean acidification) and a program was initiated to sample for microbial genetics and transcriptomics ("omics"). The Pacific Fisheries Management Council decided, in April 2014, that a temperature index based on CalCOFI measurements be incorporated in the harvest guideline algorithm used to determine the annual quota of sardine. Progress continued on the use of an algorithm to estimate the past aragonite saturation state based on historical CalCOFI data on temperature, salinity, and dissolved oxygen; this will provide one of the world's longest time series of variables relevant to ocean acidity. A book (Sam McClatchie, editor) on CalCOFI was published (Springer).

Many publications in peer-reviewed journals were based on CalCOFI. These included top national and international venues, ranging from the *Proceedings of the National Academy of Science* to *Global Biogeochemical Cycles* to *Fisheries Oceanography* to *Nature*. Topics included ocean circulation, primary production, microbial genomics and production, carbon flux, fish assemblages, mesopelagic fish, climate effects, and statistical and dynamic models. Notable was a Perspectives piece in *Nature* on the value of long



time series of ocean biology and CalCOFI as a model program. Three PhD dissertations relied heavily on CalCOFI data. Climate effects on the marine ecosystem were deduced from the analysis of data on CalCOFI hydrography and plankton, including fish eggs and larvae.

Collectively, the CalCOFI activities in the reporting period directly addressed our goals of continuing the 65-year old time series of observing the marine ecosystem off California and providing the understanding necessary to inform management and policy affecting living marine resources.

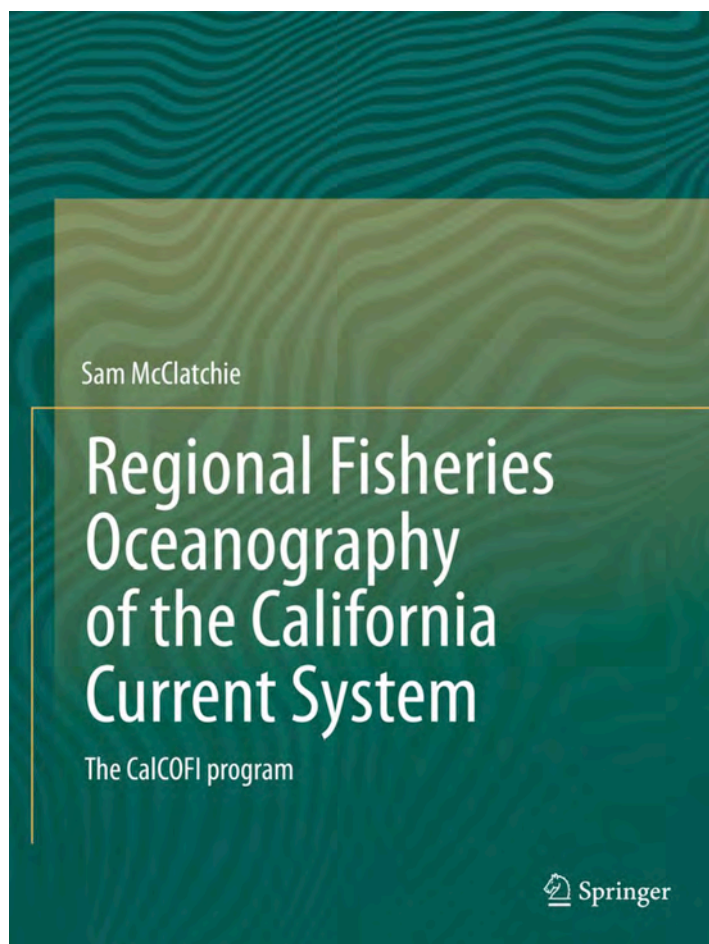
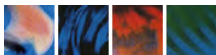


Fig. 1 Cover of McClatchie, S. 2013. Regional Fisheries Oceanography of the California Current System. Springer. Summarizes 60 years of the California Cooperative Oceanic Fisheries Investigation (CalCOFI). Provides an up to date reference on fisheries oceanography in the California Current System. Excellent reference point for multidisciplinary fisheries scientists and biological oceanographers



Fig. 2 Deploying a bongo net with Laser Optical Plankton Counter and mini-CTD during CalCOFI cruise off Southern California. To right is rosette with CTD inside. Photo credit: James Wilkinson, SIO-CalCOFI



Studies in Anadromous Fisheries

Darren Ward (HSU)

NOAA Technical Contact: Steve Miller (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

Amendment No.: 33

Research Objectives and Specific Plans to Achieve Them

This project provides support for research activities at Humboldt State University that provide information for restoration and conservation of anadromous salmonids in Northern California and the Klamath basin. Current research emphasizes ecological studies of species and habitats of conservation concern, evaluation of restoration effectiveness, and assessment of issues relating to improvement and restoration of salmon production in the northern California and the Klamath River system.

Research Accomplishments

For the 2013-2014 project extension, this project primarily supported the thesis research of a graduate student in the Ward lab, Meiling Roddam. Roddam's research focused on evaluating the relative productivity of the two primary rearing areas for Chinook salmon in the Shasta River in terms of numbers of outmigrating smolts and the characteristics of the smolts. Roddam's work supported by this project during in 2013-2014 focused on strontium stable isotope analysis of otoliths from juvenile Chinook salmon. Roddam mounted, polished, and analyzed 80 juvenile otolith samples, received training at the UC Davis/Interdisciplinary Center for Plasma Mass Spectrometry in inductively coupled plasma mass spectrometry using laser ablation, and performed sample analyses.



Center for the Advancement of Population Assessment Methodologies (CAPAM)

Brice Semmens (SIO)

NOAA Technical Contact: J. McDaniels (NMFS/SWFSC)

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

Amendment No.: 66

Research Objectives and Specific Plans to Achieve Them

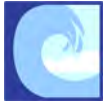
The goals of the new Center for the Advancement of Population Assessment Methodology (CAPAM) are to improve quantitative methods generally used in stock assessment modeling efforts, provide guidance regarding good practices in stock assessment methods, and afford the educational opportunities necessary to train the next generation of highly skilled stock assessment scientists. Specifically, emphasis will be on assumptions used in contemporary stock assessment models, e.g., selectivity/catchability, growth, natural mortality, stock-recruitment relationship, covariates, spatial structure, data/likelihoods weighting, multi-species and ecosystem considerations, and diagnostics.

Research will be carried out through collaboration among CAPAM research candidates (e.g., postdoctoral researchers), SIO faculty (Dr. Semmens), SWFSC/IATTC staff (Drs. Crone and Maunder), and visiting scientists. Visiting scientists will be involved on a systematic basis to provide expertise for more complex problems associated with topics of interest. The candidates will also work alongside analysts (collaborators) on formal species-specific assessments to ensure the integration of practical aspects of stock assessment modeling in their independent research projects, and to provide them with invaluable training/mentorship for working in permanent stock assessment positions in the near future. Workshops will be held to disseminate the research efforts of CAPAM candidates, staff, and visiting scientists, as well as receive input from interested parties and outside experts. An advisory committee will act in the role of a 'review' panel by ensuring the research is timely, sound, and relevant to the needs of stock assessment practitioners (committee membership: R. Methot, A. Punt, J. Ianelli, R. Deriso, and S. Cadrin). Links will be made with developers of general stock assessment programs (e.g., *Stock Synthesis*) so that results generated through CAPAM can be formally implemented as default options in the respective modeling programs. Finally, support of a core group of researchers devoted to stock assessment-related analysis at SIO, SWFSC and IATTC will attract interest from other working groups attempting to achieve similar goals, which will broaden the scope, enhance this effort, and provide a potential source of collaborative funding/research in the future. During the first two years of CAPAM activities, research will be focused on developing a stock assessment *Good Practices* guide, and on research related to selectivity parameterization in stock assessments. To that end, the specific aim is to fund a highly skilled postdoctoral fellow over a two-year period to work closely with the PI and project collaborators in developing the *Good Practices* guide, and carry out cutting edge research in stock assessment methodologies.

Research Accomplishments

Good Practices in Stock Assessment Modeling

The World Conference on Stock Assessment Methods (WCSAM) held in Boston July 15-19, 2013 identified the development of "Good Practices" guidelines as a major priority for fisheries assessment. They specifically highlighted the selectivity workshop organized by CAPAM as an example of the type of activities needed in order to develop such guidelines. To solidify "good practices" formulated during the Selectivity workshop last year, CAPAM personnel organized a special issue of the journal *Fisheries Research* titled "Model selection for selectivity in fisheries stock assessments". The special issue, now published, contains 22 publications written by participants of the CAPAM Selectivity workshop held in March of 2013 (<http://www.sciencedirect.com/science/journal/01657836/158>).



Education and Outreach

CAPAM staff, in collaboration with scientists from NOAA and other institutions, organized courses on stock assessment and modeling in the US and Internationally.

CAPAM Research Scientist Dr. Juan Valero taught an introduction to fisheries stock assessment course in December, 2013 at Scripps Institution of Oceanography, La Jolla CA, USA. Course participants included 23 students, researchers and staff from 8 institutions, including SWFSC. CAPAM PI Dr. Mark Maunder taught the course Integrated Analysis Using Stock Synthesis: appropriate use of multiple data sets in January, 2014 at the University of Miami. CAPAM Research Scientist Dr. Juan Valero co-taught two courses on the stock assessment modeling platform "Stock Synthesis" during early 2014 in both Argentina and Chile. CAPAM PI Brice Semmens is currently teaching a graduate level Bayesian Population Analysis course at SIO, UCSD. Last Fall Brice also taught an undergraduate Statistical Methods in Marine Biology course at UCSD.

Graduate Student and Postdoctoral Research Mentoring

Graduate student and post-doctoral research associated with CAPAM programs has progressed substantially, in large part due to active support, guidance, and mentoring from CAPAM personnel. Below we highlight recent research activities in this regard.

White Seabass Assessment Project

A collaborative project is underway with the Pflieger Institute of Environmental Research (PIER) and California Department of Fish and Wildlife (CDFW) in order to assess the stock of white seabass (*Atractoscion nobilis*) in California. CAPAM took on this project in order to provide SIO graduate students with "real world" stock assessment experience, and to participate in a marine resource assessment associated with a stock actively managed by the state of California (expected to be completed and reviewed by Fall/Winter 2014). CAPAM research scientist Dr. Juan Valero will be working with SIO graduate student Lynn Waterhouse on this stock assessment.

Coastal Angler Tagging Cooperative

SIO graduate student Lyall Bellquist is working with the recreational fishing community, the California Department of Fish and Game, and the San Diego Oceans Foundation to implement an assessment of *Paralabrax* spp. populations, vital rates, and movement patterns. The project aims to generate important demographic rate parameters used in stock assessments (e.g., mortality and growth). This information will help clarify *Paralabrax* spp. status and trends for the purpose of identifying appropriate population monitoring metrics for adaptive management. So far, over 8000 fishes from the species calico bass (*Paralabrax clathratus*), sand bass (*Paralabrax nebulifer*), and spotted bay bass (*Paralabrax maculatofasciatus*) have been tagged.

Phenotypic variation and selective mortality as major drivers of recruitment variability in fishes

Former CAPAM/SIO postdoctoral researcher Darren Johnson focused on methods for modeling recruitment variability as a function of phenotypic variation and selective mortality during his tenure at SIO. This work culminated in a review article in *Ecology Letters*. The paper includes a review of the literature on selective mortality and defines an analytical framework that accounts for variation in selection. This past Fall, Darren was hired as an assistant professor of quantitative ecology at California State University, Long Beach, in September 2013.



Fig. 1 Attendees of Stock Synthesis (SS) Course in Argentina. This course was organized by CAPAM Research Scientist Dr. Juan Valero, Dr. Melissa Haltuch (NOAA), Dr. Richard Methot (NOAA) and Dr. Billy Ernst (UDEP,



Chile). This is part of CAPAM's Education and Training Program. The course was taught at Instituto Nacional de Investigacion y Desarrollo Pesquero (INIDEP), Mar del Plata, Argentina during February 17-21, 2014. Funding was also provided by the National Marine Fisheries Service International Science Strategy (NMFS ISS).



Fig. 2 Attendees of the CAPAM Introduction to Stock Assessment Methods Short Course. The course was held at Scripps Institution of Oceanography, December 9-13, 2013. Students learned modern statistical models used in fisheries stock assessment and natural resource modeling, providing instruction, demonstration, and exercises in fishery stock assessment modeling. Topics covered during the course included 1) Models and data, 2) Model fitting, 3) Alternative modeling approaches, 4) Statistical age-structured models, 5) Stock assessment concepts, and 6) Introduction to SS.



Training the Next Generation of Marine Population Dynamics Scientists

Brice Semmens (SIO)

NOAA Technical Contact: S. 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

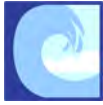
NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

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

Amendment No.: 5, 31, 45, 91

Research Objectives and Specific Plans to Achieve Them

The goal of this project was to facilitate the initiation of a research program for new faculty member Brice Semmens. Brice Semmens was hired during a search for a marine population dynamics scientist with the ability to train future practitioners in the science of population assessment and development of enhanced assessment methods that incorporate environmental variability, food web linkages and spatial heterogeneity. The intent of the appointment was to build upon a long record of accomplishment and collaboration between Scripps Institution of Oceanography and NOAA Fisheries Service. Thus, the objective of these funds included: build a working laboratory suitable for both research and training, initiate field studies, and jumpstart the overall research program on population assessment and dynamics, and characterization of community interactions.



Research Accomplishments

Since April 2013, I continued my collaboration with other scientists through the new Center for the Advancement of Population Assessment Methodology (CAPAM). Other CAPAM principal investigators include Mark Maunder (IATTC) and Paul R. Crone (SWFSC). Following the March 2013 workshop on Selectivity held at the SWFSC, I and the other CAPAM PIs edited a special issue of Fisheries Research. This special issue included 21 peer-reviewed articles; CAPAM PIs or personnel were authors or co-authors on 7 of these articles. To date, CAPAM personnel have authored over 20 publications directly related to stock assessment methods.

In December of 2013, CAPAM hosted a 5-day Introduction to Stock Assessment short course at Scripps Institution of Oceanography (SIO) in La Jolla, CA. The course was taught by CAPAM & IATTC employee Juan Valero with 23 students attending. This spring quarter, I am teaching a graduate level course on Bayesian population analysis (including mark-re-capture analysis), and a undergraduate course in lab and field techniques. This past Fall, I taught a course in undergraduate frequentist statistics. Outside of formal teaching activities, my lab has jointly coordinated a quantitative seminar series with the SWFSC that meets monthly, and I participate as a faculty representative to the R users group weekly meeting held on the SIO campus.

Over this last year, I developed partnership with Chris Lowe (Cal. State Long Beach), Michael Shane (Hubbs Seaworld Research Institute), John Hyde (SWFSC), and Nick Wegner (SWFSC). We are in the process of drafting a constitution to establish a California Acoustic Tracking Network (CATN) to enhance marine conservation and management by bringing together multiple institutions to increase the geographic scope and the combined listening capacity of acoustic arrays in southern California.

In addition to maintaining CAPAM and establishing CATN, I oversee 4 PhD students (Lynn Waterhouse, Brian Stock, Josh Stewart, Lyall Bellquist), 2 MS students, 1 staff member and 7 undergraduate volunteers. Students are working on diverse issues in fisheries resource management, including the spatial ecology and population structure of oceanic manta, mark-re-capture studies on locally important recreational marine fish species, the development of novel quantitative tools for abundance and animal movement estimation, stable isotope analysis, and the development of stock assessment methods for data-limited fisheries.



Fig. 1 Brice Semmens presenting a Perspectives on Ocean Science Lecture at Birch Aquarium, Scripps Institution of Oceanography

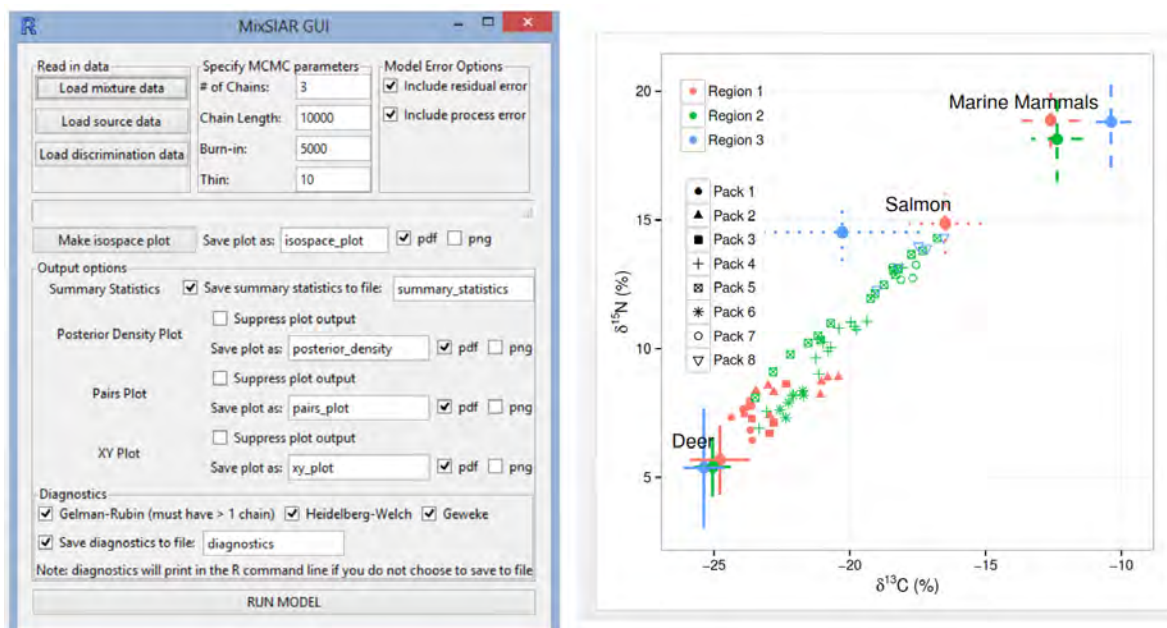


Fig. 2 (Left) MixSIAR graphical user interface for stable isotope analysis and (right) isospace plot output from the MixSIAR GUI, open-source software for stable isotope analysis



Workshop on Application of Non-Linear Time Series Analysis

George Sugihara (SIO)

NOAA Technical Contact: Roger Hewitt (NMFS/SWFSC)

Links to NOAA Strategic Plan:

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

Amendment No.: 38

Research Objectives and Specific Plans to Achieve Them

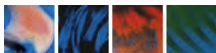
A 3-day workshop was held at SIO for 30 NMFS stock assessment scientists in order to fast-track methods and concepts of nonlinear time series analysis (NLTS) and State Space Reconstruction (SSR) into NMFS the portfolio of quantitative methods used by stock assessment scientists. The methods provide a rigorous foundation for ecosystem-based management of fisheries (EBM) as well as a means for forecasting stock abundance.

The first of the 3 days involved lectures, dissemination and open discussion of the new methods as they might meet challenges of EBM. The second and third days involved hands-on training with NLTS software tools developed by the Sugihara Lab. The third day involved applying these tools to two actual fishery time series brought in by the NMFS participants. These were selected to be challenging to the methods: stocks with apparently random recruitment (atlantic menhaden and pacific hake).

Research Accomplishments



We held a workshop at Scripps Institution of Oceanography in April, attended by roughly thirty fisheries scientists from NOAA NMFS Fisheries Science Centers, along with members and collaborators of the Sugihara lab, and WHOI. The purpose of the workshop was to explain how state-space reconstruction methods could be used to study and predict fishery time series, and how the methods might be adapted for use by NMFS stock assessment scientists. Initial collaborations suggests that the methods might produce reasonable forecasts for Atlantic Menhaden and Pacific Hake recruitment, which have not been successfully predicted by other methods.



Deep-Ocean Industrialization : A New Stewardship Frontier

Lisa Levin (SIO)

NOAA Technical Contact: D. Squires (NMFS/SWFSC)

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

Amendment No.: 93

Research Objectives and Specific Plans to Achieve Them

One of the greatest challenges of the 21st century is managing our deep ocean sustainably, for it is vast, remote, expensive to study, and highly vulnerable to disturbance. Exploiting its wealth while maintaining the integrity of its ecosystems, their diversity, functions and services will require a cross-disciplinary conversation and interdisciplinary research at the intersection of biodiversity, climate science, law, policy, and resource economics as well as stakeholder engagement.

A symposium addressing these themes (*Deep-Ocean Industrialization: A New Stewardship Frontier.*) was held in Chicago Feb. 14-17, 2014 as part of the AAAS meeting *Meeting Global Challenges: Discovery and Innovation*. The session is submitted under the categories (1) Sustainability and Resource Management (2) Environment and Ecology and (3) Public Policy. Organizers are Lisa A. Levin (Scripps Institution of Oceanography) and Kristina Gjerde (International Union for Conservation of Nature).

Research Accomplishments

The following talks were given:

Lisa A. Levin (SIO, UCSD): A vision for global, deep-ocean stewardship

Kristina Gjerde (IUCN): Crossing jurisdictions and sectors: laws, policies and plans for the deep ocean

Linwood Pendleton (Duke University): Balancing the value of living and non-living resources in the deep sea

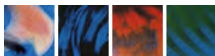
Samantha Smith (Nautilus Minerals): Mineral production from the deep sea: Social and environmental considerations

Cindy Lee Van Dover (Duke University): Environmental planning for mining in the seabed area beyond national jurisdiction

Bronwen Currie (NatMIRC, Namibia): Deep dilemmas: Developing nations concerns on deep seabed exploitation



Fig. 1 Artwork by Tanya Young depicting present and planned human activities in the deep ocean. Prepared for the AAAS Symposium.



Frontiers of Marine Resources Course

Mark Jacobsen (UCSD)

NOAA Technical Contact: D. Squires (NMFS/SWFSC)

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

Amendment No.: 83

Research Objectives and Specific Plans to Achieve Them

We seek to increase the educational opportunities available for graduate students in economics with an interest in marine resources. Our plans to achieve this include both formal coursework (in the form of a short course combining lecturers from inside and outside the university) as well as additional lectures at the frontier of marine resource economics. The idea is to expose the students to ideas and methods that they would not receive in their regular coursework in the economics department.



Research Accomplishments

We offered a new short course on deep ocean resources, targeted to economics graduate students, in April of 2014. The course was divided into four sections: deep sea ecosystems, current policy, dynamic resource economics, and fisheries economics. Each section was taught by a different lecturer and focused on the problems in regulating and making use of deep ocean resources. The policy and science are evolving very rapidly, and the opportunity to expose our graduate students to questions at the frontier was extremely valuable.

We exceeded our expectations for enrollment with 12 students enrolled and one auditor. The group included 9 PhD students in Economics (our main audience) and another four graduate students from across divisions at UCSD. The course combined broad, interdisciplinary views of the ecosystems and policy with much more sharply focused economic models of dynamic resource extraction. The goal was to teach students the concepts of timing, externalities, and overexploitation side-by-side with an application to a very new application in marine resources. The students produced a variety of interesting papers as part of the course requirements, and our hope is that these ideas and tools will make their way into dissertations as the students progress through the PhD program.



Fig. 1 Students and faculty attending Economics 297: Deep Sea Resources (April 2014)



OUTREACH

“Evolution Around Us” Program

Designed teacher workshops for K-12 education that incorporates evolutionary biology principles, in partnership with the Seymour Marine Discovery Center.

Integration of HF Radar data on Surface Currents into public exhibit

To educate and bring awareness of ocean energy to the general public, the “Boundless Energy Exhibit” at Scripps’ Birch Aquarium was updated with integrated surface currents as collected by the HF radar network.

Voices in the Sea

Web site (www.voicesinthesea.org) with marine mammal vocalizations allows the public and students to hear how “voices” between species compare, providing a unique dimension to learning about marine mammals. Created in partnership with the Pacific Life Foundation and the Aquarium of the Pacific.

Programme “PEOPLE” (European Union)

Researcher mobility program between U.S. (SIO), Italy, Brazil, Bulgaria and Portugal, in collaboration with Dr. Diego Vicinanza.

Guest lectureship at Pacific Charter School

K. Richerson of CSTAR served as guest lecturer on Antarctic ecology at Pacific Charter School in Santa Cruz, CA.

Science Fair Project mentoring

Evolutionary biologists mentors Watsonville High School students with their Science Fair projects.

Environmental Education Development

CSTAR members collaborated with various teachers at the Watsonville High School district, Watsonville, CA, on developing environmental education modules to incorporate with social and natural science classes.

STEM Fellows in K-12 Education

Lynn Waterhouse participated in an NSF Grade K-12 fellowship program. The NSF Graduate STEM Fellows in K-12 Education (GK-12) Program supports fellowships and training for graduate students in science, technology, engineering, and mathematics (STEM). Through interactions with teachers and students in K-12 schools, graduate fellows can improve communication and teaching skills while enriching STEM content and instruction for their K-12 partners

SeaCamp

Lyll Bellquist taught elementary students about marine reserves and population assessment methods at SeaCamp. The goal of SeaCamp is to stimulate student interest in the ocean sciences and to broaden their understanding of marine research.

High School Mentoring on Aquaculture project in Uganda

Brian Stock mentored University City High School students on their class aquaculture project. The goal of the mentorship program was to provide feedback on a draft grant proposal students wrote to establish an aquaculture project in Uganda.

Educational Outreach hosted by Santa Barbara Natural History Museum

Josh Stewart mentored minority students through educational outreach program hosted by Santa Barbara Natural History Museum. The goal is to provide science and research opportunities to underrepresented high school students that have a passion for science.

Volunteering at Birch Aquarium

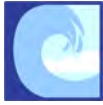
Lynn Waterhouse participated as a volunteer diver and educator at the Birch Aquarium. Birch aquarium divers help communicate ocean science and research to youth.

Grunion Bowl Judging

Lynn Waterhouse judged high school Grunion Bowl at Birch Aquarium. The National Ocean Sciences Bowl was created to stimulate student interest in the ocean sciences and to broaden their understanding of marine research.

Fish Biology and Fisheries Science Workshops

Darren Ward presented two hour-long workshops on fish habitat, ecology and morphology for fifth-grade



students in an effort to introduce elementary students to fish biology and fisheries science.

Salmon Biology K-12 Outreach – Gary Griggs and Eric Palkovacs (UC Santa Cruz)

Classroom presentations, DeLaveaga Elementary School (Santa Cruz CA) and Santa Catalina High School (Monterey CA)

Workshop for K-12 teachers in salmon biology and conservation

Provided information to elementary and high school students on salmon biology and conservation and research at Santa Cruz laboratory.

Trained 20 K-12 teachers in a salmon biology and conservation curriculum for the classroom

Monterey Bay Salmon and Trout Project

San Francisco Exploratorium



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	
CCHDO web site http://cchdo.ucsd.edu/	Disseminate all public CCHDO data, documentation, and data information via the CCHDO web site http://cchdo.ucsd.edu .	NOAA
CalCOFI communications	CalCOFI web site (www.calcofi.org) Provide information & data to public on field work, conference, publications, volunteer opportunities	
Department seminar, Ecology and Evolutionary Biology Department, UC Santa Cruz	Described research and networked with interested members of the UCSC community	UCSC
Presentation at the 2014 CDFW Salmon Information Meeting	Presented salmon abundance forecasts and a preliminary outlook for 2014 ocean salmon fisheries	CDFW, salmon fishing industry
Ocean Mysteries w/ Jeff Corwin	Television show for kids on tagging blue whales in Southern California	ONR, SEA, Cascadia, Stanford, Oregon State University
UCSC Environmental Studies outreach program 2014.	Inform volunteer docents about research conducted at the laboratory	UCSC
Evolution Around Us Program	Introduce the public to Evolution through examples of contemporary evolution	Seymour Marine Discovery Center
Cetacean public information website www.cetus.ucsd.edu	Provide on-line information on marine mammal research activity	Pacific Life Foundation
Argo Science Team web site (http://www-argo.ucsd.edu)	Provide information on the Argo project, its objectives, status and data system, including how to access Argo data.	International Argo partnership
Argonautics Newsletter (http://www.argo.ucsd.edu/Frnewsletter.html)	Distribute information on Argo status, applications, and progress on key issues.	International Argo partnership
Spray glider website (http://spray.ucsd.edu)	Provide real time status and plots of glider data	International Argo partnership
Spray public data access: (http://coastwatch.pfeg.noaa.gov/erddap2/tabledap/scrippsGliders.html)	Public access to Spray glider data	International Argo partnership



Presentations at the Birch Aquarium's Perspectives on Ocean Science lecture series and to the American Cetacean Society	Provide information on beaked whale studies and ocean noise issues to a broad audience.	A. Sirovic, Birch Aquarium at SIO; American Cetacean Society
Argo Marine Atlas project ftp://kakapo.ucsd.edu/pub/argo/Pacific_Marine_Atlas	Develop a data display tool to allow students and educators view Argo and other ocean datasets as maps, vertical sections, time-series plots, and line drawings.	PI-GOOS, SEREAD
Global Drifter Program media precense	<p>Pacific Partnership-SIO collaboration. Press release. http://www.navy.mil/submit/display.asp?story_id=74471</p> <p>Radio interview, Pacific Beat, ABC radio, Melbourne, Australia, June 2, 2013 on the Pacific Partnership 2013 and the Global Drifter Program, http://www.radioaustralia.net.au/international/radio/program/pacific-beat/more-buoys-keeping-watch-on-pacific-weather-currents/1140394</p> <p>Photo of the Week, Vessel of Opportunity, Scripps news, Feb 18, 2014</p> <p>Newspaper article, New York Times, "Plane Debris Would Be Modest Clue Two Weeks After a Crash, Experts Say", http://www.nytimes.com/2014/03/20/world/asia/plane-debris-would-be-modest-clue-two-weeks-after-a-crash-experts-say.html?_r=0</p> <p>Newspaper article, The Malaysia Insider, 'For experts, locating flight MH370 still challenging even if plane debris is found', http://www.themalaysianinsider.com/malaysia/article/locating-flight-mh370-still-challenging-even-if-plane-debris-is-found-say-e</p> <p>Newspaper article, The New York Times, 'The Search for Malaysia Airlines Flight 370', http://www.nytimes.com/interactive/2014/03/17/world/asia/search-for-flight-370.html?_r=0</p> <p>Newspaper article, The Los Angeles Times, 'Advanced U.S. aircraft combs Indian Ocean for Malaysia Airlines jet', http://articles.latimes.com/2014/mar/20/world/la-fg-malaysia-plane-20140321</p> <p>Newspaper Article, Video Interview, The Wall Street Journal, 'Malaysia Airlines Flight MH370: No Confirmed Debris Found', http://online.wsj.com/news/articles/</p>	L. Centurioni, SIO



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Interview with China's Xinhua News Agency L.A. Bureau, March 20, 2014

Magazine Article, Discovery News, 'Malaysian Plane Debris? Why It's a Race to Find Out',

<http://news.discovery.com/earth/oceans/malaysian-plane-debris-why-its-a-race-to-find-out-140320.htm>

TV interview, The Hannity Show, March 21, 2014

TV Interview, MSNBC, March 20, 2014, 'Now, with Alex Wagner: Lessons from Air France flight 447 search',

<http://www.msnbc.com/now-with-alex-wagner/watch/lessons-from-air-france-flight-447-search-201403971766>

TV Interview, CTV news Channel, March 22, 2014 CTV News Channel: "Technology used in search. Luca Centurioni with Scripps Institute of Oceanography discusses the technology being used in the search for the missing Malaysian airliner."

<http://www.ctvnews.ca/search-results/search-ctv-news-7.137?q=centurioni>

TV interview, CNN, Piers Morgan Live, March 21, 2014 "How satellite buoys may be the key to discovering debris from missing Flight 370",

http://piersmorgan.blogs.cnn.com/2014/03/21/how-satellite-buoys-may-be-the-key-to-discovering-debris-from-missing-flight-370/?hpt=pm_mid and

<http://transcripts.cnn.com/TRANSCRIPTS/1403/21/pmt.01.html>

Device Could Expand Oceanographic Studies with Unmanned Sensors, Scripps news, Apr, 4, 2014, <https://scripps.ucsd.edu/news/device-could-expand-oceanographic-studies-unmanned-sensors>

TV Interview, CNN, State of the Union with Candy Crowley, <http://edition.cnn.com/TRANSCRIPTS/1403/23/sou.02.html>

TV Interview, Rai News 24, April 10, 2014

<http://www.youtube.com/watch?v=WPweaPmUKPo>

TV interview, TVSI, May 7, 2014, 'Berna-Roma-L.A. #2 Luca



Centurioni, Storie di italiani e svizzeri negli USA',
<http://www.tvsvizzera.it/attualita/tvs-vizzera/Berna-Roma-L.A.-2-Luca-Centurioni-613729.html>

Public Presentations on Atmospheric CO₂ and O₂

May 2013: Filming for: State of California video series "Climate Changers: Hot Lessons and Cool Solutions."

R. Keeling, SIO

May 2013: TV and radio appearances: Al Jazeera TV, CBS Evening News, National Public Radio, Canadian Broadcasting Corporation, Climate-One, KPBS San Diego, WFHB in Bloomington, Bloomberg Radio "Taking Stock", ABC Radio in Canberra, Envision Radio Network America Weekend

May 2013: Interviews for written media: New York Times, Los Angeles Times, The Guardian, San Diego Union, New Scientist, Yale Environment 360, On Earth Magazine. UCSD press release on 400ppm picked up on countless outlets.

July 31 2013: Presentation to San Diego City Committee on Natural Resources and Culture on the local implications of climate change.

16 Dec 2013: Keynote speaker at ACEES Technical Tour (group of Japanese students and hosts). Talk title: "The unfolding story of rising atmospheric CO₂ and life in the greenhouse".

5 Feb 2014: Speaker at San Diego Cap and Trade Forum held at the offices of Procopio (Law Firm) in downtown San Diego, and sponsored by Procopio, The San Diego Foundation, CleanTech, San Diego, Climate Resolve, Climate Action Reserve, Talk title: "An update on the status of climate change".

8 Feb 2014: Presentation to "Science Journalism Workshop for Mexico City Journalists" held at Institute of the Americas on UCSD campus. Talk title: "The unfolding story of rising atmospheric CO₂ and life in the greenhouse".



20 Feb 2014: U. Indiana, School of Public and Environmental Affairs (SPEA), Environmental Science Seminar. Talk title: "The unfolding story of rising atmospheric CO₂ and life in the greenhouse".

Professional Presentations:

29 May 2013, Presentation for Symposium for Ray Weiss at the Scripps Institution of Oceanography. "Atmospheric signatures of changing land and ocean biogeochemistry"

4 June 2013, 9th International Carbon Dioxide Conference in Beijing. Poster presentation on atmospheric O₂ measurements since 1990 (with A Manning).

10 June 2013, 17th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases, and Related Measurement Techniques (GGMT). Presentation on "Assessment of reference gas calibrating system for carbon dioxide in air standards at Scripps"

22 Nov 2013, Weekly colloquium speaker at the Geophysical Fluid Dynamics Laboratory at Princeton New Jersey. Talk title: "Atmospheric signatures of changing global biogeochemistry".

10 Dec 2013, Invited speaker at the 2013 Fall AGU Meeting: "Atmospheric signatures of changing global biogeochemistry".

22 Feb 2014: Presentation to Jim Anderson 70th birthday fest at Harvard on Jim and the O₂ program.

Articles on deep sea environment conservation

<http://phys.org/news/2014-02-deep-ocean-policy-stewardship.html>

2.

<http://www.bbc.co.uk/news/science-environment-25638838>

3.

http://voiceofrussia.com/news/2014_02_18/Oil-gas-exploration-fishing-endangering-ocean-ecosystems-scientists-0258/

4.

<http://www.ft.com/intl/cms/s/0/26c9>

L. Levin, SIO



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5.
<http://www.redorbit.com/news/science/1113072976/deep-oceans-need-protection-before-too-late-021714/>

6.
<http://www.thedailystar.net/business/deep-water-ecosystems-hurt-by-human-resource-needs-11799>

7.
<http://www.tgdaily.com/general-sciences-features/88201-why-the-deep-ocean-is-earths-last-frontier>

8.
<http://www.independent.co.uk/news/science/scientists-warn-over-coming-era-of-deep-sea-mining-9134448.html>

9.
http://actu.orange.fr/environnement/news/des-scientifiques-sonnent-l-alarme-sur-l-exploitation-des-fonds-marins-afp_2835706.html

10.
<http://www.greenreport.it/news/aree-protette-e-biodiversita/negli-oceani-ci-sono-molti-piu-pesci-del-previsto/>

11.
<https://student.societyforscience.org/article/mining-metals-amidst-seafloor-animals>

12.
<https://scripps.ucsd.edu/news/scientists-call-new-stewardship-deep-ocean>

13.
<http://www.ewsp.com/latest-news/science/science-a-environmental/50234-scientists-warn-against-mass-industrialization-of-deep-sea.html>

14.
<http://www.skynews.com.au/eco/article.aspx?id=951362>

15.
<http://www.spyghana.com/humanity-must-think-exploiting-deep-sea/>

16.
<http://www.ft.com/cms/s/0/26c96126-97ed-11e3-ab60-00144feab7de.html#axzz2thyMzplf>

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<http://www.rappler.com/science-nature/environment/50827-deep-water-ecosystems-threatened-humanshttp://www.eurekalert.org/p>



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18.
<http://www.globalpost.com/dispatch/news/afp/140217/human-resource-needs-putting-deep-water-ecosystems-peril>
19. <http://en.newswire.com/2014/02/18/deep-oceans-need-stewardship-to-prevent-industrial-damage/>
20.
<http://environmentalresearchweb.org/cws/article/yournews/56288>
21.
<http://www.mintpressnews.com/scientists-warn-mass-industrialization-deep-sea/179883/>
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<http://www.laboratoryequipment.com/news/2014/02/scientists-call-stewardship-deep-ocean>
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<http://www.treehugger.com/ocean-conservation/scientists-warn-deep-sea-minings-destructive-potential.html>
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http://www.sciencecodex.com/deep_ocean_needs_policy_stewardship_where_it_never_existed-128016
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<http://www.scidev.net/global/bioprospecting/news/scientists-treaty-protect-deep-ocean.html>
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<http://www.japantimes.co.jp/news/2014/03/01/world/deep-sea-ocean-ecosystems-endangered/#.UxTRqI7wMnU>
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<http://allafrica.com/stories/201403032032.html>
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<http://www.abc.net.au/radionational/programs/scienceshow/deep-sea-being-damaged-by-mining2c-trawling/5307534>
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<http://www.srf.ch/wissen/technik/goldrausch-am-meeresgrund>
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<http://uk.news.yahoo.com/human-needs-putting-deep-water-ecosystems-peril-123835438.html#zRQtNKc>
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<http://news.msn.co.nz/worldnews/8801074/oceans-in-peril-say-us-scientists>
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<http://www.enn.com/wildlife/article/47107>

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<https://www.commondreams.org/headline/2014/02/17-1>

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<http://www.sciencedaily.com/releases/2014/02/140216151359.htm>

35.

http://www.nacion.com/vivir/ciencia/Cientificos-alertan-uso-fondos-marinos_0_139

Population Dynamics communications
Built new website for the La Jolla Acoustic Array Project (www.lajollaarray.org)

The new La Jolla Acoustic Array project website was designed to increase public understanding of movement and behavior of La Jolla's marine animals. In particular, how animals use established marine reserves in California and the impact of animal behaviors in the context of fisheries management.

SIO, UCSD

Lyall Bellquist interviewed by "Let's Talk Hook-up" fishing radio show

Educate the public about the Coastal Angler Tagging Cooperative tagging and research in local San Diego coastal marine ecosystems.

"Let's Talk Hook-Up" fishing radio show

Article published in Pacific Coast Sportfishing magazine about Lyall Bellquist and the Coastal Angler Tagging Cooperative project

Educate the public about the Coastal Angler Tagging Cooperative tagging and research in local San Diego coastal marine ecosystems.

Pacific Coast Sportfishing magazine

Article published in the La Jolla Light magazine about Lyall Bellquist and the Coastal Angler Tagging Cooperative project

Educate the public about the Coastal Angler Tagging Cooperative tagging and research in local San Diego coastal marine ecosystems.

The La Jolla Light newspaper

Article published in the San Diego Union Tribune about Lyall Bellquist and the Coastal Angler Tagging Cooperative project

Educate the public about the Coastal Angler Tagging Cooperative tagging and research in local San Diego coastal marine ecosystems.

San Diego Union Tribune newspaper

Article published in the San Diego Downtown News about Lyall Bellquist and the Coastal Angler Tagging Cooperative project

Educate the public about the Coastal Angler Tagging Cooperative tagging and research in local San Diego coastal marine ecosystems.

San Diego Downtown News

Article published online with BD Outdoor News about Lyall Bellquist and the Coastal Angler Tagging Cooperative project

Educate the fishing community about the Coastal Angler Tagging Cooperative tagging and research in local San Diego coastal marine ecosystems.

BD Outdoors <http://www.bdoutdoors.com/>



Article published in the La Jolla Light about Josh Stewart and the Oceanic Manta Population Dynamics project	Educate the local community about the manta tagging and population research conducted by local scientists at SIO.	La Jolla Light newspaper
SOPAC website	Precise hourly orbits are published on the SOPAC Web Site (http://sopac.ucsd.edu) and freely available.	International GNSS Service (IGS)
Jarrod Santora Invited to present to NMFS Cordell Bank Marine Sanctuary Council	Communicate science results on spatio-temporal dynamics of forage species and top predators within the National Marine Sanctuary	CSTAR, NOAA/NMFS
High Resolution XBT Network web site: http://www-hrx.ucsd.edu	Describe scope and objectives of the Pacific/Indian HRX network; display data from all cruises; provide downloadable datasets on a cruise-by-cruise basis.	CSIRO Australia, NIWA New Zealand, Tohoku University Japan

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 collaboration with CAMEO project (Curchitser, Rose, 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 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	ICES Fisheries Acoustics Science and Technology Working Group (WGFAST)



globally

Collaborative Fisheries Work	Involve Commercial Passenger Fishing Vessel (CPFV) captains and volunteer anglers in fisheries research projects to support collaborative fisheries conservation efforts.	California CPFV operators and volunteer anglers
Annual Meeting of PEW Fellows in Marine Ecology	Communicate research ideas and results to conservation-focused foundations	CSTAR, NOAA/NMFS
Atmospheric CO2 and O2 web sites	scrippsO2.ucsd.edu scrippsCO2.ucsd.edu	R. Keeling, SIO
River Herring Technical Expert Working Group (TEWG)	Convene experts to develop a consensus on the status of river herring and objectives for recovery	NMFS, Atlantic States Marine Fisheries Commission (ASMFC)
Eco-evolutionary Dynamics in Aquatic Systems Special Session at JASM Portland	Convene experts to present up-to-date studies on eco-evolutionary dynamics in freshwater and marine ecosystems	Mike Kinnison (Univ. of Maine)
AFS Symposium	Convene speakers to discuss anadromous fishes, watershed health, and ocean production	Thomas Bigford (NMFS), Karin Limburg (SUNY), Ted Castro-Santos (USGS)
Lynn Waterhouse presented for prospective students at SIO diversity recruitment event	SIO diversity recruitment events are designed to strengthen our institution and our mission by increasing the range of personal experiences, values, and worldviews that arise from differences of culture and circumstance among students, faculty, and staff.	SIO, UCSD
Lynn Waterhouse appointed SIO representative for the Graduate Student Association (GSA)	To advocate the rights and interests of graduate students at UCSD.	UCSD Associated Students
Lynn Waterhouse appointed graduate student representative for the Chancellor's Committee on Status of Women at UCSD	To identify and analyze issues relating to the status of women at UCSD, including faculty, staff and students, to inform and educate the campus community about conditions that affect the status of women within the University, to advise and make recommendations to the Chancellor regarding policies and procedures that would improve conditions for women.	UCSD Chancellor's Office
Lynn Waterhouse elected secretary for the Estuaries Section of American Fisheries Society (AFS)	The Estuaries Section is dedicated to protecting, maintaining and enhancing the viability of the	AFS



	fisheries and other aquatic living resources dependent upon healthy estuaries.	
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	Area Committee – Contingency Plans for Oil Spill Response	NOAA OR & R and Office of Spill Prevention and Response
Group on Earth Observations (GEO)	To promote HF radar derived surface currents standards and distribution	NOAA and International Partners
Pacific Island Global Ocean Observing System (PI-GOOS) Advisory Committee (Roemmich)	Assist Pacific island nations in gaining benefit from global ocean observations and products.	South Pacific Applied Geosciences Commission (SOPAC), NOAA, BoM Australia, NIWA New Zealand, Intergovernmental Oceanographic Commission, South Pacific nations

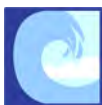
ACTIVITY TYPE	OBJECTIVE	PARTNERS
Academic Development		
CCHDO Training	Train undergraduate research assistants in under-the-hood operations of a data center and web site via real-world experience with ongoing CCHDO activities.	
Fisheries Biology training	Train undergraduate and graduate students in Fisheries Biology. Teach the following courses: Fish Conservation and Management, Advanced Fish Conservation and Management, Ecology of Freshwater Fishes, Biology of Pacific Salmon, Graduate Seminar. Primary research advisor for 4 graduate students and 2 undergraduate research interns. Serve on graduate committees for 7 graduate students.	D. Ward, Humboldt State University
Marine Biology course	Teach Statistical Methods in Marine Biology course to undergraduate students at UCSD	B. Semmens, UCSD
Brian Stock completed first-year of PhD coursework	The goal of first-year coursework is to establish a strong educational foundation in the marine sciences during the beginning of a marine biology PhD.	SIO, UCSD
Brian Stock trained for scientific diving	Scientific diver training and certification is required for students to safely and effectively dive during fieldwork.	SIO, UCSD
Lyall Bellquist attended 36 units as part of 5 th year PhD coursework at UCSD	The goal of yearly coursework is to establish a strong educational foundation in the marine sciences during the course of a PhD.	SIO, UCSD



Lynn Waterhouse, Lyall Bellquist, Noah Ben-Aderet and Brian Stock attend CAPAM Introduction to Stock Assessment short course	Introduce students to modern statistical models used in fisheries stock assessment and natural resource modeling, providing instruction, demonstration, and exercises in fishery stock assessment modeling.	CAPAM, SIO, SWFSC, IATTC
Brice Semmens taught a graduate level Introduction to Bayesian Population Analysis course	This 4-credit course introduces many key models used in the analysis of distribution, abundance and survival, as well as their spatial and temporal patterns, in a Bayesian analysis framework.	SIO, UCSD
Brice Semmens taught undergraduate Statistical Methods in Marine Biology course	This 4-credit course introduces marine biology students to statistical inference. Emphasis is on constructing statistics for specific problems in marine biology. Topics include probability, distributions, sampling, replication, and experimental design.	SIO, UCSD
Juan Valero taught an Introduction to stock assessment methods short course at Scripps Institution of Oceanography	This 5 day short course introduced students and professionals to stock assessment principles and the Stock Synthesis platform. Course participants included 23 students, researchers and staff from 8 institutions (Scripps Institution of Oceanography, Southwest Fisheries Science Center-NOAA, California Department of Fish and Wildlife, Pflieger Institute of Environment Research, University of Hawaii, Hubbs Sea World Research Institute, Inter-American Tropical Tuna Commission, and San Diego State University)	SIO, UCSD, SWFSC, CDFW, Pflieger Institute of Environmental Research, Hubbs Sea World Research Institute, Inter-American Tropical Tuna Commission, SDSU
Juan Valero taught an applied stock assessment Methods Short Course in Chile	<p>This course was organized by CAPAM Research Scientist Dr. Juan Valero, Dr. Melissa Haltuch (NOAA), Dr. Richard Methot (NOAA) and Dr. Billy Ernst (UDEEC, Chile). This is part of CAPAM's Education and Training Program. The course was taught at the Universidad de Concepcion, Concepcion, Chile during March 3-7, 2014. Funding was provided by the National Marine Fisheries Service International Science Strategy (NMFS ISS).</p> <p>The course was attended by 20 fishery scientists and students from Brasil, Perú, Colombia, Chile and USA. Course participants</p>	NOAA/NMFS, UDEC Chile.



	received instruction and demonstrations on SS model capabilities as well as worked on implementing SS model configurations using data for fisheries they are responsible for conducting stock assessments or are conducting research on. Course program can be seen here. Participants work resulted in SS model configurations of different complexity for 11 stocks	
DBCP-WIO4 Recruitment	Recruit GDP partners in the Indian Ocean Regio	Kenya Fisheries Research Institute (KFRI), Mauritius Oceanographic Institute(MOI), Mauritius Meteorological services (MMS), Tanzania Meteorological Agency (TMA)
Programme "PEOPLE" (European Union) Internship/Fellowship	Researcher mobility between US, Italy, Brazil, Bulgaria and Portugal	Dr. Diego Vicinanza
CCE Academic Development	Graduate students Samuel Wilsons, Jesse Powell, and Xue Fan are using the CCE mooring data for their research	U. Send, SIO
Precise Point Positioning development	Developed PPP (Precise Point Positioning) based real-time tropospheric delay estimation procedure as a part of hazard early warning system. Provide ongoing scientific and technical consultations to scientists and graduate students from USA as well as worldwide	Y. Bock, SIO
Training in Ecology and Evolutionary biology	Postdocs: 1 PhD Students: 2 Graduate Thesis Committees: 5 Graduate Exam Committees: 5 Undergraduate Training: 3	E. Palkovacs
Jarrod Santora ROMS-biologist working group (UCSC Ocean Science Dept.)	Build communication ties between ocean modelers and biologists	CSTAR, NOAA/NMFS
Mentored students that participated in the Santa Cruz County, CA Science fair	Assist Watsonville high school students in designing and conducting research projects presented at the Santa Cruz County Science Fair	
Science mentor for Watsonville Area Teens Conserving Habitats (WATCH)	Served as a mentor and science advisor for a group of high school students as they carried out a year-long research project. Research was carried out at the Elkhorn Slough National Estuarine Research Reserve.	Monterey Bay Aquarium Research Institute
CalCOFI academic development	Approximately 6 people per year provided opportunity to experience oceanographic research,	D. Checkley, SIO



volunteering on CalCOFI cruises

Programme "PEOPLE" (European Union)	Reseracher mobility between US, Italy, Brazil, Bulgaria and Portugal	Dr. Diego Vicinanza,
SERREAD program	Develop curricular units and conduct teacher training seminars for teaching of weather, climate, sea level, and the ocean's role in climate in Pacific island school systems. See http://www.argo.ucsd.edu/FrEducational_use.html	SOPAC, UNESCO, NOAA, NIWA/NZ, IOC, Education ministries in Cook Is, Samoa, and Tonga.
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
CORC Student Development in Ocean Remote Sensing	Undergraduate student Samuel Wilsons joined CORC. In addition, 2 postdocs and 2 graduate student were partially supported by CORC	U. Send, SIO
CO2 and O2 Data used in Postdoctoral theses	The data have and lab operations were relevant to the Ph.D. thesis projects of two students, Jonathan Bent and Yassir Eddebbar, and to Laure Resplandy (postdoc	R. Keeling, SIO
Undergraduate students: 12	Provide research experience in fisheries science through school-year and summer employment	UCSC
Graduate students: 2 PhD, 5 MS	Support graduate education and research	UCSC, Duke University
Post-doctoral scholars: 6	Support professional development	UCSC
Teaching: Stanford@SEA	Course for Stanford students on Seafaring and Marine biology	Stanford University
Teaching: Oregon State University	Course for NOAA scientists and OSU faculty and students on using satellite data in fisheries applications	Oregon State University



AWARD	RECIPIENT	YEAR
Awards and Honors		
NSF Office of Polar Programs Addition of biological sampling aboard R/V Gould supply transit cruises (3 field- based research trips to the Antarctic Peninsula; 2014-2015)	Jarrod Santora	2013
Best postdoctoral talk, ASN 2014	Carl Boettiger	2014
Grant from Sloan Foundation	Carl Boettiger	2013
National Marine Fisheries Service Office of Science and Technology, Grant Program for Economic Data Collection and Research Grant	Duran Fiack	2013
California Institute for Water Resources Research Grant	Duran Fiack	2014
Fellow, Society for Industrial and Applied Mathematics (SIAM)	Marc Mangel	2013
Doctor of Science, <i>honoris causa</i> , University of Guelph	Marc Mangel	2013
Citation: "This degree is awarded in recognition of your significant academic contribution combining mathematics and statistics with theoretical ecology and evolutionary biology. You have profoundly influenced an entire generation of ecologists, environmental scientists and applied mathematicians on how to solve important practical problems and make the world a better place"		
Myers Ocean Trust Award	Gina Contolini	2014
NSF Graduate Research Fellowship	Brian Stock	2014
SIO Biological Regents Fellowship	Lynn Waterhouse	2012-2013
NSF GK-12 Fellowship	Lynn Waterhouse	2013
Jeff Graham Marine Biology Fellowship	Lyall Bellquist	2014



NMFS Population Dynamics Fellowship	Lynn Waterhouse	2013
"Best Talk" at the Student Conference on Conservation Science at the American Museum of Natural History	Josh Stewart	2013
"Skinner award" for the American Fisheries Society national meeting	Lynn Waterhouse	2013
NSF Graduate Research Fellowship	Josh Stewart	2012-2015



REPRESENTING CIMEC

EVENT	DATE / LOCATION	REPRESENTATIVE
11 th Annual Stanford-UCSC Species Interactions Workshop	December 7, 2013, Stanford University, Palo Alto, CA	Kate Richerson, Melissa Monk, Vanessa Labrada-Martagon
20th Biennial conference on marine	December 2013, Dunedin, New Zealand	E. Hazen
29th Data Buoy Cooperation Panel Session.	23 - 27 September 2013, Paris, France.	L. Centurioni.
2nd workshop of Global Ocean Acidification Observing Network	July 2013, St. Andrews/Scotland	Mark Ohman et al
A Perspective on Steepness and Its Implications for Fisheries Management.	Feb 18, 2014 World-wide (about 200 attendees)	Marc Mangel
A Profiling CTD from the Liquid Robotics Wave Glider. UMST Program Review.	Panama City, FL Jan 28, 2014	L. Centurioni.
American Association for the Advancement of Science (AAAS)	Feb 14-16, 2014	L. Levin and others
Academic Seminar, Graduate Program Marine Biology, CIBNOR	August, 2013 La Paz, Baja California Sur, Mexico	Vanessa Labrada Martagón
Ad hoc International Forum of Users of Satellite Data Telecommunication Systems (SatCom Forum),	3 - 4 October 2013, Paris cedex 07, France	Yehuda Bock
AGU 2014 Annual Meeting	December 10-14, San Francisco, CA	Yehuda Bock
AGU Ocean Sciences Meeting	February, 2014, Honolulu	Various Fellows
American Fisheries Society	September 8-12, 2013, Little Rock, AK	Lynn Waterhouse, Brian Stock, S. Hayes, M. Sabal
American Society of Naturalists (ASN)	January 13-15, 2014 / Pacific Grove, California	Various Fellows
An Overview of the Lagrangian Drifter Lab., Presentation to House Armed Services Committee Professional Staff Member Kevin Gates,	30-Aug-13	L.R. Centurioni.
ASLO 2014 Ocean Sciences Meeting	23-28 Feb 2014, Honolulu, HI	Byron E. Pedler, Lihini I. Aluwihare, and Farooq Azam, Kahru, M
Assessment modeling using Stock Synthesis (SS)	February 17-21, 2014, Mar del Plata, Argentina.	Juan Valero et al.
BEST-BSIERP PI Closure Meeting	February 2014, Honolulu, HI	Simone Vincenzi
Biennial Conference on the Biology of Marine Mammals	7-13 December 2013 / Dunedin, New Zealand	Anne Simonis
Biowaves Workshop	February 2014 - UCSD	Greg Campbell
Birch Aquarium Magnificent Ocean	December 9, 2013, La Jolla, CA	Brice Semmens
Birch Aquarium Magnificent Ocean	October 28, 2013, La Jolla, CA	Josh Stewart
CA Ocean Protection Council	March 6, 2014, La Jolla, CA	Dave Checkley
CalCOFI Annual Meeting	December 7-10 La Jolla CA; NMFS-SWFSC	Various Fellows
CalCOFI Symposium	Dec 9-11, 2013 / La Jolla, CA	Steven Bograd, Dave Checkley, John Field, Sarah Glaser, Tony Koslow, Selina Heppell, Martin Lindegren, Sam McClatchie, John McGowan, Richard Parrish, Lindsey Sala, Bill Sydeman, and many others
California Drought Outlook Forum organizer, NIDIS,	Sacramento, CA, May 15-16, 2014	Steinemann,
California Drought Preparedness, Drought Outlook Forum, NIDIS,	Sacramento, CA, February 20, 2014	Steinemann,
California Energy Commission Integrated Energy Policy Report briefing	3-Jun-13	Cayan
California Fish and Game Commission	April 16, 2014, Ventura, CA	Dave Checkley



California Governors Office and Legislature Climate Seminar. Participated in climate change panel and discussion with California Energy Commission and Resources Agency.	May 29, 2013.	Cayan
Canadian Society of Soil Science Meeting	July 22-24, 2013, Winnipeg, ON, CA	Brice Semmens
CAPAM Introduction to Stock Assessment Methods Short Course	December 9-13, 2013, La Jolla, CA	Brice Semmens et al.
Climate change and the Sierra Nevada: Sierra Nevada Alliance Conference	South Lake Tahoe, September 2013.	Dettinger, M.D.
Climate change, ARKStorms & the Sierra Nevada: Sierra Water Working Group Summit	Kings Beach, CA, June 2013.	Dettinger, M.D.
Climate variability and change: observations and projections for California and the South Coast"	NOAA's Coastal Services Center in San Diego in October 2013.	Gershunov
CNAP and NOAA Drought Forum, Sacramento, California Participated in panel presentation, describing links between climate and drought in California.	May 15, 2014.	Cayan
COMPASS/Wilburforce Advanced Climate and Fire Science Communication Workshop, Current and Future Partnerships for Climate-Related Decision-Making in the Great Basin	23 – 25 April 2014, Seattle, Washington	Westerling
Data Moderate STAR Panel	5/11/2013. Boise, ID. Great Basin Consortium.	Oakley, N.S., K.T. Redmond, T.U. Wall, T.J. Brown,
Department of Defense Land Managers Meeting, Fallbrook CA—presented scenarios of climate change relevant to Southern California ecosystems.	April 23-26, 2013 Santa Cruz, CA	Melissa Monk
Dept. Colloquium	28-Aug-13	Cayan
Diagnosing probability models for observed daily precipitation extremes at the CLIVAR workshop	Spring, 2014, Texas A&M Galveston	George Sugihara
Discussion about climate change with U.S. Representative Duncan Hunter.	Berkeley in May 2013	Gershunov
Dong-Kyu Lee. Near-surface Monsoonal Circulation of the Vietnam East Sea from Lagrangian Drifters, IWISE-OKMC-SDSCS Joint Meeting,	Oct 18, 2013.	Cayan
Downscaling climate projections for climate impact studies at the Climate Change, Disease Ecology, and Social Impacts conference	Seattle, Wa, August 12-15, 2013.	L.R. Centurioni.
Downscaling with Localized Constructed Analogs (LOCA)	1&2 May 2014, La Jolla, CA	Pierce
Drifter Observations During ITOP. ONR Physical Oceanography Peer Review	webinar with the U.S. Bureau of Reclamation and Army Core of Engineers, 6 Nov 2013.	Pierce
Drought Impacts Reporting, Cross-RISA and NIDIS meting,	Chicago, 16-20 September 2013.	L. Centurioni and V. Hormann.
Drought impacts reporting: needs, resources, and recommendations. Western States Water Council / California Department of Water Resources,	San Diego, CA, July 1, 2013	Steinemann,
Drought Preparedness for Small Water Systems and Tribes. Sponsored by NIDIS, CNAP, California DWR, and California Rural Water Association,	San Diego, CA, August 15, 2013	Steinemann,
Eastern Pacific Ocean Conference	San Diego, CA, September 24, 2013	Steinemann,
Ecological Society of America	September 16-19, 2013, Stanford Sierra Camp	E. Bjorkstedt
	August 2013, Minneapolis-St Paul,	W. Satterthwaite



	MN	
Ecological Society of America Annual Meeting	Aug 2013, Minneapolis, MN	Carl Boettiger
Ectotherms in Changing Environments: Working in Pasteur's Quadrant	November 2013, Stonybrook University	Marc Mangel
Ectotherms in Changing Environments: Working in Pasteur's Quadrant	March 2014, Simon Fraser University	Marc Mangel
EURAXESS Meeting	March 2014, New York, NY	Simone Vincenzi
European Geosciences Meeting	Vienna Austria, April 2014	F. Gasparin
European Society of Evolutionary Biology	Aug 2013, Lisbon, Portugal	Simone Vincenzi
Fire Weather and Smoke Management Forecasting in California and Nevada	12-Sep-13	Brown, T.,
Fourth In-Region Western Indian Ocean Capacity Building Workshop,	29 April - 3 May 2013, Zanzibar, Tanzania.	
Fred Hall Fishing and Boat Show	March 5-9, 2014, Long Beach, CA	Lyll Bellquist
Fred Hall Fishing and Boat Show	March 27-30, 2014, Del Mar, CA	Lyll Bellquist
Great Basin Climate Forum Series. Presented at the Climate Prediction Application Science Workshop,	April 23-25th, Logan, UT.	Wall, T. U.
Gulf and Caribbean Fisheries Institute 66 th Annual Meeting	November 4-8, Corpus Christi, TX	Brice Semmens
Gulf of Mexico Oil Spill & Ecosystem Science Conference	January 26-29, 2014 Mobile, AL	Kait Fraisier, Ana Sirovic
HFRNet Metric finalized	September 20, 2013, San Diego, CA	T. Cook
How many GCMs are really needed?" and "Localized constructed Analogs downscaling at the Climate Scenarios for the California Energy Sector meeting,	19 May 2014, Sacramento, CA.	Pierce
How to do Wildfire Research Episode 4 - The CEFA Experience	Monash University seminar, 1 May 2013.	Brown, T.,
ICES Annual Science Conference	September 2013, Reykjavik, Iceland	J. Zwolinski
Impacts of Climate Change on Water Resources a Southwest Climate Assessment Town Hall public meeting	University of Southern California, 31 March 2013.	Pierce
Improving the Flow of Climate Information in the West. EPSCoR annual meeting	Las Vegas, 27 March 2013.	Oakley, N.S., K.T. Redmond, T.U. Wall, and T.J. Brown,
Integrated Analysis Using Stock Synthesis: appropriate use of multiple data sets	January 27-29, 2014, Miami, FL	Mark Maunder
Interactive Development of Regional Climate Web Pages. Poster. 46th Annual Fall Meeting, . Geophys. Union	San Francisco, CA	Oakley, N. S., and K. T. Redmond,
Interagency Ecological Program	February, 2014, Folsom, CA	S. Lindley, D. Jackson
International Argo Data Management Team Meeting	Liverpool England, October 2013	Dean Roemmich, John Gilson, Megan Scanderbeg
International Argo Steering Team Meeting	Halifax Nova Scotia, March 2014	Dean Roemmich, Megan Scanderbeg
International Atomic Energy Agency meeting ""Integrated Isotopic Approaches for an Area-wide Precision Conservation to Control the Impacts of Agricultural Practices on Land Degradation and Soil Erosion"	November 4-8, Vienna, Austria	Brice Semmens
ISEES Software Lifecycle Workshop	August 2013, Santa Barbara, CA	Carl Boettiger
Joint Aquatic Sciences Meeting	May 2014, Portland, OR	Eric Palkovacs, Dave Fryxell, Travis Apgar, Gina Contolini
Joint Meeting of Ichthyology and Herpetology	July 10-15, 2013, Albuquerque, NM	Josh Stewart
L.R. Centurioni. Lagrangian Drifter Laboratory. FY'13 Research highlights. ENVICOP workshop,	October 16-17, 2013 Aversa ,Italy.	L.R. Centurioni.
MBI Workshop	November 2013, Columbus, OH	Carl Boettiger
Modesto Area Partners in Science, Modesto JC West Campus, Modesto, , invited	CA 22 November 2013	Westerling



symposium "Climate and Wildfires in the West.		
Monsoonal Near-Surface Circulation of the Arabian Sea	Zanzibar, Tanzania, April 29-May 3, 2013.	
NASA AMES NEX presentation, Understanding California's vulnerability to climate change..	22-May-14	Cayan
NASA Biodiversity research team meeting	May 7-9, 2014, Silver Spring, MD	Anderson, C.
National Marine Fisheries Service Recruitment Training Research Workshop	June 9-22, 2013, Gainesville, FL	Brian Stock
National Marine Fisheries Service, Southeast Fisheries Regional Office	June 20, 2013, St. Petersburg, FL	Brian Stock
National Park Service, Climate Change in America's National Parks Webinar: Changing Fire Regimes, Management, and People in the Sierras and Yellowstone National Park,	June 13 2013, invited seminar and panel.	Westerling
NCEAS Ecoinformatics Workshop	Feb 2014, Santa Barbara, CA	Carl Boettiger
Near Surface Circulation off Sri-Lanka from Surface Drifters. ASIRI workshop.	SIO. La Jolla, California. March 23-24, 2014.	L. Centurioni.
Near-Surface Circulation and Variability of the Kuroshio in the Southwestern East China Sea, 2013 International Conference of the East China Sea, TGA,	13-May-13	L. Centurioni.
Near-Surface Circulation of the Vietnam East Sea and of the Northern South China Sea from Lagrangian Drifters. ONR Physical Oceanography Peer Review,	Chicago, 16-20 September 2013.	L. Centurioni.
NOAA Center for Independent Experts – West coast joint Pacific sardine and hake SAKE survey	January 2014, Seattle, WA	D. Demer, J. Zwolinski
NOAA PI Meeting	Silver Spring, MD -- Sep 17, 2013	Andrew G. Dickson
North American Association of Fisheries Economists Forum 2013	May 21-24 2013, St Petersburg, FL	Daniel Ladd
Ocean Modeling Forum	Feb 4-8, 2014, Seattle, WA	Dave Checkley
Ocean Sciences Meeting	22-28 February 2014, Honolulu, HI	James Swift, Steve Diggs, Carolina Berys-Gonzales, Matthew Shen, Andrew Barna
Ocean Sciences Meeting	January 2014, Honolulu, HI	D. Huff, M. Yoklavich
Ocean surface Topography Science Team Meeting	October, 2013, Boulder Colorado	D. Roemmich, N. Zilberman
Oceans '13 Group on Earth Observations (GEO)	June 10-14, 2013 / Bergen, Norway	L. Hazard, M. Otero
Oceanside Anglers Meeting	July 2, 2013, Oceanside, CA	Lyll Bellquist
OceanSITES meeting	May 2013, Seoul	Uwe Send
Operational Oceanography and Global Ocean Circulation. Part 2: oceanographic scientific applications. Interactions Shipping - Marine Environment Summer School,	24th - 30th June, 2013, Chios island, Greece	Uwe Send
Overview of Climate Change and Effects on Western Great Basin. Washoe County Regional Resiliency Preparedness Study Meeting	20-Dec-13	Redmond, K., and T. Brown,
Overview of Lagrangian Salinity Drifter Deployments, Preliminary Results and Future Plans. SPURS Meeting.	Miami, Florida, Jan. 16 to Jan. 18, 2013.	L.R. Centurioni.
Perspectives in Seasonal Fire Forecasting. 4th International Fire Behavior and Fuels Conference	St. Petersburg, Russia, 1-4 July 2013.	Brown, T., E. Delgado,
PFMC, Pacific Sardine Stock Assessment Review and Data Availability Meeting	March 2014, La Jolla, CA	D. Demer, J. Zwolinski



PICES Annual Meeting 2013	October 2013, Nanaimo, Canada	E. Hazen
PICES North Marine Science Organization	Nanaimo Canada	Jarrod Santora
Pinchot Institute and Senator Wyden, US Capitol Visitors Center, Washington DC, Forest Conservation in the Anthropocene.	17-Sep-13	Westerling
POGO meeting	January 2014, Hobart	Uwe Send
Preparing for Climate Change—What Nevadans should know: League of Women Voters, Public seminar	Reno, November 2013	Dettinger, M.D.
Preparing for Climate Change—What Nevadans should know: Public seminar, Earth Day plenary speaker	Western Nevada College, Carson City, April 2013.	Dettinger, M.D.
Principles of Lagrangian Data Analysis and Examples of Scientific Interpretation of Surface Drifter Data. Fifth In-Region Western Indian Ocean Capacity Building Workshop	12 - 15 May 2014, Port Elizabeth, South Africa	L.R. Centurioni and L. Braasch.
PSFMC Pacific Coast Steelhead Management Meeting	March 2013, Skamania WA	S. Hayes
QUALCOMM corporation. Participated in discussion of San Diego 2050 climate assessment and preparedness for local decision makers.	12-Jun-14	Cayan
Quantitative Ecology Seminar	December 2, 2013, La Jolla, CA	Brian Stock
Quasi-decadal precipitation variations in Northern California—How seriously should we take them?: California Department of Water Resources Winter 2014 Outlook Meeting	La Jolla, November 2013.	Dettinger, M.D.
Radiowave Operators Working Group (ROWG)	March 3-6, 2014 / San Francisco, CA	L. Hazard, T. Cook, M. Otero, T. de Paolo, J. Chen
Robert May Public Lecture in Theoretical Ecology	Spring, 2014, Princeton Univ	George Sugihara
Russian River NIDIS Pilot Activity	Santa Rosa, CA, September 20, 2013	Steinemann,
Salmon Ocean Ecology Meeting	March 2013, Santa Cruz CA	S. Hayes, D. Huff
San Diego County Planners, presented assessment of possible climate change in the San Diego region.	8-Sep-13	Cayan
Santa Ana Winds Project: Social Science Results and Applications. Presented to leadership group, .	June 2013, at San Diego Gas and Electric Mission Control Center, San Diego, CA	Wall, T. U.
Santa Ana Winds Threat Index (Poster). Natural Hazards Workshop,	July 13-17th, 2013, Boulder, CO.	Wall, T.U. and S. Vanderburg.
Seasonal and Inter-annual Variability in the OKMC Region from Lagrangian Drifters. ONR Physical Oceanography Peer Review,	Chicago, 16-20 September 2013.	L. Centurioni and D.K. Lee,
Seasonal Forecasting for the Global EWS. GOF-C-GOLD IT, Wageningen	The Netherlands, 16 April 2013.	Brown, T.,
Seminar, University of California Berkeley	Mar 2014, Berkeley, CA	Carl Boettiger
Seminar, University of Wisconsin	Apr 2014, Madison, WI	Carl Boettiger
Senator Carol Liu (host), State Senate District 25, and Union of Concerned Scientists, Insurance in an Era of Climate Change	28 Jun 2013 Pasadena, CA	Westerling
Severe storms and California's fragile Delta—Historical impacts and new monitoring approaches: AGU Fall Meeting	San Francisco, December 2013.	Dettinger, M.D., Ralph, F.M., White, A., Anderson, M., Florsheim, J., Cayan, D., and Hinojosa, A.,
Sierra Nevada Conservancy and Sacramento/San Joaquin Delta Conservancy Joint Board Meeting. Presented overview of climate change expected in Sierra-to-Delta.	Mar 12, 2014.	Cayan



Sierra Nevada Research Institute, , California Drought and Effects, invited presentation,	Merced, CA 10 March 2014	Westerling
SIO Donor Brunch	April 6, 2014, La Jolla, CA	Lyll Bellquist
Small Water Systems and Drought Indicators, California Water Commission	San Diego, CA 3/3/2014	Steinemann,
Society for Conservation Biology annual meeting	July 2013; Baltimore, MD	E. Hazen
Society for Industrial and Applied Mathematics	June 2013, San Diego, CA	Simone Vincenzi
SOOPIP Meeting	April, 2013 , Victoria B.C.	J. Sprintall, N. Zilberman
South Korea Grid finalized	September 13, 2013, San Diego, CA	M. Otero
Staff meeting on Climate Scenarios for the California Energy Sector, California Energy Commission, participant.	Sacramento, CA, 19 May 2014,	Westerling
Stanford Department of Biology's, Think and Drink Seminar Series	February 7 2014 Stanford University, California	Vanessa Labrada-Martagon
Stay Cool, San Diego. presented outlook of possible climate change in the San Diego region.	14-May-14	Cayan
Student Conference on Conservation Science at the American Museum of Natural History	October 8-11, 2013, New York, NY	Josh Stewart
Summerville High School, Tuolumne, CA World Geography Class, , invited presentation.	26-Sep-13	Westerling
Surface Drifter Technology and Examples of Lagrangian Experiments Planning. Fifth In-Region Western Indian Ocean Capacity Building Workshop,	12 - 15 May 2014, Port Elizabeth, South Africa	L.R. Centurioni and L. Braasch.
SWFSC Student Marine Mammal Student Workshop	November 2013. Southwest Fisheries Science Center. La Jolla, CA	Greg Campbell
Tahoe AFRI stakeholder meeting,	Tahoe, CA, March 26	Westerling
Taiwan Taiwan's deputy Prime Minister in attendance, Operational Oceanography: operations, science and implications for the shipping industry. Part 1, Interactions Shipping - Marine Environment Summer School,	24th - 30th June, 2013, Chios island, Greece	Taoyuan.
The Global Drifter Program. Cooperative Institute for Marine Ecosystems and Climate (CIMEC) review.	SIO, La Jolla, California, February 7, 2014.	L. Centurioni.
The Global Drifter Program. VIETNAM (VASI)/US(NOAA) cooperation in the Vietnam East Sea.	SIO/NOAA-VASI Cooperation Meeting Hanoi, November 18, 2013	L.R. Centurioni.
The Keeling Curve: What it means for San Diego and the World at the San Diego Rotary Club Convoy Branch	10 Dec 2013, San Diego, CA	Pierce
The Lagrangian Drifter Laboratory. Presentation to JAMSTEC-MARITEC delegation.	SIO, La Jolla, California, March 7, 2014.	L. Centurioni.
The new science of atmospheric rivers and Yosemite: Parsons Lodge Public Seminar, Tuolumne Meadows	Yosemite National Park, August 2013.	Dettinger, M.D.
The uneven response of different snow measures to human-induced climate warming	lunch seminar at the Dept. of Civil Engineering, University of Washington, 10 June 2013, Seattle, WA.	Pierce
THREDDS Training	July 23-26, 2013, Boulder, CO	J. Chen
Towards an evolutionary theory of	9-13 December 2013, Leiden,	Santiago Salinas



nongenetic effects	Netherlands	
Trinational Sardine Forum	December 2013, Ensenada, Mexico	D. Demer, J. Zwolinski
Tropical Pacific Observing System Workshop (TPOS 2020)	La Jolla California, January 2014	D. Roemmich, F. Gasparin, D. Rudnick, B. Cornuelle
UC Office of the President	January 27, 2014, La Jolla, CA	Dave Checkley
UCSC EEB Research Symposium	March 7, 2014, Santa Cruz, CA	Kate Richerson
UCSD GIS Undergraduate Course	February 12, 2014, La Jolla, CA	Lyll Bellquist
Union of Concerned Scientists, Climate Science Information Day, invited participant.	California State Legislature, Sacramento, CA, 3 April 2013.	Westerling
University of California Drought Summit, Sacramento, CA. Participated in outlook of climate change and drought in California	Apr 25, 2014.	Cayan
University of California Santa Cruz Climate through the Looking Glass	Mar 1, 2014.	Cayan
University-Wide Public Lecture	Spring, 2014, Univ. Chicago	George Sugihara
USFS, Brian D'Agostino, SDG&E, Tamara Wall, DRI. Santa Ana Wilfire Fire Threat Index. Presented to the USFS R5 Board of Directors,	July 2013 at the USFS Training Center, Sacramento, CA.	Thomas Rolinski,
USGS Menlo Park Public Talk.Looking back and Looking Forward, A Climatologist Views Climate Change in California.	27-Mar-14	Cayan
Using drought indicators for assessment and prediction. Western States Water Council / California Department of Water Resources,	San Diego, CA, April 29, 2013	Steinemann,
USNC-URSI National Radio Science Meeting	January 9-12, 2013, Boulder	Seth Gutman
Wave Glider Winch System. Presentation to the Carrier Strike Group Nine,	SIO, La Jolla, California, January 17, 2014.	L. Centurioni.
Western Forest Insect Work Conference, , invited plenary presentation,	Sacramento, CA, 1 April 2014	Westerling
Western Groundfish Conference	February, 2014, Victoria, Canada	S. Sogard, R. Fields
Western Society of Naturalists	November 7-10, 2013, Oxnard, CA	Lyll Bellquist
WHOI Seminar	July 2013, Woods Hole, MA	Carl Boettiger
Wildlife Disease Association Conference	July 27 through August 1, 2014 Albuquerque, New Mexico USA	Tracey Goldstein
Woods Institute for the Environment & IPCC, Uncommon Dialogue: Managing the Risks of Extreme Climate Events and Disasters,	11 April 2013, Stanford University, Palo Alto, CA.	Westerling
Workshop on Stock Assessment of Peruvian Small Pelagics	September 2-6, 2013	Mark Maunder
World Conference on Stock Assessment Methods	July 15-19, 2013, Boston, MA	Mark Maunder et al.



CIMEC PARTNERS AND COLLABORATORS

INTERAGENCY

Antarctica Ecosystem Research Division, NMFS
Atlantic Oceanic and Meteorological Laboratory (AOML)
Fisheries Ecology Division, NMFS
Integrated Ocean Observing System (IOOS)
Monterey Bay National Marine Sanctuary
National Aeronautics and Space Agency (NASA)
 AMES Research Center
 Jet Propulsion Lab (JPL)
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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	22	30	76	89	24	6	38	15	11	38	40	69
Non Peer Reviewed	19	9	29	23	14	8	10	5	7	14	13	10
	41	39	105	112	38	14	48	25	18	52	53	79

Total Publications for this period: 216

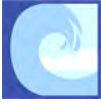


ACRONYMS

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
CCMA	Center for Coastal Monitoring and Assessment
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
NCCOS	National Centers for Coastal Ocean Science
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
OAP	NOAA/Ocean Assessment Program
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

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