EXECUTIVE SUMMARY

The **California Current Ecosystem** (CCE) **Long-Term Ecological Research** (LTER) site is part of a unique network of 26 LTER research sites funded by NSF, representing terrestrial, freshwater, and marine ecosystems. The CCE site is mid-way through our 6 year grant and is undergoing the normal mid-term site review. The outcome of this review will provide criticism and advice that we hope will improve our competitiveness for another 6-year funding cycle, in a renewal proposal that will be written about 2 years from now.

The CCE site concerns "*Nonlinear transitions in the California Current Coastal Pelagic Ecosystem.*" It is built upon our observations of relatively abrupt changes in plankton communities in the California Current, often linked to changes in physical state of the system. We are addressing 4 hypotheses for mechanisms underlying such ecosystem changes:

- *Sustained, anomalous alongshore advection of different assemblages*
- *In situ food web changes in response to altered stratification and nutrient supply*
- *Changes in cross-shore transport and loss/retention of organisms*
- *Altered predation pressure*

The research addresses lower-frequency (i.e., years to decades) variations in the pelagic ecosystem, on scales linked to climate forcing. The 5 main programmatic elements of our site are: (1) Experimental Process Cruises, (2) Time Series studies, (3) Modeling and Synthesis, (4) Information Management, and (5) Education and Outreach.

Experimental Process Cruises

The Experimental Process component of CCE focuses on understanding the ecological dynamics of the California coastal pelagic ecosystem in relation to variable physical forcing affecting stratification and nutrient supply. To extend our understanding to a broad range of likely climate-driven system scenarios, our experimental strategy exploits the pronounced spatial variability in hydrographic and community characteristics that exists at any given time in our study region off Southern CA. Cruises are organized around Lagrangian experiments conducted over several activity cycles, each of several days duration, in contrasting ocean conditions. Site selection and mesoscale mapping are supported by SIO satellite imagery and glider programs, by shipboard MVP (Moving Vessel Profiler) surveys, and by prognostic ROMS modeling. We use a drogued, satellite-tracked drifter as a moving frame of reference to follow the temporal evolution of the marked water parcel and as an *in situ* incubation platform for experimental studies of plankton production and community interactive processes. A broad range of complementary shipboard sampling and experiments is also conducted during each experimental cycle to understand system dynamics and net rates of change.

Two major process cruises have been successfully completed: in May-June 2006 (30 days) and April 2007 (20 days), and a third is planned for seasonally contrasting oceanographic conditions in late summer 2008. These studies have each involved a scientific party of about 30 people and provided shipboard experience and research opportunities for 14 SIO grad students, 2 SIO post docs and 5 grad students from other institutions; many more students (including undergrads) have been involved in the shore-based analyses. Process studies also inspired the development of a new undergraduate course in 2007 (SIO 101 - *California Coastal Oceanography*). Process studies are strongly linked to observational time-series (e.g., CalCOFI) through a core of common measurements, and the resulting rates, relationships and mechanistic insights will be used to parameterize and validate ecosystem models looking at long-term climate-driven trends.

Time Series Measurements

The CCE-LTER program assesses scales of variability in the California Current Ecosystem - interannual to decadal - using time series programs. The key element is augmentations to the quarterly CalCOFI cruises to characterize biological communities and essential characteristics of ocean biogeochemistry. These measurements will allow us to close elemental budgets and understand the time-variability in distribution and abundance of organisms ranging from bacteria to pelagic fish in ways that were not previously feasible. CCE-LTER investigators are also working actively with the joint CalCOFI-CCE data set. This research, usually coupled to the program's modeling component, will allow us to understand the mechanisms that drive the variability of the CCE ecosystem. SIO graduate students and post docs have been particularly involved in these efforts as evidenced by numerous high-profile papers emerging from this work. Other important time series in which CCE investigators are involved include the ocean glider program (along lines 80 and 90); deep sea benthic time series program at Sta. M (CCE Associate Ken Smith, now at MBARI); and satellite remote sensing imagery used to infer Chl*a*, primary production, and export production. In addition, our outreach partner, the Ocean Institute at Dana Point, has established under our guidance a coastal hydrographic and biological time series, both to allow us to document the linkages between the offshore and coastal regions and also to involve students – high school to college – in the CCE LTER work. To date 1200 students have been involved in the OI program at sea, in addition to more than 20 volunteers on CCE-augmented CalCOFI cruises..

Two SIO graduate courses (SIO 278, *The LTER Approach to Ecosystem Research*, and SIO 279, *California Current Ecosystem Dynamics*) have been developed from this research.

Modeling

The modeling component of the CCE-LTER was designed to provide i) a mathematical structure for quantifying the dynamics underlying the observations, ii) a synoptic environmental context for point observations, and a means for dynamic interpolation between observations in space and time, iii) a platform for hypothesis testing through numerical experiments and process models, and iv) guidance in the optimization of the sampling program. We have had success in all these areas. Through the synthesis of models and data we have identified and analyzed a previously unrecognized climate pattern (the "North Pacific Gyre Oscillation" NPGO) that explains decadal variations of ocean climate and ecosystems recorded in long-term observations of the Northeast Pacific. The ROMS model has also been used to identify the source of upwelled waters in positive and negative states of the PDO. It has further been used to successfully forecast ocean upwelling intensity in advance of a CCE Process Cruise. Using a novel continuum size-structured model, supported by data from the CCE, we have begun to explore the details of physical (bottom-up) and predator (top-down) forcing of ecosystem diversity and structure in the face of variable climate forcing. We have shown that ecosystems dominated by specialist predators will tend to be more diverse, have lower biomass, and have smoother size spectra than ecosystems with generalist predators. Nonlinear hindcast models have been used to contrast the dynamics of physical and biological properties of ocean ecosystems. The CCE-LTER modeling component has involved researchers,

postdocs and graduate students across SIO, UCSB, Georgia Tech, the University of Hawaii, Rutgers, NOAA/NMFS, and the University of Western Brittany (UBO) in France. Seven SIO graduate students, 3 SIO postdocs, and 2 graduate students in France have been involved in the modeling team. CCE-LTER modeling results have been incorporated into SIO 285 *Physical-Biological Interactions* and formed the core of SIO 279 *Special Topics in Biological Oceanography*.

Information Management

The CCE LTER initiated at SIO in 2004 enabled launch of a new approach to local information management. This new "Ocean Informatics" meets the requirements of interdisciplinary science focusing on data flow, knowledge generation, and information exchange. The developments at CCE build upon work done in the Palmer Station LTER at SIO since 1991 and include growing links with CalCOFI at SIO, SWFSC, and associated digital data initiatives at Woods Hole and MIT. The principal activities of the CCE LTER Information Management to date have been to develop an information infrastructure that includes: a) a cross-project, open source architecture with collaborative tools such as remote mount disks and shared data spaces; b) a project web site (http://cce.lternet.edu) with dynamic elements such as bibliography and media gallery; c) an information system designed for data discovery, integration, and access, as well as for query and joining of diverse datasets; d) an information system architecture anchored by data dictionaries and metadata (Ecological Metadata Language); and e) a suite of tools supporting local data handling such as a grid calculator and interactive data mappers.

Over the last three years, we have provided a field study site and collaborative ties for 3 UCSD Science Studies graduate students and one Communication Department postdoc. We have served as informatics guides for CCE LTER participants, including graduate and undergraduate students.

Education and Public Outreach

CCE's Education and Public Outreach Coordinator has created a bridge of communication and interaction with the surrounding community made possible through a series of Schoolyard LTER supplements. Our K–12 educational efforts at CCE are founded in large part upon the Ocean Literacy Principles (2005) and thus aligned with state and national education standards. CCE's educational program has a unique outreach partnership with the Dana Point Ocean Institute (OI), a facility known for its hands-on marine science, environmental education, and maritime history programs. In the local San Diego community, the CCE EPO program works with students and teachers in several schools, including the UCSD Preuss School, a minority-serving charter school, and Rancho Bernardo High School. CCE is developing, in collaboration with the Palmer Station LTER, a children's book entitled the "Tale of Two Krill," to contrast temperate upwelling and ice-covered polar ocean ecosystems.

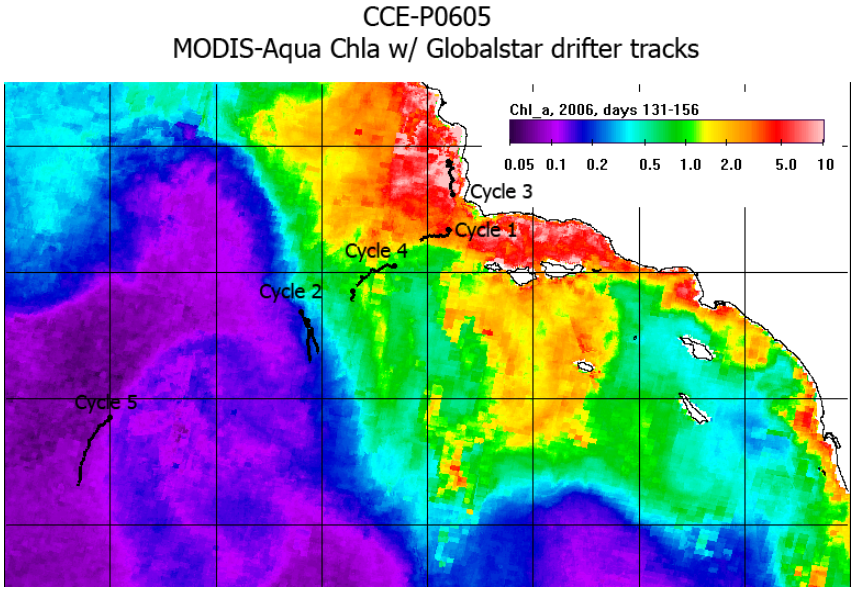
In addition to the approximately 2,900 K-12 students exposed to CCE site science through field trips at OI, classroom presentations, and use of instructional materials, 5 local high school students and numerous undergraduates have also worked in several CCE scientist's laboratories.

Participation in the CCE Site

Twenty-six scientists are involved in the CCE-LTER site as either co-PI's or Associates. Of these, 21 are located at SIO. In addition, 3 visiting scientists have participated actively in aspects of the CCE program. A total of 6 postdocs (5 at SIO), 22 SIO graduate students, and 7 visiting or foreign-based graduate students have been involved in the program to date. Two NSF-funded REU (Research Experience for Undergraduates) students worked full time in CCE labs in summer 2007 and many other undergraduates have benefited from lab experience. Approximately 40 cruise volunteers from across the U.S. (and Mexico and South Korea) have participated in CCE process cruises or augmented CalCOFI-LTER cruises.

Several other, independently awarded grants at SIO have already successfully leveraged NSF LTER funding and cruise opportunities.

CCE LTER
Process Cruise
Lagrangian Experiments



CCE LTER
Time Series Sampling