

Annual Report for Period:03/2003 - 03/2004**Submitted on:** 01/20/2004**Principal Investigator:** Reed, Daniel C.**Award ID:** 9982105**Organization:** U of Cal Santa Barbara**Title:**

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

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:**

Serves on our executive committee, directed research on hydrological and hydrochemical aspects in streams.

Name: Holbrook, Sally**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Cooper, Scott**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Serves on our executive committee. Directs studies of in-stream processing of nutrients and organic matter.

Name: Gaines, Steven**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Washburn, Libe**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Served on Executive Committee, participates in UNOLS cruises (including occasionally serving as Chief Scientist. Directs research on physical oceanography.

Name: Brzezinski, Mark**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Serves on Executive Committee. Active participant on UNOLS cruises, and frequently serves as the chief scientist. Directs research on phytoplankton ecology and physiology.

Name: Page, Henry**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Directed wetland ecology research.

Name: Schimel, Joshua**Worked for more than 160 Hours:** No**Contribution to Project:**

serves on our Executive Committee and directs soil ecology research.

Name: Siegel, David

Worked for more than 160 Hours: Yes

Contribution to Project:

Serves on our executive committee, directs ocean remote sensing work and participates on UNOLS cruises.

Name: Zimmerman, Richard

Worked for more than 160 Hours: Yes

Contribution to Project:

Investigates primary production in giant kelp

Name: Shima, Jeff

Worked for more than 160 Hours: Yes

Contribution to Project:

Research and outreach coordinator for SBC LTER. Investigates recruitment processes in reef fishes.

Name: Lenihan, Hunter

Worked for more than 160 Hours: Yes

Contribution to Project:

Reef ecologist investigating trophic interactions

Name: Schmidt, Russell

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Schmidt is a reef ecologist collaborating on SBC kelp forest studies

Name: Nisbet, Roger

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Nisbet is a theoretical ecologist working on food web models

Name: Kendall, Bruce

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Kendall is a theoretical ecologist working on food web models

Name: Dugan, Jenny

Worked for more than 160 Hours: Yes

Contribution to Project:

Sandy beach ecologist. examines influence of kelp wrack on beach consumers. Serves as the project's Research and Education coordinator.

Name: Warner, Robert

Worked for more than 160 Hours: No

Contribution to Project:

reef ecologist

Name: Frew, James

Worked for more than 160 Hours: No

Contribution to Project:

Oversees project's information management

Name: Mertes, Leal

Worked for more than 160 Hours: No

Contribution to Project:

works on sediment transport from watersheds to the coastal ocean

Name: Keller, Arturo

Worked for more than 160 Hours: No

Contribution to Project:

Studies pollutants and models hydrochemistry of watersheds

Name: Dunne, Tom

Worked for more than 160 Hours: No

Contribution to Project:

Contributes to hydrological modeling

Name: Holden, Patricia

Worked for more than 160 Hours: No

Contribution to Project:

Works on the ecology of stream microbes

Name: Reichman, Jim

Worked for more than 160 Hours: No

Contribution to Project:

Helped facilitate the implementation of our information management system. Conducts research on soil disturbance by gophers

Name: Carlson, Craig

Worked for more than 160 Hours: Yes

Contribution to Project:

Works on dissolved Organic Carbon release in coastal ocean including kelp forest ecosystems

Name: Allen, Jon

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on food web modeling

Post-doc

Name: Leydecker, Al

Worked for more than 160 Hours: Yes

Contribution to Project:

Participated in design and execution of chemical sampling and hydrological measurements for coastal streams and analysis of data.

Name: Busse, Lilian

Worked for more than 160 Hours: No

Contribution to Project:

Conducting studies of nutrient-grazer relations in Mission Creek and studies of diatoms and nutrients in Carpinteria Marsh

Name: Beighley, Ed

Worked for more than 160 Hours: Yes

Contribution to Project:

responsible for hydrological modeling

Name: Mcphee-Shaw, Erika

Worked for more than 160 Hours: Yes

Contribution to Project:

Analyzes physical-oceanographic data sets from fixed moorings and cruises, investigates inner-shelf dynamics and mechanisms for cross-shelf nutrient delivery.

Graduate Student

Name: Levenbach, Stuart

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in subtidal field research.

Name: Robinson, Tim

Worked for more than 160 Hours: Yes

Contribution to Project:

participated in chemical sampling of streams and coordination of GIS of coastal catchments

Name: Simpson, Julie

Worked for more than 160 Hours: Yes

Contribution to Project:

Conducts studies of nutrients and aquatic plants in streams

Name: Beherens, Michael

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in subtidal field research

Name: Anderson, Clarissa

Worked for more than 160 Hours: Yes

Contribution to Project:

Participated UNOLs cruises, collection and laboratory processing of monthly water samples. Analyzes phytoplankton species composition in the SB Channel using microscopy and HPLC. Examines the effects of plankton community composition on rates of nutrient cycling as well as the potential effects of freshwater runoff on phytoplankton distributions.

Name: Rassweiler, Andy

Worked for more than 160 Hours: Yes

Contribution to Project:

works on kelp forest ecology, participates in kelp forest community surveys and giant kelp primary production studies. Assists in data management and analyses.

Name: Harrison, Lee

Worked for more than 160 Hours: No

Contribution to Project:

Assists in data entry, stream sampling and GIS work

Name: Brinckman, Jeff

Worked for more than 160 Hours: Yes

Contribution to Project:

conducted surveys of water chemistry, physical factors, and benthic algae and invertebrates at approximately 30 coastal stream sites between Gaviota and Carpinteria

Name: Demarest, Mark

Worked for more than 160 Hours: No

Contribution to Project:

works on ocean primary production

Name: Anghera, Michelle

Worked for more than 160 Hours: No

Contribution to Project:

works on saltmarsh invertebrate assemblages

Name: Kelner, Julie

Worked for more than 160 Hours: No

Contribution to Project:

studies spatial and temporal variation in the infauna of sandy beach communities near to d far from sources of terrestrial runoff

Name: Katie, Arkema

Worked for more than 160 Hours: Yes

Contribution to Project:

works on kelp forest ecology, participates in kelp forest community surveys and giant kelp primary production studies.

Name: Bassin, Corinne

Worked for more than 160 Hours: Yes

Contribution to Project:

Analyzed oceanographic data, participated in one UNOLS cruise

Name: Beckenbach, Edwin

Worked for more than 160 Hours: Yes

Contribution to Project:

Analyzed surface current data from high frequency radars

Name: Otero, Mark

Worked for more than 160 Hours: Yes

Contribution to Project:

Analyzed satellite ocean color and SST imagery. Completed MS degree partially supported by the

Name: Kinlan, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

Works on spatial dynamics of kelp forests using the historical kelp data base

Name: Bose, Rajenda

Worked for more than 160 Hours: No

Contribution to Project:

works on database technology

Name: Broitman, Bernardo

Worked for more than 160 Hours: No

Contribution to Project:

works on recruitment of reef organisms

Name: Goldman, Darcie

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Klose, Kristie

Worked for more than 160 Hours: Yes

Contribution to Project:

Conducts studies of impact of exotic crayfish on stream biota

Name: Lester, Sarah

Worked for more than 160 Hours: No

Contribution to Project:

Name: Nelson, Craig

Worked for more than 160 Hours: No

Contribution to Project:

Name: Parker, Sophie

Worked for more than 160 Hours: Yes

Contribution to Project:

Conducts studies of impact of exotic crayfish on stream biota

Name: Senyk, Natalie

Worked for more than 160 Hours: Yes

Contribution to Project:

Works on spatial dynamics of kelp

Name: Petrey, Danielle

Worked for more than 160 Hours: Yes

Contribution to Project:**Undergraduate Student**

Name: Galst, Carey

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists in subtidal data collection, monthly water sampling and data management and support.

Name: Boch, Charles

Worked for more than 160 Hours: Yes

Contribution to Project:

Prepared and managed kelp database and assisted with subtidal field work.

Name: Deward, Amy

Worked for more than 160 Hours: No

Contribution to Project:

assisted with filtration of water samples

Name: Pau, Staphanie

Worked for more than 160 Hours: No

Contribution to Project:

conducted GIS analysis and stream sampling as part of a senior thesis

Name: Quinn, Andy

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in subtidal field research and the laboratory processing of samples collected in the field

Name: Fuchs, Maria

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in subtidal field research and the laboratory processing of samples collected in the field

Name: Ecker, John-Michael

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in subtidal field research and the laboratory processing of samples collected in the field

Name: Jones, Julia

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in subtidal field research and the laboratory processing of samples collected in the field

Name: Bradford, Stephen

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in subtidal field research and the laboratory processing of samples collected in the field

Name: Kendall, Daniel

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in subtidal field research and the laboratory processing of samples collected in the field

Name: Green, Kristen

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in subtidal field research and the laboratory processing of samples collected in the field

Name: Seruto, Cherlyn

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in assembling field guide to marine plants and animals of the SBC LTER

Name: Doty, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in the laboratory processing of samples collected in the field and on UNOLS cruises

Name: DeMent, Andrea

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in subtidal field research

Name: White, Jada

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in subtidal field research

Name: Benson, Jeremy

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in subtidal field research and the laboratory processing of samples collected in the field

Name: Blythe, Jonathan

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in subtidal field research and the laboratory processing of samples collected in the field

Name: Briggs, Amanda

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in the deployment and retrieval of moored oceanographic instruments

Name: Scalliett, Helene

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in the deployment and retrieval of moored oceanographic instruments, UNOLs cruises, collection and laboratory processing of monthly water samples

Name: Nimmer, Andrew

Worked for more than 160 Hours: No

Contribution to Project:

assisted in stream sampling

Name: Blum, Marguerite

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with lab processing of stream samples

Name: Nguyen, John

Worked for more than 160 Hours: No

Contribution to Project:

assisted with lab processing of stream samples

Name: Jung, Katrina

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with lab processing of stream samples

Name: Jones, Jamie

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with lab processing of stream samples

Name: Asao, Shinichi

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with lab processing of stream samples

Name: Collins, Craig

Worked for more than 160 Hours: No

Contribution to Project:

Assists in chemical analyses of stream samples

Name: Grisafe, Michael

Worked for more than 160 Hours: No

Contribution to Project:

Assists in chemical analyses of stream samples

Name: Kostadinov, Tiho

Worked for more than 160 Hours: No

Contribution to Project:

Name: Guebels, Caroline

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists in processing of stream samples

Name: Moore, Kelly

Worked for more than 160 Hours: No

Contribution to Project:

Assists in processing of stream samples

Name: Reed, Aimee

Worked for more than 160 Hours: No

Contribution to Project:

Assists in processing of stream samples

Name: Dias, Kristen

Worked for more than 160 Hours: No

Contribution to Project:

Assists in processing of stream samples

Name: Tiff, Lubren

Worked for more than 160 Hours: No

Contribution to Project:

Assists in processing of stream samples

Name: Diaz, Kristin

Worked for more than 160 Hours: Yes

Contribution to Project:

assisted with laboratory processing stream samples

Name: Wisniewski, Andrea

Worked for more than 160 Hours: Yes

Contribution to Project:

assisted with laboratory processing stream samples

Name: Grant, Britteny

Worked for more than 160 Hours: Yes

Contribution to Project:

assisted with laboratory processing stream samples

Name: Prendergast, Christie

Worked for more than 160 Hours: Yes

Contribution to Project:

assisted with laboratory processing stream samples

Name: Ramirez, Maria

Worked for more than 160 Hours: No

Contribution to Project:

assisted with laboratory processing stream samples

Name: Matko, Una

Worked for more than 160 Hours: No

Contribution to Project:

collected storm runoff samples

Name: Winneker, Triston

Worked for more than 160 Hours: No

Contribution to Project:

collected storm runoff samples

Name: Borasi, Anthony

Worked for more than 160 Hours: No

Contribution to Project:

collected storm runoff samples

Name: Crecey, Greg

Worked for more than 160 Hours: No

Contribution to Project:

collected storm runoff samples

Name: Babbs, Garrett

Worked for more than 160 Hours: No
Contribution to Project:
collected storm runoff samples
Name: Desautels, Christine

Worked for more than 160 Hours: No
Contribution to Project:
collected storm runoff samples
Name: Unmack, Brett

Worked for more than 160 Hours: No
Contribution to Project:
collected storm runoff samples
Name: Schott, Heidi

Worked for more than 160 Hours: No
Contribution to Project:
collected storm runoff samples
Name: Rindsberg, Tony

Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted nutrient analyses and data entry
Name: Bill, Shimp

Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted nutrient analyses and data entry
Name: Welche, Thomas

Worked for more than 160 Hours: Yes
Contribution to Project:
assisted in subtidal studies of benthic species interactions
Name: Reger, Cian

Worked for more than 160 Hours: No
Contribution to Project:
assisted in subtidal studies of benthic species interactions
Name: Kane, Cori

Worked for more than 160 Hours: Yes
Contribution to Project:
assisted in subtidal studies of benthic species interactions
Name: Rogers, Bonnie

Worked for more than 160 Hours: No
Contribution to Project:
Assisted in studies of kelp forest productivity and population dynamics
Name: Betheny, Allen

Worked for more than 160 Hours: No
Contribution to Project:
Assisted in the deployment and retrieve of oceanographic instruments
Name: Herrer, Shannon

Worked for more than 160 Hours: Yes
Contribution to Project:

Assisted in studies of kelp forest productivity and population dynamics

Name: Buckies, Christine

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in studies of kelp forest productivity and population dynamics

Name: Minnich, Victoria

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in studies of kelp forest productivity and population dynamics

Name: Sakaria, Amy

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in laboratory sample processing, cruise preparations, and data entry

Name: Twohey, Becky

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in laboratory sample processing, cruise preparations, and data entry

Name: Wright, Matt

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in studies of kelp forest productivity and population dynamics

Technician, Programmer

Name: Evans, Bryn

Worked for more than 160 Hours: Yes

Contribution to Project:

Bryn works full time collecting and processing ocean and reef data

Name: Anghera, Mike

Worked for more than 160 Hours: Yes

Contribution to Project:

Mike works full time collecting and processing ocean and reef data

Name: Salazar, David

Worked for more than 160 Hours: Yes

Contribution to Project:

David- prepares and services oceanographic instruments for deployment in the field.

Name: Jones, Janice

Worked for more than 160 Hours: Yes

Contribution to Project:

participates on UNOLS cruises, monthly sampling of water column properties around kelp forests, deployment of in situ nitrate analyzers on targeted reefs.

Name: Emery, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

Managed and performed data collection using CODAR-type high frequency radar systems.

Name: Lertcheraonyong, Krisada

Worked for more than 160 Hours: Yes

Contribution to Project:

Analyzed data collected by CODAR-type high frequency radar.

Name: Setaro, Frank

Worked for more than 160 Hours: Yes

Contribution to Project:

oversees processing of stream samples for chemical analyses

Name: Doyle, Alan

Worked for more than 160 Hours: Yes

Contribution to Project:

oversees chemical analyses of stream samples

Name: Seydel, Keith

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in subtidal field research and the laboratory processing of samples collected in the field

Name: Kay, Matt

Worked for more than 160 Hours: Yes

Contribution to Project:

worked on kelp production studies and nutrient addition experiments on reef community structure

Name: Polyakov, Olga

Worked for more than 160 Hours: Yes

Contribution to Project:

Participated on UNOLS cruises.

Name: Mutz, Stephen

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in subtidal field research

Name: Gotschalk, Chris

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in subtidal field research and in the deployment and retrieval of moored oceanographic instruments

Name: Luan, Wei-yee

Worked for more than 160 Hours: Yes

Contribution to Project:

Data manager for SBC LTER

Name: Goodman, Darcie

Worked for more than 160 Hours: No

Contribution to Project:

community volunteer who assists in stream sampling

Name: Fields, Erik

Worked for more than 160 Hours: Yes

Contribution to Project:

writes programs for analyzing oceanographic data

Name: Menzies, David

Worked for more than 160 Hours: Yes

Contribution to Project:

Helped maintain oceanographic instrumentation. Participated on UNOLS cruises

Name: Polyakov, Olga

Worked for more than 160 Hours: Yes

Contribution to Project:

Participated on UNOLS cruises.

Name: Jones, Chris

Worked for more than 160 Hours: Yes

Contribution to Project:

helped direct data management system for project

Name: Woods, Jim

Worked for more than 160 Hours: Yes

Contribution to Project:

provided IT support for the project

Name: Coombs, Scott

Worked for more than 160 Hours: Yes

Contribution to Project:

Conducts and manages field sampling, operates gauging stations and conducts data analysis

Name: Mardian, Brent

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in reef and oceanographic research and data analyses

Name: Asao, Shinichi

Worked for more than 160 Hours: No

Contribution to Project:

conducted nutrient analyses

Name: O'Brien, Margaret

Worked for more than 160 Hours: Yes

Contribution to Project:

performed management and analyses of oceanographic data

Name: Lippincott, Melissa

Worked for more than 160 Hours: Yes

Contribution to Project:

assisted with studies of wrack input and pore water nutrients on sandy beaches

Name: Chakos, Diane

Worked for more than 160 Hours: No

Contribution to Project:

assisted with studies of wrack input and pore water nutrients on sandy beaches

Name: Hubbard, David

Worked for more than 160 Hours: No

Contribution to Project:

assisted with studies of wrack input and pore water nutrients on sandy beaches

Name: Tarmann, Jennifer

Worked for more than 160 Hours: No

Contribution to Project:

assisted with studies of wrack input and pore water nutrients on sandy beaches

Name: Johnston, Karina

Worked for more than 160 Hours: No

Contribution to Project:

assisted with studies of wrack input and pore water nutrients on sandy beaches

Other Participant

Name: Killion, Lisa

Worked for more than 160 Hours: No

Contribution to Project:

assists in stream sampling

Name: Barkley, Andre

Worked for more than 160 Hours: No

Contribution to Project:

assists in stream sampling

Name: Melkonian, Al

Worked for more than 160 Hours: No

Contribution to Project:

assists in stream sampling

Name: Talgo, Diane

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling in the Carpinteria area

Name: Stanford, Wendy

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling in the Carpinteria area

Name: Sperry, Paul

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling in the Carpinteria area

Name: Prussing, Rik

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling in the Carpinteria area

Name: Ridsen, Dan

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling in the Carpinteria area

Name: Benson, Vera

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling in the Carpinteria area

Name: Aston, Darcie

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling in the Carpinteria area

Name: Powers, Cherly

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling in the Carpinteria area

Name: Montague, Luke

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling in the Carpinteria area

Research Experience for Undergraduates

Name: Willis, Allan

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted in subtidal field 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): Doctoral Degree

Fiscal year(s) REU Participant supported: 2001

REU Funding: REU supplement

Name: Ow, Leah

Worked for more than 160 Hours: Yes

Contribution to Project:

assisted in the analysis of physical oceanographic data

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): Doctoral Degree

Fiscal year(s) REU Participant supported: 2002 2001

REU Funding: REU supplement

Name: Ecker, John-Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

surveyed biodiversity and community dynamics in reef ecosystems. Assisted in studies on primary production in kelp.

Years of schooling completed: Freshman

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: 2002

REU Funding: REU supplement

Name: Blum, Marguerite

Worked for more than 160 Hours: Yes

Contribution to Project:

Participated in studies of the ecology of stream biota

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): Doctoral Degree

Fiscal year(s) REU Participant supported: 2002

REU Funding: REU supplement

Name: McMillan,, Jeffrey

Worked for more than 160 Hours: Yes

Contribution to Project:

Participated in studies of ecology of stream biota

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): Doctoral Degree

Fiscal year(s) REU Participant supported: 2002

REU Funding: REU supplement

Name: Visin, Kyle

Worked for more than 160 Hours: Yes

Contribution to Project:

processed and analyzed physical oceanographic data

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): Doctoral Degree

Fiscal year(s) REU Participant supported: 2003

REU Funding: REU supplement

Name: Kane, Cori

Worked for more than 160 Hours: Yes

Contribution to Project:

assisted in subtidal studies of benthic species interactions

Name: Hansen, Bethany

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on nutrients and stream algae

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: 2003

REU Funding: REU supplement

Name: Watts, Miranda

Worked for more than 160 Hours: Yes

Contribution to Project:

Classified freshwater benthic invertebrates, and extracted chlorophyll a and AFDM from periphyton samples

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): Doctoral Degree
Fiscal year(s) REU Participant supported: 2003
REU Funding: REU supplement

Organizational Partners

University of California, Office of the President, Oakland

The UC Office of the President funds the UC Toxic Substances Research & Teaching Program. One component of this program is the UC Coastal Toxicology Program (UCCTP) whose mission is to help resolve pollution-related problems in California's coastal ecosystems. UCCTP accomplishes this mission by facilitating new research endeavors by UC faculty, and by providing students with research support and interdisciplinary training in the broad area of environmental toxicology. UCCTP is providing support for two graduate students (including salary and the cost of student fees and health insurance) for each year of our project to work on SBC LTER related issues.

The Minerals Management Service

The Minerals Management Service funds a large study of ocean circulation in the Santa Barbara Channel region. The program is run through Scripps Inst. of Oceanography and includes extensive arrays of moorings to measure and ultimately model ocean swells and circulation in this region (http://cdip.ucsd.edu/models/sb_channel.gif).

In addition, MMS supports a large interdisciplinary research program at UCSB to investigate the effects of the offshore oil and gas industry on coastal marine resources (<http://www.mms.gov/omm/pacific/enviro/cmi.htm>). Investigators funded by this program are collaborating with LTER scientists on a wide range of projects in the SBC site including, ocean circulation in the Santa Barbara Channel, long-term monitoring of rocky intertidal shores, sea otter foraging behavior, trophic interactions in sandy communities, and seagrass ecology

Department of Interior National Park Service

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.

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 marine protected areas.

ISP Alginates

ISP Alginates (formerly Kelco Co.) has collected information on the abundance of giant kelp in California and Mexico from routine (approximately monthly) aerial surveys since 1958. They have supplied us with copies of all their archived records and we have converted them into a digital database that will allow us to more easily evaluate long-term trends in the abundance of giant kelp. Kelps surveys by ISP Alginates are ongoing and we are continuing to work closely with them to keep the database on giant kelp current.

University of Colorado at Boulder

We are collaborating with with Mark Williams and Diane McKnight (ISTAAR, Univ. of Colorado) on a LTER cross site comparison grant to investigate dissolved organic N in streams.

University of New Hampshire

We are collaborating with with Bill McDowell (Univ.of NH) on a LTER cross site comparison grant to investigate dissolved organic N in streams.

Santa Barbara Watershed Resource Center

Santa Barbara Watershed Resource Center is a collaborative partner in SBC's outreach program

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 the Land Trust as they protect and manage the property.

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

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 intensive catchments (Mission and Arroyo Burro) are within the City, and we are interacting with its staff to help them plan their restoration efforts.

Santa Barbara County Project Clean Water

Santa Barbara County's Project Clean Water in 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.

Other Collaborators or Contacts**Other Collaborators or Contacts**

The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) 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 and Warner) is tightly linked with the Santa Barbara LTER and considerable sharing of resources and data in studies pertaining to physical, chemical, and biological oceanography. (<http://www.piscoweb.org>)

NASA funds a long-term (>6 y) study at UCSB (referred to as Plumes and Blooms) that investigates the interaction of marine plankton blooms and terrestrial runoff. The goal of this project (awarded to 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 and MODIS satellite sensors. (<http://www.icess.ucsb.edu/PnB/PnB.html>)

With funding from the Los Angeles Regional Water Quality Control Board (RWQCB), Arturo Keller has developed a detailed nutrient (N and P) source loading and water quality model for the Santa Clara River watershed, the largest watershed (> 4,000 km²) in our LTER study area. It has supported significant agricultural activity for more than a century, although it is transitioning to suburban and urban land uses. The project involves developing a decision-support model for determining a Total Maximum Daily Load for nutrients, allocating the TMDL to point and non-point sources (including agriculture), and evaluating various Best Management Practices. We have implemented the Watershed Analysis Risk Management Framework model, using data from local (e.g. United Water Conservation District, Ventura County Flood Control District, Los Angeles County Department of Public Works, Ventura County Farm Bureau, four large wastewater treatment plants, city governments, agricultural associations, environmental organizations, land developers), regional/state (e.g. Southern California Association of Governments,

RWQCB, State Water Resources Control Board, California Air Resources Board) and national (e.g. USEPA, USGS, NOAA, USFWS) sources for meteorology, land use, fertilizer application rates, atmospheric deposition, point source flow and concentrations, water quality and gauged flow.

The Environmental Protection Agency funds the Western Center for Estuarine Ecosystem Indicator Research (CEEIR) whose primary objective is to develop a suite of biological, ecological, and chemical indicators of wetland ecosystem health for the California Coast. Several key scientists (Nisbet, Holden, Kendall, Page) working on this program are closely aligned with SBC and there is much interest in establishing common study sites, sharing data, and developing a joint curricula for graduate students working on the two projects. The estuarine focus of CEEIR nicely compliments the kelp forest focus of SBC. Collectively, the two programs will provide an in-depth assessment of the natural and human processes affecting two of the most important and conspicuous coastal ecosystems in California.

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. 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 for our project and nicely complement those that are being collected by SBC and CEEL. Another major component of the SONGS mitigation program is the creation of kelp forests on artificial reefs to replace kelp habitat destroyed by the power plant. Large-scale (i.e. 10 ha) experiments are being done to determine how reef topography and size influence the colonization and development of kelp and other reef associated organisms. There is considerable exchange of ideas, information and personnel between SBC and the SONGS mitigation project on all issues pertaining to kelp forest research.

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. In 2002, four post docs, 23 graduate students, four REU students and more than 25 additional undergraduate students participated in SBC research. Educational opportunities at SBC are not limited to university students and post docs. 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 abundance. In November 2001, SBC organized and sponsored a symposium titled 'The effects of human activities on ecosystems at the land/ocean margin' for the annual meetings of the Western Society of Naturalists. The symposium was attended by more than 400 people (scientists, students, and the general public) and included speakers from all over the U.S.

The SBC-LTER program has jointly developed a graduate student training program with three other existing programs on the UCSB campus: the Center for Estuarine Indicator Ecosystem Research (CEIER) funded by U.S. Environmental Protection Agency, the UC Coastal Toxicology Program funded by University of California, and the Partnership for Interdisciplinary Studies of Coastal Oceans funded by the Packard Foundation. This program emphasizes interdisciplinary research to examine how coastal ecosystems change in response to natural and human-induced alternations in the environment, and seeks to create a diverse scientific community of students that have a respect and appreciation for other disciplines. In 2002, the program included 23 graduate students and four postdoctoral fellows, with research interests spanning terrestrial, aquatic, and marine ecology, physiology, geology, oceanography, and policy. Students and postdoctoral fellows participated in a quarter-long seminar that student and post doc research projects. In April, 2002 three SBC graduate students presented posters on their research at the 15th Annual UC Toxic Substances Research and Teaching Program Symposium, Long Beach, California. In September 2002, five SBC graduate students, Co-PI Holbrook and three Associate Investigators, attended the Annual Coastal Toxicology Retreat at the Bodega Marine Laboratories to discuss research integration among faculty and graduate students. Topics covered included research needs, on-going research projects, and future research collaborations between the Toxicology Program and the SBC LTER. Three of the students attended a week long interdisciplinary short course on eco-toxicological research. In addition, students, postdoctoral fellows, and Senior Investigators participated in the second Annual SBC-LTER Science Meeting, where results from SBC research were presented.

Outreach Activities:

Growing concern over frequent beach closures due to high bacterial pollution continues to focus public attention on the declining water quality

of Santa Barbara's creeks and beaches. SBC-LTER has partnered with the Community Environmental Council to develop sets of educational tools and resources housed at the South Coast Watershed Resource Center (SCWRC) to inform the public about: (1) the importance of our watershed resources, (2) the connections between watersheds and coastal ocean ecosystems, (3) how these resources are impacted by human activities, (4) the role watershed restoration plays in improving water quality, and, (5) ways that the community can actively protect our creeks, wetlands, and ocean. SCWRC opened its doors in August 2001 and has since provided education programs for numerous elementary schools, organized public workshops on a variety of environmental issues, and hosted numerous meetings and tours for a wide variety of non-profit environmental awareness groups. SBC researchers worked with SCWRC staff to develop displays depicting ongoing research in the watersheds and nearshore waters in the Santa Barbara area. Schoolyard funds supplied by NSF have been used to purchase start-up equipment for the school programs as well as the production of student journals that were used by all the students who participated in the programs.

In 2002 the main focus of the SBC's Schoolyard program was the develop an interactive computer animation model of the Arroyo Burro Watershed, which empties into the ocean at the site of SCWRC.. The computer animation model will provide an interactive tool for 4-8th grade students, instructors, and the general public using SCWRC. The animation model, which will be made available on CD as well as on-line through SBC LTER's website has two main components: 1) an animated fly over tour coupled with static pages that allow the user to view images and information of the various ecosystems and land uses characteristic of the Arroyo Burro watershed; and 2) an interactive animated water surface response of the Arroyo Burro Creek as it flows by the SCWRC that allows the user to alter various land use and rainfall configurations. The animation program provides an interactive educational tool that emphasizes both the spatial distribution of the various ecosystems and land uses within the Arroyo Burro Watershed, and the effects of land use change on flooding.

Common Ground is a group of stakeholders who are developing a consensus on management for the Gaviota coast. We are involved to provide a scientific perspective.

The SBC-LTER outreach program also played host to Eagle Scout Tim Brox, selected by NSF's Polar Programs to visit US research stations in Antarctica. A 'cross-site' LTER outreach effort (in conjunction with the Palmer Station LTER) introduced Tim to ongoing studies at the SBC-LTER and emphasized the value of long-term research efforts.

Several SBC investigators routinely give lectures in local k-12 schools on LTER related topics (e.g. kelp forest ecology, watershed processes, ocean circulation, etc.). In addition to these many lectures, post doc Erika McPhee-Shaw co-taught a classroom project through the 'Kids do Ecology' program, which is run through NCEAS, and has some direct ties with Los Marineros (http://www.nceas.ucsb.edu/nceas-web/kids/main_pages/classweb.htm). Additional outreach activities done by SBC investigators include: a segment on live TV for Project Oceanography (<http://www.marine.usf.edu/pjocean/>) on SBC research in the Santa Barbara Channel, assisting the Channel Islands Marine Sanctuary in developing curriculum on associations between terrestrial runoff and phytoplankton blooms, and giving several public presentations on LTER related research to non-scientist groups.

The JASON PROJECT (<http://www.jason.org/jason14/home>) is a multi-disciplinary educational program that sparks the imagination of students and enhances the classroom experience by developing and supporting curricula that enable students and their teachers to do field work from the classroom and exposes students to leading scientists and their research as they examine basic biological and geological questions. SBC-LTER investigators worked with the JASON PROJECT in the development of JASON XIV: From Shore to Sea, which is now available for school year 2002-03. In this new and exciting program, the JASON team explores the terrestrial and marine ecosystems that extend from California's coast to the Channel Islands Marine Sanctuary.

Journal Publications

Airame, S., J. E. Dugan, K. D. Lafferty, H. M. Leslie, D. A. McArdle, and R. R. Warner., "Applying ecological criteria to marine reserve design: a case study from the California Channel Islands", *Ecological Applications*, p. s170, vol. 13, (2003). Published

Allison, G. W., S. D. Gaines, J. Lubchenco, and H. P. Possingham, "Ensuring persistence of marine reserves: Catastrophes require adopting an insurance factor", *Ecological Applications*, p. s8, vol. 13, (2003). Published

Blanchette, C. A., S. D. Gaines, and B. Miner, "Geographic variability in form, size, and survival of *Egregia menziesii* (Turner) Areschoug around Point Conception, California.", *Marine Ecology Progress Series*, p. 69, vol. 239, (2002). Published

Botsford, L. W., A. Hastings, and S. D. Gaines., "Dependence of sustainability on the configuration of marine reserves and larval dispersal distance", *Ecology Letters*, p. 144, vol. 4, (2001). Published

Gaines, S. D., B. Gaylord, and J. L. Largier, "Avoiding current oversights in marine reserve design.", *Ecological Applications*, p. s32, vol. 13, (2003). Published

- Gaylord B., D. C. Reed, P. T. Raimondi, L. Washburn, and S. R. McLean, "A physically-based model of macroalgal spore dispersal in the wave and current-dominated nearshore", *Ecology*, p. 1239, vol. 83, (2002). Published
- Gerber, L. R., S. J. Andelman, L. W. Botsford, S. D. Gaines, A. Hastings, S. R. Palumbi, and H. P. Possingham, "Population models for marine reserve design: A retrospective and prospective synthesis.", *Ecological Applications*, p. s47, vol. 13, (2003). Published
- Mertes L. A. K., and J. A. Warrick, "Measuring flood output from 110 coastal watersheds in California with field measurements and SeaWiFS", *Geology*, p. 659, vol. 29, (2001). Published
- Phillips, N. E., and S. D. Gaines, "Spatial and temporal variability in size at settlement of intertidal mytilid mussels from around Pt. Conception, California", *Invertebrate Reproduction and Development*, p. 171, vol. 41, (2002). Accepted
- Sagarin, R. and S. D. Gaines, "Geographical abundance distributions of coastal invertebrates: using one-dimensional ranges to test biogeographic hypotheses.", *Journal of Biogeography*, p. 985, vol. 29, (2002). Accepted
- Sagarin, R., and S. D. Gaines, "The "abundant center" distribution: to what extent is it a biogeographic rule?", *Ecology Letters*, p. 137, vol. 5, (2002). Published
- Schroeter S. C., D. C. Reed, D. J. Kushner, J. A. Estes, and D. S. Ono, "The use of marine reserves in evaluating the dive fishery for the warty sea cucumber (*Parastichopus parvimensis*) in California, U.S.A.", *Canadian Journal of Fisheries and Aquatic Science*, p. 1773, vol. 58, (2001). Published
- Wares, J., S. D. Gaines, and C. Cunningham., "A comparative study of asymmetric migration events across a marine biogeographic boundary", *Evolution*, p. 295, vol. 55, (2001). Published
- Holbrook, S. J., D. C. Reed, D. C., and J. S. Bull, "Survival experiments with outplanted seedlings of surfgrass (*Phyllospadix torreyi*) to enhance establishment on artificial structures", *ICES Journal of Marine Science*, p. 350, vol. 59, (2002). Published
- Shima, J.S., and A.M. Findlay, "Pelagic larval growth rate impacts benthic settlement and survival of a temperate reef fish.", *Marine Ecology Progress Series*, p. 303, vol. 235, (2002). Published
- Chomko, R.M., H.R. Gordon, S. Maritorena and D.A. Siegel, "Simultaneous determination of oceanic and atmospheric parameters for ocean color imagery by spectral optimization: a validation", *Remote Sensing of the Environment*, p. 208, vol. 84, (2003). Published
- Dugan, J. E., D. M. Hubbard, M. McCrary, and M. Pierson, "The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California.", *Estuarine, Coastal and Shelf Science*, p. 133, vol. 58s, (2003). Published
- Hubbard, D. M., and J. E. Dugan, "Shorebird use of an exposed sandy beach in southern California.", *Estuarine, Coastal and Shelf Science*, p. 169, vol. 58s, (2003). Published
- Lubchenco, J., S. Palumbi, S. D. Gaines, and S. Andelman., "Plugging a hole in the ocean: an introduction to the special feature on marine reserves", *Ecological Applications*, p. s3, vol. 13, (2003). Published
- Page, H. M., S. Schroeter, D. C. Reed, R.F. Ambrose, J. Callaway, J. Dixon., "An inexpensive method to identify the elevation of tidally inundated habitat in coastal wetlands", *Bulletin of the Southern California Academy of Sciences*, p. 130, vol. 103, (2003). Published
- Roberts, C. G. Branch, R. Bustamante, J. Carlos-Castilla, J. Dugan, B. Halpern, H. Leslie, K. Lafferty, J. Lubchenco, D. McArdle, M. Ruckelshaus, and R. Warner, "Application of ecological criteria in selecting marine reserves and developing reserve networks", *Ecological Applications*, p. s215, vol. 13, (2003). Published
- Sax, D., J. Brown, and S. D. Gaines., "Species invasions exceed extinctions on islands world-wide: a comparative study of plants and birds", *American Naturalist*, p. 171, vol. 160, (2002). Published

- Siegel, D.A., P. Kinlan, B. Gaylord and S.D. Gaines, "Lagrangian descriptions of marine larval dispersion", Marine Ecology Progress Series, p. 83, vol. 260, (2003). Published
- Zacherl, D. C., P. H. Manríquez, G. Paradis, R. W. Day, J. C. Castilla, R. R. Warner, D. W. Lea & S. D. Gaines, "Trace elemental fingerprinting of gastropod statoliths to study larval dispersal strategies", Marine Ecology Progress Series, p. 297, vol. 248, (2003). Published
- Shipe, R.F., U. Passow, M.A. Brzezinski, D.A. Siegel and A.L. Alldredge, "Effects of the 1997-98 El Nino on seasonal variations in suspended and sinking particles in the Santa Barbara Basin", Progress in Oceanography, p. 105, vol. 54, (2002). Published
- Boles, J.R., J.F. Clark, I. Leifer, and L. Washburn, "Temporal variations in natural hydrocarbon seep rate due to tides, Coal Oil Point area, California", J. Geophys. Res, p. 27,077, vol. 106, (2001). Published
- Nishimoto, M.M., and L. Washburn, "Patterns of coastal eddy circulation and abundance of pelagic juvenile fish in the Santa Barbara Channel, California, USA", Marine Ecological Progress Series, p. 183, vol. 241, (2002). Published
- Washburn, L., K. A. McClure, B. H. Jones, and S. M. Bay, "Spatial Scales and Evolution of Stormwater Plumes in Santa Monica Bay", Marine Environmental Research, p. 103, vol. 56, (2003). Published
- Bay, S., B. H. Jones, K. Schiff, and L. Washburn, "Water Quality Impacts of Stormwater Discharges to Santa Monica Bay", Marine Environmental Research, p. 202, vol. 56, (2003). Published
- Beighley, R.E., D.L. Johnson, and A.C. Miller, "A subsurface response model for storm events within the Susquehanna River Basin", Journal of Hydrologic Engineering, ASCE, p. 185, vol. 8, (2002). Published
- Beighley, R.E. and G.E. Moglen, "Assessment of Stationarity in Rainfall - Runoff Behavior in Urbanizing Watersheds", Journal of Hydrologic Engineering, ASCE, p. 27, vol. 7, (2002). Published
- Beighley, R.E. and G.E. Moglen, "Adjusting Measured Peak Discharges from an Urbanizing Watershed to Reflect a Stationary Land Use Signal", Water Resources Research, p. 1093, vol. 39, (2003). Published
- Moglen, G.E. and R.E. Beighley, "Spatially Explicit Hydrologic Modeling of Land Use Change", Journal of the American Water Resources Association, p. 241, vol. 38, (2002). Published
- Strayer, D.L., R.E. Beighley, L.C. Thompson, S. Brooks, C. Nilsson, G. Pinay, and R.J. Naiman, "Effects of land-cover change on stream ecosystems roles of empirical models and scaling issues", Ecosystems, p. 407, vol. 6, (2003). Published
- Kinlan, BP, SD Gaines, "Propagule dispersal in marine and terrestrial environments: a community perspective", Ecology, p. 2007, vol. 84, (2003). Published
- Roberts, C, G. Brandch, R. Bustamante, J. Carlos-Castilla, J. Dugan, B. Halpern, H. Leslie, K. Lafferty, J. Lubchenco, D. McArdle, M. Ruckelshaus, R. Warner, "Application of ecological criteria in selecting marine reserves and developing reserve networks.", Ecological Applications, p. s215, vol. 13, (2003). Published
- Kinlan, BP, MH Graham, PK Dayton, "Arrested development of embryonic sporophytes in the perennial giant kelp *Macrocystis pyrifera* (Phaeophyceae): a mechanism for delayed recruitment?", Journal of Phycology, p. 47, vol. 39, (2003). Published
- McCuen, RH RE Beighley, "Seasonal flow frequency analysis", Journal of Hydrology, p. 43, vol. 279, (2003). Published
- Thorner, CS, SD Gaines, "Spatial and temporal variation of haploids and diploids in populations of four congeners of the marine alga *Mazzaella*", Marine Ecology Progress Series, p. 65, vol. 258, (2003). Published
- Zacherl D, SD Gaines, SI Lonhart, "The limits to biogeographical distributions: insights from the northward range extension of the marine snail *Kelletia delletii* (Forbes, 1852)", Journal of Biogeography, p. 913, vol. 30, (2003). Published

- Bull, JS, DC Reed, SJ Holbrook, "An experimental evaluation of different methods of restoring *Phyllospadix torreyi* (Surfgrass)", *Restoration Ecology*, p. , vol. 12, (2004). Accepted
- Gaylord, B, DC Reed, L. Washburn, and PT Raimondi, "Biological-physical coupling in spore dispersal of kelp forest macroalgae", *Journal of Marine Systems*, p. , vol. , (). Accepted
- Guichard, FR, S. Levin, A. Hastings, D. Siegel, "Toward a metacommunity approach to marine reserve theory", *Bioscience*, p. , vol. , (). Accepted
- Otero, MP, DA Siegel, "Spatial and temporal characteristics of sediment plumes and phytoplankton blooms in the Santa Barbara Channel", *Deep Sea Research*, p. , vol. , (). Accepted
- Reed, DC, SC Schroeter, PT Raimondi, "Spore supply and habitat availability as sources of recruitment limitation in giant kelp.", *Journal of Phycology*, p. , vol. , (2004). Accepted
- Robinson, TH A.Leydecker, AA Keller, JM Melack, "Nutrient export coefficient modeling in Mediterranean Coastal Streams", *Agricultural Water Management*, p. , vol. , (). Accepted
- Thornber, DC, BP Kinlan, MH Graham, JJ Stachowicz, "Population ecology of the invasive kelp *Undaria pinnatifida* in California: environmental and biological controls on demography", *Marine Ecology Progress Series*, p. , vol. , (). Accepted
- Warrick, JA, LAK Mertes, DA Siegel, and C MacKenzie, "Estimating suspended sediment concentrations in turbid coastal waters with SEaWiFS", *International Journal of Remote Sensing*, p. , vol. , (). Accepted
- Roberts, C.M., S. Andelman, G. Branch, R. H. Bustamante, J. C. Castilla, J. Dugan, B. S. Halpern, K.D. Lafferty, H. Leslie, J. Lubchenco, D. McCardle, H. Possingham, M Ruckelshaus, and R.R. Warner, "Ecological criteria for evaluating candidate sites for marine reserves.", *Ecological Applications*, p. s199, vol. 13, (2003). Published

Books or Other One-time Publications

- Robinson, T. H., Al Leydecker, J. M. Melack, and A. A. Keller, "Nutrient Concentrations in Coastal Streams and Variations with LandUse in the Carpinteria Valley, California.", (2002). Conference Proceedings, Accepted
Collection: California and the World Ocean '02.
Bibliography: Santa Barbara, CA, USA
- Robinson, T. H., A.Leydecker, J. M. Melack, and A. A. Keller, "Nutrient Concentrations in Southern California Streams related to Landuse", (2002). Proceedings, Published
Editor(s): Lesnick, John R.
Collection: . Coastal Water Resources, AWRA 2002 Spring Specialty Conference Proceedings, American Water Resources Association
Bibliography: Middleburg, Virginia, TPS-02-1, pp 339-343
- Bull, J. S., "An Experimental Evaluation of Different Methods of Restoring *Phyllospadix torreyi* (Surfgrass)", (2002). Thesis, Published
Bibliography: University of California, Santa Barbara.
- Rennebarth, T., "Impact of nutrients on diatom communities in a California Salt Marsh (Einflüsse von Nährstoffeinträgen auf die Diatomeengesellschaften einer kalifornischen Salzmarsch)", (2002). Thesis, Published
Bibliography: Technical University of Munich, Limnological Field Station at the Osterseen, Germany.
- Warrick, J. A., "Short-term (1997-2000) and long-term (1928-2000) observations of river water and sediment discharge to the Santa Barbara Channel.", (2002). Thesis, Published
Bibliography: Dissertation. University of California, Santa Barbara
- Otero, M. P., "Spatial and Temporal Characteristics of Sediment Plumes and Phytoplankton Blooms in the Santa Barbara Channel.", (2002).

Thesis, Published

Bibliography: Thesis. University of California, Santa Barbara, CA 113 pp.

Web/Internet Site

URL(s):

<http://sbc.lternet.edu>

Description:

This is our project's website that was created to describe the activities and results of this award

Other Specific Products

Product Type: Data or databases

Product Description:

ISP Alginates (formerly Kelco Co.) has collected information on the abundance 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. ISP Alginates has provided us with copies of all their archived records. We have 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. Kelps surveys by ISP Alginates are ongoing and we are continuing to work closely with them to keep the database on giant kelp current.

Sharing Information:

Our historical kelp database can be accessed on the SBC website at <http://sbc.lternet.edu/data/research/reef/historical-kelp-data/>.

Product Type: Data or databases

Product Description:

SST imagery from NOAA-AVHRR polar orbiters of the Santa Barbara Channel

Sharing Information:

The database is available at <http://www.icesb.ucsb.edu/avhrr/ViewSBchnlGifs.html>

Product Type: Data or databases

Product Description:

Surface currents by high frequency radar around Point Conception California

Sharing Information:

The data are available at <http://www.icesb.ucsb.edu/iog/codar.htm>

Product Type: Teaching aids

Product Description:

Field guide to the common subtidal plants and animals. Santa Barbara Coastal Ecosystem Long-Term Ecological Research Program.

Sharing Information:

available online at: <http://sbc.lternet.edu/data/research/reef>.

Contributions

Contributions within Discipline:

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.

Our stream experiments have shown that the relative importance of nutrient and grazer limitation to algal biomass changes across habitats and through the seasons. This temporal and spatial variation needs to be considered in examining controls on algal biomass and in examining the effects of stream organisms on nutrient processing. The stable isotope work indicates that stable isotope techniques can be used to delineate food webs across streams draining basins experiencing different types of land use. The Carpinteria Salt Marsh work suggests that marsh diatoms can be used as bioindicators of nitrogen inputs.

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, our understanding of ecosystem level processes 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 primary production, of stable isotope analyses of kelp forest food webs, and of the role of nutrients in altering these 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 begun to quantitatively assess the flux of nutrients due to each mechanism. This research is providing valuable information about transport processes on the inner shelf, which is 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 fills an important gap in that it 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.

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, and informatics. SBC is now completing its fourth year of research and the major contributions of our research have yet to be realized. It is our intent that coordinated studies among the many disciplines represented in SBC will lead to an improved understanding of the patterns and processes that link land and ocean environments and their consequences to coastal ecosystems. Such an improved understanding will not only contribute to furthering the many disciplines listed above, but should be of considerable value to those in the social sciences 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 and three social scientists from SBC attended the 2003 LTER All Scientists Meetings in September 2003.

Contributions to Human Resource Development:

Our project provides significant opportunities for research and teaching in science at multiple levels. In 2003, three post docs, 23 graduate students, two REU students and more than 20 additional undergraduate students participated in SBC research. In addition to gaining valuable research experience, many of the undergraduate students earned academic credit or were given monetary compensation. One of our past REU students is Hispanic and recently graduated from UCSB in biology. He continued to work on our project as a research technician while actively exploring his options for furthering his education in graduate school. He recently was accepted into the graduate program at Columbia University beginning spring 2003. Several of our undergraduate students have applied for and received funding to pursue independent studies associated with SBC research activities. One of these students recently graduated and she has been accepted into a Ph.D program at UC Riverside. 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. Educational opportunities at SBC are not limited to university students and post docs. Two pre-college teachers and several 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. Using supplemental Schoolyard funds from NSF we developed a partnership with the South Coast Watershed Resource Center, a local non-profit group that promotes conservation of coastal ecosystems through education and training. Built at the request of Santa Barbara County in response to growing concerns about the South Coast's water quality, the Watershed Resource Center makes the connection between healthy watersheds and each of our own personal habits such as cleaning up after pets, landscaping with native plants, and properly disposing of everyday chemicals. It gives school kids an opportunity to experience our environment first-hand, provides information to educators about watershed-related subjects (including those studied by SBC), and educates the general public about coastal ecosystems and their conservation. NSF Schoolyard funds have been used to enhance hands-on school and public programs, teacher workshops, and computer based activities at the Center, and to develop an interactive computer animation module featuring the Arroyo Burro Watershed.

In 2003, SBC increased the exposure of SBC research activities to K-12 students and teachers by partnering with UCSB Marine Science Institute's Oceans into the Classroom program which offers educational research cruise experience for 6th -8th-graders on a 75' vessel in the Santa Barbara Channel. Working under the direction of MSI professional staff and UCSB students, 6th -8th graders and their teachers conduct oceanographic research in the Santa Barbara Channel. One of the six shipboard research stations is being developed to focus on SBC LTER research.

SBC investigators have also worked closely with the Channel Islands National Marine Sanctuary, the Santa Barbara Maritime Museum and the Santa Barbara Museum of Natural History in developing curricula and exhibits that expose non-scientist members of the public to SBC research activities.

Contributions to Resources for Research and Education:

NSF funds from our project were used to purchase 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.

Our project contributed to institutional resources and education by way of providing support to the Western Society of Naturalists, which is one of only a handful of societies that provide a forum for young marine ecologists and naturalists to present their work. PI Reed was invited to organize a symposium on human effects on ecosystems at the land/ocean margin for the annual meetings of WSN. WSN specifically asked that the symposium be broad in scope, but it did not have funds to pay for all the travel costs of attracting speakers from areas outside of the west coast. We used NSF funds from this project to pay the travel expenses of some of the symposia speakers. The result was a symposium that featured speakers from all over the continental US and Hawaii speaking on a wide variety of topics. The society received many compliments on the symposium and was very appreciative of NSF's support.

SBC's web site 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. During 2003 the redesign of our website to better convey the wide range of research and education activities being done by our project was completed.

Contributions Beyond Science and Engineering:

SBC investigators have been very active in applying their knowledge of Santa Barbara's coastal ecosystems to implement changes in local and regional policies.

The Channel Islands National Marine Sanctuary (NOAA) and the California Department of Fish and Game developed a joint state and federal process to consider marine reserves in the Channel Islands National Marine Sanctuary (<http://www.cinms.nos.noaa.gov/nmpreserves.html>). This joint federal and state process stemmed from a shared concern for sustaining California's marine resources, as well as areas of overlapping and complimentary jurisdiction. The public process was based on both extensive stakeholder input and the best available science. A Science Panel was formed to assimilate, analyze and interpret all scientific data pertinent to the process. Seven of the 15 member Science Panel are senior investigators associated with SBC. Many of the recommendations made by the Science Panel were based, in part, on first-hand knowledge obtained by SBC investigators. Relying heavily on information compiled by the Science Panel, the California Fish and Game Commission voted to implement a no-take marine reserve system in the Channel Islands beginning January 1, 2003. The marine reserve network at the Channel Islands is one of the largest ones in the country. The process of establishing marine reserves in the Santa Barbara Channel is ongoing and SBC investigators continue to play an important and active role in working with state and federal agencies on these issues. In March 2003, several SBC Co-Principal Investigators and Associate Investigators participated in a two day workshop on developing monitoring and evaluation approaches for the new marine reserves in the Channel Islands.

Santa Barbara Channel has a long history of oil and gas development. Many of the platforms in the channel are nearing the end of their operating lives and there is much controversy over whether decommissioned platforms should be dismantled and removed or abandoned in place to serve as artificial reefs for fish and other reef associated organisms. Co-PI Holbrook chaired the UC Marine Council committee that wrote a report commissioned by the California State Legislature on scientific issues related to decommissioning California oil platforms. She and other committee members drew upon their knowledge of reef ecosystems in the Santa Barbara Channel and evaluated all other existing information on issues relating to production on artificial and natural reefs. The report was released in fall 2000, and can be found at http://www.ucop.edu/research/ucmc_decommissioning/

SBC research is playing 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 we and they share our 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. 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 intensive catchments (Mission and Arroyo Burro) are within the City, and we are working with city staff to help them plan their restoration efforts. 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 UCSB 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 the sites that we sample intensively, and we will continue to provide useful information to the Land Trust as they protect and manage the property. The Santa Barbara Channel Keepers 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. Tim Robinson, an SBC graduate student doing his dissertation research in the Carpinteria watershed is an active participant in the Carpinteria Creek Watershed Coalition, whose mission is to restore and preserve Carpinteria Creek sufficiently to reestablish a steelhead run (steelhead is an endangered species in California). Tim also serves on the Technical Advisory Committee to the Santa Barbara County Task Force, Southern California Wetlands Recovery Project. Al Leydecker, a post doc with SBC, helped organize, collect and prepare nutrient samples for 'Snapshot' day, a one day stream testing campaign organized by the California State Water Quality Resources Board to sample streams across the state, in San Luis Obispo, Santa Barbara and Ventura counties. Al also participated in an Arroyo Burro Watershed Visioning process meeting. Melack serves on Common Ground, a stakeholder group formulating plans for long-term preservation and economic viability for the Gaviota coast. Dugan has been invited to serve on the Science Advisory Panel for the Goleta Beach Visioning Process.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: less than 20 percent of current funds

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

RESEARCH ACTIVITIES

The research focus of SBC is on ecological systems at the land-ocean margin. Although there is increasing concern about the impacts of human activities on coastal watersheds and nearshore marine environments, there have been few long-term studies of linkages among terrestrial, estuarine, nearshore, and oceanic habitats. The primary research objective of SBC is to help fill this gap by determining the relative contributions of land vs. ocean-derived constituents in structuring kelp forest ecosystems, which are among the most productive systems in the world. SBC research involves interdisciplinary studies coordinated among more than twenty investigators working in watersheds, subtidal reefs, and the coastal ocean. These studies are designed to determine the effects of land use patterns on the distribution and movement of nutrients, sediments, and organisms across landscapes, their transport and modification by streams and estuaries, and the effects of stream outflows and coastal ocean processes (e.g., upwelling, currents, waves, and water column productivity) on population, community and ecosystem level processes in giant kelp forests.

Below we detail our research activities as they pertain to land, reef and ocean processes.

WATERSHED STUDIES

Runoff, stream chemistry and transport

In water year 2002, we modified our first year strategy of studying a large number of streams representing broad land-use or geographic categories to intensively studying a few selected creeks. The selected streams were sampled as they cross land-use boundaries, as well as at the previously sampled tidal limit. We also sampled a few, well-defined, smaller drainages tributary to single land uses (e.g., residential, agricultural drains, and light commercial) in an effort to better define the effect of land-use on nutrient export. We sampled both baseflow and stormflow for dissolved inorganic nutrients (nitrate, phosphate and ammonium), total dissolved nitrogen, particulate N, P and C, and total suspended solids

Our 2003 sampling goals were to regularly sample stormwater chemistry at Gaviota, Refugio, Arroyo Hondo, Arroyo Burro, Mission, Santa Monica, Franklin and Carpinteria creeks, and to sample at least one storm on the Ventura River. This selection is derived from a number of considerations: (1) the need to sample the same creeks as in 2002 and 2001 because of the absence of a storm large enough to generate whole-catchment runoff in 2002 and only one such storm in 2001; (2) to expand coverage in the western LTER region by adding auto-sampling at Refugio and Gaviota; and (3) include the Ventura as both an eastern LTER location and to supplement the on-going "point in time" monthly river sampling program. Sampling at Gaviota, Arroyo Hondo and Ventura is being done at a single sampling point. All the other creeks are being sampled at multiple locations. The reasons for multiple sampling on a single creek are to determine how export varies with land use, and to model south-coast export and its probable variation with changing land use.

We have established 30 stream gauging stations in the SBC LTER study region. At these sites, stream stage and water temperature are recorded at a 5-min temporal resolution. To convert our measured stage values to discharge, we are developing rating curves by measuring channel cross-sections and roughness to characterize the channel reaches, and then, using the HEC-RAS (streamflow hydraulics) program, the channel properties are used to simulate rating tables that associate stage and discharge for a given site. 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 also record conductivity. Continuous (5-min) conductivity data will 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. Currently, we have installed 7 rainfall gauges (3 of the remote gauges are equipped with spread spectrum telemetry). Additional sites have been identified, and we are currently in the process of gaining access to those sites for rainfall gauges.

Hydrologic modeling of the catchments requires detailed spatially distributed data. The following datasets have been compiled and subsetted for our catchments:

Digital Elevation Models: 3, 30 and 60 meter grid cell resolution.

National Hydrography Dataset (NHD) contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells.

Soil Survey Geographic (SSURGO) data base, which is the most detailed level of soil mapping done by the Natural Resources Conservation Service (NRCS).

State Soil Geographic Database (STATSGO) is a soil map made by generalizing the detailed SSURGO data.

National Land Cover Data derived from the early to mid-1990s Landsat Thematic Mapper satellite data with a 21-class land cover classification scheme.

Land Use/Land Cover derived from digital 1:42,000 scale orthophotos taken in 1998.

Various coverages from the City of Santa Barbara and Santa Barbara County: zoning, parcels, storm drains, roads, etc.

Using the SBC-LTER and existing gauging networks, we calibrated and validated two rainfall-runoff models for streams in the study region for the recent 14-year period (10/1/1988 through 9/30/2002). The recent 14-year period is well suited for studying climate variability in the region because there are 4, 4 and 6 years classified as having El Niño, La Niña and normal climatic conditions, respectively. Initially, the HEC-HMS rainfall-runoff model was used to simulate runoff for the current land use conditions for the 14-year period. Then, historical and future land use conditions were obtained, and the model was used to simulate the effects of land use change on the annual distribution of streamflow.

Building on the initial modeling effort, we have developed a model better suited to the SBC-LTER region. The model simulates runoff from three sources (surface, steep shallow soils and groundwater) and is designed to integrate nutrient and sediment export modules, which represents the future research direction of the terrestrial component of the SBC-LTER. The SBC rainfall-runoff model has been calibrated and validated for one watershed for the recent 14-year period using the current land use conditions. Predevelopment and future development land use conditions have also been simulated.

We have used supplemental NSF funding to establish on-line access to archived and on-going hydrologic and environmental datasets from the SBC-LTER by linking to both the CLIM-DB and HYDRO-DB.

Catchment and in-stream processing of and responses to nutrients

Four studies of stream ecology have been done or are in progress: (1) The biotic effects of introduced crayfish are under investigation. (2) Stable isotope analyses are being used to decipher trophic structure in different seasons and habitats. (3) Surveys of water chemistry, physical factors, and benthic algae and invertebrates were conducted at approximately 30 coastal stream sites between Gaviota and Carpinteria. The purpose of this study is to examine correlations between the distribution of invertebrates and physical-chemical factors in coastal streams and to examine the use of stream invertebrates as bioindicators for stream "health". This work may form the basis for long-term LTER collaborations with the County of Santa Barbara, which is interested in developing assays for measuring stream "health". (4) To assess the effects of nutrients on species composition and biomass of benthic and floating algae in coastal streams, the relationship between in-stream nutrient concentrations and algal growth is being investigated in several streams. Surveys of water chemistry and algal abundance and species composition were conducted throughout the watersheds, and N and P supply were experimentally manipulated using nutrient diffusers to assess algal growth responses

Effects of nitrogen enrichment in salt marshes

Many coastal embayments are influenced by nitrogen inputs from agricultural and urban development in adjoining watersheds. Elevated dissolved inorganic nitrogen concentrations in coastal environments can cause eutrophication because these ecosystems are usually nitrogen limited. Nitrogen enrichment in salt marshes and shallow lagoons may alter the biological community by stimulating algal and plant growth, and reducing nighttime levels of dissolved oxygen. Indicators are needed that reflect the potential biological effects of nitrogen enrichment on salt marsh ecosystems. Benthic microalgae, especially diatoms, are known to be very sensitive to changes in water quality, and were investigated as bioindicators

in Carpinteria Salt Marsh, a site within the SBC LTER with previous and on-going studies on the sources, fates, and effects of watershed-derived nutrient inputs. Nitrate concentrations in the marsh channels exceed values in the coastal ocean by 10 to 100 fold. Within the marsh we chose 14 sampling sites, representing different levels of nutrients and salinity. Water samples and sediment pore-water samples for nutrient analyses were collected from the channels in the marsh. Temperature, salinity, and conductivity were measured at the same sites *in situ*. Simultaneously, samples of benthic microalgae were taken to determine the species composition of diatoms. We also measured densities of the dominant grazer, the snail *Cerithidea californica*, at the sites. We explored spatial and temporal patterns in diatom communities in relation to nutrient concentration and salinity using diversity indices as well as cluster analysis using the relative abundances of component species.

REEF STUDIES

Kelp forest community monitoring

The primary objectives of our 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 sites close to and far from sources of terrestrial runoff. In the summer of 2001, we increased the number of sites that we sample from three to nine. Two to eight 40 m long transects were installed at each site. The transects were marked with metal stakes fastened to the bottom at eight meter intervals. The abundance of relatively large solitary algae (e.g., kelps) and invertebrates 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, invertebrates, and cryptic fish 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 along each transect is determined at 80 uniformly positioned points along each 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. All nine reef sites were sampled in the summers of 2001, 2002 and 2003. We installed temperature loggers that record the temperature on the bottom every 30 minutes at each site.

We also continue to sample 11 reefs at Santa Cruz Island. 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 band 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. 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. 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. Efforts to include sections in the Field Guide on reef fish and marine mammals are underway.

Historical database on giant kelp abundance

ISP Alginates (formerly Kelco Co.) has collected information on the abundance 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. ISP Alginates has provided us with copies of all their archived records. We have 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 the data 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. In 2002 we added maps and other descriptive information on the kelp beds of Central, Southern, and Baja California to the database. Aerial kelp surveys by ISP Alginates are ongoing and we are continuing to work closely with them to keep the database on giant kelp current.

Primary production in giant kelp

In 2001 we initiated field studies designed to examine spatial and temporal patterns of variation in the production 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 are thought to live about 6-8 months. In 2002 we refined the methodology that we use to estimate changes in standing stock over time and we have implemented this new methodology in our monthly surveys since May 2002. The methodology consists of (1) estimating the density and length of all fronds > 1 m tall along fixed transects at three sites (Mohawk Reef, Arroyo Burro, Arroyo Quemado); (2) measuring frond turnover (i.e., birth, and death) on marked individuals at each site; and (3) whole plant dissections in the laboratory for estimating weight-length relationships of fronds, and for determining the chemical composition (C, N) of different tissue types. Net primary production (NPP) of giant kelp is estimated as the change in biomass + the loss in biomass as follows:

$$NPP = [B_{t+1} - B_t] + [B_t p + B_t(1-p)f]$$

where: B is the dry mass of kelp carbon m^{-2} , p is the fraction of plants lost during the period between t and $t+1$, and f is the fraction of fronds lost by plants that survived the period between t and $t+1$.

The methodology outlined above is quite labor intensive, and thus is difficult to apply over a broad region. We are exploring the potential for estimating plant standing crop and productivity using in situ spectroscopy. In this method a radiometrically calibrated HydroRad spectroradiometer fitted with cosine collectors is mounted to a portable frame for underwater operation by a SCUBA diver. Downwelling irradiance spectra are being measured inside and outside our three kelp forest sites where we are measuring kelp productivity. Canopy absorbance of spectral irradiance is determined by differences in downwelling irradiances measured inside and outside the kelp forest. The resulting absorbance spectra are compared to spectrophotometrically determined absorbances of individual kelp blades measured in the laboratory. Optical data collected in the field are taken concurrently with more labor intensive diver measurements of kelp biomass. The optical data are used to calculate a Blade Area Index (BAI) for use in estimating standing crop. Estimates of standing crop based on BAI are being compared to those obtained from diver measurements to determine the validity of using optical data for assessing standing crop in giant kelp.

Nitrate consumption and phytoplankton grazing within 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. We began investigating these processes in a collaborative study with investigators from Stanford University (Drs. Steve Monosmith, Jeff Koseff, and Rob Dunbar) and Eilat University, Israel (Dr. Amatzia Genin). In May 2002, we measured the flow field and concentrations of chlorophyll a , POC, PON, DOC, and nutrients at three stations along a transect extending from 20 m upcurrent of the edge of a bed to 41 m inside the *Macrocystis* forest at Mohawk Reef.

Food web studies using stable isotope

Potentially important food sources to primary consumers on shallow subtidal reefs include phytoplankton-dominated seston, kelp-derived detritus, and for locations adjacent to sources of freshwater runoff, 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.

A considerable portion of our efforts have focused on characterizing variability in the isotope values of potential food sources (phytoplankton, kelp, and terrestrial POM). This information is needed to evaluate whether these isotopic values differ enough from one another to permit the use of mixing models to estimate the contribution of each source to the reef food web.

Field experiments: the role of nutrients in trophic interactions

Kelp forests have two major food webs: a well studied one in which macroalgae are consumed directly by large grazers (i.e. sea urchins), which in turn are consumed by large predators (i.e., sea otters), and a little studied one in which macroalgae serves as a substrate for a periphyton and small crustacean grazers, which are preyed upon extensively by benthic reef fish. A question of interest to SBC is the degree to which nutrients control species interactions within each food web. To address this question, we began devising a suite of short and long-term experiments in 2002 to investigate how changes in nitrogen supply influence trophic interactions in the little studied macroalgal/periphyton based food web. The experiments feature a multi-factor design in which nutrients, primary producers (macroalgae, and periphyton), and consumers are manipulated and responses in the species composition, numerical abundance, and biomass of different trophic levels are being followed. We plan to follow these experiments through time to track both short-term (weeks-months) and long-term (years-decades) responses. Much of the work done to date has focused on testing various techniques of delivering nutrients to reef benthos and measuring the response of microalgae and macrofaunal crustacean, polychaete, and molluscan fauna.

In summer 2002, we initiated an experiment to investigate the main and interactive effects of elevated nutrient supply and sea urchin grazing on benthic community structure at one of our experimental reef sites, Naples Reef (12-13 m water depth). The experiment consists of fourteen 15 m² plots, seven of which sea urchins are excluded from. Three 0.5 m² plots were established in the center of each of the 15 m² plots and were randomly assigned one of three nutrient treatments (diffuser with nutrients, diffuser without nutrients, and no-diffuser). At the beginning of the experiment the species composition, abundance, and biomass of algal and invertebrate fauna of benthic community were sampled using the same methods employed in the reef community monitoring section described above.

In Fall, 2002, a short-term (i.e. two-week) field experiment was set up to test whether predation by benthic reef fishes alters the species composition and abundance of their primary food (meso-crustacean grazers) under nutrient replete conditions when crustacean grazers are most likely not food limited. This was done by placing artificial algal substrates on nutrient diffusers within and outside of fish exclusion cages. In Winter 2003, another two-week field experiment was set up at Naples Reef to test whether the addition of nutrients, sea urchin grazing, and fish predation interact to influence the standing crop of periphyton, and the assemblage of meso-crustacean grazers that feed on it. While sea urchins do not graze periphyton on benthic algae, they may have indirect effects on periphyton by grazing on larger algae (e.g., kelps) that outcompete periphyton for light. In this experiment, we varied nutrient supply by placing artificial algal substrates on nutrient diffusers with and without time-release fertilizer. Substrates on diffusers with and without fertilizers were placed within and outside of fish exclusion cages in plots with and without sea urchins. In addition to quantifying the abundance and species composition of crustacean grazers, we also measured chlorophyll and phaeophytin on recruitment substrates as a means of quantifying the production of periphyton.

Kelp subsidies to sandy beach communities

The condition and productivity of kelp forests may directly affect that of other coastal habitats which depend on subsidies of kelp drift material. Exposed sandy beaches are a dominant coastal habitat in the SBC-LTER region, making up over 50% of the mainland shoreline. The rich macroinfauna of beaches in the region depend largely upon allochthonous sources of organic matter and carbon because relatively little primary production occurs on the beach itself. Kelp forests are important sources of organic matter and can provide large subsidies of drift macrophytes (>450 kg m⁻¹ y⁻¹) to sandy beach food webs in the SBC-LTER. With collaborative support from University of California Sea Grant, we are studying the responses of infaunal invertebrates, shorebird predators, sediments and dune vegetation to macrophyte subsidies from coastal reefs using comparative surveys and manipulative field experiments. With supplemental support from NSF in 2003, we initiated research on nutrient cycling associated with the delivery and processing of drift macroalgae in sandy beaches of the Santa Barbara Channel.

OCEAN STUDIES

We are using a combination of time series measurements at reef sites, survey cruises over the entire Santa Barbara Channel and satellite observations to examine the transport of nutrients and other constituents to and from the reef ecosystem. Three permanent reef sites are being monitored through a combination of sampling from small boats, instrumented moorings, and satellite imagery. The principal goal of these observations is to establish baseline data for detecting key events that can affect the reef ecosystem. These include the prevalence of freshwater plumes at each reef site, the flux of nutrients to the macrophytes, and the character and flux of particulate material that fuel the sessile invertebrate community. We have also undertaken a series of channel-wide cruises on the R.V. Point Sur, to monitor the seasonal characteristics of physical, chemical, and biological parameters in the offshore waters that are the source of these materials to the reef.

Channel surveys

We conducted three channel-wide surveys of hydrographic and biological parameters during February, March, and September of 2002, and 2003. Each cruise includes using an undulating towed vehicle called a Scanfish to obtain high resolution, two-dimensional maps of temperature, salinity, beam attenuation at 660 nm (a measure of water turbidity), and chlorophyll from the surface to ~ 100 meters depth. A set of cross-channel transects of CTD profiles along the Scanfish tracks provides vertical profiles of the same water properties measured by the Scanfish, but from the surface to the bottom. Additional parameters such as nutrient and particle characteristics are derived from bottle samples obtained during the CTD surveys. Depth profiles of primary production are also done to assess the relative roles of phytoplankton vs. macrophyte production. Other instruments on the CTD platform measure optical properties used to characterize the particle fields and dissolved components of the water column. The spatial variability of currents is measured continuously during the cruises with a ship-board Acoustic Doppler Current Profiler (ADCP).

The data from these cruises provide a valuable measure of the “background state” of the Channel with respect to water characteristics, nutrient concentration, phytoplankton biomass and primary productivity. It is necessary to characterize seasonal patterns in these properties, as well as changes at shorter time scales due to oceanic dynamics, in order to assess the role of “open channel” nutrient delivery to kelp reefs, and to adequately compare it to delivery from terrestrial sources. Valuable complementary data on the seasonal evolution of water masses, nutrients and particle fields is obtained from twice-monthly cruises of the Plumes and Blooms project (funded by NASA). We are developing a series of computer programs to automate the processing of the Scanfish and other survey data. Currently we have completed the work on the ScanFish processing allowing near real time data processing and graphical visualization of the data while at sea. Efforts continue to streamline and automate the processing of other data sets.

Monthly sampling

We continued monthly sampling of water properties at two reef sites (Carpinteria Reef and Naples Reef) that we initiated in November 2000 and began additional sampling at a third reef site (Arroyo Quemado) in March 2001. Sampling at the three reefs is conducted with small boats. We have reduced the number of stations samples at each site to a single site at each reef due to budgetary constraints. Last year we sampled three locations near each reef site. Sampling stations were located inshore of each reef, halfway between the surf zone and the reef, immediately adjacent to each reef, and about a kilometer offshore of each reef. This year we have reduced our sampling effort to the single site at each reef due to budgetary constraints. A CTD equipped with a chlorophyll fluorometer and transmissometer is lowered at each station and data on temperature, salinity, chlorophyll, and suspended sediments are recorded throughout the water column. Pumped water samples are collected from the surface down to 25 m (depending on water depth) and analyzed for nutrient concentrations (nitrate, silicate, and phosphate). Samples of particulate mater are collected at each depth and analyzed for carbon and nitrogen isotopes, particulate organic carbon, organic nitrogen, and silica concentrations, and chlorophyll concentration. All water samples are filtered within hours of collection and stored frozen for analysis in the Marine Science Institute Analytical Laboratory at UCSB. This year we stopped collecting samples of particulate silica concentration due to budgetary constraints.

We continue to maintain a permanent mooring at each core reef site (Carpinteria, Naples Reef, and Arroyo Quemado). These permanent moorings allow us to sample ocean conditions at a higher frequency and in a wider range of conditions than can be achieved using small boats. This is especially important during storm events when sampling from boats is not possible. Each mooring is equipped with a conductivity sensor, temperature sensor, pressure sensor, and fluorometer and backscatter meter deployed at 2 m. An ADCP is deployed on the bottom adjacent to each mooring to monitor ocean current patterns. During 2002 and 2003 we deployed an automated nutrient analyzer manufactured by WS Oceans near the Naples and Arroyo Quemado moorings. This nutrient analyzer allows us to obtain a time series of nitrate concentration with at sampling intervals as low as 20 minutes, and allows detailed investigations of the role of inner shelf processes, such as upwelling and internal tides, in supplying nutrients to the reef. We were successful in timing one of the winter deployments to coincide with the first major rainstorm of the year allowing us to examine the effects of a first flush of nitrate on the reefs. We were also successful in obtaining funds through the ONR DURIP program to purchase two additional nutrient analyzers. An additional WS Oceans device was obtained in December 2002 and a new optical nitrate analyzer from Satlantic Corporation was purchased in spring 2003 and used with on the undulating vehicle in the September 2003 channel-wide cruise to define the variance in nitrate concentration along isopycnal surfaces that impinge on the reefs.

Surface Current Patterns

Over the past year we continued to operate an array of high frequency (HF) radars to monitor surface currents in the Santa Barbara Channel. Data are available in the western Channel for most of 2002 and 2003 from the five site array centered on Point Conception. We are now reconfiguring the radar array to have better coverage over the LTER study area. Sites at Point Conception and Point Arguello are being moved to sites in the eastern Santa Barbara Channel. We are awaiting permit approvals on new sites). The HF radars provide hourly maps of surface currents around-the-clock out to a distance of about 42 km offshore. This array presently encompasses two of our three reef sites and will cover the third when the new sites are established in the eastern channel. We are using data from the HF radar array to examine how the larger scale circulation patterns in the Channel influence flow over the inner shelf and through the reef ecosystem.

Satellite Data

Local area coverage imagery from the SeaWiFS and AVHRR missions are 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. 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.

We have focused our initial studies on assessing the space/time characteristics of the chlorophyll imagery from SeaWiFS and the processes which control phytoplankton blooms. This work was presented at the 2001 ASLO Aquatic Science meetings in Albuquerque. We find good relationships among upwelling indices (wind and SST) and chlorophyll distribution and strong east to west differences in chlorophyll are apparent. Ocean color imagery is also used to assess the dispersion of sediment plumes within the Santa Barbara Channel. These data provide a unique large scale view of ocean processes in the Santa Barbara Channel. We plan to submit a manuscript using these data to the special issue of Deep-Sea Research, Part II on SeaWiFS applications.

Runoff "Event" Sampling

We have initiated "event" sampling during periods of storm runoff. Thus far we have samples from events in 2002 and 2003. Currently we are sampling with a CTD and transmissometer, and collecting water samples for analysis of dissolved nutrients and suspended particulate matter. This sampling is coordinated between the ocean and watershed groups to ensure changes in the ocean can be related to terrestrial runoff. Our current efforts focus on the outflow from the Carpinteria salt marsh and watershed. We will broaden our event sampling to include other watersheds once we gain a better understanding of the fate and transport of runoff plumes.

PRESENTATIONS

2003

- Anderson, C.R., D.A. Siegel, M.A. Brzezinski, N. Guillocheau and D.A. Toole, 2003. A time series assessment of phytoplankton community structure in the Santa Barbara Channel. Poster. 2003 ASLO Aquatic Sciences meeting, Salt Lake City, UT, February 2003.
- Anderson, C.R., and M. Brzezinski Harmful Algal Blooms in the Santa Barbara Channel. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA
- Anderson, C.R., and M. Brzezinski Harmful Algal Blooms in the Santa Barbara Channel. Poster. LTER All Scientists Meeting, Seattle, WA.
- Arkema, K. 2003. Recruitment Strategies of Macroalgae In Varying Environmental Conditions. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA
- Barth, J., A. Baptista, P.M. Kosro, D. Martin, J. Newton, L.K. Rosenfeld, F. Chavez, M. McManus, M. McNutt, E. Terrill, and L. Washburn, T. Garfield, and J. Hunter. 2003: An Update on the Regional Ocean Observing Systems along the US West Coast. Presented at Eastern Pacific Ocean Conference, Catalina Island, CA
- Bassin, C. J., L. Washburn, and E.E. McPhee-Shaw. 2003: Sub-mesoscale eddies along the northern Santa Barbara Channel: A possible mechanism for nutrient delivery to the inner shelf. Presented at Eastern Pacific Ocean Conference, Catalina Island, CA.
- Bassin, C. J. and L. Washburn 2003. Coastal Submesoscale Eddies and Nutrient Dynamics. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA
- Behrens, M. 2003. Kelp Forest – Barrens Dichotomy: Multivariate Description, Community Patterns, and the Effects of Marine Reserves and Urchin Disease. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA
- Beighley, R.E., A. Leydecker, T. Dunne and J.M. Melack. 2003. Integrating spatial watershed and runoff (quantity and quality) data to map and quantify the dominate sources of watershed runoff. American Geophysical Union Meeting, San Francisco, CA.
- Beighley, R.E., T. Dunne and J.M. Melack. 2003. Impacts of urbanization on storm runoff frequency distributions in southern California's coastal watersheds," 2003 American Water Resources Association Annual Conference, San Diego, CA.
- Beighley, R.E., J.M. Melack and T. Dunne 2003. Urbanization effects on streamflow magnitude and variability from mountainous coastal catchments in a Mediterranean climate. Poster. Long Term Ecological Research Network All Scientists Meeting, Seattle WA.
- Beighley, R.E., T. Dunne, and J.M. Melack. 2003. Impacts of urbanization on stormflow frequency distributions in a Mediterranean climate, European-American workshop on Long Term Environmental Research," Motz, France.
- Beighley, R.E. 2003. Incorporating Geographic Information Systems (GIS) into the Civil and Environmental Engineering Curriculum. Seminar San Diego State University, Department of Civil and Environmental Engineering, San Diego, CA.
- Beighley, R.E. and J.M. Melack 2003. Impacts of Urbanization on Storm Runoff Frequency Distributions in a Mediterranean Climate. Poster University of California Toxic Substances Research and Teaching Program, 16th Annual Research Symposium, Oakland, CA.
- Beighley, R.E. 2003. Streamflow Quantity and Quality in Coastal Watersheds: Impacts of Land Use Change and Climate Variability in Santa Barbara, California. California State University, Long Beach, Department of Civil Engineering, Long Beach, CA.
- Beighley, R.E., T. Dunne, and J.M. Melack 2003. Annual and Interannual Streamflow Variability for Coastal Watersheds with a Mediterranean Climate in Relation to Land Use Change and Climate Variability. American Society of Limnology and Oceanography, The Earth's Eyes: Aquatic Sciences Through Space and Time, Salt Lake City, UT.
- Bose, R.K., 2003. Delivering Data Lineage for Earth Science Research Computing. Presented at March 2003 Japan-US Workshop on Annotation and Resource Discovery of Geographic Image Data (A Joint Workshop by the National Institute of Informatics (NII), Japan, and National Center for Geographic Information and Analysis (NCGIA), USA), Nikko, Japan.
- Bose, R.K., 2003. Delivering Data Lineage for Earth Science Research Computing. Presented at Bren School of Environmental Science and Management Spring 2003 Ph.D. research seminar.
- Bose, R.K., 2003. Using Data Lineage to Document Ocean Production Estimates for the Santa Barbara Channel. Poster. Long Term Ecological Research (LTER) All Scientists Meeting, Seattle, WA.

- Bose, R.K., 2003. Using Data Lineage to Document Ocean Production Estimates for the Santa Barbara Channel. Poster. Long Term Ecological Research. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA
- Broitman, B. 2003. Biophysical Forcing of Recruitment Dynamics. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA
- Broitman, B.R. and B.P. Kinlan, 2003: A Coupled Spatial Pattern of Benthic and Pelagic Ecosystem Structure in a Coastal Upwelling System. Presented at the 2003 East Pacific Ocean Conference, Wrigley Marine Science Center, Catalina, CA.
- Busse, L. 2003. Benthic diatoms in Carpinteria Salt Marsh. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA
- Busse, L. 2003. Diatom Communities As Indicators Of Nutrient Enrichment: A Test In A Southern California Estuary. Presented at the H2O Headwaters to Ocean Conference, Long Beach, CA, 23-25. Oct 2003.
- Crecely, G. J. Simpson, and S. Cooper. 2003. Effects of elevated nutrient conditions and variation in irradiance levels on the growth of the floating algae, *Enteromorpha intestinalis*. Poster. Undergraduate Research Colloquium, University of California, Santa Barbara, CA
- Dugan, J. E. 2003. Ecology of sandy beaches. Invited presentation and field trip for the NOAA Damage Assessment Center Rapid Assessment Program meetings, September 2003, Monterey, CA.
- Dugan, J. E. 2003. Sandy beach ecology for teachers. 2003. Invited presentation and field trip for the NOAA National Marine Sanctuaries LiMPETS Teacher Workshop. March 2003, San Francisco, CA
- Dugan, J. E. 2003. Response of sandy beach ecosystems to macrophyte wrack subsidies from coastal reefs. 2003. Lecture to Ecology course. October 2003, University of California, Santa Barbara, CA
- Dugan, J. E., D. M. Hubbard and H. M. Page 2003. Response of sandy beach ecosystems to macrophyte wrack subsidies from coastal reefs. Poster. LTER All Scientists Meeting, Seattle, WA.
- Goldberg S., Gray, K., Volper, E., Carlson, C. 2003. Stocks and distributions of dissolved organic carbon (DOC) and bacterioplankton in the Santa Barbara Channel. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA.
- Green, K. and M. Brzezinski 2003. Effects of nitrate limitation on coastal kelp growth. Poster. Undergraduate Research Colloquium, University of California, Santa Barbara, CA
- Guerrini, A. and J. E. Dugan 2003. Historicizing ecological restoration: a case study of a California coastal wetland. Poster. LTER All Scientists Meeting, Seattle, WA.
- Kane, C. and S. Levenbach 2003. The effects of sedimentation on a local colonial sea anemone, *Corynactis californica*. Poster. Undergraduate Research Colloquium, University of California, Santa Barbara, CA
- Kinlan, B.P. and B.R. Broitman, 2003: A Coupled Spatial Pattern of Benthic and Pelagic Ecosystem Structure in Coastal Upwelling Regions. Presented at 84th Annual Meeting of the Western Society of Naturalists, Long Beach, CA.
- Kinlan, B.P. and S.D. Gaines, 2003: Consequences of Life History and Larval Duration for the Scale of Larval Transport. Presented at the 2003 East Pacific Ocean Conference, Wrigley Marine Science Center, Catalina, CA.
- Kinlan, B.P., 2003: Environmental Forcing of Kelp Forest Community Dynamics in the Northeast Pacific. Presented at the 2003 East Pacific Ocean Conference, Wrigley Marine Science Center, Catalina, CA.
- Kinlan, B.P., 2003: Spatial and Temporal Variability of Kelp Forest Habitat Structure in the Northeast Pacific. Presented at the 6th International Temperate Reef Symposium, Christchurch, New Zealand.
- Kinlan, B.P., M.H. Graham, and J.M. Erlandson, 2003: Late-Quaternary Changes in the Size, Shape and Isolation of the California Channel Islands. Presented at the 6th California Islands Symposium, Ventura, CA.
- Kinlan, B.P., 2003: Linking Environmental Forcing, Kelp Forest Habitat Dynamics, and Community Structure in the NE Pacific. Presented at the 2003 Phycological Society of America Annual Meeting, Glendon Beach, OR.
- Kinlan, B.P., 2003: Linking Environmental Forcing, Kelp Forest Dynamics, and Community Structure in the NE Pacific. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA.
- Kinlan, B.P., 2003: Large-scale, Long-term Studies of Coastal Ecosystem Structure in the Northeast Pacific. Presentation to Five-Year Independent Review Committee for the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), Santa Barbara, CA.

- Klose, K. 2003. Effects of an Invasive Consumer on Stream Biota of the Santa Ynez River, Santa Barbara County, California. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA.
- Lester, S. 2003. The effect of dispersal on marine species' distributions at different scales. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA.
- Levenbach S. 2003. The Effect of Siltation on the Colonial Sea Anemone, *Corynactis californica*, Poster presented at 16th Annual Research Symposium, UC Toxic Substances Research and Teaching Program, 2003
- Levenbach S. 2003. The Effect of Siltation on the Colonial Sea Anemone, *Corynactis californica*, Poster. SBC-LTER Midterm Review, University of California, Santa Barbara, CA
- Leydecker, A., J. Simpson, and L. A. Grabowski 2003. 2001: Nutrient Uptake and Cycles of Change: the Ventura River in Southern California. Presented at 2003 AGU Fall meeting, San Francisco, CA.
- McPhee-Shaw, E., L. Washburn, and D. Siegel 2003. Low-frequency dynamics and nutrient flux to the inner shelf of the Santa Barbara Channel. Presented at the 50th Eastern Pacific Ocean Conference, Catalina Island, Sept. 2003.
- McPhee-Shaw, E. , M. Brzezinski, D. Siegel, and L. Washburn 2003. Mechanisms for nutrient delivery to the inner shelf: Observations from the Santa Barbara Channel. Poster presented at UC Toxics Symposium, Oakland, CA, May 2003.
- McPhee-Shaw, E. , M. Brzezinski, D. Siegel, and L. Washburn 2003. Mechanisms for nutrient delivery to the inner shelf: Observations from the Santa Barbara Channel. Invited seminar. Lamont-Doherty Earth Observatory.
- McPhee-Shaw, E. , M. Brzezinski, D. Siegel, and L. Washburn 2003. Mechanisms for nutrient delivery to the inner shelf: Observations from the Santa Barbara Channel. Invited seminar. University of New Hampshire.
- McPhee-Shaw, E. , M. Brzezinski, D. Siegel, and L. Washburn 2003. Mechanisms for nutrient delivery to the inner shelf: Observations from the Santa Barbara Channel. Invited seminar. Dept. of Oceanography at the U.S. Naval Postgraduate School.
- Ow, L., L. Washburn, D.A. Siegel, and E.E. McPhee-Shaw, 2003: Moored observations of biological and physical variability near kelp reefs in the Santa Barbara Channel. Poster presented at the 2003 ASLO Aquatic Sciences meeting, Salt Lake City, UT, February 2003.
- Ow, L., L. Washburn, D.A. Siegel, and E.E. McPhee-Shaw, 2003: Moored observations of biological and physical oceanographic variability near kelp reefs in the Santa Barbara Channel. Poster. Undergraduate Research Colloquium, University of California, Santa Barbara, CA
- Page, H. M, D. Reed, M. Brzezinski, J. E. Dugan 2003. The incorporation of land and ocean sources of organic matter into kelp forest food webs: evaluation using stable isotopes. Poster. LTER All Scientists Meeting, Seattle, WA.
- Parker, S. S. and J. P. Schimel 2003. The seasonal dynamics of nitrogen losses from California grasslands. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA
- Rassweiler, A., K. 2003. Mechanisms Maintaining Species Assemblages in the Santa Barbara Channel. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA.
- Rassweiler, A., K. Arkema, D. Reed, D. Zimmerman 2003. Patterns and causes of variation in NPP in the giant kelp, *Macrocystis pyrifera*. Poster. LTER All Scientists Meeting, Seattle, WA.
- Reed, D. S. Holbrook, C. Blanchette, R. Schmitt. 2003. Differential reproductive responses to environmental fluctuations in marine species with contrasting demographies. Sixth International Temperate Reef Symposium, Christchurch NZ.
- Reed, D., S. Holbrook, R. Schmitt. 2003. Patterns and causes of temporal and spatial variability in kelp forests. LTER All Scientist Meetings, Seattle, WA
- Reed, D. M. Brzezinski, S. Cooper, J. Dugan, S. Gaines, S. Holbrook, T. Holden, J. Melack, M. Page, J. Schimel, D. Siegel, and L. Washburn 2003. Santa Barbara Coastal Long Term Ecological Research. Poster. LTER All Scientist Meetings, Seattle, WA
- Reed, A. Rassweiler, K. Arkema, R. Zimmerman. 2003. Patterns and controls of growth and primary production in the giant kelp, *Macrocystis pyrifera*. Meetings of the Western Society of Naturalists, Long Beach, CA.
- Robinson, T. H. 2003. Nutrient Flux from Mediterranean Coastal Streams: Carpinteria Valley, California. Talk, AGU 2003 Fall Meeting, San Francisco, California.

- Robinson, T. H. 2003. Nutrient Loading to Export Coefficient Modeling of Mediterranean Coastal Streams. Invited Talk: Channel Islands Chapter of the California Native Plants Society monthly seminar, Santa Barbara Botanical Gardens, Santa Barbara, California.
- Robinson, T. H. 2003. Nutrient Loading to Export Coefficient Modeling of Mediterranean Coastal Streams. Poster. Annual Meeting of the American Water Resources Association, San Diego, California.
- Robinson, T. H. 2003. Speaker: LTER Science/Policy Seminar (10/03), "Nutrient TMDL for the Santa Clara River Watershed", UC Santa Barbara, Santa Barbara, California.
- Robinson, T. H. 2003. VI Inter-Regional Conference on Environment–Water, Land and Water Use Planning and Management (9/03). Nutrient Export Coefficient Modeling in Mediterranean Coastal Streams. Centro Regional de Estudios de Agua, Universidad de Castilla-La Mancha, Albacete, Spain.
- Robinson, T. H. 2003. Nutrient Loading to Mediterranean Coastal Streams and Nutrient Export Coefficient Modeling. Poster, SBC-LTER Mid-Term Review, UC Santa Barbara, Santa Barbara, California.
- Robinson, T. H. 2003. Nutrient Loading to Mediterranean Coastal Streams and Nutrient Export Coefficient Modeling. Presented at Southern California Society of Environmental Toxicology and Chemistry 2003 Annual Meeting (5/03), UC Santa Barbara, Santa Barbara, California.
- Robinson, T. H. 2003. Development of a Nutrient TMDL for the Santa Clara River Watershed. Poster, Southern California Society of Environmental Toxicology and Chemistry 2003 Annual Meeting, UC Santa Barbara, Santa Barbara, California.
- Robinson, T. H., A. Leydecker, J.M. Melack, A. A. Keller. 2003. Nutrient Loading to Mediterranean Coastal Streams and Nutrient Export Coefficient Modeling. Poster. LTER All Scientist Meetings, Seattle, WA
- Schroeter, S. D. Reed, D. Toole, D. Huang 2003. Experimental studies of factors affecting the recruitment of two structure forming reef species with contrasting demographics. Sixth International Temperate Reef Symposium, Christchurch NZ.
- Senyk, N., D.A. Siegel 2003. Using remotely sensed data to describe spatial and temporal habitat distributions of the giant kelp, *Macrocystis pyrifera*. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA.
- Siegel, D.A., O. Polyakov, E. Fields and N. Guillocheau, 2003. Comparison of SeaWiFS and MODIS water leaving radiance spectra with in situ observations from the Santa Barbara Channel: Role of aerosol absorption, Poster presented at the NASA Ocean Color Science Team Meeting, Miami FL, April 2003.
- Siegel, D., C. Costello, S. Gaines, R. Hilborn, B. Kendall, S. Polasky, R. Warner, and K. Winters, 2003. Flow, Fish and Fishing: Sources and Implications of Uncertainty in Nearshore Fishery Management. Presented at the 50th Eastern Pacific Ocean Conference, Catalina Island, Sept. 2003.
- Simpson, J. 2003. Anthropogenic influences on biological uptake and transformations of nitrogen and phosphorus in southern California coastal streams. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA.
- Simpson, J., and A. Leydecker 2003. Anthropogenic influences on biological uptake and transformations of nitrogen and phosphorus in southern California coastal streams. Poster presented at September 2003 Long Term Ecological Research (LTER) All Scientists Meeting, Seattle, WA.
- Whitmer, A., and J. Dugan 2003. Connecting communities with their watersheds and coastal oceans through integrated environmental education. Poster presented at September 2003 Long Term Ecological Research (LTER) All Scientists Meeting, Seattle, WA.
- Zimmerman, R.C. 2003. Imaging spectroscopy in optically shallow water: new technology for revealing the secrets of the sea. Presented at 2003 Temperate Reef Symposium, Christchurch, NZ

2002

- Beckenbach, E.H. and L. Washburn, 2002: Observations of Wavelike Phenomena in the Santa Barbara Channel Using HF Radar, Ocean Sciences Meeting, 11-15 February, Honolulu, HI.
- Beighley, R.E. 2002. (Invited), Advancements in GIS and Hydrologic Modeling: Adjusting Measured Flow Data from Urbanized Watersheds and a case study of the SBC-LTER, Water Science Group, University of California, Santa Barbara, CA, February 19, 2002.
- Beighley, R.E. 2002. Hydrologic modeling for the SBC-LTER. Water Science Group Meeting, UCSB.

- Beighley, R.E., and J.M. Melack, 2002. Spatial Database Development and Integration into Hydrologic Modeling in Coastal Watersheds for the Santa Barbara Channel – Long Term Ecological Research Project, California and the World Ocean 2002, Santa Barbara, CA, October 28, 2002.
- Beighley, R.E., T. Dunne, and J.M. Melack, 2002. Annual and Interannual Streamflow Variability for Mountainous Coastal Catchments in a Mediterranean Climate in Relation to Land Use Change and Climate Variability, American Geophysical Union, Fall Meeting, San Francisco, CA, December 9, 2002.
- Cudaback, C., and L. Washburn, 2002. Circulation near Pt. Conception California, PISCO Symposium, Monterey, CA, 10 March.
- Cudaback, C., L. Washburn, E.P. Dever, 2002, Inner-Shelf Circulation Near Point Conception, California. Ocean Sciences Meeting February, Honolulu, HI, 11-15 Feb.
- Cudaback, C., L. Washburn, J. Caselle, C. Blanchette, B. Gaylord. 2002. High frequency sampling of nearshore coastal circulation and invertebrate settlement near Santa Barbara California, Eastern Pacific Ocean Conference, Timberline Lodge, OR, 25-28 Sept.
- DiGiacomo, B. Holt, and L. Washburn, 2002. Pollution Hazards Off the Southern California Coast: Satellite and In Situ Observations of Naturally Occurring Oil Seepage, Storm Water Runoff and Wastewater Plumes. Water Quality: Ocean Modeling, Observations and Remote Sensing, California and the World Ocean, Santa Barbara, CA, 27-30 Oct.
- DiGiacomo, P. M., B. Holt, and L. Washburn, 2002, Pollution Hazards off the Southern California Coast: Satellite and In-Situ Observations of Naturally Occurring Oil Seepage and Storm Water Runoff Plumes. Ocean Sciences Meeting February, Honolulu, HI, 11-15.
- DiGiacomo, P.M., B. Holt, and L. Washburn, 2002, An Examination of Small-Scale Coastal Eddies and Pollution Hazards off California Using an Integrated Multi-Sensor/In-Situ Approach. AIRSAR Workshop, Jet Propulsion Laboratory, Pasadena, CA, 5 March.
- Dugan, J. E. 2002. Ecological effects of grooming on exposed sandy beaches in southern California. Invited Seminar, California State University Northridge.
- Dugan, J. E. 2002. Ecological impacts of grooming on exposed sandy beaches in southern California. Paper presentation, California and the World Ocean '02, Santa Barbara, CA
- Dugan, J. E. 2002. Response of sandy beach ecosystems to macrophyte wrack subsidies. Presented at NOAA Hazardous Materials Response Division annual meeting, Santa Barbara, CA
- Dugan, J.E. 2002. Effects of beach grooming on sandy beaches in California. Presented to San Diego City Council, Natural Resources and Culture Committee, San Diego, CA
- Gaines, S. D. 2002. Fluid connections. Seminar for the UCSB Board of Trustees, University of California, Santa Barbara. October 2002
- Gaines, S. D. 2002. Large scale perspectives on marine ecology . Department seminar. University of California, Santa Barbara. November 2002.
- Gaines, S. D. 2002. Large scale perspectives on marine ecology. Department seminar, California State University, Fullerton. November 2002.
- Lenihan, H.S. 2002. Santa Barbara Channel LTER: an example of multidisciplinary coastal marine research at UCSB. UCSB Bren School of Environmental Science and Management Fall Student Orientation.
- Levenbach, S. 2002. Human and Natural Causes of Variation in Benthic Community Composition on Nearshore Rocky Reefs. UCTSR&TP 15th Annual Symposium, April 5-6, 2002, Long Beach, CA
- Leydecker, A. and J. Altstatt. 2002. Nutrient response of the Ventura River to drought conditions in southern California. . American Geophysical Union, Fall Meeting (San Francisco.)
- McPhee-Shaw, 2002. Internal waves over continental slopes: implications for the suspension and transport of sediment. Invited presentation. American Geophysical Meeting, San Francisco, CA, December, 2002.
- McPhee-Shaw, E, Siegel D, Washburn, L, and M. Brzezinski, 2002. The Santa Barbara Channel LTER. Oceanographic data from near-shore stations, 2001, with implications for nutrient delivery to kelp reefs. Departmental seminar at the Applied Physics Laboratory at the University of Washington.
- McPhee-Shaw, E. 2002. Inner-Shelf Observations from the Santa Barbara Channel LTER. Departmental seminar, UCSB.
- McPhee-Shaw, E., M. Brzezinski, D. Siegel, and L. Washburn, 2002. The Santa Barbara Channel LTER: Oceanographic data from near-shore stations, 2001-2002, with implications for nutrient delivery to kelp reefs. California and World Ocean '02 Conference, Santa Barbara, CA, October 27-30, 2002.
- McPhee-Shaw, Washburn, Siegel, and Brzezinski, 'The Santa Barbara Channel LTER (Long-term ecological research) study. Oceanographic time-series data from nearshore stations, 2001, with

- implications for nutrient delivery to kelp reefs. Talk given at EPOC (Eastern Pacific Ocean Conference) meeting, Mt Hood, OR, September 25-28, 2002.
- Otero, M.P., 2002: Physical Forcing of Plumes and Blooms in the Santa Barbara Channel: Department seminar, UCSB. November 2002
- Otero, M.P., D.A. Siegel and E. Fields, 2002: Physical Forcing of Plumes and Blooms in the Santa Barbara Channel: An Integrated Satellite Approach. Poster presented at 2002 AGU/ASLO Ocean Sciences meeting, Honolulu HI, February 2002.
- Robinson, T. 2002. Santa Barbara Coastal Long Term Ecological Research (LTER); Nutrient Concentrations in Coastal Streams, Variations with Land Use in the Carpinteria Valley, California. Paper presentation, California and the World Ocean '02, Santa Barbara, CA
- Senyk, N., and D.A. Siegel, 2002: Using remotely sensed data to describe spatial and temporal habitat distributions of the giant kelp, *Macrocystis pyrifera*. Poster presented at the California and World Ocean '02 Meeting. Santa Barbara, CA, November 2002.
- Siegel, D.A., 2002: How to design a marine protected area. Public talk presented at the Entrepreneurs² - National Resource Defense Council Joint Meeting on Catalina Island, September 2002.
- Siegel, D.A., 2002: Satellite Views of Plumes and Blooms in the Santa Barbara Channel. Six minutes of live television presented as part of the Project Oceanography program on the Santa Barbara Channel (see www.marine.usf.edu/pjoocean/)
- Simpson, J. 2002. Stream communities in natural and nutrified coastal watersheds. Habitat restoration seminar, EEMB, University of California, Santa Barbara, CA .
- Warrick, J.A., L.A. Mertes, D.A. Siegel and L. Washburn, 2002: River plumes in the Santa Barbara Channel, California - observations of river discharge and plume forcing. Presented at 2002 AGU/ASLO Ocean Sciences meeting, Honolulu HI, February 2002.
- Washburn, L., 2002, How does the ocean flow in the Santa Barbara Channel?, Geography Awareness Week presentation to three 5th grade classes, Adams School, 18, 26 November.
- Washburn, L., 2002, Hydrocarbon seepage in the Santa Barbara Channel, seminar presented to Sanctuary Naturalist Corps, Volunteer-in-training program of the Channel Islands National Marine Sanctuary", Will Rogers School, Ventura.
- Washburn, L., D. Reed, C. Ohlmann, C. Cudaback, E. Dever, 2002, A coastal observing system on the South-Central Coast for understanding links between the regional circulation, pollutant transport, and dispersion, California and the World Ocean, Santa Barbara, CA, 27-30 Oct.
- Washburn, L., P.M. DiGiacomo, and B. Holt, 2002. Interpreting SAR Imagery from Surface Currents Obtained from High Frequency Radar Near Point Conception, California, AIRSAR Workshop, Jet Propulsion Laboratory, Pasadena, CA, 5 March.
- Washburn, L., S. Gaines, E. P. Dever, and D. Reed, 2002, An Observational Network for Multidisciplinary Time Series on the Central California Coast, Ocean Sciences Meeting February, Honolulu, HI, 11-15 Feb.
- Zimmerman, R.C., and Reed, D.C. 2002. In situ spectroscopy of submerged plant canopies: application to the quantification of standing crop and potential productivity. Ocean Optics XVI, 18-22 November 2002, Santa Fe, NM.

2001

- Beighley, R.E., T. Dunne, J. M. Melack and L .A. Mertes. 2001. Hydrologic modeling for the Santa Barbara Coastal Long Term Ecological Research Project. American Geophysical Union Chapman Conference, "State-of-the-Art Hillslope Hydrology," Sunriver, Oregon,
- Bull, J. S, S. J Holbrook, and D. C Reed. 2001. Evaluation of restoration techniques to mitigate losses of surfgrass (*Phyllospadix torreyi*) from anthropogenic impacts. 14th Annual UC Toxic Substances Research and Teaching Program Symposium, Lake Tahoe, California. Poster.
- Busse, L. 2001. The effects of nutrients and grazers on algae in Mission Creek. Water Quality Meeting, UCSB
- Chomko, R., H.R. Gordon, S. Maritorena and D.A. Siegel, 2001: Simultaneous Determination of Oceanic and Atmospheric Parameters for Ocean Color Imagery by Spectral Optimization: A Validation. Presented at 2001 AGU Fall meeting, San Francisco CA, December 2001.
- Dugan, J. E., D. M. Hubbard and H. M. Page. 2001. Ecological effects of grooming on exposed sandy beaches in southern California. 82nd Annual Meeting of the Western Society of Naturalists, Ventura, CA.

- Kellner, J and R Nisbet. 2001. Populations dynamics in heterogeneous environments: the role of spatial and temporal variability. 14th Annual UC Toxic Substances Research and Teaching Program Symposium, Lake Tahoe, California, Poster.
- Levenbach, S, S. J Holbrook, and R. J Schmitt. 2001. Human and natural causes of variation in forage species on nearshore reefs. 14th Annual UC Toxic Substances Research and Teaching Program Symposium, Lake Tahoe, California, Poster.
- Leydecker, A. 2001. Water quality in coastal streams. Santa Barbara Channel Keepers, Santa Barbara, CA.
- Leydecker, A., T. Robinson and J.M. Melack. 2001. Stormflow nutrient concentrations in coastal streams tributary to the Santa Barbara Channel, California: A common urban response. American Geophysical Union, Fall Meeting (San Francisco.)
- Maritorena, S., D.A. Siegel and the NASA SIMBIOS Team, 2001: Dominance of Colored Dissolved Organic Material in Determining Light Availability in the Sea. Presented at 2001 AGU Fall meeting, San Francisco CA, December 2001.
- Melack J.M., 2001. Overview of LTER activities. Project Clean Water, Santa Barbara County.
- Mertes, L. A., D. Siegel, J. A. Warrick and M. Otero. 2001. Seasonality of plumes and blooms for 1997-2001 in the Santa Barbara Channel, California. 82nd Annual Meeting of the Western Society of Naturalists, Ventura, CA.
- Otero, M. P., D. A. Siegel, and E .A. Fields, 2001: Satellite view of plumes and blooms in the Santa Barbara Channel; Validation and description. ASLO Aquatic Sciences Meeting in Albuquerque, NM. Poster.
- Reed, D. 2001. Effects of human activities on ecosystems at the land/ocean margin: Introduction. 82nd Annual Meeting of the Western Society of Naturalists, Ventura, CA.
- Reed, D. 2001. Patterns and consequences of spore dispersal in giant kelp *Macrocystis pyrifera*. Departmental seminar, University of Maine, Orono, Maine.
- Schmitt, R, 2001. The SB Coastal Ecosystem LTER – A Multidisciplinary Research Program. University of California Coastal Toxicology Retreat, Bodega, CA.
- Siegel, D.A., 2001: Education and Research at the University of California or Satellite Views of Plumes and Blooms of the Santa Barbara Channel. Presented at the Space Coast Summit 2001, Santa Maria, CA.
- Siegel, D.A., L. Washburn, J.A. Warrick, D.A. Toole, R.C. Smith, O. Polyakov, M. Otero, L.A. Mertes, N. Guillocheau and M.A. Brzezinski, 2001: An Ocean Color Assessment of Sediment Plumes and Phytoplankton Blooms in the Santa Barbara Channel, California. Presented at 2001 AGU Fall meeting, San Francisco CA, December 2001.
- Siegel, D.A., N.B. Nelson, T.K. Westberry, M.C. O'Brien and A.F. Michaels, 2001: Bio-Optical Modeling of Primary Production on Regional Scales: The Bermuda BioOptics Project (BBOP). Presented at 2001 AGU Fall meeting, San Francisco CA, December 2001.
- Warrick, J. 2001. The Source and Fate of River Water and Sediment in the Santa Barbara Channel, California. Departmental seminar, UCSB.
- Washburn, L., 2001, The physical environment of the Santa Barbara Channel", seminar presented to Sanctuary Naturalist Corps, Volunteer-in-training program of the Channel Islands National Marine Sanctuary", Chase Palm Park.

2000

- Busse, L. 2000. The use of diatoms as indicators for water quality in streams and wetlands. Water Quality Meeting, UCSB.
- Reed, D, S. Cooper, S. Gaines, S. Holbrook, J. Melack, H. M. Page.2000. Introducing the Santa Barbara Coastal Ecosystem Long-Term Research Project. LTER All Scientist Meeting, Snowbird, Utah. Poster.
- Washburn, L, D. Reed, S. Cooper, S. Gaines, S. Holbrook, J. Melack, M. Page, 2000: An overview of the Santa Barbara Long-Term Ecological Research (LTER) Program, Eastern Pacific Ocean Conference, Victoria, BC, Canada.

RESEARCH FINDINGS

WATERSHED STUDIES

Modeling runoff

We are modeling runoff from a subset of watersheds, which is challenging because of their considerable spatial and temporal heterogeneity. Soil conditions range from dry sandy soils to saturated clays, and steep slopes, large variations in elevation, and patchy storm patterns amplify the problem of spatially and temporally distributed rainfall. To evaluate available data and our understanding of the regional hydrology, our initial modeling effort used the HEC-HMS rainfall-runoff model (USACE 2000). Using Green-Ampt infiltration, kinematic wave routing for both channel and overland flow, and a decay function for baseflow recession, the HEC-HMS model was successfully calibrated to individual runoff events in water year 2001 using 5-minute rainfall and 15-minute discharge for the Mission Creek watershed. Our results indicate that a significant amount of groundwater recharge occurs in the upper portions of the watersheds and that the storm response is sensitive to initial watershed conditions.

Building on the above analysis, a geographic information system (GIS) integrated approach for modeling storm response was devised. To investigate the impacts of urbanization and climatic fluctuations on the magnitude and variability of discharge, the HEC-HMS rainfall-runoff model was parameterized and used to simulate streamflow for a 14-year period (9/1/1988 to 8/31/2002) in the Atascadero Creek watershed for 1929, 1998, and forecasted 2050 land use conditions (8, 38 and 52 percent urban, respectively).

Urbanization increased peak discharges and runoff, but decreased annual and interannual variability. This point is illustrated in Figure 1, which shows that the 1929 scenario produces the greatest difference between El Niño and La Niña conditions; the difference between these two extreme climatic conditions decreases with increasing urbanization. However, increased peak discharges and annual runoff were not proportional to increases in urbanization because the effects of urbanization are compounded by orographic rainfall and decreased travel times. Further, only a few large storms dominate runoff regardless of land use.

The significance of variability in runoff to stream habitats was observed in water year 2001, when there was a large storm that cleared the channels of vegetation and accumulated debris. In contrast, water year 2002 had no large runoff events, and at the start of water year 2003, the stream channels were heavily vegetated. As we progress through our study, we will assess the impacts of such variability on stream ecosystems and on the delivery of nutrients, sediment and organic material to the ocean.

While the HEC-HMS model provides meaningful estimates of combined stream flow for varied land use and climate conditions, it is not intended to track the various sources of runoff (i.e., surface, interflow and groundwater) separately. Hence, we have developed an improved modeling approach that is better suited for simulating runoff and corresponding constituents from the primary flow sources and pathways. Our approach assumes that basin landscapes possess an identifiable spatial structure, fashioned by climate, geology and land use that affects their hydrologic response. The model utilizes a time step of 15 minutes and source-to-sink routing to simulate streamflow at the watershed outlet and other points of

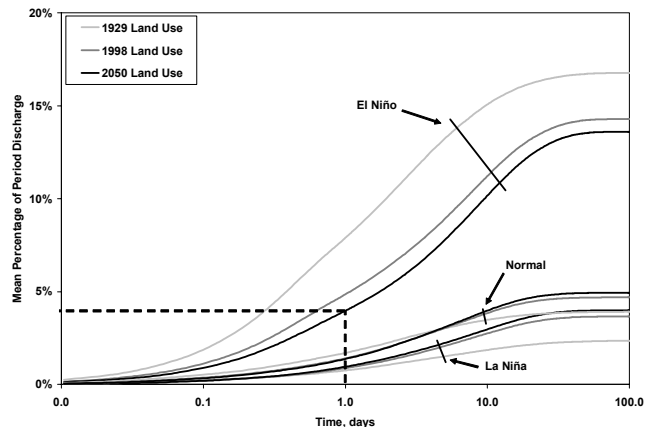


Figure 1. Mean percentage of annual discharge for 1929, 1998, and 2050 land use conditions (normalized by the total 14-year discharge associated with the corresponding land use conditions) exceeded in a given time period from La Niña, El Niño, and normal years, where the annual distribution is ranked from the maximum to the minimum 15-minute discharge (e.g., in 1 day, the average El Niño year for the 2050 land use scenario accounts for 4% of the total 14-year discharge simulated under the 2050 land use conditions).

interest. The model is spatially averaged at the hydrologic response unit (HRU) scale enabling watershed-scale spatial patterns to be incorporated into the rainfall, runoff generation, and routing processes. The model is designed to simulate two runoff forms: surface and subsurface. Incorporating hydrogeological interpretation, the two runoff forms are separated into two subclasses: (a) surface – urban or rural and (b) subsurface – interflow or groundwater flow. Comparing measured and simulated streamflow at gauge locations shows that our modeling approach yields reasonable estimates of combined streamflow. In addition, we are using silica concentrations to assess individual runoff components based on an end member-mixing model.

Stream chemistry and transport

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 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. Subsets of samples are analyzed for silica, major cations and anions, and the natural abundances of ^{15}N and ^{13}C . While the SBC LTER is relatively new (i.e., < 3 years of data), there is sufficient chemical data to begin to characterize storm responses and assess annual fluxes (see <http://sbc.lternet.edu/sites/coastwatershedmap.html> for more information on the locations of our watershed study sites and the data that are collected at them).

During the first year of research (water year 2001), we sampled 18 coastal watersheds to evaluate the range of baseflow and stormflow nutrient concentrations.

Concentrations proved to be dependent on coastal plain land use. Nitrate concentrations varied over 3-orders of magnitude, from a few micromoles per liter in relatively undeveloped catchments, to a few hundred micromoles per liter in agricultural and urban watersheds, to thousands of micromoles per liter where intensive greenhouse agriculture dominates. Phosphate concentrations had a similar, but smaller, variation from 1 to 100 $\mu\text{mol/L}$ (Figure 2). Typically, stormflow concentrations of dissolved nutrients decreased in streams with high baseflow concentrations, and increased in streams with low baseflow levels. All streams with appreciable urban development on the coastal plain had a similar response to stormflow: phosphate concentrations rose and fell in parallel with the hydrograph, nitrate was out of phase with phosphate, and ammonium declined after a peak at the beginning of storms. The stormflow responses of non-urban streams lacked a common pattern, but, in general, nitrate, phosphate and particulate concentrations followed variations in the hydrograph, and ammonium concentrations remain low.

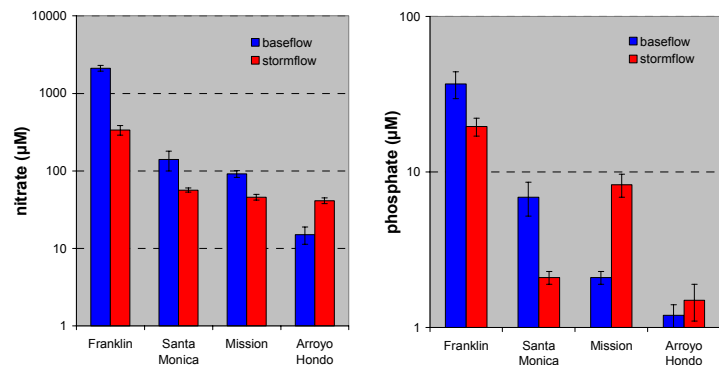


Figure 2. Annual mean concentrations (flow-weighted for stormflow) for four LTER streams in water year 2001. The streams typify coastal plain land uses in the LTER: industrial agriculture for Franklin (greenhouses and nurseries); agriculture for Santa Monica (row crops and orchards); urban for Mission Creek; and relatively undeveloped for Arroyo Hondo (National Forest and fallow ranchland). All streams were sampled at the tidal limit and the error bars indicate standard errors of the mean.

The nutrient concentration-discharge relationships for the urban streams showed hysteresis and fit a 3-compartment baseflow/surface-flow/soilwater model. However, the pattern for each species was different. Our inferences are that high ammonium concentrations are produced by early surface-flow flushing of urban surfaces, high baseflow nitrate concentrations are diluted by impervious surface and soil water runoff, and phosphate, highly correlated with sediment load, is characterized by a flashy urban effect superimposed on an overall catchment response.

The relative export associated with urban streams was consistent: phosphate export at least 5-times that of ammonium and nitrate at least 5-times that of phosphate. Export on the rising hydrograph limb was most important for ammonium (where 30 to 50 % of the ammonium is lost) and somewhat important for phosphate (~25 % of total export), while most nitrate was exported on the receding hydrograph (85 to 90 %). Export from all coastal watersheds was highly episodic, 90 % of the annual runoff occurred in less than 30 days, the majority of dissolved nutrient export in less than 7 days, and almost all particulate export in less than 3 days.

In the project's second year (water year 2002), we shifted emphasis to more intensive sampling of fewer watersheds. Six watersheds were selected (2 urban, 1 urban with intensive agriculture, 2 agricultural, and 1 undeveloped) and multiple sampling points were chosen in each drainage to monitor changes in nutrient flux and concentration at transitions in dominant land use. The winter of 2002 was relatively dry, and runoff was only about a quarter of the previous year. More importantly, almost no runoff was generated from catchment areas above the coastal plain, providing an opportunity to analyze nutrient export from developed land uses without the confounding effects of contributions from undeveloped areas (Figure 3). Nitrate export was relatively unchanged (~80 %) from the year before, the decrease in runoff being offset by increased concentrations, confirming that coastal plain land uses are the major source of nitrate. Phosphate and dissolved organic nitrogen (DON) concentrations in stormflow increased, but annual export decreased (~50 %) indicating storm intensity (i.e., sediment load) and export from higher elevation catchment areas have important roles in the annual budget for these species. The most significant differences in flux were in particulates; on average, particulate export in 2002 was only 10 % of 2001 export.

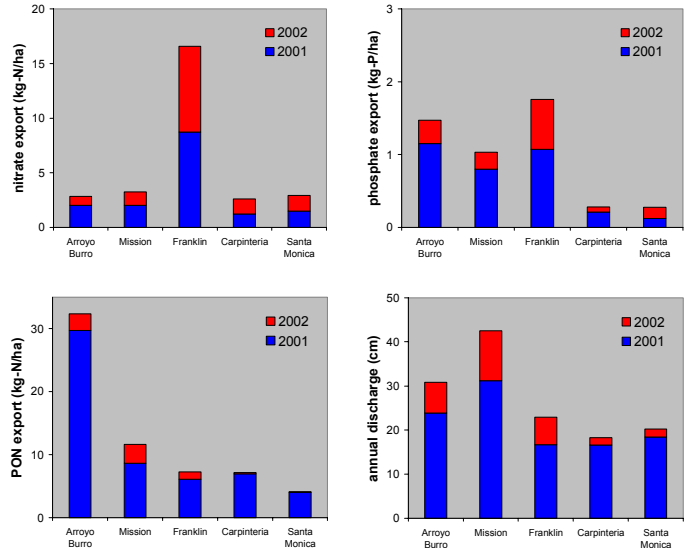


Figure 3. Estimated annual (water-year) fluxes for 5 SBC LTER streams: 2001 and 2002. Annual runoff in 2002 was, on average, only a quarter of 2001, and almost no runoff was generated from catchment elevations above the coastal plain. The lack of appreciable flood flows can be seen in the notably lower 2002 fluxes for particulate organic N (PON) and phosphate, the fluxes for these species being highly correlated with sediment load; however, the nitrate flux was relatively unchanged since nitrate originates, almost exclusively, from developed uses on the coastal plain.

Along a gradient from undeveloped to urban, we observed a steady increase in nitrate and DON. Along Mission Creek, concentrations generally double at the transitions from undeveloped to light residential and from light residential to urban (Figure 4). Phosphate concentrations abruptly increase at the transition from undeveloped to light residential, urban open space or agricultural use. However, dense urban development produces a decrease in concentration. Phosphate and particulate fluxes are highly correlated with sediment load, and the extent of channel stabilization (concrete lining, bank stabilization) has a dominant influence on the annual flux in years when most of the sediment load originates from the coastal plain.

In the third year, water year 2003, we have continued the sampling program of 2002 while adding two additional agricultural watersheds, increased sampling on the Ventura River, and modeling of nutrient export in the upper Santa Clara Basin. Fortunately, large storms have occurred, and, while data analysis is still incomplete, we anticipate the results will offer important insights when contrasted with data from the two previous years.

The Ventura River drains 580 km² of mountainous coast and ranges in flow from near 0 to 11 m³ s⁻¹. Monthly synoptic sampling 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

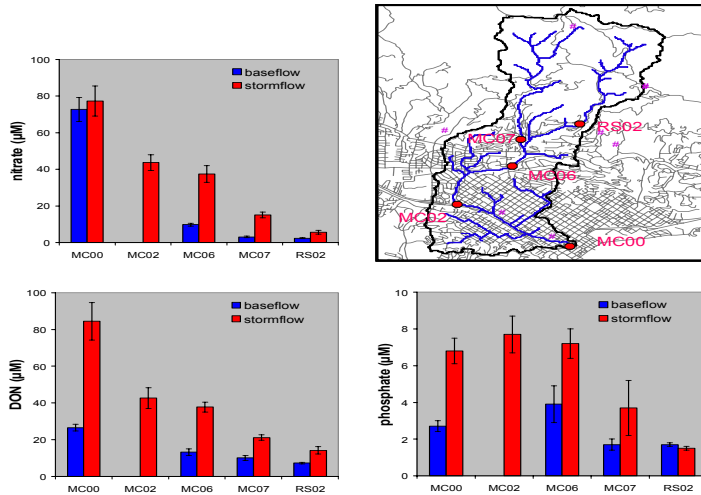


Figure 4. 2002 annual mean (\pm 1 SE) concentrations for stormflow (flow-weighted) and baseflow for 5 sampling locations (shown on the inset map) on the Mission Creek drainage. The sampling stations in the figures are arranged in a gradient from highly urban to undeveloped (from left to right). Increased development produces increasing nitrate and DON concentrations, while phosphate and other sediment-related concentrations decrease with increased amounts of impervious surfaces and channel stabilization in urban areas.

phosphate (0 to 35 μM) on 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. Rainfall in the winter of 2001-02 was only 40 % of the annual mean, insufficient to meet end-of-dry-season soil moisture deficits and generate runoff from upland areas; subsequent groundwater inflows to rivers and creeks were severely diminished. Average flow was $0.15 \text{ m}^3 \text{ s}^{-1}$, in contrast with a 72 yr mean of $4.6 \text{ m}^3 \text{ s}^{-1}$. In the absence of stormflows, which usually scour the channel, exuberant plant growth covered the lower river and macrophytes have replaced algae as dominant primary producers. Phosphate concentrations following the drought winter remained similar to those measured during the previous year, except where treated sewage effluent is discharged.

The large Santa Clara River watershed has supported significant agricultural activity for more than a century, although it is transitioning to suburban and urban land uses. Funded largely by the Los Angeles Regional Water Quality Control Board (RWQCB), we have developed an N and P source loading and water quality model for the Santa Clara River watershed. The project involves developing a decision-support model for determining a Total Maximum Daily Load (TMDL) for nutrients, allocating the TMDL to point and non-point sources (including agriculture), and evaluating various Best Management Practices. We have implemented the Watershed Analysis Risk Management Framework (WARMF) model using data from local (e.g., United Water Conservation District, Ventura County Flood Control District, Los Angeles County Department of Public Works, Ventura County Farm Bureau, four large wastewater treatment plants, city governments, agricultural associations, environmental organizations, land developers), regional/state (e.g., Southern California Association of Governments, RWQCB, State Water Resources Control Board, California Air Resources Board) and national (e.g., USEPA, USGS, NOAA, USFWS) sources for meteorology, land use, fertilizer application rates, atmospheric deposition, point source flow and concentrations, water quality, gauged flow. The model has been implemented at a daily time step, posing some limitations to our ability to accurately predict loading and load assimilation, since the watershed has flashy behavior.

Initial results indicate that loading of nutrients to the land surface is dominated by agriculture and atmospheric deposition, but that a large fraction (typically $> 90\%$) is assimilated or transformed so that it is not available for transport during storm events. The relative contributions from point and non-point sources vary along the watershed for each nutrient. Although ammonium salts are used as fertilizer and are also found in atmospheric deposition, NH_4^+ is transformed relatively fast to NO_3^- , resulting in little in-stream ammonium loading from non-point sources. Nitrite inputs are low, mostly from the wastewater

treatment plants. Nitrate is reaching the river from a number of sources, from direct releases, through stormflow and shallow subsurface flow, and from deeper groundwater that intersects the river at various locations.

Catchment and in-stream processing of and responses to nutrients

An important mechanistic question is what regulates the movement of nutrients from terrestrial ecosystems to ground and surface waters. Our initial work on N cycling in annual grasslands near Santa Barbara indicated that groundwater nitrate concentrations could be quite high, and soil solution nitrate concentrations could be as high as 40-50 $\mu\text{g N L}^{-1}$. Our initial hypothesis was that cattle grazing (plant removal and N deposition in urine) was responsible for the high nitrate levels, but in experimental cattle exclosures, we found no evidence for reduced N availability or leaching compared to control plots that were grazed. Our alternative hypothesis was that during the fall and early winter, soils become moist and soil microbes become active, but with annual grasses dominating the ecosystem there would be no plant N sink. Thus, N mineralization and nitrification should be active, establishing the possibility for extensive nitrate leaching at the transition from the dry summer to the wet winter. Our research on the movement of nutrients in ground and surface waters has led in two directions: (1) effect of different plant communities on N cycling and ecosystem “leakiness.”, and (2) effects of drought and of drying/rewetting events on microbial processes in soils, including mineralization and nitrification. We have found that drying/rewetting processes specifically stimulate nitrifiers, and cause a release of DOC from recalcitrant soil organic matter. Research in these two areas is being done at the Sedgwick Reserve in the adjacent Santa Ynez Valley because the reserve provides a protected area for doing experimental research that is unavailable within the actual LTER watersheds.

Biological processing of nitrogen and phosphorus in streams and coastal wetlands 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. SBC graduate student, Julie Simpson, has been studying nutrient processing in streams draining small watersheds in the Santa Barbara area exposed to different levels of development. She has found that alga 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 also 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.

Microcosm experiments have shown that grazers have large effects on algal biomass and species composition in streams of the Santa Barbara region (Dudley & D’Antonio 1991; Sarnelle et al. 1993). Because algae are major consumers of nutrients, indirect effects arising from trout predators on grazers may have effects on nutrient spiraling. Furthermore, these effects on nutrient spiraling may change with climatic and hydrological regimes. We have been using stable isotope analyses to gain a better understanding of stream food web dynamics as controls on nutrient retention in streams. The stable isotopes of nitrogen (^{15}N) and carbon (^{13}C) provide powerful tools for estimating carbon sources for consumers in the food web, the number of trophic levels, and the importance of anthropogenic nutrient sources. We examined seasonal changes in the food web of Rattlesnake Creek by sampling all trophic levels in riffles and pools during spring (March), summer (May), fall (September) and winter (December) using standard techniques. Patterns in stable isotope signatures were similar between pools and riffles, and results showed that herbivores had $\delta^{15}\text{N}$ values of 0-3 ‰ and predators had $\delta^{15}\text{N}$ values of 3-5 ‰. Across all sampling days we found a $\delta^{15}\text{N}$ enrichment of ca. 2 ‰ from herbivores to predators. There was little variation in the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of predators throughout the year; however, temporal variation in these signatures was higher for herbivores and even higher for POM and periphyton. Isotopic signatures of $\delta^{13}\text{C}$ were different among different basal food sources at our study site. $\delta^{13}\text{C}$ values for leaf litter were stable (between -28 and -26 ‰), and the values for fine particulate organic matter ranged between -22 and -24 ‰ over the study period. The filamentous green algae, *Cladophora*, had stable $\delta^{13}\text{C}$ isotopic signatures of

about -34 and -32 ‰, but $\delta^{13}\text{C}$ values for periphyton varied substantially over the year (between -31 and -24). In riffles, *Eubrianix*, Heptageniids, *Baetis*, and Glossomatidae obtained their nutrition from algae whereas Nemourids, Tipulids, and Chironomids appeared to feed on a mixture of leaf litter and detritus. The predators (mostly *Sweltsa*, *Rhyacophila*, *Cordulegaster*, *Argia*, and *Octogomphus*) appeared to feed mostly on algivores, detritivores, and other predators.

The population dynamics and community structure of algal assemblages are often determined by resource limitation and consumer control. The most promising approach for determining the magnitudes of top-down (via consumption by herbivores) and bottom-up (via growth-limiting resources, such as nutrients and light) controls on periphyton community structure is to conduct experiments in which both resources and consumers are manipulated simultaneously. To determine if stream periphyton is controlled by bottom-up or top-down forces, we experimentally examined the responses of algal biomass and species composition to different grazer densities across two different nutrient treatments (ambient vs. augmented) across seasons and in different stream habitats (riffles and pools) in Mission Creek. Results from this experiment indicated that nutrients limited algal biomass accrual in the summer, but that grazers controlled algal biomass in the autumn. The composition of the grazer assemblage differed between summer and autumn, with Chironomids and *Baetis* dominating in summer and caddis larvae dominating in fall. In general, understory algae appeared to be more responsive to nutrients and grazers than overstory algae.

Because bacteria rapidly and measurably respond to their local environment, their assemblages in creeks and coastal lagoons may be determined in large part by human development and pollution. Nutrient input or “inoculation” by sewage-associated bacteria in urban settings are selective pressures that could shift bacterial community composition and/or diversity. To test this hypothesis, we PCR-amplify 16S rRNA genes from community DNA extracts, then we evaluate terminal restriction fragment length polymorphisms (TRFLP) using standard, published protocols and protocols that we have developed for quantifying diversity indices from TRFLP data. Using our approaches in Mission Creek and Arroyo Burro watersheds, we found that bacterial community composition and, more weakly, diversity, correlate negatively with increasing percent urbanization of the surrounding watershed (LaMontagne & Holden, in press). We also found that, during the rainy season, the bacterial community in downstream creek waters (discharging into the coastal lagoon) appeared similar to bacterial communities in lagoon waters. However, during the dry season, the creek and lagoon communities were distinct. This suggests that bacteria, like other “contaminants”, are exported from watersheds during rainfall events and leave a measurable imprint on water quality downstream.

We developed and published a mass balance-based mathematical model of bacterial transport and fate through the coastal lagoon at Arroyo Burro (Steets & Holden 2003). Our model predicts lagoon sediment scouring with low water residence time during the rainy season while, during the dry months, sediment-associated bacteria enter with year-round creek flow, settle and accumulate. Coupled with our TRFLP analysis of particle-associated versus free-living communities in the lagoon, this work suggests that the lagoon could strongly modulate coastal water quality for sediment-associated pollutants (chemicals or bacteria) by accumulation during the summer and release during the winter. For bacterial pollutants (e.g. pathogens), the seasonality of coastal water quality could be stronger if, for example, summer lagoon conditions favor amplification. Taken together, our work indicates that bacterial communities are apt tracers of watershed urbanization and that the impact of sediment-associated pollutants, including pathogenic bacteria, on coastal water quality is strongly, albeit seasonally, modulated by coastal lagoons when they are present.

Effects of nitrogen enrichment in salt marshes

We found a total of 125 diatom species in Carpinteria Salt Marsh. Cluster analysis differentiated five diatom assemblages. Correlation analysis between these assemblage groups and environmental factors revealed a variety of relationships. The Class 1 assemblage was found on sediments with high organic content ($p < 0.05$), the Class 2 assemblage was associated with a low density of snails ($p < 0.05$), and the Class 3 assemblage was positively correlated with increasing nitrate and phosphate concentrations ($p < 0.01$) and high salinities in overlying water ($p < 0.05$). The Class 3 assemblage also was positively related to increasing silicate concentrations in pore water ($p < 0.05$) and increasing densities of snails ($p < 0.05$). The Class 4 assemblage was positively correlated with increasing temperatures ($p < 0.05$) and negatively

correlated with increasing snail densities ($p < 0.01$), whereas the Class 5 assemblage was associated with high concentrations of nitrate in overlying water.

REEF STUDIES

Kelp forest community monitoring

Results from the first three years of our monitoring indicate the species assemblages on reefs that have been deforested by grazing sea urchins are highly variable. At one end of the spectrum is Carpinteria Reef, which has little foliose algae (< 1%) and is dominated by encrusting coralline algae with relatively few reef-associated fish. In contrast, the abundances of understory algae (mainly red algal turf) and fish on Naples Reef are relatively high. Interestingly, the algal turf on Naples Reef is usually associated with aggregations of the clonal sea anemone, *Corynactis californica*. The mechanisms causing the species assemblages at Carpinteria and Naples to differ are unclear. One possibility is that sea urchins avoid the stinging tentacles of sea anemones. As a consequence, sea anemones provide a spatial refuge from grazing and allow patches of red algae to persist despite high densities of grazing sea urchins. The conspicuously low abundance of clonal anemones at Carpinteria

Reef could result from high rates of sedimentation, which inhibits suspension feeders as well as turf algae. One important source of sedimentation on nearshore reefs is terrestrial runoff, which likely differs between the two sites. Unlike Naples Reef, which is located offshore relatively far from sources of runoff, Carpinteria Reef is situated inshore close to the outfall of a major drainage system in a heavily developed watershed. Thus, sedimentation from runoff could reduce algal abundance and the forage base for fishes on Carpinteria Reef directly via burial, or indirectly by reducing the abundance of sea anemones that provide them refuge from grazing sea urchins. We

have obtained matching funds from the University of California Marine Council for stipend support for a graduate student (Stu Levenbach) to work on testing these and other related hypotheses for his dissertation. Mr. Levenbach's results to date indicate that sea urchins do indeed avoid clonal sea anemones (Figure 5). Experiments are underway to determine (1) threshold densities of *Corynactis californica* needed to illicit an avoidance response in sea urchins, and (2) the role of sediment in determining the distribution and abundance of *Corynactis californica*.

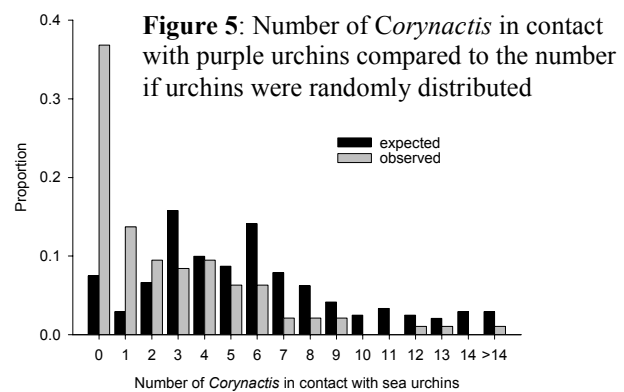


Figure 5: Number of *Corynactis* in contact with purple urchins compared to the number if urchins were randomly distributed

In addition, to our mainland reef sites we continue to monitor 11 reefs at Santa Cruz Island, which have been sampled yearly (or more often) for several decades, as part of ongoing research by Sally Holbrook and Russ Schmitt. Long-term sampling at these sites and at other sites on the mainland has revealed some dramatic ecosystem changes in reef communities along the California coast that are related to climate oscillations that produce abrupt regime shifts that typically occur every 20-35 years. We have seen shifts to dominance by southern species in kelp forest fish as well as large changes in standing stocks of reef fishes and invertebrates. Since the early 1970's the proportion of species in fish assemblages that are cold-water, northern species has dropped by about half, while the proportion of southern, warm-water species has increased nearly 50 percent. Overall, there has been a substantial decline in total fish abundance, which correlates closely with declines in productivity. These patterns suggest an ongoing redistribution of marine species along the coast of California that is consistent with predicted northward shifts in species' ranges in response to ocean warming.

Historical database on giant kelp abundance

SBC graduate student Brian Kinlan has been using the database on giant kelp abundance that we compiled from ISP alginates records to investigate the spatiotemporal dynamics of giant kelp forests throughout their range in California and Mexico. He found that canopy biomass varied interannually at dominant periods of 4-5 y, 11-13 y and ~20 y, and at spatial scales ranging from local (~30 km) to mesoscale (~100-150 km) and regional (~330 km) (Figure 6). Temporal dynamics were strongly related to basin-scale climate fluctuations (El Niño-Southern Oscillation, Pacific Decadal Oscillation) and spatial patterns were

correlated with coastline geomorphology. Digital canopy maps revealed that changes in biomass were associated with shifts in the spatial structure of the kelp habitat.

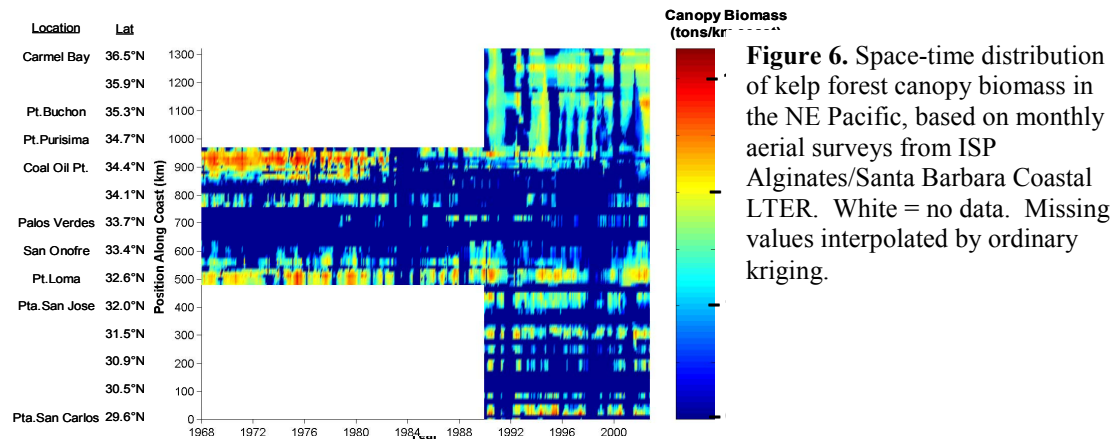


Figure 6. Space-time distribution of kelp forest canopy biomass in the NE Pacific, based on monthly aerial surveys from ISP Alginates/Santa Barbara Coastal LTER. White = no data. Missing values interpolated by ordinary kriging.

Primary production in giant kelp

NPP in giant kelp was substantial during the period May – December 2002, averaging $3.8 \text{ g C m}^{-2} \text{ d}^{-1}$ over all sites. Variation in NPP was explained in large part by standing crop, which decreased at all sites in the fall when nutrient concentrations decreased and storm activity increased; significant frond loss was observed following several large storms in October. The large fluctuations in NPP observed at Mohawk during the first three months reflected the loss of the canopy portion of fronds due to kelp harvesting. Partial frond loss is not accounted for in our loss term due to the logistical difficulty of measuring individual frond size. We have since worked with harvesters to develop a plan that eliminates harvesting at our study areas.

Spectral shapes of the calculated canopy absorbance spectra showed similarities with laboratory measurements of individual blades and provided a simple means for calculating the horizontally projected blade area index (*BAI*) of the overlying canopy. Optical estimates of horizontally projected *BAI* were correlated to the more laborious direct counts and harvest estimates, but the slope of the relationship was 0.22, perhaps in part due to our relatively low sample size at this point in time. Application of the cosine law to this slope suggests the average angular distribution of kelp blades within the canopy to be about 13° with respect to the nadir. We are continuing to evaluate the utility of in situ spectroscopy for rapid, non-destructive evaluation of submerged plant canopies in optically shallow waters and plan to obtain more data under a wider range of canopy densities.

Data collected to date suggest that optical data are a good predictor of standing biomass as measured by the more labor intensive diver count. The shallow slope between optically determined *BAI* and diver measurements (0.1105) indicates a significant package effect with respect to light harvesting by the plants and blade distribution within the canopy. This package effect (less light absorption per unit blade area than predicted from laboratory measurements of blade absorbances) probably results from the aggregation of blades near the stipe columns and surface canopy, rather than being randomly dispersed throughout the water column, and perhaps from angular orientation of the blades relative to the incoming light field. Nonetheless, the highly predictive relationship to Diver Measured *BAI* indicates that the optical measurement can provide a reliable estimate of kelp standing crop for about 1/3 the effort required for direct counts.

Kelp forest community metabolism

Our measurements show a remarkable decrease of chlorophyll *a*, POC, and PON, primarily near the bottom, and a similarly remarkable decrease of nitrate, nitrite and phosphate in the upper water column inside the kelp forest (Figure 7). These trends indicate the occurrence of intense,

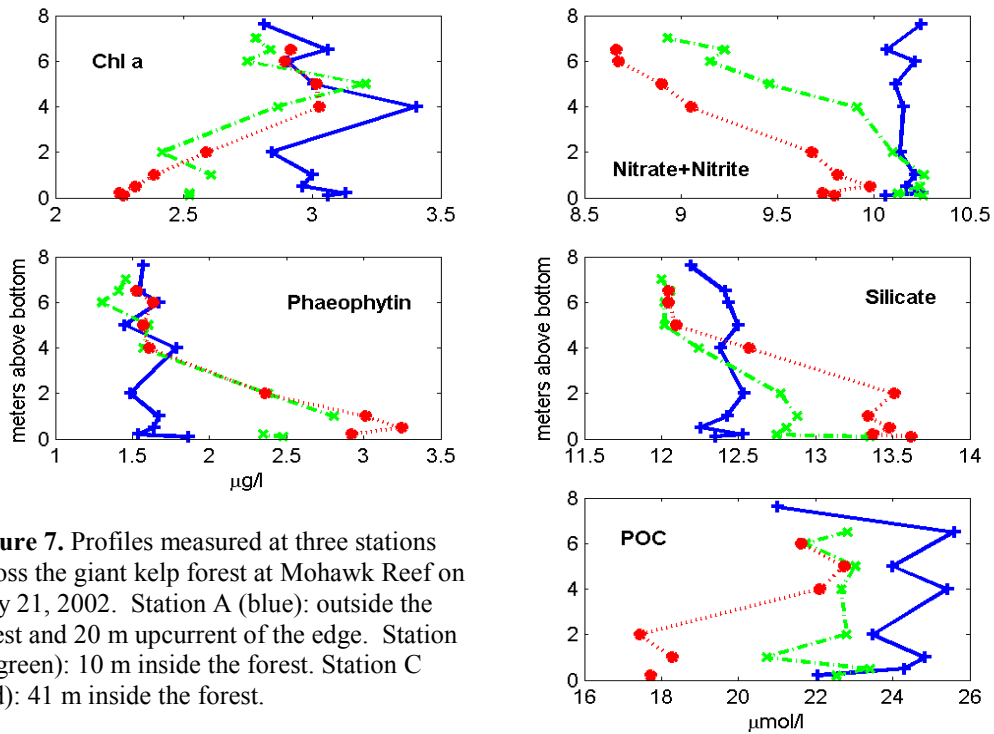


Figure 7. Profiles measured at three stations across the giant kelp forest at Mohawk Reef on May 21, 2002. Station A (blue): outside the forest and 20 m upcurrent of the edge. Station B (green): 10 m inside the forest. Station C (red): 41 m inside the forest.

previously undocumented grazing on phytoplankton and other organic particles near the bottom and pronounced uptake of nutrients closer to the surface where most of the kelp biomass is located. The large increase in phaeophytin near the bottom corroborates the conclusion that grazing was intense, while the corresponding near-bottom increase in silicate suggests significant benthic regeneration of silica.

Assuming an average flow velocity of 2 cm s^{-1} and a distance of 41 m between station C and the edge of the forest (station A), the water column-integrated decline in chlorophyll was 2.07 mg m^{-2} and that of POC was $29.9 \text{ mmol C m}^{-2}$. Extrapolating these values to 24 hrs and converting chlorophyll to carbon (using C: Chl ratio of 100 for this region), the estimated decline from outside to 41 m inside the forest was $8.7 \text{ g C m}^{-2} \text{ d}^{-1}$ and $15.1 \text{ g C m}^{-2} \text{ d}^{-1}$, for chlorophyll and POC, respectively. These values indicate that nutrient uptake by kelp and grazing on oceanic phytoplankton by benthic suspension feeders within the bed can be quite high.

Food web studies using stable isotope

Preliminary data are encouraging in showing separation in the isotope values of terrestrially derived POM in storm runoff ($\sim -26\text{‰}$) and kelp ($\sim -12.4\text{‰}$). Marine POM consists of a mix of phytoplankton, macroalgal detritus, terrestrially-derived POM, and other material (Figure 8). Our data also show separation in the values for marine POM and kelp during much of the year, although overlap occurs between these values in the fall. The fall months are periods of low phytoplankton standing stock, and marine POM values may reflect a predominance of sources other than phytoplankton. To investigate sources of variability in values of marine POM, including contributions from phytoplankton,

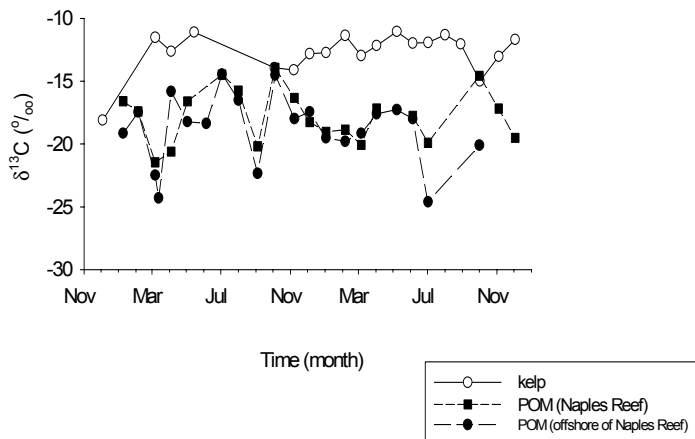


Figure 8. $\delta^{13}\text{C}$ values for the giant kelp, *Macrocystis pyrifera*, and marine POM sampled on and offshore of Naples Reef.

kelp detritus and terrestrial inputs, we are collecting samples of POM further offshore, at locations less likely to be influenced by inputs from kelp or terrestrial runoff and more likely to reflect a primarily phytoplankton source. We will continue to collect and analyze samples of these source materials to extend our data set.

To identify food sources used by reef consumers under different conditions of runoff, ocean climate and kelp production, we have begun sampling a variety of reef consumers chosen to represent different trophic levels. Tissue samples were collected in April, 2002 from the same species of consumers at four reef sites (Carpinteria, Naples, Mohawk, Arroyo Quemada), which vary in their proximity to sources of runoff and in their standing stock of giant kelp. The $\delta^{13}\text{C}$ values of these consumers at all sites reflected marine rather than terrestrial sources of carbon with values of the filter-feeding tunicate, *Stylea*, similar to values for offshore marine POM and values for the sea urchin, *Strongylocentrotus*, similar to values for kelp, the

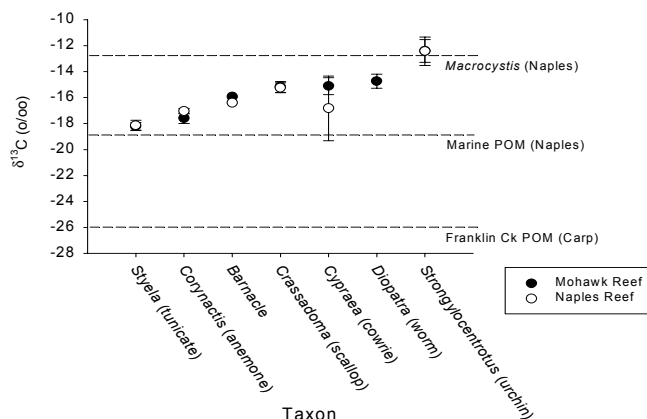


Figure 9. $\delta^{13}\text{C}$ values for common invertebrate consumers from Naples and Mohawk Reefs together with mean values (dotted lines) for the giant kelp, *Macrocyctis*, offshore POM from Naples Reef, and POM values from Franklin Creek (1997-98). Consumer data from samples collected in March 2000. Mean values $1\pm\text{SD}$, $n=5$.

preferred food of this genus (Figure 9). Values of other taxa were between these two extremes, suggesting that both phytoplankton and macroalgal-derived carbon contributed to the diet of these consumers. Similar tissue samples were collected from the same sites in April 2003, which followed a winter that had above average rainfall. These samples are currently being analyzed. We anticipate collecting similar samples in future years to take advantage of natural variation in rainfall and kelp standing crop.

We are also collaborating with the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) on experiments that use small mussels transplanted to strategic locations to evaluate the effects of runoff, ocean climate, and kelp production on the sources of carbon and nitrogen used by reef consumers. Experimental populations of small mussels (*Mytilus californianus*) will be deployed to the LTER moorings located at Carpinteria, Naples, and Arroyo Quemado. Carpinteria and Arroyo Quemado are close to a runoff source while Naples Reef is less influenced by runoff. Mussels will also be transplanted to existing PISCO mooring sites north of Pt. Conception (Jalama, Purisima, and Pt. Sal) where upwelling and phytoplankton production are quite high relative to that in the Santa Barbara Channel. Small mussels grow rapidly, providing sufficient tissue increase, and thus carbon and nitrogen turnover, to reflect local dietary sources of POM. To investigate possible temporal changes in the importance of food sources to reef consumers, mussels will be transplanted during periods of lowest (August) and highest (December to March) terrestrial runoff.

Field experiments: the role of nutrients in trophic interactions

To date, we have developed a diffuser system that will deliver nutrients to the reef benthos, and we initiated a set of experiments to determine how increases in nutrients interact with grazing and predation to influence benthic community structure and trophic interactions. Our nutrient diffuser consists of a flexible 2.5-cm diameter PVC pipe with large screen mesh windows that contains a slow release plant fertilizer (Osmocote; by wt. = 10% ammonium, 9% nitrate, 6% phosphate, and 12% potassium). Laboratory tests determined that the optimal diffuser design (PVC pipes with $\frac{1}{2}$ surface area covered with 2 mm screen mesh openings) provided a substantial and linear increase in ammonium and nitrate concentrations in the mesocosms. We are in the process of collecting field samples of nitrogen (ammonium and nitrate)

concentrations in 0.10 m² areas surrounding the plots to determine if nitrogen values measured in laboratory aquarium tests reflect concentrations delivered to benthos on reefs.

Results from the fall 2002 experiment investigating the effects of fish predation and added nutrients on the abundance and species composition of mesocrustacean grazers (e.g., amphipods, cumaceans, tanaids, and isopods) indicated that reef fishes can substantially reduce the abundance of their small crustacean prey, thereby potentially indirectly influencing the standing crop of periphyton upon which the meso-crustaceans graze. In the experiment conducted in winter 2003 we found that sea urchin grazing had a strong effect on both the total abundance of meso-crustacean grazers and the total concentration of chlorophyll and phaeophytin; numbers of crustaceans and the production of periphyton both were greater in plots grazed by urchins. We did not observe the same top-down effect of fish grazing in this experiment that we observed in the Fall, 2002 experiment. These results suggest that sea urchin grazing can have a positive indirect effect on periphyton (possibly through the reduction of canopy-forming kelps that shade the bottom), which in turn may lead to greater abundances of meso-crustacean grazers. Further experimental work is underway to examine these complex interactions among top-down effects of predation and grazing, and the bottom-up effects of nutrient addition.

Kelp subsidies to sandy beach communities

Macrophyte wrack deposited on beaches in the SBC-LTER study area consisted primarily of giant kelp, *Macrocystis pyrifera*, and surfgrass, *Phyllospadix spp.*. The standing crop of macrophyte wrack was estimated monthly by measuring the cover of wrack in the intertidal zone of the study beaches. Mean cover of macrophyte wrack varied over an order of magnitude among beaches in the SBC-LTER region. Standing crop of wrack also varied among months and years (Figure 10). Variation in the standing crop of wrack on beaches may be closely linked to the dynamics and condition of kelp forests and coastal reef ecosystems. For example, the standing crop of wrack was consistently very low at a beach adjacent to our core reef site at Carpinteria. This reef has been dominated by sea urchins the last several years and it supported little foliose macroalgae during this study.

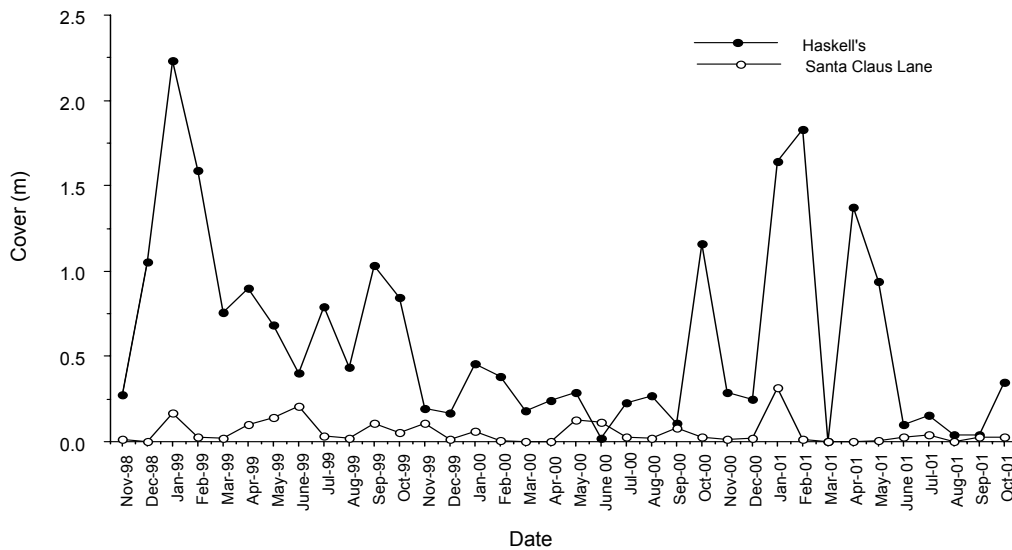


Figure 10. Time series of the mean cover of *Macrocystis pyrifera* wrack at two beaches, Haskell's and Santa Claus Lane, located near core reef sites, Naples and Carpinteria, respectively, from October 1998 - October 2001.

Results of our field studies suggest that changes in the amount and type of macrophyte wrack available significantly affects infaunal community biodiversity, structure and dynamics, and alters prey availability to higher trophic levels, such as shorebirds, on sandy beaches. Wrack-associated invertebrates, including amphipods, isopods, and insects, made up an average of >37% of the macrofaunal species on natural beaches. Overall species richness and abundance, and the species richness, abundance, and biomass of wrack-associated fauna and taxa were significantly correlated with the standing crop of macrophyte wrack. The abundance of two shorebird species that forage visually, Black-bellied Plovers and Western Snowy Plovers, was positively correlated with the standing crop of wrack and with the abundance of wrack-associated invertebrate prey. Surveys of beaches that are regularly groomed to remove wrack provided an opportunity to assess the importance of wrack subsidies to macrofauna communities in a large scale manipulative “experiment”. The species richness, abundance, and biomass of wrack-associated macrofauna were significantly depressed on groomed beaches compared to natural beaches with high or low standing crops of macrophyte wrack (Figure 11).

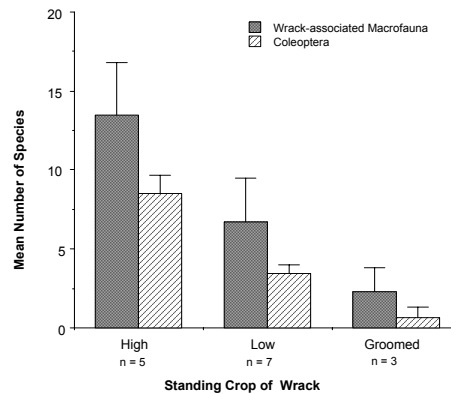


Figure 11. Mean species richness of wrack-associated macrofauna (solid bars) and Coleoptera (hatched bars) for beaches with high and low standing crop of macrophyte wrack, and for groomed beaches. Error bars represent standard errors.

Recently initiated research on the cycling of nutrients derived from drift kelp and other macroalgae on sandy beaches of the SBC-LTER has found that the beach porewater can contain very high concentrations of nitrate and ammonia (1000's of $\mu\text{mol l}^{-1}$) and may be a potential source of nitrogen to nearshore waters and reefs. Nitrogen concentrations in beach porewater were positively correlated with the standing crop of drift macrophytes (kg m^{-1}) in preliminary comparisons.

OCEAN STUDIES

Seasonal patterns in temperature and nutrient concentrations in the Santa Barbara Channel.

In the Santa Barbara channel, the dominant spatial gradient in nutrient concentration is set by the large-scale coastal currents of the eastern Pacific. Cold water influenced by the equatorward-flowing California Current enters the channel from the north delivering relatively high nutrient levels. Warmer, low-nutrient waters of the Southern California Counter Current enter the eastern boundary from the Southern California Bight (SCB). The “front” between cold, northern CA water masses and warm, southern CA water masses moves seasonally.

During spring, relatively cold waters are found throughout the channel, while during the summer and fall, warm waters from the south are found. Changes in the net transport through the eastern channel are part of the larger-scale pressure systems and wind flows over the Pacific and the North American continent. There are other cross-channel differences. For example the south western region of the Channel is strongly influenced by cold water flowing in from the California Current. This region is also affected by open-ocean Ekman pumping, caused by the strong wind stress divergence in the Point Conception region, and elevated mixing near the islands. Both processes lead to elevated nutrient concentrations at the surface. However, nutrient delivery to surface waters also occurs on the mainland side of the channel. Work by SBC graduate students Warrick (2002) and Otero (2002) demonstrated that input from terrestrial plumes can lead to surface phytoplankton blooms near the coast on the northern/northeastern side of the Channel. Vertical nutrient and temperature gradients also play a critical role in determining nutrient availability for productivity in near-surface waters. There is large seasonal variation in the depth of the thermocline and

nutricline (Figure 12). In a typical mid-summer period (July through September), the 13° isotherm and corresponding nitrate levels of ~5 to 10 $\mu\text{mol l}^{-1}$ are found at depths between 50 and 75 m. In contrast, between March and April, these cold temperatures and high nutrients are found closer to the surface, typically between 5 and 20 m depth. During the spring, vertical motion in the water column or slight increase of vertical mixing can transport high nutrient waters to shallow depths, where they can be utilized by phytoplankton and benthic algae. In the summer, however, such events are rare. There are also seasonal differences in shelf currents, winds, and baroclinic processes that drive such exchange. Further, there are large inter-annual changes in thermocline and nutricline depths driven by El Nino (97/98) and La Nina (98/99) events.

The effects of seasonality on primary production of phytoplankton in the channel

Phytoplankton blooms occur in two general locations in the Santa Barbara Channel. The first is the western Channel where productivity is influenced by inflow and vertical Ekman pumping of cold, high-nutrient waters. These blooms are observed in satellite data as well as with data collected during the LTER cruises. These cruises, scheduled three times per year, have provided an assessment of phytoplankton biomass and primary productivity associated with mid-channel blooms. The second location of focused surface blooms is the coastal waters influenced by local river plumes, predominantly from the Santa Clara River in the eastern Channel. These have been primarily observed through satellite measurements, as well as in recently conducted “event” surveys, in which depth profiles of temperature, salinity, assorted nutrients and chlorophyll a, were collected from a small boat in the nearshore immediately after a big rainstorm to assess the hydrographic and nutrient conditions caused by terrestrial plumes. Phytoplankton primary production is measured seasonally during our UNOLS cruises from the surface to the 1 % light depth along seven stations in the center of the CTD grid (also the line used in Plumes and Blooms sampling), and at 5 m depth at each station of the channel-wide CTD grid using ^{14}C labeled bicarbonate incorporation (see <http://sbc.lternet.edu/sites/coastoceanicmap.html> for locations of sampling sites). Productivity tends to be higher along the mainland with the highest integrated primary productivity occurring in April/May 2002 (Figure 12). An important trend is that peaks in both primary production rates and assimilation numbers (primary production normalized to chl a concentration) are skewed toward the mainland side of the channel. This pattern is not as evident in the integrated chlorophyll data suggesting that phytoplankton removal processes are higher near the mainland. The peaks in phytoplankton primary productivity coincided with the coldest sea water temperatures and highest nutrient conditions observed for that year. This demonstrates the importance of seasonal climate and the effects of spring upwelling on channel-wide primary productivity. Productivity in February and September of both years was lower than in spring, with no clear seasonal difference between winter and fall.

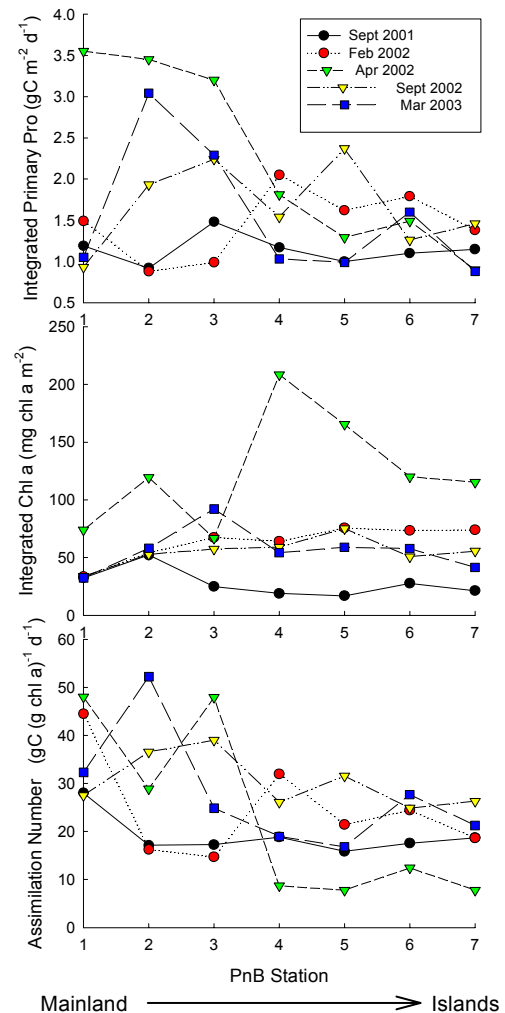


Figure 12. Integrated Primary Productivity, chlorophyll concentration and assimilation number along the cross Channel transect.

One of our long-term goals is to establish a time series of primary production within the basin to examine how phytoplankton respond to climatic forcing such as El Nino and the Pacific Decadal Oscillation. Our data set is presently inadequate to address these issues, but the average integrated primary production along

the Plumes and Blooms line is beginning to reveal a seasonal trend (data not shown). We will be using these data along with maps of primary production from our CTD grids and satellite imagery to interpolate monthly rates of phytoplankton production over the entire basin.

Terrestrial inputs to kelp forests also vary seasonally. A satellite depiction of a proxy for suspended sediments from the El Niño storms of 1998 shows extensive nearshore regions where ocean turbidity is elevated (Figure 13). In this image high values of ocean turbidity resulted from outflow of the Santa Clara River in the eastern channel and watersheds north of Point Conception to the west. The influence of the smaller watersheds along the channel and island coasts is also seen. Mertes and Warrick (2001) have found that these small water sheds discharge disproportionately large amounts of sediment to the channel given their small drainage areas. The timing of terrestrial discharges is highly seasonal with elevated levels in the late winter and early spring

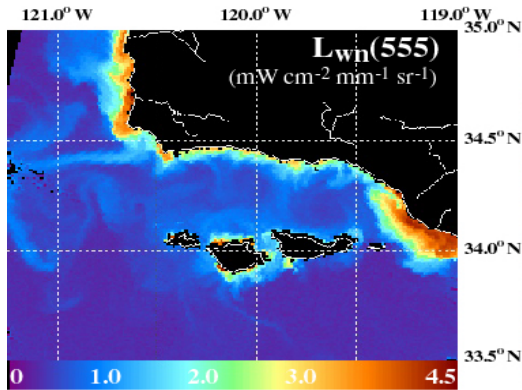


Figure 13. SeaWiFS ocean color image from 15 February 1998 showing an index for suspended sediment concentrations (the normalized water leaving radiance at 555 nm) during the El Niño storms (taken from Otero & Siegel, 2003).

Effects of seasonal and channel-wide dynamics on the transport of dissolved nitrogen to shallow nearshore reefs

Time series measurements obtained from moored instruments and monthly water samples at three mainland reef sites provide important information on the temporal features of temperature, salinity, currents, and

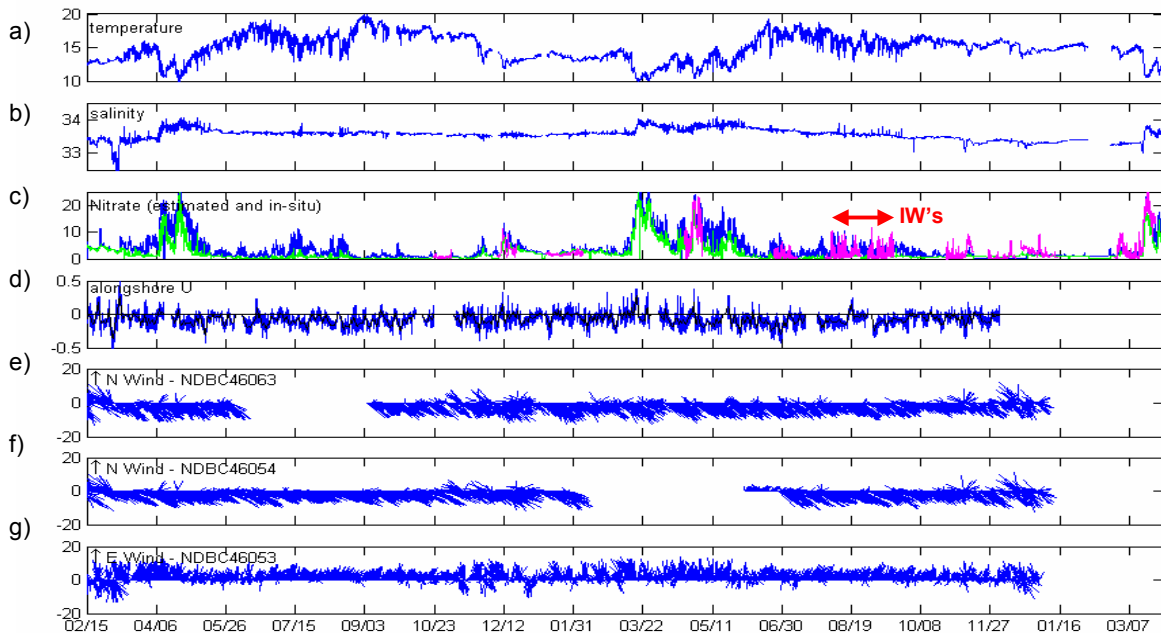


Figure 14. Time series of water constituents at the LTER Naples site: a) temperature; b) salinity; c) measured nitrate near bottom (pink) and nitrate regressed from temperature at surface (green) and bottom (blue); d) alongshore velocity; e) winds at NDBC buoy 46063; f) winds at NDBC buoy 46054; g) winds at NDBC buoy 46053.

ambient nutrient concentrations in water masses surrounding the kelp forests. Our longest time series is from Naples Reef, the most centrally located of the three reef sites (Figure 14). The same seasonal pattern characterizing open-channel conditions also dominates the temperature and nutrient “climate” at the shallow reef sites. Pulses of cold water ($< 11^\circ$) and high salinity occur in spring. These bring the highest nutrient peaks (nitrate concentration $> 20 \mu\text{mol}$ per liter) lasting 4 to 8 days. These pulses are due to local coastal upwelling and occurred during the spring of 2001 and 2002.

Aside from the period of spring upwelling, nutrients at the surface (green line, Figure 14c) tend to be fairly low. However, nutrients in the bottom half of the water column inferred from temperature (blue line), and in-situ measurements (pink line) are substantially higher. In situ nitrate measurements were initiated after May 2001. The nitrate time series demonstrates the importance of water column stratification on the nearshore habitat. Although surface waters are warm and have low nitrate concentrations throughout the summer, the nitrate measured at 12 to 14 m depth experiences frequent fluctuations and pulses up to 5 to 10 μmol per liter. For example, a period of internal wave activity occurred around 08/19/2002 and produced large pulses of nitrate concentration (internal waves at this time are identified in Figure 14 by the double-ended red arrow labeled IW's). These fluctuations are caused by diurnal-frequency internal waves, which are most energetic during the strong stratification of summer. These internal motions can lift cold water and high nutrients from depths greater than 20 to 30 m to the shallow reef. The internal waves often do not have a surface expression, yet they have a profound effect on the temperature and nutrient conditions at reef waters greater than 8 meters depth. Kelp biomass spans the depth range from bottom (20 m) to surface and thus may use these pulses of nutrients, which frequently bathe the bottom half of kelp plants approximately once per day during summer.

The effects of strong coastal upwelling on spatial patterns of temperature, salinity, and nutrients were evident from data collected during our spring 2002 UNOLS cruise (Figure 15). Concentrations of nitrate and phosphate (and other constituents not shown here) reached high levels at this time due to upwelled deep water masses. Such intense upwelling events in the Channel appear to be associated with strong westerly (eastward) winds inside the channel and some interesting reversals in the north-south winds near Pt. Conception.

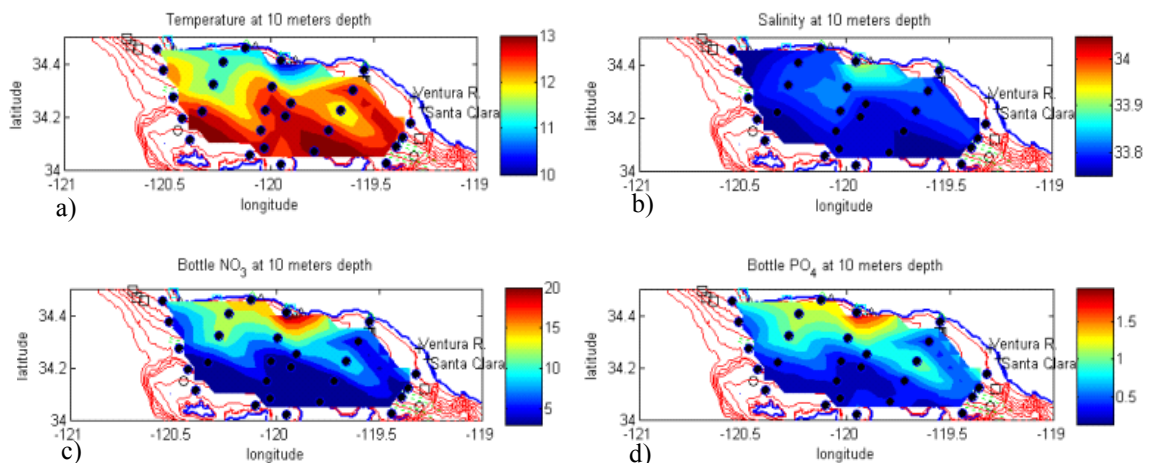


Figure 15. Contours of a) temperature ($^\circ\text{C}$); b) salinity; c) nitrate (μM); and d) phosphate (μM) from the LTER ship survey of April - May 2002 showing the effects of strong wind-driven upwelling within the channel.

During November and December of both 2001 and 2002 we observed additional nitrate peaks with durations greater than several days (Figure 16). These events coincided with episodic reversals of the alongshore shelf current, which has a mean westward (poleward) flow. However, significant cooling events that bring deep water up to the shallow reefs were often accompanied by reversals when the current direction switched to eastward. These cold pulses and flow reversals occur concurrently at all three mooring sites, suggesting that such events are a channel-wide phenomenon. We hypothesize that these synoptic-frequency, large-scale events may be governed by: 1) dynamics relating geostrophic shelf currents

to changes in the wind stress field; or 2) coastal-trapped wave dynamics. The same dynamics may be responsible for onshore transport events observed during both the spring and fall seasonal transitions.

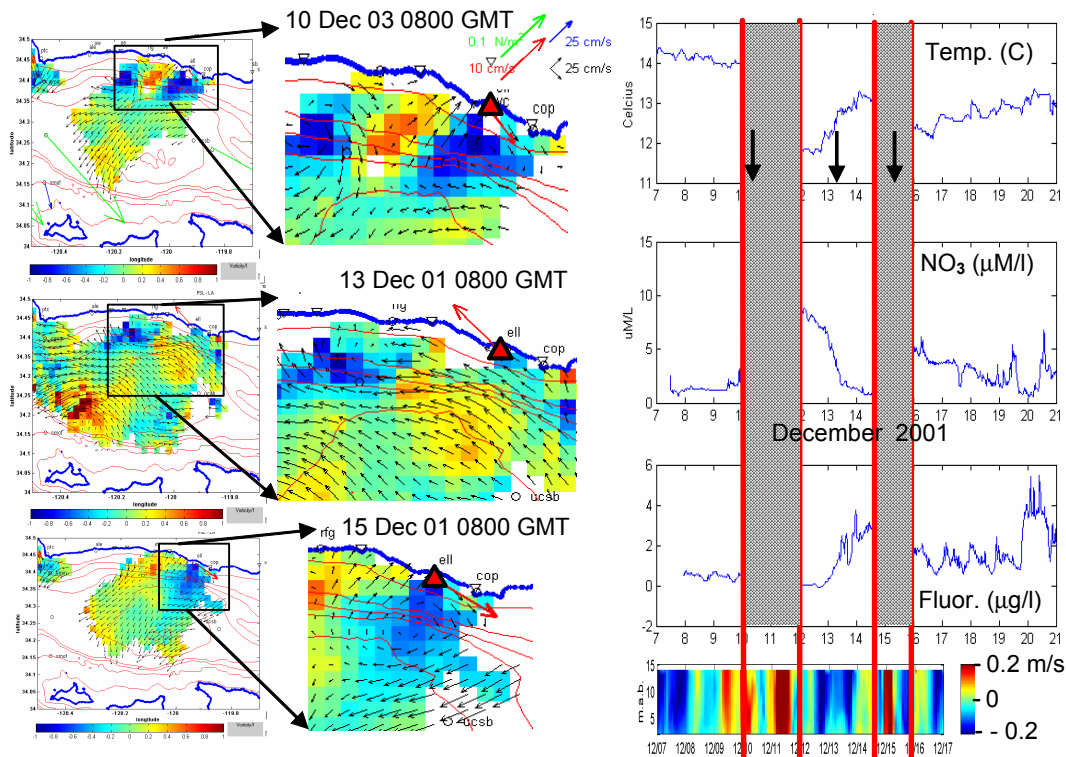


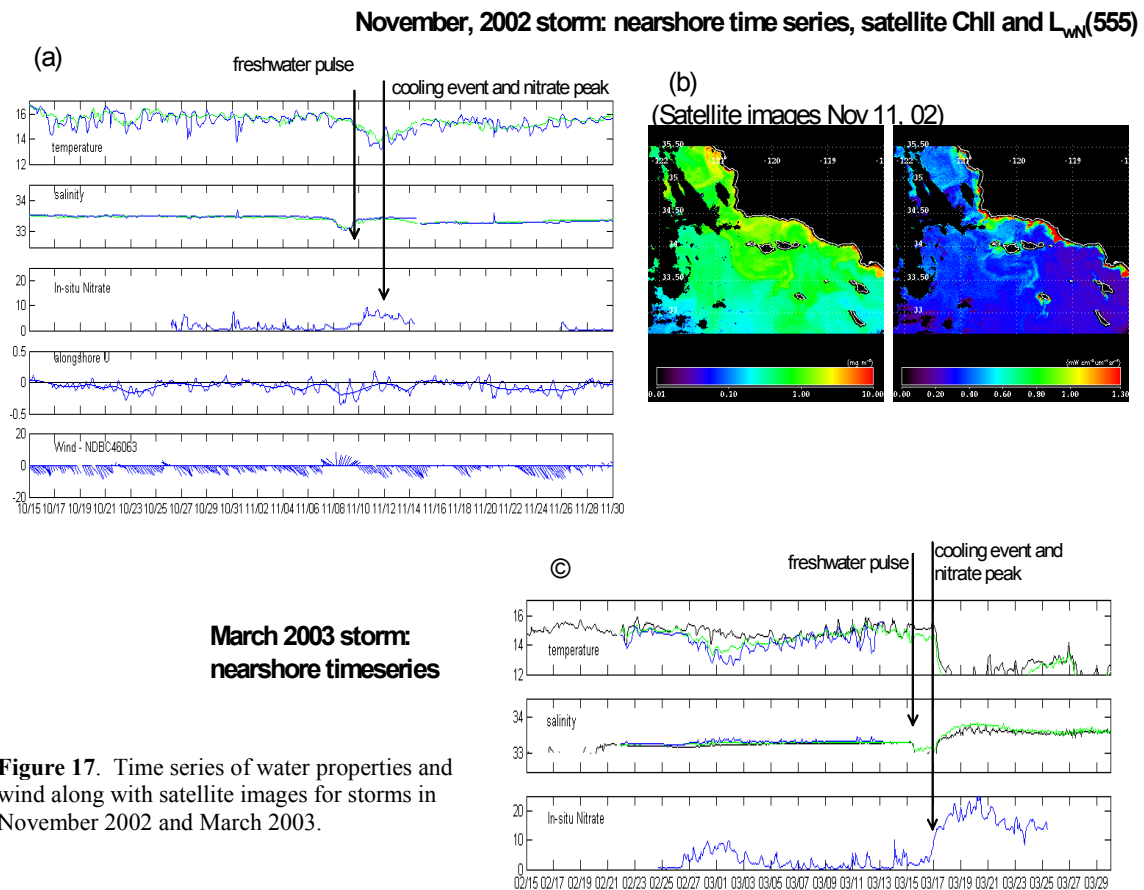
Figure 16. Panels on left show evolution of near shore eddy structures from 10-15 Dec 2001. Cooling and increased nitrate concentration accompany the eddies which also cause nearshore flow reversals as shown by center and right-hand panels. Arrows along the x-axis in the upper right panel show times of the three surface current maps. In center panel red triangles indicate mooring at Naples and yellow circles are HF radar locations. Time-depth contours in lower left panel show along shore velocities over 15 m water column. Eastward flow is red and westward flow is blue.

Another mechanism producing nearshore current reversals and transport of nutrients to the inner shelf are small-scale eddy features, which is a recent finding of SBC LTER. The eddy patterns and their effects are revealed in spatial patterns of surface currents from the high frequency radar at Coal Oil Point and Refugio Beach (yellow circles in center panels) along with times series measurements from our moored instruments at Naples Reef. Panels on the left in Figure 16 show patterns of surface currents around the Naples mooring (red triangles) on 10, 13, and 15 December 2001. Blue shading on the maps from 10 and 15 December mark the positions of near shore, anti-cyclonic eddies which are just offshore from the Naples mooring. The absence of this pattern on 13 December indicates that the eddy patterns change rapidly. Eastward flow due to the eddies is evident in the near surface vectors from the ADCP (red arrows in current maps) and in the ADCP time-depth contours at the lower right. When the eddy first appeared on 10 December, temperatures at the mooring dropped by over 2°C and nitrate concentrations (measured in situ every 20 minutes by a moored sensor) increased by about a factor of eight. Cooling and elevated nitrate concentrations return with another eddy on 15 December. An increase in chlorophyll fluorescence indicating a phytoplankton bloom beginning on 13 December followed the first eddy by about 2 days. A future research direction will be to understand the importance of these flow structures as nutrient delivery mechanisms to the kelp forest.

Terrestrial inputs

Terrestrial input of freshwater and nutrients was a relatively weak signal in the overall time series, however, evidence of the large storm occurring March 3-6, 2001 shows up in the salinity record as a strong low-salinity pulse near the beginning of the record (Figure 14b). The in situ nitrate analyzer was not

available during this storm event, and because temperature does not function as a proxy for nutrients during storm events, we have no record of the nitrate concentration at the reef associated with this event. However, using nitrate concentration values from streams collected by the SBC LTER watershed team, we estimated the likely nitrate concentration based on freshwater dilution. The results suggest a peak of between approximately 4 and 8 μmol per liter with a duration of 2 days. Measurements from more recent rainstorms of November 2002 and March 2003 suggest that the nutrient response to such events is constrained to surface waters. Low-salinity was observed at 4.5-m depth during these events (Figure II.C.8), however, the in situ nitrate sensor located at a depth of 12 m, did not measure elevated nitrate in response to the storm. Nonetheless, an interesting storm effect occurred in which wind reversals and a sudden switch to eastward currents at the shore coincided with abrupt cooling for a day or so after each storm. Thus, low-frequency dynamics driving onshore transport of cold, deep water appear to be important for nutrient elevation after storm events. The low-salinity signal of the November rainstorm (Figure 17a) also appeared in satellite measurements of water-leaving irradiance (L_{WN555}), a proxy for near-surface suspended sediment (Figure 17b), as plumes spreading near the coast at several locations. However, corresponding satellite Chl a measurements indicate no nearshore phytoplankton bloom was associated with the terrestrial inflow.



Response of Macrocytis to the supply of nitrate

Nitrogen is the nutrient that most commonly limits growth and reproduction in giant kelp. SBC undergraduate Kristen Green has been working with SBC investigators (Brzezinski and Reed) in investigation the extent to which temporal changes in the nitrogen content of *Macrocytis* in the Arroyo Quemado kelp forest is related to seasonal changes in the supply of nitrate. This work entailed constructing time courses of: (1) the average kelp nitrogen content normalized to wet weight using data on kelp biomass and the nitrogen content of different kelp tissue types, and (2) the supply of nitrate to the reef from time series of temperature measured by thermister arrays moored at the site, and the relationship between

temperature and nitrate concentration established from our deployments of the *in situ* nitrate analyzer. The result was a continuous record of nitrate concentration at three depths that was integrated over depth and time to provide an estimate of the nitrogen supplied to the reef for the 30 days preceding each monthly estimate of kelp nitrogen content.

Kelp N content generally followed the pattern of nitrate delivery in spring and early summer with a lag time of about one month between N delivery and the corresponding change in the N content of kelp. Kelp tissue N increased late in the year without a concomitant increase in nitrate supply suggesting that a nitrogen source other than nitrate may support kelp production at this time.