

Annual Report for Period:03/2004 - 03/2005**Submitted on:** 01/13/2005**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

Name: Briggs, Cody

Worked for more than 160 Hours: No

Contribution to Project:

assisted in the laboratory on kelp forest research

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.

Name: Greenberg, David

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Lucato, Sergio

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

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: Arkema, Katie

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:

Name: Pitterle, Ben

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Phillips, Jeff

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Hamrin, Katrina

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Smoot, Kristina

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: del Santo, Tonya

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Pelc, Robin

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Henkle, Sarah

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Zippay, Mackenzie

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Heintzelman, Sara

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on developing curricula for watershed education module funded by Schoolyard LTER

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: Creceley, 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: 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: Wright, Matt

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in studies of kelp forest productivity and population dynamics

Name: Fisher, Derek

Worked for more than 160 Hours: Yes

Contribution to Project:

assisted in chemical analyses of stream samples

Name: Feliciano, Holly

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in processing stream samples

Name: Resch, Shannon

Worked for more than 160 Hours: No

Contribution to Project:

assisted in processing stream samples

Name: Huttenbrauck, Leigh

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling

Name: Viel, Lisan

Worked for more than 160 Hours: No

Contribution to Project:

Assisted in stream sampling

Name: Morales, Veronica

Worked for more than 160 Hours: No

Contribution to Project:

assisted with stream sampling

Name: Hewson, William

Worked for more than 160 Hours: No

Contribution to Project:

assisted with stream sampling

Name: Anderson, Kaite

Worked for more than 160 Hours: No

Contribution to Project:

assisted with stream sampling

Name: Burrows, Jesse

Worked for more than 160 Hours: No

Contribution to Project:

assisted with stream sampling

Name: Larson, William

Worked for more than 160 Hours: No

Contribution to Project:

assisted with stream sampling

Name: Hammond, Tanis

Worked for more than 160 Hours: No

Contribution to Project:

assisted with stream sampling

Name: Layns, Arron

Worked for more than 160 Hours: No

Contribution to Project:

assisted with stream sampling

Name: Fisher, Rachelle

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Smith, Colby

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Parsons-Field, Avery

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Beyers, Sabrina

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Fejtek, Stacie

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Holloway, Stephen

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Burt, Chad

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Shulman, Danielle

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Sprague, Josh

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Al-Humaidi, Alia

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Craig, Alexandria

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Kunkel, Katy

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Worton, Leslie

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Bethany, Allen

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Hoesterey, Justin

Worked for more than 160 Hours: Yes

Contribution to Project:

assisted in subtidal kelp forest research

Name: Littlejohn, Tom

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Jolley, Margaret

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Hobbart, Sean

Worked for more than 160 Hours: No

Contribution to Project:

assisted in subtidal kelp forest research

Name: Pearson, Justin

Worked for more than 160 Hours: Yes

Contribution to Project:

Processes data from the moorings at the three core reef sites. In the processing he edits, filters, then merges data from the various sensors on the moorings. He works with the SBC-LTER data manager to put the data on the SBC-LTER server for use by other investigators.

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
Name: Risdien, 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
Name: Uwins, James

Worked for more than 160 Hours: No
Contribution to Project:
 assisted in stream sampling
Name: Phillips, Jeff

Worked for more than 160 Hours: No
Contribution to Project:
 assisted in stream sampling
Name: Hearney, Euan

Worked for more than 160 Hours: No
Contribution to Project:

assisted in subtidal kelp forest research

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: Herrer, Shannon

Worked for more than 160 Hours: Yes

Contribution to Project:

Worked on studies of kelp NPP and population dynamics

Years of schooling completed: Other
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: 2004
REU Funding: REU supplement

Name: Sakaria, Amy

Worked for more than 160 Hours: Yes

Contribution to Project:

worked on studies of kelp NPP and kelp forest community dynamics

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: 2004
REU Funding: REU supplement

Name: Twohey, Becky

Worked for more than 160 Hours: Yes

Contribution to Project:

worked on studies of kelp NPP and kelp forest community dynamics

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: 2004

REU Funding: REU supplement

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:

worked on cray fish ecology studies

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: Lee, Hung

Worked for more than 160 Hours: Yes

Contribution to Project:

worked on crayfish ecology studies

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 is engaged in sampling local creeks during the initial rise of the hydrograph and measuring a suite of pollutants including metals, pesticides and herbicides. Our intensive sampling of nutrients and particulates during the whole hydrograph for

most storms complements the County's effort, and we and they share data and interpretations. To further communication with Project Clean Water, we attend their monthly stakeholder meetings and have given public presentations of our results in that forum.

UNIVERSITY OF CALIFORNIA DAVIS

Conducting collaborative research on biophysical coupling in kelp forests

UNIVERSITY OF CALIFORNIA SANTA CRUZ

Conducting collaborative research on biophysical coupling in kelp forests

STANFORD UNIVERSITY

Conducting collaborative research on biophysical coupling in kelp forests

Old Dominion University

Dick Zimmerman and Lisa Drake are collaborating with the SBC LTER on studies of kelp primary production and photosynthesis

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 2004, 3 postdocs, 23 graduate students, 2 REU students and more than 30 undergraduate students participated in SBC research. Educational opportunities at SBC are not limited to university students and post docs. Teachers and numerous volunteers from the general public regularly participate in our stream sampling program and gain considerable knowledge on the constituents of runoff and of the processes that influence their concentrations.

The SBC-LTER program is part of a jointly developed 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 2004, the program included 23 graduate students and three postdoctoral fellows, with research interests spanning terrestrial, aquatic, and marine ecology, physiology, geology, oceanography, and policy. In April, 2004 three SBC graduate students presented posters on their research at the 16th Annual UC Toxic Substances Research and Teaching Program Symposium, Oakland, California. In September 2003, three SBC graduate students, Co-PI Holbrook and two 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. Two of the students attended a week long interdisciplinary short course on eco-toxicological research. A graduate student in Education worked with SBC to develop environmental education curriculum for SBC's Schoolyard project as part of her thesis. SBC students, postdoctoral fellows, and investigators participated in the SBC-LTER Spring Science Retreat, where results from SBC research were presented in a poster session, ocean and watershed field trips, and presentations. Two SBC-LTER graduate students and five investigators participated in followup working groups and planning grant meetings for the LTER network.

Outreach Activities:

Increased exposure of SBC's research to K-12 students and the general public comes by way of collaborative educational efforts with two existing outreach programs, including the South Coast Watershed Resource Center and UCSB's Oceans to Classrooms program. These two programs offer K-12 students, teachers, and the general public the opportunity to connect local environmental issues with basic principles of science education for a lifetime of learning. A main focus of these two programs is to engage K-12 teachers in watershed and marine science, and aid them in developing curricula based on research by SBC and other research entities that can be integrated into their lesson plans. The South Coast Watershed Resource Center (SCWRC) is located at the mouth of the Arroyo Burro Creek (a study site of SBC). Its mission is to develop sets of educational tools and resources aimed at informing 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 2004, the main focus of the SBC's Schoolyard program was working with a local science teachers and an graduate student in education to develop and conduct classroom testing of environmental education curriculum to complement the SBC-LTER Schoolyard outreach module on the Arroyo Burro Watershed, which empties into the ocean at the site of SCWRC with the goal of enhancing and increasing its classroom use. This effort included the production and classroom testing of coordinated lesson plans and activity kits in Janine Tuttle's classroom and will form part of a master's thesis for Sarah Heintzelman, a graduate student in Education. The module includes a computer animation model and natural history lessons 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.

SBC is expanding its outreach efforts to better engage students and teachers in its marine research by partnering with UCSB Marine Science Institute's Oceans into the Classroom program. This program offers educational research cruise experience for 6th -8th-graders aboard the 75' vessel Condor Express. 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 that is related to ongoing research at UCSB. Plans are underway to develop one of the six shipboard research stations with a focus that engages students and teachers in SBC LTER research. Each of the six stations builds on State Science Standards to introduce students and teachers to critical issues in marine science.

Alison Whitmer, the SBC education coordinator, is building on these existing collaborations by developing a program to enhance opportunities for research experience and training of K-12 teachers and their involvement in developing curricula that highlight SBC research for use in classrooms. In 2004, SBC provided support for an ROV workshop for high school teachers. The workshop formed the basis for developing 2 ROV teams from Cabrillo High School. The teams advanced to and competed in the MATE National ROV Competition, which was hosted by the Marine Science Institute on the UCSB campus. The competition brought approximately 3 dozen high school and community college teams to UCSB for the event. Community and agency partners included the Channel Islands National Marine Sanctuary, the Santa Barbara City College Diving Technology program and the Marine Advanced Technology Education (MATE) Center (an NSF-funded center). As a follow up, SBC supported the attendance of 2 Cabrillo High School teachers, Greg Eisen and Bob Ranard to an Advanced ROV workshop at the MATE Center in Monterey. We also supported 2 high school teachers who had attended the ROV workshop and who are working to integrate LTER research related themes into their biology and marine biology courses (Michelle Pouquette from Cabrillo High School and Bill Fraser from Santa Barbara High School).

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 program, the JASON team explores the terrestrial and marine ecosystems that extend from California's coast to the Channel Islands Marine Sanctuary. In 2004, SBC supported a group of 5 area junior high school teachers who worked on aligning the JASON XIV 'From Shore to Sea' curriculum with California state science education standards and the most commonly used science text books in our region. These alignments will facilitate the integration of the 'From Shore to Sea' curriculum and lab activities into our local area classrooms. We partnered with the Channel Islands National Marine Sanctuary, Channel Islands National Park and the Ventura County School District for this component.

A number of 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, graduate student Katie Arkema co-taught a classroom project through the 'Kids do Ecology' program, which is run through NCEAS, and has some direct ties with the Los Marineros educational program. http://www.nceas.ucsb.edu/nceas-web/kids/main_pages/classweb.htm. SBC investigators, Craig Carlson and Dan Reed, mentored two high school and one junior high students on their science fair projects. SBC graduate student, Clarissa Anderson mentored students through the WISE program. Dan Reed served as a science and technical advisor for Waves, Wetlands, and Watersheds, a classroom-based hands-on science activity guide that integrates California Coastal Commission areas of critical concern (wetlands, coastal processes, marine debris and pollution, and endangered species) with California Science Content Standards for grades three through eight (www.coastforyou.org).

Direct outreach to the public is an active area for many SBC investigators and students. A number of the public outreach activities that SBC has participated in are listed below

Tim Robinson, a 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). The Coalition has become a hallmark for community-led watershed planning and restoration efforts in southern California. It has obtained over \$500,000 in grant funding to develop a watershed plan, remove fish barriers and do public outreach. Tim coordinates a bi-monthly column in the local newspaper (The Carpinteria Coastal View) entitled 'In the Watershed', where farmers, citizens, researchers, agency representatives and regulators can express their interests in watershed management. To date, six SBC scientists have contributed articles about their research for the column.

Al Leydecker, a SBC post doc, assists and help direct stream and river monitoring, education and sampling programs for several community environmental organizations including Santa Barbara Channel Keeper, Isla Vista Surf Rider and Ventura Surf Rider. As part of this effort, Al co-authored a stream sampling guide for Santa Barbara Channel Keeper in 2003. In 2003, Al also helped organize, collect and prepare nutrient samples for 'Snapshot' day in San Luis Obispo, Santa Barbara and Ventura counties. 'Snapshot' day was a one day stream testing campaign organized by the California State Water Quality Resources Board to sample streams across the state. Samples were analyzed by the LTER as a community service and results reported to the state at a later date. Data are available at <http://www.coastal.ca.gov/publiced/snapshot/snapshot1.html>.

SBC investigators participated in several public groups to provide education and a scientific perspective including, Common Ground, a group of stakeholders who are developing a consensus on management for the Gaviota coast, the Goleta Beach Working Group, a group of stakeholders developing a vision for management to address coastal erosion at Goleta Beach County Park and the Channel Islands National Marine Sanctuary Scientific Advisory Panel.

Jenny Dugan, SBC science coordinator, worked with students from the Brooks Institute, the Ty-Warner Ocean Channel and the Santa Barbara Museum of Natural History on a short documentary film about SBC research on the links between kelp forests and sandy beaches and the design and content of new exhibits for the Sea Center in Santa Barbara.

Additional outreach activities done by SBC investigators and graduate students 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 outreach curriculum on associations between terrestrial runoff and phytoplankton blooms, assisting with public education at a local site where an endangered shorebird nests, leading tidepool tours, and giving numerous public presentations on LTER related research to non-scientist groups in the region (see list below). SBC-LTER investigators and graduate students also contributed to a number of articles on SBC-LTER research to magazines, newsletters and other publications for the public, including Making Waves, Coast and Ocean, Coastlines, and California Wild.

Public Outreach Talks in 2004

Dugan, J. E., Hubbard, D. M., and Page, H. M. 2004. Response of sandy beach ecosystems to macrophyte wrack subsidies from coastal reefs. Talk for Snowy Plover RU5 Fall meeting, November 16, Grover Beach, CA.

Dugan, J. E. 2004. Monitoring of Coastal Contaminants Using Sand Crabs. Presentation to the Marine Interest Group, San Luis Obispo, CA May 2004.

Dugan, J. E. 2004. Ecology of Sandy Beaches. Science Panel presentation to the Goleta Beach Working Group. January 2004.

Schimmel, J. 2004. Processes controlling groundwater NO₃. Talk presented to Santa Ynez Natural History Society.

Schimmel, J. 2004. California Ecosystems: A tale of nitrate, cows, & vegetation change. Talk hosted by the Environmental Studies Associates, Santa Barbara Main Library:

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 *Egrecia 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). Published
- 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
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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.icess.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.ices.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>.

Product Type:**Data or databases****Product Description:**

An ArcSDE/ArcIMS database of geographic data to support the design and study of California Marine Protected Areas

Sharing Information:

via California Department of Fish & Game who funded this database

Product Type:**Data or databases****Product Description:**

SBC-LTER online data catalog: Datasets are linked to queries for each of major research area, including primary production of kelp and phytoplankton, community dynamics, ocean and stream chemistry, ocean currents and hydrology

Sharing Information:

The data catalog can be accessed from the SBC website at <http://sbc.lternet.edu/catalog>,

Product Type:**Data or databases****Product Description:**

Digital Maps of the Historical Distribution of Giant Kelp in California: maps of historical giant kelp cover from archived aerial infrared photos provided by ISP Alginates, Inc.

Sharing Information:

In progress: database will be linked to SBC-LTER website

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, of the role of

nutrients in altering these food webs and of links to sandy beach food webs.

Our coastal ocean research has identified several physical transport mechanisms important for delivering nutrients to kelp forest ecosystems. Examples include upwelling, runoff, and internal tides, and we have 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, environmental history and informatics. SBC is now completing its fifth year of research and the major contributions of our research are beginning 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 2004, three post docs, 23 graduate students, four REU students and more than 30 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 continued to work on our project as a research technician after graduating from UCSB in biology. He went on to earn a Master's at Columbia University in spring 2004. One of our 2004 REU students was awarded a foreign exchange fellowship to Study at James Cook University in Australia, while another 2004 REU student was selected for a curatorial internship at Reef HQ in Townsville Australia following her graduation from UCSB. The research experience gained by these two individuals while participating in SBC's REU program was critical to their being selected for these competitive awards. Several of our undergraduate students have applied for and received funding to pursue independent studies associated with SBC research activities. One of these students is now in the 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 and test an interactive computer animation module and classroom lessons and activities featuring the Arroyo Burro Watershed.

In 2003-4, 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:

Physical resources

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.

Information Resources

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 and regular updates are conducted. SBC also published a site brochure which has been distributed to a wide array of interested user groups

Institutional resources for research and education

SBC LTER 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.

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 serves on the Science Advisory Panel for the Goleta Beach Visioning Process. Stuart Levenbach, an SBC graduate student, is working with the Santa Barbara Peace Corps Association grant program to review and fund development grants from actively serving Peace Corps Volunteers. Grant topics are very applied, but often include ecotourism and sustainable development projects which target minimizing a community's environmental impacts.

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 during 2004 as they pertain to land, reef and ocean processes.

WATERSHED STUDIES

Runoff, stream chemistry and transport

Our 2003 – 2004 (water year 2004) sampling goals were to regularly sample baseflow and 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.

Our 2004- 2005 (water year 2005) sampling goals are maintain our core sites from earlier years, to add two or three catchments with a majority of land use in agriculture (Rincon, Bell and Tecolote, if permission is obtained), and to sample intensively catchments and subcatchments burned by the June 2004 Gaviota fire (Arroyo Hondo, Gaviota and San Onofre). Examination of the influence of the fire on stream hydrology and chemistry will be the focus of a Master’s thesis by Scott Coombs.

We have established 31 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 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 12 rainfall gauges (6 of the remote gauges are equipped with spread spectrum telemetry).

Using the SBC-LTER and exiting gauging networks, we calibrated and validated two rainfall-runoff models for streams in the study region. The second, more advanced model simulates runoff from three sources (surface, steep shallow soils and groundwater) and is designed to integrate nutrient and sediment export modules, which represents a future research direction of the terrestrial component of the SBC-LTER.

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.

On-going data analyses by Tim Robinson, as part of his PhD, and by post doctoral associate, Al Leydecker, are deciphering statistical and process-based relationships among the characteristics of the catchments and the hydrochemical fluxes.

Estuarine studies

To investigate the effects of land use changes on a seasonally opened coastal estuarine habitat, studies, as part of Darcie Goodman's PhD, have begun on Devereux Slough. Measurements of sediment accumulation, dissolved oxygen, salinity, temperature and fish and invertebrate composition are in progress. An analysis of relevant public policy issues are an integral aspect of the overall study.

Catchment and in-stream processing of and responses to nutrients

Two studies of stream ecology are in progress: (1) The biotic effects of introduced crayfish are under investigation as part of the PhD research of Kristie Klose. Her study uses an experimental approach to delineate the effects of a widespread exotic species, the crayfish (*Procambarus clarkii*), on benthic invertebrates and primary producers in the Santa Ynez and Ventura Rivers. (2) 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 are being conducted throughout the watersheds, and N and P supply were experimentally manipulated using nutrient diffusers to assess algal growth responses. These studies are part of Julie Simpson's PhD research.

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 three sites located along the mainland coast in the Santa Barbara Channel at varying distances from sources of terrestrial runoff. Six additional mainland sites were added in the summer of 2001, and two sites at Santa Cruz Island were added in the summer of 2004. Two to eight 40 m long transects were installed at each site. The transects are marked with metal stakes fastened to the bottom at eight meter intervals. The abundance of relatively large solitary algae (e.g., kelps), invertebrates, and cryptic species of bottom-dwelling reef fish are counted in a 1 m wide area on both sides of each 40 m transect. Smaller species (and smaller individuals of large species) of algae, and invertebrates are counted in six permanently placed 1 m² quadrats that are located at eight meter intervals along each transect. The percentage cover of understory algae, sessile invertebrates, and various substrate types is determined along each transect by recording the biota and substrate intersecting an imaginary perpendicular line positioned at 1 m intervals located 0.5 m on both sides of each transect (n = 80 points per transect). The abundance and size of mobile reef fish are sampled on the bottom in a 2 m wide and 2 m high corridor along each transect. Sampling of all sites is done once per year in the summer, with the exception of mobile reef fish which are sampled every time a site is visited (sampling frequency ranges between 2 to 20 times per year). Tidbit temperature loggers are positioned on the bottom at each site and sample at a frequency of once every 15 minutes.

We also continue to sample 11 reefs at Santa Cruz Island as part of a pre-LTER ongoing effort. The goal of this component of our research is to assess abundances of certain demersal fish and their benthic crustacean food, and ascertain the state of each reef (forested by giant kelp and/or by understory algae, urchin barren, etc.). These reefs have been sampled yearly (or more often) since 1982, as part of ongoing research by Russell Schmitt and Sally Holbrook. At each reef, six key species of demersal fish are counted by divers along permanent 2 meter wide transects at depths of 3m, 6m, and 9m. Random point contact line transects are used to assess the composition of benthic substrates (rock, sand, and species of algae or invertebrate) along the band transects. Benthic samples are removed from 0.1m² quadrats, brought to the lab and processed to obtain counts and size structure of crustaceans and other invertebrates as well as

species composition and biomass of algae. Adding two of these 11 sites to our core kelp forest monitoring program in the summer of 2004 allows us integrate the long-term nature of the Santa Cruz Island study with the more taxonomically comprehensive sampling of our mainland sites. Collectively, these data afford a rich opportunity to track long-term changes in these reef communities, and relate observed variation to large scale physical and biotic processes that occur in the Southern California Bight. .

In 2002 we completed a field guide to the common kelp forest algae and invertebrates of the SBC LTER that contains photographs, key characteristics and habits of all the species sampled in our kelp forest monitoring program. During 2004 we made significant progress in expanding the field guide to include reef fish and nearshore marine mammals. This document is used to train students, staff and PIs in the identification of the species that are being monitored on the project, and helps to ensure quality control of the data being collected. It is available to the public at large on the SBC website, where it serves as a useful tool in describing the marine fauna and flora of the SBC LTER.

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 live about 3-5 months. In 2002 we refined the methodology that we use to estimate changes in standing crop 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 turnover (i.e., birth, and death) of fronds on marked individuals at each site; and (3) whole plant dissections in the laboratory for estimating weight-length relationships of the water column and surface portion of fronds, and for determining the water and 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:

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

where: B is the dry mass of kelp m^{-2} , p is the fraction of plants lost during the period between t and $t+1$, f is the fraction of whole fronds lost by plants that survived the period between t and $t+1$, and c is the portion of a frond that survived the period between t and $t+1$ that cut (and hence lost) by boat traffic or kelp harvesting .

NPP represents growth of an initial standing crop. However, obtaining direct measurements of whole plant growth are logistically challenging in a large, fast-growing species like *Macrocystis*, which undergoes a near complete regeneration of frond biomass two to three times per year. Consequently, we do not directly measure growth when estimating NPP in *Macrocystis*. Instead we estimate NPP by measuring the change in standing crop and accounting for the losses in biomass. Nonetheless, it is important to understand how NPP is influenced by variation in growth vs. variation in initial standing crop, as well as the extent to which growth is influenced by variation in the supply of resource (e.g. light and nutrients). To investigate these

and other issues, we estimate mass specific growth (G) (i.e. the fraction of new tissue produced by existing tissue per unit time) of giant kelp as:

$$G = NPP / B_t$$

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.

Biological and Physical coupling within giant kelp forests

Currents impinging on the kelp forest transport nutrients, plankton and organic carbon that can substantially subsidize the kelp community. The kelp forest in turn modifies the flow around and within its boundaries, and forest producers and consumers alter the flux of nutrients and particulates within the forest. 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. Results from this work led to a two-year multicampus (UC Santa Barbara, UC Davis, and UC Santa Cruz) award from the University of California Marine Council (through its California Environmental Quality Initiative) in summer 2004 to explore the linkages between hydrodynamics and kelp forest function in greater detail. The major focus of this effort is to investigate: (1) the degree to which impinging flows enter the forest as opposed to being diverted around it, (2) rates of consumption and production of waterborne subsidies (i.e., nutrients, POM, DOM) by kelp forests, (3) the interaction of nutrients, light, and flow in determining kelp growth, and (4) the implications of forest-flow interactions for forest-dwelling suspension feeding invertebrates. Our efforts in this endeavor will employ extensive measurements of flow and kelp forest community structure, geochemical and biochemical analyses, and experimental manipulations in exploiting a breadth of expertise in hydrodynamics, marine ecology, biological oceanography, and algal physiology. This work is in its early stages and to date has focused on equipment acquisition, design, construction, and testing of sampling apparatuses, site selection, and the development and parameterization of a model of flow mediated nutrient uptake in kelp that is being used to design field experiments examining the mass balance of water borne subsidies in giant kelp forests...

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

Food web studies using stable isotope

Potentially important food sources to primary consumers on shallow subtidal reefs include phytoplankton, macroalgae, and terrestrially-derived POM. We are using stable carbon and nitrogen isotope ratio analysis of producers and consumers of varying trophic status to evaluate the relative contribution of these sources to reef food webs. A considerable portion of our efforts has focused on characterizing variability in the

stable isotope values of potential food sources (phytoplankton, giant kelp, and terrestrial POM). This information is needed to evaluate whether isotopic values differ enough from one another to permit the use of mixing models to identify food sources to the reef food web.

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 macroalgal 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 allocthonous 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 ($>450 \text{ kg m}^{-1} \text{ y}^{-1}$) to sandy beach food webs in the SBC-LTER. With collaborative support from University of California Sea Grant and the Air Force, we are studying the responses of infaunal invertebrates, shorebird predators (including the endangered Western Snowy Plover), sediments and coastal dune vegetation to macrophyte subsidies from coastal reefs using comparative surveys and manipulative field experiments. With supplemental support from NSF in 2003-4, we conducted research on nutrient cycling associated with the delivery and processing of drift macroalgae on sandy beaches of the Santa Barbara LTER coast.

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 are also conducting 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 channel-wide surveys of hydrographic and biological parameters during February, May, and September 2004 using the UNOLS vessel R.V. Point Sur. Each cruise included using an undulating towed vehicle called a Triaxus to obtain high resolution, two-dimensional sections of temperature, salinity, beam attenuation at 660 nm (a measure of water turbidity), and chlorophyll from the surface to ~ 100 meters depth or the bottom in shallower depths. A set of cross-channel transects of CTD profiles along the Triaxus tracks provides vertical profiles of the same water properties measured by the Triaxus, but from the surface to the bottom everywhere in the Santa Barbara Channel. 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). These ship-board ADCP data are being processed for the SBC-LTER by Dr. Curtis Collins of the Naval Postgraduate School in Monterey, CA. We are currently working on data and metadata formats for including the ADCP data sets into the SBC-LTER database.

During the May 2004 cruise the Triaxus was lost when its on-board computer re-booted itself as it approached the bottom. This caused the Triaxus to crash into the bottom and break loose from its tow cable. UCSB lost two instruments, a bathyphotometer built by James Case's lab at UCSB and an ISUS nitrate sensor built by Satlantic. The value of the UCSB instrumentation was about \$47K which we are working to replace. The loss of the nitrate sensor in particular is a severe loss to our field program since it was one of the best ways currently available to measure nitrate rapidly at high spatial resolution..

The data from these cruises provide a valuable measure of the changing seasonal “background states” 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 nutrient delivery to kelp reefs from the larger scale flow in the channel. It is also required for comparison with 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 continuing our development of a series of computer programs to automate the processing of the Triaxus and other survey data while at sea. Currently we have completed the work on the ScanFish algorithms allowing near real time data processing and graphical visualization of the data while at sea. During the past year we adapted the Scanfish algorithms to the Triaxus to accomplish these tasks. Efforts continue to streamline and automate the processing of other data sets.

Our seasonal oceanographic cruises aboard the RV Pt. Sur have provided us with a unique opportunity to investigate toxic algal blooms in the Santa Barbara Channel. In addition to collecting water for our standard analyses listed above, we also analyze water for domoic acid content on select cruises when its concentrations are most likely to be high. Domoic acid is a very strong neurotoxin that is produced by some diatoms, the most notable in California being *Pseudo-nitzschia*. SBC graduate student Clarissa Anderson has been studying local phytoplankton community composition, and specifically has been investigating *Pseudo-nitzschia* bloom dynamics. She has been actively collecting data on phytoplankton abundance (cell counts using light microscopy), species identification (SEM), and domoic acid analyses. Ambient domoic acid concentrations were acquired using HPLC analytical procedures developed in the labs of Raphael Kudela and Mary Silver at the University of California, Santa Cruz. This collaboration is proving fruitful for understanding the toxic effects of *Pseudo-nitzschia* in the Santa Barbara Channel since this same ubiquitous diatom group has been well-studied by these labs in the Monterey Bay area. She has completed a five year time series study of the phytoplankton community in the Santa Barbara Channel (using pigment concentrations) using Plumes and Blooms and SBC LTER samples. Two separate methods of data analyses were used: 1) CHEMTAX, a Matlab program for describing community structure from pigments and 2) Empirical Orthogonal Functions for decomposing variance in a large dataset such that the resulting modes of variance explain much of the drivers of variability in phytoplankton community composition observed over the concrete time series.

Moored instruments and monthly sampling

We continued monthly sampling of water properties at three core reef sites, Carpinteria Reef, Arroyo Quemado, and Naples Reef, that we initiated in November 2000 (Carpinteria and Naples) and in March 2001 (Arroyo Quemado). Sampling at the three reefs is conducted with small boats and with instrumented moorings. We reduced the number of stations sampled at each site to a single reef station due to budgetary constraints. In previous years we sampled three stations at each site and we are using the resulting data sets to examine spatial variability on small scales around the reefs. The three sampling stations at each site 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. During small boat sampling at each station, a CTD equipped with a chlorophyll fluorometer and transmissometer is lowered and data on temperature, salinity, chlorophyll, and suspended sediments are recorded throughout the water column. Water samples are collected from the surface down to 25 m or the bottom and analyzed for nitrate, silicate, and phosphate. Samples of particulate matter 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.

During 2004 we continued to maintain permanent moorings at Carpinteria, Naples Reef, and Arroyo Quemado. These moorings allow us to sample ocean conditions at a higher frequency and over a wider range of conditions than can be achieved using small boats. This is especially important during storm events and high winds when sampling from boats is not possible. Each mooring is equipped with a conductivity sensor, temperature sensor, pressure sensor, and fluorometer and backscatter meter deployed at about 2 m. An ADCP is deployed on the bottom adjacent to each mooring to measure vertical profiles of

current velocity throughout the water column. During 2002 and 2003 we occasionally deployed an automated nutrient analyzer (manufactured by WS Oceans) near the Naples and Arroyo Quemado moorings. The nutrient analyzer has allowed us to obtain a time series of nitrate concentration at hourly sampling intervals for periods of up to several weeks through multiple deployments. The resulting data sets permit detailed investigations of the role of inner shelf processes, such as upwelling and internal tides, in supplying nutrients to the reef. We analyzed much of this data during the past year and are currently synthesizing it with other observations of coastal circulation and near-shore ecology.

Runoff "Event" sampling

Data from two runoff events were obtained during the rainy season of 2003-2004. During the first runoff event, a series of CTD casts and water samples were collected near Arroyo Burro over a small grid pattern (~2 km alongshore) during a rain event in December 2003. These data showed turbid water, low salinity water near shore with high nitrate levels as measured by bottle sampling. The second was a larger scale survey conducted during one of our cruises aboard the R.V. Point Sur and we were fortunate to obtain an extensive along-shore and cross-shore set of transects of near-surface water properties (~3 m depth). We inserted our ISUS nitrate sensor into the ship's underway system for this survey which allowed us to obtain highly resolved horizontal profiles of nitrate concentration along the mainland coast of the Santa Barbara Channel. Data from runoff event sampling are important for quantifying the quantities of freshwater and associated nutrients impinging on reef sites under a wide range of forcing conditions.

Regional Surface Current Patterns

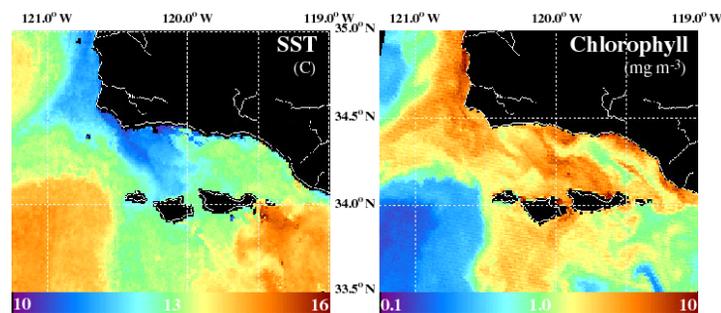
Since the beginning of the SBC-LTER an array of three to four high frequency (HF) radars have been operating around the Santa Barbara Channel to map the regional surface ocean circulation. Emery et al. 2004 describe the array and its performance in more detail. Over the past year Corinne Bassin, an SBC-LTER graduate student, has been developing a description of sub-mesoscale eddies which appear near shore along the mainland coast. She is doing this work as part of her Masters thesis. The occurrence of these eddies is also apparent from time series obtained from the SBC-LTER mooring at the Naples reef site. We are exploring the importance of these eddies as nutrient delivery mechanisms eddies to help reefs in the SBC-LTER study area.

Another important surface current pattern discovered through observations of the HF radar array was the occurrence of propagating eddies across the Santa Barbara Basin. As discussed by Beckenbach and Washburn (2004) the eddies are the resonant response of the basin to large scale coastal trapped waves which move along the coast from north to south. Both the resonant eddies and the coastal trapped waves are important causes of flow variability on time scales of ~2 weeks in the SBC-LTER study area.

Satellite Data

Local area coverage SeaWiFS ocean color and AVHRR thermal imagery have been collected and analyzed as part of the SBC-LTER program. This provides 1-km scale synoptic views of ocean chlorophyll concentrations and sea surface temperature over the entire Santa Barbara Channel. Co-registered five-day composite fields for SST and chlorophyll concentration are created on a routine basis for the Santa Barbara Channel. All imagery is hand navigated and de-clouded (see <http://www.icess.ucsb.edu/avhrr> & <http://www.icess.ucsb.edu/~fields/wifsTest> for example imagery).

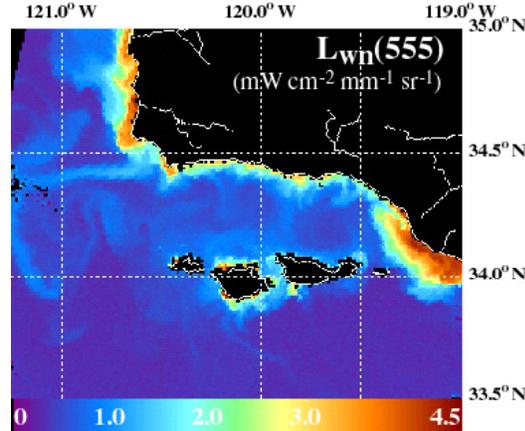
We have focused our initial studies on assessing the space/time characteristics of the chlorophyll and SST imagery to address the processes which control phytoplankton blooms and sediment plumes in the Santa Barbara Channel. Ocean color imagery is used to denote chlorophyll concentrations



Paired AVHRR SST and SeaWiFS Chl images during an upwelling event on April 18, 1998. The SST image is a single-day composite of four passes throughout the day. Note the correspondence between cool water temperatures and high chlorophyll concentrations

which are good assays for phytoplankton blooms.

Further, the water-leaving radiance at 555 nm, an ocean color data product, is shown to be a good proxy for suspended sediment concentrations enabling the dispersion of sediment plumes within the Santa Barbara Channel to be diagnosed (FIGURE B). These data, along with available ancillary data sets, provide a unique large scale view of ocean processes in the Santa Barbara Channel. This work has recently been published in Deep-Sea Research, Part II (Otero and Siegel, 2004).



SeaWiFS Lwn(555) image, a proxy for sediment concentrations, during a massive terrestrial runoff event on February 15, 1998. Suspended sediment concentrations are significant if values of Lwn(555) are greater than $1.4 \text{ mW cm}^{-2} \text{ mm}^{-1} \text{ sr}^{-1}$ (Otero and Siegel, 2004). Note the relation between high sediment concentrations and the location of the Santa Clara and Santa Ynez river mouths for this realization of an El Niño storm event.

PRESENTATIONS

2004

- Anderson, C.R., M.A. Brzezinski., D.A. Siegel, L. Washburn, and R.Kudela, 2004: Toxic Pseudo-nitzschia Blooms in the Santa Barbara Channel. Presented at 2004 ASLO Winter meeting, Honolulu, Hawaii.
- Anderson, C. R. M. A. Brzezinski, D. A. Siegel, L. Washburn, L. and N. Guillocheau. 2004. Are harmful algal blooms responsible for the variability in phytoplankton species composition during spring blooms in the Santa Barbara Channel? Presented at the 2004 ASLO/TOS Oceans Conference, Honolulu, HI, February.
- Anderson, C.R., M.A. Brzezinski., D.A. Siegel, L. Washburn, and R. Kudela, 2004: Physical Controls of Toxic Phytoplankton Blooms in the Santa Barbara Channel. Presented during the LTER CC meeting field trip April 29, 2004, Santa Barbara, CA
- Anderson, C.R., M.A. Brzezinski., D.A. Siegel, L. Washburn, and R. Kudela, 2004 (poster): Physical Controls of Toxic Phytoplankton Blooms in the Santa Barbara Channel, CA. Presented at 2004 NASA EarthSystems Scholars Network, Adelphi, MD.
- Arkema, K. 2004. Impacts of Giant Kelp on Suspension-Feeding Invertebrates Mediated by Changes in Water Flow and Particulate Deposition. Poster. University of California Toxic Substances Research and Teaching Program, 16th Annual Research Symposium, San Diego, CA
- Bassin, C.J., L. Washburn, E.E., and McPhee-Shaw, 2004. Sub-mesoscale eddies along the northern Santa Barbara Channel: A possible transport mechanism for particle transport across the inner shelf. ASLO/TOS Ocean Science Research Conference, Honolulu, HI, February.
- Beighley, R.E., A. Leydecker, J.M. Melack. 2004. Modeling water and nutrient export from coastal watersheds in southern California. Southern California Academy of Sciences, 2004 Annual Meeting, California State University, Long Beach, CA, May 4, 2004.
- Beighley, R.E., D. Alsdorf, T. Dunne, J.M. Melack. 2004. Hydrologic & Hydraulic Modeling for Decomposing the GRACE Signal in the Amazon Basin. GRACE Hydrology Workshop joint with NASA Surface Water Working Group Meeting, National Academies Beckman Center, Irvine, CA, March 18, 2004.
- Bose, R.K., 2004. Lineage retrieval for scientific geospatial data products. Presented at the Edinburgh Earth Observatory (EEO) Spatial Data Workshop, Institute of Geography, School of Geosciences, University of Edinburgh, Scotland. (December 10, 2004).
- Bose, R.K., 2004. Retrieving the lineage of scientific data products across organizations. Presented at Database Group Seminar, Laboratory for Foundations of Computer Science (LFCS), School of Informatics, University of Edinburgh, Scotland. (November 29, 2004)

- Bose, R.K., 2004. Retrieving the lineage of scientific data products across organizations. Presented at the Department of Spatial Information Science and Engineering, University of Maine at Orono. (October 12, 2004)
- Bose, R.K., 2004. Seeing the lineage of LTER ocean color data products: an environmental informatics case study. Presented at Santa Barbara Coastal Long Term Ecological Research (LTER) Science Retreat, UCSB. (May 18, 2004)
- Bose, R.K., 2004. Composing and Conveying Lineage Metadata for Earth Science Research Computing. Presented at Institute for Computational Earth System Science (ICESS), UCSB. (April 2, 2004)
- Cao, Y. 2004. Denitrification in Carpinteria Salt Marsh by Particle-Associated and Free-Living Bacteria. Presented at SBC-LTER Annual Retreat. Santa Barbara, CA.
- Costello, C. 2004. Coupling human and natural systems: flow, fish and fishing in the Santa Barbara Channel. Presented at SBC-LTER Annual Retreat. Santa Barbara, CA.
- Dugan, J. E. 2004. Monitoring of Coastal Contaminants Using Sand Crabs. Presentation to the Marine Interest Group, San Luis Obispo, CA May 2004
- Dugan, J. E. 2004. Ecology of Sandy Beaches. Science Panel presentation to the Goleta Beach Working Group. January 2004.
- Dugan, J. E. 2004. The Santa Barbara Coastal LTER: A project overview. Presented to the Association of Pacific Rim Universities Fellows. August 2004.
- Dugan, J. E., Hubbard, D. M., and Page, H. M. 2004. Response of sandy beach ecosystems to macrophyte wrack subsidies from coastal reefs. Poster presented at Snowy Plover - Biology and Conservation on the West Coast: Range-wide Symposium February 24-25, Rohnert Park, CA
- Dugan, J. E., Hubbard, D. M., and Page, H. M. 2004. Response of sandy beach ecosystems to macrophyte wrack subsidies from coastal reefs. Talk for Snowy Plover RU5 Fall meeting, November 16, Grover Beach, CA
- Dugan, J. E., D. M. Hubbard, M. James, H. M. Page 2004. Exchanges between kelp forests and sandy beaches: remineralization of nitrogen from kelp wrack. Presented at SBC-LTER Annual Retreat. Santa Barbara, CA.
- Eggert, K., R.E. Beighley, T. Dunne, K. Verdin, 2004. A continental scale river modeling framework designed around topographic modeling units with both hydrologic and hydraulic realism, Ninth Annual Community Climate System Model Workshop, Santa Fe, NM, July 7, 2004.
- Emery, B.M., M.M. Nishimoto, L. Washburn, and M. Love, 2004. Do Oil and Gas Platforms Off California Affect the fate of Recruiting Bocaccio? An Analysis Based on HF Radar Derived Surface Trajectories. Fourth International Radiowave Oceanography Workshop, Townesville, Australia, 21-23 April
- Gaylord, B. P. 2004. Disturbance mechanics and material processing in kelp ecosystems. Presented at SBC-LTER Annual Retreat. Santa Barbara, CA.
- Gaylord, B., D.C. Reed, L. Washburn, and P.T. Raimondi. 2004. Physical modeling and field measurements of spore dispersal from an experimental kelp forest. Presented at the Western Society of Naturalists meeting, Rohnert Park, CA., November, 2004.
- Grabowski, L. A. and A. Leydecker, 2004. Tracking enterococci bacteria during a rainstorm on Mission Creek. Presented at the 2004 Headwaters-to-Ocean (H₂O) Conference, Long Beach, CA.
- Guerrini, A., R. Bergstrom, J. Dugan and B. Schwartzberg. 2004. Historicizing Ecological Restoration : A Case Study of a California Coastal Wetland. Poster presented at "Cultural Places and Natural Spaces: Memory, History, and Landscape" joint meeting of American Society for Environmental History (ASEH) and the National Council on Public History (NCPH).
- Holden, P. A. Water, interfaces and environmental complexity at the microscale, Plenary talk at "Water: Challenges at the Intersection of Human and Natural Systems Workshop", a PNL sponsored NSF/DOE Workshop, Richland, WA September 16-17, 2004.
- Holden, P. A. and LaMontagne, M.G. Molecular community analysis in environmental monitoring. Abstracts of the 2004 Association of Environmental Health Sciences (AEHS), March 16, 2004, San Diego.
- Holden, P. A. 2004. Charting the course of human waste migration from watersheds through coastal waters. 2004 ASLO Ocean Sciences Meeting, Honolulu, HI.
- Kinlan, B P., D.A. Siegel, B. Gaylord, and S.D. Gaines, 2004: Marine Larval Dispersion and Prediction in Coastal Fisheries Science. Presented at the 2004 AGU Ocean Sciences Meeting, Portland OR. January 2004.

- Kinlan, B.P. and B.R. Broitman. A coupled spatial pattern of benthic and pelagic ecosystem structure in coastal upwelling regions. 2004 Ocean Sciences Meeting, American Geophysical Union, Portland, OR, 26-30 January 2004.
- Kinlan, B.P., D.C. Reed, P.T. Raimondi, L. Washburn, B. Gaylord, and P.T. Drake. The metapopulation ecology of giant kelp in southern California. Western Society of Naturalists, 85th Annual Meeting, Rohnert Park, CA, 11-14 November 2004.
- Klamberg, J. K.; Nelson, N. B.; Siegel, D. A., 2004: Seasonal modeling of colored dissolved organic material dynamics at the BATS site. Presented at the 2004 ASLO/TOS Oceans Conference, Honolulu, HI, February 2004.
- Klose, K. 2004 Evaluating the Impacts of Biotic Invasions: the Role of an Invasive Consumer (*Procambarus clarkii*) on the Biota of the Ventura River, California". Poster. Santa Barbara Coastal LTER Retreat, Univ. of California, Santa Barbara, CA.
- Kostadinov, T. S.; Siegel, D. A.; Maritorena, S.; Guillocheau, N. 2004: Assessment of optical closure using the plumes and blooms in-situ optical dataset, Santa Barbara Channel, California. Presented at the 2004 ASLO/TOS Oceans Conference, Honolulu, HI, February 2004.
- James, M., D. M. Hubbard and J. E. Dugan. 2004. On the Banks of the River of Sand: Restoration of Ecological and Physical Processes in the Coastal Strand Zone Presented at 2004 H₂O Conference, Long Beach, CA
- Levenbach, S. 2004. Silt as a Marine Contaminant: Its Effect on Demographic Rates in the Colonial Sea Anemone, *Corynactis Californica*, and Important Indirect Effects on the Benthic Community, 17th Annual Research Symposium, UC Toxic Substances Research and Teaching Program.
- Leydecker, A., J. Simpson, L. A. Grabowski, and M. D. Lim, 2004. Nutrient uptake and cycles of change: The Ventura River in Southern California. Presented at 228th American Chemical Society National Meeting, Philadelphia, PA.
- Leydecker, A., T. H. Robinson, and J. M. Melack, 2004. Nitrate storm flux from coastal catchments in southern California. AGU 2004 Fall meeting, San Francisco, CA.
- McPhee-Shaw, E.E. D.A. Siegel, L. Washburn, D. Reed, M. Brzezinski, 2004. Spring Upwelling in the Southern California Bight - Three Seasons of Observation. Presented at the 2004 AGU Ocean Sciences Meeting, Portland OR. January 2004.
- Rassweiler, A. 2004. Effects of Terrestrial Runoff on the Distribution of Dense Aggregations of Filter Feeders. Poster presented at UC Toxics Symposium, San Diego, CA, April 2004.
- Reed, D. 2004. Coastal Research in the LTER network. Invited speaker at the Workshop on the feasibility of an Antarctic Coastal Ecosystem LTER. San Jose, CA, May.
- Reed, D. A. Rassweiler, K. Arkema, R. Zimmerman. 2004. Interactive effects of disturbance and climate on primary production in giant kelp. LTER symposium on interactive effects of climate and disturbance. Fairbanks, AK. August
- Schimmel, J. 2004. Processes controlling groundwater NO₃. Talk presented to Santa Ynez Natural History Society.
- Schimmel, J. 2004. California Ecosystems: A tale of nitrate, cows, & vegetation change. Talk hosted by the Environmental Studies Associates, Santa Barbara Main Library:
- Senyk, N. A. and D.A. Siegel 2004. Using remotely sensed data to describe spatial and temporal habitat distributions of giant kelp, *Macrocystis pyrifera*. Poster presented at the 2004 ASLO/TOS Oceans Conference, Honolulu, HI, February.
- Siegel, D.A., B.P. Kinlan, B. Gaylord, and S.D. Gaines, 2004: Lagrangian descriptions of marine larval dispersion. Presented at the 2004 ASLO/TOS Oceans Conference, Honolulu, HI, February 2004.
- Siegel, D.A. 2004: Applying LTER principals to the establishment of marine reserves in coastal systems. Presented at the 4th NSF-LTER Symposium at the National Science Foundation, Arlington VA, February 26, 2004.
- Siegel, D.A., 2004: Flow, Fish and Fishing. Seminar presented to the Biological Sciences Department of the University of Southern California. March 9, 2004.
- Siegel, D.A., 2004: The Dirty Truth of Coastal Ocean Color Remote Sensing. Oral presentation to the GOES-R Coastal Water Imager Science Team Meeting, Corvallis OR, September.
- Washburn, L., E.H. Beckenbach, B.M. Emery, C.J. Bassin, C.N. Cudaback, and J.C. Ohlmann, 2004. Recent results from an array of HF radars on the South-central California Coast. Fourth International Radiowave Oceanography Workshop, Townesville, Australia, 21-23 April

Washburn, L., C. Blanchette, C.N. Cudaback, B.M. Emery, and C. Gotschalk, 2004, Poleward flow events around Pt. Conception, California: An analysis based on HF radar and moored time series. Fall AGU Meeting, San Francisco, CA, 13-17 December.

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, Glenden 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 demographics. 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 demographies. 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.
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RESEARCH FINDINGS

WATERSHED STUDIES

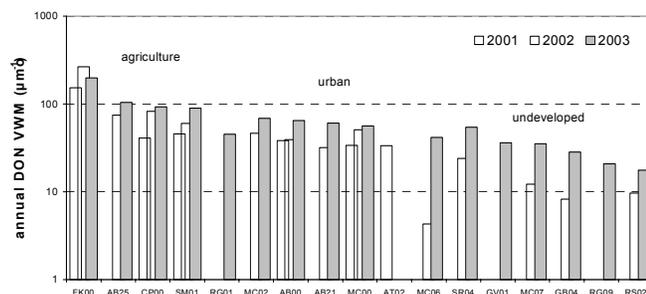
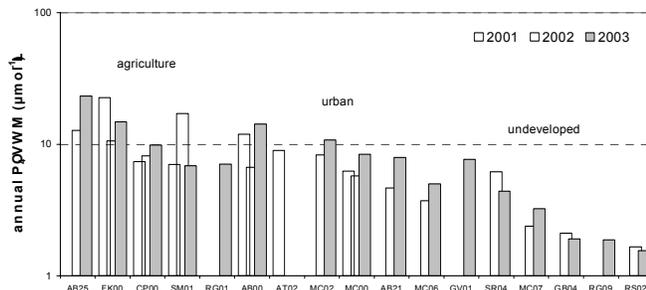
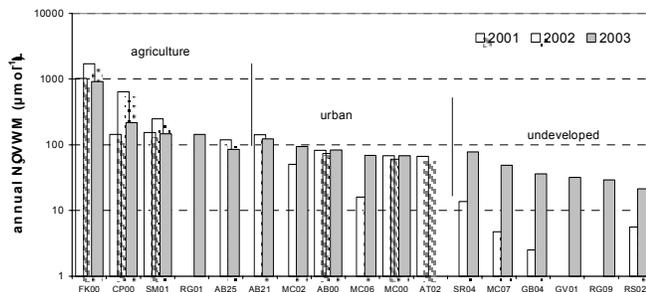
Stream chemistry and transport

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., < 4 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).

To determine how nutrient export varies with land use and annual runoff, field measurements were combined with modeling and statistical analyses. To extend measurements of stream discharge and nutrients to all the coastal catchments entering the Channel within our study area, we combined a hydrological model that generated runoff from rainfall with statistical relations among

solute concentrations and fluxes, land use and stream flow. Seventy-four small watersheds, with a total area of 790 km² (ranging from 1 to 50 km² with a mean of about 10 km²), drain from the Santa Ynez Mountains along the northern coast of Santa Barbara Channel. The topography of these coastal watersheds is characterized as mountainous headwaters and gently sloping coastal plains separated by transitional foothills. From west to east, there are both elevational and land use gradients. Headwater elevations increase from approximately 300 to 1400 m, and land uses on the coastal plain and foothills change from mostly rangeland to a combination of urban and agricultural lands. Most of the annual precipitation and corresponding runoff occurs in only a few large events resulting in high peak discharges and a rapid return to near baseflow conditions.

Volume weighted mean concentrations (VWM) and fluxes per ha of dissolved nutrients for 17 catchments or sub-catchments in WYs 2001 through 2003 can be divided into broad categories of agriculture, urban and undeveloped depending on the dominant land use. Descending order of concentration usually, but not always, follows descending intensity of use, although there are no clearly defined boundaries between land uses. For example, catchment MC07 has some agricultural and residential usage even though it is primarily undeveloped, and SM01 could be classified as agriculture in a dry year, and undeveloped in a wet year, based on the relative



Volume weighted mean (VWM) concentrations of nitrate, phosphate and dissolved organic nitrogen for sampled and gauged catchments or subcatchments in WYs 2001, 2002 and 2003: FK (Franklin), CP (Carpinteria), SM (Santa Monica), RG (Refugio), AB (Arroyo Burro), MC (Mission), AT (Atascadero), SR (San Roque), GB (Gobernador), GV (Gaviota), RS (Rattlesnake). Designations of 00 or 01 are sites at the tidal limit near the stream mouths; other numerical codes refer to sites within the catchments.

importance of a small amount of agriculture near the creek mouth. FK00 has exceptionally high nitrate and DON, most likely because of extensive greenhouse-based agriculture within the catchment. Other agricultural catchments have nitrate and DON values similar to the more intensively developed urban catchments. Although there is a difference in nitrogen concentrations and export between urban and undeveloped catchments, values gradually decrease as less intensive urban development grades into less developed conditions. Nitrate VWM concentrations generally range from 5 to 25 $\mu\text{mol L}^{-1}$ in undeveloped areas, increase to about 100 $\mu\text{mol L}^{-1}$ for urban and most agricultural catchments, and are in excess of 1000 $\mu\text{mol L}^{-1}$ in catchments with greenhouse-based agriculture. Comparative values for DON are 10 to 25 $\mu\text{mol L}^{-1}$ for undeveloped, 60 to 100 $\mu\text{mol L}^{-1}$ for urban and agricultural, and about 200 $\mu\text{mol L}^{-1}$ for greenhouse-based agriculture.

A conspicuous difference is the wet-year to dry-year contrast: the difference between WY 2002 and the other two years of data. While total export depended primarily on discharge, much lower in WY 2002, the flux per ha was also lower. Lower dry-year rainfall presumably reduced the flushing of nutrients in non-urban areas while urban contributions, usually concentrated during the first flushing storm of the season, remain relatively consistent.

There is almost a 4-order-of-magnitude difference in nitrate VWM concentrations, a variability caused by land use and annual runoff differences. The more heavily developed the catchment the more likely stormflow diluted coastal-plain baseflow concentrations; lower concentrations in upper catchment or impervious surface runoff dilute higher concentrations found in agricultural and urban drainages and groundwater inflows. The contrast between near-zero concentrations from undeveloped watersheds and exceptionally high concentrations associated with greenhouse-based agriculture during low-rainfall years account for the wide range in nitrate.

Differences in phosphate concentrations were observed between greenhouse-based agriculture and urban or less intensive agricultural usage, and between urban and undeveloped catchments, but other factors play a role because there is no clear relation between intensity of use and phosphate concentrations or export. For example, AB00 is less urban than AB21, yet phosphate concentrations at AB00 are almost twice as high. Phosphate concentrations are correlated with sediment loading. The width and condition of streamside buffer areas, the extent of stream bank armoring and the proximity of unvegetated, easily erodible soil to the channel or storm drain inlet are likely to influence phosphate concentrations. Except occasionally, as in the case of industrial agriculture runoff in the Franklin Creek catchment (FK00), phosphate in stormflow is higher than in baseflow. Overall, phosphate exhibited a single-order-of-magnitude difference among the catchments.

The stormflow regression models were developed to estimate the flux (mol ha^{-1}) for a given storm based on the percentage of catchment area used for agriculture or classified as impervious surface, the estimated discharge during the storm and the cumulative water year discharge at the end of the storm. Daily models were also developed to estimate the daily flux ($\text{mol ha}^{-1} \text{d}^{-1}$) using daily flow and the cumulative water year discharge at the end of the given day.

Hourly discharges at the outlets of 74 coastal watersheds were simulated for water years 2001, 2002 and 2003. These fluxes were summed to produce annual fluxes. Total annual fluvial fluxes ranged, among the water years and different regression equations, from 3,095 to 18,635 kmoles for nitrate, from 141 to 1,132 kmoles for phosphate and 408 to 7259 kmoles for DON. A major proportion of the annual fluxes occurred during a single large storm. In WY 2001, 50, 40 and 47% of the respective nitrate, phosphate and DON fluxes were exported during the largest event; corresponding percentages in WY 2003 were 46, 28 and 40. During WY 2002, a year without a major storm, the largest rainfall still accounted for 31, 9 and 29% of the total respective export.

The Ventura River drains 580 km^2 of mountainous coast and ranges in flow from near 0 to 11 $\text{m}^3 \text{s}^{-1}$. 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 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.

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

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 algal biomass varies greatly depending on the surrounding land use, ranging from 1.6 mg m^{-2} chlorophyll *a* in an undeveloped watershed site to 4000 mg m^{-2} chlorophyll *a* at an urban site. Dissolved nutrient concentrations were 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.

Aquatic bacterial community composition and diversity quantifiably shifts in response to environmental stresses such as chemical pollutants; shifts may also occur when natural systems are inoculated with non-indigenous bacteria such as those occurring in soils or in waste streams. For example, by evaluating terminal restriction fragment length polymorphisms (TRFLP) in PCR-amplified 16S rRNA genes from extracted community DNA, we found quantifiable influences of specific land uses on microbial community structure and diversity (M. LaMontagne, E. Beighley, P. Holden, unpublished data) within two SBC-LTER watersheds. This is consistent with our earlier work focused on the lagoon at Arroyo Burro whereby rainfall induced runoff conveys upland sediment-associated microbial communities into the lagoon, thereby changing the microbial community structure from distinct to more closely resembling that of upstream waters (LaMontagne & Holden, 2003). Additionally, nitrate, as a chemical pollutant and nutrient to Carpinteria Salt Marsh sediment-associated bacteria, was shown to alter microbial communities that in turn remove nitrate from the system. Our work indicates that denitrification in this system is predominately mediated by particle-associated bacteria which, presumably, are advantaged to perform this function in the biofilm growth mode (Y. Cao and P. Holden, unpublished data).

Several land use changes (i.e., construction of dams and canals, urbanization and the conversion of land to agriculture) have significant and long-term effects on freshwater biodiversity and ecosystem function. Many of these land use changes strongly increase the impact of invasive species in freshwater communities. In particular, invasions of aquatic species have large potential for altering stream communities, including reductions in the abundances of indigenous taxa. In Europe and North America, non-indigenous crayfishes have eliminated or reduced native crayfishes, amphibians, other invertebrates, and aquatic vegetation from lakes and streams, apparently displacing fish and invertebrates that use these resources. The red swamp crayfish, *Procambarus clarkii*, is an invasive macroinvertebrate in many lakes and streams throughout the western U.S., including Santa Barbara and Ventura Counties, California. Because this species is a generalized omnivore, determining its potential impacts on native taxa is important for predicting community responses to this widespread exotic species in California and elsewhere. In 2002, SBC graduate student, Kristie Klose, performed a field experiment in the Santa Ynez River of Santa Barbara County, California using a gradient of *P. clarkii* densities in *in situ* experimental stream channels, then measured the responses of invertebrate and primary producer abundance to different crayfish densities. Her results are in agreement with similar studies detailing the effects of other crayfish species on benthic invertebrate prey, suggesting that crayfish have strong impacts on large, conspicuous benthic invertebrates such as snails (e.g., *Physella gyrina*), and positive indirect impacts on the abundance of periphyton. In an effort to determine crayfish effects in streams within distinct watersheds and

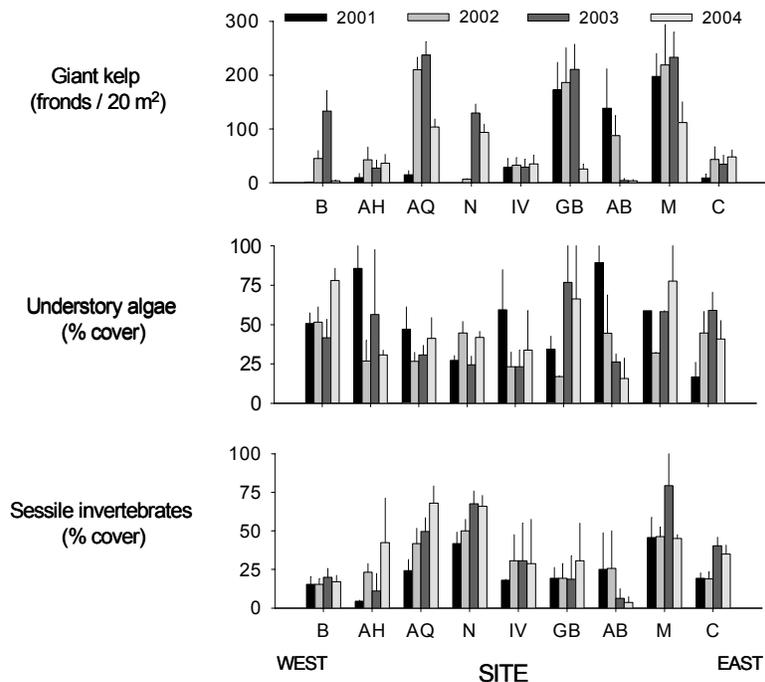
contrasting current velocities (e.g., standing versus moderate flow), in 2003 she performed a similar field experiment as the one described previously for 2002 in the Ventura River. Preliminary results from this study are similar to and support those found for the Santa Ynez River. During 2004, she examined biological responses to the individual and combined effects of *P. clarkii* and *P. gyrina* in a cross-classified field experiment using a 2x2 factorial design to determine the individual and combined effects of *P. clarkii* and *P. gyrina* on a common resource (i.e., periphyton) and each other (i.e., growth and survival).

Year long sampling of temperature, salinity, and dissolved oxygen in Devereux Slough indicate that the slough is a highly dynamic system. Salinity levels are strongly affected by tidal and stormwater influence. Before the breaching of the berm, when slough water mixed with sea water, the water column was stratified and the surface water was < 10 ppt and bottom salinities were hypersaline. During all seasons of the year, low dissolved oxygen levels were recorded near the bottom of the water column. Seine surveys for fish during the winter found *Fundulus parvipinnis* (California killifish), *Gillichthys mirabilis* (longjaw mudsucker), *Atherinops affinis* (topsmelt) and *Eucyclogobius newberryi*, (tidewater goby). The tidewater goby is an endangered species and has not been recorded in the slough since the early 1960s.

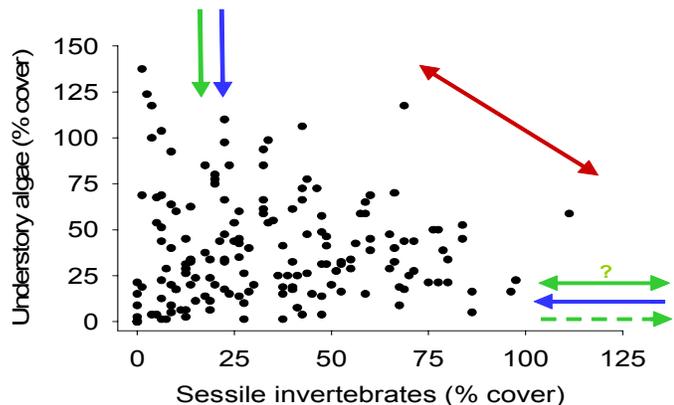
REEF STUDIES

Kelp forest community monitoring

Results from our kelp forest monitoring program show that the kelp forest ecosystems in the Santa Barbara Channel are extremely dynamic in both space and time. Site specific differences in the timing and intensity of sea urchin grazing, exposure to wave disturbance and sand accretion caused the abundance of giant kelp at the nine mainland sites to vary asynchronously over time. During the four year time series, the abundance of giant kelp remained relatively high at Mohawk (M), low at Arroyo Hondo, Isla Vista and Carpinteria (AH, IV, C) and highly variable at Bulito, and Arroyo Quemado (B, AQ). It generally increased at Naples (N) and decreased at Arroyo Burro (AB).



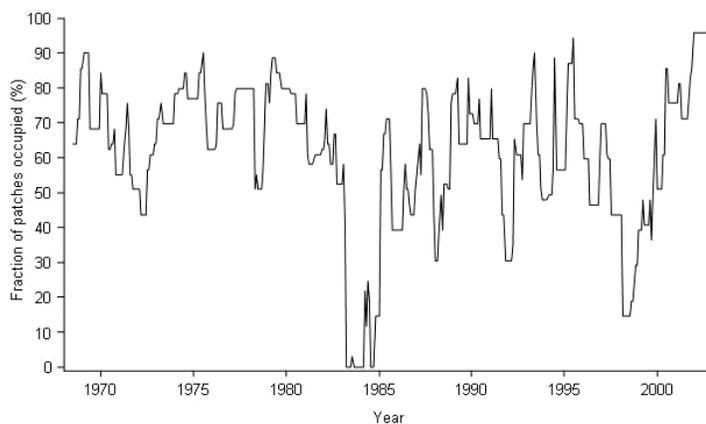
Understory algae and sessile invertebrates also displayed substantial variation among sites and years, which is not surprising given the large fluctuations seen in giant kelp, which is known to influence other components of the kelp forest community. For example, a dense *Macrocystis* canopy can reduce light levels near the bottom inhibiting understory algal recruitment and growth. This in turn may affect the distribution and abundance of sessile invertebrates, which may compete with understory algae for space. These different species interactions are tempered



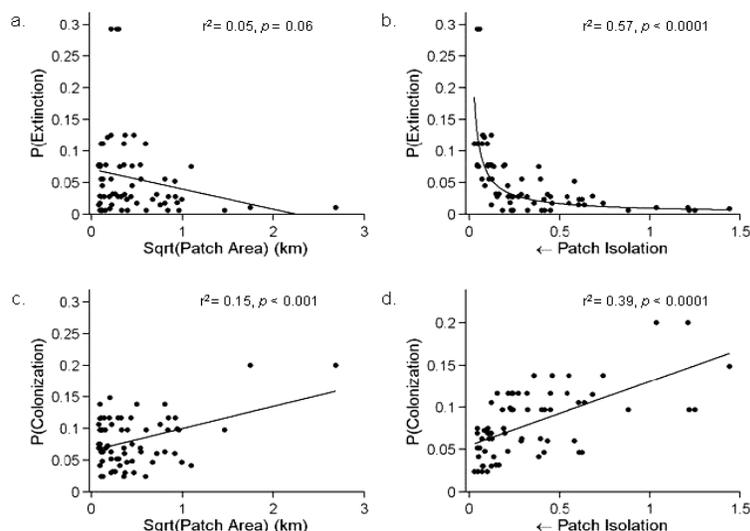
by physical and biological disturbances that indiscriminately reduce the abundance of all algae and sessile invertebrates. Collectively, these processes interact to produce a wedge-shaped relationship between the abundance of kelp forest algae and invertebrates in the Santa Barbara region. Competition for space between bottom-dwelling algae and invertebrates drives the relationship along a diagonal (red arrow). Shading from kelp leads to a reduction in understory algae (solid green arrow), which allows invertebrate abundance to increase (dashed green arrow). Unknown direct effects of kelp on invertebrates are shown by the double headed solid green arrow. Severe disturbances decrease the abundances of both algae and invertebrates (blue arrows). In addition to continuing our long term monitoring we are investigating these relationships in greater detail with experiments and mathematical models.

Historical database on giant kelp abundance

Discrete stands of giant kelp have been shown to go extinct and reappear at irregular intervals. A collaborative effort led by graduate student B. Kinlan has been using the SBC historical kelp database in combination with digital maps of giant kelp canopy derived from aerial infrared imagery (California Dept of Fish and Game) to examine rates of patch extinction and colonization in giant kelp throughout southern California (a patch is defined here as a discrete area of suitable habitat that can potentially be colonized by giant kelp). Our analyses confirm that at a regional scale, occupancy of the giant kelp habitat mosaic is extremely dynamic. During the 34-year study period, the estimated fraction of patches occupied in southern California approached 100% in some months, but dipped to ~0% after a major El Nino event (1982-1984). In fact, for much of the time from 1982-1984, no surface canopy was detected in the aerial biomass surveys. Extinction probabilities, defined here as the monthly probability of a patch going from occupied to extinct, ranged from 0.005 to 0.292 (mean \pm SD = 0.057 ± 0.063). Recolonization probabilities, defined as the monthly probability of a patch going from extinct to occupied, ranged from 0.023 to 0.200 (mean \pm SD = 0.080 ± 0.040). On average, extinction of a patch in southern California lasted from six months to four years, and patches remained occupied for one to five years. However, in certain cases extinctions lasted as little as a few months or as much as 13 years and patches of kelp persisted for several months to 15 years.



Extinction and recolonization rates varied with patch size and patch isolation. Patch isolation explained more variation in extinction (Figure b) and recolonization (Figure d) rates than patch size (Figure a,c), suggesting that immigration rates of kelp are dependent on distance between patches and source population size. The lower extinction rates in highly connected (i.e., low isolation) patches indicates that rescue effects may play an important role in patch dynamics. The lower colonization rates in highly isolated patches (Figure

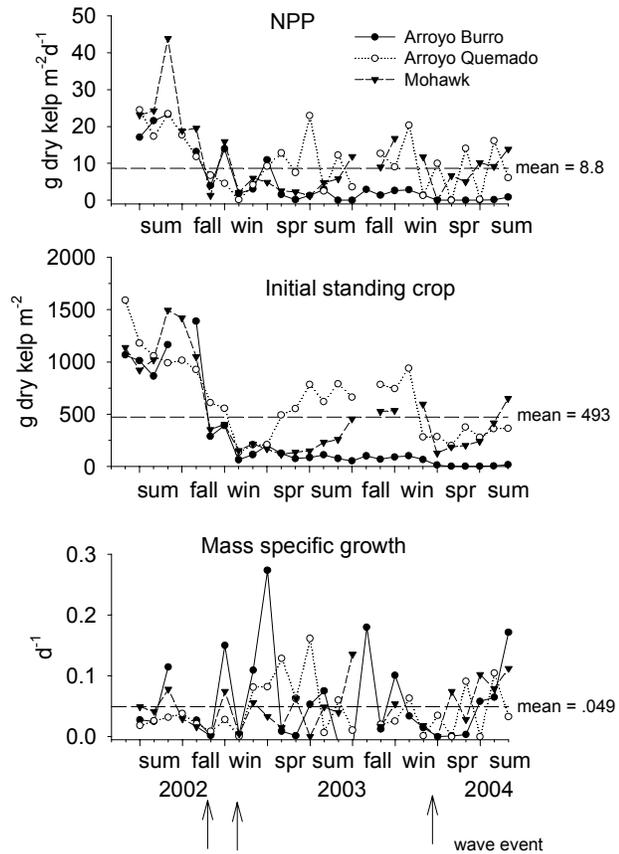


d) indicates that immigration rates may limit recolonization of isolated patches. The statistical significance of the relatively low correlations between patch size and extinction (Figure a) and recolonization (Figure c) was driven primarily by the two or three largest patches. Large kelp forests may have a low chance of stochastic extinction because of their large population size. Moreover, the greater amount of suitable habitat in large kelp forests may increase the likelihood that at least some portion of the patch is recolonized. Collectively, these results confirm impressions from smaller-scale studies that kelp forests are dynamic mosaics, characterized by frequent extinction and recolonization from nearby patches.

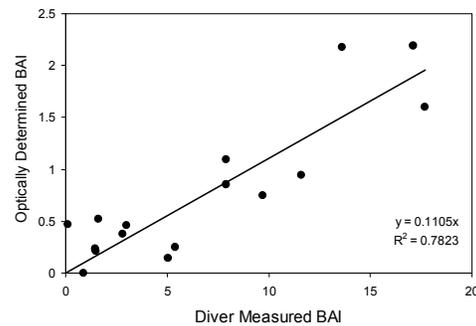
Primary production in giant kelp

NPP in giant kelp averaged 8.8 g dry mass (2.5 g C) m⁻²d⁻¹ over all sites during the period June 2002 – Aug 2004. That the relatively high NPP resulted from a moderately low standing crop (mean = 493 g dry mass m⁻²) suggests that a high mean growth rate is responsible for the high mean NPP. Indeed that was found to be the case as kelp growth averaged nearly 5% of the dry mass per day. Abrupt declines in NPP coincided with abrupt declines in standing crop, which coincided with large wave events. Two of the three sites recovered following the April 2003 wave event. Standing crop and NPP remained low at Arroyo Burro because sand movement caused by the waves buried the reef and prevented kelp from recolonizing. The highest standing crops occurred during periods of low wave activity, whereas high wave activity always resulted in low standing crops. Growth rates were not only relatively high, but they were also extremely variable and displayed little seasonality. Surprisingly, growth rate was unrelated to tissue nitrogen, which was generally high (usually above 2%) throughout the sampling period. Growth rate was inversely correlated to standing crop indicating that variation in growth resulted largely from competition for light in the canopy.

Collectively, these data suggest that variation in climatic factors that influenced the delivery and uptake of nitrogen were largely unimportant in determining variation in NPP during the two-year study period. These observations appear to reflect the recent return to cool nutrient-rich conditions in the Santa Barbara Channel, which are characteristic of the cool phase of the Pacific Decadal Oscillation. Such year-round nutrient-replete conditions were unusual during the previous 25 years.



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.

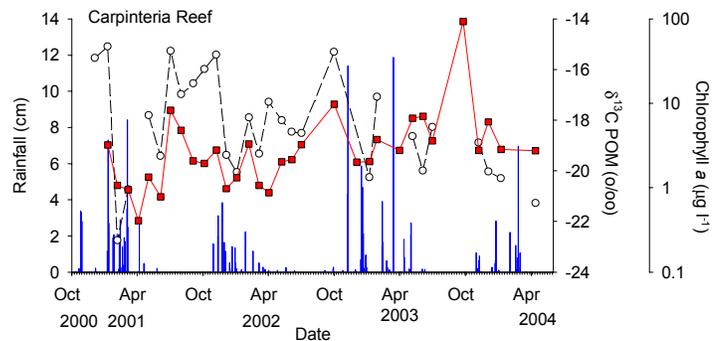
Data collected to date suggest that optical data are a good predictor of standing biomass as measured by the more labor intensive diver count. The shallow slope between optically determined BAI and diver measurements (0.1105) indicates a significant package effect with respect to light harvesting by 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.

Biological and Physical coupling within giant kelp forests

Results to date from the collaborative research on the ecomechanics of kelp indicate, as expected, dramatically higher rates of disturbance during winter months, both among monitored subtidal giant kelp populations and in populations of other intertidal kelps. Complementary biomechanical recordings of second-by-second forces imposed on these seaweeds under a variety of hydrodynamic conditions are also revealing a tidal dependence on force, and a non-intuitive capacity of currents to partially ameliorate the detrimental consequences of waves in causing dislodgment.

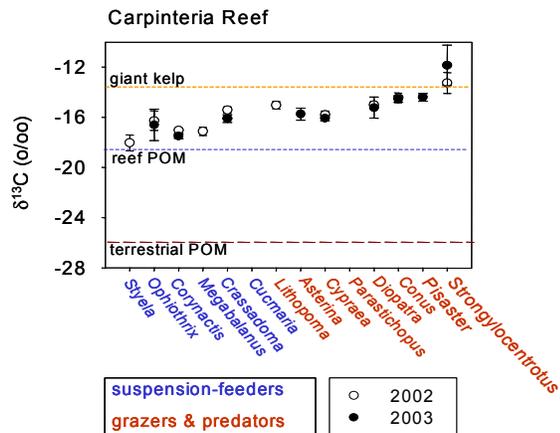
Food web studies using stable isotope

Suspended POM at shallow subtidal reefs consists of a mix of phytoplankton, macroalgal detritus, terrestrially-derived POM, and other material. Our data show that the isotopic composition of the suspended POM varies temporally in association with inputs of terrestrially derived material and with phytoplankton standing stock measured as chlorophyll *a* concentration. $\delta^{13}\text{C}$ values tend to drop during storm events and are highest during phytoplankton “bloom” events.



Temporal variation in $\delta^{13}\text{C}$ values of reef suspended POM (○) together with data rainfall measured daily in Santa Barbara (blue bars) and chlorophyll *a* concentration measured monthly at the reef (■). $\delta^{13}\text{C}$ values and chlorophyll *a* concentration measured at a depth of 1 m.

To identify food sources used by reef consumers under different conditions of runoff, ocean climate and kelp production, we sampled a variety of reef consumers chosen to represent different trophic levels. Tissue samples were collected in March-April, 2002 and 2003, from consumers at four reef sites (Carpinteria, Naples, Mohawk, Arroyo Quemado), 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 in 2002 and 2003 with values of the filter-feeding tunicate, *Stylea*, similar the overall mean value for reef suspended POM and values for the sea urchin, *Strongylocentrotus*, similar to values for kelp, the preferred food of this genus. Values of



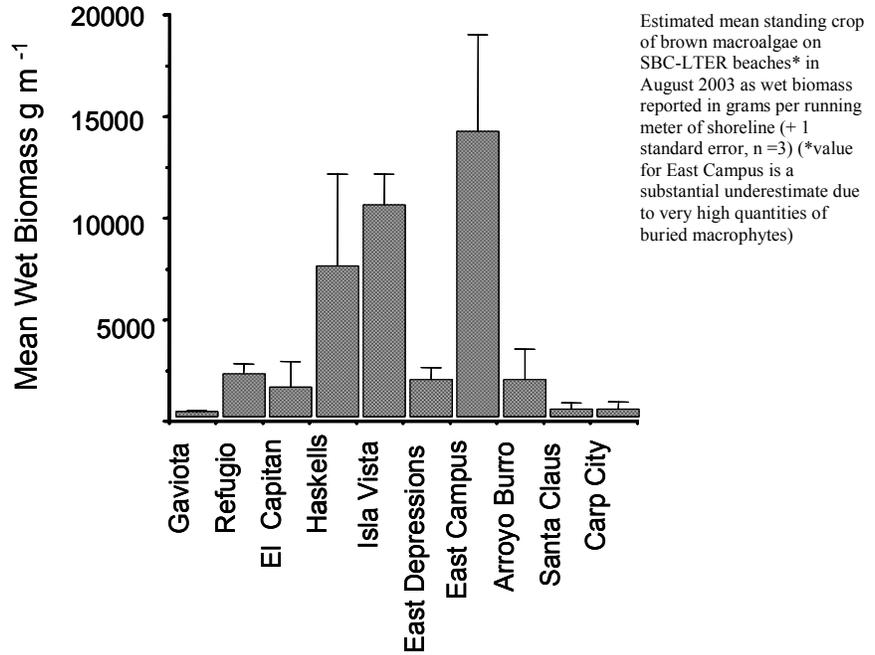
$\delta^{13}\text{C}$ values for common invertebrate consumers from Carpinteria Reef together with mean values (dotted lines) for the giant kelp, *Macrocystis*, and suspended POM from the reef, and POM values from Franklin Creek (1997-98). Consumer data from samples collected in March-April 2002, 2003. Mean values $1 \pm \text{SD}$, $n=5$

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 2004. These samples are currently being analyzed.

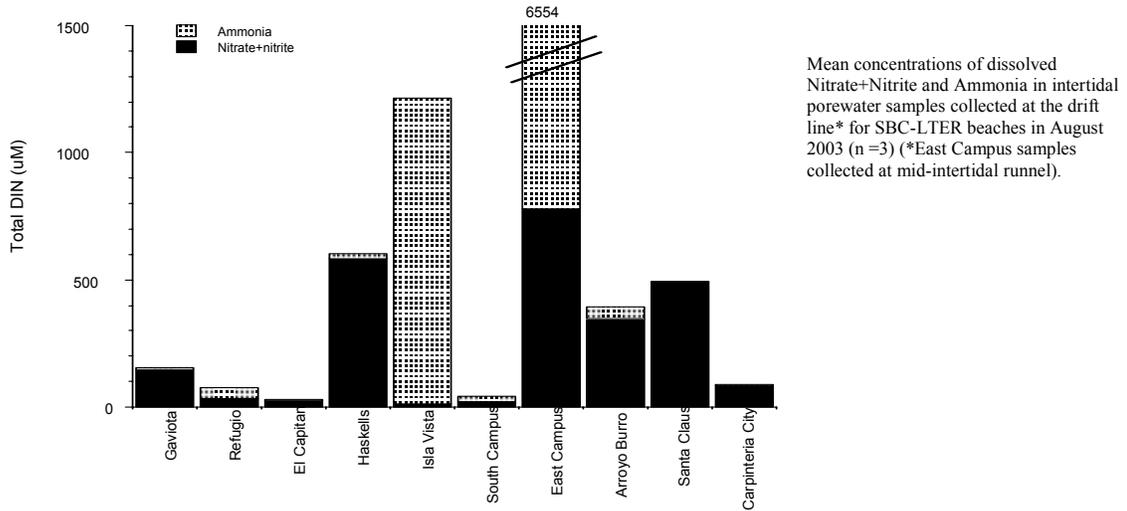
Kelp subsidies to sandy beach communities

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 (biomass) of macrophyte wrack was estimated by measuring the cover and accumulated biomass of wrack in the intertidal zone of the 10 study beaches. Mean biomass of macrophyte wrack varied over an order of magnitude among beaches in the SBC-LTER region. 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 beaches adjacent to our reef site at Carpinteria (Santa Claus). This reef has been dominated by sea urchins the last several years and it supported little foliose macroalgae during this study.



Our ongoing research on the cycling of nutrients derived from drift kelp and other macroalgae on sandy beaches of the SBC-LTER has found that the porewater in the intertidal water table of SBC-LTER sandy beaches can contain very high concentrations of DIN (dissolved inorganic nitrogen) and thus may represent a potential source of nitrogen to nearshore waters and reefs. Concentrations of nitrate + nitrite in intertidal beach porewater ranged from 0.05 to 1957 μM and ammonia concentrations ranged from 0.5 to 10,744 μM. Overall, mean total DIN concentrations varied over an order of magnitude among SBC-LTER beaches. In



general, nitrate was the most important nitrogen species in intertidal porewater. However, in some cases

very high concentrations of ammonia were found in association with high standing crops of drift macroalgae and anoxic conditions. Nitrogen concentrations in intertidal porewater were positively correlated with the standing crop of drift macrophytes in our comparisons in July and August when beach profiles and sand levels were at their fullest. That relationship weakened as beaches eroded with the onset of winter storms, populations of intertidal consumers declined and beach water table dynamics shifted.

OCEAN STUDIES

Channel surveys – *Pseudo-nitzschia* bloom dynamics

A large *Pseudo-nitzschia* bloom was observed in the Santa Barbara Channel during the May 2003 cruise. The event followed a strong spring upwelling event driven by Ekman-induced flow over the continental shelf. The bloom was dominated by the domoic-acid producing *P. australis* and covered most of the channel. We observed a patchy distribution of cell abundance, domoic acid concentrations, and cellular toxicity that was in part associated with the silicate-limited nutrient regime. Toxicity, though, was better predicted by mesoscale circulation and appeared to be enhanced by the retention of physiologically-stressed *P. australis* cells in the center of a convergent eddy.

In the Santa Barbara Channel, the Si:N of upwelled waters in spring is approximately 1.5 and contains non-limiting silicate concentrations from 20 - 40 μM . We can expect that the initial bloom community is a consortium of diatom species that can efficiently utilize the recently upwelled silicate. The consumption of silicate in surface waters appears extremely rapid in cruise snapshots of upwelled water taken from bottle samples during our study period. Experimental evidence suggests that at initial growth rates under silicate-replete conditions, the silicate-consumption rates of *Pseudo-nitzschia* cells will be high compared to that of nitrate and phosphate. This may serve to rapidly drive the system towards silicate-limitation. Such changes in nutrient ratios may have been the cause of the competitive displacement of other net-phytoplankton by *Pseudo-nitzschia* spp in 2003. These conditions are known to favor domoic acid production and were indeed found to strongly associate with its ambient distribution in May 2003 in the Santa Barbara Channel. While physiological stress has been demonstrated to induce enhanced production rates of cellular domoic acid in the lab, our field results do not point to stress as a good predictor of cellular toxicity. Other factors might be driving the dynamics of cellular production in nature, and as our results show, have the potential to be trumped by dominant circulation effects present during a coastal bloom. The role of mesoscale circulation has proved important in predicting not only the distribution of highly toxic cells but also its transport.

Mean surface community structure ascertained from CHEMTAX analysis changes very little across seasons in the Santa Barbara Channel, despite large changes in seasonally averaged chlorophyll concentrations. As expected for a neritic environment, diatoms are the most abundant phytoplankters year-round and only increase slightly in relative abundance during winter and spring months when new nutrient delivery is enhanced. The spring bloom peak in mean chlorophyll levels does not appear to be driven solely by diatoms, given that the maximal diatom contribution (30%) to total chlorophyll-*a* also occurs during winter when chlorophyll levels are appreciably lower. Dinoflagellate abundance varies inversely with that of diatoms, with greatest relative numbers during summer and fall months and an overall abundance that is much lower than expected given the relative frequency of the red tide-forming dinoflagellates in the Southern California Bight. With the exception of *Phaeocystis*-like haptophytes (i.e.

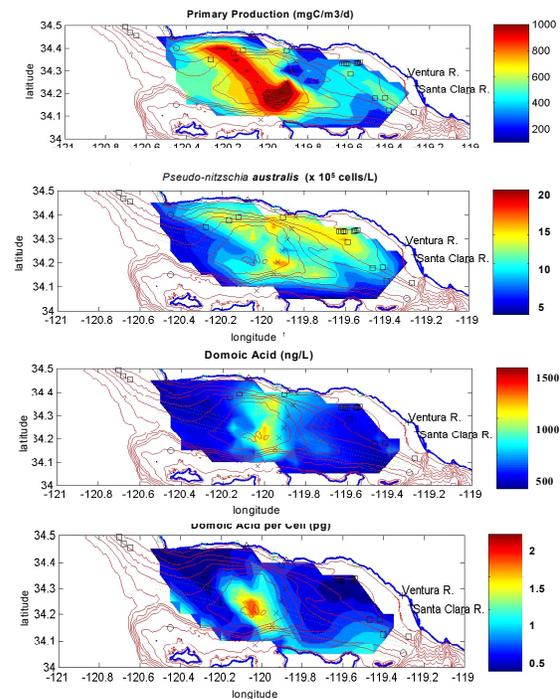


Figure 1. Contour plots of primary production rates, toxic cell abundance, toxin concentration, and toxicity (toxins/cell) collected from 5-meters along the LTER grid and Plume and Blooms transect during the May 2003 bloom.

non-coccolith) all other classes specified in the CHEMTAX analysis contribute roughly equal amounts to total chlorophyll concentrations and vary little on average across seasons.

The relatively small intra-annual changes in class composition discovered with CHEMTAX relate to the first EOF mode for which all 11 pigment concentrations move in concert with one another in a sort of background state. As this mode accounts for the majority of the total variance in the pigment dataset, it seems to relate to the relatively static view of annual phytoplankton community composition from the CHEMTAX results. The episodic events that spawn transient blooms of specific taxa are evident in the second, third, and fourth EOF modes. The magnitude of their amplitude time series mapped in space and time determines where these bloom events have the greatest biogeochemical and ecosystem impacts. The second largest EOF mode for the Santa Barbara Channel is driven by large increases in fucoxanthin, correlates strongly with biogenic silica, and is most pronounced in spring months. The last two orthogonal modes of phytoplankton pigment concentrations relate to the bloom events of various flagellate groups, including dinoflagellates. Nano- and pico-plankton impacts on the ecosystem and biogeochemistry are more varied and difficult to investigate. While these groups are present year-round and increase in abundance during the spring bloom season, there are two assemblages of flagellates that appear to oscillate both temporally and spatially in the Santa Barbara Channel. The time series of all pigments analyzed here misses the majority of the 1997-1998 El Niño event but does encapsulate the transition to the 1999 La Niña thus allowing for some interpretation of remote forcing on phytoplankton community structure.

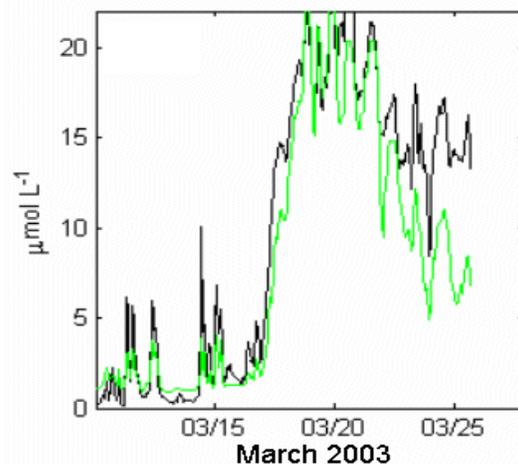
Moored instruments and monthly sampling – Annual nutrient budget for kelp reefs

Observations from moorings at the three core reef sites spanning the eastern to western end of the Santa Barbara Channel were used by McPhee-Shaw et al. (2004) to describe the dominant sources of nutrients to kelp reefs in the shallow, inner shelf over annual time scales. Time series data from a nitrate auto-analyzer spanning two years beginning in February 2001 elucidate the features of an annual cycle in oceanic and terrestrial nutrient input to the reef system. The four primary mechanisms for transporting nutrients to inner shelf ecosystems in the SBC-LTER area are: 1) coastal upwelling; 2) cross-shelf transport associated with reversal of alongshore currents in late fall; 3) diurnal internal waves; and 4) terrestrial runoff events. Data collected to date show that the mechanism supplying the most nutrients to kelp forests in the Santa Barbara Channel is upwelling.

We have estimated an annual budget for supply of nitrate to shallow reefs on the inner-shelf via these mechanisms from March to March of 2001-2002 and 2002-2003. Low-frequency pulses of cold water and high nutrients associated with spring upwelling and alongshore current reversals in the late fall deliver most of the nitrate supplied to the reefs. Dynamics associated with changes in wind stress may be responsible for baroclinic motions and cross-shelf transport associated with these events in both the spring and fall. In summer, nitrate is delivered to reef depths primarily by diurnal internal waves. In our future work, we are working to quantify better the various nutrient delivery mechanisms, particularly number 2 which may also be related to sub-mesoscale eddy processes described below.

Runoff “Event” Sampling

Preliminary analyses of data from the second runoff event sampled onboard the RV Pt. Sur showed high levels of nitrate occupied a band of freshened coastal waters from Alegria in the western Channel to the eastern limit of the survey near the Santa Clara River mouth. The width of the band of runoff-influenced water was typically of order 2 km. Very high nitrate levels were occasionally encountered along the coast



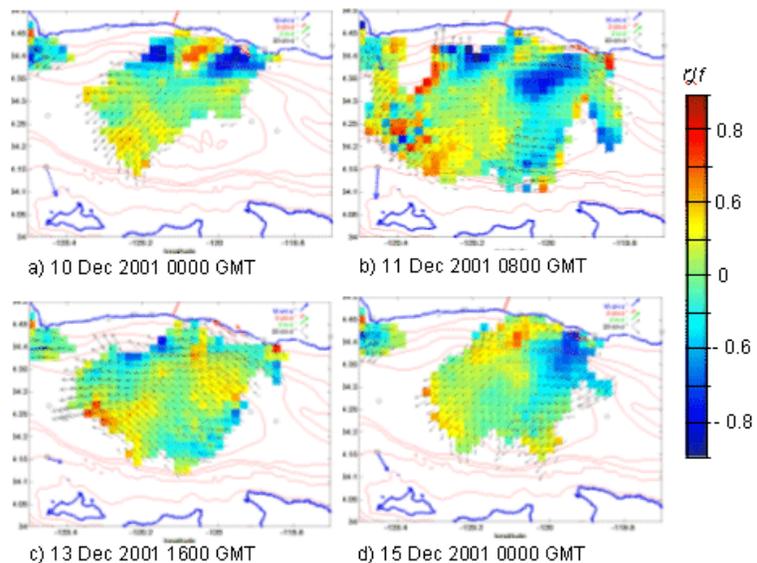
Nitrate time series (green line) at the SBC-LTER Naples Reef site measured by a moored auto-analyzer during strong upwelling conditions in March 2003. Nitrate concentrations increased rapidly with the onset of upwelling from background levels of $\sim 0.05 \text{ mmol L}^{-1}$ to over 20 mmol L^{-1} . Nitrate time series estimated from temperature (black line) is consistent with measured nitrate over most of the period. Departures between measured and estimated nitrate after 21 March 2003 may result from nitrate uptake by phytoplankton

near creek and river outflows. Peak values near $80 \mu\text{mol L}^{-1}$ were encountered offshore of Mission Creek in Santa Barbara and further east near the mouth of the Santa Clara River. Using these data sets, we will analyze the spatial variability of nitrate concentrations over scales of a few meters to a few 10^3 's of km. Describing this spatial variability is important for quantifying subsidies of nutrients to kelp reefs in our study region.

Surface Current Patterns

Small scale eddies were observed near shore based on evolving surface current patterns measured by an array of HF radars. The eddies are 4-15 km in diameter and typically last about 2 days, although some last up to 6 days. Most of the eddies are anti-cyclonic (clockwise) with maximum relative vorticity (quantification of their rotation rate) of $-0.4f$ to $-0.8f$ where f is the Coriolis parameter, a measure of the earth's rotation rate. The anti-cyclonic rotation probably arises because the eddies form in a westward flowing current with a coastal boundary to the right of the flow direction. Subjective examination of a 4-year time series of radar observations near Coal Oil Point, California shows that eddies are present 11% of the time and occur throughout the year. No seasonal trend in eddy frequency has been found. Swirl velocities of the eddies are sufficiently strong ($\sim 0.3 \text{ m s}^{-1}$) to reverse the normally poleward (westward) flow near the mainland coast.

Moored observations over the inner shelf (12 m water depth at the Naples Reef mooring) of a sequence of two eddies in December 2001 show an increase in nitrate from the detection limit of $\sim 1 \mu\text{M}$ to a maximum of 10-12 μM when the eddies were present. Decreases in temperature of 1-3 $^{\circ}\text{C}$ and increases in salinity accompanied the higher nitrate concentrations. The source of the low temperature, high salinity, high nitrate water is the subject of ongoing research, but is likely the result of onshore advection of water which upwelled along the coast to the west of the mooring. Acoustic Doppler current profiler observations showed that the velocity field of the eddy extended throughout the shallow water column. We speculate that these eddies are an important transport mechanism for nutrients and biogenic particles to inner shelf ecosystems of the Southern California Bight, including the SBC-LTER area.



Eddy sequence base on evolution of the surface velocity field at four times during 10-15 December 2001. Black arrows indicate surface current vectors measured by HF radars. Colors indicate relative vorticity (a measure of rotation rate) normalized by the Coriolis parameter f (a measure of the earth's rotation rate at a given latitude) as scaled according to the color bar. Red shades indicate counter-clockwise rotation and blue shades indicate clockwise rotation. Red arrows near shore are current velocities measured 12 m above bottom by the current profiler at Naples Reef and another mooring nearby at Ellwood mooring. Blue arrows are current velocities measured at 5 m depth at offshore moorings. Scale for velocity vectors is at upper right in each panel

Satellite Data

Satellite ocean-color and sea-surface temperature (SST) imagery are used to assess the occurrence, extent and duration of surface sediment plumes from discharged stormwater and phytoplankton blooms in the Santa Barbara Channel (Otero and Siegel, 2004; Warrick et al. 2004). Monthly mean annual cycles of SST, chlorophyll (Chl) and the water-leaving radiance at 555nm ($L_wN(555)$), an index for sediment-affected waters, show plumes associated with runoff in winter, while blooms occur in the late spring-early summer and are associated with cool SST and upwelling favorable winds. Interannual variations are consistent with

remote forcing by El Niño cycles. During the 1997–1998 El Niño, Chl concentrations are moderate, and El Niño-induced floodwater discharges result in high LwN(555) values throughout the Santa Barbara Channel. However, a correspondence between El Niño–La Niña a state and Chl is not found for the Santa Barbara Channel due to what appears to be the advection of nutrient-depleted waters from the east. Empirical orthogonal function analysis is used to spatially and temporally deconvolve processes regulating SST, Chl and LwN(555). This is described in detail in the recent publication by Otero and Siegel (2004).

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

