

Preview of Award 1232779 - Annual Project Report

Cover

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Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Daniel C Reed

Accomplishments

* What are the major goals of the project?

The Santa Barbara Coastal LTER (SBC) seeks to develop a predictive understanding of how land and ocean processes alter the biological structure and ecological functions of giant kelp forests under varying conditions of disturbance and climate. The amount of inorganic nutrients, organic matter, and sediments exchanged between kelp forests and the land and sea that adjoin them varies in response to changes in climate, ocean conditions and land use. Variation in the supply of these materials interacts with natural and human-caused disturbances to influence the abundance and species composition of the forest inhabitants, their ecological functions and the ecosystem services that they provide. Thus a general goal of SBC is to understand how coastal ecosystems at the land-sea margin are linked through the exchange of materials. Giant kelp forests are highlighted in our research because they are prominent coastal ecosystems in California and other temperate regions of the world. Site-based research focuses around the following three inter-related themes: (1) Biotic and abiotic drivers of kelp forest structure and function, (2) Material exchange at the land-ocean margin, and (3) Movement and fluxes of inorganic and organic matter in the coastal ocean.

The major goal of each research theme is as follows:

Theme 1: To determine how variations in climate, wave disturbance and fishing influence the structure and dynamics of kelp forest communities and the fate of net primary production by giant kelp.

Theme 2: To determine how the input of dissolved and particulate nutrients from watersheds and coastal margins to nearshore waters varies as a function of land use, disturbance by fire and storms, seasonality and longer term climate variations.

Theme 3: To determine how oceanographic processes act to influence: (a) the dilution and dispersal of freshwater runoff plumes, (b) nitrogen recycling and efflux from benthic sediments within and adjacent to kelp forests, and (c) the fate of net primary production by phytoplankton.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities: We collected data for a core group of long-term integrated measurements on land and in the ocean aimed at quantifying inorganic and organic subsidies to and from giant kelp forests in the Santa Barbara Channel and their effects on kelp forest community structure, productivity and dynamics (see attached document). Other major activities for each research theme follow below.

Theme 1a. Effects of wave disturbance on kelp forest structure and function

We continued to monitor and maintain our long-term kelp removal experiment designed to investigate the consequences of increased wave disturbance on kelp forest communities. The conversion of time-series data of abundance (% cover and density) into biomass was completed and analyses of biomass data have begun to investigate the ability of subordinate algae to compensate for the reduction in NPP following the loss of dominant species and the effects of diversity and species composition on spatial and temporal variation in kelp forest NPP. We worked with scientists from the National Park Service and the US Geological Survey to assemble time series data and meta-data from long-term monitoring of island kelp forests in the Santa Barbara Channel. Using the Landsat time series of kelp biomass we characterized the temporal synchrony of patches of giant kelp throughout the Southern California Bight and began developing a model of kelp metapopulation dynamics.

Theme 1b. Determining the fate of kelp NPP

Time-series data of frond initiation and survival were analyzed to determine the extent to which biomass dynamics of giant kelp is related to external environmental factors vs. intrinsic biological characteristics. Field and laboratory incubations aimed at measuring rates of dissolved and particulate losses from kelp blades and stipes were coupled with time series data of standing biomass to estimate spatial and temporal variability in the production of DOC and suspended POC by giant kelp forests. Dissections to quantify gut contents and stable isotope analyses of muscle tissue were done to evaluate the diet and trophic position of common kelp forest consumers.

Theme 1c. Effects of fishing on kelp forest structure and function

Quarterly sampling of community structure and NPP in experimental plots was completed at two reefs protected from fishing and three reefs unprotected from fishing. Densities of the extensively fished spiny lobster (a key kelp forest predator) were also assessed at these reefs and lobster fishing effort was measured twice per month during the fishing season. We completed a field study with colleagues at Chapman University that tested whether prey reductions in marine protected areas (MPAs) caused lobsters to broaden their diet to include less palatable prey that are ignored outside reserves, thereby amplifying top-down effects on community structure. We initiated studies inside and outside of MPAs to determine whether fishing increased susceptibility to invasion by the introduced seaweed *Sargassum horneri*.

Theme 2a Export of nutrients from watersheds

We continue to determine stream discharge and to measure concentrations and calculate fluxes of dissolved and particulate nutrients, organic matter and sediments in streams representing various land uses and in watersheds recovering from fires. We began using the ecohydrological model RHESSys to assess how climate variability influences hydrologic responses and associated nutrient fluxes over a range of time scales and fire frequency/severity scenarios. We conducted field-based sampling and simulation modeling of soil nitrogen dynamics in burned and unburned watersheds.

Theme 2b. Trajectories of landscape changes in coastal watershed

Because a significant aspect of material input to nearshore waters concerns how fire, urbanization and agriculture alter the landscape to modify these inputs, we are using a variety of remotely sensed imagery to classify and map changes in land cover and characterize biophysical properties of the vegetation. To examine longer term aspects of landscape change we performed cosmogenic radionuclide analysis of riverine sands and collected and analyzed sediment cores from accumulated deposits at Carpinteria Slough.

Theme 2c. Exchanges of nutrients on beaches

We measured inputs of macroalgal wrack to beaches, densities of beach wrack consumers, and nutrient composition and concentration in intertidal porewater at beaches with and without sea walls to assess the effects of coastal armoring on beach food web structure and biogeochemical cycling. We regularly sampled the dissolved and particulate C and N chemistry, and other analytes including dissolved oxygen, radon-222, and specific conductance, to estimate rates of biogeochemical processing in beach porewater. We designed and constructed flow-through reactors for laboratory experiments aimed at determining how the source and age of POM in beach sands affects biogeochemical cycling.

Theme 3a. Dilution and dispersal of freshwater runoff plumes

We performed numerical simulations and collected in situ measurements of storm runoff plumes to parameterize the dilution field surrounding kelp forests as a function of water properties, ocean currents, surface waves, and wind conditions. Numerical simulations with the Regional Ocean Modeling System (ROMS) of storm water plumes from two creeks near Mohawk Reef encompassed the wet seasons of two years. Additional ROMS simulations were done to examine the spatiotemporal evolution of stormwater plumes. An array of CTDs and ADCPs were deployed during the 2012 runoff season to monitor freshwater plumes near Mohawk Reef.

Theme 3b. Nitrogen recycling and efflux from sediments

Time series data of dissolved inorganic nitrogen collected from water samples were analyzed to investigate diel and interannual variation in concentrations of different forms of nitrogen in kelp forests.

Theme 3c. Transport and fate of phytoplankton NPP

We performed high-resolution numerical simulations of the dispersal of water masses, collected high-frequency data of cross-shelf exchanges using an autonomous oceanographic glider, and analyzed a large data set collected during oceanographic cruises from 2000-2006. Simulations and analyses of nearshore

water mass dispersal were done for autumn and winter using billions of individual particle trajectories generated with ROMS. Simulated dispersal was analyzed with respect to direction relative to the shelf, distance from the shore, coastal geometry, and energy of the flow. Additional analyses that included the effects of surface waves on water mass dispersal were done to evaluate transport by the wave-induced Stokes Drift. We completed four cross-shelf glider missions (each ~ 17 d duration), and two missions where the glider was used as a virtual mooring (sampling one single location for 3 and 10 days respectively) to resolve sub-hourly changes in physical and bio-optical water properties in nearshore depths between 20 and 70 m. Sampling was designed to: 1) characterize the factors controlling phytoplankton distribution, oxygen utilization and net community production on time scales of days to weeks; 2) characterize the timing, shape and persistence of diel cycles of bio-optical properties across various environmental conditions; and 3) understand the bio-physical links between the inner and outer shelf using complementary satellite data.

Specific Objectives: *Theme 1a. Effects of wave disturbance on kelp forest structure and function*

Determine the importance of wave disturbance on kelp forest community structure primary production and metapopulation dynamics under different climatic conditions from analyses using data from long-term experiments and core time-series measurements.

Theme 1b. Determining the fate of kelp NPP

Determine the amount, rates and forms of biomass lost by giant kelp, the factors affecting these losses and the proportion of giant kelp NPP that is retained and utilized in the kelp forest versus exported to other ecosystems.

Theme 1c. Effects of fishing on kelp forest structure and function

Experimentally investigate the short and long-term effects of fishing on kelp forest structure and function, and place these effects within the context of past variability resulting from different climatic conditions.

Theme 2a. Export of nutrients from watersheds

Determine climatic variation in the fluxes of dissolved and particulate nutrients, organic matter and sediments to the Santa Barbara Channel from watersheds with different fire histories and land uses. Estimate post-fire nitrogen cycling and vegetation growth in chaparral ecosystems and determine the factors controlling the amount of nitrogen exported from them.

Theme 2b. Trajectories of landscape changes in coastal watersheds

Use time series of airborne hyperspectral data to develop land cover maps before and after fires for use in ecohydrological modeling, nutrient flux calculations and examination of riparian conditions along streams. Calculate gully depths and erosion rates from Lidar data for unburned and burned catchments. Extend the time scale of our examination of landscape changes with cosmogenic radionuclide analysis of riverine sands and analyses of sediment cores taken from estuaries that border the Santa Barbara Channel.

Theme 2c. Exchanges of nutrients on beaches

Determine the degree to which beach ecosystems supply recycled marine

nutrients to nearshore waters. Determine the effect of varying organic matter source and processing history on the dissolved organic and inorganic carbon and nitrogen dynamics in beach sands.

Theme 3a. Dilution and dispersal of freshwater runoff plumes

Simulate several realizations of stormwater plumes to enable a robust statistical characterization of the dispersal and dilution of runoff in the coastal environment. Analyze the flow fields generated with ROMS and data collected from moored instrument arrays during the 2012 runoff season to better understand cross-shelf exchanges in the nearshore due to runoff.

Theme 3b. Nitrogen recycling and efflux from sediments

Determine the importance of regenerated N to the nitrogen demand of giant kelp by measuring rates of nitrogen efflux from sediments and rates of N recycling by kelp forest consumers

Theme 3c. Transport and fate of phytoplankton NPP

Characterize coastal dispersal with respect to several environmental parameters such as season, coastal geometry, distance from the shore, surface wave forcing, and flow characteristics. Deploy an autonomous glider to obtain highly resolved cross-shelf sections of physical and bio-optical properties for various oceanographic conditions. Calculate and validate derived bio-optical information, including net community production, particle size distribution, particulate organic carbon, and transport velocities. Use statistical methods and time-series data from moored instruments and cruises to determine patterns and sources of variation in ocean physics, particle distributions, net community production and chlorophyll at biologically relevant time and space scales.

Significant Results:

Theme 1a. Effects of wave disturbance on kelp forest structure and function

Analyses of time series data did not provide support for the hypothesis that NPP by subordinate understory algae fully compensate for the loss of NPP by giant kelp caused by wave disturbance. The diversity (H') and evenness (S) of the algal community was negatively related to giant kelp biomass and community NPP while species richness of the algal community was unrelated to these variables. Two data papers containing time series data and metadata from kelp forests in the Channel Islands were accepted for publication in *Ecology*. Analyses of Landsat data revealed that population synchrony in giant kelp decreased with distance. Synchrony at small scales (< 1.3 km) was related to local processes controlling recruitment success and grazing intensity while synchrony at larger scales was related to wave climate.

Theme 1b. Determining the fate of kelp NPP

The loss of whole fronds was the most important factor contributing to biomass dynamics in giant kelp. Internal biological processes such as progressive senescence rather than external environmental factors accounted for the majority of variation observed in frond loss. Incubation experiments coupled with time series data of NPP revealed that production released as DOC accounts for 17% of NPP by giant kelp. Trends in DOC production were tightly linked to standing biomass; other factors such as time of day, tissue age, and tissue type explained only about 3% of the variation in DOC production. Small suspended particles of

detritus shed from kelp blades contributed < 0.2 % of total suspended POC and PON in the forest suggesting that small kelp detrital particles do not represent a significant food source to kelp forest suspension feeders. The $\delta^{15}\text{N}$ values of kelp forest consumers increased from known herbivores to higher-level consumers, which fed largely on invertebrates rather than on fish, as is often assumed.

Theme 1c. Effects of fishing on kelp forest structure and function

Lobsters attacked unpalatable sea hares exclusively inside old (> 20 years) reserves, where lobster density was high and prey density was low; no attacks were observed in fished areas, or in a more recently established (9 year old) reserve. Palatable market squid were attacked equally inside and outside reserves. Such trait-mediated effects on predators are likely to amplify the ecological effects of MPAs. Densities of the invasive seaweed *Sargassum horneri* were higher outside reserves compared to inside reserves.

Theme 2a. Export of nutrients from watersheds

Stream discharges and nutrient fluxes were quite low in 2013 due to low rainfall. RHESSys parameterizations for chaparral vegetation produced reasonable estimates of NPP, biomass, leaf area index and nitrification rates for chaparral ecosystems. Microbial biomass in soils was high after fire, but decreased over the subsequent growing season to levels well below those observed in unburned areas. Thus, it appears that post-fire ash deposition provided a flush of nutrients that stimulated soil microbial growth, followed by a decline when resources were depleted. RHESSys simulations using real climate data and fires starting in May or November for each of 15 different years allowed comparison of the effects of fire as a function of both season and the climate. Initial modeling results suggest that the strongest variability occurs during the first few years of recovery.

Theme 2b. Trajectories of landscape changes in coastal watersheds

All hyperspectral data acquired by AVIRIS were georectified and converted to surface reflectance; spatial resolutions varied from 16 m (2004), 12 m (2009 through April 2010), 7.5 m (July, November 2011) and 3.5 m (fall 2010). Products include a 2004 species-level/land-cover map, liquid water, vegetation indices and spectral fractions for all images through 2011. Cosmogenic radionuclide analyses that integrate catchment-scale erosion rates over 100s to 1000s of years indicated erosion rates of 0.2 mm/y for the steep, upper catchments. Analyses of Lidar data revealed highly dissected parts of the landscape with gully depths > 2m indicating that 50% of the erosional signal can be explained by gully formation. Two important pollen horizons were identified in sediment cores collected from Carpinteria Slough that mark the onset of European cultivation in the area (1770-1786) and the introduction of eucalyptus (1870s).

Theme 2c. Exchanges of nutrients on beaches

Wrack abundance, nutrient concentrations and POM composition in intertidal porewater were altered by armoring, suggesting seawalls affect nutrient cycling on beaches. Concentrations of DOC and DON and the proportion of DIN to DON increased with porewater residence time as microbial processing enriches the porewater in dissolved nitrogen. Ammonium was the dominant form of dissolved nitrogen in beach porewater, elevated nitrate was only observed at the water table surface and upper intertidal zone, making ammonium the primary form of

dissolved nitrogen flux from beach sand to the coastal ocean.

Theme 3a. Dilution and dispersal of freshwater runoff plumes

The numerical simulations of storm water runoff predict plumes that are generally trapped against the coast and cross-shelf exchange that is largely influenced by surface winds and submesoscale flow structures. Flow within a few kilometers of shore is organized into frontal structures that are generally aligned with the coast that can inhibit cross-shelf transport. Tidal harmonic analysis of velocity data from the ADCP array indicate that the alongshore velocities were predominantly driven by tides, whereas the cross-shore velocities were due to non-tidal processes that include waves and winds. The depth-averaged wave-driven Stokes drift cross-shore velocity at 11 m depth ranged from 1 – 4 cm/s, which was comparable to the Eulerian mean cross-shore velocity, suggesting the importance of wave-driven transport at shallow depths.

Theme 3b. Nitrogen recycling and efflux from sediments

Time series data show the ambient concentrations of ammonium rivals that of nitrate+nitrite during summer and autumn. This approximate doubling of dissolved inorganic nitrogen (DIN) is sufficient to account for the apparent deficit in N supply required to balance kelp N production during summer and bring total DIN concentrations above the threshold needed to sustain kelp growth. Ammonia distributions within and offshore of the Mohawk kelp forest suggest a benthic source that is consistent with efflux of ammonium from sediments or its excretion by benthic reef consumers.

Theme 3c. Transport and fate of phytoplankton NPP

Simulations showed water mass dispersal increases with distance from the shore and is predominantly aligned along-shelf close to shore. Headlands are more dispersive than bays. Coastal dispersal was parameterized with a power-law model as a function of coastal geometry, distance from the shore, energy of the flow, including that due to submesoscales. Thus far, the parameterization does not include effects due to surface waves, which may play a significant role in water mass dispersion. The 480 cross-shelf snapshots of bio-optical properties obtained from glider missions captured pre and post phytoplankton blooms, upwelling and relaxation events, the development of intermediate boundary layers, and a runoff episode. Data from the virtual mooring experiments showed diel changes in particle backscatter that can have important ecological and biogeochemical implications for the production and export of phytoplankton. Analysis of cruise data showed high levels of chlorophyll biomass well below the deepest euphotic zone depths indicating rapid vertical transport to depth. Bulk water mass advection to depth and isopycnal mixing appear to be the dominant physical transport mechanisms.

Key outcomes or
Other achievements: See significant results.

*** What opportunities for training and professional development has the project provided?**

Education and training are tightly integrated into all aspects of SBC research. During the past year (year 1 of SBC III), 5 postdoctoral fellows, 25 graduate students, 4 REU students and 116 additional undergraduate students participated in SBC research and outreach activities. UCSB undergraduates have a high propensity to get involved in sponsored research and SBC contributes substantially in this regard. In addition to gaining valuable research

experience, many undergraduates earned academic credit or received monetary compensation for participating in SBC research as interns and honors students. REU students work closely with SBC researchers on a wide range of topics and most choose to pursue an advanced degree following their undergraduate education.

The focus of SBC's mentoring and training of postdoctoral scientists is on providing them with strong interdisciplinary skills, professional development opportunities, and the experience, and support required for them to transition to career faculty positions. In addition to the specific training associated with SBC LTER, postdoctoral scientists are mentored through grant proposal development and writing and the job application and interview process by SBC investigators and via access to UCSB's resources for postdoctoral scientists. Co-PI Siegel served as the primary mentor for post doc, Leonel Romero, on a proposal submitted to NSF's Physical Oceanography program and on a paper published in the journal *Physical Oceanography*. Romero spends a portion of his time at UCLA working with SBC Investigator, Jim McWilliams. During this past year post doc, Matt Kay, accepted a position at Santa Barbara City College as an Assistant Professor in Biology, and post doc, Kyle Cavanaugh, was awarded a post doctoral fellowship at the University of Maryland to apply his SBC acquired skills in the spatial ecology of kelp to mangrove systems.

SBC graduate student and postdoctoral training is coordinated with several graduate programs on the UCSB campus to promote opportunities for interdisciplinary graduate training in ecology, physiology, geology, geography, hydrology, oceanography, and coastal policy. This enables valuable cross-training on environmental issues pertaining to coastal ecosystems, provides a common language for communicating scientific information on these issues, and contributes to the creation of a diverse scientific community of students and postdocs that fosters a respect and appreciation for other disciplines. In 2013 Co PI Melack taught a graduate seminar on SBC's coastal watersheds that engaged students from several departments with broad interests in watershed science. Investigator Carlson taught an immersion course on Microbial Oceanography at the Bermuda Institute of Ocean Sciences in Summer 2013. This lecture and laboratory course provided training in various techniques in microbial ecology and oceanography used by both SBC and MCR LTER.

SBC graduate student, C. Yorke joined a cross site working group called "A guide to successful graduate student socio-ecological research: Insights from the Long Term Ecological Research Network" that is producing a manuscript on this topic. SBC student R. Barron attended the LTER DOM workshop in May 2013 which provided valuable training for her thesis research. Graduate students from SBC, MCR and CCE co-organized and participated in the 3rd cross-site graduate student symposium in March 2013 at UC San Diego.

UCSB's teaching aquarium (Research Experience & Education Facility know as the "REEF") features SBC research and serves as a marine ecology teaching facility for several departments at UCSB and many area colleges. Funds from the SBC's Schoolyard LTER program provide teaching materials for curriculum and salaries for staff and undergraduate interns. Student interns gain a solid foundation in marine ecology and training in communicating their knowledge in an educational format. A total of 65 undergraduate interns were trained this year in a rigorous and pedagogically sound program. Many of these students go on to participate in SBC research thereby furthering their training in marine science.

SBC research staff also receive specialized training that enhances their professional development. During the past year marine technicians/programmers Stuart Halewood, Erik Stassinis and Chris Gotschalk continued their development of SBC's autonomous glider program, which included hands on experience in programming missions, trouble shooting equipment failures and developing methods of processing and analyzing sensor data. David Salazar, a senior marine technician at UCSB, gained additional experience in seagoing operations and captaining a 27-foot research vessel used in SBC research and Eduardo Romero, a former SBC REU recently hired as a marine technician, received training in the operation of numerous instrument systems including HF radar and the many types of moored sensors used in the project.

*** How have the results been disseminated to communities of interest?**

1. Schoolyard LTER (sLTER).

SBC's sLTER program is organized around a theme of kelp forest ecology in the context of SBC research.

Curriculum is developed and delivered through the Research Experience & Education Facility (REEF), UCSB's teaching aquarium and the Marine Science Institute's *Oceans-to-Classrooms* curricula. Through *Oceans-to-Classrooms* and the REEF, SBC based curriculum, rich in STEM content, was provided to over 15,000 visitors from 7 counties in two states last year through outreach visits to schools, community events and on-campus programs. Our integrated program extends year round and focuses on long-term connections with local, regional and state schools through partnerships with on and off campus programs. This year, SBC's sLTER focused on four partnership programs, 1) the American Association of University Women's (AAUW): Tech Trek Program, 2) Math-Science-Partnership (MSP) Project: Pathways to Environmental Literacy, 3) Santa Barbara Unified School District (SBUSD) *Explore the Sea Summer Program* and 4) and Girls Inc.: Eureka!. Collectively, the content of these four targeted programs reached nearly 6,000 K-12 students this past year.

- Tech Trek is an on-campus residential science and math summer program designed to develop interest, excitement and self-confidence in young women entering the eighth grade. Tech Trek is part of a partnership involving science, technology, engineering, and math departments at UCSB through the Office of Education Partnerships (OEP). The goal of OEP is to build college-going communities that improve student learning, increase college-going rates in underrepresented populations, and provide equal access to higher education for California's diverse students. In working with Tech Trek, the SBC sLTER program engaged two groups of 78 girls each from junior high and middle schools from Santa Barbara and surrounding areas, representing a diverse range of socioeconomic and demographic groups. During a weeklong residential camp at UCSB, students participated in "core" science courses that included socio-ecological and science and math activities. This year, the program focused on a real-world problem: What to do with decommissioned oil rigs in response to "rigs-to-reefs" initiatives. Participants enrolled in a "core" class in their discipline of interest: Physics, Alternative Energy, Chemistry, or Marine Ecology. The girls engaged in a number of place-based, hands-on, activities that promoted concept application and citizenship, including a trip to Platform Holly, visits to SBC kelp forest study sites and the SBC-based Floating Lab. Through this long-term commitment, we are now seeing former program participants enrolling in UCSB including three who have worked at the REEF.
 - The MSP project connects the research and education strengths of universities and LTER sites with teacher professional development in science and mathematics of partner middle schools and high schools. Four LTER sites (SBC, SGS, BES, KBS) and their partnering institutions, the LTER Network Office, and local K-12 schools and districts are involved. This year, SBC worked with 15 teachers from our previous year's program and several targeted district elementary, junior high, and high school teachers to providing professional development to deliver in-class science curriculum based on SBC field sites, data and ecological principles to over 2,000 Santa Barbara County and Ventura County students. The MSP project engaged and supported a program coordinator, a post-doctoral fellow, a graduate student, a Teacher in Resident (TIR) and 4 undergraduate assistants. Students visited one of two nearby LTER monitoring sites and an on-campus visit that included an SBC research seminar and SBC ecology-based activities. SBC graduate students, post-docs and investigators gave talks on their research and led activities for field trips and programs.
 - SBC conducted program pilots with Santa Barbara Unified School District (SBUSD) *Explore the Sea Summer Program*) and Carpinteria Girls Inc. Eureka!. Content for both programs focused on place and culture of the Santa Barbara Channel maritime communities and how research applies to the multifaceted aspects of this community from conservation and resource management, to fisheries and eco-tourism. The SBUSD After School Education and Safety program is a committed schools-families-communities partnership working to help children and youths reach their full potential. It is designed to provide K-12 students with an academically enriching summer program to address literacy issues. Carpinteria Girls Inc. Eureka! encourages girls ages 12-18 to explore career paths and post-secondary educational opportunities in STEM fields. The program targets girls in middle school who are at high risk of losing interest in STEM and features an intensive 4-6 week experience on a college campus during the summer.
2. SBC graduate student Heather Berry was on the Geography Outreach and Visibility Committee for local K-12 schools and survey coordinator of outreach for the Graduate Students for Diversity in the Sciences group.
 3. SBC hosted a booth at the 2013 Santa Barbara Earth Day Festival to raise public awareness about LTER research. This year's festival attracted 35,894 people. New this year was a virtual kelp forest in which SBC students and staff acted as 'dive buddies' for children who toured the forest and collected data.

4. SBC investigators and students contributed to the following stories that appeared in newspapers and other media outlets.

- UCSB Scientists Capture Clues to Sustainability of Fish Populations, <http://www.bloggero.info/ucsb-scientists-capture-clues-sustainability-fish-populations-32475> and <http://www.sciencenewsline.com/summary/2012092719120057.html> and <http://esciencenews.com/articles/2012/09/27/ucsb.scientists.capture.clues.sustainability.fish.populations>
- Fish populations hinge on available food, <http://www.futurity.org/fish-populations-hinge-on-available-food/>
- Bracing for Impact: Scientists study the effects of increasing ocean acidity on California's marine ecosystems , <http://www.dfg.ca.gov/marine/impact.asp>
- Sea urchins can cope with acidic waters, <http://www.nature.com/news/sea-urchins-can-cope-with-acidic-waters-1.11482>
- The Importance of Kelp: UCSB Researchers Investigate Beach Ecosystem, <http://www.independent.com/news/2013/feb/03/importance-kelp/#c90426>
- Southern California Crustacean Sand-dwellers Suffering Localized Extinctions <http://www.sciencenewsline.com/summary/2013071813150009.html>
- Beach 'roly polies' vanishing in Southern California, study says, <http://www.latimes.com/local/lanow/la-sci-sn-beach-roly-polies-extinction-california-20130719,0,4438992.story>
- 'Pretty' beaches leave tiny critters homeless, <http://www.futurity.org/pretty-beaches-leave-tiny-critters-homeless/>
- Beachcombing: Loss of isopods raises questions about beach health (article and radio broadcast), <http://www.scpr.org/news/2013/08/02/38494/ucsb-scientists-look-for-isopods-to-check-for-beach>.

*** What do you plan to do during the next reporting period to accomplish the goals?**

Continue as planned.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
Core long term monitoring table.pdf	Table of SBC LTER core long term monitoring measurements	Daniel Reed	08/31/2013

Products

Journals

Miller, R. J., H. M. Page and M. A. Brzezinski (2013). Delta C-13 and delta N-15 of particulate organic matter in the Santa Barbara Channel: drivers and implications for trophic inference. *Marine Ecology Progress Series*. 474 53-66.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.3354/meps10098

Cavanaugh, K. C., B. E. Kendall, D. A. Siegel, D. C. Reed, F. Alberto, J. Assis (2013). Synchrony in dynamics of giant kelp forests is driven by both local recruitment and regional environmental controls. *Ecology*. 94 (2), 499.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Colman, B. P., J. P. Schimel (2013). Drivers of microbial respiration and net N mineralization at the continental scale. *Soil Biology and Biochemistry*. 60 65.

Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Harrer, S. L., D. C. Reed, R. J. Miller, S. J. Holbrook (2013). Patterns and controls of the dynamics of net primary production by understory macroalgal assemblages in giant kelp forests. *Journal of Phycology*. 49 248.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/jpy.12023

Klose, K. and S. D. Cooper (2013). Complex impacts of an invasive omnivore and native consumers on stream communities in California and Hawaii. *Oecologia*. 171 (4), 945-960.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s00442-012-2449-y

Krause, J. W., M. A. Brzezinski, D. A. Siegel and R. C. Thunell (2013). Biogenic silica standing stock and export in the Santa Barbara Channel ecosystem. *Journal of Geophysical Research: Oceans*. 118 736-749.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1029/2012JC008070

Nelson, C. E., D. M. Bennett, B. J. Cardinale (2013). Consistency and sensitivity of stream periphyton community structural and functional responses to nutrient enrichment. *Ecological Applications*. 23 159.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Padilla-Gamiño, J. L., M. W. Kelly, T. G. Evans and G. E. Hofmann. (2013). Temperature and CO2 additively regulate physiology, morphology and genomic responses of larval sea urchins, *Strongylocentrotus purpuratus*. *Proceedings of the Royal Society B*. 280 20131055.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Barron, R. K., D. A. Siegel, N. Guillocheau (). Evaluating the importance of phytoplankton community structure to the optical properties of the Santa Barbara Channel, California. *Limnology and Oceanography*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Alber, M., D. Reed and K. J. McGlathery (2013). Coastal long term ecological research: Introduction to the special issue. *Oceanography*. 26 (3), 14-17.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5670/oceanog.2013.40

Brzezinski, M. A., D. C. Reed, S. Harrer, A. Rassweiler, J. M. Melack, B. Goodridge and J. E. Dugan (2013). Multiple sources and forms of nitrogen sustain year-round kelp growth on the inner continental shelf of the Santa Barbara Channel. *Oceanography*. 26 (3), 114-123.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5670/oceanog.2013.53

Byrnes, J. E., B. J. Cardinale and D. C. Reed (2013). Interactions between sea urchin grazing and prey diversity on temperate rocky reef communities. *Ecology*. 94 (7), 1636-1646.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1890/11-2310.1

Carney, L. T., A. J. Bohonak, M. S. Edwards and F. Alberto (). Genetic and experimental evidence for a mixed age, mixed origin bank of kelp microscopic stages in southern California. *Ecology*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Cavanaugh, K. C., D. A. Siegel, P. T. Raimondi and F. Alberto (). Patch definition in metapopulation analysis: a graph theory approach to solve the mega-patch problem. *Ecology*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Coombs, J. S. and J. M. Melack (). The initial impacts of a wildfire on hydrology and suspended sediment and nutrient export in California chaparral watersheds. *Hydrological Processes*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Cooper, S. D., P. S. Lake, S. Sabater, J. M. Melack and J. L. Sabo (). The effects of land use changes on streams and rivers in Mediterranean climates. *Hydrobiologia*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Dugan, J. E., D. M. Hubbard and B. J. Quigley (2013). Beyond beach width: Steps toward identifying and integrating ecological envelopes with geomorphic features and datums for sandy beach ecosystems. *Geomorphology*. 199 95-105.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.geomorph.2013.04.043

Harrison, C. S., D. A. Siegel and S. Mitarai (2013). Filamentation and eddy-eddy interactions in marine larval accumulation and transport. *Marine Ecology Progress Series*. 472 27-44.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.3354/meps10061

Hofmann, G. E., C. A. Blanchette, E. B. Rivest and L. Kapsenberg (2013). Taking the pulse of marine ecosystems: the importance of coupling long-term physical and biological observation in the context of global change biology. *Oceanography*. 26 (3), 140-148.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5670/oceanog.2013.56

Hubbard, D. M., J. E. Dugan, N. K. Schooler and S. Viola (). Local extirpations and regional declines of endemic upper beach invertebrates in southern California. *Estuarine, Coastal and Shelf Science*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.ecss.2013.06.017

Johansson, M. L., P. T. Raimondi, D. C. Reed, N. C. Coelho, E. A. Serrão and F. A. Alberto (). Looking into the black box: simulating the role of self-fertilization and mortality in the genetic structure of *Macrocystis pyrifera*. *Molecular Ecology*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/mec.12444

Kelly, M. W., J. L. Padilla-Gamiño, G. E. Hofmann (). Natural variation and the capacity to adapt to ocean acidification in the keystone sea urchin *Strongylocentrotus purpuratus*. *Global Change Biology*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/gcb.12251

Kenner, M. C., J. A. Estes, M. T. Tinker, J. L. Bodkin, R. K. Cowen, C. Harrold, B. B. Hatfield, M. Novak, A. Rassweiler and D. C. Reed (). A multi-decade time series of kelp forest community structure at San Nicolas Island, California. *Ecology*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Lafferty, K. D., J. P. McLaughlin and J. E. Dugan (2013). Novel foraging in the swash zone on pacific sand crabs (*Emerita analoga*, Hippidae) by mallards. *The Wilson Journal of Ornithology*. 125 (2), 423-426.

Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1676/12-141.1

Paduan, J. D. and L. Washburn (2013). High-frequency radar observations of ocean surface currents. *Annual Review of Marine Science*. 5 115-136.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1146/annurev-marine-121211-172315

Page, H. M., A. J. Brooks, M. Kulbicki, R. Galzin, R. J. Miller, D. C. Reed, R. J. Schmitt, S. J. Holbrook and C. Koenigs (2013). Stable isotopes reveal trophic relationships and diet of consumers in temperate kelp forest and coral reef ecosystems. *Oceanography*. 26 (3), 180-189.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5670/oceanog.2013.61

Rassweiler, A., C. Costello and D. A. Siegel (2013). Marine protected areas and the value of spatially optimized fishery management. *Proceedings of the National Academy of Sciences*. 109 (29), 11884-11889.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1073/pnas.1116193109

Robinson, T. H. and J. M. Melack (2013). Modeling nutrient export from coastal California watersheds. *Journal of the American Water Resource Association*. 49 (4), 739-809.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/jawr.12037

Rodriguez, G. E., A. Rassweiler, D. C. Reed and S. J. Holbrook (2013). The importance of progressive senescence in the biomass dynamics of giant kelp (*Macrocystis pyrifera*). *Ecology*. 94 (8), 1848-1858.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1890/12-1340.1

Romero, L., Y. Uchiyama, J. C. Ohlmann, J. C. McWilliams and D. A. Siegel (). Simulations of nearshore particle-pair dispersion in Southern California. *Journal of Physical Oceanography*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1175/JPO-D-13-011.1

Simons, R. D., D. A. Siegel and K. S. Brown (2013). Model sensitivity and robustness in the estimation of larval transport: a study of particle tracking parameters. *Journal of Marine Systems*. 119-120 19-29.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.jmarsys.2013.03.004

Verkaik, I., M. Rieradevall, S. D. Cooper, J. M. Melack, T. L. Dudley and N. Prat (). Fire as a disturbance in mediterranean climate streams. *Hydrobiologia*. .

Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s10750-013-1463-3

Viola, S., J. E. Dugan, D. M. Hubbard and N. K. Schooler (). Burrowing in beach fill, implications for recovery of sandy beach ecosystems. *Estuarine, Coastal and Shelf Science*. .

Status = ACCEPTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Washburn, L. and E. E. McPhee-Shaw (2013). Coastal transport processes affecting inner-shelf ecosystems in the California current system. *Oceanography*. 26 (3), 34-43.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI:

10.5670/oceanog.2013.43

White, J. W., A. J. Scholz, A. Rassweiler, C. Steinback, L. W. Botsford, S. Kruse, C. Costello, S. Mitarai, D. A. Siegel, P. T. Drake and C. A. Edwards (2013). A comparison of approaches used for economic analysis in marine protected area network planning in California. *Ocean and Coastal Management*. 74 77-89.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.ocecoaman.2012.06.006

Books

Book Chapters

Foster, M. S., D. C. Reed, M. H. Carr, P. K. Dayton, D. P. Malone, J. S. Pearse and L. Rogers-Bennett (). Kelp forests in California. *Research and Discoveries: The Revolution of Science Through SCUBA, Smithsonian Contributions to the Marine Sciences* Lang, M.. Smithsonian Institution Press. .

Status = AWAITING_PUBLICATION; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Schlacher, T. S., A. R. Jones, J. E. Dugan, M. Weston, L. Harris, D. S. Schoeman, D. Hubbard, F. Scapini, R. Nel, M. Lastra, A. McLachlan and C. H. Peterson (). Open-coast sandy beaches and coastal dunes, Chapter 5. *Coastal Conservation* Maslo, B. and J. L. Lockwood. Cambridge University Press. .

Status = AWAITING_PUBLICATION; Acknowledgement of Federal Support = No ; Peer Reviewed = No

Thesis/Dissertations

Emery, K.. *Does evidence matter? How middle school students make decisions about socioscientific issues.* (2013). University of California, Santa Barbara.

Acknowledgment of Federal Support = Yes

Conference Papers and Presentations

Barron, R. K., D. A. Siegel and N. Gillocheau (2013). *UV-absorbing substances linked to phytoplankton community dynamics in a coastal ocean.* ASLO 2013 Aquatic Sciences Meeting. New Orleans, Louisiana, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = No

Bell, T. (2013). *Kelp Photosynthetic Pigments.* LTER California Graduate Student Symposium. Scripps Institute of Oceanography, La Jolla, Calif.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Benitez-Nelson, C., C. R. Anderson, R. Thunell, E. Sekula-Wood and D. A. Siegel (2013). *Increasing Pseudo-nitzschia abundance and domoic acid toxicity of sinking particles in the Santa Barbara basin associated with changes in source waters.* ASLO 2013 Aquatic Sciences Meeting. New Orleans, Louisiana, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = No

Byrnes, J. (2013). *Causes and consequences of ecological complexity.* Invited Seminar. Dalhousie University, Halifax, Nova Scotia, Canada.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Byrnes, J. (2013). *Causes and consequences of ecological complexity.* Invited Seminar. Brown University, Providence, Rhode Island.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Emery, K., A. Whitmer, D. Harlow and S. D. Gaines (2013). *How do middle school students make decisions about socioscientific issues related to water, biodiversity and carbon? (Poster)*. UCSB Marine Science Graduate Student Showcase. University of California, Santa Barbara, CA.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Freitas, F. H., D. A. Siegel, S. Halewood and E. Stassinis (2013). *Short time scale variability of optical properties and phytoplankton distribution in the coastal Santa Barbara Channel, California (Poster)*. UCSB Geography Department Graduate Student Showcase. University of California, Santa Barbara, CA.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Freitas, F. H., D. A. Siegel, S. Halewood, E. Stassinis and L. Washburn (2013). *Variability of phytoplankton and particles in the inner shelf Santa Barbara Channel on scales of hours to seasons*. 60th Annual Eastern Pacific Ocean Conference. Fallen Leaf Lake, California, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Hanan, E. J., J. P. Schimel and C. Tague (2012). *Interactive effects of climate, hydrology and fire on nitrogen retention and export in coastal California chaparral (Poster)*. American Geophysical Union Fall Meeting. San Francisco, California, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = No

Kapsenberg, L. (2013). *Ocean acidification: assessment of pH in the Channel Islands National Park and its effect on sea urchin fertilization*. LTER California Graduate Student Symposium. Scripps Institute of Oceanography, La Jolla, Calif.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Marks, L. (2013). *Do healthy kelp forest communities confer resistance to seaweed invasions? A case study: Sargassum horneri in southern California*. California LTER Graduate Student Symposium. Scripps Institute of Oceanography, La Jolla, Calif.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Melack, J. M. (2012). *Nutrient fluxes from coastal California watersheds as a function of land use, fire and rainfall variability*. Invited Seminar. Stroud Water Research Ctr, Avondale, Pennsylvania.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Okamoto, D. K., R. J. Schmitt and S. J. Holbrook (2013). *Food availability, density dependence and the dynamics of natural mortality in a temperate marine fish*. UCSB Ecology, Evolution and Marine Biology Graduate Student Symposium. University of California, Santa Barbara, CA.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Okamoto, D. K., R. J. Schmitt, S. J. Holbrook and D. C. Reed (2013). *Food availability, density dependence and the dynamics of natural mortality in a temperate marine fish*. LTER California Graduate Student Symposium. Scripps Institute of Oceanography, La Jolla, Calif.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Roberts, D. A., P. Dennison, K. Roth and G. Hulley (2013). *Relationships between species composition, fractional cover, and land surface temperature in a Mediterranean ecosystem*. Whispers 2013. Gainesville, Florida, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = No

Rodriguez, G.E. (2013). *A multi-faceted investigation of foliage turnover in giant kelp*. ASLO 2013 Aquatic Sciences Meeting. New Orleans, Louisiana, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Rodriguez, G. E. (2013). *Leaf lifespan theory explains turnover of giant kelp blades*. LTER California Graduate Student Symposium. Scripps Institute of Oceanography, La Jolla, Calif.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Romero, L. (2013). *Simulations of particle dispersal in the coastal zone*. UCSB Interdepartmental Graduate Program in Marine Science Seminar. University of California, Santa Barbara, CA.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Romero, L. (2013). *Nearshore dispersal of material in southern California*. Invited Seminar. University of California, Santa Barbara, CA.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Washburn, L., C. J. Ohlmann, D. P. Ellis, M. R. Fewings, C. Gotschalk, D. Oldenburg, O. Schofield and M. Moline (2013). *Observations of poleward-propagating coastal currents and a persistent poleward jet-like flow along the central California coast*. Gordon Research Conference: Coastal Ocean Circulation. Biddeford, Maine, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Washburn, L. (2013). *Water quality activities within the Southern California Coastal Ocean Observing System*. Southern and Central Coastal Ocean Observing Systems Joint Strategic Advisory Committee Meeting. La Jolla, California, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = No

Washburn, L., M. A. Brzezinski, N. Dellaripa and C. Gotschalk (2013). *Water mass subduction and eddy effects on phytoplankton distributions in the Santa Barbara Channel*. Discover the Natural Reserve System: A Conference Celebrating the UCSB NRS. University of California, Santa Barbara, CA.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Washburn, L. and C. A. Blanchette (2013). *Wind relaxations, settlement and biogeographical boundaries*. PISCO Workshop. Los Altos, California, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = No

Washburn, L., D. Aragon, C. Haldeman, C. Ohlmann, C. Gotschalk, N. Couto, T. Miles, I. Robbins, O. Schofield, M. Moline and J. M. Kerfoot (2012). *Observing poleward relaxation flows along the central California coast using gliders as virtual moorings*. American Geophysical Union 2012 Annual Meeting. San Francisco, California, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Wear, E. K., C. A. Carlson, M. A. Brzezinski, D. A. Siegel, N. Guillocheau and L. Windecker (2013). *Patterns of bacterioplankton composition along biogeochemical and productivity gradients in the Santa Barbara Channel, USA*. ASLO 2013 Aquatic Sciences Meeting. New Orleans, Louisiana, United States.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Yorke, C. (2013). *Kelp Detritus*. LTER California Graduate Student Symposium. Scripps Institute of Oceanography, La Jolla, CA.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Publications

Technologies or Techniques

Nothing to report.

Patents

Nothing to report.

Inventions

Nothing to report.

Licenses

Nothing to report.

Websites

Title: SBC LTER website

URL: <http://sbc.lternet.edu>

Description: This is the project website which describes the research questions, progress, people, outreach, publications, presentations and data products of the Santa Barbara Coastal LTER.

Other Products

Product Type: Databases

Description: SBC datasets on climate, hydrology, stream chemistry, watershed characteristics, coastal ocean currents and biogeochemistry, net primary production of kelp, historical kelp biomass, cover of sessile organisms on reefs, reef fish abundance, abundance and size of giant kelp, reef invertebrate and algal density and stable isotope data from kelp forest food webs are being collected and updated annually. Available final datasets are listed in the metadata catalog on the site's website <http://sbcdata.lternet.edu/catalog/>

Other:

Participants

Research Experience for Undergraduates (REU) funding

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Daniel C Reed	PD/PI	4
David A Siegel	Co PD/PI	2
Sally J Holbrook	Co PD/PI	2

Name	Most Senior Project Role	Nearest Person Month Worked
Angela Haas	Undergraduate Student	3
Matthew Meyerhof	Technician	11
Scott Cooper	Co-Investigator	2
Steven Sadro	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Colette Cooper	Undergraduate Student	1
Mayra Fulgencio	Undergraduate Student	2
Evan Cole	Undergraduate Student	3
Andrea Pappas	Undergraduate Student	3
Erica Kim	Research Experience for Undergraduates (REU) Participant	3
Sarah Aisawa	Undergraduate Student	3
Margaret O'Brien	Other Professional	12
Kristie Klose	Staff Scientist (doctoral level)	2
Elisa Halewood	Technician	2
Laura Reynolds	Graduate Student (research assistant)	6
Daniel Livesay	Graduate Student (research assistant)	1
Lauren Simkins	Graduate Student (research assistant)	1
Jonathan Rice	Graduate Student (research assistant)	1
Angela Roman	Undergraduate Student	1
Elisabeth Steel	Undergraduate Student	1
Filipe Alberto	Co-Investigator	1
Bodo Bookhagen	Co-Investigator	1

Name	Most Senior Project Role	Nearest Person Month Worked
Alexander Simms	Co-Investigator	1
Mark Brzezinski	Co-Investigator	1
Carla D'Antonio	Co-Investigator	1
Gretchen Hofmann	Co-Investigator	1
Hunter Lenihan	Co-Investigator	1
David Lopez-Carr	Co-Investigator	1
Robert Miller	Co-Investigator	2
Jenifer Dugan	Co-Investigator	4
Sally MacIntyre	Co-Investigator	1
Jim McWilliams	Co-Investigator	1
John Melack	Co PD/PI	2
Henry M Page	Co-Investigator	1
Pete Raimondi	Co-Investigator	1
Dar Roberts	Co-Investigator	1
Josh Schimel	Co-Investigator	1
Russ Schmitt	Co-Investigator	1
Naomi Tague	Co-Investigator	1
Vanessa Lang	Undergraduate Student	1
Carly Haack	Undergraduate Student	2
Lauren Perkins	Undergraduate Student	3
Daniel Nevitt	Undergraduate Student	1
Shane Kinahan	Undergraduate Student	1

Name	Most Senior Project Role	Nearest Person Month Worked
Alex Delgadillo	Undergraduate Student	1
An Nguyen	Undergraduate Student	1
Brian Ulanski	Undergraduate Student	3
Colleen McGee	Undergraduate Student	2
Kylie Anderson	Undergraduate Student	1
Derek Smith	Undergraduate Student	1
Kaitlin Cottrell	Undergraduate Student	2
Marina Varano	Undergraduate Student	1
Amelia Duvall	Undergraduate Student	3
Annika Vawter	Undergraduate Student	2
Alyssa Lind	Research Experience for Undergraduates (REU) Participant	6
Cameron Puidak	Undergraduate Student	2
Hannah Ake	Undergraduate Student	3
Jaylyn Babitch	Undergraduate Student	3
John Buck	Research Experience for Undergraduates (REU) Participant	6
Paulina Salinas-Ruiz	Undergraduate Student	3
Samantha Koda	Undergraduate Student	2
Sean Marks	Undergraduate Student	2
Tanya Silva	Undergraduate Student	2
Alan Hong	Undergraduate Student	2
Paula Ezcurra	Undergraduate Student	4

Name	Most Senior Project Role	Nearest Person Month Worked
Dylan Brady	Undergraduate Student	1
Matt Olsen	Undergraduate Student	1
Clint Nelson	Technician	12
Shannon Harrer	Technician	12
Crystal Weaver	Technician	3
Nicholas Schooler	Graduate Student (research assistant)	6
Anthony Ferrendelli	Undergraduate Student	2
Matthew Warham	Undergraduate Student	2
Wes Barloon	Undergraduate Student	2
Taylor Eaton	Undergraduate Student	2
Julianne Fernandez	Undergraduate Student	2
Libe Washburn	Co-Investigator	1
David Salazar	Technician	3
Cyril Johnson	Other Professional	1
Eduardo Romero	Technician	2
Ali Whitmer	Co-Investigator	1
Conner Applewhite	Undergraduate Student	1
Kim Armantrout	Undergraduate Student	1
Silke Bachhuber	Undergraduate Student	1
Zhiping Bao	Undergraduate Student	1
Marissa Bills	Undergraduate Student	1
Alexandra Bowers	Undergraduate Student	1

Name	Most Senior Project Role	Nearest Person Month Worked
Kelsey Briggs	Undergraduate Student	1
Andy Bruckman	Undergraduate Student	1
Lisa Camilo	Undergraduate Student	1
Nick DaSilva	Undergraduate Student	1
Kira De la Torre	Undergraduate Student	1
Krista Derouin	Undergraduate Student	1
Crystal Dolis	Undergraduate Student	1
Rachel Doran	Undergraduate Student	1
Christina Dover	Undergraduate Student	1
Dayna Drewniak	Undergraduate Student	1
Danielle Edelman	Undergraduate Student	1
Kristen Eggers	Undergraduate Student	1
Devyn Flaherty	Undergraduate Student	1
Kristina Garcia	Undergraduate Student	1
Gad Girling	Undergraduate Student	1
Fernando Gomez	Undergraduate Student	1
Kali Gutierrez	Undergraduate Student	1
Katherine Hanson	Undergraduate Student	1
Emily Heber	Undergraduate Student	1
Rebecca Howard	Undergraduate Student	1
Inji Issac	Undergraduate Student	1
Peter Johnson	Undergraduate Student	1

Name	Most Senior Project Role	Nearest Person Month Worked
Kim Keller	Undergraduate Student	1
Vivian Kim	Undergraduate Student	1
Lauren Knox	Undergraduate Student	1
Rachel Kwon	Undergraduate Student	1
Erik Stassinis	Technician	3
Chris Gotschalk	Other Professional	2
Stuart Halewood	Technician	2
Samantha Lepore	Undergraduate Student	1
David Hubbard	Other Professional	1
Maria Loberg	Undergraduate Student	1
Kylie Logan	Undergraduate Student	1
Carmen Lu	Undergraduate Student	1
Sophia Macarewich	Undergraduate Student	1
Shannon Malone	Undergraduate Student	1
Craig Carlson	Co-Investigator	1
Robert Minick	Undergraduate Student	1
Christian Molina	Undergraduate Student	1
Ayla Nelson	Undergraduate Student	1
Jillian Niederberger	Undergraduate Student	1
Caroline Pickett	Undergraduate Student	1
Anastasia Quintana	Undergraduate Student	1
Thea Rogier	Undergraduate Student	1

Name	Most Senior Project Role	Nearest Person Month Worked
Sara Rosenblatt	Undergraduate Student	1
Chris Schmuckal	Undergraduate Student	1
Katie Schutz	Undergraduate Student	1
Derek Schwenkmeyer	Undergraduate Student	1
Kyla Sebens	Undergraduate Student	1
Katrina Shao	Undergraduate Student	1
Sophie Sheridan	Undergraduate Student	1
Cooper Smith	Undergraduate Student	1
Katie Sun	Undergraduate Student	1
Christina Terracciano	Undergraduate Student	1
Shannon Trumbull	Undergraduate Student	1
Hayley Verner	Undergraduate Student	1
Jonathan Webster	Undergraduate Student	1
Mac Wing	Undergraduate Student	1
Erin Winslow	Undergraduate Student	1
Emilie Wood	Undergraduate Student	1
Alana Yurkanin	Undergraduate Student	1
Sarah Zuziak	Undergraduate Student	1
Carol Blanchette	Co-Investigator	1
Jaclyn Mandoske	Undergraduate Student	2
Jessica Madden	Undergraduate Student	1
Mark Bitter	Undergraduate Student	2

Name	Most Senior Project Role	Nearest Person Month Worked
Michael Benaron	Undergraduate Student	1
Evan Barba	Undergraduate Student	2
Raymond Akol	Undergraduate Student	1
Jarrett Byrnes	Co-Investigator	1
Melanie Fewings	Co-Investigator	1
Anita Guerrini	Co-Investigator	1
Carter Ohlmann	Co-Investigator	1
Uta Passow	Co-Investigator	1
Steve Schroeter	Co-Investigator	1
Bill Wright	Co-Investigator	1
Claudia Benitez-Nelson	Co-Investigator	1
Natalie Testa	Undergraduate Student	3
Scott Simon	Other Professional	1
Michelle Johnson	Other Professional	1
Nathalie Guillocheau	Technician	1
Michelle Sakai-Hart	Undergraduate Student	3
Erik Fields	Technician	1
Erika McPhee-Shaw	Co-Investigator	1
Christie Yorke	Graduate Student (research assistant)	6
Emma Wear	Graduate Student (research assistant)	6
Sheila Wiseman	Technician	6
Sloane Viola	Technician	3

Name	Most Senior Project Role	Nearest Person Month Worked
Caitlyn Teague	Undergraduate Student	3
Catherine Shields	Graduate Student (research assistant)	6
Kevin Selder	Research Experience for Undergraduates (REU) Participant	3
Leonel Romero	Postdoctoral (scholar, fellow or other postdoctoral position)	10
Andrew Rassweiler	Co-Investigator	1
Gabriel Rodriguez	Graduate Student (research assistant)	6
Daniel Okamoto	Graduate Student (research assistant)	6
Susan Meerdink	Graduate Student (research assistant)	6
Lindsay Marks	Graduate Student (research assistant)	6
Matt Kay	Postdoctoral (scholar, fellow or other postdoctoral position)	6
Lydia Kapsenberg	Graduate Student (research assistant)	6
Kevin Johnson	Graduate Student (research assistant)	6
Anna James	Graduate Student (research assistant)	6
Simon Ho Chuen Wong	Graduate Student (research assistant)	6
Fernanda Hendrikx Freitas	Graduate Student (research assistant)	6
Erin Hanan	Graduate Student (research assistant)	6
Rachel Simons	Staff Scientist (doctoral level)	1
Craig Nelson	Staff Scientist (doctoral level)	1
Toby Moyneur	Technician	3
Blair Goodridge	Graduate Student (research assistant)	10

Name	Most Senior Project Role	Nearest Person Month Worked
LaTisha Hammond	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Kristen Mollura	Undergraduate Student	2
Keyon Lemus	Undergraduate Student	3
Andres Lapostol	Undergraduate Student	3
Maiya Greenwood	Undergraduate Student	3
Daniel Ellis	Graduate Student (research assistant)	6
Daniel Dauhajre	Graduate Student (research assistant)	3
Aubrey Cano	Graduate Student (research assistant)	3
Kyle Cavanaugh	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Erik Young	Undergraduate Student	3
Tom Bell	Graduate Student (research assistant)	6
Heather Berry	Graduate Student (research assistant)	6
Danuta Bennett	Staff Scientist (doctoral level)	6
Rebecca Barron	Graduate Student (research assistant)	6
Rolando Araujo	Undergraduate Student	3

What other organizations have been involved as partners?

Name	Location
American Assoc. Univ. Women, Tech Trek	Santa Barbara, CA
Arizona State University	Tempe, Arizona
California Sea Grant Extension Program	La Jolla, CA
Carpinteria Girls Inc. Eureka	Carpinteria, CA
Channel Islands National Marine Sanctuary	Santa Barbara, CA

Name	Location
Channel Islands National Park	Ventura, CA
City of Santa Barbara	Santa Barbara, CA
County of Santa Barbara	Santa Barbara, CA
Hope School District GATE Program	Santa Barbara, CA
ILTER Math Science Partnership	Santa Barbara, CA
La Cumbre Junior High School	Santa Barbara, CA
Monash University	Melbourne, Australia
Moss Landing Marine Laboratory	Moss Landing, CA
Santa Barbara Channel Keeper	Santa Barbara, CA
Santa Barbara Unified School District (SBUSD)	Santa Barbara, CA
Scripps Institution of Oceanography	La Jolla, CA
Southern California Coastal Ocean Observing System (SCCOOS)	California
Stanford University	Stanford, CA
US Geological Survey	Santa Cruz, CA
University of Barcelona	Barcelona, Spain
University of California Davis	Bodega Bay, CA
University of California Los Angeles	Los Angeles, CA
University of California San Diego	La Jolla, CA
University of California Santa Cruz	Santa Cruz, CA
University of Connecticut	Groton, CT
University of Girona	Girona, Spain
University of South Carolina	Columbia, SC
University of Wisconsin	Milwaukee, WI

Have other collaborators or contacts been involved? Y

Impacts

What is the impact on the development of the principal discipline(s) of the project?

Results from SBC research are helping to address the growing need for understanding ecosystem level processes in kelp forests. Of particular significance are our unique time series data and findings pertaining to: (1) controls and fate of primary production, (2) the movement and utilization of different sources and forms of nutrients, (3) environmental drivers of nearshore food webs, and (4) exchange of organic and inorganic materials among ecosystems.

SBC's development of an ongoing time series of canopy biomass for giant kelp in California and Mexico from Landsat satellite imagery has provided an unprecedented opportunity to study the patterns and drivers of population dynamics of this foundation species at unprecedented temporal resolution and spatial and temporal scales. The time series has generated considerable interest from the science community and led to several new collaborations this past year. Recent results on the spatial extent of population synchrony in giant kelp revealed processes affecting synchrony differed from local to regional scales.

Our recent finding that predator-prey interaction strengths can be altered by reserve protection has important implications for conservation and management. Marine protected areas are increasingly being used as a fisheries management tool and their effects on fisheries are often inferred from models that do not take account changes in per-capita interaction strengths and broadening of diet. Our results point towards a suite of potential changes in trophic structure that must be understood in order to make sound decisions about reserve design.

SBC's partnership with other research programs to maintain spatially extensive array of moored sensors is providing spatially comprehensive high frequency data on ocean properties including currents, temperature and pH.

SBC investigators are sharing regional ocean modeling system (ROMS) simulation codes that they developed for SBC reefs with investigators at the Okinawa Institute of Science and Technology to help them understand cross shelf transport in their coral reef ecosystems. In particular, we are assisting them in their modeling the roles of surface gravity waves on ocean circulation in their system.

SBC investigators have broadened the reach of SBC research through the following cross site collaborations within a variety of disciplines.

- Former SBC post doc and current Affiliated Investigator Byrnes convened a NCEAS working group that brought together a team of international scientists to examine the effects of global climate change on kelp forest ecosystems SBC data served as a cornerstone of the working group and SBC sampling protocols and experiments were adopted as a model for a newly formed global Kelp Ecosystem Ecology Network (KEEN) to use in future collaborations.
- Using remote sensing methods developed as part of his SBC research post doc Kyle Cavanaugh obtained funding from the LTER Network Office to generate a cross-site database of existing Landsat TM satellite imagery (1985-present) that included all 26 sites in the US LTER network. He also worked with researchers from a subset of LTER sites to create higher-level cross-site data products including atmospherically corrected surface reflectance data and time-series maps of detailed land cover/land use change.
- SBC research on the ecological responses of beaches to coastal armoring stimulated the development of a cross site LTER working group during 2012-2013. Led by SBC, GCE and VCR, representatives from five coastal LTERs, including investigators, postdocs and graduate students, met twice to develop a new synthesis of the responses of soft sediment ecosystems to armoring and coastal squeeze.
- Investigator Cooper is a member of a LTER working group that is conducting a meta-analysis of the effects of nutrient inputs on stream ecosystems. He also serves on the STREON technical advisory committee, advises NEON personnel on stream ecology issues, and in a member of the steering committee for a NSF RCN proposal dealing with the effects of nutrient loading, biodiversity loss, and extreme events on stream ecosystems.
- Lead Investigator Reed served as a guest editor for a special issue of *Oceanography* featuring research

advances from the eight coastal LTER sites. SBC investigators contributed 4 papers to the special issue.

What is the impact on other disciplines?

The research mission of SBC LTER is very interdisciplinary in scope. As such, our research contributes to a wide range of disciplines including: terrestrial, aquatic and marine ecology, physical, biological and chemical oceanography, hydrology, geology, geography, science education and informatics.

Additional SBC research in environmental history has revealed exciting new questions, sources, and methods that expand the notion of long-term data. Associate Investigators Guerrini and Dugan are involved in LTER cross-site efforts to use historical methods as a means of investigating the length and intensity of human impacts and the extent of landscape change over longer periods than the typical timespan of LTER datasets. This work was stimulated by a poster that they co-authored at the 2012 LTER All Scientists Meeting comparing SBC wetlands (which have long been inhabited by humans) to those in the McMurdo Dry Valleys (which have only recently been impacted by humans). Guerrini and Dugan also are collaborating on a website and an interdisciplinary multi-authored book on the human and environmental history of a Santa Barbara coastal wetlands and watersheds.

What is the impact on the development of human resources?

Our project provides significant opportunities for scientific training in research at multiple levels. During the past year: 120 undergraduate students, 25 graduate students and 5 post doctoral fellows were trained by SBC through their direct participation in research and education activities. Former SBC graduate students and postdoctoral fellows go on to hold academic positions where the training legacy from SBC LTER will continue. In 2013, these included graduate student Kyle Cavanaugh, now a post doctoral fellow at the University of Maryland, postdoctoral fellow, Matt Kay, now an assistant professor at Santa Barbara City College, and postdoctoral fellow, Jarrett Byrnes, now an assistant professor at the University of Massachusetts, Boston.

SBC faculty investigators actively incorporate the activities and findings of SBC LTER research into their teaching and curriculum development, thereby extending the project's contributions to the broader student body. The routine integration of undergraduate students into research activities by the project's investigators, post docs, graduate students produces students that are prepared to conduct independent research projects on related questions. SBC participants mentor these undergraduate students and high school students on their own research projects.

Additional impacts on the development of human resources is achieved through SBC's extensive outreach programs (see Accomplishments), which primarily target K-12 students and teachers.

What is the impact on physical resources that form infrastructure?

NSF funds awarded to SBC were used to purchase and maintain a custom 22' research vessel that is specially designed for diving and oceanographic research. Research groups collaborating with SBC have access to this vessel for their research needs.

What is the impact on institutional resources that form infrastructure?

Nothing to report.

What is the impact on information resources that form infrastructure?

SBC's publicly available data holdings increased by about 10% during 2012-2013. About half our holdings represent ongoing time series that are updated annually. All datasets include methods and/or protocol documents to provide context. All metadata are available in the XML specification Ecological Metadata Language (EML), and because SBC's data catalog is also based on EML, datasets are identical whether accessed from local or Network data catalogs. SBC's data catalog is organized into sampling collections, and also accessible from the website's research descriptions and sampling sites map. Our infrastructure provides nightly back-up for archival and work-in-progress, and a file system in which write access is limited to those responsible for collection and maintenance. Data products presented through the catalog are stored separately from internal and support material, and work-in-progress.

SBC co-developed (with Moorea Coral Reef LTER, MCR) a generic system for managing its data package inventory in a relational database. All aspects of the data package life cycle can be tracked, which provides SBC with a mechanism to maintain records of data products that are anticipated, or in development or draft stages. Another LTER site (Hubbard Brook) has already adopted the schema and other sites have indicated interest. SBC's code for export of scientific metadata from GCE-Metabase is also of interest to other sites. EML dataset metadata are exported with object-relational mapping, and an abstraction layer is included so that input may be redirected without the need to modify the underlying system. Collaborative development (also with MCR) ensures that the new code is reusable at other LTER sites or with other data models or web services.

In 2013, SBC's information manager (O'Brien) completed a 3-year term as co-chair of the LTER Network's Information Management Committee. As such, she was influential in promoting improved practices for technical and content aspects of data package handling, and increased contributions and availability within the Network. She continues to lead a working group defining a system of quality standards for data packages contributed to the LTER Network catalog, and her expertise in the use of the EML schema has directly benefited more than half the LTER sites. O'Brien was invited to join the DataONE Semantics working group in 2013, a position that highlights the use of SBC data in integration, and increases the visibility of LTER data in that federated data system.

What is the impact on technology transfer?

Nothing to report.

What is the impact on society beyond science and technology?

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

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

SBC researchers are also engaged in informing policy for local watershed issues. We have developed mutually beneficial, cooperative associations with local and national government agencies and departments, and NGOs. Our intensive sampling of nutrients and particulates during the entire hydrograph for most storms complements the agency data collection, and we cooperatively share data and interpretations. In 2013 we performed high quality nutrient chemistry analyses on water samples from local streams and rivers for Santa Barbara Channelkeeper.

SBC investigator Hofmann was a featured speaker at a conference on ocean acidification, Defining the Science of ocean acidification, that was part of a series entitled Towards a Sustainable 21st Century hosted by UC Irvine and the Newkirk Center for Science and Society. Hofmann also served on a panel about ocean change, acidification and food security at Edible Institute 2013 in Santa Barbara. <http://www.ediblecommunities.com/santabarbara/category-food/edible-institute-2013.htm>

As a follow-up to their participation in a Fall 2012 workshop on climate change adaptation and planning for the greater Santa Barbara region, SBC investigators Reed, Melack, Page and Dugan are co-investigators on a new climate change vulnerability study entitled "Santa Barbara Area Coastal Ecosystem Vulnerability Assessment" recently approved for funding by NOAA and Sea Grant. This new study will rely largely on SBC core datasets and will engage the cities of Santa Barbara, Goleta and Carpinteria in assessment and evaluation of the responses of

SBC coastal ecosystems to climatic forcing.

The conservation and management of sandy beach ecosystems lags behind that of coastal wetlands and riparian habitats. Our research findings from sandy beaches has led to the recognition of kelp and other macroalgal wrack as an ecological resource by local and state agencies and contributed to the development of new policies for coastal management. SBC Investigator Dugan plays an active advisory role with coastal consortiums and groups concerned with improving the conservation and management of beach ecosystems including the NSF-funded Coastal Barrier Island Network (CBIN), which focuses on the management of barrier island ecosystems under the pressure of global climate change and urbanization, the California Coastal Commission, and the Beach Ecology Coalition, a professional organization for beach managers that provides a forum for education, outreach, training and development of best practices and cooperative research on sandy beach ecosystems in California.

Changes

Changes in approach and reason for change

Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them

Nothing to report.

Changes that have a significant impact on expenditures

Nothing to report.

Significant changes in use or care of human subjects

Nothing to report.

Significant changes in use or care of vertebrate animals

Nothing to report.

Significant changes in use or care of biohazards

Nothing to report.