

Annual Report for Period:12/2007 - 11/2008

Submitted on: 05/19/2008

Principal Investigator: Reed, Daniel C.

Award ID: 0620276

Organization: U of Cal Santa Barbara

Submitted By:

Title:

LTER: Land/Ocean Interactions and the Dynamics of Kelp Forest Communities

Project Participants

Senior Personnel

Name: Reed, Daniel

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Melack, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Holbrook, Sally

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Gaines, Steven

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Siegel, David

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Dugan, Jenny

Worked for more than 160 Hours: Yes

Contribution to Project:

Project coordinator and sandy beach research

Name: Whitmer, Allison

Worked for more than 160 Hours: Yes

Contribution to Project:

Directs on campus marine outreach and education activities

Name: Page, Henry

Worked for more than 160 Hours: Yes

Contribution to Project:

Reef ecology research including stable isotope analyses

Name: Washburn, Libe

Worked for more than 160 Hours: Yes

Contribution to Project:

Oceanographic research

Name: Brzezinski, Mark

Worked for more than 160 Hours: Yes

Contribution to Project:

Coastal Oceanography research

Name: Cooper, Scott

Worked for more than 160 Hours: No

Contribution to Project:

Stream ecology research

Name: Carlson, Craig

Worked for more than 160 Hours: Yes

Contribution to Project:

Marine microbial ecology

Name: Cardinale, Brad

Worked for more than 160 Hours: Yes

Contribution to Project:

Long term experiments and synthesis

Name: Guerrini, Anita

Worked for more than 160 Hours: Yes

Contribution to Project:

Historical research on coastal watersheds

Name: Zimmerman, Richard

Worked for more than 160 Hours: No

Contribution to Project:

Algal physiology and ecology research

Name: Schmitt, Russell

Worked for more than 160 Hours: Yes

Contribution to Project:

kelp forest community ecology

Name: Schimel, Joshua

Worked for more than 160 Hours: Yes

Contribution to Project:

Watershed nutrient research

Name: Nisbet, Roger

Worked for more than 160 Hours: Yes

Contribution to Project:

Ecological modeling

Name: McPhee-Shaw, Erika

Worked for more than 160 Hours: Yes

Contribution to Project:

Coastal oceanographic research

Name: MacIntyre, Sally

Worked for more than 160 Hours: Yes

Contribution to Project:

Limnologic and oceanographic research

Name: Even, Thomas

Worked for more than 160 Hours: No

Contribution to Project:

Stream ecology

Name: Gaylord, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

Kelp forest hydrodynamics and biomechanics

Name: Lenihan, Hunter

Worked for more than 160 Hours: Yes

Contribution to Project:

Reef ecology and fisheries

Name: Carr, David

Worked for more than 160 Hours: Yes

Contribution to Project:

Reef fisheries research

Name: Dudley, Tom

Worked for more than 160 Hours: No

Contribution to Project:

watershed and invasive plant research

Name: Beighley, Ed

Worked for more than 160 Hours: Yes

Contribution to Project:

Watershed hydrology

Name: Freudenburg, William

Worked for more than 160 Hours: No

Contribution to Project:

Sociological studies

Name: Clarke, Keith

Worked for more than 160 Hours: No

Contribution to Project:

Land use research

Name: Holden, Patricia

Worked for more than 160 Hours: Yes

Contribution to Project:

Microbial Ecology including bacterial and water quality research in coastal watersheds

Name: Tague, Christina

Worked for more than 160 Hours: No

Contribution to Project:

Research and modeling on how eco-hydrologic systems are altered by changes in land use and climate

Post-doc

Name: Miller, Robert

Worked for more than 160 Hours: Yes

Contribution to Project:

Develop apparatus and experiments investigating primary production of understory algae and phytoplankton in kelp forests

Name: Fram, Jonathan

Worked for more than 160 Hours: Yes

Contribution to Project:

Analysis of current, temperature, nutrient data for kelp forest and nearshore ocean

Name: Stewart, Hannah

Worked for more than 160 Hours: Yes

Contribution to Project:

Researched kelp forest dynamics in response to nutrient flow

Name: Revell, David

Worked for more than 160 Hours: No

Contribution to Project:

Sediment and sandshed dynamics of coastal beaches

Name: Miterai, Satoshi

Worked for more than 160 Hours: Yes

Contribution to Project:

ROMS modeling of larval connectivity with headlands

Name: Alberto, Filipe

Worked for more than 160 Hours: No

Contribution to Project:

Population genetics of kelps

Name: He, Yiping

Worked for more than 160 Hours: Yes

Contribution to Project:

watershed hydrology research

Name: Leydecker, Al

Worked for more than 160 Hours: Yes

Contribution to Project:

Watershed sampling and analyses

Name: Fewings, Melanie

Worked for more than 160 Hours: Yes

Contribution to Project:

Physical Oceanography

Graduate Student

Name: Arkema, Katie

Worked for more than 160 Hours: Yes

Contribution to Project:

Kelp forest community ecology, kelp primary production

Name: Rassweiler, Andrew

Worked for more than 160 Hours: Yes

Contribution to Project:

Kelp forest community ecology, kelp primary production

Name: Carney, Laura

Worked for more than 160 Hours: Yes

Contribution to Project:

kelp population genetics research

Name: Nickols, Kerry

Worked for more than 160 Hours: Yes

Contribution to Project:

kelp biomechanics research

Name: Hettinger, Annliese

Worked for more than 160 Hours: Yes

Contribution to Project:

kelp biomechanics research

Name: Guenther, Carla

Worked for more than 160 Hours: Yes

Contribution to Project:

Fishery socioeconomics and management in kelp forests

Name: Simon, Scott

Worked for more than 160 Hours: Yes

Contribution to Project:

Coordinates on campus marine outreach and education activities

Name: Hammond, Latisha

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with on-campus marine outreach and education

Name: Klose, Kristie

Worked for more than 160 Hours: Yes

Contribution to Project:

Stream ecology research

Name: Shulman, Rachel

Worked for more than 160 Hours: Yes

Contribution to Project:

Long term experiments and synthesis

Name: Burnette, Don

Worked for more than 160 Hours: No

Contribution to Project:

History of botanical research on a coastal watershed

Name: Cavanaugh, Kyle

Worked for more than 160 Hours: Yes

Contribution to Project:

SPOT analysis of kelp cover/biomass

Name: Watson, James

Worked for more than 160 Hours: Yes

Contribution to Project:

modeling of larval & genetic connectivity for SBC-LTER

Name: Chaffey, Tim

Worked for more than 160 Hours: Yes

Contribution to Project:

ROMS modeling of larval connectivity with headlands

Name: Kostadinov, Tiho

Worked for more than 160 Hours: Yes

Contribution to Project:

coastal oceanographic research

Name: Anderson, Clarissa

Worked for more than 160 Hours: Yes

Contribution to Project:

coastal oceanographic research

Name: Wallner, Elisa

Worked for more than 160 Hours: Yes

Contribution to Project:

coastal oceanographic research

Name: Goldberg, Stuart

Worked for more than 160 Hours: Yes

Contribution to Project:

coastal oceanographic research

Name: Goodman, Jo

Worked for more than 160 Hours: Yes

Contribution to Project:

coastal oceanographic research

Name: Levenbach, Stuart

Worked for more than 160 Hours: Yes

Contribution to Project:

Kelp forest community ecology

Name: Lester, Sarah

Worked for more than 160 Hours: No

Contribution to Project:

Kelp forests and population biology of urchins

Name: Brinkman, Jeff

Worked for more than 160 Hours: No

Contribution to Project:

Stream ecology

Name: Kinlan, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

ecology of kelp forests

Name: Kargar, Maryann

Worked for more than 160 Hours: Yes

Contribution to Project:

watershed hydrology research

Name: Bogonko, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

watershed hydrology research

Name: Shields, Catherine

Worked for more than 160 Hours: Yes

Contribution to Project:

Watershed research and modeling

Name: Smyth, Robyn

Worked for more than 160 Hours: Yes

Contribution to Project:

Research on biogeochemical responses to physical processes in the coastal ocean.

Name: Finger, Helene

Worked for more than 160 Hours: Yes

Contribution to Project:

Research on biogeochemical responses to physical processes in the coastal ocean.

Name: Landgren, Kristin

Worked for more than 160 Hours: Yes

Contribution to Project:

Research on coastal ocean productivity

Name: Goodman, Darcie

Worked for more than 160 Hours: Yes

Contribution to Project:

Research on coastal watersheds and estuaries

Name: Melton, Christopher

Worked for more than 160 Hours: Yes

Contribution to Project:

Research on coastal ocean productivity and conditions

Undergraduate Student

Name: Jolley, Margaret

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research, data and lab sample processing

Name: Horii, Stephanie

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research, data and lab sample processing

Name: Rompel, Jenna

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research, data and lab sample processing

Name: Creason, Jamie

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research and lab sample processing

Name: Kondo, Emi

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research and lab sample processing

Name: Zimmer-Faust, Amy

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research and lab sample processing

Name: James, Kelsey

Worked for more than 160 Hours: No

Contribution to Project:

Assists with on-campus marine outreach and education

Name: Le, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research and lab sample processing

Name: Finstad, Sarah

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research and lab sample processing

Name: Santschi, Christen

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research and lab sample processing

Name: Quigley, Yasmin

Worked for more than 160 Hours: No

Contribution to Project:

Assists with on-campus marine outreach and education

Name: Naranjo, Vanessa

Worked for more than 160 Hours: No

Contribution to Project:

Assists with on-campus marine outreach and education

Name: Olsen, Lani

Worked for more than 160 Hours: No

Contribution to Project:

process stream samples, filter water samples for particulates, measure conductivity on stream samples

Name: Teeza, Inteema

Worked for more than 160 Hours: No

Contribution to Project:

process stream samples, filter water samples for particulates, measure conductivity on stream samples

Name: Minter, Thomas

Worked for more than 160 Hours: No

Contribution to Project:

Sample collection from streams during storm events

Name: Padilla, Emmanuel

Worked for more than 160 Hours: No

Contribution to Project:

Sample collection from streams during storm events

Name: Bowen, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

Performed nutrient analyses and data entry in laboratory for watershed, stream and beach samples, performed some quality control analyses.

Name: Moon, Evan

Worked for more than 160 Hours: Yes

Contribution to Project:

assisting in SPOT data analysis

Name: Fairbarn, Kenneth

Worked for more than 160 Hours: Yes

Contribution to Project:

assisting in SPOT data analysis

Name: Nielsen, Jessica

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Cady, Samantha

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Madras, Marie

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Silbert, Matthew

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: You, Jiayang

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Griffiths, Marc

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Allman, Erin

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Christie, Jocelyn

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Miller, Kate

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Jew, Gregory

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Most, Mackenzie

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Hazen, Michael

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Barkley, Yvonne

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Artis, Austin

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Linard, Erica

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Dilley, Eric

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Schwarzkopf, Zacary

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Lever, Jeremie

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Chanco, Michael

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Edwards, Kristen

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Gower, Yvonne

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Judge, Jenna

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Gherardi, Kristyn

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Karm, Debi

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Swann, Justine

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: McAlexander, Laurie

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Phares, Natalie

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Stroud, Ashley

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Novoa, Anai

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Flores, Jonathan

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Borchart, Sinaed

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Boccio, Gina

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Nicholson, Lisa

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Gibson, Carolyn

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab sample processing

Name: Yu, Gordon

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with maintenance of the SBC-LTER real-time data display system on Stearns Wharf.

Technician, Programmer

Name: Harrer, Shannon

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with reef and oceanographic research and data management

Name: Nelson, Clint

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with reef and oceanographic research and data management

Name: Fisher, Rachelle

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with reef and oceanographic research and data management

Name: Goodridge, Blair

Worked for more than 160 Hours: Yes

Contribution to Project:

: Assisted with reef, oceanographic and watershed research

Name: Kissinger, Michelle

Worked for more than 160 Hours: No

Contribution to Project:

Assists with on-campus marine outreach and education

Name: Nakase, Dana

Worked for more than 160 Hours: No

Contribution to Project:

Assists with on-campus marine outreach and education

Name: O'Brien, Margaret

Worked for more than 160 Hours: Yes

Contribution to Project:

IM coordinator

Name: Schooler, Nicolas

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with reef and sandy beach research

Name: Setaro, Frank

Worked for more than 160 Hours: Yes

Contribution to Project:

Processing stream and watershed samples in laboratory

Name: Doyle, Allen

Worked for more than 160 Hours: Yes

Contribution to Project:

Analytical lab manager, performed and coordinated nutrient analyses for freshwater inorganic and total nutrients. Logged samples, created spreadsheets, performed quality analysis

Name: Fields, Erik

Worked for more than 160 Hours: Yes

Contribution to Project:

satellite image data processing

Name: Jones, Janice

Worked for more than 160 Hours: Yes

Contribution to Project:

coastal oceanographic research

Name: Gotschalk, Chris

Worked for more than 160 Hours: Yes

Contribution to Project:

coastal oceanographic research and data processing

Name: Court, David

Worked for more than 160 Hours: No

Contribution to Project:

remote sensing data analyses

Name: Emery, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

ocean surface currents research

Name: Ireson, Kirk

Worked for more than 160 Hours: Yes

Contribution to Project:

ocean surface currents research

Name: Guillocheau, Nathalie

Worked for more than 160 Hours: Yes

Contribution to Project:

Plumes and Blooms research

Name: Wiseman, Sheila

Worked for more than 160 Hours: No

Contribution to Project:

Stream ecology

Name: Morris, Jordan

Worked for more than 160 Hours: Yes

Contribution to Project:

server and database management

Name: Burt, Chad

Worked for more than 160 Hours: Yes

Contribution to Project:

information management

Other Participant

Name: Ralph, Yvette

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with subtidal kelp forest research

Research Experience for Undergraduates

Name: Davenport, Lars

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU supplement

Name: Craig, Alexandra

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU supplement

Name: Heidelberger, Sara

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest sampling and lab sample processing

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU supplement

Name: Cody, Tim

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest sampling and lab sample processing

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported:

REU Funding: REU supplement

Name: Honig, Susanna

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with subtidal kelp forest research and lab sample processing

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU supplement

Organizational Partners

NOAA National Marine Sanctuary Program

A major goal of the Channel Islands National Marine Sanctuary (<http://www.cinms.nos.noaa.gov/home.htm>) is to direct research and monitoring programs that will yield a body of information that can be used to evaluate existing management practices and provide improved understanding for future management decisions. CINMS has provided ship time and staff expertise to UCSB's Plumes and Blooms project and has offered similar support to the SBC LTER. CINMS has been an enthusiastic supporter of SBC because information generated by SBC will assist them in their efforts to manage and protect the Sanctuary. CINMS is currently considering expanding its boundaries to include much of the mainland coast in the Santa Barbara Channel and has been active in state-wide efforts to establish marine reserves. Both of these activities could greatly influence the level of protection afforded to marine habitats in the SBC LTER. Six SBC investigators served on a science advisory panel to CINMS to develop a plan to create a network of marine protected areas in the sanctuary and state waters.

Santa Barbara Land Trust

The Santa Barbara Land Trust has purchased the lower half of the Arroyo Hondo catchment, a parcel owned for generations by a couple of families and only slightly altered; the upper portion is administered by the US Forest Service as natural watershed. As part of a Bren School's Masters of Environmental Science and Management thesis project, we developed a natural resources management plan for the Land Trust. Further, the catchment is one of our intensive sites, and we will continue to provide useful information to the Land Trust as they protect and manage the property.

University of California, Davis, CA

Old Dominion University

Research collaborations on studies of kelp primary production

Los Angeles Conservation Corps

Collaborate on SBC-LTER's schoolyard program for K-12 education

Santa Barbara Channel Keeper

The Santa ChannelKeepers conduct monthly collections along the Ventura River, and we participate in this field work and complement their in situ measurements with high quality nutrient chemistry.

Ventura CoastKeeper

Provides stream sampling volunteers and sample collections for watershed research.

Carpinteria Creek Watershed Coalition

Univ. California Natural Reserve System

Friends of the Santa Clara River

City of Santa Barbara

The City of Santa Barbara recently obtained special funding through a voter approved tax increase to reduce polluted runoff that has resulted in beach closures. Two of our intensively studied catchments (Mission and Arroyo Burro) are within the City, and we are interacting with city staff to help plan their restoration efforts.

Santa Barbara County Project Clean Water

Santa Barbara County's Project Clean Water is engaged in sampling local creeks during the initial rise of the hydrograph and measuring a suite of pollutants including metals, pesticides and herbicides. Our intensive sampling of nutrients and particulates during the whole hydrograph for most storms complements the County's effort, and we and they share data and interpretations. To further communication with Project Clean Water, we attend their monthly stakeholder meetings and have given public presentations of our results in that forum.

Channel Islands National Park

Since 1982 Channel Islands National Park (<http://www.nps.gov/chis/>) has collected data annually on the abundance of a wide variety of species that inhabit intertidal reefs and kelp forests at a multitude of sites on the five northern Channel Islands (<http://www.nature.nps.gov/im/chis/index.htm>). These data have proved extremely valuable in evaluating the response of nearshore reef communities to large disturbances (e.g. El Nino) that have occurred in the last 20 years. SBC has adopted sampling protocols similar to those used by NPS to examine long-term changes in reef populations on the mainland. When used in combination, NPS and SBC data provide large spatial resolution for evaluating changes in reef communities that occur in the future. This collaboration is important because it provides NPS with important information on the physical and biological oceanography of the Santa Barbara Channel, which otherwise would not be available to them. This information is useful in helping NPS manage and protect the unique and valuable resources of the Channel Islands.

Terra Image USA

UC Santa Barbara and Terra Image USA, the company which owns the academic rights to SPOT data for the U.S., entered into a research partnership which gives UCSB students and researchers [nearly] unlimited access to archived SPOT imagery and the ability to acquire new scenes (www.ia.ucsb.edu/pa/display.aspx?pkey=1311; also www.spot.ucsb.edu). Currently we have 27 SPOT 4 & 5 multispectral scenes covering parts of the Santa Barbara Channel from October 2004 to Jan 2006. Beginning Jan 2006, the SPOT Corporation has tasked its satellites to provide at least bi-monthly coverage of the entire Santa Barbara Channel in support of this agreement.

Center for Integrative Coastal Observ.

Other Collaborators or Contacts

The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)(<http://www.piscoweb.org>) is a large-scale marine science research program funded by the David and Lucile Packard Foundation that focuses on understanding the nearshore ecosystems of the U.S. West Coast. Representing a collaboration of scientists from four universities (including UCSB), the interdisciplinary research ranges from long-term monitoring of ecological and oceanographic processes at dozens of coastal sites to experimental work in the lab and field to explore how individual organisms and populations are affected by environmental change. PISCO research at UCSB (PIs Gaines, Warner, and Washburn) is tightly linked with the Santa Barbara LTER and considerable sharing of resources and data in studies pertaining to physical, chemical, and biological oceanography.

NASA funds a long-term (>10 yr) study at UCSB (referred to as Plumes and Blooms) (<http://www.ices.ucsb.edu/PnB/PnB.html>) that investigates marine plankton blooms associated with runoff. The goal of this project (Lead PI Siegel) is to develop new satellite ocean color algorithms to use in coastal waters influenced by terrigenous materials (sediments, dissolved organic materials, etc.). In situ optical quantities and in-water constituents are collected every two weeks along a 7 station transect crossing the Santa Barbara Channel and related to simultaneous ocean color images from the SeaWiFS satellite sensor. Siegel is also the lead PI on another NASA funded project whose research objective is to develop a predictive understanding of giant kelp forests in the nearshore waters of California using a combination of: (1) high-resolution remote sensing of kelp cover, biomass & its physiological state, (2) metapopulation modeling of kelp patch dynamics, and (3) Bio-optical modeling of kelp productivity. The project builds on the findings of SBC-LTER funded research and there is substantial coordination and information exchange between the two projects.

The San Onofre Nuclear Generating Station (SONGS) mitigation program was instituted by the California Coastal Commission as a means of compensating for the loss of coastal marine resources caused by the operation of the nuclear power plant, which is located on the coast in

northern San Diego County. SBC PI Reed and Associate Investigator Page are lead investigators on the SONGS mitigation program and are responsible for designing and implementing monitoring programs that evaluate the effectiveness of the various mitigation projects. One component of the mitigation program requires the restoration of tidal wetlands. Carpinteria salt marsh is one of the reference sites being used to evaluate the performance of San Dieguito Lagoon (the wetland to be restored, which is located in San Diego County). Data on water quality, tidal inundation, and species composition and abundance of wetland biota are being collected at Carpinteria and three other wetlands in southern California as part of this project. These data are available to us and nicely complement those that are being collected by SBC LTER. Another large component of the SONGS mitigation program involves mitigating the loss of kelp forest habitat via the creation of artificial reefs. The design of the long term monitoring of the artificial reef and nearby natural kelp forests that are used for reference is similar to that used by SBC LTER to monitor changes in kelp forests in the Santa Barbara region and provides an excellent opportunity for regional comparisons.

SBC investigators are actively collaborating with researchers from the Centre of Marine and Environmental Research (CMER) at the Universidade do Algarve, Portugal on issues pertaining to gene flow, inbreeding depression and population connectivity in the giant kelp *Macrocystis pyrifera*. CMER is a member of the Marine Biodiversity and Ecosystem Functioning (MarBEF) program, which is a network of excellence funded by the European Union. It consists of 91 European marine institutes and is a platform to integrate and disseminate knowledge and expertise on marine biodiversity with links to researchers, industry, stakeholders and the general public. CMER is also a member of CORONA (Coordinating Research of the North Atlantic), an NSF-funded multidisciplinary research network to study the marine biota of the North Atlantic. The network includes 118 scientists from 13 countries across the North Atlantic. The major research and education goals of CMER, MarBEF, and CORONA are complimentary to those of SBC LTER, providing the ideal opportunity for collaboration.

SBC-LTER investigators are collaborating with the California Cooperative Extension/Sea Grant program on projects investigating aquatic invasive species and on collaborative fisheries research with fishing partners.

CALobster (<http://www.calobster.org/>), a new collaborative fishery research program recently initiated by an SBC investigator and his graduate students, focuses on the spiny lobster fishery with a goal of promoting and conducting community-based research that lead to the best management practices and help maintain working harbors.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings: (See PDF version submitted by PI at the end of the report)

Training and Development:

Education and training are tightly integrated into all aspects of SBC research. As of May 2008 six post docs, 21 graduate students, 5 REU students and more than 25 undergraduate students have participated in SBC research during this funding cycle. Educational opportunities at SBC are not limited to university students and post docs. Teachers and numerous volunteers from the general public regularly participate in our stream sampling program and gain considerable knowledge on the constituents of runoff and of the processes that influence their concentrations. SBC students, postdoctoral fellows, and investigators participated in the 2008 SBC-LTER Spring Science Meeting in June. Results from SBC research and collaborative projects were presented in an interactive poster session, and oral presentations. SBC graduate students also participated in the first UC-LTER graduate postdoc symposium organized by the CCE-LTER in May 2008.

SBC hosted the fall 2007 Ecological Society of America SEEDS field trip for underrepresented undergraduate students in October 2007. ESA's SEEDS (Strategies for Ecology, Education, Development and Sustainability) program mission is to diversify and advance the profession of ecology through opportunities that stimulate and nurture the interest and involvement of underrepresented students (<http://www.esa.org/seeds/>). The first day of the field trip featured a visit to the SBC kelp forest and research divers at Arroyo Burro reef aboard the R/V Cormorant led by PI Dan Reed, a guided tour of Santa Barbara's working harbor led by California Sea Grant Extension Advisor, Carrie Culver, meeting with Roberta Cordero, a Chumash Elder at the SB Maritime Museum, a visit to UCSB's REEF and rocky intertidal and beach monitoring activities at Campus Point followed by sunset and dinner at the Cliff House at Coal Oil Point. After dinner SBC graduate students Carla Guenther, Kyle Cavanaugh, and Andy Rassweiler and SBC faculty investigators Sally Holbrook and Mark Brzezinski discussed their experiences and highlighted opportunities for graduate studies at UCSB. Saturday's activities began with a presentation on SBC watershed research followed by a tour of SBC watersheds and study sites led by John Melack. In the afternoon, the students explored downtown Santa Barbara before returning to their lodging at Camp Whittier in the Santa Ynez Mountains. The SEEDS field trip to SBC was

made possible by a special supplemental grant from NSF.

In November 2007, ESA's SEEDS program received the 2006 Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring sponsored by the National Science Foundation. This prestigious award recognized the important mentoring and experiences provided by the SEEDS program to underrepresented students.

Outreach Activities:

The SBC-LTER Summer Diversity Program 2008

SBC's Schoolyard LTER (SLTER) program is organized around a theme of watershed ecology. This approach allows for an integrated program that includes K-12 students, K-12 teachers, undergraduate and graduate students. In 2008 we are focusing on developing long-term connections with local middle schools in Santa Barbara County through a partnership with UCSB's Office of Academic Preparation and Education Outreach (APEO). The goal of APEO is to build college-going communities that improve student learning, increase college-going rates, and provide equal access to higher education for California's diverse students. In an effort to forge long-term connections with local schools, primarily those identified as underserved or low-achieving, the office has staff coordinators who work directly on the school campuses with teachers, administrators and students. With the infrastructural support of APEO, the SBC SLTER program aims to engage middle school students and teachers in local schools through the academic year and summers, and throughout their secondary school education.

Program Format: We are using the successes we had with our LACC summer program (2004-2007) to guide development of our Santa Barbara-based program. First, we continue to work with our undergraduate interns in a rigorous and pedagogically sound program of training in marine science and science pedagogy. These interns engage directly with middle school students as teachers and role models. Second, we continue to develop and adapt marine science lesson plans that engage students with learning about their local environment. These lesson plans incorporate ongoing SBC LTER research and include working with data generated by monitoring and experiments. The program is developed to build student's skills in scientific inquiry through a series of activities that move from structured or guided investigation to open-ended experimentation. Third, our program includes a combination of school-based activities, field trips, and an on-campus residential experience that immerses students in the environment of a college campus.

The SBC SLTER program is working with two Santa Barbara County middle schools: Santa Barbara Junior High School and Goleta Valley Junior High School. Both schools serve a diverse population of students with a large population of students on free or reduced lunch programs.

Students selected by APEO coordinators to participate in their education programs comprise the population of students eligible to participate in the SBC SLTER program. In order for students and their parents to become acquainted with the UCSB campus they are invited to an introductory day-long visit to the campus. An estimated 40 students and their parents or guardians are invited to a Saturday orientation to UC Santa Barbara during which they tour the campus, participate in a panel discussion lead by undergraduate students, and engage in a series of hands-on marine biology lessons. Then, beginning in the fall semester, SBC SLTER undergraduate interns conduct biweekly activities for students in an after school program format. As mentioned previously, these activities guide students through marine science activities aimed at improving science literacy and inquiry skills. School year activities also include a field trip to the UCSB aquarium, an SBC LTER research site, and on a Floating Lab trip into the Santa Barbara Channel. Finally, students are invited to participate in a weeklong residential program on the UCSB campus. These students are engaged in SBC LTER research- based learning activities, conduct field research, and explore the possibility of attending a 4-year college. Follow-up with students and their families includes college counseling and application advice as well as support of Spanish language classes for parents on post-secondary education in California, supported primarily through APEO.

An additional benefit expected in future years is the long-term connection we will maintain with participating students both through APEO support (they work with these same students throughout their high school years) and through continued engagement with students as they move into high school. We envision a program that supports interested students with science fair projects, summer research opportunities, and mentoring opportunities with our middle school program.

Research Experience & Education Facility (REEF)

The Santa Barbara Coastal (SBC) LTER outreach, education and training programs benefit from a close association with the University of California at Santa Barbara's Research Experience & Education Facility, better known as the REEF, an interactive aquarium facility. The REEF is equipped with state-of-the-art, aquaria and touch tanks, ranging from 2 to 2,000 gallons. The REEF also utilizes a high-tech life support system for the Research Tank, which highlights current, on-going research at UCSB and the Marine Science Institute, including SBC-LTER research.

One of the joint goals of the SBC LTER and the REEF program is to provide UCSB undergraduates, majoring in Aquatic Biology, with a solid

foundation in temperate marine ecology and research. The REEF training provides them with the basis for communicating this knowledge in an educational format. To that end, the REEF develops its curriculum around a number of research programs at UCSB. The SBC LTER is a significant contributor to this endeavor. Support from the SBC LTER schoolyard program has allowed the REEF to obtain teaching supplies and equipment for curriculum and teacher professional development, as well as provide stipends for teachers, undergraduate and graduate internships. The REEF also utilizes graduate students from the SBC LTER to train REEF undergraduate staff, which, in turn, enhances their training as laboratory and field assistants and research divers for SBC LTER research.

The REEF program has been busy during 2008, between outreach visits to schools, community events and on-campus programs, the REEF provided marine science and environmental education to over thousands of children and adults. This includes hosting educational visits from primary and secondary schools from King City in Monterey Co., to Sacramento and San Diego. The REEF also serves as a marine laboratory for many colleges including Cal Lutheran Thousand Oaks, CSU Channel Islands, and UCSB. At UCSB, the REEF serves as an interdisciplinary adjunct laboratory for undergraduate courses including: Geology 4 (Intro to Oceanography), EEMB 3 (Intro Biology), EEMB 106 (Biology of Fishes), Writing 2 and Writing 109 ST. This year the REEF had over 3,000 on-campus visitors. The REEF also serves UCSB outreach and summer programs, including the SBC-LTER Schoolyard Program.

OceansAlive!

SBC LTER students participate in the OceansAlive! program of the UCSB Marine Science Institute (MSI), a collaboration with a number of UCSB departments and research programs to provide 125 local junior high, middle school and high school students with UCSB undergraduate and graduate student mentors for science fair projects. These secondary school students then compete at the local level with the opportunity to progress to the state and national levels.

Other SBC Outreach Activities

Direct outreach to the public is an active area for many SBC investigators and students. Al Leydecker, a SBC post doc, assists and helps direct stream and river monitoring, education and sampling programs for several community environmental organizations including Santa Barbara Channel Keeper, Isla Vista Surf Rider and Ventura Surf Rider and the Friends of the Santa Clara River. Jenny Dugan gave a K-12 teacher workshop on the ecology of sandy beaches in San Francisco in May 2008.

SBC investigators also participated in several public groups to provide education and a scientific perspective including the Santa Barbara Community Environmental Council, Friends of the Santa Clara River, Santa Barbara Creeks Council and the UCSB Shoreline Preservation Fund.

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Collection: Principles and Standards for Measuring Net Primary Production in Long-Term Ecological Studies.
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 Hector, C. Perring
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Guerrini, A., J. E. Dugan, "Coastal Dynamics: Toward informing
 ecological restoration in a coastal
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 Collection: Restoria
 Bibliography: Routledge, Oxford

Web/Internet Site

URL(s):

<http://sbc.lternet.edu/index.html>

Description:

This is the project website which describes the research questions, progress, people, outreach, publications, presentations and data products of the Santa Barbara Coastal LTER. The SBC website was converted from a collection of static pages to a scripted system which streamlines the addition of new material and facilitates editing of dynamic menus or style changes. During the conversion, new material was added so that the website is now compliant with LTER recommendations.

Other Specific Products

Product Type:

Data or databases

Product Description:

SBC publications database: Like our datasets, SBC publications are described by the EML schema. We have continued to extend EML for the

reporting and multi-use needs of bibliographic references. We are also continuing work on the web application to accommodate searches and reports, and to increase speed.

Sharing Information:

SBC Publications database is available at <http://sbc.lternet.edu/publications>

Product Type:

Software (or netware)

Product Description:

Query interface for EML datasets: SBC's growing data time series requires tools for querying and sub-setting data tables. We have developed a generic web application which can be applied to many types of data tables described by EML. The application's use of the EML format means it can potentially be applied by many other research groups.

Sharing Information:

This query interface is available through links at <http://sbc.lternet.edu/data>.

Product Type:

Data or databases

Product Description:

SBC datasets on climate, hydrology, stream chemistry, watershed characteristics, coastal ocean currents and biogeochemistry, net primary production of kelp, historical kelp biomass, cover of sessile organisms on reefs, reef fish abundance, abundance and size of giant kelp, reef invertebrate and algal density and stable isotope data from kelp forest food webs are being collected and updated annually.

Sharing Information:

Available final datasets are listed in the metadata catalog on the site's website <http://sbcdata.lternet.edu/catalog/>

Contributions

Contributions within Discipline:

Giant kelp forests have been the subject of numerous studies over the last four decades. The vast majority of this work has been done at the species, population, or community level. Despite learning much about the ecology of kelp forest communities, the understanding of ecosystem level processes in kelp forests remains quite primitive. Results from our reef studies are helping to fill this little studied, yet ecologically important area of research. Of particular significance are our studies of 1) primary production, 2) stable isotope analyses of kelp forest food webs, 3) the role of nutrients in altering these food webs and 4) links between kelp forests and sandy beach food webs.

Our coastal ocean research has identified several physical transport mechanisms important for delivering nutrients to kelp forest ecosystems. Examples include upwelling, runoff, and internal tides, and we have been quantitatively assessing the flux of nutrients due to each mechanism. This research is providing valuable information about transport processes on the inner shelf, which are poorly understood. Quantifying fluxes into and out of the inner shelf is extremely important for understanding the cross-margin transport of carbon, nutrients, and sediments. Most inner-shelf process studies to date have been done on the Atlantic coast of North America. Our work in the Santa Barbara Channel thus fills an important gap and is one of the first studies to focus on a coastal upwelling system.

Our oceanographic research is also helping to further our understanding of physical mixing of freshwater plumes as they enter the coastal ocean. Satellite ocean color estimates of sediment content show that less than 0.01% of sediment discharged in runoff events remains suspended in offshore plumes. Presumably the remainder settles quickly onto the inner-shelf substrate, and some of it may then be redistributed through resuspension or via buoyancy-driven flows. Our measurements will be important for determining the fate of this sediment, and this may have important consequences for the distribution of nutrients after the runoff season is over. Our moored instruments, with their combination of hydrographic and biological sensors allow us to measure outflow events even from very small streams. This allows us to better characterize the transport of materials from land to ocean ecosystems.

Our extensive and intensive measurements of solute and particulate concentrations and export from the steep, flashy catchments along the central/southern coast of California provide important comparative information to the field of watershed science that is otherwise lacking.

Contributions to Other Disciplines:

The research mission of SBC is very interdisciplinary in scope. As such, contributions are being made to a wide range of disciplines including:

terrestrial, aquatic and marine ecology, physical, biological and chemical oceanography, hydrology, geology, geography, toxicology, environmental history and informatics. Coordinated studies among the many disciplines represented in SBC are leading to an improved understanding of the patterns and processes that link land and ocean environments and their consequences for coastal ecosystems. This improved understanding is not only contributing to furthering the many disciplines listed above, but is of considerable value to those interested in studying the extent to which society is influenced by human impacts to coastal systems. SBC is actively initiating ties with the social science community. Investigator Siegel directs the Institute for Computational Earth System Sciences (ICESS) and is head of the SPOT Resource Center (<http://www.spot.ucsb.edu/>) to provide SPOT imagery (a high spatial resolution commercial data set) from the SPOT constellation of satellite sensors to UCSB researchers, including the LTER. To date over 35,000 high resolution scenes have been provided to UCSB investigators. Investigator Lenihan leads a collaborative fishery research program, CALobster (<http://www.calobster.org/>), focused on the spiny lobster fishery with a goal of promoting and conducting community-based research that lead to the best management practices and help maintain working harbors. Investigators Page and Dugan conduct collaborative research on crab fisheries with local trap fisherman. Dugan and Guerrini are writing an interdisciplinary multi-authored book on the deep human and environmental history of a SBC coastal wetland and watershed.

Contributions to Human Resource Development:

Our project provides significant opportunities for research and teaching in science at multiple levels. As of May 2008 six post docs, 21 graduate students, 5 REU students and more than 25 undergraduate students have participated in SBC research during this funding cycle. In addition to gaining valuable research experience, many of the undergraduate students earned academic credit or were given monetary compensation.

Our project's research also finds its way into the classroom as SBC investigators routinely incorporate activities and findings of SBC-sponsored research into their teaching, thereby extending the project's contributions to the broader student body. Many SBC investigators give guest lectures and class demonstrations on SBC research to university courses. SBC investigators, graduate students and staff work with undergraduate students including interns and honors students and mentor independent research by undergraduates and high school students.

The SBC-LTER also provided training opportunities for two teams of undergraduate students from the Department of Mechanical Engineering at UCSB. These teams have been working on two senior design projects. One group is developing a low cost wave sensor and the other is developing an integrated water sampling device. Both will be available for use in the SBC-LTER programs. Members of under-represented groups are present on both teams.

Educational opportunities at SBC are not limited to university students and post docs. Pre-college teachers and non-scientists from the local community routinely participate in our ongoing stream sampling program and gain considerable knowledge on the constituents of runoff and of the processes that influence their abundance.

Increased exposure to the SBC research activities has come by way of the LTER Schoolyard program. In 2008, SBC has continued to increase the exposure of SBC research activities to K-12 students and teachers by developing an exciting new environmental education program for middle school students. The new program partners with local middle schools through a partnership with UCSB's Office of Academic Preparation and Education Outreach (APEO) for environmental education programs including field trips, an educational cruise and individual research projects. The goal of APEO is to build college-going communities that improve student learning, increase college-going rates, and provide equal access to higher education for California's diverse students.

The Santa Barbara Coastal (SBC) LTER outreach, education and training programs benefit from a close association with the University of California at Santa Barbara's Research Experience & Education Facility, better known as the REEF, an interactive aquarium facility. The REEF is equipped with state-of-the-art, aquaria and touch tanks, ranging from 2 to 2,000 gallons. The REEF also utilizes a high-tech life support system for the Research Tank, which highlights current, on-going research at UCSB and the Marine Science Institute, including SBC-LTER research. This program reaches thousands of students annually.

SBC-LTER hosted a SEEDS field trip for 24 undergraduate students from throughout the US and its surrounding territories in October 2007. SEEDS is an education program of the Ecological Society of America whose goal is to diversify and advance the profession of ecology by providing opportunities that stimulate and nurture the interest of underrepresented students. Focused at the undergraduate level, opportunities sponsored by the program include student field trips such as the one to SBC in October 2007.

Contributions to Resources for Research and Education:**Physical resources**

NSF funds from our project are used to maintain a custom 22' research vessel that is specially designed for scuba and oceanographic research. Other research groups on the UCSB campus have access to this vessel for their research needs as well.

Information Resources

SBC's website contributes to information resources by providing the scientific community and the general public access to unique datasets that are of interest to a diverse array of people. Some examples of such datasets include: historical data on giant kelp abundance in the northeast Pacific, SST imagery from NOAA-AVHRR polar orbiters of the Santa Barbara Channel, high frequency radar data of surface currents in the Santa Barbara Channel, precipitation data and soil mapping and land-use coverage of the Santa Ynez Mountains. In 2008 access and format of these datasets were enhanced on our website which was redesigned to fit LTER network standards and updated for content.

Contributions Beyond Science and Engineering:

SBC investigators have been very active in applying their knowledge of Santa Barbara's coastal ecosystems to inform and implement changes in local and regional policies. SBC investigators serve as advisors and committee and board members for a number of local and national groups concerned with conservation and management of natural resources.

Investigator Gaines serves on several committees and advisory groups concerned with fisheries and marine conservation including the Science Advisory Panel for the California Marine Life Protection Act, the advisory board for the California Oiled Wildlife Care Network, the Science Advisory Group for the Interagency Ecological Program of the California Department of Water Resources, the Marine Life Protection Act Baseline Science Management Panel and the University of California Marine Council. He is also a science advisor for the Joint Ocean Commission.

Investigator Schimel is a member of the Kearney Foundation of Soil Science Advisory Committee and Chair of the Arctic System Science Steering Committee (Arctic Consortium of the US).

Investigators Reed and Page work with the staff of the California Coastal Commission (CCC) on a large multidimensional program designed to mitigate for the loss of coastal marine resources caused by the operation of the San Onofre Nuclear Generating Station (SONGS), a coastal power plant located in north San Diego County. The major emphasis in this program is compensation for lost marine resources via wetland and kelp forest restoration. Reed and Page's primary responsibilities are to consult with the employees of the power plant (Southern California Edison), the CCC and their staff, and other resource agencies on ecological issues relating to the design of the mitigation projects and to develop and implement monitoring programs capable of determining whether the biological and physical performance of these projects meet pre-determined standards. Much of the science done on these mitigation projects is quite complementary to that done by SBC LTER and there is considerable exchange of information and ideas between the two projects.

SBC research plays a prominent role in shaping policy towards local watershed issues as well. We have developed mutually beneficial, cooperative associations with local government departments and NGOs. Santa Barbara County's Project Clean Water is engaged in sampling local creeks during the initial rise of the hydrograph and measuring a suite of pollutants including metals, pesticides and herbicides. Our intensive sampling of nutrients and particulates during the entire hydrograph for most storms complements the County's effort, and they and we share our data and interpretations. The Santa Barbara Channel Keepers conduct monthly collections along the Ventura River, and we participate in this fieldwork and complement their in situ measurements with high quality nutrient chemistry. Al Leydecker, a SBC post doc, continued to assist and help direct stream and river monitoring, education and sampling programs for several community environmental organizations including Santa Barbara Channel Keeper, Isla Vista Surf Rider and Ventura Surf Rider in 2008.

Investigator Melack serves on the Water Quality Committee (Hydrology Section) of the American Geophysical Union. He is also on the Standard Methods Committee of the American Water Works Association and the Technical Advisory Committee for Friends of Santa Clara River water quality monitoring program.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

RESEARCH FINDINGS

REEF STUDIES

Kelp forest community dynamics

Results from our annual subtidal community surveys show that the kelp forest ecosystems in the Santa Barbara Channel are extremely dynamic in both space and time. Site specific differences in the timing and intensity of sea urchin grazing, exposure to wave disturbance and sand accretion caused the abundance of giant kelp at the nine mainland sites to vary asynchronously over time and independently in space. Understory algae and sessile invertebrates also displayed substantial variation among sites and years, which is not surprising given the large fluctuations seen in giant kelp, which is known to influence other components of the kelp forest community. For example, a dense *Macrocystis* canopy can reduce light levels near the bottom inhibiting understory algal recruitment and growth. This in turn may affect the distribution and abundance of sessile invertebrates, which may compete with understory algae for space. These different species interactions are tempered by physical and biological disturbances that indiscriminately reduce the abundance of all algae and sessile invertebrates. Such interactions among giant kelp understory algae and sessile invertebrates are evident from analyses of our long term monitoring data, which show a significant positive relationship between interannual variation in the density of giant kelp and interannual variation in the relative abundance of understory algae and sessile invertebrates (Figure 1). This relationship reflects the substantial heterogeneity in community dynamics present among our permanent transects. Transects characterized by high interannual variation in giant kelp abundance were also locations where the structure of the benthic community was highly variable. Conversely, transects with low interannual variability in giant kelp abundance showed less variation in the relative abundance of understory algae and sessile invertebrates.

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In addition to continuing our long term monitoring we are investigating relationships between understory algae and sessile invertebrates in greater detail with experiments and mathematical models. For example, the PhD research of Andrew Rassweiler is investigating dramatic shifts between two very different benthic communities, one in which *Pachythyone rubra*, a filter feeding sea cucumber, persists at high density (>1000 per m²) and one which is dominated by algae and other invertebrates. Spatial and temporal distribution of these communities suggests that they may represent alternate stable states, in which mechanisms reinforce each phase once it is established. He is investigating competition with algae as one such mechanism. Rassweiler has used mathematical models to show that space competition with algae can cause alternate stable states when filter feeders are also consuming algal spores. He has also shown experimentally that the sea cucumbers are competing with algae, and that algal settlement is more than twice as high when the sea cucumbers are removed, indicating that spore predation may be strong. Not all interactions between understory algae and sessile invertebrates are negative. Graduate student Stu Levenbach found that the sessile colonial anemone, *Corynactis californica*, creates a refuge for benthic macroalgae on rocky reefs that are intensively grazed by sea urchins. Within areas heavily grazed by sea urchins, benthic macroalgae and small mobile invertebrates were relatively more abundant among *Corynactis* colonies. Results from field experiments showed that *Corynactis* facilitated the recruitment of macroalgae and tubicolous amphipods in barren areas subjected to intensive grazing. In areas forested by

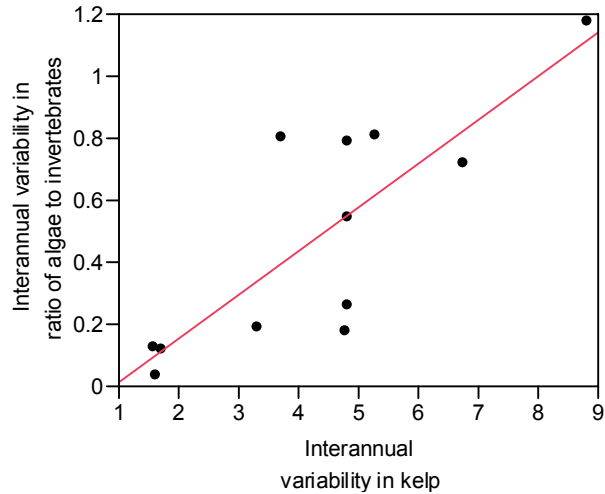


Figure 1. Relationship between interannual variability in the ratio of % cover algae to % cover invertebrates and interannual variability in kelp abundance measured as fronds/m² ($r^2 = 0.66$, $p < 0.0013$). Interannual variability was calculated as the standard deviation in the abundance of kelp and ratio of algae to invertebrates among six years of data (2000-2005).

giant kelp where grazing intensity was low, *Corynactis* suppressed algal recruitment, but facilitated tubicolous amphipods. A manipulation of fish and sea urchins suggested that grazing by urchins, as opposed to predation from fish (primarily surfperch), suppressed tubicolous amphipods and this activity was hindered by the presence of *Corynactis*.

Regional studies of giant kelp abundance

SBC LTER grad student Kyle Cavanaugh is leading an effort to develop a method for the remote assessment of giant kelp (*Macrocystis pyrifera*) canopy cover and biomass using multispectral data from the SPOT 4 and 5 satellites. A time series of 11 dates of satellite imagery for the Santa Barbara Channel was collected between October of 2004 and January of 2007. An algorithm used to determine the surface canopy area identifies kelp-covered pixels using the near-infrared to green band ratio after atmospheric correction by the dark pixel method. A series of common satellite vegetation indices are applied to the imagery and compared to SCUBA diver measurements of frond density and biomass, which are measured monthly at three sites (Arroyo Burro, Arroyo Quemado, and Mohawk) where we are collecting long-term measurements of

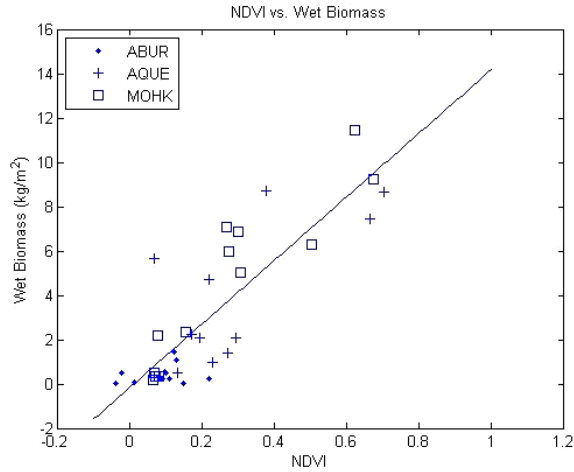


Figure 2. Linear regression of NDVI and biomass measurements ($r^2 = 0.71$; $p < 1 \times 10^{-10}$). The different symbols represent the three sites: ABUR = Arroyo Burro, AQUE = Arroyo Quemado, and MOHK = Mohawk.

NPP by giant kelp. The Normalized Difference Vegetation Index (NDVI) obtained from the satellite images was highly correlated with diver measurements of kelp biomass (Figure 2. $r^2 = 0.71$). The relationship we found between biomass and NDVI was used to transform maps of kelp canopy cover into maps of area specific biomass. We are continuing to build our database of satellite imagery with bi-monthly collections over the entire Santa Barbara Channel, and we are using our recently developed remote sensing techniques to tracked large scale changes in giant kelp biomass along the Santa Barbara coastline. Satellite data of kelp canopy area and validated with diver measurements of area specific biomass will be used to make regional scale analyses of kelp population dynamics in response to various biophysical forcings.

Primary production of giant kelp forest ecosystem

Net primary production (NPP) is influenced by disturbance-driven fluctuations in foliar standing crop (FSC) and resource-driven fluctuations in rates of recruitment and growth, yet most studies of NPP have focused primarily on factors influencing growth. We quantified NPP, FSC, recruitment, and growth rate for the giant kelp, *Macrocystis pyrifera* at three kelp forests in southern California over a 54 month period and determined the relative roles of FSC, recruitment and growth rate in contributing to variation in annual NPP. NPP averaged between 0.42 to 2.38 kg dry mass $m^{-2} y^{-1}$ at the three sites. The initial FSC present at the beginning of growth year and the recruitment of new plants during the year explained 63% and 21% of the inter-annual variation observed in NPP, respectively (Figure 3a). The previous year's NPP and the loss rate (caused primarily by disturbance from waves) collectively accounted for 80% of the inter-annual variation in initial

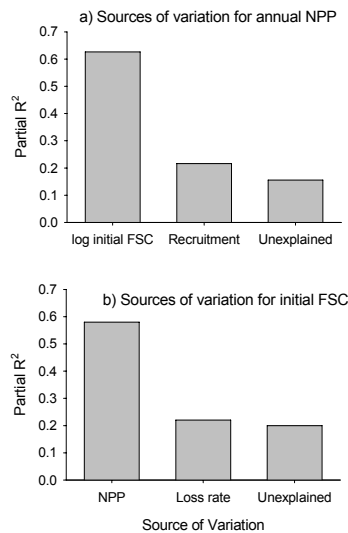


Figure 3. Results from stepwise multiple regression analyses investigating the relative contributions of: (a) standing crop at the start of the growing season (log initial FSC) and annual recruitment density of giant kelp to variation in annual net primary production (NPP), and (b) previous year's NPP and loss rate of kelp biomass in autumn of the previous year (loss) to initial FSC.

FSC (Figure 3b). No correlation was found between annual growth rate and annual NPP, largely because annual growth rate was consistent compared to initial FSC and recruitment, which fluctuated greatly among years and sites. Although growth rate was a poor predictor of variation in annual NPP, it was principally responsible for the high mean values observed for NPP by *Macrocystis*. These high mean values reflected rapid growth ($\sim 2\% \text{ d}^{-1}$) of a relatively small standing crop (maximum annual average = $444 \text{ g dry mass m}^{-2}$) that replaced itself an average of about seven times per year. Disturbance-driven variability in FSC may be generally important in explaining variation in NPP, yet is rarely examined because cycles of disturbance and recovery occur over timescales of decades or more in many systems. Considerable insight into how variation in FSC drives variation in NPP may be gained by studying systems like giant kelp forests that are characterized by frequent disturbance and rapid rates of growth and recruitment.

The algorithms developed to explore regional estimates of giant kelp productivity were applied to hyperspectral images of the Carmel Bay region in central California. Analyses of these images revealed 1.74 km^2 of identifiable kelp canopy along from Cypress Point to Yankee Point (Figure 4) in Monterey County. Regions of highest biomass and productivity were found at the west entrance to Stillwater Cove, along the rocky shore south of Carmel Beach and the south side of Pt. Lobos. The identified aerial coverage of giant kelp exceeded 1.7 km^2 over the 15 km stretch of coastline. This represents a standing giant kelp biomass of 1.3 million Kg (dry mass) and a daily production rate of $20,000 \text{ Kg}$ (dry mass) d^{-1} . The annualized production based on this daily rate is equivalent to 7.1 million Kg (dry mass) and 2.1 million Kg carbon exported to adjacent beaches, the coastal ocean and the deep sea.

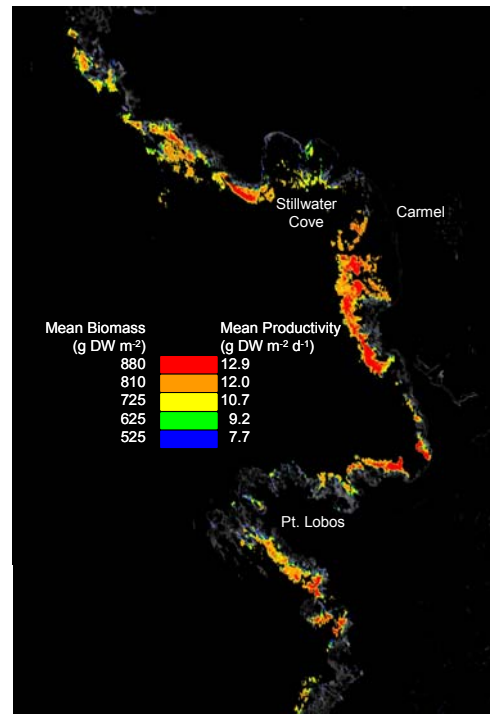


Figure 4. Map of giant kelp biomass and productivity along the Carmel Bay region calculated from NDVI analysis of the PHILLS imagery collected in 2004. Color bars indicate levels of productivity ranging from highest (red) to lowest (blue).

Measurements of oxygen evolution in chambers placed on the bottom under a sparse canopy of giant kelp at Naples Reef showed that production of foliose red algal assemblages was approximately twice that of red turfing algae on a per area basis (GPP foliose red = 12.3 ± 2.2 (S.E.) $\text{mmol O}_2 \text{ m}^{-2} \text{ hr}^{-1}$, turfing red = $5.4 \pm 0.7 \text{ mmol O}_2 \text{ m}^{-2} \text{ hr}^{-1}$). These values are similar to rates previously measured for benthic macroalgae. Assuming a photosynthetic quotient of 1 and that these measurements (which were taken in fall) represent the entire year, we estimate that foliose red algae at Naples Reef produce net $\sim 0.4 \text{ kg C m}^{-2} \text{ yr}^{-1}$, which is comparable to the estimates that we have obtained for sparse populations of giant kelp. These results support the idea that understory algae may be a significant component of kelp forest production, particularly when kelp biomass is low. Although lower in net primary production, turf communities had significantly higher biomass-specific production rates (ANOVA $df = 1,21$, $F=5.9$, $p= 0.02$), suggesting that temperate turf assemblages, like their counterparts on tropical coral reefs, have relatively high growth rates, and may be heavily cropped by grazers. Kelp forests, however, lack the diversity of grazing fishes found on reefs, suggesting that the abundant micrograzers, (e.g. amphipods) found in these turfs may be important in controlling turf biomass.

Monthly chamber measurements of oxygen evolution for understory communities, using 1-hour incubations throughout the day, have shown thus far no significant diel variation in macroalgal production, suggesting photosynthetic saturation at very low light levels. For spring 2007, mean GPP outside the kelp forest at Mohawk Reef was 17.8 ± 5.3 (S.E.) $\text{mmol O}_2 \text{ m}^{-2} \text{ hr}^{-1}$, while rates inside the forest averaged $5.1 \pm 1.0 \text{ mmol O}_2 \text{ m}^{-2} \text{ hr}^{-1}$, affirming a strong affect of the kelp canopy on understory algal production. Phytoplankton production was even more strongly affected by the presence of kelp, with rates outside the forest >50 fold higher than rates inside the kelp forest (275 vs. $5 \text{ mg C m}^{-3} \text{ day}^{-1}$). We are continuing these

monthly measurements to better understand: (1) how seasonal variations in kelp canopy may affect primary production of understory algae and phytoplankton, (2) the extent that production by these ecosystem components complements each other, and (3) the primary sources of variation in their production.

Gene flow, inbreeding depression and population connectivity in giant kelp

We found extensive polymorphism in the microsatellite markers that we tested, which was indicated by the high allelic richness found within each of our nine long-term study sites. Preliminary results to date show that kelp populations along the mainland coast of the Santa Barbara Channel have a low genetic structure, which is indicative of high gene flow. Despite this apparent high gene flow we still found a significant pattern of isolation by distance. Moreover, all nine of the populations sampled showed high F_{IS} values, which is consistent with high levels of inbreeding. We are in the process of testing alternative explanations for these patterns (e.g., frequency of other alleles or other genotyping related problems).

Biological and Physical coupling within giant kelp forests

Findings from the deployment of extensive arrays of flow sensors within and around the kelp forest at Mohawk Reef indicated a clear reduction of current speeds within the forest that is dependent on the density of kelp individuals, a visible downstream wake characterized by slower flows, a zone of marked flow acceleration along the offshore boundary of the forest, and strong effects of water depth on velocity. These features have implications for understanding the degree to which nearshore flows pass through kelp forests as opposed to being diverted around them. This in turn bears on the capacity of kelp forest ecosystems to influence a variety of nearshore waterborne commodities, including nitrate, dissolved and particulate carbon, phytoplankton, and zooplankton, each of which may be produced or consumed by members of the kelp forest community.

To determine the relative importance of different sources of nitrate to the annual nitrogen demand by *Macrocystis pyrifera*, we: (1) quantified ambient nitrate concentrations in the kelp forest at our Mohawk study for 13 months using an in situ nitrate analyzer, and (2) characterized physical supply mechanisms using water column thermal structure and flow regime data obtained in the forest's interior and at its outside edge. Monthly nitrate supply varied by a factor of 50 over the 13 month study, while measured net uptake of nitrogen varied only five fold. Maximum net nitrogen acquisition rates for fronds in the interior of the forest were $0.18 \text{ mmol N g}^{-1} \text{ month}^{-1}$ during spring upwelling in 2005 and declined to $0.04 \text{ mmol N g}^{-1} \text{ month}^{-1}$ during autumn until upwelling resumed the following year. The net nitrogen acquisition rate for growing canopy fronds at the edge of forest averaged 22% higher than for those in the forest's interior. Modeled gross nitrogen uptake with consideration of Michaelis-Menten uptake kinetics for nitrate and mass transfer limitation was higher than measured acquisition throughout the study except during the highly stratified summer and autumn months when observed net uptake exceeded modeled gross uptake (Figure 5). The late summer and fall shortfall in modeled nitrogen uptake suggested that the kelp forest received

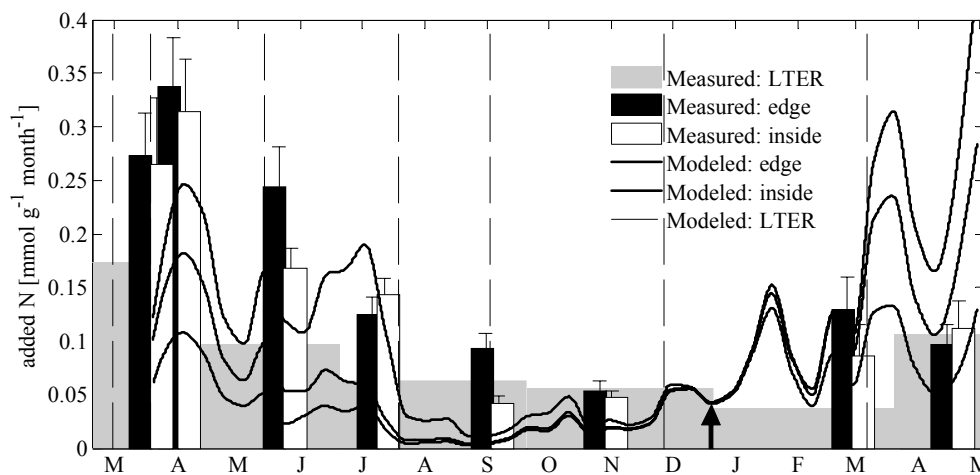


Figure 5. Time series of measured acquisition and modeled uptake of nitrogen in $\text{mmol g}^{-1} \text{ month}^{-1}$ by growing canopy fronds at the edge and inside the Mohawk kelp forest, and of all fronds in a 40 m x 40 m area of the interior of the forest (LTER) for the period 21 March 2005 through 30 April 2006.

over half of its nitrogen from sources other than seawater nitrate, possibly ammonium from epibionts. Internal waves and local streams supplied less than 9% of the total annual nitrate supply, but internal waves contributed 20% of the supply during stratified periods. Calculations of nitrate flux into the forest relative to both measured and modeled uptake indicate that kelp utilized < 7% of the nitrate supplied to the forest throughout the study. Nitrate supply to this modest sized kelp forest was roughly equivalent between alongshore (45%) and cross-shore flows (55%), which distinguishes it from large kelp forests in which cross-shore flows dominate exchange.

Reduced flow, nutrients and PAR in the interior of the forest appear to have significant effects on kelp physiology and growth. We found that kelp fronds grew faster and into bushier shapes at the edge of the Mohawk kelp bed relative to the interior. Differences in growth between fronds at the edge and interior of the bed appear to be more pronounced at higher frond densities. Data collected on flow velocities, light, temperature, and seawater nitrate from moored instruments coupled with semi-monthly analyses of kelp tissue nitrate and carbohydrate storage compounds (mannitol, laminarin) are being used to investigate the specific mechanisms that cause kelp growth to differ at the edges and interior of the forest.

Sessile suspension feeding invertebrates rely on water flow to bring them food particles. Thus, their short term rates of food capture and longer term rates of growth may be affected by current speed. LTER graduate student Katie Arkema is using field transplant experiments and laboratory analyses of gut fullness to investigate the effects of current speed on food capture and colony growth rate in the encrusting bryozoan *Membranipora tuberculata*. *Membranipora tuberculata* feeds on phytoplankton and is arguably the most abundant suspension feeder in southern California kelp forests, where its colonies occur mostly as an epiphyte on giant kelp. Results

to date show that food capture rates (as indicated by gut chlorophyll *a* concentrations) are greatest at intermediate flow speeds (Figure 6). Previous laboratory flume studies have shown that the feeding structures of *Membranipora* are inhibited in fast flows, which is consistent with Arkema's finding of low concentrations of chlorophyll *a* in the guts of *Membranipora* at high flow sites. The relationship between colony growth rate and current speed was similar to that between food capture and current speed; growth rates were slowest at sites where current speeds were consistently low (<5cm/s) or consistently high (>20 cm/s) and fastest at sites with intermediate current speeds (5-20 cm/s). Growth rates also varied within sites. Position in the forest also affected *Membranipora* growth rates as colonies transplanted to the edges of kelp forests grew faster than colonies transplanted to the interiors of kelp forests. This last finding is consistent with the results of our hydrodynamic studies done at Mohawk Reef where we found a significant reduction in current speeds within the forest that was dependent on the density of kelp (see above) and suggests that the slow growth rates observed for *Membranipora* colonies in the interiors of kelp forests relative to the edges result from reduced food capture in slower water flows created by the dampening effect of giant kelp.

As part of the research collaborative on the ecomechanics of kelp, extensive second-by-second recordings were made of hydrodynamic forces imposed on two important and common seaweeds: *Macrocystis pyrifera* (the giant kelp) and *Egregia menziesii* (the feather boa kelp). These measurements demonstrated that forces due to waves impinging directly on emergent organisms and forces arising from flexible organisms whiplashing in flow often greatly exceeded forces imposed by classic velocity-dependent drag. Such impingement and inertial forces routinely exceeded those imposed by drag by over a factor of three. Findings from the force measurements have also informed patterns of kelp dislodgement

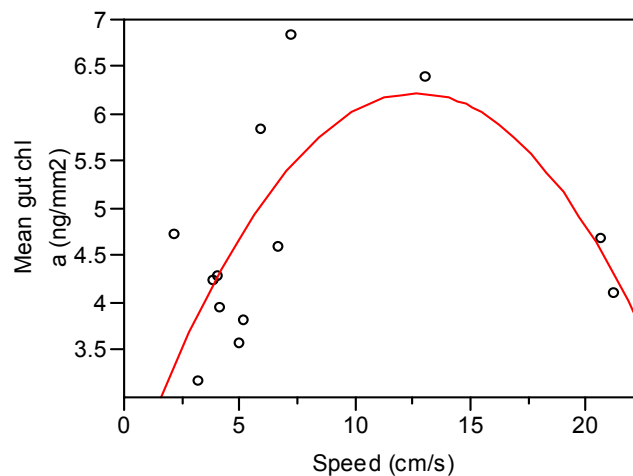


Figure 6. Mean gut chlorophyll *a* concentration (ng/mm²) as a function of ambient current speed (cm/s). Current speed explains 42% of the variation in gut chlorophyll *a* concentration ($r^2 = 0.45$, $p < 0.05$).

quantified via a 3-year monitoring program that tracked the fate of several hundred tagged giant kelp individuals at Mohawk Reef. It is well known that wave-driven flows associated with winter storms create strong seasonal patterns of kelp disturbance. However, the potential roles of wave-induced dislodgement in modulating size and age-structure in kelp forests have not been examined. Results of this project reveal strong effects of shape and size on the susceptibility of giant kelp to physical disturbance. Such size and shape-dependent consequences cascade to influence the interaction of overall forests with arriving flows, the degree of exchange of interior waters with exterior fluid masses, and levels of uptake and production of limiting ecosystem-level constituents such as nitrate and carbon.

Food web studies using stable isotope

$\delta^{13}\text{C}$ values of suspended particulate organic matter (POM) on reefs tended to decrease following periods of significant rainfall at the reef site most influenced by freshwater runoff, increase with phytoplankton standing crop at all reefs, and generally decline in both wet and dry years in late fall-early winter at all reefs in the absence of obvious drivers. Stable isotope values of reef consumers indicated little direct use of terrestrially-derived POM. However, a pattern of ^{15}N -enrichment in two common species, the sea urchin, *Strongylocentrotus purpuratus* and annelid, *Diopatra ornata*, with increasing influence of watershed runoff suggested that terrestrially-derived nitrogen may enter the food web indirectly through a trophic intermediate such as microbes or algae (Figure 7). The importance of giant kelp to the reef food web varied with consumer feeding mode. In contrast to previous studies, $\delta^{13}\text{C}$ values of suspension-feeders suggested little use of kelp-derived material, based on the similarity in isotope values of these consumers among reefs during the first two years of the study when kelp biomass was low, and the absence of a directional shift in isotope values that would indicate the use of more ^{13}C -enriched production during the last two years of the study when kelp biomass was higher at two of the reefs. However, isotope values for herbivores were generally ^{13}C -enriched relative to suspension-feeders, reflecting the use of local giant kelp or other ^{13}C -enriched benthic algal production. Thus, spatial and temporal fluctuations in the biomass of giant kelp would be least likely to impact the food resources of suspension-feeders and have greatest effect on benthic herbivores.

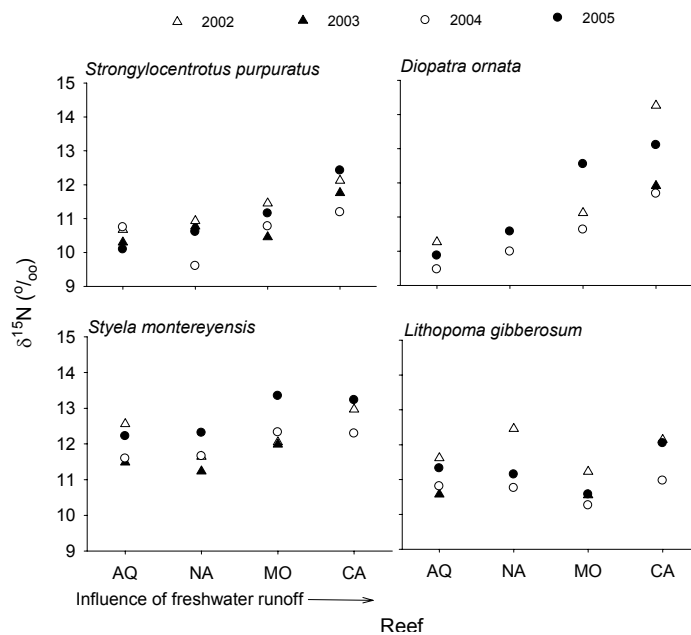


Figure 7. Variation in the $\delta^{15}\text{N}$ values of selected consumers among reefs. Reefs are arranged from left to right relative to increasing influence of freshwater runoff as measured by variation in salinity (AQ= Arroyo Quemado, NA = Naples, MO = Mohawk, CA = Carpinteria).

OCEAN STUDIES

Moored instruments and monthly sampling – Data from the time series of monthly water column sampling and moored observations continue to support ongoing activities including assessments of mechanisms of nutrient delivery to kelp forests (McPhee Shaw et al. 2007, Fram et al. in prep.), the affect on kelp forests on current flow through and around kelp forests (Gaylord et al.2007) and the carbon and nitrogen isotopic composition of suspended particulate matter in the past (Page et al. in review). These findings are largely detailed in the section entitled “*Biological and Physical Coupling within Giant Kelp Forests*”. Data are used by SBC investigators, post docs, graduate students and in collaborative efforts with other projects. An example of a new collaborative effort that is making use of these data is work that the SBC LTER is doing with Drs. Grace Chang and Tommy Dickey of UCSB and Erika McPhee Shaw of Moss Landing Marine Laboratory to further examine cross-shelf physical processes that deliver nutrients to the inner shelf.

UCSB's ocean physics laboratory has deployed moorings on the shelf in the Santa Barbara Basin for several years, but at greater depths than those deployed adjacent to kelp forests by us. By combining data from the SBC LTER and these moorings we obtain a more comprehensive cross-shelf instrument array. The data from these mooring are being combined and used to assess cross-shelf processes on a larger spatial scale that previously done using only SBC LETR data from moorings adjacent to reefs.

Surface Current Patterns

Surface current data from HF radars are being used to understand a number of important dynamical processes in the Santa Barbara Channel. As described in the section on analysis of SBC-LTER cruise data, surface current patterns are being incorporated into the ongoing analysis of primary productivity in the channel. They provide an important link between synoptic circulation patterns in the channel and sub-surface property fields observed by ship board instrumentation. HF observations are also being used to examine the response of inner shelf currents to changes in wind forcing along the mainland coast from Carpinteria to Point Sal. A hypothesis of this research is that wind relaxation events are an important trigger for poleward flows that connect kelp habitats in the Southern California Bight with kelp beds along the central California coast.

Cross Shelf Processes

The deep velocity structure of a cyclonic eddy is shown in Figure 8 (right-hand panel). The surface flow of the eddy observed by the HF radars (Figure 8 left-hand panel) extended to about 400 m depth, which indicates eddies transport phytoplankton over the full range of depths spanning the euphotic zone. The rotation of the eddy also causes uplift of the density surface which may drive primary production processes in the eddy.

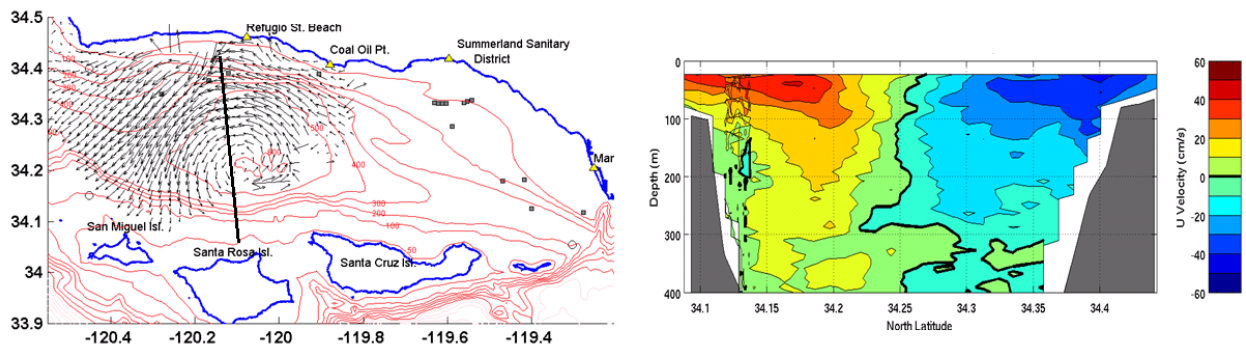


Figure 8. Left-hand panel shows mean velocity field during Sept. 2002 cruise. Shipboard ADCP section shows subsurface velocity field along ship track in left-hand panel.

We assembled the 5 meter productivity data from all the cruises to obtain a better understanding of phytoplankton distributions in the Santa Barbara Channel and the processes that control their rates of primary productivity. Results show that regions of high chlorophyll (red and yellow shades in Figure 9) are concentrated in areas where the 25.52 density surface is uplifted due to ocean currents. Our analyses to date indicate that the euphotic zone is 20 m deep or less, and the presence of fluorescence at greater depths suggests isopycnal transport processes may be important in re-distributing phytoplankton vertically. Jo Goodman, a graduate student, participated in these analyses along with Chris Gotschalk, a staff research associate.

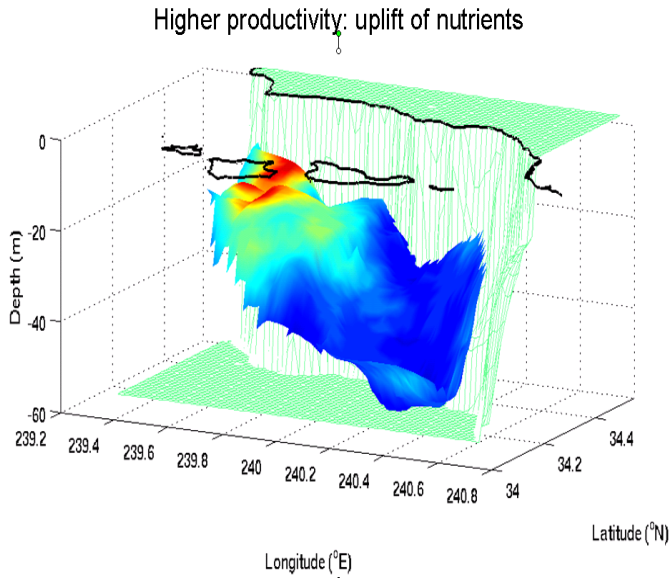


Figure 9. 3-dimensional image of fluorescence, an indicator of phytoplankton concentration, draped on the 25.52 kg m^{-3} potential density surface during SBC-LTER Cruise #5 for the period 9-12 Sept 2002. The coastline is in light blue and bathymetric data are truncated at 60 m depth

Analysis of the productivity data resulted in several important findings over the past year. Grouping of cruises according to season revealed that seasonal upwelling drives a maximum during spring in phytoplankton biomass and productivity in the SBC as shown in Figure 10. A second maximum occurs in the western basin during fall. These biological patterns appear linked to cyclonic rotation that develops in the western Santa Barbara Basin during spring and fall. Primary production and chlorophyll biomass are significantly elevated within the cyclonic flow (Figure c), but carbon assimilation numbers, a measure of primary productivity per unit mass of chlorophyll, is not (Figure 11). This suggests that accumulation of phytoplankton by convergence within the cyclonic flow, rather than nutrient injection, is the dominant process affecting primary production. These and other results from this analysis were presented by Mark Brzezinski at the ASLO meeting in February 2007.

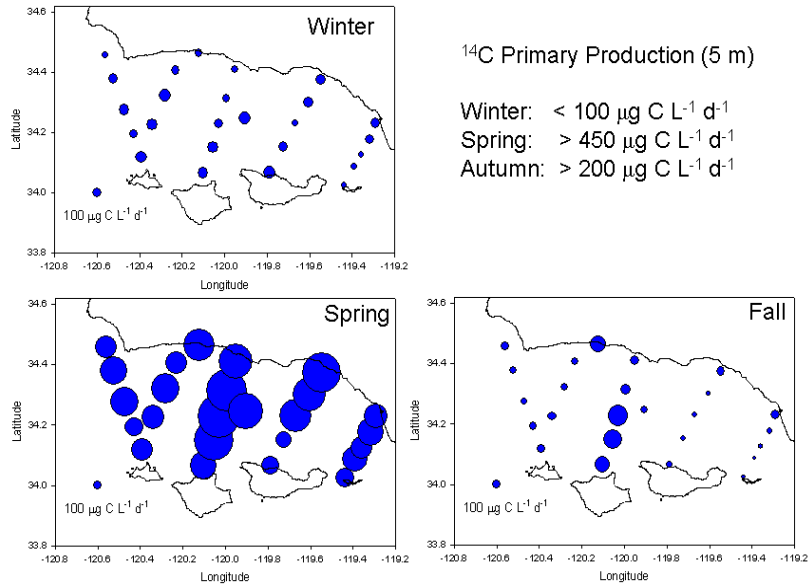
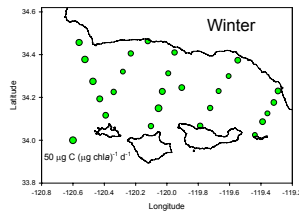


Figure 10. Upper, and lower two panels show seasonal composites of primary productivity at 5 m depth from fifteen cruises for which data are available. The size of the blue dots indicates the magnitude of productivity according the scale in each panel.



Carbon Assimilation Number (5 m)

Similar for all seasons
 $50 - 90 \mu\text{g C } (\mu\text{g chl}a)^{-1} \text{ d}^{-1}$

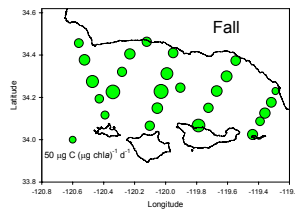
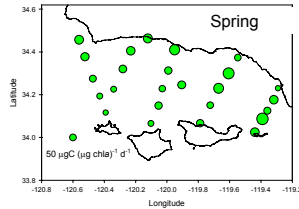
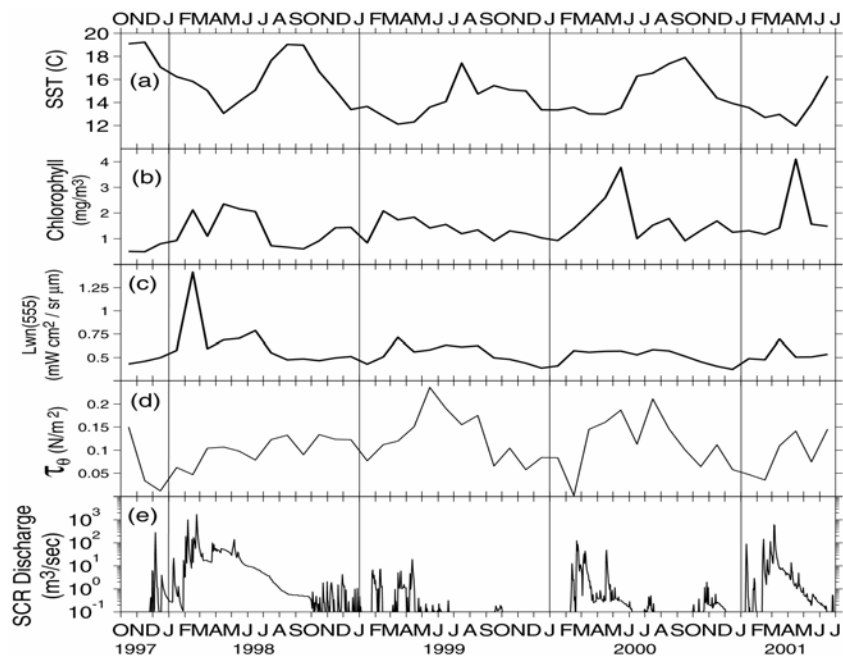


Figure 11. Upper and lower two panels show seasonal composites of carbon assimilation number at 5 m depth from fifteen cruises for which data are available. The size of the green dots indicates the magnitude of the assimilation number according to the scale in each panel.

Satellite Data

Satellite ocean-color and sea-surface temperature (SST) imagery are used to assess the occurrence, extent and duration of surface sediment plumes from discharged stormwater and phytoplankton blooms in the Santa Barbara Channel (Otero and Siegel, 2004; Warrick et al. 2004). Monthly mean annual cycles of SST, chlorophyll (Chl) and the water-leaving radiance at 555nm (LwN(555)), an index for sediment-affected waters, show plumes associated with runoff in winter, while blooms occur in the late spring–early summer and are associated with cool SST and upwelling favorable winds. Interannual variations are consistent with remote forcing by El Niño cycles (Figure 12). During the 1997–1998 El Niño, Chl concentrations are moderate, and El Niño-induced floodwater discharges result in high LwN (555) values throughout the Santa Barbara Channel. However, a correspondence between El Niño–La Niña a state and Chl is not found for the Santa Barbara Channel due to what appears to be the advection of nutrient-depleted waters from the east. Empirical orthogonal function analysis is used to spatially and temporally deconvolve processes regulating SST, Chl and LwN (555).

Figure 12. Santa Barbara Channel (SBC) regional mean time-series of (a) SST, (b) Chl and (c) LwN(555) averaged on a monthly basis. Only scenes with a minimum of 70% coverage (88% coverage for SST) are used in computing spatial averages over the SBC. Local forcing by (d) wind stress at the west channel buoy along the principal axis (aligned 1221 clockwise from north) and (e) daily discharge from the Santa Clara River as measured by the USGS.



WATERSHED STUDIES

Nutrient concentrations and fluxes as a function of land use and variations in runoff

The coastal watersheds of the Santa Barbara Channel experience a Mediterranean climate with mild, moist winters and moderately warm, generally rainless summers and offer a rich range of conditions for experimental and observational study. The mainland drainage areas are comprised of three watershed scales: 74 small coastal catchments draining from the Santa Ynez Mountains varying in size from 1 km² to ~ 50 km² with a total area of 790 km²; the Ventura River draining 590 km²; and the Santa Clara River draining 4200 km². Steep mountain slopes composed of readily eroded material over shallow bedrock layers and strongly seasonal rainfall create large sources of sediments. The catchments differ widely in the proportion of agricultural and urban development. The topography of the coastal watersheds is characterized as mountainous headwaters and gently sloping coastal plains separated by transitional foothills. From west to east, there are both elevational and land use gradients. Headwater elevations increase from approximately 300 to 1400 m, and land uses on the coastal plain and foothills change from mostly rangeland to a combination of urban and agricultural lands. Most of the annual precipitation and corresponding runoff occurs in only a few large events resulting in high peak discharges and a rapid return to near baseflow conditions.

Water year (WY) 2007 had very low rainfall and consequently small amounts of export of nutrients to the coastal ocean. We observed much lower concentrations of nitrate and ammonium in comparison to WY 2005 in the San Onofre catchment, as it continues to recover from a wildfire that buried nearly the entire area. Results from WY 2005 indicated that nitrate concentrations during storm runoff from burned catchments increased by as much as 7 times, and phosphate concentrations increased by 4 to 5 times. A large ammonium flush occurred during the first two storms of the season, and ammonium concentrations were greater than nitrate concentrations in the first storm.

The Ventura River ranges in flow from near 0 to 11 m³ s⁻¹. Monthly synoptic sampling, in collaboration with the Santa Barbara Channelkeepers, of nutrients at 15 locations indicates nitrate peaks in early winter, presumably from mineralization and mobilization after the advent of the rainy season, with concentrations decreasing to a minimum by late summer. Phosphate follows a similar pattern. Variation in nitrate (0 to 550 μM) and phosphate (0 to 35 μM) in the river and its tributaries is considerable. During winter stormflow, nitrate concentrations in the lower, urbanized portion of the catchment are decreased by dilution from surface runoff, while phosphate concentrations increase throughout the basin coincident with sediment mobilization.

The Santa Clara River has been sampled monthly at 5 to 6 sites since November 2005 in collaboration the Friends of the Santa Clara River. The sites span the length of this large watershed and include forest service lands, extensive orchards and urban reaches. Nitrate concentrations ranged from 0.7 to 182 μM and phosphate ranged from 1.1 to 5.8 μM.

In-stream and estuarine processing of and responses to nutrients and invasive species

Biological processing of nitrogen and phosphorus in streams can alter both the form and the total amounts of N and P that are delivered to coastal systems. Understanding the structure and function of the stream biota with regard to nutrient processing is therefore necessary in order to understand the transport and fate of these nutrients. The organisms principally responsible for uptake and transformation of N and P include algae, vascular plants, and microscopic heterotrophs. PhD student, Julie Simpson has found that algal biomass varies greatly depending on the surrounding land use, ranging from 1.6 mg m⁻² chlorophyll *a* in an undeveloped watershed site to 4000 mg m⁻² chlorophyll *a* at an urban site. Dissolved nutrient concentrations were highly variable across sites and had a broad range of N:P ratios. Results from nutrient diffuser experiments showed that the accrual of algal growth at the sites in watersheds with little to no development was consistently nitrogen limited. Benthic communities at these sites included diverse diatom assemblages, red algae, and N-fixing cyanobacteria. However, algal growth on the nutrient diffusers did not show a significant positive response to either N or P addition at most of the anthropogenically influenced sites.

Ludwigia hexapetala is an invasive, emergent vascular plant on the lower Ventura River. Presence of this plant appears to inhibit filamentous green macroalgae, while facilitating growth of shade-tolerant diatoms and has ecosystem-level effects. Wastewater effluent enters the river and produces stream water nitrate concentrations of 100-200 μM. Nitrate uptake rates downstream of the treatment plant inputs averaged 5 kg N/km/day, and direct uptake by *Ludwigia* could account for 20-40% of this nitrate

drawdown. Further nitrate removal from the water column may be indirectly facilitated by the presence of *Ludwigia* through facilitation of diatom population growth.

Coastal marshes can modify nutrient-rich runoff from upland catchments and can augment export of organic matter to near-shore communities via tidal exchanges. To understand these influences, PhD student Steve Sadro characterized vegetation, flushing rates and residence time of water within Carpinteria salt marsh. Vegetation mapping from airborne hyperspectral data permitted discrimination of the dominant vegetation classes. Analysis of tidal fluctuations have yielded inundation-elevation curves that indicate *S. virginica* and *J. carnosa* are dominant in areas that are inundated for periods of 14-17 % while multi-species mixtures and grasses are dominant in areas that are inundated for periods of 6-9 %.

PhD student Darcie Goodman continues to study the Devereux Slough ecosystem, a seasonally closed canyon mouth estuary located just west of Coal Oil Point. The purpose of this research is to obtain an in-depth understanding of the ecological conditions of the estuary through intensive monitoring conducted over a four-year period. WY 2007 was the first year of the study in which the slough did not flush and there was no exchange with the ocean, which resulted in peculiar conditions. Of the nine most common fish species recorded at the slough, only three species have been abundant this spring and fall following the dry storm season: *Fundulus parvipinnis* (California Killifish), *Gillichthys mirabilis* (Longjaw Mudsucker) and the endangered tidewater goby, *Atherinops affinis* (topsmelt), which is usually very abundant during the spring and early summer, has been rare this year. *Gammarus* (freshwater shrimp) and *Baetis* (mayfly) are the most abundant invertebrates found in sediment samples. *Salicornia virginica* is the most common vegetation found in the slough system, and the salt grass *Distichlis spicata* and *Frankenia salina* (Alkali Heath) are the most common species in the riparian zone.

The red swamp crayfish, *Procambarus clarkii*, is an invasive macroinvertebrate in many lakes and streams throughout the western U.S., including Santa Barbara and Ventura Counties, California. Because this species is a generalized omnivore, determining its potential impacts on native taxa is important for predicting community responses to this widespread exotic species in California and elsewhere. PhD student, Kristie Klose performed field and lab experiments to examine several aspects of the ecological interactions of the crayfish in southern California. The first part of her field research entailed field experiments delineating the effects of a *P. clarkii* density gradient on benthic invertebrate biomass and diversity, basal resources, and sediment levels in two disparate Californian stream communities. These experiments showed that habitat type, invertebrate composition, and dominant trophic linkages influenced the effects of omnivory in both streams, ranging from effects on large benthic invertebrates in the Santa Ynez River to indirect effects on small consumers in the Ventura River. The second part incorporated field experiments delineating the individual and combined effects of *P. clarkii* on two native consumers, snails (*Physella gyrina*) and atyid shrimp (*Atyoida bisulcata*). The results indicated that *P. clarkii* generated complex and different effects, probably mediated through multiple trophic interactions involving benthic invertebrates, periphyton, leaf litter, and non-trophic activities including effects on sedimentation and snail behavior. The third part included laboratory experiments examining the effects of species interactions (i.e., crayfish vs. snails) on consumer behavior and survival through snail spatial and temporal microdistributional changes as a consequence of crayfish movement limitations and foraging activities at night. These results indicate that cues produced by predators (e.g., chemical, mechanical) altered prey microdistributions, but that prey responses (e.g., moving above the water line or to horizontal refugia without crayfish) depended on the intensity and nature of cues.

Preliminary analyses of stream experiments testing bi-directional relationships between algal diversity and primary production suggest strong direct effects of both nutrient loading and algal species richness on primary production, but that nutrient loading and richness did not interact to influence production as expected. This may be due to the fact that nutrient levels in streams around Santa Barbara are already excessively high due to eutrophication and, as a result, nutrient loading did not alter richness as many studies predict.

INFORMATION MANAGEMENT

Publications database

Like our datasets, SBC publications are described by the EML schema and are available online <http://sbc.lternet.edu/publications>. We have continued to extend EML for the reporting and multi-use needs of bibliographic references. We are also continuing work on the web application to accommodate searches and reports, and to increase speed.

Query interface for EML dataset

SBC's growing data time series requires tools for querying and sub-setting data tables. We have developed a generic web application which can be applied to many types of data tables described by EML (available through links at <http://sbc.lternet.edu/data>). The application's use of the EML format means it can potentially be applied by many other research groups.

SBC-LTER Website

The SBC website (<http://sbc.lternet.edu>) was converted from a collection of static pages to a scripted system which streamlines the addition of new material and facilitates editing of dynamic menus or style changes. During the conversion, new material was added so that the website is now compliant with LTER recommendations.

RESEARCH ACTIVITIES

REEF STUDIES

Kelp forest community dynamics

The primary objectives of our long-term kelp forest monitoring are to: (1) determine patterns of regional variability in the structure and dynamics of kelp forest communities over short and long temporal scales, and (2) obtain data for assessing population and community level responses to variation in the magnitude and composition of terrestrial and oceanic inputs to coastal reefs. To achieve these objectives we initiated an annual kelp forest monitoring program in the summer of 2000 (the first year of our project) in which the abundance of kelp forest plants and animals are recorded along permanent transects at three sites located along the mainland coast in the Santa Barbara Channel at varying distances from sources of terrestrial runoff. Six additional mainland sites were added in the summer of 2001, and two sites at Santa Cruz Island were added in the summer of 2004. Two to eight 40 m long transects were installed at each site. The transects are marked with metal stakes fastened to the bottom at eight meter intervals. The abundance of relatively large solitary algae (e.g., kelps), invertebrates, and cryptic species of bottom-dwelling reef fish are counted in a 1 m wide area on both sides of each 40 m transect. Smaller species (and smaller individuals of large species) of algae, and invertebrates are counted in six permanently placed 1 m² quadrats that are located at eight meter intervals along each transect. The percentage cover of understory algae, sessile invertebrates, and various substrate types is determined along each transect by recording the biota and substrate intersecting an imaginary perpendicular line positioned at 1 m intervals located 0.5 m on both sides of each transect (n = 80 points per transect). The abundance and size of mobile reef fish are sampled on the bottom in a 2 m wide and 2 m high corridor along each transect. Sampling of all sites is done once per year in the summer (late July), with the exception of mobile reef fish which are sampled every time a site is visited (sampling frequency ranges between 2 to 20 times per year). Tidbit temperature loggers are positioned on the bottom at each site and sample at a frequency of once every 15 minutes.

We also continue to sample 11 reefs at Santa Cruz Island as part of a pre-SBC LTER ongoing effort. The goal of this component of our research is to assess abundances of certain demersal fish and their benthic crustacean food, and ascertain the state of each reef (forested by giant kelp and/or by understory algae, urchin barren, etc.). These reefs have been sampled yearly (or more often) since 1982, as part of ongoing research by Russell Schmitt and Sally Holbrook. At each reef, six key species of demersal fish are counted by divers along permanent 2 meter wide transects at depths of 3m, 6m, and 9m. Random point contact line transects are used to assess the composition of benthic substrates (rock, sand, and species of algae or invertebrate) along the band transects. Benthic samples are removed from 0.1m² quadrats, brought to the lab and processed to obtain counts and size structure of crustaceans and other invertebrates as well as species composition and biomass of algae. Adding two of these 11 sites to our core kelp forest monitoring program in the summer of 2004 allows us integrate the long-term nature of the Santa Cruz Island study with the more taxonomically comprehensive sampling of our mainland sites. Collectively, these data afford a rich opportunity to track long-term changes in these reef communities, and relate observed variation to large scale physical and biotic processes that occur in the Southern California Bight.

In 2002 we completed a field guide to the common kelp forest algae and invertebrates of the SBC LTER that contains photographs, key characteristics and habits of all the species sampled in our kelp forest monitoring program. During 2006 we produced the 3rd edition of the field guide which was expanded to include reef fish and nearshore marine mammals. This document is used to train students, staff and PIs in the identification of the species that are being monitored on the project, and helps to ensure quality control of the data being collected. It is available to the public at large on the SBC website, where it serves as a useful tool in describing the marine fauna and flora of the SBC LTER. Updating and improving the field guide is an ongoing task that our summer REU interns routinely participate in.

Long term experiment on species interactions

One of the predictions for climate change during the next several decades is for increased winter storm activity in California. Such changes are likely to have profound effects on giant kelp forest ecosystems because winter storms are a major source of disturbance that removes kelp and other biota. An increasing frequency of severe winter storms would likely result in large losses of giant kelp every winter. Giant kelp is the foundation species of the ecosystem and our long-term monitoring shows that the dynamics of the benthic community of understory algae and sessile invertebrates are directly linked to the dynamics of giant kelp.

Specifically, giant kelp (which is a dominant competitor for light) has a direct negative effect on understory algae and an indirect positive effect on sessile invertebrates (which compete with algae for space). To investigate the ecological consequences of regular kelp loss during winter to the structure and function of kelp forest communities in the Santa Barbara Channel, we initiated a long-term experiment in winter 2008 in which giant kelp is removed once per year in winter from permanent plots to simulate the effects of increased storm frequency on giant kelp. Adjacent plots where kelp is left undisturbed serve as controls. Changes in the structure (e.g. species abundance, diversity) and function (e.g. primary production of understory algae, detrital accumulation) of the benthic community are being followed over time with twice seasonal monitoring.

Regional studies of giant kelp abundance

ISP Alginates (formerly Kelco Co.) has collected information on the biomass of giant kelp in California and Mexico from routine (approximately monthly) aerial surveys since 1958. A standard protocol is used by an observer in a small fixed-wing aircraft to visually estimate the harvestable tonnage of giant kelp biomass for 109 designated kelp beds. Observations are recorded on data sheets and archived in notebooks housed at ISP Alginates. In the summer of 2000 ISP Alginates provided us with copies of all their archived records. We used these records to create a digital database on the historical abundance of giant kelp throughout its range in California and Mexico. Quality control on this database was completed in 2001 and maps and other descriptive information on the kelp beds of Central, Southern, and Baja California were added to the database in 2002. ISP alginates ceased operations in California in 2006 after more than fifty years of harvesting kelp. Mr. Dale Glantz, who performed the kelp surveys for ISP Alginates for the last 25 years, is continuing to conduct aerial kelp surveys and SBC LTER has entered into an agreement with him to purchase kelp data from these flights. All data and metadata are available on the SBC website at <http://sbc.lternet.edu/data/research/reef/historical-kelp-data/>. This database enables us to more easily evaluate long-term trends in the abundance of giant kelp and allows us to place our observations of kelp abundance within SBC into a much broader regional perspective.

We have also begun exploring regional dynamics of giant kelp using SPOT high spatial resolution (10 & 20 m) multispectral satellite imagery. UCSB was recently designated as a SPOT imagery research center, giving UCSB students and researchers nearly unlimited, nearly free access to SPOT imagery and the ability to acquire new scenes (details at <http://www.spot.ucsb.edu>). Recently we developed a robust method for delineating kelp-covered pixels by using a near-infrared to green band ratio in multispectral SPOT imagery. In 2007 SBC Investigators Siegel, Zimmerman and Gaines obtained funding from NASA for a collaborative project with SBC LTER that integrates kelp data from SPOT imagery and SBC diver surveys with physiological and population modeling with the goal of producing spatially explicit forecasts of kelp forest ecosystem responses to a suite of regional scenarios representing the range of anticipated changes in climate and human activities.

Primary production of giant kelp forest ecosystems

In 2001 we initiated field studies designed to examine long-term spatial and temporal patterns of variation in the net primary production (NPP) of the giant kelp *Macrocystis pyrifera* and the factors that control them. *Macrocystis* is the largest alga in the world and it is believed to be one of the most productive organisms on earth. A single individual can be more than 30 m tall and consist of over a 100 fronds. Plants may live up to four to six years, while individual fronds live about 3-5 months. In May 2002 we refined the methodology that we use to estimate changes in standing crop. The current methodology consists of estimating the standing crop of giant kelp monthly in fixed plots at three sites (Mohawk Reef, Arroyo Burro, and Arroyo Quemado) from diver measurements of the density and length of all fronds > 1 m tall. Allometric equations are used to convert these measurements into an estimate of the total length of all fronds in the water column and surface canopy portions of each plant and relationships generated from length and weight measurements of 55 adult *M. pyrifera* collected from our study sites are used to convert field estimates of total length to total wet weight. The wet weight of each plant is converted to dry weight, carbon weight and nitrogen weight based on the analyses of blades collected from 10 to 15 plants at each site during each monthly survey. Independent instantaneous loss rates for entire plants and for fronds on surviving plants each month from 10 to 15 tagged plants at each site. Using our estimates of the standing crop at the beginning and end of each sampling interval (S_0 , S_t) and the loss rate (l) during the sampling interval we calculate the average growth rate g of *M. pyrifera* as:

$$g = \frac{1}{T} \ln\left(\frac{S_t}{S_0}\right) + l$$

where T is the number of days in the sampling interval. This exponential model implies that NPP at any moment is the product of g and S . By assuming that growth is constant over the period and expressing S at any time t as a function of initial FSC, growth rate, and loss rate ($S_t = S_0 e^{(g-l)t}$) we estimate daily NPP for each sampling interval by integrating instantaneous NPP over the interval and dividing by T :

$$NPP = \int_0^T g S_t dt$$

Seasonal NPP and seasonal growth rate of *M. pyrifera* are calculated as the mean NPP and mean growth rate for all days in the season.

We have been exploring the physical, chemical and biological factors controlling growth and NPP in giant kelp using regression analyses. Seawater temperature and nutrient concentration and physical disturbance from waves and standing crop are currently the focus of these investigations.

The methodology outlined above is quite labor intensive and difficult to apply over a broad region. With collaborative funding from the Center for Integrative Coastal Observations, Research and Education (CICORE) SBC investigator R. Zimmerman has been developing algorithms to evaluate the condition and estimate the productivity, of giant kelp canopies along the California coast based on the analysis of PHILLS and SAMSON hyperspectral imagery. The consistent optical signature of the kelp canopy produces a Blade Area Index (BAI, identical to Leaf Area Index used in terrestrial vegetation studies) that is linearly related to SBC LTER diver measurements of kelp abundance (Figure 1a). The slope (0.1) indicates that the canopy structure exerts a strong package effect on the optical efficiency of light absorption. The ability to predict BAI allows retrieval of standing biomass and productivity from measurements of below-canopy irradiance and above canopy reflectance. Estimates of kelp blade area can be linearly related to standing biomass and daily productivity (Figures 1b and 1c).

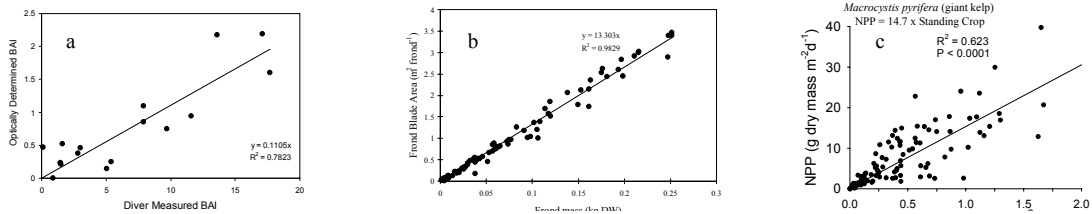


Figure 1. Relationships between (a) optical and direct diver-made counts of kelp blade area index, (b) frond mass and blade area per frond, and (c) kelp standing crop and net primary productivity.

The strong reflectance signal in the NIR allows absolute kelp abundance and productivity to be calculated and mapped across the habitat from remotely sensed hyperspectral imagery using the normalized difference vegetation index (NDVI). Knowledge of kelp blade optical properties (data not shown here), combined with linear regression of the relationships illustrated in Fig. 1 provide a quantitative link between the remotely sensed reflectance signals from giant kelp canopies detected by the hyperspectral imager, optically determined NDVI, kelp blade area, standing crop and productivity.

Production of benthic macroalgae in the kelp forest understory, and of phytoplankton in the water column, may be affected by shading, flow attenuation, and other factors influenced by the primary canopy of *Macrocystis*. Since these factors, particularly shading, negatively affect understory algae and phytoplankton, the relative importance of primary production of these ecosystem components may be inversely related to that of giant kelp, potentially complementing it in space and time. Beginning in June 2006, we developed and refined a method of in-situ measurement of understory algal production by measuring oxygen evolution in closed chambers. The chambers are built of acrylic and Tefzel plastic, with electric pumps driving water circulation, and an optical probe with logger that records dissolved oxygen concentration and temperature once per minute. Light and dark incubations provide estimates of production and respiration, respectively, and the algae inside the chamber are harvested for biomass measurement. In 2006 we used this method to estimate production of two important understory

assemblages, red algal turf and foliose red algae, at one of our long-term monitoring sites, Naples Reef. In 2007, we began using the method to measure understory production inside and outside the kelp forest at one of our monthly kelp production sites, Mohawk Reef. We are also measuring phytoplankton production monthly, inside and outside the kelp forest at the same site, using light and dark bottle incubations with ^{13}C -labeled bicarbonate as a tracer. The overarching goal is to address the question: How does the negative effect of giant kelp on understory algae and phytoplankton interact with wave disturbance and N loading to affect the magnitude and interannual variability of NPP of the kelp forest ecosystem?

We have begun assembling components for a bio-optical model of understory algae production with the goal of modeling understory production inside and outside the kelp forest at our monthly kelp production sites (Mohawk Reef, Arroyo Burro, Arroyo Quemado) based on the standing crop of understory algae and amount of light available to them. Three key components of this model are 1) Spatially detailed and high-frequency photosynthetically active radiation (PAR) data 2) monthly estimates of understory biomass and 3) Photosynthesis vs. irradiance (P/E) curves describing species-specific responses of algae to the spectrum of available PAR. In June we deployed PAR loggers inside and outside the kelp forest at Mohawk Reef, logging PAR data every 2 minutes. We plan to deploy identical PAR loggers at the remaining monthly sites in late August. To estimate understory biomass for 2 species of dominant understory kelps, *Laminaria farlowii* and *Pterygophora californica*, we have developed relationships between plant allometry and biomass to enable non-destructive estimation of biomass at our monthly primary production sites. For the remaining components of the understory algae community, we are developing a relationship between percent cover and biomass of dominant species by measuring percent cover in field quadrats, harvesting the quadrats, and measuring biomass in the lab. We are currently developing a laboratory setup to measure P/E curves for dominant understory species. The results from this model will be compared with the benthic chamber results, and could be used to extend these measurements into a long-term fine-scale dataset that would be logistically impossible otherwise.

Gene flow, inbreeding depression and population connectivity in giant kelp

Our prior NSF funded research examined the population dynamics of giant kelp (*Macrocystis pyrifera*) forests in southern California from a metapopulation perspective taking into account rates of colonization, extinction, and occupancy of discrete kelp patches, and the degree of connectivity (via spore dispersal) among them, and inbreeding depression (Raimondi et al. 2004, Reed et al. 2006, Gaylord et al. 2007). Our estimates of connectivity and rates of self-fertilization were based on empirical measurements from experimental populations, and physical modeling. Confirmation of our estimates of connectivity and inbreeding is best done using genetic analyses. With NSF funds we developed a molecular library for *Macrocystis* with greater than 90% polymorphism. In collaboration with Drs. Filipe Alberto and Ester Serrao from the Centre of Marine and Environmental Research (CMER) at the Universidade do Algarve, Portugal we are using this library to develop microsatellites that can be used to evaluate levels of connectivity and self-fertilization in giant kelp. With funding from Portugal, Alberto visited UCSB in summer 2006 to collaborate with us in developing a sampling protocol that would enable us to examine the genetic structure and dynamics of kelp populations in the Southern California Bight and elsewhere in the world. During his stay we used this sampling protocol to obtain kelp samples from each of our nine mainland long-term study sites. The samples were processed in our laboratory and the genetic analyses are being done in Dr. Alberto's laboratory at CMER. Alberto returned to UCSB in summer 2007 to work with us in interpreting the results of his genetic analyses and to collect additional samples that would provide further insight into the spatial patterns of genetic relatedness within and among kelp forests in the Santa Barbara Channel.

Biological and physical coupling within giant kelp forests

Currents impinging on the kelp forest transport nutrients, plankton and organic carbon that can substantially subsidize the kelp community. The kelp forest in turn modifies the flow around and within its boundaries, and forest producers and consumers alter the flux of nutrients and particulates within the forest. With collaborative funding from the University of California's Coastal Environmental Quality Initiative SBC investigators Gaylord, Brzezinski, Carlson, Holbrook, McIntyre, and Reed have been investigating the linkages between hydrodynamics and kelp forest function with a specific focus on determining: (1) the degree to which impinging flows enter the forest as opposed to being diverted around it, (2) rates of consumption and production of waterborne subsidies (i.e., nutrients, POM, DOM) by kelp forests, (3) the interaction of nutrients, light, and flow in determining kelp growth, and (4) the implications of forest-flow

interactions for forest-dwelling suspension feeding invertebrates. Our efforts in this endeavor employ extensive measurements of flow and kelp forest community structure, geochemical and biochemical analyses, and experimental manipulations in exploiting a breadth of expertise in hydrodynamics, marine ecology, biological oceanography, and algal physiology.

SBC LTER is also actively collaborating with an NSF-funded project examining the ecomechanics of flexible marine organisms. This project (led by Brian Gaylord) is focusing on understanding the details of how important habitat-forming species like giant kelp interact with waves and currents, and how aspects of their mechanical design drive patterns of kelp mortality (via dislodgement) and subsequent population dynamics, which profoundly influence net primary production and trophic interactions of kelp forests. This research is largely being done at one of our kelp primary production sites (Mohawk Reef) and SBC LTER personnel and boats are actively involved in the collection of data for this project.

Food web studies using stable isotope

Potentially important food sources to primary consumers on shallow subtidal reefs include phytoplankton, macroalgae, and terrestrially-derived POM. We are using stable carbon and nitrogen isotope ratio analysis of producers and consumers of varying trophic status to evaluate the relative contribution of these sources to reef food webs. Our efforts thus far have focused on characterizing variability in the stable C and N isotope values of potential food sources (phytoplankton, giant kelp, understory algae and terrestrial POM) and of different types of consumers on reefs that vary in their influence of freshwater runoff and in the biomass of giant kelp.

Kelp subsidies to sandy beach communities

Kelp forests export large subsidies of drift macrophytes ($>450 \text{ kg m}^{-1} \text{ y}^{-1}$) to sandy beach food webs in the SBC LTER. These subsidies are key resources for the beach food web supporting large numbers and a high diversity of consumers. With collaborative support from the State of California's Office of Oil Spill Prevention and Response, we have conducted field experiments on two spatial scales to investigate the responses of infaunal wrack-dependent macroinvertebrates to macrophyte subsidies from coastal reefs using kelp wrack additions to beach habitats. These data will be used in developing methods for recovery of beach ecosystems following oil spills and cleanup activities. Sample processing in the laboratory is ongoing for these experiments. We continued our research on nutrient cycling associated with the delivery and processing of drift macroalgae on a range of sandy beaches of the SBC-LTER coast by processing samples collected in 2003-2006 for DOC and DON. This effort is still ongoing with some analytical challenges to meet, including a lack of complete oxidation in pore water samples with very high ammonia concentrations as is typical of some of the study beaches.

OCEAN STUDIES

Three permanent reef sites are being monitored through a combination of sampling from small boats, instrumented moorings, and satellite imagery to provide baseline data for focused studies taking place within and the kelp forests and their surrounding waters of the Santa Barbara Channel. A primary objective for collecting these observations is to understand the inherent natural variability in the oceanographic conditions in this region, which is needed to detect sudden shifts or ongoing directional changes in climate and ocean properties that affect the structure and function of kelp forest ecosystems. The oceanographic conditions of primary interest to us include the sources and fluxes of nutrients to macrophytes in the kelp forest, the character and flux of particulate material that fuels the diverse assemblage of kelp forest suspension feeders, and the prevalence and consequences of freshwater plumes in kelp forests. During the past year budgetary constraints have caused us to adjust the level of oceanographic sampling done at our reef sites and to suspend basin wide surveys of oceanographic conditions and processes across the Santa Barbara Channel, although analyses of data from past cruises is currently underway.

Moored instruments and monthly sampling

We conduct monthly sampling of water properties from our 22' research vessel at Arroyo Quemado, Arroyo Burro and Mohawk, which are the three reef sites where we collect monthly measurements of giant kelp biomass and primary production. Monthly water sampling at two other sites (Carpinteria and Naples Reef) was discontinued in 2006 due to budgetary constraints. Water samples are collected from the surface down to 10 m adjacent to the offshore edge of the kelp forests at each site and in the interior of the kelp

forests at Arroyo Quemado and Mohawk. Samples are analyzed for nitrate, silicate, ammonium and phosphate, particulate organic carbon, particular organic nitrogen, and chlorophyll concentration. Sampling for carbon and nitrogen isotopes in suspended particulates reported in previous years has been suspended for the time being. All water samples are filtered within hours of collection and stored frozen for analysis in the Marine Science Institute Analytical Laboratory at UCSB. During each sampling period a CTD equipped with a fluorometer and transmissometer is lowered at each station and data on temperature, salinity, chlorophyll fluorescence, and suspended sediments are recorded throughout the water column.

We continued to maintain long-term instrumented moorings at Carpinteria, Naples Reef, Arroyo Quemado, and Mohawk in water depths ranging from 7 to 13 m. These moorings are equipped with sensors that allow us to sample conductivity, temperature, and depth more frequently (i.e., once every minutes) and over a wider range of ocean conditions than can be achieved using small boats. This is especially important during storm events and high winds when sampling from boats is not possible. High rates of bio-fouling and budgetary constraints have caused us to discontinue the deployment of fluorometers and backscatter sensors on these moorings. An Acoustic Doppler Current Profiler (ADCP) is deployed on the bottom adjacent to each mooring to measure vertical profiles of current velocity throughout the water column. Bottom temperature is also measured by the ADCPs. We also maintain an instrument package near the surface below mean low water on Stearns Wharf near downtown Santa Barbara, which consists of an array of sensors that measure conductivity, temperature, depth, chlorophyll fluorescence, and bio-luminescence. The maintenance of this instrument package is a collaborative effort among SBC-LTER, the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), and the Southern California Coastal Ocean Observing Systems (SCCOOS) and the data collected from it are publicly available in near-real time on our website at http://sbcddata.lternet.edu/data/stearns_wharf/index.php.

Regional Surface Current Patterns

With collaborative funding from several other projects LTER Investigator Libe Washburn has been operating an array of **three to five** high frequency (HF) radars on land boarding the Santa Barbara Channel to map the regional surface ocean circulation. These data provide an important link between synoptic circulation patterns in the channel and sub-surface property fields observed by moored instruments and ship board instrumentation. Currently there are five HF radars in operation, the latest on Santa Cruz Island. We are working to get additional sites to improve coverage in the SBC LTER study region. These include sites at: Vandenberg Air Force Base, Gaviota, Nicolas Canyon, San Nicolas Island, Point Arguello, and Point Mugu. Emery et al. 2004 describe an earlier configuration of the array and its performance in more detail. SBC LTER investigators have used surface current data from HF radars to examine a variety of physical and biological processes in the Santa Barbara Channel including the formation of small eddies, coastal trapped waves, larval fish distributions, and basin-wide circulation (e.g., Beckenbach and Washburn, 2004; Nishimoto and Washburn, 2002; Bassin et al. 2005; Anderson et al. 2007). Ongoing studies utilizing HF radar data are examining the effects of eddies on phytoplankton primary production, larval transport, and the propagating response of inner shelf circulation due to wind relaxation events, which may serve as an important trigger for poleward flows that connect kelp habitats in the Southern California Bight with kelp beds along the central California coast

Cross Shelf Processes

During the past year, we made substantial progress on a research campaign designed to improve our understand cross-shelf processes in the Santa Barbara Channel that transport materials to and from kelp forests. Much of our efforts on this topic focused on analyzing data from the sixteen SBC-LTER cruises in the Santa Barbara Channel conducted during 2000-2006. Data analysis procedures were employed to visualize and quantify sub-surface property distributions obtained from the extensive suite of shipboard, moored, and land-based instrumentation. Particular attention was given to processing acoustic Doppler current profiler (ADCP) data, which are critical for understanding the role of ocean currents in structuring density, nutrient, and phytoplankton distributions offshore of the kelp forests. Substantial progress was also made on interpreting patterns of phytoplankton primary productivity obtained during the cruises.

Satellite Data

Local area coverage SeaWiFS ocean color and AVHRR thermal imagery have been collected and analyzed as part of the SBC-LTER program. This provides 1-km scale synoptic views of ocean chlorophyll concentrations and sea surface temperature over the entire Santa Barbara Channel. Co-registered five-day

composite fields for SST and chlorophyll concentration are created on a routine basis for the Santa Barbara Channel. All imagery is hand navigated and de-clouded (see <http://www.icess.ucsb.edu/avhrr> & <http://www.icess.ucsb.edu/~fields/wifsTest> for example imagery).

WATERSHED STUDIES

Runoff, stream chemistry and fluxes

Fluvial transport and processing of nutrients, organic matter, and sediment are the primary means by which land masses influence coastal ecosystems. The volume and geophysical/chemical properties of runoff are determined by the amount and pattern of rainfall, terrain, lithology, land use, vegetation, and perturbations to the watershed and adjoining estuary. As part of our long-term monitoring we have established stream gauging stations throughout the SBC LTER study region where stream stage and water temperature are recorded every five minutes throughout the year. To convert our measured stage values to discharge, we develop rating curves by measuring channel cross-sections and roughness to characterize the channel reaches, and then use the HEC-RAS (stream flow hydraulics) program. The dynamics of stream channels requires these rating tables be updated periodically with revised channel surveys and verified field measurements of stage and discharge. In addition to stream stage and temperature, we have installed three transducers that record conductivity. Continuous (5-min) conductivity data help discern the various sources (surface, soil and groundwater) of runoff contributing to storm hydrographs. To understand and model the rainfall-runoff processes we have established a rainfall gauge network consisting of 12 sites with rainfall gauges. Gauges at five of our most remote sites are also equipped with spread spectrum telemetry.

On a weekly to bi-weekly and storm (hourly for rising limb and at 2-4 hour intervals on falling limb) basis, water samples from streams are collected and all or a subset are analyzed for (a) nitrate, ammonium, total dissolved nitrogen, and particulate nitrogen; (b) soluble reactive phosphorus, total dissolved phosphorus and particulate phosphorus; (c) particulate organic carbon; (d) total suspended sediments; and (e) conductivity.

The locations where samples for chemical analyses have been obtained have changed during the course of our studies. During the last year regular sampling was conducted at Gaviota, San Onofre (to follow post fire recovery), Arroyo Hondo, Refugio, Bell Canyon, Devereux, Atascadero, Rattlesnake and Mission. Additions to our regular hydrological sampling include:

- In collaboration with Channel Islands National Park, we have surveyed streams on Santa Rosa Island for chemical conditions, bacteria and macroinvertebrates.
- In collaboration with Santa Barbara Channelkeepers, we have conducted monthly sampling at a series of stations throughout the Ventura River catchment.
- In collaboration with the Friends of the Santa Clara River, we have conducted monthly sampling at a series of stations throughout the Santa Clara River catchment.
- In collaboration with the City of Santa Barbara, we have performed analyses of nutrients for quarterly samples in creeks within the City.

Estuarine studies

Studies of Carpinteria salt marsh, partly funded by NASA, combined remote sensing and ground-based methods to determine the vegetation patterns and to generate a digital elevation model, which was combined with stage measurements to calculate inundation dynamics and permit estimation of tidal exchanges with the coastal ocean. PhD student Darcie Goodman's ecological studies of Devereux Slough include measurements of nutrient loading from its catchment, vertical profiles of temperature, salinity and dissolved oxygen, transparency, bathymetry, and water levels as well as monitoring of macroinvertebrate, fish, vegetation and bird species assemblages.

Stream ecology studies

Two studies of stream ecology were completed: (1) The biotic effects of introduced crayfish were investigated as part of the PhD research of Kristie Klose. Her study used an experimental approach to delineate the effects of a widespread exotic species, the crayfish (*Procambarus clarkii*), on benthic invertebrates and primary producers in the Santa Ynez and Ventura Rivers. (2) As part of Juliet Simpson's PhD research, the effects of nutrients on species composition and biomass of benthic and floating algae and aquatic plants in coastal streams and rivers was investigated.

SBC investigators have been collaborating with several agencies and NGOs on a variety of conservation issues pertaining to watersheds in the SBC region. Tom Dudley has been working with

Stillwater Sciences and the California Coastal Conservancy in characterizing floodplain vegetation in the Santa Clara River to determine conservation and restoration needs, including management of non-indigenous invasive species. The primary species of management concern is *Arundo donax* (giant reed), the dominant riparian species in much of the watershed. The presence and impacts of several specialist herbivores are being examined as part of a study to develop a biological control program against *Arundo*. Anadromous runs of steelhead trout are a high conservation priority and studies for California Fish & Game of smolt growth and survival in both the Santa Clara and Santa Ynez rivers are underway. Dudley is also working with the University of California Co-Operative Extension program to develop a monitoring plan for detecting expansion of New Zealand Mud Snail in Piru Creek, a major tributary to the Santa Clara River.

One of the oldest and richest questions in ecology is that of how species diversity relates to biological productivity. Historically, researchers have viewed differences in biodiversity among communities or ecoregions as being a consequence of differences in levels of productivity. In recent years, ecologists have begun to view the relationship between diversity and productivity from a fundamentally different angle, examining how biodiversity controls, rather than simply responds to, the production of biomass in ecosystems. These contrasting perspectives have led to nearly a decade of debate - Is biodiversity the cause or the consequence of productivity? In the summer of 2006 we performed an experiment to clarify how species diversity and productivity can simultaneously influence one another. We hypothesized that the 'productivity-drives-diversity' and 'diversity-drives-productivity' perspectives can be unified by carefully distinguishing between three causal pathways that operate concurrently to influence biomass production: (1) a direct effect of nutrient supply on productivity, (2) a direct effect of species richness on productivity, and (3) an indirect effect of nutrient supply on production that is mediated through its control over species richness. This set of pathways postulates that nutrient supply rate places an upper bound on the number of species that can locally coexist, but the number of coexisting species ultimately determines how efficiently resources are utilized and converted into new biomass. To test this prediction, we used nutrient diffusing substrates to manipulate the supply rate of nitrate and phosphate by 6-orders of magnitude in 12 streams in the Santa Barbara Coastal and Santa Ynez watersheds. These streams were chosen to span a gradient in algal species richness (33-89 species) that accompanies gradients in eutrophication previously established by LTER studies of stream nutrient dynamics. After allowing substrates to colonize with algae for six weeks, we measured species diversity and rates of 1° production on each substrate. The identification and counts of 75+ samples of algae were completed in July 2007, and we just beginning to analyze the data.

INFORMATION MANAGEMENT

The primary objective of the SBC LTER IM system is to facilitate research and outreach efforts by focusing on data organization and integrity, ease of access, and long-term preservation. We maintain an open, cross-platform system that is based on Internet standards, leveraging existing systems where possible, and building new tools geared toward collaboration and integration between data collection and publication. The SBC LTER IM system is integrated with other research groups at MSI, particularly Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) and the Moorea Coral Reef LTER (MCR LTER) since these groups share several scientists and sampling protocols.

SBC has been closely involved with the recent installation of an information management system for the MCR LTER (also at MSI/UCSB), and in development of scripted processing methods which are of use to several groups of local researchers. SBC is also well-represented in the activities of the LTER Information Managers Committee (IMC). Since SBC has adopted community-vetted components for its IM system, its products are well suited to deployment elsewhere in the ecological informatics community.

LTER NETWORK AND SYNERGISTIC ACTIVITIES

As a lead PI Reed serves on the LTER Science Council. He is also member of the LTER Executive Board, Publications Committee, and the Writing Team which produced the LTER Strategic Plan. Reed along with investigators John Melack and Brad Cardinale were members of the LTER Network Planning Committee and active in the LTER Network's Planning Grant process. Melack also organized a special session on NSF's Long-term Ecological Research Program for the AGU Meeting in December 2006. Investigator Libe Washburn serves on the LTER Network Information Systems Advisory Committee (NISAC). SBC Information Manager Margaret O'Brien is extremely active in the LTER Network 's information

management arena. She serves on the Executive committee of the LTER Network's IM committee. She is currently involved in the following IM working groups and activities: (1) a Network-level working group on quality control which held a workshop in winter 2007, (2) Units working group responsible for establishing a collection of vetted measurement units which can be consulted by sites during metadata creation, (3) Controlled Vocabulary working group that evaluates the usefulness of keyword thesauri for browsing and querying metadata, (4) IM committee meeting logistics coordinator, (5) editor of the metadata section of the IM Committee's website which facilitates content, recommendations and discussions regarding metadata standards and implementation, and (6) member of the EML Project Committee, which is a national-level informatics group that oversees the development and maintenance of the EML schema.

PRESENTATIONS

2006

Schimel, J. P. 2006. The role of microbial stress responses in regulating ecosystem-level responses to episodic pulse weather events. American Geophysical Union Annual Meeting Symposium: "Impact of Climate Variability and Extreme Weather on Ecosystem Structure and Function Across Spatiotemporal Scales." December 2006.

2007

- Anderson, C. R. 2007. Towards the remote detection of toxic diatom blooms. Poster, SBC-LTER Annual Meeting June 2007.
- Anderson, C. R. Environmental controls of phytoplankton community structure in the Santa Barbara Channel: Application to the dynamics and detection of harmful diatom blooms. PhD. Seminar, Interdepartmental Graduate Program in Marine Science UC Santa Barbara.
- Anderson, C. R., D.A. Siegel, M.A. Brzezinski, N. Guillocheau. 2007. Sources of variability in the phytoplankton community structure of the Santa Barbara Channel, California. Oral presentation, ASLO Aquatic Sciences Meeting, Santa Fe, NM, February 5, 2007.
- Arkema, K. 2007. Temporal variability in giant kelp abundance influences benthic community structure. Poster, SBC-LTER Annual Meeting, June 2007.
- Arkema, Katie K. 2007. Immediate and opposite effects of giant kelp, *Macrocystis pyrifera*, influence temporal variability in benthic community structure. Presented at the 88th Annual Meeting of the Western Society of Naturalist, Ventura, California.
- Brzezinski, M. L. Washburn, and D. Siegel. 2007. Physical drivers of spatial patterns in phytoplankton primary productivity in the Santa Barbara Channel, CA, USA - Poster, SBC Annual Meeting, June 2007.
- Brzezinski, M.A, L. Washburn, and D.A. Siegel, 2007. Physical drivers of spatial patterns in phytoplankton primary productivity in the Santa Barbara Channel. Meeting of the American Society of Limnology and Oceanography, Honolulu, HI, Feb 4-9, 2007.
- Brzezinski, M.A, L. Washburn, and D.A. Siegel. 2007. Physical drivers of spatial patterns in phytoplankton primary productivity in the Santa Barbara Channel, USA, Aquatic Sciences Meeting, 4-9 February, Santa Fe, NM.
- Cadotte, M. W., B. J. Cardinale, and T. H. Oakley. 2007. Can the functional consequences of species extinction be predicted by evolutionary history? Ecological Society of America 92nd annual conference, San Jose, CA, August 2007.
- Cardinale, B. 2007. Does community production drive species diversity drive or vice versa? Towards resolution of a diversity paradox. Poster, SBC-LTER Annual Meeting, June 2007.
- Cardinale, B. J. 2007. Does productivity drive diversity or vice versa? Towards resolution of a chicken-or-egg paradox. Department of Ecology & Environmental Science, Umeå University, Sweden.
- Cardinale, B. J. 2008. Biodiversity and Ecosystem Functioning: Cause, consequence, or reciprocal causality? 2nd Annual Meeting for Young Researchers in Earth Science, New Orleans, LA. Sponsored by the National Science Foundation.
- Cardinale, B. J., D. Bennett, and K. Gross. 2007. Does community production drive species diversity drive or vice versa? Towards resolution of a diversity paradox. Ecological Society of America 92nd annual conference, San Jose, CA, August 2007.

- Cardinale, B. J., D. Bennett, and K. Gross. 2007. Does community production drive species diversity drive or vice versa? Towards resolution of a diversity paradox. Ecological Society of America 92nd annual conference, San Jose, CA.
- Carlson, C. 2007. Near-shore shelf transport & sources and fate of DOM & POM. Presented at SBC Research Discussion Series meeting.
- Carroll, I. T., and B. J. Cardinale. 2007. Balancing niche and neutral theory to predict the effects of biodiversity on ecosystem production. Ecological Society of America 92nd annual conference, San Jose, CA, August 2007.
- Cavanaugh, K. 2007. Remote Sensing of Giant Kelp Forests in the Santa Barbara Channel using SPOT Imagery"-Poster, SBC Annual Meeting, June 2007.
- Cavanaugh, K. C.; Siegel, D. A.; Reed, D. C.; Kinlan, B. P. 2007: Remote sensing of giant kelp in the Santa Barbara Channel using SPOT imagery. Poster, ASLO Aquatic Sciences Meeting, Santa Fe, NM, February 7, 2007.
- Cavanaugh, K., D.A. Siegel, B.P. Kinlan and D.C. Reed, 2007: Remote Sensing of Giant Kelp Forest Cover and Biomass Using SPOT Multispectral Imagery. Poster presented at the 2007 American Geophysical Union meeting, San Francisco CA, December 14, 2007.
- Chaffey, T. 2007. A description of the effects of headlands on marine larval dispersal using computational models. Poster, SBC Annual Meeting, June 2007.
- Chaffey, T. F.; Mitarai, S.; Siegel, D. A. 2007: A description of the effects of headlands on marine larval dispersal using computational models. Poster, ASLO Aquatic Sciences Meeting, Santa Fe, NM, February 7, 2007.
- Coombs, S, J. Melack 2007. Export of nutrients after a fire. Poster, SBC-LTER Annual Meeting, June 2007.
- Costello, C.J., Polasky, S., Siegel, D. A.; Watson, J., Kaffine, D., Kendall, B. E.; Warner, R. R.; Gaines, S. D.; Mitarai, S.; 2007: Optimal harvesting of stochastic spatial resources. Invited oral presentation at the 2007 American Fisheries Society meeting, San Francisco CA, September 4, 2007.
- Dudley, T., A.M. Lambert, P. Dalin, et al. 2007. Invasive species and riparian ecosystem linkages in the Santa Clara watershed, Santa Barbara County, Poster, SBC-LTER Annual Meeting, June 2007.
- Dugan, J., M. Page, D. Hubbard and M. Lastra 2007. Exchanges between kelp forests and sandy beaches: macroalgal wrack input, processing and fate. Poster, SBC-LTER Annual Meeting, June 2007.
- Fram, J. P. 2007. Physical pathways and utilization of nitrate supply to the giant kelp. . Poster, SBC-LTER Annual Meeting, June 2007
- Fram, J.P. 2007. How an environmental engineer sees nutrient uptake and release by organisms with complex morphology, Research Seminar for Undergraduates, UCSB, 2007.
- Fram, J.P. 2007. Nitrate supply and utilization in a kelp bed, Liepmann-Ludwig Seminar, Max-Planck Institute, Goettingen, Germany, 2007.
- Gaines, S. D. 2007. Market Based Solutions to Fisheries Challenges, National Press Club, Washington DC, March 2007.
- Gaines, S. D. 2007. Science Guidelines for the Design of Marine Reserve Networks, MLPA Science Advisory Team, San Francisco, July 2007.
- Gaines, S. D. 2007. The Emerging Science of Marine Reserve Networks, Oregon State University, January 2007.
- Gaines, S. D. 2007. The Emerging Science of Marine Reserve Networks, UCLA, May 2007.
- Gaines, S. D. 2007. The Emerging Science of Marine Reserve Networks, Society for Conservation Biology, Port Elizabeth, South Africa, July 2007.
- Gaines, S. D. 2007. The Geography of Dispersal and the Design of Marine Reserves, International Biogeography Society, Keynote Address. January 2007.
- Gaines, S. D. 2007. The Role of Science in California's Marine Life Protection Act, AAAS meetings, February 2007.
- Gaines, S. D. 2007. The Role of Science in California's Marine Life Protection Act, Arizona State University, June 2007.
- Gaines, S. D. 2007. The Role of Science in California's Marine Life Protection Act, Ocean Conference, Portland Oregon, July 2007.
- Gaines, S. D. 2007. Unique Features of the Channel Islands, Gordon and Betty Moore Foundation Board Retreat, May 2007.

- Gaylord, B., D.C. Reed, P.T. Raimondi, and L. Washburn. 2007. Ecomechanics of macroalgal spore dispersal in coastal environments: Insights from theory and experiment. Society of Integrative and Comparative Biology Conference, Phoenix, Arizona, January 2007.
- Gross, K. and B. J. Cardinale. 2007. Does species richness drive community production or vice versa? Reconciling historical and contemporary paradigms in models of competitive communities. Ecological Society of America 92nd annual conference, San Jose, CA.
- Guenther, C. D. Carr and H. Lenihan 2007. Assessing socioeconomic impacts of Channel Islands State Marine Reserves and habitat on the regional commercial spiny lobster fishery. Poster, SBC Annual Meeting, June 2007.
- Guerrini, A. and J. Dugan. 2007. Historical connections in coastal landscapes. Paper presented at ESA/SER joint meeting. San Jose, CA, August 2007.
- Guerrini, A. and J. Dugan. Historicizing ecological restoration: a case study of a California coastal wetland. Poster, SBC-LTER Annual Meeting, June 2007
- He, Y. and Ed Beighley 2007. GIS –based regional landslide susceptibility mapping: a case study in southern California. Poster, SBC-LTER Annual Meeting, June 2007.
- Hofmann, G. L. Hammond and M. O'Donnell 2007. Using genomics-based tools to forecast the impacts of climate change on calcifying marine organisms: the effect of ocean acidification on skeleton formation in sea urchin larvae. Poster, SBC-LTER Annual Meeting, June 2007.
- Klose, Kristie. 2007. Complex effects of an invasive consumer *Procambarus clarkii* on temperate and tropical stream benthic communities PhD.Seminar. Dept. of Ecology, Evolution and Marine Biology, University of California, Santa Barbara.
- Kostadinov, T 2007. Coastal Ocean Optics in the Santa Barbara Channel, California. Poster, SBC-LTER Annual Meeting, June 2007.
- Kostadinov, T. S.; Siegel, D. A.; Maritorena, S.; Guillocheau, N.; Brzezinski, M. 2007: Next-generation semi-analytical bio-optical modeling for optically complex sites. Case study in the Santa Barbara Channel, California. Oral presentation, ASLO Aquatic Sciences Meeting, Santa Fe, NM, February 5, 2007.
- Levenbach, S. 2007. Community-wide ramifications of an associational defense on shallow temperate reefs. PhD. Seminar. Dept. of Ecology Evolution and Marine Biology, University of California Santa Barbara, CA. May 2007.
- Leydecker, A. 2007. Nutrient export from the Ventura River and it's variation with rainfall. Poster, SBC-LTER Annual Meeting, June 2007.
- Lynham, J., and Siegel, D.A., 2007: Income targeting and the evolution of a fishery. Poster presented at the 2007 American Fisheries Society meeting, San Francisco CA, September 3, 2007.
- McPhee-Shaw, E. G. Chang-Spada, and T. Dickey 2007. The SCCOOS Shelf to Shoreline Observatory Development Santa Barbara Channel Mooring: An Ongoing Time Series of Currents, Thermal Structure and Optical Properties of the Water Column over the Continental Shelf. Poster, SBC-LTER Annual Meeting, June 2007.
- Miller, B. 2007. Kelp forest communities and net primary production. Presented at SBC Research Discussion Series meeting.
- Miller, R. 2007. How is primary production of understory algae and phytoplankton affected by giant kelp? Poster, SBC-LTER Annual Meeting, June 2007.
- Mitarai, S.; Siegel, D. A.; Kendall, B. E.; Warner, R. R.; Gaines, S. D.; Costello, C.J., Winters, K. B. 2007: Hydrodynamic connectivity in nearshore fisheries. Invited oral presentation at the 2007 American Fisheries Society meeting, San Francisco CA, September 4, 2007.
- Mitarai, S.; Siegel, D. A.; Warner, R. R.; Gaines, S. D.; Kendall, B. E.; Winters, K. B. 2007: A scaling tool to account for inherent stochasticity in larval dispersal. Oral presentation, ASLO Aquatic Sciences Meeting, Santa Fe, NM, February 8, 2007.
- Mitarai, S. D. Siegel B, Kendall, R. Warner, S. Gaines, C. Costello, K. Winters 2007. Hydrodynamic Connectivity in Nearshore Marine Population Dynamics Poster, SBC Annual Meeting, June 2007.
- Page, M. 2007. The incorporation of land and ocean sources of organic matter into kelp forest food webs using stable isotopes. Poster, SBC-LTER Annual Meeting, June 2007.
- Rassweiler, A. 2007. Filter feeding generates patchiness in systems of marine space competitors Poster, SBC-LTER Annual Meeting, June 2007.
- Rassweiler, A. 2007. Filter-feeding leads to thresholds and alternate stable states in communities of space competitors. ESA/SER joint meeting. San Jose, CA, August 2007.

- Rassweiler, A., D. Reed, and K. Arkema. 2007. Net primary production of giant kelp. Oral presentation, LTER Science Council Meeting, Portland, OR, May 2007.
- Reed, D. 2007. Environmental drivers and biological sources of inter-annual variation in net primary production by giant kelp. Departmental seminar. Bodega Marine Laboratory, UC Davis. 23 May 2007.
- Reed, D. 2007. Giant kelp forests as a model system for linking social and ecological systems. Keynote address. SBC-LTER Annual Meeting, June 2007.
- Reed, D. 2007. Social - Ecological Interactions in Coastal Marine Ecosystems. LTER/NSF symposium. Washington D.C. March 2007.
- Reed, D. 2007. Social-ecological interactions in the Santa Barbara Coastal region. Guest Lecture, NCEAS, Santa Barbara, CA, September 2007.
- Revell, D. 2007. Long Term and Storm Event Changes to the Santa Barbara Sandshed. PhD. Seminar. University of California, Santa Cruz.
- Revell, D., J. Dugan and D. Hubbard 2007. Long Term and El Nino Changes in the Santa Barbara Sandshed Seminar to USGS. Santa Cruz, CA
- Revell, D., J.E. Dugan, D. Hubbard. 2007. Physical and ecological responses to the 1997-98 El Nino along sandy beaches of the Santa Barbara coast. Presented at: Headwaters to Oceans Conference Long Beach, CA
- Robinson, M. 2007. Heterogeneous fishing effort and catch: Effects on stocks & yields” Poster, SBC-LTER Annual Meeting, June 2007.
- Schimel, J. P. 2007. Linking from microsite microbial processes to catchment biogeochemistry. Gordon Research Conference on Catchment Science: Interactions of Hydrology, Biology & Geochemistry. New London, NH. July 2007.
- Schimel, J. P. 2007. Microbial function in nature: connecting physiology and physics. Keynote address: EuroDiversity workshop: Microbial Diversity and Ecosystem Functioning. Lunz am See, Austria. March 2007.
- Schimel, J. P. 2007. Regulating denitrification: Regulating denitrification: linking physiology and physics in soil N cycling. Keynote Address: COST 856 Conference– Denitrification: A challenge for Pure and Applied Science. Aberdeen, Scotland. March 2007.
- Schimel, J. P. 2007. Soil structure and chemistry: the mediators between microorganisms and ecosystem function. Keynote address: Workshop– Microscale approaches to macroscale issues in ecology. Washington, D.C., April 2007.
- Shulman, R. 2007. Effects of press and pulse drivers on kelp forest structure and function. Poster, SBC Annual Meeting, June 2007.
- Siegel, D. A. and K. Cavanaugh. 2007. Productivity and patch dynamics of kelp forests using remote sensing. Presented at SBC Research Discussion Series meeting.
- Siegel, D. A., Costello, C., Gaines, S., R. Hilborn 2007. Flow, Fish & Fishing Biocomplexity Project Poster, SBC-LTER Annual Meeting, June 2007.
- Siegel, D. A., N. Guillocheau, S. Maritorea, M. Brzezinski, L. Washburn 2007. Plumes and Blooms: seasonal to [nearly] time scale decadal ocean water mass variability in the SB Channel Poster, SBC-LTER Annual Meeting, June 2007.
- Siegel, D. A., S. Gaines, Hill, B. Kinlan, Kyriakidis, D. Reed and D. Zimmerman 2007. NASA Kelp Dynamics Interdisciplinary Science Project Poster, SBC-LTER Annual Meeting, June 2007.
- Siegel, D. A.; Watson, J., Costello, C.J., Kaffine, D., Mitarai, S.; Kendall, B. E.; Warner, R. R.; Gaines, S. D.; 2007: Spatial scenarios for nearshore fisheries. Invited oral presentation at the 2007 American Fisheries Society meeting, San Francisco CA, September 4, 2007.
- Siegel, D.A., and S. Mitarai, 2007: Mixing and Stirring in Aquatic Ecosystems: A Micro-Review. Invited mini-review 2007 ASLO Aquatic Sciences Meeting, Santa Fe, NM, February 8, 2007.
- Simon, S. 2007. Poster, “SBC-LTER Watershed Education Program”-SBC-LTER Annual Meeting ,June 2007.
- Stewart, H 2007 Biological response of kelp individuals to habitat modification by the bed. North West Algal Symposium.
- Stewart, H 2007. Physical-biological interactions in nearshore marine systems Guest Lecture, Marine zoology/botany course, Friday Harbor Labs, University of Washington.
- Stewart, H. 2007 The interplay between seaweed morphology, physiology and performance across barrier reefs and kelp beds Invited seminar, Dept of Botany, University of British Columbia.

- Stewart, H. 2007. Growth and physiological response of *M. pyrifera* to alteration of physical factors in Mohawk kelp bed." Poster, SBC-LTER Annual Meeting, June 2007.
- Truesdale-Carney, L. 2007. Delayed development of *Macrocyctis* gametophytes. Poster, SBC-LTER Annual Meeting, June 2007.
- Verdin, K., E. Beighley, Y. He and Y. Gummadi 2007. Automated Pfafstetter watershed subdivision: an assessment of hydrologic characteristics at varying spatial scales and topographic settings. Poster, SBC-LTER Annual Meeting, June 2007.
- Wallner, E and C. Carlson 2007. Distribution and bioavailability of dissolved organic carbon in the Santa Barbara Channel. Poster, SBC-LTER Annual Meeting, June 2007.
- Washburn L. and M. Brzezinski. 2007. Control of primary production by mesocale features in the Santa Barbara Channel. Poster, SBC Annual Meeting, June 2007.
- Washburn, L., M.A. Brzezinski, C. Gotschalk, J. Goodman, D.A. Siegel. 2007. Cross shore transport and cruise analysis campaign. Presented at SBC Research Discussion Series meeting. 29 November 2007.
- Washburn, L., B.M. Emery, K. Laws, J.D. Paduan, 2007, Recent experiments on data procedures, algorithm development, and antenna modifications, using an array of current-measuring radars on the South-Central California Coast, Seventh Radiowave Oceanography Workshop, 28-31 May 2007, Cancun, Mexico.
- Watson, J., Siegel, D. A.; Mitarai, S.; 2007: A spatially explicit nearshore stock demographic model for the Santa Barbara Channel. Poster presented at the 2007 American Fisheries Society meeting, San Francisco CA, September 3, 2007.
- Watson, J.R. 2007. Simulating Larval Dispersal in the Santa Barbara Channel. Poster, SBC Annual Meeting, June 2007.
- Watson, J.R., D.A. Siegel, S. Mitarai. 2007: Simulating larval dispersal in the Santa Barbara Channel using different velocity field resolutions with a Lagrangian fluctuating component. Poster ASLO Aquatic Sciences Meeting, Santa Fe, NM, February 7, 2007.
- Zimmerman, D. 2007. Modeling and mapping the productivity of giant kelp. Poster, SBC Annual Meeting, June 2007.

2008

- Anderson, C. R.; Siegel, D. A.; Kudela, R. M.; Brzezinski, M. A. 2008: An empirical approach to estimating the probability of toxigenic *Pseudo-Nitzschia* blooms in the Santa Barbara Channel. Presented at the 2008 Ocean Sciences Meeting, Orlando FL., March 4, 2008.
- Cardinale, B. J. 2008. Biodiversity and Ecosystem Functioning: Cause, consequence, or reciprocal causality? 2nd Annual Meeting for Young Researchers in Earth Science, New Orleans, LA. Sponsored by the National Science Foundation.
- Cardinale, B. J. 2008. Biodiversity loss and the functioning of aquatic ecosystems: The rivet hypothesis revisited. North American Benthological Society 56th annual meeting, Salt Lake City.
- Cardinale, B. J. 2008. Direct and indirect effects of nutrient loading on primary production in streams. Presented at SBC Research Discussion Series meeting
- Cardinale, B. J. 2008. Effects of biodiversity on the functioning of ecosystems ... one summary of, and vision for a paradigm. Department of Environmental Sciences, Policy and Management, University of California-Berkeley.
- Chaffey, T. F.; Mitarai, S.; Siegel, D. A. 2008: Circulation and demographic modeling of the structuring of marine populations along irregular coastlines. Presented at the 2008 Ocean Sciences Meeting, Orlando FL., March 4, 2008.
- Dugan, J.E. 2008. Effects of Coastal armoring on sandy beach ecosystems. Invited paper, Spring Workshop : Recent Advances in Coastal Analyses Affecting California. California Shore and Beach Preservation Association Meeting. May 2008, Pacifica, CA.
- Guenther, C. 2008. Socioeconomic changes in the California spiny lobster fishery around the Channel Islands. Paper presented at the 7th California Islands Symposium. Special Session: The First Five Years of Monitoring the Channel Islands Marine Protected Area Network.
- Holden, P. 2008. Diagnosis of human waste contamination in two Santa Barbara coastal creeks. Presented at SBC Research Discussion Series meeting.
- Kay, M. H. Lenihan, C. Miller, K. Barsky. 2008. Influence of Channel Islands marine reserves on California spiny lobster: results of a collaborative trapping program designed to nurture community-

- based fishery management. Paper presented at the 7th California Islands Symposium. Special Session: The First Five Years of Monitoring the Channel Islands Marine Protected Area Network.
- Kinlan, B. 2008. Changes in kelp forest habitats in and around the Channel Islands Marine Protected Areas. Paper presented at the 7th California Islands Symposium. Special Session: The First Five Years of Monitoring the Channel Islands Marine Protected Area Network.
- Lenihan, H. 2008. Collaborative lobster fishery research in the Santa Barbara Channel. Presented at SBC Research Discussion Series meeting.
- Melack, J. 2008. Hydrochemical and biological conditions in streams on Santa Rosa Island. Presented at SBC Research Discussion Series meeting.
- Mitarai, S.; Siegel, D. A.; Kendall, B. E.; Warner, R. R.; Gaines, S. D.; Costello, C.J., Winters, K. B. 2007: Hydrodynamic connectivity in nearshore fisheries. Invited oral presentation at the 2007 American Fisheries Society meeting, San Francisco CA, September 4, 2007.
- Mitarai, S.; Siegel, D. A.; Warner, R. R.; Gaines, S. D.; Kendall, B. E.; Costello, C. J.; Winters, K. B., 2008: Larval dispersal and population dynamics in a turbulent coastal ocean. Presented at the 2008 Ocean Sciences Meeting, Orlando FL., March 5, 2008.
- O'Hirok, W, D. Siegel and S. Maritorena, 2008: Diagnosing Atmospheric Correction Performance for the Santa Barbara Channel: Do We Really Know Aerosol Optical Properties for Complex Coastal Environments? . Poster presented at the NASA Carbon Cycle and Ecosystems workshop, College Park MD, May 2008.
- Reed, D. 2008. Social - Ecological Interactions in Coastal Marine Ecosystems. Invited speaker, Annual Science Council Meeting, Long Term Ecological Research Network. Baltimore MD.
- Reed, D. 2008. Social-ecological interactions in giant kelp forests. Invited symposium speaker, Annual meeting of the Southern California Academy of Sciences. California State University, Dominguez Hills.
- Schroeter, S.C. H. M. Page, J. E. Dugan, C. S. Culver, B. Steele, R. Guiterrez, D. Kushner. 2008. Scales of variability in larval settlement with in the Channel Islands National Marine Sanctuary and along the mainland coast. Paper presented at the 7th California Islands Symposium. Ventura, CA
- Siegel, D. A.; Guillocheau, N.; Washburn, L.; Warrick, J. A.; Toole, D. A.; Kostadinov, T. S., Brzezinski, M. A.; Anderson, C. R. 2008: A time-series assessment of sediment plumes and phytoplankton blooms in the Santa Barbara Channel, California. Presented at the 2008 Ocean Sciences Meeting, Orlando FL., March 5, 2008.
- Tague, C. 2008. Climate and land-use impacts on terrestrial hydrology and biogeochemical cycling in semi-arid regions: RHESSys model results and next-steps in the Santa Barbara LTER region. Presented at SBC Research Discussion Series meeting.
- Washburn, L., B.M. Emery, C. Johnson, C. Ohlmann, Kirk Ireson, C. Melton, and C. Gotschalk, 2008, Application of HF radars for observing poleward flows due to relaxation of upwelling favorable winds, Eight Radiowave Oceanography Workshop, Honolulu, HI., 28 April-31 May 2008,
- Washburn, L., C. Melton, C. Gotschalk, C. Blanchette, and C. Cudaback. 2008. The propagating response of inner shelf circulation to wind relaxations in a coastal upwelling system. 2008. AGU-ASLO Ocean Sciences Meeting, Orlando, FL., 3-7 March 2008.
- Watson, J. R.; Selkoe, K.; White, C.; Siegel, D. A.; Dong, C.; McWilliams, J. C. 2008: Simulating the impact of El Nino on the gene flow of marine species in the Southern California Bight. Presented at the 2008 Ocean Sciences Meeting, Orlando, FL., March 6, 2008.