University of California

Southern California Educational Initiative

Annual Report

July 2000

University of California

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and
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Marine Science Institute
University of California
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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 SOUTHERN CALIFORNIA EDUCATIONAL INITIATIVE

A University Research Initiative Program
involving the

University of California,
the State of California

and the

Minerals Management Service
US Department of Interior

ANNUAL REPORT

PROGRAM YEAR 11

July 15, 2000

PROGRAM MANAGER'S REPORT

xxThe Southern California Educational Initiative (SCEI) was initiated in May 1989 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. The university-based research program has just completed its tenth year, the fifth year of our renewed 6-year contract. This Annual Report summarizes activities and research progress during Program Year 10 (July 1, 1998 - June 30, 1999).

Major programmatic progress achieved during Program Year 10 of the SCEI is summarized below.

- ♦ Full proposals for 4 new projects were received and reviewed;
- ♦ Contract negations were completed for the start of 4 new projects in Spring 1999;
- ♦ A research retreat, co-sponsored by the SCEI and the complimentary state-funded training program (the UC Coastal Toxicology Program) was held in September 1998 at the Bodega Marine Laboratory to discuss and integrate findings by SCEI natural and social scientists and the UC Coastal Toxicology Program;
- ♦ In April 1999, the SCEI, in cooperation with the UC Coastal Toxicology Program, hosted the Annual Symposium of the UC Toxic Substances Research and Teaching

Program at Santa Barbara, California, at which studies sponsored by the SCEI were presented;

- This year, SCEI-sponsored studies produced 8 peer-reviewed papers that were published with an additional 6 manuscripts that are in press;
- Seven Project Final Reports were completed and distributed;
- During the past year 19 regular and research faculty, 30 trainees (1 postdoctoral, 10 graduates, and 19 undergraduates) and 10 staff from 7 campuses and laboratories participated in SCEI research projects.

SUMMARY OF RESEARCH PRGRESS

Effects of Biologically Degraded Oil on Marine Invertebrate and Vertebrate Embryos and Larvae

Principal Investigators: **Gary N. Cherr**, Bodega Marine Laboratory, University of California, Davis, CA 94923, **Rick Higashi**, Crocker Nuclear Laboratory, University of California, Davis, CA 95616, **Frederick J. Griffin**, Bodega Marine Laboratory, University of California, Davis, CA 94923.

Background

The removal of volatile compounds through weathering of crude oil results in the release of low boiling point aromatic and saturated hydrocarbons. It has been thought that those components hold the greatest toxicity to marine life (Capuzzo, 1987; Galt *et al*., 1991; Payne *et al*., 1991; Venkateswaran *et al*., 1995). Although biodegradation of crude oil can be considered a component of the weathering process, the process continues well after initial weathering and the elimination of volatile compounds has occurred. Known results of this continued microbial degradation include a measurable decrease in sediment crude oil along with a measurable organic enrichment in those sediments (Spies, 1987). Recently, studies (including our laboratory) have demonstrated that a by-product(s) of microbial degradation of artificially weathered Alaska North Slope crude oil is a ten fold increase in neutral water soluble hydrocarbons that exhibits significantly high toxicity to developing atherinid and clupeoid fish embryos (Middaugh *et al*., 1996, 1998). Biodegradation of crude oil occurs in regions of natural seepage (e.g., Coal Oil Point) as well as in regions of oil production and transport where elevated populations of crude oil-degrading microbes are purported to exist (Spies, 1987). It can be assumed that the process of oil biodegradation in the Santa Barbara Channel near sites of natural oil seeps and non-catastrophic release (associated with oil production) is an ongoing process and that the products of that biodegradation are chronically present, resulting in profound long range implications to the biota of the area.

Progress

We have previously found that biodegraded water soluble fractions of crude oil are toxic to some species of marine larvae. Particularly striking are the dramatic differences in susceptibility observed in larvae from two species native to the California coast, *Lytechinus anamesus* (urchin) and *Urechis caupo* (innkeeper worm). Our research in the current year suggests that BWSF exerts dramatic effects even at low concentrations on urchin embryos. Continuously exposed urchin embryos exhibit dose-dependent delay in development in concentrations as low as 1%BWSF (corresponding to a 1:200000 dilution of crude oil) in filtered seawater (Fig. 1). The effects were evident in BWSF exposed embryos not only at the pluteal stage (Fig. 2) but were also manifested earlier in a delay to hatching.

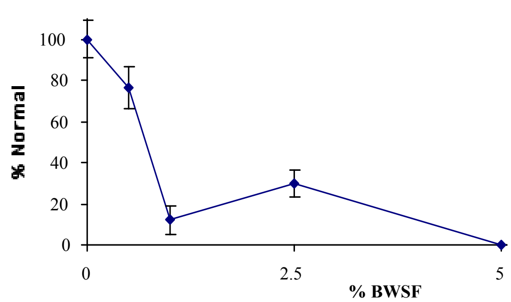

Figure 1. *Lytechinus anamesus* were exposed to different concentrations of BWSF in seawater following fertilization and scored at 96 hrs for percent that reached the pluteus larval stage.

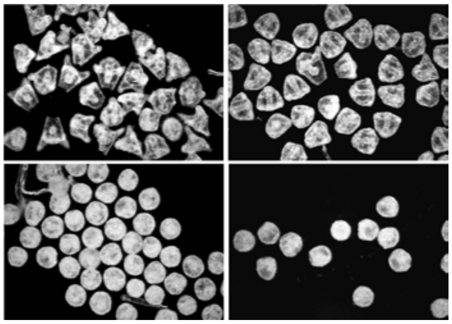

Figure 2. Effects of 1% BWSF exposure on development of plutei at 96 hrs post-fertilization. A. Control embryos incubated in seawater. B. Embryos in 1% BWSF in seawater. C. 2.5 % BWSF in seawater. D. 5% BWSF in seawater.

Previous research on stress responses of urchins has suggested that urchins do not express the full complement of stress responsive genes until after gastrulation. To investigate the hypothesis that BWSF exerts all of its effects on early life stages (prior to hatching) we assessed normal development in urchin larvae exposed to BWSF only at or after hatching. Similar effects were observed to those seen in continuously exposed embryos. We have also investigated the possibility that the difference in susceptibility to BWSF observed between the two species is caused by the different times taken to develop to larval stage at similar temperatures. We exposed *Urechis* to BWSF for 96 hours (corresponding to the time taken for normal urchins to reach the pluteus stage) and found no significant effect of BWSF.

We have shown that BWSF acts as a competitive inhibitor of ATPase mediated dye efflux. Our results suggest that this efflux is mediated by a homologue of the mammalian multi-drug resistance protein (MXR). Figure 3 shows the expression of multi-xenobiotic resistance protein (MXR) throughout development in both urchins and *Urechis*. Consistent with observations in the purple urchin, *Lytechinus* do not express MXR at any stage. In contrast, *Urechis* express relatively uniform amounts of this protein throughout development. Thus the expression of MXR is consistent with the observed absence of stage specificity in susceptibility of urchins or *Urechis*.

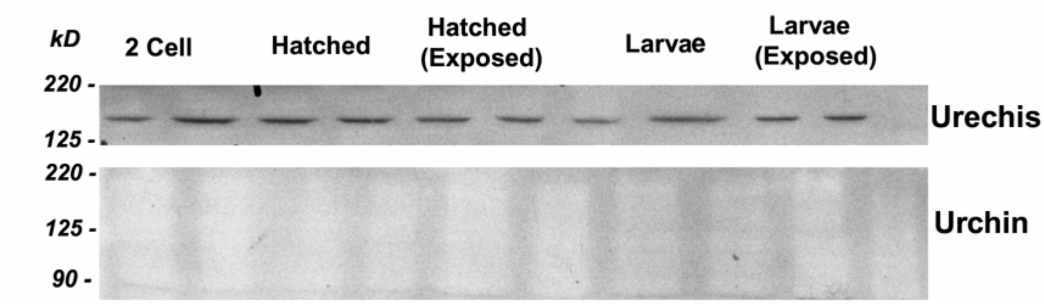

Figure 3.

To confirm that the dye efflux results observed in urchins and *Urechis* are not due to species specific differences in membrane permeability to dye we developed a dye efflux assay using calcein-AM (acetoxymethyl ester). The AM form of calcein is membrane permeable, while the free form is not. Moreover only the free form is fluorescent. Because the AM group is rapidly cleaved off by intracellular esterases the assay measures only the fluorescence of calcein trapped within the cells. The results are identical to those previously reported using the dye rhodamine.

Detecting Ecological Impacts: Effects of Taxonomic Aggregation in the Before-After/Control-Impact Paired Series Design

Principal Investigators: Sally Holbrook, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106, **Mark H. Carr**, Department of Biology, University of California, Santa Cruz, CA 95064, **Craig W. Osenberg,** Department of Zoology, University of Florida, Gainesville, FL 32611-8525

The fourth year of this study involved three overall objectives listed and addressed separately below. Two objectives include database development and data analysis for three separate datasets collected for three studies: the Carpinteria produce water discharge, Gaviota produce water discharge, and the San Onofre Nuclear Generating Station (SONGS) cooling water intake and discharge study conducted by the Marine Review Committee (MRC). A third objective is the size frequency analysis of targeted species from the Gaviota and Carpinteria studies. In addition to the objectives below, we are continuing to work to have the benthic samples archived at the Natural History Museum of Los Angeles County.

Objective 1: *Size frequency analyses of Gaviota and Carpinteria benthic samples*

Size frequency samples are processed at Carr's lab at UC Santa Cruz. Samples are imaged and digitized with a video camera, frame grabber, and Adobe Photoshop software (Mac and PC-based systems). Images are measured using NIH imaging software. The focus this past year has been on processing (imaging and measuring) bivalve species. We focused primarily on *Tellina carpenteri* because of its abundance and ubiquity among sampling stations and dates. Preliminary size frequency distributions have been, and continue to be, generated and analyzed. This effort produced one undergraduate independent research project and is also the focus of an undergraduate senior thesis.

Objective 2: *Database development for MRC and MMS/UC SCEI samples*

Data acquisition, transcription and database development

Prior to any transcription of species identities and abundance data into any database, a master species list had to be compiled with the original and revised taxonomic designations for the pre-existing MRC-SONGS species list. This master species list includes all molluscs, polychaetes, crustaceans, and miscellaneous species found in all three studies (MRC, Carpinteria and Gaviota). All species have also been assigned the appropriate phylum, class, order, and family designations. All species have also been assigned an individual species code, compatible with the pre-existing codes in the original MRC-SONGS species list. A large number of taxa were new to the existing species list provided by the MRC surveys, so they have been assigned species-level codes compatible with pre-existing codes assigned to the MRC data. Lovell and Associates supplied the codes, and have reviewed them and the taxonomic classifications to insure that the proper codes were used and the classification of animals is current. This entire file has now been re-checked and validated by cross-reference with SCAMIT (1998). We had originally hoped to provide functional group designations for each taxon also, but we were unable to get the necessary information from a potential collaborator. After many requests and after waiting over a year for the promised information, we have abandoned this aspect of the project (although some portions of this might be salvable using information from the MRC study).

In addition to the master species list, individual databases for both Gaviota and Carpinteria for each sampling method (emergence traps, re-entry traps and biocores) have been compiled as Excel spreadsheets for eventual transformation to SAS datasets. These databases include appendices with information for interpreting the codes used in each database, a process trail indicating personnel involved in the identifications and data transcription and entry, and notes indicating alterations to the databases subsequent to their original formulation. Over 98% of these files have now been proofed and cross-checked by comparison back to the original datasheets and the taxonomic list. This process was extremely time-consuming. As soon as the proofing is completed, we will fully document and archive these files for storage (on CD), and then conduct the final analyses on these data.

Objective 3: *Analysis of MRC and MMS/UC SCEI samples*

Analysis of each of the three datasets requires complete and updated taxonomic data. It also requires the completed data files. We are now in the very last stages of proofing the files. As soon as this is completed, we will begin our analyses of the patterns of spatial and temporal variation and the influence of taxonomic aggregation for the MRC, Gaviota and Carpinteria studies.

Time Frame:

This project has been far more time-intensive that first estimated. In addition, there have been several unforeseen delays. As a result, the project will not be completed by the project end date. We expect completion to require at least one additional year. Carr and Osenberg will, however, allocate time over the coming year to complete the documentation and conduct the analyses. The delay was caused by an initial delay (of ~1 yr.) in obtaining the species-level identifications, the additional delay caused by the errors in the files provided to Osenberg's lab (which required extensive proofing), the delay caused while waiting for the functional group designations, and associated delays related to personnel (e.g., having people hired when we anticipated having raw data, but then not receiving those data until after the employment period ended). We will also continue our efforts to have all samples not designated for size frequency analysis to be archived at the Natural History Museum of Los Angeles County.

Research Productivity:

Despite delays in our analyses of the effects of taxonomic aggregation, we have made significant progress in other areas of great interest to MMS. For example, application of the BACIPS sampling design and analytical framework, which is the focus of this study, was presented at two scientific meetings this year. These talks discussed the application of BACIPS in evaluating the effectiveness of marine reserves and artificial reef programs for management of coastal resources. The theoretical framework developed in the context of artificial reefs also has relevance to the recent discussion of the "rigs-to-reef" programs, and was further discussed in two other presentations.

One paper was published this year using data collected at Carpinteria by the SCEI program; two others related to artificial reefs are in review. New funding was also provided to these new research efforts that were stimulated by the SCEI program.

Effects of an Oil Spill on Multispecies Interactions that Structure Intertidal Communities

Principal Investigator: Peter Raimondi, Department of Biology, University of California, Santa Cruz, California 95460

Summary of Research

Empirical Results

The effects of tar cover on barnacle recruitment

Experiments were designed to (1) assess the effects of disturbance on intertidal community structure and (2) determine if there is a difference in the effects of tar cover and clearings on intertidal communities. If there is no difference in the effects of tar cover and clearings on intertidal populations and/or communities, the wealth of past research on the effects of clearings can be used to further understand the susceptibility of intertidal communities to oil spills and, subsequently, improve management strategies.

Twenty-four 10x10cm^2 plots were permanently marked at Boathouse, Vanderberg Airforce Base, in February 1998. Tar patches were collected from the adjacent beach under the assumption that natural tar produced from subtidal oil seeps can be used to mimic the effects of an oil spill. On half of the plots, tar patches were applied to live barnacles at one of three levels of cover (25%, 50%, and 100%). The remaining plots were cleared of 25%, 50% or 100% of all organisms. Both treatments were randomly assigned to the plots. The number and sizes of barnacle recruits were sampled in the cleared patches every three months. The number and sizes of recruits were sampled in the tar patches quarterly beginning in December 1998. Barnacles were removed from the plots after sampling.

Data on recruitment was analyzed using repeated measures analysis of variance. The percent disturbed had a significant effect on the number of recruits (Table 1). When averaged over time and the type of disturbance, the number of recruits was higher in the 100% disturbed treatment than in the 50% and 25% disturbed treatments (Fig 1). Time also had a significant effect on the number of recruits (Table 1; Fig 2A). The univariate analysis showed no significant difference between tarred and cleared plots on the number of recruits (Table 1).

There was significant interaction between month and the type of disturbance (Table 1). The tarred and cleared plots had about the same number of recruits at the start of the experiment (Fig 2B). The number of recruits was higher in the tarred plots throughout the sampling dates that corresponded with the peak season for barnacle recruitment (Fig 2B). On the last sampling date, the number of recruits was higher in the cleared plots (Fig 2B).

The effect of tarring on barnacle recruitment depends both on the time of year and the size of the disturbance. Thus, the results of this research have important implications to managing coastal ecosystems in the event of an oil spill. The recovery of populations with obligate dispersive phases, such as barnacles, from oil spills may depend strongly on the size of the spill and the time of year that the spill occurs.

Our results show that barnacles will recruit to tar. The next question to ask is 'how does tar affect the growth and survival of barnacles that recruit onto it?' We are currently monitoring growth and survival of barnacles on the same plots used to test for the effects of tar cover on barnacle recruitment. Growth and survivorship of barnacles on tar will be compared to that of barnacles on rock. The results of this experiment will add to our understanding of how barnacle populations might recover from oil spills.

Variability in tar patch accumulation and persistence

Variability in tar patch accumulation and persistence may result from, temperature, zonation and wave exposure. These factors not only contribute to the weathering (degradation) of tar, but may have an effect on where the tar accumulates. The disappearance of tar may also be a function of the species assemblage upon which it landed.

In November 1999 and May 2000, we performed surveys (at Point Sierra Nevada, Shell Beach and Boathouse) to (1) assess the accumulation and persistence of tar within different zones and (2) to determine which species would potentially be most susceptible to an oil spill. These surveys allowed us to calculate the percent cover of tar in two different zones (barnacle and *Endocladia*) and to do site comparisons (Fig. 4). Overall, we found more tar at both Pt. Sierra Nevada and Boathouse and less tar at Shell Beach. We found that at both Pt. Sierra Nevada and Shell Beach tar cover was consistently higher in the barnacle zone (primarily *Chthamalus sp*.) as compared to the *Endocladia* zone (Fig. 4). This result was consistent with what we expected, based on the analyzed slides from our data base and previous field observations. In contrast, at Boathouse the percent tar cover was lower in the barnacle zone as compared to the *Endocladia* zone (Fig. 4). This may be a result of the upwards shift in species assemblages at this site. For example, in 1992 the mean tidal height of the barnacle zone was approximately 3.5 ft and in 2000 the mean tidal height of the barnacle zone is 5.1 ft. Thus, we predict that with time (at Boathouse), the percent tar cover will increase in the barnacle zone and decrease in the *Endocladia* zone. The number, size and relative freshness of tar patches per marked plot were recorded at each of the three sites. Additionally (during the fall surveys) at Pt. Sierra Nevada, four tar patches were found in the mussel zone (in contrast, no tar was found in the mussel zones at Shell Beach or Boathouse). These four tar patches were marked and measured in late October and when we returned to this site in early December all four of the patches had disappeared. This result was also as expected based on slide data and previous field observations that suggest tar does not persist long in the mussel zone. The insight gained by determining where tar is accumulating and persisting allows us to predict which species would be most impacted by an oil spill.

Experiments were designed to measure variability in tar patch accumulation and persistence as a function of species assemblage. We know that tar accumulates and persists in the barnacle zone longer than any other zone. This may be due to longer exposure period (the tar has a chance to stick) or it may also result in part form the texture of barnacles. In contrast, tar does not accumulate and persist in the algal zones, this may be due to a shorter exposure period (the tar may not heat up enough to stick) or it may also be biological in nature since many alga produce mucilage that may inhibit tar from sticking. To test these ideas we (1) made casts of barnacles (with a material that not only mimics the texture of barnacles, but also allows tar to stick) and (2) placed sixty 10x10cm^2 barnacle casts in the intertidal at each of our three sites (from north to south: Point Sierra Nevada, Shell Beach and Boathouse) in April 2000. At each of our sites, we placed fifteen casts into each "zone"(the barnacle zone (control), *Endocladia, Pelvetia* and mussel zones). The casts were then checked bimonthly (beginning April 30,2000) for the presence of tar (Fig.5). At Point Sierra Nevada tar was only found on 12% of the casts in the *Endocladia* zone. At Shell Beach and Boathouse tar accumulated primarily in the barnacle zone, with 27% and 47% respectively (Fig. 5). In contrast to the other sites, 5% of the casts in the *Mytilus* zone at Boathouse had tar. It will be interesting to see if tar persists on the plates in the *Mytilus* zone over the next few months. However, it is still to early to make generalizations about the accumulation and persistence of tar.

We have been utilizing a tide program to make predictions regarding variability in tar patch accumulation and persistence as a function of tidal height and exposure (Fig. 6). Using the tide program we were able to create a model specific to the conditions near Boathouse. Using 10 minute intervals of all outgoing tides during a one month period (April 15, 2000 to May 15, 2000) we were able to get a feel for the proportion of time the mean tide was at a given point on the shore. Then we compared the approximate vertical distributions of the three zones, within which the barnacle casts were placed (Fig. 6). Assuming that most tar is deposited during an outgoing tide and that tidal heights above 4.0 ft are exposed for longer periods, it makes sense that the barnacle zone is accumulating more tar and that when it does it persists longer. Lastly, we assume that wave exposure plays a greater role at tidal heights less than 3.5 ft. While this information is useful, it does not explain the patterns we see entirely. At this point it seems that the variability in tar patch accumulation and persistence can not be simply explained by a single physical or biological factor, in fact, it seems that several factors are working in concert.

We will continue to monitor both the number and size of tar patches, as well as the percent tar cover in the marked plots on a biannual basis. In addition, we will continue to monitor the barnacle casts for tar accumulation on a monthly basis. We also plan to use a thermistor to examine the mean temperatures of each zone and thus, elucidate the effects of temperature on the accumulation and persistence of tar.

Theoretical Results

The effects of tar cover on barnacle recruitment

We investigated the effects of tar cover on growth, reproduction and population dynamics of barnacles using a mathematical model. Increasing the probability of tar cover has little affect on the reproductive output of an individual barnacle. It is only when the probability of tar cover is combined with recruitment variation that differences in population dynamics between populations exposed to high vs. low probabilities of tar cover are seen (Fig 3).

Research Presentations and Publications

A manuscript based on the results of the dynamic state variable model, entitled "Assessing individual-level and population-level consequences of an oil spill: predictions from a dynamic model" is in review in Ecological Applications. Samantha

Forde will present the results of the model at the Annual Meeting of the Ecological Society of America in August 2000.

Inventory of Rocky Intertidal Resources in San Luis Obispo and Northern Santa Barbara Counties

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

Summary of Progress and Project Goals

This report summarizes the accomplishments of the Inventory of Rocky Intertidal Resources for San Luis Obispo and Northern Santa Barbara Counties from July1999 to June 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.

Research Presentations:

Readdie, Mark. 2000. Long Term Change in Intertidal Zonation. Can Succession Drive Vertical Shifts in Species Zones? Poster presentation at the Monterey Bay National Marine Sanctuary Symposium.

Raimondi, P.T. and Carr, M.C. 2000. Partnership for Interdisciplinary Studies of Coastal Oceans. PISCO at Santa Cruz. Larval Biology Meeting. UCSC.

Inventory of Rocky Intertidal Resources in Southern Santa Barbara and Ventura Counties

Principal Investigator: Richard F. Ambrose, Department of Environmental Health Sciences, University of California, Los Angeles

Project Summary:

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 were 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.

Table 1. Sampling schedule for Fall 1998 and Spring 1999.

Location	Date	Researchers	Comments
Little Harbor	Oct 8	J.Engle, S.Lee, J. Wible, M. Buttner, F.Starkey	UCSB, Hopkins, and Catalina Conservency help
Bird Rock	Oct 9	J.Engle, S.Lee, M.E.Dunaway, J.Wible, M.Buttner	UCSB, MMS, and Hopkins help
Carpinteria	Oct 24	S.Lee, M.McCrary, H. Leedy, M. Pierson	MMS help
Alegria	Oct 25	S.Lee, M.E. Dunaway, S. Morton	MMS, SB County help
Point Fermin	Oct 26 & Nov 24	S.Lee, S. Bergquist, S. Lawrenz-Miller, E. Mastro, L. Chilton, S. Vogel	Site creation and initial sampling at Point Fermin with Cabrillo Marine Aquarium personnel help
White's Point	Nov 7	S.Lee S. Luce, R. Sepulveda	SCMI help
Coal Oil Point	Nov 8	S.Lee, S. Morton	SB County help
Old Stairs	Nov 9	S.Lee, S.Luce, S.Bergquist, J.Smith, K.Johnston	UCLA personnel only
Paradise Cove	Nov 21	S.Lee, Sh.Lee, S.Bergquist, J.Smith	UCLA personnel only
Mussel Shoals	Nov 22	S.Lee, S.Anghera, M.Myers, C.Ching, K.Gazzaniga	UCLA and UCSB personnel
Arroyo Hondo	Nov 23	S.Lee, Sh.Lee, S.Bergquist, S.Morton	SB County help
Old Stairs	March 6 & March 17	S.Lee B.Hajduczek, E.Ramirez	UCLA personnel only – had to revisit site because of big swells on first sampling day
Coal Oil Point	March 14 & March 19	S.Lee, S.Morton, B.Hajduczek, J.Smith	SB County help – had to revisit site because of a film winding problem
Alegria	March 15	S.Lee, S.Morton, B.Hajduczek, S.Bergquist	SB County help
Carpinteria	March 16	S.Lee, S.Morton, B.Hajduczek, S.Bergquist	SB County help
Paradise Cove	March 17	S.Lee, S.Bergquist, S.Luce, B. Hajduczek	UCLA personnel only
Mussel Shoals	March 18	S.Lee, S.Bergquist, J.Smith, B.Hajduczek	UCLA personnel only
Arroyo Hondo	March 19	S.Lee, S.Anghera, M.Anghera, S.Morton, B.Hajduczek, J.Smith	UCSB and SB County help
Point Fermin	March 20 & April 14	S.Lee, S.Lawrenz-Miller, E.Mastro, B.Hajduczez	Cabrillo Marine Aquarium help – had to revisit site because of big swells on first sampling day
White's Point	April 14	S.Lee, B.Hajduczek	UCLA personnel only
Bird Rock	May 11	J.Engle, D.Richards, J.Altstatt, S.Allen, J.Wible, E.Erikson	J.Engle and UCSB group, no UCLA personnel
Little Harbor	May 12	J.Engle, D.Richards, J.Altstatt, S.Allen, F. Starkey	J.Engle and UCSB group, no UCLA personnel

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 exception 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 masonery 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 upcoast. 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 downcoast of the spill, mussels were found gaping and clearly dead, and barcnacles 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 upcoast, 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 resampling 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.

<u>Photoplot data:</u>

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. *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 were removing the mussels for bait during the 1999 season.

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. *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.

Phyllospadix Transects:

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. 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 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. 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.

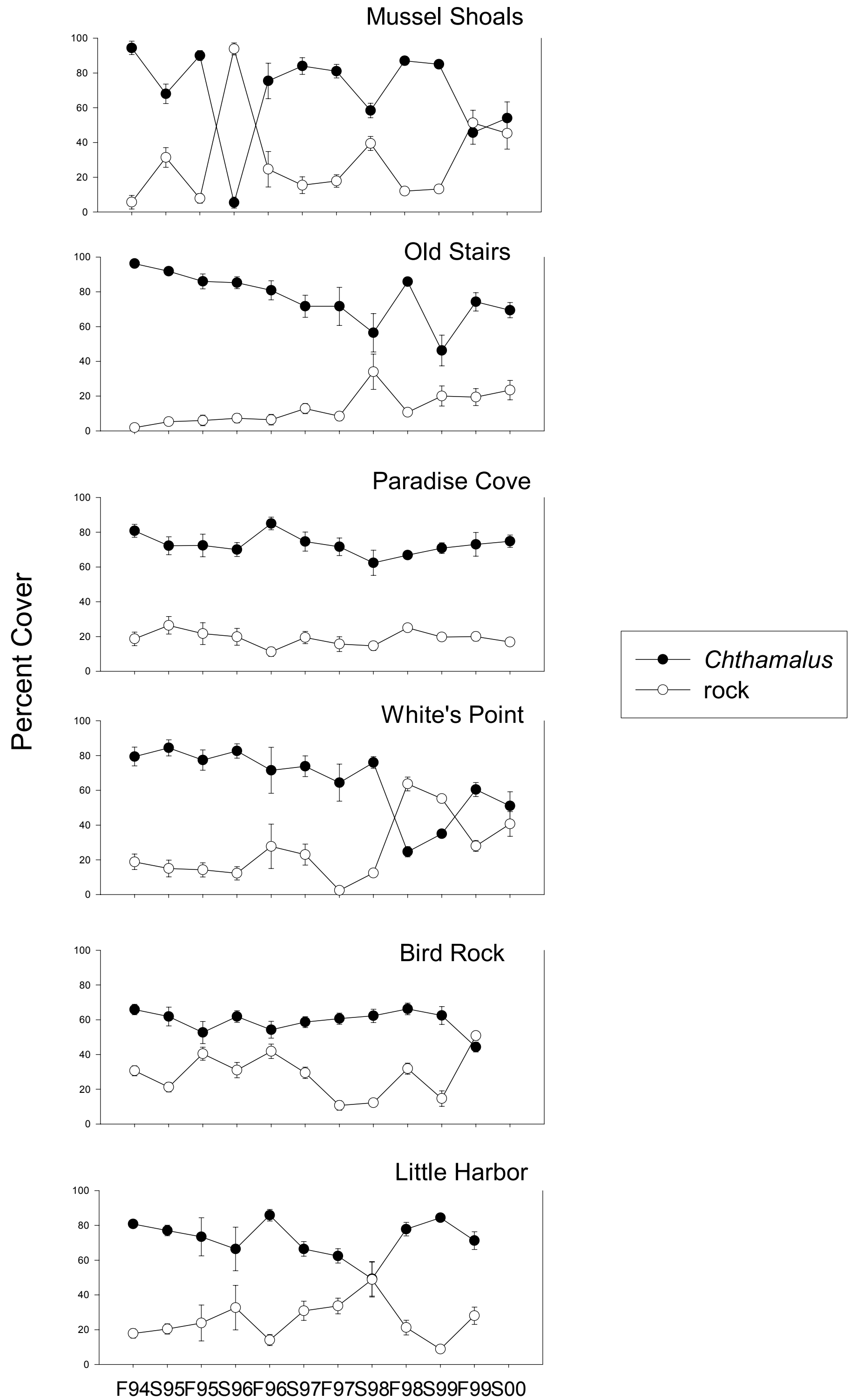

Figure 1. Trends in *Chthamalus* cover at all sites monitored.

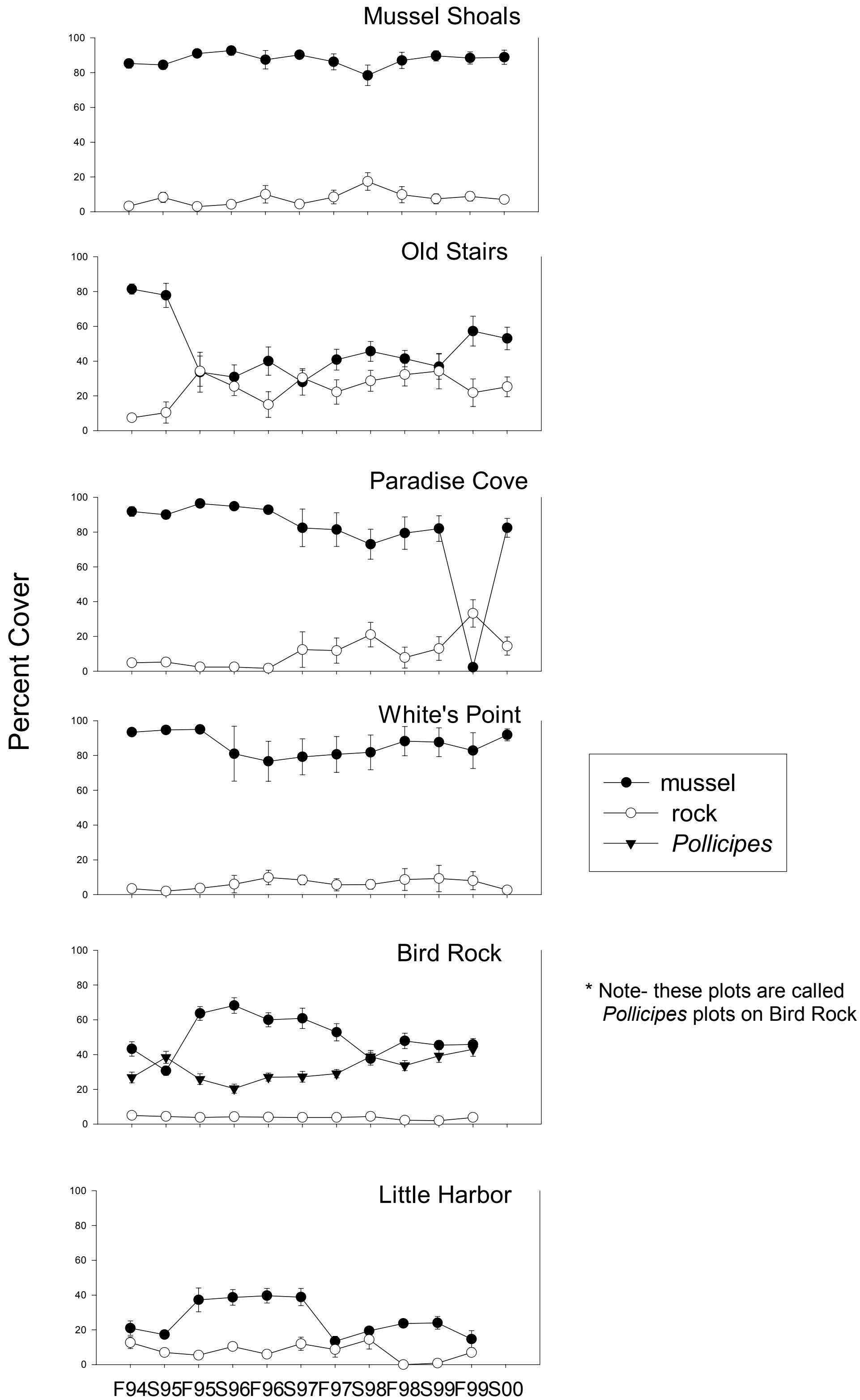

Figure 2. Trends in *Mytilus* cover at all sites monitored.

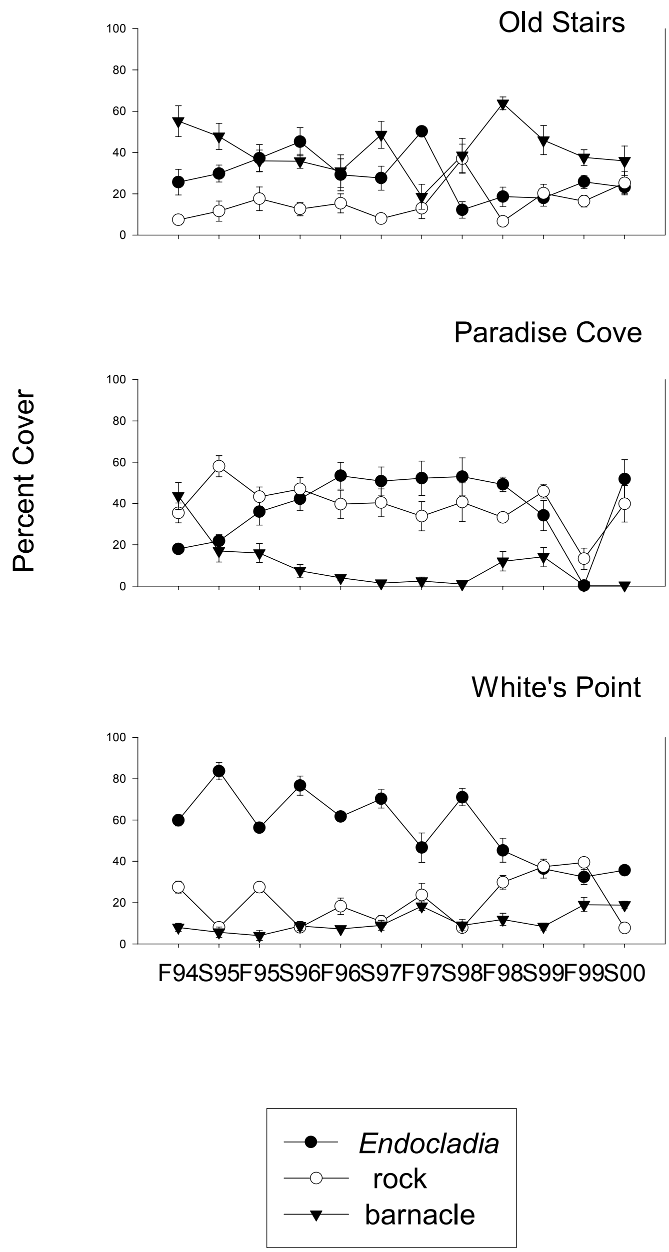

Figure 3. Trends in *Endocladia* cover at all sites monitored.

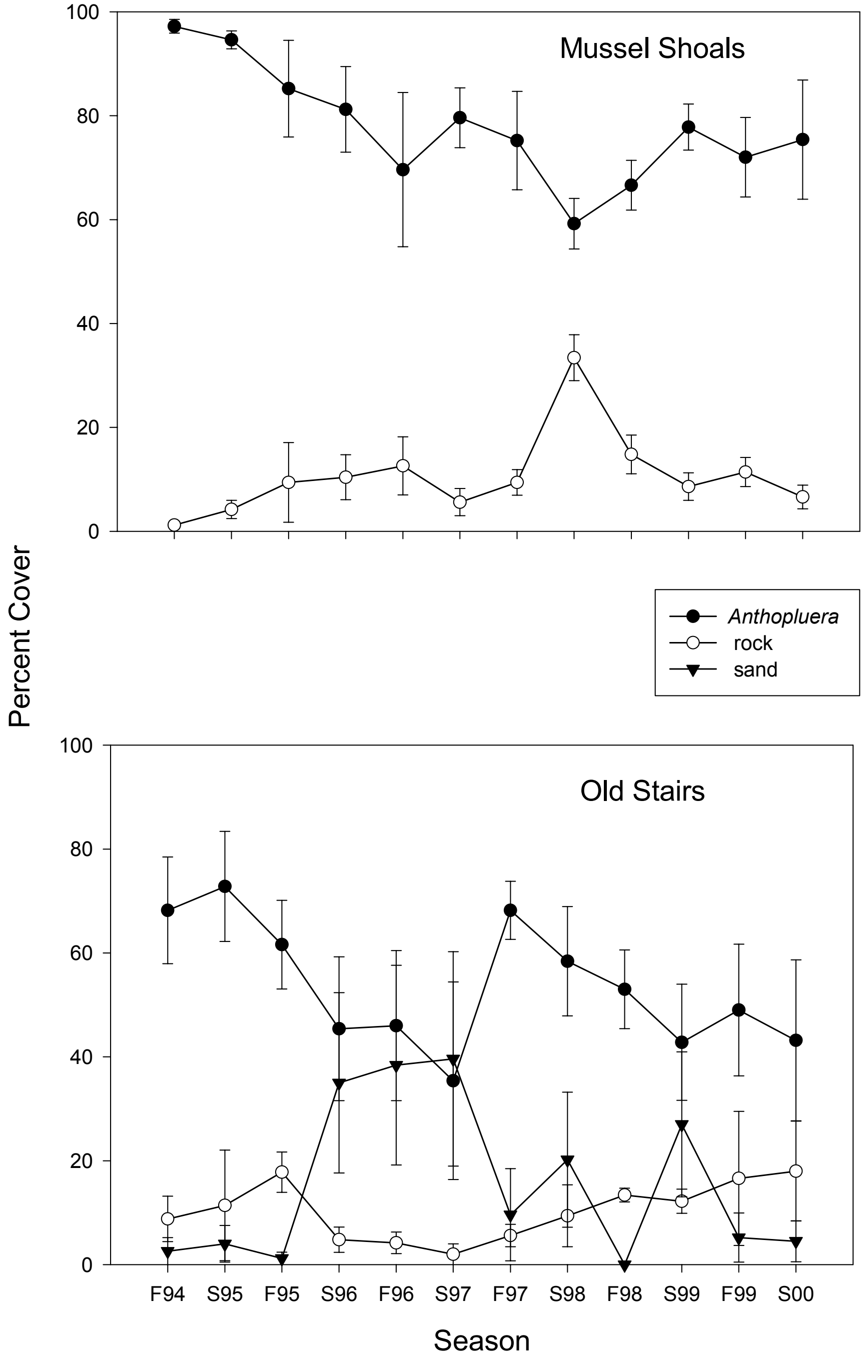

Figure 4. Percent cover of *Anthopleura* at two Ventura County sites.

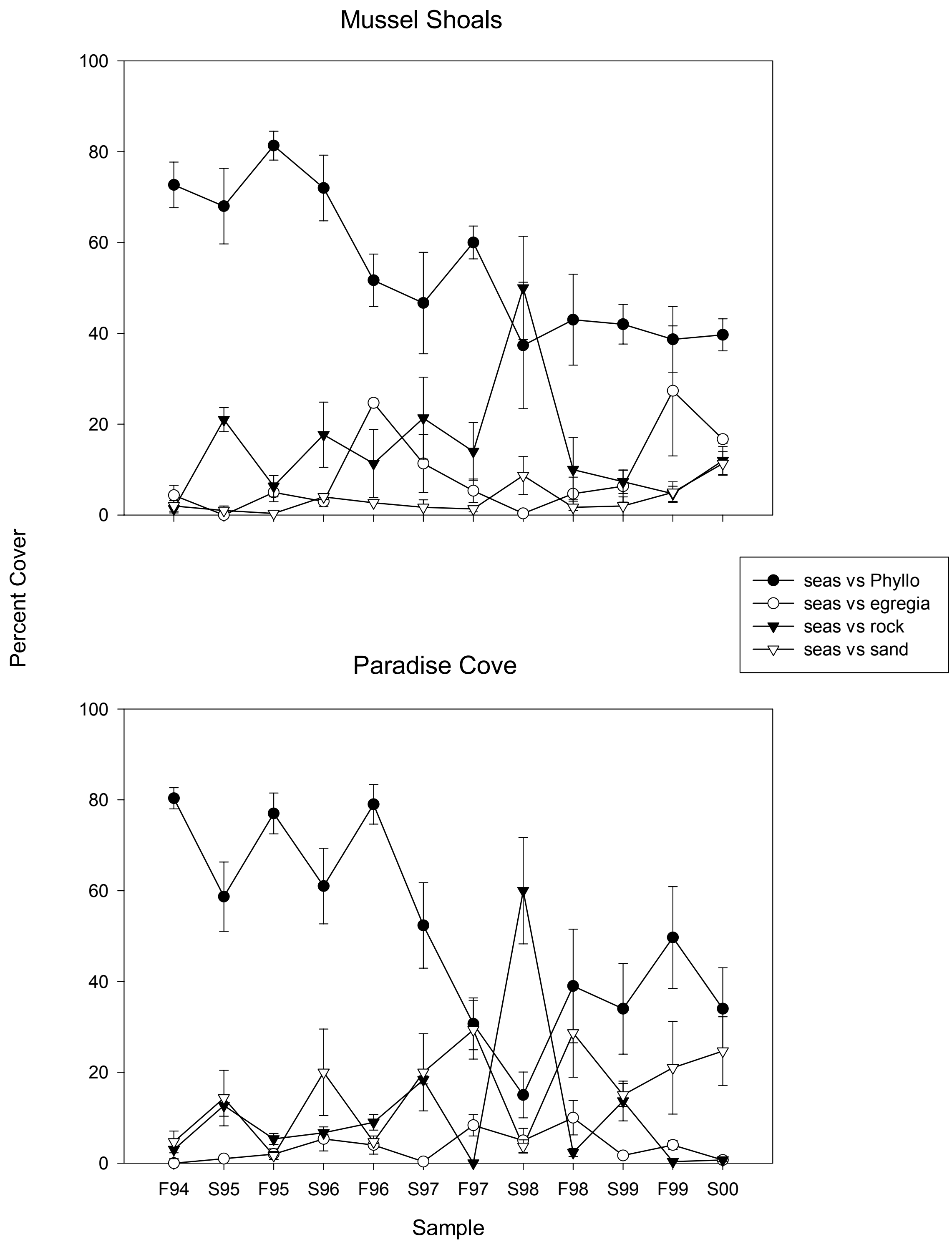

Figure 5. *Phyllospadix* cover from transects at two sites.

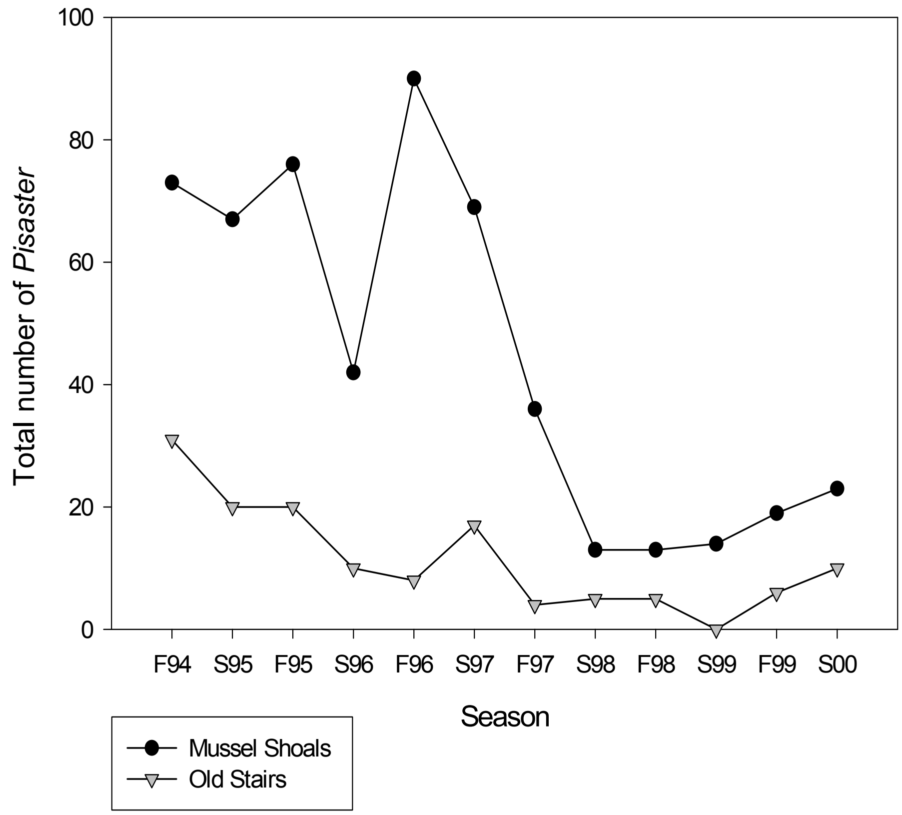

Figure 6. Total number of *Pisaster* within monitored plots at two sites in Ventura County.

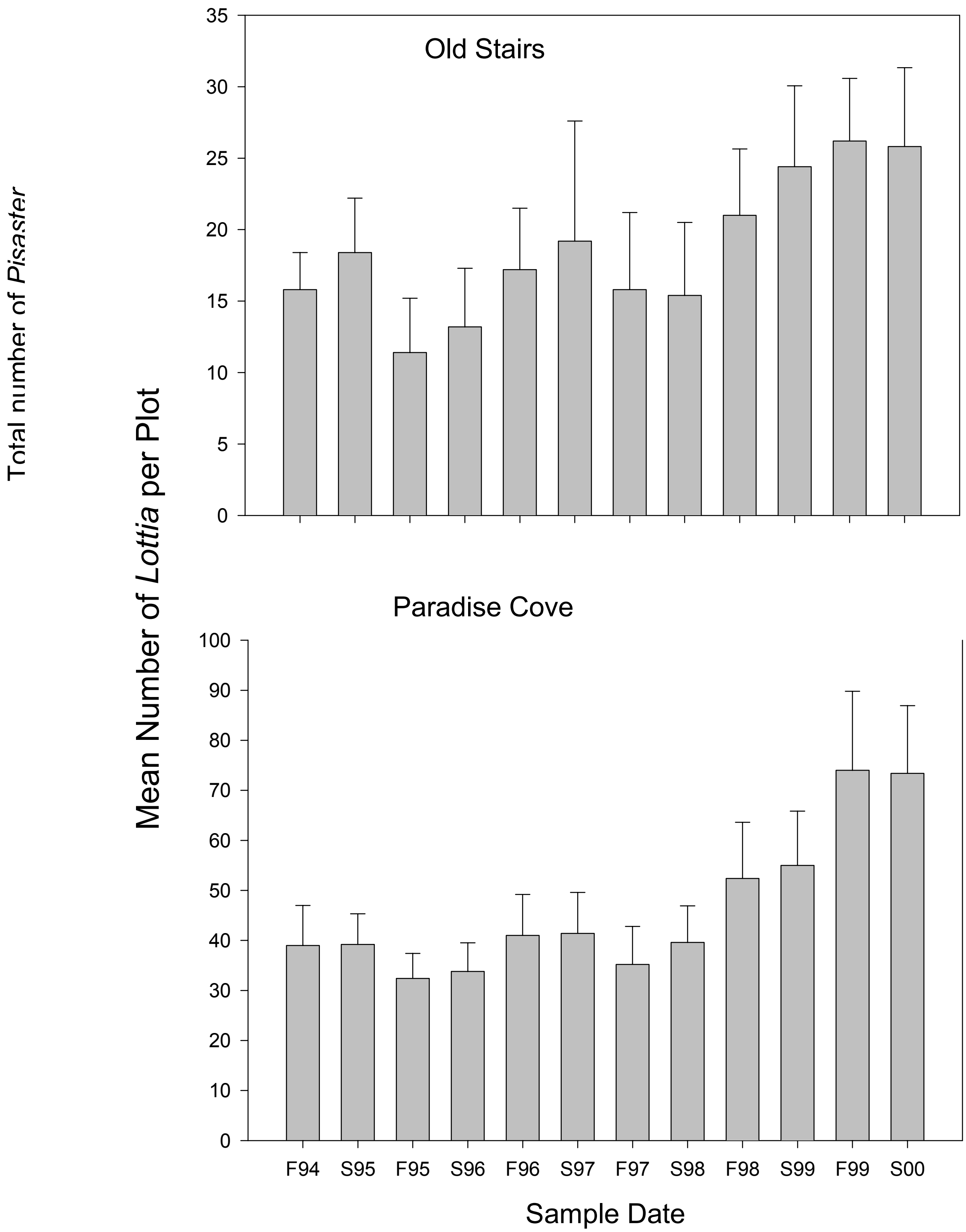

Figure 7. *Lottia* abundance at two sites in Ventura and LA counties.

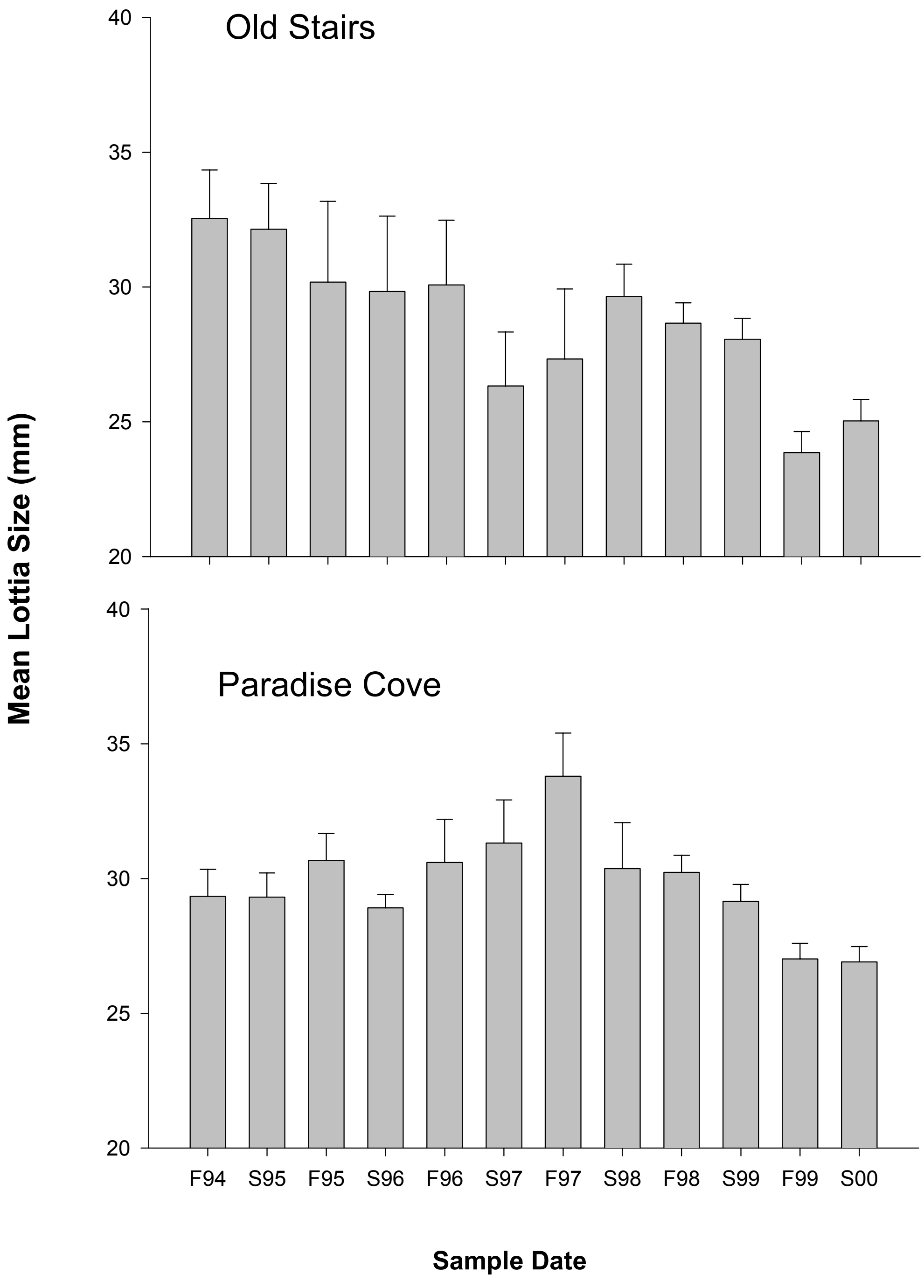

Figure 8. *Lottia* mean sizes at two sites in Ventura and LA counties.

A Design for a Time Series Study of a NIMBY Response

Principal Investigator: Eric R. A. N. Smith, Department of Political Science, University of California, Santa Barbara

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 to Date

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.

Application of genetic techniques for use in restoration of surfgrass (Phyllospadix torreyi)

Principal Investigators: Scott A. Hodges, Department of Ecology, Evolution and Marine Biology, **Douglas S. Bush**, Marine Science Institute and **Daniel C. Reed**, Marine Science Institute, University of California, Santa Barbara

Objectives of genetic research on surfgrass. Our first objective is to describe the **mating system** in *Phyllospadix torreyi*. Surfgrass is dioecious, however, the sex ratio of plants is strongly female biased. Female plants outnumber male plants by more than ten to one at most of our sites; at some sites males were never observed. Despite this apparent shortage of male flowers, most female flowers produce fruit. For successful fruit set to occur under these conditions, female flowers must either receive pollen from distant males, or produce fruit asexually. Asexual cloning via apomixis (the production of an embryo from an ovule without fertilization) is common in many plants, especially grasses. Determining whether apomixis is common in surfgrass is important if restoration is to depend on outplanting seeds or seedlings obtained from natural populations. The reason for this is that the genetic diversity and sex ratio of populations dominated by cloning would be very different from those in populations where pollination is prevalent. In particular, genetic diversity of cloning populations would be lower and the proportion of females would be much higher than in populations that reproduce sexually.

Our second objective is to determine the amount of genetic diversity within and among local populations of surfgrass. Previous work has shown that restored seagrass populations with lower genetic diversity do not perform as well as natural populations. Specifically, restored populations of eelgrass (*Zostera marina*) in southern California have lower genetic diversity than natural populations. Inbreeding depression, which is a common occurrence in populations with lower genetic diversity, has been shown to produce reduced seed set in *Zostera*. The issue of lowered genetic diversity is relevant to surfgrass management, because genetic diversity of locally-restored populations might be lower than in natural ones. Higher genetic diversity provides the potential for populations to cope with changing environmental conditions, as well as an increased capacity to occupy heterogeneous environments. Furthermore, if surfgrass populations are genetically differentiated then local adaptation may have occurred and thus restoration with germplasm from nearby sites may be most successful. Surfgrass populations occupy environments that change on a variety of temporal and spatial scales, such as climate change due (for instance) to ENSO, as well as daily and seasonal tidal fluctuations, inundation with sand, etc. Lastly, increased genetic diversity (within an individual) also has been associated with increased fitness across a wide range of species.

In our last annual report, we detailed our work on developing AFLP technology for the genetic analysis of surfgrass populations. At that time, we were using radioactively labeled primers and X-ray film to detect DNA fragments. Since that time, we have now aquired an automated, non-radioactive system. We now label primers with fluorescent tags and detect DNA fragments with a LiCor automated DNA sequencing machine. This system has greatly increased our ability to assay samples.

1) *Levels of genetic diversity in surfgrass populations*. We have used AFLPs, a DNA fingerprinting technique, to estimate the extent of clonality and the overall genetic diversity of six surfgrass populations. The populations we studied are in areas that are impacted by oil and

gas activities off the coast of Santa Barbara. We found high levels of genetic diversity in each of the six populations; we identified more than 50 variable AFLP markers, and individuals within populations differed from each other, on average, at 5 to 20% of these variable AFLP markers.

Our data also indicate that clonal propagation occurs only over limited distances. We found that genets (genetically identical plants) typically did not extend beyond one or two meters at most. When sampled along transects in the intertidal the proportion of shoots identified as clones decreased from approximately 60 % to zero as sampling interval increased from 20 cm to 50 m. In other words, shoots separated by as little as 20 cm were genetically distinct in over 40% of our samples, and only 17% of shoots separated by 8 m were identified as clones. No clones were detected in samples collected greater than 8 m apart. These data indicate that at least in the intertidal zone surfgrass populations are not comprised of a few large-sized, spatially extensive clones but rather that they consist of many relatively small-sized, genetically distinct plants. Together with the fact that rhizomes of *P. torreyi* cannot be fragmented and re-established naturally, these data further suggest that outcrossing and seedling recruitment must be important for establishing and maintaining the genetic structure of surfgrass populations. Comparable data are lacking for the subtidal and the extent to which clone size (and thus genetic diversity) vary with depth and disturbance regime await further investigation.

A third important result of our studies on genetic diversity is that surfgrass populations that we sampled were all genetically distinct from each other. Phylogenetic analysis of the AFLP data groups individuals within a population together but separates individuals from different populations. The two closest mainland populations (Shoreline and Lompoc Landing which are separated by about 100 km) were clearly separated by the analysis. The distances separating island populations were generally less than those on the mainland (i.e., about 50 km) yet they too were distinguished from each other in the analysis. The island samples are, of course, separated by open ocean rather than shoreline which may decrease the distance where differentiation may occur compared with contiguous coastline. In any case, these data indicate that gene flow between populations along a shoreline can be restricted over distances as little as 100 km leading to genetic differentiation and, possibly, local adaptation. Additional analyses with greater spatial resolution are needed to refine the spatial scale over which local surfgrass populations are genetically differentiated.

2) *Relative contribution of apomixis (cloning) vs. outcrossing to the breeding system*. Along the Santa Barbara coast, *Phyllospadix* produces abundant seeds even in populations where males are rare or apparently absent. This, together with our initial assumption that *Phyllospadix* has low genetic diversity, led us to hypothesize that seed production might occur through apomixis (cloning) rather than through outcrossing. To determine if apomixis occurs, we compared DNA fingerprints from mother/seedling pairs in two populations, one where the frequency of flowering males is rare (Females : Males , 13:1) and one where they are common (Females : Males, 1:0.95). Our results clearly show that even in the population where males are rare, i.e. at Shoreline, seedlings are genetically distinct from their mother as we found no instance where the DNA fingerprint of the mother matched that of the seed. Apomixis, therefore, does not occur in *Phyllospadix* at any detectable level and seeds are produced

sexually. Because *Phyllospadix* is dioecious, the seed produced must be the result of outcrossing.

The results of these studies of the genetics of seed production corroborate those described above that show high levels of genetic diversity within surfgrass populations. Furthermore, they lend strong support to the hypothesis that seedling recruitment is important for establishing and maintaining the genetic structure of surfgrass populations.

3) Identifying genetic markers linked to gender determination.

Strong female-biased sex ratios have long been reported for *Phyllospadix torreyi* (Dudley 1893). Because the causes and consequences of this skewed gender bias are not fully understood (Williams 1995), the prudent course of action for restoration is to maintain the natural ratio and distribution of male and female plants. It is important to note, however, that the reported sex ratios in *P. torreyi* have been based on observations of flowering, which may not be an accurate depiction of the relative abundance of male and female plants. Many individuals in a population fail to flower in any given year and determining the primary distribution of the sexes using vegetative morphology cannot accurately be done. Because of the need to know the relative abundance and distribution of the sexes for restoration, we sought to identify genetic markers that are linked to gender determination. We screened for gender-specific markers by pooling DNA from known (flowering) males or females of several populations. By using AFLP analysis on these pools, we can determine if a single individual in the pool has a particular marker (data not shown). In this way we are able to rapidly screen a large number of individuals and populations for potential gender-specific markers. We screened three male and three female pools for 32 AFLP primer pairs and identified 25 markers that appeared in all of the pools of one sex but not the other. We have identified 23 potential male markers and 2 potential female markers using this method. The predominance of male markers is consistent with the existence of an XY system of sex-determination like that of humans and a number of plant species (Dellaporta and Calderon-Urrea 1993). In these systems only males possess the Y chromosome and all individuals possess at least one copy of an X chromosome, thus genetic markers on the Y chromosome are sex specific and restricted to males.

Research presentations involving MMS sponsored research:

Brian Counterman presented the results of his investigation of chloroplast DNA variation in a poster at the annual Toxics Substances Research and Teaching symposium in San Diego.

Undergraduate Personnel:

Brian Counterman conducted a senior project where he investigated chloroplast DNA (cpDNA) variation in surfgrass. For this project, he PCR amplified and then sequenced a number of individuals to look for sequence variation. In addtion, Brian worked on the main portion of the grant by isolating DNA and learning the AFLP technology to study genetic variation.

Chris Adams started working in our laboratory this past year. He has worked on the isolation of DNA samples from surfgrass and has begun learning how to conduct AFLP analyses.

Early Development of Fouling Communities on Offshore Oil Platforms

Principal Investigators: Henry M. Page and **Jenifer E. Dugan,** Marine Science Institute, University of California, Santa Barbara
Graduate Student: Jason Bram

Offshore oil platforms provide hard attachment sites for an array of sessile animal species, including barnacles, mussels, scallops, tunicates, bryozoans, and sea anemones. In an otherwise soft-bottom environment these platforms provide habitat for a diverse community of invertebrates that otherwise would not exist there. In addition, the sessile invertebrate community provides habitat and food for many small mobile invertebrates, such as gammaridean and caprellid amphipods, as well as for larger invertebrates and fishes. In general, previous studies of platform invertebrate communities have been descriptive in nature, with little investigation of the processes that influence development and structure of this community. We are quantifying the role of selected physical and biological factors in the rate of accumulation and structure of the invertebrate community on two platforms in the Santa Barbara Channel.

Using platforms "Houchin" and "Hogan" (Pacific Operators Offshore), we are:
(1) quantifying changes in biomass and community composition on these structures over time following maintenance cleaning, (2) using experimentally scraped surfaces and plates to evaluate the effects of time from disturbance, time-of-year, and depth on the early development of the invertebrate community; this includes testing the models of facilitation and inhibition in order to better understand the effect of the presence of a species on community development, (3) determining relationships between the species composition, biomass, and thickness of the fouling community and rates of faunal litterfall to the benthos, and (4) quantifying the growth of organisms of economic and biological importance. Our research will contribute to decisions regarding platform cleaning and maintenance operations and the design of platform structures.

We are measuring the accumulation of biomass (as dry weight) at three depths (6 m, 12 m, and 18 m) on vertical support members (n=4 members) using three techniques: (1) samples obtained from ceramic tiles placed on Platform Houchin and subsequently exposed for various intervals (2-month, 4-month, 6-month, 12-month, 24-month), and (2) samples obtained from the destructive sampling of experimental plots (20x20 cm) on the support members at 2-month, 4-month, 6-month, and 12-month intervals. For the latter samples, each quadrat is scraped and vacuumed to remove settled invertebrates from the plot. Our third technique estimates the biomass of the organisms settling on more structurally complex settlement surfaces (plastic mesh tuffys), which are deployed and collected monthly. The tiles and tuffys are attached by cable ties to a PVC frame reinforced with rebar, which was attached to each vertical support member with cable ties. The experimental plots are located just below the frames on the support members. The percent cover of dominant organisms on the tiles is determined in the laboratory using point contact methods. The percent cover of dominant organisms in the experimental plots will be determined from photographs taken with a digital camera and image analysis software. The tiles are also photographed after their retrieval. We have initiated the image analysis of the photographic record and will begin formal analyses during the next 3 months.

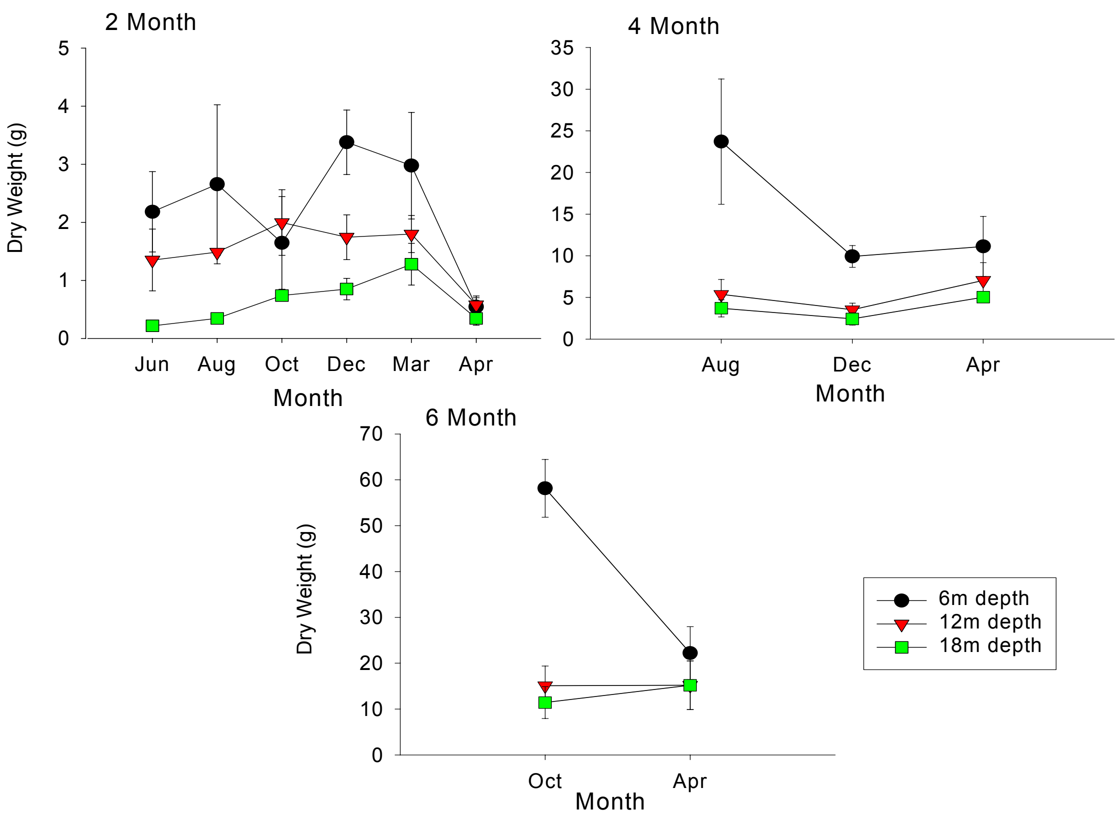

Figure 1. Comparison of biomass accumulation on tiles from Platform Houchin exposed for intervals of 2, 4, or 6 months. (x± 1SE, n= 4 tiles).

A general pattern found on all of the experimental surfaces (tiles, tuffys, scraped areas) is illustrated in Figure 1: biomass decreases with depth at all time periods between disturbances, with the 6 m depth having a much greater biomass accumulation than the deeper depths. In addition, Figure 1 shows temporal variation in biomass accumulation with the lowest values in April. Also evident is the much greater biomass as time between disturbances is increased, with over 20 times the biomass at the 6-month disturbance time at 6 m compared to the 2-month disturbance time at the same depth. It is interesting to note that mussel recruitment has been extremely low on these surfaces when compared to other studies on platforms in the Santa Barbara Channel (data not shown).

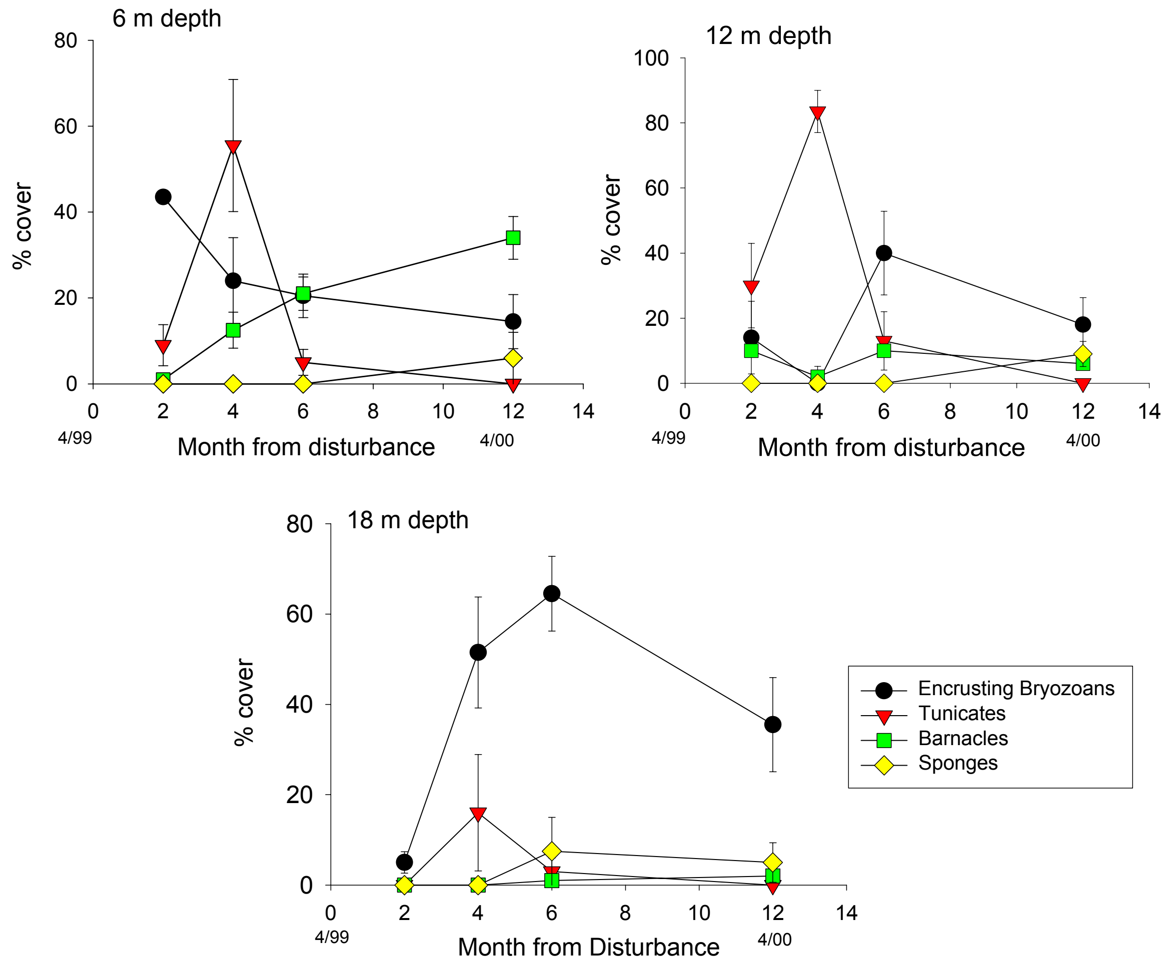

Figure 2. Changes in percent cover of selected invertebrate taxa over time on ceramic tiles at Platform Houchin at depths of 6, 12, and 18 m (x± 1SE, n=4 tiles).

Community composition on the tiles changes over time and among depths (Fig. 2). For example, at a depth of 6 m, encrusting bryozoans dominate early, followed by a gradual decrease in the cover of this taxa and an increase in the cover of tunicates. However, the cover of tunicates decreases to 0% after 12 months. Barnacles show a continual increase in percent cover, and sponges slowly begin to become part of the assemblage after 12 months. At the 12 m depth, the tunicates dominate early, with a large increase in cover after 4 months of exposure time. However, the cover of tunicates at this depth decreases to 0% after 12 months. At the 18 m depth, the community takes longer to develop, with little coverage from any group of organisms after 2 months. Both the tunicates and encrusting bryozoans show an increase in cover after 4 months, with the bryozoans being dominant.

We are also estimating the rates and composition of faunal litterfall from the invertebrate community using circular plastic hoops with attached mesh bags as "traps". The faunal litterfall traps are located on Platform Hogan at a depth of 18 m (n=8 traps). On average, we have collected approximately 200 g/trap of litterfall monthly. *Mytilus galloprovincialis* is the dominant component of these samples to date. We are also measuring the thickness of and photographing the invertebrate community at Platform Hogan, quarterly at depths from 6 m to 18 m. The thickness and cover of the invertebrate community has generally increased over time at all depths.

To compare relative flow among depths we have attached clod cards to each PVC frame at each depth (n=12). Early data suggest that water flow is lower at deeper depths, a result that corresponds with our observations of a lower biomass and invertebrate species richness, although more samples will be taken.

To examine the effects of dominant space occupying species on the early development of the invertebrate community we are conducting removal experiments using the anemone, *Anthopleura elegantissima,* and the mussels, *Mytilus californianus* and *M. galloprovincialis*. Experimental removals were initiated in April and data will be collected through the next year, using a digital camera. We predict that mussels or other species will colonize plots in which the anemones are removed more rapidly than control plots, if anemones consume or otherwise interfere with settling larvae. Similar predictions can be made for the mussel removal plots, which we predict will have other species colonizing these areas more rapidly than control plots with mussels present.

To quantify temporal and spatial variation in commercially important and dominant organisms on the platforms we measure the sizes of all mussels, scallops, urchins and crabs and barnacles collected. These measurements will allow us to compare the growth rates of selected species over time and at different depths.

Over the next year we will continue to deploy, retrieve, and measure invertebrates from the tiles, the tuffys, and the experimental plots. Video photoplots will be analyzed, and sampling will continue as described above. The litterfall will be collected monthly. The thickness of the invertebrate community will will be measured quarterly. Video data from the removal experiments will be collected and analyzed and flow data will be collected. Continued sampling and analysis of the data will provide greater insight into the factors that influence the early development of the invertebrate communities on offshore oil platforms.

The Political Economy of the Rigs to Reef Option for Decommissioning Oil and Gas Structures

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Scholars have examined the political dimensions of oil and gas leasing, exploration and production associated with the Outer Continental Shelf (OCS) in the three primary OCS REGIONS, the Gulf of Mexico, Alaska and California. The history of OCS oil and gas development varies greatly from one region to another. Researchers have uncovered critical differences among OCS oil and gas regions, due to their particular legal, technological, and socio-economic contexts. As a result, the local and regional politics of OCS oil and gas development varies among these regions. OCS oil and gas development is contingent upon socio-cultural factors endemic to particular places, regions and localities and not just related to the presence of OCS oil and gas reserves, governments' willingness to create opportunities for the development of oil and gas, or the availability of modern technologies to develop oil and gas.

California has entered a new era of OCS oil and gas activity. The decommissioning of offshore oil and gas facilities is rapidly becoming an issue of public concern. Since 1998, government and private interests have been proposing various options to complete removal, including "rigs-to-reefs". The importance of socio-economic, legal and political factors notwithstanding, the implications of the rigs-to-reefs option and other decommissioning alternatives have received little systematic consideration by social scientists.

This study addressed three primary questions: (1) what are the potential costs and benefits of various options to decommission California OCS oil and gas structures? (2) what is the policy history of state artificial reef and rigs-to-reefs programs in the Gulf of Mexico (as a point of comparison with California)? and (3) what is the history of California's artificial reef program, and how does it fit into the current policy debate over rigs-to-reefs as an alternative to complete removal of platforms slated for decommissioning?

California's particular social reality and ecological concerns will shape the politics of decommissioning policy-making. Because of the stark differences between the California setting and that of the Gulf of Mexico, we propose that California policymakers should not use the Gulf state programs as a blueprint for the development of a rigs-to-reef program.

(1) The potential costs and benefits of various options to decommissioning of California OCS oil and gas structures

The National Research Council (1985) estimated that the cumulative costs for removal of all platforms in the OCS could total $2.9 billion by 2005 and $9.9 billion by 2020. More recently, the GAO (1994) estimated total decommissioning costs at $4.4 billion. The GAO (1994) review of offshore structure removal operations concluded that the MMS needs to better understand the risk of ecosystem damage posed by certain decommissioning practices, such as the use of explosives as a removal technique.

We analyzed three alternatives for decommissioning oil platforms: "Complete Removal", "Partial Removal" (i.e., removing the platform from one marine location to another) and "Leave in Place". We identified variables that are associated with the costs and benefits of these three alternatives. We also determined monetary values to quantify these costs and benefits, then compared those costs and benefits of each alternative within and across categories. We found that there are a range of values associated with each alternative, suggesting that they can be compared relatively, with low and high bounds of the ranges enabling the ranking of alternatives. The range for Partial Removal has an upper bound that makes accounting for two sites (original platform site and site where rig is transported to) less attractive than the Complete Removal and Leave in Place alternatives. The overlap of ranges for Complete Removal versus Leave in Place means it is more likely that each platform should be considered individually in order to derive more specific estimates of costs and benefits to weigh alternatives. However, economies of scale from grouping platforms together for Complete Removal can be considered by accounting for spreading the costs from the engineering and planning, mobilization and demobilization, and platform and structural removal across several platforms.

Since this part of the study is an objective information document, we do not rank alternatives. Instead, our results identify the factors associated with decommissioning alternatives, especially for platforms standing in varied water depths that often exceed the depth of platforms that have been decommissioned in other geographic areas such as the Gulf of Mexico.

One category of interest that is not quantified here is liability. The oil producer retains all liability for the platform and wells under each of the decommissioning options. Liability for accidents during lease clearance and abandonment is a cost to contend with in terms of personal injury, property damage and environmental damages for the Complete Removal alternative. The platform can still cost the operators long after ceasing oil production. Platforms can become top-heavy from biofouling growth that supports fisheries habitat; this can cause them to topple, and possibly cause ecological damage, personal injury or property damage. Moreover, for both the Partial Removal and Leave in Place alternatives, liability for any recreational or fishing accident that might occur constitutes an additional cost. This lingering liability suggests that platform operators need to reserve financial resources to cover these potential costs.

The potential costs of liability with the Leave in Place or Partial Removal alternatives call into question the logic of pending legislation in California, Senate Bill 241 (Alpert). SB 241 outlines a voluntary program whereby platform operators would yield to a portion of cost savings from partially removing or leaving a platform in place to support fisheries mitigation projects. SB 241 does not release operators from liability, and could reduce the incentives for platform operators to pursue the rigs-to-reef option.

(2) The policy history of state artificial reef and rigs-to-reefs programs in the Gulf of Mexico

This part of the study had two goals: a) to describe the historical development of the rigs-to-reefs alternative to Complete Removal in the Gulf of Mexico, and b) to characterize the general administration and operation of Gulf states' rigs-to-reef programs.

In the early 1980s, the Department of the Interior joined with the president of the National Ocean Industries Association to form the Recreational Environmental Enhancement for Fishing in the Seas (REEFS) task force. The task force was composed of fishery representatives, private industry and resource agencies primarily in the Gulf of Mexico region. Its goal was to create a strategy that would lead to the creation of a national rigs-to-reef policy, plan and program. Commercial and sport fishing industries lobbied state and federal government for an act that would accomplish this goal.

In late 1984 President Reagan signed the National Fishing Enhancement Act (NFEA). The NFEA does not apply to the decommissioning of California's OCS oil and gas structures (i.e., oil and gas structures in federal waters off California). The NFEA: 1) recognized social and economic values in developing artificial reefs, 2) established national standards for artificial reef development, 3) called for creation of a National Artificial Reef Plan under leadership of the Department of Commerce, and 4) established a reef permitting system under the US Army Corps of Engineers that limits the liability of participants in the program.

Although the law encourages the development of artificial reefs, it authorizes no direct appropriations for administration, planning, construction, enforcement, monitoring, or research on artificial reefs. States and regions have had to develop programs with scarce resources. The NFEA was enabling legislation that allowed Gulf states to develop and implement rigs-to-reef programs. State programs have been developed out of existing artificial reef programs. For example, in June 1986, Louisiana enacted legislation (Act 100--The Louisiana Fishing Enhancement Act) authorizing a state-directed rigs-to-reef program. The program is administered by the Louisiana Department of Wildlife and Fisheries and conducted jointly with staff from Louisiana State University. This section describes several examples of local and state rigs-to-reef programs and their administrative operation. From 1987-1995, of the over 941 platforms removed from Louisiana and Texas waters, 90 platforms or approximately 10% were transformed into artificial reefs.

(3) The history of California's artificial reef program and the current policy debate over a rigs-to-reef option to complete removal

SB 241, California's pending "rigs-to-reefs" legislation, would establish a state rigs-to-reef program closely tied to the state's artificial reef program. SB 241 cites the rigs' potential value as fish attraction and production sites, and would extend the Department's artificial reef management authority to federal waters.

Although the California Department of Fish and Game (CDFG) began a program of artificial reef research and development in 1958, legislation providing for the formal establishment of the program and allocation of (limited) personnel and financial resources did not occur until

1985. CDFG initiated its program of artificial reef development in the late 1950s in the interest of enhancing nearshore sport fishing opportunities in southern California. Using donated materials (due to a lack of funding), the Department oversaw the construction of several artificial reefs (e.g., at Paradise Cove in Northern Santa Monica Bay and Redondo Beach). CDFG biologists used these reefs to test the effectiveness of such structures in attracting fish; the study showed aggregation of fishes at both reef sites. This success led to a program to investigate the cost-effectiveness and practicality of different reef materials using aseries of "replication reefs" in Santa Monica Bay. These studies determined that quarry rock was the most effective material (Lewis and McKee 1989:3).

From the late 1960s through 1980, little systematic study was done on these or newly placed reefs. In 1980, however, CDFG began a major program of artificial reef construction and research in connection with Southern California Edison's required mitigation for the negative impacts of warm water discharge on coastal kelp beds. That mitigation plan included a 6-year cooperative project with CDFG for the construction of Pendleton Artificial Reef (in northern San Diego County) and studies to evaluate the reef's potential for enhancing marine resources (Lewis and McKee 1989:3). Although it was clear that the reefs attracted fish, there were concerns this could lead to increased local fishing pressure and resultant negative effects on populations. Next the program turned to an emphasis on designs that would promote production (by augmenting shelter and forage), as well as attraction. Research has shown that high relief, open structures serve best to attract fish, and better enable fishery exploitation, while low relief, complex structured reefs provide better nurseries and afford more diverse assemblages of fish and other organisms. As a CDFG biologist noted, a drawback to rigs as reefs is that they are high relief, which works against survival of young-of-the-year fish, suggesting they may not be a source of production but rather simply an attraction site.

Artificial reef construction thus became one aspect of CDFG's Nearshore Sportfish Habitat Enhancement Program for restoring or enhancing sportfish habitat along the southern California coastline (Lewis and McKee 1989:1). The program's objective is to maintain sportfishing success in the face of the cumulative effects of increasing fishing pressure as well as negative impacts on the nearshore ecosystem (Lewis and McKee 1989:1). It is supported, in part, by Dingell-Johnson/Wallop-Breaux Federal Aid in Sport Fish Restoration Act Funds.

Although CDFG is charged with managing the state's artificial reefs and the program, several other agencies play a role in the pre-construction permitting process. Siting artificial reefs in California waters requires a (federal) permit for ocean dumping from the U.S. Army Corp of Engineers, a coastal development permit from the California Coastal Commission (CCC), and a lease from the State Lands Commission (SLC) for activity on submerged state lands. In waters outside the three-mile state jurisdiction, an SLC permit is not required, but the CCC must issue a consistency finding before the Corps of Engineers will issue a permit. Other agencies that may be involved in the process include the U.S. Coast guard (for navigation), and the U.S. Environmental Protection Agency may require an environmental impact statement showing no negative impact.

At present, there are some 36 artificial reefs consisting of hundreds of modules off the coast of California, but resources to support monitoring these sites and the state's program more generally are quite limited. Three CDFG personnel are assigned to the program, part-time. There are no funds available for building new reefs, so materials for any new construction come from demolition projects or other donations. The Department maintains a keen interest, however, in building several large reefs. Meanwhile, CDFG periodically monitors and continues to augment two artificial reefs outside of state waters. These reefs were permitted prior to any public discussion about CDFG's role in a rigs-to-reef program. When CDFG lawyers started looking at rigs-to-reefs, they informed CDFG personnel that they have no legal standing beyond California state waters, with the exception of the two above-mentioned reefs.

RESEARCH PRODUCTIVITY

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B.S.	University of California, Irvine	1975
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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:

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

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Positions:

1998-Present	Associate Research Biologist, Marine Science Institute, UC Santa Barbara
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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
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Research Interest:

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.

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Henry Rutgers Fellow, 1990
EMBO Workshop Fellowship, Patch Clamp Techniques, Göttingen, West Germany, 1987
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Selected Publications:

Bush, D.S., D. Reed, S. Holbrook and S.A. Hodges. Mating system estimation in *Phyllospadix torreyei*.

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Jones RL, DS Bush, and AK Biswas. 1987. Gibberellic acid and calcium participate in the synthesis of active α-amylase molecules. In: "British Plant Growth Regulator Group, Monograph". **15**:31-42.

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

Projects:	*Detecting Ecological Impacts: Effects of Taxonomic Aggregation in the Before-After/Control-Impact Paired Series Design*		
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:

Reed, D.C., P.T. Raimondi and M.H. Carr. Role of dispersal potential in determining spatial variability in the abundance of benthic reef organisms. *Ecology.*

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

Murray, S.N., R.F. Ambrose, J.A. Bohnsack, L.W. Botsford, M.H. Carr, G.E. Davis, P.K. Dayton, D. Gotshall, D.R. Gunderson, M.A. Hixon, J. Lubchenco, M. Mangel, A. MacCall, D.A. McArdle, J.C. Ogden, J. Roughgarden, R.M. Starr, M.J. Tegner and M.M. Yoklavich. 1999. No-take reserve networks: Protection for fishery populations and marine ecosystems. *Fisheries* **24**:11-25.

Reed, D.C., P.T. Raimondi, M.H. Carr and L. Goldwasser. The role of dispersal and disturbance in determining spatial heterogeneity in sedentary organisms. *Ecology* **81**:2011-2066.

Carr MH, and PT Raimondi. 1999. Marine protected areas as a precautionary approach to management. *CALCOFI reports* **40**:71-76.

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.

Allison, G., J. Lubchenco, and M.H. Carr. 1998. Marine reserves are necessary but not sufficient for marine conservation. *Ecological Applications* **8(1)**:Supplement S79-S92.

Hixon, M.A., M.H. Carr, and J.P. Beets. Artificial reefs: importance of comparisons with natural reefs. *In*: W. Seaman, ed., *Future Artificial Reefs in the U.S. Coastal Ocean: Can Science Resolve the Biological Enhancement Question?* Atlantic States Marine Fisheries Commission, Washington D.C. Special Report XX.

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

Caley, M.J. M.H. Carr, M.A. Hixon, T.P. Hughes, G.P. Jones, and B.A. Menge. 1996. 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. 1995. Predation effects on early survivorship of coral reef fishes. *Marine Ecology Progress Series* **124**:31-42.

Carr, M.H. 1994. Effects of macroalgal dynamics on recruitment of a temperate reef fish. *Ecology* **75**:1320-1333.

Carr, M.H. 1994. Predicting the recruitment of temperate reef fishes in response to changes in macrophyte density caused by disturbance. Pp. 255-269 in: *Theory and Application of Fish Feeding Ecology*, D.J. Stouder, K.L. Fresh and R.J. Feller, eds. The Belle W. Baruch Library in Marine Science Number 18, University of South Carolina Press, Columbia, SC.

Carr, M.H. and D.C. Reed. 1993. Conceptual issues relevant to marine harvest refuges: examples from temperate reef fishes. *Canadian Journal of Aquatic Sciences and Fisheries* **50**:2019-2028.

Love, M.S., M.H. Carr, and L.J. Haldorson. 1991. The ecology of substrate-associated juveniles of the genus *Sebastes*. *Environmental Biology of Fishes* **30**:225-243.

Carr, M.H. 1991. *Patterns, mechanisms and consequences of recruitment of a temperate marine reef fish*. Doctoral Dissertation, University of California, Santa Barbara, California, 190p. NOAA Sea Grant publication, University of Southern California Sea Grant Program.

Carr, M.H. 1991. Habitat selection and recruitment of an assemblage of temperate zone reef fishes. *Journal of Experimental Marine Biology and Ecology* **146**:113-137.

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Holbrook, S.J., M.H. Carr, R.J. Schmitt, and J.A. Coyer. 1989. The effect of giant kelp on local abundance of reef fishes: the importance of ontogenetic resource requirements. *Bulletin of Marine Science* **41**:104-114.

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University of California, Davis
Bodega Marine Laboratory
Bodega Bay, CA

Project:	*Effects of Biologically Degraded Oil on Marine Invertebrate and Vertebrate Embryos and Larvae*		
Education:	B.A.	Biology, Sonoma State University	1979
	Ph.D.	Zoology, University of California, Davis	1984
Positions:	1995-present	Lecturer, Division of Biological Sciences, University of California, Davis	
	1995-present	Adjunct Associate Professor, Sonoma State University	
	1994-present	Associate Research Biologist III, Bodega Marine Laboratory, University of California, Davis	
	1990-1994	Assistant Research Biologist IV, Bodega Marine Laboratory, University of California, Davis	
	1988-90	Assistant Research Biologist III, Bodega Marine Laboratory, University of California, Davis	
	1986-88	Assistant Research Biologist II, Bodega Marine Laboratory, University of California, Davis	
	1984-86	Postdoctoral Fellow, National Institute of Health, Department of Obstetrics & Gynecology, School of Medicine, University of California, Davis	
Distinctions:	1984	National Institute of Health Postdoctoral Fellowship, Reproductive Training Grant	
	1983	Best Student Paper Award, Annual American Fisheries Society Meeting	

Research Interests:

Dr. Cherr's laboratory investigates cell functioning during fertilization and early development in marine and estuarine organisms, and the effects of pollutants and environmental stressors. The systems utilized in the laboratory include gametes and embryos from algae, molluscs, echinoderms, and fishes. Since these systems exhibit temporally and mechanistically distinct cellular events during development, they can be used to discern the mode of action of pollutants at the subcellular levels. A major emphasis is placed on the effects of pollutants on cytoskeletal dynamics, intracellular ion activities, and cell-extracellular matrix interactions during fertilization and development. The laboratory is also involved in isolation and identification of pollutants in complex mixtures and investigates structure/function relationships of the pollutants using the above biological systems. Dr. Cherr is Chair of the State of Washington Biomonitoring Science Advisory Board, and is on the State of California's Marine Bioassay Protocol Review Committee.

Selected Publications:

Vines, C.A.; T. Robbins, F.J. Griffin, and G.N. Cherr. 2000. The effects of diffusible creosote-derived compounds on development in Pacific herring (*Clupea pallasi*) *Aquatic Toxicology* 51.

Huovinen, P.S.; A.O.J. Oikari, M.R. Soimasuo, and G.N. Cherr. 2000. Impact of UV radiation on the early development of the giant kelp (*Macrocystis pyrifera*) gametophytes. *Photochemistry and Photobiology* **72**.

Yudin, A.I., G.N. Cherr, C.A. VandeVoort, and J.W. Overstreet. 1998. Rearrangement of the PH-20 protein on the surface of macaque spermatozoa following exposure to anti-PH-20 antibodies or binding to zona. *Molecular Reproduction and Development* **50:**207-220.

Clegg, J.S., K.R. Uhlinger, S.A. Jackson, G.N. Cherr, E. Rifkin, and C.S. Friedman. 1998. Induced thermotolerance and the heat shock protein-70 family in the Pacific oyster, *Crassostrea gigas. Molecular Marine Biology and Biotechnology* **7:**21-30.

Griffin F.J., M.C. Pillai, C.A. Vines, R. Yanagimachi, and G.N. Cherr. 1998. Effects of salinity on sperm motility, fertilization, and development in the Pacific herring, *Clupea pallasi. Biological Bulletin* **194:**25-35.

Middaugh, D.P., M.W. Shelton, C.L. McKenney Jr., G.N. Cherr, P.J. Chapman, and L.A. Courtney. 1998. Preliminary observations on responses of embryonic and larval Pacific herring, *Clupea pallasi,* to neutral fraction biodegradation products of weathered Alaska North Slope Oil. *Archives Environmental Contamination and Toxicology* **34:**188-196.

Cherr, G.N. 1998. The use of developing organisms for assessing contamination in the marine environment. In: *Effects of Multiple Impacts on Ecosystems*, J.J. Cech, B.W. Wilson and D.C. Crosby, eds. Lewis Publishers, Chelsea, MI.

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Garman, G.D., G.N. Cherr, and S.L. Anderson. 1997. Developmental abnormalities and DNA-protein crosslink induction in sea urchin embryos exposed to metals. *Aquatic Toxicology* **39**:247-265.

Meyers, A.S., A.I. Yudin, G.N Cherr, C.A. Vandevoort, D.G. Myles, P. Primakoff, and J.W. Overstreet. 1997. Hyaluronidase activity of macaque sperm assessed by an *in vitro* cumulus penetration assay. *Molecular Reproduction and Development* **46**:392-400.

Pillai, M.C., H. Blethrow, R.M. Higashi, C.A. Vines, and G.N. Cherr. 1997. Inhibition of the sea urchin sperm acrosome reaction by a lignin-derived macromolecule. *Aquatic Toxicology* **37**:139-156.

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Olin, K.A., G.N. Cherr, E. Rifkin, and C.L. Keen. 1996. The effects of some redox-active and reactive aldehydes on DNA-protein cross-links *in vitro. Toxicology* **110**:1-8.

Spagenberg, J.M. and G.N. Cherr. 1996. Developmental effects of barium in a marine bivalve (*Mytilus californianus*). *Environmental Toxicology and Chemistry* **15**:1769-1774.

Garman, G.D., M.C. Pillai, L.J. Goff, and G.N. Cherr. 1995. Nuclear events during early development in *Macrocystis pyrifera* gametophytes and the temporal effects of a marine contaminant. *Marine Biology* **121**:355-362.

Garman, G.D., M.C. Pillai, and G.N. Cherr. 1994. Inhibition of cellular events during algal gametophyte development: Effects of select metals and an aqueous petroleum waste. *Aquatic Toxicology* **28**:127-144.

Pillai, M.C., R. Yanagimachi, and G.N. Cherr. 1994. *In vivo* and *in vitro* initiation of sperm motility using fresh and cryopreserved gametes from Pacific herring, *Clupea pallasi*. *Journal of Experimental Zoology* **269**:62-68.

Cherr, G.N., T.W-M. Fan, M.C. Pillai, T. Shields, and R.M. Higashi. 1993. Electrophoretic separation, characterization, and quantification of biologically active lignin derived macromolecules. *Analytical Biochemistry* **214**:521-527.

JENIFER E. DUGAN
Marine Science Institute
University of California
Santa Barbara, CA

Project: *Early Development of Fouling Communities on Offshore Oil Platforms*

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:

Schoeman, D., A. McLachlan and J. E. Dugan. Lessons from a disturbance experiment in the intertidal zone of an exposed sandy beach. *Est. Coastal Shelf Sci.*

Jaramillo, E., J. Dugan, and H. Contreras. Abundance, population structure, tidal movement and burrowing rate of *Emerita analoga* (Stimpson 1857) (Anomura, Hippidae) at a dissipative and a reflective beach in south central Chile. *Mar. Ecol. Nap.*

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.

Dugan, J.E., D.M. Hubbard, J.M. Engle, D.L. Martin, D.M. Richards, G.E. Davis, K.D. Lafferty, and R.F. Ambrose. 2000. Macrofauna communities of exposed sandy beaches on the Southern California mainland and the Channel Islands. Fifth California Islands Symposium, Santa Barbara Museum of Natural History, OCS Study, MMS 99-0038, pgs. 339-346.

Page, H.M., J.E. Dugan, D.S. Dugan, and J. Richards. 2000. Effects of an offshore oil platform on the distribution and abundance of commercially important crab species. *Mar. Ecol. Prog. Ser.* **185**:47-57.

Dugan, J.E. and A. McLachlan. 1999. An assessment of longshore movement in *Donax serra*: Röding (Bivalvia: Donacidae) on an exposed sandy beach. *J. Exp. Mar. Bio. Ecol.* **234**:111-124.

Barron, MG, T. Podrabsky, R.S. Ogle, J.E. Dugan, and others. 1999. Sensitivity of the sand crab *Emerita analoga* to a weathered oil. *Bull. Environmental Contamination & Toxicology* **62**:469-475.

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Dugan, J.E., D.N. Hubbard, and A.M. Wenner. 1998. A catalog of the sandy beaches of San Luis Obispo and Santa Barbara Counties. Report prepared for Minerals Management Service, Camarillo, CA.

McLachlan, A., J. Dugan, O. Defeo, A. Ansell, D. Hubbard, E. Jaramillo, and P. Penchaszadeh. 1997. Beach clam fisheries. *Ocean. Mar. Biol. Ann. Rev.* **34**:163-232.

Dugan, J.E. and D.M. Hubbard. 1996. Local variation in populations of the sand crab. *Emerita analoga* (Stimpson) on sandy beaches in southern California. *Revista Chilena de Historia Natural* **69**:579-588.

Dugan, J.E., D.M. Hubbard, and H.M. Page. 1995. Scaling population density to body size: tests in two soft sediment intertidal communities. *J. Coast. Res.* **11**:849-857.

Jamarillo, E.A, McLachlan, and J. Dugan. 1995. Total sample area and estimate of species richness in exposed sandy beaches. *Mar. Ecol. Prog. Ser.* **119**:311-314.

McLachlan, E. Jamarillo, O. Defeo, J.E. Dugan, A. DeRuyck, and P. Coetzee. 1995. Adaptations of bivalves to different beach types. *J. Exp. Mar. Biol. Ecol.* **187**:147-160. .

Dugan, J.E., D.M. Hubbard, and A.M. Wenner. 1994. Geographic variation in life history in populations of the sand crab, *Emerita analoga* (Stimpson), on the California coast: relationships to environmental variables. *J. Exp. Mar. Bio. Ecol.* **181**:255-278.

Dugan, J.E. and G.E. Davis. 1993. Applications of fishery refugia to coastal fishery management. *Can. J. Fish. Aquat. Sci*. **50**:2029-2042.

Dugan, J.E. and G.E. Davis. 1993. Introduction to the international symposium on fishery refugia. *Can. J. Fish. Aquat. Sci*. **50**:1991-1992.

Wenner, A.M., J.E. Dugan, and D. Hubbard. 1993. Sand crab population biology on the California Islands and mainland. Pp. 335-348 in: *Third California Islands Symposium, Recent Advances in Research on the California Islands,* F.G. Hochberg, ed. Santa Barbara Museum of Natural History, CA.

Page, H.M., J.E. Dugan, and D.M. Hubbard. 1992. Comparative effects of two infaunal bivalves on an epibenthic microalgal community. *J. Exp. Mar. Biol. Ecol.* **157**:247-262.

Davis, E.G., S. Jameson, and J. E. Dugan. 1991. Potential benefits of harvest refugia in Channel Islands National Park and Channel Islands National Marine Sanctuary. Pp. 2962-2972 in: *Coastal Zone '91: Proceedings of the 7th Symposium on Coastal and Ocean Management*, O. Magoon, H. Converse, V. Tippie, L. Tobin and D. Clark, eds. Long Beach, CA.

Dugan, J.E., A.M. Wenner, and D.M. Hubbard. 1991. Geographic variation in the reproductive biology of the sand crab, *Emerita analoga* (Stimpson), on the California coast. *J. Exp. Mar. Biol. Ecol*. **150**:63-81.

Wenner, A.M., J.E. Dugan, and H. Wells. 1991. Estimating egg production in multibrooding populations. In: *Egg Production. Crustacean Issues Vol. 7,* A. Wenner and A. Kuris, ed. Balkema, Netherlands.

Dugan, J.E. 1990. *Geographic and temporal variation in the life history, growth, and reproductive biology of the sand crab, Emerita analoga (Stimpson)*. Ph.D. Dissertation. University of California, Santa Barbara. 329p.

Hubbard, D.M. and J.E. Dugan. 1989. Northern occurrences of two estuarine crabs, the fiddler crab, *Uca crenulata* and the burrowing crab, *Malacoplax californiensis. Calif. Fish and Game* **75**:55-57.

Wenner, A.M., Y.O. Richard, and J.E. Dugan. 1987. Hippid crab population structure and food availability on Pacific shorelines. *Bull. Mar. Sci*. **41**:221-233.

LINDA FERNANDEZ
Department of Environmental Sciences
University of California
Riverside, CA

Project: *The Political Economy of the Rigs-to-Reef Option for Decommissioning of Offshore Oil and Gas Structures*

Education:

Ph.D.	Agricultural and Resource Economics, UC Berkeley	1996
M.S.	Agricultural and Resource Economics, Univ. of Hawaii	1989
B.S.	International Agricultural Development, UC Davis	1985

Positions:

1999-present	Assistant Professor of Economics, Department of Environmental Sciences, University of California, Riverside
1997-1999	Visiting Assistant Professor, School of Environmental Science and Management, UC Santa Barbara
1996-1997	Lecturer, School of Environmental Science and Management, UC Santa Barbara
1993-1996	Graduate Research Associate, Dept. of Agricultural and Resource Economics, UC Berkeley
1987-1988	Graduate Research Assistant, Water Resources Research Center and East-West Center, University of Hawaii, Honolulu.

Professional Positions:

1989-1993	Environmental Scientist, U.S. Environmental Protection Agency, Region IX, Water Management Division, San Francisco.

Grants and Awards:

University of California Toxic Substances Program, Grant for 1998
Institute on Global Conflict and Cooperation, UC San Diego, Grant for 1997-1998
Institute of Industrial Relations, UC Berkeley, Grant for 1995-1996
College of Natural Resources, UC Berkeley, Grant for 1994-1995
U.S. Environmental Protection Agency, Region IX, Grant for 1993-1994
UC Berkeley Graduate Division Fellowship, 1991-1993

Selected Publications:

Fernandez, L. Solving water pollution problems along the US-Mexico border. *Environment and Development Economics.*

Fernandez, L. 2000. Trade's dynamic solutions to transboundary pollution. *Journal of Environmental Economics and Management*. In press.

Fernandez, L. and A. Keller. 2000. Cost-benefit analysis of MTBE and alternative gasoline formulations. Environmental Science and Polidy. In press.

Fernanez, L. 1999. An analysis of economic incentives in wetlands policies addressing biodiversity. *The Science of the Total Environment* **240**:107-122.

Fernandez, L and L Karp. 1998. Restoring wetlands through wetlands mitigation banks. *Environmental and Resource Economics* **12**:323-344.

Fernandez, L. 1997. Estimation of wastewater treatment objectives through maximum entropy. *Journal of Environmental Economics and Management* **32**:293-308.

Fernandez, L. 1997. An application of entropy estimation to public wastewater management. *Advances in Econometrics* Vol. 12.

Fernandez, L and D. Zilberman. 1997. Trade Liberalization and the Environment in the Pacific Basin: Coordinated Approaches to Trade and Environmental Policy. Economic Development and Cooperation in the Pacific Basin: Trade, Investment, and Environmental Issues, H. Lee and D. Roland-Holst, eds. Cambridge University Press, New York.

Fernandez, L. 1991. Demonstration of pesticide best management practices for controlling nonpoint source pollution in the Monterey Bay watershed. Proceedings from the Seventh Symposium on Coastal and Ocean Management. Long Beach, CA.

Fernandez, L. 1991. Environmental and economic feasibility of water supply alternatives in Hawaii and California-desalination, water marketing, and conservation. Proceeding from the Seventh Symposium on Coastal and Ocean Management. Long Beach, CA.

FRED J. GRIFFIN
Division of Biological Sciences
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Davis, CA

Project: *Effects of Biologically Degraded Oil on Marine Invertebrate and Vertebrate Embryos and Larvae*

Education:	B.S.	Agricultural Business Management, University of California, Davis	1970
	B.A., M.A.	Biology, Sonoma State University	1981
	Ph.D.	Zoology, University of California, Davis	1987

Positions:	1996-present	Lecturer, Division of Biological Sciences, University of California, Davis
	1994-present	Assistant Research Biologist II, University of California, Davis
	1986-1994	Staff Research Associate, University of California, Davis, Bodega Marine Laboratory
	1981-1985	Research Assistant/Teaching Assistant, University of California, Davis

Selected Publications:

Vines, C.A.; T. Robbins, F.J. Griffin, G.N. Cherr. 2000. The effects of diffusible creosote-derived compounds on development in Pacific herring (*Clupea pallasi*). *Aquatic Toxicology* **51**.

Baldwin, J.B., F.J. Griffin, and W.H. Clark, Jr. 1999. Immunological characterization of the acrosomal filament in the marine shrimp *Sicyonia ingentis*. *Zygote* **6**:329-339.

Griffin, F.J., J.D. Baldwin, T.-I. Chen, and W.H. Clark, Jr. 1999. The composition and functions of the sperm acrosome reaction in Penaeoidean shrimp. *J. Reprod. Dev.* **44**:8.

Griffin, F.J., M.C. Pillai, C.A. Vines, J. Kääriä.T. Hibbard-Robbins, R. Yanagimachi, and G.N. Cherr. 1998. Effects of salinity on sperm motility fertilization, and development in the Pacific herring, *Clupea pallasi. Biol. Bull.* **194:**25-35.

Wang, S.W., F.J. Griffin, and W.H. Clark. 1997. Cell-cell association directed mitotic spindle orientation in the early development of the marine shrimp *Sicyonia ingentis*. *Development* **124**:773-780.

Griffin, F.J., C.A. Vines, M.C. Pillai, R. Yanagimachi, and G.N. Cherr. 1996. Sperm motility initiation factor (SMIF) is a minor component of the Pacific herring egg chorion. *Development, Growth & Differentiation* **38**:193-202.

Clark, W.H., Jr., F.J. Griffin, and A.H. Wikramanayake. 1994. Pre-fusion events of sperm-oocyte interactions in the marine shrimp, *Sicyonia ingentis. Sem. Dev. Biol*. **5:**225-231.

Clark, W.H., Jr. and F.J. Griffin. 1993. Acquisition and manipulation of Penaeoidean gametes. Pp. 133-152 in: *Handbook of Techniques for Crustacean Aquaculture*, J. McVew, ed. Second Edition., Vol. 1, CRC Press, Boca Raton.

Wikramanayake, A.., K. R. Uhlinger, F.J. Griffin, and W.H. Clark., Jr. 1992. Sperm of the shrimp *Sicyonia ingentis* undergo a bi-phasic capacitation accompanied by morphological changes. *Dev. Growth & Diff* **34**.:347-355.

Keller, R., F.J. Griffin, and W.H. Clark, Jr. 1991. *Gastrulation: Movements, Patterns and Molecules,* Bodega Marine Laboratory, Marine Sciences Series 3. Plenum Press, New York.

Clark, W.H., Jr., T.I. Chen, M.C. Pillai, K. Uhlinger, J. Shoffner-Mcgee, and F.J. Griffin. 1991. The biology of gamete activation and fertilization in *Sicyonia ingentis* (Penaeoidea); present knowledge and future direction. *Bull. Inst. Zool., Academia Sinica* **16:**553-571.

Pillai, M.C., F.J. Griffin, and W.H. Clark, Jr. 1990. Post spawning changes in the extracellular matrices in the eggs of *Sicyonia ingentis*. Pp. 201-207 in: *Advances in Invertebrate Reproduction*, M. Hoshi and O. Yamashita, eds. Vol. 5. Elsevier Science Publishers.

Griffin, F.J. and W.H. Clark, Jr. 1990. Induction of acrosomal filament formation in the sperm of *Sicyonia ingentis. J. Exp. Zool*. **254**:296-304.

Clark, W.H., Jr., A. Yudin, J.W. Lynn, F.J. Griffin, and M.C. Pillai. 1990. Jelly formation in penaeoidean shrimp eggs. *Biol. Bull.* **178**:295-299.

Chen, T.I., F.J. Griffin, L. Crowe, and W.H. Clark, Jr. 1990. The anterior granule in the sperm of the shrimp *Sicyonia ingentis. J. Cell Biol*. 111, 113a.

Pillai, M.C., F.J. Griffin, and W.H. Clark, Jr. 1989. Pre and post spawning alterations of the extracellular matrices in the eggs of Sicyonia ingentis. *Fifth International Congress of Invertebrate Reproduction.*

SCOTT HODGES
Department of Ecology, Evolution and Marine Biology
University of California
Santa Barbara, CA

Project: *Application of Genetic Techniques for use in Restoration of Surfgrass (Phyllospadix torreyi)*

Education:

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

Positions:

2000 - present	Associate Professor, Dept. of Ecology, Evolution and Marine Biology, UCSB
1995 - 2000	Assistant 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

Publications:

Bush, D.S., D. Reed, S. Holbrook and S.A. Hodges. Mating system estimation in *Phyllospadix torreyei*. In prep.

Bush, D.S., D. Reed, S. Holbrook and S.A. Hodges. Degree of clonality and population genetic variation in the surfgrass *Phyllospadix torreyi*. In prep.

Taylor, D.L., T. Bruns and S.A. Hodges. Mycorrhizal host specificity in Hexelectris. In prep.

Taylor, D.L., T. Bruns and S.A. Hodges. Evolution of mycorrhizal host specificity in Corallorhiza. In prep.

Taylor, D.L., T. Bruns and S.A. Hodges. Mycorrhizal host-races in a non-photosynthetic orchid. In prep.

Collie, S. and S.A. Hodges. 2000. Analysis of AFLP band homology among species of Aquilegia and Semiaquilegia: implications for population and phylogenetic analysis. In prep.

Hodges, S.A., J.B. Whittall, M. Fulton, J.Y. Yang. 2001. Ecology and genetics of floral isolation between *Aquilegia formsoa* and *A. pubescens*. *American Naturalist*.

Fulton, M. and S.A. Hodges. 1999. Floral isolation between *Aquilegia formosa* and *A. pubescens*. (Submitted, *Proceedings of the Royal Society of London, Series B* **266**:2247-2252.

Bushakra, JM, SA Hodges, JB Cooper and DD Kaska. 1999. The extent of clonality and genetic diversity in the Santa Cruz Island Ironwood *Lyonothamnus floribundus*. *Molecular Ecology* **8**:471-476 (cover photo).

Baker, HG, I. Baker, and SA Hodges. 1998. Sugar composition of nectars and fruits consumed by birds and bats in the tropics and subtropics. *Biotropica* **30**: 559-586.

Hodges, SA. 1997. Floral nectar spurs and diversification. *International Journal of Plant Sciences* **158:**S81-S88.

Hodges, SA. 1997. A rapid adaptive radiation via a key innovation in *Aquilegia*. Molecular evolution and adaptive radiations. pg. 391-405. Eds. T. Givinish and K. Sytsma. Cambridge University Press, Cambridge.

Emms, SK, SA Hodges, and ML Arnold. 1996. Pollen-tube competition, siring success and consistent asymmetric hybridization in the Louisiana irises. *Evolution* **50**:2201-2206.

Hodges, SA, J Burke and ML Arnold. 1996. Natural formation of iris hybrids: experimental evidence on the establishment of hybrid zones. *Evolution* **47**:2504-2509

Carney, SE, SA Hodges and ML Arnold. 1996. Effects of differential pollen-tube growth on hybridization in the Louisiana irises. *Evolution* **47**:1432-1445.

Hodges, SA and ML Arnold. 1995. Spurring plant diversification: Are floral nectar spurs a key evolutionary innovation? *Proceedings of the Royal Society of London, Series B* **262**:343-348.

Arnold, ML and SA Hodges. 1995. The fitness of Hybrids - A response to Day and Schluter. Trends in Ecology and *Evolution* **10**: 289.

Arnold, ML and SA Hodges. 1995. Are natural hybrids fit or unfit relative to their parents? *Trends in Ecology and Evolution* **10**:67-70.

Hodges, SA 1995. The influence of nectar production on hawkmoth behavior, self pollination and seed production in *Mirabilis multiflora* (Nyctaginaceae). *American Journal of Botany* **82**:197-229.

Hodges, SA and ML Arnold 1994. Columbines: a geographically wide-spread species flock. *Proceedings of the National Academy of Sciences, USA* **91**:5129-5132.

Hodges, SA and ML Arnold. 1994. Floral and ecological isolation between *Aquilegia formosa* and *A. pubescens*. *Proceedings of the National Academy of Sciences, USA* **91**:2493-2496.

Hodges, SA 1993. Consistent interplant variation in nectar characteristics of *Mirabilis multiflora*. *Ecology* **74**:542-548.

Hodges, SA 1987. Some preliminary observations on hawkmoth pollination of *Oenothera caespitosa* and *Mirabilis multiflora*. pages. 244-249 In: C. A. Hall and V. Doyle- Jones, eds., Plant Biology of Eastern California. Natural History of the White-Inyo Range Symposium, Vol. 2. University of California, White Mountain Research Station, Los Angeles, California.

SALLY J. HOLBROOK
Department of Biological Sciences
University of California
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Project: *Detecting Ecological Impacts: Effects of Taxonomic Aggregation in the Before-After/Control-Impact Paired Series Design*

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

Positions:	1987-present	Professor, Department of Biological Sciences, 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:

Schmitt, R.J. and S.J. Holbrook. 2000. Habitat-limited recruitment of coral reef damselfish. *Ecology* **81**.

Holbrook, S.J., D.C. Reed, K. Hansen, and C.A. Blanchette. 2000. Spatial and temporal patterns of predation on seeds of surfgrass, *Phyllospadix torreyi*. *Marine Biology* **136**:739-747.

Holbrook, S.J., G.E. Forrester, and R.J. Schmitt. 2000. Spatial patterns in abundance of a damselfish reflect availability of suitable habitat. *Oecologia* **122**:109-120.

Holbrook, S.J., Reed, D.R. and J.S. Bull. 1999. Methods for enhancing habitat value of artificial structures by establishing surfgrass (*Phyllospadix torreyi*). Pp. 582-589 in Proceedings of Seventh International Conference on Artificial Reefs and Related Aquatic Habitats (7th CARAH), San Remo, Italy, G. Relini, G. Ferra and E. Massaro (eds.).

Schmitt, R.J., S.J. Holbrook 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.

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.

Schmitt, R.J. and S.J. Holbrook. 1999. Settlement and recruitment of three damselfish species: larval delivery and competition for shelter space. *Oecologia* **118**:76-86.

Schmitt, R.J. and S.J. Holbrook. 1999. Mortality of juvenile damselfish: implications for assessing processes that determine abundance. *Ecology* **80**:35-50.

Schmitt, R.J. and S.J. Holbrook. 1999. Temporal patterns of settlement of three species of damselfish of the genus *Dascyllus* (Pomacentridae) in the coral reefs of French Polynesia. Pp. 537-551 *in* Proc. 5th Indo-Pacific Fish Conf., Noumea, 1997. B Seret and J-Y Sire, eds. Paris: Soc. Fr. Ichtyol.

Holbrook, S.J. and R.J. Schmitt. 1999. *In Situ* Nocturnal Observations of Reef Fishes Using Infrared Video. Pp. 805-812 in Proc. 5th Indo-Pacific Fish Conf., Noumea, 1997. B Seret and J-Y Sire, eds. Paris: Soc. Fr. Ichtyol.

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Reed, D.C., S.J. Holbrook, E. Solomon, and M. Anghera. 1998. Studies on germination and root development in the surfgrass *Phyllospadix torreyi*: Implications for habitat restoration. *Aquatic Botany* **62**:71-80.

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. *8th International Coral Reef Symposium* **2**:1143-1148.

Holbrook, S.J., R.J. Schmitt, and J.A. Stephens Jr. 1997. Changes in an assemblage of temperate reef fishes associated with a climate shift. *Ecological Applications* **7:**1299-1310.

Holbrook, S.J. and R.J. Schmitt. 1996. On the dynamics and structure of reef fish communities: are resources tracked? Pp. 1948 in: *Long-term Studies of Vertebrate Communities*, M.L. Cody and J. A. Smallwood eds. Academic Press, NY.

Osenberg, C.W., R.J. Schmitt, S.J. Holbrook, K.E. Abu-Saba, and A.R. Flegal. 1996. Detection of environmental impacts: natural variability, effect size, and power analysis. Pp. 83-108 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats*, R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA. [Republication of Osenberg *et al.* 1994, Ecological Applications **4**:16-30.]

Schmitt, R.J. and S.J. Holbrook. 1996. Fine-scale patterns of larval settlement in a planktivorous damselfish - do they predict recruitment? *Australian Journal of Marine and Freshwater Research* **47**:449-463.

Steichen, D.J. Jr., S.J. Holbrook, and C.W. Osenberg. 1996. The response of benthic and demersal macrofauna to organic enrichment at a natural oil seep. *Marine Ecology Progress Series* **138**:71-82.

Holbrook, S.J., M.J. Kingsford, R.J. Schmitt, and J.S. Stephens, Jr. 1995. Spatial and temporal patterns in assemblages of temperate reef fish. *Amer. Zoologist* **34**:463-475.

Holbrook, S.J. and R.J. Schmitt. 1995. Compensation in resource use by foragers released from interspecific competition. *J. Exp. Mar. Biol. Ecol*. **185**:219-233.

Osenberg, C.W., R.J. Schmitt, S.J. Holbrook, K.E. Abu-Saba, and A.R. Flegal. 1994. Detection of environmental impacts: power analysis and spatial inference. *Ecological Applications* **4**:16-30.

Holbrook, S.J. 1993. The effect of food density and dispersion on patch selection by foraging black surfperch. Pp. 485-493 in: *Third California Islands Symposium: Recent Advances in Research on the California Islands,* F.G. Hochberg, ed. Santa Barbara Museum of Natural History, CA.

Holbrook, S.J., S.L. Swarbrick, R.J. Schmitt, and R.F. Ambrose. 1993. Reef architecture and reef fish: Correlates of population densities with attributes of subtidal rocky environments. Pp. 99-106 in: *Proceedings of the Second International Temperate Reef Ecology Symposium*, Battershill, C.N., D.R. Schiel, G.P. Jones, R.G. Creese, and A.B. MacDiamid eds. National Institute of Water and Atmospheric Research, New Zealand Oceanographic Institute.

Holbrook, S.J. 1992. Review of "*Ecology of Coral Reef Fish*" by P.F. Sale. *Ecology* **73**:1934-1935.

Holbrook, S.J. and R.J. Schmitt. 1992. Causes and consequences of dietary specialization in surfperches: patch choice and intraspecific competition. *Ecology* **73**:402-412.

MICHAEL V. McGINNIS
Marine Science Institute
University of California
Santa Barbara, CA

Project: *The Political Economy of the Rigs-to-Reef Option for Decommissioning of Offshore Oil and Gas Structures*

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:	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
	1991	Technical Consultant, Santa Barbara County Energy Division
	1990	Lecturer, Department of Political Science, University of California, Santa Barbara

Selected Publications:

McGinnis, M.V. 1999. Making the watershed connection. *Policy Studies Journal* **27**:497-501.

Woolley, J.T. and M.V. McGinnis. 1999. The politics of watershed policymaking. *Policy Studies Journal* **27**:578-594.

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

McGinnis, M.V. 1998. *Bioregionalism: The Tug and Pull of Place*. London and New York: Routledge.

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. Perceptions and restoration ecology: A comparison of restoration discourses. *Inquiry: An Interdisciplinary Journal of Philosophy.*

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

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

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

McGinnis, M.V. 1994. The politics of restocking vs. restoring salmon in the Columbia River Basin. *Restoration Ecology* **2**:1-7.

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.

McGinnis, M.V. and J.T. Lima. 1993. California ocean use conflict management--An assessment of two integrating approaches. Pp. 705-722 in: *International Perspective on Coastal and Ocean Space Utilization,* P.M. Griffman and J. Fawcett, eds. University of Southern California Sea Grant, CA.

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,

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.

CRAIG W. OSENBERG
Department of Zoology
University of Florida
Gainesville, FL

Project: *Detecting Ecological Impacts: Effects of Taxonomic Aggregation in the Before-After/Control-Impact Paired Series Design*

Education:	B.A.	Biology, University of California, Santa Barbara (*summa cum laude*)	1980
	Ph.D.	Ecology, Michigan State University	1988

Positions:	1998-present	Associate Professor, Department of Zoology, University of Florida
	1995-1998	Assistant Professor, Department of Zoology, University of Florida
	1991-1995	Assistant Professor, Department of Integrative Biology, University of California, Berkeley (on leave without pay, 1991-92, 1995-96)
	1989-1996	Assistant Research Biologist, Marine Science Institute, University of California, Santa Barbara
	1988-1993	Research Associate, Kellogg Biological Station, Michigan State University
	1988-1992	Lecturer, Department of Biological Sciences, University of California, Santa Barbara
	1988-1991	Post-graduate Research Biologist, Marine Science Institute, University of California, Santa Barbara

Distinctions:	1987	Kellogg Biological Station Scholarship Award
	1985-1986	MSU College of Natural Sciences Fellowship
	1982-1985	National Science Foundation Predoctoral Fellowship

Research Interests:

Size and stage-structured interactions, and their implications for population dynamics and community patterns. The roles of predation and food limitation in aquatic ecosystems. Quantification of effect size (and interaction strength) and its variation among organisms and environments. The design and implementation of whole ecosystem experiments and environmental assessment studies.

Selected Publications:

Osenberg, C.W., C.M. St. Mary, J.A. Wilson, and W.J. Lindberg. A quantitative framework to evaluate the attraction-production controversy, with application to marine ornamental fisheries. *ICES Journal of Marine Science.*

Wilson, J.A., C.W. Osenberg, C.M. St. Mary, C.A. Watson, and W.J. Lindberg. Artificial reefs, the attraction-production issue, and density-dependence in marine ornamental fishes. *Aquarium Sciences and Conservation.*

St. Mary, C.M., C.W. Osenberg, T.K. Frazer, and W.J. Lindberg. 2000. Stage structure, density dependence, and the efficacy of marine reserves. *Bulletin of Marine Sciences.*

Scheiner, S.M., S B. Cox, M. Willig, G.G. Mittelbach, C.W. Osenberg, and M. Kaspari. 2000. Species richness, species-area curves, and Simpson's paradox. *Evolutionary Ecology Research.*

Gough, L., C.W. Osenberg, K.L. Gross, and S.L. Collins. 2000. Fertilization effects on species density and primary productivity in herbaceous plant communities. *Oikos* **89**:428-439.

Huckins, C.J.F., C.W. Osenberg, G.G. Mittelbach. 2000. Consequences of introducing species beyond their native range: an example with sunfishes. *Ecological Applications* **10**:612-625.

Wilson, W.G. C.W. Osenberg, R.J. Schmitt and R. Nisbet. 1999. Complementary foraging behavior allows coexistence of two grazers. *Ecology* **80**:2358-2372.

Schmitt, R.J., S.J. Holbrook, 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.

Osenberg, C.W., O. Sarnelle, D.E. Goldberg. 1999. Meta-analysis in ecology: concepts, statistics, and applications. *Ecology* **80**:1103-1104.

Downing, J., C.W. Osenberg, and O. Sarnelle. 1999. Meta-analysis of marine nutrient-enrichment experiments: variation in the magnitude of nutrient limitation. *Ecology* **80**:1157-1167.

Osenberg, C.W., O. Sarnelle, S.D. Cooper, and R.D. Holt. 1999. Resolving ecological questions through meta-analysis: goals, metrics and models. *Ecology* **80**:1105-1117.

Mittelbach, G.G., C.W. Osenberg, and P. Wainwright. 1999. Variation in feeding morphology between pumkinseed populations: phenotypic plasticity or evolution? *Evolutionary Ecology Research* **1**:111-128.

Osenberg, C.W. and C.M. St Mary. 1998. Meta-analysis: synthesis or statistical subjugation? *Integrative Biology: Issues, News and Reviews* **1**:37-41. (Invited and reviewed by editor)

Moeller, R.E., R.G. Wetzel, C.W. Osenberg. 1998. Concordance of phosphorus limitation in lakes: Bacterioplankton, phytoplankton, epiphyte-snail consumers, and rooted macrophytes. Pp. 318-325 in: *The Structuring Role of Submersed Macrophytes in Lakes,* E. Jeppesen, M. Søndergaard, M. D Søndergaard, and K. Christoffersen eds. Springer-Verlag, Berlin.

Osenberg, C.W., O. Sarnelle, and S.D. Cooper. 1997. Effect size in ecological experiments: in the application f biological models in meta-analysis. *American Naturalist* **15**:798-812.

Steichen, D.J., Jr., S.J. Holbrook, and C.W. Osenberg. 1996. The response of benthic and demersal macrofauna to organic enrichment at a natural oil seep. *Marine Ecology Progress Series* **138**:71-82.

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.

Osenberg, C.W. and R.J. Schmitt. 1996. Detecting ecological impacts caused by human activities. Pp. 3-17 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats*, R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA.

Osenberg, C.W., R.J. Schmitt, S.J. Holbrook, K.E. Abu-Saba, and A.R. Flegal. 1996. Detection of environmental impacts: natural variability, effect size, and power analysis. Pp. 83-108 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats*, R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA. [Republication of Osenberg *et al.* 1994, *Ecological Applications* **4**:16-30.]

Schmitt, R.J. and C.W. Osenberg (editors and contributing authors). 1996. *Detecting Ecological Impacts: Concepts and Applications in Coastal Marine Habitats*. Academic Press, San Diego, CA. 401p.

Schmitt, R.J., C.W. Osenberg, W.J. Douros, and J. Chesson. 1996. The art and science of administrative environmental impact assessment. Pp. 279-291 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats*, R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA.

Mittelbach, G.G., A.M. Turner, D.J. Hall, J.E. Rettig, and C.W. Osenberg. 1995. Perturbation and resilience: a long-term whole-lake study of predator extinction and reintroduction. *Ecology* **76**:2347-2360.

H. MARK PAGE
Marine Science Institute
University of California
Santa Barbara, CA

Project: *Early Development of Fouling Communities on Offshore Oil Platforms*

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., E. P. Glenn, H. M. Page, L. A. Galindo-Bect, J. M. Hernandez-Ayon, R. L. Petty, and J. Garcia-Hernandez. 2000. Analysis of peneid shrimp landings in the northern Gulf of California in relation to Colorado River discharge. *Fishery Bulletin* **98**:222-225.

Page, H.M., J. E. Dugan, D. Dugan, 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.

Page, H.M. 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., R.L. Petty, 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.

Dugan, J.E., D.M. Hubbard, 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., J.E. Dugan, 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., A. Fiala-Medioni, C.R. Fisher, 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., C.R. Fisher, 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.

CAROLYN POMEROY
Institute of Marine Science
University of California
Santa Cruz, CA

Project:	*The Political Economy of the Rigs-to-Reef Option for Decommissioning of Offshore Oil and Gas Structures*		
Education:	B.A.	Yale University, Southeast Asian Studies	1985
	M.A.	University of Miami, Rosenstiel School of Marine and Atmospheric Science Marine Affairs	1989
	Ph.D.	Texas A&M University, Wildlife & Fisheries Sciences	1993
Positions:	1995-present	Assistant Research Scientist, Institute of Marine Sciences, UCSC	
	1998-present	Lecturer, Ocean Sciences Board, UCSC	
	1995-96	Lecturer, California State University, Monterey Bay	
	1993-95	Visiting Scientist, Workshop in Political Theory & Policy Analysis, Indiana University	
	1994	Lecturer, School of Public and Environmental Affairs, Indiana University	

Research experience and interests:

Local institutions for common pool resource management; cooperative management of local fisheries; territorial use rights in fisheries (Big Sur, CA; Lake Chapala, Mexico; Quintana Roo, Mexico; Skagit System Cooperative, Washington)

Social identity and cooperation in the commons (Lake Chapala, Mexico; Skagit System Cooperative, Washington)

Marine resource conflicts and conflict resolution (Lake Chapala, Mexico; Quintana Roo, Mexico; Santa Barbara Channel, CA; Skagit System Cooperative, Washington; Southeast Asian artisanal fisheries)

Social and economic organization of fisheries; social and economic impact assessment, for fishery management, mitigation of fish contamination, and offshore oil platform decommissioning (California market squid; Mare Island Naval Shipyard and Vallejo, CA; Santa Barbara Channel, CA)

Management of coastal and marine protected areas (Miami, FL; Half Moon Caye, Belize; Big Creek, CA, coastal CA)

Honors and awards:

1997	Most Innovative Poster, Sanctuary Currents '97, Santa Cruz, CA
1994	Grant-in-Aid, Research and the University Graduate School, Indiana University
1993	Travel Research Grant, Workshop in Political Theory & Policy Analysis, Indiana University
	Graduate Program, Texas A&M University
	Enhancement Fund Grant
1992	Exploration Fund Grant-in-Aid, Explorers Club
	F.T. Griswold Scholarship, Pan American Round Tables of Texas
1991	SEASPACE Scholarship, Houston Underwater Club
	Grant-in-Aid of Research, Sigma Xi
1990-91	Gamma Sigma Delta, Agriculture Honor Society
1989	International Enhancement Grant, Texas A&M University
	Regent's Fellowship, Texas A&M University
1987	Rosenstiel Fellowship, University of Miami

Selected Publications:

Pomeroy, C. 1999. Social considerations for marine resource management: Evidence from Big Creek Ecological Reserve. *California Cooperative Oceanic Fisheries Investigation*s *Reports* **40**:118-125.

Pomeroy, C. and J. Beck. 1999. An experiment in fisheries co-management: evidence from Big Creek. *Society and Natural Resources* 12:719-739.

Pomeroy, C. and M. FitzSimmons. 1998. Information needs for effective management of the California market squid fishery: The role of social science research. *California Cooperative Oceanic Fisheries Investigation*s *Reports* **39**:108-114.

Bailey, C., and C. Pomeroy. 1996. Resource dependency and community stability in coastal fishing communities of Southeast Asia. *Society and Natural Resources* **9**:191-199.

Pomeroy, C. 1995. Review of *Ecological Identity* by Mitchell Thomashow. *Journal of Political Ecology* **2**:47-51.

Pomeroy, C. 1994. Obstacles to institutional development in the fishery of Lake Chapala, Mexico. Pp. 17-41 in *Folk Management in the World's Fisheries*, C.L. Dyer and J.R. McGoodwin, eds. Niwot, CO: University Press of Colorado.

PETER T. RAIMONDI
Department of Biology
University of California
Santa Cruz, CA

Projects: *Effects of an Oil Spill on Multispecies Interactions that Structure Intertidal Communities*
Inventory of Rocky Intertidal Resources in 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:

Reed, D.C., P.T. Raimondi and M.H. Carr. Role of dispersal potential in determining spatial variability in the abundance of benthic reef organisms. *Ecology.*

Carr MH, and PT Raimondi. 1999. Marine protected areas as a precautionary approach to management. *CALCOFI reports* **40**:71-76.

Reed, D.C., P.T. Raimondi, M.H. Carr and L. Goldwasser. The role of dispersal and disturbance in determining spatial heterogeneity in sedentary organisms. *Ecology* **81**:2011-2066.

Carr MH and PT Raimondi. Concepts relevant to the design and evaluation of harvest reserves. Proceedings of workshop on rockfish refugia.

Raimondi, P.T., S.E. Forde, L.F. Delph, C.M. Lively. 2000. Processes structuring communities: evidence for trait-mediated indirect effects through induced polymorphisms. *Oikos* **91**.

Raimondi PT and ANC Morse. 2000. The consequences of complex larval behavior in a coral. *Ecology* **81**.

Raimondi, P.T., A.M. Barnett, and P.R. Krause. 1997. The effects of drilling muds on marine invertebrate larvae and adults. *Environmental Toxicology and Chemistry* **16**:1218-1228.

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.

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., A. Morse, N. Hooker, and P.T. Raimondi. 1994. Morphogen-based chemical flypaper for Agaricia humilis larvae. *Biological Bulletin* **186**:172-181.

Lively, C.M., P.T. Raimondi, and L.F. Delph. 1993. Intertidal community structure: space-time interactions in the Northern Gulf of California. *Ecology* **74**:162-173.

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. 1992. Adult plasticity and rapid larval evolution in a recently isolated barnacle population. *Biological Bulletin* **182**:210-220.

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. 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.

DANIEL C. REED
Marine Science Institute
University of California
Santa Barbara, CA

Project: *Application of Genetic Techniques for use in Restoration of Surfgrass (Phyllospadix torreyi)*

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:

Reed, D.C., P.T. Raimondi, M.H. Carr and L. Goldwasser. The role of dispersal and disturbance in determining spatial heterogeneity in sedentary organisms. *Ecology* **81**:2011-2066.

Reed, D.C. 2000. The microecology of macroalgal blooms. *Journal of Phycology* **36**:1-2.

Holbrook, S.J., D.C. Reed, K. Hansen, and C. A. Blanchette. 2000. Spatial and temporal patterns of predation on seeds of surfgrass, *Phyllospadix torreyi*. *Marine Biology* **136**:739-747.

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

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., M.A. Brzezinski, D.A. Coury, W.M. Graham, and R.L. Petty. 1999. Neutral lipids in macroalgal spores and their role in swimming. *Marine Biology* **133**:737-744

Reed, D.C., S.J. Holbrook, E. Solomon, and M. Anghera. 1998. Studies on germination and root development in the surfgrass *Phyllospadix torreyi*: Implications for habitat restoration. *Aquatic Botany* **62**:71-80.

Reed, D.C., T.W. Anderson, A.W. Ebeling, and M. Anghera. 1997. Role of reproductive synchrony in the colonization potential of kelp. *Ecology* **78**:2443-2457.

Canestro, D. P.T. Raimondi, D.C. Reed, R.J. Schmitt, 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.

Reed, D.C., A.W. Ebeling, T.W. Anderson, and M. Anghera. 1996. Differential reproductive responses to fluctuating resources in two seaweeds with different reproductive strategies. *Ecology* **77**:300-316.

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.

Ambrose, R.F., J. Boland, W.W. Murdoch, P.T. Raimondi, 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.

Reed, D.C., R.J. Lewis and M. Anghera. 1994. Effects of an open coast oil production outfall on patterns of giant kelp (*Macrocystis pyrifera*) recruitment. *Marine Biology* **120**:26-31.

Reed, D.C. 1994. Giant forests of the sea. *The World and I* **July**: 202-207.

Reed, D.C. and R.J. Lewis. 1994. Effects of an oil and gas production effluent on the colonization potential of giant kelp (*Macrocystis pyrifera*) zoospores. *Marine Biology* **119**:277-283.

Brzezinski, M, D.C. Reed, and C.D. Amsler. 1993. Neutral lipids as major storage products in *Macrocystis pyrifera*. *J. Phycology* **29**:16-23.

Carr, H.H. and D.C. Reed. 1993. Conceptual issues relevant to marine harvest refuges: examples from temperate marine fishes. *Can. J. Fish. Aquat. Sci.* **5**0:2019-2028.

Neushel, M, C.D. Amsler, D.C. Reed, 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.

Amsler, C.D., D.C. Reed, and M. Neushul. 1992. The microclimate inhabited by algal propagules. *British Phycological Journal* **27**:253-270.

Reed, D.C., C.D. Amsler, and A.W. Ebeling. 1992. Dispersal in kelps: factors affecting spore swimming and competency. *Ecology* **73**:1577-1585.

Carr, M.H. and D.C. Reed. 1992. Harvest refuges and their potential for enhancing reef fisheries in southern California. Pp. 63-68 in: *Perspectives on the Marine Environment,* P.M. Grifman and S.E. Yoder, Eds. Sea Grant Program, University of California, Los Angeles.

Reed, D.C., M. Neushul, 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., C.W. Sutton, W.M. Hempel, D.C. Reed, 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., D.C. Reed, M.S. Foster, 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.

Neushul, M., C.D. Amsler, D.C. Reed, and R.J. Lewis. 1990. The introduction of marine plants for aquacultural purposes. In: *Movement and dispersal of biotic agents into aquatic ecosystems*. A. Rosenfield, ed. Maryland Sea Grant College, College Park, MD.

Reed, D.C. 1990. An experimental evaluation of density dependence in a subtidal algal population. *Ecology* **71**:2286-2296.

Reed, D.C. 1990. The effects of variable settlement and early competition on patterns of kelp recruitment. *Ecology* **71**:776-787.

RUSSELL J. SCHMITT
Department of Ecology, Evolution and Marine Biology and
Coastal Research Center, Marine Science Institute
University of California
Santa Barbara, CA

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
Distinctions:	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:

Schmitt, R.J. and S.J. Holbrook. 2000. Habitat-limited recruitment of coral reef damselfish. *Ecology* **81**.

Holbrook, S.J., G.E. Forrester, and R.J. Schmitt. 2000. Spatial patterns in abundance of a damselfish reflect availability of suitable habitat. *Oecologia* **122**:109-120.

Schmitt, R.J., S.J. Holbrook 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.

Schmitt, R.J. and S.J. Holbrook. 1999. Settlement and recruitment of three damselfish species: larval delivery and competition for shelter space. *Oecologia* **118**:76-86.

Schmitt, R.J. and S.J. Holbrook. 1999. Mortality of juvenile damselfish: implications for assessing processes that determine abundance. *Ecology* **80**:35-50.

Schmitt, R.J. and S.J. Holbrook. 1999. Temporal patterns of settlement of three species of damselfish of the genus *Dascyllus* (Pomacentridae) in the coral reefs of French Polynesia. Pp. 537-551 *in* Proc. 5th Indo-Pacific Fish Conf., Noumea, 1997. B Seret and J-Y Sire, eds. Paris: Soc. Fr. Ichtyol.

Wilson, W.G., C.W. Osenberg, R.J. Schmitt, R.M. Nisbet. 1999. Complementary foraging behaviors allow coexistence of two consumers. *Ecology* **80**:2358-2372.

Holbrook, S.J. and R.J. Schmitt. 1999. *In Situ* Nocturnal Observations of Reef Fishes Using Infrared Video. Pp. 805-812 in Proc. 5th Indo-Pacific Fish Conf., Noumea, 1997. B Seret and J-Y Sire, eds. Paris: Soc. Fr. Ichtyol.

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., R.J. Schmitt, and J.A. Stephens Jr. 1997. Changes in an assemblage of temperate reef fishes associated with a climate shift. *Ecological Applications* **7:**1299-1310.

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. and R.J. Schmitt. 1996. On the dynamics and structure of reef fish communities: are resources tracked? Pp. 19-48 in: *Long-term Studies of Vertebrate Communities,* M.L. Cody and J.A. Smallwood, eds. Academic Press, San Diego, CA.

Schmitt, R.J. 1996. Exploitation competition in mobile grazers - trade-offs in use of a limited resource. *Ecology* **77**:408-425.

Schmitt, R.J. and S.J. Holbrook. 1996. Fine-scale patterns of larval settlement in a planktivorous damselfish - do they predict recruitment? *Australian Journal of Marine and Freshwater Research* **47**:449-463.

Ambrose, R.F., R.J. Schmitt, 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.

Osenberg, C.W. and Schmitt, R.J. 1996. Detecting ecological impacts caused by human activities. Pp. 3-16 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats*, R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA.

Osenberg, C.W., R.J. Schmitt, S.J. Holbrook, K. E. Abu-Saba, and A. R. Flegal. 1996. Detection of environmental impacts: natural variability, effect size, and power analysis. Pp. 83-108 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats*, R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA. [Republication of Osenberg *et al.* 1994, Ecological Applications **4:**16-30.]

Schmitt, R.J. and C.W. Osenberg (editors and contributing authors). 1996. *Detecting Ecological Impacts: Concepts and Applications in Coastal Marine Habitats*. Academic Press, San Diego, CA. 401p.

Schmitt, R.J., C.W. Osenberg, W.J. Douros, and J. Chesson. 1996. The art and science of administrative environmental impact assessment. Pp. 281-293 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats*, R.J. Schmitt and C.W. Osenberg, eds. Academic Press, San Diego, CA.

Holbrook, S.J., M.J. Kingsford, R.J. Schmitt, and J.S. Stephens Jr. 1994. Spatial and temporal patterns in assemblages of reef fish. *American Zoologist* **34**:463-475.

Osenberg, C.W., R.J. Schmitt, S.J. Holbrook, K.E. Abu-Saba, and A.R. Flegal. 1994. Detection of environmental impacts: natural variability, effect size and power analysis. *Ecological Applications* **4**:16-30.

Osenberg, C.W. and R.J. Schmitt. 1994. Detecting human impacts in marine habitats. *Ecological Applications* **4**:1-2

ERIC R.A.N. SMITH
Department of Political Science
University of California
Santa Barbara, CA

Project: *A Design for a Time Series Study of a NIMBY Response*

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, E.R.A.N. What is public opinion? *Critical Review*.

Smith, E.R.A.N. and S. Garcia. Californians' attitudes toward energy policy.

Smith, E.R.A.N. and S. Woodlief. Problems with the single peaked preference assumption in the spatial theory of elections.

Smith, E.R.A.N. How Political Activists See Offshore Oil Development: An In-depth Investigation of Attitudes on Energy Development. Final Study Report to the Minerals Management Service, U.S. Department of the Interior, July, 1998.

Fox, R.L. and E.R.A.N. Smith. 1998. The role of candidate sex in voter decision-making. *Political Psychology* **19**:405-419.

Smith, ERAN. 1997. Book Review: *What Americans know about politics and why it matter*s, by M.X.D. Carpini, S. Keeter. *Political Science Quarterly* **112**:314-315.

Smith, E.R.A.N. 1996. Book Review: *The two majorities - the issue context of modern American politics*, B.E. Shafer and W.J.M. Claggett. *American Political Science Review* **90**:438-439.

Smith, E.R.A.N. 1996. Book Review: *The changing American mind - how and why American public opinion changed between 1960 and 1988*, W.G. Mayer. *Critical Review* **10**:95-105.

Smith, E.R.A.N. 1996. Book Review: *The rational public - fifty years of trends in American policy preferences*, B. Page and R. Shapiro. *Critical Review* **10**:95-105.

Smith, E.R.A.N. 1996. Book Review: *Public opinion in America - moods, cycles and swings, J.A. Stimson*. *Critical Review* **10**:95-105.

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., T. Epperlein 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., E.R.A.N Smith, J. Lindsay 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., R. Herrera and C.L. Herrera. 1992. Public opinion and congressional representation. *Public Opinion Quarterly* **56**:185-205.

Smith, E.R.A.N., R. Herrera and C.L. Herrera. 1990. The measurement characteristics of congressional roll call indexes. *Legislative Studies Quarterly* **15**:283-295.

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