Final Report for Period: 04/2007 - 03/2008 **Submitted on:** 12/21/2007
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:
* This report is duplicative of the prior annual report submitted on 1/11/2007. It is being re-submitted because of FastLane internal error.*

In addition to managing the project D. Reed is the lead investigator of the research on kelp forest ecology.

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 ocassionally 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. Invetigates recruitment processes in reef fishes.

Name: Lenihan, Hunter

Worked for more than 160 Hours: Yes

Contribution to Project:
Reef ecologist investigating trophic interactions

Name: Schmitt, Russell

Worked for more than 160 Hours: Yes

Contribution to Project:
Dr. Schmitt 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

Name: Petty, Robert
Worked for more than 160 Hours: No
Contribution to Project:
oversees analysis of water and isotope samples by analytical instruments

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

Name: Miller, Robert
Worked for more than 160 Hours: Yes
Contribution to Project:

Conducted research on primary production of benthic reef communities

Name: Fram, Jonathan
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted research on the role of currents and flow in delivery of nutrients to kelp forests

Name: Stewart, Hannah
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted research on response of kelp forest dynamics to nutrient flow

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: Goodman, Darcie

Worked for more than 160 Hours: No

Contribution to Project:
graduate student who assists in stream sampling

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: Kellner, 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: Kostadinov, Tiho
Worked for more than 160 Hours: Yes
Contribution to Project:
conducts research on coastal ocean dynamics using ocean color

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: Coombs, Scott
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducts and manages field sampling, operates gauging stations and conducts data analysis, conducted research on watershed responses to fire

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

Name: Buenau, Kate
Worked for more than 160 Hours: Yes
Contribution to Project:
participated in development of ecological models on kelp forest states

Name: Cavenaugh, Kyle
Worked for more than 160 Hours: Yes
Contribution to Project:
worked on kelp cover remote sensing using SPOT

Name: Hammond, LaTisha
Worked for more than 160 Hours: No
Contribution to Project:
Assisted with 7th International Temperate Reefs Symposium

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 managment 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: 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: No
Contribution to Project:
Assisted with stream sampling and analyses

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: Crecely, 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:
Assisted with stream sampling and analyses

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: 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:
assited with stream sampling

Name: Hewson, William
Worked for more than 160 Hours: No
Contribution to Project:
assited with stream sampling

Name: Anderson, Kaite
Worked for more than 160 Hours: No
Contribution to Project:
assited with stream sampling

Name: Burrows, Jesse
Worked for more than 160 Hours: No
Contribution to Project:
assited with stream sampling

Name: Larson, William
Worked for more than 160 Hours: No
Contribution to Project:
assited with stream sampling

Name: Hammond, Tanis
Worked for more than 160 Hours: No
Contribution to Project:

assited with stream sampling

Name: Layns, Arron
Worked for more than 160 Hours: No
Contribution to Project:
Assisted with stream sampling and analyses

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: Yes
Contribution to Project:
Alia worked on nitrogen and kelp relationships

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: Betthany, Allen

Worked for more than 160 Hours: No

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: Yes

Contribution to Project:
Assisted with kelp forest sample processing

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.

Name: Mendez, Clara

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with stream sampling and analyses

Name: Rich, Shannon

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with stream sampling and analyses

Name: Brown, Amanda

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with stream sampling and analyses

Name: Young, Tarajane

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with watershed research

Name: Kleiner, Joshua

Worked for more than 160 Hours: No

Contribution to Project:
Made the data transmission scheme for transferring real time data from the SBC-LTER instrument package on StearnsÆ Wharf to the SBC-LTER web server

Name: Ireson, Kirk

Worked for more than 160 Hours: No

Contribution to Project:
Developed website for real time display of oceanographic data from the SBC-LTER instrument package on StearnsÆ Wharf.

Name: Johnson, Cyril

Worked for more than 160 Hours: No

Contribution to Project:
Assisted in maintenance and construction of the SBC-LTER instrument package on StearnsÆ Wharf. Developed bio-luminescence sensor on the package.

Name: James, Kelsey

Worked for more than 160 Hours: No

Contribution to Project:
conducted beach porewater sampling

Name: Haskell, Dan

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with kelp forest monitoring and sample processing

Name: Tu, Devin

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with kelp forest monitoring and sample processing

Name: Doctor, Benjamin

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with subtidal kelp forest research- Stipend support

Name: Resch, Shannon

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with stream and subtidal kelp forest research- volunteer

Name: Scarborough, Courtney

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with subtidal kelp forest research- volunteer

Name: Allen, Matt

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with subtidal kelp forest research- hourly employee

Name: Beritzhoff, Michelle

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with subtidal kelp forest research- volunteer

Name: Jolly, Margaret

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with kelp forest research, data, and lab processing- hourly employee

Name: Harney, Reis

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with kelp forest research, data, and lab processing- volunteer

Name: Bekins, Elyse

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with kelp forest research, data, and lab processing- Volunteer

Name: Simarro, Ryan

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with kelp forest research, data, and lab processing- Volunteer

Name: Horii, Stephanie

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with subtidal kelp forest research- Volunteer

Name: Morales, Noah

Worked for more than 160 Hours: Yes

Contribution to Project:
Assisted with subtidal kelp forest - Volunteer

Name: Krueger, Ruby

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with kelp forest research and lab processing-volunteer

Name: Severson, Ella

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with kelp forest research and lab processing- volunteer

Name: Rompel, Jenna

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with kelp forest research and lab processing-Volunteer

Name: Robertson, Holly

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with kelp forest research and lab processing-volunteer

Name: Kopecky, Susanna

Worked for more than 160 Hours: No

Contribution to Project:

Assisted with kelp forest research and lab processing- volunteer

Name: Saxer, Meghan
Worked for more than 160 Hours: No
Contribution to Project:
Assisted with subtidal kelp forest research- volunteer

Name: Nakase, Dana
Worked for more than 160 Hours: No
Contribution to Project:
Mentored and assisted in teaching K-12 curriculum

Name: Minter, Thomas
Worked for more than 160 Hours: No
Contribution to Project:
Mentored and assisted in teaching K-12 curriculum

Name: McClintock, R. Spencer
Worked for more than 160 Hours: No
Contribution to Project:
Mentored and assisted in teaching K-12 curriculum

Name: Schwab, Anastasia
Worked for more than 160 Hours: No
Contribution to Project:
Mentored and assisted in teaching K-12 curriculum

Name: Barnhart, Laurie
Worked for more than 160 Hours: No
Contribution to Project:
Assisted with stream sampling and analyses

Name: Chasin, Elliot
Worked for more than 160 Hours: No
Contribution to Project:
Assisted with stream sampling and analyses

Name: Chen, Jerry
Worked for more than 160 Hours: Yes
Contribution to Project:
Assisted with stream sampling and analyses

Name: Cornell, Amanda
Worked for more than 160 Hours: Yes
Contribution to Project:
Assisted with stream sampling and analyses

Name: Healy, Peter
Worked for more than 160 Hours: No
Contribution to Project:
Assisted with stream sampling and analyses

Name: Kinney, Laura
Worked for more than 160 Hours: No
Contribution to Project:
Assisted with stream sampling and analyses

Name: Olsen, Lani

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with stream sampling and analyses

Name: Raymond, Scott

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with stream sampling and analyses

Name: Teeza, Inteema

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with stream sampling and analyses

Name: Wilkinson, Whitney

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with stream sampling and analyses

Name: Wyatt, Kylah

Worked for more than 160 Hours: No

Contribution to Project:
Assisted with stream sampling and analyses

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: 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: 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: Harrer, Shannon
Worked for more than 160 Hours: Yes
Contribution to Project:
Assisted with reef and oceanographic research and data management. Worked on studies of kelp NPP and population dynamics as an REU student

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

Name: Hoesterey, Justin
Worked for more than 160 Hours: Yes
Contribution to Project:
assisted in subtidal kelp forest research

Name: Fisher, Rachelle
Worked for more than 160 Hours: Yes
Contribution to Project:
assisted with subtidal kelp forest research and water sampling, conducted beach porewater sampling and analysed sediment samples

Name: O'Connor, Beth
Worked for more than 160 Hours: No
Contribution to Project:
conducted beach porewater sampling and image acquisition

Name: Allen, Peter
Worked for more than 160 Hours: No
Contribution to Project:
programmed the animation for watershed education module

Name: Pessino, Monica
Worked for more than 160 Hours: No
Contribution to Project:
Developed webpages and framework for watershed education module

Name: Clinton, William
Worked for more than 160 Hours: No
Contribution to Project:
oversees analysis of water and isotope samples by analytical instruments

Name: Simon, Scott
Worked for more than 160 Hours: No
Contribution to Project:
coordinates on campus marine outreach and education activities

Name: Kissinger, Michelle
Worked for more than 160 Hours: No
Contribution to Project:
assists with on-campus marine outreach and education

Name: Jones, Jeff
Worked for more than 160 Hours: No
Contribution to Project:
assisted with animation for watershed curriculum project

Name: Nelson, Clint
Worked for more than 160 Hours: Yes
Contribution to Project:
conducted kelp forest monitoring, monthly ocean sampling and reef experiments

Name: Wright, Matt
Worked for more than 160 Hours: Yes
Contribution to Project:

Assisted with kelp forest flow studies

Name: Burt, Chad
Worked for more than 160 Hours: Yes
Contribution to Project:
assisted with information management projects

Name: Grabner, Sabine
Worked for more than 160 Hours: No
Contribution to Project:
helped direct data management system for project

Name: Morris, Jordan
Worked for more than 160 Hours: Yes
Contribution to Project:
provided IT support for the project

Name: Parsons-Field, Avrey
Worked for more than 160 Hours: No
Contribution to Project:
Provided field assistance for oceanographic studies

Name: Goodridge, Blair
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted stream and watershed research

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: Risden, 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

Name: Ralph, Yvette
Worked for more than 160 Hours: No
Contribution to Project:
Assisted with 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:
assised 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: 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

Name: Craig, Alexandra
Worked for more than 160 Hours: Yes
Contribution to Project:
Assisted with subtidal kelp forest research- REU support

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): Bachelor's Degree
Fiscal year(s) REU Participant supported: 2006
REU Funding: No Info

Name: Harrer, Shannon
Worked for more than 160 Hours: Yes
Contribution to Project:
Assisted with subtidal kelp forest research

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
Fiscal year(s) REU Participant supported: 2004
REU Funding: REU supplement

Name: Davenport, Lars
Worked for more than 160 Hours: Yes
Contribution to Project:
Assisted with subtidal kelp forest research

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Associate's Degree
Fiscal year(s) REU Participant supported: 2006
REU Funding: REU supplement

Organizational Partners

University of California, Office of the President, Oakland

The UC Office of the President funds the UC Toxic Substances Research & Teaching Program. One component of this program is the UC Coastal Toxicology Program (UCCTP) whose mission is to help resolve pollution-related problems in California's coastal ecosystems. UCCTP

accomplishes this mission by facilitating new research endeavors by UC faculty, and by providing students with research support and interdisciplinary training in the broad area of environmental toxicology. UCCTP is providing support for two graduate students (including salary and the cost of student fees and health insurance) for each year of our project to work on SBC LTER related issues.

The Minerals Management Service

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

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

Department of Interior National Park Service

Since 1982 Channel Islands National Park (http://www.nps.gov/chis/) has collected data annually on the abundance of a wide variety of species that inhabit intertidal reefs and kelp forests at a multitude of sites on the five northern Channel Islands (http://www.nature.nps.gov/im/chis/index.htm). These data have proved extremely valuable in evaluating the response of nearshore reef communities to large disturbances (e.g. El Nino) that have occurred in the last 20 years. SBC has adopted sampling protocols similar to those used by NPS to examine long-term changes in reef populations on the mainland. When used in combination, NPS and SBC data provide large spatial resolution for evaluating changes in reef communities that occur in the future. This collaboration is important because it provides NPS with important information on the physical and biological oceaography 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 McKnigt (ISTAAR, Univ. of Colorado) on a LTER cross site comparison grant to investigate dissolved organic N in streams.

University of New Hampshire

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

Santa Barbara Watershed Resource Center

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

Santa Barbara Land Trust

The Santa Barbara Land Trust has purchased the lower half of the Arroyo Hondo catchment, a parcel owned for generations by a couple of

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

Santa Barbara Channel Keeper

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

City of Santa Barbara

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

Santa Barbara County Project Clean Water

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

UNIVERSITY OF CALIFORNIA DAVIS

Dr. Brian Gaylord and his students have been collaborting with SBC LTER on the interactions between giant kelp and hydrodynamic flows

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

Los Angeles Conservation Corps

Univ. of Calif. Natural Reserve System

Ventura CoastKeeper

Carpinteria Creek Watershed Coalition

Friends of the Santa Clara River

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 CEEI. 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 were tightly integrated into all aspects of SBC LTER research. During the first 6 years, 9 post docs, 40 graduate students,14 REU student and more than 126 undergraduate students participated in SBC LTER research. Educational opportunities at SBC LTER were not limited to university students and post docs. Teachers and numerous volunteers from the general public regularly participated in our stream sampling program and gained considerable knowledge on the constituents of runoff and of the processes that influence their concentrations. A number of high school students were mentored in summer science programs and science projects during the school year by SBC LTER investigators.

The SBC LTER program was part of a jointly developed graduate student training program with four 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, the Interdisciplinary Marine Science PhD Program, and the Partnership for Interdisciplinary Studies of Coastal Oceans funded by the Packard Foundation. This program emphasized interdisciplinary research to examine how coastal ecosystems change in response to natural and human-induced alternations in the environment, and sought to create a diverse scientific community of students who developed a respect and appreciation for other disciplines. The program supported over 100 graduate students and more than a dozen postdoctoral researchers, with research interests spanning terrestrial, aquatic, and marine ecology, physiology, geology, oceanography, and policy. SBC LTER graduate students and post docs presented posters on their research at the Annual UC Toxic Substances Research and Teaching Program Symposium each year of the program. SBC LTER graduate students, postdocs and Investigators attended the Annual Coastal Toxicology Retreat at the Bodega Marine Laboratories to discuss research integration among faculty and graduate students each year. Topics covered included research needs, on-going research projects, and research collaborations between the Toxicology Program and the SBC LTER. Two or more SBC LTER graduate students attended an annual week long interdisciplinary short course on eco-toxicological research each year. SBC LTER students, postdoctoral fellows, and investigators participated in the annual SBC LTER Spring Science Retreats, where results from SBC research were presented in a poster session and presentations. SBC LTER graduate students, postdocs and investigators participated in the LTER All Scientists meetings in 2003 and 2006. SBC LTER graduate students and investigators also participated in follow-up working groups and planning grant meetings for the LTER network planning process in 2003-2006.

Outreach Activities:

Increased exposure of SBC LTER's research to K-12 students and the general public during the first 4 years of the project came by way of collaborative educational efforts with existing outreach programs, including the South Coast Watershed Resource Center and UCSB's Oceans to Classrooms program. These two programs offered 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 was to engage K-12 teachers in watershed and marine science, and aid them in developing curricula based on research by SBC LTER and other scientific entities that could 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 LTER). 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 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 were 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.

SBC LTER expanded 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 offered 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 conducted oceanographic research in the Santa Barbara Channel that is related to ongoing research at UCSB. Each of the six shipboard stations was built on State Science Standards to introduce students and teachers to critical issues in marine science. Alison Whitmer, the SBC education coordinator, built 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 highlighted SBC research for use in classrooms. As an example SBC LTERprovided support for an ROV workshop for high school teachers in 2004. 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. 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).

In 2005 and 2006 the SBC LTER piloted an exciting new environmental education program for middle school students. The program brought underrepresented students from inner city Los Angeles to Santa Barbara-area sites for residential environmental education programs. Up to sixty students spent a 3-day weekend camping, working, and learning about watershed ecology at the UCSB Sedgwick Natural Reserve. Following that experience, up to 20 students attended a 2-week education program on the UCSB campus, hosted by the SBC LTER, . Students participated in coastal marine ecology activities, field trips ê including a day-long educational cruise aboard a local whale watching vessel and conducted group research projects on marine organisms. Students presented their research findings with poster presentations to their peers, program leaders, and UCSB scientists and staff.

The SBC LTER Schoolyard project developed a virtual tour and educational module for a local watershed, the Arroyo Burro Creek Watershed. The virtual tour includes a flyover of the watershed, an interactive rain and runoff animation activity, natural history chapters and lesson plans. The animation model 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. Working with SBC LTER scientists and UCSB staff, we collaborated with a curriculum developer to complete this online education application focused on an SBC LTER watershed. The stream level animation and fly over of the Arroyo Burro watershed were refined to fit the curriculum developed by Sarah Heintzelman, a graduate student in Education, who produced a watershed-focused curriculum for 7th grade (set of 5 lessons) as part of her M.S. degree. The Arroyo Burro Watershed Virtual Tour was completed and released in 2006. This educational module is now available as a CD-ROM from SBC-LTER. An abbreviated web version of the module was made available be viewed on our education webpage, Resources for Teachers, and copies of the CD-ROM can be requested from sbc_outreach@msi.ucsb.edu.

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 for school year 2002-03. In this program, the JASON team explored 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 facilitated 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 LTER investigators routinely give lectures in local K-12 schools on LTER related topics (e.g. kelp forest ecology, watershed processes, ocean circulation, etc.). SBC investigators and students also mentor high school students for science fair, summer programs and other projects.

Direct outreach to the public is an active area for many SBC LTER investigators and students. The public outreach activities that SBC has participated in are listed in our annual reports. SBC LTER 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.

Additional outreach activities done by SBC LTER 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, a documentary on kelp wrack for the Ty Warner Sea Center exhibits, 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 a number of articles on SBC LTER research to magazines, newsletters and other publications for the public, including Making Waves, Coast and Ocean, Coastlines, PISCO Coastal Connections, and California Wild.

Journal Publications

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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.icess.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 f 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:

Interactive 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:

http://maps.msi.ucsb.edu/kelp

Product Type:

Data or databases

Product Description:

Database of SBC's publications, using Metacat, an XML database developed by NCEAS and LTER.

Sharing Information:

http://sbcdata.lternet.edu/catalog/style/skins/sbclter/sbcPubsDisplay.jsp

Product Type:

Data or databases

Product Description:

Real-time display of ocean water properties from a mooring at Stearns Wharf

Sharing Information:

http://sbc.lternet.edu/data/stearns_wharf/index.html

Product Type:

Data or databases

Product Description:

Interactive GIS and Decision Support Tool to support the California Marine Life Protection Act initiative, developed in partnership with Will McClintock at MSI and the California Dept. of Fish & Game

Sharing Information:

http://maps4.msi.ucsb.edu/mlpa

Product Type:

Data or databases

Product Description:

Contribute data to ClimbDB and HydroDB regularly

Sharing Information:

http://www.fsl.orst.edu/climhy/climdb/

Product Type:

Teaching aids

Product Description:

Interactive watershed education curriculum

Sharing Information:

in progress-preview of curriculum will be available at our website: http://sbc.lternet.edu and also as DVDs by request.

Product Type:

Data or databases

Product Description:

Remote sensing data for kelp forest obtained using SPOT

Sharing Information:

http://www.spot.ucsb.edu/

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 provided important comparative information to the field of watershed science that was otherwise lacking.

Our stream experiments showed 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 indicated that stable isotope techniques can be used to delineate food webs across streams draining basins experiencing different types of land use. The work we conducted in Carpinteria Salt Marsh suggested 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 helped fill in gaps in this little studied, yet ecologically important area of research. Of particular significance were our studies of primary production, stable isotope analyses of kelp forest food webs, the role of nutrients in altering these food webs and links to sandy beach food webs.

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

Our oceanographic research also helped to further our understanding of physical mixing of freshwater plumes as they enter the coastal ocean. Satellite ocean color estimates of sediment content showed 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 allowed us to measure outflow events even from very small streams. This allowed us to better characterize the transport of materials from land to ocean ecosystems.

Contributions to Other Disciplines:

The research mission of SBC LTER is very interdisciplinary in scope. As such, contributions during the grant period were 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. After the first six years of research, the major contributions of our investigations began to be realized. Coordinated studies among the many disciplines represented in SBC LTER led 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 not only contributed to furthering the many disciplines listed above, but can 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. To that end, SBC LTER actively initiated ties with the social science community. SBC LTER Sociologist Freudenburg organized a dual session entitled: ' Integrating the Social Sciences into Long-Term Socio-Ecological Research for the 2006 LTER All Scientists Meeting. Three social scientists from SBC LTER attended the 2003 LTER All Scientists Meeting in September 2003. In 2004-2006, ecologist Dugan and historian Guerrini organized a monthly Research Focus Group on the topic 'Historicizing Ecological Restoration' sponsored by the UCSB Interdisciplinary Humanities Center. This group includes historians, anthropologists and ecologists interested in discussing papers and lectures concerning the incorporation of historical information into landscape interpretation, land use planning and ecological restoration. In 2005-6 Dugan and Guerrini began preparation of an interdisciplinary multi-authored book on the deep history of a Santa Barbara coastal wetland and watershed.

Contributions to Human Resource Development:

Our project provided significant opportunities for research and teaching in science at multiple levels. During the period of funding, 9 post docs, 40 graduate students, 14 REU students and more than 125 undergraduate students participated in SBC LTER research. In addition to gaining valuable research experience, many of the undergraduate students earned academic credit or monetary compensation. Many of our REU students continued to pursue science and academics. For example, a past REU student who is Hispanic went on to earn a Master's at Columbia University. One of our REU students was awarded a foreign exchange fellowship to Study at James Cook University in Australia, while another was selected for a curatorial internship at Reef HQ in Townsville Australia. Several of our undergraduate students have applied for and received funding to pursue independent studies associated with SBC LTER research activities. A number of these students are now in graduate degree programs. Our project's research also finds its way into the classroom as SBC LTER investigators routinely incorporate activities and findings of SBC LTER sponsored research into their teaching, thereby extending the project's contributions to the broader student body. Many SBC LTER investigators gave guest lectures and class demonstrations on SBC LTER research to university courses. SBC LTER investigators, graduate students and staff worked with undergraduate students, including interns and honors students, and mentored independent research by undergraduates and high school students.

Educational opportunities at SBC LTER were not limited to university students and post docs. Pre-college teachers and a number of non-scientists from the local community routinely participated in our ongoing stream sampling program and gained considerable knowledge on the constituents of runoff and of the processes that influence their availability. Increased exposure to the SBC LTER research activities also occurred 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 LTER), and educates the general public about coastal ecosystems and their conservation. NSF Schoolyard funds were 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.

We increased the exposure of SBC research activities to K-12 students and teachers by piloting an exciting environmental education program for middle school student which brought underrepresented students from inner city Los Angeles to Santa Barbara-area sites for residential environmental education programs including field trips, an educational cruise and individual research projects. SBC LTER continued 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 conducted oceanographic research in the Santa Barbara Channel. SBC LTER investigators also worked closely with the Channel Islands National Marine Sanctuary, the Santa Barbara Maritime Museum and the Santa Barbara Museum of Natural History to develop curricula and exhibits that exposed 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 and maintain a custom 22' research vessel that was specially designed for scuba and oceanographic research. Other research groups on the UCSB campus were given access to this vessel for their research needs as well.

Information Resources

SBC's web site contributed 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 datasets produced in the first 6 years 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, soil mapping and land-use coverage of the Santa Ynez Mountains. Access and use of these datasets and others was enhanced on the SBC LTER website. Our website was redesigned and updated regularly to better convey the wide range of research and education activities supported by our project. SBC LTER also published a site brochure which was distributed to a wide array of interested user groups.

Institutional resources for research and education

SBC LTER contributed to institutional resources and education by providing support to different conferences and symposia. In June 2006 SBC-LTER co-sponsored the 7th International Temperate Reefs Symposium at the University of California at Santa Barbara. PI Dan Reed, Co PI Steve Gaines, and Education Coordinator Ali Whitmer were co-organizers of the symposium which featured four major symposia and over 125 contributed papers and posters with participants from around the world. SBC LTER also supported 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. In 2001 PI Reed organized a symposium on human effects on ecosystems at the land/ocean margin for the annual meetings of WSN. We co-sponsored this symposium by using NSF funds from this project to pay the travel expenses of some of the symposia speakers. The result was a well-received and attended symposium that featured speakers from all over the continental US and Hawaii speaking on a wide variety of topics.

Contributions Beyond Science and Engineering:

SBC LTER investigators were very active in applying their knowledge of Santa Barbara's coastal ecosystems to inform and implement changes in local and regional policies. Policy areas of particular focus for SBC LTER investigators included design, monitoring and evaluation of marine reserves, offshore oil and gas production platform decommissioning and water quality and watershed issues.

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 were senior investigators associated with SBC LTER. Many of the recommendations made by the Science Panel were based, in part, on first-hand knowledge obtained by SBC LTER investigators. Relying heavily on information complied 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 established by this process at the California 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. Several SBC LTER Investigators participated in workshops on developing monitoring and evaluation approaches for the new marine reserves in the Channel Islands. SBC LTER Investigator Dave Siegel assisted the SoCal Urchin Divers group working on modeling stock assessments for the SoCal Bight and set up a Research Center to provide SPOT imagery (a high spatial resolution commercial data set) to UCSB researchers, including the LTER.

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 valuated all other existing information on issues relating to production on artificial and natural reefs. The report, released in 2000, and can be found at http://www.ucop.edu/research/ucmc_decommissioning/

SBC LTER research played a prominent role in shaping policy towards local watershed issues as well. We developed mutually beneficial, cooperative associations with local government departments and NGOs. Santa Barbara County's Project Clean Water sampled 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 complemented the County's effort and led to mutually beneficial sharing of both data and interpretations. To further communication with Project Clean Water, SBC investigators attended their monthly stakeholder meetings and gave public presentations of SBC results. The City of Santa Barbara 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 worked with city staff to help them plan their restoration efforts. The Santa Barbara Land Trust 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 sampled intensively, and provides useful information to the Land Trust as they protect and manage the property. Al Leydecker, a SBC post doc, assisted and helped 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. He wrote a number of water quality analysis reports and other publications for Channel Keeper and played a large part in the development of the group's website, http://www.stream-team.org/ (all articles listed above available here), devoted to these sampling efforts. As part of this ongoing effort, Al co-authored a stream sampling guide for Santa Barbara Channel Keeper and 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 SBC LTER as a community service and results reported to the state. Data are available at http://www.coastal.ca.gov/publiced/snapshot/snapshot1.html.

Tim Robinson, an SBC graduate student whose dissertation research focused on the Carpinteria watershed, was an active participant in the Carpinteria Creek Watershed Coalition, served on the Technical Advisory Committee to the Santa Barbara County Task Force, Southern California Wetlands Recovery Project and coordinated a bi-monthly column in the local newspaper (The Carpinteria Coastal View) entitled 'In the Watershed', where farmers, citizens, researchers, agency representatives and regulators expressed their interests in watershed management. SBC LTER students and postdocs also actively participated in the newly formed Santa Clara River Watershed Monitoring Program and wrote the Watershed Monitoring Plan, the Quality Assurance Project Plan, the Assessment and Evaluation Plan, and the Field Guide for the Friends of the Santa Clara River, a nonprofit group that received a grant from the Regional Water Quality Control Board to monthly monitor water quality in the river. SBC LTER collaborated with this effort to gather and analyse nutrient flux data throughout this watershed.

Categories for which nothing is reported:

RESEARCH ACTIVITIES

The research focus of SBC LTER 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 our first six years of research was 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 LTER research involved interdisciplinary studies coordinated among more than twenty investigators working in watersheds, subtidal reefs, and the coastal ocean. These studies were 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.

Our research activities as they pertain to land, reef and ocean processes are detailed below.

WATERSHED STUDIES

Runoff, stream chemistry and fluxes

We established stream gauging stations throughout the SBC LTER study region. At these sites, stream stage and water temperature were recorded at a 5-min temporal resolution. To convert our measured stage values to discharge, we developed rating curves by measuring channel cross-sections and roughness to characterize the channel reaches, and then, used 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 installed three transducers that also record conductivity. Continuous (5-min) conductivity data help discern the various sources (surface, soil and groundwater) of runoff contributing to storm hydrographs.

To understand and model the rainfall-runoff processes we established a rainfall gauge network. Currently, we have installed 12 rainfall gauges (5 of the remote gauges are equipped with spread spectrum telemetry).

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

- Digital Elevation Models: 3, 30 and 60 meter grid cell resolution.
- National Hydrography Dataset (NHD) contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells.
- Soil Survey Geographic (SSURGO) data base, which is the most detailed level of soil mapping done by the Natural Resources Conservation Service (NRCS).
- State Soil Geographic Database (STATSGO) is a soil map made by generalizing the detailed SSURGO data.
- National Land Cover Data derived from the early to mid-1990s Landsat Thematic Mapper satellite data with a 21-class land cover classification scheme.
- Land Use/Land Cover derived from digital 1:42,000 scale orthophotos taken in 1998.
- Various coverages from the City of Santa Barbara and Santa Barbara County: zoning, parcels, storm drains, and roads.

Using the SBC LTER and existing 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 was designed to integrate nutrient and sediment export modules, which represents a future research direction of the SBC LTER.

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 were 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 were analyzed for silica, major cations and anions, dissolved organic carbon and the natural abundances of ^{15}N and ^{13}C.

The locations where hydrological measurements and samples for chemical analyses were obtained changed during the course of our studies. Based on a survey of catchments in the summer of 2000, we initiated sampling of streams representing all significant land uses in our region in WY 2001 (October 2000 through September 2001). Santa Monica, Franklin, Carpinteria, Arroyo Burro and Arroyo Hondo catchments were sampled intensively, while Gaviota, San Onofre, Refugio, El Capitan, Atascadero, Mission, Sycamore, Montecito, Rincon, Javon and Ventura catchments were synoptically sampled regularly. Several sites contained USGS gauging stations, and we installed stream stage gauging equipment beginning in the summer of 2001 at many more sites, eventually at a total of 31 locations.

We selected a set of catchments as core sites based on representativeness and logistics. We maintained stream gauges and regular sampling of baseflow and stormwater at one or more sites in Gaviota, Refugio, Arroyo Hondo, Arroyo Burro, Rattlesnake, Mission, Santa Monica, Franklin and Carpinteria creeks. In WY 2004 we added Devereux Creek to complement a study of Devereux slough, and Tecolotito and Los Carneros creeks to augment our agricultural and suburban coverage. As part of an examination of nutrient export from landscape-units and development of a model of nutrient export, subunits of the Santa Monica, Franklin and Carpinteria catchments were gauged and intensively sampled in WYs 2002 and 2003.

To improve our representation of catchments dominated by agricultural land uses, we added two sites (on Rincon and Bell Canyon creeks) in WY 2005. To provide information on a suburban catchment without much upland influence, we also added Atascadero catchment in WY 2005. Subsequent to a wildfire that burned portions of Gaviota and Arroyo Hondo catchments (two of our core sites) and almost all of San Onofre catchment, we installed a gauging station in San Onofre creek in the summer of 2004 and initiated intensive sampling as WY 2005 began. We continued our regular sampling at Gaviota, San Onofre, Arroyo Hondo, Refugio, Bell Canyon, Devereux, Tecolotito, Atascadero, Rattlesnake and Mission in WY 2006.

Other additions to our regular hydrological sampling include:

- In July 2005 and in collaboration with Channel Islands National Park, we conducted a yearlong survey of streams on Santa Rosa Island, one of the large offshore islands bordering the Santa Barbara Channel noted for sediment inputs.
- In collaboration with Channelkeepers, we conducted monthly sampling at a series of stations throughout the Ventura River catchment for WYs 2002, 2003, 2004 and 2005.
- We 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 were used in deciphering statistical and process-based relationships among the characteristics of the catchments and the hydrochemical fluxes.

Estuarine studies

On-going studies of Carpinteria salt marsh, partly funded by NASA, combined remote sensing and ground-based methods to determine the vegetation patterns and to generate a digital elevation model, which will be combined with stage measurements to calculate inundation dynamics and permit estimation of tidal exchanges with the coastal ocean. High-resolution, hyperspectral images using the airborne visible and infrared imaging spectrometer (AVIRIS) were acquired in May 2002 and October 2004. Lidar imaging data were acquired in January 2004. Two water level sensors were deployed in the marsh in August 2005; a third water level sensor is maintained by the Water Resources Division of Santa Barbara County. During October and November 2005 we conducted extensive true ground height surveys using a Topcon Total Survey Station in order to evaluate and correct horizontal and vertical components of the lidar dataset. The following number of measurements were collected: 295 vegetation points, 80 mudflat points, and 185 road points. We surveyed 73 tidal channel cross sectional profiles to account for channel bathymetry, which lidar is unable to measure. In order to evaluate lidar canopy penetration, we collected canopy height and density data for each of the vegetation points surveyed.

PhD student Darcie Goodman's ecological studies of Devereux Slough included measurements of nutrient loading from its catchment, vertical profiles of temperature, salinity and dissolved oxygen, transparency, bathymetry, and water levels as well as monitoring of macroinvertebrate, fish, vegetation and bird species assemblages. Weekly measurements of dissolved oxygen, salinity, temperature, water clarity, and water level were made at three locations in the Slough; stage is also monitored continuously with a pressure transducer. Phosphorus and nitrogen loading into the Slough was determined at the mouth of Devereux Creek. Fish surveys were conducted using a 10 meter seine near the mouth of the slough as well as a series of fish traps deployed in different vegetative habitats twice a month. Additional surveys were conducted following seasonal events such as the opening of the slough to the ocean. Macroinvertebrates were sampled in each inundated habitat.

Catchment and in-stream processing of and responses to nutrients

Two studies of stream ecology were completed: (1) The biotic effects of introduced crayfish was part of the PhD research of Kristie Klose. Her study used an experimental approach to delineate the effects of a widespread exotic species, the crayfish (*Procambarus clarkii*), on benthic invertebrates and primary producers in the Santa Ynez and Ventura Rivers. (2) To assess the effects of nutrients on species composition and biomass of benthic and floating algae and aquatic plants in coastal streams and rivers, the relationship between in-stream nutrient concentrations and algal growth was investigated. Surveys of water chemistry and algal and plant abundance and species composition were conducted, and N and P supply were experimentally manipulated using nutrient diffusers to assess algal growth responses. These studies, conducted in the Ventura River, Malibu Creek and in four catchments near Santa Barbara, were part of Julie Simpson's PhD research .

REEF STUDIES

Kelp forest community monitoring

The primary objectives of our kelp forest monitoring were 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 were 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 were 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 were counted in six permanently placed 1 m^2 quadrats that are located at eight meter intervals along each transect. The percentage cover of understory algae, sessile invertebrates, and various substrate types was 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 were sampled on the bottom in a 2 m wide and 2 m high corridor along each transect. Sampling of all sites was done once per year in the summer, with the exception of mobile reef fish which were sampled every time a site is visited (sampling frequency ranges between 2 to 20 times per year). Tidbit temperature loggers were positioned on the bottom at each site and sample at a frequency of once every 15 minutes.

We also continued to sample 11 reefs at Santa Cruz Island as part of a pre-SBC LTER ongoing effort. The goal of this component of our research was 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 were counted by divers along permanent 2 meter wide transects at depths of 3m, 6m, and 9m. Random point contact line transects were used to assess the composition of benthic substrates (rock, sand, and species of algae or invertebrate) along the band transects. Benthic samples were removed from 0.1m^2 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 allowed 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 expanded the field guide to include reef fish and nearshore marine mammals. This document was 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.) collected information on the abundance of giant kelp in California and Mexico from routine (approximately monthly) aerial surveys from 1958-2006. A standard protocol was 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 were recorded on data sheets and archived in notebooks housed at ISP Alginates. ISP Alginates provided us with copies of all their archived records. We used these records to create a digital database on the historical abundance of giant kelp throughout its range in California and Mexico. Quality control on this database was completed in 2001 and the data were made available on the SBC website at http://sbc.lternet.edu/data/research/reef/historical-kelp-data/. This database enabled us to more easily evaluate long-term trends in the abundance of giant kelp and allowed 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 surveys of California kelp beds by ISP Alginates ended in 2006 and we have worked closely with one of their former scientists to continue the database on giant kelp abundance in the region.

Primary production in giant kelp
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 in 2001. *Macrocystis* is the largest alga in the world and it is believed to be one of the most productive organisms on earth. A single individual can be more than 30 m tall and consist of over a 100 fronds. Plants may live up to four to six years, while individual fronds live about 3-5 months. In May 2002 we refined the methodology that we used to estimate changes in standing crop. The resulting methodology consisted of estimating the density and length of all fronds > 1 m tall along fixed transects at three sites (Mohawk Reef, Arroyo Burro, Arroyo Quemado). Data obtained from laboratory dissections of whole plants collected from the field allowed us to reliably estimate weight-length relationships of the water column and surface portions of fronds, and to determine the water and chemical composition (C, N) of different tissue types. At each site we also measured the average rate of frond loss between sampling dates by tracking fronds on marked individuals, and estimated the rate of plant loss at the site based on changes in plant density. We used the above information to calculate the mean growth rate of kelp in each month at each site based on the change in biomass and our estimates of loss. Net primary production (NPP) was calculated as the integral of mean growth rate (g) multiplied by biomass (B_t), plus the biomass of plants recruiting during that period (R).

$$NPP = \int_0^t gB_t dt + R$$

The physical and chemical factors controlling NNP in giant kelp were examined using correlation analyses. Seawater temperature and nutrient concentration and physical disturbance from waves were the focus of these investigations and data on these variables were obtained from moored sensors.

The methodology outlined above was quite labor intensive and difficult to apply over a broad region. To this end we explored the use of in situ spectroscopy for estimating kelp standing crop and productivity. In this method a radiometrically calibrated HydroRad spectroradiometer fitted with cosine collectors was mounted to a portable frame for underwater operation by a SCUBA diver. Downwelling irradiance spectra were measured inside and outside our three kelp forest sites where we measured kelp productivity. Canopy absorbance of spectral irradiance was determined by differences in downwelling irradiances measured inside and outside the kelp forest. The resulting absorbance spectra were compared to spectrophotometrically determined absorbances of individual kelp blades measured in the laboratory. Optical data collected in the field were taken concurrently with more labor intensive diver measurements of kelp biomass. The optical data were used to calculate a Blade Area Index (BAI) for use in estimating standing crop. Estimates of standing crop based on BAI were 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 investigated 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 was 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 employed extensive measurements of flow and kelp forest community structure, geochemical and biochemical analyses, and experimental manipulations in exploiting a breadth of expertise in hydrodynamics, marine ecology, biological oceanography, and algal physiology.

SBC LTER actively collaborated with an NSF-funded project examining the ecomechanics of flexible marine organisms. This project (led by Brian Gaylord) focused 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 was largely conducted at one of our kelp NPP sites (Mohawk Reef) and SBC LTER personnel and boats were 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 used 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 focused on characterizing variability in the stable isotope values of potential food sources (phytoplankton, giant kelp, and terrestrial POM). This information was 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 subsides to sandy beach communities
The condition and productivity of kelp forests can 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 because relatively little primary production occurs on the beach itself. Kelp forests are important sources of organic matter and can provide

large subsidies of drift macrophytes (>450 kg m^{-1} y^{-1}) to sandy beach food webs in the SBC LTER. With collaborative support from University of California Sea Grant and the Air Force, we studied 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 a range of sandy beaches of the SBC LTER coast. In 2005-6, we expanded this effort to investigate temporal variation in macroalgal drift-associated nutrient cycling on sandy beaches by regularly sampling dissolved nutrients in beach porewater and the standing crop of macrophyte drift on a sandy beach that receives very high macroalgal drift inputs and like many SBC LTER beaches experiences a large seasonal flux of sand, eroding to an exposed bedrock platform in winter and spring.

OCEAN STUDIES

We used 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 were monitored through a combination of sampling from small boats, instrumented moorings, and satellite imagery. The principal goal of these observations was to establish baseline data for detecting key events that can affect the reef ecosystem. These included 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 also conducted 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 14 channel-wide surveys of hydrographic and biological parameters from 2001-2005 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 provided 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 were derived from bottle samples obtained during the CTD surveys. Depth profiles of primary production were done to assess the relative roles of phytoplankton vs. macrophyte production. Other instruments on the CTD platform measured optical properties used to characterize the particle fields and dissolved components of the water column. The spatial variability of currents was measured continuously during the cruises with a ship-board Acoustic Doppler Current Profiler (ADCP). These ship-board ADCP data were 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 lost UCSB instrumentation was about $47K and we were not successful in our efforts to secure the funds to replace them. The loss of the nitrate sensor has had considerable consequences 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 provided 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 was obtained from twice-monthly cruises of the Plumes and Blooms project (funded by NASA). We continued our development of a series of computer programs to automate the processing of the Triaxus and other survey data while at sea. We completed the work on the ScanFish algorithms allowing near real time data processing and graphical visualization of the data while at sea. We adapted the Scanfish algorithms to the Triaxus to accomplish these tasks. Efforts to streamline and automate the processing of other data sets are ongoing.

Our seasonal oceanographic cruises aboard the R/V Pt. Sur 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 analyzed 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 studied local phytoplankton community composition, and specifically investigated *Pseudo-nitzschia* bloom dynamics. She collected 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 was 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 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 conducted monthly sampling of water properties at three core reef sites, Carpinteria Reef, Arroyo Quemado, and Naples Reef, initiated in November 2000 (Carpinteria and Naples) and in March 2001 (Arroyo Quemado). Sampling at the three reefs was conducted with small boats and with instrumented moorings. In 2006 we reduced the number of stations sampled at each site to a single reef station due to budgetary constraints. In previous years we had sampled three stations at each site and we used 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 was lowered and data on temperature, salinity, chlorophyll, and suspended sediments were recorded throughout the water column. Water samples were collected from the surface down to 25 m or the bottom and analyzed for nitrate, silicate, and phosphate. Samples of particulate matter were 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 were filtered within hours of collection and stored frozen for analysis in the Marine Science Institute Analytical Laboratory at UCSB. In 2004 we stopped collecting samples of particulate silica concentrations due to budgetary constraints.

We maintained permanent moorings at Carpinteria, Naples Reef, and Arroyo Quemado. These moorings allowed us to sample ocean conditions at a higher frequency and over a wider range of conditions than can be achieved using small boats. This was especially important during storm events and high winds when sampling from boats is not possible. Each mooring was equipped with a conductivity sensor, temperature sensor, pressure sensor, and fluorometer and backscatter meter deployed at about 2 m. An ADCP was deployed on the bottom adjacent to each mooring to measure vertical profiles of current velocity throughout the water column. During 2002, 2003 and 2005 we occasionally deployed an automated nutrient analyzer (manufactured by WS Oceans) near instrumented moorings at Naples Reef, Arroyo Quemado, and Mohawk Reef. The nutrient analyzer 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 permitted detailed investigations of the role of inner shelf processes, such as upwelling and internal tides, in supplying nutrients to the reef.

Runoff "Event" sampling

Data from two runoff events were obtained during the rainy seasons of 2003-2004 and 2004-2005. 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

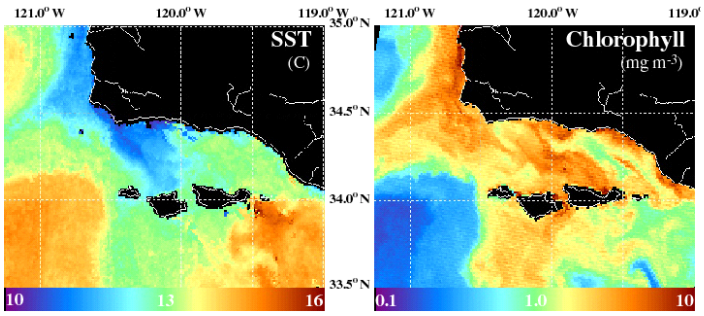
Since the beginning of the SBC LTER an array of three to four high frequency (HF) radars have been operating around the Santa Barbara Channel to map the regional surface ocean circulation. Emery et al. 2004 describe the array and its performance in more detail. SBC LTER graduate student Corinne Bassin,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

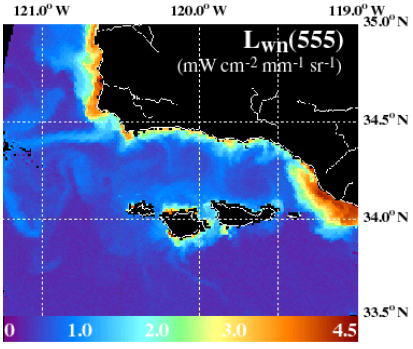
Local area coverage SeaWiFS ocean color and AVHRR thermal imagery were collected and analyzed as part of the SBC LTER program. This provided 1-km scale synoptic views of ocean chlorophyll concentrations and sea surface temperature over the entire Santa Barbara Channel. Co-registered five-day composite 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 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 was used to denote chlorophyll concentrations which are good assays for phytoplankton blooms.



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

Further, the water-leaving radiance at 555 nm, an ocean color data product, was shown to be a good proxy for



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 mW cm^{-2} μm^{-1} 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.

suspended sediment concentrations enabling the dispersion of sediment plumes within the Santa Barbara Channel to be diagnosed. These data, along with available ancillary data sets, provided a unique large scale view of ocean processes in the Santa Barbara Channel. This work was published in Deep-Sea Research, Part II (Otero and Siegel, 2004).

PRESENTATIONS

2006

Anderson, C. R., D. A. Siegel, M. A. Brzezinski, and R.l Kudela 2006. *Pseudo-nitzschia* Blooms in the Santa Barbara Channel: Field Observations Applied to Predictive Regional Modeling Poster. AGU Ocean Sciences Meeting, Honolulu, HI

Arkema, K. 2006. The ability of kelp forest suspension-feeding invertebrates to filter nearshore waters and impact water quality. Poster. 19th Annual Research Symposium, University of California Toxic Substances Research and Teaching Program, San Diego CA.

Arkema, K., D. Reed, S. Schroeter. 2006. An ecosystem engineer influences temporal variability in community structure. Contributed talk. 7th International Temperate Reef Symposium, June 2006, Santa Barbara CA.

Arkema, K. A. D. Reed, S. Schroeter. 2006. Giant kelp influences temporal variability in benthic community structure. Contributed talk, 7th International Temperate Reef Symposium. Santa Barbara, CA

Arkema, K. 2006. The ability of kelp forest suspension-feeding invertebrates to filter nearshore waters and impact water quality. Poster. California and the World Ocean Conference, September 2006, Long Beach CA.

Arkema, K. , D. Reed, S. Schroeter. 2006. An ecosystem engineer influences temporal variability in community structure. Poster. LTER All Scientists Meeting, September 2006, Estes Park CO.

Arkema, K. 2006. Regional differences in flow regime and phytoplankton abundance influence growth rate and feeding success of a kelp forest suspension feeding. Annual Meeting of the Western Society of Naturalists, Redmond WA.

Buenau, K.E., Rassweiler A., Nisbet R.M. 2006. Space competition and regime shifts on structured landscapes. Poster. LTER All Scientists Meeting, Estes Park, CO.

Cardinale, B. J. 2006. Biodiversity as both a cause and consequence of ecosystem functioning. Institute of Environmental Sciences, University of Zurich, Switzerland, December 2006.

Cardinale, B. J. 2006. Effects of biodiversity on the functioning of ecosystems -towards a food-web perspective. BioMERGE/Diversitas joint symposium on 'The Consequences of Changing Biodiversity - Solutions and Scenarios'. Michel Loreau, Andy Hector, and Shahid Naeem (organizers). Ascona, Switzerland.

Carlson, C.A. S. J. Goldberg, A. Cano, E. Wallner. 2006. Distribution and bioavailability of dissolved organic carbon in the Santa Barbara Channel. Poster. LTER All Scientists Meeting, Estes Park, CO.

Cavenaugh, K., B. Kinlan, D. Reed, D. Siegel. 2006. Kelp density and biomass estimates from SPOT satellite NDVI for the Santa Barbara Channel. Poster. LTER All Scientists Meeting, Estes Park, CO.

Coombs, J.S. The impact of fire on hydrology, suspended sediment export, and nutrient export in southern California chaparral watersheds. MS Seminar. University of California, Santa Barbara.

Dugan, J. E., H. M. Page, and D. Hubbard. 2006 Bottom up processes on sandy beaches: the influence of macrophyte wrack subsidies on community structure. Paper presented at IV Symposium on Sandy Beaches, Vigo, Spain.

Dugan, J. E., H. M. Page, M. Lastra, and D. Hubbard. 2006 Exchanges between kelp forests and sandy beaches: macroalgal wrack input, fate and processing. Poster. LTER All Scientists Meeting, Estes Park, Colorado.

Dugan, J. E. Shorebirds and Sandy Beaches on California's Coast. 2006. Seminar to the MMS OCS Scientific Committee, Annual plenary meeting, Santa Barbara, CA

Dugan, J. E. and D. M. Hubbard. 2006. Ecological responses to coastal armoring on exposed sandy beaches. Invited Seminar, USGS/University of California Santa Cruz.

Dugan, J. E and D.M. Hubbard. 2006. Ecological patterns and processes on exposed sandy beaches. Invited Seminar. Beach Ecology for Managers Meeting, Pepperdine University, California.

Fram, J.P., H. Stewart, B. Gaylord, S. MacIntyre, D. Reed, M. Brzezinski, S. Williams. Spatial and temporal variability of nitrate fluxes to a kelp forest. Contributed paper. 2006 International Temperate Reef Symposium, Santa Barbara, CA.

Fram, J.P., B. Gaylord, S. MacIntyre, D. Reed, H. Stewart, M. Brzezinski, S. Williams. Nutrient transport mediated by a kelp forest. Poster. 2006 LTER All Scientists Meeting, Colorado.

Gaines, S. D. 2006. Connectivity in the sea. Landscape Ecology Meeting, San Diego

Gaines, S. D. 2006. The science of marine reserves. Invited Seminar. California State University, Fullerton

Gaines, S. D. 2006. Macro views on reef ecology. 7th International Temperate Reef Symposium, Santa Barbara CA

Gaines, S. D. 2006. Science guidelines for the design of marine reserve networks. California and the World Ocean Conference, Long Beach CA

Gaylord, B., J. Rosman, J. Koseff, D. Reed, J. Fram, S. MacIntyre, M. Brzezinski, C. McDonald, J. Largier, K. Arkema, S. Monismith, P. Raimondi, and B. Mardian. 2006. Spatial patterns of flow in and around giant kelp forests: Kelp beds as permeable filters of nearshore waters. AGU Ocean Sciences Meeting, Honolulu, Hawaii.

Gaylord, B. 2006. Progagule transport and material processing within and around giant kelp forests. Invited seminar, Romberg Tiburon Center for Environmental Studies.

Gaylord, B. 2006. Progagule transport and material processing within and around giant kelp forests. Invited seminar, Department of Biological Sciences, University of Southern California.

Guerrini, A. 2006. Writing Ecological History. Invited paper, American Society for Eighteenth-Century Studies, Montréal

Guerrini, A. 2006. High Society in Goleta: the Campbell Ranch in the 1920s. Invited lecture, UCSB History Associates, Santa Barbara

Guerrini, A. 2006. Coastal Dynamics: Restoring a California Wetland. Invited seminar, International workshop on "Restoring or Renaturing," Zűrich, Switzerland

Hubbard, D.M. and J. E. Dugan 2006 Ecological effects of coastal armoring on sandy beaches in southern California. Paper presented at IV Symposium on Sandy Beaches, Vigo, Spain.

Kostadinov, T. S. 2006. Bio-Optical Modeling of the Santa Barbara Channel, California. Studying Coastal Ocean Dynamics Using Ocean Color. Poster. Long-Term Ecological Research (LTER) Network All Scientists Meeting, Estes Park, CO

Lester, S. E. and S. D. Gaines. 2006. The biogeography of reproduction in the sea urchin, *Strongylocentrotus purpuratus*. Poster. Long-Term Ecological Research (LTER) Network All Scientists Meeting, Estes Park, CO.

Lester, S. E., and S. D. Gaines. 2006. Geographic patterns of reproductive output in intertidal invertebrates: insights from two temperate systems. International Temperate Reef Symposium, Santa Barbara, CA.

Lester, S. E., and S. D. Gaines. 2006. Including larval production in the connectivity equation: geographic patterns of reproductive output in intertidal invertebrates. Poster. Ocean Sciences Meeting, Honolulu, HW.

Lastra, M. H. M. Page, J. E. Dugan and D. Hubbard. 2006 Processing of allochthonous macrophyte subsidies by sandy beach consumers: estimates of feeding rates and impacts on food resources. Poster. IV Symposium on Sandy Beaches, Vigo, Spain.

Levenbach, S. 2006. An associational defense for algae on rocky reefs and implications for land use policy, Poster. 19th Annual Research Symposium, UC Toxic Substances Research and Teaching Program.

McPhee-Shaw, E., G. Chang, and T. Dickey.2006. The SCCOOS shelf to shoreline observatory development Santa Barbara Channel mooring,: An ongoing time series of currents, thermal structure, and optical properties of the water column over the continental shelf. Poster. AGU Ocean Sciences Meeting, February 2006, Honolulu HI.

McPhee-Shaw, E., D. Reed, D. Siegel, and L. Washburn. Interannual variability in the onset of spring upwelling and the response of giant kelp. Poster AGU Ocean Sciences Meeting, February 2006, Honolulu HI.

McPhee-Shaw, E., D. Reed, D. Siegel, and L. Washburn. 2006. Interannual variability in the onset of spring upwelling and the response of giant kelp. Poster. LTER All Scientists Meeting, Estes Park CO.

McPhee-Shaw, E., D. Reed, D. Siegel, and L. Washburn. 2006. Interannual variability in the onset of spring upwelling and the response of giant kelp. Poster. SBC LTER Annual Retreat.

Melack, J, A. Leydecker, R. E. Beighley. 2006. Regionalization of nutrient export by streams in coastal California. Poster. LTER All Scientists Meeting, Estes Park CO.

Page, H. D. Reed, M. Brzezinski, J. Melack, J. Dugan. 2006. Assessing the importance of land and ocean subsidies to shallow subtidal rocky reef communities. Poster. LTER All Scientists Meetings. Estes Park, CO.

Rassweiler A. 2006. Mechanisms maintaining distinct community states in the Santa Barbara Channel. Poster. LTER All Scientists Meeting, Estes Park CO, September

Rassweiler A.2006. Competitive interactions between algae and filter feeders and their role maintaining distinct community states in the Santa Barbara Channel. 7th International Temperate Reef Symposium. Santa Barbara CA,.

Rassweiler A. 2006. The role of runoff in preventing *Pachythyone rubra* beds from forming: why are aggregations so rare on the mainland side of the Santa Barbara Channel? Poster. 2006 TSR&TP Research Symposium, San Diego CA.

Reed, D. , K. Arkema, A. Rassweiler, and R. Zimmerman. 2006. Patterns and causes of variation in NPP in the giant kelp *Macrocystis pyrifera*. Poster. LTER All Scientists Meetings. Estes Park, CO.

Reed, D. C., M. Brzezinski, S. Gaines, S. Holbrook, J. Melack, H.M. Page, J. Schimel, D. Siegel, L. Washburn. 2006. The Santa Barbara Coastal LTER. Poster. LTER All Scientists Meetings. Estes Park, CO.

Reed, D., B. Gaylord, P. Raimondi, and L.Washburn. 2006. Dispersal and recruitment in giant kelp: The consequences of small scale patterns on larger scale processes. Invited plenary talk, 7th International Temperate Reef Symposium. Santa Barbara, CA.

Simpson, J. Dynamics of plant and algal communities in urban, Mediterranean-climate streams. Ph.D. Seminar. University of California, Santa Barbara.

Stewart, H.L., D. Reed, B. Gaylord, S. Williams, B. Mardian, S. MacIntyre, J. Fram, and M. Brzezinski. Biological response of giant kelp to different physical conditions in and around a kelp bed. AGU Ocean Sciences Meeting, Honolulu, Hawaii, February 2006.

Stewart, H.L 2006. Living in flow: Physical-biological interactions in nearshore marine systems. Invited Seminar. Dept of Ecology and Evolutionary Biology University of California Los Angeles.

Stewart, H.L 2006. The interplay between seaweed morphology, physiology and performance across barrier reefs and kelp beds. Invited Seminar. Dept of Botany University of British Columbia

Stewart, H. L., D. Reed, B. Gaylord, S. Williams, B. Mardian, S. MacIntyre, J. Fram, and M. Brzezinski 2006. Biological Response of Giant Kelp to different physical conditions in and around a kelp bed. Honolulu, HI., Contributed paper. AGU Ocean Sciences/ASLO Meeting.

Stewart, H. 2006 Kelp makes its bed and lies in it: growth and physiological response of kelp to engineering by the bed Friday Harbor Labs, University of Washington seminar series.

Whitmer, A. , S. Simon. 2006. SBC LTER Watershed Education Program. Poster.LTER All Scientists Meetings. Estes Park, CO

2005

Anderson, C. R. 2005. Toxic *Pseudo-nitzschia* blooms in the Santa Barbara Channel. Oral presentation at the LTER Graduate Student Collaborative Research Symposium, HJ Andrews Experimental Forest, Blue River, Oregon. 14 April 2005.

Anderson, C. R., Siegel, D., Brzezinski, M. A., Washburn, L., and R. Kudela 2005. Remote detection of toxic phytoplankton blooms in the Santa Barbara Channel. Poster presentation at the NASA Biodiversity and Ecological Forecasting Team Meeting, Washington D.C., 29-31 August 2005.

Arkema, K. 2005. 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

Arkema, K, B. Gaylord, D. Reed, 2005: Giant kelp influences the feeding success of a suspension feeder, *Membranipora tuberculata*, by modifying water flow and food availability across a subtidal reef. Presented at 2005 Annual Meeting of the Western Society of Naturalists, Monterey CA.

Arkema, K., S. Abramson, B. Dewsbury 2005. Ecosystem-based Management (EBM): The Challenges of Moving from Scientific Definitions to Management Applications. Presented at 2005 Annual Ecological Society of America Meeting, Montreal, Canada.

Coombs, S. 2005 The impacts of wildfire on hydrologic response, suspended sediment yield, and dissolved nutrients in California chaparral watersheds. Seminar presented for the Interdisciplinary Marine Science Program Seminar, University of California, Santa Barbara.

Dugan, J. E. and D. M. Hubbard 2005. Ecological responses to coastal armoring on exposed sandy beaches. California H_2O conference. Huntington Beach, CA

Dugan, J. E., Hubbard, D. M., Page, H. M. 2005. Responses of sandy beach ecosystems to macrophyte wrack subsidies. Invited talk, 3rd annual Range-wide Western Snowy Plover Conference, January 11-12, Morro Bay, CA

Gaines, S. D. 2005. Changes in biodiversity at different spatial scales. Seminar, NCEAS, Santa Barbara, CA

Gaines, S.D. 2005. The science of marine reserve networks, Invited Seminar Univesity of North Carolina,.

Gaines, S.D. 2005. The science of marine reserve networks, Invited Seminar Univesity of Southern California.

Gaines, S. D. 2005. Marine reserve design in a warming ocean. Invited Talk to Environmental Defense Fund, New York NY.

Gaines, S. D. 2005. Proposed educational standards on marine biological diversity. Invited talk. Long Beach Aquarium, Long Beach, CA

Gaylord, B. 2005. Biological-physical connections in the coastal ocean: Ecology and hydrodynamics across levels of scale. Invited seminar, Dept. of Marine Sciences, Univ. of North Carolina, Chapel Hill, NC.

Gaylord, B., J. Rosman, J. Largier, D. Reed, J. Koseff, C. McDonald, S. MacIntyre, K. Arkema, S. Monismith, P. Raimondi, and M. Brzezinski. 2005. Flow modification by kelp forests: Implications for subtidal ecology and nearshore ecosystems. Western Society of Naturalists Meeting, Seaside, CA.

Holbrook, S.H. D.C. Reed, R. J. Schmitt, and A.J. Brooks. 2005. Quantifying the performance of different artificial reef designs in mitigating losses to kelp forest fishes in southern California, USA. Presented at the LTER/NSF mini symposia on marine research in the LTER. Arlington, VA

Holbrook, S.J., D. Reed, R.J. Schmitt, A. Brooks 2005. Diversity responses to change in habitat-forming species on temperate and tropical reefs, LTER Symposium, March 3, 2005, NSF

Holbrook, S.J., D. Reed, A. Brooks, R.J. Schmitt. Diversity responses to change in habitat-forming species on temperate and tropical reefs. 7th Indo-Pacific Fish Conference, May 16-20, Taipei, Taiwan

Holbrook, S.J., D. Reed, R.J. Schmitt, A. Brooks. Diversity responses to change in habitat-forming species on temperate and tropical reefs, Scientific Roundtable, CRIOBE (Centre de Recherches Insulaires et Obseervatoire de l'Environnement), Moorea, French Polynesia,

Kinlan, B.P., S.D. Gaines, and D.A. Siegel. 2005. Do observed self-recruitment rates require special behavioural and oceanographic features? Using null models to evaluate the evidence for alternative hypotheses. International Ocean Research Conference, Paris, France,.

Kinlan, B.P. 2005. Scaling and forecasting the spatiotemporal dynamics of coastal ecosystems. Fannie and John Hertz Fellowship Research Symposium. San Jose, CA

Kinlan, B.P. 2005. Topography, nearshore oceanography and the spatial structure of coastal upwelling ecosystems: an interhemispheric comparison. Mellon Ecosystem Dynamics Consortium Symposium, Cape Town, South Africa.

Kinlan, B.P., B.R. Broitman, S.D. Gaines, C.A. Blanchette, E. Wieters, S.E. Lester, and P.T. Raimondi. 2005. Predictability in intertidal ecosystems: scale-dependent coupling of coastal geomorphology, oceanography, and benthic community structure. 86th Annual Meeting of the Western Society of Naturalists, Seaside, CA.

Kostadinov, T.S. D. A. Siegel, S. Maritorena, and N. Guillocheau, 2005. Ocean Color Variability Assessment in the Santa Barbara Channel, California. Local Tuning of a Semi-Analytical Bio-Optical Algorithm Using Genetic Algorithms. Presented at the 2005 International Ocean Research Conference, Paris, France.

Kostadinov, T. S., Siegel, D. A.; Maritorena, S.; Guillocheau, N. 2005: Local tuning of a semi-analytical bio-optical algorithm for case II waters using genetic algorithms. Talk. 2005 American Society of Limnologists and Oceanographers Meeting Salt Lake City, UT.

Lastra, M., H. M. Page, J. E. Dugan, and D. M. Hubbard. 2005. Processing of allochthonous macrophyte subsidies by sandy beach consumers: estimates of feeding rates and impacts on food resources. Poster. American Society of Limnologists and Oceanographers, Santiago de Compostela, Spain

Lester, S. E. and S. D. Gaines. 2004. The biogeography of reproduction: latitudinal variation in sea urchin fertility. Western Society of Naturalists Meeting, Sonoma, CA, November 2004.

Lester, S. E. 2005. Geographic patterns of reproductive output in intertidal invertebrates: Baja to Cape Town. Western Society of Naturalists Meeting, Monterey, CA, November 2005.

Lester, S. E. 2005. Geographic patterns of reproductive allocation in intertidal invertebrates. Marine Ecosystems Dynamics Consortium Meeting, funded by the Mellon Foundation, Cape Town, South Africa, August 2005.

Levenbach, Stu. 2005. SBC LTER Graduate Student contributions to Land-Ocean Margin Research. Talk at the the LTER Graduate Student Collaborative Research Symposium, HJ Andrews Experimental Forest, Blue River, Oregon. 14 April 2005

Melack, J.M., A. Leydecker and E. Beighley. 2005. Regionalization of nutrient export by streams in coastal California. Talk. American Society of Limnologists and Oceanographers Winter Meeting, Salt Lake City, Utah.

Melack, J.M., A. Leydecker, E. Beighley, T. Robinson and S. Coombs. 2005. Nutrient fluxes from coastal California catchments with suburban development. Talk. AGU Winter Meeting, San Francisco, CA.

Mitarai, S., D.A. Siegel, and K.B. Winters 2005. A numerical study of stochastic larval settlement in nearshore environments. Talk. 2005 American Society of Limnologists and Oceanographers Meeting Salt Lake City UT.

McPhee-Shaw, E. D. Siegel, L. Washburn, and M. Brzezinski 2004. Cross-shelf transport processes: Observations from the Southern California Bight. U. S. Geological Survey, Santa Cruz, CA, December 2004.

McPhee-Shaw, E. D. Siegel, L. Washburn, and M. Brzezinski 2004. Cross-shelf transport processes: Observations from the Southern California Bight.. Wednesday seminar series at the Monterey Bay Aquarium Research Institution (MBARI), Moss Landing, CA, November 2004.

McPhee-Shaw, E. E., D. Reed, D. Siegel, and L.Washburn 2005. Interannual variability in the onset of Spring upwelling and the response of giant kelp. Gordon Research Conference on Coastal Ocean Circulation, Colby-Sawyer College, New Hampshire. 5-10 June 2005.

Nishimoto, M. M. , L. Washburn, M. Love, D. Schroeder, and B.M. Emery 2005. Is the delivery of juvenile fishes settling on offshore platforms linked to transport by ocean currents?, 8th International Conference on Artificial Reefs and Related Aquatic Habitats (CARAH). April 10-14. Biloxi, MS

Page, H. M., J.E. Dugan, M. Love, D. M. Schroeder, and M. Nishimoto 2005. Trophic links and ecological performance: comparisons among offshore oil platforms and natural reefs for a resident fish and its prey. 8th International Conference on Artificial Reefs and Artifical Habitats, Biloxi, Mississippi

Rassweiler, A.. 2005. Mechanisms maintaining distinct community states: A marine example from the Santa Barbara Channel, LTER Coordianting Committee Meeting, Norfolk, VA.

Rassweiler, A. 2005. Effects of Terrestrial Runoff on the Distribution of Dense Aggregations of Filter Feeders. Poster presented at UC Toxics Symposium, Sacramento CA, April 2005

Reed, D. C. Schroeter, S.C., D. Huang. T.W. Anderson, and R.A. Ambrose. 2005 Quantifying the performance of different artificial reef designs in mitigating losses to kelp forest fishes in southern California, USA. Presented at 8th International Conference on Artificial Reefs and Related Aquatic Habitats. Biloxi, MS.

Reed, D. C. Schroeter, S.C., D. Huang, R. Grove. 2005. Quantifying the performance of different reef designs on kelp bed fish and benthic community development at the San Clemente experimental artificial reef. Talk. Annual meeting of Southern California Academy of Sciences, Los Angeles, CA

Robinson, T. H. 2005. Modeling nutrient export from coastal California streams. Talk. American Water Resources Association Annual Conference, Seattle, WA.

Schimel, J. 2005. The Arctic Plant-Soil Feedback Loop: A Belowground Driver of the Arctic Climate. Departmental Seminar, University of California, Santa Barbara, CA

Schmitt, R.J. and S.J. Holbrook. 2005. Demographic buffering of environmental variation in surfperches. 7th Indo-Pacific Fish Conference, Taipei, Taiwan, May 16-20, 2005

Schroeter, S.C. D.C. Reed, D. Huang. 2005. Effects of material type and amount on benthic community development of an artificial reef in southern California. Presented at 8th International Conference on Artificial Reefs and Related Aquatic Habitats. Biloxi, MS.

Siegel, D.A., 2005: It's Stirred, Not Mixed!! Role of Fluid Stirring in Aquatic Ecosystems. Plenary talk presented at the 2005 ALSO Meeting Salt Lake City, February 2005.

Siegel, D.A., Costello, C., Gaines, S.D., Hilborn, R.W., Kendall, Polasky, S., Warner, R.R., Winters, K.B., 2005: Flow, Fish And Fishing: A Biocomplexity Project. Talk presented at the 2005 ALSO Meeting Salt Lake City, February 2005.

Simpson, J.C., A.P. Leydecker and J.M. Melack. 2005. Community and ecosystem-level impacts of an emergent macrophytes on the Ventura River, California. Talk presented to the North American Benthological Society, New Orleans, May 2005.

Stewart, H. 2005. Biological response of giant kelp (*Macrocystis pyrifera*) to variation in physical factors within a kelp bed.. Poster presented at ASLO Dialog, Dauphin Island, Alabama.

Stewart, H. 2005. Hydrodynamic consequences of buoyancy and stiffness in a tropical alga. Talk presented at ASLO Dialog, Dauphin Island, Alabama.

Whitmer, A. 2005. A Role for LTER in Marine Science Education. Talk at NSF LTER Mini-symposium February 2005, Washington, DC.

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 PhytoplanktonBlooms 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

Gaines, S. D. 2004. A larval biologists view of fisheries management. Talk to Alaska Fish & Game Dept.

Gaines, S. D. 2004. The science of marine reserve networks, Invited Seminar, University of Alaska, Anchorage, Alaska

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.

Gaylord, B. 2004. Ecomechanics of seaweeds and spore dispersal in nearshore habitats. Invited seminar, Department of Civil and Environmental Engineering, Stanford University, Stanford, CA.

Grabowski, L. A. and A. Leydecker, 2004. Tracking enterococci bacteria during a rainstorm on Mission Creek. Presented at the 2004 Headwaters-to-Ocean (H_2O) 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 ofthe 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 H_20 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

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

Schimel, 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 H20 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-Quartenary 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, Gleneden 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 at16th Annual Research Symposium, UC Toxic Substances Research and Teaching Program, 2003

Levenbach S. 2003. The Effect of Siltation on the Colonial Sea Anemone, *Corynactis californica*, Poster. SBC LTER Midterm Review, University of California, Santa Barbara, CA

Leydecker, A., J. Simpson, and L. A. Grabowski 2003. 2001: Nutrient Uptake and Cycles of Change: the Ventura River in Southern California. Presented at 2003 AGU Fall meeting, San Francisco, CA.

McPhee-Shaw, E., L. Washburn, and D. Siegel 2003. Low-frequency dynamics and nutrient flux to the inner shelf of the Santa Barbara Channel. Presented at the 50th Eastern Pacific Ocean Conference, Catalina Island, Sept. 2003.

McPhee-Shaw, E. , M. Brzezinski, D. Siegel, and L. Washburn 2003. Mechanisms for nutrient delivery to the inner shelf: Observations from the Santa Barbara Channel. Poster presented at UC Toxics Symposium, Oakland, CA, May 2003.

McPhee-Shaw, E. , M. Brzezinski, D. Siegel, and L. Washburn 2003. Mechanisms for nutrient delivery to the inner shelf: Observations from the Santa Barbara Channel. Invited seminar. Lamont-Doherty Earth Observatory.

McPhee-Shaw, E. , M. Brzezinski, D. Siegel, and L. Washburn 2003. Mechanisms for nutrient delivery to the inner shelf: Observations from the Santa Barbara Channel. Invited seminar. University of New Hampshire.

McPhee-Shaw, E. , M. Brzezinski, D. Siegel, and L. Washburn 2003. Mechanisms for nutrient delivery to the inner shelf: Observations from the Santa Barbara Channel. Invited seminar. Dept. of Oceanography at the U.S. Naval Postgraduate School.

Ow, L., L. Washburn, D.A. Siegel, and E.E. McPhee-Shaw, 2003: Moored observations of biological and physical variability near kelp reefs in the Santa Barbara Channel. Poster presented at the 2003 ASLO Aquatic Sciences meeting, Salt Lake City, UT, February 2003.

Ow, L., L. Washburn, D.A. Siegel, and E.E. McPhee-Shaw, 2003: Moored observations of biological and physical oceanographic variability near kelp reefs in the Santa Barbara Channel. Poster. Undergraduate Research Colloquium, University of California, Santa Barbara, CA

Page, H. M, D. Reed, M. Brzezinski, J. E. Dugan 2003. The incorporation of land and ocean sources of organic matter into kelp forest food webs: evaluation using stable isotopes. Poster. LTER All Scientists Meeting, Seattle, WA.

Parker, S. S. and J. P. Schimel 2003. The seasonal dynamics of nitrogen losses from California grasslands. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA

Rassweiler, A., K. 2003. Mechanisms Maintaining Species Assemblages in the Santa Barbara Channel. Poster. Santa Barbara Coastal LTER Midterm Review, University of California, Santa Barbara, CA.

Rassweiler, A., K. Arkema, D. Reed, D. Zimmerman 2003. Patterns and causes of variation in NPP in the giant kelp, *Macrocystis pyrifera*. Poster. LTER All Scientists Meeting, Seattle, WA.

Reed, D. S. Holbrook, C. Blanchette, R. Schmitt. 2003. Differential reproductive responses to environmental fluctuations in marine species with contrasting demographies. Sixth International Temperate Reef Symposium, Christchurch NZ.

Reed, D., S. Holbrook, R. Schmitt. 2003. Patterns and causes of temporal and spatial variability in kelp forests. LTER All Scientist Meetings, Seattle, WA

Reed, D. M. Brzezinski, S. Cooper, J. Dugan, S. Gaines, S. Holbrook, T. Holden, J. Melack, M. Page, J. Schimel, D. Siegel, and L. Washburn 2003. Santa Barbara Coastal Long Term Ecological Research. Poster. LTER All Scientist Meetings, Seattle, WA

Reed, A. Rassweiler, K. Arkema, R. Zimmerman. 2003. Patterns and controls of growth and primary production in the giant kelp, *Macrocystis pyrifera.* Meetings of the Western Society of Naturalists, Long Beach, CA.

Robinson, T. H. 2003. Nutrient Flux from Mediterranean Coastal Streams: Carpinteria Valley, California. Talk, AGU 2003 Fall Meeting, San Francisco, California.

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Bull, J. S, S. J Holbrook, and D. C Reed. 2001. Evaluation of restoration techniques to mitigate losses of surfgrass (Phyllospadix torreyi) from anthropogenic impacts. 14th Annual UC Toxic Substances Research and Teaching Program Symposium, Lake Tahoe, California. Poster.

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Mertes, L. A., D. Siegel, J. A. Warrick and M. Otero. 2001. Seasonality of plumes and blooms for 1997-2001 in the Santa Barbara Channel, California. 82nd Annual Meeting of the Western Society of Naturalists, Ventura, CA.

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Siegel, D.A., L. Washburn, J.A. Warrick, D.A. Toole, R.C. Smith, O. Polyakov, M. Otero, L.A. Mertes, N. Guillocheau and M.A. Brzezinski, 2001: An Ocean Color Assessment of Sediment Plumes and Phytoplankton Blooms in the Santa Barbara Channel, California. Presented at 2001 AGU Fall meeting, San Francisco CA, December 2001.

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2000

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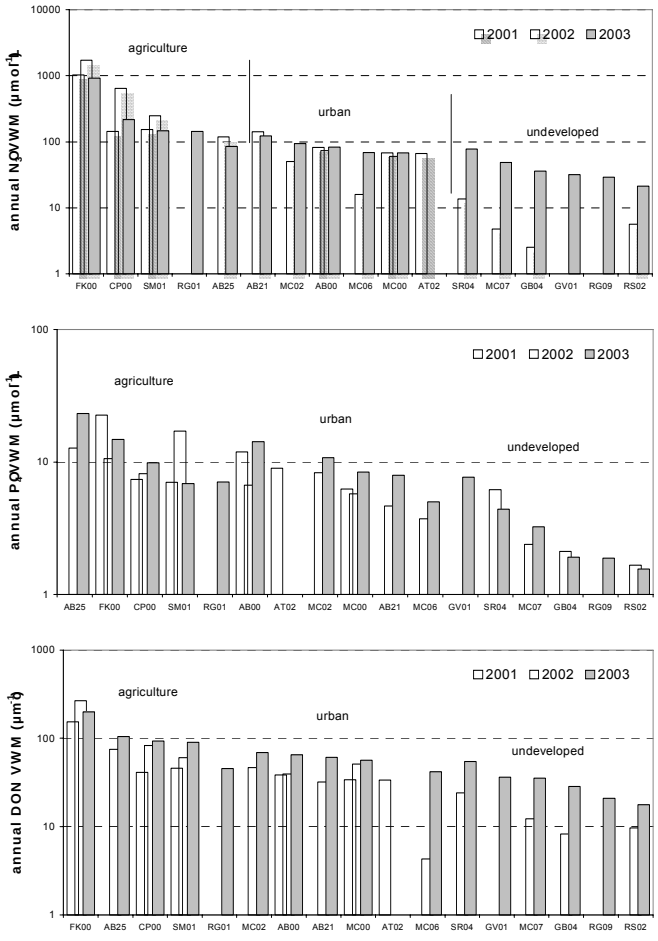
RESEARCH FINDINGS

WATERSHED STUDIES

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

The coastal watersheds of the Santa Barbara Channel experience a Mediterranean climate with mild, moist winters and moderately warm, generally rainless summers and offer a rich range of conditions for experimental and observational study. The mainland drainage areas are comprised of three watershed scales: 74 small coastal catchments draining from the Santa Ynez Mountains varying in size from 1 km^2 to ~ 50 km^2 with a total area of 790 km^2; the Ventura River draining 590 km^2; and the Santa Clara River draining 4200 km^2. Steep mountain slopes composed of readily eroded material over shallow bedrock layers and strongly seasonal rainfall create large sources of sediments. The catchments differ widely in the proportion of agricultural and urban development. The El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) combine to produce significant interannual variability in precipitation.

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 (Leydecker et al. submitted). The topography of the coastal watersheds is characterized as mountainous headwaters and gently sloping coastal plains separated by transitional foothills. From west to east, there are both elevational and land use gradients. Headwater elevations increase from approximately 300 to 1400 m, and land uses on the coastal plain and foothills change from mostly rangeland to a combination of urban and agricultural lands. Most of the annual precipitation and corresponding runoff occurs in only a few large events resulting in high peak discharges and a rapid return to near baseflow conditions.



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.

Volume weighted mean concentrations (VWM) and fluxes per ha of dissolved nutrients for 17 catchments or sub-catchments can be divided into broad categories of agriculture, urban and undeveloped depending on the dominant land use. Descending order of concentration usually follows descending intensity of use. For example, 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. Nitrate VWM concentrations generally range from 5 to 25 µmol L^{-1} in undeveloped areas, increase to about 100 µmol L^{-1} for urban and most agricultural catchments, and are in excess of 1000 µmol L^{-1} in catchments with greenhouse-based agriculture.

Comparative values for DON are 10 to 25 µmol L^{-1} for undeveloped, 60 to 100 µmol L^{-1} for urban and agricultural, and about 200 µmol L^{-1} for greenhouse-based agriculture.

A conspicuous difference is the wet-year to dry-year contrast. 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 greatest during the first flushing storm of the season, remain relatively consistent.

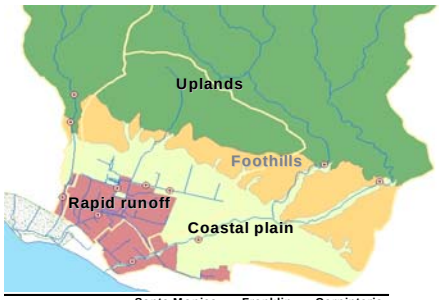
There is almost a 4-order-of-magnitude difference in nitrate VWM concentrations, a variability caused by land use and annual runoff differences. The more heavily developed the catchment the more likely stormflow diluted coastal-plain baseflow concentrations; lower concentrations in upper catchment or 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 erodable 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 (mol ha^{-1} 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, from 2480 to 22750 kmoles for nitrate, from 180 to 1050 kmoles for phosphate and 1180 to 8790 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.

As a refinement of the regional analyses



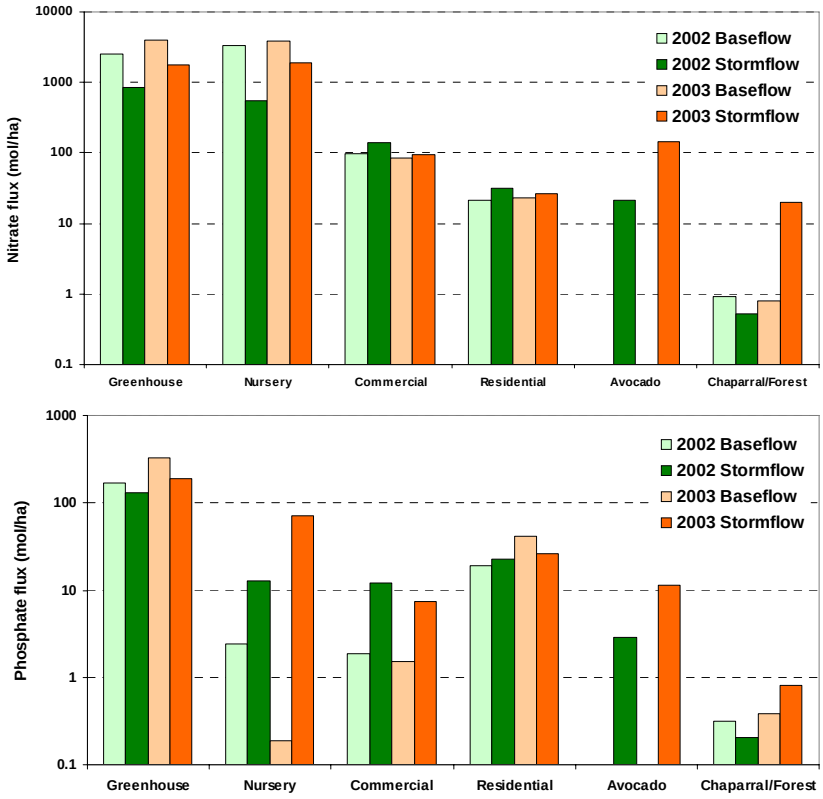
		Santa Monica	Franklin	Carpinteria
Area	(ha)	981	1112	3998
Upland	(%)	95	38	78
Foothill	(%)	2	15	9
Coastal Plain	(%)	2	29	10
Rapid Runoff	(%)	1	17	3

Landscape and geomorphological units near Carpinteria with sampling sites shown as red dots

described above, the PhD research of Tim Robinson focused on measuring and modeling nutrient loading at the landscape-unit scale in three coastal watersheds near Carpinteria. The research incorporated high frequency sampling of specific land uses over a three-year period from October 2000 through September 2003. Hourly volume weighted mean concentrations and fluxes of nutrients were determined for each site and were tabulated by individual storms and as baseflow, stormflow and annual totals. Discernable differences were seen in the nutrient fluxes and VWM concentrations among the landscape units: the two intensive agricultural land uses, greenhouse and nursery, were in general higher than the two urban classes, commercial and residential, which in turn were higher than the undisturbed sections of the watersheds. The avocado signal was similar to those of the two urban sites and was well below the intensive agricultural sites. The observed order (ranked from highest to lowest) of nitrate and phosphate fluxes and VWM concentrations by landscape units were generally as follows:

NO_3-fluxes: nursery, greenhouse, commercial, avocado, residential, and chaparral
NO_3-VWMs: nursery, greenhouse, commercial, avocado, residential, and chaparral
PO_4-fluxes: greenhouse, residential, nursery, commercial, avocado, and chaparral
PO_4-VWMs: greenhouse, residential, nursery, commercial, avocado, and chaparral

The phosphate fluxes had similar rankings to those of nitrate except that the residential site had higher export than the avocado, commercial and nursery sites. The greenhouse and nursery nitrate VWM concentrations and fluxes had an elevated baseflow component, whereas the others were more influenced by stormflow. The commercial site produced more nitrate export than the residential site, whereas the conditions were reversed for phosphate fluxes.



Annual nitrate and phosphate fluxes by baseflow and stormflow for each of the landscape units

Chaparral had low baseflow nutrient VWM concentrations and fluxes that increased during appreciable stormflow from large rainfall events when antecedent soil moisture conditions favored runoff. During the first year of the study (WY2002), dry conditions did not produce substantial baseflow or stormflow NO_3, DON or PO_4 export, and annual totals were circa 1.6, 1.9 and 0.5 mol ha^{-1}, respectively. With increased stormflow during the second year of the study (WY2003), the stormflow nitrate flux increased 20-fold but baseflow fluxes remained low; DON followed a similar pattern but fluxes were approximately 15% less. The importance of DON concentrations in streams diminished from the forested and undisturbed areas to the urban and agricultural regions where nitrate loading and export superseded DON and its proportional contribution to the total nitrogen flux became small.

Nutrient export from avocado orchards was well below the intensive agricultural (greenhouse and nursery) sites, between the two urban sites (commercial being above and residential above) for nitrate, below the urban sites for phosphate, and above the chaparral site for all constituents. Export patterns followed the general trends observed at the chaparral sites, although the magnitudes of concentration and flux were higher, indicating that the nutrient export was stormflow driven.

Although residential and commercial landscaping received regular soil amendments, stream nutrient concentrations were far less than intensive agricultural sites. NH_4 and PO_4 annual fluxes were comparatively high at the residential site, possibly due to excessive use of specific fertilizers for ornamental plants. These urban sites had first flush characteristics where a sharp rise in the nutrient chemograph at the onset of a storm was diluted shortly thereafter with impervious surface runoff. This pattern was not seen at the upland or avocado sites where appreciable rainfall was needed to generate storm water runoff Stormflow greenhouse and nursery fluxes were similar and higher than any other land use. NO_3 and particularly PO_4 originated from coastal plain greenhouse and nursery areas with nitrate storm fluxes near 100 mol ha^{-1} per event; avocado, residential and commercial were near or less than 10 mol ha^{-1} per event, and the chaparral sites were at or below 1 mol ha^{-1} per event except for the 3/15/03 storm when appreciable upper-basin runoff generated fluxes near 10 mol ha^{-1}. Baseflow NO_3 fluxes at the intensive agricultural sites were higher than stormflow fluxes for both years presumably due to continuous dry season tailwater and nitrate-rich groundwater discharges, producing a relatively continuous increase in cumulative export curves. This was in contrast to other land uses where stormflow driven export generated a stair-step pattern to their curves. PO_4 storm fluxes had a similar distribution among land uses: greenhouse (10 mol ha^{-1}), commercial (1 mol ha^{-1}) and chaparral (0.1 mol ha^{-1}) sites. The nursery PO_4 stormflow signal was consistently less than the greenhouse drain during both years of the study although the residential stormflow and baseflow signals were slightly higher than the nursery site during the dry year. Compared to the high mobility of NO_3, PO_4 was relatively immobile and depended on the amount of sediment that can be flushed into the channel for a given storm and antecedent condition.

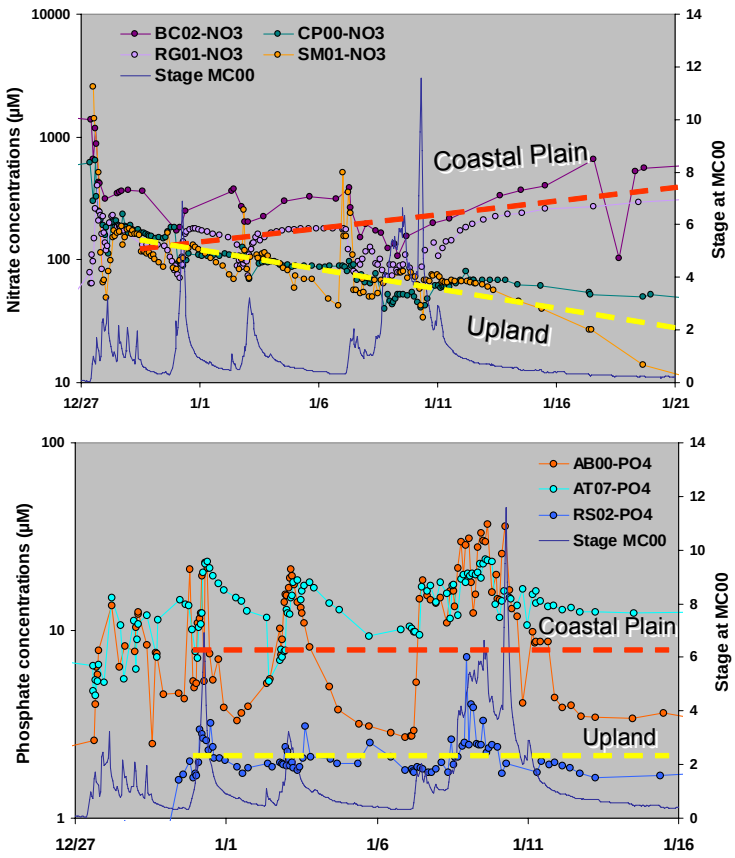
From October 2001 through January 2002, a series of 10 small storms, all with 2.5 cm or less rainfall, presented an opportunity to analyze coastal plain nutrient contributions since little or no upper basin runoff was generated. At urban sampling points, nitrate concentrations decreased during storms caused by stormflow dilution of high nitrate in baseflow. The first storm of the season (following 6 months of dry weather) was an exception, and generated a substantial nitrate (and phosphate) pulse. Urban phosphate concentrations during the October to January series of storms exhibited two contrasting patterns: decreasing with runoff where impervious surfaces dominated, and increasing in areas with significant urban green space (parks, open space, lawns and gardens). The increasing phosphate concentrations were seen mainly on the falling hydrograph limb, indicative of soil water drainage. Both maximum and minimum urban phosphate concentrations decreased with successive storms indicating depletion of the urban reservoir.

The large variation in chemical concentration with the stormflow hydrograph require the modeling of nutrient export in these "flashy" relatively short and steep coastal streams at a time step significantly less than one day. For example, nitrate, soluble reactive phosphate (SRP) and particulate organic nitrogen (PON) vary with the hydrograph, albeit in different patterns: SRP varies in phase with outflow, nitrate exhibits the opposite pattern, and PON concentrations, along with other particulates, reach a maximum on the rising limb of the first storm pulse. Different patterns imply different mechanisms and/or sources for the various species. Concentration-discharge (C-D) plots for constituents provide insight into what these mechanisms and sources may be. A counter-clockwise loop as occurs for nitrate and silica requires a minimum of three sources. Assuming surface runoff dominates on the rising hydrograph limb, shallow soil flow is predominant on the falling limb, and that groundwater exerts an influence at hydrograph peaks and controls baseflow concentrations, the magnitude of nitrate concentrations in the various source waters must be soilwater > groundwater > surface runoff. The silica pattern, while similar, exhibits relative concentrations of groundwater > soilwater > surface runoff. However, source concentrations may vary both between storms and within a storm, e.g., due to the flushing and exhaustion of dry-season deposition, or end of growing season mineralization and reduced residence time of stormflow.

An important mechanistic question is what regulates the movement of nutrients from terrestrial ecosystems to ground and surface waters. Our initial work on N cycling in annual grasslands near Santa Barbara

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

WY2005 rainfall was 220% of the long-term average precipitation, the majority of which came in a sequence of storms during the middle of the winter. This presented an opportunity to determine if depletion of nutrient stock occurred after extensive rainfall over two months, a condition not seen in the previous four years. Sites with large upland areas (SM01 and CP00) showed signs of nitrate depletion, indicated by the downward trending line in the figure below. In contrast, the coastal plain areas with extensive agriculture, such as Bell Canyon and Refugio creeks had trend lines of increased concentrations with consecutive storms. This supports observations that the coastal plain nitrate reservoir is large and exhaustion of that source from repetitive flushing in any single year is unlikely. Phosphate concentrations followed the hydrograph with no indication of either increase or decrease with consecutive storms in upland (RS02), coastal plain (AT07), or rapid runoff urban (AB00) areas.



Nitrate and phosphate concentration trends during the mid-winter sequence of storms in WY2005. Sampling sites are Bell Canyon Creek outlet (BC02), Refugio Creek outlet (RG01), Santa Monica Creek outlet (SM01), Carpinteria Creek outlet (CP00), Arroyo Burro Creek outlet (AB00), Atascadero Creek at Puente Drive (AT07), and Rattle Snake Creek at Skofield Park (RS02). The upper dashed line is associated with the coastal plain sites whereas the lower dashed line is for the upland sites.

From June 5 to 12, 2004, a wildfire consumed 3011 hectares within our study area. The fire extended from the Gaviota watershed in the west to the Arroyo Hondo watershed in the east. Both the Gaviota watershed (12% burned) and the Arroyo Hondo watershed (20% burned) had been extensively monitored for discharge, dissolved and particular nutrients, and suspended sediment for the previous 3 years, allowing for comparison to baseline pre-fire conditions. In addition to continued monitoring at Gaviota and Arroyo

Hondo, the San Onofre watershed (97% burned) was added in WY2005. Scott Coombs conducted his thesis research on the impact of the wildfire on hydrologic response and nutrient plus suspended sediment flux. Because the WY2005 rainfall totals far exceeded previously monitored years, modeling efforts were conducted to determine how the monitored catchments would have responded to this above average rainfall, had they been unburned. Results from WY2005 indicated that nitrate concentrations during storm runoff from burned catchments increased by as much as 7 times, and phosphate concentrations increased by 4 to 5 times. At San Onofre, a strong ammonium flush occurred during the first two storms of the season, where ammonium concentrations were greater than nitrate concentrations in the first storm, peaking at 295μM NH_4 and 134μM NO_3. In undisturbed watersheds, ammonium concentrations rarely exceed 10μM. The runoff during these first two storms also contained a large amount of ash and fire debris. After the first rains, microbes converted the high levels of ammonium in the soil to nitrate, and process resulted in the highest nitrate concentrations of the year in the next large storm of the season with concentrations of ~740μM NO_3 at San Onofre. This compared to a peak concentration value of ~180μM at Rattlesnake Creek, an unburned upland catchment, during the same storm.

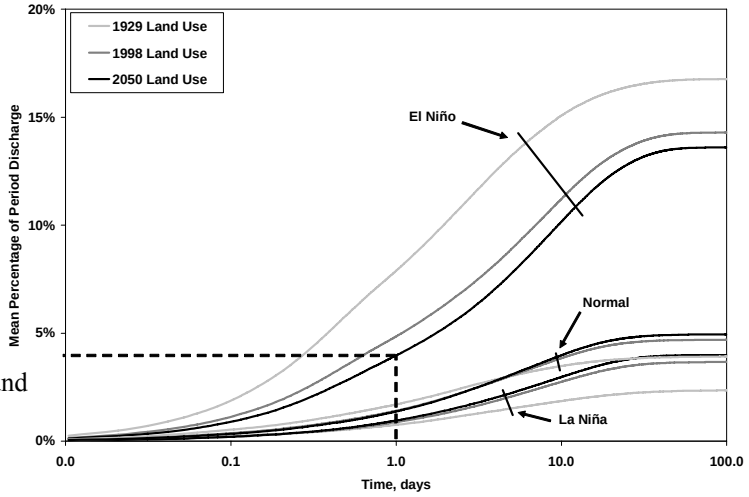
The Ventura River drains 580 km^2 of mountainous coast and ranges in flow from near 0 to 11 $m^3 s^{-1}$. Monthly synoptic sampling of nutrients at 15 locations indicated nitrate peaks in early winter, presumably from mineralization and mobilization after the advent of the rainy season, with concentrations decreasing to a minimum by late summer. Phosphate followed a similar pattern. Variation in nitrate (0 to 550 μM) and phosphate (0 to 35 μM) on the river and its tributaries was considerable. During winter stormflow, nitrate concentrations in the lower, urbanized portion of the catchment decreased by dilution from surface runoff, while phosphate concentrations increased 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 $m^3 s^{-1}$, in contrast with a 72 yr mean of 4.6 $m^3 s^{-1}$. In the absence of stormflows, which usually scour the channel, exuberant plant growth covered the lower river and macrophytes 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 was discharged.

Modeling runoff and chemical conditions

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

Building on our initial analysis, a geographic information system (GIS) integrated approach for modeling storm response was devised. To investigate the impacts of urbanization and climatic fluctuations on the magnitude and variability of discharge, the HEC-HMS rainfall-runoff model was parameterized and used to simulate streamflow for a 14-year period (9/1/1988 to 8/31/2002) in the Atascadero Creek watershed for 1929, 1998, and forecasted 2050 land use conditions (8, 38 and 52 percent urban, respectively). Urbanization increased peak discharges and runoff, but decreased annual and interannual variability. This point is illustrated in the figure below, which shows that the 1929 scenario produces the greatest difference between El Niño and La Niña conditions; the difference between these two extreme climatic conditions decreases with increasing urbanization. However, increased peak discharges and annual runoff were not proportional to increases in urbanization because the effects of urbanization are compounded by orographic rainfall and decreased travel times. Further, only a few large storms dominate runoff regardless of land use.

While the HEC-HMS model provides meaningful estimates of combined stream flow for varied land use and climate conditions, it is not intended to track the various sources of runoff (i.e., surface, interflow and groundwater) separately. Hence, we developed an improved modeling approach that is better suited for simulating runoff and corresponding constituents from the primary flow sources and pathways. Our approach assumes that landscapes possess an identifiable spatial structure, fashioned by climate, geology and land use that affects their hydrologic response. The model utilizes a time step of 15 minutes and source-to-sink routing to simulate streamflow at the watershed outlet and other points of interest. The model is spatially averaged at the hydrologic response unit (HRU) scale enabling watershed-scale spatial patterns to be incorporated into the rainfall, runoff generation, and routing processes. The model is designed to simulate two runoff forms: surface and subsurface. Incorporating hydrogeological interpretation, the two runoff forms are separated into two subclasses: (a) surface – urban or rural and (b) subsurface – interflow or groundwater flow. Comparing measured and simulated streamflow at gauge locations showed that our modeling approach yielded reasonable estimates of combined streamflow.



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

The large Santa Clara River watershed has supported significant agricultural activity for more than a century, although it is transitioning to suburban and urban land uses. Funded largely by the Los Angeles Regional Water Quality Control Board (RWQCB), A. Keller and T. Robinson implemented the Watershed Analysis Risk Management Framework (WARMF) model (Chen et al., 1996) for the Santa Clara River watershed. WARMF is a decision-support model for determining a Total Maximum Daily Load (TMDL) for nutrients, allocating the TMDL to point and non-point sources, and evaluating various Best Management Practices. 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 were used. The model was implemented at a daily time step, posing some limitations to our ability to accurately predict loading and load assimilation, since the watershed has flashy behavior.

Initial results indicate that loading of nutrients to the land surface is dominated by agriculture and atmospheric deposition, but that a large fraction (typically > 90%) is assimilated or transformed so that it is not available for transport during storm events. The relative contributions from point and non-point sources vary along the watershed for each nutrient. Although ammonium salts are used as fertilizer and are also found in atmospheric deposition, NH_4^+ is transformed relatively fast to NO_3^-, resulting in little in-stream ammonium loading from non-point sources. Nitrite inputs are low, mostly from the wastewater treatment plants. Nitrate is reaching the river from a number of sources, from direct releases, through stormflow and shallow subsurface flow, and from deeper groundwater that intersects the river at various locations..

In-stream and estuarine processing of and responses to nutrients, bacteria and invasive species
Biological processing of nitrogen and phosphorus in streams can alter both the form and the total amounts of N and P that are delivered to coastal systems. Understanding the structure and function of the stream biota with regard to nutrient processing is therefore necessary in order to understand the transport and fate of these nutrients. The organisms principally responsible for uptake and transformation of N and P include algae, vascular plants, and microscopic heterotrophs. PhD student, Julie Simpson, studied nutrient processing in streams draining small watersheds in the Santa Barbara area, at six sites within a single larger watershed near Malibu, CA and at a series of locations along the Ventura River. She 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.

Ludwigia hexapetala is a pervasive, emergent vascular plant on the lower Ventura River. Presence of this plant appears to inhibit filamentous green macroalgae, while facilitating growth of shade-tolerant diatoms. Four sites on the river were monitored during 2003; three downstream of a wastewater treatment plant, where *Ludwigia* is present, and one upstream site where it is absent. Filamentous algae occured at all four sites, but declined rapidly at the below-treatment plant sites as growth and cover of vascular plants increased. By late summer, percent cover at these sites was dominated by *Ludwigia*, while the upstream site was consistently dominated by green macroalgae. Submerged plant parts provided substrate for diatom colonization, roughly doubling benthic diatom biomass (measured as chlorophyll *a*) at the downstream sites. Presence of the *Ludwigia* population also had strong ecosystem-level effects. The wastewater effluent produced typical stream water nitrate concentrations of 100-200 μM. Nitrate uptake rates downstream of the treatment plant inputs averaged 5 kg N/km/day, and direct uptake by *Ludwigia* could account for 20-40% of this nitrate drawdown. Further nitrate removal from the water column may be indirectly facilitated by the presence of *Ludwigia* through facilitation of diatom population growth.

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-amplifed 16S rRNA genes from extracted community DNA, M. LaMontagne, E. Beighley and P. Holden (MS submitted) found quantifiable influences of specific land uses on microbial community structure and diversity within two SBC-LTER watersheds. This is consistent with earlier work focused on the lagoon at Arroyo Burro whereby rainfall induced runoff conveyed 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. PhD student Y. Cao's work indicated 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.

Many coastal embayments are influenced by nitrogen inputs from agricultural and urban development in adjoining watersheds. Elevated dissolved inorganic nitrogen concentrations in coastal environments can cause eutrophication because these ecosystems are usually nitrogen limited. Nitrogen enrichment in salt marshes and shallow lagoons may alter the biological community by stimulating algal and plant growth, and reducing nighttime levels of dissolved oxygen. Indicators are needed that reflect the potential biological effects of nitrogen enrichment on salt marsh ecosystems. Benthic microalgae , especially diatoms, are known to be very sensitive to changes in water quality, and were investigated as bioindicators in Carpinteria Salt Marsh. Nitrate concentrations in the marsh channels exceed values in the coastal ocean by 10 to 100 fold. Within the marsh we chose 14 sampling sites, representing different levels of nutrients

and salinity. Water samples and sediment pore-water samples for nutrient analyses were collected from the channels in the marsh. Temperature, salinity, and conductivity were measured at the same sites *in situ*. Simultaneously, samples of benthic microalgae were taken to determine the species composition of diatoms. We also measured densities of the dominant grazer, the snail *Cerithidea californica* at the sites. We explored spatial and temporal patterns in diatom communities in relation to nutrient concentration and salinity using diversity indices, as well as cluster analysis using the relative abundances of component species.

A total of 125 diatom species were identified in Carpinteria salt marsh. Cluster analysis differentiated five diatom assemblages:

Class 1 was characterized by the following species: *Oestrupia spec., Nitzschia compressa*, *Fragilaria pinnata var. pinnata*, *Amphora copulata*, *Nitzschia frustulum*.

Class 2 was characterized by *Navicula incertata*, *Nitzschia inconspicua*, *Navicula phyllepta*, *Navicula microdigioradiata*, and *Achnanthes clevei*.

Class 3 was characterized by *Amphora copulata c.f.*, *Navicula incertata*, and *Fragilaria pinnata var. pinnata*.

Class 4 was characterized by *Nitzschia frustulum*, *Nitzschia inconspicua*, *Nitzschia compressa*, *Fallacia pygmaea*, and *Achnanthes bahusiensis*.

Class 5 was characterized by the dominance of *Nitzschia inconspicua* and *Navicula pseudolanceolata*.

Correlation analysis between these assemblage groups and environmental factors revealed a variety of relationships. The Class 1 assemblage was found on sediments with high organic content ($p<0.05$), the Class 2 assemblage was associated with a low density of snails ($p<0.05$), and the Class 3 assemblage was positively correlated with increasing nitrate and phosphate concentrations ($p<0.01$) and high salinities in overlying water ($p<0.05$). The Class 3 assemblage also was positively related to increasing silicate concentrations in pore water ($p<0.05$) and increasing densities of snails ($p<0.05$). The Class 4 assemblage was positively correlated with increasing temperatures ($p<0.05$) and negatively correlated with increasing snail densities ($p<0.01$), whereas the Class 5 assemblage was associated with high concentrations of nitrate in overlying water.

Coastal marshes can modify nutrient-rich runoff from upland catchments and can augment export of organic matter to near-shore communities via tidal exchanges. To understand these influences, PhD student Steve Sadro characterized vegetation, flushing rates and residence time of water within Carpinteria salt marsh. Vegetation mapping from AVIRIS data allowed ready discrimination of the dominant vegetation classes. The plant distribution in Carpinteria salt marsh was distributed across an elevational range of approximately 30cm. *Salicornia virginica* and *Jaumea carnosa* were dominant at elevations of between +0.70 and +0.75 meters (NGVD 1929). Multi species mixes and grasses tended to occur at elevations of between +0.80 and +1.00 meters (NGVD 1929). Preliminary analysis of tidal fluctuations yielded inundation-elevation curves that indicate *S. virginica* and *J. carnosa* are dominant in areas that are inundated for periods of 14-17 % while multi species mixes and grasses are dominant in areas that are inundated for periods of 6-9 %.

In order to better understand inundation dynamics that may be affecting salt marsh plants and influence exchanges of nutrients and organic matter, different modeling approaches were considered. One approach used locally measured tidal fluctuations to characterize frequency, timing, depth, and duration of inundation. Using the digital elevation model, marsh storage capacity was derived, stage-storage curves developed, and rates of change of storage modeled. More complex 1D and 2D finite element hydrologic models may be adapted to analyze the velocity and direction of surface flow within the marsh.

PhD student Darcie Goodman examined ecological conditions in Devereux Slough, a seasonally exchanging coastal wetland located west of Coal Oil Point. Salinity, dissolved oxygen and temperature data in Devereux Slough indicated that the water column was stratified January to April during both 2004 and 2005. Mixing of the water column occurred during the summer with temperatures of 26 C° from June to the end of August. During storm events, surface salinities were <10 g L^{-1} and bottom salinities were 15-30 g L^{-1}. Beginning in April, the water mixed to the bottom until the first rains in October, and the water can

become hypersaline (>40 g L^{-1}) from July until October. The water near the bottom became anoxic after storms when the water was not well mixed. Highest dissolved oxygen levels were recorded at the end of spring and beginning of summer.

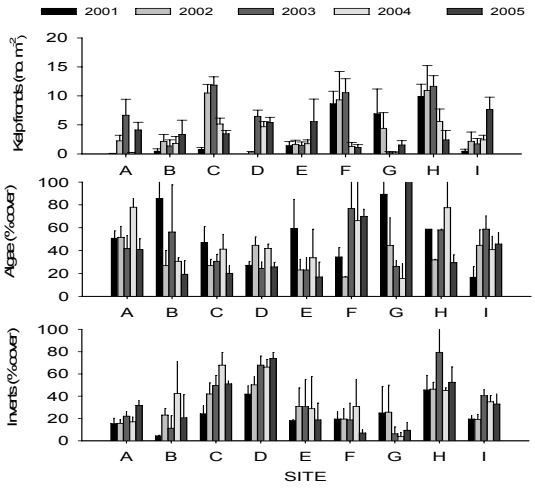
Nine species of fish were recorded in the year of surveying. The most abundant species in Devereux Slough are *Atherinops affinis* (topsmelt) and *Fundulus parvipinnis* (California Killifish). Topsmelt were most abundant during summer months and killifish most abundant in the early spring. The endangered tidewater goby was first recorded in Devereux Slough during the spring of 2004, and had last been recorded in Devereux slough in the early 1970s. Invertebrate species found in core samples included the amphipod, *Synchelidium*, nemerteans, nematodes and spionid polychaetes. *Salicornia virginica* was the most common vegetation found in the slough system, and the salt grass *Distichlis spicata* was most common in the riparian zone.

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 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. SBC graduate student, Kristie Klose, performed field experiments in the Santa Ynez River of Santa Barbara County, California using a gradient of *P. clarkii* densities in *in situ* experimental stream channels to measure the responses of invertebrate and primary producer abundance to different crayfish densities. Her results were 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), she performed a similar field experiment as the one described previously for 2002 in the Ventura River in 2003. Results from this study were similar to and supported 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).

REEF STUDIES

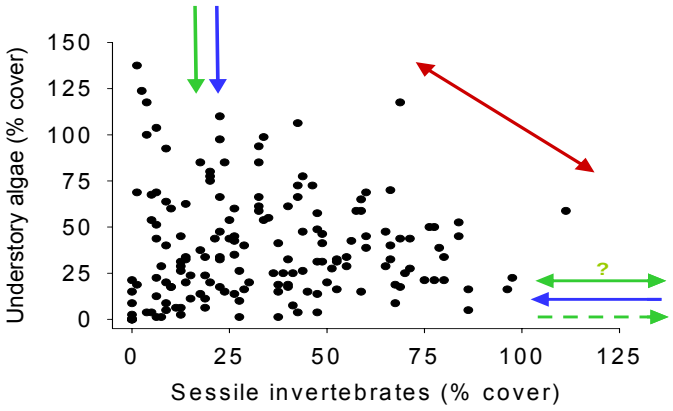
Kelp forest community monitoring

Results from our annual subtidal community surveys showed that the kelp forest ecosystems in the Santa Barbara Channel are extremely dynamic in both space and time. Site specific differences in the timing and intensity of sea urchin grazing, exposure to wave disturbance and sand accretion caused the abundance of giant kelp at the nine mainland sites to vary asynchronously over time and independently in space. Understory algae and sessile invertebrates also displayed substantial variation among sites and years, which was 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



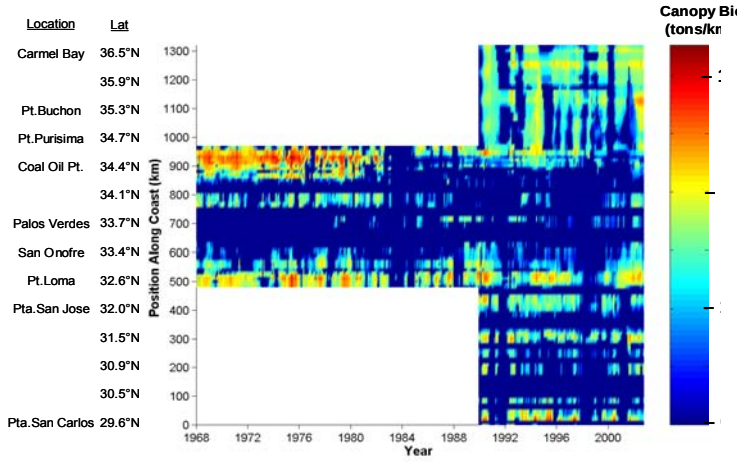
Annual abundance of giant kelp, understory algae, and sessile invertebrates at 9 mainland sites. Sites lettered A though I from west to east

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 investigated these relationships in greater detail with experiments and mathematical models. For example, the Ph.D research of Andrew Rassweiler investigated dramatic shifts between two very different benthic communities, one in which *Pachythyone rubra*, a filter feeding sea cucumber, persists at high density (>1000 per m^2) and one which is dominated by algae and other invertebrates. Spatial and temporal distribution of these communities suggests that they may represent alternate stable states, in which mechanisms reinforce each phase once it is established. He investigated competition with algae as one such mechanism. Rassweiler used mathematical models to show that space competition with algae can cause alternate stable states when filter feeders are also consuming algal spores. He also experimentally showed that the sea cucumbers compete with algae, and that algal settlement is more than twice as high when the sea cucumbers are removed, indicating that spore predation may be strong. Under the supervision of Associate Investigator Roger Nisbet, LTER graduate student, Kate Buenau, explored how realistic space affects the potential for systems to have alternate stable states. Using a generic model in which two species compete for space, Buenau found that recruitment facilitation caused alternate states in the well mixed version of her model, when explicit space was added, the range of parameters that can produce alternate states was reduced, and when realistic landscape heterogeneity was introduced this range of parameters shrank further (Buenau et al 2007).



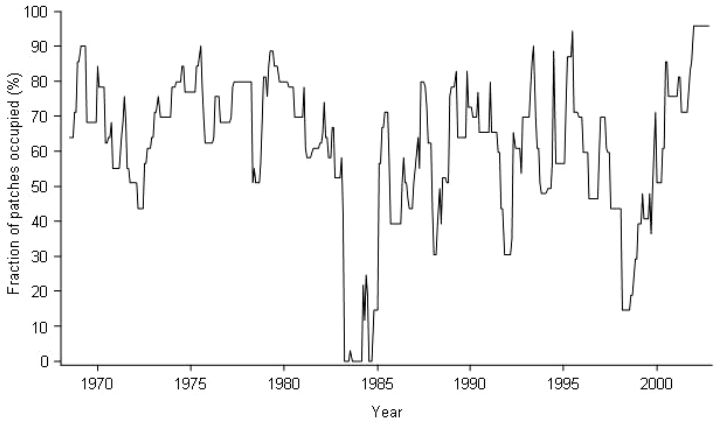
Historical database on giant kelp abundance

We used the database on giant kelp abundance that we compiled from ISP alginates records to investigate the spatiotemporal dynamics of giant kelp forests throughout their range in California and Mexico. SBC graduate student, Brian Kinlan, found that canopy biomass varied interannually at dominant periods of 4-5 y, 11-13 y and ~20 y, and at spatial scales ranging from local (~30 km) to mesoscale (~100-150 km) and regional (~330 km). Temporal dynamics were strongly related to basin-scale climate fluctuations (El Niño-Southern Oscillation, Pacific Decadal Oscillation) and spatial patterns were correlated with coastline geomorphology. Digital canopy maps revealed that changes in biomass were associated with shifts in the spatial structure of the kelp habitat.



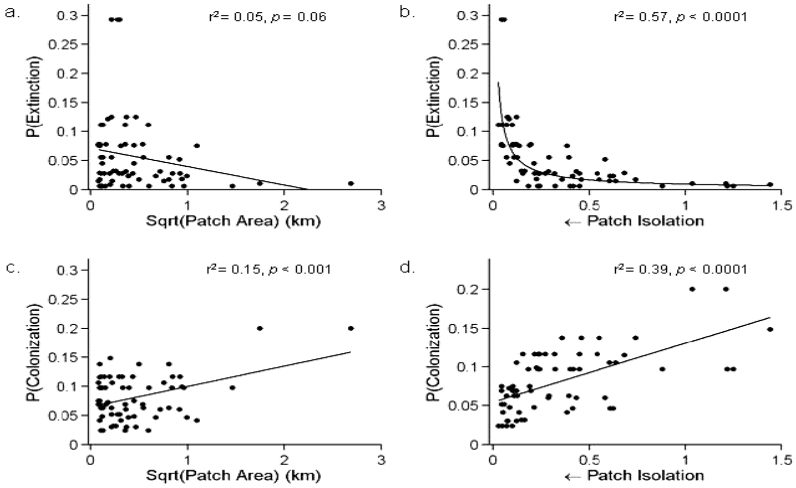
Space-time distribution of kelp forest canopy biomass in the NE Pacific, based on monthly aerial surveys from ISP Alginates/Santa Barbara Coastal LTER. White = no data. Missing values interpolated by ordinary kriging.

A common feature of giant kelp forests is that discrete stands of giant kelp go extinct and reappear at irregular intervals. We used 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 (led by B. Kinlan) confirmed 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



Percent of giant kelp patches along the mainland coast of southern California (n = 69 patches) occupied on a monthly basis from January 1968 to October 2002 as estimated from surface canopy observations made during aerial over flights.

Duration of patch extinctions and patch persistence of giant kelp along the mainland coast of southern California based on a 34-year monthly time series of surface canopy biomass. Upper panels (a, b) show histograms of the average extinction and persistence time for n=69 discrete patches. Lower panels (c, d) show the durations of all extinction and persistence intervals observed during the 34-year study, revealing extremely long and extremely short extinction and persistence intervals not reflected by the averages in (a) and (b).

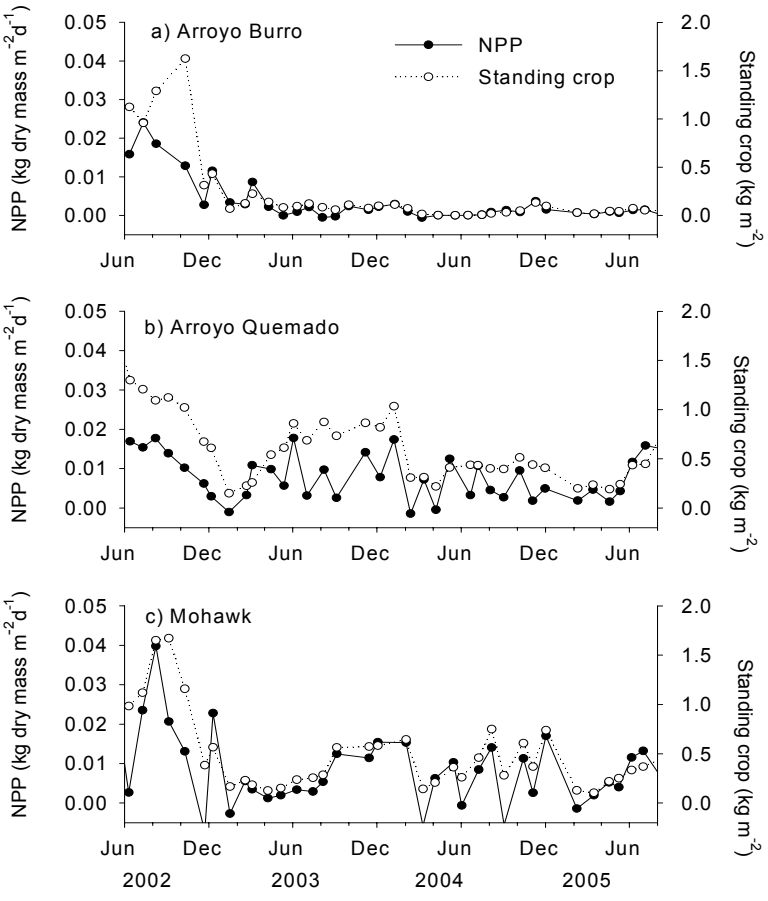


going from occupied to extinct, ranged from 0.005 to 0.292 (mean ± SD = 0.057 ± 0.063). Recolonization probabilities, defined as the monthly probability of a patch going from extinct to occupied, ranged from 0.023 to 0.200 (mean ± SD = 0.080 ± 0.040). On average, extinction of a patch in southern California 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 and recolonization rates than patch size, 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 indicates that immigration rates may limit recolonization of isolated patches. The statistical significance of the relatively low correlations between patch size and extinction and recolonization 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

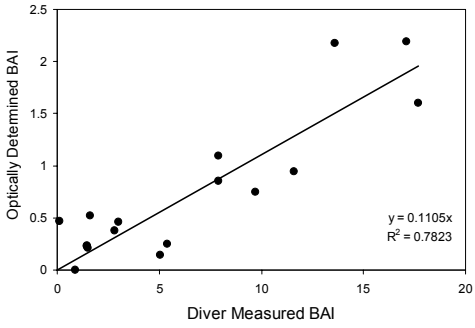
NPP in giant kelp averaged 3 to 8 g dry mass $m^{-2}d^{1}$ (= 0.9 to 2.3 g C $m^{-2}d^{1}$) over the three sites during the period July 2002 – June 2005. That the relatively high NPP resulted from a moderately low standing crop (mean = 195 to 560 g dry mass m^{-2}) suggested that a high mean growth rate coupled with high turnover was responsible for the high mean NPP. That was found to be the case as kelp growth and loss averaged nearly 2% 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 an 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



Monthly estimates of net primary production and standing crop of giant kelp at three sites (a) Arroyo Burro, (b) Arroyo Quemado, and (C) Mohawk.

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 disturbance, as opposed to the delivery and uptake of nitrogen, were more important in determining variation in NPP during the three-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 continued to evaluate the utility of in situ spectroscopy for rapid, non-destructive evaluation of submerged plant canopies in optically shallow waters and obtained more data under a wider range of canopy densities.



Optically determined BAI plotted as a function of diver-based surveys. The relationship determined by least-squares regression is indicated by the diagonal line. Error bars represent standard errors

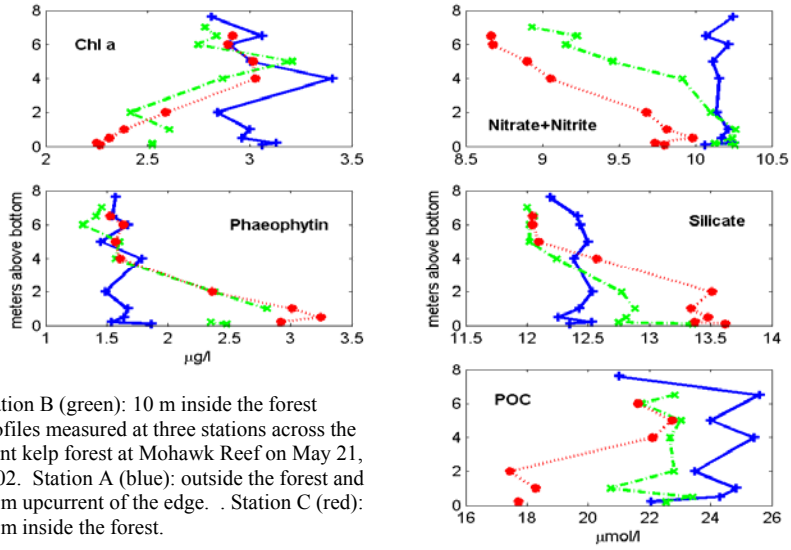
Data collected to date suggest that optical data are a good predictor of standing biomass as measured by the more labor intensive diver count. The shallow slope between optically determined BAI and diver measurements (0.1105) indicate a significant package effect with respect to light harvesting by the 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 indicated that the optical measurement can provide a reliable estimate of kelp standing crop for about 1/3 the effort required for direct counts.

Ecomechanics of giant kelps

Results to date from the collaborative research on the ecomechanics of kelp indicated, 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 revealed a tidal dependence on force, and a non-intuitive capacity of currents to partially ameliorate the detrimental consequences of waves in causing dislodgement.

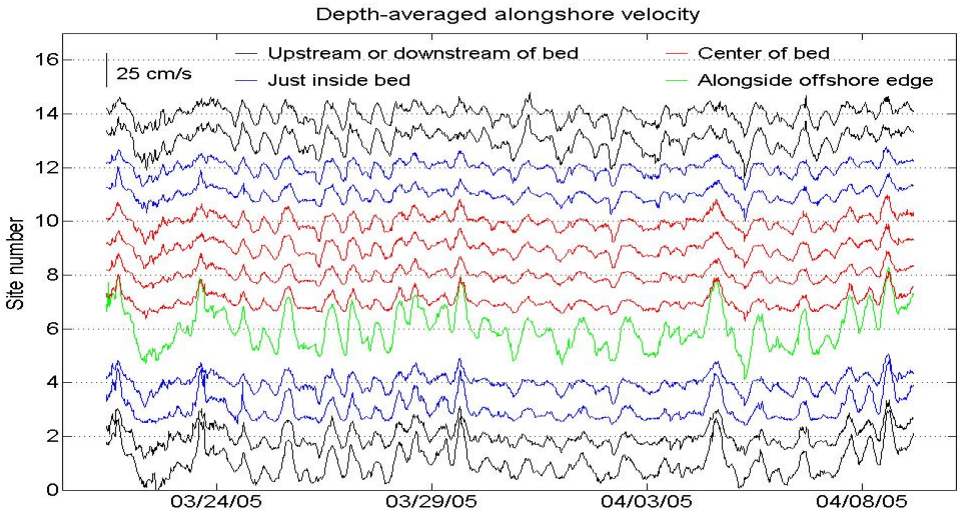
Biological and Physical coupling within giant kelp forests

Our measurements of water column constituents within and immediately outside the kelp forest at Mohawk Reef showed a remarkable decrease of chlorophyll *a*, POC, and PON, primarily near the bottom, and a similarly remarkable decrease of nitrate, nitrite and phosphate in the upper water column inside the kelp forest. These trends indicated the occurrence of intense, previously undocumented grazing on phytoplankton and other organic particles near the bottom and pronounced uptake of nutrients closer to the surface where most of the kelp biomass is located. The large increase in phaeophytin near the bottom corroborated the conclusion that grazing was intense, while the corresponding near-bottom increase in silicate suggested significant benthic regeneration of silica. Assuming an average flow velocity of 2 cm s^{-1} and a distance of 41 m between station C and the edge of the forest (station A), the water column-integrated decline in chlorophyll was 2.07 mg m^{-2} and that of POC was 29.9 mmol C m^{-2}. Extrapolating these values to 24 hrs and converting chlorophyll to carbon (using C: Chl ratio of 100 for this region), the estimated decline from outside to 41 m inside the forest was 8.7 g C m^{-2} d^{-1} and 15.1 g C m^{-2} d^{-1}, for chlorophyll and POC, respectively. These values suggest that nutrient uptake by kelp and grazing on oceanic phytoplankton by benthic suspension feeders within the bed can be quite high.



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

In 2005 we conducted two parallel studies involving the deployment of extensive arrays of flow sensors within and around the kelp forest at Mohawk Reef. Findings from these studies indicated a clear reduction of current speeds within the forest that was dependent on the density of kelp individuals, a visible downstream wake characterized by slower flows, a zone of marked flow acceleration along the offshore boundary of the forest, and strong effects of water depth on velocity. These features have implications for understanding the degree to which nearshore flows pass through kelp forests as opposed to being diverted around them. This in turn bears on the capacity of kelp forest ecosystems to influence a variety of nearshore waterborne commodities, including nitrate, dissolved and particulate carbon, phytoplankton, and zooplankton, each of which may be produced or consumed by members of the kelp forest community.

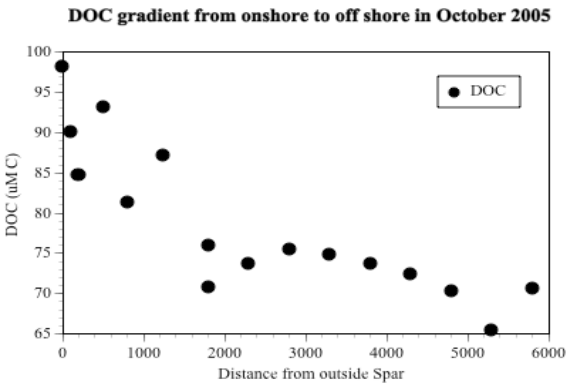


Depth averaged alongshore current velocity at Mohawk Reef during March and April 2005.

Additionally we began a time series of temperature and velocity measurements at sites ~10 m outside and ~ 10 m inside the kelp forest in March 2005. Nitrate concentrations were measured every 15 minutes outside the bed. Not surprisingly, nitrate concentrations during the upwelling season were high. Nitrate concentrations dropped as water temperatures rose at the end of the spring upwelling season. Subsequently, high nitrate concentrations occurred intermittently and were linked with cold water incursions due to internal wave induced upwelling of thermocline waters. From May until the middle of July these cold water incursions continued to supply the kelp forest as the upwelled water that reached the outside of the bed also reached inside the bed. However, in later summer, the importance of this mechanism for nutrient supply declined as cold, nutrient rich waters only occurred outside the bed 44% of the time and inside the bed only 15% of the time.

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

DOC measurements collected at Mohawk Reef and its surrounding waters showed elevated concentrations relative to those in the Santa Barbara Channel (i.e. > 80µM DOC near Mohawk vs. < 70 µM C offshore). These data indicate that dissolved organics produced in shore (perhaps by the kelp forest) may be retained by the very near shore coastal system. During our UNOLS cruise (LTER 14) we established an inshore – offshore transect and collected DOC samples every 100 – 500 m from just out side the kelp bed at Mohawk to approximately 6 km off shore to test for a DOC gradient. We found a significant decreasing gradient in DOC concentration from the near shore to the offshore. Further work is being conducted to



Gradient in dissolved organic carbon observed within and offshore of Mohawk Reef in October 2005

explore the sources and fate of this DOM and how it influences C export from a reef to a pelagic environment in the Santa Barbara Channel

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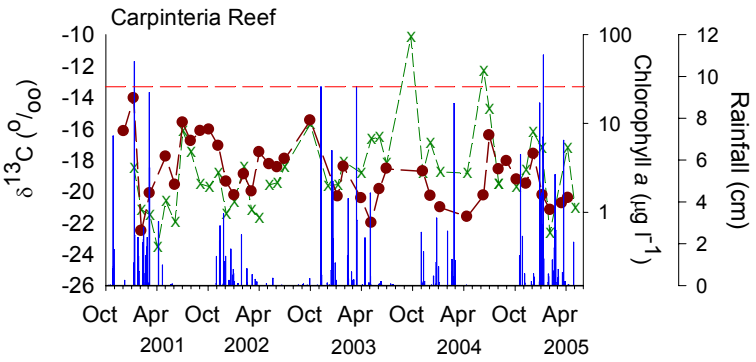
Food web studies using stable isotope

To identify food sources used by reef consumers under different conditions of runoff, ocean climate and giant kelp standing stock, we sampled potential food sources from 2001 through 2005 at four reef sites that differed in cover of giant kelp and proximity to freshwater runoff. We sampled reef suspended POM and giant kelp approximately monthly and understory algae annually to characterize variability in the isotope values of these potential food sources. The sampling period included water years (defined as from September through August) of low rainfall and freshwater runoff (2001-02, 2003-04) as well as a year of high rainfall (2004-05). We also investigated potential sources of variability in the isotope values of reef POM, including contributions from phytoplankton and terrestrial inputs. Phytoplankton biomass (as chlorophyll *a*) was measured monthly at each reef. We also measured the isotope values of POM in stream

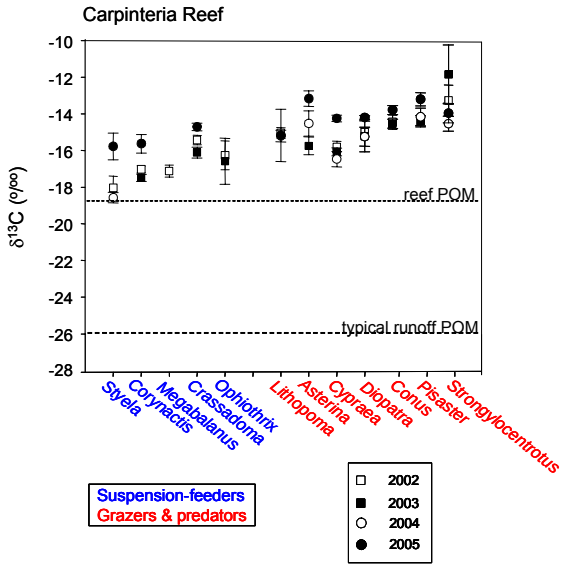


Temporal variation in $\delta^{13}C$ values of reef suspended POM (●) together with daily rainfall data measured in Santa Barbara (blue bars) and chlorophyll *a* concentration (x) measured monthly a Carpinteria Reef. Mean $\delta^{13}C$ value fo giant kelp (x±1SD=13.3±1.4‰) at thi reef (---) is also shown.

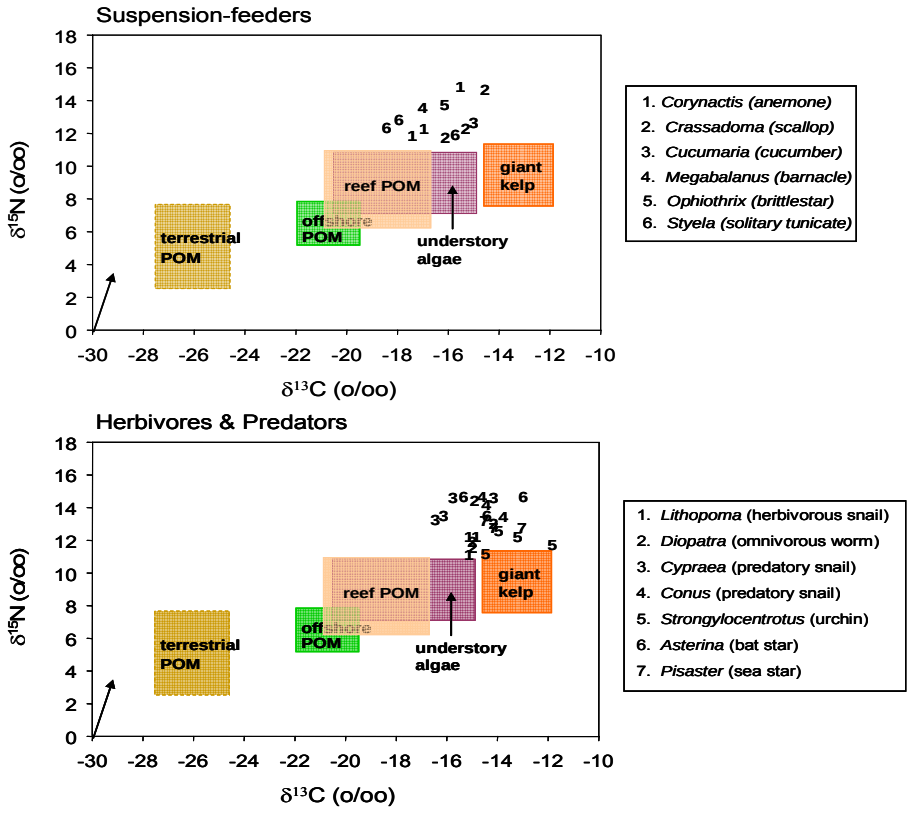
runoff during major storm events and of POM collected further offshore, at locations less likely to be influenced by inputs from reef benthic production or terrestrial runoff and more likely to reflect primarily a phytoplankton signature. Our data showed that the C isotope values of reef suspended POM differed from that of giant kelp with the greatest separation in values occurring in winter and early spring (Fig. 1). Reef POM consists of a mix of phytoplankton, macroalgal detritus, terrestrially-derived POM, and other material. Isotope values of reef POM varied over time in association with inputs of terrestrially derived material and with phytoplankton standing stock. This pattern was shown clearly at Carpinteria Reef, which is located offshore of 3 major streams. $\delta^{13}C$ values tend to drop during storm events and were highest during phytoplankton "bloom" events.

To identify food sources used by reef consumers, we sampled a variety of invertebrates of different trophic levels and feeding modes in March-April, from 2002 through 2005, at the four reef sites. The $\delta^{13}C$ values of consumers reflected marine rather than terrestrial sources of carbon even during the year of heaviest rainfall (2005), a pattern clearly evident at Carpinteria Reef. Plots of $\delta^{15}N$ versus $\delta^{13}C$ values can help better resolve potential food sources used by consumers. For Carpinteria Reef, isotope values of reef POM were intermediate to those of offshore POM, understory algae, and giant kelp, suggesting a mixture of sources. The isotope values of the suspension-feeders overlapped values of reef-suspended POM, after inclusion of the trophic enrichment factors, suggesting the incorporation of both phytoplankton and macroalgal-derived carbon.

$\delta^{13}C$ values for common invertebrate consumers from Carpinteria Reef together with mean values (dotted lines) for the giant kelp, *Macrocystis*, and suspended POM



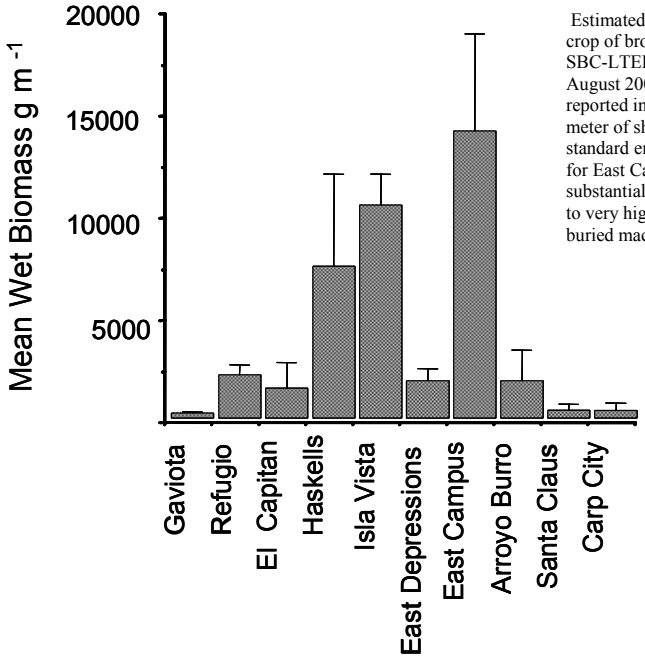
$\delta^{15}N$ versus $\delta^{13}C$ values for common invertebrate consumers from Carpinteria Reef together with mean values (±1SD) enclosed by rectangles for the giant kelp, *Macrocystis*, and suspended reef POM, understory algae, offshore POM, and terrestrial POM sampled during major storm events. Consumer data from samples collected in March-April 2002-2005. Arrow indicates the trophic enrichment in isotope values expected for C (+1°/oo) and N (+3.5°/oo).



Isotope values for herbivores and predators were shifted to the right relative to suspension-feeders, reflecting the importance of C derived from understory macroalgae and giant kelp in the diet of these consumers. Overall, the isotopic composition of reef invertebrates indicated the importance of phytoplankton and local benthic production to the reef food web.

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.*. Brown algal wrack composed 50% or more of the wrack at 5 of the 10 study beaches. Giant kelp, *Macrocystis pyrifera,* was an important component of the brown macroalgal wrack and composed more than 50% of that biomass at 8 of the 10 study beaches averaging 74%.



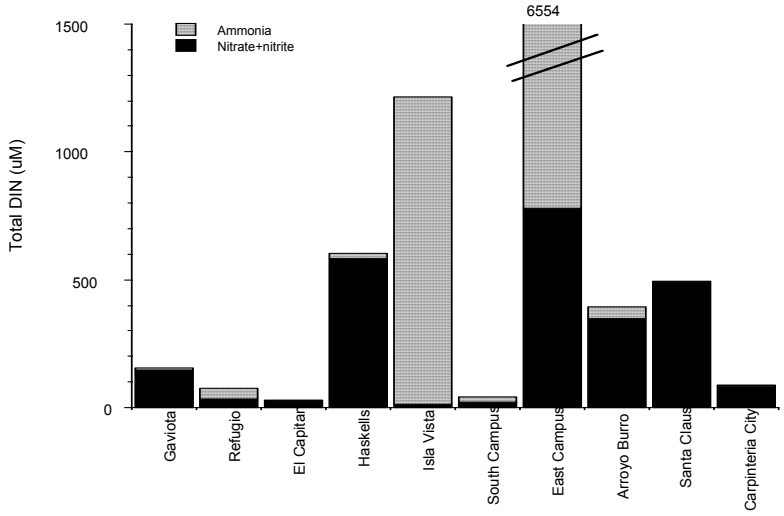
Estimated mean standing crop of brown macroalgae on SBC-LTER beaches* in August 2003 as wet biomass reported in grams per running meter of shoreline (+ 1 standard error, n =3) (*value for East Campus is a substantial underestimate due to very high quantities of buried macrophytes)

The standing crop of wrack (as wet biomass) varied over an order of magnitude among the 10 study beaches with mean values ranging from 246 to 14010 g m^{-1} of shoreline and values for individual transects ranged from 0 to 20080 g m^{-1} of shoreline. The estimated total standing crop of wrack varied significantly among the study beaches as did the total mean standing crop of brown algae. The standing crop of *M. pyrifera* also varied significantly among study beaches with mean values ranging from 207 to 8500 g m^{-1} of shoreline. Variation in the standing crop of wrack on beaches appears to 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) from 1998-2001 a period when this reef was dominated by sea urchins and supported little foliose macroalgae.

Our research on the cycling of nutrients derived from drift kelp and other macroalgae on sandy beaches of the SBC-LTER found that the porewater in the intertidal water table of many SBC-LTER sandy beaches contains very high concentrations of DIN (dissolved inorganic nitrogen) and thus may represent a potential source of nitrogen to nearshore waters and reefs. In comparisons of 10 beaches, the 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.

Total nitrogen concentrations in intertidal porewater were significantly and 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.

The concentration of total DIN in intertidal pore water also varied significantly with sampling level in most comparisons. The highest concentrations of nitrogen in intertidal porewater were generally found in the vicinity of the drift line where wrack accumulation and detrital consumer activity is highest (Lastra et al in press). The total concentrations of nitrogen (DIN) of intertidal porewater in samples from the high tide strand line and the mid beach were significantly greater than that of swash zone water at every beach sampled. However, the total concentrations of nitrogen (DIN) at the high swash level of the beach did not consistently differ from that of the swash zone water.



Mean concentrations of dissolved Nitrate+Nitrite and Ammonia in intertidal porewater samples collected at the drift line* for SBC-LTER beaches in August 2003 (n =3) (*East Campus samples collected at mid-intertidal runnel).

Our results also suggested that beach topography and terrestrial sources of N may affect the accumulation of nitrogen in beach porewater. One of the study beaches, East Campus, is narrow and bluff-backed but often has very high standing crops of wrack and can have well developed longshore runnels in the mid-intertidal zone. On this beach, the highest concentration of N in porewater was found in samples from a mid-intertidal runnel. At two of our study beaches, Santa Claus and Carpinteria City, higher concentrations of nitrogen were found in porewater samples from the upper beach well above the drift line. Although at the majority of the study beaches, the salinity of intertidal porewater was close or equal to the salinity of the surf zone water, porewater samples from Santa Claus and Carpinteria City were lower in salinity suggesting a upland source of nitrogen may also be present at these beaches.

OCEAN STUDIES

Channel surveys

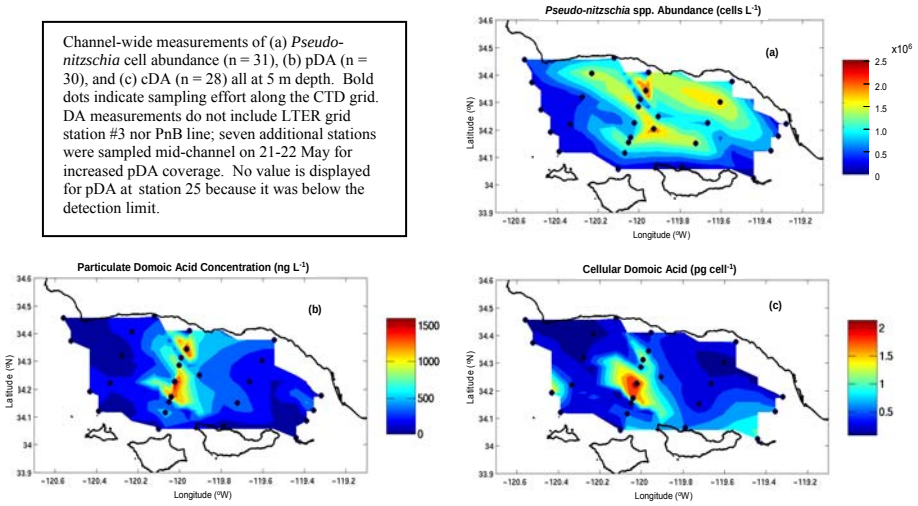
Pseudo-nitzschia bloom dynamics

Basin scale studies of the physical, chemical and biological properties of the Santa Barbara Channel (SBC) were examine during 14 cruises aboard the R/V Point Sur during the winter, spring and autumn of 2001-2005. These cruises were originally designed to examine the relationship between the circulation state of the basin and the distribution of physical, chemical and biological properties with the long-term goal of relating circulation state to the delivery of resources to nearshore rocky reefs. The cruises also proved extremely valuable in sampling blooms of toxic phytoplankton in the Santa Barbara Channel. SBC LTER successfully sampled two of these blooms at times when significant marine mammal deaths were occurring due to domoic acid poisoning. These cruise data were analyzed by one of our graduate students, Clarissa Anderson, as part of her Ph.D. dissertation.

The Southern California Bight has historically been a region of few nuisance phytoplankton, but blooms of the pennate diatom genus *Pseudo-nitzschia* have become frequent in recent years. Though toxin-production is rare in diatoms, several species of *Pseudo-nitzschia* can synthesize the toxin, domoic acid (DA), which bio-accumulates in shellfish and finfish. Once consumed by sea mammals, DA replaces a crucial neurotransmitter, resulting in deleterious health effects and causing amnesic shellfish poisoning in humans. While *Pseudo-nitzschia* spp. have long been recorded in surveys of phytoplankton species composition for the Southern California Bight, the apparent recent rise in cell abundance and toxigenic events in this region parallels recent worldwide increases in harmful algal bloom frequency and the entire west coast of California experienced devastating impacts to marine life due to extensive blooms of the toxigenic *P. australis* and *P. multiseries*, recorded from Monterey to Santa Barbara. In the springs of 2002 and 2003, two blooms of *Pseudo-nitzschia* spp. in the Santa Barbara Channel (SBC) resulted in >1,500 pinniped deaths, which has raised questions regarding the causes and natural frequency of local toxic events.

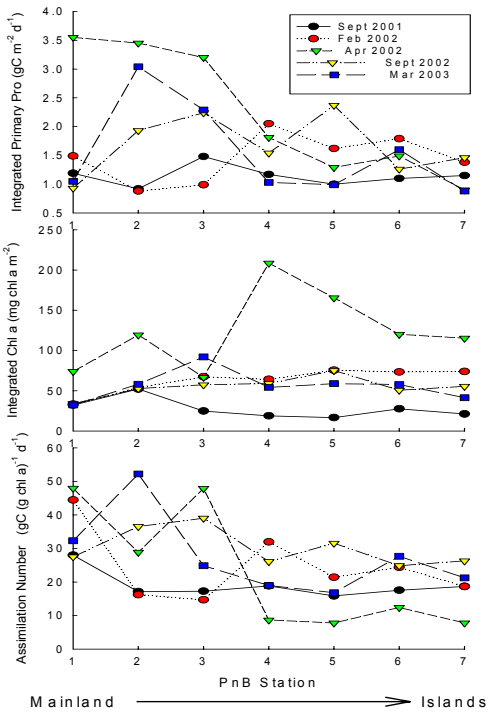
The toxic bloom of May 2003 was particularly interesting as it revealed a possible relationship between bloom toxicity and the mesoscale circulation of the basin. The bloom followed a period of strong, spring upwelling along the continental shelf of the SBC. The bloom was dominated by the domoic-acid (DA) producing species *Pseudo-nitzschia australis* and covered most of the channel. *P. australis* abundance ranged from 0.4 x 10^5 - 2 x 10^6 cells L^{-1} with particulate DA concentrations of 32-1,684 ng L^{-1}. High *P. australis* abundance was observed along the mainland coast but the highest levels of cellular DA (0.14 - 2.1 pg $cell^{-1}$) were found offshore. This zone of elevated cellular domoic acid coincided with the location of a mesoscale eddy in the western basin. These eddys occur regularly within the SBC and are known to be convergent. Convergence within the eddy may have concentrated *P. australis* cells for at least a week. The presence and apparent westward movement of the eddy in the SBC indicated that coherent circulation features may help predict the fate of harmful algal blooms in coastal systems.

Channel-wide measurements of (a) *Pseudo-nitzschia* cell abundance (n = 31), (b) pDA (n = 30), and (c) cDA (n = 28) all at 5 m depth. Bold dots indicate sampling effort along the CTD grid. DA measurements do not include LTER grid station #3 nor PnB line; seven additional stations were sampled mid-channel on 21-22 May for increased pDA coverage. No value is displayed for pDA at station 25 because it was below the detection limit.



Phytoplankton primary production

Phytoplankton blooms occur in two general locations in the Santa Barbara Channel. The first is the western Channel where productivity is influenced by inflow and vertical Ekman pumping of cold, high-nutrient waters. These blooms are observed in satellite data as well as with data collected during the LTER cruises. These cruises, scheduled ~three times per year for 5 years, provided an assessment of phytoplankton biomass and primary productivity associated with mid-channel blooms. The second location of focused surface blooms is the coastal waters influenced by local river plumes, predominantly from the Santa Clara River in the eastern Channel. These were primarily observed through satellite measurements, as well as in selected "event" surveys, in which depth profiles of temperature, salinity, assorted nutrients and chlorophyll a, were collected from a small boat in the nearshore immediately after a big rainstorm to assess the hydrographic and nutrient conditions caused by terrestrial plumes. Phytoplankton primary production was measured seasonally during our UNOLS cruises from the surface to the 1 % light depth along seven stations in the center of the CTD grid (also the line used in Plumes and Blooms sampling), and at 5 m depth at each station of the channel-wide CTD grid using ^{14}C labeled bicarbonate incorporation (see http://sbc.lternet.edu/sites/coastoceanicmap.html for locations of sampling sites). Productivity tended to be higher along the mainland with the highest integrated primary productivity occurring in April/May 2002. An important trend was that peaks in both primary production rates and assimilation numbers (primary production normalized to chl a concentration) were skewed toward the mainland side of the channel. This pattern is not as evident in the integrated chlorophyll data suggesting that phytoplankton removal processes are



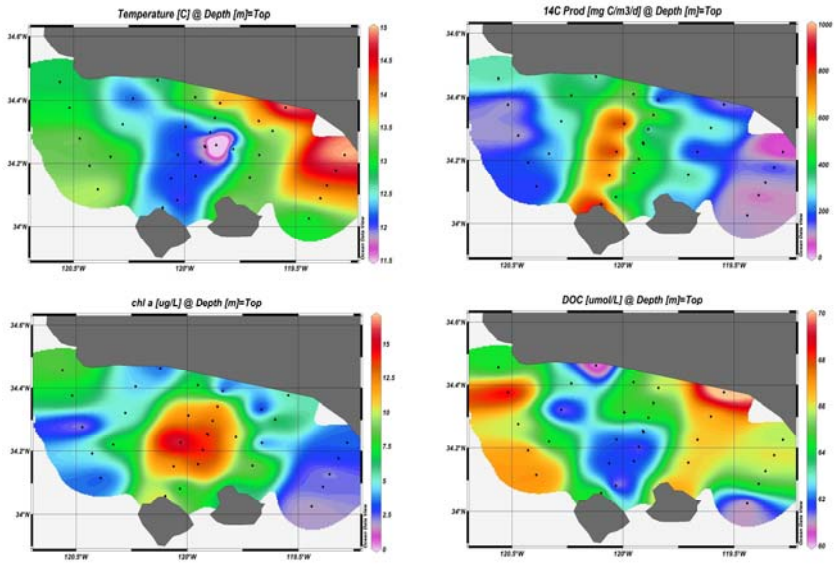
higher near the mainland. The peaks in phytoplankton primary productivity coincided with the coldest sea water temperatures and highest nutrient conditions observed for that year. This demonstrated the importance of seasonal climate and the effects of spring upwelling on channel-wide primary productivity. Productivity in February and September of both years was lower than in spring, with no clear seasonal difference between winter and fall.

One of our long-term goals was to establish a time series of primary production within the basin to examine how phytoplankton respond to climatic forcing such as El Nino and the Pacific Decadal Oscillation. Our data set is presently inadequate to address these issues, but the average integrated primary production along the Plumes and Blooms line is beginning to reveal a seasonal trend (data not shown). We will use these data along with maps of primary production from our CTD grids and satellite imagery to interpolate monthly rates of phytoplankton production over the entire basin.

Spatial and temporal patterns of dissolved organic carbon

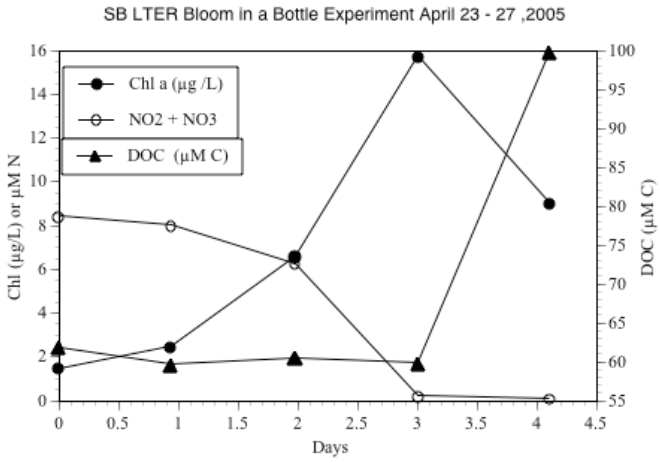
Despite its proximity to the coast and being a site of relatively high phytoplankton productivity(> 2 g C m^{-2} d^{-1}) we observed DOC concentrations in the Santa Barbara Channel that were less than or equal to DOC concentrations measured at the Bermuda Atlantic Time-Series (BATS) site located in the subtropical oligotrophic gyre of the North Atlantic. However, significant heterogeneity in DOC concentrations was observed throughout the channel. The variability in DOC concentrations is controlled by DOC production and removal processes as well physical dilution processes within this upwelling system. Studying the sources and fate the DOC produced in upwelled water masses can provide insight to bioavailability of this organic pool and perhaps provide insight into the physiological state of the phytoplankton blooms.

Surface contour maps of Temperature, 14C primary productivity, Chl a, and DOC in the Santa Babara channel April 2005 (LTER 13).



During our UNOLS cruise in April of 2005 we found that DOC concentrations decreased during upwelling as a result of entraining low DOC water from depth to the surface. Interestingly DOC concentrations remained relatively low even as primary production and Chl *a* levels increased in response to upwelled inorganic nutrients. Because oceanic DOC is ultimately controlled by the magnitude of primary production it may appear counter intuitive that DOC concentration remains relatively low in the presence of elevated primary production. We observed a similar pattern during hyperproductive blooms in the Ross Sea Antarctica (Carlson et al. 2000). Experimental results from work conducted on our cruise in April 2005 helped to explain this pattern. To simulate an upwelling event water from surface and 60 m were mixed together and incubated in an on-deck incubator for 4 days. Samples for nutrients, chl a and DOC were monitored over the course of the incubation. The results indicated that the release of DOC and large-scale accumulation of DOC from the plankton community appears to be related to the physiological state of the bloom. For example, during periods when nutrients are replete and phytoplankton are in log growth, the phytoplankton efficiently retained the newly produced organic matter in particulate form. As the nutrient

field transitions from nutrient replete to nutrient depleted conditions and Chl a decreased, DOC was actively released and accumulated. This work demonstrated that upwelling and physiological state of the phytoplankton bloom have an impact on DOC concentrations and variability and likely control the lability of this organic pool.

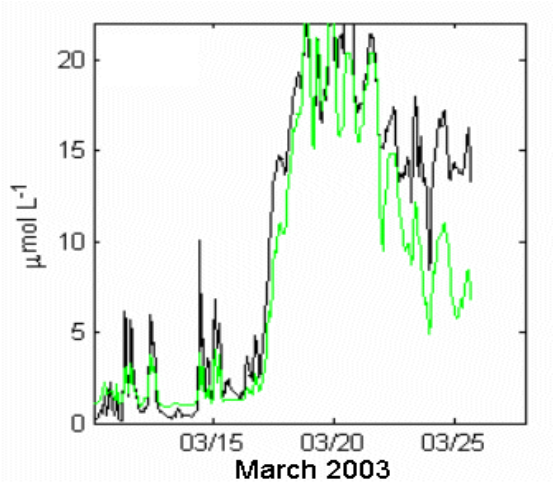


<u>DOM Bioreactivity Index</u>

Cowie and Hedges (1994) revealed that changes in total carbohydrates (TCHO) relative to bulk DOC could be used as a diagenetic index of reactivity in oceanic settings. Bulk carbohydrates (TCHO) are the largest constituents of the characterized fraction of DOM, accounting for 20-40% of organic matter in surface waters. Our preliminary work comparing the bioavailability of DOC in the Santa Barbara Channel and BATS site showed that DOM from the SBC supported greater microbial growth and carbon utilization than DOM derived from the oligotrophic Sargasso Sea (Figure 4, Goldberg and Carlson unpublished data). TCHO:DOC ratios for SBC surface waters were roughly 33% greater than the oligotrophic Sargasso Sea. The enhanced reactive nature of this dissolved substrate significantly affects microbial metabolic processes. Seawater remineralization experiments revealed a 2-fold increase in bacterial carbon and a 6-7 uM C drawdown of DOC by microbes grown on this enriched carbohydrate substrate. Such bioavailability may also be related to nitrogen rich DOM pool (i.e. lower C:N ratio). While the use of these bioreactivity indices can be applied over large spatial scales, the goal of this work was to characterize sources of DOM within the smaller scale of the SBC and predict bioavailability of these specific sources. These experimental results are consistent with bioreactivity predicted by DOM quality proxies.

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

We used observations from moorings at the three core reef sites spanning the eastern to western end of the Santa Barbara Channel 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 we collected showed that the mechanism supplying the most nutrients to kelp forests in the Santa Barbara Channel is upwelling (McPhee et al. 2007).



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 ~0.05 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

We 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 near creek and river outflows. Peak values near 80 μmol 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's of km. Describing this spatial variability is important for quantifying subsidies of nutrients to kelp reefs in our study region.

Surface Current Patterns

An important finding for the SBC-LTER was the discovery of small, coastal eddies which may be important for supplying nutrients and biogenic particles to kelp forests and other inner shelf habitats of the Southern California Bight. HF radar observations show that rotary, eddy-like circulation patterns frequently occur along the mainland coast of the Santa Barbara Channel (SBC) within the SBC-LTER study area. The eddies are 4-15 km in diameter and typically last about 2 days, although some last up to 6 days. Most eddies within the radar coverage area are anti-cyclonic with relative vorticities of -0.4 *f* to -0.8 *f* where *f* is the Coriolis parameter, but cyclonic eddies are also observed. Figure 1 below shows the evolution of small anti-cyclones near Coal Oil Point, CA (COP) during 10-15 December 2001. On 10 December, an anti-cyclonic eddy about 7 km in diameter was centered over the 75 m isobath on a steeply sloping section of the shelf (Figure 1a).

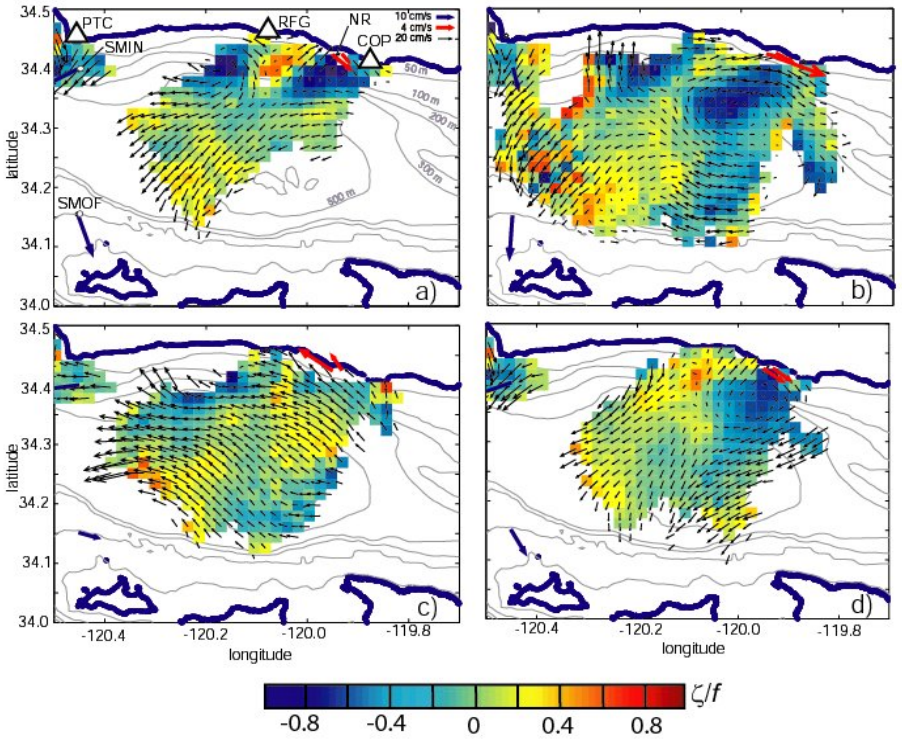


Figure 1. Evolution of the surface velocity field in 2001 on a) 10 December 0000 GMT, b) 11 December 0800 GMT, c) 13 December 1600 GMT, d) 15 December 0000 GMT. Black arrows indicate surface current vectors measured by HF radars (triangles) at Coal Oil Point (COP), Refugio (RFG), and Pt. Conception (PTC). Colors indicate normalized relative vorticity ζ/f scaled according to the color bar. Red arrows west of COP are current velocities measured 12 m above bottom by ADCP's at Naples (NR) and the nearby Ellwood mooring (not labeled). Blue arrows are current velocities measured at 5 m depth at moorings SMIN and SMOF (circles)

Another anti-cyclonic eddy was also present about 15 km to the west, although it was only partially resolved due to reduced radar coverage. An acoustic Doppler profiler (ADCP) at the Naples Reef (NR) mooring also showed that currents had reversed with eastward speeds of 0.1-0.2 m s^{-1} over the water column (gray lines,

Figure 2a). Velocity time series obtained from the HF radar grid point nearest the NR mooring (black line, Figure 2a) were consistent with those from the ADCP. Rotation was strong with $\zeta/f \approx -0.8$, (Coriolis parameter $f = 8.2 \times 10^{-5}$ s^{-1}). By 11 December the eddy near COP on 10 December had moved offshore and expanded to 10-15 km in diameter (Figure 2b). The eddy coincided with eastward velocities of 0.2-0.4 ms^{-1} at the NR mooring (Figure 2a). The eddy to the west remained, but was not well resolved within the radar coverage. On 13 December the eddy off COP had been replaced by westward flow, the prevailing current direction along this section of the coast, with little rotation near shore (Figure 1c). On 15 December another anti-cyclonic eddy was present, this one with a diameter of about 13 km and maximum $\zeta/f \approx -1$ (Figure 1d). The eddy was associated with eastward flow near shore with a maximum speed of ~0.3 ms^{-1} at the NR mooring (Figure 2b). This eddy was centered over the 300 m isobath. By 16 December the eddy was gone and alongshore flow to the west prevailed near shore.

Time series of water properties at the NR mooring indicate that these eddies can transport cooler, higher salinity, and higher nitrate waters to the inner shelf. Temperature dropped by about 2.5 °C and salinity increased by 0.4 when the first anti-cyclonic eddy was at the NR mooring on 10-11 December (Figure 2b). Temperature dropped by about 1 °C and salinity increased by about 0.1 when the second eddy was present on 15 December. However, at the same time other processes such as larger scale water mass advection were also producing temperature and salinity variability at longer timescales. Nitrate concentration rose sharply when the eddies were present (Figure 2c). During the passage of the first eddy when eastward flow at the NR mooring was strong, nitrate increased from background levels of 1-2 μM to a maximum of around 12 μM over 10-12 December. Nitrate concentration then decreased to 1-2 μM by 14 December

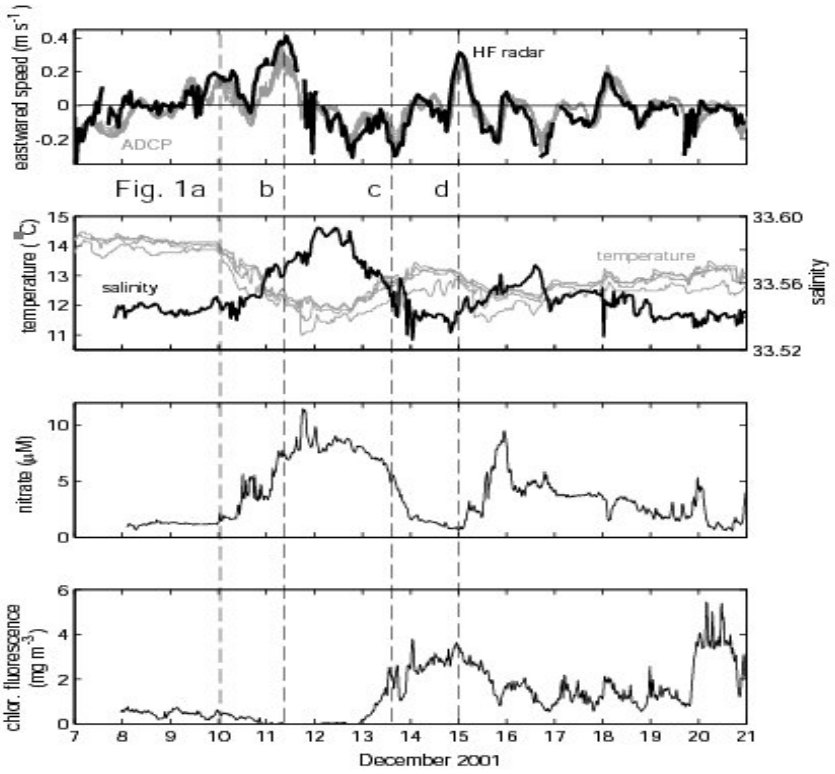


Figure 2. Time series during 7-20 December 2001. a) Black line is the eastward component of current velocity measured by HF radar for the grid point nearest the NR mooring. Gray lines are the eastward components of current velocity from all ADCP bins (1 m depth intervals). b) Black line is salinity (right hand scale) and gray lines are temperature (left hand scale) measured at four depths at the NR mooring. c) Nitrate measured near the NR mooring. d) Chlorophyll fluorescence measured at the NR mooring. Vertical dashed lines indicate times of panels in

when westward flow returned. A pulse of nitrate with a maximum of 9 μM occurred on 15 December as the velocity at NR changed from eastward, during the passage of the second eddy, to westward. Chlorophyll fluorescence, expressed in Fig. 2d as approximate chlorophyll concentration, increased following the first eddy, possibly due to advection or phytoplankton growth in response to the increased nitrate. The time lag between the beginning of elevated nitrate and the beginning of the elevated fluorescence was about 3 d.

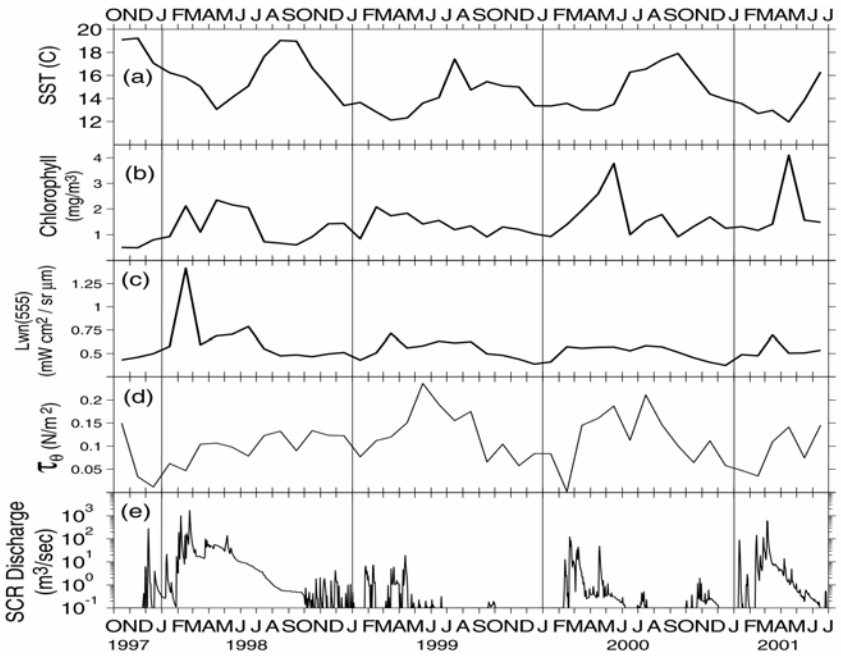
The coast west of COP had the best HF radar coverage and was used to examine the occurrence frequency, and duration of a 4-year time series radar observations. Over 1998-2001, a period which spans part of an

El Niño event (1998) and a La Niña event (1999), eddies occurred 11% of the time or ~ 41 dy^{-1}. No clear seasonal trend in eddy occurrence was found. Eddies ranged in diameter from 4-15 km and were typically centered between the 50 m and 300 m isobaths. They persisted from 1- 6 d, averaging about 1.5-2 d. Typical azimuthal velocities were 0.1-0.2 m s^{-1} corresponding to spatially-averaged ζ/f of about -0.5 to -1 for a 10 km diameter eddy. Maximum azimuthal velocities were ~0.4 m s^{-1}.

Sub-mesoscale eddies, mostly anti-cyclonic, are common features over the slope and inner shelf of the northern coast of the SBC. Previous studies have shown that sub-mesoscale eddies on comparable spatial scales, but mostly cyclonic, are ubiquitous in the upper ocean. Details of their generation are not well understood due in part to a lack of *in situ* observations. We speculate that the anti-cyclonic relative vorticity of the eddies near COP results from bottom friction acting on the prevailing westward current with a coastal boundary to the north. Collectively, our observations indicate that the eddies can transport high concentrations of nitrate to the shallow waters of the inner shelf which is important habitat for beds of the giant kelp, *M. pyrifera* in the Southern California Bight. *M. pyrifera* is an important habitat forming species along the California and Baja Californa coasts. In summer, especially during El Nino events, when nitrate concentrations fall below ~1 μM, nutrient limitation inhibits growth of *M. pyrifera*. Thus, the eddies may be an important mechanism for sustaining *M. pyrifera* beds under otherwise nutrient limiting conditions.

Satellite Data

Satellite ocean-color and sea-surface temperature (SST) imagery were used to assess the occurrence, extent and duration of surface sediment plumes from discharged stormwater and phytoplankton blooms in the Santa Barbara Channel (Otero and Siegel, 2004; Warrick et al. 2004). Monthly mean annual cycles of SST, chlorophyll (Chl) and the water-leaving radiance at 555nm (LwN(555)), an index for sediment-affected waters, showed plumes associated with runoff in winter, while blooms occur in the late spring–early summer were associated with cool SST and upwelling favorable winds. Interannual variations were consistent with remote forcing by El Niño cycles. During the 1997–1998 El Niño, Chl concentrations were moderate, and El Niño-induced floodwater discharges resulted in high LwN(555) values throughout the Santa Barbara Channel. However, a correspondence between El Niño–La Niña a state and Chl was 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 was used to spatially and temporally deconvolve processes regulating SST, Chl and LwN(555) (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) were 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.