University of California

Coastal Marine Institute

Annual Report

2000 - 2002

University of California

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Program Manager, CMI
and
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Marine Science Institute
University of California
Santa Barbara, California 93106-6150

Mission of the Coastal Research Center

The Coastal Research Center of the Marine Science Institute, UC Santa Barbara, facilitates research and research training that foster a greater understanding of the causes and consequences of dynamics within and among coastal marine ecosystems. An explicit focus involves the application of innovative but basic research to help resolve coastal environmental issues.

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THE COASTAL MARINE INSTITUTE

A Cooperative Program
involving the

University of California,
the State of California

and the

Minerals Management Service
US Department of Interior

ANNUAL REPORT
PROGRAM YEARS 6, 7, & 8

March 21, 2003

PROGRAM MANAGER'S REPORT

The Coastal Marine Institute (CMI) was initiated in July 1994 as a cooperative research and research training program involving the Minerals Management Service, the State of California and the University of California. The focus is on long-term environmental, social and economic consequences of oil and gas production activities in the Pacific Outer Continental Shelf region. This Annual Report summarizes activities and research progress during Program Year 6 (July 1, 1999 - June 30, 2000), Program Year 7 (July 1, 2000 – June 30, 2001), and Program Year 8 (July 1, 2001 – June 30, 2002).

Major programmatic progress achieved during Program Year 6 of the CMI:

- During 1999 – 2000, 18 regular and research faculty, 36 trainees (2 postdoctoral, 6 graduates, 26 undergraduates, and 2 high school students) and 3 staff from 6 campuses and laboratories participated in CMI research projects;

- This Program year, CMI-sponsored studies published 16 peer-reviewed papers, with an additional 24 research presentations. In addition, 2 draft final reports were submitted for review and 1 MMS final report was completed.

Major programmatic progress achieved during Program Year 7 of the CMI:

- During 2000-2001, 20 regular and research faculty, 65 trainees (24 graduates, 39 undergraduates, and 2 high school students) and 25 staff from 3 campuses and laboratories participated in CMI research projects;

- This Program year, CMI-sponsored studies published 17 peer-reviewed, with an additional 29 research presentations. In addition, 3 draft final reports were submitted for review and 1 MMS final report was completed.

Major programmatic progress achieved during Program Year 8 of the CMI:

- During 2001-2002, 31 regular and research faculty, 54 trainees (2 postdoctoral, 16 graduates, and 36 undergraduate students) and 24 staff from 7 campuses and laboratories participated in CMI research projects;

- This Program year, CMI-sponsored studies published 11 peer-reviewed papers, with an additional 4 manuscripts that are in press, and 33 research presentations. In addition, 2 MMS draft final reports were submitted for review.

SUMMARY OF RESEARCH PROGRESS

Task No. 12387: *Ecological Consequences of Alternative Abandonment Strategies for POCS Offshore Facilities and Implications for Policy Development*

Principal Investigators: Mark H. Carr, Department of Biology, University of California, Santa Cruz, CA 95064, **Graham E. Forrester,** Dept. of Biology, University of California, Los Angeles, CA 90095-1606, and **Michael V. McGinnis,** Coastal Research Center and Ocean and Coastal Policy Center, Marine Science Institute, University of California, Santa Barbara, CA 93106-6150

Rationale for project

Critical to formulation of appropriate decommissioning policy is an understanding of the ecological, economic and social consequences of different decommissioning options and identification of the mechanisms by which such information is incorporated, or not, into legislation and public policy. Perhaps the most important ecological consequence of abandoning POCS facilities is a potential change in regional fish production (the biomass of fish accrued per year), which may in turn influence yields to fisheries. Hard substratum reefs represent a small fraction of the available offshore habitat in California, but are sites of high fish production. However, prior to this study, only one study provided quantitative estimates of species composition and abundance of fishes at a single platform off southern California.

Objective 1: Ascertaining the ecological and related economic effects of total or partial removal of offshore structures

A. Quantitative description of fish assemblages on natural reefs and offshore structures.

One objective of this study has been to quantify the species and sizes of fishes associated with platforms and natural reefs. Such information is required to determine what species and life stages might be influenced by the various decommissioning options. Do fish recruit to each habitat type from the plankton (as larvae) or migrate on to one habitat type from the other as older stages (benthic juveniles and adults)? Comparison of fishes between platforms and natural reefs provides information on what stages use the two habitat types. Patterns of fish sizes over time can also provide information on how long fishes associate with each habitat type and how well they grow and survive. Such information is critical to understanding the relative value of natural reefs and platforms as fish habitat.

B. Estimates of transfer of fish production between offshore structures and other habitats.

Fundamental to understanding the net contribution of local populations to regional production is information on the size-specific rate of migration of fishes among local, reef-associated populations. In the context of platform decommissioning, knowledge of the net direction and rate of transfer of biomass between platforms and natural reefs is crucial. For example if fish recruit to natural reefs and eventually migrate to platforms, accumulation of fish biomass on platforms would be incorrectly attributed to production at the platform habitat. Conversely, if platforms provide recruitment habitat for fish that eventually migrate to natural reefs, the contribution of platforms to regional production may be grossly underestimated by simply measuring production in the two habitats. Movement information is also important to determine whether the loss of fish at a site is due to emigration rather than mortality. Therefore, we have conducted a tagging study determine how much and what direction (from platforms to reefs or vice versa) fish move, the rate of that movement, and net direction of exchange.

Objective 2: Examining whether and how scientific information has influenced prior abandonment policy

The southern and central regions of California are rapidly entering a new era of OCS oil and gas activity. Decommissioning of offshore oil and gas facilities is rapidly becoming an issue of concern. The ultimate cultural and ecological impacts of decommissioning OCS oil and gas structures is not well understood by scientists, policy makers or the general public. Scholars have examined the political dimensions of oil and gas leasing, exploration and production associated with the Outer Continental Shelf (OCS). Researchers have uncovered critical differences between OCS oil and gas regions; the politics of OCS oil and gas development is based on important local, regional, legal, technological, and socio-economic considerations. These considerations are unlikely to be generalizable across regions, places or locations. In other words, OCS oil and gas development is contingent upon sociocultural factors that are endemic to particular places, regions and localities and not just the presence of OCS oil and gas reserves, government's willingness to create opportunities for the development of oil and gas, or the availability of modern technologies to develop oil and gas. Similarly, development of decommissioning policy, including the role of scientific information as a basis for such policy, is likely to be more or less important among OCS regions, depending on socio-economic considerations.

Progress during 1999-2000

During this year efforts were focused primarily on processing and analyzing data. The primary tasks included: Further species and assemblage level comparisons of recruitment and density (fish per unit volume) among platforms and between platforms and reefs and analyses of fish size distributions among depths and habitats (platforms vs. natural reefs) in conjunction with fish movement data from the tagging study. In addition to analyses, tasks included preparing text, tables and figures for the final report and publications.

Also during this Program year, principal investigators Mark Carr and Pete Raimondi joined the University of California Select Scientific Committee on Decommissioning Alternatives established by the University of California's Office of the President (UCOP) and the University of California Marine Council.

Progress during 2000-2001

Our major focus over the past year has been to analyze and prepare the final report, related publications, and contribute to the report by the University of California Select

Scientific Advisory Committee on Decommissioning established by the University of California's Office of the President (UCOP) and the University of California Marine Council. Co-investigators on this CMI project, M. Carr and P. Raimondi, were two of six co-authors this report, chaired by Dr. Sally Holbrook at UC Santa Barbara. This Annual Report focuses on the contribution of this CMI funded project to that report and subsequent activities.

The report to the University of California Marine Council, "Ecological Issues Related to Decommissioning of California's Offshore Production Platforms", was produced in response to California State Senator Dede Alpert's request that the University of California provide her with background information for the development of legislation on alternatives for the decommissioning of oil production platforms in California state waters. The council convened an advisory committee comprised of Drs. Sally J. Holbrook (Chair, UC Santa Barbara), Richard Ambrose (UC Los Angeles), Louis Botsford (UC Davis), Mark Carr (UC Santa Cruz), Peter Raimondi (UC Santa Cruz), and Mia Tegner (Scripps Institute of Oceanography). The purpose of the report was threefold: (1) to identify and explain the necessity for the kinds of scientific information required to understand and predict ecological consequences of decommissioning alternatives and how well existing information fulfilled those information needs, (2) to summarize much of the scientific information available regarding the *ecological* consequences of various proposed decommissioning alternatives and indicate the sources and magnitude of uncertainty in our understanding of such consequences, and (3) identify gaps in our knowledge and recommend future research directions to fill such gaps. The full report (41 pp) is available on the internet at: http://www.ucop.edu/research/ucmc_decommissioning/.

The UCMC report summarized existing knowledge of species and life stages associated with offshore production platforms, spatial (local and geographic) and temporal (seasonal and interannual) variation in species and life stage composition, vertical distribution along platforms, and key life history traits (larval duration and adult movement) of species associated with platforms. Almost all of this information was gleaned from the collaborative research programs funded by the UCSB-MMS-CMI (Carr et al.: 14-35-0001-30758, Task 12387, Page and Dugan: 14-35-0001-30758, Task 12391) and USGS-BRD (Love et al.: CR-19999-007). The report also summarizes available information on the physical (structural) characteristics of the platforms and their surrounding environment (e.g., water depth, geographic location).

The report recommended several key research directions that would contribute fundamentally to the knowledge necessary to better understand the ecological consequences of the various decommissioning alternatives. These research recommendations are summarized in the Executive Summary of the report.

Subsequent to the dissemination of the report by the UC Marine Council, a nonprofit organization, California Artificial Reef Enhancement (CARE) Program, convened a panel of agency and academic representatives to discuss the UCMC report and develop a separate set of research recommendations. M. Carr attended that meeting to address questions the panel had with respect to the UCMC report and contribute further to research recommendations created by that panel. The two-day facilitated workshop, "The Ecological Consequences of Decommissioning California's Offshore Oil Platforms" was held in San Diego, in May of 2001. The panel developed a series of research recommendations which the CARE program would consider for their efforts to support research on the ecological consequences of decommissioning.

We also continued to focus our efforts on writing the Final Report and associated publications this past year. The primary tasks conducted this past year were further analyses of fish abundance and size distributions among depths and habitats (platforms vs. natural reefs) and preparing text, tables and figures for the final report and publications.

Progress during 2001-2002

Unfortunately, the slow acquisition of our no-cost extension constrained the amount of time our technicians could devote to data analysis during this period. As a result, little work on this project occurred until the extension cleared. After that issue was sorted out we re-hired technicians to complete analyses, text, tables and figures. Our estimated time for completion of the final report and associated publications is April 15, 2003.

Task No. 12388 *&* **Task No. 17610:** *Joint UCSB-MMS Pacific OCS Student Internship and Trainee Program*

Principal Investigators: Jenifer Dugan, Marine Science Institute, University of California, Santa Barbara, CA 93106-6150 and **Edward Keller**, Environmental Studies and Geological Sciences Departments, University of California, Santa Barbara, CA 93106-9630

Summary of Research

Progress during 1999-2000

Over this year, 10 graduate and undergraduate students have participated as interns in 8 research projects. Some of the interns have been jointly mentored by MMS staff and a member of the UCSB faculty or professional researcher. During the 1999-00 academic year, CMI interns have been involved in a variety of projects including: i) the creation of user-friendly keys and web pages based on the MMS sponsored Invertebrate Taxonomic Atlas (Ms. Carla Navarro mentored jointly by Dr. James Lima (MMS) and Dr. Paul Scott (Santa Barbara Museum of Natural History)), ii) a literature review of intertidal mussel ecology and biology (Ms. Heather Walling mentored jointly by Mr. Mike McCrary, Mr. Mark Pierson, Ms. Mary Elaine Dunaway and Mr. Maurice Hill from MMS and Dr. Jenifer Dugan (UCSB)), iii) a field survey-based study of beach attendance in Los Angeles and Orange Counties (Mr. Morgan Matlock, Ms. Lisa Woo and Ms. Carly Gocal mentored by Dr. Linwood Pendleton (USC)), iv) the development of an offshore pipeline database (Mr. Brandon Dayoan mentored by Ms. Theresa Bell (MMS)), v) a research project on decommissioning of oil platforms (Mr. Brendon Applegate mentored by Dr. Michael V. McGuiness (UCSB)), vi) development of a regional database for use in site-specific geological and engineering evaluation of producing offshore fields in the Santa Maria Basin, Santa Barbara Channel and offshore Long Beach (Mr. Jeffrey Marsh mentored by Ms. Joan Barminski (MMS) and vii) comparative study of policies and social aspects of programs for conversion of oil rigs to reefs in the USA (Mr. Geoff Cline jointly mentored by Dr. Michael V. McGuiness (UCSB) and Dr. James Lima (MMS)).

During Winter and Spring 2000, we worked with MMS personnel to develop position descriptions and advertise five internships. One new intern position was initiated in June '99. The project combines the job description of two internships and involves the entry and proofing of seabird data, seabird monitoring and a literature review on the effects of human activity on seabirds. The intern is Ms. Jodie Henri who is jointly mentored by Mr. Mike McCrary and Mr. Mark Pierson of MMS and Paige Martin (CINP). This internship will continue through the summer. Three new positions working with the MARINE rocky intertidal monitoring network and Ms. Mary Elaine Dunaway of MMS were filled and will be initiated in July 2000.

The program experienced continued success this year with increasing interest by prospective interns and mentors. Feedback from all participating interns and mentors has been extremely positive and encouraging. Based on this positive response, we will continue the internship program as an important part of the new MMS/ UC Coastal Marine Institute cooperative agreement. The UC Santa Barbara Environmental Studies Internship Program has continued to serve as an excellent mechanism for advertising positions, screening applicants and reviewing intern performances. We have expanded our distribution of advertisements for intern positions to other academic departments at UC Santa Barbara including: Department of Ecology, Evolution and Marine Biology, Department of Geography and the Donald Bren School of Environmental Science and Management.

Joint UCSB-MMS Pacific OCS Graduate Trainee Program

Graduate students and post-doctoral researchers continue to be directly or indirectly exposed to research sponsored by the Coastal Marine Institute. This exposure has ranged from short-term participation in field studies to the development of thesis proposals related to CMI projects. Students involved in short-term participation in CMI projects have received summaries of the objectives and the relevance of the studies to decision-making and policy development at MMS. In addition, some of the information produced by CMI sponsored projects has been incorporated into graduate and undergraduate curricula at UC Santa Barbara. A list of participating graduate students and postdoctoral researchers appears in the Trainees and Staff section of this Annual Report.

Information Transfer Seminars (ITS)

We arranged the presentation of results from recent UC Santa Barbara research projects by principal investigators and postdoctoral researchers in Information Transfer Seminars (ITS) at the POCS headquarters this year. In cooperation with Dr. Fred Piltz and Dr. James Lima of MMS, the following ITS seminar was presented:

Dr. Eric R.A.N. Smith –The Role of Knowledge in Attitudes toward Risky Environmental Technologies. Talk delivered at the U.S. Minerals Management Service, Camarillo, California, 8 February 2000.

Progress during 2000-2001

Over the past year, 10 graduate and undergraduate students participated as interns in 5 research projects. During the academic year, we worked with MMS personnel to develop position descriptions and advertise several new internships. Some of the interns have been jointly mentored by MMS staff, BRD staff, NPS staff and/or a member of the UCSB faculty or professional researcher. During the 2000-2001 academic year, CMI interns have been involved in a variety of projects including: i) entry and proofing of data on seabirds from aerial surveys and monitoring of seabirds in the Santa Barbara Channel and a literature review on the effects of human activity on seabirds (Jodi Henri, and Kerry Sawyer mentored by Michael McCrary at MMS, USGS-BRD personnel and NPS personnel), ii) assisting with data collection, data entry, and databases, coordination of intertidal monitoring efforts among different agencies and universities and in the field on the mainland for the MARINE rocky intertidal monitoring network (Jessica Hayden-Spear, Brent Mardian and Mike Asakawa mentored by Ms. Mary Elaine Dunaway of MMS, Dan Richards of NPS and Mark Shildhauer of UCSB-NCEAS), iii) supporting the MMS marine archeology program by digitizing maps, organizing and archiving archeological information into an existing database, and creating narratives and website information on archeological resources from the region (Jason Chau and Mike Williams mentored by Dr. Jim Lima of MMS), iv) assisting with a regional database for use in site-specific geological and engineering evaluation of producing offshore fields in the Santa Maria Basin, Santa Barbara Channel and offshore Long Beach (Luke Hamlin and Benjamin Russell mentored by Ms. Joan Barminski, Mr. Mayerson and Mr. Mike Brickey of MMS), and v) re-bagging, organizing and archiving geologic samples from well sites for long term storage (Joe Moulton mentored by Mr. Scott Drewry of MMS).

The program experienced continued success this year with increasing interest by prospective interns and mentors. Feedback from all participating interns and mentors has been extremely positive and encouraging. Based on this positive response, the internship program continues as an important part of the new MMS/ UC Coastal Marine Institute cooperative agreement. The UC Santa Barbara Environmental Studies Internship Program has continued to serve as an excellent mechanism for advertising positions, screening applicants and reviewing intern performances. Our expanded distribution of advertisements for intern positions to other academic departments at UC Santa Barbara including: Department of Ecology, Evolution and Marine Biology, Department of Geology, Department of Geography and the Donald Bren School of Environmental Science and Management has been successful in reaching students from a range of academic majors and backgrounds.

Joint UCSB-MMS Pacific OCS Graduate Trainee Program

Graduate students and post-doctoral researchers continue to be directly or indirectly exposed to research sponsored by the Coastal Marine Institute. This exposure has ranged from short term participation in field studies to the development of thesis proposals related to CMI projects. Students involved in short-term participation in CMI projects have received summaries of the objectives and the relevance of the studies to decision making and policy development at MMS. In addition, some of the information produced by CMI sponsored projects has been incorporated into graduate and undergraduate curricula at UC Santa Barbara. A list of participating graduate students and postdoctoral researchers appears in the Trainees and Staff section of this Annual Report.

Information Transfer Seminars (ITS)

No information transfer seminars were arranged this year at the request of MMS personnel.

Progress during 2001-2002

Over the past year, 8 graduate and undergraduate students participated as interns in 5 research projects. We worked with MMS personnel to develop position descriptions and advertise several new internships through UCSB academic departments and programs. Student interns were jointly mentored by MMS staff, USGS-BRD staff, NPS staff and/or a member of the UCSB faculty or professional research staff. During the Summer of 2001 and the 2001-2002 academic year, CMI interns were involved in a variety of projects including: i) entry and proofing of data on seabirds from aerial surveys and monitoring of seabirds in the Santa Barbara Channel (Kerry Sawyer and Regina Butala mentored by Michael McCrary and Mark Pierson at MMS, USGS-BRD personnel and NPS personnel), ii) supporting the MMS marine archeology program by digitizing maps, organizing and archiving archaeological information into an existing database, and creating narratives and website information on archaeological resources from the region (Jason Chau and Mike Williams mentored by Dr. Jim Lima and Fred Piltz of MMS), iii) assisting with a regional database for use in site-specific geological and engineering evaluation of producing offshore fields in the Santa Maria Basin, Santa Barbara Channel and offshore Long Beach (Tim Wolff and Benjamin Russell mentored by Ms. Joan Barminski, Mr. Mayerson and Mr. Mike Brickey of MMS), iv) assisting with the collection and organization of geologic data and samples from offshore sites (Luke Hamlin mentored by Ms. Joan Barminski of MMS) and v) rebagging, organizing and archiving geologic samples from well sites for long term storage (Joe Moulton mentored by Mr. Scott Drewry of MMS).

The CMI internship program experienced continued success this year with excellent interest and participation by prospective interns and mentors. Feedback from all participating interns and mentors has been extremely positive and enthusiastic. Based on this positive response, the internship program continued as an important part of the new MMS/ UC Coastal Marine Institute cooperative agreement. The UC Santa Barbara Environmental Studies Internship Program continued to serve as an excellent mechanism for advertising positions, screening applicants and reviewing intern performances. Our expanded distribution of advertisements for intern positions to other academic departments at UC Santa Barbara continued this year including: Department of Ecology, Evolution and Marine Biology, Department of Geology, Department of Geography, Girvetz Graduate School of Education and the Donald Bren School of Environmental Science and Management . This expanded distribution continued to be successful in reaching students from a range of academic majors and backgrounds to fill internship openings.

Joint UCSB-MMS Pacific OCS Graduate Trainee Program

Graduate students and post-doctoral researchers continued to be directly or indirectly exposed to research sponsored by the Coastal Marine Institute through a variety of mechanisms. This exposure ranged from short term participation in field studies to the development of thesis proposals related to CMI projects. Students involved in short-term participation in CMI projects received summaries of the objectives and the relevance of the studies to decision-making and policy development at MMS. In addition, some of the information produced by CMI sponsored projects has been incorporated into graduate and undergraduate curricula at UC Santa Barbara. A list of participating graduate students and postdoctoral researchers appears the Trainees and Staff section of this Annual Report.

Information Transfer Seminars (ITS)

On May 2, 2002, five talks based on CMI research projects were presented to MMS at the headquarters in Camarillo. The titles of the talks and the authors are listed below (* denotes speaker).

1. "Early development of subtidal invertebrate assemblages on offshore oil platforms in the Santa Barbara Channel"- Jason Bram*, Mark Page and Jenny Dugan.

2. "Spatial patterns of distribution, abundance and dynamics of invertebrates on offshore oil platforms" in the Santa Barbara Channel"-Carrie Culver*, Brent Mardian, Mark Page and Jenny Dugan.

3. "Habitat value of shell mounds at existing and former offshore oil platform sites to mobile benthic invertebrates"- Erin Bomkamp*, Mark Page and Jenny Dugan.

4. "Effects of grooming on exposed sandy beaches in southern California"-Jenny Dugan*, David Hubbard and Mark Page.

5. "Declines in regional fish populations: species responses to environmental change and the nature of community organization"- Andy Brooks*, Russell Schmitt and Sally Holbrook.

Task No. 13094: *Application of Coastal Ocean Dynamics Radars for Observation of Near-Surface Currents off the South-Central California Coast*

Principal Investigators: Libe Washburn, Department of Geography, University of California, Santa Barbara, CA 93106-4060, **Steven D. Gaines,** Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106-9610

Progress during 1999-2000:

During this year, we continued operation of a network of five high frequency (HF) radars along the northern coastline of the Santa Barbara Channel and the central coast north of Pt. Conception, California. Overall the sites have worked well, although we have experienced data loss at Point Conception due to very limited access. Because we can only access this site quarterly, we are unable to check on this site as regularly as we would like. Nevertheless we do have data from the site over the part of the reporting period.

A major focus of our research has been the evaluation of HF radars as instruments for the measurement of surface currents. Our approach is to compare time series of currents at selected locations from the HF radars with *in situ* currents measured from moored current meters located in our coverage area. Specifically we compare radial currents measured with the HF radars with the radial component of currents at various mooring locations. We have been using current data from a mooring maintained by UCSB and from an array of current meters in the Santa Barbara Channel and Santa Maria Basin maintained by the Center for Coastal Studies at Scripps.

The comparisons reveal that most of the variance in the radar-derived surface currents is accounted for by currents at 5 m depth ($r^2 \sim 0.5 - 0.7$). However, we have detected a pointing error that varies with bearing of about 5 degrees, sometimes as large as 15-20 degrees. We are working with radar engineers at CODAR Ocean Sensors to correct for these offsets. We speculate that the offsets arise from imperfections in the antenna patterns. Recent work has also focused on the degree to which surface currents are forced by the wind. This analysis is based on meteorological data from buoys in the Santa Barbara Channel and near Pt. Conception. We are currently working on a manuscript describing our findings on HF radar performance.

At the beginning of this year we extended our analysis of our HF radar data based on empirical orthogonal functions (EOF's). The patterns in the Santa Barbara Channel reveal that the cyclonic eddy mode explains about 27% of the variance over our coverage area in the western Channel. We also find that the eddy is consistently located over the Santa Barbara Basing suggesting that topography plays a role in steering the eddy and surface flow field. In addition, the mean currents for the period 1 April 1998 through 31 March 1999 clearly show the eddy centered over the basin.

Sampling of the various sites for inter-tidal organisms continued over the reporting period. We are working to combine these data with the flow fields from our HF radars so that the role of circulation processes in controlling species ranges can be addressed.

Problems Encountered: We had the continuing problem over the reporting period of limited access to our HF radar site at Pt. Conception.

Progress during 2000-2002:

Analyses and writing culminated in the final report, which was submitted to the Coastal Research Center on March 15, 2001.

Washburn, L. and S. Gaines. Summary of findings for using high frequency radar in physical oceanographic and ecological studies. MMS OCS Study 2001-056. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 14-35-0001-30758. 31 pages.

Task No. 13095: *Effects of Produced Water on Complex Behavioral Traits of Invertebrate Larvae and Algal Zoospores*

Principal Investigator: Peter Raimondi, Department of Biology, University of California, Santa Cruz, CA 95064

Summary of Research

Progress during 1999-2000

In the beginning of this year we obtained new samples of Produced Water (PW) from MMS. Despite the fact that the project had changed direction (see previous reports), we were able to finish some (albeit very few) of the originally planned experiments. This was completed before our Post-Doctoral Researcher (Anthony Boxshall) left for Australia in January of 2000. Prior to this occurrence, the project had finished for all intents and purposes and the analysis and writing phase had commenced. Apart from the few, new, small experiments with the miraculously-produced PW, the writing and analysis will continue as scheduled.

Progress during 2000-2001 and 2001-2002

Analyses and writing culminated in the final report, which was completed in December 2001.

Raimondi, P. T. and Boxshall A. Effects of Produced Water on Complex Behavior Traits of Invertebrate Larvae. MMS OCS Study 2002-050. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 14-35-0001-30758. 38 pages.

Task No. 14181: *Population Trends and Trophic Dynamics in Pacific OCS Ecosystems: What Can Monitoring Data Tell Us?*

Principal Investigators: **Russell J. Schmitt,** Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106-9610 and **Andrew J. Brooks,** Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, CA 93106-6150

Summary of Research

A number of entities (including MMS) have devoted considerable effort and resources to the long-term monitoring of various components of the coastal marine ecosystems in the Southern California outer-continental shelf (OCS) region. The primary goals of such monitoring are to estimate the current state of the biota and to identify long-term trends in population demographics. Data from such studies are vital to resource and regulatory agencies as they provide critical baseline information needed for accurate assessment of potential effects arising from such particular activities as offshore oil and gas production. The growing number of coastal marine monitoring programs that have been implemented in Southern California is evidence of the fundamental need for such information.

The behavior of the California Current System plays a critical role in determining the conditions of the nearshore marine environment off Southern California. The typically high productivity of this system is attributed to coastal upwelling that brings deeper, nutrient-rich water to the surface near shore. This high supply rate of nutrients enhances primary productivity, which in turn increases secondary productivity of the nearshore pelagic and benthic food webs. Time series studies of the California Current System conducted by the California Cooperative Fisheries Oceanic Investigations since the 1940's have revealed distinct seasonality within a year, and periodic wholesale change during El Niño Southern Oscillation (ENSO) events that have relatively brief (1-2 years) durations. There is abundant evidence that the California Current System has undergone a longer, interdecadal length change since the late 1970's and early 1980's. One manifestation of this apparent regime shift off Southern California was a rapid, large, and persistent increase in seawater temperature. Between 1976-1977, mean annual surface temperatures in the Southern California Bight rose an average of 1^{o}C or more above the mean for the previous two decades. A number of changes in other physical processes and events that can influence marine biota were associated with this warming event. Among the more important manifestations of these altered physical conditions in Southern California was a decrease in productivity in surface waters near shore. Although the exact physical explanation is still under study, it appears reasonably certain that the amount of nutrients upwelled into surface waters have declined during this recent period of elevated seawater temperature. There is compelling evidence that the abundances of many coastal species off Southern California also have undergone dramatic declines over the past 1-2 decades in response to falling productivity in near shore, surface waters.

The vast amount of long-term data on nearshore biota collected by a large number of separate monitoring programs in the Southern California OCS region represents a relatively untapped "gold mine" of information for environmental managers. The occurrence of a regime shift in the ocean climate in the North Pacific in the past two decades provides a unique opportunity to determine whether and how various components of the biota respond to this source of perturbation. Data from long-term monitoring programs not only indicate the current state and recent history of the biota, but also can revel much about the ecological structure of various coastal ecosystems, including the dynamical behavior and regulation of different food webs. Such knowledge provides managers with better understanding and enhanced predictive ability regarding the potential impacts to these ecosystems from other potential sources of disturbance. Further, analyses of existing data sets can expose whether and how our ability to estimate or interpret responses of the biota may be constrained by present monitoring practices.

Our MMS-UC CMI funded research encompasses two separate, but related objectives: (1) the analysis and synthesis of existing long-term monitoring data and (2) the continued annual surveys of subtidal reef communities at Santa Cruz Island.

Progress during 1999-2000

(1) The analysis and synthesis of existing long-term monitoring data.

In the beginning of this year we completed the incorporation and standardization of 9 datasets into our master database. By analyzing these data for coherencies in abundance patterns we found that within species patterns are consistent throughout the Southern California Bight. In addition, we continued with our initial efforts to obtain all potential sources of appropriate time series data. We obtained all of our originally targeted data sets and continued the process of converting these data from their original hard copy format into a standardized digital format. As we anticipated, this proved to be a very time consuming process. We hired an additional graduate student to help us maintain, integrate, and error check new data sets.

By converting the raw abundance data contained in many of the original data sets into standardized measures of abundance, we were able to identify biologically meaningful measures of population responses to the decline in productivity for use in our meta-analyses. We completed this process for all of the fish species contained in our datasets and used this reduced data set to develop many of the time series techniques, e.g. data de-trending and smoothing functions, needed for many of our proposed analyses.

By the end of the year, we analyzed 8 separate datasets collected in three different ecological systems; subtidal rocky reef, kelp bed, and open ocean pelagic. Trends in population abundances show consistent declines in all three systems over the last 10-15 years. Most interesting, within each system examined, trends for each component trophic level show approximately the same degree of decline. This pattern holds across spatial scales ranging from a single island within the northern Channel Islands group to the entire Southern California Bight. Also interesting is the fact that data collected using extremely different methodologies, e.g. coastal power plant impingement studies versus diver visual surveys, provide similar estimates of the magnitudes of these declines.

(2) The continued annual surveys of subtidal reef communities at Santa Cruz Island.

We continued our monitoring of the abundances of surfperches, their invertebrate prey, and the cover of benthic microhabitats at the 11 permanent study sites on the south coast of Santa Cruz

Island. Sampling of fish (via visual counts along permanent band transects) and of the cover of benthic microhabitats (via random point contact methods) were accomplished in the manner described in our proposal. However, sampling of invertebrate densities on benthic microhabitats (via collection of all materials in 0.1 m^2 quadrats) was completed for only 2 of the 3 study sites as proposed. The failure to collect samples at the third site was due to extended periods of bad weather that precluded trips to Santa Cruz Island. Such incomplete sampling has occurred occasionally in past years and does not greatly affect our estimation of the densities of macroinvertebrates used as food by the fishes. All algal samples collected were identified and weighed. All samples collected for the purpose of identifying potential invertebrate prey were sorted and the individual organisms identified to the lowest taxon possible. Then, all data were error checked and entered into the appropriate data sets.

Progress during 2000-2001

(1) The analysis and synthesis of existing long-term monitoring data.

To date we have analyzed 8 separate datasets collected in three different ecological systems; subtidal, rocky reef, kelp bed, and open ocean pelagic. Trends in population abundances show consistent declines in all three systems over the last 10-15 years. Most interesting, within each system examined, trends within several simple food webs (subtidal, rocky reef: kelp bass, surfperches, epifaunal invertebrates, and foliose algae; kelp bed: sheephead, sea urchins, and understory algae; open ocean, pelagic: piscivorous seabirds, zooplanktivorous, epipelagic fishes, and zooplankton) show approximately the same degree of decline within each component trophic level. This pattern holds across spatial scales ranging from a single island within the northern Channel Islands group to the entire Southern California Bight. Also interesting is the fact that data collected using extremely different methodologies, e.g. coastal power plant impingement studies versus diver visual surveys, provide similar estimates of the magnitudes of these declines.

Our most recent efforts have centered around attempts to explore the generality of these results using a much larger dataset on marine fishes. The species examined were classified as to trophic level, mode of reproduction and longevity, and habitat. In general, the magnitude of decline was similar for all species, regardless of classification. Trends were similar at all locations examined within the Bight, suggesting regional declines in abundances rather than redistribution of individuals. These patterns are consistent with the explanation that a regional decline in productivity is responsible for observed regional declines in non-exploited fish stocks.

(2) The continued annual surveys of subtidal reef communities at Santa Cruz Island.

We have continued with our monitoring of the abundances of surfperches, their invertebrate prey, and the cover of benthic microhabitats at the 11 permanent study sites on the south coast of Santa Cruz Island. Collection of invertebrate prey and algal substrate samples as well as estimates of fish densities (using visual counts along permanent band transects) and the cover of benthic macroalgae (via random point contact methods) were accomplished at all 11 sites in the manners described in our proposal. We have completed the sorting, taxonomic identification, and enumeration of all invertebrate and algal samples collected through 1999. We also have completed the taxonomic identification and biomass estimation of all algal samples collected during our most recent surveys in 2000. Invertebrate samples collected in 2000 have been rough sorted and are now in the process of being identified and enumerated.

Our results indicate a continuing decline in the abundances of benthic algae, algal associated meso-invertebrates, surfperches, and piscivorous kelp bass at our 11 permanent study sites. The magnitudes of these declines are approximately equal for the four trophic levels investigated (~ 60-70% decline in standardized abundance). Previous work has documented tight linkages between the amount of cover and quality of understory algae (primary production), densities of meso-invertebrates, the production of surfperch offspring by resident, adult surfperches, and the number of top level consumers (kelp bass) found at a given site. That declines in populations of other sub-tidal fishes, invertebrates, and algae observed throughout the Southern California Bight (see 1 above) are consistent with the declines we have observed occurring off Santa Cruz Island in both their timing and magnitude suggests that the declines observed in these other species also may be related directly to the large-scale patterns of decreased primary productivity which have been observed throughout the Bight since the 1976-77 regime shift.

Progress during 2001-2002

(1) The analysis and synthesis of existing long-term monitoring data.

To date we have analyzed 8 separate datasets collected in three different ecological systems; subtidal rocky reef, kelp bed, and open ocean pelagic. Trends in population abundances show consistent declines in all three systems over the last 10-15 years. Most interesting, within each system examined, trends for each component trophic level show approximately the same degree of decline. This pattern holds across spatial scales ranging from a single island within the northern Channel Islands group to the entire Southern California Bight. Also interesting is the fact that data collected using extremely different methodologies, e.g. coastal power plant impingement studies versus diver visual surveys, provide similar estimates of the magnitudes of these declines. Most recently, we conducted time-series analyses on these data sets to describe their temporal trends and explore the timing and magnitude of change. The species examined were classified as to trophic level, mode of reproduction, extent of geographic range, association with benthic or pelagic food webs, and habitat. In general, the magnitude of decline was similar for all species, regardless of classification. Trends were similar at all locations examined within the Bight, suggesting regional declines in abundances rather than redistribution of individuals. These patterns are consistent with the explanation that a regional decline in productivity is responsible for regional decline in fish stocks.

Our most recent efforts have focused on disseminating results of this research to the scientific community, through peer-reviewed publications and presentations at scientific meetings. During this fiscal year our research was well received at three scientific conferences: the Western Society of Naturalists, the 6th Annual Indo-Pacific Fish Conference, and the Southern California Academy of Sciences. In addition, we published our results in one peer-reviewed journal (*Journal of Freshwater and Marine Research*), and began preparing two additional manuscripts for publication in the coming year.

(2) The continued annual surveys of subtidal reef communities at Santa Cruz Island.

Through an enormous effort by our undergraduate research assistants, we completed identifying epifaunal invertebrate samples collected during our 2000 and 2001 surveys. We also collected additional monitoring data on the abundances of surfperches, their invertebrate prey, and the algal cover present in benthic microhabitats at 11 permanent study sites on the south coast of Santa Cruz Island. Sampling of fish (via visual counts along permanent band transects) and algal cover (via random point contact methods) were accomplished in the manner described in our proposal. Epifaunal invertebrates collected from these sites have been sorted and preserved for later taxonomic identification. We were able to complete sampling at all of our study sites in 2001.

Task No. 15116: *Wave Prediction in the Santa Barbara Channel*

Principal Investigators: **Robert T. Guza**, Center for Coastal Studies, Scripps Institution of Oceanography, La Jolla, CA 92093 and **William C. O'Reilly**, Center for Coastal Studies, Scripps Institution of Oceanography, La Jolla, CA 92093

Summary of Research

Progress during 1999-2000

Wave Reflection from the Channel Island Coastlines

Waves propagating into the Santa Barbara Channel from the W-WNW impinge on the northern coasts of San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands, and a significant amount of the incident wave energy reflects from these rugged coasts back into Channel. This adds a significant southerly component to the Santa Barbara County wave climate in the lee of Pt. Conception during these wave events.

A detailed analysis was performed on three sets of directional buoy measurements made in 50m water depth, ~2*km* offshore of the north coasts of Santa Rosa and Santa Cruz Island. In general, the relative amount of reflected wave energy depends greatly on the wave frequency, with observed reflection at low frequencies ($f < 0.07$*Hz*) being two or more times larger than at higher frequencies.

The greatest amount of wave reflection (10-70%, depending on the wave frequency) was observed at the western end of the north side of Santa Cruz Island, where long, sheer coastal cliffs extend directly into 10-20*m* water depth. Slightly lower overall reflection was observed at the north-east end of Santa Cruz Island, where the more irregular cliffs are found, and off Santa Rosa Island, where the coast is better characterized as rocky shallows rather than sheer cliffs.

While the overall amount of observed reflection was similar for these three different types of rugged coasts, the estimated reflection coefficients at Santa Rosa were strongly energy dependent. The low waves were much more "reflective" (20-50%) compared to higher energy conditions (5-20%), presumably owing to a more active dissipation region in the rocky shallows with higher waves. A similar, but somewhat weaker dependence can be seen at the East Santa Cruz Island site, and only a slight energy dependence is observed at the West Santa Cruz site with its wall-like coastal cliffs.

These observations suggest the following wave reflection scenarios: During time periods when small, low energy swell propagate into the channel from the WNW, a significant amount of this swell energy is reflected back into the Channel by *all* the islands. The lower frequency, longer period swell ($T > 14$ *s.*) experience the highest amount of reflection (30%+). However, during time periods when larger swell is present in the Channel, active dissipation zones develop along most of the island coastlines, reducing the *relative* size of their reflected wave fields compared to low wave height events. Only the western half of the north coast of Santa Cruz, and perhaps the north side of Anacapa Island, continue to be highly reflective under energetic conditions.

Reflected Wave Energy in the Channel

Once waves have reflected from an island, they propagate northward across the Channel to the Santa Barbara County coastline. Data from two NOAA buoys in the Channel (46053 & 46054), and a directional buoy offshore of Montecito, CA, near Santa Barbara, were used to study reflected wave energy in the far-field of the islands.

NOAA Buoy 46053, located along the east-west axis of the Channel and due north of the western tip of Santa Cruz Island, provided the most compelling evidence of a reflected wave field emanating from the islands. While this buoy has moderate exposure to waves from the WNW, it is almost completely sheltered from waves from the south by Santa Rosa and Santa Cruz Island. Nevertheless, the buoy consistently sees a broad secondary peak from the south during WNW swell events. The reflected waves only contribute modestly to the overall energy at this location under typical conditions (5-15%). However, larger relative contributions were observed on occasions when the swell approached the Channel from more extreme NNW directions, placing the buoy in the wave energy shadow of Pt. Conception while the islands were still exposed to the incident swell.

The wave field measured by the Montecito buoy (~10*km* SE of Santa Barbara) proved to be more complex, but nevertheless yielded additional evidence of reflected wave energy reaching the Santa Barbara county coastline. This location is highly sheltered from WNW waves by Pt. Conception, but is exposed to waves directly from the west and, interestingly, waves from the SSE that enter the Channel through the passages on either side of Anacapa Island. The measured secondary peaks represented a larger portion of the overall energy at this site. In fact, the peak from the south actually became the larger of the two peaks at times. However, it is difficult to unambiguously separate island reflected north swell energy from south swell arriving from the Southern Hemisphere and entering the Channel near Anacapa. The strongest evidence of reflected energy at this site is seen at wave periods of 8-10 seconds. These waves have too short a period to be arrivals from the Southern Hemisphere, but too long a period to be generated in the Channel. The buoy measurements at these periods show a broad directional distribution of wave energy arriving from the south with no favoritism towards the Anacapa Island passage directions as was observed for the longer wave periods.

Numerical Modeling of Reflected Waves

The numerical prediction of wave energy at the buoy locations, using deep water wave measurements from Harvest Platform at Pt. Conception and a spectral refraction model, provided further evidence that wave reflection by the Islands is important to the overall wave climate in the Channel. The Harvest Platform measurement site is exposed to Southern Hemisphere swells, so the swell energy entering into the Channel via the Anacapa passages is included. Nevertheless, wave energy at the Montecito buoy site was consistently underpredicted by the model during WNW wave events when reflection was not included in the model.

Various modeling methods were implemented to account for the reflected wave energy, and the most consistent results were obtained for the entire data set by treating the islands as a diffuse source of wave energy. The coastlines were characterized as either non-reflective (beaches, most of the eastern section of Santa Cruz), moderately reflective (rocky shallows, Santa Rosa and San Miguel), or highly reflective (western half of Santa Cruz and Anacapa). The reflection coefficient used for each section was frequency dependent, based on the observations from the island buoys. In addition, the reflection coefficients for the moderately reflective sections were assigned an energy dependence to account for the more active coastal dissipation zone under more energetic conditions. While the frequency dependence proved to be important when validating this model at the Montecito buoy, the energy dependence was of limited importance at this location, with the predicted reflection being dominated by the highly reflective, non-energy dependent section of Santa Cruz Island.

Progress during 2000-2001

Analyses and writing culminated in the final report, which was completed in January 2001.

R. Guza and W. O'Reilly. Wave Prediction in the Santa Barbara Channel. MMS OCS Study 2001-055. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 14-35-0001-30758. 8 pages.

Task No. 15117: *Assessing Toxic Effects on Population Dynamics Using Individual-Based Energy Budget Models*

Principal Investigators: **Roger M. Nisbet,** Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106 and **Erik B. Muller,** Marine Science Institute, University of California, Santa Barbara, CA 93106

Summary of Research

Progress during 1999-2000

During this year we have pursued our ecotoxicological research along three lines: refinement of our toxicological model for individuals; analysis of our growth model in variable environments; and development of tools to assess top-down and bottom-up effects of toxicants. These projects are in various stages of development, and we will report on them in sequential order.

Toxic compounds may reduce the fecundity, development rate, and/or survival probability of individual organisms. In a previous annual report, we presented a model describing sublethal effects of toxicants on individuals. This model includes a module describing growth and reproduction in absence of pollutants; this module is the κ-rule outlined in Figure 1. Another module describes the accumulation of toxicants within the organism, and yet another module describes the feedback mechanisms of toxicant action on various parameters of the growth model. The sublethal effect of a toxicant is to alter the flow of one or more energy fluxes (see Figure 1). Those feedback mechanisms represent toxicants with a rather non-specific mode of action, such as narcotic compounds and metals. We tested our toxicity model with published data on various combinations of organism and toxicant, including marine mussels and oysters.

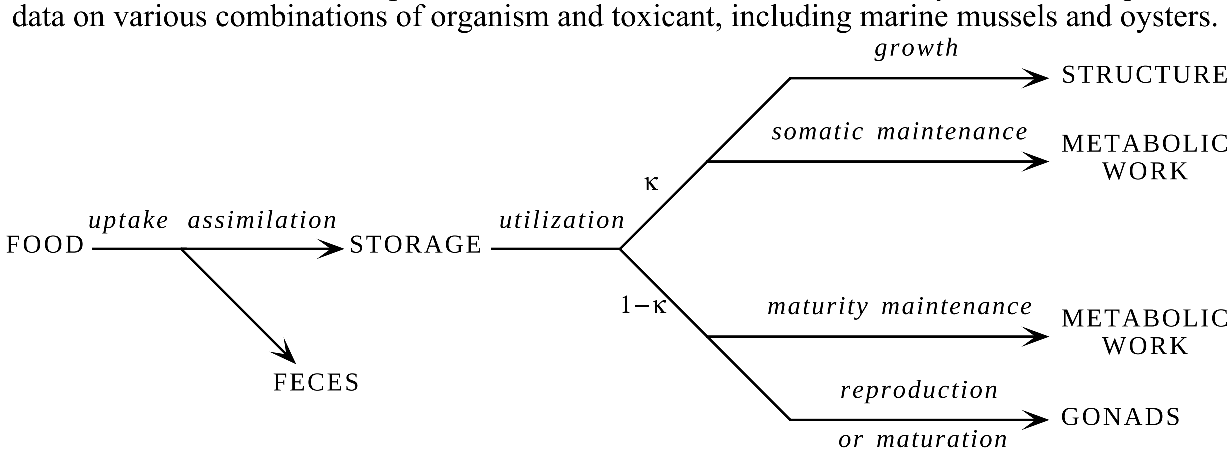

Figure 1: The κ -rule model assumes that an organism ingests food at a rate dependent on its size and the food density. Energy is extracted from food and added to the reserves. The rate at which energy becomes available to the organism depends on its size and stored energy density. Provided somatic maintenance requirements are met, a fixed proportion κ of the available energy is allocated to somatic maintenance and growth combined, and the remaining 1- κ to either maturation (for embryos and juveniles) or to reproduction and maturity maintenance (for adults). Growth ceases when this fixed fraction κ just meets somatic maintenance demands. Then, the organism may still reproduce, provided that energy made available exceeds the requirements for somatic and maturity maintenance. Toxicants may be taken up via food, or via the skin, gills, etc, but in any case need to pass a barrier that scales approximately with the surface area of an organism; a similar argument applies to the excretion of toxicants. The uptake and excretion rates of toxicant are therefore taken to be a function of size and the ambient or body concentration of toxicant. Toxicants in the body reduce the flow of energy via a hyperbolic relationship between rate and body burden, except in the case of maintenance, which requirement increases linearly with the body burden of toxicant.

The model yields satisfactory descriptions of sublethal effects. The problem, however, is that model fits are rather insensitive to the choice of parameters being affected by toxicant action. This is the result of a lack of data rather than a deficiency of the model. Ideally, we would like to use data that have a direct link to model assumptions, but data that are available are functions of multiple energy fluxes, such as data on growth and reproduction. The good news is that the model can provide adequate descriptions of growth and reproduction in the presence of a toxicant even if we do not know exactly how that toxicant acts, a situation that is often encountered in practice. The bad news is that predictions beyond the scope of the test data may be inaccurate. Various mechanisms of toxicological action may describe growth data equally well, but predictions for, for instance, the population level may be very different. Therefore, we needed to refine our testing methodology in order to discern subtle differences among predictions from model variants.

We therefore developed a testing program based on ratio likelihood testing. We developed and tested computer programs to estimate parameters from nonlinear equations using weighted least squares and maximum likelihood principles. Those programs yield robust results with both regular functions and ordinary differential equations ("inverse methods"). From likelihood profiles we can calculate error bounds (which are indicative only because of smoothing assumptions). With likelihood ratio tests we can test whether toxicity parameters deviate significantly from zero, that is, whether a particular energy flux is being affected by the toxicant or not. We are now in the process of applying this methodology to data. We will use data from various phyla and various toxicants, including metals and lipophilic toxicants.

Our second line of research is the analysis of our growth model in variable environments. We have previously reported in detail on this work. Since then we have completed the analysis and submitted a paper, for which reviews are pending. Here we summarize the main conclusions.

Organisms that live in an environment with a limited food supply are more susceptible to detrimental effects of toxicants than individuals that live with abundant food. We investigated the effects of food availability changing either periodically or stochastically. Both types of fluctuations stimulate growth; the magnitude of the (average) increase in size depends on both the strength and duration of the fluctuations. In a stochastic environment, the risk of mortality due to starvation increases with increasing fluctuation intensity. Those two outcomes make intuitive sense, and thus add credibility to our growth model. Less intuitive is that the mean lifespan is also a function of the model parameter κ, which characterizes the partitioning of energy between somatic and reproductive tissues (see Figure 1). Organisms committing a large fraction of resources to reproduction endure periods of food shortage relatively well. The effects of food fluctuations on reproduction are complex. With stochastic food, reproduction in survivors increases with increasing fluctuation intensities, but lifetime reproduction decreases. Periodic fluctuations may enhance reproduction, depending on the value of κ. Thus, a variable food supply stimulates growth, increases mortality and may enhance reproduction, depending on life history.

Our last line of research concerns the observable effects of toxicants. A toxicant may, for instance, reduce feeding success, with the implication that ambient food levels remain relatively high, which may lead to the (partial) compensation of a toxic effect. We are developing tools with which we can assess how a toxic effect may affect standing stocks of the species being targeted by the toxicant, its food and its predators. With these tools we can visualize the indirect effects of toxicants in natural systems. Currently we are able to predict how equilibrium values in a partially closed system with three trophic levels will change as a function of any toxic effect on the vital parameters. The conclusions we have derived are universal, since the analysis does not involve specific assumptions about functional forms for growth and toxic effect. This is not a central component of the current proposal; rather it is a spin-off which may serve as a seed for future funding.

Progress during 2000-2001

Analyses and writing culminated in the final report, which was completed in March 2001.

Nisbet, Roger and Erik Muller. Sublethal effects of toxicants on organisms: a modeling approach with dynamic energy. MMS OCS Study 2001-043. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Numbers 14-35-0001-30761 & 14-35-0001-30758. 164 pages.

Task No. 15118: *An Experimental Evaluation for Methods of Surfgrass (Phyllospadix spp.) Restoration Using Early Life History Stages*

Principal Investigators: Daniel C. Reed, Marine Science Institute, University of California, Santa Barbara, CA 93106-6150 and **Sally J. Holbrook**, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106-9610.

Summary of Research

Our research addresses the important issue of mitigation of adverse effects of OCS (Outer Continental Shelf) oil and gas related activities on surfgrass (*Phyllospadix* spp.) communities. *Phyllospadix* is an important structure-forming plant in the intertidal and shallow subtidal zones that is impacted by a number of activities associated with offshore oil and gas production. With funding from Santa Barbara County and the MMS - UC Coastal Marine Institute Program, we gathered much needed information on the reproductive ecology of *Phyllospadix* and we identified the most appropriate life stages of surfgrass for use in restoration. The primary objectives of our current MMS - UC Coastal Marine Institute funded research are to: (1) test the feasibility of various techniques of outplanting laboratory reared seedlings to the field and evaluate their usefulness in restoring damaged surfgrass populations, (2) collect information on the growth and survivorship of naturally recruited surfgrass seedlings for use in estimating the time required for restored populations to fully recover, (3) test the feasibility of transplanting plugs of adult plants as a viable means of restoration and to compare their performance (growth and survivorship) to that of laboratory-reared seedlings outplanted to the field.

Progress during 1999-2000

1) *Testing various outplanting techniques*:

Our first attempts of outplanting laboratory-reared seedlings to the field involved manually attaching seedlings to various species of macroalgae that surfgrass most commonly recruit to in nature. This technique proved to be very tedious (especially in subtidal habitats) and was largely unsuccessful. During this past year of research we have restricted our outplanting efforts to two methods, which are easier to implement and more effective in establishing seedlings. These two methods consist of (1) attaching seedlings to artificial substrates in the laboratory and outplanting these seeded artificial substrates to the field, and (2) directly outplanting seedlings to the sea floor using underwater epoxy. The artificial substrate used in the first method is braided nylon netting that is attached to a small wire frame. Seedlings are attached to the netting by inserting one of the arms of the seedling into an opening of the nylon braid, which is made by untwisting the braid one half turn. The opening is closed upon relaxation of the braid thereby locking the seedling in place. Many seedlings can be securely fastened to the nylon nets relatively quickly using this technique. The seeded nets are then transported to the study site in coolers and fastened to the reef using underwater marine epoxy. We have found that an important source of seedling mortality on the nets occurs when the arms of the fruit become entangle with other algae and dislodge the seedling from the net. The second method that we have been investigating removes this potential source of mortality as the arms of the fruit are embedded in the epoxy that secures the seedling to the bottom. Moreover, attaching seeds underwater with epoxy is even less time consuming than attaching them to nylon netting in the laboratory.

In June 2000 we set up two experiments to evaluate various aspects of these two transplant methods. Regarding the first method (i.e., seedlings outplanted on braided nylon netting) we are testing the effects of net size (20 cm squares vs. 10 cm squares), seedling density, age/size of seedling at time of transplant, and depth (intertidal vs. subtidal on seedling growth and survivorship. For the second method (seedlings affixed directly to the reef using underwater epoxy) we are investigating the effects of seedling density and depth on growth and survivorship. Preliminary results indicate early survivorship is higher in transplanted seedlings glued directly to the bottom compare to seedlings outplanted on nylon nets.

2) Growth and survivorship of naturally recruited surfgrass seedlings

The twenty five seedlings that were initially mapped at our More Mesa intertidal site in November 1998 were buried under an average depth of 20 cm sand until May 1999. Only two seedlings survived this extended burial. Both seedlings were still alive as of June 2000 and have shown substantial growth since being uncovered in May 1999. On 3 February 2000 an additional 110 naturally recruited seedlings were mapped at More Mesa. Data on their specific algal host, number of leaves, average leaf length, total leaf length, survivorship and sand depth have been recorded for each seedling each month. Only about 10 % of these seedlings were still alive in June 2000. In addition to providing information on growth of established seedlings, these data will provide much need information on the degree to which surfgrass seedlings can withstand burial by sand.

3) Adult transplants

A potential drawback to restoring populations of surfgrass with seedlings is that restoration efforts are confined to periods of the year when seedlings are available. Restoring populations by transplanting older life stages may be an advantage in this regard. To test the feasibility of transplanting older life stages we collected three different sized plugs of adult surfgrass (n=6 plugs for each size class) and transplanted them to nearby areas of bare rock in both subtidal and intertidal habitats in June of 1999. Unlike previous restoration attempts that glued the plants directly to the reef we pulled the leaves of a transplanted plug through a piece of nylon netting and then glued the netting to the reef in a manner that kept the rhizomes of the plug pressed against the bottom. This technique was also used to transplant the growing tips of rhizomes. Survivorship and growth (number of leaves and area of reef covered by rhizome) of the transplanted plugs and rhizomes were measured monthly.

Nearly all transplanted plugs have survived to date; however, they have shown no significant growth in the 12 months since transplanting. Moreover, the bare patches from which the plugs were taken increased in size soon after the plugs were removed. We are continuing to monitor these disturbed areas to estimate the time needed for full recovery. Data collected to date indicate that recovery of a disturbed patch created by taking a 20 cm x 20 cm plug will take approximately one year.

Transplants tips of rhizomes also showed high survivorship. However, in contrast to transplanted plugs, the transplanted rhizome tips have grown substantially. This has led us to investigate more efficient techniques for attaching tips of rhizomes to rocky substrates. In May 2000 we transplanted 30 rhizome tips to both a subtidal and an intertidal site by gluing the cut edge of the rhizome directly to the reef using underwater epoxy. Because we were interested in examining a method that would enhance the rhizome's ability to attach to the reef, we trimmed the leaves from half of the transplanted rhizome tips to reduce drag. Survivorship and growth (number of leaves and area of reef covered by rhizome) is being monitored monthly. The growth of these transplants will be compared to that of undisturbed rhizome tips as well as to the cut rhizome from which the tip was removed.

Progress during 2000-2001

1) Testing various seedling outplanting techniques:

Our first attempts of outplanting laboratory-reared seedlings to the field involved manually attaching seedlings to various species of macroalgae that surfgrass most commonly recruit to in nature. This technique proved to be very tedious (especially in subtidal habitats) and was largely unsuccessful. Since then we have restricted our efforts of outplanting seedlings to two methods, (1) attaching seedlings to an artificial substrate (i.e. nylon twine) in the laboratory and outplanting these seeded artificial substrates to the field, and (2) directly outplanting seedlings to the sea floor using underwater epoxy. During the past year we initiated experiments designed to test the efficacy of these two techniques for use in restoration. In addition, we have continued to monitor the growth and survivorship of naturally recruited seedlings. Results collected to date show that survivorship and growth of outplanted seedlings is similar to that of naturally recruited seedlings. Nonetheless, because the survivorship of natural and outplanted seedlings was equally poor (i.e. < 1% after 6 months) and the effort involved in outplanting seedlings is relatively high, restoration efforts involving outplanting laboratory-reared seedlings is not likely to be a cost-effective endeavor.

2) Adult transplants

Aside from poor survivorship an additional drawback to restoring populations of surfgrass with seedlings is that restoration efforts are confined to periods of the year when seedlings are available. Restoring populations by transplanting older life stages may be an advantage in this regard. To test the feasibility of transplanting older life stages we collected three different sized plugs of adult surfgrass (n = 6 plugs for each size class) and transplanted them to nearby areas of bare rock in both subtidal and intertidal habitats in June of 1999. Unlike previous restoration attempts that glued the plants directly to the reef we pulled the leaves of a transplanted plug through a piece of nylon netting and then glued the netting to the reef in a manner that kept the rhizomes of the plug pressed against the bottom. This technique was also used to transplant the growing tips of rhizomes. Survivorship and growth (number of leaves and area of reef covered by rhizome) of the transplanted plugs and rhizomes were measured monthly.

Nearly all transplanted plugs have survived to date; however, they have shown little growth in the 24 months since transplanting. Moreover, many of the bare patches from which the plugs were taken greatly increased in size soon after the plugs were removed. We are continuing to monitor these disturbed areas to estimate the time needed for full recovery. Data collected to date indicate that recovery of a disturbed patch created by taking a 20 cm x 20 cm plug will take approximately one year.

In addition to plugs we have experimented with transplanting actively growing rhizome tips, which like transplanted plugs have shown high survivorship. Unlike plugs, however, transplanted rhizome tips have grown substantially. This has led us to investigate more efficient techniques for attaching tips of rhizomes to rocky substrates. During the past year we have been monitoring an experiment in which we transplanted 30 rhizome tips to both a subtidal and an intertidal site by gluing the cut edge of the rhizome directly to the reef using underwater epoxy. The experiment was repeated in summer and winter to account for potential seasonal effects on growth and survivorship. Survivorship and growth (number of leaves and area of reef covered by rhizome) of transplanted tips are being compared to those of undisturbed rhizome tips as well as to the cut rhizome from which the tip was removed. Growth and survivorship or transplanted rhizome tips have been exceptionally high and we have not seen any evidence that survivorship is influenced by the timing of transplantation. Moreover, plants from which rhizomes were collected have shown rapid rhizome regeneration.

The efficacy of the three different methods of restoration tested in our study (i.e. seedlings, plugs, and rhizome tips) is the topic of Scott Bull's master's thesis. He, in collaboration with Reed and Holbrook, is currently preparing a manuscript on this work.

Progress during 2001-2002

Our efforts this fiscal year have focused on completing analyses and disseminating results of this research to the scientific community. One manuscript was published (*ICES Journal of Marine Science*) and another is currently in review (*Restoration Ecology*). In addition, we invested a significant amount of time in our graduate student, J. Scott Bull, as he completed his thesis and prepared for graduation in June 2002. We have made some progress toward our final report; however, we are still awaiting publication and preparing an additional manuscript. The estimated time for completion of our final report is spring 2003.

Task No. 17601: *Habitat Value of Shell Mounds to Ecologically and Commercially Important Benthic Species*

Principal Investigators: Mark Page, Marine Science Institute, University of California, Santa Barbara, CA 93106-6150, **Jenifer Dugan**, Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, CA 93106-6150, **James Childress,** Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106-9610.

Summary of Research

Shell mounds form over time under offshore oil platforms as encrusting invertebrates, chiefly mussels, barnacles, and scallops, fall from the platform support surfaces and accumulate on the substratum. These mounds provide habitat for a diverse invertebrate community that depends on organic input in the form of faunal litterfall from the overlying structure for nourishment. When platforms are decommissioned and removed, the shell mounds remain, but faunal litterfall is no longer available as a food source for the shell mound community. The fate of shell mounds following platform decommissioning and removal is controversial, because their habitat value is unknown. To assess habitat value of these mounds relative to shell mounds with existing platforms and to natural reefs, we are comparing the distribution and abundance of commercially important crab species (*Cancer antennarius*, *C. anthonyi*, *C. productus*, and *Loxorhynchus grandis*) and other invertebrate and fish taxa. In addition we are comparing the size structure and growth rates of these organisms among habitats.

Using shell mounds under existing platforms "Hogan," "Houchin" (Pacific Operators Offshore), and "Gina" (Nuevo Energy Company), and shell mounds at the sites of four decommissioned platforms "Hazel", "Hilda", "Hope", and "Heidi" we are: (1) quantifying the abundance and distribution of ecologically and commercially important benthic organisms on the shell mounds, (2) determining the population size structure of the most abundant taxa at each site, (3) using the growth rates of organisms to evaluate the habitat value of shell mounds. The results of our research will potentially contribute to decisions regarding shell mound fate following platform decommissioning.

We are investigating the distribution and abundance of benthic invertebrates using two techniques. For commercially important crabs, baited commercial crab traps are deployed at each soft bottom, reef, shell mound, and platform location (excluding platform Gina). Traps are lowered to the bottom at each sampling location and retrieved after a 24-hour soak time. Captured crabs are counted, sexed, and carapace length (for majid crabs) or carapace width (for cancrid crabs) is measured. Sampling is repeated once a month for 4 months beginning in September. Our second technique uses band transects to estimate the abundance of invertebrate taxa other than crabs on the two shallow shell mounds (Hazel and Hilda), on soft bottom adjacent to Hazel, Hilda, and Gina, and on the shell mound at platform Gina. Divers attach transect lines to a central point (the buoy chain at the shallow shell mounds, the research vessel's anchor line on the soft bottom sites and a conductor pipe on platform Gina), and extend the lines out in a radial fashion; the result is a "wheel spoke" sampling regime. The divers then swim the length of the transects and collect selected benthic macroinvertebrate taxa in a one meter swath. In order to correct for potential over sampling of the area closest to the central point inherent in this sampling design, the transects are divided into 4 segments. For analysis, data are weighted with regard to distance from the central point, e.g. the segments closest to the central point are weighted less than those farther away.

Progress during 2000-2001

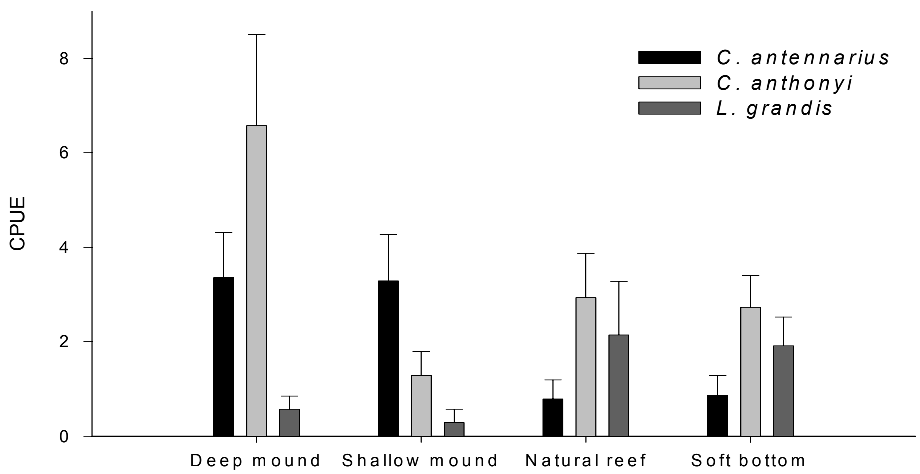

Figure 1. Relative abundances of *Cancer antennarius*, *C. anthonyi*, and *Loxorhynchus grandis* (as CPUE) trapped on soft bottom (n=11 deployments), natural reef (n=7), and deep and shallow shell mounds (n=7 at each) (x ± 1SE).

Crab densities varied among species and among habitat types (Fig 1). *C. antennarius* was more abundant at the shell mounds (~3 crabs per trap at both deep and shallow mounds) than at reef or soft bottom (less than 1 crab per trap). *C. anthonyi* was most abundant on deep mounds (about 7 crabs per trap). The abundance of *C. anthonyi* was similar on reef and soft bottom (2-3 crabs per trap), and about 2 crabs per trap were caught at shallow mound sites. *L. grandis* were more abundant on reef and soft bottom habitats (2 crabs per trap) than at mounds (less than one crab per trap at both deep and shallow mounds). Catch of *C. productus* was negligible during the 2000 sampling period – only four individuals were caught in our traps.

Table 1. Species and total number of fish caught in traps deployed on deep and shallow shell mound, natural reef, and soft bottom.

Common Name	**Species**	**Deep shell mound**	**Shallow shell mound**	**Natural reef**	**Soft bottom**
Brown rockfish	*Sebastes auriculatus*	12	13	5	8
White croaker	*Genyonemus lineatus*		2		2
Shiner surfperch	*Cymatogaster aggregata*		1		3
Barred sand bass	*Paralabrax nebulifer*			1	
Brown Smoothhound	*Mustelus henlei*			1	
Swell Shark	*Cephalloscyliu m ventriosum*				1

Six different species of fish were also captured in the crab traps (Table 1). Brown rockfish (*Sebastes auriculatus)* comprised 78% of the total individuals from all sites, and 66% of *S. auriculatus* were captured on shell mounds.

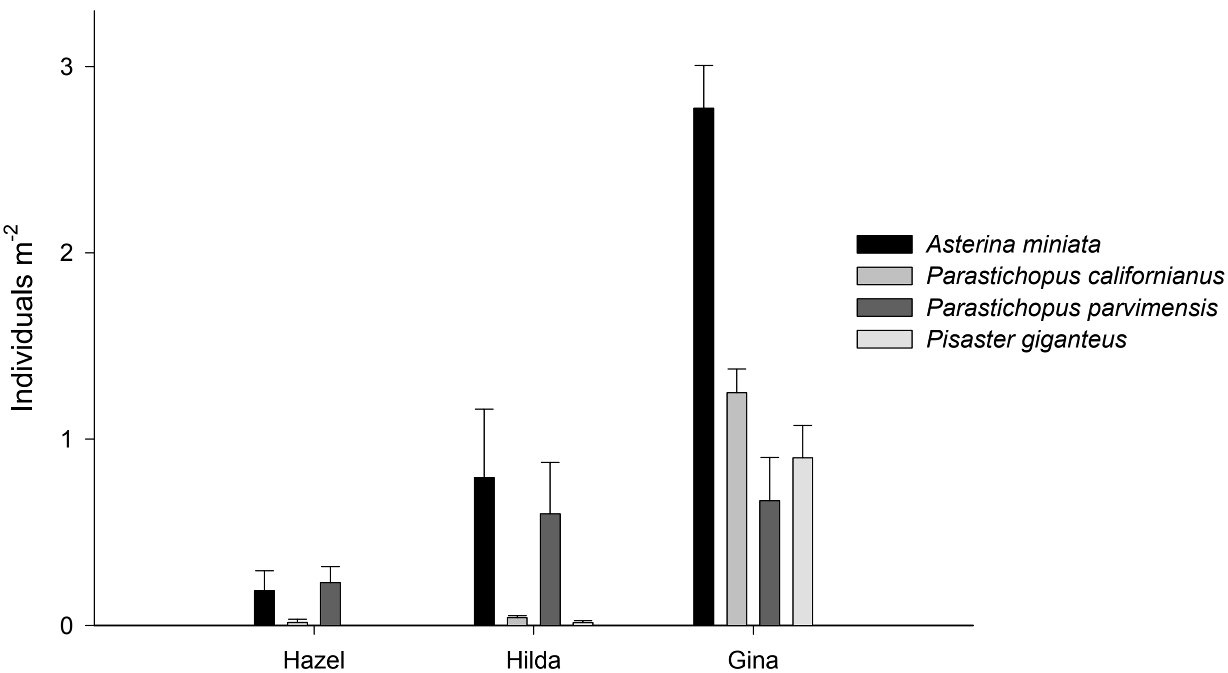

Figure 2. Mean relative abundances of *Asterina miniata, Parastichopus californianus*, *Parastichopus parvimensis*, and *Pisaster giganteus* (as individuals m^{-2}) at Hazel mound (n=3 transects), Hilda mound (n=5 transects), and the mound under Platform Gina (n=3 transects) (x ± 1SE).

Estimated densities of invertebrates at the shell mounds without platforms, Hazel and Hilda, were generally lower than those observed on the mound under Platform Gina (Fig 2). Densities of *Asterina miniata* were lowest at Hazel mound (0.20 ± 0.10 individuals m^{-2}), slightly higher at Hilda mound (0.80 ± 0.40 individuals m^{-2}), and greatest at the mound under Platform Gina (2.90 ± 0.20 individuals m^{-2}). Densities of *Parastichopus californianus* followed the same general pattern: 0.02 ± 0.01 individuals m^{-2} on Hazel mound, 0.05 ± 0.01 individuals m^{-2} on Hilda mound, and 1.25 ± 0.13 individuals m^{-2} on the mound under Platform Gina. That trend of higher densities at mounds with overlying platform structure was not observed for *Parastichopus parvimensis*. For that species, Hilda mound and the mound under Platform Gina both had 0.70 ± 0.20 individuals m^{-2}, and there were only 0.20 ± 0.09 individuals m^{-2} on the Hazel mound. Two taxa, *Cypraea spadicea* and *Pisaster giganteus*, were observed only on Hilda mound and the mound under Gina at densities of 0.09 ± 0.04 individuals $^{-2}$ and 0.02 ± 0.01 individuals $^{-2}$ at Hilda and 0.40 ± 0.15 individuals m^{-2} 0.90 ± 0.17 individuals $^{-2}$ at Gina, respectively.

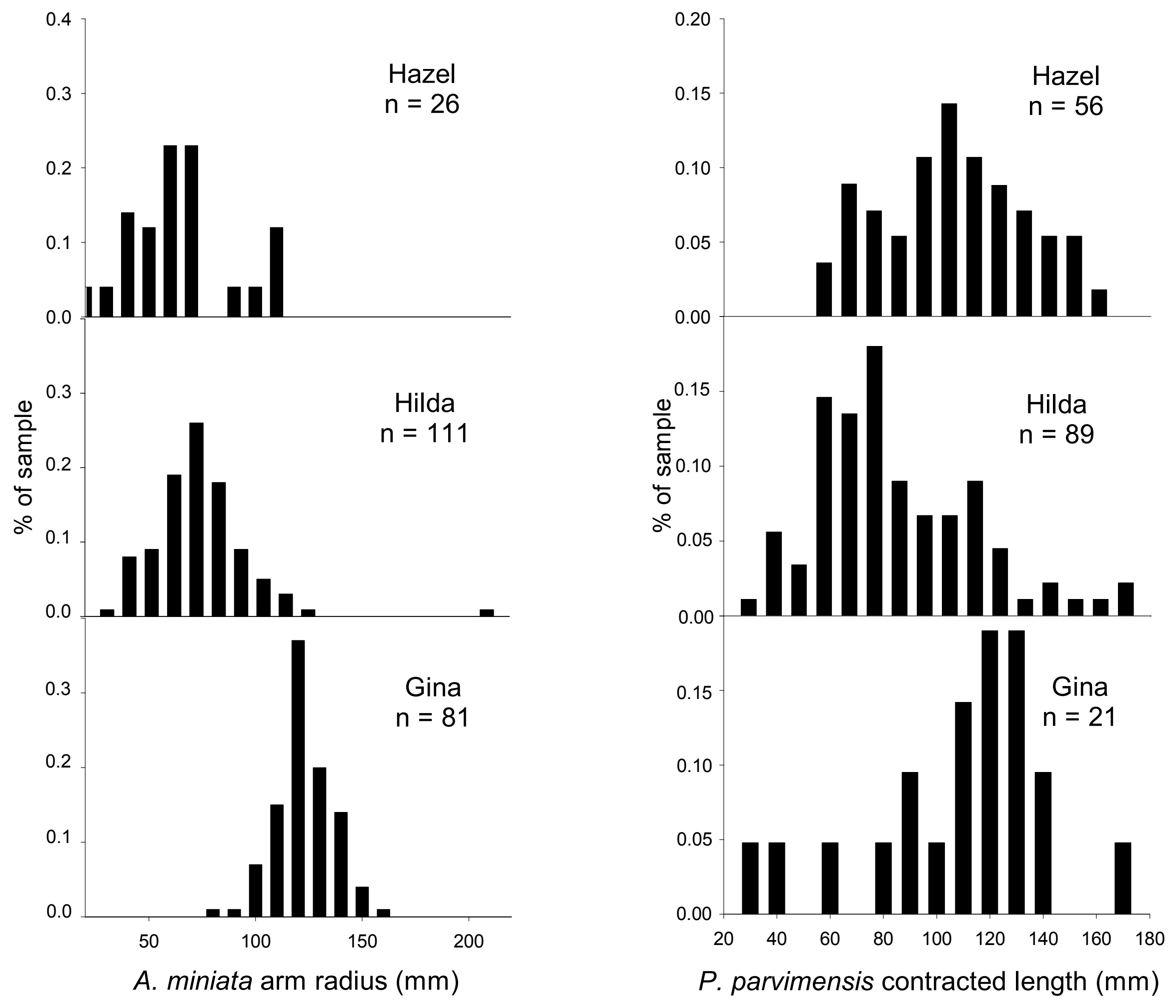

Figure 3. Size frequency distribution of *A. miniata* and *P. parvimensis* at mounds at Hazel, Hilda, and under Platform Gina.

Our results suggest that benthic invertebrates, including a number of echinoderm species, are generally larger on mounds under existing platforms than on mounds without platforms (Fig. 3). *A. miniata* were significantly larger on the mound under Platform Gina (127 ± 2 mm mean arm radius, n=51), than on Hazel mound (69 ± 5 mm mean arm radius, n=19) and Hilda mound (76 ± 2 mm mean arm radius, n=110)(p = 0.000, *F* =193.308, df = 2, 1-way ANOVA). The same trend was evident for other invertebrate taxa. The mean contracted length of *P. californianus* was 114 ± 7 mm on Hilda mound (n=8), and 165 ± 7 mm on the mound under Platform Gina (n=39) (p = 0.002, *F* =10.714, df = 1, 1-way ANOVA). *Pisaster giganteus* were almost twice as big on the mound under Platform Gina (334 ± 8 mm mean arm radius, n=26) than on Hilda mound (181 ± 7 mm mean arm radius, n=2). For *P. parvimensis*, size varied significantly across sites (p = 0.000, *F* = 16.583, df = 2, 1-way ANOVA). Overall, individuals of this species appeared to reach slightly larger sizes at the mound under Platform Gina (110 ± 7 mm contracted length, n=15) than at the Hazel mound (128 ± 6 mm mean contracted length, n=22) and were smallest at the Hilda mound (92 mm ± 3 mm mean contracted length, n=82). Post-hoc tests showed that the mean contracted length of this species was significantly larger at the Hazel mound than at Hilda mound but the sizes of the individuals on Gina did not differ significantly from the other two sites (post-hoc Tukey test).

To assess the habitat value of shell mounds, we are using the RNA/DNA ratio – a biochemical index of protein synthesis – to compare the short-term relative growth rates of crabs, other invertebrates, and fishes across locations. Tissue samples were taken from selected captured individuals and immediately frozen at –70 C for later RNA/DNA assays. We are refining specific extraction techniques for RNA and DNA at this time and will initiate assays of RNA/DNA ratios on our frozen samples in the next few months. We predict that growth rates will be higher at shell mounds with existing platforms than mounds without platforms and natural reefs because of greater food availability derived from the sloughing of mussels and other organisms from the platform structure to the bottom.

Over the next year we will continue sampling the distributions, relative abundances, and population size structures of benthic invertebrates using crab traps and band transects. Frozen tissue samples will be assayed for RNA/DNA ratios to compare growth rates among habitats. Continued sampling and analysis of the data will help assess the habitat value of shell mounds.

Progress during 2001-2002

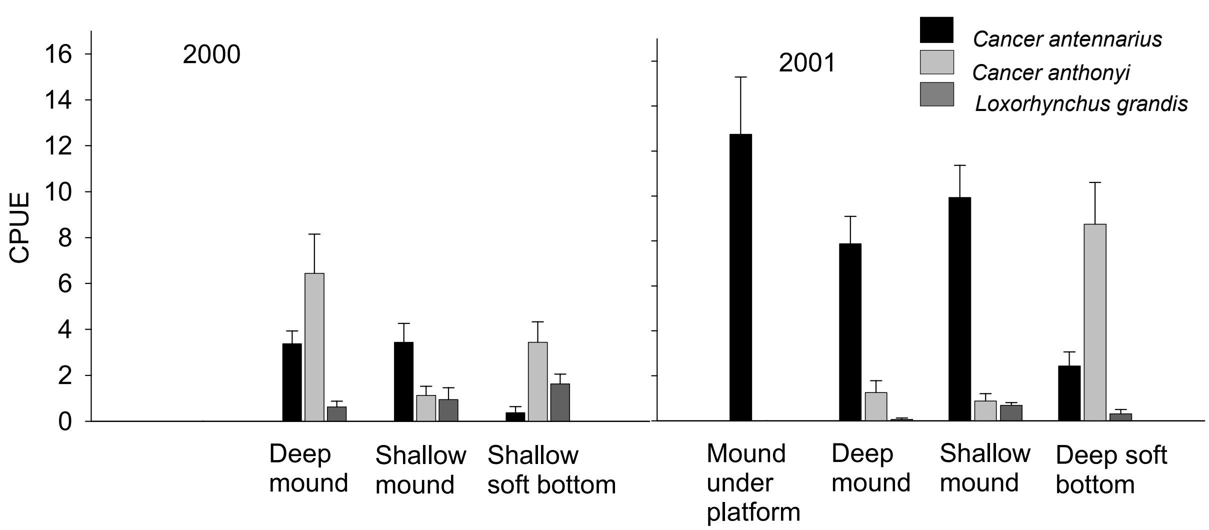

Figure 1: Relative abundances of *Cancer antennarius*, *C. anthonyi*, and *Loxorhynchus grandis* (as CPUE) in 2000 trapped on deep and shallow shell mounds (n=7 at each) and shallow soft bottom (n=8 deployments), and in 2001 trapped on mounds under platforms (n=7 deployments), deep and shallow shell mounds (n=8 deployments at each), and deep soft bottom (n=8 deployments) (x ± 1SE).

In 2001, traps were also deployed at shell mounds beneath existing platforms (Hogan and Houchin), and at deep instead of shallow soft bottom sites. *Cancer antennarius* were most abundant at the mounds under platforms (13 individuals/ trap), with slightly lower abundances at deep and shallow shell mounds (8-10 individuals/ trap), and significantly less at deep soft bottom (3 individuals/ trap). In contrast, *C. anthonyi* were much more abundant on deep soft bottom (8 individuals/ trap) than on deep or shallow shell mounds (~1 individual/ trap), and none were captured on shell mounds beneath existing platforms. Few *Loxorhynchus grandis* were captured at deep soft bottom and shell mound sites (<1 individual/ trap), and none were found on shell mounds beneath existing platforms. No *C. productus* were captured during the 2001 sampling period.

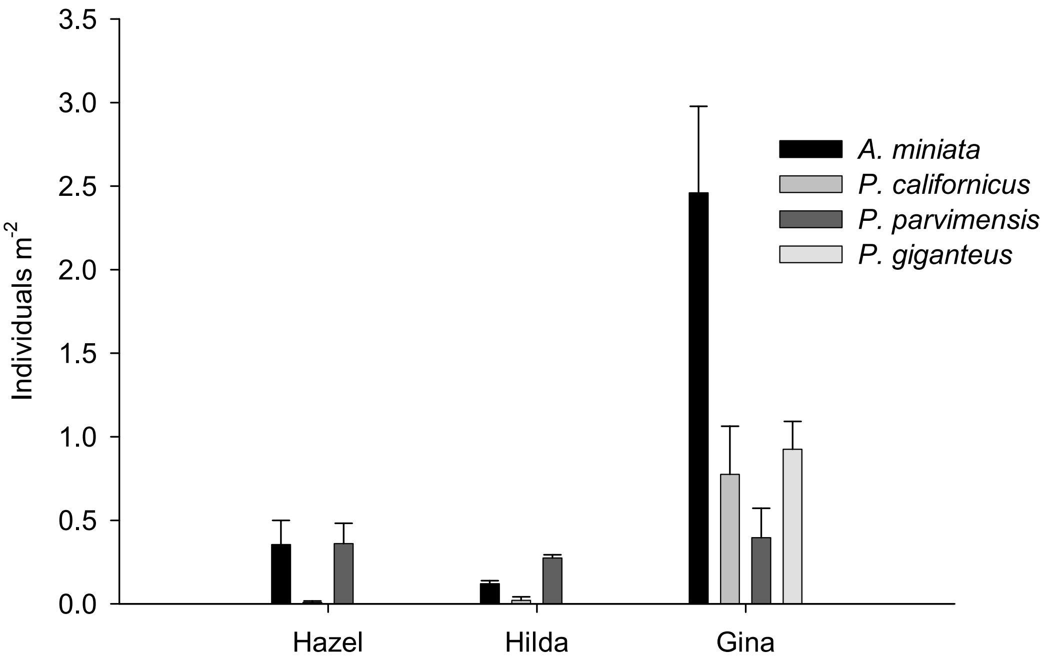

Figure 2. Mean relative abundances of *Asterina miniata, Parastichopus californicus*, *Parastichopus parvimensis*, and *Pisaster giganteus* (as individuals m^{-2}) at Hazel mound (n=4 transects), Hilda mound (n=3 transects), and the mound under Platform Gina (n=3 transects) (x ± 1SE).

Estimated densities of invertebrates at the shell mounds without platforms, Hazel and Hilda, were generally lower than those observed on the mound under Platform Gina (Fig 2). Densities of *Asterina miniata* were lowest at Hilda mound (0.12 ± 0.02 individuals m^{-2}), slightly higher at Hazel mound (0.34 ± 0.14 individuals m^{-2}), and greatest at the mound under Platform Gina (2.54 ± 0.53 individuals m^{-2}). Densities of *Parastichopus californicus* followed the same general pattern: 0.02 ± 0.02 individuals m^{-2} on Hilda mound, 0.05 ± 0.05 individuals m^{-2} on Hazel mound, and 0.74± 0.30 individuals m^{-2} on the mound under Platform Gina. The trend of higher densities at mounds with overlying platform structure was also observed for *P. parvimensis*, with greater abundances observed on the mound under platform Gina (0.45 ± 0.13 individuals m^{-2}) than on Hilda mound (0.28 ± 0.14 individuals m^{-2}) and Hazel mound (0.25 ± 0.14 individuals m^{-2}). The predatory seastar *Pisaster giganteus* was observed only on the mound under platform Gina at a density of 0.89 ± 0.17 individuals m^{-2}.

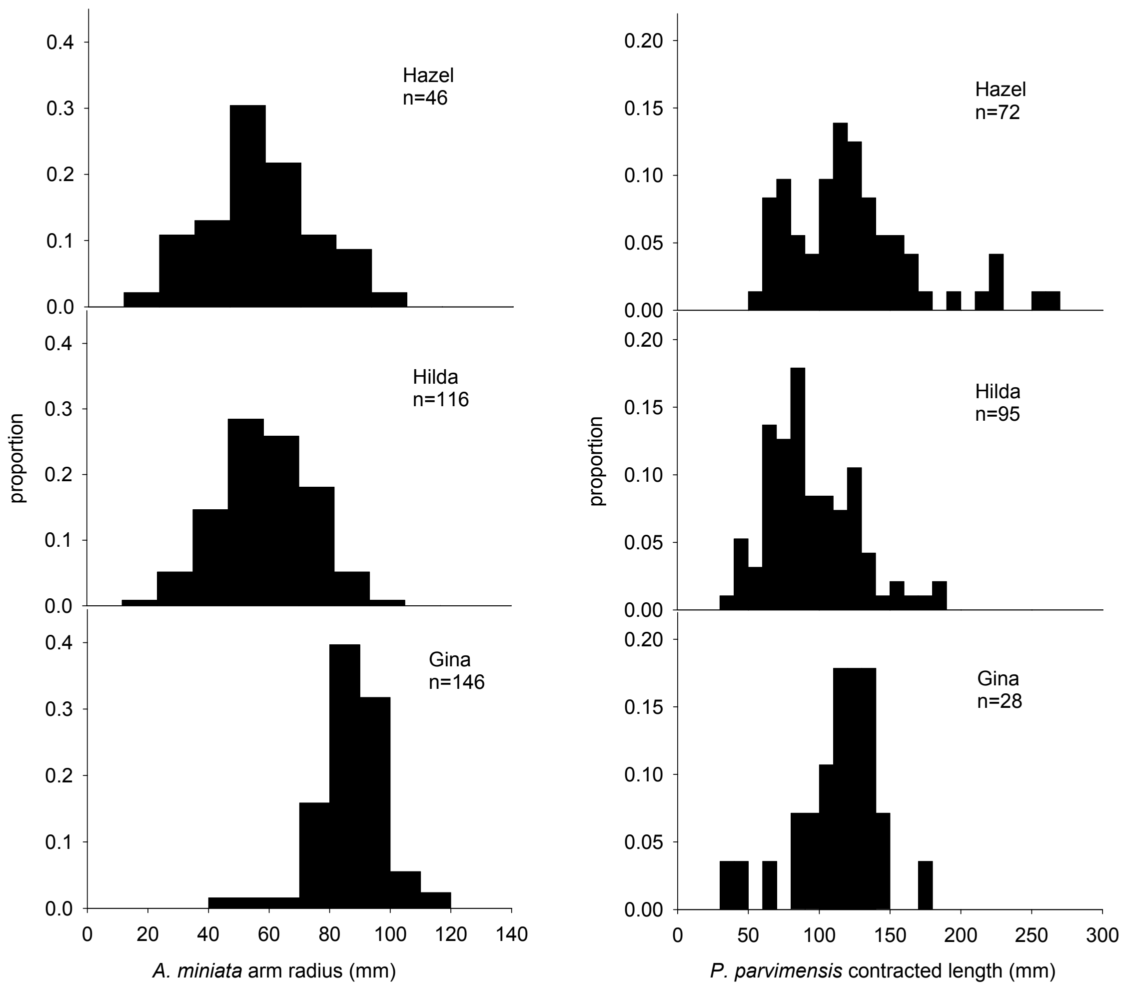

Figure 3. Size frequency distribution of *A. miniata* and *P. parvimensis* at mounds at Hazel, Hilda, and under Platform Gina.

Our results suggest that benthic invertebrates, including a number of echinoderm species, are generally larger on mounds under existing platforms than on mounds without platforms (Fig. 3). *Asterina miniata* were significantly larger on the mound under Platform Gina (87 ± 1 mm mean arm radius, n=126), than on Hazel mound (48 ± 2 mm mean arm radius, n=46) and Hilda mound (51 ± 1 mm mean arm radius, n=116)($p = 0.000$, F =244.13, df = 2, 1-way ANOVA). The same trend was evident for other invertebrate taxa. The mean contracted length of *Parastichopus californicus* was smaller on Hilda mound (114 ± 7 mm, n=8) than on the mound under Platform Gina (162 ± 6 mm, n=46) ($p = 0.002$, F =10.63, df = 1, 1-way ANOVA). *Pisaster giganteus* were almost twice as big on the mound under Platform Gina (336 ± 6 mm mean arm radius, n=40) than on Hilda mound (181 ± 7 mm mean arm radius, n=2). For *P. parvimensis*, size varied significantly among sites, but did not follow the pattern seen in other species ($p < 0.001$, F = 13.49, df = 2, 1-way ANOVA). Overall, individuals of this species appeared to reach slightly larger sizes at the Hazel mound (123 ± 5 mm mean contracted length, n=72) than at the mound under Platform Gina (110 ± 5 mm contracted length, n=28) and were smallest at the Hilda mound (93 mm ± 3 mm mean contracted length, n=95). Post-hoc tests showed that the mean contracted length of this species was significantly larger at the Hazel mound than at Hilda mound but the sizes of the individuals on Gina did not differ significantly from the other two sites (post-hoc Tukey test).

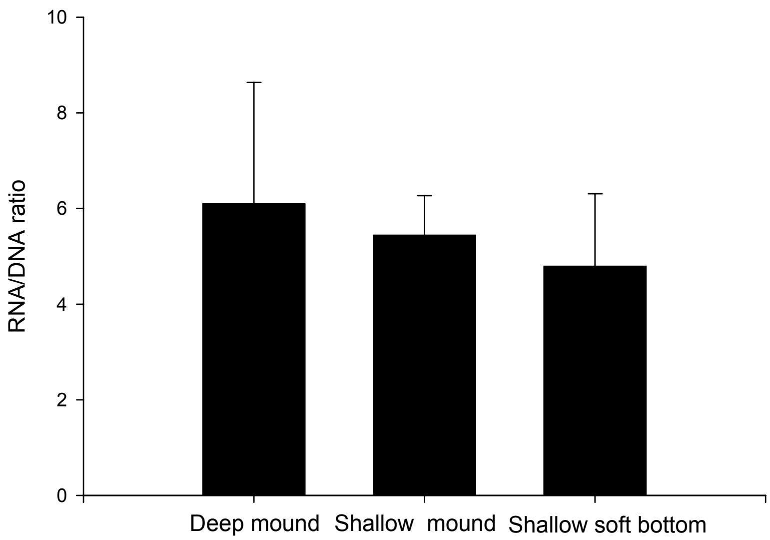

Figure 4. Mean RNA/DNA ratios of *Sebastes auriculatus* individuals captured from deep mound (n=8), shallow mound (n=6), and shallow soft bottom (n=8) (x ± 1SD).

To assess the habitat value of shell mounds, we are using the RNA/DNA ratio – a biochemical index of protein synthesis – to compare the short-term relative growth rates of crabs, other invertebrates, and fishes across locations. Immediately after capture, muscle tissue was excised from selected individuals and frozen at –70 C. For the RNA/DNA ratio assay, each tissue sample is homogenized and combined with a nucleic acid-binding fluorophore, and fluorescence measured with a fluorescence spectrometer. RNA and DNA concentrations in the samples are determined by comparison to the fluorescence of nucleic acid standards of known concentration. Tissues are now being processed from both the 2000 and 2001 field seasons. Preliminary results indicate that RNA/DNA ratios of brown rockfish, *Sebastes auriculatus,* do not differ significantly between shallow soft bottom (4.79 ± 0.62), shallow shell mound (5.45 ± 0.33), and deep shell mound (6.20 ± 0.85) locations (Fig. 4). Assays of samples from shell mounds with existing platforms will be run soon. We predict that those assays will indicate that growth rates are higher on mounds under platforms than on mounds without platforms and on soft bottom because of the greater food availability derived from the sloughing of mussels and other organisms from the platform structure to the bottom.

Over the next year we will continue to assay frozen tissue samples for RNA/DNA ratios to compare growth rates among habitats. Continued analysis and integration of field and laboratory data will help us evaluate the habitat value of shell mounds.

Task No. 17602: *Inventory of Rocky Intertidal Resources in Southern Santa Barbara, Ventura and Los Angeles Counties*

Principal Investigators: Richard F. Ambrose, Department of Environmental Health Sciences and Environmental Science and Engineering Program, University of California, Los Angeles, CA 90095-1772

Summary of Research

Progress during 1999-2000

This year marks the second report period for which the inventory of Ventura County rocky intertidal monitoring program was supported by MMS funding. In addition to the two established Ventura County sites, four southern Santa Barbara County sites are still being monitored by the UCLA group (Pete Raimondi's portion of the Inventory Program, at UC Santa Cruz, is responsible for the four northern Santa Barbara County sites.) Under the current arrangement, our UCLA group collects and enters the data for the southern Santa Barbara sites, but then the data files are sent to the UCSC group for data analysis. The Orange County sites are monitored and managed entirely by Steve Murray's group at Cal State Fullerton, and their report is presented separately.

During this period, all monitoring sites were sampled as scheduled. During the Fall 1999 sampling there were no problems with data collection and the sampling efforts went smoothly. Sampling during the Spring 2000 low tide series occurred during a period of heavy swells and a few of the sites could not be finished on the first sampling day. All of those sites were eventually completed within the Spring sampling season, however. In addition to the normal eight sites, an additional site was developed this quarter at Point Fermin in San Pedro on the Palos Verdes Peninsula. This site was established in collaboration with the Cabrillo Marine Aquarium, and is located in the Cabrillo Marine Reserve. The rocky intertidal begins just upcoast of the Cabrillo State Beach. There is a steep sandstone cliff that extends toward the intertidal. A footpath skirts this cliff face with access from the beach. This is deemed dangerous and is the justification for a proposed boardwalk to allow visitors, including the disabled, access to the rocky intertidal. Due to the potential increase in foot traffic at the site as a result of this boardwalk, Aquarium staff was interested in establishing a monitoring program at this site. On October 26, 1999 we met onsite with Susanne Lawrenz-Miller and other Aquarium personnel to survey and set up a monitoring site consistent with our inventory program. We established sets of five *Chthamalus* barnacle plots, *Mytilus* mussel plots, and *Sylvetia* (=*Pelvetia*) plots, and three 10 meter surfgrass (*Phyllospadix*) transects. No barnacle recruitment plates or clearings were established at this site. The site was then revisited for its initial sampling on November 24, 1999, during which the Aquarium personnel were trained on sampling procedures and use of equipment so that they may do future sampling independently. As of the Spring 2000 sampling, the aquarium personnel had yet to purchase their own sampling equipment and were, otherwise, not ready to sample the site independently. We will need to help them for at least one more sampling season if not two.

The Fall 1999 and most of the Spring slides have been scored, and the respective data have been entered into the computer files. The only exceptions are the slides and data for the two Catalina

Island sites, Little Harbor and Bird Rock. Jack Engle's group collected the data during a late spring sampling trip, but has yet to send the slides and data sheets to the UCLA group for scoring and management. For the rest of the sites, the data up to and including the Spring 2000 season have been graphed and are included below.

We have continued to monitor barnacle recruitment at most of our intertidal sites. In addition to the *in situ* measurements and recruitment plates that we exchange during our normal spring and fall sampling, we are also revisiting the sites in the summer months to collect additional barnacle data. We have been getting close to 100% recovery of the recruitment plates each season. The exception is Carpinteria, which has very soft mudstone substrate that doesn't hold the masonry anchors very well. We have been losing one or two plates each season. After collecting the old plates from the sites, we have been sending the plates and data sheets to the UCSC group, who has been maintaining the barnacle recruitment database.

In the early morning hours of April 9, a gasoline tanker truck crashed on the Hwy 101 freeway and spilled at least 1900 gallons of gasoline that drained through an old culvert to the ocean, just south of our Mussel Shoals site. On April 13, we visited the site to survey our intertidal monitoring site for damage due to the spill. While significant visible effects of the gas were seen in the area immediately surrounding the input, no evidence of direct impacts were seen at our monitoring site, which lies 200-300 m up-coast. The extent of the spill's impact was clearly recognized by the "burning" of the ephemeral algae communities on boulders. Normally green *Ulva* and *Enteromorpha* algae became bleached with a near-complete disintegration of their thalli. In many places, distinct divisions could be seen in the algae between affected and non-affected areas. In other areas, especially in the lower portions of rip rap down-coast of the spill, mussels were found gaping and clearly dead, and barnacles were found dead as well. Some dead snails and crabs were found, but most of these had already been removed by cleanup crews. Most of the damage appeared minor or ephemeral. It was unlikely that any evidence of the spill could be detected in our monitoring site up-coast, so we did not repeat any of the normal surveys. We took numerous still photo shots and pans within the immediate area of the spill. These slides have been developed, but no further analysis has been made to date.

The recent decision to replace the video surveys with still photo surveys was implemented during the Fall 1999 sampling season and continued in Spring 2000. Using our new Nikon camera, we experimented with different methods until we came up with what we believe to be a good procedure for gathering photo survey information in a quick and effective way at the sites. We decided to use all of the video reference points that were indicated in the most recent video protocol compiled by Dr. Engle for consistency with the previous video footage. Standing at one of those reference points, the photographer uses a handheld field compass to locate magnetic north. That position is used as the center of the first field of view with the camera set at its widest focal distance (35mm on the variable focus lens). The top of the viewfinder (the viewable area, not the viewfinder's indicator marks) is held level even with the horizon. This is best found by looking first out to sea, and then extending that horizon line along the shore. Once the first picture is taken, the photographer takes a mental note of a terrain feature at extreme right edge of the viewfinder and then moves the camera clockwise and level until that feature is at the left edge of the new view. This process is continued until the entire 360-degree pan is complete. Photo surveys of this nature were taken at all of the sites on 35mm-slide film, and these were later developed, organized and labeled. We recently received our new Sony digital video camera, which we will also use to document sites as needed for oil spill documentation.

Also this year, we received a new computer to serve as a workstation for the manipulation and storage of photographic images for the inventory project. To this computer we attached the new slide scanner, which includes a bulk loader, and a newly obtained CD-RW drive that can write CDs to hold the digitized photographs from our surveys. After some time was spent becoming familiar with the equipment, we started scanning both the photographic survey images as well as the photoplot images from the Fall 1999 sampling season. We purchased a software program that joins our 360 pans into a continuous image. During the course of this past year, we have scanned in the entire backlog of photoplot images since the inception of the project, and these have been stored and archived on CD media, copies of which have been distributed to the different groups involved in the project. In addition, we have scanned a considerable portion of the UCSC group's photoplot and photosurvey slides in using our bulk loader.

Future Plans:

In a recent meeting of the PI's, the decision was made to repeat the "One-Time" surveys at all of the sites and to view them as comprehensive surveys that will be repeated occasionally, perhaps at 5-year intervals. The UCSC and UCSB groups have begun re-sampling the northern sites this spring, including Alegria. It is our intention to comprehensively resample the remainder of the LA, Ventura, and Southern Santa Barbara County sites this upcoming fall or winter. We also plan to coordinate our sampling the Dr. Murray's group at CSUF. This will require a considerable amount of increased planning, personnel and equipment over and above our normal sampling efforts.

Data Summary For Ventura County:

Although we have not completed a full analysis of the past year's data, in this section we provide graphical summaries of the data to date, as well as brief narratives about possible trends.

Photoplot data:

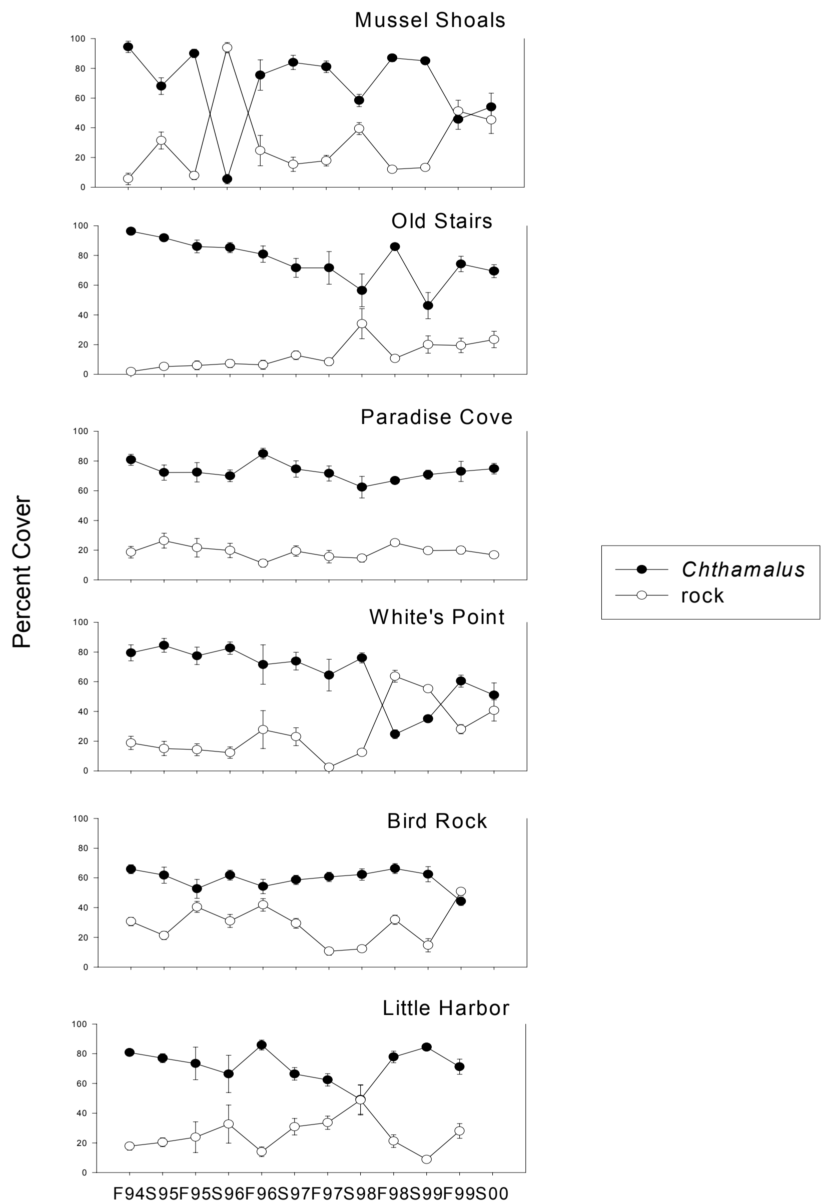

Figure 1. Trends in *Chthamalus* cover at all sites monitored.

Figure 1: *Chthamalus* cover decreased again at Mussel Shoals in the last two sampling periods and is currently at the lower end of what we have seen throughout the study. At Old Stairs, the downward trend in *Chthamalus* cover seen throughout the study has been interrupted to some extent by a moderate increase in the Fall of 1999. Cover at White's Point was also up in the fall, while slight declines were seen across the channel at the two Catalina Island sites.

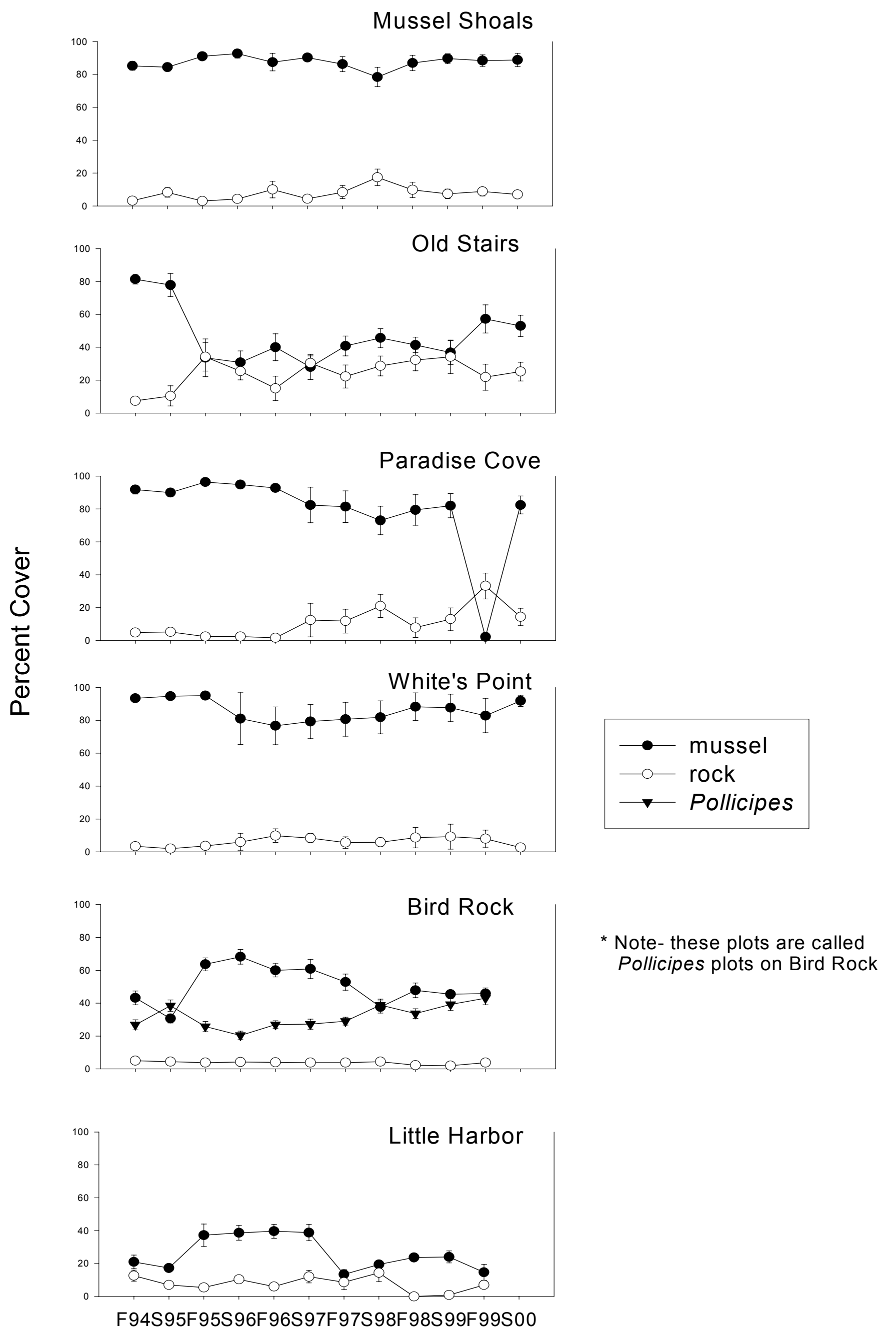

Figure 2. Trends in *Mytilus* cover at all sites monitored.

Figure 2: *Mytilus* cover has remained roughly stable at most of our sites with only slight fluctuations. One notable exception is at Paradise Cove where mussels underwent a sharp decline in Fall 1999 followed by a significant recovery. This decline may be due to fisherman who removed the mussels for bait during the 1999 season.

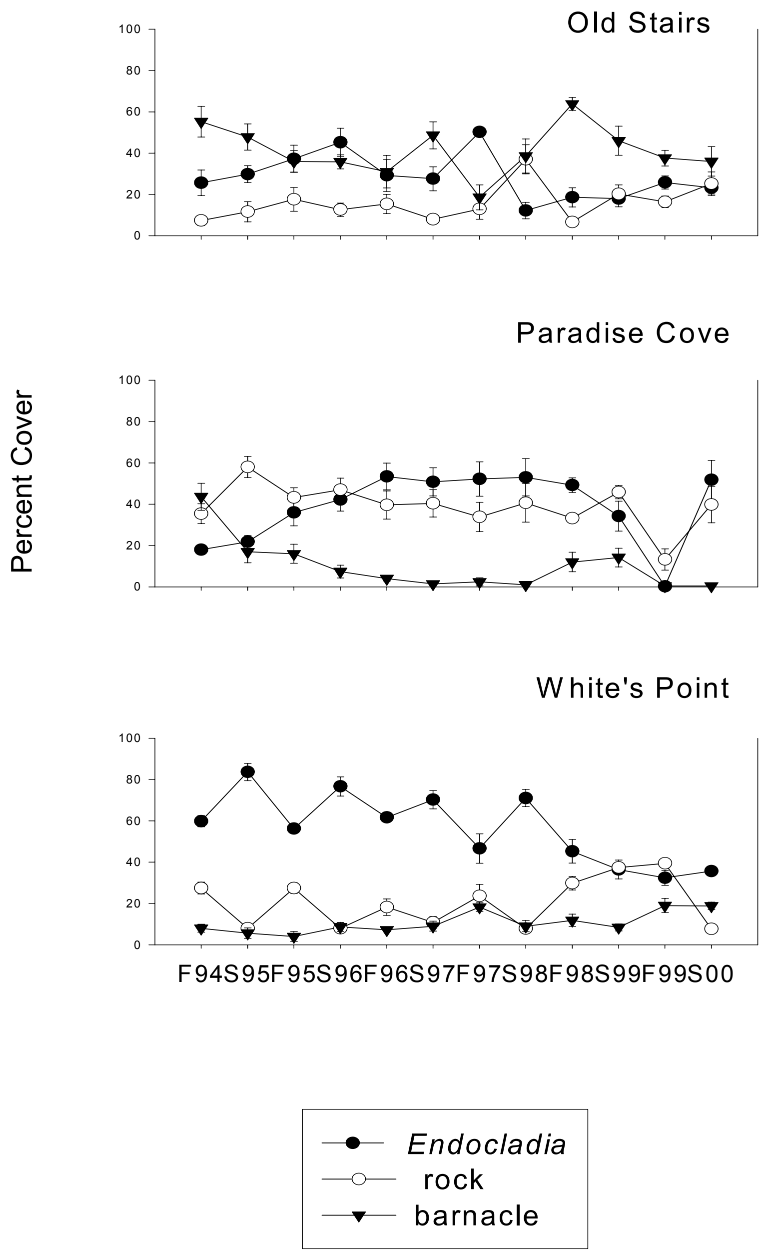

Figure 3. Trends in *Endocladia* cover at all sites monitored.

Figure 3: *Endocladia* cover may be declining at White's Point. At Paradise Cove, there was a substantial drop in cover in Fall 1999 with a subsequent increase in Spring 2000.

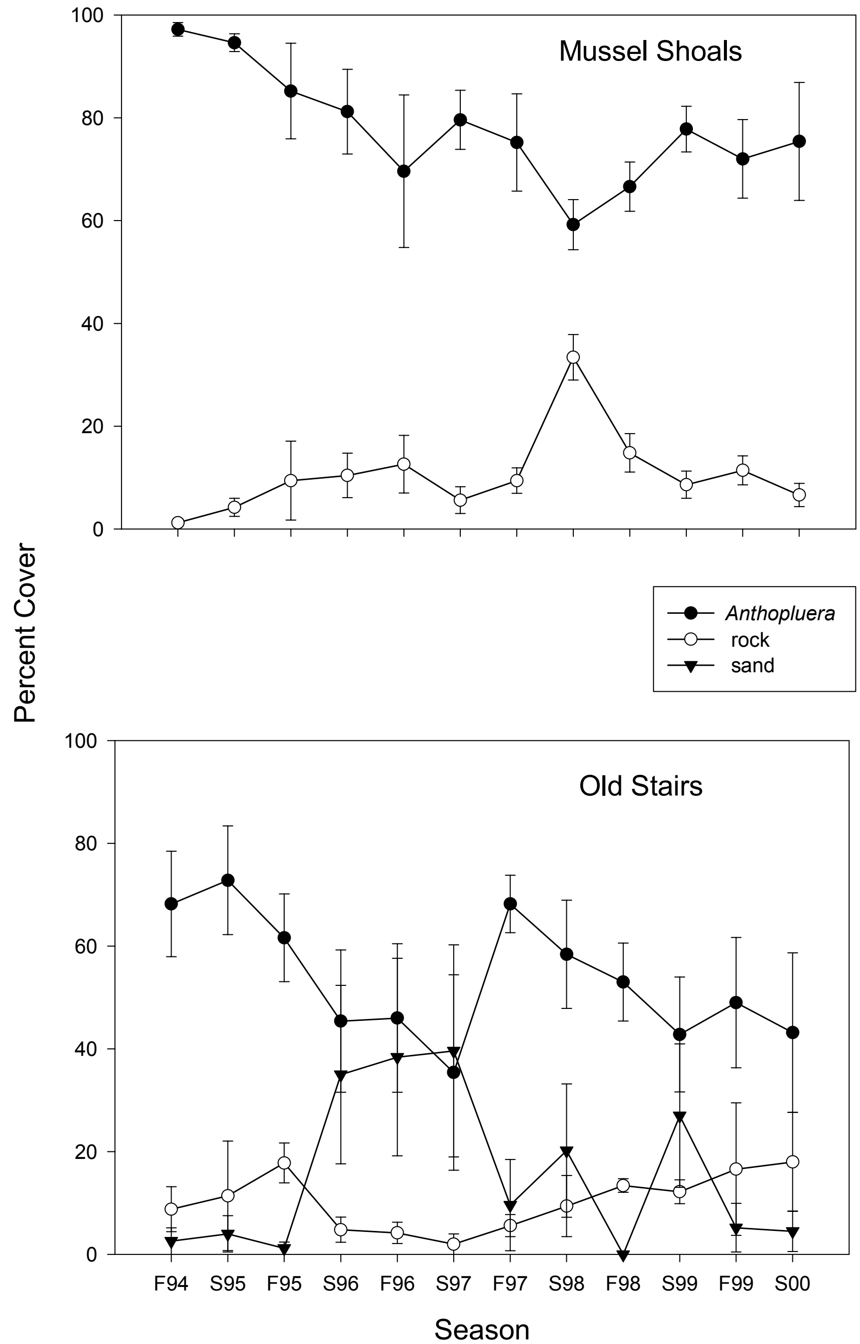

Figure 4. Percent cover of *Anthopleura* at two Ventura County sites.

Figure 4: *Anthopleura* cover seems to be increasing at Mussel Shoals, while it is declining at Old Stairs. These trends are present over the last four sampling seasons.

<u>*Phyllospadix* Transects:</u>

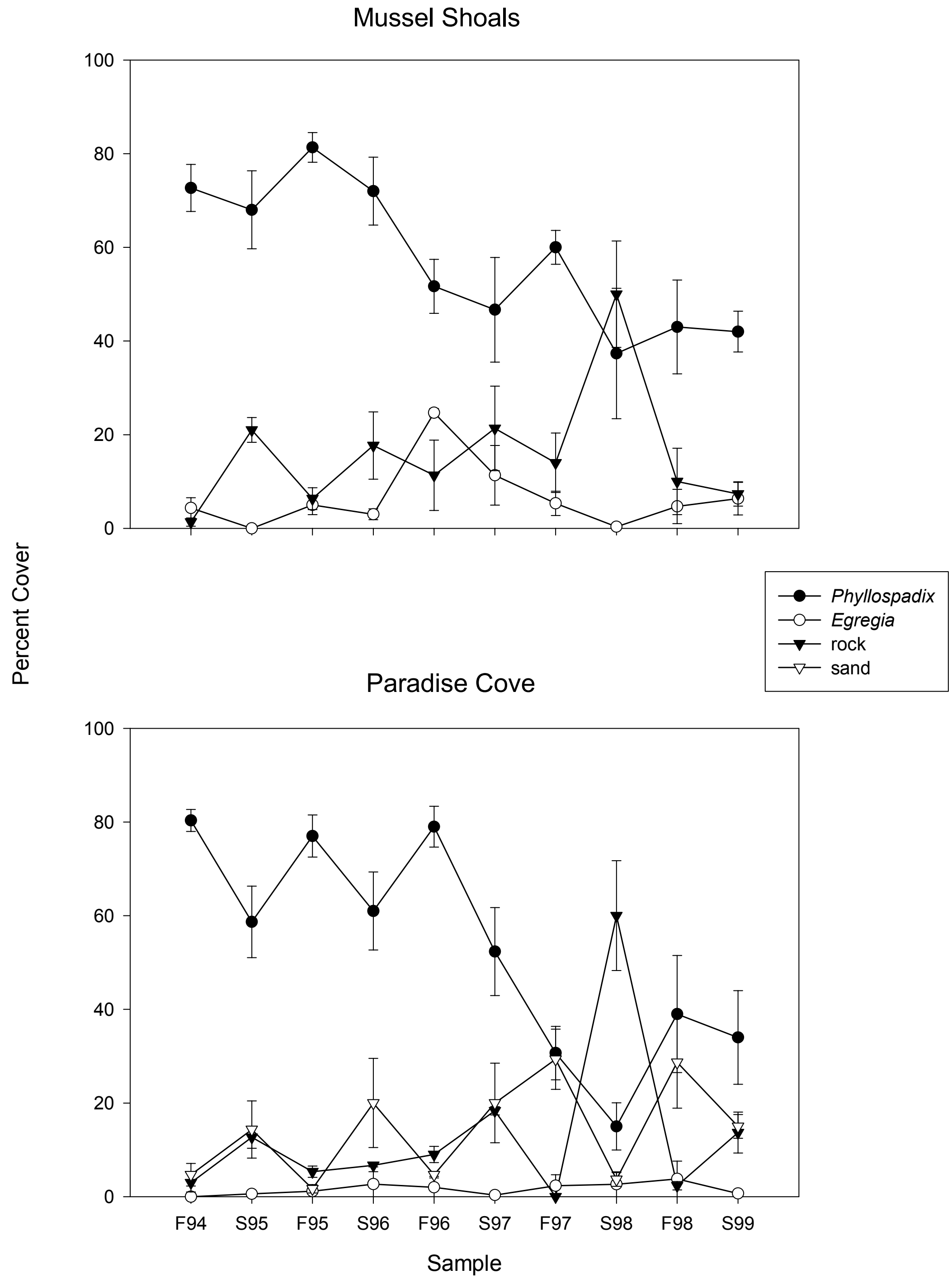

Figure 5. *Phyllospadix* cover from transects at two sites.

Figure 5: At Mussel Shoals, *Phyllospadix* cover within the transects experienced a marked decline following a peak in Fall 95 and has since seemed to stabilize. At Paradise Cove, *Phyllospadix* cover seems much more sporadic and may be indicating some seasonal patterns. *Egregia* cover has also increased slightly during the last four seasons at Mussel Shoals.

Pisaster Plots:

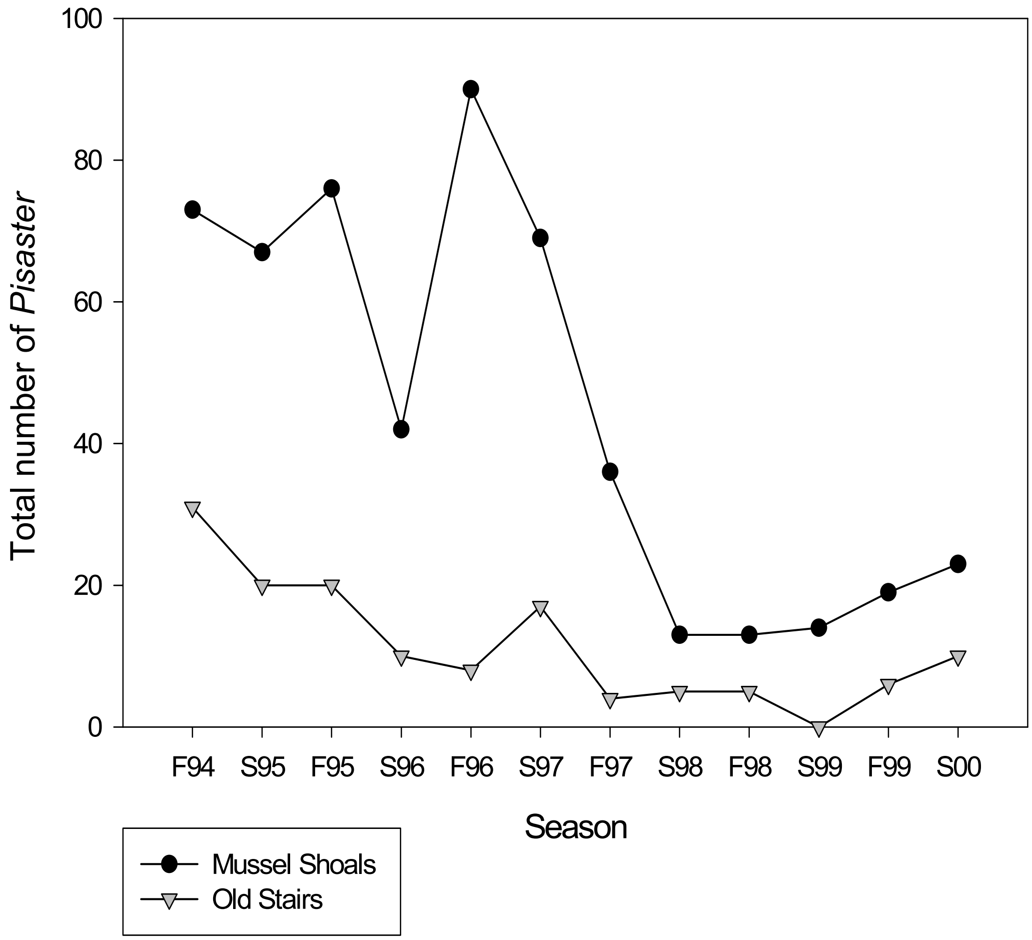

Figure 6. Total number of *Pisaster* within monitored plots at two sites in Ventura County.

Figure 6: The total number of *Pisaster* found at our two Ventura sites remains at very low levels compared to previous years, with a suggestion of a slight increase recently. At Old Stairs, the decline has been severe: no sea stars were found at this site during the Spring 2000 sampling date. This could be related to the fluctuating sand levels at this site, with recent high sand levels covering the areas sea stars previously inhabited.

Lottia Plots:

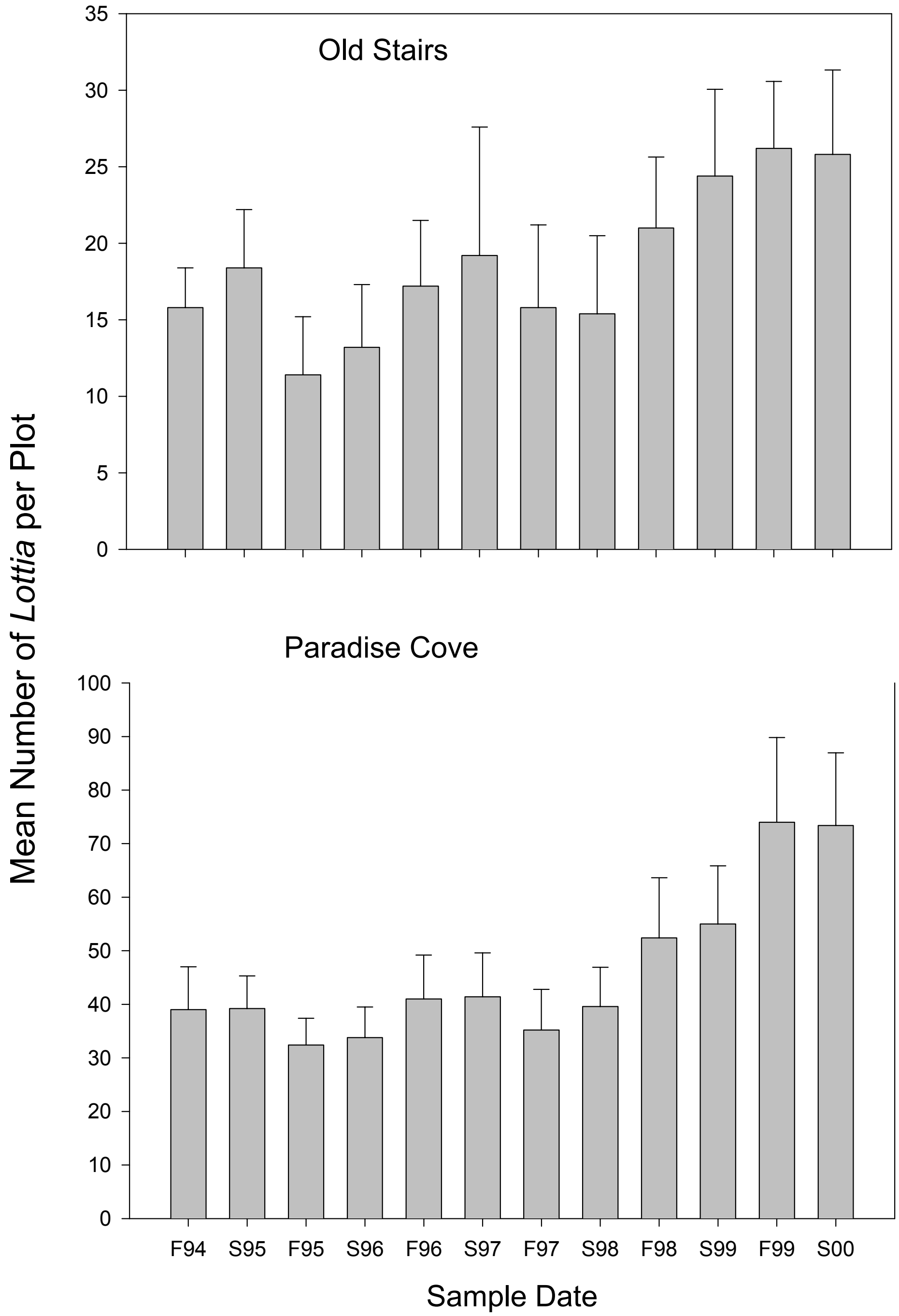

Figure 7. *Lottia* abundance at two sites in Ventura and LA counties.

Figure 7: *Lottia* abundance at Old Stairs has remained quite stable throughout the study with little change over the years. This is still true for the last several seasons, but abundance has increased (although not statistically) and is currently at the highest level seen to date.

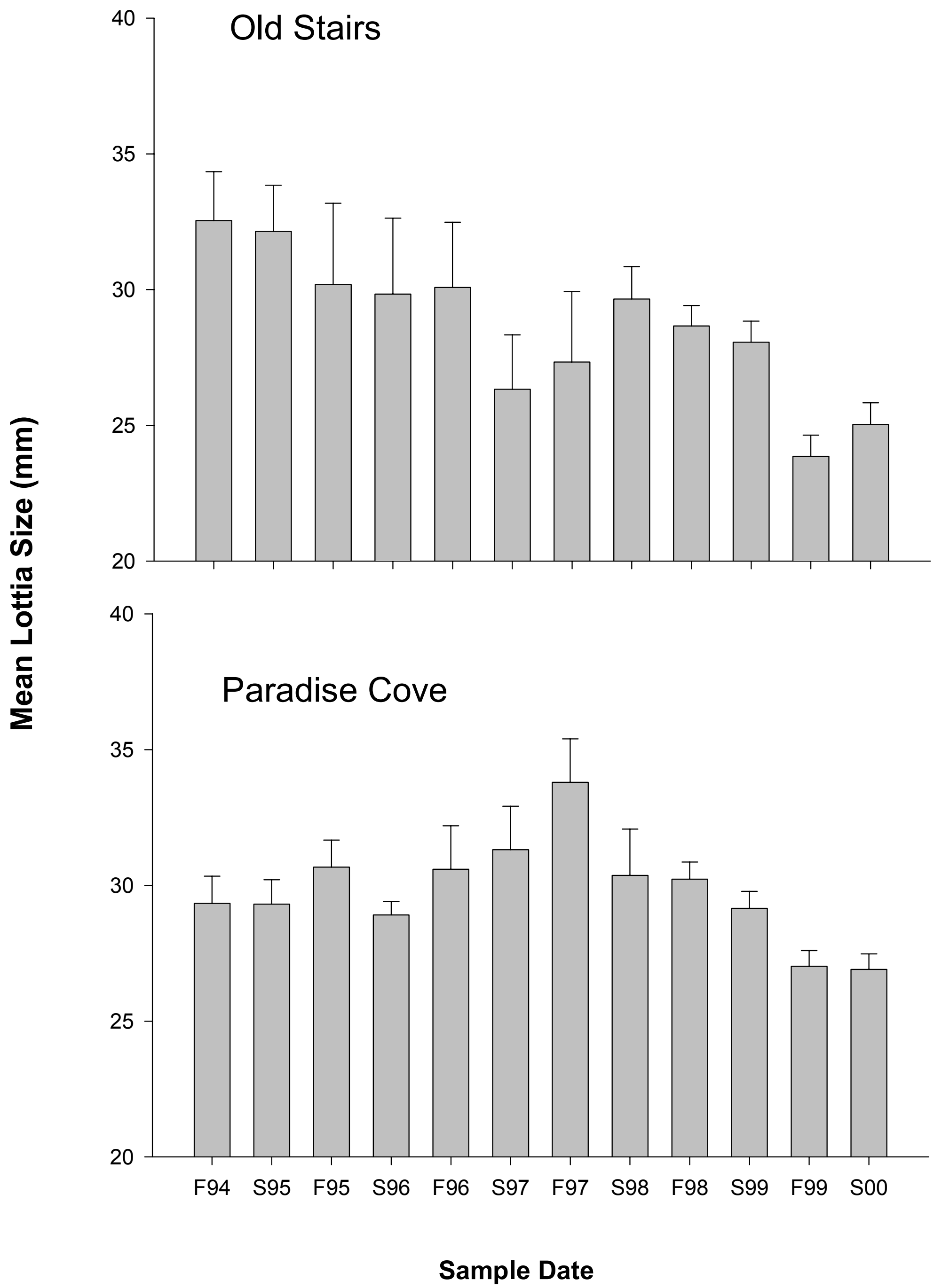

Figure 8. *Lottia* mean sizes at two sites in Ventura and LA counties.

Figure 8: Mean *Lottia* size at Old Stairs has also remained stable throughout the study. During the last two seasons, mean size has declined somewhat (presumably due to recruitment, since abundance has also increased), and the differences may be getting statistically significant.

Progress during 2000-2001

This year marks the first report period for which the inventory of Los Angeles County rocky intertidal monitoring program was supported by MMS funding, and the third period for Ventura County. Two long-term monitoring sites in Los Angeles County (White's Point and Paradise Cove), previously funded by another funding agency, and one newly established site at Point Fermin will now be included in this annual report. In addition to these and the two Ventura County sites, four southern Santa Barbara County sites are still being monitored by the UCLA group. UC Santa Cruz is responsible for the Inventory Program's four northern Santa Barbara County sites. Under the current arrangement, our UCLA group collects and enters the data for the southern Santa Barbara sites, then the data files are sent to the UCSC group for data analysis. The Orange County sites are monitored and managed entirely by Cal State Fullerton, and their report is presented separately.

During this report period, all monitoring sites were sampled as scheduled. During the Fall 2000 sampling there were no major problems with data collection and the sampling efforts went smoothly. This season marked the beginning of mobile invertebrate data collection within the photoplot quadrats, a pilot effort aimed at obtaining better estimates of mobile invertebrate abundances as well as possible relationships between invertebrate abundances and the cover of key species in our quadrats. Mobile invertebrate data were taken within *Chthamalus*, Mussel, *Endocladia*, and *Pelvetia* photoplots. No mobile invertebrate data were collected within *Balanus*, *Pollicipes*, or Anemone plots. During the initial sampling of this pilot effort, there was some uncertainty about the specific methods to be used. For example, it was unclear whether every representative mobile invertebrate group should be sampled within each photoplot assemblage and whether we should be subsampling certain groups of mobiles. In future seasons subsampling will be conducted when mobile invertebrate densities are high. In addition, a new seastar protocol was implemented this period, with seastar radius measurements and color collected in addition to simple counts. Due to the uncertainty over the new protocols, this first data set (Fall 2000 season) has some data gaps that should not be present in subsequent seasons.

Some of the sampling during the Spring 2001 low tide series occurred during a period of heavy swells and a couple of the sites could not be finished on the first sampling day. All of those sites were eventually completed within the Spring sampling season, however.

The Fall 2000 and Spring 2001 slides have been scored and the data entered into the computer files. The slides for the two Catalina Island sites, Little Harbor and Bird Rock, have been developed and labeled, but they have not been scored because these sites are not included in our project funding. Jack Engle's group collected the data for the Catalina sites during a late spring (actually early summer) sampling trip. Thus, most of the data from the two Catalina sites will not be included in this report. For the rest of the sites, the data up to and including the Spring 2001 season have been graphed and are included below.

We have continued to monitor barnacle recruitment at most of our intertidal sites. In addition to the *in situ* measurements and recruitment plates that we exchange during our normal spring and fall sampling, we are also revisiting the sites in the summer months to collect additional barnacle data. We have been getting close to 100% recovery of the recruitment plates each season. The exception is Carpinteria, which has very soft mudstone substrate that doesn't hold the masonry anchors very well, where we have been losing one or two plates each season. After collecting the old plates from the sites, we have been sending the plates and data sheets to the UCSC group, who has been maintaining the barnacle recruitment database. The summer 2001 barnacle data have yet to be collected.

Early this year (January 17-19), a monitoring workshop was held at the new Kenneth Norris Reserve in Cambria. While the main purpose of this workshop was a review of the Channel Islands National Park Service's rocky intertidal monitoring program, the protocols of the entire MARINE group were discussed. Among the issues discussed were the upcoming comprehensive surveys, the newly established mobile invertebrate sampling protocols, and the use of Handspring Visor computers with barcode adapters to collect intertidal data. No significant changes will be made to our protocols as a result of this workshop, but we will be making small changes so that all groups are collecting comparable data. Noteworthy changes include:

1. We should replace our variable focus lens with a fixed focus lens for improved optics and error reduction when taking the site overview photographs.
2. All mobile invertebrates except littorines should be counted within the plots rather than limiting counts to certain key species. For example, all species of chitons should be counted rather than just *Lepitochitona*.
3. Better, more repeatable still photo survey protocols should be developed.
4. Where possible, numbers of plots should be uniform across sites. For example, an extra surfgrass transect should be added at Arroyo Hondo to bring the total transects sampled from two to three.
5. Periodic comprehensive surveys are a valuable supplement to our regular, fixed-plot design.

These changes have been implemented beginning with the Spring 2001 sampling season. We have begun counting all mobile invertebrates within as many of the photophot quadrats as possible. These counts will always be done in the Chthalamus (barnacle) plots, mussel plots, *Sylvetia* (= *Pelvetia*) plots, and *Endocladia* plots, and in the *Balanus* barnacle plots at White's Point. The current plan is that they will not be done within the *Pollicipes* or Anemone plots. During the Sping 2001 season, we sampled mobiles within the *Balanus* plots at White's Point for the first time. Mobile invertebrate sampling has not yet begun at the Catalina Island sites due to a lack of funding for those sites. Also in the spring, a third surfgrass transect was established at Arroyo Hondo to bring the total number of transects up to the standard three. The available surfgrass habitat at this site is limited. Consequently, the location of this new transect (running parallel to the others rather than in a line) is atypical.

Throughout the second half of this report period, the newly established intertidal "swat team" has been performing repeated comprehensive surveys throughout the MARINE network of sites. Our group joined the swat team in the comprehensive sampling of the LA, Ventura, and So. Santa Barbara County sites. The only exceptions are Coal Oil Point, which was assigned a low priority for completion, and the Catalina Island sites, which are not currently funded. While the swat team coordinated all of the sampling days and is managing the database, our group was able to provide assistance with the decision making about where the survey transects would be located to ensure the maximum possible inclusion of our monitoring plots and transects.

We continued this year to use still photo surveys rather than video surveys at all of our sites. This method is an improvement over the video protocol due to the speed of image collection and the utility of the resulting slides. Once developed, survey panoramas from different seasons can be placed alongside each other on a light table for a quick look at changes that might have occurred through time. For the most part we used the old video reference points for use in this protocol, but there have been some modifications wherein some photo points have been deleted and others added. These modifications have proven to cause some confusion in the absence of a revised still photo survey protocols, so these have recently been developed for our sites. The overall protocol (discussed in the preceding annual report) remains unchanged; the new "protocol" simply outlines the locations and the extent (180° vs 360°) of the survey pans. While the decision was made to replace the variable focus lens for our Nikon camera with a fixed focus lens, we have not yet received the new lens. Hopefully, the new lens will arrive before the upcoming Fall sampling season.

Also this year, we received from MMS a new 1GHz computer to serve as a workstation for the manipulation and storage of photographic images for the inventory project. To this computer we attached the scanner, slide scanner, which includes a bulk loader, and a color printer. With its integrated CD-RW drive we can write CDs to hold the digitized images from our photoplots and photosurveys. We are continuing the process of scanning our images, saving them to CD's and distributing the CD's to all of the parties involved in the project. We received two Hanspring Visor handheld computers this year for use in field data collection, but one of these was stolen from our office. We also received the new version of Adobe Photoshop software from MMS as well as a new laser-leveler.
During the week of June 18 to June 22, Steven Lee attended a 40-hour Hazwoper course in Vallejo, CA. The course was completed with both state and federal certifications. The course did not include respirator fit testing, and a respirator was not included in the cost of the course.

Future Plans:

During the week of July 22, we will be revisiting all of our sites for the Summer 2001 barnacle recruitment sampling. Beginning with the next funding year, there will be a restructuring of duties allotted to the various MARINE groups. The details are not yet complete, but it is likely that our group will be responsible for writing manuscripts that synthesize the MARINE data.

Data Summary For Ventura County:

Although we have not completed a full analysis of the past year's data, in this section we provide graphical summaries of the data to date, as well as brief narratives about possible trends.

Photoplot data:

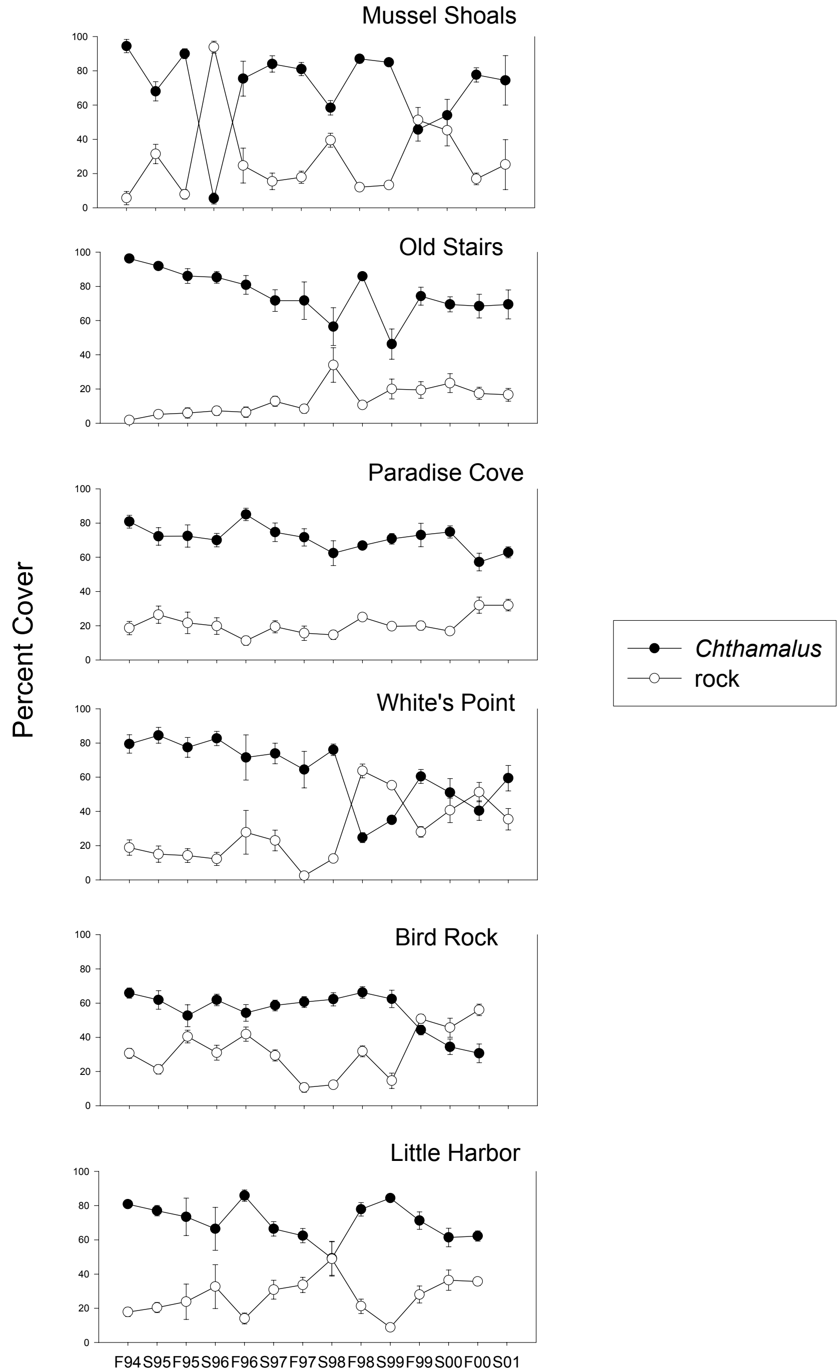

Figure 1. Trends in *Chthamalus* cover at all sites monitored.

Figure 1: *Chthamalus* cover increased again at Mussel Shoals in the last two sampling periods and is currently at the higher end of what we have seen throughout the study. At Old Stairs, the downward trend in *Chthamalus* cover seen throughout the study has been interrupted to some extent by a moderate increase in the fall of 1999, and has remained stable since. Cover at White's Point was also up in the spring after a gradual decline in the previous three seasons.

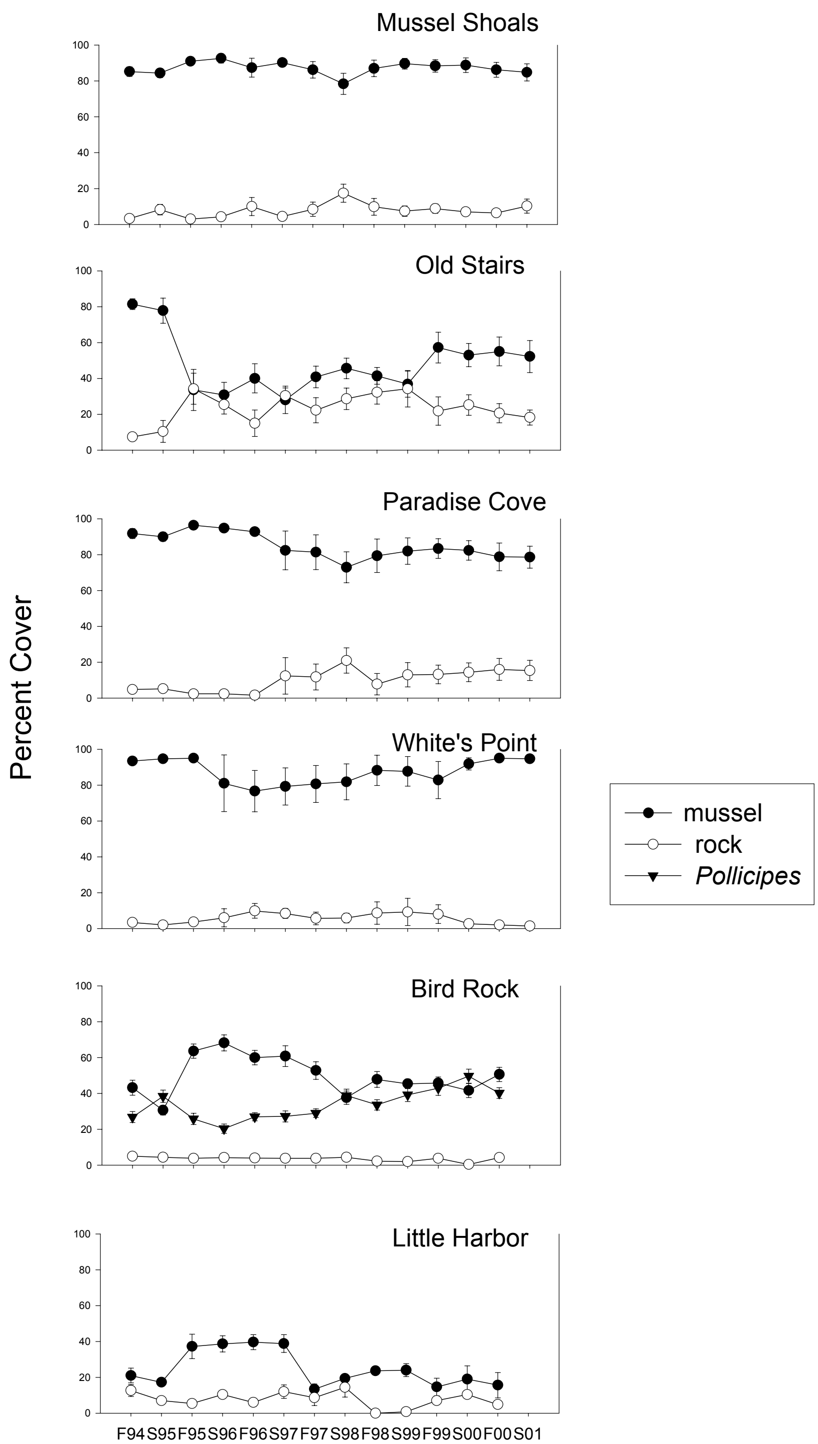

Figure 2. Trends in *Mytilus* cover at all sites monitored.

Figure 2: *Mytilus* cover has remained roughly stable at most of our sites with only slight fluctuations. One notable exception is at Old Stairs where mussels underwent a sharp decline in Fall 1995 and have been at lower levels since. In the last four seasons, however, mussel cover has come back to about 70% of the original level.

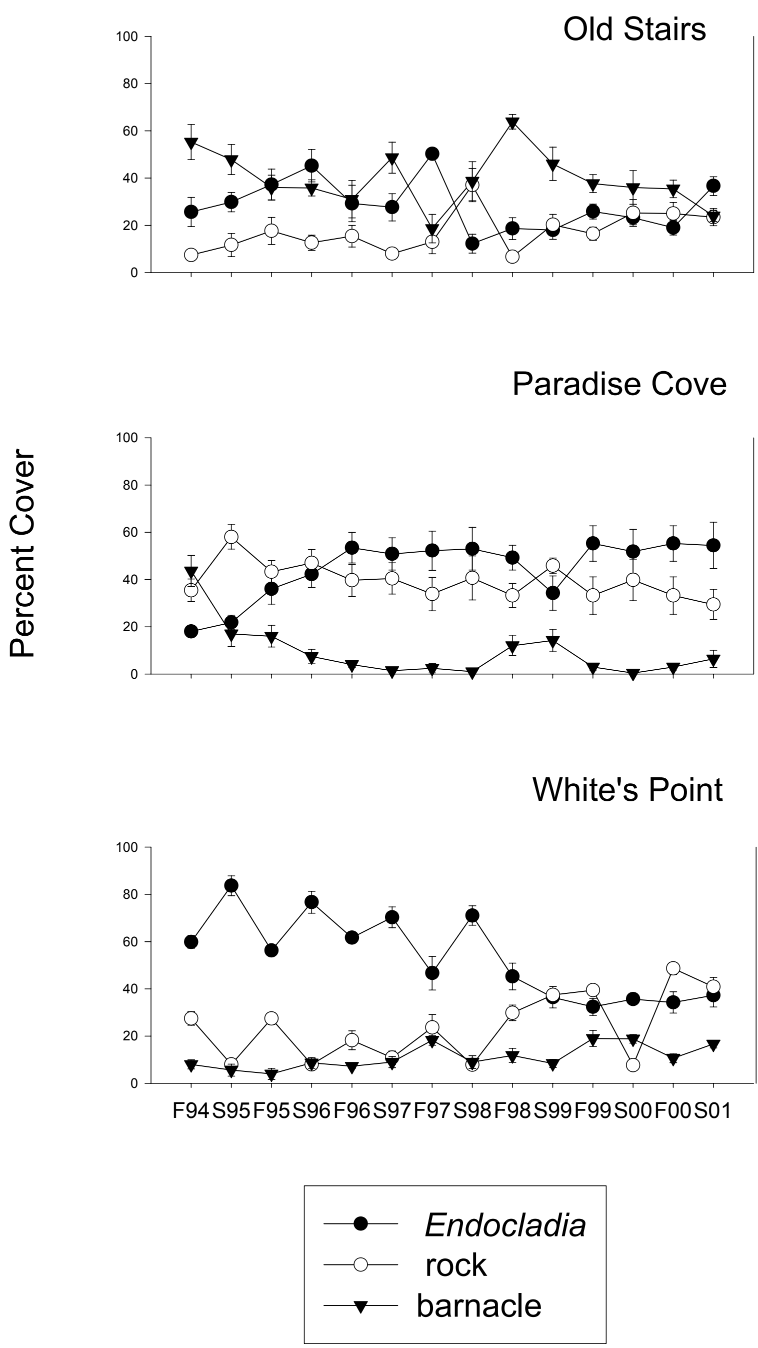

Figure 3. Trends in *Endocladia* cover at all sites monitored.

Figure 3: *Endocladia* cover at Old Stairs has been quite variable throughout the study. In Fall 2000, *Endocladia* was near the low end of the cover we have recorded, but cover increased substantially in Spring 2001. All sites seem to show seasonal patterns in cover, with at least slight increases in the spring. At Paradise Cove, *Endocladia* cover has been increasing throughout the study and the level is currently among the highest that have been seen. White's Point, on the other hand, has seen an overall decline in cover and a damping of the seasonal fluctuations.

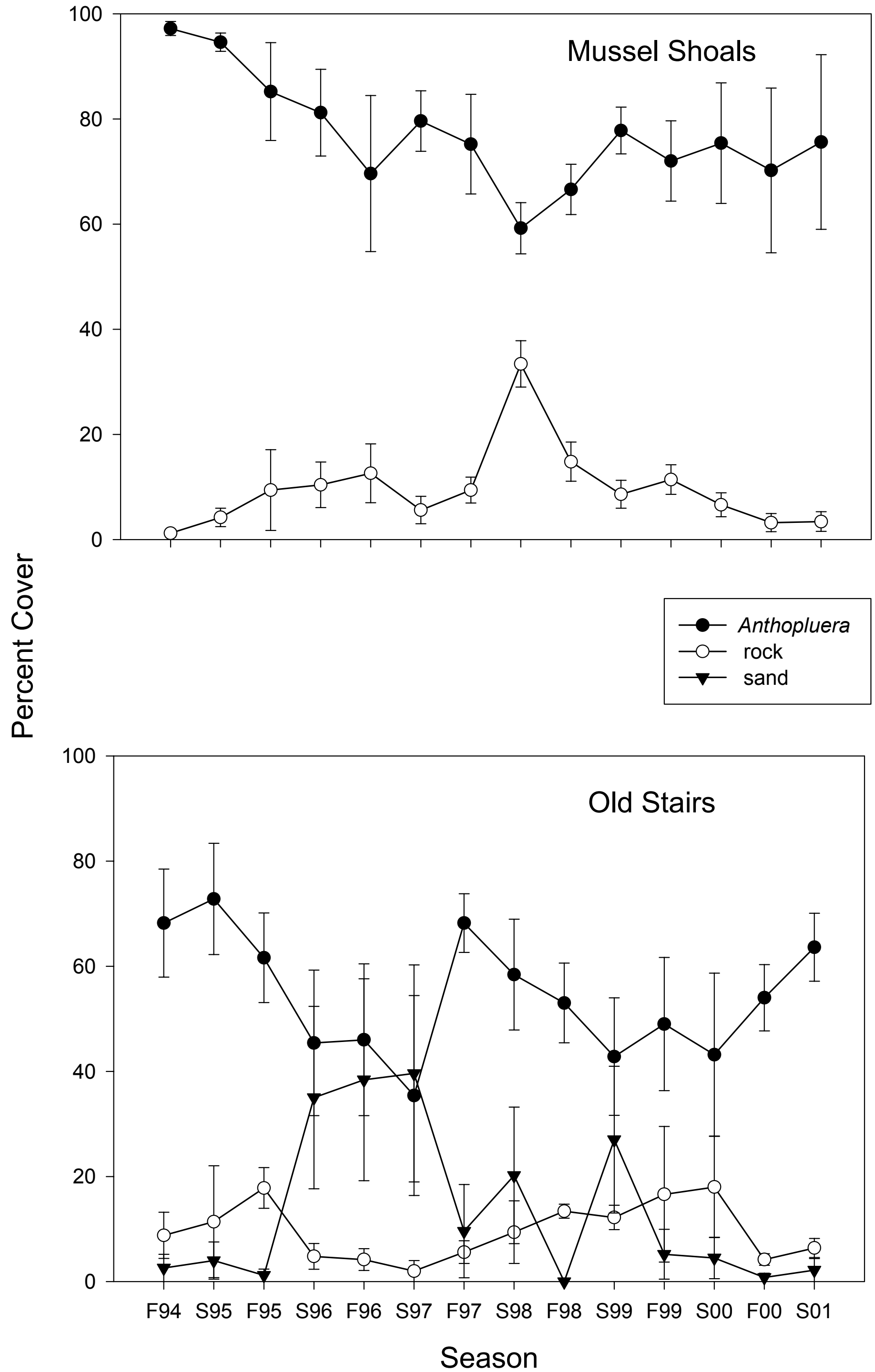

Figure 4. Percent cover of *Anthopleura* at two Ventura County sites.

Figure 4: *Anthopleura* cover at both sites has been marked by rapid increases followed by gradual declines. Cover at Mussel Shoals is near the middle of the range we have observed since monitoring began, with cover holding steady during the past year. At least one plot (A5) at Mussel Shoals has been almost entirely overgrown by mussels. Cover at Old Stairs is a bit below the high end of the range we have observed, with increases in both Fall 2000 and Spring 2001.

<u>*Phyllospadix* Transects:</u>

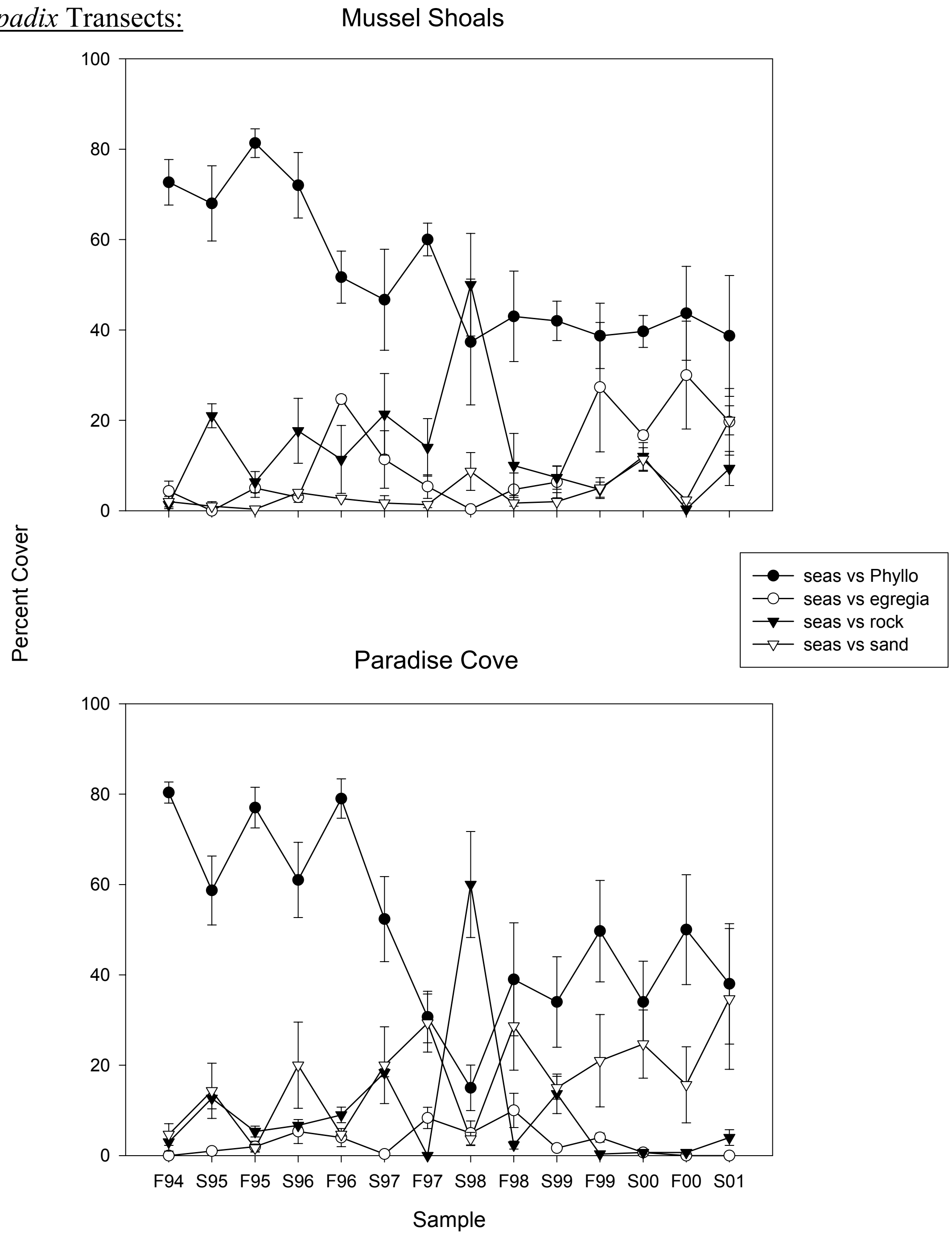

Figure 5. *Phyllospadix* cover from transects at two sites.

Figure 5: At Mussel Shoals, *Phyllospadix* cover within the transects experienced a marked decline following a peak in Fall 95 and has seemed to stabilize at around 40% cover since 1998. *Egregia* cover has increased during the last four seasons at Mussel Shoals. At Paradise Cove, *Phyllospadix* cover seems much more sporadic, with stronger seasonal patterns than at Mussel Shoals. Cover at Paradise Cover underwent a precipitous decline following Fall 1996 and has since recovered to about half of its original cover. Cover during the last two surveys were similar to the previous two surveys, varying between 30% and 50% cover.

Pisaster Plots:

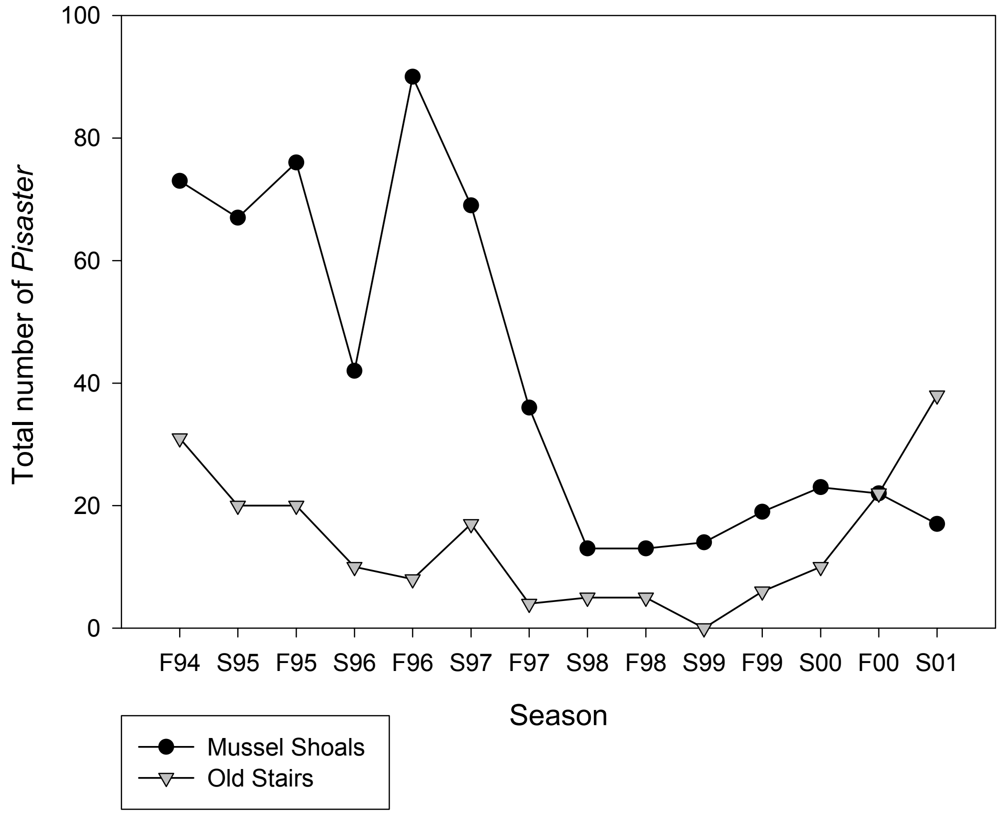

Figure 6. Total number of *Pisaster* within monitored plots at two sites in Ventura County.

Figure 6: The total number of *Pisaster* found at our two Ventura sites dropped significantly throughout the first years of the study. In the last few seasons, however, the numbers seem to have increased to some extent and this trend follows observations that have been occurring throughout Southern California. At Mussel Shoals, this increase has been gradual and even seems to be tapering off (in fact, there was a slight decline in Spring 2001), and in any case current numbers are a small fraction of the original abundances. However, the recovery has been substantial at Old Stairs; in Spring 2001, the number of sea stars at Old Stairs actually exceeded the initial number. Sea star abundance at our sites, especially Old Stairs, seems to be highly dependent on the degree of sand inundation.

<u>*Lottia* Plots:</u>

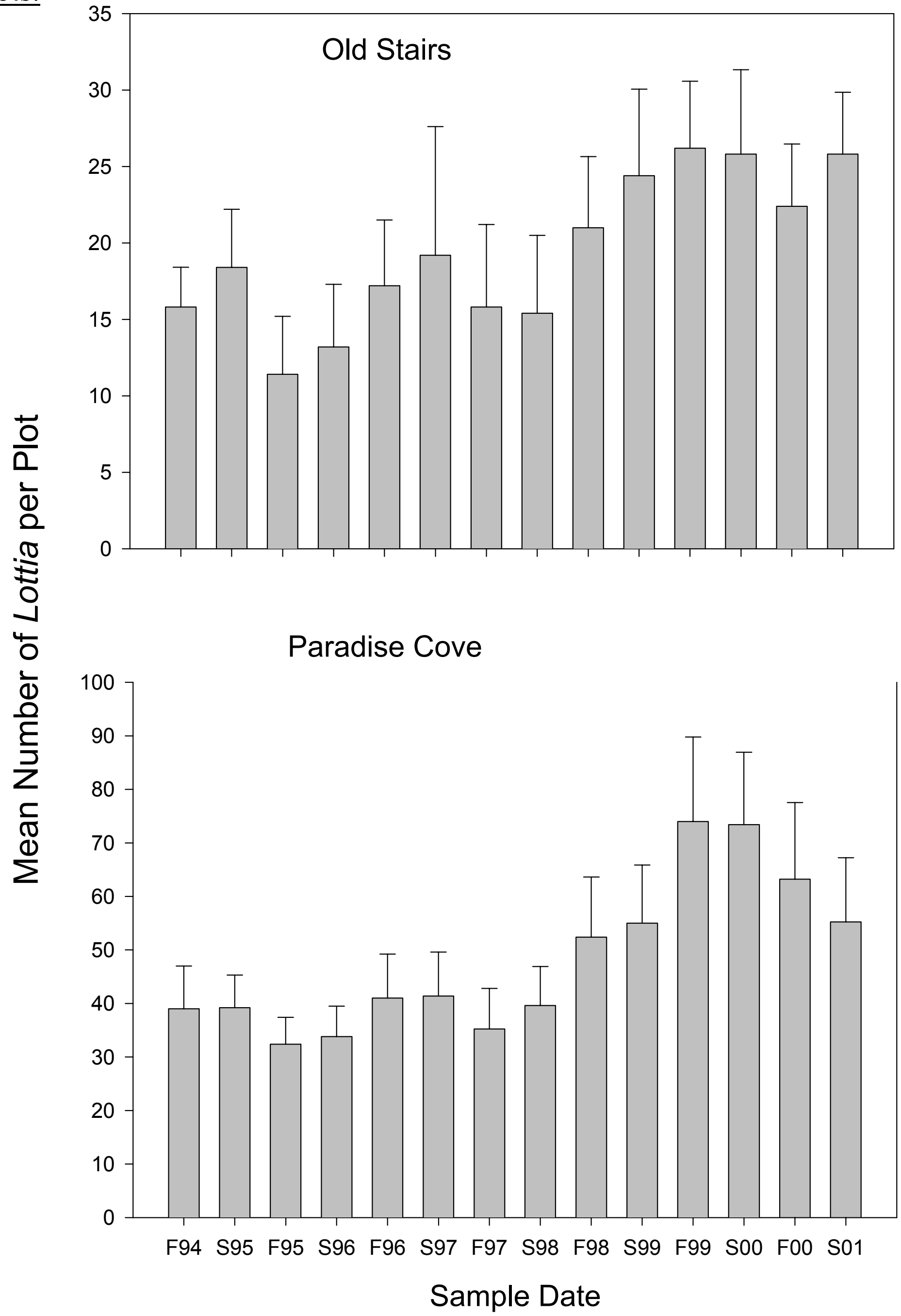

Figure 7. *Lottia* abundance at two sites in Ventura and LA counties.

Figure 7: *Lottia* abundance at Old Stairs and Paradise Cove has remained quite stable throughout the study with little change throughout the first several years. *Lottia* abundance increased somewhat around Spring or Fall 1999, especially at Paradise Cove. Abundance remains somewhat higher at Old Stairs, but numbers have been declining somewhat at Paradise Cove since the Fall 1999 increase.

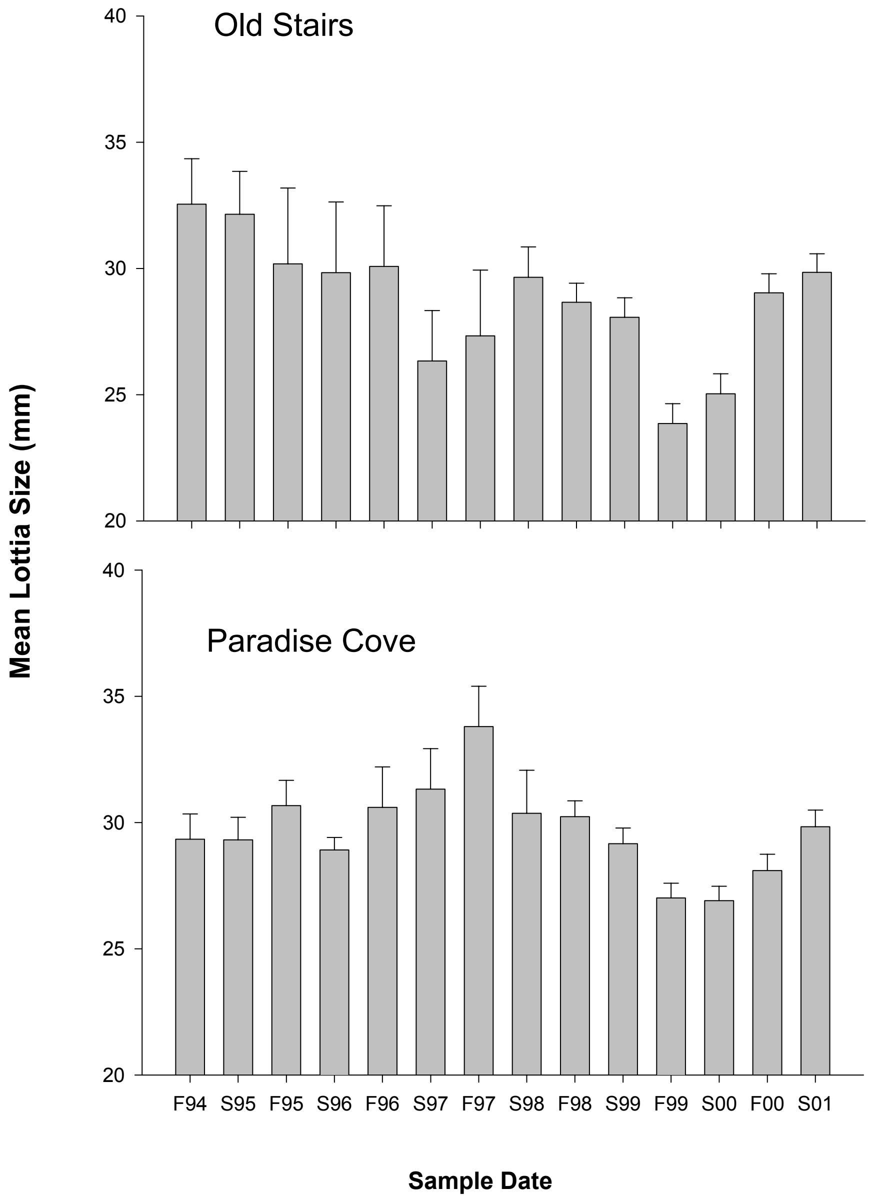

Figure 8. *Lottia* mean sizes at two sites in Ventura and LA counties

Figure 8: Mean *Lottia* size at Old Stairs has mostly remained stable throughout the study, but with a moderate drop after the Spring 99 season. This drop in mean size corresponds to the increase seen in the abundance data, suggesting that recruitment of small individuals led to the increased abundances. This could be due to a change in personnel that occurred during that time and a possible increase in search image for smaller individuals. However there have been fewer small individuals seen during the last two seasons and this is reflected in the small increase in mean size that is observed in the figure.

Problems Encountered:

Heavy swell hindered some of our sampling efforts this report period; however, all data were collected eventually.

One problem discovered during the preparation of this report was that some confusion has developed around the names of photoplots. At the Catalina sites (and possibly others, though not among our nine mainland sites), some of the original plots were renamed because the original target species (mussels) had diminished in abundance. These plots were renamed "*Tetraclita*" plots at both sites. In addition, the *Pollicipes* plots at Bird Rock were renamed "mussel" plots because mussels in those plots were in high abundance. The mussel data that we have been reporting in these reports have been from the *Pollicipes* plots at Bird Rock. No mussel data have been reported from the "*Tetraclita*" (mussel) plots from Bird Rock. Starting with the Spring 2001 sample, this problem will be fixed and all data sheets and slides will refer to the "*Tetraclita*" plots as mussel plots. There will no longer be any photoplots named "*Tetraclita*" plots.

Another problem discovered during the Spring 2001 sampling concerned the placement of one of the surfgrass transects (SG1) at Mussel Shoals, which has been positioned and sampled incorrectly since the Spring 1999 sampling season. The reason for the mistake was due to ambiguity and incompleteness of the site map and the serendipitous distance of 10m (the normal transect length) between two of the reference bolts. Another compounding factor was that no bolt was installed at the 10m mark of this transect; the tape was supposed to be reeled out to the beginning of the next transect which was a distance of ~15 meters. About half of this original transect was still sampled with the start having been shifted 4.65 meters. A statistical analysis of the data collected before and after this error occurred showed no significant difference. Therefore, we have chosen to deal with this problem by taking the data in the original location beginning with the Fall 2001 season and simply noting that the change occurred.

MMS Action Required:

We are currently awaiting delivery of some new Visor handheld computers for field data entry as well as a fixed focus 35mm lens for the Nikon camera. The Visors should be coming with barcoders, backup modules, hotsync adaptors, and waterproof bags. Also we are awaiting the delivery of a respirator for Steve since one was not provided for him in the Hazwoper course.

Progress during 2001-2002

This year marks the second report period for which the inventory of Los Angeles County rocky intertidal monitoring program was supported by MMS funding, and the fourth period for Ventura County. The primary staff researcher responsible for managing and executing this project is Steven Lee, now in his fourth year on the project. Sean Bergquist has provided assistance for the last two years and two other technicians, Katie Arkema and Meera Venkatesan, also assisted during this report period. This core team of researchers, along with regular help from MMS personnel, has provided the project with consistent, high quality data collected with notable efficiency.

The seven long term monitoring sites included in this report include five sites in Los Angeles County (Paradise Cove, White's Point, Point Fermin, Bird Rock and Little Harbor), and two in Ventura County (Old Stairs, and Mussel Shoals). Two of these sites, Bird Rock and Little Harbor, continue to be sampled without funding by Jack Engle (UC Santa Barbara) during Channel Islands Research Program cruises to the island. While the minimum set of photoplot photographs are taken during these visits, the full sampling effort including photosurveys and motile invertebrate data collection has not been completed for several years. The Catalina photoplot slides are sent to UCLA for slide scoring and data management. In addition, the UCLA group is monitoring four southern Santa Barbara County sites (Alegria, Arroyo Hondo, Coal Oil Point and Carpinteria). Pete Raimondi at UC Santa Cruz is responsible for the Inventory Program's four northern Santa Barbara and San Luis Obisbo County sites. Under the current arrangement, our UCLA group collects and enters the data for the southern Santa Barbara sites, then the data files are sent to the UCSC group for data analysis and report preparation.

During this report period, all monitoring sites were sampled as scheduled with no major problems. The Fall 2001 and Spring 2002 slides have been scored and the data entered into the computer files. Data up to and including the Spring 2002 season have been graphed and are included below. This report includes, for the first time, data from the recently established site at Point Fermin. We now have three years of data for this site, and these are treated separately below. We also include data from our two sites on Santa Catalina Island. These data have not been included in previous reports because they were sampled without funding. They have, however, been included in the funding cycle reflected by this report.

Several new plots were established and monitored during this report period. During Fall 2001, three new surfgrass transects were established and sampled at Alegria, and five new *Lottia gigantea* circular plots were established and sampled at Carpinteria. In Spring 2002, three new seastar irregular plots were established and sampled at Alegria, five new *Lottia gigantea* circular plots were established and sampled at Mussel Shoals, and three new seastar irregular plots were established and sampled at Paradise Cove. Inter-bolt measurements and photographs were taken for all of these plots (except bolt measurements for *Lottia* at Mussel Shoals). At Alegria, the new surfgrass transects are located just offshore and slightly downcoast of the mussel plots. Transect 1 and 3 are in a straight line using a continuous transect tape, and transect 2 is just inshore of these, beginning slightly upcoast of transect 1. All transects are in a downcoast to upcoast orientation. The three seastar irregular plots are just offshore of the surfgrass transects and encompass the series of high relief rocky reef structures present in that area. These seastar plots are partially formed on their inshore side by the continuous transect tape which delineates the surfgrass transects #1 and #3. Several bolts were installed to mark the locations of these plots, and these were carefully documented. The plots are in a downcoast to upcoast orientation beginning with plot #1. At Carpinteria, the five *Lottia gigantea* plots are located near the barnacle and *Pollicipes* plots, on the offshore point of the reef structure. The first four circular plots are located on the upcoast-facing side of the reef, and plot #5 is located around the other side facing downcoast. At Mussel Shoals, the five *Lottia gigantea* plots are located on the offshore facing side of the high reef structure that encompasses the mussel and seastar plots. The plots are actually inside seastar plots #2 and #3. These circular plots are in a downcoast to upcoast orientation beginning with plot #1. At Paradise Cove, the new seastar irregular plots were positioned in an onshore to offshore fashion in the vicinity of the mussel plots. Seastar plot #1 begins in the vicinity of mussel plot #3, and continues offshore from there.

This spring marked the third season of mobile invertebrate data collection within the photoplot quadrats, an effort aimed at obtaining better estimates of mobile invertebrate abundances as well as possible relationships between invertebrate abundances and the cover of key species in our quadrats. Mobile invertebrate data were taken within *Chthamalus*, mussel, *Endocladia*, and *Pelvetia* photoplots. In addition, starting in Fall 2001, motile invertebrate were surveyed in all *Pollicipes* plots and in *Balanus* plots at White's Point. No mobile invertebrate data were collected within anemone plots at any of the sites. During the initial sampling of pilot effort, there was some uncertainty about the specific methods to be used. For example, it was unclear whether every representative mobile invertebrate group should be sampled within each photoplot assemblage and whether we should be subsampling certain groups of mobiles. The guidelines that were agreed upon and are currently being implemented are as follows: Larger and more infrequent mobiles are surveyed in all plots, limpets are sampled in all plots except mussel and *Pollicipes* with the exception of *Lottia gigantea*, littorines are only sampled within barnacle (mainly *Chthamalus*) plots. Subsampling is taxon specific and is done only when necessary. For example in a barnacle plot where large and medium sized limpets are common (<50 individuals), but small limpets and littorines are abundant, only the latter two groups will be subsampled. Subsampling involves the use of a standard quadrat divided by monofilament line into 66 squares (100 cross-sections). If the substratum is relatively uniform and the target taxon is not visibly clumped, a haphazardly chosen sector of the quadrat is sampled with a target range of 50 to 100 individuals. Every effort is made to reduce the bias of the researcher in choosing which sector to sample. If individuals are too numerous, visibly clumped, or some other feature of the plot prevents a sector based approach, individual squares are selected randomly until the last square sampled brings the total count to the range of 50-100 individuals

We have continued to monitor barnacle recruitment at most of our intertidal sites. In addition to the *in situ* measurements and recruitment plates that we exchange during our normal spring and fall sampling, we are also revisiting the sites in the summer months to collect additional barnacle data. We have been getting close to 100% recovery of the recruitment plates each season. The exception is Carpinteria, which has very soft mudstone substrate that doesn't hold the masonry anchors very well. At this site, we have been losing one or two plates each season. After collecting the old plates from the sites, we have been sending the plates and data sheets to the UCSC group, who has been maintaining the barnacle recruitment database. The summer 2002 barnacle data have yet to be collected.

The intertidal SWAT team continued to sample some of the sites that were not completed in the previous report period. Coal Oil Point and the two Santa Catalina Island sites were among the southern California sites sampled. These comprehensive survey protocols have been applied to other projects as well. Throughout this winter and spring, these methods were employed by our group at UCLA in an unrelated project investigating the impacts of human use on rocky intertidal sites in the Santa Monica Bay area. Five sites were surveyed on the Palos Verdes peninsula (Point Fermin [two sites], White's Point, Inspiration Point, and Abalone Cove) and five on the Malibu coast (Paradise Cove, Little Dume, Point Dume, and Leo Carrillo Beach [two sites]). Based on the biological data collected at these sites, along with corresponding data for human use, we intend to make recommendations to the California Coastal Conservancy for the potential protection and/or restoration of intertidal sites in the Santa Monica Bay. Through these two projects, new points of coastal access have been arranged, allowing us much closer access to our inventory site at Paradise Cove. This improved access will eliminate the long walk from the Paradise Cove parking lot to our site, and will reduce the time required to complete the sampling by almost an hour.

Early this report period (October 12-13), a taxonomy workshop was held at the UC Santa Cruz Long Marine Laboratory. This workshop was attended by most of the researchers associated with this project, plus Kathy Ann Miller and John Pearse, who acted as taxonomic experts for algae and invertebrates, respectively. This workshop was very useful, but further workshops should include field visits to the various sites in the MARINE network. A HAZWOPER refresher course held at the MMS offices in Camarillo on December 4 was attended by Rich Ambrose and Steve Lee from UCLA. Both received and were fit-tested for new respirators on that day. On March 20, a protocol and database standardization meeting was held at the UC Santa Barbara campus, which included members from most of the groups, plus a representative from SCCWRP who will be helping with database standardization under contract. Several issues were discussed at this meeting regarding protocol standardization and some were resolved. A tentative list of core taxa was developed; these were species or larger taxonomic groupings that all monitoring groups would include on their respective datasheets and computer databases. Steve Murray was not able to attend this meeting, so many of these issues still need to be resolved. Another meeting regarding database standardization is scheduled for June 11 at MMS.

We continued this year to use still photo surveys rather than video surveys at all of our sites. This method is an improvement over the video protocol due to the speed of image collection and the utility of the resulting slides. Once developed, survey panoramas from different seasons can be placed alongside each other on a light table for a quick look at changes that might have occurred through time. For the most part we used the old video reference points for use in this protocol, but there have been some modifications wherein some photo points have been deleted and others added. A simple protocol for these still photo surveys has been developed for our nine mainland sites and these have been implemented during the last two sampling seasons. We received and have been using our new fixed focus 35mm lens for these photosurveys, which has significantly improved the repeatability of these surveys

Also this year, we received from MMS a new 1.6 GHz computer to replace a previous computer that had a fatal hard drive failure. This is now the main technician's computer where all inventory related files are created and stored. The 1.0 GHz computer purchased in the previous year houses the scanner and slide scanner, which includes a bulk loader, and a color printer. We have requested a third computer that will have additional speed, and a flat panel monitor for image processing. We are continuing the process of scanning our images, saving them to CD's and distributing the CD's to all of the parties involved in the project. We purchased a new Handspring Visor (through an unrelated source of funds) to replace the one that was stolen last year.

Future Plans:

During the weekend of July 13, we will be revisiting all of our sites for the Summer 2002 barnacle recruitment sampling.

After several years of uncertainty regarding the quality of digital photography, we are now confident that the technology is good enough to warrant a transition away from the use of standard emulsion film. We plan in this year to acquire and incorporate a good quality digital camera into our monitoring efforts. This digital camera will be placed inside a waterproof housing to protect it from the elements. Though we still plan to use standard film as a backup in the upcoming Fall 2002 season, we will also shoot our photoplots with the new digital camera and these images will be displayed on the new flat panel computer monitor for the scoring of percent cover.

We will also be working with Jack Engle and Larry Cooper from SCCWRP toward the creation of a standardized database and sampling protocol. We hope to settle on a final list of core species, agreed to by all parties involved that will be implemented in the upcoming Fall 2002 season.

We will continue to explore the possibility of augmenting sites with new plots. We hope to establish mussel and seastar plots at Coal Oil Point, and seastar and *Lottia gigantea* plots at White's Point and at Point Fermin. The other sites are at capacity with respect to available species, and/or workload.

Data Summary:

Although we have not completed a full analysis of the past year's data, in this section we provide graphical summaries of the data to date, as well as brief narratives about possible trends.

Photoplot data:

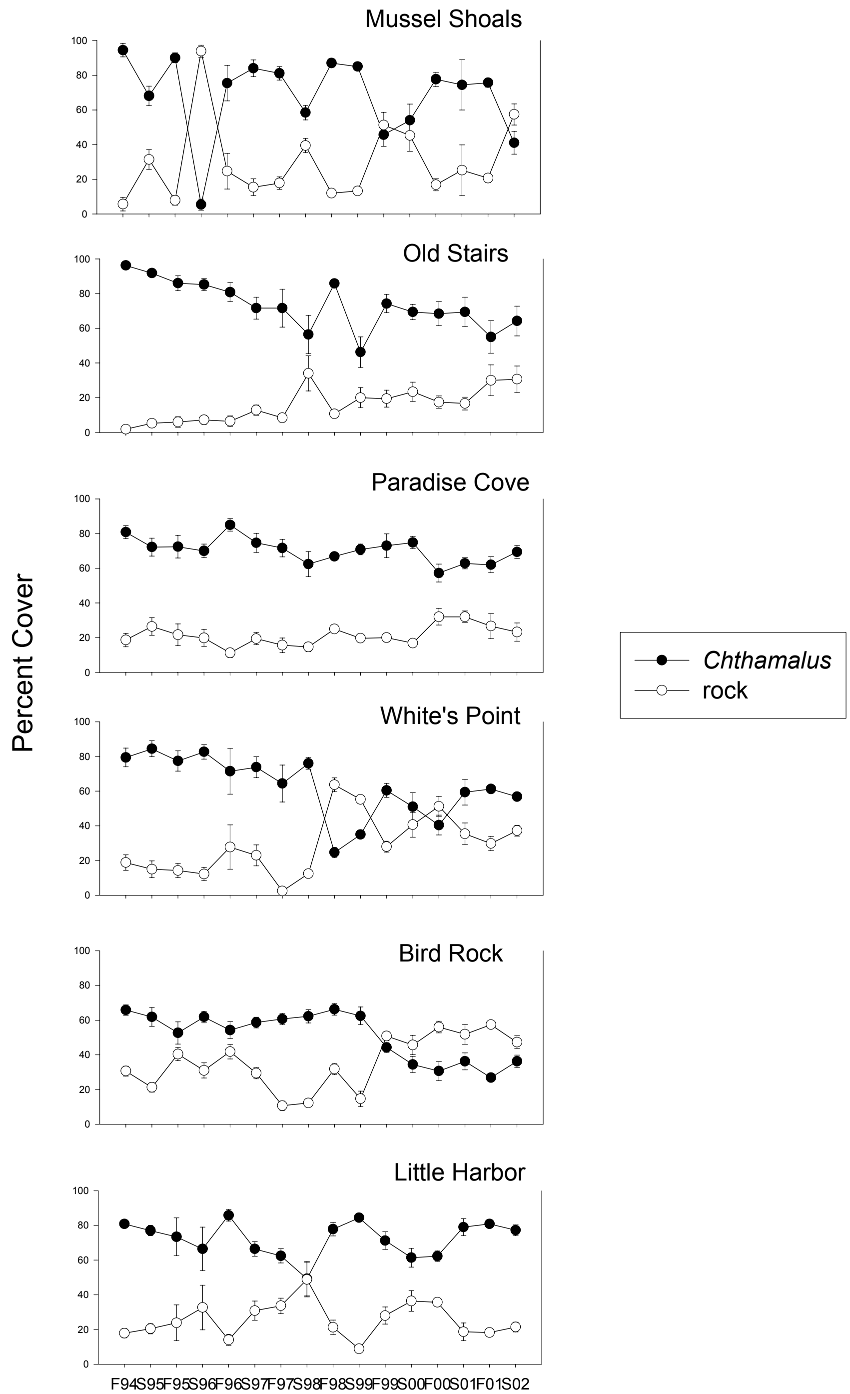

Figure 1. Trends in *Chthamalus* cover at all sites monitored.

Figure 1: *Chthamalus* cover decreased again at Mussel Shoals in Spring 2002. While this decline is not as severe as that seen in the Spring of 1996, where nearly all barnacles disappeared, they have experienced a 50% decline. At Old Stairs, the downward trend in *Chthamalus* cover seen throughout the study began again during the fall, though it rebounded in Spring. Barnacle cover seems relatively stable at the other sites.

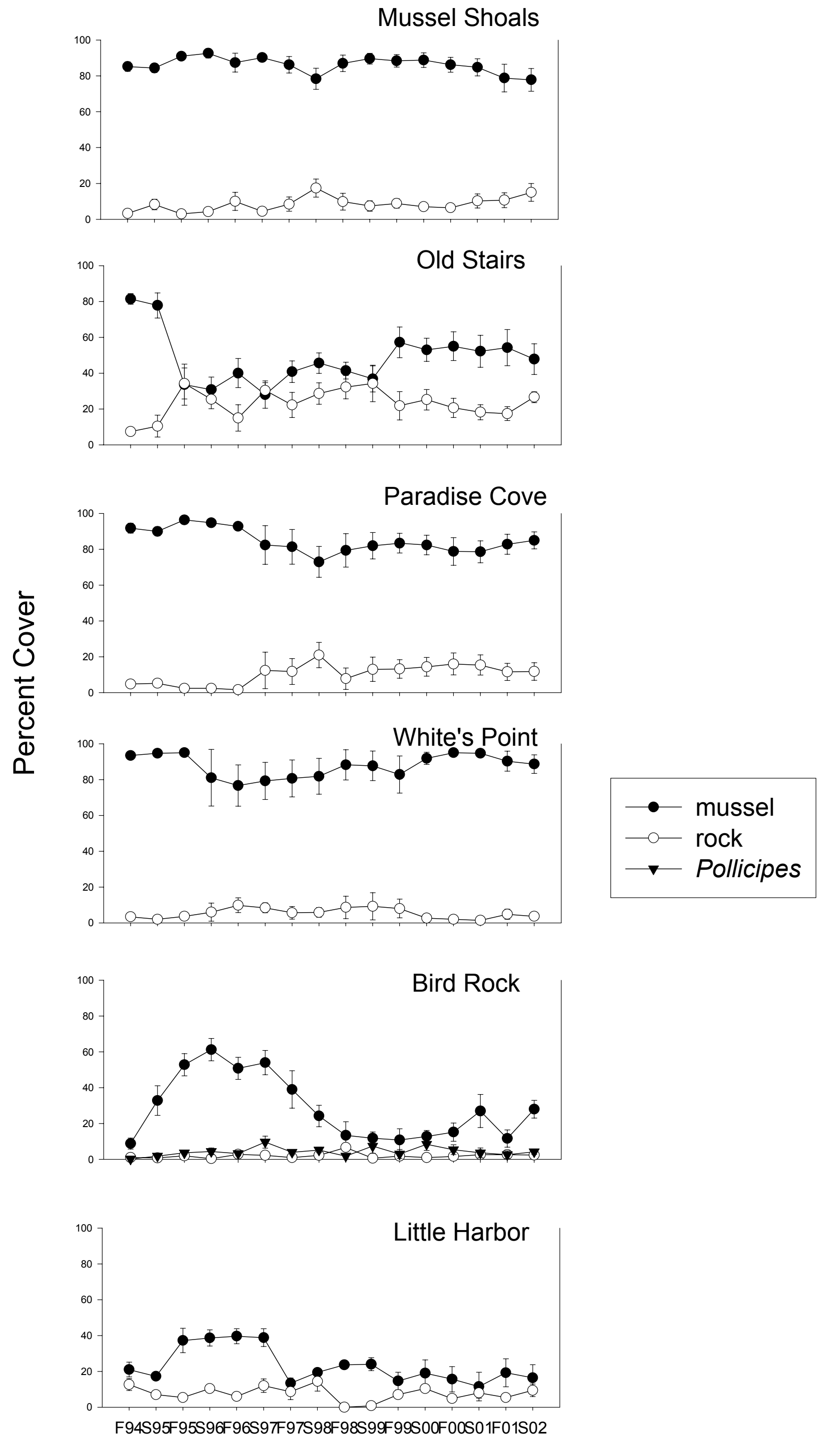

Figure 2. Trends in *Mytilus* cover at all sites monitored.

Figure 2: *Mytilus* cover has remained roughly stable at most of our sites with only slight fluctuations. One notable exception is at Old Stairs where mussels underwent a sharp decline in Fall 1995 and have been at lower levels since. In the last six seasons, however, mussel cover has come back to about 70% of the original level. Slight increases in mussel cover have been seen during the last two spring seasons at Bird Rock.

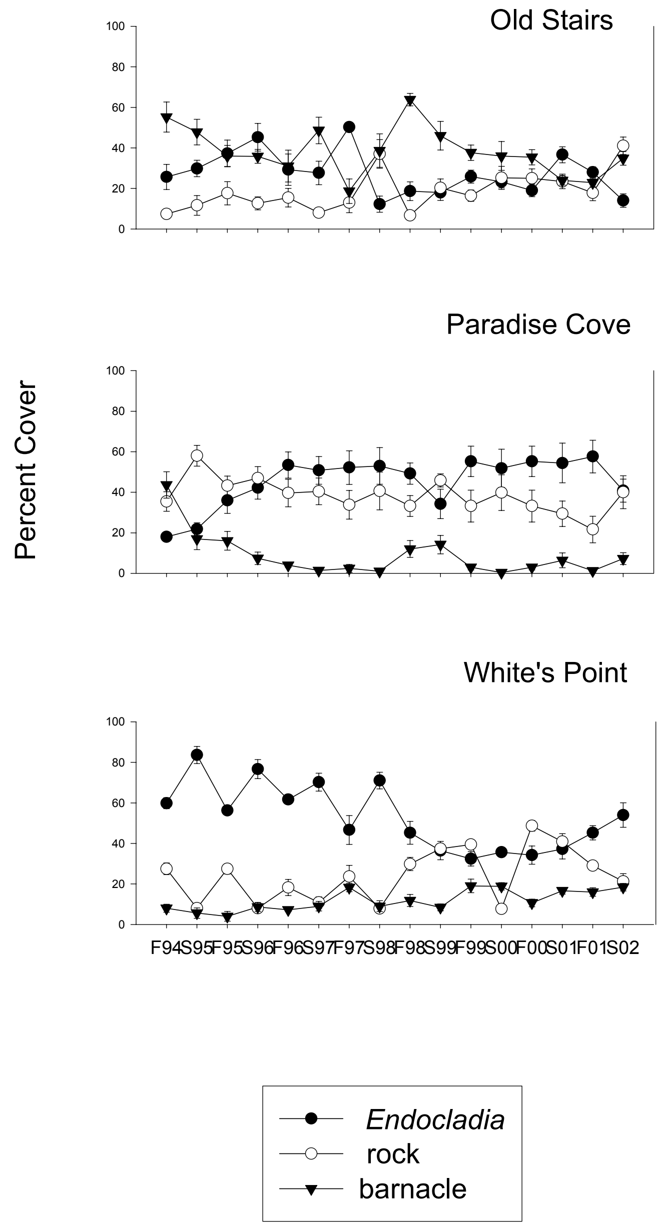

Figure 3. Trends in *Endocladia* cover at all sites monitored.

Figure 3: *Endocladia* cover at Old Stairs has been quite variable throughout the study. In Fall 2000, *Endocladia* was near the low end of the cover we have recorded, but cover increased substantially in Spring 2001. Since then it has declined again. All sites seem to show seasonal patterns in cover, with at least slight increases in the spring. At Paradise Cove, *Endocladia* cover has been increasing throughout the study, but was down slightly this spring. Interestingly, qualitative observations show *Endocladia* to be spreading up further into the barnacle zone over the past year. White's Point, which had been experience a gradual decline, seems to be on the increase again over the past two years.

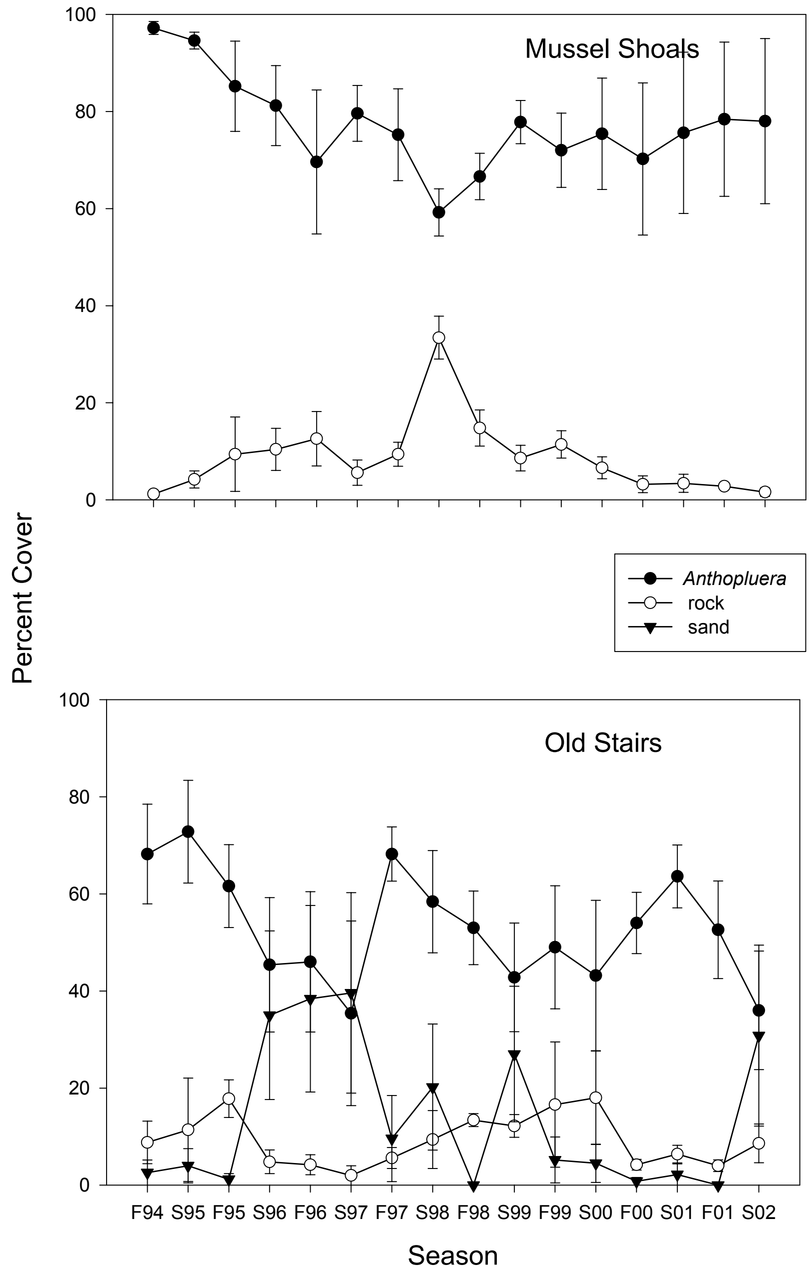

Figure 4. Percent cover of *Anthopleura* at two Ventura County sites.

Figure 4: *Anthopleura* cover at Old Stairs has been marked by rapid increases followed by gradual declines. While qualitative observations do support this pattern to some extent, other factors such as sand burial also contribute to the apparent decline. This past season, sand levels were very high and some of the plots were obscured partially, or in one case almost completely, by sand. The anemones typically survive this sand burial. Mean cover at Mussel Shoals has declined overall, but has been roughly stable since the Spring of 1999. The variance, however, appears to have increased since that time as evidenced by the wide error bars. This pattern is almost certainly due to anemone plot #5, which has been almost entirely overgrown by mussels. The other plots, and the site overall, seem to have stable or even increasing cover of *Anthopleura*.

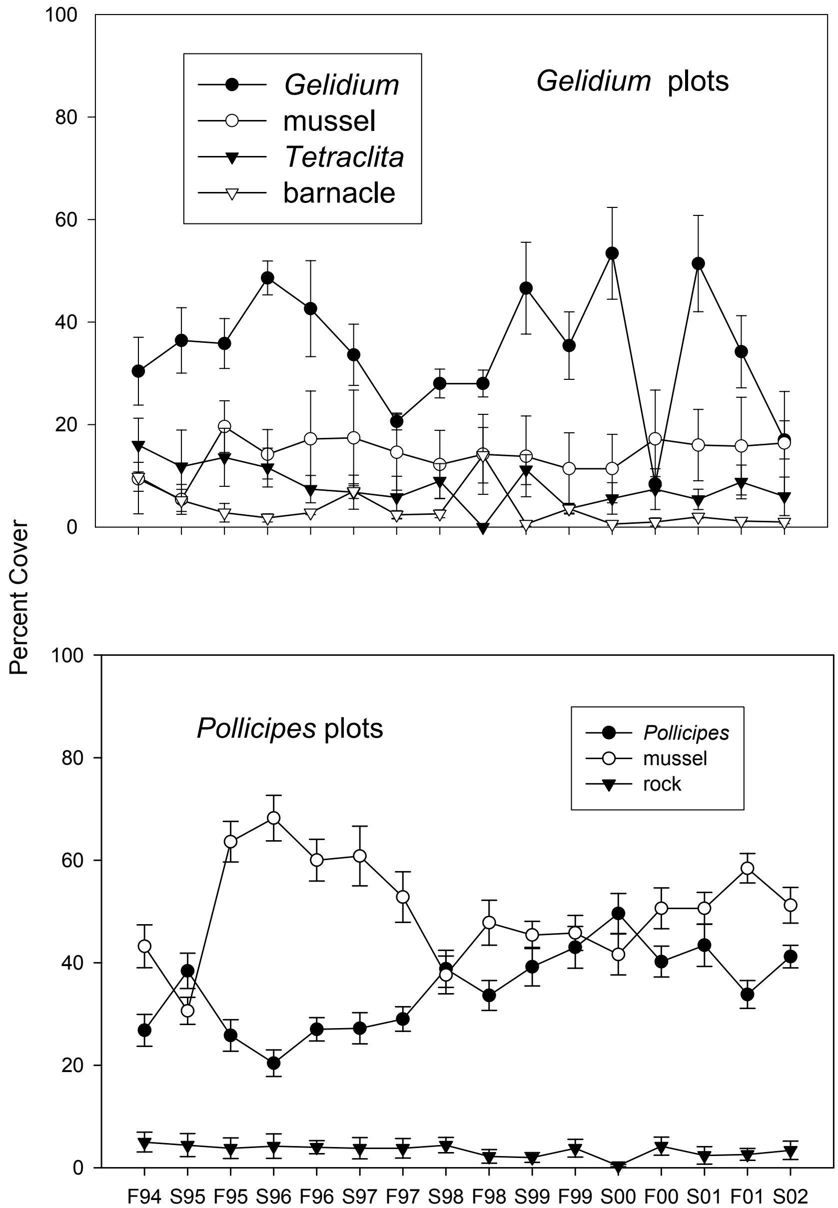

Figure 5. Trends in *Gelidium* and *Pollicipes* plots at Bird Rock.

Figure 5: This figure shows the cover of species within *Gelidium* and *Pollicipes* plots at Bird Rock on Catalina Island. These data have not been included in previous reports because sampling was done without any funding. Within *Gelidium* plots, sessile invertebrate species exhibited low and relatively stable cover. *Geliduim*, however, has undergone substantial fluctuations. It is unclear what is responsible for these fluctuations, but is likely due to the contributions of other red algae such as geniculate corallines and low turfy species. These plots are extremely difficult to score and *Gelidium* is only recorded when the identification is certain. Much of what is considered turf is likely low-growing *Gelidium*. Future graphs will include these other red algae species.

Within the *Pollicipes* plots, mussels and *Pollicipes* have co-varied through the seasons with mussels dominating the plots for the majority of the time. After an early decline, mean *Pollicipes* cover has increased gradually since the spring of 1996.

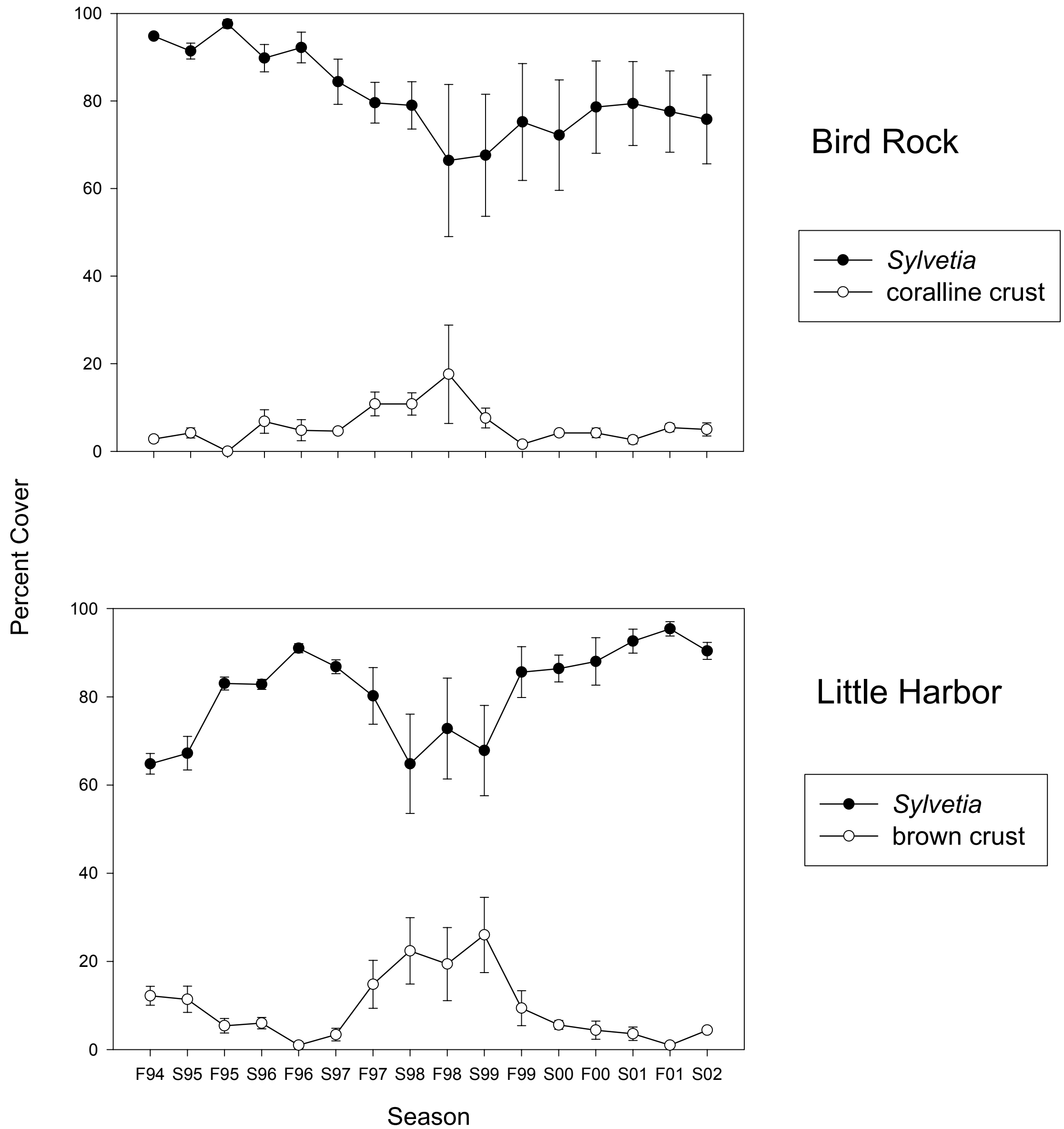

Figure 6. Trends in *Pelvetia* plots at Catalina Island.

Figure 6: This figure shows the cover of *Sylvetia* at the two Catalina Island sites. At Bird Rock, mean *Sylvetia* cover has declined by about 20% since the first survey. Cover was the lowest in the Fall of 1998 and has been at a slightly higher level since the Fall of 2000. At Little Harbor, mean *Sylvetia* cover is near its highest level since being monitored. Cover increased for the first two and one half years, declined to near the original level between 1997 and 1999, and has increased since. The suggestion of seasonal variation can be seen in these data, but they are mostly obscured by larger, non-seasonal changes.

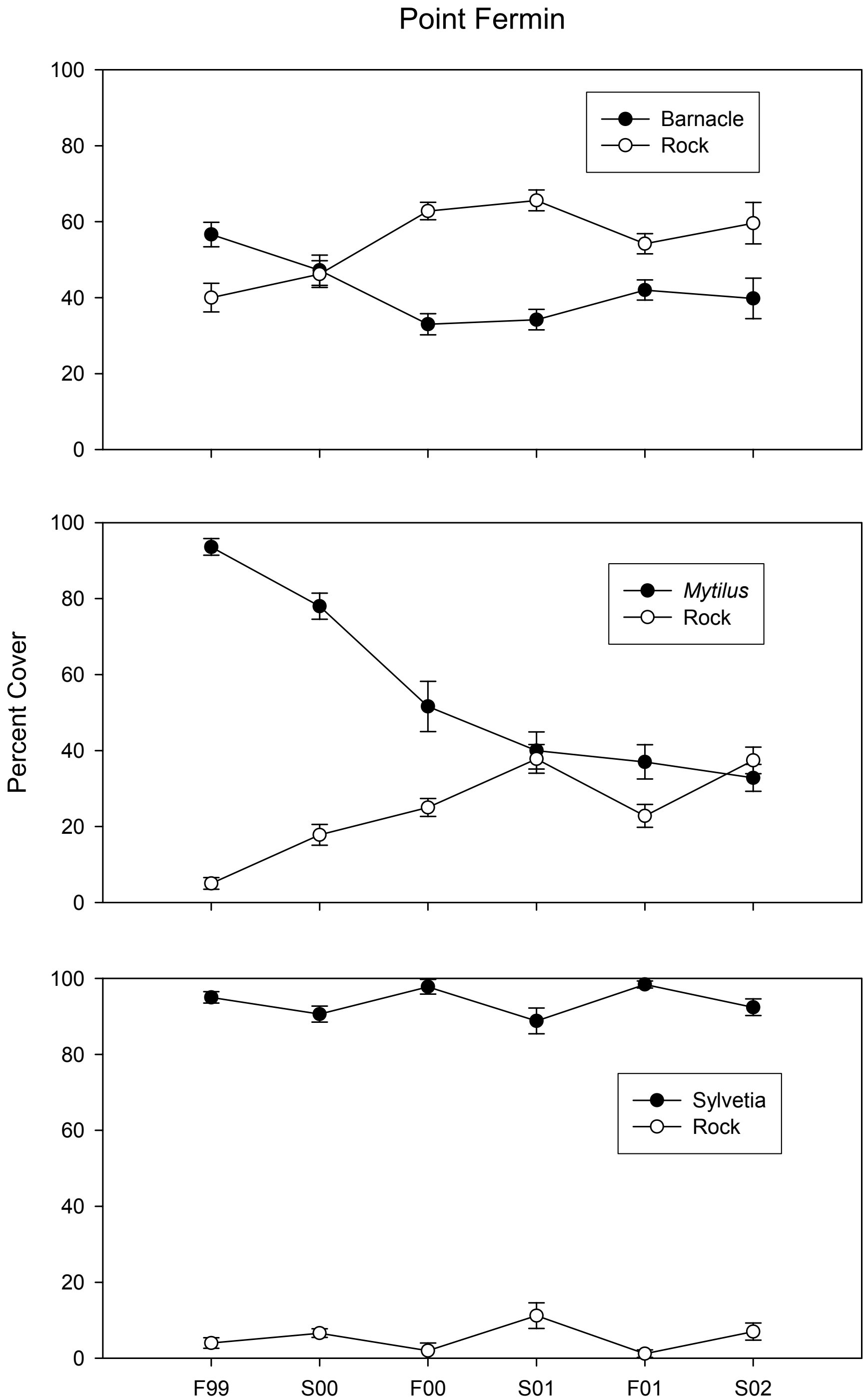

Figure 7. Photoplot data from Point Fermin

Figure 7: This figure shows the cover of species monitored within photoplots at Point Fermin since the first sampling in fall of 1999. This is the first time these data have been included in the annual report. Both *Chthamalus* and mussels have declined since the plots were established. Mean *Chthamalus* cover declined in the first two sampling seasons from an initial high of ~60% to ~40%, where it has remained since. This decline is similar to the general decline we see after establishing plots, since plots are typically established in high-density locations and even random fluctuations would lead to declines. Mean mussel cover was very high when the plots were established (over 90%), but has been declining with every subsequent sampling season. In the first two years, this decline was rapid (from >90% to ~40%), and in the last year it was more gradual with an overall decline of over 60%. This decline is more severe than we would normally expect from random processes after the establishment of a plot. *Sylvetia* cover has shown seasonal variation over the last three years, but with no apparent decline. Our qualitative observations support these patterns for the site as a whole. Mussels seem to be getting sparse, at least in the vicinity of our plots, and *Sylvetia* seems to be very healthy if not increasing at the site.

<u>*Phyllospadix* Transects:</u>

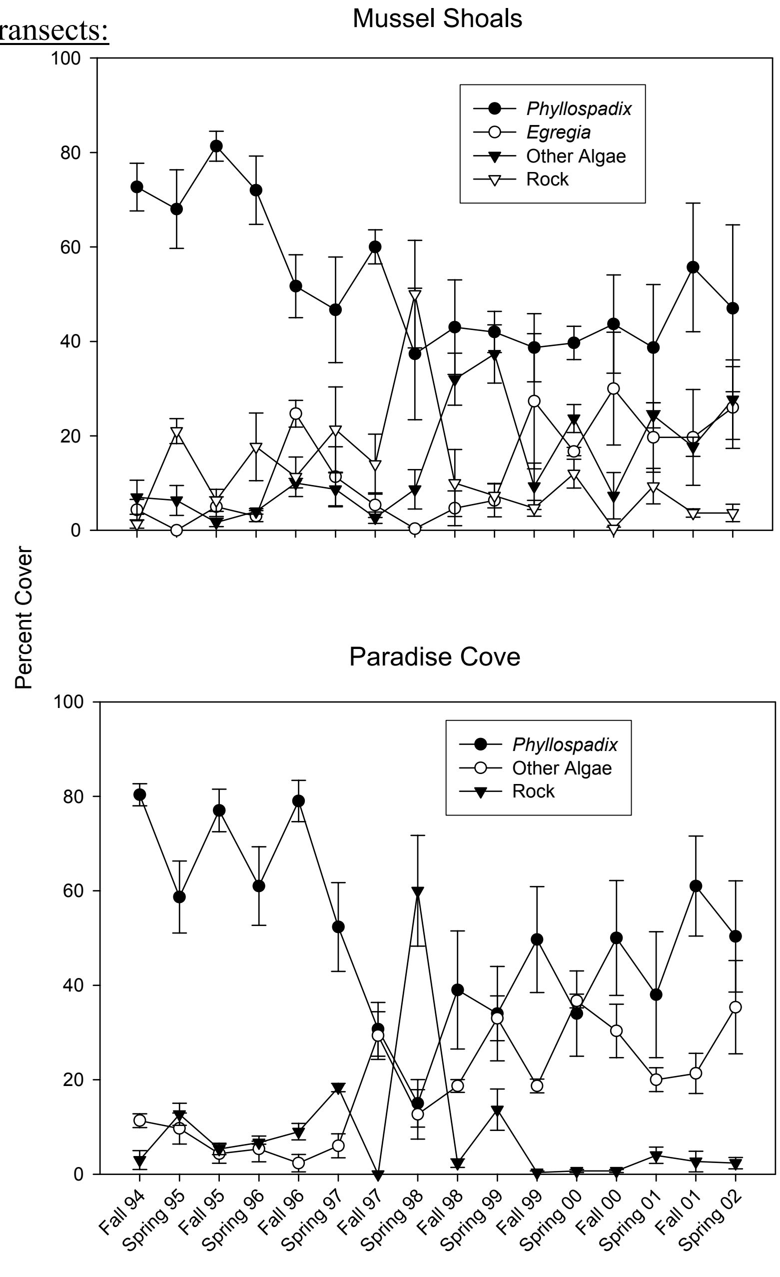

Figure 8. Percent cover of *Phyllospadix* at Mussel Shoals and Paradise Cove.

Figure 8: At Mussel Shoals, *Phyllospadix* cover had experienced a marked decline following a peak in Fall 95 and has seemed to stabilize at around 40% cover since 1998. In the past year there was a moderate increase in the fall followed by a slight decrease in the spring. At Paradise Cove, *Phyllospadix* cover seems much more sporadic, with stronger seasonal patterns than at Mussel Shoals. Cover at Paradise Cover underwent a precipitous decline following Fall 1996 and has been increasing episodically ever since. The sharp declines at both of these sites demonstrate the succession patterns common following disturbance. Concurrent with the declines was a sharp increase in the cover of bare substrate. Since that time increases in other algae (mostly filamentous and turf species) followed by an increase in *Egregia* (at Mussel Shoals) were seen.

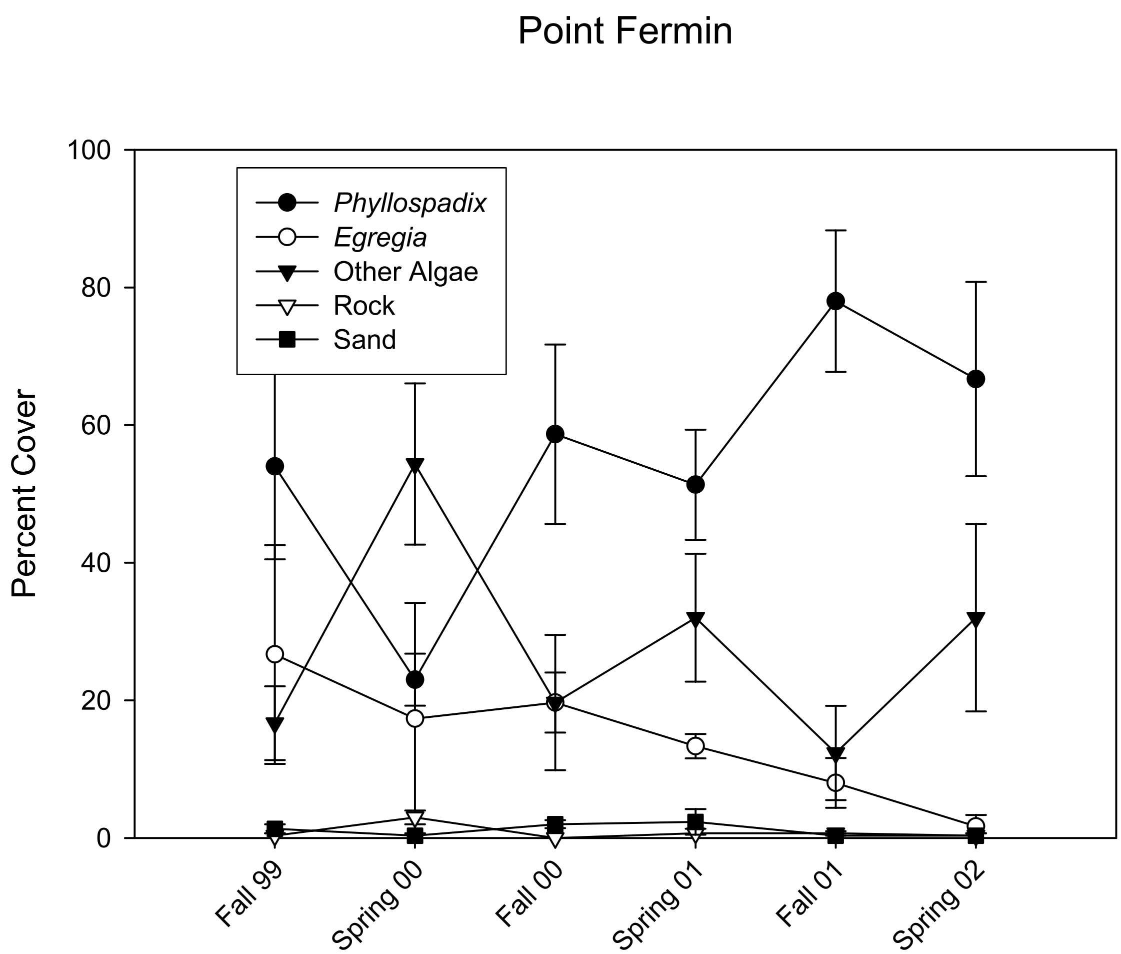

Figure 9. Percent cover of *Phyllospadix* at Point Fermin

Figure 9. Within the surfgrass transects at Point Fermin, bare rock or sand are uncommon. *Phyllospadix* seems to show seasonal patterns similar to the other sites with higher cover in the fall than in the spring. Cover seems to have increased since the first sampling in Fall 1999, with opposing cover of algae reflecting its seasonality. *Egregia* has become less common since the beginning of the surveys, at least in the vicinity of the transects.

<u>*Pisaster* Plots:</u>

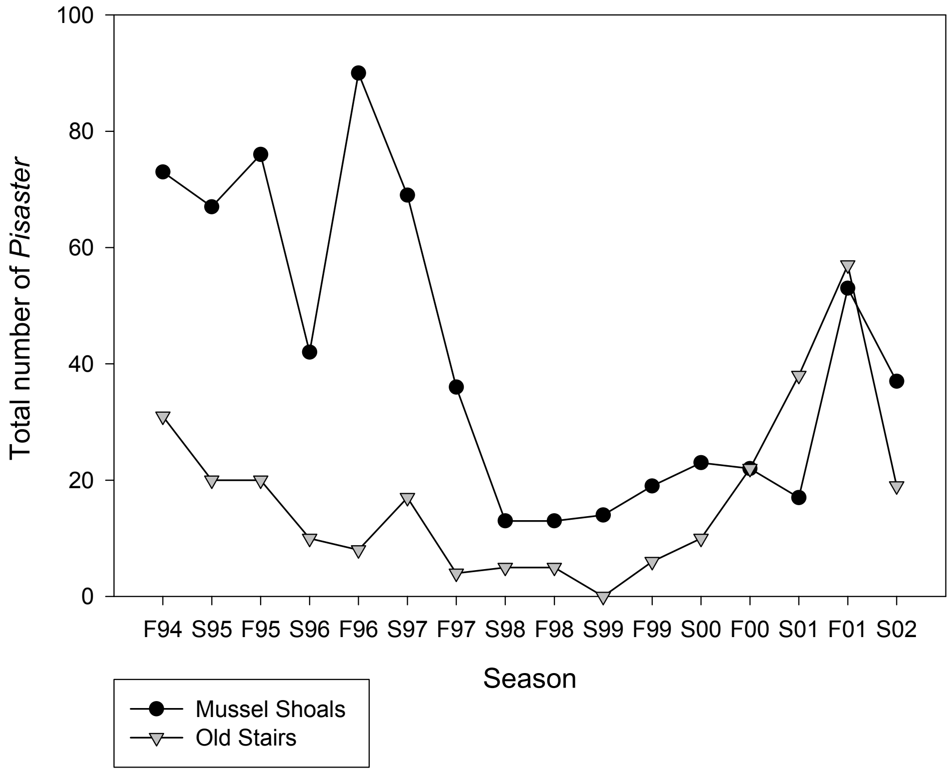

Figure 10. Total number of *Pisaster* within monitored plots at two sites in Ventura County

Figure 10: The total number of *Pisaster* found at our two Ventura sites dropped significantly throughout the first years of the study. In recent seasons, however, the numbers seem to have increased substantially, a trend that follows observations throughout Southern California. Unfortunately, the numbers have again dropped at both sites in the most recent spring season. It remains to be seen if this will persist in future seasons. Sea star abundance at our sites, especially Old Stairs, seems to be highly dependent on the degree of sand inundation, and this certainly is having an impact on the apparent decline seen in our data. The decline at Mussel Shoals seems to have less to do with sand.

<u>*Lottia* Plots:</u>

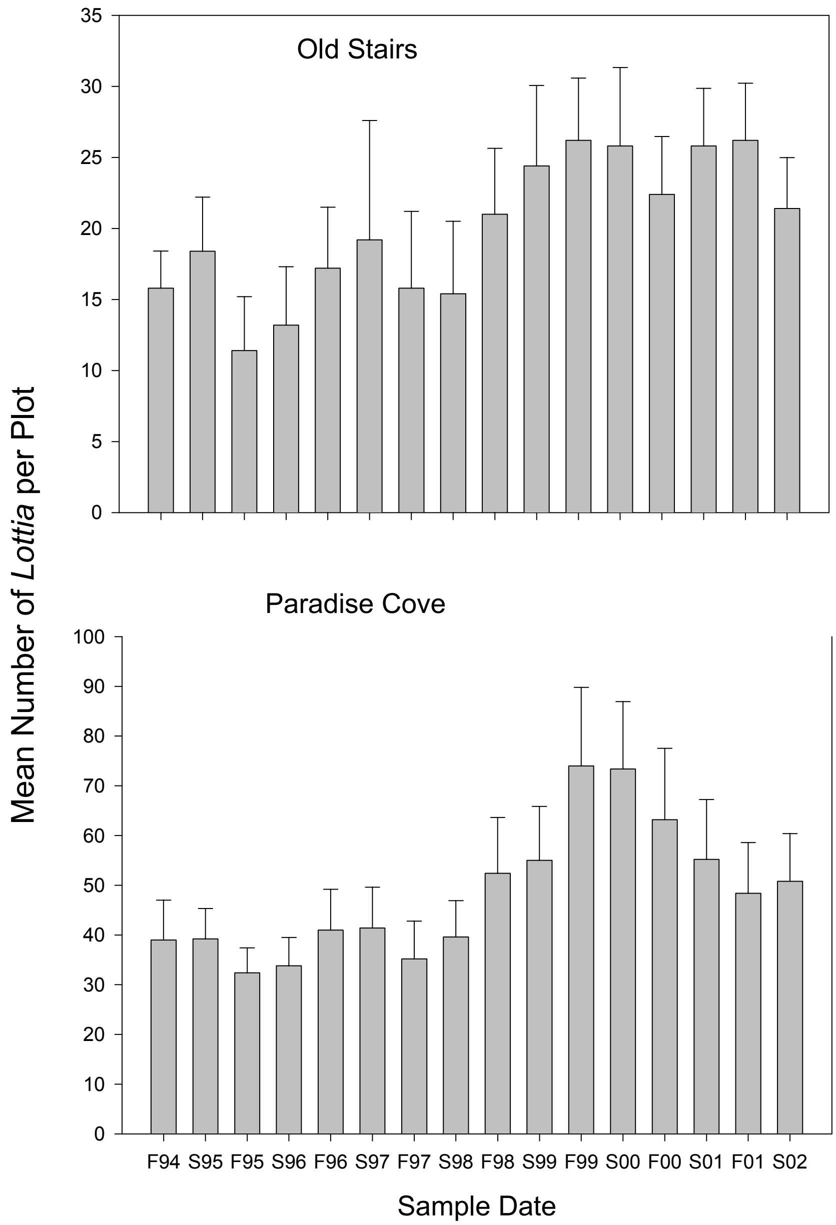

Figure 11. *Lottia* abundance at two sites in Ventura and LA counties.

Figure 11. *Lottia* abundance at Old Stairs and Paradise Cove has remained quite stable throughout the study with little change throughout the first several years. *Lottia* abundance increased somewhat around Spring or Fall 1999, especially at Paradise Cove. Abundance remains somewhat lower at Old Stairs, but this is probably not significant. Numbers have been declining somewhat at Paradise Cove since the Fall 1999 peak, but these may have begun to level off this spring.

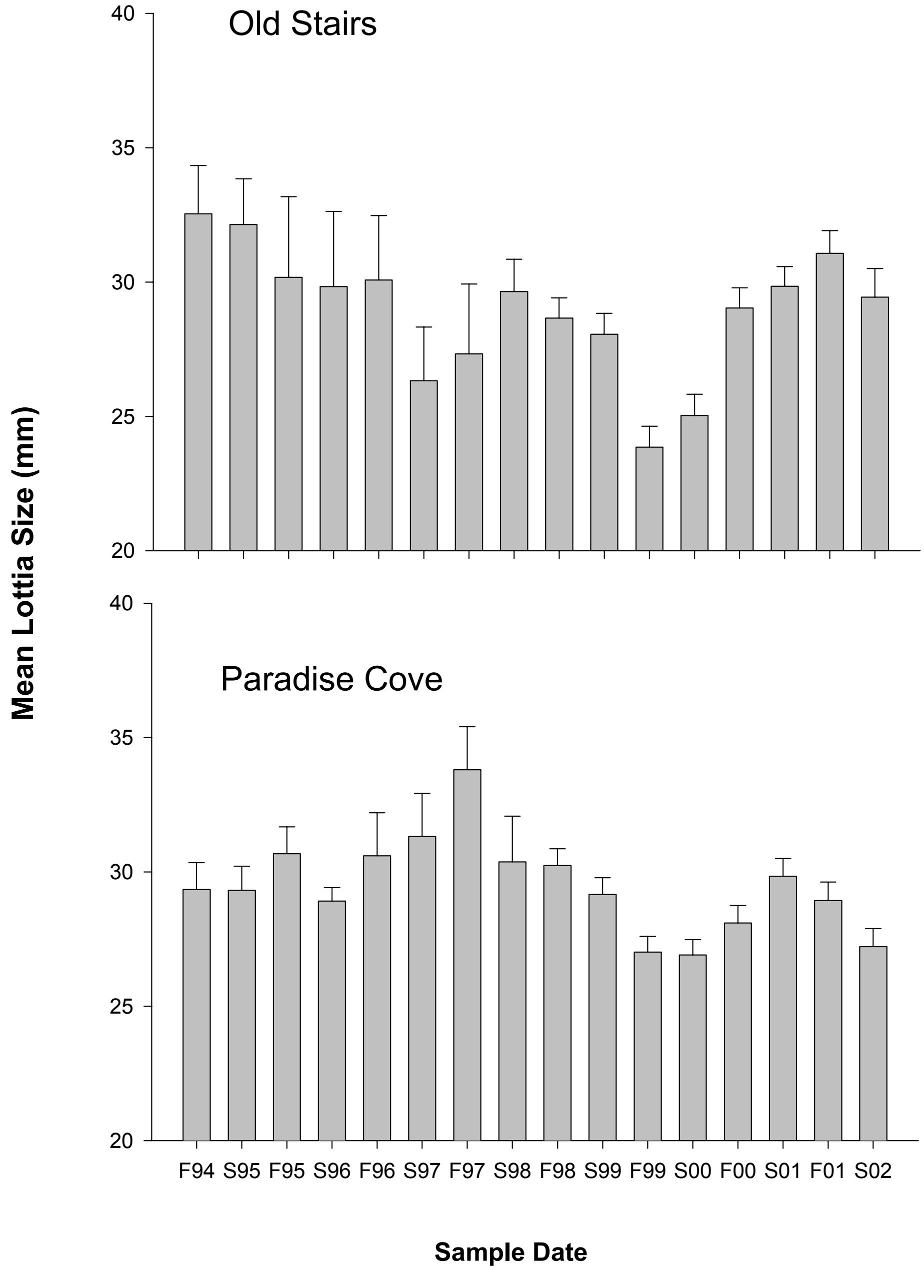

Figure 12. *Lottia* mean sizes at two sites in Ventura and LA counties.

Figure 12: Mean *Lottia* size at Old Stairs has mostly remained stable throughout the study, but with a moderate drop after the Spring 99 season. This drop in mean size corresponds to the increase seen in the abundance data, suggesting that recruitment of small individuals led to the increased abundances. This could be due to a change in personnel that occurred during that time and a possible increase in search image for smaller individuals. However there have been fewer small individuals seen during the last several seasons and this is reflected in the small increase in mean size that is observed in the figure.

Problems Encountered:

We were unable to sample the mussel plots and seastar transects during the Fall at Carpinteria due to seals that were present on the rocks. The seals were not present during the Spring, however, and we were able to complete all of the surveys at that site. Rain was a hindrance during one the field days (Arroyo Hondo) in Fall. Photoplots at two sites had to be re-photographed during the Spring 2002 season due to a problem with a film canister. Our Nikon slide scanner malfunctioned in the middle of this period, which prevented the timely archival and distribution of the 2001 photographic images and data. We were unable to have this unit repaired due to the budget problems and the four month gap in funding we experienced. After several months, MMS learned of the problem and agreed to pay for the repairs. The scanner is back in service and we are now current with respect to issues of archiving.

The funding cycle changed in the middle of this report period, with the previous contract ending in October. The subsequent funding term did not start until early March, which left a four-month funding gap between the months of November through February. To remedy this problem, interim funding was requested, which was provided by MMS as two short-term contracts. However, administrative problems prevented these interim funds from becoming available until after the new funding cycle began in March, which caused some inefficiencies in terms of staff time and the postponement of supply purchases and equipment repairs.

MMS Action Required:

We are currently awaiting delivery of our new high-speed computer and flat panel monitor. We expect to use this computer to test new methods of image analysis prior to the upcoming fall season. We are also working with Steve Murray toward the purchase of our new digital camera. We are still trying to determine the appropriate camera and housing combination that will best serve our needs in the upcoming years.

Task No. 17604: *Shoreline Inventory of Intertidal Resources of San Luis Obispo and Northern Santa Barbara Counties*

Principal Investigator: Pete Raimondi, Department of Biological Sciences, University of California, Santa Cruz, CA 95064

Summary of Research

Progress during 1999-2000

This report summarizes the accomplishments of the Inventory of Rocky Intertidal Resources for San Luis Obispo and Northern Santa Barbara Counties from July1999 to July 2000. The purpose of the Shoreline Inventory Project is to provide baseline information on the rocky intertidal plants and animals along the central and southern California coast. Information on coastal biota in these areas would be essential in the event of an oil spill or other major impact. In addition, the monitoring studies yield important data on population dynamics on a local and regional scale which can be utilized for more effective resource management as well as provide fundamental ecological knowledge about the dynamics of the systems. The rocky intertidal surveys of five sites in Northern Santa Barbara County (NSB) represent a continuation of previous semi-annual monitoring conducted for the Minerals Management Service from 1992 to 1999. Five additional sites were established in 1995 for San Luis Obispo County (SLO). The combination of previous and current year surveys in the two counties has resulted in a total of 17 samples for NSB sites, and 10 samples for SLO sites.

The sampling protocol focuses on target species or assemblages. Permanent photoplots are established in assemblages such as barnacles, mussels, anemones, turfweed, and rockweed. Cover of the major taxa is determined by point-contact photographic analysis. Permanent plots are also established for large motile species such as owl limpets, black abalone, and seastars. Line transects are used to estimate the cover of surfgrass. Photographic overviews and field notes are used to describe general conditions at the site and to document the distribution and abundance of organisms not found within the photoplots.

Table 1 summarizes the field activities of this past fall and spring for both counties. Government Pt. (an NSB site) could not be sampled in Fall 1999 because access to the surrounding private land was denied to all researchers working in the area. Data for all sites have been entered and analyzed for all work completed through spring 2000.

Table 1: Summary of Rocky Intertidal Field Activities for San Luis Obispo and Northern Santa Barbara Counties.

Dates	County	Activity
11/21-11/24	Northern Santa Barbara	Fall 1999 sample
11/21, 12/4-12/5, 12/9	San Luis Obispo	Fall 1999 sample
3/1-3/5	San Luis Obispo	Spring 2000 sample
3/14-15, 5/8	Northern Santa Barbara	Spring 2000 sample

A species by species summary of the results of the past year's monitoring follows. The summaries are broken into 3 sections: Photoplot Invertebrates, Photoplot Algae and Surfgrass, and Motile Invertebrates. A final section describes related work.

Photoplot Invertebrates

Anemones, (*Anthopleura elegantissima*), were sampled at only one NSB site, and showed similar percent cover as compared to previous years. Barnacle cover (*Chthamalus* spp. & *Balanus* spp.) has experienced a gradual decline over time at all sites in both counties. This trend continued in the fall 1999/spring 2000 (F99/SP00) sampling period. This general decline is likely due to a gradual die-off of adult barnacles accompanied by low recruitment of new individuals into the communities. The decline is especially apparent at two of the NSB sites, Occulto and Boat House, where initial barnacle cover of approximately 80% has dropped to less than 20%. The gooseneck barnacle, *Pollicipes polymerus*, has experienced almost no change in percent cover over time at the one NSB site where it is sampled. Mussel cover (*Mytilus californianus*) remained high at nearly all SLO and NSB sites. Two exceptions were Stairs (an NSB site), which experienced a decline of approximately 30% in the F98/SP99 sampling period, and Shell Beach (SLO) where mussels declined in cover by over 50% during the same period. Neither of these sites experienced further decline in mussel cover during the F99/SP00 year.

Photoplot Algae and Surfgrass

Although cover of the rockweed, *Pelvetia compressa,* exhibits a strong seasonal fluctuation (higher in the fall, lower in the spring), overall cover remained fairly constant over time at all but one of the seven sites where it was sampled. At Stairs (an NSB site) *Pelvetia* cover has been gradually declining, and continued to decline during the F99 and SP00 samples. Percent cover for this species at Stairs has dropped from an initial high of nearly 90% to approximately 20%. Another species of rockweed, *Hesperophycus harveyanus*, has declined in cover at Pt. Sierra Nevada, the northernmost SLO site, from an initial 90% to approximately 20%. *Hesperophycus* cover at another SLO site (Cayucos) experienced an initial sharp decline, but appeared to level off after SP97, and even showed a slight increase during the F99/SP00 sampling period. Cover of the high intertidal turfweed, *Endocladia muricata*, increased during F99/SP00 from the previous year at 5 sites, and decreased at just two. At one of the sites where a decrease was observed (Boat House), *Endocladia* is slowly being replaced by the rockweed, *Pelvetia*. Mark Readdie, a graduate student in the Raimondi lab at UCSC, is investigating this replacement of *Endocladia* by *Pelvetia* and a brief summary of his work is included below. *Endocladia* cover was greater in spring than fall at all sites—a seasonal dynamic that holds true for nearly all previous samples. The red alga, *Mastocarpus papillatus*, showed an opposite seasonal trend at one SLO site, with higher cover in the fall than the spring. At both sites where *Mastocarpus* was sampled, a decreasing trend was observed, with cover for the F99/SP00 sampling period lower than all previous samples. Cover of *Mazzaella* spp., another red alga, appeared to be relatively stable over time, with no substantial change in the F99/SP00 sampling period. Surfgrass cover (*Phyllospadix* spp.) remained high over time at all sites except Stairs (NSB), where plots were decimated by the 1997/98 El Niño storms. However, a slow but steady recovery of surfgrass occurred at this site over the period following this destructive event, and cover is now at approximately 1/3 of its initial value.

Motile Invertebrates

Seastar numbers have fluctuated at most sites over time, and counts for the F99/SP00 samples did not appear to be abnormally high or low at any site. Numbers of the owl limpet, *Lottia gigantea*, were about the same in the F99/SP00 sample as in previous years for the 3 NSB and 2 SLO sites where they are sampled. Individuals measured in the plots were on average larger during this sampling period than those in the previous year at all sites except Government Pt. This trend can be attributed to growth of the limpets, combined with little or no new recruitment into the plots. Black abalone (*Haliotis cracherodii*), are at extremely low densities at all NSB sites, but further decline due to the fatal condition termed “withering syndrome” was not observed in the F99/SP00 sampling period. F99/SP00 abalone numbers at Pt. Sierra Nevada (SLO) were similar to those recorded for previous years, while those at Piedras Blancas (SLO) declined in SP00. This decline was due to a rock break-out in one of the plots at this site that destroyed approximately half of the suitable abalone habitat in the plot. A new abalone plot was set up at Piedras Blancas to adjust for this loss.

Related Work

The study by Mark Readdie mentioned above in the “Photoplot Algae” section, developed from the observation that at some sites, plots that were previously dominated by barnacles had turned into *Endocladia* dominated plots, and plots that initially contained high cover of *Endocladia* had become partially or wholly covered by *Pelvetia*. Further investigation suggested that the barnacle zone at these sites had shifted upward, into areas that were previously bare rock. It has long been assumed that the upper limits of species’ zones are set by physical factors such as temperature and exposure time, and are thus stable, while the lower limits are set by biological interactions (e.g. competition & predation). However, the upward shifts of species zones that have been documented at some of the monitored sites suggest that facilitation, a biological factor, is important for establishing species’ upper limits. In this case, barnacles are facilitating the upward movement of *Endocladia*, and *Endocladia* is providing suitable habitat for *Pelvetia*, above the zone where it was restricted to 8 years ago. In the upcoming sampling year, 1-time vertical transect surveys that were done in 1992 will be repeated at all sites monitored in order to determine whether changes in the upper limits of these species have occurred elsewhere.

Progress during 2000-2001

This report summarizes the accomplishments of the Inventory of Rocky Intertidal Resources for San Luis Obispo and Northern Santa Barbara Counties from July 2000 to July 2001. The purpose of the Shoreline Inventory Project is to provide baseline information on the rocky intertidal plants and animals along the central and southern California coast. Information on coastal biota in these areas would be essential in the event of an oil spill or other major impact. In addition, the monitoring studies yield important data on population dynamics on a local and regional scale which can be utilized for more effective resource management as well as provide fundamental ecological knowledge about the dynamics of the systems. The rocky intertidal surveys of five sites in Northern Santa Barbara County (NSB) represent a continuation of previous semi-annual monitoring conducted for the Minerals Management Service from 1992 to 2000. Five additional sites were established in 1995 for San Luis Obispo County (SLO). A sixth site at which only black abalone are monitored was recently added in SLO County. The combination of previous and current year surveys in the two counties has resulted in a total of 19 samples for NSB sites, and 12 samples for SLO sites (with the exception of the newly added sixth site).

The sampling protocol focuses on target species or assemblages. Permanent photoplots are established in assemblages such as barnacles, mussels, anemones, turfweed, and rockweed. Cover of the major taxa is determined by point-contact photographic analysis. Permanent plots are also established for large motile species such as owl limpets, black abalone, and seastars. Line transects are used to estimate the cover of surfgrass. Photographic overviews and field notes are used to describe general conditions at the site and to document the distribution and abundance of organisms not found within the photoplots. Newly added to this past year's protocol were counts and measurements of smaller mobile invertebrates that occur within the photoplots. Species counted include *Tegula funebralis*, *Acanthina* spp., *Nucella emarginata*, *N. canaliculata*, *Ocenebra circumtexta, Lepidochitona harwegii*, 3 species of *Pagurus*, and various limpets.

One drawback of this protocol is that observations made within our plots cannot be extended to the site as a whole (because they are fixed). To alleviate this problem, we have begun to do comprehensive surveys in conjunction with the normal monitoring. The comprehensive surveys are funded through separate awards, but are mentioned here because of their close ties to our established monitoring work. These surveys are done at each site on a less frequent basis (approximately every 3 years). They incorporate a permanent, 30m transect that runs parallel to shore above the organisms in the high zone. Eleven transects are laid out perpendicular to this "baseline" transect at each 3m mark, starting at 0. Transects are then sampled using a point intercept method in which the organism or substrate occurring directly under each point is recorded as well as the two closest species. Point spacing varies according to transect length. These surveys allow us to 1) monitor overall diversity at each site, 2) determine site-wide abundance for various species, 3) assess the vertical distribution of species within each site and 4) detect long-term temporal changes in diversity, abundance and distribution of species.

Table 1 summarizes the field activities of this past fall and spring for both counties. Data for all sites have been entered and analyzed for all work completed through spring 2001.

Table 1: Summary of Rocky Intertidal Field Activities for San Luis Obispo and Northern Santa Barbara Counties.

Dates	**County**	**Activity**
10/26-10/29	San Luis Obispo	Fall 2000 sample
11/11-11/14	Northern Santa Barbara	Fall 2000 sample
3/5-3/11, 3/19	San Luis Obispo and Northern Santa Barbara	Spring 2001 sample
3/20-3/24, 5/1	Northern Santa Barbara	Comprehensive surveys
4/2-4/5	San Luis Obispo	Comprehensive surveys
5/3	San Luis Obispo	Set up new black abalone site

A species by species summary of the results of the past year's monitoring follows. The summaries are broken into 3 sections: Photoplot Invertebrates, Photoplot Algae and Surfgrass, and Motile Invertebrates.

Photoplot Invertebrates

Anemones, (*Anthopleura elegantissima*), were sampled at only one NSB site, and showed similar percent cover as compared to previous years. There was an overall trend of decline for barnacle cover (*Chthamalus* spp. & *Balanus glandula*) at all sites. However, during the fall 2000/spring 2001 (F00/SP01) sampling period, a few sites (Government Pt., Occulto and Shell Beach) experienced slight increases. These were likely due to a large recruitment event that occurred in F00. In SP01 we began to sample the barnacle plots in the field in order to distinguish between *Chthamalus* and *Balanus*, since this is impossible to do using slides. Only three sites contained *Balanus*. Government Pt. and Hazards were nearly equally split in cover of *Chthamalus* and *Balanus*, while Cayucos was largely dominated by *Chthamalus*. The gooseneck barnacle, *Pollicipes polymerus*, has experienced almost no change in percent cover over time at the one NSB site where it is sampled. Mussel cover (*Mytilus californianus*) declined at five of the eight sites where they are sampled. Shell Beach experienced the most drastic decline (over 50%) during the F98/SP99 sampling period, but cover has since remained stable.

Photoplot Algae and Surfgrass

Cover of the rockweed, *Silvetia compressa* (formally *Pelvetia compressa*), exhibited a strong seasonal fluctuation (higher in the fall, lower in the spring), at nearly all sites. This alga also declined in cover at five of the seven sites where it is sampled. This decline was most pronounced at Stairs (an NSB site), where cover has gone from over 90% to less than 20%. Another species of rockweed, *Hesperophycus harveyanus*, has declined in cover at Pt. Sierra Nevada, the northernmost SLO site, from an initial 90% to less than 20%. *Hesperophycus* cover at another SLO site, Cayucos, experienced an initial sharp decline, but appeared to level off after SP97, and even showed a slight increase over the past two year sampling period. Cover of the high intertidal turfweed, *Endocladia muricata*, has fluctuated drastically over time (up to 40% higher in spring than in fall) but has changed little overall at all sites but Hazards (SLO). *Endocladia* at this site was much lower in cover over the past two year period than in previous years. *Endocladia* cover at Boat House appears to have recovered slightly from previous samples, where plots were nearly completely taken over by *Silvetia*. The red alga, *Mastocarpus papillatus*, showed an opposite seasonal trend at one SLO site, with higher cover in the fall than the spring. At both sites where *Mastocarpus* was sampled, a decreasing trend was observed which continued into the F00/SP01 sampling period. Cover of *Mazzaella* spp., another red alga, appeared to be relatively stable over time, with no substantial change in the F00/SP01 sampling period. Surfgrass cover (*Phyllospadix* spp.) remained high over time at all sites except Stairs (NSB), where plots were decimated by the 1997/98 El Niño storms. However, a slow but steady recovery of surfgrass occurred at this site over the period following this destructive event, and cover is now at nearly 1/2 of its initial value. All sites except Cayucos (SLO) experienced slight seasonal fluctuations, with higher cover in the fall than the spring. Surfgrass transects at Cayucos are located within permanent pools, so it makes sense that there would be no seasonal differences in cover at this site.

Motile Invertebrates

Seastar numbers have fluctuated at most sites over time, and counts for the F00/SP01 samples did not appear to be abnormally high or low at any site. Numbers of the owl limpet, *Lottia gigantea*, were about the same in the F00/SP01 sample as in previous years for the three NSB and two SLO sites where they are sampled. The fatal condition termed "withering syndrome" has caused drastic declines in black abalone (*Haliotis cracherodii*) populations as far north as Cayucos (SLO). Recovery of these decimated populations is unlikely as recruitment is thought to be very localized and the remaining individuals at these sites are probably too sparsely spaced to allow for successful spawning. A new abalone monitoring site was established at the Rancho Marino UC Reserve, which is located just north of Cayucos. Unfortunately, evidence of withering syndrome was already present at the site, and populations are expected to crash by F01. Abalone numbers at Piedras Blancas, just upcoast of Rancho Marino, were stable while those at the northernmost site (Pt. Sierra Nevada) actually increased slightly. This increase was attributed to recruitment of black abalone into our plots at this site.

New to this past year's sampling was the addition of small mobile invertebrate counts in our photoplots. Species targeted in these plots are listed above. *Nucella* were the most commonly found animal in mussel plots at all sites except Shell Beach, where mussels have experienced a substantial decline in cover. *Nucella* could also be found in other plot types in lower numbers. *Acanthina*, which are known to feed on barnacles, were found in barnacle plots, but were actually more common in *Silvetia* and *Endocladia* plots. *Lepidochitona* were most common under *Silvetia*, which is though to provide refuge from desiccation for these chitons, but like *Nucella* they could be found in other plot types in lesser abundance. *Ocenebra* were fairly rare, which made it difficult to draw any conclusions about habitat preference. Limpets were common in all plot types. Large numbers of very small limpets often dominated barnacle plots.

In conclusion, the long term monitoring of intertidal sites in NSB and SLO Counties (and other areas not mentioned in this report) has allowed us to document many aspects of intertidal community structure that had previously not been shown to exist on a large scale. These findings include: 1) Zone shifts, where a species "band" moves (generally up) or expands in tidal height and replaces another species "band" (e.g. *Silvetia* replacing *Endocladia*), 2) Differential community responses to disturbance (e.g. El Niño storm damage and recovery, community response to an oil spill), 3) Systematic spreading of a disease and the resulting changes in communities, 4) Short and long term variability in species abundance, and 5) Variability and to some extent the scale of recruitment events.

Progress during 2001-2002

This report summarizes the accomplishments of the Inventory of Rocky Intertidal Resources for San Luis Obispo and Northern Santa Barbara Counties from July 2001 to July 2002. The purpose of the Shoreline Inventory Project is to provide baseline information on the rocky intertidal plants and animals along the central and southern California coast. Information on coastal biota in these areas would be essential in the event of an oil spill or other major impact. In addition, the monitoring studies yield important data on population dynamics on a local and regional scale which can be utilized for more effective resource management as well as provide fundamental ecological knowledge about the dynamics of the systems. The rocky intertidal surveys of five sites in Northern Santa Barbara County (NSB) represent a continuation of previous semi-annual monitoring conducted for the Minerals Management Service from 1992 to 2001. Five additional sites were established in 1995 for San Luis Obispo County (SLO). A sixth site at which only black abalone and owl limpets are monitored was recently added in SLO County. The combination of previous and current year surveys in the two counties has resulted in a total of 21 samples for NSB sites, and 14 samples for SLO sites (with the exception of the newly added sixth site).

The sampling protocol focuses on target species or assemblages. Permanent photoplots are established in assemblages such as barnacles, mussels, anemones, turfweed, and rockweed. Cover of the major taxa is determined by point-contact photographic analysis for all plots except barnacles, which are scored in the field to allow samplers to distinguish *Chthamalus* spp. from *Balanus glandula*. Counts of mobile invertebrates occurring within the barnacle, mussel, *Endocladia, Mastocarpus, Silvetia*, and *Hesperophycus* photoplots are also done in the field. Additional permanent plots are established for large motile species such as owl limpets, black abalone, and seastars. Line transects are used to estimate the cover of surfgrass. Photographic overviews and field notes are used to describe general conditions at the site and to document the distribution and abundance of organisms not found within the photoplots.

One drawback of this protocol is that observations made within our plots cannot be extended to the site as a whole (because they are fixed). To alleviate this problem, we have begun to do comprehensive surveys in conjunction with the normal monitoring. The comprehensive surveys are funded through separate awards, but are mentioned here because of their close ties to our established monitoring work. These surveys are done at each site on a less frequent basis (approximately every 3 years). They incorporate a permanent, 30m transect that runs parallel to shore above the organisms in the high zone. Eleven transects are laid out perpendicular to this "baseline" transect at each 3m mark, starting at 0. Transects are then sampled using a point intercept method in which the organism or substrate occurring directly under each point is recorded as well as the two closest species. Point spacing varies according to transect length. These surveys allow us to: 1) monitor overall diversity at each site, 2) determine site-wide abundance for various species, 3) assess the vertical distribution of species within each site and 4) detect long-term temporal changes in diversity, abundance and distribution of species.

Table 1 summarizes the field activities of this past fall and spring for both counties. Data for all sites have been entered and analyzed for all work completed through spring 2002.

Table 1: Summary of Rocky Intertidal Field Activities for San Luis Obispo and Northern Santa Barbara Counties.

Dates	**County**	**Activity**
11/14-11/17	Northern Santa Barbara	Fall 2001 sample
11/29-12/2	San Luis Obispo	Fall 2001 sample
3/11-3/13	San Luis Obispo	Spring 2001 sample
3/23-3/28	San Luis Obispo and Northern Santa Barbara	Spring 2001 sample
3/24	San Luis Obispo	Set up new *Lottia* site at Rancho Marino UC Reserve

A species by species summary of the results of the past year's monitoring follows. The summaries are broken into 3 sections: Photoplot Invertebrates, Photoplot Algae and Surfgrass, and Motile Invertebrates.

Photoplot Invertebrates

Anemones, (*Anthopleura elegantissima*), were sampled at only one NSB site, and showed similar percent cover as compared to previous years. Barnacle cover (*Chthamalus* spp. & *Balanus glandula*) has been decreasing over time at five of the eight monitored sites, but experienced a slight recovery at three sites (Pt. Sierra Nevada, Cayucos and Boat House) during the past year. Cover at two sites (Occulto and Stairs) remained extremely low. At Occulto the barnacle zone has shifted up in tidal height, and "barnacle" plots are now dominated by algae and mussels. Barnacles at Stairs have been steadily declining over time due to a lack of recruitment of new individuals into the site. In SP01 we began to sample the barnacle plots in the field in order to distinguish between *Chthamalus* and *Balanus*, since this is impossible to do using slides. Only three sites were found to contain *Balanus*. Government Pt. and Hazards were nearly equally split in cover of *Chthamalus* and *Balanus*, while Cayucos was largely dominated by *Chthamalus*. The gooseneck barnacle, *Pollicipes polymerus*, has experienced almost no change in percent cover over time at the one NSB site where it is sampled. Mussel cover (*Mytilus californianus*) declined at five of the eight sites where they are sampled. Shell Beach experienced the most drastic decline (over 50%) during the F98/SP99 sampling period, but cover has since remained stable.

Photoplot Algae and Surfgrass

Cover of the rockweed, *Silvetia compressa* (formally *Pelvetia compressa*), typically exhibits a strong seasonal fluctuation (higher in the fall, lower in the spring), at nearly all sites. However, this pattern did not hold for the 2001-2002 sampling period for SLO sites. *Silvetia* cover did not change much between the F01 and SP02 sampling periods at these sites. *Silvetia* declined in cover at five of the seven sites where it is sampled. This decline was most pronounced at Stairs (an NSB site), where cover has gone from over 90% to less than 20%. Another species of rockweed, *Hesperophycus harveyanus*, has declined in cover at Pt. Sierra Nevada, the northernmost SLO site, from an initial 90% to less than 20%. *Hesperophycus* cover at another SLO site, Cayucos, experienced an initial sharp decline, but appeared to level off after SP97, and even showed a slight increase over the past three year sampling period. Cover of the high intertidal turfweed, *Endocladia muricata*, has fluctuated seasonally over time (up to 40% higher in spring than in fall) but has also declined over time at four of the seven sites where it is sampled. *Endocladia* in plots at two of these sites has been gradually replaced by other species (*Silvetia* at Boat House and mussels at Occulto). The red alga, *Mastocarpus papillatus*, was higher in cover in the fall than the spring at one SLO site. A decreasing trend was observed over time at both sites where *Mastocarpus* was sampled. Cover of *Mazzaella* spp., another red alga, appeared to be relatively stable over time, with no substantial change in the F01/SP02 sampling period. Surfgrass cover (*Phyllospadix* spp.) remained high over time at all sites except Stairs (NSB), where plots were decimated by the 1997/98 El Niño storms. However, a slow but steady recovery of surfgrass occurred at this site over the period following this destructive event, and cover is now at nearly 1/2 of its initial value. All sites except Cayucos (SLO) experienced slight seasonal fluctuations, with higher cover in the fall than the spring.

Surfgrass transects at Cayucos are located within permanent pools, so it makes sense that there would be no seasonal differences in cover at this site. Surfgrass transects were established at Hazards in F01, but could not be re-sampled in SP02 because they remained underwater at low tide.

Motile Invertebrates

Seastar numbers have fluctuated at most sites over time, and counts for the F01/SP02 samples did not appear to be abnormally high or low at any site. Numbers of the owl limpet, *Lottia gigantea*, were stable at all sites except Cayucos, where a sharp decline that began in SP00 continued into the F01/SP02 sampling period. The mean size of *Lottia* remained fairly constant at all sites except Hazards, where animals were found to be larger on average than in previous years. The fatal condition termed "withering syndrome" has caused drastic declines in black abalone (*Haliotis cracherodii*) populations as far north as Cayucos (SLO). Recovery of these decimated populations is unlikely as recruitment is thought to be very localized and the remaining individuals at these sites are probably too sparsely distributed to allow for successful spawning. Although evidence of withering syndrome was seen at Rancho Marino (the SLO site just north of Cayucos) in SP00, numbers have not declined as rapidly as expected. Abalone numbers at Piedras Blancas, just upcoast of Rancho Marino, were stable while those at the northernmost site (Pt. Sierra Nevada) continued to increase slightly. This increase was attributed to recruitment of black abalone into our plots prior to the F00 sample.

A somewhat recent addition to the sampling protocol are counts of the small mobile invertebrates that occur within our photoplots. Species targeted in these plots include *Tegula funebralis*, *Acanthina* spp., *Nucella emarginata*, *N. canaliculata*, *Ocenebra circumtexta, Lepidochitona harwegii*, 3 species of *Pagurus*, and various limpets. *Tegula* was the most abundant mobile invertebrate found in the photoplots, particularly at the SLO sites, where it was found in all plot types. *Nucella* were the most commonly found animal in mussel plots at all sites except Shell Beach and Cayucos. *Nucella* could also be found in other plot types in lower numbers. *Acanthina*, which are known to feed on barnacles, were found in barnacle plots, but were actually most common in *Silvetia* plots. *Lepidochitona* were also most common under *Silvetia*, which is though to provide refuge from desiccation for these chitons, but like *Nucella* they could be found in other plot types in lesser abundance. *Ocenebra* were rare or absent from most sites except in the mussel plots at Shell Beach, and the *Pelvetia* plots at Cayucos. Limpets were common in all plot types.

In conclusion, the long term monitoring of intertidal sites in NSB and SLO Counties (and other areas not mentioned in this report) has allowed us to document many aspects of intertidal community structure that had previously not been shown to exist on a large scale. These findings include: 1) Zone shifts, where a species "band" moves (generally up) or expands in tidal height and replaces another species "band" (e.g. *Silvetia* replacing *Endocladia*), 2) Differential community responses to disturbance (e.g. El Niño storm damage and recovery, community response to an oil spill), 3) Systematic spreading of a disease and the resulting changes in communities, 4) Short and long term variability in species abundance, and 5) Variability and to some extent the scale of recruitment events.

Task No. 17605: *Population Dynamics and Biology of the California Sea Otter at the Southern End of its Range*

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Summary of Research

Progress during 2000-2001

After receiving funds and acquiring all required permits, research activity began with captures of study animals in mid March 2001. Table 1 summarizes the results of capture activities. In the northern study area (Piedras Blancas) capture operations began 24 March and ended 12 April. The target number of 15 animals – 13 females and 2 males – were captured and instrumented with VHF transmitters (8 were equipped with Time Depth Recorders). An additional 3 animals were captured and tagged, but were not instrumented with radios: two of these were dependant pups and one was a palpably pregnant female. In the southern study area (Pt. Conception) capture operations began 8 May and ended 10 May. Of the targeted 15 animals, 14 (all males) were captured for instrumentation (8 were equipped with Time Depth Recorders): the 15th male was tagged only but not instrumented because one of the radio transmitters was damaged during transport. The damaged radio will be repaired and added to next years target number of instrumented study animals. There were no injuries or mishaps during capture activities, and after surgery all study animals were released successfully and in good condition to their site of capture. All blood and tissue samples collected during captures have undergone initial processing and have been sent to university and/or state laboratories for analysis, or are stored at the Fish and Game center in Santa Cruz for later analysis.

Monitoring of study animals by radio telemetry is ongoing by fieldworkers based at Piedras Blancas field station, San Simeon CA. Fieldwork is conducted by shore-based observers in most areas, and by boat-based observers in those areas (such as Point Conception) where shore-based access is limited or where sea otters occur far offshore. Data collection on movement patterns, activity budgets and foraging behavior/diet is progressing well, and all data are entered immediately into the wild sea otter database (WSOD). As of 25 June, a total of 423 re-sightings of study animals had been recorded and added to the database (Table 1). Resight data include precise location (measured using triangulation or visuals sightings with GPS and laser rangefinders) and information on behavior and reproductive status. Activity budgets are measured by 24-hour focal animal monitoring and result in continuous data on movement, activity, temperature and foraging behavior for a focal animal: 24-hour sessions have been recorded for 4 animals, comprising 576 activity records. Foraging observations have been recorded for 39 separate foraging bouts; these data consist of information from 1,453 forage dives (dive time, surface time, success of dive, location of dive) and 716 records on prey type, size and number of items. Data on fine-scale movements are also collected during forage bouts, and will allow detailed analysis of habitat use patterns (Figure 1).

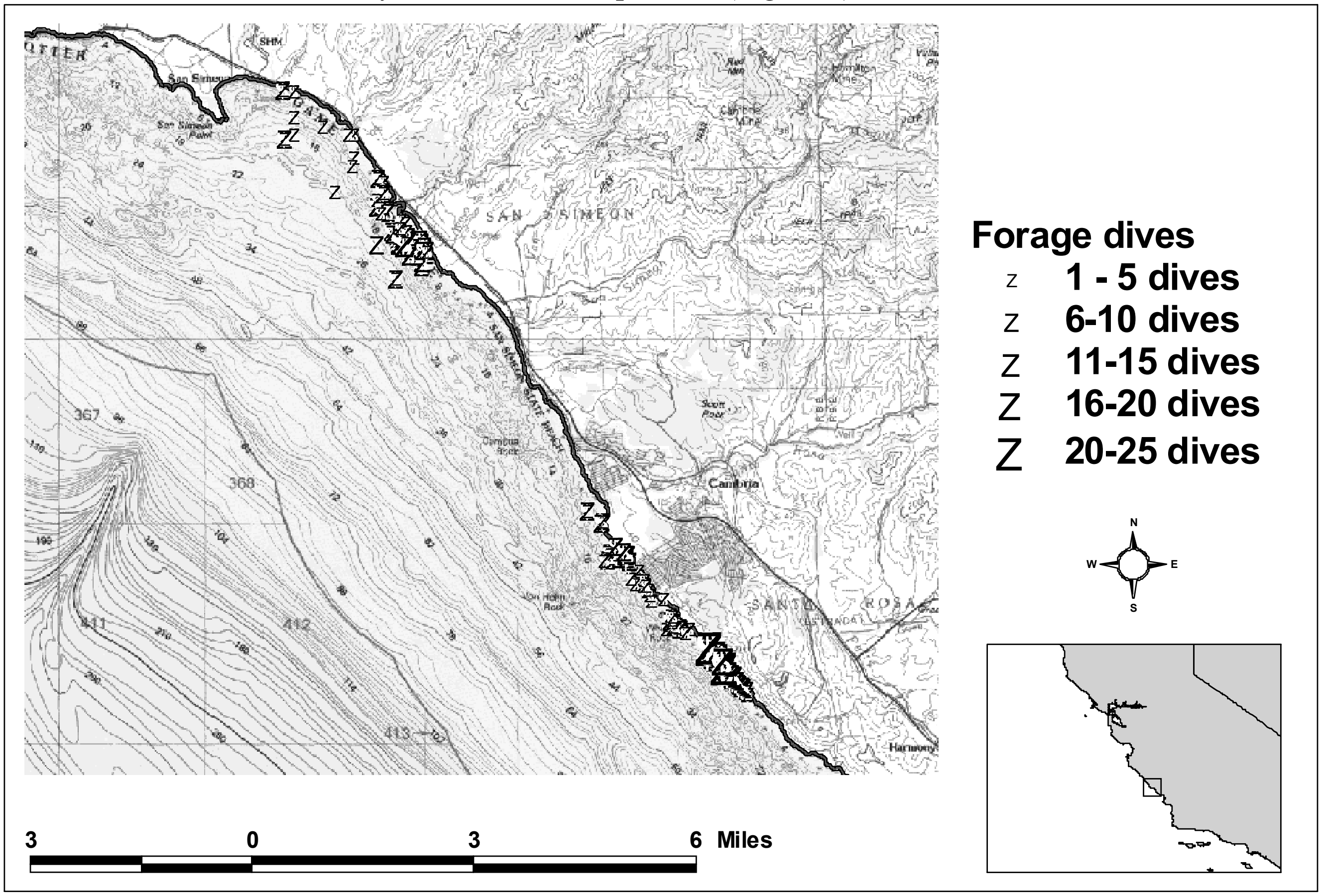


Figure 1. Map of forage data collected between San Simeon Point and Rancho Marina Reserve between April and June 2001. Locations of recorded forage dives are indicated by triangular symbols, scaled to the number of dives at a particular coordinate.

The spring 2001 range-wide sea otter survey occurred May 14 - 28. The total count of 2,161 sea otters reflects a decrease of 6.7 percent since the 2000 spring survey of 2,317 individuals. Observers recorded 1,863 independents (adults and sub adults), down 9.3 percent from last year's count of 2,053 independents. The pup count, however, increased by 12.9 percent to 298 individuals. Overall, the survey results indicate that the population decline that began in 1995 may be leveling off and that population numbers may be stabilizing: however, population status remains uncertain because results from any one year are subject to considerable variability, and it is only the longer time series (three-year averages) that can be used to assess population trends.

Beach walks for sea otter carcasses are ongoing: all collected carcasses undergo preliminary field examination and necropsy, and then are transported to the Marine Wildlife Veterinary and Research Center in Santa Cruz (CDFG) for detailed necropsy and pathology analysis. To-date, two study animals have died: one was a recently weaned pup and one an aged adult: pathology reports indicate "natural causes" in both cases (parasite induced peritonitis, and emaciation with possible heart infection, respectively), with no indication of premature death caused by capture activities.

Table 1. Summary of Capture information and current monitoring status (as of 06/25/01) for all study animals

Date Tagged	Capture Location	VHF Freq.	Universal Otter #	Sex	Last Seen	# Resights	Status
24-Mar-01	Rancho Marina (Cambria)	166.008	N-1066-01-S	female	23-Jun-01	47	Regularly sighted
24-Mar-01	Rancho Marina (Cambria)	166.089	N-1067-01-S	female	24-Jun-01	36	Regularly sighted
24-Mar-01	Rancho Marina (Cambria)	166.030	N-1068-01-S	female	23-Jun-01	19	Regularly sighted
24-Mar-01	Rancho Marina (Cambria)	166.041	N-1069-01-S	female	24-Jun-01	22	Regularly sighted
24-Mar-01	San Simeon	166.055	N-1070-01-S	female	24-Jun-01	33	Regularly sighted
24-Mar-01	Rancho Marina (Cambria)	(no radio)	N-1081-01-S	female	05-Jun-01	2	Occaisionally sighted
24-Mar-01	Rancho Marina (Cambria)	(no radio)	N-1082-01-S	female	24-Mar-01	1	Rarely sighted
24-Mar-01	Rancho Marina (Cambria)	(no radio)	N-1083-01-S	male	24-Mar-01	1	**Dead (natural mortality)**
25-Mar-01	San Simeon	166.067	N-1071-01-S	female	24-Jun-01	35	Regularly sighted
25-Mar-01	San Simeon	166.107	N-1073-01-S	female	04-Apr-01	4	Currently unable to locate
25-Mar-01	Rancho Marina (Cambria)	166.116	N-1074-01-S	female	25-Jun-01	31	Regularly sighted
25-Mar-01	San Simeon	166.132	N-1075-01-S	female	24-May-01	21	**Dead (natural mortality)**
25-Mar-01	Rancho Marina (Cambria)	166.193	N-1079-01-S	male	22-Jun-01	12	Regularly sighted
11-Apr-01	San Simeon	166.015	N-1072-01-S	female	24-Jun-01	31	Regularly sighted
12-Apr-01	San Simeon	166.142	N-1076-01-S	female	24-Jun-01	35	Regularly sighted
12-Apr-01	San Simeon	166.157	N-1077-01-S	female	23-Jun-01	37	Regularly sighted
12-Apr-01	Rancho Marina (Cambria)	166.183	N-1078-01-S	male	24-May-01	5	Occaisionally sighted
12-Apr-01	Rancho Marina (Cambria)	166.208	N-1080-01-S	female	24-Jun-01	22	Regularly sighted
08-May-01	Coho cove	166.171	N-1084-01-S	male	31-May-01	3	Occaisionally sighted Cojo Cove
08-May-01	Coho cove	166.216	N-1085-01-S	male	14-Jun-01	4	Occaisionally sighted Cojo Cove
08-May-01	Coho cove	166.226	N-1086-01-S	male	14-Jun-01	5	Occaisionally sighted Cojo Cove
08-May-01	Coho cove	166.242	N-1087-01-S	male	22-Jun-01	4	Moved north to Pt. Estero
08-May-01	Coho cove	166.259	N-1088-01-S	male	22-Jun-01	6	Regularly sighted Cojo Cove
08-May-01	Coho cove	(no radio)	N-1089-01-S	male	08-May-01	1	Rarely sighted Cojo Cove
08-May-01	Coho cove	166.283	N-1090-01-S	male	22-Jun-01	5	Occaisionally sighted Cojo Cove
09-May-01	Coho cove	166.298	N-1091-01-S	male	09-May-01	1	Rarely sighted Cojo Cove
09-May-01	Coho cove	166.309	N-1092-01-S	male	14-Jun-01	5	Occaisionally sighted Cojo Cove
09-May-01	Coho cove	166.316	N-1093-01-S	male	22-Jun-01	3	Moved north to Morro Bay
09-May-01	Coho cove	166.332	N-1094-01-S	male	22-Jun-01	6	Occaisionally sighted Cojo Cove
09-May-01	Coho cove	166.268	N-1099-01-S	male	31-May-01	3	Occaisionally sighted Cojo Cove
10-May-01	Coho cove	166.382	N-1095-01-S	male	22-Jun-01	6	Regularly sighted Cojo Cove
10-May-01	Coho cove	166.356	N-1096-01-S	male	22-Jun-01	6	Regularly sighted Cojo Cove
10-May-01	Coho cove	166.371	N-1097-01-S	male	22-Jun-01	4	Occaisionally sighted Cojo Cove

Progress during 2001-2002

Progress on the project continues as projected in the study proposal: Table 1 summarizes the results of capture activities for both years of the study. In the northern study area (San Simeon) capture operations in March, 2002 resulted in the addition of 18 new animals and the recapture of 4 previously implanted animals. In the southern study area (Pt. Conception) capture operations in April 2002 resulted in 11 new study animals. There were no injuries or mishaps during capture activities, and after surgery all study animals were released successfully and in good condition to their site of capture. Of the 16 study animals implanted with TDRs in 2001, 11 still need to be recaptured: further recapture efforts are anticipated over the next 4 months. Analysis of initially retrieved TDR instruments revealed a problem with the instrument performance, whereby some of the instruments ceased collecting data prematurely. This issue was investigated by the manufacturing company, and it was determined that the failures were due to a design flaw in the instruments. To compensate for lost data, the manufacturer has agreed to provide free replacement instruments of a newer model (in which the design problem has been remedied): 15 of these new instruments will be implanted over the next fiscal year of the project, more than compensating for data lost due to premature failures of the original batch of instruments.

Monitoring of study animals by radio telemetry is ongoing by fieldworkers based at Piedras Blancas field station, San Simeon CA. Data collection on movement patterns, activity budgets and foraging behavior/diet is progressing well, and all data are entered immediately into the wild sea otter database (WSOD). At this time the database includes 4,172 re-sightings of study animals (recording location, reproductive status, etc.); 3,158 records for activity budgets (behavior, location, body temperature); and 13,748 observational records of feeding dives (dive success, prey type, dive location). Of the 59 study animals captured to-date, 4 are confirmed dead, 2 are missing and presumed to be dead, and the remainder are accounted for and frequently observed (Table 1). Necropsies have been conducted of the 4 retrieved carcasses: 2 were aged females with "natural cause of death", 1 was an adult male killed by boat strike, and the 4th was an adult male where the cause of death was unconfirmed due to advanced decomposition (the probable cause of death was Domoic Acid toxicity).

Perhaps the most remarkable finding of the study so far relates to the movement patterns of animals from the Pt. Conception area: the majority of males captured here have made northerly movements of 100 km or more, with some traveling as far north as Monterey and Moss Landing (requiring swim distances of up to 400 km; Figure 1).

Table 1. Summary of capture date and current status (as of 05/31/02) of study animals. Dead animals indicated with bold; italics indicate non-radioed animals.

Capture Date	Otterno	Sex	Last Date Obs.	Status	Resightings
2001 Captures, San Simeon Study Area					
24-Mar-01	N-1066-01-S	f	27-May-02	Recently observed, San Simeon	365
24-Mar-01	N-1067-01-S	f	28-May-02	Recently observed, San Simeon	336
24-Mar-01	N-1068-01-S	f	28-May-02	Recently observed, San Simeon	233
24-Mar-01	N-1069-01-S	f	28-May-02	Recently observed, San Simeon	286
24-Mar-01	N-1070-01-S	f	29-May-02	Recently observed, San Simeon	268
25-Mar-01	N-1071-01-S	f	27-May-02	Recently observed, San Simeon	329
11-Apr-01	N-1072-01-S	f	27-May-02	Recently observed, San Simeon	326
25-Mar-01	N-1073-01-S	f	04-Apr-01	**Missing, presumed dead**	3
25-Mar-01	N-1074-01-S	f	11-Nov-01	**Dead, necropsy performed**	157
25-Mar-01	N-1075-01-S	f	24-May-01	**Dead, necropsy performed**	20
12-Apr-01	N-1076-01-S	f	11-Jul-01	**Missing, presumed dead**	46
12-Apr-01	N-1077-01-S	f	27-May-02	Recently observed, San Simeon	352
12-Apr-01	N-1078-01-S	m	24-May-02	Recently observed, Morro Bay	183
25-Mar-01	N-1079-01-S	m	02-Jul-01	**Dead, necropsy performed**	14
12-Apr-01	N-1080-01-S	f	27-May-02	Recently observed, San Simeon	176
24-Mar-01	*N-1081-01-S*	*f*	*11-May-02*	*Recently observed, San Simeon*	*24*
2001 Captures, Pt. Conception Study Area					
08-May-01	N-1084-01-S	m	24-May-02	Recently observed, Fossil Pt.	33
08-May-01	N-1085-01-S	m	28-May-02	Recently observed, Ragged Pt.	33
08-May-01	N-1086-01-S	m	24-May-02	Recently observed, Pt. Conception	13
08-May-01	N-1087-01-S	m	24-May-02	Recently observed, Pt. Estero	20
08-May-01	N-1088-01-S	m	27-May-02	Recently observed, San Simeon	119
08-May-01	N-1090-01-S	m	24-May-02	Recently observed, Pt. Conception	24
09-May-01	N-1091-01-S	m	24-May-02	Recently observed, Mcway slide	19
09-May-01	N-1092-01-S	m	24-May-02	Recently observed, Purissima Pt.	17
09-May-01	N-1093-01-S	m	24-May-02	Recently observed, Oceano	23
09-May-01	N-1094-01-S	m	24-May-02	Recently observed, Pt. Conception	20
10-May-01	N-1095-01-S	m	24-May-02	Recently observed, Pismo pier	33
10-May-01	N-1096-01-S	m	24-May-02	Recently observed, Pt. Conception	26
10-May-01	N-1097-01-S	m	24-May-02	Recently observed, Pt. Conception	16
09-May-01	N-1099-01-S	m	24-May-02	Recently observed, Moss Landing	12
2002 Captures, San Simeon Study Area					
20-Mar-02	*N-1113-02-S*	*f*	*22-Apr-02*	*Recently observed, San Simeon*	*2*
20-Mar-02	N-1114-02-S	f	27-May-02	Recently observed, San Simeon	62
20-Mar-02	N-1115-02-S	f	28-May-02	Recently observed, San Simeon	46
21-Mar-02	N-1116-02-S	f	27-May-02	Recently observed, San Simeon	64
20-Mar-02	N-1117-02-S	f	29-May-02	Recently observed, San Simeon	55
21-Mar-02	N-1118-02-S	m	24-May-02	Recently observed, San Simeon	21
22-Mar-02	N-1119-02-S	m	24-May-02	Recently observed, Morro Bay	7
21-Mar-02	N-1120-02-S	f	27-May-02	Recently observed, San Simeon	53
22-Mar-02	N-1121-02-S	f	27-May-02	Recently observed, San Simeon	46
22-Mar-02	N-1122-02-S	f	27-May-02	Recently observed, San Simeon	62
22-Mar-02	N-1123-02-S	f	31-May-02	Recently observed, San Simeon	51
25-Mar-02	N-1124-02-S	m	25-Apr-02	**Dead, necropsy performed**	15
22-Mar-02	N-1125-02-S	m	24-May-02	Recently observed, Pt. Conception	2
22-Mar-02	N-1126-02-S	f	22-May-02	Recently observed, San Simeon	23
25-Mar-02	N-1127-02-S	f	29-May-02	Recently observed, San Simeon	53
25-Mar-02	N-1130-02-S	f	27-May-02	Recently observed, San Simeon	58
21-Mar-02	N-1132-02-S	m	24-May-02	Recently observed, Pt Buchon	5
25-Mar-02	*N-1134-02-S*	*m*	*31-Mar-02*	*Recently observed, San Simeon*	*2*
2002 Captures, Pt. Conception Study Area					
22-Apr-02	N-1133-02-S	m	24-May-02	Recently observed, Pt. Conception	1
22-Apr-02	N-1136-02-S	m	24-May-02	Recently observed, Pt. Conception	2
22-Apr-02	N-1137-02-S	m	24-May-02	Recently observed, Pt. Conception	2
24-Apr-02	N-1138-02-S	m	24-May-02	Recently observed, Gaviota pier	1
24-Apr-02	N-1139-02-S	m	24-May-02	Recently observed, Pfieffer Pt.	2
24-Apr-02	N-1140-02-S	m	24-May-02	Recently observed, Pt. Conception	2
24-Apr-02	N-1141-02-S	m	24-May-02	Recently observed, Pt. Conception	2
25-Apr-02	N-1142-02-S	m	24-May-02	Recently observed, Pt. Conception	1
25-Apr-02	N-1145-02-S	m	24-May-02	Recently observed, Pt. Conception	1
22-Apr-02	N-1147-02-S	m	24-May-02	Recently observed, Pt. Conception	2
22-Apr-02	N-1149-02-S	f	24-May-02	Recently observed, Pt. Conception	2

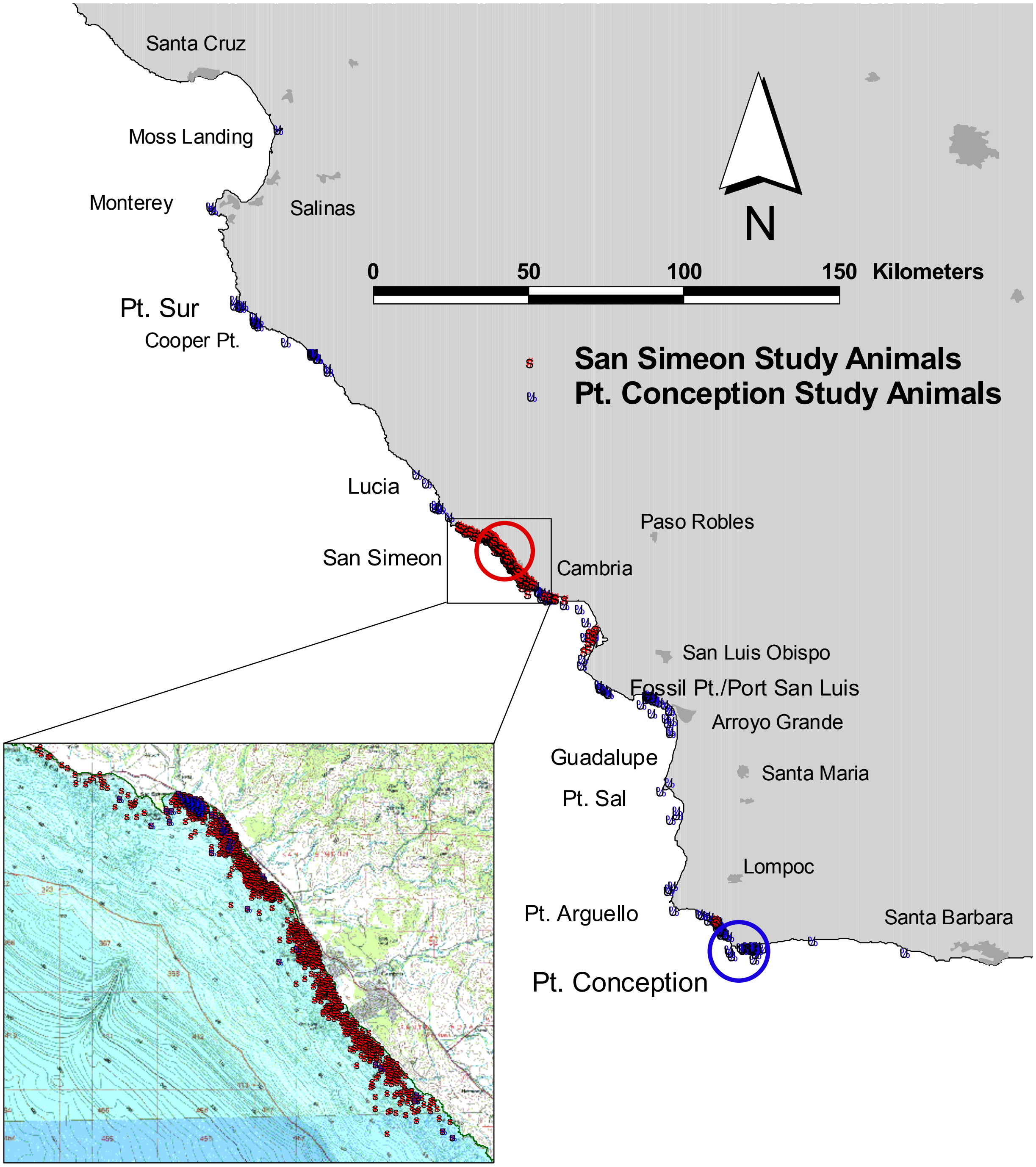


Figure 1. Map of Central California showing initial capture locations (large open circles) and subsequent re-sight locations (small filled circles and squares) of animals from the San Simeon study site (colored red) and the Pt. Conception study site (colored blue). Insert map shows a blow-up of the intensive study area at San Simeon.

Task No. 17606: *Population Genetics of surfgrass (Phyllospadix torreyi) for use in restoration*

Principal Investigators: Scott Hodges, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106-9610; **Douglas Bush,** Marine Science Institute, University of California, Santa Barbara, CA 93106-6150; **Sally J. Holbrook**, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106-9610 and **Daniel C. Reed,** Marine Science Institute, University of California, Santa Barbara, CA 93106-6150

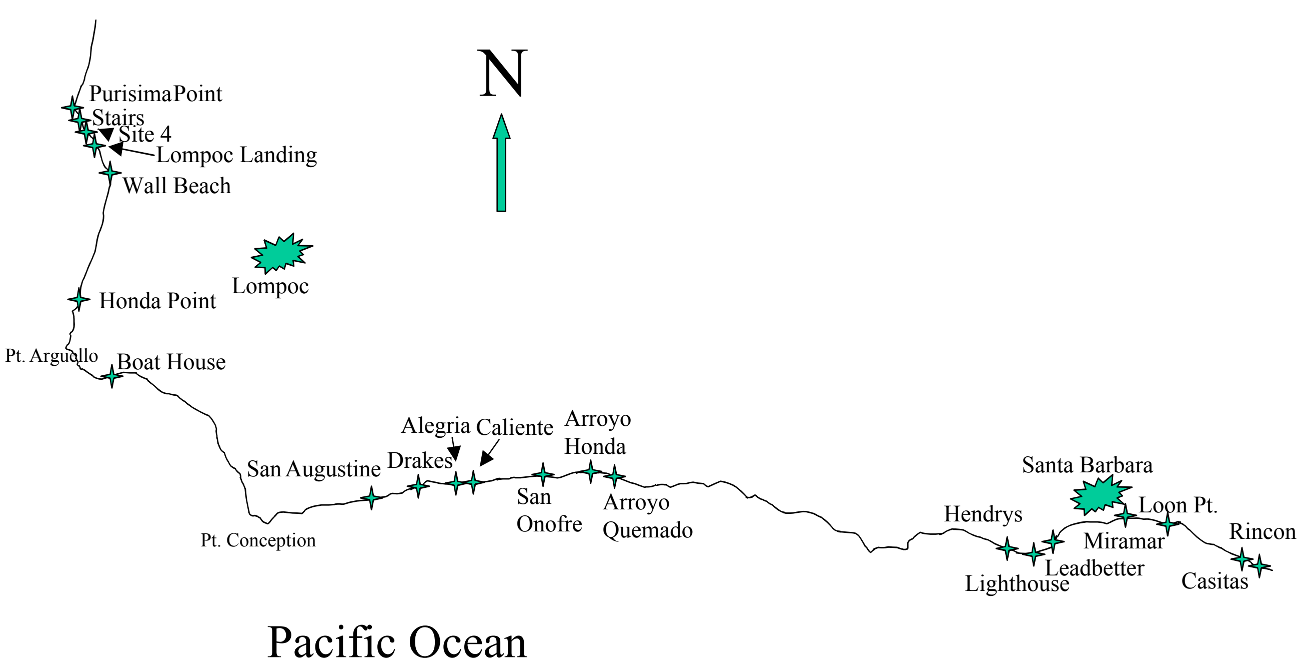
Summary of Research

The overall objective of our study is to characterize genetic factors that may affect the success of restoring surfgrass populations in Santa Barbara County. Our proposed work focuses on two major factors. The first is the spatial boundaries of genetically differentiated populations and the second is the spatial distribution of male and female plants within interbreeding populations. This information will enhance restoration efforts that aim to maintain current levels of genetic diversity. It will be valuable not only in practical aspects of restoration practice, such as the choice of material for restoration, but it will also greatly increase our understanding of processes by which surfgrass stands are maintained and restored in nature.

Our study has three specific objectives:

1. To identify the boundaries of genetically differentiated surfgrass populations.
2. To determine if there is genetic differentiation within populations with respect to clone size and depth.
3. To develop genetic markers linked to gender and characterize the spatial distribution of male and female plants within surfgrass populations.

SurfgrassSampling Sites



Progress during 2000-2001

During the first 8 months of our project we have done all of the field work and some of the laboratory analysis for the first specific objective.

In our proposal we identified 3 distinct regions of the Santa Barbara Coastline from which we would sample: 1) Purisima Point to Point Arguello, 2) San Augustine to Trajiguas, and 3) Arroyo Burro to Rincon. An important accomplishment of this initial phase of our study has been to choose the specific sites at which we would do our sampling and analysis. Our preliminary data showed that genetic differentiation could occur over distances less than 100 km. Thus, we chose 21 sampling sites that separate the three major regions from each other by 30 to 40 km but cluster together within each region. This sampling strategy will provide essential information about the extent of genetic differentiation over short distances and will allow us to define population boundaries. At the same time, this sampling will provide important information on the extent of genetic differentiation over the entire coastline of Santa Barbara County: a total distance of appoximately160 km.

Table 1: Location of sampling sites listed from north to south.

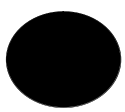
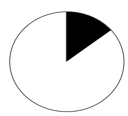
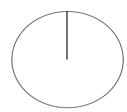
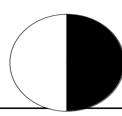
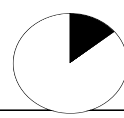
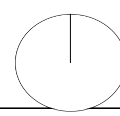
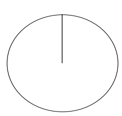
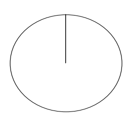
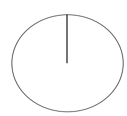
Region **Site**	**Distance from Purisima Point (Km)**
Purisima Point to Pt. Arguello	
Purisima point	0
Site 4	1
Stairs	2
Lompoc Landing	4
Wall Beach	6
Honda Point	18
Boat House	28
San Augustine to Trajiguas	
San Augustine	61
Drakes	66
Alegria	70
Caliente	72
San Onofre	79
Arroyo Honda	84
Arroyo Quemado	86
Arroyo Burro to Rincon	
Hendry's	130
Lighthouse	132
Leadbetter	135
Miramar	143
Loon Pt.	148
Casitas	158
Rincon	159

We collected 10 pairs of surfgrass samples from the intertidal region at these 21 sites in Santa Barbara County (for a total of 425 samples). Samples were taken in pairs at each of the sites. Members of each pair were separated by 10 cm. This sampling strategy was used to provide information on the second specific objective of our proposal, the spatial extent of clonal growth. Our preliminary data showed clones extend over relatively short distances in the intertidal, generally less than a few meters. Sampling over distances a short as 10 cm will allow us to precisely determine the lower limits of clone size. To fully address the question of clone size, however, additional sampling along transects will be undertaken in the coming year.

In the laboratory, we have isolated DNA from all of the samples that we have collected. The yields of DNA have been relatively high (the average is 23 ng/µl for 560 samples). These yields are well in excess of what we need to construct AFLP fingerprints. We have also checked that the DNA is of sufficiently high quality for our purposes. 95% of the DNAs we have tested (approximately 120 samples) have yield good AFLP fingerprints.

The work described in our proposal consists of three distinct phases: Field work (sample collection), Laboratory work (DNA isolation and AFLP-fingerprint construction), and Data Analysis (band scoring and statistical analysis). In order to track our progress on each of our specific goals we have diagramed the fraction of work completed as the dark portion of the circles in Table 2. For example, we have completed all of the field work to determine population boundaries and half of the field work for our studies on genetic variation with depth and clone size.

Table 2: Fraction of work completed

Specific Goal	Field Work	Laboratory Work	Data Analysis
1. Population Boundaries			
2. Variation with Depth and Clone Size			
3. Gender markers			

Progress during 2001-2002

In the last year we have made significant progress on all three of these objectives, and this progress is summarized in detail below. Briefly, however, preliminary analyses of our new data show clear evidence for genetic differentiation of surfgrass populations between the three regions of our study area. These analyses also indicate that there is genetic differentiation within single populations between individuals growing at shallow depths (intertidal) and those growing in deeper water (subtidal). Finally, we believe we have identified a number of genetic markers that allow us to identify male plants. Although we are still characterizing these markers, they indicate that males are much less common than females and males grow in both the intertidal and subtidal regions. These data will impact restoration efforts insofar as they indicate that plants or seedlings used in restoration should come from local populations, and should be genetically highly diverse. Finally, they indicate that since males are rare, but found throughout surfgrass beds, special efforts should be made to identify male plants in the material used for restoration to insure that males are planted both in the intertidal and subtidal.

Progress and findings for Goal 1: To identify the boundaries of genetically differentiated surfgrass populations.

During the last year, we completed DNA-fingerprinting using AFLPs on 603 individual surfgrass samples collected from 21 sites along the Santa Barbara coast from Purisima Point to Rincon. The precise location of these sample sites are documented in our first annual report. Briefly, however, the sample sites cluster into 3 regions that are separated by approximately 40 km. The first, northernmost, region extends from Purisima Point to Point Arguello, the second extends from San Augustine to Trajiguas, and the third extends from Arroyo Burro to Rincon. Within each of these regions, population samples were collected at 7 separate sites. This sampling strategy allows us to quantify genetic variation over a large range of spatial scale from a few meters (within individual populations) to more than 100 km (between regions).

DNA-fingerprinting with AFLPs has generated approximately 400 genetic markers for each individual (the precise number is not known because we have not finished the analysis of all of the DNA-fingerprints). A preliminary analysis of 120 of these markers indicates that 68% of the genetic variation found in surfgrass occurs within individual populations (see column "Overall" of Table 1 on the following page). This reflects a high degree of genetic diversity within individual populations. Nevertheless, a relatively large fraction of the genetic variation occurs between populations (20%, Table1) and among the regions (12%, Table1). These data indicate that genetic differentiation does occur over short distances that separate individual populations.

Progress and findings for Goal 2: To determine if there is genetic differentiation within populations with respect to clone size and depth.

During the last year, we collected surfgrass samples growing at subtidal depths in order to determine if genetic differentiation occurred across the depth gradient within individual populations. For this purpose, we sampled 10 individuals at each of 9 sites from which we had previously collected in the intertidal. The individual sites were as follows:

- Region 1 (Purisima Point to Point Arguello): Site 4, Lompoc Landing, and Boat House.
- Region 2 (San Augustine to Trajiguas): Caliente, Arroyo Quemado, and San Onofre.
- Region 3 (Arroyo Burro to Rincon): Hendry's, Leadbetter, and Miramar.

DNA-fingerprints have been constructed for all of the subtidal samples and preliminary analysis of this data shows that 15% of the genetic variation within populations can be attributed to differences in depth (Table 1, Depth). This reflects a high degree of partitioning of variation within populations and could reflect specialization to different habitats within populations

Table 1. Analysis of molecular variance (AMOVA) for *Phyllospadix torreyi* (surfgrass) along the Santa Barbara coast of California. Analysis were performed using 120 variable genetic markers. Overall genetic variation (Overall) was analyzed for 603 individuals representing 21 separate populations that cluster in three regions. Genetic variation due to intertidal or subtidal location (Depth) was analyzed for 9 populations where samples were collected in both the intertidal and subtidal.

Genetic Variation in Surfgrass (%)			
Overall		Depth	
Among Regions	12	Among Populations	20
Among Populations within Regions	20	Intertidal/ Subtidal within Populations	15
Within Populations	68	Within Populations	64

In order to determine if clone size differed with depth, we also collected samples from the subtidal and intertidal along transects at each of two sites. These sites, Alegria (in Region 2) and at Shorline (in Region 3), were chosen to represent sites with high wave-action (Alegria) and those that are relatively calm (Shoreline). In both the intertidal and the subtidal samples were collected along 5 transects at intervals of 0, 0.2, 1, 2, 4 and 10 m for a total of 25 samples in the subtidal and 25 samples in the intertidal at each of the two sites. DNA-fingerprints have been constructed for all these new samples and they are now ready to be analyzed to determine clone size.

Progress and findings for Goal 3. To develop genetic markers linked to gender and characterize the spatial distribution of male and female plants within surfgrass populations.

Because the sexes are separate in surfgrass (plants produce either male or female flowers) it is important for restoration efforts to determine the frequency and spatial distribution of the sexes in natural populations. Currently, male and female plants can only be distinguished by their flowers. In order to develop a more robust assay for gender, we have looked for AFLP-markers that are correlated with gender. In our proposal, we identified 32 putative gender markers. During the last year, we have tested approximately 90 new male and 90 new female plants for these putative markers. Nine of these markers appear to be strongly correlated with maleness. None of the markers we have yet found are convincingly linked to femaleness. A summary of 5 of the male-makers we have characterized is shown in Table 2.

Table 2. Frequency of putative male markers in 603 surfgrass samples (Total Population) and in known males (Known Males) and females (Known Females). Markers are labeled by the AFLP-primer pair used to generate them and their molecular weight).

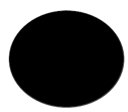
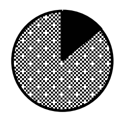
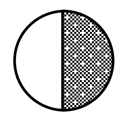
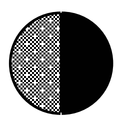
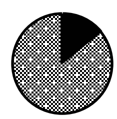
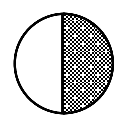
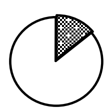
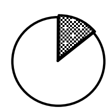
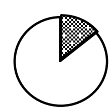
	Frequency of Putative Male Marker (%)		
Marker (molecular weight)	Total Population	Known Males	Known Females
ACA/CAT (130)	4	73	2
ACT/CTG (161)	4	73	0
ACA/CTT C (130)	3	55	0
AAG/CTC (700)	3	64	0
AAC/CTC (218)	2	55	0

These data indicate that no single marker is present in every male but that each marker is present in high frequency in males. This means that several markers must be used together to identify all males. Undoubtedly the most striking finding from these preliminary results is the low frequency of males in the population.

Summary of progress

The work described in our proposal consists of three distinct phases: Field work (sample collection), Laboratory work (DNA isolation and AFLP-fingerprint construction), and Data Analysis (band scoring and statistical analysis). In order to track our progress on each of our specific goals we have diagramed the fraction of work completed as the dark portion of the circles in Table 2. Work completed in the first year is shown in black, work completed in the current year is shown as black pattern. Uncompleted work is shown as white.

Table3. Fraction of work completed

Specific Goal	Field Work	Laboratory Work	Data Analysis
1. Population Boundaries			
2. Variation with Depth and Clone Size			
3. Gender markers			

Future Work

Future work will focus on completing data analysis for objectives 1 and 2. Both field and laboratory work remain to be done for objective 3. During the next flowering period (Summer 2002) we will collect 60 males and 60 females at one site from each of the three regions. We will use these additional samples to confirm the validity of our putative male markers. In the laboratory, our work will be divided between cloning and sequencing the putative male markers and constructing DNA-fingerprints for the newly collected male and female plants.

Task No. 17607: *Public Perceptions of Risk Associated with Offshore Oil Development*

Principal Investigators: Eric R.A.N. Smith, Department of Political Science, University of California, Santa Barbara, CA 93106-9420

Project Objective

The goal of this project is to design a set of public opinion surveys and news media content analysis methods in preparation for a time series analysis of NIMBY responses to proposed offshore oil development projects along the Santa Barbara coast in California. Current oil-lease holders are considering a number of new drilling projects. This project will prepare a set of methods to study the public's reaction to the debate surrounding these proposed projects.

Background

Whenever a neighborhood or community group objects to a local development, someone suggests that the objections are part of a NIMBY, or "Not in My Backyard" pattern of responses. NIMBY behavior has been responsible for slowing or blocking a wide variety of government and industry proposals—including offshore oil developments. In some cases, such as housing developments, NIMBY resistance is motivated by people's preferences about the quality of life in their communities. In other cases, NIMBY resistance is motivated by people's perceptions of risks associated with the developments. In some of these cases, critics allege, the fears are irrational because they are based on misinformation. That is, people are said to fear hazards that have extremely small probabilities of occurring. Offshore oil development is one area in which exaggerated perceptions of risks may influence public opinion, and therefore government and industry decisions.

Despite the prominent role of NIMBY influence on many government and industry decisions, researchers have not yet developed a full understanding of it. Although there is a substantial literature on risk perceptions, relatively little of it examines risk perceptions in the context of actual NIMBY behavior, and none it has examined the development of a NIMBY response over an extended period of time. That is, no investigator has yet used a series of public opinion surveys to explore how people's knowledge, risk perceptions, policy preferences, and behavior change over time during the course of a public debate about proposed development such as a new offshore oil platform. This study is developing a research design to do just that.

The core of the design will be a series of public opinion surveys extending for a period of five years so that we can measure change over time. A baseline survey—the 1998 Offshore Oil Drilling and Energy Policy Survey, funded by the University of California's Toxic Substances Research and Teaching Program—has already been conducted. Subsequent surveys will measure the public's knowledge of oil development in general and the proposed projects in particular, as well as the public's perceptions of various risks associated with the projects, including both risks to people and to the environment. In addition, the surveys will measure people's preferences about the projects and the extent to which they act on their preferences by writing letters, attending meetings, and engaging in other forms of political activity. Finally, the surveys will measure a variety of variables that various theories suggest may explain people's knowledge, perceptions of risk, preferences, and activism.

In order to explain the public's response to the drilling project, we will also study the sources from which the public receives information or persuasive communications—that is, the news media, industry advocates, and political activists. These efforts will include a content analysis study of local newspapers, television news, and radio as well as an effort to obtain and analyze any direct mail or other communications from the oil industry or advocates on either side of the conflict. Measuring these communications will allow us to test theories explaining changes in the public's knowledge, opinions, and behavior over time.

Progress during 1999-2000

Initial efforts focused on developing a set of content analysis methods for monitoring newspaper coverage of oil drilling and other oil-related issues. The news media are most people's primary sources of information on the world. To understand how people form opinions on issues such as oil development, we must first understand their sources of information.

Two types of content analysis measures have been developed. The first focuses on information about oil development and the oil industry; the second on the availability of comparative risk assessment information. For the oil industry, we have developed a coding scheme and are now collecting data so that we can test and refine the measure. This measure categorizes newspaper stories about oil according to the ways in which they should influence public opinion. For example, one category consists of stories about real or potential accidents that threaten people or the environment because those stories all hypothetically influence public in the same manner—they tend to make people anti-oil development. A second category consists of stories about gasoline price hikes because those stories may make people slightly more disposed toward additional oil drilling.

For the comparative risk assessment analysis, we developed a coding scheme to allow us to discover what sorts of information people receive about potential causes of death. The original intent was to measure both the extent of risk information related to the oil industry and the extent to which the information allowed readers to compare various risks. We sought to discover, for example, how much information people could learn about the likelihood of getting cancer from various sources—including the oil industry. To do this, we cast our net widely, and attempted to code all information in any story that indicated a potential cause of death.

Using the *Los Angeles Times*, by reputation one of the nation's most comprehensive newspapers, we developed and refined a set of measures of various types of risk information. Our categories included, for example, stories about simple events (e.g., cancer deaths) which could be used by readers to estimate probabilities, and stories about scientific studies which directly presented risk estimates.

Our initial data indicate a surprising finding. Although there are literally hundreds of newspaper stories that include information about death events, there is remarkably little information about either actual probabilities of death from any given cause or comparative risk probabilities. These findings are surprising because the academic literature on risk perceptions assumes that people can learn about actual risks posed by various hazards. Researchers who claim that people behave "irrationally" when they fear hazards that are highly improbable implicitly assume that people either know or can find out what the risks are. Yet that information is almost completely lacking in the *Los Angeles Times* and one must presume in other newspapers as well. If risk information is not available to the public, there is no basis for claiming irrationality. Given the surprising nature of our findings, we have prepared an article based on these data, which we will submit shortly.

A second area of progress in the questionnaire development has been in testing alternative theories of attitude formation using the 1998 Offshore Oil Drilling and Energy Policy Survey. Although a single survey cannot fully test theories of change over time, it does allow preliminary examination of how well alternative theories explain attitudes. The analysis showed that a set of questions measuring egalitarianism worked well, a parallel set measuring individualism worked in one case, and a set measuring postmaterialism did not work at all. These findings, presented in a paper delivered at the World Association of Public Opinion Research, allow us to omit the postmaterialism questions from the questionnaire.

Progress during 2000-2001

People misperceive the risks they face from potential environmental hazards. They exaggerate the statistical odds of some potential causes of injury or death, while they underestimate others. The goal of this project is to use public opinion survey data and news media content analysis to test and refine a new theory to explain people's perceptions of the risks associated with offshore oil development. The specific product of this project will be an analysis of a two-wave, public opinion panel-survey. A content analysis of how newspapers report news about oil development will provide some of the explanatory variables. The two-wave, panel design will allow us to see how individuals change their attitudes over time, and should give us a far better understanding of opinion dynamics than would surveys conducted at a single point of time.

In the beginning months of this research project, we developed a draft public opinion questionnaire. This work was informed by the findings from a previous MMS-funded research project, "A Design for a Time Series Study of a NIMBY Response." The draft survey must be approved by the Office of Management and Budget (OMB) before the survey is conducted.
We also designed and began to implement a newspaper content analysis. We are currently gathering data from the *Santa Barbara News Press*. The goal of this analysis is to discover how newspapers cover the oil and gas industry, how that coverage has changed over time, and how that coverage affects perceptions of risk and public opinion about oil development. The results of the analysis will be merged with the public opinion survey data to help model changes in the public's attitudes over time.

The future plans for this project include finalizing the survey with OMB approval, and conducting the survey.

Progress during 2001-2002

During this year, we completed drafting the public opinion questionnaire that is central to this research project. The process of OMB approval is long and includes a number of steps, including publication of a notice in the Federal Register and consideration of public input. We began the OMB-approval process by submitting a Federal Register statement to MMS in the fall. While waiting for approval to be granted, we focused our efforts on gathering data for the news media content-analysis and preparatory data for the first survey. We also gathered data to help analyze past public opinion survey data, in an effort to help explain opinion changes through time.

Task No. 17608: *Observing the Surface Circulation Along the South-Central California Coast Using High Frequency Radar: Consequences for Larval and Pollutant Dispersal*

Principal Investigators: Libe Washburn, Department of Geography, University of California, Santa Barbara, CA 93106-4060 and **Stephen Gaines,** Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106-9610

Summary of Research

Progress during 2000-2001

1. HF radar operations

An important focus of our MMS/CMI-funded research this year has been to survey available technologies for accessing our remote radar sites and diagnosing their operational status. We also looked for methods which would also allow us to download data remotely from the sites. Two modem technologies looked promising: one used a cell phone and the other used a radio link. After some preliminary tests with cell phones revealed intermittent or poor coverage at our remote sites, we began experimenting with "Freewave" radio modems. These units use line-of-site radio transmission to move data between locations up to about 50 miles apart. At each site a directional Yagi-type radio antenna transmits and receives packets of data and commands. Curvature of the earth requires that the antennas be located as high as possible to maintain line of site at long ranges.

Our most difficult site to access is the radar system located at the Point Conception, CA so we installed a radio modem there in March 2001. Our only consistent means of access is to fly to Point Conception on an MMS helicopter used for oil platform inspections. This method has worked very successfully, however, and we have been able to maintain the site such that it is reliable. We located the modem antenna high on a hill at Point Conception. We also located a matching antenna on a 6-story building on the UCSB campus.

Initially we had problems arising from weak signal reception which prevented us from establishing a good remote link. After some experimenting with the modem antenna at UCSB and software adjustments, we successfully acquired data from the site at Point Conception. This is a major advance for our program because we will now be able to produce daily current maps incorporating data from this site.

At present, our real time data (see http://www.icess.ucsb.edu/iog/codar.htm) comes from two of our sites, one at Refugio and the other at Coal Oil Point on the UCSB campus. We are currently working on an automated computer-based procedure for downloading data from Point Conception for near-real time display via the internet. We expect to finish this in the next few weeks.

2. Channel circulation

2.1 Propagating eddies

Another goal of our project is to investigate the circulation in the western Santa Barbara Channel by taking advantage of the 2-dimensional mapping capabilities of HF radars. During the first year of this project we discovered evidence for propagating eddies moving westward through the Channel. Earlier studies such as that of [*Harms and Winant*, 1998] also documented propagating features, but they were unable to provide their details due to limited spatial resolution of their moored current arrays. Figure 1 shows an example from 1 July 1999.

The propagating eddies show up clearly in a 3-year record of surface currents obtained over the Santa Barbara Basin. The record for 1998-2000 used in the analysis comes from an area over which surface currents are available 80% of the time. The eddies appear as trains of oppositely-rotating, circular current patterns moving westward at about 7 km/day. Their horizontal length scale is about 20 km. The strength of rotation of the eddies, as measured by their vorticity, is ~0.3 f, where f is the Coriolis parameter. We first detected them in 36-hour-averaged data from the radars (to remove tides), but they appear most clearly after band pass filtering in the 10-20 day band. The eddies are most common in summer, but also occur in the other seasons. Generally the eddies do not occur in isolation, but rather in trains lasting up to a few months.

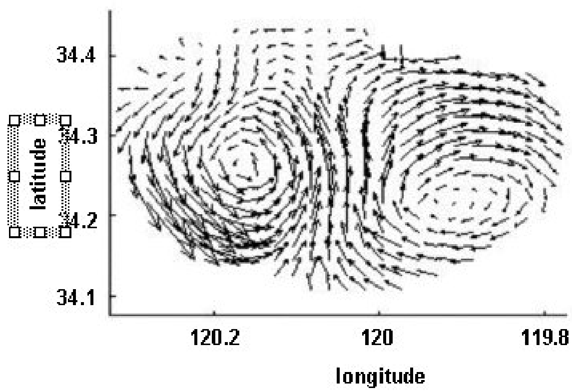


Figure 1. Example of a pair of propagating eddies observed on 1 July 1999 in the western Santa Barbara Channel. The eddies are circular flow patterns with opposite rotation. The mainland coast to the north and the Channel Islands to the south lie just outside the coverage area.

The eddies are important because they appear to disrupt the large cyclonic circulation typically present in the western Channel spring through fall. Results of our research on the eddies was presented by Beckenbach et al. (2000) and Washburn et al. (2000) at the Fall Meeting of the American Geophysical Union in San Francisco. A manuscript summarizing our findings is in preparation.

2.2 Poleward flow events

The HF radar data also have revealed some of the characteristics of poleward flow events, strong flows that move water northward around Point Conception. These events are important because they are a mechanism by which organisms and other constituents such as oil can be carried against the prevailing flow.

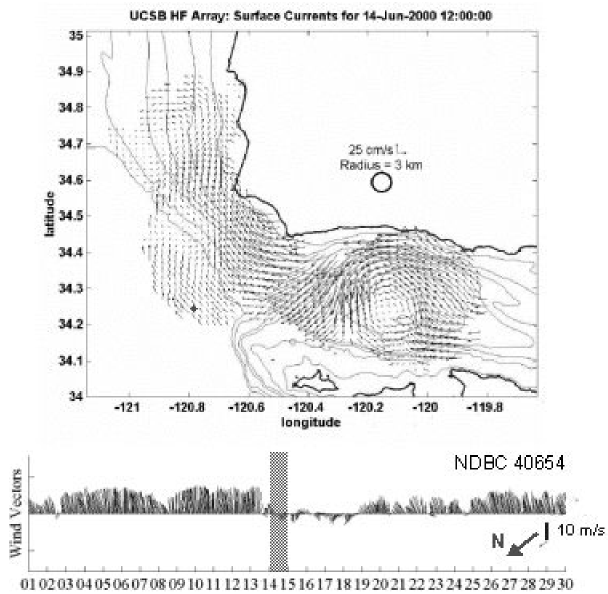


Figure 2. Upper panel shows pattern of northward-flowing surface currents during a poleward flow event in June 2000. Each arrow is a 24 hour average of currents. Lower pane is the wind time series recorded at buoy NDBC 40654 (location shown by black dot) for June 2000.

Typically relaxations or reversals produce the poleward flow events. The event of Fig. 2 occurred after a sudden relaxation in winds beginning on 13 June 2000 GM. Response of surface currents was very rapid; the currents reversed within a several hours of the wind relaxation. The radar data show the poleward flow events typically last about a week. Although this example is a summertime event, winter events appear to be more common. We are investigating the characteristics of these events, such as duration and horizontal scales, along with their effectiveness as larval transport mechanisms.

3. Coastal circulation and larval retention

Over the past year we have continued our collaboration with Mary Nishimoto, a researcher (and now graduate student) at the Marine Science Institute at UCSB. As reported by [*Nishimoto and Washburn*, 2001], midwater trawling surveys in June 1998 revealed high concentrations of fishes in the center of the cyclonic eddy typically found in the western Santa Barbara Channel. We have been working to understand the role of the local mesoscale circulation in producing these high concentrations. Recent results suggest that the flow patterns in the weeks before the trawling surveys produced larval retention in 1998, but not in 1999 when cooler, windier conditions prevailed.

As shown in Fig. 3 (left panel), over the 6-week period beginning 1 May 1998 (which included the trawling surveys), the pattern of mean surface currents observed by HF radar was consistent with a stable eddy circulation and closed streamlines. Vectors shown in Fig. 3 were obtained from the area of highest coverage by the radars; total vectors were available for at least 80% of the time over a 3 year record. The eddy was centered over the deepest part of the Santa Barbara Basin with mean azimuthal speeds of ~0.1 m s^{-1}. Higher flow speeds prevailed in the northwest portion of the eddy, possibly due to higher northwest winds in the western part of the Channel. Current direction approximately followed bathymetric contours around the basin.

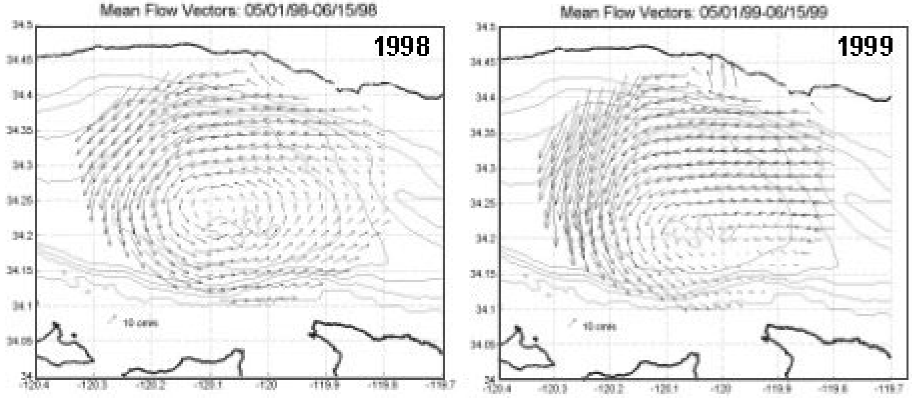


Figure 3. Left panel shows mean surface current vectors in the western Santa Barbara Channel from 1 May – 15 June 1998. Right panel is similar, but shows mean vectors for the same period in 1999.

In contrast to the stable eddy circulation in 1998, highly variable flow prevailed in the weeks before and during the trawling surveys of 1999. The pattern of mean flow over the 6 weeks beginning 1 May 1999 was not eddy-like. Instead it was a cyclonic turning of a broad westward flow along the northern Santa Barbara Basin into a southeast flow toward the Channel Islands (Fig. 3, right panel). The turning flow from westward to southward and then to southeastward approximately followed isobaths. This flow pattern with its open streamlines was unlikely to have retained larvae prior to the trawling surveys.

4. Invertebrate settlement patterns and surface circulation

Our results over the past year suggest a link between coastal circulation in the region around Point Conception and recruitment patterns. Prevailing regional flow patterns are offshore upwelling flow at Point Conception and counter-clockwise flow in the Santa Barbara Channel. Figure 4 shows both of these flow patterns from surface current vectors averaged over 6 June – 26 July 2000 based on observations from the array of 5 HF radars (radar sites indicated by triangles). Offshore flow up to 0.15 m s^{-1} around Point Conception resulted from strong winds blowing to the southeast (equatorward). Further east in the Santa Barbara Channel the flow turned cyclonically from a westward jet along the mainland coast to a southwestward flow of ~0.2 m^{-1} at the west channel entrance. Often the cyclonic flow closes on itself to form an eddy in the western Channel over the Santa Barbara Basin (marked by the closed bathymetric contour at 500 m depth).

The inset bar graph of Fig. 4 shows the average number of settlers of 13 invertebrate species collected over two week intervals. Data were collected from 1997 to 1999 by substrates mounted on piers along the coast, as indicated below the x-axis. Three sampling piers, Ellwood, Gaviota, and Boathouse (locations indicated by squares), fell within the coverage area of the HF radars. The settlement pattern across the piers shows a drop in abundance at Boathouse by at least a factor of 5 compared with surrounding locations. The offshore flow associated with the Point Conception upwelling center likely reduced settlement at the Boathouse pier since larval transport to nearshore areas would often be unlikely in this flow regime.

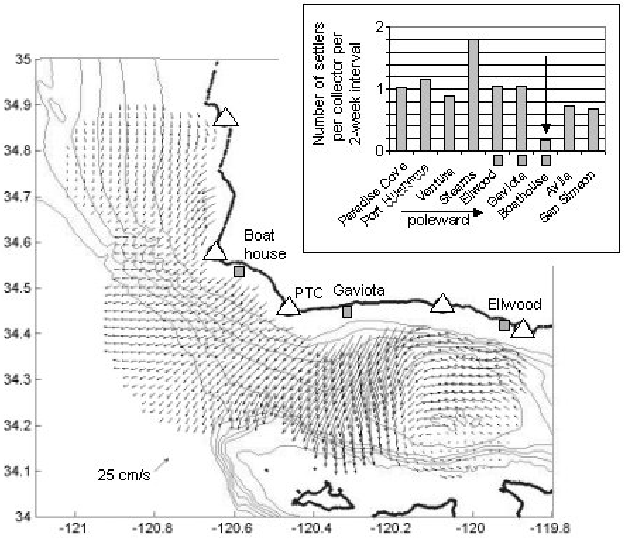


Figure 4. Mean surface flow field near Pt. Conception, CA (PTC) for 6 June-26 July 2000 showing strong offshore flow due to coastal upwelling. HF radar sites are indicated with triangles. Inset shows settlement pattern of 13 invertebrate species along the coast at locations indicated below x-axis. Arrow indicates low settlement at Boathouse pier, probably due to offshore flow. Gray squares mark sampling piers. Bathymetric contours are shown for depths of 100, 200, 300, 400, and 500m.

Recruitment patterns along the coast also appear to vary with season due to changes in circulation and timing of spawning. Numbers of the scallop *Leptopecten latiauratis*, an animal spawning mostly in summer, dropped sharply north of Point Conception. Typical summertime flow patterns derived from the HF radar observations suggests the cause: persistent strong offshore transport southward away from Point Conception. Poleward flow of the Southern California Counter-current brings this animal from its spawning areas in the Channel and broader Southern California Bight, but the prevailing offshore flow at Point Conception may inhibit its spread northward.

Species of the snail genus *Tricolia* exhibited a contrasting settlement pattern in which they settled on both sides of Point Conception. These snails generally spawn in winter when frequent poleward flow events transport water poleward around the Point. The HF radar array has observed several of these flow events, especially in winter when winter storms often blow strongly toward the northwest. Poleward flow events also occur in summer, but then they typically result from wind relaxations, not reversals, and are less frequent. Poleward flow events usually last from a few days to a week, depending on the evolution of the wind field. These preliminary results suggest that the timing of settlement may couple with seasonally varying flow patterns to control species patterns along the south central California coastline.

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Progress during 2001-2002

Progress on our MMS-CMI project was good over the past year. We again have five HF radars operating along the coast. Real time data is now available by radio modem from our remote site at Pt. Conception and we are experimenting with cell phone modems to get real time data from our two northernmost sites at Pt. Arguello and Fallback, just south of Pt. Sal. Our continuing analysis of Santa Barbara Channel circulation has caused us to re-evaluate some of our earlier conclusions. In particular, what we previously thought were propagating eddies in the western Channel, we now believe are a type of coastal trapped wave. We have also found that local winds drive a broad region of convergence and downwelling in the western channel which is probably important for concentrating water borne materials such as pollutants and organisms. Examination of the HF radar and in situ current data shows that inner shelf currents are strongly correlated with offshore currents, but with greatly reduce speeds. We are now analyzing a large interdisciplinary data set collected last summer through fall to examine how coastal circulation affects invertebrate recruitment.

1. Operation of the HF radar array

Our high frequency (HF) radar systems continued to operate successfully in the Santa Barbara Channel and north of Pt. Conception, despite some difficulties encountered through the year. A number of events occurred during the last year which affected the performance and the coverage of the array and our access to some field sites.

In February 2001 the NOAA Environmental Testing Laboratory (NOAA/ETL) of Boulder, CO requested that we temporarily return the two HF radar systems used at our northern-most sites at Pt. Arguello and Pt. Sal. These systems had been on loan at no cost to this project. We returned the radars immediately upon receiving the request from NOAA/ETL and had no coverage from the area north of Point Arguello for several months. However, through our continuing collaboration with Jack Harlan of NOAA/ETL we were able to borrow the two radar systems again in late November. These two systems were re-installed at Pt. Arguello and Fallback (just south of Pt. Sal) in December 2001.

Another important development during the year was the acquisition of a new HF radar system. One of us (LW) submitted a proposal to the California Environmental Quality Initiative (CEQI) sponsored by the University of California Marine Council. Of 22 proposals submitted for the competition, three were funded. The success of this proposal was partly due to the CMI-MMS funding from this project. The new system was ordered in July 2001, received in August, and installed at the vacant site at Pt. Arguello in early September. This new system temporarily replaced one of the systems returned to NOAA/ETL.

Due to heightened security on Vandenberg Air Force Base following the terrorist attacks of 11 September, we were unable to access the new system at Pt. Arguello until early November. Some data loss during the September-November period occurred because of a hardware problem in the transmitter of the new system. Such problems with new equipment are not unusual and we worked with the manufacturer (CODAR Ocean Sensors, Ltd., Los Gatos, CA) to repair the system. The new system remained at Pt. Arguello until late early December when we replaced it with one of the borrowed NOAA/ETL systems.

Currently we are working with the UCSB Budget and Planning Department (UCSB/DBP) and the California State Lands Commission to gain access to a site for the new radar in the eastern Santa Barbara Channel on the Rincon Oil Island. Initially we worked with Venoco, Inc., a Carpinteria-based oil company to locate the new radar on the company pier in the city of Carpinteria. After obtaining company permission, we installed the new radar on the pier in early December for a series of tests to determine coverage area and to measure antenna patterns. The testing revealed severe distortion of the receive antenna patterns due to the extensive amount of metal on the pier such as support beams and a large, movable crane. Based on this we concluded that the site was probably not suitable. We are in the process of applying to the California State Lands Commission and the County of Ventura to place the new radar system on the Rincon Oil Island. The extensive permit requirements have extended the application process, but we are hopeful that we can begin operating at Rincon Island in the next few months.

We are also working with the UCSB/DBP and the Coast Guard to relocate the Coal Oil Point radar to the Coast Guard Santa Barbara Light facility. With radars at these two locations we will have extensive radar coverage over the eastern Santa Barbara Channel, including most of the active oil production platforms in the region.

An important operational objective of this project is to acquire data from the entire radar array in real time. Pt. Conception, Pt. Arguello, and Fallback near Pt. Sal are the most challenging in this regard. Over the past year we examined two technologies for communicating with our remote sites: radio modems and cell phone modems. Our initial focus was on establishing a link with Pt. Conception and in March 2001 we installed a radio modem system at this site. Despite the long range between this site and our laboratory at UCSB, we now are able to communicate with the system daily. After some experimentation, we found that the key to successful operation of the modem system was using directional Yagi-type antennas and placing the transmit and receive antennas as high as possible to overcome the effects of the earth's curvature.

Our testing also revealed that radio modems would not work at the Pt. Arguello and Fallback sites because of the great distances involved and the lack of clear lines of sight to the sites. However, we are able to use cell phones at these sites and recently purchased two cell phone modems for data transmission. We just received the modems and have begun experimenting with them. Once we become familiar with their operation, our plan is to install them at the Pt. Arguello and Fallback sites over the next month.

2. Regional circulation

2.1 Surface circulation in the Santa Barbara Channel

We have continued analyzing the extensive data set obtained by the HF radar array, particularly from the western Santa Barbara Channel, to investigate the regional surface circulation. Our observations compliment the extensive physical oceanographic investigations such as those of [*Dever et al.*, 1998; *Harms and Winant*, 1998; *Hendershott and Winant*, 1996; *Winant et al.*, 1999], among others. In particular, we have been focusing on aspects of the circulation not extensively examined in these previous studies including the two-dimensional flow field and flow over the inner shelf.

During our investigations in 2001 we concluded that propagating eddies account for much of the variability in circulation on time scales from 10 – 20 days [*Beckenbach et al.*, 2000]. The eddies appear as trains of counter-rotating, circular eddies moving westward at about 7 km/day with horizontal length scales comparable to the 40 km Channel width. The strength of rotation of the eddies, as quantified by their relative vorticity, is ~0.3 f, where f is the Coriolis parameter (f = 8.22×10^{-5} s^{-1}). These eddies are most common in summer, but can occur any time of year. Generally the eddies occur in trains lasting up to a few months. During our analysis of this year we have extensively revised our earlier hypothesis concerning these eddies. Based on analysis over the past year, we now hypothesize that what we thought were eddies are actually a type of coastal trapped wave that propagates over the Santa Barbara Basin.

Careful examination of the data set using the technique of complex empirical orthogonal function (CEOF) analysis showed that first two patterns of variability, or modes, account for 65% of the variance (45% in mode 1 and 20% in mode two). Both modes propagate with periods of about two weeks, closely matching the periods of coastal trapped waves described by [*Auad et al.*, 1998]. The first mode accounts for the propagating eddies we described previously; the second mode describes a long wavelength wave that produces oscillatory currents in the Channel. This analysis has led us to conclude that both modes represent coastal trapped waves rather than freely propagating eddy trains. This hypothesis is supported by our other recent analysis which shows an amplification of the first mode over the Santa Barbara Basin with a rapid decrease in amplitude further west over the sill at the western channel entrance (Fig. 1).

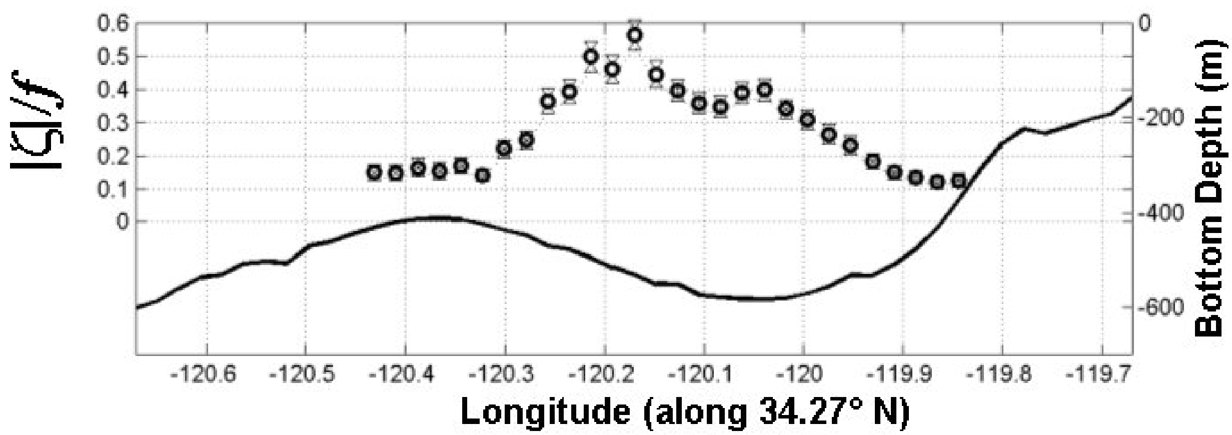

Figure 1. Cross section of water depth (solid line) and normalized vorticity (symbols 1 standard deviation) of the first (propagating) EOF mode along the center of the Santa Barbara Basin at 34.27° north latitude. The increase of normalized vorticity over the western slope of the basin is consistent with a resonant response of the basin to the passage of long wavelength (order 700 km wavelength) coastal trapped waves.

Our picture of flow in the 10-20 day band consists of a series of long waves (described by mode 2) whose wavelength greatly exceeds the length of the Santa Barbara Channel. When the frequency of these waves matches a resonant frequency of the Santa Barbara Basin, a second wave (described by mode 1) is amplified which appears as trains of counter-rotating eddies over the Basin (Fig. 2). This work was presented recently at the Ocean Sciences Meeting in Hawaii [*Beckenbach and Washburn*, 2002].

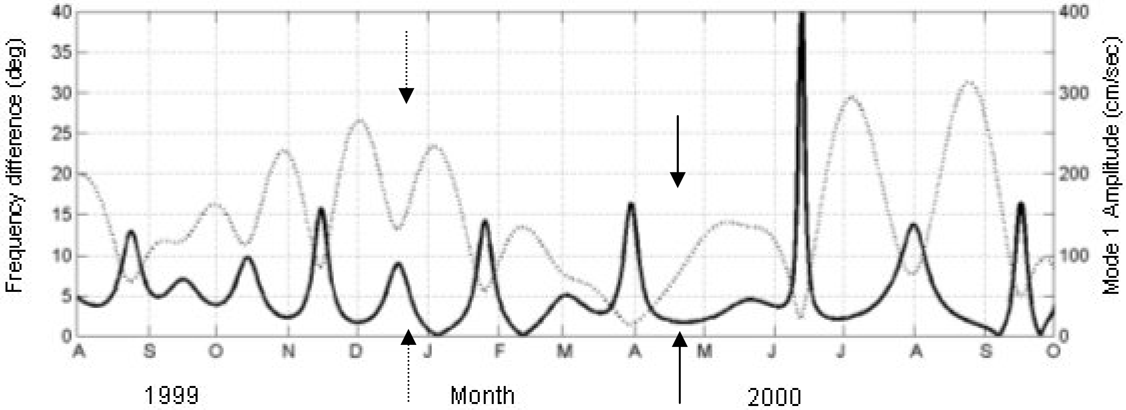

Figure 2. Time series of the amplitude of the first (propagating) EOF mode (dotted line, right hand scale) and frequency difference between first and second EOF modes (solid line, left hand scale) for several months in 1999 and 2000. The second EOF mode represents a long coastal trapped wave. When the frequency difference is small the amplitude of the propagating mode is large. This occurs at several places in the record such as December 1999 as indicated by the dotted arrows. In contrast when the frequency difference is large, such as at the end of February 2000 as indicated by solid arrows, the amplitude of the propagating mode is small. This is consistent with a resonant excitation of the propagating mode in the Santa Barbara Basin with the long coastal trapped wave.

2.2 Wind-driven vorticity and divergence in the western Santa Barbara Channel

An important advantage of oceanographic HF radars over other measurement techniques, such as moored current meter arrays, is their ability to measure the two dimensional flow field of the coastal ocean. We have used this fact to examine the divergence and vorticity fields of the Channel. Divergence is important because it leads to upwelling and downwelling flows which have important biological implications, such as nutrient delivery to surface waters and subduction of phytoplankton out of the euphotic zone. Vorticity, a measure of fluid rotation, is important because it can be used to quantify the strength of the predominantly the counter-clockwise rotary flow pattern in the western Channel.

In his dissertation work, Edwin Beckenbach, a Ph.D. candidate supported by this project, has found that the local wind field frequently drives a broad region of strong convergence and downwelling in the western Channel. This may concentrate water-borne materials and organisms and partially account for the high biological productivity in the area. The high concentrations of late-stage larval and juvenile fishes found by [*Nishimoto and Washburn*, 2002] in the western Channel may have resulted from this convergence.

Conventional empirical orthogonal (EOF) function analysis shows that the regional wind field is dominated by the first two modes with over 85% of the variance explained. Mode 1 has a pattern resembling the mean wind field; mode 2 describes a strong wind shear or curl. The divergence and vorticity fields of the western Channel were conditionally averaged according to the strength the first two wind modes. The analysis shows that divergence responds mainly to the first wind mode while vorticity responds to the second mode. The vorticity response to the local wind supports a previous hypothesis of [*Münchow*, 2000].

2.3 Flow over the inner shelf

In a collaboration with Cynthia Cudaback, a researcher at the Marine Sciences Institute at UCSB, we have been examining the circulation and forcing mechanisms acting on the inner shelf. Flow processes over the inner shelf are not well understood, but are important because they deliver pollutants such as oil to the shoreline and transport settling organisms to inter-tidal and sub-tidal habitats. Our instrumentation for examining inner shelf circulation consists of the HF radar array along with bottom-mounted acoustic Doppler current profilers (ADCP's), and thermistor strings, all deployed on the 10 m isobath. The in situ instrumentation was funded from other sources including the National Science Foundation and the David and Lucille Packard foundation.

The study revealed strong coherence in temperature time series along the coast from Ellwood to Pt. Sal which is north of Pt. Conception. The coherence appears as consistent warming and. cooling across the array of thermistor moorings The HF radars show that when inner shelf warming occurs, it is associated with weakening (or reversing) winds and poleward flow events lasting a few days to a week.

We found strong correlation between inner shelf currents and those further offshore. Over the inner shelf, however, flow speeds are factors of 3-5 slower than over the mid-shelf and outer shelf. Upwelling is well documented along the California coast north of Pt. Conception, but less so in the Santa Barbara Channel. We found strong wind-driven upwelling at a mooring near Gaviota, CA on the mainland channel coast. An upwelling flow pattern with offshore surface flow and onshore bottom flow occurs in response to strong offshore winds which prevail in this region. We hypothesize that the upwelling is driven by down wind acceleration rather than the Ekman-type upwelling prevalent elsewhere along the California coast. Results of our analysis were presented at the recent Ocean Science Meeting in Honolulu. They are also summarized in a paper submitted to Continental Research [*Cudaback et al.*, 2002].

2.4 Coastal circulation and larval settlement

From June through December 2001 we conducted an intensive experiment to understand the links between coastal circulation processes and larval settlement. A principal goal of the experiment was to determine what physical transport processes were associated with settlement events of various invertebrate species. Our approach was to frequently sample for settling organisms while simultaneously observing certain coastal circulation processes which we hypothesize are responsible for transporting larvae to shore. These include the internal tide, local wind-driven upwelling, alongshore advection, and cross shore advection.

We chose a site on the mainland coast centered on the pier near Ellwood California because of the range of possible transport processes which are observed there and the ease of access for biological sampling. The heart of the experiment was every-other-day sampling of larval settlement onto substrates such as ceramic tiles and plastic scrub pads. The substrates were suspended from two locations on the Ellwood pier. Every two days the substrates were recovered, taken to our laboratory at UCSB, and sorted to identify what organisms had settled.

The experiment was very successful and resulted in the collection of a large interdisciplinary data set which we are currently analyzing. At this point all of the organisms have been identified from the substrates, a task which required several months and which has only just been completed. We are now analyzing the settlement time series in relation to the flow and water mass time series.

Preliminary analysis of the thermistor and ADCP time series shows a strong internal tide during summer on a spring-neap cycle. We will test the hypothesis that larval delivery results from onshore transport by the internal tide, as has been observed elsewhere. A competing hypothesis for larval delivery is that settlement results from along shore advection of water masses from the east or west. The HF radar array and near shore ADCP shows that the cyclonic circulation in the Channel produces strong westward flow over the inner shelf at the Ellwood pier. We explore this hypothesis through a careful examination of near shore current and water mass variability in relation to larval settlement.

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Task No. 17609: *Advancing Marine Biotechnology: Use of OCS Oil Platforms as Sustainable Sources of Marine Natural Products*

Principal Investigators: **Russell J. Schmitt,** Department of Ecology, Evolution and Marine Biology, **Jenifer Dugan,** Marine Science Institute; **Scott Hodges,** Department of Ecology, Evolution and Marine Biology; **Robert Jacobs,** Department of Ecology, Evolution and Marine Biology; **Mark Page,** Marine Science Institute, **Leslie Wilson,** Department of Molecular, Cellular and Developmental Biology, and **Stephen Gaines,** Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106-9610

Summary of Research

Several natural products useful for medical and industrial purposes have been isolated from marine organisms over the past few decades. However, the harvest of sufficient quantities of these organisms has proven to be difficult. Further, when harvest has been possible, there has been concern about ecological impacts resulting from the potential over-harvesting of these species. The harvest of marine organisms associated with man-made structures, such as offshore oil and gas platforms, may provide an untapped source of such organisms thereby eliminating impacts to natural habitats.

Study Sites

We are conducting research at seven oil and gas platforms in the Santa Barbara Channel (Fig. 1, Table 1). These platforms are located in varying water depths, distances from shore and oceanographic conditions (e.g., water temperature, wave height and current flow). Further, these platforms are arrayed along strong environmental and biogeographic gradients, because this region is the transition zone where the Oregonian and Californian Provinces meet.

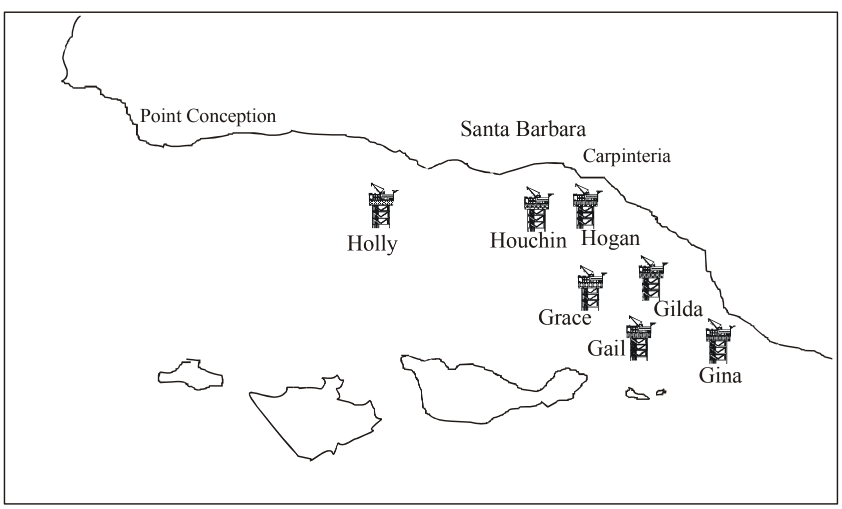

Figure 1. Locations of oil platforms in the Santa Barbara Channel involved in this study.

Table 1. List of platform study sites in the Santa Barbara Channel.

	Distance from shore (mi.)	*Depth (m)*	*Coordinates*
Gina	5.0	29	34° 07.03', 119° 16.58'
Gail	13.2	225	34° 07.50', 119° 24.01'
Gilda	11.9	64	34° 10.93', 119° 25.11'
Grace	14.4	97	34° 10.78', 119° 28.08'
Hogan	5.1	46	34° 20.25', 119° 32.63'
Houchin	7.0	49	34° 20.10', 119° 33.13'
Holly	2.9	64	34° 23.40', 119° 54.31'

Progress during 2000-2001

ECOLOGY:

Distribution/Abundance Surveys

We observed significant differences in the composition of encrusting invertebrate communities among the OCS platforms under study. Taxa that are abundant on one OCS platform may be rare or even absent on a nearby platform. These results indicate that the potential for OCS platforms to harbor different abundances of organisms containing natural products is very high. For example, a rare species of sea anemone, which has not been previously investigated in any natural product surveys, occurs in high abundances on Platform Gail. It has not been observed on any other platform under study. In addition, we have readily found *Bugula neritina*, a species that contains a known anticancer drug candidate (Bryostatin 1), at several depths at Platform Hogan. However, preliminary surveys indicate that it is less abundant at Platform Houchin (a neighboring platform) and rare at Platform Holly. We have also noticed that sponge diversity is quite high on some of the platforms under study. Voucher specimens of several taxa of sponges, including a genus known to contain promising natural products, have been collected, archived and sent for identification to Shirley Pomponi, a sponge expert at the Harbor Branch Oceanographic Institute.

To verify our observations of differing invertebrate communities among platforms we will conduct systematic photographic surveys. The necessary equipment has been purchased, photo-frame constructed, and preliminary photographs taken. We anticipate the photo surveys will begin in August 2002. Photo-quadrats from four randomly chosen conductor pipes and two vertical support members will be taken at four depths (6m, 12m, 18m, 24m), both up and down current. Species composition and percent cover will be determined using image analysis software and point contact techniques.

Growth Studies

Most of the sessile invertebrates attached to oil platforms, including those that may contain promising natural products, are suspension-feeders. To identify areas of "optimal" invertebrate growth, we are comparing growth of the mussel, *Mytilus galloprovincialis* among the seven platforms. We deployed four PVC frames supporting a mesh cage containing mussels. The PVC frames were attached to lines between the conductor pipes at 15m, with two frames placed on the outside row of pipes and two on the inside. Because mussel growth is greatly reduced upon reaching maturity, new sets of mussels are deployed approximately every 90 days. Upon retrieval, mussels are measured and growth calculated and compared among platforms.

Mussel growth rates did not vary significantly among platforms during the winter, averaging 6.9 mm per month. This growth rate agrees with rates obtained in previous studies at Platform Holly (Page 1986; Page and Hubbard 1987). In general, mussel growth tends to be slow during this time of year, as water temperatures and food availability are typically low. Comparisons of mussel growth throughout the year will help determine whether growth varies among the platforms.

In addition to comparing growth of mussels among platforms, we have developed a method for attaching sponges to standard surfaces. Preliminary growth experiments, utilizing a sponge of potential pharmaceutical importance, are ongoing. Additional experiments will allow us to compare sponge growth rates among platforms, providing an additional model suspension-feeder.

Recruitment Studies

To assess recruitment patterns of organisms at the platforms, we attached two settlement surfaces (tiles) to the PVC frames that were deployed for the mussel growth experiment. The surfaces contained a rough (corrugated) side and a smooth side, with each side exposed up and down current. Tiles were retrieved after 5 months and percent cover of dominant species (e.g., barnacles, bryozoans, hydroids, tunicates) was recorded using random point contact. Barnacle recruitment varied significantly among platforms during the winter/early spring period ($p = 0.004$; Figure 2). Few barnacles, averaging 2.4 or fewer individuals surface $^{-1}$, were present at Platforms Holly, Houchin and Grace, Barnacle numbers at Platforms Gail, Gilda, Gina and Hogan were higher averaging 4.7 to 8.2 individuals surface $^{-1}$. Growth of the barnacles also varied significantly among platforms ($p = 0.005$). Barnacles at Platform Holly were much smaller (both in diameter and height) than those at all other platforms. However, this result could be related to differences in the time of settlement over the five months of exposure.

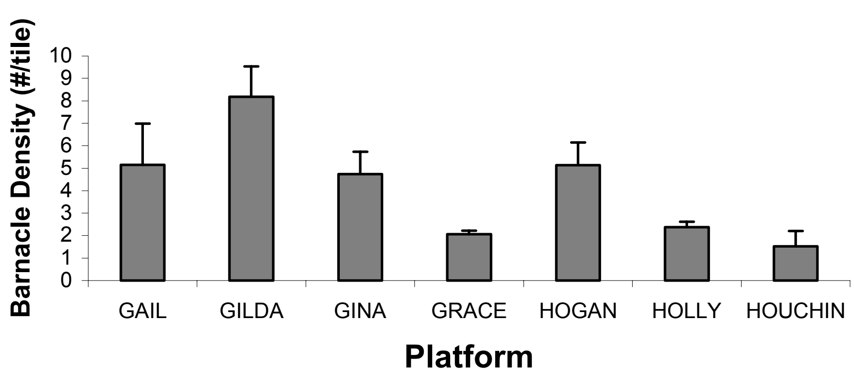

Figure 2. Recruitment of the barnacle *Megabalanus californicus* at seven OCS oil and gas platforms in the Santa Barbara Channel.

We also attached small cages with filamentous material (Tuffy®) to the bottom of the PVC frames to assess settlement of organisms at the platforms. The cages were retrieved and the tuffys examined for newly settled organisms after approximately 50 days. Preliminary results indicate that recruitment of bryozoans (particularly *Hippodiplosia insculpta* and *Crissia* spp.) and bivalves (*Mytilus* spp. and scallops) varied significantly among platforms in the late spring (Figure 3). Platforms Hogan and Houchin had significantly more bryozoan recruits ($p < 0.001$), while significantly more bivalves recruited to the cages at Platforms Hogan and Grace ($p < 0.001$).

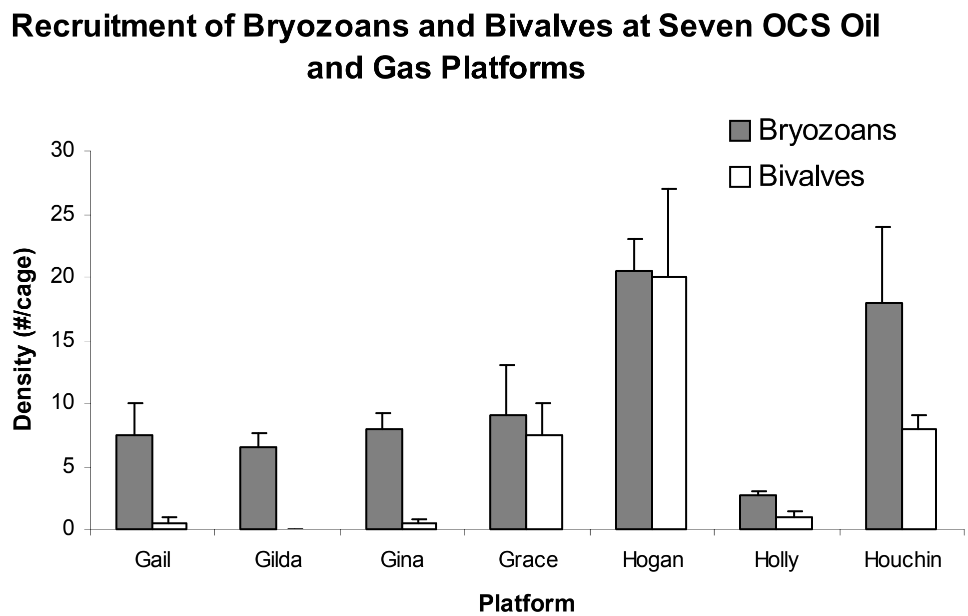

Figure 3. Recruitment of bryozoans and bivalves at seven OCS oil and gas platforms in the Santa Barbara Channel

Future Plans

Over the next year we will conduct systematic photo-quadrat surveys to assess species composition and abundance at the OCS oil and gas platforms under study. We will also continue evaluating the growth of *Mytilus galloprovincialis* and selected species of sponges, particularly those of potential pharmaceutical importance, to determine locations suitable for potential culture of various species of interest. Recruitment studies will also continue to provide additional information on locations that might support harvesting of potentially important species. Taken together, these studies will help evaluate the feasibility of utilizing OCS oil and gas platforms for harvest and/or culture of species containing potentially important marine products.

PHARMACOLOGY: Antiproliferative Properties of Coumarin Molecules

Sources of compounds for studies on effects of proliferation

Thus far we have collected 23 samples. Of that twenty are sponges, two of which have been identified tentatively, and three species of sea anemones. One species of sea anemone, known as the stripped anemone (a small ¾ inch rare anthozoan), has been selected to characterize and prepare extracts specific from the dinoflagellate symbionts present. To our knowledge, this species is rare along the coast of California and difficult to collect due to its small size. It has been found growing in abundance on one, but not all, of the oil platforms. Cliff Ross and Claudia Moya have focused their fieldwork in collecting this species in sufficient quantities for investigation.

Laura Mydlarz (a graduate student in our group) has developed expertise in the biosynthesis of natural products from geranylgeranyl pyrophosphate metabolism. Her primary studies deal with biosynthesis of the anti-inflammatory natural product pseudopterosin. We believe similar or related biochemical pathways may be found in the stripped sea anemone because of its relatively close phylogenetic relationship to the soft corals. Laura will undertake the chemistry and isolation in preparation of the extracts.

Model Systems

a. We continue to develop the *tetrahymena* model in order to investigate phagocytosis and its relationship to the inflammatory response. Claudia Moya is investigating suitable buffers and formulations that can be ultimately used for investigations of extracts of the stripped anemone.

b. The mouse ear inflammatory model remains central to obtaining primary information.

c. Hamta Madari has developed several models for investigating the site and mechanism of action of natural products by measuring cell cycle inhibition in the fertilized sea urchin embryo. She has recently completed the method for identifying drug sites of action using immunofluorescent technology in collaboration with Dr. Kathy Foltz. Over the last six months she has also developed methods in collaboration with Dr. Leslie Wilson for analyzing microtubule dynamics and the effects of natural products. She has established that dicoumarol seems to have a taxol-like mechanism. This compound, derived from a clover, is closely related to the coumarins present in the marine algae Dasycladales and will be the standard for future natural product comparisons.

Summary

In summary, we have identified important resources relevant to this project and selected organisms for study. These are siphonous green algae Dasycladales and the anemone species *Halilanella luciae.*

Progress during 2001-2002

ECOLOGY:

Assessing the potential use of OCS oil platforms as sustainable sources of marine natural products requires knowledge of the distribution and abundance of potentially important species. In addition, an understanding of the population dynamics (recruitment and growth) of these target species is needed to determine whether such populations can be sustained over time. We are investigating the community and population ecology of invertebrate assemblages on seven oil platforms in the Santa Barbara Channel to evaluate the feasibility of using OCS oil platforms as potential harvest and culturing sites for marine invertebrates that contain important natural products. Specifically, we are: 1) investigating spatial and temporal patterns in the distribution and abundance of invertebrates at the platforms, 2) exploring whether the population dynamics (recruitment and growth) of invertebrates vary among platforms (both spatially and temporally) and 3) examining the relationship between the patterns found at the platforms and selected environmental factors. To address our objectives we are photographically sampling existing invertebrate assemblages and conducting field experiments to measure growth and recruitment of invertebrates. Results from this work will not only help determine which, if any, platforms provide favorable growing conditions and/or sustainable populations of specific species, but more broadly they will help assess the quality of the platforms as reef habitat.

Distribution/Abundance Surveys

To investigate the distribution and abundance of platform invertebrates we conducted systematic photographic sampling at four depths (6m, 12m, 18m, 24m) both up and down current at the four outside platform legs and from four randomly chosen conductor pipes (64 pictures per platform; 448 pictures total). Species composition and percent cover of invertebrates is being determined in photoquadrats using point contact methods. Although data analyses are ongoing, preliminary analyses of the conductor pipes at 12m indicate that the distribution and abundance of platform invertebrates varies markedly among platforms. For example, the distribution of some species of sea anemones (*Metridium exilis*) is limited among platforms, while that of others (*M. senile*, *Corynactis californica*) is more widespread (Fig. 2). Further, the abundance of these anemones is highly variable among platforms (Fig. 2).

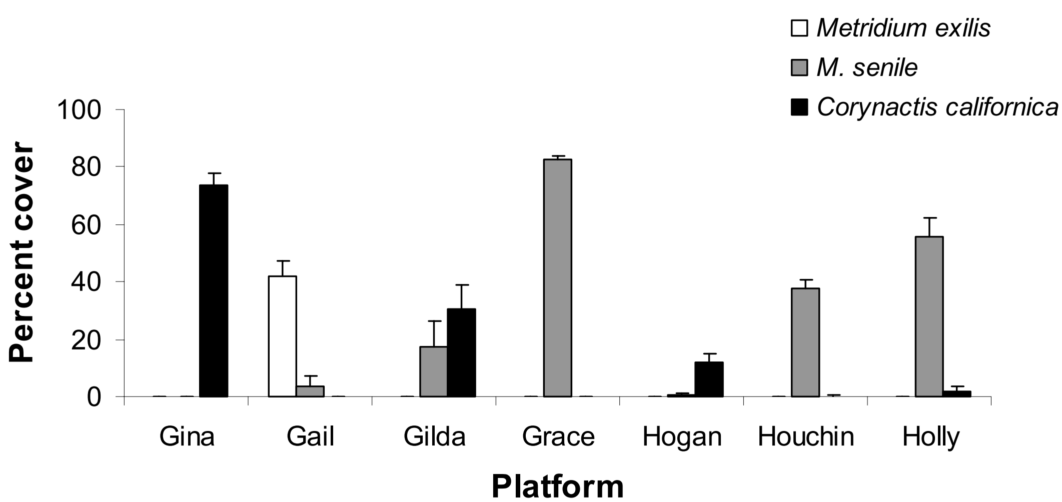

Figure 2. Distribution and abundance of three anemone species at seven oil and gas platforms in the Santa Barbara Channel.

Similar patterns occur in other invertebrate taxa; the encrusting bryozoans (e.g., *Hippodiplosia insculpta*, *Membranipora tuberculata*, *Dendrobeania laxa*) and hydroids (*Aglaophenia* sp. *Plumaria* sp.) have limited distributions, whereas the sponges (e.g., *Haliclona* sp., *Hymeniacidon* sp.) are more widespread (Fig. 3). Abundance of these invertebrate taxa also varies considerably among platforms (Fig. 3).

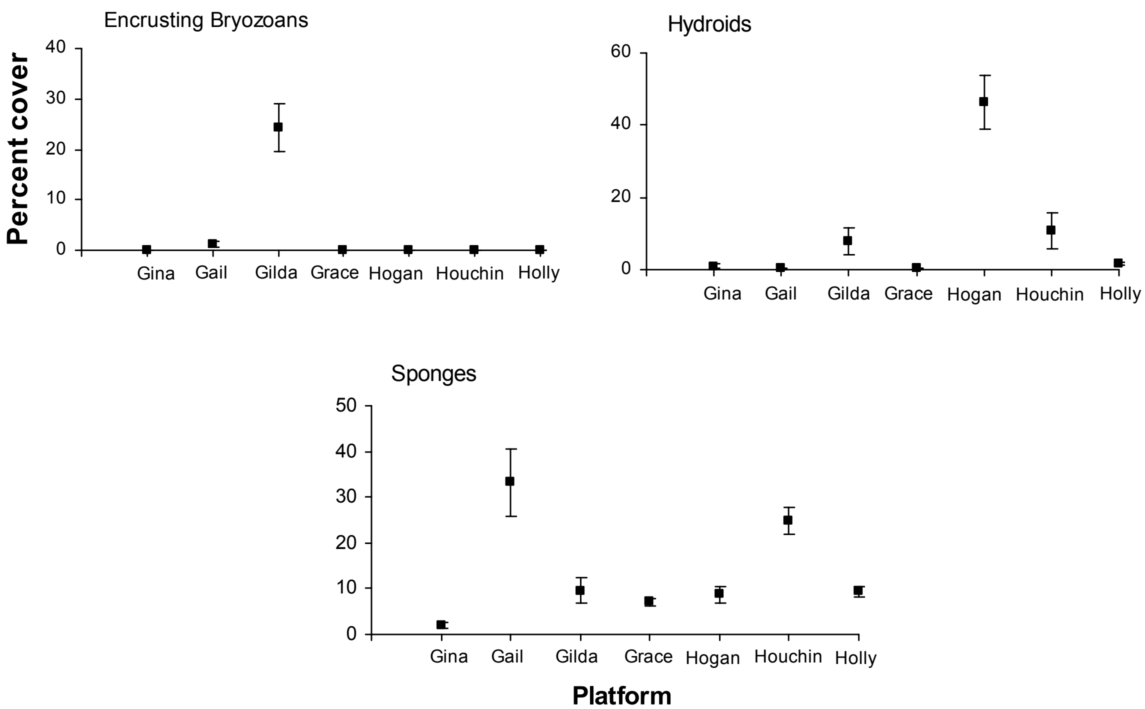

Figure 3. Distribution and abundance of selected taxa on the conductor pipes at seven oil and gas platforms in the Santa Barbara Channel at a depth of approximately 12m.

Results from our photographic surveys will help determine which of the OCS platforms may be important sources for specific organisms containing potentially important natural products. For example, if the sea anemone *Metridium exilis* proves to have valuable natural products, harvest and culturing efforts in the Santa Barbara Channel would be limited to Platform Gail as this is the only platform known to harbor this species. Likewise, the distribution of the encrusting bryozoan, *Hippodiplosia insculpta*, is limited to Platforms Grace and Gilda. In contrast, if the anemones *Metridium senile* and *Corynactis californica* are of interest, several different platforms could serve as sources for these species. Sponges could also be harvested from several of the platforms.

<u>*Recruitment Studies*</u>

To investigate temporal and spatial patterns of recruitment of selected invertebrate taxa, we have deployed two types of substrates; hard substrates (ceramic tiles) and soft, fibrous substrates (dish scrub pads; Tuffy®). The use of both tiles and Tuffys® allows us to assess recruitment of a wide variety of invertebrates, as some species like to settle on hard substrates (e.g., encrusting bryozoans, tunicates, sponges, barnacles) while others like to settle on more fibrous (filamentous) substrates (e.g., branching bryozoans, bivalves). To conduct these studies we have used an "experimental module" consisting of a PVC frame with two tiles attached to the top and bottom of the inside of the frame and a mesh cage containing 3 Tuffys® attached to outside bottom of the frame. A mesh cage containing mussels is also included in the inside, center of the frame for growth studies (see next section). Four modules were deployed at each platform at a depth of approximately 15m. The modules were deployed and retrieved approximately every 90 days, with recruitment cages with Tuffys® changed approximately every 45 days. Recruitment of selected taxa on the tiles is measured as percent cover using point contact methods and in the Tuffys® as individual counts.

Preliminary results indicate there were significant spatial and temporal differences in recruitment of several taxa. For example, recruitment of barnacles (predominantly *Balanus trigonus*, but also including *Megabalanus californicus*, *B. pacificus* and *B. regulis*) varied significantly among platforms during Summer 2001, with more recruits occurring at the southeastern platforms (Gina and Gail) than at the northwestern platforms (Hogan, Houchin, Holly) (Fig. 4). Recruitment of hydroids, in particular *Plumaria* sp., also varied during that period (Fig. 5). However, higher recruitment of hydroids occurred at the northwestern platforms as compared with the southeastern platforms. The distribution of tunicates in Summer 2001 also varied and was quite spatially limited in comparison to other taxa as recruits were only found at two of the seven platforms (Fig. 6). Temporal variation in recruitment was also exhibited by many taxa, appearing seasonal for some species, and continuous for others. In particular, hydroid recruitment was restricted to a single time of year (Fig. 5). Barnacle recruitment varied temporally at some platforms (e.g., Hogan, Gilda) and was more continuous at others (e.g., Gina, Gail) (Fig. 4).

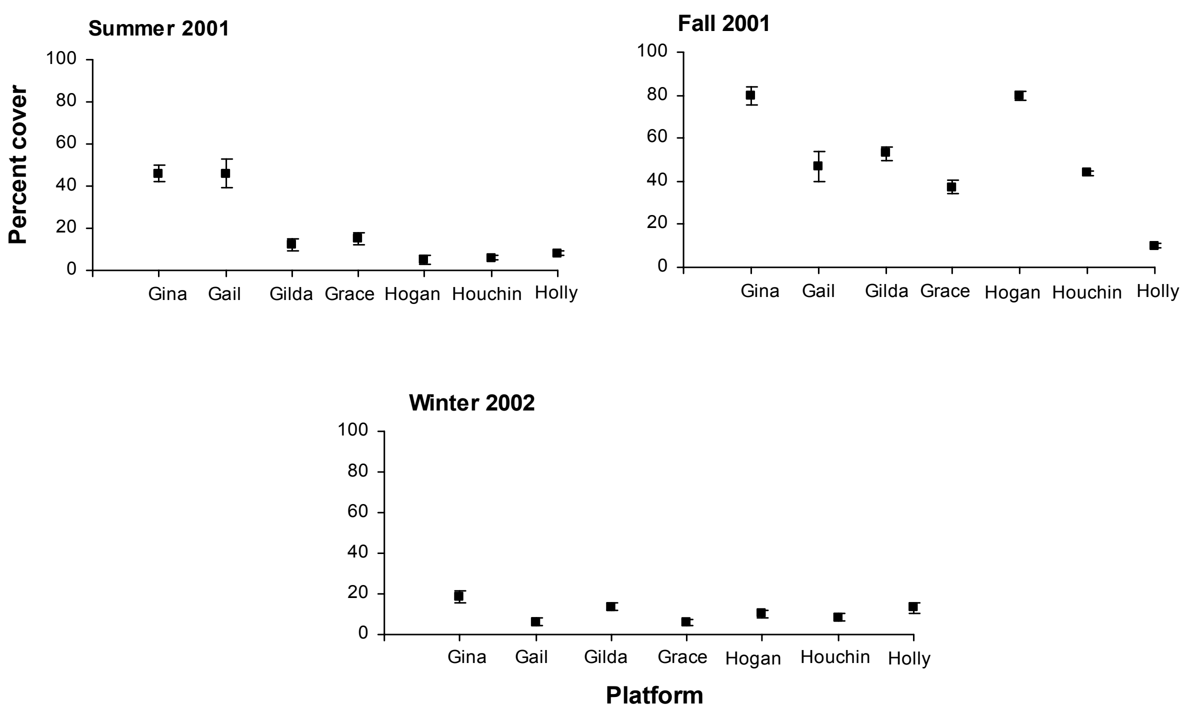

Figure 4. Recruitment of barnacles at seven oil and gas platforms in the Santa Barbara Channel.

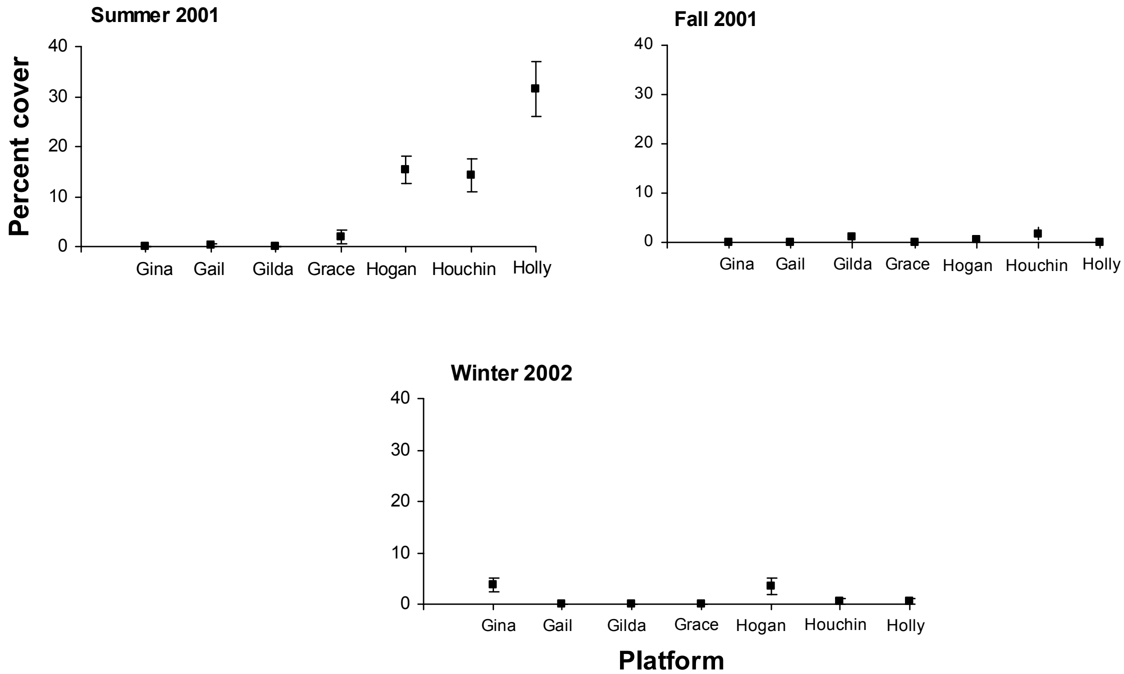

Figure 5. Recruitment of hydroids at seven oil and gas platforms in the Santa Barbara Channel.

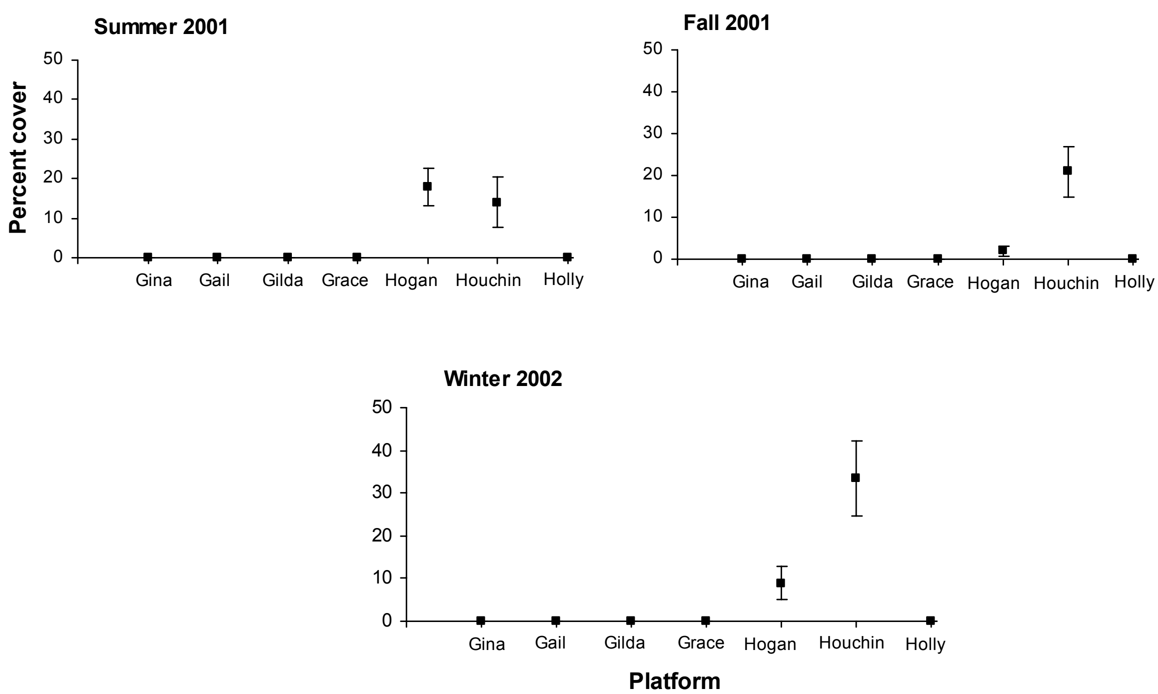

Figure 6. Recruitment of tunicates at seven oil and gas platforms in the Santa Barbara Channel.

Results from our recruitment studies will help in the evaluation of which platforms may provide sustainable sources of invertebrate species containing natural products of interest. For example, if hydroids are found to contain important natural products, harvesting and culturing efforts of such organisms should be directed at the northwestern platforms. Further, efficient collections of start-up cultures could exploit periods of high recruitment (e.g., summer months). In addition, if platforms are to be used for offshore culture of the organism of interest, platforms with high barnacle recruitment would need to be avoided as gear would likely become fouled without the use of effective barnacle control techniques.

<u>*Growth Studies*</u>

In addition to evaluating recruitment dynamics at the platforms, we are also assessing spatial and temporal patterns of growth of the mussel, *Mytilus galloprovincialis*. Most of the platform-associated sessile invertebrates are suspension-feeders, including those that may contain promising natural products. Thus, we are using *M. galloprovincialis* as a model suspension feeder to determine which platforms provide the best growing conditions for filter feeding organisms. We placed 10 mussels of small size (30 mm) in each of four mesh cages attached to the experimental modules (see previous section for details). Because mussel growth is greatly reduced upon reaching maturity, new cohorts of small mussels were deployed approximately every 90 days. After approximately 90 days, mussels were measured and growth rates calculated and compared among platforms.

Mussel growth rates varied significantly among platforms during the summer 2001, with faster growth occurring at the southeastern platforms (Fig. 7). In contrast, mussel growth rates were not different among platforms during the fall 2001 or winter 2002. Further, mussel growth was slower during the fall and winter than in the summer at all platforms. Overall, these results indicate that the four most southeastern platforms provide slightly more favorable growing conditions for suspension-feeders, due to the higher summer growth rates. Results from our spring experiment will further our understanding of how variable growing conditions may be among platforms throughout the year.

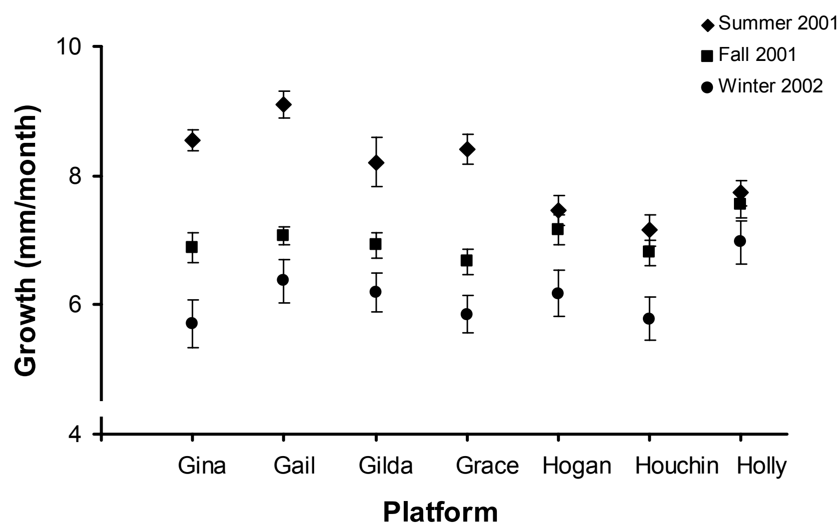

Figure 7. Growth of *Mytilus galloprovincialis* at seven oil and gas platforms in the Santa Barbara Channel.

<u>*Future Plans*</u>

Over the next 3 months we will continue analyzing the data from the photoquadrats to compare species composition and abundance at our seven OCS study sites. In addition, we will conclude our studies of recruitment and growth, and analyze the data. Relationships between recruitment dynamics and the distribution and abundance of invertebrate assemblages at the platforms will also be evaluated. Upon determining patterns associated with the population dynamics of platform-associated invertebrates, we will also explore the potential influence of oceanographic conditions on these processes. In particular, we will investigate whether such patterns are associated with temperature or chlorophyll regimes in the Santa Barbara Channel. These results will be part of a manuscript for publication. In addition to contributing to the general understanding of the distribution, abundance and dynamics of invertebrates inhabiting the platforms, our results will also be useful for evaluating some of the options for the decommissioning of the platforms. In particular, we will be able to evaluate the importance of each of the seven platforms as potential aquaculture sites by determining which, if any, provide favorable growing conditions for, and/or sustainable populations of, species of interest. In addition, we will be able to assess the quality of the seven platforms as reef habitat by determining if any of them may act as major larval sources for certain species. While our results will not provide definitive data regarding larval source issues, it will be useful for identifying sites with large populations of various species. This information could be especially important for those species that are uncommon on natural reefs.

GENETICS:

The development of marine biotechnology is not only dependent on the identification of useful compounds that organisms produce**,** but also on the accurate identification of the organisms which produce them. Without accurate identification, sampling of individuals may result in variable yields of target compounds or worse, no yield at all.

Currently, we are conducting studies to determine the population genetic variation in a bryozoan, *Bugula neritina,* on offshore oil platforms in the Santa Barbara Channel. There were three primary goals for the genetic component of our research. The first goal was to identify the forms of *B. neritina* growing on OCS oil platforms. Previously, Davidson & Haygood (1999) showed that though *Bugula neritina* had been thought to be a single cosmopolitan species, it actually consists of two cryptic species, one that occurs primarily at shallow depths and one that occurs primarily at deeper depths. In addition, only one of these species (*Bugula neritina*-deep) produces the potential anti-cancer compound bryostatin I. Furthermore, each of these two species harbors bacterial symbionts which are genetically distinct from each other. It is thought that the bacterial symbiont may actually be the source of the anticancer compound (Davidson *et al.* 2001). Our second goal was to assess the genetic diversity of the Bryostatin 1 containing species of *B. neritina* on OCS oil platform. Our third goal was to determine the genetic diversity of *B. neritina* on natural reefs and to determine if we could identify likely source populations for the populations that have colonized OCS oil platforms.

Using a restriction site difference in the COI gene of the mitochondrial DNA (mtDNA), we have assayed samples of *Bugula neritina* from three OCS platforms at depths ranging from 20-60 ft. All of these samples matched the restriction enzyme pattern produced by *B. neritina*-deep. Furthermore, using a restriction site difference of the SSU rDNA region we have also determined that all of these samples contain the bacterial symbiont identified by Davidson & Haygood (1999). Thus, to date, we have only found *B. neritina*-deep with its bacterial symbiont on OCS platforms (which is the source of the anticancer compound bryostatin I).

Because different populations of *Bugula neritina* contain different bryostatins (Davidson & Haygood 1999) we are seeking to determine the scale of genetic differentiation among *B. neritina*-deep populations. We first sequenced the COI region of the mtDNA to determine if there is variation in this region to assess population differentiation. Unfortunately, we have found COI to be invariable in *B. neritina*-deep as did Davidson & Haygood (1999). Thus, we are now developing additional markers that are more likely to be genetically variable. First, we are PCR amplifying and sequencing additional regions of the mtDNA. We have successfully amplified approximately 500 bp of the cytochrome oxidase b (cytb) gene. Cytb is often used to assess genetic diversity at the interpopulation level (Avise 1994). To amplify this region we have used the primers cobF and cobR.

We have also successfully amplified a 1.4 kb fragment between the COI gene and the 16S rDNA gene. To do this, we designed specific primers to the COI and the 16S rDNA genes using gene sequences found in GeneBank. As yet, we do not know which, if any, genes occur in the region between the COI gene and the LSU rDNA gene. This is because no complete sequence of mtDNA has been made for any bryozoan to date and thus we do not have a basis to predict the order of genes in the mtDNA for this species. Once we sequence the cytb PCR product we plan to design specific primers to this region as well and to see if we can amplify segments of the mtDNA between it and the other mtDNA regions for which we have sequence information. In this manner, we will likely identify regions of mtDNA that contain higher levels of sequence variation than that found in the genes examined thus far. We are also preparing to develop microsatellite markers for *B. neritina*-deep. As noted above, microsatellites are often highly variable within species and therefore provide excellent discrimination among populations.

In anticipation of developing population-level genetic markers, we are collecting and preparing population samples of *Bugula neritina*-deep from both OCS platforms and nearby natural reefs. Our goal is to have between 20 and 30 samples from each OCS platform where *B. neritina* is found and similar sample sizes from natural reefs along the Santa Barbara Co. coastline as well as the Northern Channel Islands. We now have the requisite samples from OCS oil-platforms Houchin and Hogan. We also have collected samples from platform Holly. From natural reefs we have collected samples from four locations along the mainland coastline (Arroyo Burro, Loon Point, Mohawk and UCSB). In addition we have collected samples from two sites at Anacapa Island and several from Santa Cruz Island. Additional trips to these sites should provide us with the necessary sample sizes to answer questions 2 & 3 above.

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PHARMACOLOGY:

Marine organisms that inhabit the subtidal structures of offshore oil production platforms are a potential source of novel compounds for pharmaceutical use. These organisms provide an unparalleled opportunity to study natural product chemistry from populations of organisms living in ecologically unique habitats. Research has shown that growth rates of certain invertebrate species living in the platform community can be quite high (Page, 1986; Page and Hubbard, 1987). As well, the platform community supports many encrusting and soft-bodied organisms, which rely on rapid growth rates, alleopathic effects, and chemical warfare to compete for space in the habitat and avoid predation. Such habitat characteristics (as in the example of coral reefs) have been shown to sustain many organisms that produce compounds with potential pharmaceutical application (Look *et al*, 1986; Jacobson and Jacobs, 1992, 1992). This project will focus on the study of natural products from sea anemones and algae living on the intertidal and subtidal portions of off shore oil production OCS (outer continental shelf) platforms in the Santa Barbara Channel.

<u>Anthozoans</u>

Sea anemones are sessile, soft-bodied members of the phylum Cnideria and class Anthozoa. In coastal Santa Barbara, they inhabit shallow intertidal zone areas, as well as the intertidal and subtidal zones of oil rigs and pier pilings. Sea anemones have been a source of interesting natural toxins including neurotoxic and cardiotoxic peptides (Bruhn *et al*. 2000), and cytolysins (Pederzolli *et al*. 2001). Most sea anemones contain symbiotic dinoflagellates in their gastroepidermal tissue. These symbionts aid in nourishing the anemone by translocating lipids to the host. Recent discoveries in our laboratory have shown that dinoflagellate symbionts have biosynthetic capabilities to produce bioactive natural products.

Several genera of anemones inhabit the OCS oil platforms. *Anthropleura*, a symbiont-containing anemone, is found on several of the platforms. The asymbiotic anemones such as *Epiactus irregularis*, and *Corynactis californica* are also found on several platforms while *Metridium exiles* is found solely on platform Gail. The goals of this project are 1) to collect and identify all genus and species of anemones from the OCS platforms, 2) to determine the presence of and identify dinoflagellate symbionts, and 3) to prepare extracts of the asymbiotic anemones, anemone tissue, and symbiotic algae, and test these extracts for biological activity.

<u>Chlorophytes</u>

One group of natural products we focused on were the coumarins. The coumarins, members of a large family of structurally related compounds that occur widely in terrestrial plants, have only recently been observed in marine algae. Menzel *et al* (1983) first discovered the presence of 3,6,7-trihydroxycoumarin in the green algae, *Dasycladus vermicularis*. The genus *Dasycladus* belongs to the order Dasycladales, a group of primitive marine unicellular green algae that are members of the kingdom Protoctista (Bonotto, 1988; Floyd and O'Kelly, 1990). We have successfully isolated semi-pure extracts containing the 3,6,7-trihydroxycoumarin compound in *Batophora oerstedii*, a species of the same family indigenous to the gulf coast. *Batophora oerstedii* has also been found to grow abundantly on several oilrigs in the Gulf of Mexico. In view of the relative simplicity of the coumarin molecules thus far reported in green algae and our recent discovery that these compounds inhibit mitosis, suppress microtubule dynamics, and potentiate taxol. We invested a significant portion of our effort to define the mode of action of dicoumarol, a model pharmacophore, at the molecular level as a prelude screening for new species of courmarins in marine algae.

Collection and Identification of Anthozoan and Algae specimens

After initial reconnaissance work, the collection of target anemone species was performed. These collections might include the same species from more than one platform or from different microhabitats within same platform. The location of collected species will be mapped. Species will be identified, numbered, and archived. Unidentified species will be sent to taxonomic specialists for identification. Specimens will be collected from the platforms, identified and immediately flash frozen. Symbiotic dinoflagellate will be removed by established methods and DNA samples will be taken for identification. Each specimen will be vouched and a sample preserved for positive identification. This includes the date of the collection the actual location, and the depth and other relevant information including water temperature and salinity. A portion of the voucher will be frozen and become a permanent part of the UCSB viable collection. The other part will be stored in 10% formalin for permanent storage at the Santa Barbara Museum of Natural History.

Anthozoans

Extracts of the sea anemone *Metridium exiles* were prepared and tested in the sea urchin embryo assay. The crude organic extract was active in inhibiting the first cleavage of sea urchin embryos division in a concentration dependant manner with 50% inhibition occurring at approximately 118 ug/ml (Fig. 1). The organic extract was also examined for the ability to inhibit proliferation in the human lung cancer cell line, A549, and found to be highly active. The extract inhibited cell proliferation in a concentration dependant manner with 50% inhibition occurring at 23 ug/ml (Fig. 2).

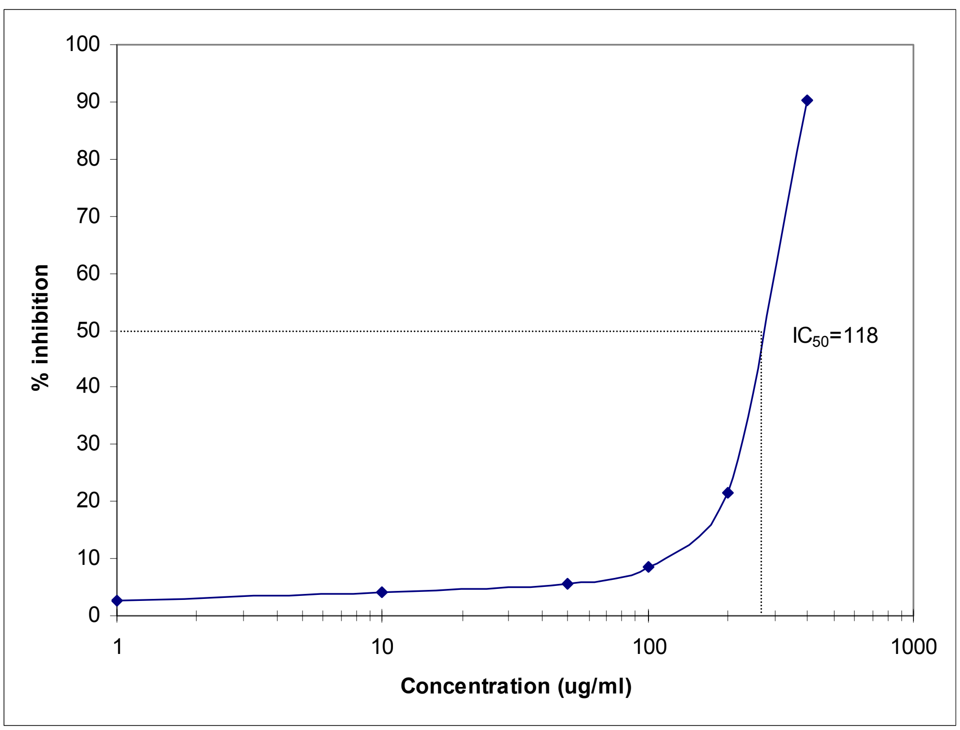


Figure 1: Concentration dependent inhibition of sea urchin embryo division by *Metridium exiles* extract.

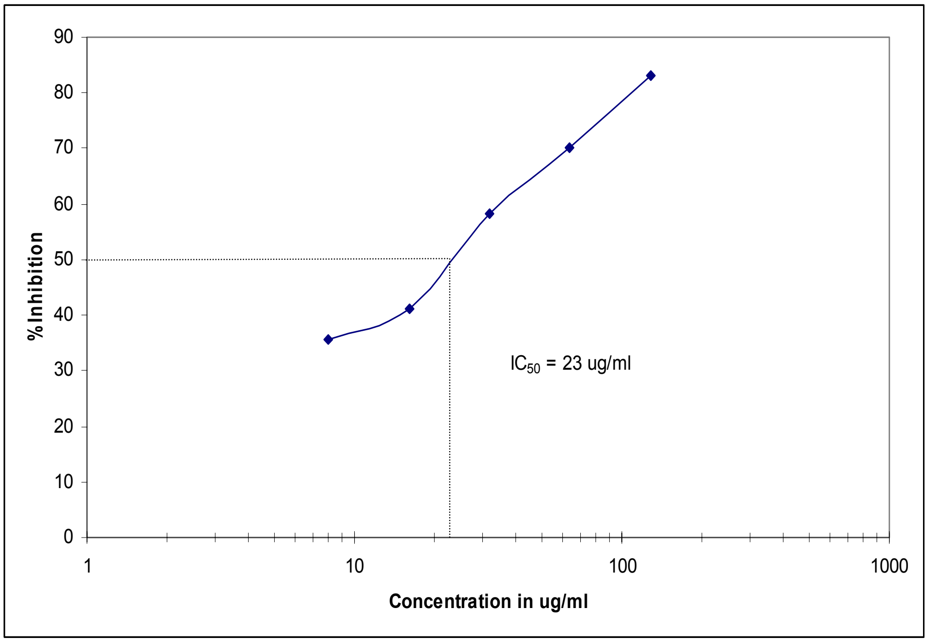


Figure 2: Concentration dependent inhibition of A439 lung cancer cell proliferation by *Metridium exiles* extract.

Chlorophytes

In studies on the anti-mitotic actions of coumarin compounds, we initially discovered that dicoumarol (a coumarin anticoagulant chemically designated as 3,3'-methylenebis [4-hydroxycoumarin]) inhibits the first cleavage of S. *purpuratus* (sea urchin) embryos in a concentration dependent manner, with 50% inhibition occurring at approximately 10 μM drug (Fig. 3).

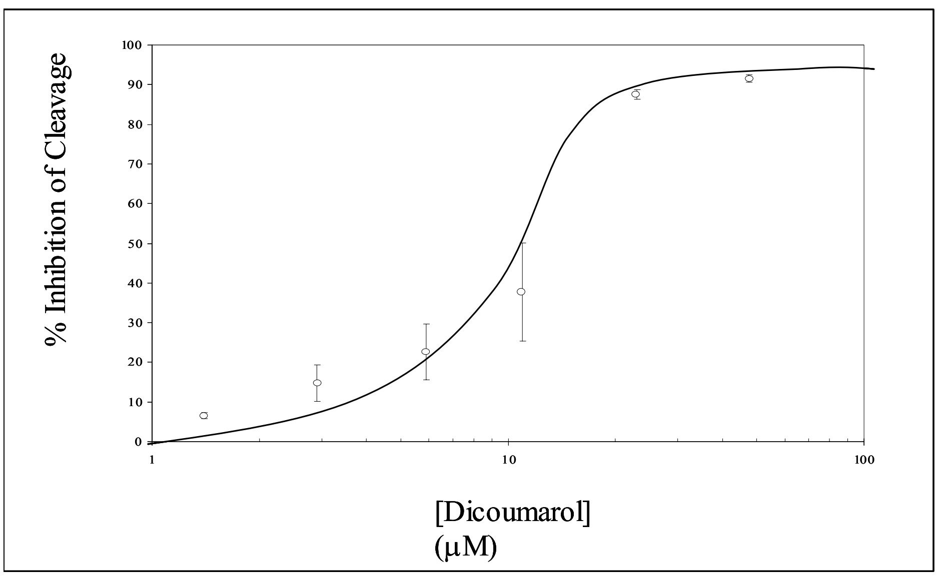
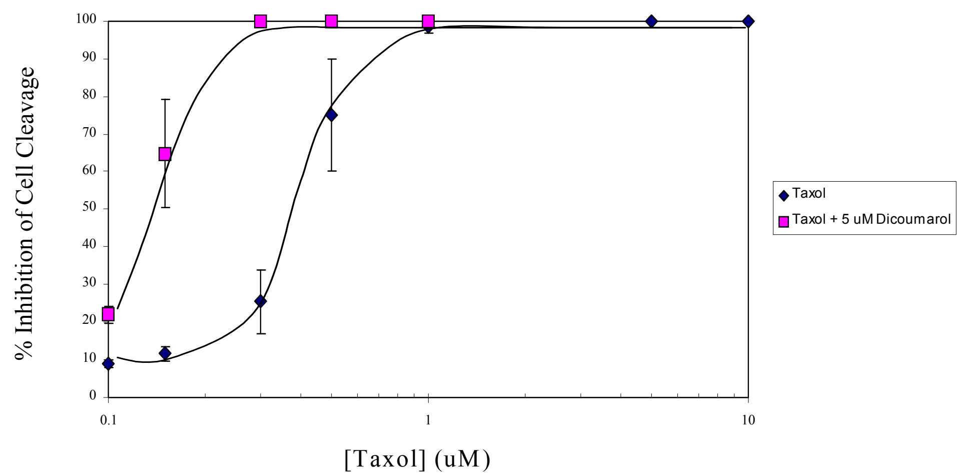


Figure 3: Concentration dependent inhibition curve of sea urchin embryo division by *Metridium exiles* extract.

Because the sea urchin assay is highly selective for agents that are targeted to tubulin and microtubules, we reasoned that the active compounds might inhibit cell division by interfering with the polymerization or dynamics of the mitotic spindles. By video microscopy, we did indeed find that dicoumarol (1 μM) suppresses the growing and shortening dynamics of bovine brain microtubules at plus ends *in vitro* at concentrations substantially below those required to perturb microtubule polymer mass, an action typical of a number of important antimitotic anticancer drugs including taxol and vincristine. Dicoumarol reduced the rate and extent of shortening, it increased the percentage of time the microtubules spent in an attenuated (paused) state, and it reduced the overall dynamicity of the microtubules. Using fluorescent spectroscopy, we determined that dicoumarol binds directly to tubulin dimers *in vitro* with a moderately high affinity (Kd, 23 μM). These results suggest that coumarins, such as dicoumarol, possess a unique anti-proliferative mechanism of action and possibly related pharmacophores are mediated by tubulin binding and the kinetic stabilization of spindle microtubule dynamics. We believe the coumarin pharmacophore may represent an attractive one for development of new drugs for cancer treatment. We recently demonstrated that taxol inhibition of sea urchin embryo division is potentiated by low concentrations of dicoumarol (Fig. 4).

A



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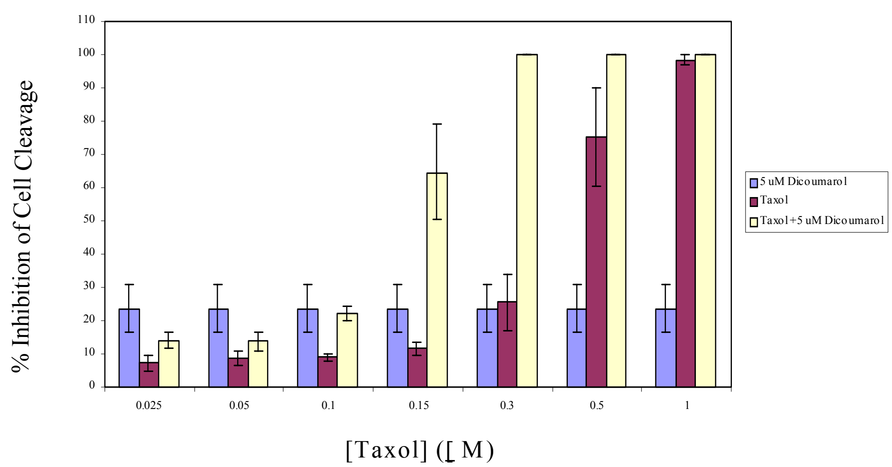

Figure. 4. Synergy between Taxol and dicoumarol. The combination of Taxol with dicoumarol decreases the concentration of Taxol required to induce 50% inhibition of cell proliferation in the sea urchin cell division assay. The results are expressed as the percentage of inhibition compared with vehicle; bars, SE.

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Task No. 17610: *Industrial Activity and Its Socioeconomic Impacts: Oil and Three Coastal California Counties (A Product of the Joint UCSB-MMS Pacific OCS Student Internship and Trainee Program)*

Principal Investigators: Jenifer Dugan, Marine Science Institute, University of California, Santa Barbara, CA 93106-6150 and **Edward Keller**, Environmental Studies and Geological Sciences Departments, University of California, Santa Barbara, CA 93106-9630

Collaborating Scientist: Michael R. Adamson, Marine Science Institute, University of California, Santa Barbara, CA 93106-9610

Summary of Research

Progress during 2001-2002

Analyses and writing culminated in a DRAFT of the final report, which was submitted in January 2002. In addition, a manuscript stemming from this research was published during the 2001-2001 fiscal year.

Task No. 17611: *Simulation of a Subsurface Oil Spill by a Hydrocarbon Seep (SSOS-HYS)* and
Task No. 18211: *Oil Slicks in the Ocean: Predicting their Release Points Using the Natural Laboratory of the Santa Barbara Channel*

Principal Investigators: Jordan Clark, Department of Geological Sciences, University of California, Santa Barbara, CA 93106-9630; **Bruce Luyendyk**, Department of Geological Sciences, University of California, Santa Barbara, CA 93106-9630 and **Ira Leifer,** Institute of Crustal Studies, University of California, Santa Barbara, CA 93106-1100

Summary of Research

Progress during 2000-2001

Our approach has been to use divers to collect high resolution (1 m) horizontal sampling of dissolved and bubble and dissolved gas composition, bubble size distribution, and fluid motions at various depths (usually four) spanning the sea floor to the sea surface. Bubble gas and water samples are collected and analyzed by gas chromatography and spectrofluorometry. Bubble size distributions are determined from video images, and fluid motions are determined from dye tracer releases. Recently, we have begun sampling dissolved methane outside of the seep bubble plume to quantify the exchange rate between the plume and bulk ocean.

Significant progress has been made in understanding seep processes, some of which is described in this section. The near surface plume water was discovered to be saturated with CH_4, and exhibited strong upwelling flows. These flows had a large impact on small bubble survivability. A dissolved oil plume was identified by fluorometry. Bubble gas composition showed an increasing enhancement with alkane size, and a decrease in CH_4 at the surface for deeper seeps. The bubble distribution peaked at ~2500 µm radius, and was consistent with sensitivity studies showing that the observed alkane enhancement requires 3000-µm bubbles to dominate gas transfer.

1. Dissolved methane and higher alkanes

Aqueous methane, CH_4, concentrations near the surface in the bubble plumes have been found to be substantially greater (>10^8 times) than atmospheric equilibrium values. At three of the four seeps sampled, CH_4 near the surface was slightly supersaturated with respect to the bubble's partial pressure (Leifer et al., 2000a). Thus the rate limiting step for CH_4 dissolution into the water column was not bubble gas transfer, but rather mixing (by advection and diffusion) between the saturated bubble plume water and the bulk ocean. At the sea floor, bubbles are about 90% CH_4 and 10% higher hydrocarbons while at the surface of the deeper seeps (65 m) they are about 60% CH_4 , 30% air, and 10% higher hydrocarbons. The decrease in CH_4 at a shallow seep (20 m) was much less; the surface composition was about 70% CH_4, 15% air, and 15% higher hydrocarbons. For alkanes heavier than CH_4 (i.e., crosses on Fig. 1), the ratio of the surface to sea floor mole fraction showed a linear enhancement (see Fig. 1) with increasing alkane number. CH_4 behaved differently because the water column was saturated with CH_4.

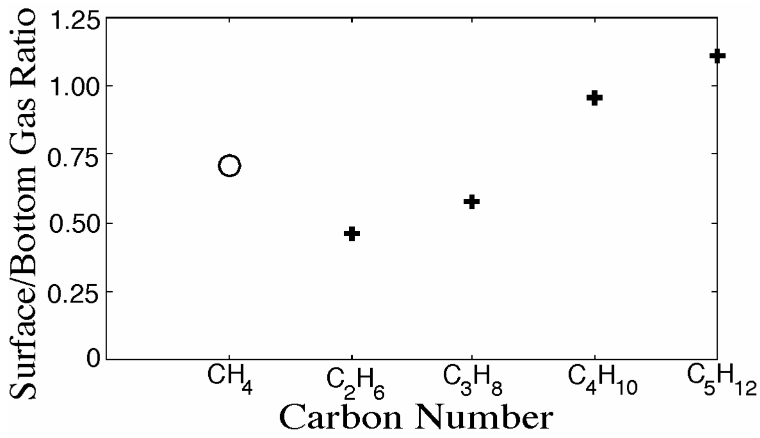

Figure 1: Alkane ratio from sea floor to sea surface for Seep Tent seep (34° 53.35' N, 119° 23.05' W) bubble gas.

2. Dissolved oils

Preliminary investigations have shown that spectrofluorometry can be used to investigate oil dissolution from the bubble plume. Water samples were obtained in a horizontal transect under the seep surface expression at a depth of 1 m for fluorometric and gas chromatographic (GC) analysis. The features of the surface expression of the seep are shown in Fig. 2a. The current was towards the north, while the transect line was cross current (east to west). Within this surface expression, there were three different regions, the central upwelling area where most bubbles surfaced, an outwelling region where flow from the central region dominated, and an outer region where oil slicks were visible.

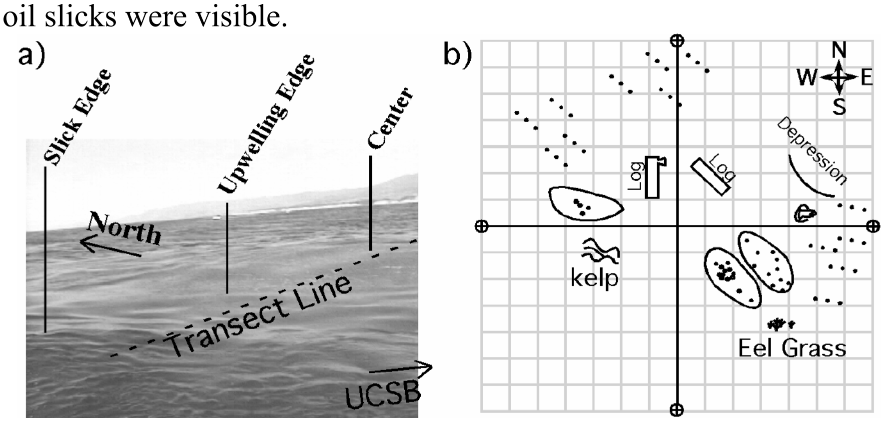

Figure 2: Shane Seep (34°24.37’ N, 119° 53.41’ W) surface expression showing features and sampling transect (a), and sea floor map at 20 m depth (b). Squares in (b) are is 1 m by 1 m and dots represent seafloor vents.

Transitions between these regions are marked on Fig. 2a. There were two strong bubble plumes in the central region, presumably one for each of the large sea floor vents - located in mud volcanoes. A sea floor map of the major Shane Seep features is shown in Fig. 2b. Preliminary spectrofluorometry results are shown in Fig. 3. Excitation was at 337 nm, emission was integrated over 350 - 600 nm, and values are normalized to quinine sulfate. Spectra showed clear oil signatures. Using GC analysis of collected oil from the sediment, these values will be ground truthed to provide dissolved oil components. The transect (shown in Fig. 2a) was cross current, and the surface slick features corresponding to Fig. 2a are indicated on Fig. 3a. The 0 m coordinate is centered in one of the bubble plumes. Between the two bubble plumes was a surface convergence zone (+2 m) that showed a local fluorescence maxima. The highest fluorescence was located under the visible surface slick (-10 m), while the lowest was in the center (+3 m). This trend was also observed at 15 m (Fig. 3b), and is consistent with "pulling" by the strong current of dissolved oil out of the bubble plume.

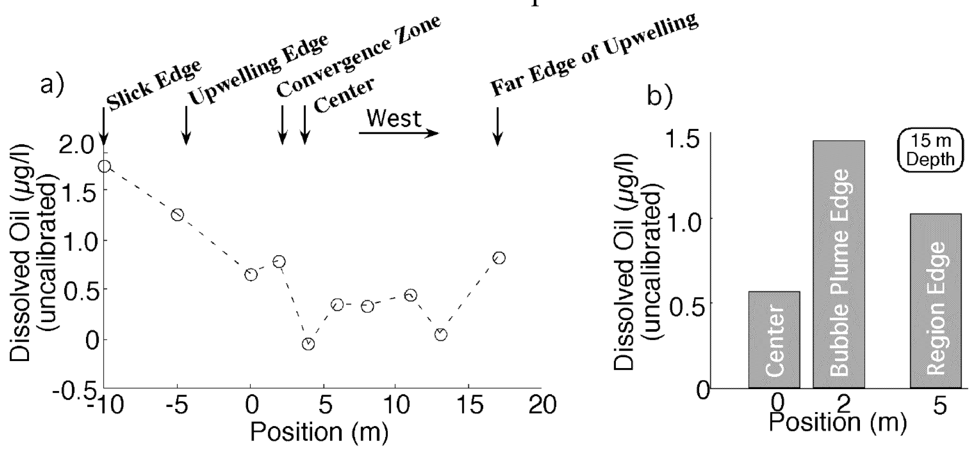

Figure 3: Plot of excitation-emission fluorescence, normalized to quinine sulfate with background subtracted, for 1 m depth (a) and 15 m depth (b) for Shane Seep.

3. Bubble observations

Under current MMS funded research, a seep Bubble Measurement System (BMS) was designed and constructed. A schematic of the design is shown in Fig. 4. Images of a pool test of the BMS are shown in Fig. 5. Lights, screen and camera are all mounted on an adjustable rail. Bubble blockers are used to prevent the bubble density from being too high in the field of view, to ensure that bubbles are all at a known (i.e., calibrated) distance, and to ensure that the view is not obscured by blurry bubbles too close to the camera. Illumination is by backlighting through a diffuser screen. This BMS design also allows the camera and lights to be easily rotated to view the overall seep, or to look at fluid motions within the bubble stream.

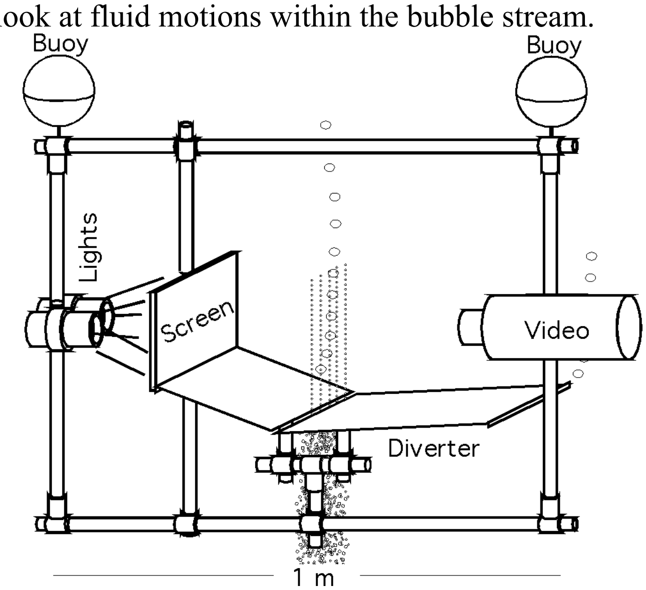

Fig. 4. Schematic of open Bubble Measurement System.

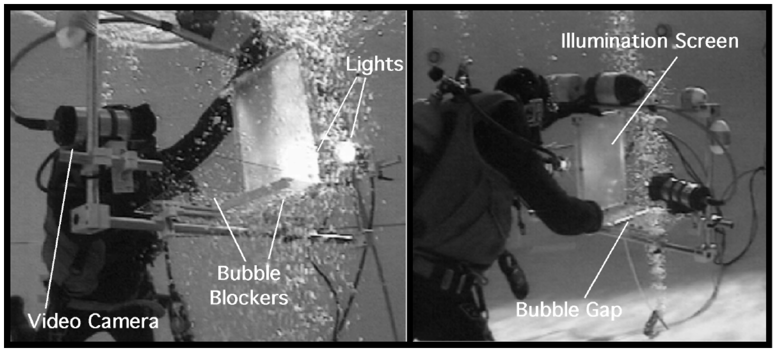

Fig. 5. Pool test of the seep Bubble Measurement System.

Near surface images from Shane Seep (see Fig. 6a) were digitized and analyzed to determine the size distribution, Φ (Fig. 6b), defined as the number of bubbles per size increment (1 μm) in the entire measurement field. Φ shows a relatively broad peak centered at 2500 μm. Minimum resolution for this optical setting was circa 1500 μm. A power law was fit to Φ for r > 3000 μm, where r is bubble radius, and showed a steep decrease with $\Phi \sim r^{-3.1}$. Total seep gas in this image is ~7 cm^3. Φ can be converted to a mass flux by determining the vertical velocity, $V_Z(r)$, which is the sum of the upwelling flow and bubble buoyancy and scaling to the plume cross section. This method was used by Leifer and MacDonald (2001) to estimate seep bubble flux in the Gulf of Mexico.

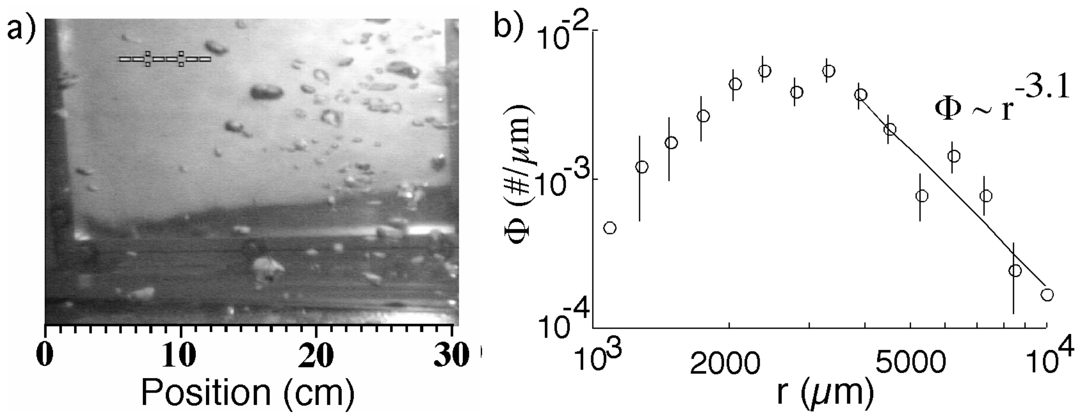

Fig. 6. Image of bubbles from Shane Seep (a) and bubble size distribution, Φ, as a function of radius, r.(b).

Significant problems were encountered at the surface using the BMS shown in Fig. 5 due to strong currents which sometimes caused the bubbles to drift towards (or away from) the camera, changing their apparent size. In addition, sunlight interfered with the backlighting scheme, preventing automated analysis of the images. A second, closed BMS was designed and constructed and is shown schematically in Fig. 7. A gap at the bottom can be adjusted narrower, and camera, lights, and screen can all be adjusted on a moving rail. The closed BMS has the advantage that light from the surface is blocked, as are currents. This system was deployed at Shane Seep on June 26, 2001, and bubble images were recorded from the bottom to the surface in 5 m intervals. An image at the surface is shown in Fig. 8.

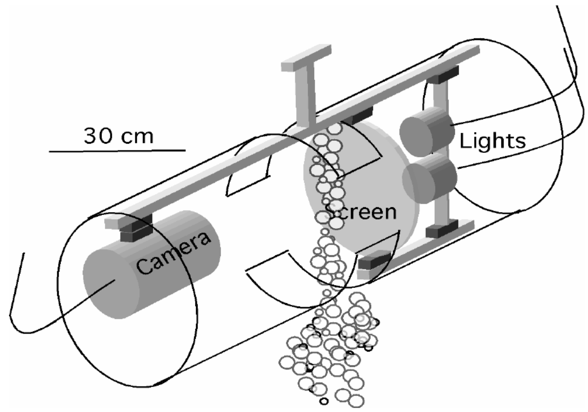

Fig. 7. Schematic of closed seep Bubble Measurement System (BMS).

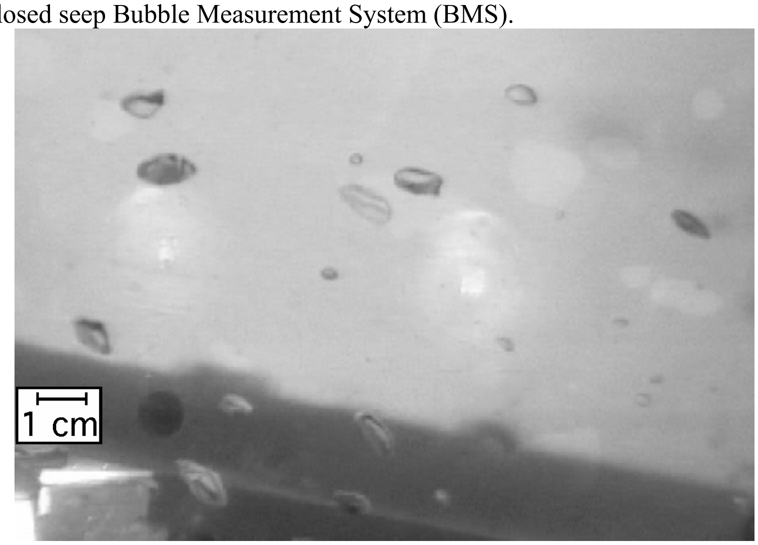

Fig. 8. Image of bubbles from Shane Seep using the closed BMS.

4. Fluid motions and bubble plume/ocean interaction

Strong upwelling velocities were observed at larger seeps and all showed surface divergence. Dye released at La Goleta Seep rose at circa 30 cm/s, while at both Shane Seep and the Seep Tent Seep, vertical rise was in excess of 1 m/s, and very unsteady. Our present research is addressing not only bubble plume dynamics and geochemistry but also ocean-bubble plume interactions. For example, saturation of the bubble plume water is very important to the bubble dissolution rate (i.e., survivability). Thus, the exchange rate between the bubble plume and the bulk ocean (that is significantly undersaturated with respect to the bubbles) is critical for determining the fraction that dissolves during transit. Dye was released at the bottom of Shane Seep and observed to rise the 22 m depth in 54 s, or 41 cm/s. During the dye release, the dye initially spread out into a cloud ten meters or so in diameter; however, over the subsequent minute, all of the dye was entrained and arrived at the surface.

5. Numerical bubble model

An existing bubble model (*Leifer and Patro*, 2001) has been modified for application to the hydrocarbon seeps in the Santa Barbara channel. This model has been used for sensitivity studies on data collected in the Santa Barbara Channel. The model solves the differential equations describing the time evolution of the bubble molar content of major (air and CH_4) and trace gases (carbon dioxide, alkanes, etc.), *r*, and position (depth). Each bubble size class is initialized at the sea floor with observed partial pressures and allowed to rise due to buoyancy and upwelling flows. Numerical integration is by a third-fourth order Runge-Kutta routine with variable step size and is terminated when the bubble reaches the surface or dissolves to 5-µm radius. Each bubbles size class is individually simulated and is combined with the size flux distribution (i.e., the number of bubbles of each size emitted per second) to calculate total flux of each gas. The model then calculates the gas flux (methane, alkanes) into the water column at each depth, and to the atmosphere.

A bubble tends to grow due to air inflow and changes in hydrostatic pressure while it tends to dissolve due to outflow of CH_4 and other hydrocarbons. Whether the bubble dissolves or not depends upon the balance between these two processes. Because oil collects at the bubbles' gas-water interface and is entrained in the upwelling flow, the model can calculate the oil flux and whether or not the oil is “deposited” in subsurface layers.

Bubble model predictions are strongly influenced by the rise speed, V_B, and gas transfer, k_{Bub}, parameterizations, which are strongly dependent upon bubble size, oiliness, and water temperature. Parameterizations are based upon a combination of field observations, laboratory experiments, and best estimates from the literature. Gas kinetics (solubility and diffusivity) are based on the literature (e.g., *Waninkhof*, 1992; *Sander*, 2000), although several are largely unknown, and require laboratory investigations.

Regarding fluid motions, the model allows specification of a 2D flow field which can include complex motion generated by the rising bubbles (upwelling flow), waves orbital motions, turbulence, and Langmuir cells. Currently, the model is not fully 2D; bubbles are assumed to originate from a single source, and can move in 2D due to the flow field, However, the 2D position and gas fluxes are not stored; model output consists of only the overall gas fluxes at each depth. Needed model improvements include 2D storage of all variables, incorporation of mixing with the ocean (turbulence and advection due to currents) and calculation of the bubble plume induced fluid motions, and are described in Section 3.5.

Sensitivity studies

Using this model, sensitivity of bubble-mediated CH_4 transport to ambient conditions was studied. Strong sensitivities to aqueous CH_4 saturation, upwelling flows (*Leifer and Patro*, 2001), and oil contamination were identified. Subsequent field data collected as part of the current MMS project discovered and quantified these parameters (*Leifer et al.*, 2000a; *Leifer and Clark,* 2001).

The model investigated alkane transport to the surface for La Goleta Seep (34° 52.44' N, 119° 23.65' W), for two upwelling flows, V_{up} = 10 and 30 cm/s. Dissolved CH_4 was 0.9 Atm, small bubbles were assumed contaminated, large bubbles clean. The predicted surface *r* is shown in Fig. 9. For V_{up} = 10 cm s^{-1} (Fig. 9a), a 2000-µm bubble reaches the surface with *r* ~ 2000 µm, while a 900-µm bubble reaches the surface with *r* ~ 300 µm. Stronger upwelling (Fig. 9b) causes less bubble dissolution (bubbles are subsurface for a shorter time). These two sensitivity studies show a strong sensitivity of bubble survivability to V_{up}. In one scenario a 500-µm bubble dissolves, depositing its oil subsurface. In the other it doesn’t.

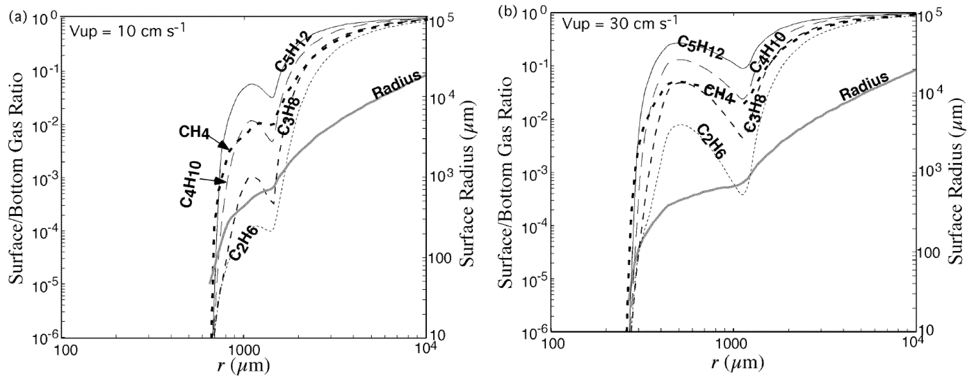

Fig. 9 Sensitivity results showing predicted ratio of bubble alkane molar content at surface to sea floor versus initial bubble radius, *r* for (a) upwelling flow, V_{up}, of 10 cm s^{-1}, and (b) 30 cm s^{-1}. Also shown is the surface *r* on the right vertical axis. Data key on plot.

Also shown in Fig. 9 is the surface/bottom ratios for alkanes to pentane. For all bubbles, the ratio increases with alkane number, except for CH_4, which behaves differently due to its saturation of the water column. The relative enhancement of heavier versus lighter alkanes is greatest for bubbles that dissolved slightly, and least for the largest bubbles (which grow). For the largest bubbles this results from the large volume, i.e., during their ascent to the surface, gas exchange changes the bubble's total mass little. In contrast, when a bubble dissolves, as indicated by a large decrease in CH_4 (e.g., r<800 μm - Fig. 9a), all gases are equally forced from the bubble, and thus there is little enhancement of heavier alkanes. As a result, only a narrow size range can explain observed alkane enhancements (e.g., Fig. 1). In fact, circa 3000-μm bubbles produce a relative enhancement of 2 for pentane versus ethane. For these conditions, bubbles with initial *r* circa 3000 μm must be responsible for most of the gas transport in the plume. Since these bubbles grow only slightly, this agrees with observed surface Φ for La Goleta Seep.

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Progress during 2001-2002

Summary: During the most recent quarter (spring), our efforts have focused on data analysis, writing, with a single field mission, due in large part due to the difficulty of field operations during the winter/spring. Also during this time period, the laboratory was relocated to the Engineering Research Center (ERC) and the new facilities available at the ERC are now being taken advantage of. Results were presented at the AAPG meeting in Vancouver, MMS Pacific office in Camarillo, CA, and UC Santa Cruz. Educational outreach efforts have also continued.

Gas and Liquid measurements:

A technique using an evacuated Teflon bag was successfully tested in the laboratory for sample collection of oil, gas and water from vents at Shane Seep.

Bubble measurements:

Shane seep (34°24.37' N, 119° 53.41' W) consists of numerous small vents, with three or four main vents in three mud volcano like features. Video of the main vents and several smaller vents have been analyzed, and show distinctly different distributions. The main vents have significant bubble breakup and thus flat distributions, outside the main vent, smaller vents produce highly peaked narrow distributions. Near-surface bubble measurements can be related to seabed features…. i.e., the main surface bubble plume has a distinctly different distribution than outside the plume at the surface.

Fluid motions:

Using the dye release technique developed in the fall, dye was successfully released at the seabed and video-recorded by two seabed cameras, a surface camera, and an airplane overflight video camera. Rise time was 28 s to rise 22 m. During the dye release experiment a gas blowout was observed. Flow motions associated with the dye release and blow out videos are being analyzed using digital particle imaging velocimetry to derive the fluid motions, entrainment rate, turbulence generation, etc. Flow entrainment is clearly visible. The upwelled water was clearly observed to outflow at the sea surface and then sink.

Numerical bubble model:

The bubble model was used to simulate Shane seep bubbles. Model simulations showed that showed that the upwelling flow as necessary to correctly predict sea surface bubble size distributions. Furthermore, the model predicted different bubble gas composition at the surface for gas from the main vents and from minor vents due to the different size distributions. In field measurements this summer we will seek to verify the predicted partitioning of gas composition between the main plume and peripheral plume bubbles.

Calibration:

The laboratory has been relocated to the off-campus Engineering Research Center and is now located adjacent to a large 40 m by 5 m by 3 m wind-wave channel. This large pool is being used both for testing of the BMS and other field deployed instruments, as well as for calibration purposes. Bubble plumes are created in the pool and the effect of distance on the apparent bubble size is being investigated. Although bubble blockers limit the distance of the bubble stream, there is an uncertainty of ten to fifteen centimeters. Calibration experiments are being used to determine the error introduced and whether a narrower gap between the bubble blockers is better.

Task No. 18212: *Transport over the Inner-Shelf of the Santa Barbara Channel*

Principal Investigators: Carter Ohlmann, Institute of Computational Earth System Science, University of California, Santa Barbara, CA 93106-3060

Summary of Research

The primary goals of this research are to collect surface current data over the inner-shelf of the Santa Barbara Channel with Pacific Gyre's "Microstar" Lagrangian drifters, and use the data to: identify characteristic features of the flow field such as convergences, divergences and cross shelf transports, determine the surface velocity and velocity variance distributions, examine flow patterns on scales that are too small to be resolved in CODAR current measurements, and investigate how well particle paths determined from Eulerian CODAR fields represent measured Lagrangian flows.

Progress during 2001-2002

An improved drifter for use in the near-shore region has been developed by Mr. Andy Sybrandy (Pacific Gyre Corp), Dr. Carter Ohlmann (UCSB), and Dr. Peter Niiler (SIO). The near-shore, "Microstar", drifters record their position with GPS and transmit the position data in near real-time using the Mobitex™ narrow band, data-only, cellular communications system. Position data is accurate to within ~10 m in the southern California region. Position updates are recorded every few minutes. The spatial resolution and ability to transmit data in near-real time enable the drifters to be recovered and redeployed in a "catch-and-release" manner. Recoverability greatly enhances the economy of an observation program. Most importantly, the drifters utilize a well characterized subsurface drogue so that error due to slip (< 3 cm s^{-1} in moderate wind and sea conditions) can be quantified.

A set of four drifter experiments have been carried out since the inception of this project. On 6 November 2001 a single drifter was deployed alongside a small boat off the Santa Barbara coast to test the drifter communications system. Communications tested successfully. Three drifters were deployed along the 50 m isobath off Naples Point on 1 February 2002 and left to sample for the day. The drifters transmitted accurate continuous position data, with only a few missed GPS updates. A single drifter was placed aboard the *R/V Point Sur* from 19 through 26 February 2002 to test Mobitex™ network coverage. Successful data transmission occurred over the entire Santa Barbara Channel, and even northwest of Point Conception.

Three deployments of up to 18 drifters occurred over the inner shelf off the Santa Barbara coast during the week of 29 April 2002. Conditions ranged from calm to rough, with sustained winds over 12 m s^{-1} and 3-6 foot wind waves at the East Santa Barbara channel NOAA/NWS buoy. Drifters mostly moved west and northwest, opposite the local wind direction. One drifter eventually crossed the Santa Barbara channel. Some drifters suffered occasional data losses due to the inability to receive updated GPS positions. Erroneous positions were sometimes recorded. Both of these problems are likely due to a weak connection in the drifter electronics that is being remedied. All drifters were eventually recovered and are available for future use.

Final drifter design and development details have been worked out. Deployment and recovery logistics necessary for successful experiments have become much better understood. No drifters have been lost. Repeated drifter deployments will provide necessary and sufficient data for determining circulation patterns, computing both Lagrangian and Eulerian velocity statistics, determining regions of pronounced cross-shelf flow, and calculating dispersion coefficients in the near-shore region.

Task No. 18213: *Use of Biological Endpoints in Flatfish to Establish Sediment Quality Criteria for Polyaromatic Hydrocarbon Residues and Assess Remediation Strategies*

Principal Investigators: Daniel Schlenk, Department of Environmental Sciences, University of California, Riverside, CA

Summary of Research

Progress during 2001-2002

As the funding only arrived December, the amount of experimentation completed this fiscal year was limited. The first task consisted of generating concentration-response curves in laboratory studies with various PAH-contaminated sediments from Southern California and biochemical indicators of PAH exposure in flatfish. Sediments were collected from an oil seep near Santa Barbara (Coal Oil Point) and a location near oil drilling platforms which, historically, has not been impacted by urban contaminants (i.e. is relatively free of PAHs). The sediments were diluted into 0, 33 67, and 100 percentages of the seep sediment. Horneyhead turbot were exposed for one week and fed throughout the exposure. Animals were euthanized and livers/blood removed. Initial data indicate a dose-dependent increase in DNA damage in the liver. We are currently measuring CYP1A expression and fluorescent aromatic compounds (FACs) from the bile.

Problems Encountered:

The only real problem we encountered was finding a location to carry out the exposures. After our eviction from the Cal-Tech laboratory in Corona Del Mar we began conducting the exposures at the Southern California Coastal Water Research Project in Westminster, CA.

Future plans:

Work will proceed as proposed.

TRAINEES AND STAFF

TRAINEES AND STAFF FUNDED BY THE COASTAL MARINE INSTITUTE

1999-2000

Name	Status	Task
Anghera, Michele	Post-Graduate Researcher	Surfgrass Restoration[1]
Applegate, Brendon	Undergraduate Student	UCSB-MMS Internship [2]
Blanchette, Carol	Post-Doctoral Researcher	Surfgrass Restoration
Boxshall, Anthony	Post-Doctoral Researcher	Effects of Produced Water[3]
Bunch, Jake	Undergraduate Student	Surfgrass Restoration
Bull, J. Scott	Graduate Student	Surfgrass Restoration
Carlisle, Juliet	Graduate Student	Public Perceptions of Risk[4]
Cline, Geoff	Undergraduate Student	UCSB-MMS Internship
Dayoan, Brandon	Undergraduate Student	UCSB-MMS Internship
DeMent, Andrea	Undergraduate Student	Population Trends[5]
Diener, Julia	High School Student	Surfgrass Restoration
Engle, Jack	Post-Graduate Researcher	S. Shoreline Inventory[6]
Faist, Chris	Undergraduate Student	Surfgrass Restoration
Fogelman, Rachel	Undergraduate Student	Surfgrass Restoration
Galst, Carey	Undergraduate Student	Surfgrass Restoration
Gocal, Carly	Undergraduate Student	UCSB-MMS Internship
Hayden-Spear, Jessica	Undergraduate Student	Population Trends
Henri, Jodie	Undergraduate Student	UCSB-MMS Internship
Herms, William	Graduate Student	Public Perceptions of Risk
King, Rachel	Undergraduate Student	Surfgrass Restoration
Lawyer, Jorine	Graduate Student	Population Trends
Lee, Melissa	High School Student	Surfgrass Restoration
Lee, Steven	Post-Graduate Researcher	S. & N. Shoreline Inventory
Marsh, Jeffery	Undergraduate Student	UCSB-MMS Internship
Matlock, Morgan	Graduate Student	UCSB-MMS Internship
McTee, Sarah	Undergraduate Student	Population Trends
Miyagishima, Juliet	Undergraduate Student	Public Perceptions of Risk
Mutz, Stephanie	Undergraduate Student	Population Trends
Navarro, Carla	Undergraduate Student	UCSB-MMS Internship
Readdie, Mark	Graduate Student	N. Shoreline Inventory[7]
Rodriques, Holly	Undergraduate Student	Surfgrass Restoration
Rossman, Ashleigh	Undergraduate Student	Surfgrass Restoration
Seydel, Keith	Post-Graduate Researcher	Population Trends
Smith, Brooke	Undergraduate Student	Population Trends
Smith, Derek	Undergraduate Student	Effects of Produced Water
Snyder, Garrett	Undergraduate Student	Surfgrass Restoration
Walling, Heather	Undergraduate Student	UCSB-MMS Internship
Woo, Lisa	Undergraduate Student	UCSB-MMS Internship
Williamson, Bonnie	Staff	UCSB-MMS Internship
Wilson, Melissa	Staff Research Technician	N. Shoreline Inventory
Yonehiro, Jason	Undergraduate Student	Effects of Produced Water
Zamacona, Brian	Undergraduate Student	Surfgrass Restoration
Zimmerman, Eric	Staff	UCSB-MMS Internship

2000-2001

Name	Status	Task
Adam, Chris	Undergraduate Student	Surfgrass Population Genetics[8]
Alfano, Christine	Graduate Student	Sea Otter Population Dynamics[9]
Alstatt, Jessica	Post-Graduate Researcher	S. Shoreline Inventory
Ammann, Arnold	Graduate Student	Platform Abandonment[10]
Anderson, Shane	Staff Research Diver	SSOS-HYS[11]
Anghera, Michele	Post-Graduate Researcher	Pop. Trends & Surfgrass
Arnold, Christine	Undergraduate Student	Sea Otter Population Dynamics
Asakawa, Mike	Graduate Student	UCSB-MMS Internship
Ashley, Erin	Undergraduate Student	Marine Biotechnology[12]
Aumack, Craig	Graduate Student	Habitat Value of Shell Mounds[13]
Barbosa, Todd	Undergraduate Student	Habitat Value of Shell Mounds
Beckenbach, Edwin	Graduate Student	Surface Circulation[14]
Bentall, Gena	Staff Research Technician	Sea Otter Population Dynamics
Bergquist, Sean	Graduate Student	S. Shoreline Inventory
Blanchette, Carol	Assistant Research Biologist	Surfgrass Restoration
Boch, Charlie	Undergraduate Student	Surfgrass Restoration
Bolles, Julie	Undergraduate Student	Habitat Value of Shell Mounds
Bomkamp, Erin	Graduate Student	Shell Mounds & Marine Biotech.
Bracken, Heather	Undergraduate Student	Population Trends
Bram, Jason	Graduate Student	Shell Mounds & Marine Biotech.
Brinkman, Mark	Undergraduate Student	Shell Mounds &Surfgrass Restor.
Bull, J. Scott	Graduate Student	Surfgrass Restoration
Bunch, Jake	Undergraduate Student	Surfgrass Restoration
Chau, Jason	Undergraduate Student	UCSB-MMS Internship
Chess, Katie	Staff Research Technician	Sea Otter Population Dynamics
Clark, Scott	Staff Research Technician	Marine Biotechnology
Diener, Julia	High School Student	Surfgrass Restoration
Divins, Dennis	Staff Research Diver	SSOS-HYS
Dunkin, Robin	Undergraduate Student	Sea Otter Population Dynamics
Emery, Brian	Staff Computer Technician	Surface Circulation
Engle, Jack	Post-Graduate Researcher	S. Shoreline Inventory
Faist, Chris	Undergraduate Student	Surfgrass Restoration
Farrar, Dave	Staff Research Diver	SSOS-HYS
Flaim, Bryna	Undergraduate Student	Habitat Value of Shell Mounds
Fogelman, Rachel	Undergraduate Student	Surfgrass Restoration
Fowler, Kasie	Undergraduate Student	Sea Otter Population Dynamics
Freeman, Chad	Staff Research Technician	Sea Otter Population Dynamics
Fuchs, Maria	Undergraduate Student	Surfgrass Restoration
Galst, Carey	Undergraduate Student	Surfgrass Restoration
Golden, Bill	Staff Research Diver	Habitat Value of Shell Mounds
Goldenberg, Adam	Research Technician	Marine Biotechnology
Gotshalk, Chris	Staff Research Associate	Surface Circulation
Hamlin, Luke	Undergraduate Student	UCSB-MMS Internship
Hanni, Krista	Undergraduate Student	Sea Otter Population Dynamics
Harding, Jeffrey	Staff Research Technician	Platform Abandonment
Harris, Mike	Staff Research Technician	Sea Otter Population Dynamics
Hayden-Spear, Jessica	Undergraduate Student	UCSB-MMS Internship
Henri, Jodi	Undergraduate Student	UCSB-MMS Internship
Hessel, Eric	Staff Research Diver	Shell Mounds & SSOS-HYS
Hill, Jason	Staff Research Technician	Sea Otter Population Dynamics
Kage, Alisha	Graduate Student	Sea Otter Population Dynamics
Kido, Jeanine	Staff Research Technician	Marine Biotechnology
King, Rochelle	Undergraduate Student	Surfgrass Restoration

2000-2001 (Continued)

Name	Status	Task
Lee, Glenda	Undergraduate Student	Population Trends
Lee, Melissa	High School Student	Surfgrass Restoration
Lee, Steven	Post-Graduate Researcher	S. & N. Shoreline Inventory
Lertchareonyong, Krisada	Staff Technician	Surface Circulation
Madari, Hampta	Graduate Student	Marine Biotechnology
Mardian, Brent	Staff Research Technician	Shell Mounds & Marine Biotech.
Meillier, Laurent	Graduate Student	SSOS-HYS
Mengelt, Claudia	Graduate Student	Marine Biotechnology
Moulton, Joe	Undergraduate Student	UCSB-MMS Internship
Moya, Claudia	Staff Researcher	Marine Biotechnology
Mutz, Stephanie	Undergraduate Student	Population Trends
Mydlarz, Laura	Graduate Student	Marine Biotechnology
Navarro, Carla	Staff Research Technician	Habitat Value of Shell Mounds
Nishimoto, Mary	Graduate Student	Surface Circulation
Ow, Leah	Undergraduate Student	Surface Circulation
Quinn, Andrew	Undergraduate Student	Surfgrass Restoration
Rademacher, Laura	Graduate Student	SSOS-HYS
Redlin, Jenny	Staff Research Technician	Marine Biotechnology
Rodriguez, Holly	Undergraduate Student	Surfgrass Restoration
Ross, Cliff	Graduate Student	Shell Mounds & Marine Biotech.
Rossman, Ashleigh	Undergraduate Student	Surfgrass Restoration
Sachs, Pat	Undergraduate Student	Population Trends
Salazar, David	Staff Research Associate	Surface Circulation
Santiago, Lory	Graduate Student	Marine Biotechnology
Schroeder, Donna	Graduate Student	Habitat Value of Shell Mounds
Shaw, Elizabeth	Undergraduate Student	Habitat Value of Shell Mounds
Seydel, Keith	Post-Graduate Researcher	Population Trends
Slack, William	Undergraduate Student	Surface Circulation
Snyder, Garrett	Undergraduate Student	Surfgrass Restoration
Ross, Cliff	Graduate Student	Marine Biotechnology
Roy, Luke	Graduate Student	Biological Endpoints in Flatfish[15]
Russell, Benjamin	Undergraduate Student	UCSB-MMS Internship
Sawyer, Kerry	Graduate Student	UCSB-MMS Internship
Tinker, Tim	Graduate Student	Sea Otter Population Dynamics
White, Jada-Simone	Undergraduate Student	Population Trends
Wilhelm, Frank	Undergraduate Student	Sea Otter Population Dynamics
Williams, Mike	Undergraduate Student	UCSB-MMS Internship
Williamson, Bonnie	Staff	UCSB-MMS Internship
Wilson, Melissa	Staff Research Technician	N. Shoreline Inventory
Wolcott, Bryce	Undergraduate Student	Shell Mounds & Marine Biotech.
Yeates, Laura	Graduate Student	Sea Otter Population Dynamics
Zamacona, Brian	Undergraduate Student	Surfgrass Restoration
Zimmerman, Eric	Staff	UCSB-MMS Internship

2001-2002

Name	Status	Task
Alfano, Christine	Graduate Student	Sea Otter Population Dynamics
Anghera, Michele	Post-Graduate Researcher	Population Trends
Arkema, Katie	Staff Research Assistant	S. Shoreline Inventory
Arnold, Christine	Undergraduate Student	Sea Otter Population Dynamics
Ashley, Erin	Undergraduate Student	Habitat Value of Shell Mounds
Batres, Erica	Undergraduate Student	Habitat Value of Shell Mounds
Bayer, Pam	Staff	UCSB-MMS Internship
Beckenbach, Edwin	Graduate Student	Surface Circulation
Bentall, Gena	Staff Research Technician	Sea Otter Population Dynamics
Bergquist, Sean	Graduate Student	S. Shoreline Inventory
Bomkamp, Erin	Graduate Student	Habitat Value of Shell Mounds
Bram, Jason	Graduate Student	Habitat Value of Shell Mounds
Bricker-Shanahan, Tania	Staff Research Technician	Surfgrass Population Genetics
Brinkman, Mark	Undergraduate Student	Habitat Value of Shell Mounds
Bull, J. Scott	Graduate Student	Pop. Trends & Surfgrass Restor.
Burnett, Julie	Undergraduate Student	Habitat Value of Shell Mounds
Butala, Regina	Undergraduate Student	UCSB-MMS Internship
Centerwall, Ryan	Undergraduate Student	Marine Biotechnology
Chambers, Jeanne	Staff	UCSB-MMS Internship
Chau, Jason	Undergraduate Student	UCSB-MMS Internship
Chess, Katie	Staff Research Technician	Sea Otter Population Dynamics
Cudaback, Cynthia	Staff Research Associate	Surface Circulation
Culver, Carrie	Post-Doctoral Researcher	Habitat Value of Shell Mounds
Day, Daniel	Undergraduate Student	Marine Biotechnology
DeMent, Andrea	Staff Laboratory Assistant	Population Trends
Deter, Julie	Undergraduate Student	Population Trends
Doucher, Greg	Undergraduate Student	Surfgrass Population Genetics
Dunkin, Robin	Undergraduate Student	Sea Otter Population Dynamics
Emery, Brian	Staff Computer Technician	Surface Circulation
Engle, Jack	Post-Graduate Researcher	S. Shoreline Inventory
Fowler, Kasie	Undergraduate Student	Sea Otter Population Dynamics
Freeman, Chad	Staff Research Technician	Sea Otter Population Dynamics
Furnes, Bjarte	Graduate Student	Biological Endpoints in Flatfish
Grace, Krista	Staff Research Technician	Marine Biotechnology
Hamlin, Luke	Undergraduate Student	UCSB-MMS Internship
Hanni, Krista	Undergraduate Student	Sea Otter Population Dynamics
Harlan, Jack	Graduate Student	Surface Circulation
Harris, Mike	Staff Research Technician	Sea Otter Population Dynamics
Haston, Laura	Staff	UCSB-MMS Internship
Hensic, Lori	Undergraduate Student	Marine Biotechnology
Hessell, Eric	Staff Research Diver	Habitat Value of Shell Mounds
Hill, Jason	Staff Research Technician	Sea Otter Population Dynamics
Jensen, Amanda	Undergraduate Student	Population Trends
Johnson, Robin	Staff	UCSB-MMS Internship
Kage, Alisha	Graduate Student	Sea Otter Population Dynamics
Kane, Corrine	Undergraduate Student	Population Trends
Kane, Mike	Undergraduate Student	Population Trends
Kinlan, Brian	Graduate Student	Habitat Value of Shell Mounds
Lee, Steven	Post-Graduate Researcher	S. & N. Shoreline Inventory
Lenihan, Hunter	Post-Doctoral Researcher	Habitat Value of Shell Mounds
Luu, Christine	Undergraduate Student	Population Trends
Madari, Hamta	Graduate Student	Marine Biotechnology
Martinez, Pat	Staff	UCSB-MMS Internship

2001-2002 (Continued)

Name	Status	Task
Mardian, Brent	Staff Technician	Habitat Value of Shell Mounds
Mazul, Lydia	Undergraduate Student	Marine Biotechnology
Moulton, Joe	Undergraduate Student	UCSB-MMS Internship
Mydlarz, Laura	Graduate Student	Marine Biotechnology
Myer, Paul	Undergraduate Student	Population Trends
Ow, Leah	Undergraduate Student	Surface Circulation
Porteus, Pamela	Undergraduate Student	Population Trends
Ragus, Rich	Undergraduate Student	Habitat Value of Shell Mounds
Reger, Cian	Undergraduate Student	Habitat Value of Shell Mounds
Ross, Cliff	Graduate Student	Marine Biotechnology
Rowan, Barry	Staff Technician	Habitat Value of Shell Mounds
Russell, Benjamin	Undergraduate Student	UCSB-MMS Internship
Santiago-Vazquez, Lory	Graduate Student	Marine Biotechnology
Seydel, Keith	Post-Graduate Researcher	Population Trends
Salazar, David	Staff Research Associate	Surface Circulation
Sawyer, Kerry	Graduate Student	UCSB-MMS Internship
Tinker, Tim	Graduate Student	Sea Otter Population Dynamics
White, Jada-Simone	Undergraduate Student	Population Trends
Wilhelm, Frank	Undergraduate Student	Sea Otter Population Dynamics
Williams, Mike	Undergraduate Student	UCSB-MMS Internship
Williamson, Bonnie	Staff	UCSB-MMS Internship
Wilson, Melissa	Staff Research Technician	N. Shoreline Inventory
Wittenburg, Alyssa	Undergraduate Student	Habitat Value of Shell Mounds
Wolff, Tim	Undergraduate Student	UCSB-MMS Internship
Yeates, Laura	Graduate Student	Sea Otter Population Dynamics
Zimmerman, Eric	Staff	UCSB-MMS Internship

[1]Surfgrass Restoration—Task # 15118, PIs Reed & Holbrook
[2] UCSB-MMS Internship—Task #s 12388 & 17610, PIs Dugan, Keller
[3] Effects of Produced Water—Task # 13095, PI Raimondi
[4] Public Perceptions of Risk—Task # 17607, PI Smith
[5] Population Trends—Task # 14181, PIs Schmitt & Brooks
[6] S. Shoreline Inventory—Task # 17604, PI Raimondi
[7] N. Shoreline Inventory—Task # 17602, PI Ambrose
[8] Surfgrass Population Genetics—Task # 17606, PIs Hodges et al.
[9] Sea Otter Population Dynamics—Task # 17605, PIs Estes, et al.
[10] Platform Abandonment—Task # 12387, PIs Carr, Forrester, McGinnis
[11] SSOS-HYS—Task #s 17611 & 18211, PIs Leifer, Clark, & Luyendyk
[12] Marine Biotechnology—Task # 17609, PIs Schmitt et al.
[13]Habitat Value of Shell Mounds—Task # 17610, PIs Page, Dugan & Childress
[14] Surface Circulation—Task #, 17608, PIs Washburn and Gaines
[15] Biological Endpoints in Flatfish—Task # 18213, PI Schlenk

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Culver, C., B. Mardian, H.M. Page and J. Dugan. 2001. Spatial patterns of distribution, abundance and dynamics of invertebrates on offshore oil platforms in the Santa Barbara Channel. Western Society of Naturalists, Ventura, CA, November 2001.

Culver, C., B. Mardian, H.M. Page and J. Dugan. 2002. Spatial patterns of distribution, abundance and dynamics of invertebrates on offshore oil platforms. Studies Presentation, Minerals Management Service, Camarillo, CA. May 2, 2002.

Dayan, N., Ortega, I., Riemer, J., Moya, C., and R.S. Jacobs. 2001. Pseudopterosins-Solubility Characteristics and Anti-inflammatory Activity, 200l Controlled Release Society meeting, San Diego, CA., June 23-27, 2001.

DiGiacomo, P. M., B. Holt, and L. Washburn. 2002. Pollution Hazards off the Southern California Coast: Satellite and In-Situ Observations of Naturally Occurring Oil Seepage and Storm Water Runoff Plumes. Ocean Sciences Meeting, Honolulu, HI, February 11-15.

Dugan, J. 1999. Sandy beach ecology and morphodynamics. Lecture, Santa Barbara Surfrider Foundation, Santa Barbara, CA

Dugan, J. 2000. Large scale patterns in sandy beach communities in California and Chile. Marine Macroecology and Conservation Workshop, Vina del Mar, Chile

Dugan, J. 2000. Shorebirds and sandy beach management. Seminar, California State Parks, Ventura, CA

Dugan, J. 2000. Effects of grooming on the ecology of exposed sandy beaches. Presented at the California Shore and Beach Preservation Society/ CalCoast conference, Monterey, CA.

Dugan, J., D.M. Hubbard and H.M. Page. 2001. Ecological impacts of grooming on exposed sandy beaches in southern California. Invited symposium presentation, Western Society of Naturalists, Ventura, CA.

Dugan, J. E. and D. M. Hubbard. 2001. Investigating the role of higher trophic levels on exposed sandy beaches: relationships among shorebirds, invertebrate macrofauna and morphodynamics in California. International Workshop, Beaches - What Future? An Integrated Approach to the Ecology and Evolution of Beaches and Sand Dunes. Florence, Italy Oct. 2001.

Dugan, J. E., Hubbard, D.M. and H. M. Page. 2001. Ecological effects of grooming on exposed sandy beaches in southern California. International Workshop, Beaches - What Future? An Integrated Approach to the Ecology and Evolution of Beaches and Sand Dunes. Florence, Italy Oct. 2001.

Dugan, J. 2002. Effects of beach grooming on sandy beaches in California. Presented to San Diego City Council, Natural Resources and Culture Committee, San Diego, CA.

Dugan, J. 2002. Response of sandy beach ecosystems to macrophyte wrack subsidies. Presented at NOAA Hazardous Materials Response Division annual meeting, Santa Barbara, CA.

Dugan, J., D. Hubbard, and H.M. Page. 2002. Ecological effects of grooming on exposed sandy beaches in southern California. Studies Presentation, Minerals Management Service, Camarillo, CA. May 2, 2002.

Dugan, J. 2002. Ecological effects of grooming on exposed sandy beaches in southern California. Invited Seminar, California State University, Northridge, CA.

Emery, B.M., and L. Washburn. 2000. Verifying direction finding HF radar current measurements. Ocean Sciences Meeting, San Antonio, TX, 24-28 Jan.

Emery, B.M., and L. Washburn. 2000. Summary of mooring-CODAR comparisons. Quality Review Board Meeting #7, Minerals Management Service, Scripps Institution of Oceanography, 4-6 Feb., La Jolla, CA.

Emery, B.M., and D. Salazar. 2001. Results from a 3-year time series of HF radar observations in the Santa Barbara Channel and Santa Maria Basin. HF Radar Workshop, Oceanology International of the Americas Joint Forum, Miami, FL, 4-5 April.

Emery, B.M., L. Washburn, and Jack Harlan. 2001. Evaluating radial component current measurements from CODAR high frequency radars and moored in situ current meters. Radiowave Oceanography, First International Workshop, 9-12 April, Timberline Lodge, OR.

Emery, B. M., L. Washburn, J.A. Harlan. 2002. How Accurate are Total Vector Surface Currents from a Single HF Radar Site? Ocean Sciences Meeting, Honolulu, HI, February 11-15.

Holbrook, S.J., D.C. Reed and J. S. Bull. 1999. Methods for Enhancing Habitat Value of Artificial Structures by Establishing Surfgrass (*Phyllospadix torreyi*). 7th International Conference on Artificial Reefs and Aquatic Habitats, San Remo, Italy

Jacobs, R.S., Santiago-Vazquez, L., and L. Mydlarz. 2000. Physiologically distinct protist models for studying the function and biosynthesis of eicosanoids. International Symposium on Non-mammalian Eicosanoids and Bioactive Lipids, Berlin, Germany.

Kosro, P.M., J.D. Paduan, and L. Washburn. 2000. Time series mapping of currents in the coastal ocean. Fall Meeting, American Geophysical Union, San Francisco, 15-19 September.

Kosro, P.M., J.D. Paduan, and L. Washburn. 2000. Time series mapping of currents in the coastal ocean. Fall Meeting, American Geophysical Union, San Francisco, 15-19 September.

Leifer, I., and A. Judd. 2001. Seep bubble layer deposition due to sharp bubble dissolution. XI European Union of Geosciences, Strasbourg, France, April 8-12.

Leifer, I. 2001. Bubble transport to the sea surface of seep methane. USGS Workshop on Naturally Occurring Fossil Methane Seepage as a Factor in Global Climate Change. Portland, Oregon (May 2-4, 2001).

Leifer, I., J. Clark, and B. Luyendyk, 2002. Bubble survivability and the fate of Shane Seep Methane and Oil, *Hedberg Research Conference on Near Surface Hydrocarbon Migration: Mechanisms and Seepage Rates*, Vancouver, BC, Canada, April 7-10.

Leifer, I. 2002. The Coal Oil Point Seep Field, an example of mega-seepage. Invited seminar at the University of California, Santa Cruz, CA.

MacDonald, I.R., Leifer, I., Sassen, R., Stine, P., Mitchell, R., and N. Guinasso Jr. 2002. Transfer of hydrocarbons from natural seeps to the water column and atmosphere. *Geofluids* **2**: 95-107.

Madari, H., Panda, D., Wilson, L., and R.S. Jacobs. 2001. Dicoumarol: A Coumarin compound with microtubule stabilizing properties. French-American Colloquium on Cytoskeleton and Human Disease, April 17-20, 2001, Marseille, France.

Moya, C., Mydlarz, L., and R.S. Jacobs. 2000. Physiologically distinct protist models for studying the function and biosyntesis of eicosanoids and related compounds in *Euglena gracilis* and *Tetrahymena thermophila*. Gordon Research Conference on Marine Natural Products, Ventura Beach, CA.

Muller, E.B. Living with variable food: Survival and production in a dynamic energy budget (DEB) model for individuals, Theory and Mathematics in Biology and Medicine, Amsterdam, July 2, 2000. Oral presentation.

Muller, E.B. Living with variable food: Survival and production in a dynamic energy budget (DEB) model for individuals. Annual Meeting of the Ecological Society of America, Spokane, August 11, 1999. Oral presentation.

Nisbet, R.M. Predictive power of simple population models. Theory and Mathematics in Biology and Medicine, Amsterdam, July 2, 1999.

Nisbet, R.M. Modeling population and ecosystem response to sublethal toxicant exposure. Harbor processes workshop, Office of Naval Research. Novermber 1999.

Nisbet, R.M. From molecules to ecosystems with dynamic energy budget models. UC Santa Cruz, invited seminar. May 2000.

Nishimoto, M.M., L. Washburn, and B.M. Emery. 2000. Eddy circulation in the Santa Barbara Channel and variability in abundance patterns of juvenile fishes. Ocean Sciences Meeting, San Antonio, TX, 24-28 Jan.

Raimondi, P.T. 2000. Assessing variability in intertidal community structure. PISCO/Mellon Symposium. Oregon State University

Raimondi, P.T. 2001. Assessing variability in intertidal community structure. Invited talk, Duke University.

Raimondi, P.T. 2001. Assessing variability in intertidal community structure. Invited talk, Bodega Marine Lab.

Raimondi, P.T. 2001. Assessing variability in intertidal community structure. Invited talk, California State University, Humbolt.

Raimondi, P.T. 2001. Assessing variability in intertidal community structure. Invited talk, California Polytechnic State University, San Luis Obispo.

Raimondi, P.T. 2001. Assessing variability in intertidal community structure. Seminar, California Polytechnic State University, San Luis Obispo, CA.

Raimondi, P.T. and M.C. Carr. 2001. Long-term patterns and processes in temperate rocky reef communities: stasis is not the norm. Western Society of Naturalists, Ventura, CA.

Raimondi, P.T. 2001. Intertidal Community Structure: Stasis is not the Norm. Western Society of Naturalists, Ventura, California. Invited Symposium talk.

Readdie, M. 2000. Long-term change in intertidal zonation. Can succession drive vertical shifts in species zones? Monterey Bay National Marine Sanctuary Symposium, Monterey, CA.

Readdie, M. 2002. Long-term change in intertidal zonation. Can succession drive vertical shifts in species zones?. PISCO Public Symposium, California State University Monterey Bay, Monterey, CA.

Reed, D. and S. Holbrook. 1999. Reproductive ecology of surfgrass in the context of restoration. Invited symposium speaker, Western Society of Naturalists, Monterey, CA.

Roy, L., Johnson, L., Flax, D., Steinert, S., Armstrong, J.L., and D. Schlenk. 2001. Vitellogenin, DNA Damage, FACs and CYP1A Expression in Feral Flatfish Species. *Society of Environmental Toxicology and Chemistry*.

Roy, L., Johnson, L., Lomax, D., Steinert, S., Armstrong, J.L., and D. Schlenk. 2001. Vitellogenin, DNA Damage, FACs and CYP1A Expression in Feral Flatfish Species. 11th International Symposium of Pollution Responses in Marine Organisms.

Schroeder, D M , M.M. Nishimoto, and L. Washburn. 2001. Variability in mesoscale oceanographic processes corresponds to variability in the distribution and abundance of rockfish (*Sebastes* spp.) juveniles, American Society of Limnology and Oceanography, Albuquerque 2001, Albuquerque, NM, 12-16 February.

Smith, Eric R.A.N. 2000. The Role of Knowledge in Attitudes toward Risky Environmental Technologies. Talk delivered at the U.S. Minerals Management Service, Camarillo, California, 8 February 2000.

Smith, Eric R.A.N. 2000. The Role of Knowledge in Attitudes toward Risky Environmental Technologies. Paper delivered at the annual meeting of the World Association for Public Opinion Research, Portland, Oregon, May 2000.

Stevenson, C.S., Capper, E.A., Roshak, A.K., Marquez, B., Gerwick, W.H., Jacobs, R.S., and L.A. Marshall. 2000. Scytonemin, a marine natural product inhibitor of polo-like kinase 1. Proceedings of the American Association for Cancer Research, April 2nd-5th, 2000, San Francisco, CA.

Stevenson, C.S., Capper, E.A., Roshak, A.K., Gerwick, W.H., Jacobs, R.S. and L.A. Marshall. 2000. Scytonemin, a marine natural product inhibitor of inflammation and cell proliferation. Gordon Research Conference on Marine Natural Products, Ventura Beach, CA.

Stevenson, C.S., Capper, E.A., Roshak, A.K., Gerwick, W.H., Marshall, L.A., and R.S. Jacobs. 2000. Scytonemin - A marine natural product inhibitor of inflammation and cell proliferation. 11th International Conference on Advances in Prostaglandin and Leukotriene Research: Basic Science and New Clinical Applications. June 4-8, 2000, Florence, Italy.

Tinker, M.T., J.A. Estes, and M. Mangel. 2001. Individual variation in diet and feeding behavior of sea otters: cultural transmission of foraging skills contributes to the persistence of alternative foraging specializations. 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Washburn, L. 2000. EOF and maximum likelihood interpolation applied to HF radar derived surface currents in the Santa Barbara Channel. Ocean Sciences Meeting, San Antonio, TX, 24-28 Jan.

Washburn, L. 2000. Research summary of HF radar observations off the south central California coast. Quality Review Board Meeting #7, Minerals Management Service, Scripps Institution of Oceanography, 7-9 March, La Jolla, CA.

Washburn, L. 2000. Synoptic ocean observations from Ventura to Avila Beach: Combined physical and biological oceanographic studies. California Coastal Observing System Workshop, Berkeley, CA, 15 June.

Washburn, L., M.M. Nishimoto, E.H. Beckenbach, and B.M. Emery. 2000. Surface circulation near Pt. Conception, California: A mechanism for larval retention? Fall Meeting, American Geophysical Union, San Francisco, 15-19 September.

Washburn, L. 2001. Surface circulation on the South-central coast: Mechanisms for larval transport and retention, seminar in the Dept. of Atmospheric Science, UCLA, 24 January.

Washburn, L. 2001. The physical environment of the Santa Barbara Channel, seminar presented to volunteers of the Channel Islands National Marine Sanctuary", Chase Palm Park, 1 March.

Washburn, L., E.H. Beckenbach, B.M. Emery, and Jack Harlan. 2001. An overview of HF radar surface current observations in the vicinity of Pt. Conception, California. Radiowave Oceanography, First International Workshop, 9-12 April, Timberline Lodge, OR.

Washburn, L., E.H. Beckenbach, B.M. Emery, and D. Salazar. 2001. Results from a 3-year time series of HF radar observations in the Santa Barbara Channel and Santa Maria Basin. HF Radar Workshop, Oceanology International of the Americas Joint Forum, 4-5 April, Miami, FL.

Washburn, L., S. Gaines, E. P. Dever, and D. Reed. 2002. An Observational Network for Multidisciplinary Time Series on the Central California Coast. Ocean Sciences Meeting, Honolulu, HI, February 11-15.

Wilson, M. 2001. Is *Sargassum muticum* a benign invader of tidepools on the Pacific coast? Western Society of Naturalists, Ventura, CA.

CURRICULUM VITAE

MICHAEL R. ADAMSON
Department of History
California State University
Sonoma, CA

Project: *Industrial Activity and Its Socioeconomic Impacts: Oil and Three Coastal California Counties*

Education:

B.B.A.	Finance, University of Wisconsin, Milwaukee, WI	1984
M.B.A.	Arizona State University, Phoenix, AZ	1986
M.S.	History, University of California, Santa Barbara, CA	1996
Ph.D.	History, University of California, Santa Barbara, CA	2000

Positions:

2002-Present	Adjunct Professor, Department of History, California State University, Sonoma, CA
2000-2002	Visiting Scholar, Office for History of Science and Technology, University of California, Berkeley, CA
1996-1998	Graduate Student Researcher, Marine Sciences Institute, University of California, Santa Barbara, CA
1995-1996	Teaching Assistant, Department of History, University of California, Santa Barbara, CA
1994-1997	Independent Business Analyst/ Information Technology Consultant
1992-1994	Software Engineer, Synon, Inc., Larkspur, CA
1990-1992	Business Applications Consultant, Synon, Inc., Larkspur, CA
1989-1990	Management Consultant, Coopers & Lybrand, San Francisco, CA
1986-1989	Management Consultant, Andersen Consulting, Phoenix, AZ

Selected Publications:

Adamson, M.R. 2002. Ambassadorial Roles and Foreign Policy: Elbridge Durbrow, Frederick Nolting, and the U.S. Commitment to Diem's Vietnam, 1957-61. *Presidential Studies Quarterly* **June**.

Adamson, M.R. 2002. Oil Development and the Accomplishment of Place in Santa Barbara and Ventura, California: Comment on Molotch, Freudenberg, and Paulsen. *American Sociological Review* **67**(6): 911.

Adamson, M.R. 2002. The Failure of the Foreign Bondholders Protective Council Experiment, 1934-1940. *Business History Review* **76**: 479–514.

Adamson, M.R. 2000. Review of "The Hidden Hand of American Hegemony: Petrodollar Recycling and International Markets", by David E. Spiro. *Business History Review* **74**: 344-348.

Adamson, M.R. 1999. Delusions of Development: The Eisenhower Administration and the Foreign Aid Program in Vietnam, 1955-1960. *Journal of American-East Asian Relations* **5**: 157-182.

Adamson, M.R. 1999. Review of "The Great Depression: An International Disaster of Perverse Economic Policies", by Thomas E. Hall and J. David Ferguson. *The Freeman* **49**: 57-58.

Bergstrom, R. and M.R. Adamson. 1998. Exploration and Production in Ventura, Santa Barbara, and San Luis Obispo Counties, California: Oil Well Operators, 1950-1997. Minerals Management Service*,* Camarillo, CA.

K. Paulsen, et al. 1998. Petroleum Extraction in Ventura County, California: An Industrial History. Minerals Management Service*,* Camarillo, CA.

L. Nevarez, et al. 1998. Petroleum Extraction in Santa Barbara County, California: An Industrial History. Minerals Management Service*,* Camarillo, CA.

T.D. Beamish, et al. 1998. Petroleum Extraction in San Luis Obispo County, California: An Industrial History. Minerals Management Service*,* Camarillo, CA.

RICHARD F. AMBROSE
Environmental Science and Engineering Program
Department of Environmental Health Sciences
University of California
Los Angeles, CA

Projects: *Inventory of Rocky Intertidal Resources in Southern Santa Barbara,Ventura and Los Angeles Counties*

Education:

B.S.	University of California, Irvine	1975
Ph.D.	University of California, Los Angeles	1982

Positions:

1992-present	Associate Professor, Environmental Science and Engineering Program, Department of Environmental Health Sciences, University of California, Los Angeles
1991-present	Associate Research Biologist, Marine Science Institute, University of California, Santa Barbara
1985-1991	Assistant Research Biologist, Marine Science Institute, University of California, Santa Barbara
1983-1984	Postdoctoral Fellow, Department of Biological Sciences, Simon Fraser University, Burnaby, B.C., Canada
1982	Visiting Lecturer, Department of Biology, University of California, Los Angeles
1976-1981	Teaching Assistant, Department of Biology, University of California, Los Angeles

Major Research Interests:

- Restoration ecology, especially for coastal marine and estuarine environments
- Development and scientific evaluation of mitigation techniques
- Long-term ecological monitoring
- Development of habitat valuation techniques
- Ecology of artificial and natural reefs
- Ecology of Coastal wetlands and estuaries
- Marine ecology
- Interface between environmental biology and resource management policy

Selected Publications:

Vance, R.R., R.F. Ambrose, S.S. Anderson, S. MacNeil, T. McPherson, I. Beers and T.W. Keeney. Effects of sewage sludge on the growth of potted salt marsh plants exposed to natural tidal inundation. *Restoration Ecology* (in press)

Stein, E.D. and R. F. Ambrose. Cumulative impacts of Section 404 Clean Water Act permitting on the riparian habitat of the Santa Margarita, CA watershed. *Wetlands* (in press)

Raimondi PT, Wilson CM, Ambrose RF, Engle JM, Minchinton TE. 2002. Continued declines of black abalone along the coast of California: are mass mortalities related to El Nino events? Mar Ecol-Prog Ser 242: 143-152.

Sudol, M.F. and R.F. Ambrose. 2002. The US Clean Water Act and habitat replacement: Evaluation of mitigation sites in Orange County, California. *Environmental Management* **30**: 727-734.

Boyer, K.E., P. Fong, R.R. Vance and R.F. Ambrose. 2001. *Salicornia virginica* in a Southern California salt marsh: seasonal patterns and a nutrient enrichment experiment. *Wetlands* **21** (3): 315-326.

Cohen, T., S.S. Que Hee and R.F. Ambrose. 2001. Comparison of trace metal concentrations in fish and invertebrates in three Southern California wetlands. *Marine Pollution Bulletin* **42**: 224-232.

Downs TJ, Ambrose RF. 2001. Syntropic ecotoxicology: A heuristic model for understanding the vulnerability of ecological systems to stress. *Ecosyst Health* **7**(4): 266-283.

Moeller, A, Ambrose, RF, Hee, SSQ. 2001. A comparison of techniques for preparing fish fillet for ICP-AES multi-elemental analysis and the microwave digestion of whole fish. *Food Addit Contam* **18** (1): 19-29.

Stein, E.D. and R.F. Ambrose. 2001. Landscape-scale analysis and management of cumulative impacts to riparian ecosystems: past, present and future. *Journal of American Water Resources Association* **37**(6): 1597-1614.

Ambrose, R.F. 2000. Wetland mitigation in the United States: Assessing the success of mitigation policies. *Wetlands* (Australia) **19**: 1-27.

Ambrose, R.F. and D.J Meffert. 1999. Fish-assemblage dynamics in Malibu Lagoon, a small, hydrologically altered estuary in southern California. *Wetlands* **19**: 327-340.

Lafferty, K., C. Swift and R.F. Ambrose. 1999. Extirpation and recovery of local populations of the endangered tidewater goby, *Eucyclogobius newberryi*. *Conservation Biology* **13**: 1447-1453.

Stein, E.D. and R. F. Ambrose. 1998. A rapid impact assessment method for use in a regulatory context. *Wetlands* **18**: 379-392.

Ambrose, R.F. 1997. Ecological value in restored coastal ecosystems. Pp. 67-86 in: *Saving the Seas: Values, Scientists, and International Governance,* L.A. Brooks and S.D. VanDeveer, eds. Maryland Sea Grant College, College Park, MD.

Dunaway, M.E., R.F. Ambrose, J. Campbell, J.M. Engle, M. Hill, Z. Hymanson, and D. Richards. 1997. Establishing a Southern California rocky intertidal monitoring network. Pp. 1278-1294. in: *California and the World Ocean '97,* O.T. Magoon, H. Converse, B. Baird, and M. Miller-Henson, eds. American Society of Civil Engineers, Reston, Virginia.

Engle, J.M., R.F. Ambrose, and P.T. Raimondi. 1997. Synopsis of the Interagency Rocky Intertidal Monitory Network Workshop. Final Report, OCS Study MMS 97-0012. U.S. Minerals Management Service, Pacific OCS Region. 18p.

Palmer, M.A., N.L. Poff, and R.F. Ambrose. 1997. Ecological theory and community restoration ecology. *Restoration Ecology* **5:** 291-300.

Alltstatt, J.A., R.F. Ambrose, J.M. Engle, P.L. Haaker, K.D. Lafferty, and P.T. Raimondi. 1996. Recent declines of black abalone *Haliotis cracherodii* on the mainland coast of central California. *Marine Ecology Progress Series* **142**: 185-192.

Ambrose, R.F., R.J. Schmitt, and C. W. Osenberg. 1996. Predicted and Observed Environmental Impacts: Can We Foretell Ecological Change. Pp. 343-367 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats,* R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA.

ANDREW J. BROOKS
Department of Ecology, Evolution and Marine Biology
University of California
Santa Barbara, CA

Project: *Population Trends and Trophic Dynamics in Pacific OCS Ecosystems: What Can Monitoring Data Tell Us?*

Education:

B.A.	Biology with Marine Emphasis, Occidental College	1984
Certificate	Aquatic Biology and Fisheries Management, University College of North Wales, U.K.	1987
M.A.	Biological Sciences, University of California, Santa Barbara	1993
Ph.D.	Ecology, Evolution and Marine Biology, University of California, Santa Barbara	1999

Positions:

2001-Present	Director, Carpinteria Salt Marsh Reserve, University of California
1999-Present	Assistant Research Biologist, Marine Science Institute, University of California, Santa Barbara
1998-Present	Lecturer, Dept. of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
1998-1999	Post-Doctoral Researcher, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
1998	Teaching Associate, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
1990-1998:	Research Assistant, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
1988-89	Instructor, Department of Physics, Los Angeles Valley College
1988-91	Instructor, Department of Biology, Occidental College
1987-89	Marine Ecologist and Project Leader, Vantuna Research Group, Occidental College
1984-86	Marine Ecologist, Vantuna Research Group, Occidental College

Grants and Awards:

2002-2005	W.M. Keck Foundation
2002-2004	Minerals Management Service CMI Project Award
2001-2004	US Environmental Protection Agency
2001	Member, American Institute of Fishery Research Biologists
1997-2001	Minerals Management Service CMI Project Award
1997	University Award of Distinction, University of California, Santa Barbara
1995-1999	UC TSR&TP Fellowship, University of California, Santa Barbara
1994-1996	Mildred Mathias Grant, University of California, Santa Barbara
1994-1996	Crocker Grant
1994-1995	Continuing Graduate Student Fellowship, University of California, Santa Barbara

Publications:

Swearer, S. E., Forrester, G.E., Steele, M.A., Brooks, A.J., and D.W. Lea. 2003. Spatio-temporal and interspecific variation in otolith trace-elemental fingerprints in a temperate estuarine fish assemblage. *Estuarine, Coastal and Shelf Science* (in press).

Holbrook, S.J., Brooks, A.J., and R. J. Schmitt. 2002. Are fish assemblages on coral patch reefs predictable? *Marine and Freshwater Research* **53** (2):181-188.

Brooks, A.J., Schmitt, R.J., and S. J. Holbrook. 2002. Declines in regional fish populations: have different species responded similarly to environmental change? *Marine and Freshwater Research* **53** (2):189-198.

Holbrook, S.J., Brooks, A.J., and R. J. Schmitt. 2002. Variation in structural attributes of patch forming corals and in patterns of abundance of associated fishes. *Marine and Freshwater Research* **53** (7):1045-1053.

Brooks, A.J. 1999. Factors Influencing the Structure of an Estuarine Fish Community: The Role of Interspecific Competition. Ph.D. Dissertation. University of California, Santa Barbara, 219 pp.

Nisbet, R.M., Muller, E.B., Brooks, A.J., and P. Hosseini. 1997. Models relating individual and population response to contaminants. *Environmental Modeling and Assessment* **2**: 7-12.

Love, M.S., Brooks, A.J., and J.R.R. Ally. 1996. An analysis of the commercial passenger fishing vessel fisheries for kelp and barred sand basses (*Paralabrax clathratus* and *P. nebulifer*) in the Southern California Bight. *California Fish and Game* **82**: 105-121.

Nisbet, R.M., Ross, A.H., and A.J. Brooks. 1996. Empirically-based dynamic energy budget models: theory and an application to ecotoxicology. *Nonlinear World* **3**: 85-106.

Love, M.S., Brooks, A.J., Busatto, D., Stephens Jr., J., and P. Gregory. 1996. Aspects of the life histories of the kelp bass and barred sand bass (*Paralabrax clathratus* and *P. nebulifer*) from the Southern California Bight. *Fisheries Bulletin* **94**: 472-481.

Love, M.S., Hyland, J., Ebeling, A., Herrlinger, T., Brooks, A.J., and E. Imamura. 1994. A pilot study of the distribution and abundance of rockfishes in relation to natural environmental factors and an offshore oil and gas production platform off the coast of Southern California. *Bulletin Marine Science* **55**: 1062.-1085.

Love, M.S. and A.J. Brooks. 1990. Size and age at first maturity of the California halibut, *Paralichthys californicus*, in the Southern California Bight. Pp. 167-174 in: *The California halibut*, *Paralichthys californicus, resource and fisheries.* California Fish and Game Fisheries Bulletin.

Love, M.S., Axell, B., Morris, P., Collins, R., and A.J. Brooks. 1987. Life history and fishery of the California scorpionfish, *Scorpaena guttata*, within the Southern California Bight. *Fisheries Bulletin* **85**: 99-116.

Brooks, A.J. 1987. Two species of Kyphosidae seen in King Harbor, Redondo Beach, California. *California Fish and Game* **73**: 49-61.

DOUGLAS S. BUSH
Marine Science Institute
University of California
Santa Barbara, CA

Project: *Population Genetics of Surfgrass (Phyllospadix torreyi) for Use in Restoration*

Education:

	B.A.	Botany, University of Hawaii	1974
	M.S.	Plant Physiology, UC Berkeley	1979
	Ph.D.	Plant Physiology, UC Berkeley	1983
	Postdoctoral	Botany, UC Berkeley	1984 – 1989

Positions:

1998-Present	Associate Research Biologist, Marine Science Institute, UC Santa Barbara
1998-Present	Adjunct Associate Professor, Dept. of Ecology, Evolution, and Marine Biology, UC Santa
1990-1997	Assistant/Associate Professor, Rutgers University, Dept. of Biological Sciences
1989-1990	Assistant Research Botanist, UC Berkeley, Dept. of Botany
1984-1989	Postdoctoral Associate, UC Berkeley, Dept. of Botany
1979-1983	Research Associate, UC Berkeley, Dept. of Plant and Soil Biology
1977-1979	Statistician, UC Berkeley, Dept. of Plant and Soil Biology

Research Interests:

Genetics of natural plant populations, Evolutionary Genetics, Plant cell biology, cell calcium and transduction of hormonal signals. Membrane transport events induced by plant growth regulators. Programmed cell death.

Awards:

Henry Rutgers Fellow, 1990
EMBO Workshop Fellowship, Patch Clamp Techniques, Göttingen, West Germany, 1987
Presidents Fellowship, University of California, Berkeley, 1980-1981

Selected Publications:

Rodriguez, M.T. and D.S. Bush. 1999. Gibberellin-induced cell death in the wheat aleurone. *Plant Physiology* (submitted).

Silverman, P., Assiahmah, A., and D.S. Bush. 1998. Cytokinin action in root hairs of *Medicago sativa*. *Planta* **205**: 25-31.

Subbaiah, C., Bush, D.S., and M. Sachs. 1998. Mitochondria contribution to the anoxic Ca^{2+} signal in maize suspension-cultured sells. *Plant Physiology* **118**: 759-771.

Thompson, M.D., Bush, D.S., and L.E. Bello. 1997. Possible Wilson's disease: A case presentation. *Arch Clin Neuropsych* **12**(4): 416-416.

Bush, D.S. 1996. Effects of gibberellic acid and environmental factors on cytosolic calcium in wheat aleurone cells. *Planta*. **199**: 89-99.

Kuo, A., Cappellutti, S., Cervantes-Cervantes, M., Rodriquez, M., and D.S. Bush. 1996. Okadaic acid, a protein phosphatase inhibitor, blocks calcium changes, gene expression and cell death induced by gibberellin in wheat aleurone. *The Plant Cell* **8**: 259-269.

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Bush, D.S., Sticher, L., and R.L. Jones. 1991. Gibberellic acid-regulated α-amylase synthesis and calcium transport in the endoplasmic reticulum of barley aleurone cells. In: "Gibberellins: Tokyo 1989". pp. 106-113.

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Hillmer, S., Bush, D.S., Robinson, D.G., Zingen-Sell, I., and R.L. Jones. 1990. Endomembrane structure and function in barley aleurone protoplasts. *Eur. J. Cell Biol.* **52**: 169-173.

Sticher, L., Biswas, A.K., Bush, D.S., and R.L. Jones. 1990. Heat shock inhibits α-amylase synthesis in barley aleurone without inhibiting the activity of endoplasmic reticulum marker enzymes. *Plant Physiol.* **92**: 506-513.

MARK H. CARR
Department of Biology
University of California
Santa Cruz, CA

Project: *Ecological Consequences of Alternative Abandonment Strategies for POCS Offshore Facilities and Implications for Policy Development*

Education	B.A.	Biology, University of California, Santa Cruz	1976
	M.S.	San Francisco State University	1983
	Ph.D.	University of California, Santa Barbara	1991

Positions:	1997-present	Assistant Professor III, Department of Biology, University of California, Santa Cruz, CA.
	1994-1997	Assistant Research Biologist IV, Deputy Director, SCEI and CMI, Marine Science Institute, University of California, Santa Barbara, CA.
	1992-94	Post-doctoral Research Associate, Department of Zoology, Oregon State University
	1993-94	Lecturer, Department of Zoology, Oregon State University
	1984-1991	Graduate Research Assistant, Department of Biological Sciences, University of California, Santa Barbara
	1981-1983	Research Technician, California Institute of Technology

Distinctions:	1989	Outstanding Student Paper Award, Western Society of Naturalists
	1988	EPRI Fellowship, Sport Fishing Institute
	1987	Joseph Drown Fellowship, University of Southern California, Oceanographic Associates

Research Interests:

- Population and community ecology of marine reef fishes
- Application of behavioral and ecological research to marine fisheries and conservation problems.

Selected Publications:

Carr, M.H. and C. Syms. “Recruitment: the replenishment of demersal fish populations” chapter *In:* Allen, L. (ed.) *The Ecology of California Marine Fishes*. U.C. Press. (in press)

Carr, M.H., Neigel, J.E., Estes, J.A., Andelman, S.J., Warner, R.R., and J.L. Largier. Comparing marine and terrestrial ecosystems: implications for principles of reserve design in coastal marine ecosystems. *Ecological Applications* (in press)

Shanks, A.L., Grantham, B., and M.H. Carr. Propagule dispersal distance and the size and spacing of marine reserves. *Ecological Applications* (in press)

Anderson, T.W., Bartels, C.T., Hixon, M.A., Bartels, E., Carr, M.H., and J.M. Shenker. 2002. Current flow and catch efficiency in sampling settlement-stage larvae of coral-reef fishes. *Fishery Bulletin* **100**: 404-413.

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Carr, M.H. 2000. Marine protected areas: challenges and opportunities for understanding and conserving coastal marine ecosystems. *Environmental Conservation* **27**: 106-109.

Carr, M.H. and A.A. Ammann. 2000. Contrasting effects of La Nina and El Nino on recruitment of juvenile rockfishes. Ecosystem Observations, Monterey Bay National Marine Sanctuary: 11-12.

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Carr, M.H. and P.T. Raimondi. 1999. Marine protected areas as a precautionary approach to management. *California Cooperative Oceanic Fisheries Investigations Reports* **40**: 71-76.

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Allison, G., Lubchenco, J., and M.H. Carr. 1998. Marine reserves are necessary but not sufficient for marine conservation. *Ecological Applications* **8**: S79-S92.

Anderson, T.W. and M.H. Carr. 1998. BINCKE: A highly efficient net for collecting reef-associated fishes. *Environmental Biology of Fishes* **51**: 111-115.

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Carr, M.H., Hourigan, T., Ito, D., McArdle, D., Morgan, L., Palsson, W., Parrish, R., Ralston, S., Reilly, P., Sladek, J., and R. Starr. 1998. "Working group on design considerations" pp. 143-148 *In:* M.M. Yoklavich (ed.) Marine Harvest Refugia for West Coast Rockfish: A Workshop. *NOAA/NMFS Technical Memo* SWFC-255.

Caley, M.J., Carr, M.H., Hixon, M.A., Hughes, T.P., Jones, G.P., and B.A. Menge. 1997. Recruitment and the population dynamics of open marine populations. *Annual Review of Ecology and Systematics* **27**: 477-500.

Carr, M.H. and M.A. Hixon. 1997. Artificial reefs: the importance of comparisons with natural reefs. *Fisheries* **22**: 28-33.

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Department of Ecology, Evolution and Marine Biology
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Santa Barbara, CA

Project: *Habitat Value of Shell Mounds to Ecologically and Commercially Important Benthic Species*

Education:	B.A.	Biological Sciences, Wabash College	1964
	Ph.D.	Physiology, Stanford University	1969

Positions: 1969-present Professor, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, California.

Selected Publications:

Girguis, P.R., Childress, J.J., Freytag, J.K., Klose, K., and R. Stuber. 2002. Effects of metabolite uptake on proton-equivalent elimination by two species of deep-sea vestimentiferan tubeworm, *Riftia pachyptila* and *Lamellibrachia cf luymesi*: proton elimination is a necessary adaptation to sulfide-oxidizing chemoautotrophic symbionts. *J Exp. Biol.* **205**(19): 3055-3066.

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Chevaldonne, P., Fisher, C.R., Childress, J.J., Desbruyeres, D., Jollivet, D., Zal, F., and A. Toulmond. 2000. Thermotolerance and the 'Pompeii worms'. *Mar. Ecol. Prog. Ser.* **208**: 293-295.

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Janssens, B.J., Childress, J.J., Baguet, F., Rees, J.F. 2000. Reduced enzymatic antioxidative defense in deep-sea fish. *J Exp. Biol.* **203**(24): 3717-3725.

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Thuesen, E.V., Miller, C.B., and J.J. Childress. 1998. Ecophysiological interpretation of oxygen consumption rates and enzymatic activities of deep-sea copepods. *Marine Ecology Progress Series* **168**: 95-107.

Zal, F., Leize, E., Lallier, F.H., Toulmond, A., Dorsselaer, A.V., and J.J. Childress. 1998. S-sulfohemoglobin and disulfide-exhange: The mechanisms of sulfide-binding by *Riftia pachyptila* hemoglobins. *P.N.A.S*. **95**: 8997-9002.

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Goffredi, S.K., Childress, J.J., Desaulniers, N.T., Lee, R.W., Lallier, F.H., and D. Hammond. 1997. Inorganic carbon acquisition by hydrothermal vent tubeworm *Riftia pachyptila* depends upon high external PCO_2 and on proton equivalent ion transport by the worm. *J. Exp. Biology* **200**: 883-896.

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Sanders, N.K. and J.J. Childress. 1990. Adaptations to the deep-sea oxygen minimum layer: Oxygen binding by the hemocyanin of the bathypelagic mysid, *Gnathophausia ingens* Dohrn. *Biol. Bull.* **178**: 286-294.

JORDAN CLARK
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Projects: *Simulation of a Subsurface Oil Spill by a Hydrocarbon Seep (SSOS-HYS).*
Oil Slicks in the Ocean: Predicting their Release PointsUsing the Natural Laboratory of the Santa Barbara Channel.

Education:

	B.S.	Yale University, New Haven, Connecticut	1988
	M.A.	Columbia University, New York City, New York	1991
	Ph.D.	Columbia University, New York City, New York	1995

Positions:

1996-present	Assistant Professor, Dept. of Geological Sciences and Program of Environmental Studies, University of California, Santa Barbara
1995 -1996	Post-doctoral Fellowship, Isotope Hydrology Group, Lawrence Livermore National Laboratory
1989-1995	Graduate Research Assistant, Columbia University

Selected Publications:

Aeschbach-Hertig, W., Stute, M., Clark, J.F., Reuter, R., and P. Schlosser. 2002. A paleotemperature record derived from dissolved noble gases in groundwater of the Aquia Aquifer (Maryland, USA). *Geochimica et Cosmochimica Acta* **66**: 797-817.

Boles, J.R., Clark, J.F., Leifer, I., and L. Washburn. 2002. Temporal variation in natural methane seep rate due to tides, Coal Oil Point area, California. *Journal of Geophysical Research* **106**: 27,077-27,086.

Rademacher, L.K., Clark, J.F., and G.B. Hudson. 2002. Temporal changes in stable isotope composition of spring waters: Implications for recent changes in climate and atmospheric circulation. *Geology* **20**: 139-142.

Clark, J.F. and G.B. Hudson. 2001. Tracing hydrothermal fluids in hypersaline Mono Lake using helium isotopes. *Limnology and Oceanography* **46**: 189-196.

Gamlin, J.D., Clark, J.F., Woodside, G., and R. Herndon. 2001. Tracing groundwater flow patterns in an area of artificial recharge using sulfur hexafluoride. *Journal of Environmental Engineering ASCE* **127**: 171-174.

Radamacher, L.K., Clark, J.F., Hudson, G.B., Erman, D.C., and N.A. Erman. 2001. Chemical evolution of shallow groundwater as recorded by springs, Sagehen basin, Nevada County California. *Chemical Geology* **179**: 37-51.

Clark, J.F., Washburn, L., Hornafius, J.S., and B.P. Luyendyk. 2000. Dissolved hydrocarbon flux from natural marine seeps to the southern California Bight. *Journal of Geophysical Research* 105 (11): 509-11,522.

Leifer, I., Clark, J.F., and R.F. Chen. 2000. Modifications of the local environment by natural marine hydrocarbon seeps. *Geophysical Research Letters* **27**: 3711-3714.

Macfarlane, P.A., Clark, J.F., Davisson, M.L., Hudson, G.B., and D.O. Whittemore. 2000. Late Quaternary ground water recharge in the central Great Plains from geochemical tracers in shallow ground water. *Quaternary Research* **53**: 167-174.

Quigley, D.C., Hornafius, J.S., Luyendyk, B.P., Francis, R.D., Clark, J.F., and L. Washburn. 1999. Decrease in natural marine hydrocarbon seepage near Coal Oil Point, California associated with offshore oil production. *Geology* **27**: 1047-1050.

Aeschbach-Hertig, W., Schlosser, P., Stute, M., Simpson, H.J., Ludin, A., and J.F. Clark. 1998. A $^3H/^3He$ study of groundwater flow in a fractured bedrock aquifer. *Ground Water* **36**: 661-670.

Clark, J.F, Davisson, M.L., Hudson, G.B., and P.A. Macfarlane. 1998. Noble gases, stable isotopes, and radiocarbon as tracers of flow in the Dakota aquifer, Colorado and Kansas. *Journal of Hydrology* **211**: 151-167.

Clark, J.F., Stute, M., Schlosser, P., Drenkard, S., and G. Bonani. 1997. An isotope study of the Floridan aquifer in Southeastern Georgia: Implications for groundwater flow and paleoclimate. *Water Resources Research* **33**: 281-289.

Macfarlane, P.A., Clark, J.F., Whittemore, D.O., Davisson, M.L., and G.B. Hudson. 1997. Holocene and late Pleistocene climate conditions in the central Great Plains deduced from noble gases, stable isotopes, Cl, and ^{36}Cl in shallow groundwater. Kansas Geological Survey Open-File-Report #97-77, 28 p.

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Clark, J.F., Schlosser, P., Simpson, H.J., Stute, M., Wanninkhof, R., and D.T. Ho. 1995. Relationship between gas transfer velocities and wind speeds in the tidal Hudson River determined by the dual tracer technique. In: *Air-Water Gas Transfer*, eds. Jähne, B. and E. Monahan, Aeon Verlag, Hanau, 785-800.

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Clark, J.F., Smethie Jr., W.M., and H.J. Simpson. 1995. Chlorofluorocarbons in the Hudson estuary during summer months. *Water Resources Research* **31**: 2553-2560.

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Stute, M., Clark, J.F., Phillips, F.M., and D. Elmore. 1993. Reconstruction of late glacial climates from the groundwater archive: Cl and ^{36}Cl in the Carrizo aquifer, Texas. *Applications of Isotope Techniques in Studying Past and Current Environmental Changes in the Hydrosphere and the Atmosphere*, IAEA, Vienna, 259-270.

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Clark, J.F., Simpson, H.J., Smethie Jr., W.M., and C. Toles. 1992. Gas exchange in a contaminated estuary inferred from chlorofluorocarbons. *Geophysical Research Letters* **19**: 1133-1136.

Stute, M., Schlosser, P., Clark, J.F., and W.S. Broecker. 1992. Paleotemperatures in the southwestern United States derived from noble gas measurements in groundwater. *Science* **256**: 1000-1003.

DANIEL P. COSTA
Department of Ecology and Evolutionary Biology
University of California
Santa Cruz, CA

Project: *Population Dynamics and Biology of the California Sea Otter at the Southern End of its Range*

Education:

B.A.	Zoology, University of California, Los Angeles	1974
Ph.D.	Biology, University of California, Santa Cruz	1977

Positions:

1996	Elected Fellow of the California Academy of Sciences
1995-Present	Associate Director of the Institute of Marine Sciences, University of California, Santa Cruz, CA
1995-Present	Editorial Board of Physiological Zoology
1993-Present	Professor of Biology, University of California, Santa Cruz, CA
1991-1993	Associate Professor of Biology, University of California, Santa Cruz, CA
1991-1993	Scientific Officer, Physiology and Marine Mammal Biology, Office of Naval Research
1987 & 1989	ASEE Senior Faculty Fellow, NOSC, US Navy, Hawaii
1985 & 1987	Visiting Scientist, British Antarctic Survey, Cambridge, England
1979-1982	National Institutes of Health Postdoctoral Fellowship, Scripps Institution of Oceanography, San Diego, CA

Selected Publications:

Shaffer, S.A., Costa, D.P., and H. Weimerskirch. 2001. Behavioural factors affecting foraging effort of breeding wandering albatrosses. *J. of Animal Ecology* **70**: 864-874.

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Costa, D.P. 1991. Reproductive and foraging energetics of pinnipeds: Implications for life history patterns. In: *Pinniped Behaviour*, D. Renouf ed., Chapman Hill.

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Advancing Marine Biotechnology: Use of OCS Oil Platforms as Sustainable Sources of Marine Natural Products
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Education:

A.A.	Liberal Arts, De Anza Junior College, Cupertino, CA	1977
B.A.	Aquatic Biology, University of California, Santa Barbara	1980
Ph.D.	Biology, University of California, Santa Barbara	1990

Positions:

1995-present	Assistant Research Biologist, Marine Science Institute, University of California, Santa Barbara
1990-95	Postdoctoral Researcher, Marine Science Institute, University of California, Santa Barbara
1994	Postdoctoral Fellow, Department of Marine Science, University of Otago, New Zealand
1993	Postdoctoral Fellow, Department of Zoology, University of Port Elizabeth, Republic of South Africa
1988-93	Marine Biologist, Cooperative Park Science Unit, University of California, Davis, Channel Islands National Park, Ventura, CA

Selected Publications:

Dugan, J.E. and D. Hubbard. Southern New Zealand Beaches. In: Natural History of Southern New Zealand. Darby, J. and W. Harrex (eds.) University of Otago Press and the Otago Museum, Dunedin, New Zealand. (in press)

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Education:

B.A.	Zoology, University of Minnesota	1967
M.S.	Zoology, Washington State University	1969
Ph.D.	Biological Sciences/Statistics, University of Arizona	1974

Positions:

1984-present	Supervisory Zoologist, GM-486/15, California Science Center, National Biological Service, Santa Cruz, California
1978-pressent	Adjunct Professor, Biological Sciences, University of California, Santa Cruz
1979-present	Research Biologist, Institute for Marine Sciences, University of California, Santa Cruz
1978-1981	Wildlife Biologist (Research), GS-486/12, Marine Mammal Section, National Fish and Wildlife Laboratory, FWS, Santa Cruz, California
1977-1978	Wildlife Biologist (Research), GS-486/12, Marine Mammal Section, National Fish and Wildlife Laboratory, FWS, Anchorage, Alaska
1974-1977	Wildlife Biologist (Research), GS-486/11, Marine Mammal Section, National Fish and Wildlife Laboratory, FWS, Anchorage, Alaska

Selected Publications:

Estes, J.A., Hatfield, B.B., Ralls, K., et al. 2003. Causes of mortality in California sea otters during periods of population growth and decline. *Mar. Mammal Sci.* **19**(1): 198-216.

Gelatt, T.S., Siniff, D.B., and J.A. Estes. 2002. Activity patterns and time budgets of the declining sea otter population at Amchitka Island, Alaska. *J. Wildlife Manage.* **66**(1): 29-39.

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	M.S.	Zoology, University of Sydney, Australia	1988
	Ph.D.	Zoology, University of New Hampshire	1992

Positions:	1999-Present	Assistant Professor, Department of Biological Sciences, University of Rhode Island
	1995-1999	Assistant Professor, Department of Organismic Biology, Ecology and Evolution, University of California, Los Angeles
	1993-95	Postdoctoral Research, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
	1992	Statistical Consultant, Ithaca College
	1991	Research Associate, Arizona State University
	1985	Research Technician, University of Wales

Distinctions:	1998	Faculty Career Development Award, University of California, Los Angeles
	1997	Mildred Mathias award for top rated natural science proposal to UCMEXUS Program
	1991-92	Dissertation Fellowship, University of New Hampshire
	1989	Stoye Award
	1989-1990	Summer Graduate Fellowships, University of New Hampshire
	1986-88	University Postgraduate Research Scholarship, University of Sydney

Selected Publications:

Forrester, G.E and S.E. Swearer. Quantifying the use of different nursery habitats by juvenile California halibut through the analysis of trace-elements in otoliths. *Limnology and Oceanography* (in review).

O'Bryan, L.M. and G.E. Forrester. Horizontal distributions of *Chaoborus punctipennis*: documentation of patterns and tests of moonlight as a proximal controlling factor. *Hydrobiologia* (in review).

Steele, M.A. and G.E. Forrester. Early post-settlement predation on three reef fishes: effects on spatial patterns of abundance. *Ecology* (in review).

Steele, M.A., McClean, A.M., Malone, J.C., Forrester, G.E., and M.H. Carr. A test for limitation of population size by larval supply in the kelp bass (*Paralabrax clathratus)*. *Oecologia* (in review).

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Forrester, G.E., Vance, R.R., and M.A. Steele. 2002. Simulating Large-Scale Population Dynamics Using Small-Scale Data. Invited chapter in *Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem*, P.F. Sale (editor), pp. 275-301. Academic Press.

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Observing the Surface Circulation Along the South-Central California Coast Using High Frequency Radar: Consequences for Larval and Pollutant Dispersal
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Education:

	B.S.	Biology, University of California, Irvine	1977
	Ph.D.	Ecology, Oregon State University	1982

Positions:

1997-present	Director, Marine Science Institute, University of California, Santa Barbara
1994-present	Associate Professor, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA
1993-1994	Associate Professor, Brown University, Providence, RI
1987-1993	Assistant Professor, Brown University, Providence, RI
1986-1987	Research Associate, Brown University, Providence, RI
1982-1986	Postdoctoral Fellow, Stanford University, Stanford, CA

Selected Publications:

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Project: *Wave Prediction in the Santa Barbara Channel*

Education:

B.A.	Physics, John Hopkins University	1969
M.S.	Oceanography, University of California, San Diego, CA	1971
Ph.D.	Oceanography, University of California, San Diego, CA	1974

Positions:

1994-Present	Director, Center for Coastal Studies, University of California, San Diego
1975-Present	Professor of Oceanography, Scripps Institution of Oceanography, University of California, San Diego, CA
1974-1975	PostDoctoral Fellow, Dalhousie University, Halifax, Nova Scotia

Selected Publications:

Herbers, T.H.C., Elgar, S., Sarap, N.A., and R.T. Guza. 2002. Nonlinear dispersion of surface gravity waves in shallow water. *J Phys Oceanogr* **32**(4): 1181-1193.

Noyes, T.J.A., Guza, R.T., Elgar, S., and T.H.C. Herbers. 2002. Comparison of methods for estimating nearshore shear wave variance. *J Atmos Ocean Tech* **19**(1): 136-143.

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Advancing Marine Biotechnology: Use of OCS Oil Platforms as Sustainable Sources of Marine Natural Products

Education:

B.A.	Botany & Biology, University of California, Berkeley, CA	1983
Ph.D.	Botany, University of California, Berkeley, CA	1990

Positions:

1995-Present	Assistant Professor, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA
1993-1995	Postdoctoral Associate, Departments of Botany and Genetics, University of Georgia, Athens, GA
1992	Research Associate, Department of Genetics, University of Georgia, Athens, GA
1991	Visiting Assistant Professor of Biology, Bernard College, Columbia University, New York, NY

Education:

B.A.	Botany and Biology, University of California, Berkeley	1983
Ph.D.	Botany, University of California, Berkeley	1990

Positions:

1995 - present	Assistant/Associate Professor, Dept. of Ecology, Evolution and Marine Biology, UCSB
1993 - 1995	Postdoctoral Associate, Depts. of Botany and Genetics, Univ. of Georgia, Athens, GA
1992	Research Associate, Dept. of Genetics, University of Georgia, Athens, GA
1991	Visiting Assistant Professor of Biology, Barnard College, Columbia Univ. New York, NY
1983-1990	Research Associate, Research Associate, Teaching Assistantship at UC Berkeley

Awards and Honors:

1998	UCSB nominee for Packard Fellowship
1997	Regents' Junior Faculty Fellowship
1996	Regents' Junior Faculty Fellowship
1994	Menzel Award, Genetics Section, Botanical Society of America
1988	Distinguished Instructor, University of California, Berkeley
1987-88	Regents Fellowship, University of California, Berkeley

Selected Publications:

Taylor, D.L., Bruns, T.D., Szaro, T.M., and S.A. Hodges. 2003. Divergence in mycorrhizal specialization within *Hexalectris spicata* (Orchidaceae), a non-photosynthetic desert orchid. *American Journal of Botany* (in press).

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Population Genetics of Surfgrass (Phyllospadix torreyi) for Use in Restoration

Education:	B.A.	Biology, Smith College	1970
	Ph.D.	Zoology, University of California, Berkeley	1975

Positions:	1987-present	Professor, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
	1981-87	Associate Professor, Department of Biological Sciences, University of California, Santa Barbara
	1975-81	Assistant Professor, Department of Biological Sciences, University of California, Santa Barbara

Selected Publications:

Bernardi, G., Holbrook, S.J., Schmitt, R.J., Crane, N.L., and E. DeMartini. 2002. Species boundaries, populations, and color morphs in the coral reef three-spot damselfish (*Dascyllus trimaculatus*) species-complex. *Proceedings of the Royal Society of London B* **269**(1491): 599-605.

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Project: *Advancing Marine Biotechnology: Use of OCS Oil Platforms as Sustainable Sources of Marine Natural Products*

Education:	B.S.	Biology, Northwestern University, Evanston, IL	1964
	Ph.D.	Pharmacology, Stritch School of Medicine, Loyola University, Chicago, IL	1971

Positions:	1995-Present	Professor of Pharmacology, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA
	1982-1995	Professor of Pharmacology, Department of Biological Sciences, University of California, Santa Barbara, CA
	1978-1982	Associate Professor of Pharmacology, Department of Biological Sciences, University of California, Santa Barbara, CA
	1974-1978	Assistant Professor of Pharmacology, Department of Biological Sciences, University of California, Santa Barbara, CA
	1971-1974	Assistant Professor of Pharmacology, Department of Pharmacology, Stritch School of Medicine, Loyola University, Chicago, IL

Selected Publications:

Stevenson, C.S., Capper, E.A., Roshak, A.K., Marquez, B., Eichman, C., Jackson, J.R., Mattern, M., Gerwick, W.H., Jacobs, R.S., and L.A. Marshall. 2002. The identification and characterization of the marine natural product scytonemin as a novel antiproliferative pharmacophore. *J Pharmacol Exp Ther* **303**(2): 858-866.

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Williams, A.B. and R.S. Jacobs. 1993. A marine natural product, Patellamide D, reverses multidrug resistance in a human leukemic cell line. *Cancer Letters* **71**: 97-102.

Potts, B.C.M., Faulkner, D.J., and R.S. Jacobs. 1992. Phospholipase A_2 inhibitors from marine organisms. *J. Natural Products* **55**: 1701-1717.

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Project: *Joint UCSB-MMS Pacific OCS Student Internship and Trainee Program*

Education:

B.S.	Mathematics, California State University, Fresno	1965
B.A.	Geology, California State University, Fresno	1968
M.S.	Geology, University of California	1969
Ph.D.	Geology, Purdue University	1973

Positions:

1989-92; 1993-present	Chair of the Environmental Studies Program, University of California, Santa Barbara
1976-present	Professor, Department of Geological Sciences, University of California, Santa Barbara
1973-76	Asst. Professor, Department of Environmental Studies, University of North Carolina

Selected Peer-reviewed Publications:

Keller, E.A. 2002. Introduction to Environmental Geology, second edition, Prentice Hall, Upper Saddle River, New Jersey.

Keller, E.A., and N. Pinter. 2002. Active Tectonics, 2nd edition, Upper Saddle River. New Jersey, Prentice Hall.

Keller, E.A. 2001. Environmental Geology, 8th Edition, Upper Saddle River, New Jersey, Prentice Hall.

Keller, E.A., Johnson, D.L., Laduzinsky, D.L., Seaver, D.B., and T.L. Ku. 2000. Tectonic Geomorphology of Active Folding Over Buried Reverse Faults: San Emigdio Mountain Front, Southern San Joaquin Valley, California, *Geological Society of America Bulletin* **112**: 86-97.

Botkin, D.B. and E.A. Keller. 1999. Environmental Science, 3rd Edition, New York, John Wiley and Sons, Inc.

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Pinter, N., Lueddecke, S.B., Keller, E.A., and K.R. Simmons. 1998. Late Quaternary slip on the Santa Cruz Island fault, California. *Geological Society of America Bulletin* **110**: 711-722.

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Keller, E.A. 1992. *Environmental Geology,* 6th ed. Macmillan Publishing Co., New York. 521 p.

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Education:

B.Sc.	Physics/ Astronomy, SUNY at Stony Brook, New York	1984
M.S.	Aeronomy, University of Michigan	1989
Ph.D.	Atmospheric Sciences, Georgia Institute of Technology	1995

Positions:

2001-Present	Researcher I, Marine Science Institute and Chemical Engineering Department, University of California, Santa Barbara, CA.
1999-2001	Post Doctoral Researcher, Chemical Engineering Department, University of California, Santa Barbara, CA.
1998-1999	Visiting Scientist, TNO Physics and Electronics Laboratory, The Hague, The Netherlands.
1996-1999	Post Doctoral Researcher, Martin Ryan Institute of Marine Science, National University of Ireland, Galway, Ireland.

Selected Publications:

Clark, J.F., Leifer, I., Washburn, L., and B.P. Luyendyk. 2003. Compositional changes in natural gas bubble plumes: Observations from the Coal Oil Point Seep Field. *Geo. Mar Lett*. (submitted).

Leifer, I. and I. MacDonald. 2003. Dynamics of the gas flux from shallow gas hydrate deposits: Interaction between oily hydrate bubbles and the oceanic environment. *Earth Plan. Sci. Lett*. (in press).

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Asher, W.E., Farley, P.J., Higgins, B.J., Karle, L.M., Leifer, I.S., and E.C. Monahan. 1994. The influence of bubble plumes on air-sea gas exchange, *EOS Nov. 1 Supplement* **75**(44): 369.

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B.S.	Geology/ Geophysics, San Diego State College, California	1965
Ph.D.	Oceanography/ Marine Geophysics, Scripps Inst. of Oceanography, San Diego, California.	1969

Positions:

1997-Present	Chair, Department of Geological Sciences, University of California, Santa Barbara
1988-1997	Directory, Institute for Crustal Studies, University of California, Santa Barbara
1987-1988	Acting Director for Institute of Crustal Studies, UC Santa Barbara
1981-Present	Professor, Department of Geological Sciences, University of California, Santa Barbara
1975-1981	Associate Professor, Department of Geological Sciences, UC Santa Barbara
1973-1975	Assistant Professor, Department of Geological Sciences, UC Santa Barbara

Selected Publications:

Luyendyk, B.P., Smith, C.H., and G. Druivenga. Gravity measurements on King Edward VII Peninsula, Marie Byrd Land, West Antarctica, during GANOVEX VII, Geolog. Jahrb. (in press).

Siddoway, C.H. and B.P. Luyendyk. Crustal structure and Cenozoic tectonics on the eastern margin of the Ross Sea, Marie Byrd Land. Antarctic J. of the U.S. (in press).

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Henrys, S.A., Bartek, L.R., Brancolini, G., Luyendyk, B., Hamilton, R.J., Sorlien, C.C., and F.J. Davey. 1998. Seismic stratigraphy of the pre-quaternary strata off Cape Roberts and their correlation with strata cored in the CIROS-1 drill hole, McMurdo sound. *Terra Antartica* **5**: 273-279.

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Luyendyk, B.P. 1997. Slab capture versus ridge collision as an explanation for Cretaceous extension and rifting of east Gondwana. in Ricci, C. A., ed., The Antarctic Region: Geological Evolution and Processes, Proceed. VII Symp. on Antarctic Earth Sci., Siena, 467-474.

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Schermer, E., Luyendyk, B.P., and S. Cisowski. 1996. Late Cenozoic structure and tectonics of the northern Mojave Desert. *Tectonics* **15**: 905-932.

Wateren, F.M. van der, Verbers, A.L.L.M., Luyendyk, B.P., Smith, C.H., Hofle, H. Chr., Vermeulen, F.J.M., de Wolf, H., Herpers, U., Klas, W., Kubik, P.W., Suter, W., and B. Dittrich-Hannen. 1996. Glaciation and deglaciation of the uplifted margins of the Cenozoic West Antarctic rift system, Ross Sea, Antarctica. *Geologisches Jahrbuch* **B89**, Polar issue no. 6, p. 123-155.

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Wateren, F.M. van der, Luyendyk, B.P., Verbers, A.L.L.M., and C.H. Smith. 1994. Landscape evolution model of the West Antarctic Rift system relating tectonic and climatic evolutions of the rift margins. *Terra Antarctica* **1**(2): 453-456.

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Education:	B.A.	Political Science, University of California, Los Angeles	1985
	M.A.	Political Science, University of California, Santa Barbara	1988
	Ph.D.	Political Science, University of California, Santa Barbara	1993

Positions:	2001-present	Adjunct Assistant Professor, Donald Bren School of Environmental Science & Management
	1998-00	Lecturer, UCSB Environmental Studies Program
	1996-present	Co-Director and Founder, The Center for Bioregional Conflict Resolution, Santa Cruz, California
	1995-present	Research Political Scientist, Ocean and Coastal Policy Center, Marine Science Institute, University of California, Santa Barbara
	1994	Lecturer, Department of Political Science, University of California, Santa Barbara
	1992-94	Visiting Assistant Professor, Department of Political Science, University of Oregon
	1992-94	Research Associate, Institute for Sustainable Environment, Department of Planning and Public Policy, University of Oregon
	1991	Technical Consultant, Santa Barbara County Energy Division
	1990	Lecturer, Department of Political Science, University of California, Santa Barbara

Selected Publications:

Woolley, J.T., McGinnis, M.V., and J. Kellner. 2002. The California watershed movement: Science and the politics of place. *Nat. Resour. J.* **42**(1): 133-183.

Woolley, J.T. and M.V. McGinnis. 2000. The conflicting discourses of restoration. *Soc. Natur. Resour.* **13**(4): 339-357.

McGinnis, M.V. 1999. *Bioregionalism: The Tug and Pull of Place*. London, New York: Routledge. 231 p.

McGinnis, M.V. 1999. Making the watershed connection. *Policy Stud. J.* **27**(3): 497-501.

McGinnis, M.V., Woolley, J., and J. Gamman. 1999. Bioregional conflict resolution: Rebuilding community in watershed planning and organizing. *Environmental Management* **24**: 1-12.

Woolley, J.T. and M.V. McGinnis. 1999. The politics of watershed policymaking. *Policy Stud. J.* **27**(3): 578-594.

McGinnis, M.V. 1997. An analysis of the role of ecological science in offshore continental shelf abandonment policy. In: *Proceedings of California and the World Ocean '97*, Organized and sponsored by Coastal Zone Foundation and Resources Agency of California. 9 pp.

McGinnis, M.V. 1996. Deep ecology and the foundations of restorations. *Inquiry: An Interdisciplinary Journal of Philosophy* **39**: 203-217.

McGinnis, M.V. 1996. Perceptions and restoration ecology: A comparison of restoration discourses. *Inquiry: An Interdisciplinary Journal of Philosophy.*

McGinnis, M.V. 1995. Bioregional organization: A constitution of home place. *Human Ecology Review* **2**: 72-84.

McGinnis, M.V. 1995. On the verge of collapse: The Columbia River system, wild salmon and the Northwest Power Planning Council. *Natural Resources Journal* **35**: 520-552.

McGinnis, M.V. 1994. Collective bads: The case of low-level radioactive waste compacts. *Natural Resources Journal* **34**: 563-588.

McGinnis, M.V. 1994. Myth, nature and the bureaucratic experience. *Environmental Ethics* **16**: 425-434.

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McGinnis, M.V. 1993. Low-level radioactive waste compacts: Cases in the illogic of collective action. In: *Problems and Prospects for Nuclear Waste Disposal Policy,* E.B. Herzik and A. Mushkatel, eds. Greenwood Press, CT.

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McGinnis, M.V. and W. Cohan. 1992. Ecology and international studies. Pp. 245-267 in: *Revealing the World: An Interdisciplinary Reader in International Studies,* D Lieberman and M. Gurtow, eds. Kendall/Hunt Publ. Co.

McGinnis, M.V. 1991. San Luis Obispo's measure A--check or checkmate? Pp. 119-119 in: *The California Coastal Zone Experience,* G.W. Domurat and T.H. Wakeman, eds. American Society of Civil Engineers, NY, NY.

McGinnis, M.V. 1990. *The multiple uses of the ocean and coastal zone offshore California*. California Sea Grant Publication, Working Paper P-T-51. California Sea Grant College Program, CA.

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B.S.	Biology, Vrije Universiteit, Amsterdam, The Netherlands	1986
M.S.	Biology, Vrije Universiteit, Amsterdam, The Netherlands	1988
Ph.D.	Biology, Vrije Universiteit, Amsterdam, The Netherlands	1994

Positions:

1997-present	Assistant Research Biologist, Marine Science Institute, University of California, Santa Barbara
1995-97	Postdoctoral Researcher, Marine Science Institute, University of California, Santa Barbara
1992-93	Postdoctoral Researcher, TNO Institute of Environmental Sciences, Vrije Universiteit, The Netherlands

Selected Publications:

Muller, E.B. and R.M. Nisbet. Sublethal effects of toxicants: a dynamic energy budget modeling approach compared to experimental results. *Ecological Application* (in press).

Coury, J.R., Manosso, F.G., Marques, K.A., et al. 2002. Assessment of particulates in the urban atmosphere of Sao Carlos, Brazil. *Int. J. Environ. Pollut.* **17**(3): 220-242.

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Muller, E.B., Nisbet, R.M., Kooijman, S.A.L.M., et al. 2001. Stoichiometric food quality and herbivore dynamics. *Ecol. Lett.* **4**(6): 519-529.

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Nisbet, R.M., Muller, E.B., Lika, K., et al. 2000. From molecules to ecosystems through dynamic energy budget models. *J. Anim. Ecol.* **69**(6): 913-926.

Muller, E.B. and R.M. Nisbet. 1997. Modeling the effect of toxicants on the parameters of dynamic energy budget models. Pp. 71-81 in: *Environmental Toxicology and Risk Assessment: Modeling and Risk Assessment* (Sixth Volume), F. J. Dwyer, T.R. Doane and M.L. Hinman, eds., American Society for Testing and Materials.

Nisbet, R.M, Muller, E.B., Brooks, A.J., and P. Hosseini. 1997. Models relating individual and population response to contaminants. *Environmental Modeling and Assessment* **2**: 7-12.

Van Verseveld, H.W., Muller, E.B., and P. Groeneveld. 1996. Fast determination of residual substrate in a fermentor. Why should it be fast and how can this be done. Pp. 422-427 in: *Biothermokinetics of the Living Cell,* Westerhoff, Snoep, Sluse, Wijker, Kholodenko, eds.

Muller, E.B., Stouthamer, A.H., and H.W. van Verseveld. 1995. A novel method to determine maximal nitrification rates by sewage sludge at a non-inhibitory nitrite concentration applied to determine maximal rates as a function of the nitrogen load. *Wat. Res*. **29**: 1191-1197.

Muller, E.B., Stouhamer, A.H., and H.W. van Verseveld. 1995. Simultaneous NH_3 oxidation and N_2 production at reduced O_2 tensions by sewage sludge subcultured with chemolithotrophic medium. *Biodegradation* **6**: 339-349.

Muller, E.B., Stouthamer, A.H., van Verseveld, H.W., and D.H. Eikelboom. 1995. Aerobic domestic waster water treatment in a pilot plant with complete sludge retention by cross-flow filtration. *Wat. Res*. **29**: 1179-1189.

Muller, E.B. 1994. Bacterial energetics in aerobic wastewater treatment, Ph.D. thesis, Vrije Universiteit, Amsterdam, The Netherlands.

Kooijman, S.A.L.M., Muller, E.B., and A.H. Stouthamer. 1991. Microbial growth dynamics on the basis of individual budgets. *Antonie van Leeuwenhoek* **60**: 159-174.

ROGER NISBET
Department of Ecology, Evolution and Marine Biology
University of California
Santa Barbara, CA

Project: *Assessing Toxic Effects on Population Dynamics Using Individual-Based Energy Budget Models*

Education:	B.Sc.	Physics and Theoretical Physics, University of St. Andrews	1968
	Ph.D.	Theoretical Physics, University of St. Andrews	1971

Positions:	2000-Present	Chair, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
	1995-1999	Vice Chair, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
	1991-present	Professor, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
	1989-1991	Professor, Department of Statistics and Modeling Science, University of Strathclyde, Scotland
	1985-1989	Personal Professor in Applied Physics, University of Strathclyde. [1986-88 Chair, Department of Physics and Applied Physics, University of Strathclyde]
	1985	Visiting Research Biologist, University of California, Santa Barbara
	1983-1985	Reader in Applied Physics, University of Strathclyde
	1977-79	Seconded from Strathclyde to University of the South Pacific, Suva, Fiji, as Senior Lecturer in School of Natural Resources
	1972-1977	Lecturer in Applied Physics, University of Strathclyde

Distinctions:	1991	Elected Fellows of the Royal Society of Edinburg
	1987	Van De Klaauw Chair in Biology, University of Leiden, The Netherlands
	1971-72	Nuffield Biological Scholarship
	1968-71	Carnegie Scholarship

Selected Publications:

Murdoch, W.W., Kendall, B.E., Nisbet, R.M., *et al*. 2002. Single-species models for many-species food webs *Nature* **417**(6888): 541-543.

Chase, J.M., Abrams, P.A., Grover, J.P., *et al*. 2002. The interaction between predation and competition: a review and synthesis. *Ecol. Lett.* **5**(2): 302-315.

Amarasekare, P. and R.M. Nisbet. 2001. Spatial heterogeneity, source-sink dynamics, and the local coexistence of competing species. *American Naturalist* **158**(6): 572-584.

Muller, E.B., Nisbet, R.M., Kooijman, S.A.L.M., *et al.* 2001. Stoichiometric food quality and herbivore dynamics. *Ecol. Lett.* **4**(6): 519-529.

Ellner, S.P., McCauley, E., Kendall, B.E., *et al*. 2001. Habitat structure and population persistence in an experimental community. *Nature* **412**(6846): 538-543.

Parker, H.H., Noonburg, E.G., and R.M. Nisbet. 2001. Models of alternative life-history strategies, population structure and potential speciation in salmonid fish stocks. *J. Anim. Ecol.* **70**(2): 260-272.

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Lika, K. and R.M. Nisbet. 2000. A Dynamic Energy Budget model based on partitioning of net production *J. Math. Biol.* **41**(4): 361-386.

Snyder, R.E. and R.M. Nisbet. 2000. Spatial structure and fluctuations in the contact process and related models. *B. Math. Biol.* **62**(5): 959-975.

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Nisbet, R.M., Muller, E.B., Lika, K., *et al*. 2000. From molecules to ecosystems through dynamic energy budget models. *J. Anim. Ecol.* **69**(6): 913-926.

Casas, J., Nisbet, R.M., Swarbrick, S., *et al*. 2000. Eggload dynamics and oviposition rate in a wild population of a parasitic wasp. *J. Anim. Ecol.* **69**(2): 185-193.

Donalson, D.D. and R.M. Nisbet. 1999. Population dynamics and spatial scale: Effects of system size on population persistence. *Ecology* **80**(8): 2492-2507.

McCauley, E., Nisbet, R.M., Murdoch, W.W., *et al*. 1999. Large-amplitude cycles of Daphnia and its algal prey in enriched environments. *Nature* **402**(6762): 653-656.

De Roos, A.M., McCauley, E., Nisbet, R.M., Gurney, W.S.C., and W.W. Murdoch. 1999. What individual life histories can (and cannot) tell about population dynamics. *Aquatic Ecology.*

Wilson, W.G., Osenberg, C.W., Schmitt, R.J., and R.M. Nisbet. 1999. Complementary foraging behavior allows coexistence of two grazers. *Ecology* **80**: 2358-2372.

Kendall, B.E., Briggs, C.J., Murdoch, W.W., Turchin, P., *et al*. 1999. Why do populations cycle? A synthesis of statistical and mechanistic modeling approaches. *Ecology* **80**: 1789-1805.

Briggs, C.J., Nisbet, R.M., and W.W. Murdoch. 1999. Delayed feedback and multiple attractors in a host-parasitoid system. *Journal of Mathematical Biology* **38**: 317-345.

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Noonburg, E.G., Nisbet, R.M., McCauley, E., and W.S.C. Gurney. 1998. Experimental testing of dynamic energy budget models. *Functional Ecology* **12**: 211-222.

Gurney, W.S.C. and R.M. Nisbet. 1998. *Ecological Dynamics*. New York, Oxford University Press. 385 p.

Middleton, D.A.J. and R.M. Nisbet. 1997. Population persistence time: estimates, models, mechanisms. *Ecological Applications* **7**: 107-117.

Muller, E.B. and R.M. Nisbet. 1997. Modeling the effect of toxicants on the parameters of dynamic energy budget models. Pp. 71-81 in: *Environmental Toxicology and Risk Assessment: Modeling and Risk Assessments* (Sixth Volume) F. James Dwyer, Thomas R. Doane, and Mark L. Hinman, Eds., American Society for Testing and Materials.

Murdoch, W.W., Briggs, C.J., and R.M. Nisbet. 1997. Dynamical effects of host-size and parasitoid state-dependent attacks by parasitoids. *Journal of Animal Ecology* **66**: 542-556.

J. CARTER OHLMANN
Institute for Computational Earth System Science
University of California
Santa Barbara, CA

Project: *Transport over the Inner-Shelf of the Santa Barbara Channel*

Education:

B.A.	Applied Mathematics, University of California, San Diego, CA	1986
MA.	Architecture, California Polytechnic University, San Luis Opispo, CA	1991
M.S.	Mechanical Engineering, University of Calfornia, Santa Barbara, CA	1995
Ph.D.	Geography (Oceanography), University of California, Santa Barbara, CA	1997

Positions:

2000-Present	Assistant Research Oceanographer, Institute for Computational Earth System Science, University of California, Santa Barbara, CA
1998-2000	Postdoctoral Researcher, Physical Oceanography Research Division, Scripps Institution of Oceanography, La Jolla, CA
1997-1998	Post Postdoctoral Researcher, Institute for Computational Earth System Science, University of California, Santa Barbara, CA
1992-1997	Research Assistant, Institute for Computational Earth System Science,University of California, Santa B

Selected Publications:

Ohlmann, J. C., and A.L. Sybrandy. 2002. A catch-and-release Lagrangian drifter for near-shore ocean circulation research. *Proceedings, California and the World Ocean* (in press)

Ohlmann, J.C. and P.P. Niiler. 2001. A two-dimensional response to a tropical storm on the Gulf of Mexico shelf. *J Marine Syst* **29**(1-4): 87-99.

Ohlmann, J.C., Niiler, P.P., Fox, C.A., and R.R. Leben. 2001. Eddy energy and shelf interactions in the Gulf of Mexico. *J Geophys Res-Oceans* **106**(C2): 2605-2620.

Ohlmann, J.C., and D.A. Siegel. 2000. Ocean radiant heating: Part II. Parameterizing solar radiation transmission through the upper ocean. *J Phys Oceanogr* **30**(8): 1849-1865.

Ohlmann, J.C., Siegel, D.A., and C.D. Mobley. 2000. Ocean radiant heating: Part I. Optical influences. *J Phys Oceanogr* **30**(8): 1833-1848.

Siegel, D.A., Westberry, T.K., and J.C. Ohlmann. 1999. Cloud color and ocean radiant heating. *J Climate* **12**(4): 1101-1116.

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Siegel, D.A., Ohlmann, J.C., Washburn, L., Bidigare, R.R., Nosse, C.T., Fields, E., and Y.M. Zhou. 1995. Solar-Radiation, Phytoplankton Pigments and the Radiant Heating of the Equatorial Pacific Warm Pool. *J Geophys Res-Oceans* **100**(C3): 4885-4891.

WILLIAM C. O'REILLY
Department of Civil and Environmental Engineering
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Berkeley, CA

Project: *Wave Prediction in the Santa Barbara Channel*

Education:

B.S.	Civil Engineering, University of Michigan	1983
B.S.	Environmental Eng., University of Michigan	1983
M.S.	Oceanography, University of California, San Diego	1985
Ph.D.	Oceanography, University of California, San Diego	1991

Positions:

1997-Present	Visiting Lecturer, Civil and Environmental Engineering, University of California, Berkeley, CA
1996-Present	Research Assistant Professor, Department of Oceanography, Naval Postgraduate School, Monterey, CA
1993-Present	Development Engineer, Scripps Institution of Oceanography, University of California, San Diego, CA
1991-93	Visiting Scholar, Civil Engineering Department, University of California, Berkeley
1991-93	Post-Doctoral Researcher, Scripps Institution of Oceanography, University of California, San Diego, CA
1984-91	Research Assistant, Scripps Institution of Oceanography, University of California, San Diego, CA

Selected Publications:

Ardhuin, F., Herbers, T.H.C., and W.C. O'Reilly. 2001. A hybrid Eulerian-Lagrangian model for spectral wave evolution with application to bottom friction on the continental shelf. *J Phys Oceanogr* **31**(6): 1498-1516.

Elgar, S., Guza, R.T., O'Reilly, W.C., Raubenheimer, B., and T.H.C. Herbers. 2001. Wave energy and direction observed near a pier. *J Waterw Port C-ASCE* **127**(1): 2-6.

Herbers, T.H.C., Hendrickson, E.J., and W.C. O'Reilly. 2000. Propagation of swell across a wide continental shelf. *J Geophys Res-Oceans* **105**(C8): 19729-19737.

Kaihatu, J.M., Rogers, W.E., Hsu, Y.L., and W.C. O'Reilly. 1998. Use of Phase-Resolving Numerical WaveModels in Coastal Areas, WAM Validation of Pacific Swell, Proc. 5th International Workshop on WaveHindcasting and Forecasting, Melbourne FL, January 26-30, 1998, 389-403.

O'Reilly, W.C. and R.T. Guza. 1998. Assimilating coastal wave observations into regional swell predictions. Part I: Inverse methods. *J. of Phys. Oceanogr.* **28**: 679-691.

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Elwany, M.H.S., O'Reilly, W.C., Guza, R.T., and R.E. Flick. 1995. Effects of Southern California kelp beds on waves. *J. of Waterway, Port, Coastal, and Ocean Engineering* **12**: 143-150.

Herbers, T.H.C., Elgar, S., Guza, R.T., and W.C. O'Reilly. 1995. Infragravity-frequency (0.005-0.05 Hz) motions on the shelf. Part II: Free Waves. *J. Phys. Oceanogr.* **25**: 1063-1079.

O'Reilly, W.C. 1993. The southern California wave climate: effects of islands and bathymetry, *Shore and Beach* **61**: 14-19.

O'Reilly, W.C. and R.T. Guza. 1993. A comparison of spectral wave models in the Southern California Bight, *Coastal Engineering* **19**: 263-282.

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O'Reilly, W.C. 1991. Modeling surface gravity waves in the Southern California Bight. *Ph.D. Dissertation,* Scripps Institution of Oceanography, La Jolla, CA, 90 pp.

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Munk, W.H, O'Reilly, W.C., and J.L. Reid. 1988. Australia-Bermuda sound transmission experiment (1960) revisited. *J. of Phys. Ocean.* **18**: 1876-1898.

HENRY M. PAGE
Marine Science Institute
University of California
Santa Barbara, CA

Projects: *Habitat Value of Shell Mounds to Ecologically and Commercially Important Benthic Species*
Advancing Marine Biotechnology: Use of OCS Oil Platforms as Sustainable Sources of Marine Natural Products

Education:

B.S.	University of Southern California	1973
M.A.	University of California, Santa Barbara	1977
Ph.D.	University of California, Santa Barbara	1984

Positions:

1985-present. Assistant Research Biologist, Marine Science Institute, University of California, Santa Barbara
1984-1998. Lecturer in Summer Session, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
1994-1997. Instructor, Department of Biological Sciences, Santa Barbara City College
1983-1985. Postgraduate Research Biologist, Marine Science Institute, University of California, Santa Barbara

Selected Publications:

Galindo-Bect, M.S., Glenn, E.P., Page, H.M., Galindo-Bect, L.A., Hernandez-Ayon, J.M., Petty, R.L., and J. Garcia-Hernandez. 2000. Analysis of peneid shrimp landings in the northern Gulf of California in relation to Colorado River discharge. *Fishery Bulletin - NOAA* **98**(1): 222-225.

Page, H.M., Dugan, J.E., Dugan, D., and J. Richards. 1999. Effects of an offshore oil platform on the distribution and abundance of commercially important crab species. *Marine Ecology Progress Series* **185**: 47-57.

Page, H.M. 1997. Importance of vascular plant and algal production to macroinvertebrate consumers in a southern California salt marsh. *Estuarine, Coastal and Shelf Science* **45**: 823-834.

Dugan, J.E., Hubbard, D.M., and H.M. Page. 1995. Scaling population density to body size: tests in two soft sediment intertidal communities. *Journal of Coastal Research* **11**: 849-857.

Page, H.M. 1995. Variation in the natural abundance of ^{15}N in the halophyte, *Salicornia virginica*, associated with ground water subsidies of nitrogen in a southern California salt marsh. *Oecologia* **104**: 181-188.

Page, H.M., Petty, R.L., and D.E. Meade. 1995. Influence of watershed run-off on nutrient dynamics in a southern California salt marsh. *Estuarine, Coastal and Shelf Science* **41**: 163-180.

Page, H.M., Dugan, J.E., and D.M. Hubbard. 1992. Comparative effects of infaunal bivalves on an epibenthic microalgal community. *Journal of Experimental Marine Biology and Ecology* **157**: 247-262.

Page, H.M., Fiala-Medioni, A., Fisher, C.R., and J.J. Childress. 1990. Experimental evidence for filter-feeding by the hydrothermal vent mussel, *Bathymodiolus thermophilus*. *Deep-Sea Research* **38**: 1455-1461.

Page, H.M., Fisher, C.R., and J.J. Childress. 1990. The role of filter-feeding in the nutritional biology of a deep sea mussel with methanotrophic symbionts. *Marine Biology* **104**: 251-257.

Page, H.M. and D.M. Hubbard. 1987. Temporal and spatial patterns of growth in mussels, *Mytilus edulis*, on an offshore platform: relationships to water temperature and food availability. *Journal of Experimental Marine Biology and Ecology* **111**: 159-179.

Page, H.M. 1986. Differences in population structure and growth rate of the stalked barnacle, *Pollicipes polymerus* between a rocky headland and an offshore oil platform. *Marine Ecology Progress Series* **29**: 157-164.

PETER T. RAIMONDI
Department of Biology- Ecology and Evolution
University of California
Santa Cruz, CA

Projects: *Effects of Produced Water on Complex Behavior Traits of Invertebrate Larvae and Algal Zoospores*
Effects of Temporal and Spatial Separation of Samples on Estimation of Impacts
Shoreline Inventory of Intertidal Resources of San Luis Obispo and Northern Santa Barbara Counties

Education:

	B.A.	Philosophy, Northern Arizona University	1976
	Ph.D.	Biology, University of California, Santa Barbara	1988

Positions:

1996-present	Assistant Professor, Department of Biology, University of California, Santa Cruz
1992-1996	Assistant Research Biologist, Marine Science Institute, University of California, Santa Barbara
1991-1992	Post-doctoral Research Biologist, Marine Science Institute, University of California, Santa Barbara
1989-1991	Research Fellow, Australian Research Council Fellowship, University of Melbourne, Department of Zoology
1988-1989	Research Fellow, University of Melbourne Research Fellowship
1987-1988	Post-doctoral Researcher, University of California, Santa Barbara
1986-1990	Environmental Consultant, Marine Review Committee

Distinctions:

1976	President's Scholarship for Academic Excellence. Northern Arizona University
1981-82	Dean's Award for Academic Excellence, University of Arizona
1984	Sigma Xi Grant-in-Aid of Research
1986	University of California Patent Fund
1987-88	Office of Naval Research Postdoctoral Fellowship
1988-89	University of Melbourne Research Fellowship
1989-91	Australian Research Council Fellowship

Selected Publications:

Forde, S.E. and P.T. Raimondi. Recruitment intensity and intertidal community structure: comparing observations and experiments. *Oecologia* (in review)

Gaylord, B., Reed, D.C., Raimondi, P.T., Washburn, L., and S.R. McLean. 2002. A physically based model of macroalgal spore dispersal in the wave and current-dominated nearshore. *Ecology* **83**(5): 1239-1251.

Raimondi, P.T., Wilson, C.M., Ambrose, R.F., Engle, J.M., and T.E. Minchinton. 2002. Continued declines of black abalone along the coast of California: are mass mortalities related to El Nino events? *Marine Ecology Progress Series* **242**: 143-152.

Carr, M.H. and P.T. Raimondi. 2000. Concepts relevant to the design and evaluation of harvest reserves. Proceedings of workshop on rockfish refugia.

Raimondi, P.T. and A.N.C. Morse. 2000. The consequences of complex larval behavior in a coral. *Ecology* **81**(11): 3193-3211.

Raimondi, P.T., Forde, S.E., Delph, L.F., and C.M. Lively. 2000. Processes structuring communities: evidence for trait-mediated indirect effects through induced polymorphisms. *Oikos* **91**(2): 353-361.

Reed, D.C., Raimondi, P.T., Carr, M.H., and L. Goldwasser. 2000. The role of dispersal and disturbance in determining spatial heterogeneity in sedentary organisms. *Ecology* **81**(7): 2011-2026.

Carr, M.H. and P.T. Raimondi. 1999. Marine protected areas as a precautionary approach to management. *Cal. Coop. Ocean Fish*. **40**: 71-76.

Raimondi, P.T., Barnett, A.M., and P.R. Krause. 1997. The effects of drilling muds on marine invertebrate larvae and adults. *Environmental Toxicology and Chemistry* **16-6**: 1218-1228.

Altstatt, J.A., Ambrose, R.F., Engle, J.M., Haaker, P.L., Lafferty, K.D., and P.T. Raimondi. 1996. Recent declines of black abalone *Haliotis cracherodii* on the mainland coast of central California. *Marine Ecology Progress Series* **142**: 185-192.

Keough, M.J. and P.T. Raimondi. 1996. Responses of settling invertebrate larvae to bioorganic films: Effects of large-scale variation in films. *J. Exp. Mar. Biol. Ecology* **207**: 59-78.

Raimondi, P.T. and D. Reed. 1996. Determining the spatial extent of ecological impacts caused by local anthropogenic disturbances in coastal marine habitats. Pp. 179-198 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitat*s, R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA.

Keough, M.J. and P.T. Raimondi. 1995. Responses of settling invertebrate larvae to microbial films, II: Effects of different types of films. *Marine Ecology Progress Series* **185**: 235-253.

Morse, D.E., Morse, A., Hooker, N., and P.T. Raimondi. 1994. Morphogen-based chemical flypaper for *Agaricia humilis* larvae. *Biological Bulletin* **186**: 172-181.

Lively, C.M., Raimondi, P.T., and L.F. Delph. 1993. Intertidal community structure: space-time interactions in the Northern Gulf of California. *Ecology* **74**: 162-173.

Keough, M.J. and P.T. Raimondi. 1992. Robustness of estimates of recruitment rates for sessile marine invertebrates. Recruitment Workshop Proceedings. *Australian Society of Fisheries Biologists*.

Raimondi, P.T. 1992. Adult plasticity and rapid larval evolution in a recently isolated barnacle population. *Biological Bulletin* **182**: 210-220.

Raimondi, P.T. and R.J. Schmitt. 1992. Effects of produced water on settlement of larvae: field tests using red abalone. Pp. 415-430 in: *Produced Water: Technological/Environmental Issues and Solutions.* J.P. Ray and F.R. Engelhardt, eds. Plenum Press, NY.

Raimondi, P.T. 1991. The settlement of *Chthamalus anisopoma* largely determines its adult distribution. *Oecologia* **85**: 349-360.

Raimondi, P.T. and J.E. Martin. 1991. Evidence that mating group size affects allocation of reproductive resources in a simultaneous hermaphrodite. *American Naturalist* **138**: 1206-1217.

Raimondi, P.T. 1990. Patterns, mechanisms, and consequences of variability in settlement and recruitment in an intertidal barnacle. *Ecological Monographs* **60**:283-309.

Raimondi, P.T. and M.J. Keough. 1990. Behavioral variability in marine larvae. *Aust. J. Ecology* **15**: 427-437.

Raimondi, P.T. 1988. Rock type affects settlement, recruitment, and zonation of the barnacle *Chthamalus anisopoma* (Pilsbry). *Journal of Experimental Marine Biology and Ecology* **123**: 253-267.

Raimondi, P.T. 1988. Settlement cues and determination of the vertical limit of an intertidal barnacle. *Ecology* **69**: 400-407.

Lively, C.M. and P.T. Raimondi. 1987. Desiccation, predation, and mussel-barnacle interactions in the Northern Gulf of California. *Oecologia* **74**(2): 304-309.

KATHERINE RALLS
Department of Zoological Research
National Zoological Park
Smithsonian Institution
Washington, D.C.

Project: *Population Dynamics and Biology of the California Sea Otter at the Southern End of its Range*

Education:	B.A.	Biology, Stanford University	1960
	M.S.	Biology, Radcliffe College	1962
	Ph.D.	Biology, Harvard University	1965

Positions:	1998-Present	Senior Research Biologist, Smithsonian Institution, Washington, DC
	1976-1998	Research Biologist, Smithsonian Institution, Washington, DC

Selected Publications:

Haight, R.G., Cypher, B., Kelly, P.A., Phillips, S., Possingham, H.P., Ralls, K., Starfield, A.M., White, P.J., and D. Williams. 2002. Optimizing habitat protection using demographic models of population viability. *Conserv Biol* **16**(5): 1386-1397.

Ralls, K., Pilgrim, K.L., White, P.J., Paxinos, E.E., Schwartz, M.K., and R.C. Fleischer. 2001. Kinship social relationships, and den sharing in kit foxes. *J Mammal* **82**(3): 858-866.

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Ralls, K., Eagle, T.C., and D.B. Siniff. 1996. Movement and spatial use patterns of California sea otters. *Can J Zool* **74**(10): 1841-1849.

DANIEL C. REED
Marine Science Institute
University of California
Santa Barbara, CA

Projects: *An Experimental Evaluation of Methods of Surfgrass (Phyllospadix torreyi) Restoration Using Early Life History Stages*
Population Genetics of surfgrass (Phyllospadix torreyi) for use in restoration

Education:	B.A.	Moss Landing Marine Laboratories and San Francisco State University	1978
	M.A.	Moss Landing Marine Laboratories and San Francisco State University	1981
	Ph.D.	University of California, Santa Barbara	1989

Positions:	1994-present	Associate Research Biologist, Marine Science Institute, University of California, Santa Barbara
	1989-94	Assistant Research Biologist, Marine Science Institute, University of California, Santa Barbara
	1990	Biological Consultant, Woodward-Clyde Consultants
	1987-90	Biological Consultant, Marine Review Committee
	1988-89	Biological Consultant, Michael Brandman Associates
	1986-87	Biological Consultant, Chambers Consultants

Distinctions:	1989	Lancaster Award for Outstanding Dissertation, University of California, Santa Barbara
	1984	Antarctic Service Medal of the United States of America, National Science Foundation

Selected Publications:

Gaylord, B., Reed, D.C., Raimondi, P.T., Washburn, L., and S.R. McLean. 2002. A physically based model of macroalgal spore dispersal in the wave and current-dominated nearshore. *Ecology* **83**(5): 1239-1251.

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Blanchette, C.A., Worcester, S., Reed, D., and S.J. Holbrook. 1999. Algal morphology, flow and spatially variable recruitment of surfgrass, *Phyllospadix torreyi*. *Marine Ecology Progress Series* **184**: 119-128.

Reed, D.C., Brzezinski, M.A., Coury, D.A., Graham, W.M., and R.L. Petty. 1999. Neutral lipids in macroalgal spores and their role in swimming. *Marine Biology* **133**: 737-744

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Reed, D.C., Anderson, T.W., Ebeling, A.W., and M. Anghera. 1997. Role of reproductive synchrony in the colonization potential of kelp. *Ecology* **78**: 2443-2457.

Canestro, D., Raimondi, P.T., Reed, D.C., Schmitt, R.J., and S.J. Holbrook. 1996. A study of methods and techniques for detecting ecological impacts. Pp. 53-67 in*: Methods and techniques of underwater research*, *Proceedings of the American Academy of Underwater Scientists symposium*. AAUS, Nahant, MA.

Raimondi, P.T. and D. Reed. 1996. Determining the spatial extent of ecological impacts caused by local anthropogenic disturbances in coastal marine habitats. Pp. 179-198 in: *Detecting Ecological Impacts: Conceptual Issues and Applications in Coastal Marine Habitat,* R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA.

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Ambrose, R.F., Boland, J., Murdoch, W.W., Raimondi, P.T., and D.C. Reed. 1995. The San Onofre nuclear generating station mitigation reef: monitoring issues. Pp. 587-592 in: *Proceedings from the International Conference on Ecological System Enhancement Technology for Aquatic Environments*. Japan International Marine Science and Technology Federation, Tokyo.

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Amsler, C.D., Reed, D.C., and M. Neushul. 1992. The microclimate inhabited by algal propagules. *British Phycological Journal* **27**: 253-270.

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Neushel, M., Amsler, C.D., Reed, D.C., and R.J. Lewis. 1992. The introduction of marine plants for aquacultural purposes. Pp. 103-138 in: *Movement and dispersal of biotic agents into aquatic ecosystems*, A. Rosenfield, ed. Maryland Sea Grant College, College Park, MD.

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Reed, D.C., Neushul, M., and A.W. Ebeling. 1991. The role of density on gametophyte growth and reproduction in the kelps *Macrocystis pyrifera* and *Pterygophora californica*. *J. Phycol*. **27**: 361-366.

Eardley, D.D., Sutton, C.W., Hempel, W.M., Reed, D.C., and A.W. Ebeling. 1990. Monoclonal antibodies specific for sulfated polysaccharides on the surface of *Macrocystis pyrifera* (Phaeophyceae). *Journal of Phycology* **26**: 54-62.

Hymansen, Z., Reed, D.C., Foster, M.S., and J. Carter. 1990. The validity of using morphological characteristics as predictors of age in the kelp Pterygophora californica (Laminariales, Phaeophyta). *Mar. Ecol. Prog. Ser.* **59**: 295-304.

DANIEL SCHLENK

Professor, Aquatic Ecotoxicology
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Project: *Use of Biological Endpoints in Flatfish to Establish Sediment Quality Criteria for Polyaromatic Hydrocarbon Residues and Assess Remediation Strategies*

Education:	B.S.	Toxicology, Northeast Louisiana University	1984
	Ph.D.	Toxicology, Oregon State University	1989

Positions:	2000-Present	Professor, Aquatic Ecotoxicology, Department of Environmental Sciences, University of California, Riverside, CA.
	1999-2000	Program Coordinator of Environmental Toxicology Program, Environmental and Community Health Research Program, University of Mississippi, University, MS
	1998-2000	Coordinator for the Graduate Program in Pharmacology, University of Mississippi
	1995-1998	Assistant Professor of Pharmacology and Toxicology, University of Mississippi
	1991-1995	Assistant Professor of Toxicology, University of Arkansas for Medical Sciences, Little Rock, AR
	1989-1991	Postdoctoral Fellow, Duke University Marine Laboratory, Integrated Toxicology Program, Beaufort, NC

Selected Publications:

Huggett, D.B., Brooks, B.W., Peterson, B., Foran, C.M., and D. Schlenk. 2002. Toxicity of Select Beta-Adrenergic Receptor Blocking Pharmaceuticals (b-Blockers) on Aquatic Organisms. *Archives of Environmental Contamination and Toxicology* (In press).

Schlenk, D., Sapozhnikova, E., Baquirian, J.P., and Z. Mason. 2002. Utilization of biochemical and health endpoints in fish to guide analytical chemistry analyses of sediments. *Environmental Toxicology and Chemistry* (In press).

Tilton, F., Benson, W.H., and D. Schlenk. 2002. Evaluation of Estrogenic Activity from a Municipal Wastewater Treatment Plant with Predominantly Domestic Input. *Aquatic Toxicology* (In press).

Todorov, J.R., Elskus, A.A., Schlenk, D., Ferguson, P.L., Brownawell, B.J., and A.E. McElroy. 2002. Estrogenic Responses of Larval Sunshine Bass (Morone saxatilis X M. chrysops) Exposed to New York City Sewage Effluent. *Marine Environmental Research* (In press).

Riedel, R., Schlenk, D., Frank, D., and B. Costa-Pierce. 2002. Analyses of organic and inorganic contaminants in Salton Sea fish. *Marine Pollution Bulletin* **44**: 403-411.

Elalfy, A., Grisle, S., and D. Schlenk. 2001. Characterization of Salinity-enhanced toxicity of aldicarb to Japanese medaka: sexual and developmental differences. *Environmental Toxicology and Chemistry* **20**: 2093-2098.

Schlenk, D., Huggett, D.B, Block, D.S., Grisle, S., Allgood, J.,Bennet, E., Holder, A.W., Hovinga, R.M., and P. Bedient. 2001. Toxicity of Fipronil and its Degradation Products to Procambarus sp.: Field and Laboratory Studies. *Archives of Environmental Contamination and Toxicology* **41**: 325-332.

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Debusk, B.C., Kumir, S., Rimoldi, J., and D. Schlenk. 2000. Phase I and II enzyme and activity levels in the gumboot chiton Cryptochiton stelleri following exposure to a dietary bromo-phenol, lanosol. *Comparative Biochemistry and Physiology* **127C**: 133-142.

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Department of Ecology, Evolution and Marine Biology and
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Santa Barbara, CA

Projects: *Population Trends and Trophic Dynamics in Pacific OCS Ecosystems: What Can Monitoring Data Tell us?*
Advancing Marine Biotechnology: Use of OCS Oil Platforms as Sustainable Sources of Marine Natural Products

Education:

	B.A.	Environmental Biology, University of Colorado	1972
	M.S.	Marine Science, University of the Pacific	1975
	Ph.D.	Biology, University of California, Los Angeles	1979

Positions:

1995-present	Professor, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
1994-present	Program Director, Coastal Marine Institute, University of California, Santa Barbara
1991-present	Program Director, Coastal Toxicology Program, UC Toxic Substances Research and Teaching Program
1989-present	Program Director, Southern California Educational Initiative, University of California, Santa Barbara
1987-present	Director, Coastal Research Center, Marine Science Institute, University of California, Santa Barbara
1993-1995	Associate Professor, Department of Biology and Environmental Studies Program, University of California, Santa Barbara
1987-1992	Associate Research Biologist, Marine Science Institute, University of California, Santa Barbara
1981-1987	Assistant Research Biologist, Marine Science Institute, University of California, Santa Barbara

Distictions: 1989 George Mercer Award for 1989, Ecological Society of America (best published research in field of Ecology by a scientist under age 40; Awarded for "Indirect interactions between prey: apparent competition, predator aggregation and habitat selection," *Ecology* **68**:1887-1897)

Selected Publications:

Bernardi, G., Holbrook, S.J., Schmitt, R.J., Crane, N.L., and E. DeMartini. 2002. Species boundaries, populations and colour morphs in the coral reef three-spot damselfish (Dascyllus trimaculatus) species complex. *P Roy Soc Lond B Bio* **269**(1491): 599-605.

Bolker, B.M., St Mary, C.M., Osenberg, C.W., Schmitt, R.J., and S.J. Holbrook. 2002. Management at a different scale: Marine ornamentals and local processes. *B Mar Sci* **70**(2): 733-748.

Brooks, A.J., Schmitt, R.J., and S.J. Holbrook. 2002. Declines in regional fish populations: have species responded similarly to environmental change? *Mar Freshwater Res* **53**(2): 189-198.

Holbrook, S.J. and R.J. Schmitt. 2002. Competition for shelter space causes density-dependent predation mortality in damselfishes. *Ecology* **83**(10): 2855-2868.

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Osenberg, C.W., St Mary, C.M., Schmitt, R.J., Holbrook, S.J., Chesson, P., and B. Byrne. 2002. Rethinking ecological inference: density dependence in reef fishes. *Ecol Lett* **5**(6): 715-721.

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Buko, A.M., Beckner, C., Hepp, D., Helias, N., Zhu, F., Nemcek, T., Schmitt, R.J., and J. Hochlowski. 2001. Stability testing of chemical diversity in liquid DMSO storage. *Abstr Pap Am Chem S* **222**: 210-ANYL Part 1.

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Schmitt, R.J., Holbrook, S.J., and C.W. Osenberg. 1999. Quantifying the effects of multiple processes on local abundance: A cohort approach for open populations. *Ecology Letters* **2**: 294-303.

Wilson, W.G., Osenberg, C.W., Schmitt, R.J., and R.M. Nisbet. 1999. Complementary foraging behaviors allow coexistence of two consumers. *Ecology* **80**(7): 2358-2372.

Holbrook, S.J. and R.J. Schmitt. 1998. Have field experiments aided in the understanding of abundance and dynamics of reef fishes? Pp. 152-169 in: *Issues and Perspectives in Experimental Ecology*, W.J. Resetarits and J. Bernado eds. Oxford University Press.

Holbrook, S.J. and R.J. Schmitt. 1997. Settlement patterns and process in a coral reef damselfish: *in situ* nocturnal observations using infrared video. *Proceedings of the VIIIth International Coral Reef Symposiums* **2**: 1143-1148.

Holbrook, S.J., Schmitt, R.J., and J.A. Stephens Jr. 1997. Changes in an assemblage of temperate reef fishes associated with a climate shift. *Ecological Applications* **7**: 1299-1310.

Ambrose, R.F., Schmitt, R.J., and C.W. Osenberg. 1996. Predicted and observed environmental impacts: can we foretell ecological change? Pp. 345-369 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats*, R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA.

DONALD SINIFF
Department of Ecology, Evolution and Behavior
University of Minnesota
St. Paul, MN

Project: *Population Dynamics and Biology of the California Sea Otter at the Southern End of its Range*

Education:

	B.S.	Fisheries and Wildlife, Michigan State University	1957
	M.S.	Mathematical Statistics, Michigan State University	1958
	Ph.D.	Entomology, Fisheries & Wildlife, University of Minnesota	1967

Positions: 1975-Present Professor, Department of Ecology, Evolution and Behavior, University of Minnesota, St. Paul, MN
Director of the Itasca Biology Program, University of Minnesota, St. Paul, MN
Director of the Conservation Biology Graduate Program, University of Minnesota, St. Paul, MN

Selected Publications:

Gelatt, T.S., Siniff, D.B., and J.A. Estes. 2002. Activity patterns and time budgets of the declining sea otter population at Amchitka Island, Alaska. *J Wildlife Manage* **66**(1): 29-39.

Sato, K., Mitani, Y., Cameron, M.F., Siniff, D.B., Watanabe, Y., and Y. Naito. 2002. Deep foraging dives in relation to the energy depletion of Weddell seal (Leptonychotes weddellii) mothers during lactation. *Polar Biol* **25**(9): 696-702.

Gelatt, T.S., Davis, C.S., Siniff, D.B., and C. Strobeck. 2001. Molecular evidence for twinning in Weddell seals (*Leptonychotes weddellii*). *J Mammal* **82**(2): 491-499.

White, P.J., Ralls, K., and D.B. Siniff. 2000. Nocturnal encounters between kit foxes. *J Mammal* **81**(2): 456-461.

Monson, D.H., Estes, J.A., Bodkin, J.L., and D.B. Siniff. 2000. Life history plasticity and population regulation in sea otters. *OIKOS* **90**(3): 457-468.

Watt, J., Siniff, D.B., and J.A. Estes. 2000. Inter-decadal patterns of population and dietary change in sea otters at Amchitka Island, Alaska. *Oecologia* **124**(2): 289-298.

Gelatt, T.S., Arendt, T., Murphy, M.S., and D.B. Siniff. 1999. Baseline levels of selected minerals and fat-soluble vitamins in weddell seals (Leptonychotes weddellii) from Erebus Bay, McMurdo Sound, Antarctica. *Mar Pollut Bull* **38**(12): 1251-1258.

Bowen, D. and D. Siniff. 1999. Distribution, population biology, and feeding ecology of marine mammals. *In* Biology of Marine Mammals. J.E. Reynolds and S.A. Rommel, eds. *Smithsonian Press*. pp. 423-484.

Gelatt, T. and D. Siniff. 1999. Line transect survey of crabeater seals in the Amundsen Bellingshausen Seas, 1994. *Wildl. Soc. Bulletin* **27**(2): 330-336.

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Ralls, K., Hatfield, B., and D. Siniff. 1995. Foraging patterns of California sea otters as indicated by telemetry. *Canadian Journal of Zoology* **73**: 523-531.

ERIC R.A.N. SMITH
Department of Political Science and Environmental Studies
University of California
Santa Barbara, CA

Project: *Public Perceptions of Risk Associated with Offshore Oil Development*

Education:	A.B.	University of California, Berkeley	1975
	M.A.	University of California, Berkeley	1976
	Ph.D.	University of California, Berkeley	1982

Positions:	1990-present	Associate Professor, Department of Political Science, University of California, Santa Barbara
	1986-90	Assistant Professor, Department of Political Science, University of California, Santa Barbara
	1982-86	Assistant Professor, Department of Political Science, Columbia University
	1982	Lecturer in Politics, Brandeis University

Selected Publications:

Smith, Eric R.A.N. 2003. The Role of Knowledge in the Public's Trust in Science about Offshore Oil and Gas Development. MMS OCS Study 2002-0051. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 14-35-0001-30761. 69 pages.

Smith, E.R.A.N. 2002. *Energy, the Environment, and Public Opinion*. Boulder, CO: Roman & Littlefield.

Smith, E.R.A.N. and R.L. Fox. 2001. The Electoral Fortunes of Women Candidates for Congress. *Political Research Quarterly* **54**: 205-21.

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Fox, R.L. and E.R.A.N. Smith. 1998. The role of candidate sex in voter decision-making. *Political Psychology* **19**: 405-419.

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Smith, ERAN. 1997. Book Review: What Americans know about politics and why it matters, by M.X.D. Carpini, S. Keeter. *Political Science Quarterly* **112**: 314-315.

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Smith, E.R.A.N. 1996. Book Review: The changing American mind - how and why American public opinion changed between 1960 and 1988, by W.G. Mayer. *Critical Review* **10**: 95-105.

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Smith, E.R.A.N. 1996. Book Review: The two majorities - the issue context of modern American politics, by B.E. Shafer and W.J.M. Claggett. *American Political Science Review* **90**: 438-439.

Squire, P. and E.R.A.N. Smith. 1996. A further examination of challenger quality in Senate elections. *Legislative Studies Quarterly*. **421**: 235-248.

Herrera, R., Epperlein, T., and E.R.A.N. Smith. 1995. The stability of congressional roll-call indexes. *Political Research Quarterly* **48**: 403-416.

Smith, E.R.A.N. and S.R. Garcia. 1995. Evolving California opinion on offshore oil development. *Ocean and Coastal Management* **26**: 41-56.

Squire, P., Smith, E.R.A.N., Lindsay, J. and C. Covington. 1995. *Dynamics of Democracy*. Brown-Bennchmark, Madison, Wisconsin. 596p.

Smith, E.R.A.N. 1992. Changes in the Public's political sophistication. In: *Controversies in Voting Behavior, 3rd edition*, R.G. Niemi and H.F. Weisberg, eds. Congressional Quarterly Press, Washington, D.C. (reprinted from *The Unchanging American Voter*).

Smith, E.R.A.N., Herrera, R., and C.L. Herrera. 1992. Public opinion and congressional representation. *Public Opinion Quarterly* **56**: 185-205.

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Smith, E.R.A.N., Herrera, R., and C.L. Herrera. 1990. The measurement characteristics of congressional roll call indexes. *Legislative Studies Quarterly* **15**: 283-295.

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Smith, E.R.A.N. and P. Squire. 1988. The effect of partisan information on voters in non-partisan election. *J. Politics* **50**: 169-79.

Smith, E.R.A.N. and P. Squire. 1987. Direct election of the president and the power of the states. *Western Political Quarterly* **40**: 29-44.

Smith, E.R.A.N. and P. Squire. 1987. State and National Politics in the Intermountain West. In: *The Politics of Realignment: Partisan Change in the Intermountain West*. Peter Galderisi *et al*., eds. Westview Press, Boulder, CO.

Smith, E.R.A.N. and P. Squire. 1984. Repeat challengers in congressional elections. *American Politics Quarterly* **12**: 51-70.

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LIBE WASHBURN

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Institute for Computational Earth Systems Science (ICESS)
University of California
Santa Barbara, CA

Projects: *Observing the Surface Circulation Along the South-Central California Coast Using High Frequency Radar: Consequences for Larval and Pollutant Dispersal*
Application of Coastal Ocean Dynamics Radars for Observation of Near-Surface Currents off the South-Central California Coast

Education:	B.S.	Mechanical Engineering, University of Arizona	1974
	M.S.	Engineering Science, University of California, San Diego	1978
	Ph.D.	Engineering Science, University of California, San Diego	1982

Positions:	1993-Present	Associate Professor, Department of Geography and ICESS, University of California, Santa Barbara, CA
	1991-1993	Assistant Professor, Department of Geography, University of California, Santa Barbara, CA
	1985-1990	Research Assistant Professor of Physical Oceanography, Center for Earth Sciences, University of Southern California, Los Angeles, CA
	1982-1985	Postgraduate Research Oceanographer, Scripps Institution of Oceanography, San Diego, CA

Selected Publications:

Gaylord, B., Reed, D.C., Raimondi, P.T., Washburn, L., and S.R. McLean. 2002. A physically based model of macroalgal spore dispersal in the wave and current-dominated nearshore. *Ecology* **83**(5): 1239-1251.

Nishimoto, M.M. and L. Washburn. 2002. Patterns of coastal eddy circulation and abundance of pelagic juvenile fish in the Santa Barbara Channel, California, USA. *Mar Ecol-Prog Ser* **241**: 183-199.

Powell, L.A., Calvert, D.J., Barry, I.M., and L. Washburn. 2002. Post-fledging survival and dispersal of Peregrine Falcons during a restoration project. *J Raptor Res* **36**(3): 176-182.

Boles, J.R., Clark, J.F., Leifer, I., and L. Washburn. 2001. Temporal variation in natural methane seep rate due to tides, Coal Oil Point area, California. *J Geophys Res-Oceans* **106**(C11): 27077-27086.

Washburn, L., Johnson, C., Gotschalk, C.C., and E.T. Egland. 2001. A gas-capture buoy for measuring bubbling gas flux in oceans and lakes. *J Atmos Ocean Tech* **18**(8): 1411-1420.

Clark, J.F., Washburn, L., Hornafius, J.S., and B.P. Luyendyk. 2000. Dissolved hydrocarbon flux from natural marine seeps to the southern California Bight. *J Geophys Res-Oceans* **105**(C5): 11509-11522.

Quigley, D.C., Hornafius, J.S., Luyendyk, B.P., Francis, R.D., Clark ,J., and L. Washburn. 1999. Decrease in natural marine hydrocarbon seepage near Coal Oil Point, California, associated with offshore oil production. *Geology* **27**(11): 1047-1050.

Washburn, L., Stone, S., and S. MacIntyre. 1999. Dispersion of produced water in a coastal environment and its biological implications. *J Cont Shelf Res* **19**(1): 57-78.

Ohlmann, J.C., Siegel, D.A., and L. Washburn. 1998. Radiant heating of the western equatorial Pacific during TOGA-COARE. *J. Geophys. Res*. **103**: 5379-5395.

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Jones, B.H., Washburn, L., Bay, S., and K. Schiff. 1997. Stormwater runoff into Santa Monica Bay: Identification, impact, and dispersion, Conf. Proc., California and the World Ocean '97, 24-27 March 1997, San Diego, CA.

Pinkel, R., Merrifield, M., McPhaden, M., Picault, J., Rutledge, S., Siegel, D., and L. Washburn. 1997. Solitary waves in the western Equatorial Pacific Ocean. *Geogphy. Res. Let*. **24**: 1603-1606.

Washburn, L. and B.H. Jones. 1996. Field Observations and Modeling of Dispersion Processes around Ocean Outfalls, Oceans 96 MTS/IEEE, Conf. Proc., (published on CD-ROM) 23-26 September, Fort Lauderdale, FL.

Washburn, L., Duda, T., and D. Jacobs. 1996. Interpreting conductivity microstructure: estimation of the temperature variance dissipation rate in the presence of salinity gradients. *J. Atmospheric and Oceanic Tech*. **13**: 1166-1188.

Siegel, D.A., Ohlmann, J.C., Washburn, L., Bidigare, R.R., Nosse, C.T., and Y. Zhou. 1995. Solar radiation, phytoplankton pigments and the radiant heating of the equatorial Pacific Warm Pool. *J. Geophys. Res*. **100**: 4885-4891.

Wu, Y., Washburn, L., and B.H. Jones. 1994. Buoyant plume dispersion in a coastal environment: observations of plume structure and dynamics. *J Cont Shelf Res* **14**: 1001-1023.

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Washburn, L., Jones, B.H., Bratkovich, A., Dickey, T.D., and M.S. Chen. 1992. Mixing, dispersion, and resuspension in the vicinity of an ocean wastewater plume. *J. Hydraulic Engr*. **118**: 38-58.

Huyer, A., Kosro, P.M., Fleischbein, J., Ramp, S.R., Stanton, T., Washburn, L., Chavez, F.P., Cowles, T.J., Pierce, S.D., and R.L. Smith. 1991. Currents and waste masses of the Coastal Transition Zone off Northern California, June to August 1988*. J. Geophys. Res*. **96**: 14809-14831.

Jones, B.H., Mooers, C.N.K., Reinecker, M., Stanton, T.P., and L. Washburn. 1991. Chemical and biological structure of a cool filament observed off Northern California in July 1986 (OPTOMA-21). *J. Geophys. Res*. **96**: 2207-2225.

Jones, B.H., Washburn, L., and Y. Wu. 1991. The dispersion of ocean outfall plumes: Physical and biological dynamics. Pp. 74-85 in: Coastal Zone '91 - Proceedings of the 7th Symposium on Coastal and Ocean Management. American Society of Civil Engineers.

Kadko, D.C., Washburn, L., and B.H. Jones. 1991. Evidence of subduction within cold filaments of the Northern California Coastal Transition Zone. *J. Geophys. Res*. **96**: 14,909-14,926.

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Strub, P.T., Kosro, P.M., Huyer, A., James, C., Walstad, L.J., Smith, R.L., Barth, J.A., Hood, R.R., Abbot, M.R., Brink, K.H., Hayward, T.L., Niiler, P.P., Swenson, M.S., Dewey, R.K., Chavez, F., Ramp, S.R., Batteen, M.L., Haney, R.L., Mackas, D.L., Washburn, L., Kadko, D.C., Barber, R.T., and D.B. Haidvogel. 1991. The nature of cold filaments in the California Current System. *J. Geophys. Res*. **96**: 14,743-14,768.

Washburn, L., Kadko, D.C., Jones, B.H., Hayward, T., Kosro, P.M., Stanton, T.P., Ramp, S., and T. Cowles. 1991. Water mass subduction and the transport of phytoplankton in a coastal upwelling system. *J. Geophys. Res*. **96**: 14927-14945.

TERRIE WILLIAMS
Department of Biology
University of California
Santa Cruz, CA

Project: *Population Dynamics and Biology of the California Sea Otter at the Southern End of its Range*

Education: B.A.	Biology, Douglass College	1976
M.S.	Physiology, Rutgers University	1979
Ph.D.	Environmental & Exercise Physiology, Rutgers University	1981
	Certificate Program in Molecular Biotechnology, UC San Diego	1989

Position: 1997-present Associate Professor of Biology, University of California, Santa Cruz

Selected Publications:

Fuiman, L.A., Davis, R.W., and T.M. Williams. 2002. Behavior of midwater fishes under the Antarctic ice: observations by a predator. *Mar. Biol.* **140**(4): 815-822.

Kanatous, S.B., Davis, R.W., Watson, R., *et al*. 2002. Aerobic capacities in the skeletal muscles of Weddell seals: key to longer dive durations? *J. Exp. Biol.* **205**(23): 3601-3608.

Noren, S.R., Lacave, G., Wells, R.S., *et al*. 2002. The development of blood oxygen stores in bottlenose dolphins (*Tursiops truncatus*): implications for diving capacity. *J. Zool.* **258**: 105-113 Part 1.

Williams, T.M., Ben-David, M., Noren, S., *et al*. 2002. Running energetics of the North American river otter: do short legs necessarily reduce efficiency on land? *Comp. Biochem. Phys. A* **133**(2): 203-212.

Davis, R.W., Fuiman, L.A., Williams, T.M., *et al*. 2001. Three-dimensional movements and swimming activity of a northern elephant seal. *Comp. Biochem. Phys. A* **129**(4): 759-770.

Noren, S.R., Williams, T.M., Pabst, D.A., *et al*. 2001. The development of diving in marine endotherms: preparing the skeletal muscles of dolphins, penguins, and seals for activity during submergence. *J. Comp. Physiol. B.* **171**(2): 127-134.

Williams, T.M. 2001.Intermittent swimming by mammals: A strategy for increasing energetic efficiency during diving. *Am. Zoologist* **41**(2): 166-176.

Williams, T.M. and G. Worthy. 2001. Anatomy and Physiology: The challenge of aquatic performance. In: *Marine Mammal Biology: An Evolutionary Approach*. A.R. Hoezel, ed. Blackwell Science Ltd.

Williams, T.M., Haun, J., Davis, R.W., *et al*. 2001. A killer appetite: metabolic consequences of carnivory in marine mammals. *Comp. Biochem. Phys. A.* **129**(4): 785-796.

Ben-David, M., Williams, T.M., and O.A. Ormseth. 2000. Effects of oiling on exercise physiology and diving behavior of river otters: a captive study. *Can. J. Zool.* **78**(8): 1380-1390.

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Noren, S.R., Lacave, G., Wells, R.S., *et al*. 2000. Development of blood oxygen stores in bottlenose dolphins (*Tursiops truncatus*). *Am. Zool.* **40**(6): 1152-1152.

Williams, T.M., Davis, R.W., Fuiman, L.A., Francis, J., LeBoeuf, B., Horning, M., Calambokidis, J., and D.A. Croll. 2000. Sink or swim strategies for cost efficient diving by marine mammals. *Science* **288**(5463): 133-136.

Davis, R.W., Fuiman, L.A., Williams, T.M., *et al*. 1999. Hunting behavior of a marine mammal beneath the Antarctic fast ice. *Science* **283**(5404): 993-996.

Noren, D.P., Williams, T.M., Berry, P., *et al*. 1999. Thermoregulation during swimming and diving in bottlenose dolphins, *Tursiops truncates. J Comp. Physiol. B.* **169**(2): 93-99.

Pabst, D.A., McLellan, W.A., and T.M. Williams. 1999. Locomotor functions of dolphin blubber. *Am. Zool.* **39**(5): 680 Sp. Iss. SI.

Skrovan, R.C., Williams, T.M., Berry, P.S., Moore, P.W., and R.W. Davis. 1999. The diving physiology of bottlenose dolphins (*Tursiops truncatus*) II. Biomechanics and changes in buoyancy with depth. *J. Exp. Biol.* **202**: 2749-2761.

Williams, T.M. 1999. Sink or swim strategies for low cost diving in marine mammals. *Am. Zool.* **39**(5): 15 Sp. Iss. SI.

Williams, T.M. 1999. The evolution of cost efficient swimming in marine mammals: limits to energetic optimization. *Philos. T. Roy. Soc. B.* **354**(1380): 193-201.

Williams, T.M., Haun, J.E., and W.A. Friedl. 1999. The diving physiology of bottlenose dolphins (*Tursiops truncatus*) I. Balancing the demands of exercise for energy conservation at depth. *J. Exp. Biol.* **202**(20): 2739-2748.

Williams, T.M., Noren, D., Berry, P., *et al*. 1999. The diving physiology of bottlenose dolphins (*Tursiops truncatus*) III. Thermoregulation at depth. *J Exp. Biol.* **202**(20): 2763-2769.

Estes, J.A., Tinker, M.T., Williams, T.M., *et al*. 1998. Killer whale predation on sea otters linking oceanic and nearshore ecosystems. *Science* **282**(5388): 473-476.

Shaffe, S.A., Costa, D.P., Williams, T.M., *et al*. 1997. Diving and swimming performance of white whales, *Delphinapterus leucas*: An assessment of plasma lactate and blood gas levels and respiratory rates. *J. Exp. Biol.* **200**(24): 3091-3099.

LESLIE WILSON
Department of Molecular, Cellular, and Developmental Biology
University of California
Santa Barbara, CA

Project: *Advancing Marine Biotechnology: Use of OCS Oil Platforms as Sustainable Sources of Marine Natural Products*

Education:

	B.S.	Pharmacy, Massachusetts College of Pharmacy & Allied Health Sciences, Boston, MA	1963
	Ph.D.	Pharmacology, School of Medicine, Tufts University, Boston, MA	1967

Positions:

1995-present	Professor of Biochemistry and Pharmacology, Department of Molecular, Cellular, and Developmental Biology, University of California, Santa Barbara, CA
1978-1995	Professor of Biochemistry and Pharmacology, Division of Molecular, Cellular, and Developmental Biology, Department of Biological Sciences, University of Santa Barbara, CA
1987-1991	Chair, Department of Biological Sciences, University of California, Santa Barbara, CA
1976-1978	Associate Professor, Department of Biological Sciences, University of California, Santa Barbara, CA
1969-1975	Assistant Professor, Department of Pharmacology, Stanford University School of Medicine, Stanford, CA

Selected Publications:

Jordan, M.A., Ojima, I., Rosas, F., Distefano, M., Wilson, L., Scambia, G., and C. Ferlini. 2002. Effects of novel taxanes SB-T-1213 and IDN5109 on tubulin polymerization and mitosis *Chem Biol* **9**(1): 93-101.

Newton, C.N., DeLuca, J.G., Himes, R.H., Miller, H.P., Jordan, M.A., and L. Wilson. 2002. Intrinsically slow dynamic instability of HeLa cell microtubules in vitro. *J. Biol. Chem.* **277**(45): 42456-42462.

Ojeda-Lopez, M.A., Jones, J., Miller, H., Wilson, L., Li, Y.L., and S. Cyrus. 2002. In vitro synchrotron x-ray studies of the structure of supramolecular assemblies of neuronal cytoskeletal protein fibers and associated proteins. *Biophys J.* **82**(1): 2025 Part 2.

Panda, D., Miller, H.P., and L. Wilson. 2002. Determination of the size and chemical nature of the stabilizing "cap" at microtubule ends using modulators of polymerization dynamics. *Biochemistry-US* **41**(5): 1609-1617.

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DeLuca, J.G., Newton, C.N., Himes, R.H., Jordan, M.A., and L. Wilson. 2001. Purification and characterization of native conventional kinesin, HSET, and CENP-E from mitotic HeLa cells. *J. Biol. Chem.* **276**(30): 28014-28021.

Kamath, K., Goncalves, A., Braguer, D., Martello, L., Briand, G., Horwitz, S., Wilson, L., and M.A. Jordan. 2001. Studies in taxol-resistant cells indicate that microtubule dynamics must be regulated within a narrow range for successful mitosis. *Mol Biol Cell* **12**: 1735 Suppl. S.

Ngan, V.K., Bellman, K., Hill, B.T., Wilson, L., and M.A. Jordan. 2001. Mechanism of mitotic block and inhibition of cell proliferation by the semisynthetic vinca alkaloids vinorelbine and its newer derivative, vinflunine. *Molec. Pharmacol*. **60**: 1-8.

Panda, D., Feinstein, S., and L. Wilson. 2001. Differential modulation of microtubule dynamics by 3-repeat and 4-repeat tau isoforms: Implications for neurodegenerative disease. *Mol. Biol. Cell* **12**: 938, Suppl. S.

Pfohl, T., Kim, J.H., Yasa, M., Miller, H.P., Wong, G.C.L., Bringezu, F., Wen, Z., Wilson, L., Kim, M.W., Li, Y., and C.R. Safinya. 2001. Controlled modification of microstructured silicon surfaces for confinement of biological macromolecules and liquid crystals. *Langmuir* **17**(17): 5343-5351.

Skoufias, D.A., Andreassen, P.R., Lacroix, F.B., Wilson, L., and R.M. Margolis. 2001. Mammalian Mad2 and Bub1/BubR1 recognize distinct spindle attachment and kinetochore tension checkpoints. *Proc. Nat. Acad. Sci*. (USA) **98**: 4492-4497.

Ngan, V.K., Bellman, K., Panda, D., Hill, B.T., Jordan, M.A., and L. Wilson. 2000. Novel Actions of the antitumor drugs vinflunine and vinorelbine on microtubules*.* *Cancer Res*. **60**: 5045-5051.

Panda, D., Ananthnarayan, V., Larson, G., Shih, C., Jordan, M.A., and L. Wilson. 2000. Interaction of the antitumor compound cryptophycin-52 with tubulin. *Biochemistry* **39**: 14121-14127.

Tsuchiya, E. and L. Wilson. 2000. Dynamics of microtubules composed of mutated yeast beta-tubulins in living cells. *Mol Biol Cell* **11**: 985, Suppl. S.

Jordan, M. A. and L. Wilson. 1999. The use and action of drugs in analyzing mitosis. In "Mitosis and Meiosis", *Methods in Cell Biology* **61**: 267-295.

Margolis, R.L., and L. Wilson. 1998. Microtubule treadmilling: What goes around comes around. *BioEssays* **20**: 830-836.

Wilson, L. 1998. Use of drugs to study the role of microtubule assembly dynamics in living cells. *Methods in Enzymology* **298**: 252-276.

Panda, D., Himes, R. H., Moore, R. E., Wilson, L., and M.A. Jordan. 1997. Mechanism of action of the unusually potent mitotic inhibitor, cryptophycin 1. *Biochemistry* **36**: 12948-12953.

Panda, D., Miller, H. P., Islam, K., and L. Wilson. 1997. Stabilization of microtubule dynamics by estramustine by binding to a novel site in tubulin: A possible mechanistic basis for its antitumor action. *Proc. Natl. Acad. Sci.* U.S.A. **94**: 10560-10564.

Wilson, L. and M.A. Jordan. 1995. Microtubule dynamics: taking aim at a moving target. *Chemistry and Biology* **2**: 569-573.

Davis, A., Sage, C. R., Wilson, L., and K.W. Farrell. 1993. Purification and biochemical characteriza-tion of tubulin from the budding yeast *Saccharomyces cerevisiae*. *Biochemistry* **32**: 8823-8835.

Toso, R.J., Jordan, M A., Farrell, K.W., Matsumoto, B., and L. Wilson. 1993. Kinetic stabilization of microtubule dynamic instability in vitro by vinblastine. *Biochemistry* **32**: 1285-1293.

Wendell, K.L., Wilson, L., and M.A. Jordan. 1993. Mitotic block in HeLa cells by vinblastine: ultrastructural changes in kinetochore-microtubule attachment and in centrosomes. *J. Cell Sci* **104**: 261-274.

Jordan, M.A., Thrower, D., and L. Wilson. 1992. Effects of vinblastine, podophyllotoxin, and nocodazole on mitotic spindles: implications for the role of microtubule dynamics in mitosis. *J. Cell Sci.* **102**: 401-416.

Skoufias, D. and L. Wilson. 1992. Mechanism of inhibition of microtubule polymerization by colchicine: inhibitory potencies of unliganded colchicine and tubulin-colchicine complexes. *Biochemistry* **31**: 738-746.

Skoufias, D.A., Wilson, L., and W.D. Detrich III. 1992. The colchicine binding sites of brain tubulins from an Antarctic fish and from a mammal are functionally similar but not identical; implications for microtubule assembly at low temperature. *Cell Motil & Cytosk*. **21**: 272-280.

Thrower, D., Jordan, M.A., and L. Wilson. 1991. Quantitation of cellular tubulin in microtubules and tubulin pools by a competetive ELISA. *Journal of Immunological Methods* **136**: 45-51.