University of California

Coastal Marine Institute

Annual Report

July 1999

University of California

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and
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Marine Science Institute
University of California
Santa Barbara, California 93106

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.

Disclaimer

This document was prepared by the Coastal Marine Institute, which is jointly funded by the Minerals Management Service and the University of California, Minerals Management Service contract agreement number 14-35-0001-30758. The report has not been reviewed by the Service. The views and conclusions contained in this document are those of the Program and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

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THE COASTAL MARINE INSTITUTE

A Cooperative Program
involving the

University of California,
the State of California

and the

Minerals Management Service
US Department of Interior

ANNUAL REPORT

PROGRAM YEAR 5
July 15, 1999

PROGRAM MANAGER'S REPORT

The Coastal Marine Institute (CMI) was initiated in July 1994 as a cooperative research and research training program involving the Minerals Management Service, the State of California and the University of California. The focus is on long-term environmental, social and economic consequences of oil and gas production activities in the Pacific Outer Continental Shelf region. The university-based research program has just completed the fifth year of our 6-year contract. This Annual Report summarizes activities and research progress during Program Year 5 (July 1, 1998 - June 30, 1999).

Major programmatic progress achieved during Program Year 5 of the CMI is summarized below.

- During the past year 18 regular and research faculty, 62 trainees (3 postdoctoral, 11 graduates 43 undergraduates, and 5 high school students) and 12 staff from 6 campuses and laboratories participated in CMI research projects;

- This year, CMI-sponsored studies produced 5 peer-reviewed papers that were published, with an additional 10 manuscripts that are in press. In addition, 4 MMS reports were completed.

SUMMARY OF RESEARCH PROGRESS

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

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

Rationale for project

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

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

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

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

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

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

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

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

Progress during 1998-99

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

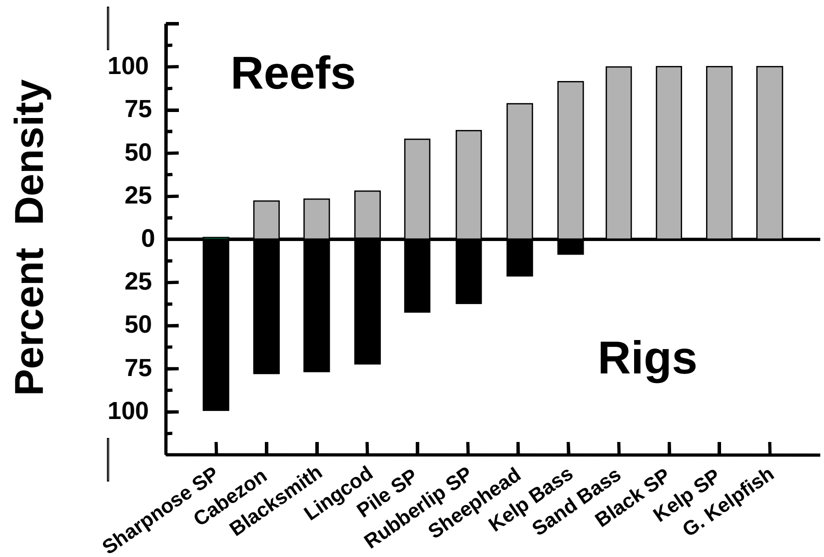
A. Quantitative description of fish assemblages on natural reefs and offshore structures.

Previously, all data from both diver and ROV surveys were entered into computer-based databases (Microsoft Excel and Access), and some preliminary findings were based on a subset of the three year database and separately for the diver and ROV databases. These databases have now been combined across sampling depths and years. The findings reported here are based on the analysis of the entire three year dataset across all sampling depths of all 6 platforms and natural reefs. Sampling design and methods have been presented in previous annual reports.

(1) Across all depths, years, and sample sites, estimates of the proportional (i.e. relative) density (number of fish per cubic volume of water) of species between platforms and natural reefs indicates that some non-rockfish species were encountered only on natural reefs (mostly surf perches and some kelp-associated species) and others primarily on platforms (Figure 1). Those species encountered only or primarily on natural reefs are not likely to be strongly influenced by the different platform decommissioning options. Many species that co-occurred at

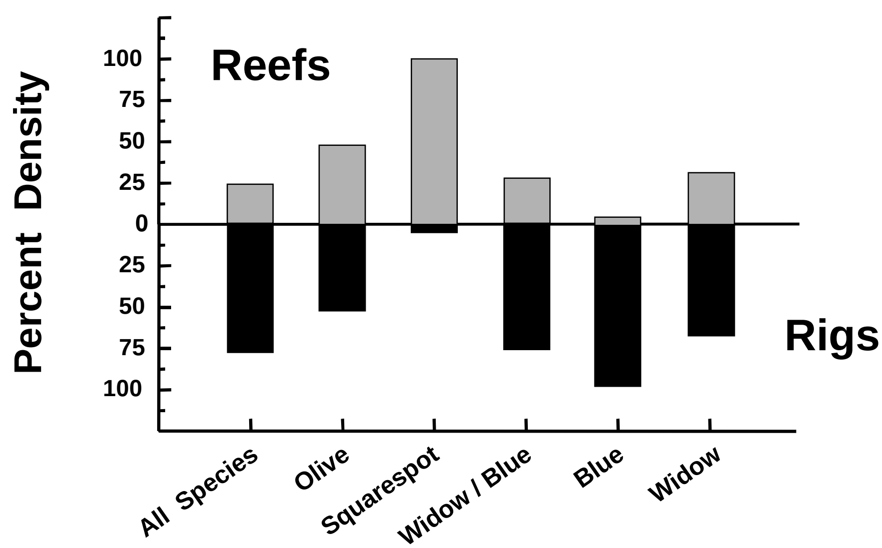
both platforms and natural reefs were often far more abundant in one habitat or the other (Figure 1).

Figure 1. Relative density of shallow non-rockfish species between platforms ("rigs") and natural reefs.



(2) Several midwater rockfish species were far more abundant on platforms than the natural reefs we sampled (Figure 2). These species include the blue rockfish, olive rockfish and widow rockfish, all of which are of economic importance to the local recreation or commercial fishery.

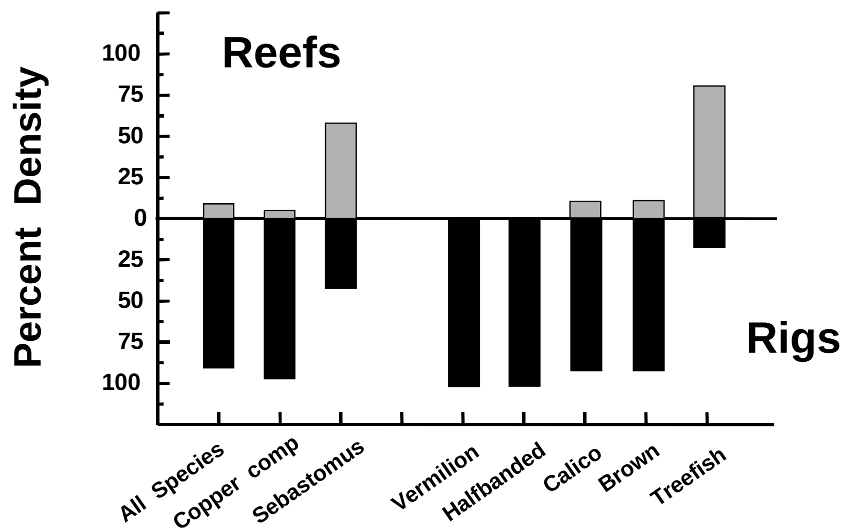
Figure 2. Relative density of midwater rockfish species between platforms ("rigs") and natural reefs.



(3) Several benthic rockfish species were far more abundant on platforms than the natural reefs we sampled (Figure 3). These species include the blue rockfish, olive rockfish and widow rockfish, all of which are of economic importance to the local

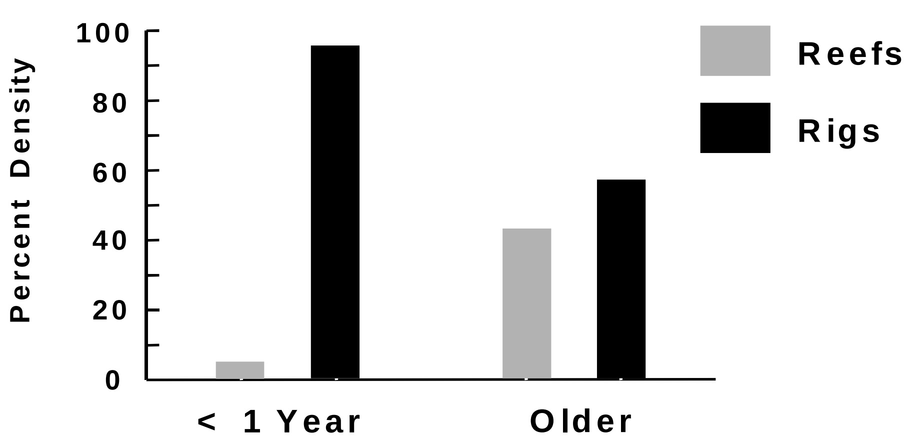
recreation or commercial fishery. The copper complex includes copper, kelp, gopher, and black and yellow rockfish.

Figure 3. Relative density of benthic rockfish species between platforms ("rigs") and natural reefs.



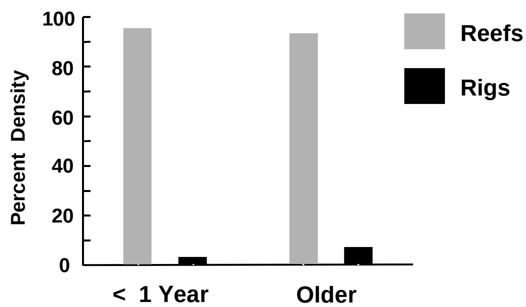
(4) Juvenile rockfishes (≤10 cm) of several species were among the most common fish species on the six platforms and were far more abundant on platforms than on the natural reefs we sampled. These patterns of rockfish recruitment have important implications for the effects of different decommissioning approaches. Firstly, platforms may be sites of increased recruitment of rockfishes in this region of the Santa Barbara Channel. Thus, complete removal of platforms might reduce regional levels of rockfish recruitment, depending on the fate of these recruits in the absence of these structures.

Figure 4. Relative density of size classes of midwater rockfishes between platforms ("rigs") and natural reefs.



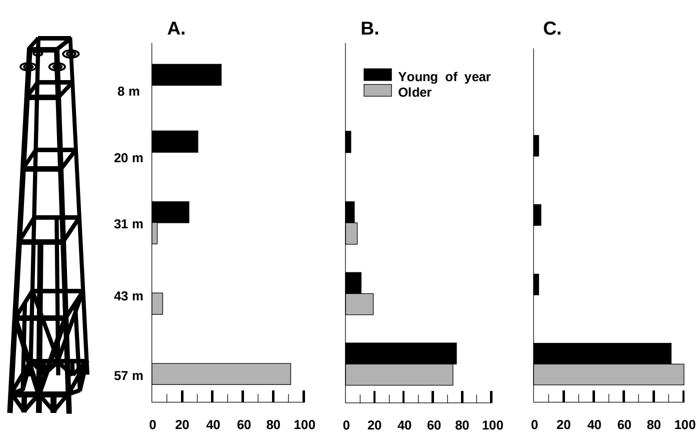
(5) In contrast to the higher abundance of rockfish recruits on platforms, very small kelp bass (< 10 cm) were almost entirely absent from platforms. However, small kelp bass were present on natural reefs and adults were present at both platforms and reefs. This suggests that platforms may not be suitable settlement habitat for larval kelp bass, and that older stages may migrate onto platforms after first recruiting elsewhere. This hypothesis is corroborated by the higher movement of tagged kelp bass among reefs than other species.

Figure 5. Relative density of size classes of kelp bass between platforms ("rigs") and natural reefs.



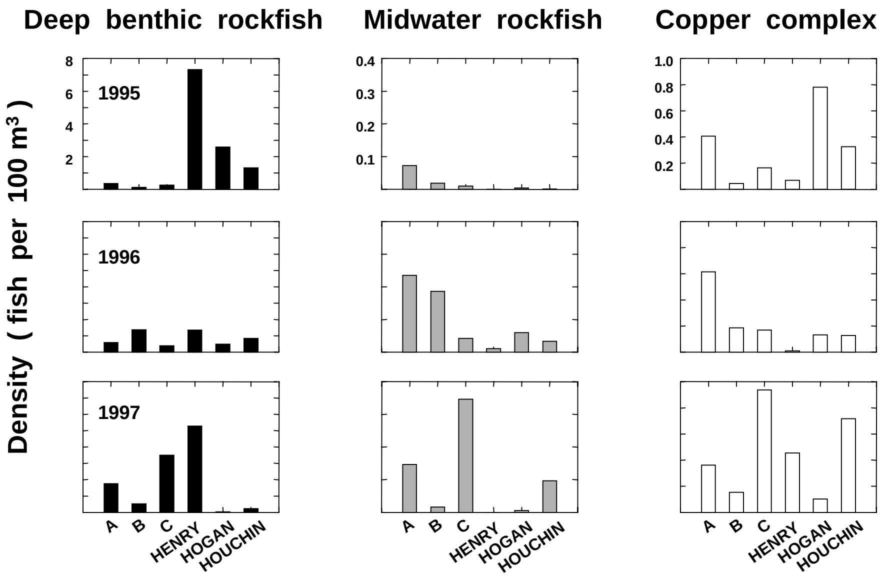
(6) Recently settled recruits of the copper rockfish complex (2-4 cm SL) occurred at the shallower levels sampled (10 and 20 m) whereas adults were more abundant at deeper depths. In contrast, recruits (4-8 cm SL) of the midwater aggregating rockfishes (widow, olive, boccacio) and the deep benthic rockfish species were most abundant at deeper levels (30 and 40 m) like their older life stages. These data suggest that removal of the upper portion of platforms (i.e., "topping" or "toppling") may reduce recruitment of some rockfish species that recruit to that section (i.e. the shallow dwelling demersal species constituting the copper complex). This result is important because the greater abundance of older rockfish may diminish if recruitment of that species is curtailed by the removal of the upper portions of platforms. This effect depends on the extent to which the abundance of older stages is reliant on recruitment to that site versus immigration of older stages from other sites. In contrast, those species that recruit directly to the lower portions of the platforms (20-30 m and deeper) would likely continue to recruit to "topped" or "toppled" platforms.

Figure 6. Differences in depth distribution between age classes of three rockfish groups on production platforms. Plotted are the relative density of young-of-year and older (A) copper rockfish complex, (B) midwater rockfishes, and (C) deep benthic rockfishes.



(7) Patterns of relative abundance of fish species within and among platforms were not consistent over the three year sampling period (Figure 7). This is important as it pertains to the constancy of the fish assemblage supported by a platform over time. This lack of temporal constancy may reflect movement of individuals among the relatively closely spaced platforms.

Figure 7. Temporal variation in relative density of rockfishes within and among platforms over the three year sampling period.



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

In collaboration with the Channel Islands National Marine Sanctuary and volunteers from the University and the local sport fishing community, we have tagged 500 fish and recaptured 50. This high return rate (10%) is attributable to the excellent cooperation by sport fishers that have called us with information on the fish they caught. Of the fish recaught, 75% were caught where they were tagged, suggesting that many of the species tagged (mostly rockfishes) remain on the reefs they were tagged at. Of course, it is not clear how much movement occurs by the many fish that were not recaptured, but we hope to continue to collect information on those individuals in the future. Some species contributed highly to the individuals that moved from reefs they were tagged at; particularly barred sand bass and kelp bass. This greater movement of kelp bass, relative to other species, helps to explain why we see many adults on platforms, but no young recruits. These data strongly suggest that a species like this is attracted to platforms, having recruited as young elsewhere, rather than recruiting to and remaining on the platforms.

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

The 1997-1998 Final Report summarized the significant findings of Michael McGinnis' three-year investigation of the role of ecological science in the decommissioning of California's OCS oil and gas facilities. McGinnis is completing a revision of a paper for journal publication that was included in a draft form in the proceedings of California and the World's Ocean '97. This paper will include an extended review of the role of science in decommissioning, and will describe a number of policy recommendations to strengthen the integration of scientific information, sociocultural and contextual values and factors. Our present project motivated a recently funded follow-up study *"The political economy of the rigs-to-reef option for decommissioning of offshore oil and gas structures"* by Michael McGinnis, Linda Fernandez and Caroline Pomeroy.

Future plans:

We are continuing the analysis of this 3 year dataset and generating a final report and manuscripts for journal publications. We also intend to merge our dataset and analyses with that collected by the USGS effort (Love *et al*.) that was designed in tandem with this study.

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

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

Summary of Research

Over the past year, we have had 11 graduate and undergraduate student interns participating in 7 research projects and assisting with a research symposium. Some interns have been jointly mentored by MMS staff and a member of the UCSB faculty or professional researcher. During the 1998-99 academic year interns have been involved in projects including: i) a literature review of intertidal mussel ecology and biology (Ms. Heather Walling mentored jointly by Mr. Mike McCrary, Mr. Mark Pierson, Ms. Mary Elaine Dunaway and Mr. Maurice Hill from MMS and Dr. Jenifer Dugan (UCSB)), ii) nearshore sediment transport and offshore pipelines (Ms. Jorine Lawyer mentored by Mr. David Panzer), iii) reservoir data analysis (Mr. Justin Urban mentored by Mr. Mike Brickey) and iv) seabird data entry and beach sediment analyses (Mr. Jeff Mason jointly mentored by Mr. Mike McCrary and Mr. Mark Pierson of MMS and Dr. Jenifer Dugan (UCSB)).

We also advertised and hired 5 student interns: 2 undergraduate students- Aurelia Alcantar and Brandon Thorne and 3 graduate students- Cassandra Hensher, Jorine Lawyer, and Peter Paige, to assist David Browne (MMS) and other MMS staff during the MMS sponsored 5th California Islands Symposium at the Santa Barbara Museum of Natural History from March 29 to April 1, 1999.

During Spring '99 ,we developed position descriptions and advertised several summer internships, some of which were initiated in June '99 including: i) the creation of user-friendly keys and web pages based on the MMS sponsored Invertebrate Taxonomic Atlas (Ms. Carla Navarro mentored jointly by Dr. James Lima (MMS) and Dr. Paul Scott (Santa Barbara Museum of Natural History)), ii) a field survey-based study of beach attendance in Los Angeles and Orange Counties (Ms. Carly Gocal mentored by Dr. Linwood Pendleton (USC)) and iii) development of an offshore pipeline database (Mr. Brandon Dayoan mentored by Ms. Theresa Bell, MMS).

We have interviewed and are in the process of hiring 3 additional summer interns on two projects: a field survey-based study of beach attendance in Los Angeles and Orange Counties (Mr. Morgan Matlock and Ms. Lisa Woo mentored by Dr. Linwood Pendleton (USC)) and a research project on decommissioning of oil platforms (Mr. Brendon Applegate mentored by Dr. Michael V. McGinnis (UCSB)).

The program experienced significant growth this year with a notable increase in the numbers of interns and research projects. Feedback from all participating interns and mentors has been extremely positive and encouraging. Based on this response, we plan to continue expanding the program in the coming months. The UC Santa Barbara Environmental Studies Internship Program continues to serve as a good mechanism for advertising positions, screening applicants and reviewing intern performances.

Joint UCSB-MMS Pacific OCS Graduate Trainee Program

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

Information Transfer Seminars (ITS)

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

Dr. Harvey Molotch "Results of the Tri-County Petroleum Extraction Study"

Task No. 12390: Testing and Calibrating the Measurement of Nonmarket Values for Oil Spills Via the Contingent Valuation Method

Principal Investigators: W. Michael Hanemann, Department of Agricultural and Resources Economics, University of California, Berkeley, California 94720, and **Jon A. Krosnick** Department of Psychology, The Ohio State University, Columbus, Ohio

Two tasks were performed this year: survey data collection and data analysis. The main emphasis was on survey data collection. During most of this year, the Center for Survey Research at Ohio State University collected data for a telephone survey experiment comparing two alternative contingent valuation survey formats based on open-ended versus closed-ended elicitation of willingness to pay (WTP). A total of approximately 3,000 adult residents of Ohio were interviewed. During the course of the interviews, which lasted 6 minutes on average, respondents were told about pollution of rivers in Ohio and were told about a proposed plan to remedy this. They were then asked their willingness to pay to implement the plan, using one of two alternative survey formats. Some respondents were asked an open-ended question requesting them to say what is the most they would be willing to pay in a one-time extra state tax payment to help cover the costs of implementing this plan. Other respondents were instead told the cost to their household of implementing the plan, in the form of a one-time extra state tax payment, and these respondents were asked whether they would vote for or against the plan if given an opportunity to do so. Among the respondents asked this closed-ended question, different ones were randomly assigned to be told different costs (“bid amounts”) to their households.

The purpose of the survey was both to compare the results obtained with the two formats and also to test several hypotheses about factors that might be responsible for differences in the two formats’ performance.

Two main hypotheses about the open-ended format are that respondents find it more difficult to answer than the closed-ended format and that their responses to the open-ended format are influenced in a downward direction by their assessment of what the program might cost. To test the first hypothesis, the survey allowed for a response of “don’t know” in both the open- and closed-ended formats. To test the second hypothesis, after the valuation question respondents where asked for their best guess of how much it would cost to implement the clean-up plan. An issue related to the closed-ended format is whether or not respondents engage is “yea-saying” – i.e. as a form of satisficing in dealing with the interview, they simply say “yes” to the question regardless of the dollar amount involved. To test this, for each bid amount a split-sample comparison was conducted using two variants of the closed-ended elicitation question: one variant asked respondents whether they would vote for or against the program while the other reversed the sequence and asked whether they would vote against or for the program. With pure yea-saying, reversing the response sequence should induce a reversal of WTP responses. Another issue with the closed-ended format is the sensitivity to the dollar amounts (bids) employed. To investigate this, the closed-ended survey employed 16 distinct bids, ranging from $15 to $240 per household. By sub-sampling the data, it will be possible to ascertain how the results would change if only subsets of these bids had been employed.

Crossed with these manipulations of question format and structure was a manipulation of scope. Some respondents (randomly selected) were told that the pollution is contaminating four Ohio rivers, whereas other respondents were told it is contaminating only one river in Ohio. The hypothesis is that there will be a larger WTP to eliminate pollution in four rivers than in one.

In addition, all respondents were asked a series of questions that we expect will be predictors of their willingness to pay, including their perceptions of the seriousness of the damage being caused by the pollution, their perceptions of the repair plan's likely effectiveness, their general support for environmental protection, their household incomes, and so on.

The collection of the survey data continued through May, 1999. This was followed by data checking and cleaning. The data analysis element, involving the estimation of mean or median WTP from the survey responses, the measurement of differences between the open- and closed-ended formats, and the testing of hypotheses relating to the two formats commenced as the data became available at the end of the year, but no final results are yet available.

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

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

Progress and Findings

The work on the original project stopped completely in November 1998 due to the inability of MMS to supply us with the Produced Water (PW) we required. As I have noted in the last 2 quarterly, we heard from Dave Panzer at MMS Camarillo that we were denied access to more PW by various oil companies. As I had no more supplies of PW , this effectively ended all our work with PW. As I have previously stated, I will complete a study, however it will not be the project MMS originally funded. The MMS-CMI director, Russ Schmitt has been fully appraised of the situation since late 1998. It was a very unfortunate turn of events and efforts should be made so similar situations do not occur in the future.

Before I completely ran out of PW, I ran a series of field experiments in the Santa Cruz Harbor looking at the growth of an adult bryozoan, *Watisipora subtorquata*, after spiked exposure of competent larvae to sub-lethal doses of produced water. This was very successful.

We exposed the larvae to various concentrations of PW ranging from 0% to 10% of pre-diffuser levels, settled them under lab conditions, followed their early growth, out-planted them and monitored their growth and survival in the field. We also monitored other more subtle sub-lethal impacts such as competitive ability of the adults. Some of the PW concentrations were chosen to elicit behavioral responses from the larvae and then allow us to follow these larvae/adults to look for longer-term effects. They may be unrealistically high compared to a common field exposure.

The larvae consistently swam less, settled less and showed less movement of any kind under the influence of higher concentrations of PW. However, there was little difference in the activity of the larvae within hours of exposure to PW if they were washed in clean, filtered seawater.

Larval mortality it tended to be in higher concentrations of PW and was visible after the first hours of exposure rather than during exposure.

There were small differences in adult mortality. However there was little evidence for strong sub-lethal effects on the growth or competitive abilities of *Watisipora subtorquata* adults. Where mortality occurred, it tended to be more for colonies exposed to concentrations of and above 10% pre-release levels. This result could have important implications for population demographics that we are currently modeling. We have further experiments studying other species of bryozoans that indicate similar, although not always the same results.

The same method and experimental design was used with two other local species of bryozoan, *Hippodiplosia insculpta* and *Schizoporella unicornis*. The data are being analyzed now. The

same method was also tried with larvae of the colonial ascidian *Botrylloides* spp twice in the summer of 1998 and once in 1999 with limited success.
I also had good success culturing the local polychaete worm, *Phragmatapoma californica* and had scheduled experiments with PW and these larvae for September 1998. These experiments went no further than the pilot stage due to the problems outlined above.

After the PW incidents, I forged a collaboration with Dr Gary Cherr from the Bodega Marine Laboratory of UC, Davis and one of his doctoral students, Amro Hamdoun. They supplied me with other sources of oil-based toxicants to use in our experiments. Initially, I am used some lyophilized PW he had in storage to round off my previous PW studies. These had mixed success. We are also collaborating on work into the sub-lethal effects of a bacterial degraded crude oil fraction (BWSF). It is progressing well and I am using the sand-tube worm, *Phragmatapoma californica*, for this work.

Future plans

Experiments will continue this summer using the local polychaete worm, *Phragmatapoma californica* and BWSF. The rest of the time is being spent analyzing data and writing papers for submission.

If I am able to obtain some PW, I have some small and quick experiments I would still like to run to round out the last, unfinished set of experiments.

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

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

Introduction

Over the past year we have continued development of a network of high frequency (HF) radars along the northern coastline of the Santa Barbara Channel and the central coast north of Pt. Conception, California. The radars are commercial systems called Coastal Ocean Dynamics Radars (CODAR's) manufactured by CODAR Ocean Sensors, Ltd. of Los Altos, CA. The network of HF radars is used for mapping ocean surface currents from coastal sites out to a range of about 40 km. They operate by transmitting radar waves over the sea surface and then observing the characteristics of the back-scattered radar waves received at the radar sites. Doppler shifts in the received signals can be used to estimate surface current velocities around the radar sites. By combining signals from all sites, maps of surface currents can be generated every hour.

Major goals for the project are to:

- evaluate HF radars for observing evolving patterns of surface currents
- observe and describe evolving surface currents in the Santa Barbara Channel and Santa Maria Basin
- study the relationship between evolving surface current patterns and spatial variability in various biological populations. These populations include intertidal organisms and pelagic juvenile fishes

HF radar array along the South-central California Coast

A major accomplishment during the past year has been the establishment of two HF radars at sites on Vandenberg Air Force Base (VAFB). This process took two years and innumerable phone calls, faxes, and emails, in addition to many changes in our project contact personnel at VAFB. The two new sites are at Pt. Arguello and Fallback-22, a site just south of Pt. Sal. The equipment for these sites is on loan to our group from the NOAA Environmental Testing Laboratory (NOAA/ETL) in Boulder, CO. Our colleague there, Jack Harlan, has been very helpful in arranging for the loan and consulting with our group on HF radar operations and analysis. Our group has greatly benefited greatly from our interactions with NOAA/ETL.

We now have HF radar systems operating at the following locations (from south to north):

site 1: Coal Oil Point – on the UCSB campus

site 2: Refugio – at the operations center for the Channel Coast Ranger District

site 3: Pt. Conception – at the lighthouse site 4: Pt. Arguello – on VAFB

site 5: Fallback-22 – on VAFB

We are able to provide real-time data from two of the sites, Coal Oil Point and Refugio. This has proven extremely valuable in conducting real-time experiments in the western Santa Barbara Channel in which we direct shipboard sampling based on observed surface current patterns. There are problems with the phone line at Pt. Conception so we cannot remotely retrieve data from this site at present. Diagnosis and repair of this phone line has proven difficult due to our lack of access to this site located on the Bixby Ranch (see below). We have been unable to get Communication Services at VAFB to install phone lines at the Pt. Arguello and Fallback-22 sites. However, we are exploring the possibility of using cell modems or radio links to retrieve data from the latter three sites.

Evaluation of HF radar performance

A major focus of our research continues to be evaluating HF radars as instruments for the measurement of surface currents. Our approach is to make two fundamental comparisons.

First we compare time series of currents at selected locations from the HF radars with *in situ* currents measured from moored current meters located in our coverage area. Second we compare currents measurements from a single HF radar site with predictions of those measurements based on data from the other sites. This provides a check on the consistency of the HF radar technique. We have two sources of *in situ* current data: the extensive array of moorings operated by the Center for Coastal Studies at the Scripps Institution of Oceanography (CCS/SIO); and a mooring operated by our research group at UCSB located about 18 km south of the UCSB campus.

We compare radar and current meter measurements by producing time series of HF radar-measured currents at several locations surrounding available current meter moorings. These are compared statistically with simultaneous current time series obtained by the current meters, located typically at 5 m depth. The normalized covariance between radar and the current meter time series, called r^2 or "r-squared," is computed for each grid location. We find that maximum r-squared values are in the range .55 to .72, indicating that roughly half to ¾ of the variance in the radar time series of surface currents can be explained by the currents measured at 5 m depth by the current meters. Differences in the time series may result from several factors including different spatial sampling, current shear near the surface, wave effects, and measurement noise (Graber, et al., 1997). An interesting result from this analysis is that there is usually a bearing error in the radar measurements, typically in the range 5 – 15 degrees. We speculate that this results from uncertainties in the antenna patterns for each radar system. We are working with colleagues in the HF radar community and at CODAR Ocean Sensors to understand and correct for this error. The effects of this error appear to be relatively small. Results from this analysis were presented at the Fall Meeting of the American Geophysical Union (Emery and Washburn, 1998).

Another comparison we make is between time series from different radar systems. In this procedure we find an area of the ocean's surface that is simultaneously observed by three radar systems. Current vectors are first computed between two sites. Then these are used to predict the radial current vectors observed by the third site. Radial currents are those observed by a single site; at least two sites are required to estimate the total current vector at a point on the ocean's surface. This work is on-going, but preliminary results indicate that about 50-60% of the variance in radial currents from one site can be explained by those estimated from surrounding sites. We are working to refine this comparison technique and understand measurement differences.

Surface current patterns on the South-central coast

Recent studies have shown that the circulation in the Santa Barbara Channel tends to be cyclonic, or counter-clockwise, much of the year (Dever et al., 1998, Hendershott and Winant, 1996, Harms and Winant, 1998). The cyclonic circulation results from a combination of local and remote forcing processes over a wide range of spatial scales. Specifically, it results from the competition between wind forcing to drive eastward flow in the Channel and sea level difference outside the Channel to drive westward flow.

We have been exploiting the ability of HF radars to observe on scales of a few km to map the evolving circulation in the Channel. Maps of vorticity, a measure of the rotation rate of water parcels, clearly shows a strong tendency for cyclonic flow, at least for 1998. Often the flow is organized into a large counter-clockwise eddy that spans most of the Channel. The location of the eddy usually coincides with the Santa Barbara Basin. Because of this we are investigating the hypothesis that the eddy is steered by the bathymetry.

To date of our results are based on data from 3 radar sites operating in the Santa Barbara Channel. We are now processing data from our two sites north of Pt. Conception so that the circulation patterns between UCSB and Pt. Sal can be observed. Our preliminary observations suggest than an anti-cyclonic (clockwise) eddy exists in the Santa Maria basin, consistent with observations made by CCS/SIO based on drifter and moored current studies. The characteristics of this eddy will be an important focus of our future research.

Interdisciplinary studies

A major focus of this research is to understand what role coastal circulation processes play in the recruitment of organisms such as barnacles, crabs, and other invertebrates into intertidal habitats. We are using the HF radars to observe patterns of coastal currents over an area in which intensive sampling of intertidal recruitment is taking place. This effort has been augmented with funding from the David and Lucille Packard Foundation. Funding from the Packard Foundation will permit us to increase the scope of the project to include sites on the Channel Islands and to examine recruitment of various fish species into sub-tidal habitats. We have recently deployed an array of moorings at 6 sites within the coverage of the CODAR array. These moorings include a variety of larval recruitment collectors. 7 additional moorings will soon be deployed around Santa Cruz Island. These moorings should yield time series of larval recruitment for a variety of invertebrate species that can be compared to circulation events recorded by the radars. Our ongoing measurements of settlement patterns have used collectors suspended from piers. Although these samples have identified abrupt changes in settlement dynamics at two locations in the vicinity of Pt. Conception, the number and location of piers is not ideal for this sampling. The new moorings will allow us to sample larval recruitment at key locations spanning the biogeographic transition at Pt. Conception.

Another interdisciplinary study arising from this project is an examination of the distribution of juvenile fishes around the Santa Barbara Channel in relation to a strong cyclonic eddy that often occurs over the Santa Barbara Basin. Data from June, 1998 revealed much higher abundance of juvenile fishes and late-stage larval fishes in the eddy compared with surrounding waters. We are conducting a second survey of juvenile fishes in the same region at the time of this writing (June, 1999).

Collaborations

We are collaborating with physical oceanographers at CCS/SIO in our investigation of circulation processes in the Santa Barbara Channel and Santa Maria Basin. Our work compliments their efforts since we can observe processes with higher spatial resolution. We benefit from the data collected by their extensive array of current meter moorings in our coverage area.

Our collaboration with Mary Nishimoto and Milton Love of UCSB's Marine Science Institute has resulted in the investigation of juvenile fishes discussed above. We continue to work with Jack Harlan of NOAA/ETL on improving the operation of HF radars and interpreting the resulting data. Over the past year we have provided personnel of the National Park Service and the Channel Islands National Marine Sanctuary examples of flow patterns in the Channel. Among other issues, they are interested in how current patterns might result in the transport of organisms and pollutants between the mainland coast and the Channel Islands.

Action requested from MMS

A serious impediment to our research is the continuing problem with access across the Bixby Ranch surrounding Pt. Conception. In September, 1998 we were denied access to Bixby Ranch property, despite the fact we had been crossing their property for the previous year without incident. So far as we can determine, we were denied access through no fault of our own. We need help from MMS to gain access to our site at Pt. Conception. The Pt. Conception area is of major scientific interest and it is essential that some sort of accommodation be reached with the Bixby Ranch Company soon. We will do whatever we can to facilitate this.

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

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

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

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

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

Progress to Date:

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

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

We have continued with our initial efforts to obtain all potential sources of appropriate time series data. We have obtained all of our originally targeted data sets and have continued the process of converting these data from their original hard copy format into a standardized digital format. As we had anticipated, this is proving to a very time consuming process. We have hired an additional graduate student to help us maintain, integrate, and error check new data sets.

We have begun the process of identifying biologically meaningful measures of population responses to the decline in productivity for use in our meta-analyses. This has involved the conversion of the raw abundance data contained in many of the original data sets into a standardized measures of abundance. To date, we have completed this process for all of the fish species contained in our datasets and are using this reduced data set to develop many of the time series techniques, e.g. data de-trending and smoothing functions, needed for many of our proposed analyses. Preliminary population trajectory analysis of these fish data indicates a continuation of the observed declines in population abundances.

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

We have continued with our monitoring of the abundances of surfperches, their invertebrate prey, and the cover of benthic microhabitats at the 11 permanent study sites on the south coast of Santa Cruz Island. Sampling of fish (via visual counts along permanent band transects) and of the cover of benthic microhabitats (via random point contact methods) were accomplished in the manner described in our proposal. All samples collected for the purpose of identifying potential invertebrate prey have been sorted and the individual organisms identified to the lowest taxon possible. All data have been error checked and entered into the appropriate data sets.

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

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

During the past year our MMS supported research has focused on two topics related to improved wave predictions in the Santa Barbara Channel: quantifying and modeling wave reflection from the cliffs of Santa Cruz Island, and wind and offshore boundary conditions for combined sea-swell model predictions for the Channel.

1. Island Reflected Waves in the Channel

The East-West oriented Santa Barbara Channel is bordered on the North by the mainland and on the South by Santa Rosa, San Miguel and Santa Cruz Islands. The Channel is therefore sheltered by the mainland from direct arrivals of energetic waves generated by northerly storms in the Gulf of Alaska and off the Oregon-Washington Coast, and is sheltered by the Islands from waves arriving from the South. Only waves arriving from the west pass through the "open window" connecting the Channel to the deep ocean and have a direct path to the easterly part of the Channel (e.g., near Santa Barbara and Ventura). Preliminary analysis suggested anomalously high wave energy levels in the eastern part of the Channel (relative to that expected with direct path arrivals) when waves are arriving from a WNW direction. The hypothesis is that these waves are reflected by the Islands back into and down the Channel, and we have analyzed historical Wave data collected by NOAA and the Coastal Data Information Program for evidence of such wave reflection.

Detailed analysis of data from directional wave buoys deployed in the Channel near the northern coasts of Santa Rosa Island and Santa Cruz Island (SCI) in 1995 confirmed that only the shear coastal cliffs of SCI reflect significant wave energy back into the Channel. Wave breaking and dissipation in the rocky shallows that border Santa Rosa (and San Miguel) greatly reduce wave reflection. The buoys offshore of the SCI measured 20-30% reflection of incident wave energy from the cliffs back into deep water when waves arrive from WNW directions. The remaining wave energy is either dissipated on the cliff face or reflected at high angles to the cliff normal and "trapped" along the cliff-lined coast by wave refraction. Little reflected energy is observed when waves arrive more directly from the West because the waves approaching the local continental shelf of SCI at a very oblique angle. Wave refraction leads to markedly reduced energy and relatively steep approach angles at the cliff face in this situation, leading to low reflected energy and possibly enhanced wave trapping. As a result, there is a steep drop-off in the total amount of energy reflected back into the Channel as the deep water approach angle of the incident waves varies from WNW (280 degrees) to West (270 degrees). This rapid decrease in reflection is used in a simple extension of an existing wave model to include island-reflected wave energy.

The SCI buoy measurements are dominated by specular reflection from the cliffs, with the wave energy remaining in the same frequency bands and reflecting at an angles nearly symmetric to a line perpendicular to the mean orientation of the cliff face. However, if this was a purely specular process, no reflected wave energy would be detected at more distant measurement sites directly to the north or to the Northwest of SCI (all the wave energy striking SCI is arriving from westerly directions and the reflections would propagate in easterly directions). Analysis of wave data measured at other locations around the Channel shows there is a secondary, lower energy nonspecular reflection of waves from SCI (i.e. a narrow directional beam of wave energy incident on the cliffs is scattered into a wide range of directions). These measurements indicate that approximately 5% of the energy incident to SCI is radiated back into the Channel with a broad range of directions.

Based on these findings, SCI wave reflection has been heuristically incorporated into an experimental version of the Southern California swell model used by the Coastal Data Information Program (CDIP). Significantly improved predictions of wave height and direction in the Channel result. The predicted incident wave spectrum of direct arrivals at a representative site at the local shelf break offshore of the SCI cliffs is used to estimate a reflected wave spectrum, whose form is based on the historical buoy data collected close to the cliffs. The estimated reflected spectrum in deep water offshore of SCI is a combination of a specular and nonspecular directional distributions of reflected wave energy. The specular directional spectrum mirrors the incident spectrum shape about due north, and contains 20% of the corresponding incident wave energy for waves arriving from angles greater than 275 degrees (the reflection "cut-off" derived from the observations). The nonspecular directional spectrum is first described at the cliff face as "white", or uniform in shape for all possible reflected directions. The nonspecular spectrum in deep water offshore of SCI is then estimated for each wave frequency by assuming the coastal cliffs face due north and that the local continental shelf is planar (parallel depth contours). Wave refraction theory is then used to transform this uniform spectrum at the cliff back into deep water. Only a limited range of angles can reach deep water from the cliff, with the remainder being trapped along the SCI coastline. This nonspecular, deep water spectrum is then adjusted to contain 5% of the total incident deep water wave energy at the representative site.

The specular and nonspecular components of the reflected wave spectrum are combined, and the resulting spectrum is assumed to be represent the reflected wave field in deep water along the entire length of SCI. This reflected energy is then added to the "standard" model predictions of direct arrivals throughout the Channel using spectral wave refraction methods to create combined incident-reflected predictions. Work is continuing of this experimental model to refine the representation of the reflected spectrum and to examine interesting wave events that have occurred in recent winters to further validate the approach. The reflection-enhanced swell predictions for the Channel will be disseminated on the CDIP web site later this year.

2. Wind-Wave Generation in the Santa Barbara Channel

Work is also underway to include local wind seas in Channel wave predictions. This effort is being coordinated with the U.S. Army Corps of Engineers, NOAA/NCEP, the U.S. Navy Fleet Numerical Meteorology and Oceanography Center (FNMOC) in Monterey, and the U.S. Navy North Pacific Meteorology and Oceanography Center (NPMOC) in San Diego.

Predicting local seas in the Channel requires a regional wind-wave generation model. A number of models exist, but they have received little validation in geographically complex areas like the Southern California Bight. Therefore, the first step towards combined sea and swell predictions for the Channel is to test state-of-the-art models. Specifically, we have validated local sea forecasts that were made for the Bight during the El Nino winter of 1997-98 by the Army Corps of Engineers using the 3rd Generation Wave Model (3G-WAM) widely used by operational wave forecast centers. The 3G-WAM model was initialized with Navy NORAPS regional wind forecasts for Southern California. The local seas model forecasts were in good agreement with the measurements at the west end of the Channel during this time period, but the model overpredicted a number of "local" sea events that occurred within the Bight.

Discussions with Dr. Clive Dorman have lead to the preliminary conclusion that the overprediction errors were caused by the absence of a marine layer in the NORAPS wind field forecast model. When a strong marine layer is present in Southern California, it "blocks" the northwesterly winds offshore of Pt. Conception from penetrating into the Bight. The lack of marine layer blocking in the NORAPS wind field is believed to result in overprediction of winds and waves in the Bight.

Recently, the Navy has phased out its NORAPS wind model in southern California and replaced it with the COAMPS (Coupled Ocean-Atmosphere Prediction System) wind model. The COAMPS model does include the marine layer and COAMPS wind fields appear to model the blocking of northwesterly winds in most situations. However, the COAMPS wind fields have not yet been linked with a wind-wave generation model in southern California for validation. The U.S. Navy NPMOC in San Diego is presently generating 3-day COAMPS wind field forecasts for Southern California. NPMOC has agreed to make these forecasts available to CDIP for research purposes, and CDIP will soon provide experimental wind forecast products for the Channel to the marine community via the CDIP web site.

Further, the Southern California sea forecasts generated by the Army Corps during the El Nino winter used a larger west coast regional wave model for offshore boundary conditions (e.g., they specify the wave field propagating into the western end of the Channel). The west coast model is not run routinely, therefore another source of boundary data will be needed for a Channel sea-swell model. As a result, we have been working with FNMOC and NOAA/NCEP to test their global wave model forecasts in the Pt. Conception area, near the western Channel mouth. Two wave models are presently run operationally on global scales and could potentially be used for sea-swell model boundary conditions: the FNMOC WAM model, and the NOAA/NCEP Wavewatch III model (also being run in an experimental mode by FNMOC). Ongoing validation of these models near Pt. Conception shows that Wavewatch III provides significantly better forecasts. Both models tend to underpredict the largest local sea events that occur at the west end of the Channel, however, FNMOC has recently linked their experimental Wavewatch III implementation with a west coast regional COAMPS wind model with encouraging results. The Wavewatch III model can be used as a regional as well as a global model and is presently the most likely candidate for implementation in the Channel to predict seas in combination with the reflection-enhanced swell model.

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

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

Research Progress

Toxic compounds may reduce the fecundity, development rate, and/or survival probability of individual organisms. In the previous annual report, we presented a model describing sublethal effects of toxicants on individuals. This model includes a module describing growth and reproduction in absence of pollutants, a module describing the accumulation of toxicants within the organism, and a module describing feedback mechanisms of toxicant action on the parameters of the growth model. We tested our toxicity model with published data on various combinations of organism and toxicant, including marine mussels and oysters.

In addition to pollution, organisms in natural environments are confronted with various other forms of environmental stress during their life-time. A form of stress that is particularly common is the lack of food, especially during off-seasons. Organisms that live in an environment with a limited food supply are more susceptible to detrimental effects of toxicants than individuals that live with abundant food. This year we therefore conducted a thorough analysis of our growth model in order to investigate the effects of a variable food source on the performance of organisms. We consider two types of food fluctuations. One is a periodically variable food environment, which may represent diurnal or seasonal changes. The other is an environment in which food fluctuates stochastically but with some memory for previous food levels (pink noise); in this way we avoid that the environment jumps back and forth between `summer' and `winter' conditions.

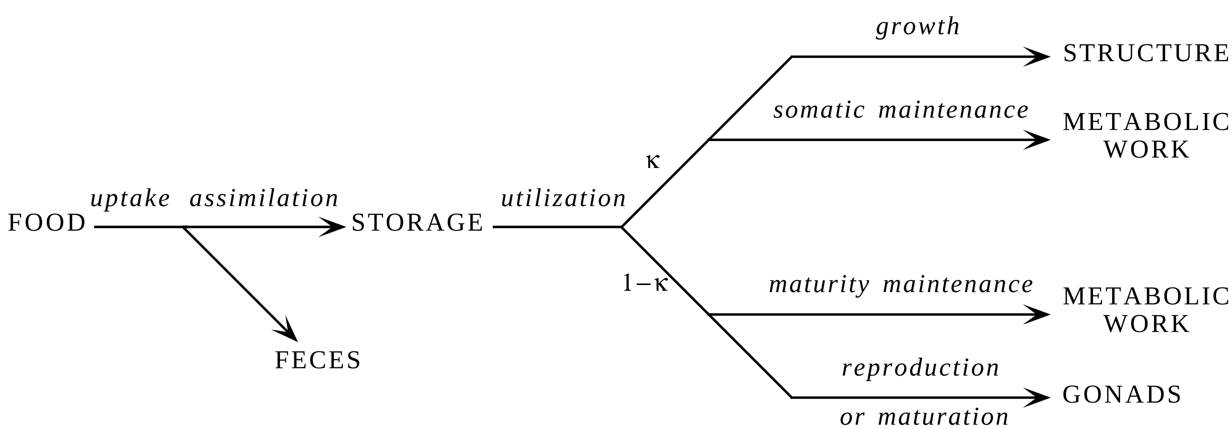

Figure 1: Kooijman's κ -rule model assumes that an organism ingests food at a rate dependent on its size and the food density. Energy is extracted from food and added to the reserves. The rate at which energy becomes available to the organism depends on its size and stored energy density. Provided somatic maintenance requirements are met, a fixed proportion κ of the available energy is allocated to somatic maintenance and growth combined, and the remaining 1- κ to either maturation (for embryos and juveniles) or to reproduction and maturity maintenance (for adults). Growth ceases when this fixed fraction κ just meets somatic maintenance demands. Then, the organism may still reproduce, provided that energy made available exceeds the requirements for somatic and maturity maintenance.

We used the κ-rule model developed by Kooijman (Kooijman, 1986; Kooijman, 1993; Nisbet *et al*., 1996). This model, which we also used in our toxicity model, is outlined in

Figure 1. Table 1 lists the assumptions and Table 2 gives the two state equations as well as expressions for reproduction. A key assumption is that when feeding conditions allow, a fixed fraction κ (hence the name of the model) of assimilated resources is used for somatic purposes; the remaining fraction 1- κ is used for reproduction and maintenance. The value of this life history parameter κ has a strong impact on the production and survival qualities of organisms in a variable food environment, and we have therefore given it a prominent place in our analysis. Other factors playing key roles in the analysis are the strength and the time scale of the food fluctuations.

TABLE 1: Model assumptions.

- There are two state variables: structural body volume, and stored energy density scaled to its maximum.
- There are six energy fluxes: assimilation; somatic maintenance; somatic growth; development; maintenance of the state of maturity; and reproduction. These energy fluxes are irreversible.
- There are maximally three life stages: embryo's, which neither feed nor reproduce; juveniles, which may feed but do not reproduce; and adults, which may feed and reproduce.
- The rate of food uptake is proportional to the surface area of an organism, and is a hyperbolic function of the food density (type II functional response).
- Energy assimilated from food becomes part of the reserves. The dynamics of the energy reserve density are first order, with a rate that is inversely proportional to the volumetric length of an organism.
- A fixed fraction of the energy released from the reserves is committed to somatic maintenance and growth; the remainder is used for maturity maintenance, and development or reproduction. Maintenance demands have priority, and the partitioning of energy is modified to meet somatic maintenance.
- Death due to starvation occurs when somatic maintenance requirements cannot be met.
- The chemical compositions of structure and reserves are constant (homeostasis), and thus the following are constant:
    - the conversion efficiency of food into energy;
    - the cost to form a unit of structure;
    - the cost to maintain a unit of structure for a period;
    - the cost to maintain the state of maturity for a period;
    - the cost to form a unit of reproductive matter.
- Life stage transitions occur when the cumulative amount of energy spent on maturation exceeds a threshold. An embryo initially has a negligibly amount of structure, and, when propagation is via eggs, its energy reserve density at hatching equals that of its mother during egg formation.

We followed two approaches in our analysis, an analytical and a numerical approach. We obtained analytical results for the long term dynamics with a periodically variable food source. We showed that, under certain circumstances, an organism may survive a periodically varying food environment for an indefinite time, and that the long-term dynamics of the state variables determine the environmental conditions for survival at any time. (There are of course many other potential mechanisms for mortality, but these were not included in the analysis as we were specifically concerned with mortality due to starvation.) In addition, survival is a function of κ, the parameter determining the partitioning of energy between somatic and reproductive tissues. Organisms with a high value for κ are more susceptible to die from starvation than organisms with a low value for κ. We also showed that organisms grow to a larger size with increasing amplitude of food fluctuations. Interestingly, the quantitative effects of a variable food source on reproduction depends on the value of κ. Individuals committing a relatively large fraction of energy to reproduction increase their reproductive output with increasing amplitude, whereas individuals spending a relatively large fraction on growth reduce their reproductive output with increasing amplitude. All results mentioned in this paragraph depend on the period of the food fluctuations. When food levels change fast with respect to physiological rates, the energy reserves of the organism provide a strong buffer against environmental change, implying that the organism experiences its environment as being essentially constant.

TABLE 2: Model equations.

reserve dynamics: $$\frac{de}{dt} = \upsilon V^{-1/3}(f - e)$$

growth: $$\frac{dV}{dt} = \frac{\left(e\upsilon V^{2/3} - mgV\right)_+}{e+g}$$

reproduction while growing: $$\frac{de_r}{dt} = (1-\kappa)\left\{\frac{ge}{g+e}\left(\upsilon V^{-1/3} + m\right) - mg\frac{V_p}{V}\right\} - e_r\frac{dV}{dt}$$

reproduction without growth: $$\frac{de_r}{dt} = e\upsilon V^{-1/3} - mg\left(\kappa + (1-\kappa)\frac{V_p}{V}\right)$$

periodic food fluctuations: $$f = f_a + a\sin(\omega t), \quad a \le \min\{f_a, 1 - f_a\}$$

stochastic food fluctuations: $$f = \begin{cases} 0 & \text{if } f_a + z(t) < 0 \\ f_a + z(t) & \text{if } 0 \le f_a + z(t) \le 1 \\ 1 & \text{if } f_a + z(t) > 1 \end{cases}$$

$$\frac{dz}{dt} = \frac{-z}{\tau} + S^{1/2}\gamma(t)$$

a	amplitude	V	structural biovolume
e	scaled energy reserves density	z	random variable
e_r	scaled density of energy reserved for reproduction	t	time
f	food (scaled density)	κ	coefficient for partitioning energy between somatic and reproductive
f_a	scaled average food density	υ	energy conductance rate
m	maintenance rate	τ	memory retention time
S	fluctuation intensity	ω	frequency

Because of the nonlinearities in the model, neither the transient dynamics with deterministically (i.e. periodically) fluctuating food, nor the behavior of the model when food varies stochastically could be determined analytically. Thus, we also analyzed the model with numerical tools. We illustrate model behavior with the marine mussel *Mytilus edulis*, for which realistic parameter values are available (see Table 3).

Table 3 Parameter values for the mussel *Mytilus edulis.*

symbol	value	correction factor[a]	reference
d_m[b]	0.333	-	van Haren et al. 1993
g	1.286	$0.8/\kappa$	van Haren et al. 1993
L_b	0.001 m	-	Seed 1976
L_m	0.100 m	$\kappa/0.8$	van Haren et al. 1993
L_p[c]	0.003 m	$0.25\ \kappa/(1-\kappa)$	Seed 1976
m^d	0.583 y^{-1}	-	Kooijman 1993
υ	0.075 $m.y^{-1}$	–	Kooijman 1993

a the values of parameters that depend on κ are calculated by multiplying the correction factor with the value listed
b converts volumetric length into shell length, $L = d_m V^{1/3}$
c the assumptions imply L_p is proportional to $\kappa/(1-\kappa)$ (Zonneveld, 1989)
d normalized to 20°C (Kooijman 1993)

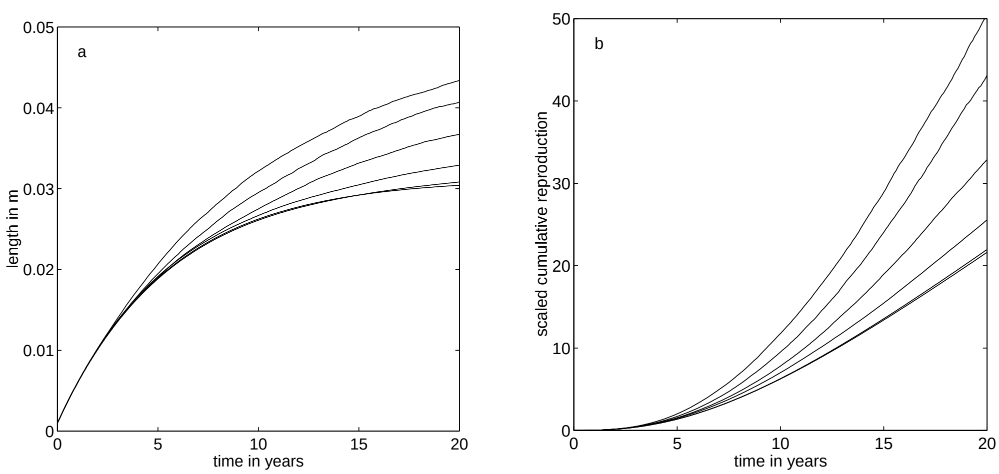

Figure 2: The average growth (a) and reproduction (b) of surviving organisms increases with the intensity of stochastic food fluctuations. From top to bottom and in sequential order, the curves represent average production with S = 0.025 y^{-1}, 0.016 y^{-1}, 0.009 y^{-1}, 0.004 y^{-1}, 0.001 y^{-1} and 0 y^{-1}, respectively. Parameters values are appropriate to the mussel *Mytilus edulis* (see Table 3) with $\kappa = 0.5$ and $\tau = 10$ y.

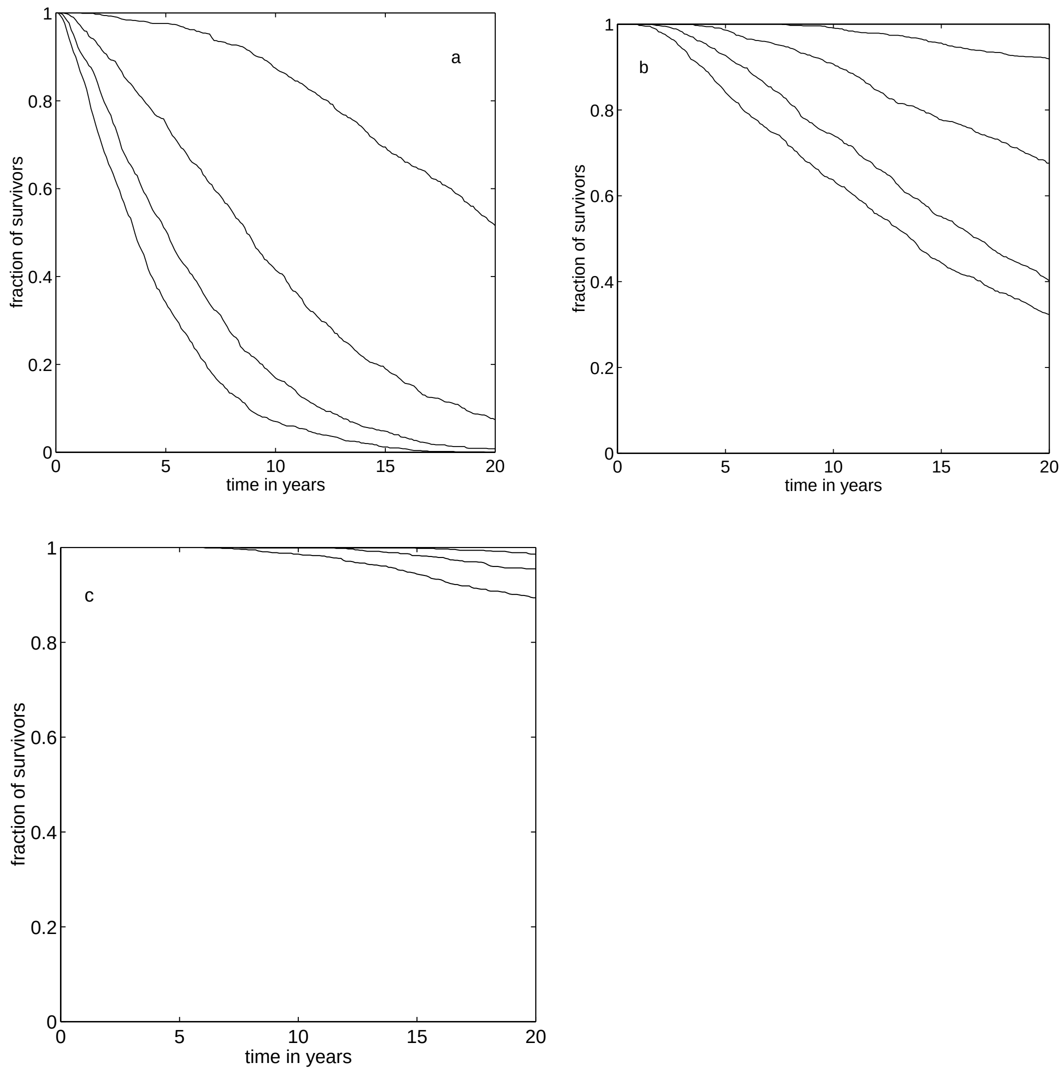

Figure 3: The probability of survival to a given age in a stochastically variable food environment declines with the intensity of the food fluctuations and depends on the memory retention time of the environment for previous food levels. The memory retention time τ is (a) 1 y, (b) 10 y or (c) 100 y (with τ = 1 d survival was 100%). In all panels, the curves represent survival probabilities with, from bottom to top and in sequential order, S = 0.25 τ^{-1}, 0.16 τ^{-1}, 0.09 τ^{-1}, 0.04 τ^{-1}, 0.01 τ^{-1} and 0, respectively. Parameters values are appropriate to the mussel *Mytilus edulis* (see Table 3) with κ = 0.5.

With a stochastically variable food source, the average production of surviving individuals increases with an increasing intensity of food fluctuations (see Figure 2). In this case, reproduction increases with increasing fluctuation intensity regardless the value of the parameter determining the partitioning of energy between somatic and reproductive tissues. The magnitude of this increase in production does not only depend on the intensity of the fluctuations, but also on the memory of the system for previous food levels (memory is the analogue of the period with periodic food). With a short memory, the food environment changes rapidly and the energy reserves filter out most fluctuations. Then, the organism behaves physiologically as it were in a constant food environment.

However, also the chance to die at a given age increases with the intensity of the fluctuations, which raises the question how the expected production of a newborn will change as a function of fluctuation intensity. Figure 3 shows how the odds for survival change as a function of the intensity of the fluctuations and the memory for previous food levels. With very short memory, starvation induced mortality does not occur (results not shown). With a very long memory, the environment changes relatively little over the life time of an organism, which accordingly has a high chance to grow old (see Figure 3c). An environment with an intermediate memory for previous food levels is most difficult for organisms to survive in, as food levels change slowly relatively to their physiology, but sufficiently fast to expect several extreme food levels during a realistic time frame. The result of this increasing mortality with increasing fluctuation intensities is that although reproduction of survivors increases, the expected life time reproduction of an organism decreases with increasing fluctuation intensities (see Figure 4).

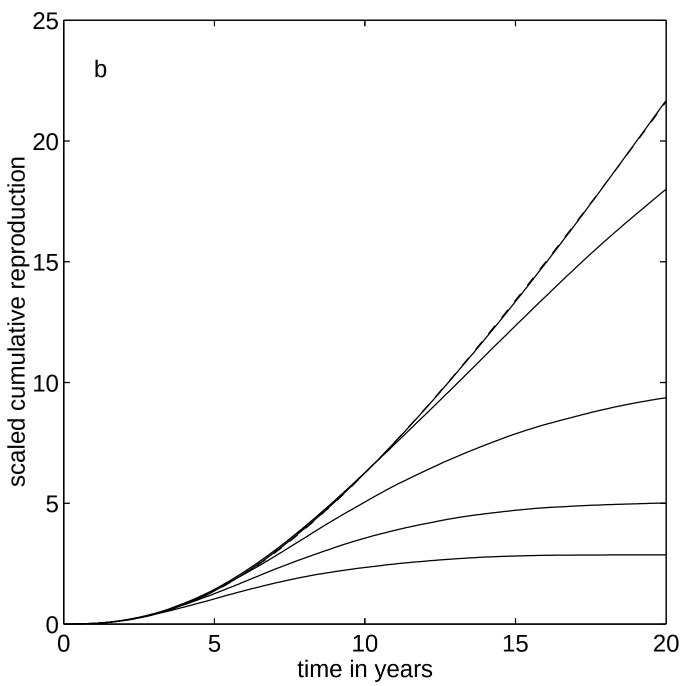

Figure 4: The expected growth and reproduction to a given age are strongly reduced by intense stochastic food fluctuations because of mortality due to starvation, but mild food fluctuations may stimulate production. The dotted curve in both panels represent production at constant food, and the solid curves represent production with, in sequential order and from bottom to top, S = 0.25 y^{-1}, 0.16 y^{-1}, 0.09 y^{-1}, 0.04 y^{-1} and 0.01 y^{-1}, respectively. Parameters values are appropriate to the mussel *Mytilus edulis* (see Table 3) with $\kappa = 0.5$ and $\tau = 1$ y.

For both periodically and stochastically varying food environments, the model makes the following predictions on (average) growth and mortality. Organisms grow bigger in a variable food environment than in a constant environment with similar average food availability. Ultimate size increases with the amplitude and period of deterministic food cycles, and with the intensity and memory retention time of stochastic food fluctuations. In variable food environments, organisms grow to a size related to the peaks in food availability, rather than to the mean. Food fluctuations may lead to death from starvation, the likelihood of which increases with the strength and duration of the fluctuations. Two processes are involved here: starvation requires a sustained period of low food, but in addition the larger individuals that are present in a fluctuating environment have greater maintenance costs than their smaller counterparts and are hence particularly vulnerable to food stress.

Various field observations are consistent with our results. Model predictions on growth in periodic food environments are in line with observations backing Bergmann's rule. Bergmann's rule predicts that the size of homeothermic organisms increases with latitude; this trend is also common for ectotherms (see e.g., Brown and Lomolino 1998, p. 488-493). Usually, this trend is related to some temperature measure, such as summer maxima or seasonal fluctuations. Our model predicts that there is a phenotypical trend showing increasing body size with stronger seasonal food fluctuations. Because food availability often covaries with temperature, our results suggest that organisms become bigger with increasing latitude due to an increasing seasonal variability in food.

The predicted effects of food fluctuations on reproduction are more complex. In a periodically variable food environment, reproduction may increase or decrease with the amplitude of the fluctuations, depending on κ, the parameter characterizing the partitioning of energy between somatic and reproductive tissues. Individuals with a high value for κ commit a relative large fraction of their resources to growth, whereas individuals with a low value for κ give a higher priority to reproduction. High κ individuals reproduce less with increasing amplitude, but low κ individuals reproduce more. Although any organism becomes bigger in a periodically variable food environment, and thus feeds at a higher rate, only high κ individuals translate this extra food intake (partly) into offspring. Low κ individuals need this extra food intake for maintenance requirements, which also increase with size. Because of the strong size dependence of reproductive output, stochastic variation in the food environment normally leads to enhanced reproduction by individuals that survive the fluctuations. However, in most cases, this increase is accompanied by a still stronger decrease in survival probabilities, causing the expected life time reproduction to decline.

The dependency of reproduction patterns on κ in periodic food environments is of particular interest as κ is an adaptive parameter whose value for any particular organism may reflect the intensity of the food fluctuations in a particular environment. The model suggests that a low value for κ would represent a food environment that fluctuates relatively strongly. Also, survival decreases with increasing κ. Thus, individuals in a highly variable food environment are likely to evolve towards a lower κ, a higher reproductive rate and a lower physiological potential for growth than their conspecifics in a less variable food environment. This is in agreement with many data showing increasing clutch sizes in birds and litter sizes in mammals with increasing latitude (Brown and Lomolino, 1998). However, the genotypical decrease of growth potential that accompanies a lower value of κ would diminish the increase in size due to higher food maxima, causing this trend to be less pronounced.

Our analysis makes several predictions for the toxic effects of pollutants in environments with a variable food source. Our toxicity model assumes sublethal effects on the processes of maintenance, and feeding and assimilation, causing organisms to grow and reproduce less in polluted environments. In general, food stress just adds to that. In an environment with large food fluctuations, fully grown organisms are large with respect to average food levels. Upon introduction of toxicants in the non-growth season, those organisms will be unable to gather sufficient food for their increased maintenance demands; they then die. In more temperate regions, fully grown organisms tend to be less 'oversized' so that they are better able to survive pollution. The expectations for organisms that are still growing are different, especially if the pollution occurs in the growth season. The model suggests that organisms increase commitment to reproduction on the expense of growth with increasing latitude, which increase implies an increased viability to endure stress. Organisms in variable food environments with low background levels of pollutants grow less than organisms in a similar uncontaminated environment. With (more or less) constant background levels of contaminants, the interaction between food and toxicant stress is quite complicated. Also the implications of this interaction for the evolution of the life history parameter κ is yet obscure. Those two issues need further scrutiny.

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

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Progress to date:

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

1) Testing various outplanting techniques:

Our first attempts of outplanting laboratory-reared seedlings to the field involved manually attaching seedlings to various species of macroalgae that surfgrass most commonly recruit to in nature. Using forceps an investigator grasped the seed of the seedling, and hooked one of its barbed arms onto a branch of the alga, in a manner that attempted to mimic the attachment of seeds in the wild. Approximately 1,000 laboratory grown seedlings were attached using this method in both intertidal and subtidal habitats. This technique proved to be very tedius (especially in subtidal habitats) and no outplanted seedlings remained attached more than a couple months. Following these results we switched our efforts to attaching seedlings to artificial substrates in the laboratory and outplanting these seeded artificial substrates to the field. We have tested two different substrates: braided nylon string and braided nylon netting. In both cases, an opening is made in the braid by untwisting it one half turn. One of the arms of the seed is inserted into the opening and hooked onto one of the braids. The opening closes upon relaxation of the braid locking the seedling in place. Many seedlings can be securely fastened to the strings and nets relatively quickly using this technique. The seeded strings and nets are then transported to the study site in coolers and fastened to the reef using marine epoxy.

Over 2,000 seedlings were attached to 20 cm long nylon strings and outplanted to intertidal and subtidal habitats between 10 Dec 1998 and 7 Jan 1999. Our previous outplant experiments indicated that survivorship of seedlings was higher in areas of reduced algal cover. Consequently, strings were outplanted to areas with dense algal cover and to areas where algae had been removed to test the effects of algal canopies on seedling survivorship.

Data on survivorship (# remaining) and growth (# leaves per seedling and mean leaf length) are collected monthly. Preliminary results show mortality was initially high in the first month following outplanting with little mortality thereafter. Survivors showed substantial growth with increases in both leaf number and leaf length.

The improved survivorship of outplanted seedlings on braided nylon led to additional tests in February and March 1999. Here nylon netting was used as the artificial substrate to better examine the effects of seedling density on survivorship. Nylon netting with 1.5 cm square mesh was cut into 20 cm x 20 cm squares and used as the outplant substrate. Determining the effects of density on seedling survivorship is critically important in evaluating the effectiveness of using outplanted seedlings to restore damaged populations. Therefore, seedlings were outplanted at three densities uniformly distributed over the net: high (105 seedlings per net) medium (20 seedlings per net) and low (5 seedlings per net). T he nets were seeded in the laboratory and outplanted to both an intertidal and subtidal site in areas where algae had canopies had been removed and in areas that were scraped to bare rock. Scraped rock was tested because many disturbances frequently remove all vegetation. A total of 1560 seedlings were outplanted for each tidal zone (n = 6 nets for each zone, density, and algal treatment combination). As in our other experiments, data on survivorship (# remaining) and growth (# leaves per seedling and mean leaf length) are collected monthly. We initiated an additional experiment in May 1999 to test whether seedling survivorship varied with the size of outplanted net . Large (20 X 20 cm) and small (10 X 10 cm) net substrates each containing 10 seedlings were outplanted in pairs to our experimental subtidal site (n = 10 nets for both sizes). The nets were attached to areas on the reef where algal canopies had been removed which enabled them to be placed flush against the rock. This experiment was motivated by our belief that smaller pieces of netting are easier to handle and can be attached more securely to the bottom, which could facilitate higher survivorship of outplanted seedlings.

2) Growth and survivorship of naturally recruited surfgrass seedlings

Twenty five seedlings that were presumed to have recruited three previous winter (Jan – Mar 1998) were mapped and measured on 8 November 1998 at our intertidal site More Mesa. Data on the number of leaves, average leaf length, total length and number of bifurcations of the rhizome, and depth of sand are collected monthly for each of the individuals. Like many of our intertidal sites there has been substantial movement of sand at this site and the young plants are frequently buried by as much as 30-40 cm of sand for periods up to several months. In addition to providing information on growth of established seedlings, the data collected at this site will provide much need information on the degree to which surfgrass seedlings can withstand burial by sand.

3) Adult transplants

In June 1999 thirty plugs of adult plants were collected from healthy stands of surfgrass in the intertidal at Coal Oil Point and transplanted to adjacent areas of bare rock. Because we were interested in determining whether size of the plug influenced its ability to become established we transplanted small (rhizome length < 5 cm) and large (rhizome length > 5 cm) plugs in a paired design. Unlike previous restoration attempts that glued the plants directly to the reef we pulled the leaves of a transplanted plug through a piece of nylon netting and then glued the netting to the reef in a manner that kept the rhizome of the plug firmly pressed against the rock. A similar experiment is being set up at one of our subtidal sites in July 1999. Survivorship and growth (number of leaves and area of reef covered by rhizome) will be measured monthly. Data obtained from these adult transplant experiments will be compared to those collected from experiments involving laboratory-reared seedlings outplanted to the field. An advantage of transplanting adults over outplanting laboratory-reared seedlings is that restoration could take place year round. A disadvantage of transplanting adults is the (presumably) short-term damage caused by removing small portions of established populations. Plans are underway to examine the time required for established populations to fill in gaps created from collecting plugs of different sizes.

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TRAINEES AND STAFF FUNDED BY THE COASTAL MARINE INSTITUTE

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Beckenbach, E.	Graduate	CODAR Project[7]
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Boxshall AJ. Impacts on adults of exposing bryozoan larvae to a toxicant**.** AMSA99, Melbourne, Aust. July 1999

Boxshall AJ. Do larvae go with the flow? Oregon Institute of Marine Biology, Coos Bay, Oregon, May 1998.

Wright JW and Boxshall AJ. Flow, chemical cues and settlement of two congeneric barnacle species. 3rd International Larval Meetings, Melbourne, Australia, January 1998

Boxshall AJ. Small scale hydrodynamics and chemical cues interact to affect invertebrate larval settlement. 3rd International Larval Meetings, Melbourne, Australia, January 1998

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Poster Presentations in 1998/1999:

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

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

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

Selected Publications:

Carr MH, and PT Raimondi. 1999. Marine protected areas as a precautionary approach to management. CALCOFI reports.

Reed DC, MH Carr, L Goldwasser and PT Raimondi. Role of dispersal potential in determining the spatial structure of an assemblage of sedentary marine organisms. *Ecology*.

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**:S79-S92.

Carr M.H. and P.T. Raimondi. 1998. Concepts relevant to the design and evaluation of harvest reserves. In: *Proceedings of the Marine Harvest Refugia for Est Coast Rockfish Workshop*. M. Yoklavich, ed. NOAA-NMFS Technical Memo #XX.

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.

Hixon, M.A. and M.H. Carr. 1997. Synergistic predation causes density-dependent mortality in marine fish. *Science* **277**:946-949.

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

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

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.

Carr, M.H. 1989. Effects of macroalgal assemblages on the recruitment of temperate zone reef fishes. *Journal of Experimental Marine Biology and Ecology* **126:**59-76.

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

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

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

Education:

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

Positions:

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

Selected Publications:

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

Page, H.M., J.E. Dugan, D.S. Dugan, and J. Richards. 1999. 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.

Barron, MG, T. Podrabsky, R.S. Ogle, J.E. Dugan, and others. 1999. Sensitivity of the mysid *Mysidopsis bahia* to a weathered oil. *Bull. Environmental Contamination & Toxicology* **62**:266-271.

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

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. 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.

GRAHAM E. FORRESTER
Department of Biological Sciences
University of Rhode Island
Kingston, RI

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

Education:

B.S.	Zoology, University College of Wales, Aberystwyth, U.K.	1985
M.S.	Zoology, University of Sydney, Australia	1988
Ph.D.	Zoology, University of New Hampshire	1992

Positions:

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

Distinctions:

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

Selected Publications:

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

Holbrook, S. J., G. E. Forrester and R. J. Schmitt. Spatial patterns in abundance of damselfish reflect availability of suitable habitat. *Oecologia*.

Forrester, G. E. and M. A. Steele. Variation in the presence and cause of density-dependent mortality in three species of reef fishes. *Ecology*.

Forrester, G. E., T. L. Dudley and N. B. Grimm. 1999. Trophic interactions in open systems: influences of predators and nutrients on food chains in streams. *Limnology and Oceanography* **44**:1187-1197.

Malone, J. M., G. E. Forrester and M. A. Steele. 1999. Effects of subcutaneous microtags on the growth, survival and vulnerability to predation of small reef fishes. *Journal of Experimental Marine Biology and Ecology* **237**:243-253.

Forrester, G. E. 1999. The influence of adult density on the settlement of larval coral reef fish. *Coral Reefs* **18**:85-89.

Steele, M. A., G. E. Forrester and G. R. Almany. 1998. Interactive effects of predators and conspecific density on recruitment patterns in three reef fishes. *Marine Ecology Progress Series* **172**:115-125.

O'Bryan, L.M. and G.E. Forrester. 1997. Effects of fish presence and moonlight gradients on nighttime horizontal movements of a predatory zooplankter (*Chaoborus punctipennis*). *Journal of Plankton Research* **19:**1441-1453.

Forrester, G.E. 1995. Strong density-dependent survival and recruitment regulate the abundance of a coral reef fish. *Oecologia*. **103:**275-182.

Douglas, P.L., G.E. Forrester, and S.D. Cooper. 1994. Effects of trout on the diel periodicity of drifting in baetid mayflies. *Oecologia* **98**:48-56.

Forrester, G. E. 1994. Influences of predatory fish on drift dispersal and local density of stream insects. *Ecology* **75:**1208-1222.

Forrester, G.E. 1994. Changes in diel patterns of drift behavior by mayflies under the risk of trout predation: Variation in response among taxa. *Canadian Journal of Fisheries and Aquatic Sciences* **51**:2549-2557.

Forrester, G.E., J.G. Chace, and W. McArthy. 1994. Diel and density-related changes in food consumption and pre selection by brook trout in a New Hampshire stream. *Environmental Biology of Fishes* **39**:310-311.

Sale, P.F., G.E. Forrester, and P.S. Levin. 1994. The fishes of coral reefs-ecology and management. *National Geographic Research and Exploration* **10**:224-235.

Forrester, G.E. 1991. Social status, individual size and group composition as determinants of food consumption by humbug damselfishes. *Animal Behaviour* **42**:701-711.

Forrester G. E. 1990. Factors influencing the juvenile demography of a coral-reef fish. *Ecology* **71**:1666-1681.

STEVEN D. GAINES

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

Project: *Application of Coastal Ocean Dynamics Radars for Observation of Near-Surface Currents off the South-Central California Coast*

Education:

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

Positions:

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

Research Interests:

Larval ecology, interactions between ocean physics and larval dispersal, population and community ecology of marine species.

Selected Publications:

Bertness, M.D., S.D. Gaines, and S.M. Yeh. 1998. Making mountains out of barnacles: the dynamics of hummock formation. *Ecology* **79:**1382-1394.

Hacker, S. and S.D. Gaines. 1997. Some implications of direct positive interactions for community species diversity. *Ecology* **78:**1990-2003.

Worcester, S. and S.D. Gaines. 1997. Quantifying hermit crab recruitment rates and larval shell selection on wave swept shores. *Marine Ecology Progress Series* **157***:307-310.*

Bertness, M., S.D. Gaines, and R. Wahle. 1996. Wind-driven settlement patterns in the acorn barnacle, *Semibalanus balanoides. Marine Ecology Progress Series* **137**:103-110.

Gaines, S.D. 1995. Modeling the dynamics of marine species: the importance of incorporating larval dispersal. Pp. 389-423 in: *Ecology of Marine Invertebrate Larvae*, Larry McEdward, ed. CRC Press.

Gaines, S.D. and M. Bertness. 1994. Does variable transport general variable settlement in coastal and estuarine species? Pp. 315-322 in: *Changes in Fluxes in Estuaries: Implications from Science to Management,* K. Dyer and R. Orth, eds. Olsen and Olsen, London.

Rice W.R. and S.D. Gaines. 1994. The ordered-heterogeneity test. *Biometrics* **50:**1-7.

Rice, W.R. and S.D. Gaines. 1994. Heads I win, tails you lose: testing directional alternative hypotheses in ecological and evolutionary research. *Trends in Ecology and Evolution* **9**:235-237.

Rice, W.R. and S.D. Gaines. 1994. Extending nondirectional heterogeneity tests to evaluate simply ordered alternative hypotheses. *Proceedings of the National Academy of Sciences* **91**:225:226.

Sanford, E., E. Bermudez, M. Bertness, and S.D. Gaines. 1994. Flow, food supply, and the population dynamics of acorn barnacles. *Marine Ecology Progress Series* **104**:49-62.

Bertness, M. and S.D. Gaines. 1993. Larval dispersal and local adaptation in acorn barnacles. *Evolution* **47**:316-320.

Gaines, S.D. and M. Bertness. 1993. The dynamics of juvenile dispersal: Why field ecologists must integrate. *Ecology* **74**:2430-2435.

Gaines, S.D. and M. Denny. 1993. The largest, smallest, highest, lowest, longest, and shortest: Extremes in ecology. *Ecology* **74**:1677-1692.

Rice, W.R. and S.D. Gaines. 1993. Calculating P-values for ANOVA with unequal variances. *Journal of Statistical Computation and Simulation* **46**:19-22.

Bertness, M., S.D. Gaines, E. Stephens, and P. Yund. 1992. Components of recruitment in populations of the acorn barnacle. *Semibalanus balanoides*. *Journal of Experimental Marine Biology and Ecology* **156**:199-215.

Gaines, S.D. and M. Bertness. 1992. Dispersal of juveniles and variable recruitment in sessile marine species. *Nature* **360**:579-580.

Bertness, M., S.D. Gaines, D. Bermudez, and E. Sanford. 1991. Extreme spatial variation in the growth and reproductive output of the acorn barnacle *Semibalanus balanoides. Marine Ecology Progress Series* **75:**91-100.

Yund, P., S.D. Gaines, and M. Bertness. 1991. Cylindrical tube traps for sampling larvae. *Limnology and Oceanography* **36**:1167-1177.

Denny, M. and S.D. Gaines. 1990. On the prediction of maximum intertidal wave forces. *Limnology and Oceanography* **35**:1-15.

Gaines, S.D. and W.R. Rice. 1990. Analysis of biological data with ordered expectations. *American Naturalist* **135**:310-317.

ROBERT T. GUZA
Scripps Institution of Oceanography
University of California
San Diego, CA

Project: *Wave Prediction in the Santa Barbara Channel*

Education:	B.A.	Physics, Johns Hopkins University	1969
	M.S..	Oceanography, University of California, San Diego	1971
	Ph.D.	Oceanography, University of California, San Diego	1974

Positions:	1994-present	Director, Center for Coastal Studies, University of California, San Diego
	1975-present	Professor of Oceanography, Scripps Institution of Oceanography, University of California, San Diego
	1974-75	PostDoctoral Fellow, Dalhousie University, Halifax, Nova Scotia

Awards:	1996	Steinbach Schole (WHOI)
	1990,1994	AGU citation for excellence in refereeing
	1993	AGU Fellow
	1991	Outstanding Journal Paper Award, Amer. Soc. Civil Eng., Ocean Division

Selected Publications:

Feddersen, F., R. T. Guza, S. Elgar, and T.H.C. Herbers. Alongshore bottom stress parameterizations. *J. Geophys. Res*.

Sheremet, A., and R. T. Guza. 1999. A weakly dispersive edge wave model. *Coastal Engineering* **38**:47-52.

Raubenheimer, B., R. T. Guza, and S. Elgar. 1999. Tidal water table fluctuations in a sandy ocean beach. *Water Res. Res*. **35**:2313-2320.

Lentz, S., R. T. Guza, S. Elgar, F. Feddersen, and T.H.C. Herbers. 1999. Momentum balances on the North Carolina Inner Shelf. *J. Geophys. Res*. **104**:18,205-18,226.

Chen, Y., and R. T. Guza. 1999. Resonant scattering of edge waves by longshore periodic topography: finite beach slope. *J. Fluid Mech.* **387**:255-269.

Herbers, T.H.C., S. Elgar, and R. T. Guza. 1999. Directional spreading of waves in the nearshore. *J. Geophys. Res.-Oceans* **104**:7683-7693.

Chen, Y., and R. T. Guza. 1998. Resonant scattering of edge waves by longshore periodic topography. *J. Fluid Mech*. **369**:91-123.

Feddersen, F., R. T. Guza, S. Elgar, and T.H.C. Herbers. 1998. Alongshore momentum balances in the nearshore. *J. Geophys. Res.* **103**:15,667-15,676.

Raubenheimer, B., S. Elgar, and R. T. Guza. 1998. Estimating wave heights from pressure measured in sand bed. *J. Waterway, Port, Coastal, and Ocean Eng.* **124:**151-154.

Gallagher, E. L., S. Elgar, and R. T. Guza. 1998. Observations of sand bar evolution on a natural beach. *J. Geophys. Res.* **103**:3203-3215.

O'Reilly, W. C., and R. T. Guza. 1998. Assimilating coastal wave observations in regional swell predictions. Part 1: Inverse methods. *J. Phys. Oceanogr.* **28***:* 679-691.

Chen, Y., R. T. Guza, and S. Elgar. 1997. Modeling spectra of breaking surface waves in shallow water. *J. Geophys. Res.*, **102:**25,035-25,046.

Elgar, S., R. T. Guza, B. Raubenheimer, T.H.C. Herbers, and E. L. Gallagher. 1997. Spectral evolution of shoaling and breaking waves on a barred beach. *J. Geophys. Res.* **102:**15,797-15,805.

Vanhoff, B., S. Elgar, and R. T. Guza. 1997. Numerically simulating nonGaussian sea surfaces. *J. Waterway, Port, Coastal, and Ocean Eng.* **123**:68-72.

Raubenheimer, B., R.T. Guza, and S. Elgar. 1996. Wave transformation across the inner surf zone. *J. Geophys. Res.* **101**:25,589-597.

Raubenheimer, B. and R.T. Guza. 1996. Observations and predictions of run-up. *J. Geophys. Res* .**101:**25,575-587.

Okihiro, M. and R.T. Guza. 1996. Observations of seiche forcing and amplification in three small harbors. *J. Waterway, Port, Coastal and Ocean Eng.* **122:**232-238.

Gallaher, E.L., W. Boyd, S. Elgar, R.T. Guza, and B. Woodward. 1996. Performance of a sonar altimeter in the nearshore. *Marine Geology* **133:**241-248.

Herbers, T.H.C., S. Elgar, and R.T. Guza. 1995. Generation and propagation of infragravity waves. *J. Geophys. Res.* **100:**24,863-872.

O'Reilly, W.C., T.H.C. Herbers, R.J. Seymour, and R.T. Guza. 1996. A comparison of directional buoy and fixed platform measurements of Pacific swell. *J. Atmos. Ocean. Technol.* **13:**231-238.

Okihiro, M. and R.T. Guza. 1995. Infragravity energy modulation by tides. *J. Geophys. Res.* **100**:16,143-16,148.

Raubenheimer, B., R.T. Guza, S. Elgar, and N. Kobayashi. Swash on a gently sloping beach. *J. Geophys. Res.* **100:**8751-8760.

Elwaney, MH.S., W.C. O'Reilly, R.T. Guza, and R.E. flick. 1995. Effects of southern California kelp beds on waves. *J. Waterway, Port, Coastal, and Ocean Eng.* **121:**143-150.

Holland, K.T., B. Raybenheimer, R.T. Guza, and R.A. Holman. 1995. Runup kinematics on a natural beach. 1995. *J. Geophys. Res.* **100:**4985-4993.

Elgar, S., T.H.C. Herbers, V. Chandran, and R.T. Guza. 1995. Higher-order spectral analysis of nonlinear ocean surface gravity waves. *J. Geophys. Res.* **100:**4977-4983.

Herbers, T.H.C., S. Elgar, R.T. Guza, and W.C. O'Reilly. 1995. Infragravity-frequency (o.005-0.05Hz) motions on the shelf, Part II: Free waves. *J. Geophys. Res.* **25:**Part 1,1063-1079.

Herbers T.H.C., and R.T. Guza. 1994. Nonlinear wave interactions and high-frequency seafloor pressure. *J. Geophys. Res.* **99:**10,035-10,048.

Elgar, S., T.H.C. Herbers, and R.T. Guza. 1994. Reflection of ocean surface gravity waves from a natural beach. *J. Phys. Oceanogr.* **24:**1503-1511.

Okihiro, M., R.T. Guza, and R.J. Seymour. 1993. Excitation of seiche observed in a small harbor. *J. Geophys. Res.* **98:**201-211.

George, R., R.E. Flick, and R.T. Guza. 1994. Observations of turbulence in the surf zone. *J. Geophys. Res.* **99:**801-810.

Elgar, S., R.T. Guza, and M.H. Freilich. 1993. Observations of nonlinear interactions in directionally spread shoaling surface gravity waves. *J. Geophys. Res.* **98:**20,299-20,305.

Herbers, T.H.C. and R.T. Guza. 1993. Comment on "Velocity observations above a rippled bed using laser doppler velocimety" by U.X. Agrawal and D.G. Aubrey. *J. Geophys. Res.* **98:**20,331-20,333.

W. MICHAEL HANEMANN

Department of Agricultural and Resource Economics
University of California
Berkeley, CA

Project: *Testing and Calibrating the Measurement of Nonmarket Values for Oil Spills Via the Contingent Valuation Method*

Education:	B.A.	Philosophy, Politics, and Economics, Oxford University, England	1965
	M.Sc.	Development Economics, London, School of Economics	1967
	M.A.	Public Finance and Decision Theory, Harvard University	1973
	Ph.D.	Economics, Harvard University	1978

Positions:	1995-present	Professor, Department of Agricultural and Resource Economics, University of California, Berkeley
	1984-1995	Associate Professor, Department of Agricultural and Resource Economics, University of California, Berkeley
	1978-1984	Assistant Professor, Department of Agricultural and Resource Economics, University of California, Berkeley
	1976-1978	Acting Assistant Professor, Department of Agricultural and Resource Economics, University of California, Berkeley.
	1976	Lecturer, Department of Economics, Northeastern University, Boston, Massachusetts
	1970-75	Staff Economist/Consultant, Urban Systems Research & Engineering, Inc., Cambridge, Massachusetts
	1970-75	Teaching Fellow, Department of Economics, Harvard University
	1967-68	Assistant to the Director, Unit for Economic and Statistical Studies on Higher Education, London School of Economics

Selected Publications:

Hanemann, W.M. and B. Kanninen. 1999. The statistical analysis of discrete-response. In: *Valuing the Environment Preferences: Theory and Practice of the Contingent Valuation Method in the US, EU and Developing Countries*, I. Bateman and K.G. Willis, eds. Oxford University Press.

Hanemann, W.M. 1999. The economic theory of WTP and WTA. In: *Valuing the Environment Preferences: Theory and Practice of the Contingent Valuation Method in the US, EU and Developing Countries*, I. Bateman and K.G. Willis, eds. Oxford University Press.

Carson, R, N.E. Flores, and W.M. Hanemann. 1998. Sequencing and valuing public goods. *Journal of Environmental Economics and Management*. **36**:314-323.

Carson, RT; WM Hanemann, RJ Kopp, JA Krosnick, and others. 1998. Referendum design and contingent valuation: The NOAA panel's no-vote recommendation. *Review of Economics and Statistics* **80**:335-338.

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Hanemann, W.M. 1998. Price and rate structures. Pp. 137-179, chapter 5 in: *Urban Water Demand Management and Planning,* D. Baumann, J. Boland, and M. Hanemann, eds. New York: McGraw-Hill.

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Hanemann, W.M. and K. Bengt. 1994. Preference uncertainty, optimal designs and spikes. In: *Advances in Environmental Economics*, Per-Olov Johansson, ed. Manchester University Press, England.

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Fisher, A.C. and W.M. Hanemann. 1993. Assessing climate change risks: Valuation of effects. In: *Assessing Climate Change Risks*, J. Darmstadter, ed. Resources for the Future, DC.

Hanemann, W.M. 1993. Economic impact on ocean fishing. Pp. 107-112 in: *Integrated Modeling of Drought and Global Warming, Impacts on Selected California Resources.* National Institute for Global Environmental Change, University of California, Davis.

Hanemann, W.M. and R. McCann. 1993. Economic impacts on the Northern California hydropower system. Pp. 55-68 in: *Integrated Modeling of Drought and Global Warming, Impacts on Selected California Resources.* National Institute for Global Environmental Change, University of California, Davis.

SALLY J. HOLBROOK
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Project: *An Experimental Evaluation of Methods of Surfgrass (Phyllospadix torreyi) Restoration Using Early Life History Stages*

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:

Holbrook, S.J., Forrester, G.E. and R.J. Schmitt. 1999. Spatial patterns in abundance of a damselfish reflect availability of suitable habitat. *Oecologia*.

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.

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Schmitt, R.J. and S.J. Holbrook. 1990. Contrasting effects of giant kelp on dynamics of surfperch populations. *Oecologia* **84**:419-429.

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

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

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

Selected Peer-reviewed Publications: (Last 5 years)

Keller EA, L Gurrola, and TE Tierney. 1999. Geomorphic criteria to determine direction of lateral propagation of reverse faulting and folding. *Geology* **27**:515-518.

Pinter N, SB Lueddecke, EA Keller, and KR Simmons. 1998. Late Quaternary slip on the Santa Cruz Island fault, California. *Geological Society of America Bulletin* **110**:711-722.

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Department of Psychology
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Project: *Testing and Calibrating the Measurement of Nonmarket Values for Oil Spills Via the Contingent Valuation Method*

Education:	A.B.	Psychology (Magna Cum Laude), Harvard University	1980
	M.A.	Social Psychology (with Honors), University of Michigan	1983
	Ph.D.	Social Psychology, University of Michigan	1986

Positions:	1986-present	Assistant to Associate to Full Professor, Departments of Psychology and Political Science, The Ohio State University.
	1987-1989	Lecturer, Survey Research Center Summer Program in Survey Research Techniques, University of Michigan.
	1986-87	Visiting Scholar, Survey Research Center, Institute for Social Research, University of Michigan.
	1985	Lecturer, Department of Psychology, The Ohio State University
	1982-85	Research Assistant, Center for Political Studies and Survey Research Center. Institute for Social Research. University of Michigan.
	1980-81	Senior Research Assistant, Department of Psychology, Harvard University
	1979-81	Senior Research Assistant, Department of Behavioral Sciences, School of Public Health, Harvard University

Selected Publications:

Krosnick, J.A., and L.R. Fabrigar. *Designing good questionnaires: Insights from cognitive and social psychology*. New York: Oxford University Press. .

Bassili, J.N. and J.A. Krosnick. Does attitude strength moderate susceptibility to response effects? New evidence using response latency, attitude extremity, aggregate indices, and continuous measures. *Political Psychology*.

Holbrook, A. L., G.Y. Bizer, and J.A. Krosnick. Political behavior of the individual. In: *Encyclopedia of Psychology*, A.E. Kazdin, ed. Washington, DC, and New York, NY: American Psychological Association and Oxford University Press.

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Visser, P. S., J.A. Krosnick, and P. Lavrakas. Survey research methods. In: *Handbook of research methods in social psychology*, H. T. Reis and C. M. Judd, eds. New York: Cambridge University Press.

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Krosnick, J. A. 1999. Survey methodology. *Annual Review of Psychology* **50**:537-567.

Miller, J. M., and J.A. Krosnick. 1998. The impact of candidate name order on election outcomes. *Public Opinion Quarterly* **62**:291-330.

Visser, P. S., and J.A. Krosnick. 1998. Development of attitude strength over the life cycle: Surge and decline. *Journal of Personality and Social Psychology* **75**:1389-1410.

Miller, J. M., J.A. Krosnick, 1997. The anatomy of the priming effect. In: *Do the media govern?: Politicians, voters, and reporters in America*, S. Iyengar and R. Reeves, eds. Thousand Oaks, CA: Sage.

Carson, R.T., W.M. Hanemann, R.J. Kopp, J.A. Krosnick, R.C. Mitchell, S. Presser, P.A. Ruud, and V.K. Smith, with M. Conaway and K. Martin. 1997. Temporal reliability of estimates from contingent valuation. *Land Economics* **73:**151-163.

Krosnick, J.A. and L.R. Fabrigar. 1997. Designing rating scales for effective measurement in surveys. In: *Survey Measurement and Process Quality*, L. Lyberg, M. Collins, L. Decker, E. Deleeuw, C. Dippo, N. Schwarz, and D. Trewing eds. New York: Wiley-Interscience.

Krosnick, J.A., S.S. Narayan, and W.R. Smith. 1996. Satificing in surveys: Initial evidence. Pp. 29-44 in: *Advances in Survey Research,* M.T. Braverman and J. K. Slater eds. San Francisco: Jossey-Bass.

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Visser, P.S., J.A. Krosnick, J. Marquette, and M. Curtin. 1996. Mail surveys for election forecasting - an evaluation of the Columbus Dispatch poll. *Public Opinion Quarterly* **60**:181-227.

Narayan, S. and J.A. Krosnick. 1996. Education moderates some response effects in attitude measurement. *Public Opinion Quarterly* **60**:58-88.

Boninger, D.S., J.A. Krosnick, and M.K. Berent. 1995. Origins of attitude importance: Self-interest, social identification and value relevance. *Journal of Personality and Social Psychology* **68**:61-80.

Fabrigar, L.R. and J.A. Krosnick. 1995. Attitude importance and the false consensus effect. *Personality and Social Psychology Bulletin* **21**:468-479.

Petty, R.E. and J.A. Krosnick, eds. 1995. *Attitude Strength: Antecedents and Consequences.* Erlbaum, Lawrence Assoc., Mahwah, NJ. 510p.

Weisberg, H.F., A.A. Haynes, and J.A. Krosnick. 1995. Social group polarization in 1992. In: *Democracy's Feast: Election in America*, H. F. Weisberg, ed. Chatham House, Chatham, NJ.

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

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

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

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.*

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McGinnis, M.V. 1990. *The multiple uses of the ocean and coastal zone offshore California*. California Sea Grant Publication, Working Paper P-T-51. California Sea Grant College Program, CA.

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Project: *Assessing Toxic Effects on Population Dynamics Using Individual-Based Energy Budget Models*

Education:	B.S.	Biology, Vrije Universiteit, Amsterdam, The Netherlands	1986
	M.S.	Biology, Vrije Universiteit, Amsterdam, The Netherlands	1988
	Ph.D.	Biology, Vrije Universiteit, Amsterdam, The Netherlands	1994

Positions:	1997-present	Assistant Research Biologist, Marine Science Institute, University of California, Santa Barbara
	1995-97	Postdoctoral Researcher, Marine Science Institute, University of California, Santa Barbara
	1992-93	Postdoctoral Researcher, TNO Institute of Environmental Sciences, Vrije Universiteit, The Netherlands

Selected Publications:

Muller, E.B. and R.M. Nisbet. Sublethal effects of toxicants: a dynamic energy budget modeling approach compared to experimental results. *Ecological Applications.*

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

Muller, E.B. and R.M. Nisbet. 1997. Modeling the effect of toxicants on the parameters of dynamic energy budget models. Pp. 71-81 in: *Environmental Toxicology and Risk Assessment: Modeling and Risk Assessment* (Sixth Volume), F. J. Dwyer, T.R. Doane and M.L. Hinman, eds., American Society for Testing and Materials.

Van Verseveld, H.W., E.B. Muller, and P. Groeneveld. 1996. Fast determination of residual substrate in a fermentor. Why should it be fast and how can this be done. Pp. 422-427 in: *Biothermokinetics of the Living Cell,* Westerhoff, Snoep, Sluse, Wijker, Kholodenko, eds.

Muller, E.B., A.H. Stouhamer, and H.W. van Verseveld. 1995. Simultaneous NH3 oxidation and N2 production at reduced O2 tensions by sewage sludge subcultured with chemolithotrophic medium. *Biodegradation* **6**:339-349.

Muller, E.B., A.H. Stouthamer, and H.W. van Verseveld. 1995. A novel method to determine maximal nitrification rates by sewage sludge at a non-inhibitory nitrite concentration applied to determine maximal rates as a function of the nitrogen load. *Wat. Res*. **29**:1191-1197.

Muller, E.B. A.H. Stouthamer, H.W. van Verseveld, and D.H. Eikelboom. 1995. Aerobic domestic waster water treatment in a pilot plant with complete sludge retention by cross-flow filtration. *Wat. Res*. **29**:1179-1189.

Muller, E.B. 1994. Bacterial energetics in aerobic wastewater treatment, Ph.D. thesis, Vrije Universiteit, Amsterdam, The Netherlands.

Kooijman, S.A.L.M., E.B. Muller, and A.H. Stouthamer. 1991. Microbial growth dynamics on the basis of individual budgets. *Antonie van Leeuwenhoek* **60**:159-174.

ROGER NISBET
Department of Ecology, Evolution and Marine Biology
University of California
Santa Barbara, CA

Project:	*Assessing Toxic Effects on Population Dynamics Using Individual-Based Energy Budget Models*		
Education:	B.Sc.	Physics and Theoretical Physics, University of St. Andrews	1968
	Ph.D.	Theoretical Physics, University of St. Andrews	1971
Positions:	1995-present	Vice Chair, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara	
	1991-present	Professor, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara	
	1989-1991	Professor, Department of Statistics and Modeling Science, University of Strathclyde, Scotland	
	1985-1989	Personal Professor in Applied Physics, University of Strathclyde. [1986-88 Chair, Department of Physics and Applied Physics, University of Strathclyde]	
	1985	Visiting Research Biologist, University of California, Santa Barbara	
	1983-1985	Reader in Applied Physics, University of Strathclyde	
	1977-79	Seconded from Strathclyde to University of the South Pacific, Suva, Fiji, as Senior Lecturer in School of Natural Resources	
	1972-1977	Lecturer in Applied Physics, University of Strathclyde	
Distinctions:	1991	Elected Fellows of the Royal Society of Edinburg	
	1987	Van De Klaauw Chair in Biology, University of Leiden, The Netherlands	
	1971-72	Nuffield Biological Scholarship	
	1968-71	Carnegie Scholarship	

Research Interests:

After Ph.D. research in statistical physics, Nisbet's main research interest since 1972 has been ecological modeling. Recent work has emphasized *individual-based population models* which aim to relate population dynamics to the physiology and behavior of individual members of a population; in particular methods for formulating tractable models of stage structured populations. These (and other) methods have been applied to the study of fluctuations in zooplankton populations, to investigations of stability and fluctuations in host-parasitoid systems, and to an investigation of the effects of toxicants on the dynamics of mussel populations. Individual-based and more traditional population models are being used in studies of population response to different forms of ecological stress. Over 90 refereed publications including one book and one monograph.

Selected Publications:

De Roos, A.M., E. McCauley, R.M. Nisbet, W.S.C. Gurney, and W.W. Murdoch. What individual life histories can (and cannot) tell about population dynamics. *Aquatic Ecology.*

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

Kendall, BE; Briggs, CJ; Murdoch, WW; Turchin, P; and others. 1999. Why do populations cycle? A synthesis of statistical and mechanistic modeling approaches. *Ecology* **80**:1789-1805.

Briggs, CJ, R.M. Nisbet, and W.W. Murdoch. 1999. Delayed feedback and multiple attractors in a host-parasitoid system. Journal of Mathematical Biology **38**:317-345.

Nisbet, RM; de Roos, AM; Wilson, WG; Snyder, RE. 1998. Discrete consumers, small scale resource heterogeneity, and population stability. *Ecology Letters* **1**:34-37.

Murdoch, WW, RM Nisbet, E McCauley, AM deRoos, and others. 1998. Plankton abundance and dynamics across nutrient levels: Tests of hypotheses. *Ecology* **79**:1339-1356.

Noonburg, EG, RM Nisbet, E McCauley, and WSC Gurney. 1998. Experimental testing of dynamic energy budget models. *Functional Ecology* **12**:211-222.

Gurney, WSC and RM Nisbet. 1998. *Ecological Dynamics*. New York, Oxford University Press. 385 p.

Nisbet. R.M., S. Diehl, W.G. Wilson, S.D.Cooper, D.D. Donalson, and K. Kratz. 1997. Primary productivity gradients and short-term population dynamics in open systems, *Ecological Monograph* **67**:535-553.

Wilson, W.G. and R.M. Nisbet. 1997. Cooperation and competition along smooth environmental gradients, *Ecology* **78**:2004-2017.

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

Murdoch, W.W., C.J. Briggs, and R.M. Nisbet. 1997. Dynamical effects of host-size and parasitoid state-dependent attacks by parasitoids. *Journal of Animal Ecology* **66**:542-556.

Muller, E.B. and R.M. Nisbet. 1997. Modeling the effect of toxicants on the parameters of dynamic energy budget models. Pp. 71-81 in: *Environmental Toxicology and Risk Assessment: Modeling and Risk Assessments* (Sixth Volume) F. James Dwyer, Thomas R. Doane, and Mark L. Hinman, Eds., American Society for Testing and Materials.

Nisbet, R.M. 1997. Delay differential equations for structured populations. Pp. 89-118 in: *Structured Population Model,* H. Caswell and S. Tuljapurkar Eds. Chapman and Hall.

Middleton, D.A.J. and R.M. Nisbet. 1997. Population persistence time: estimates, models, mechanisms. *Ecological Applications* **7**:107-117.

Gurney, W.S.C., D.A.J. Middleton, R.M. Nisbet, E. McCauley, W.W. Murdoch, and A.M. DeRoos. 1996. Individual energetics and the equilibrium demography of structured populations. *Theor. Pop. Biol.* **49**:344-368.

McCauley, E., R.M. Nisbet, A.M. DeRoos, W.W. Murdoch, and W.S.C. Gurney. 1996. Structured population models of herbivorous zooplankton. *Ecological Monographs* **66**:479-501.

Murdoch, W.W., C.J. Briggs and R.M. Nisbet. 1996. Competitive displacement and biological control in parasitoids - a model. *American Naturalist* **148**:807-826.

Nisbet, R.M., W.W. Murdoch, and A. Stewart-Oaten. 1996. Consequences for adult-fish stocks of human-induced mortality of immatures. Pp. 257-277 in: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats*, R.J. Schmitt and C.W. Osenberg, Eds. Academic Press, San Diego, CA.

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

Nisbet, R.M. and S.N. Wood. 1996. Estimation of copepod mortality rates. *Ophelia* **44**:157-169.

Shea, K., R.M. Nisbet, W.W. Murdoch, and H.J. Yoo. 1996. The effect of egg limitation in insect host-parasitoid population models. *J. Anim. Ecol.* **65**:743-755.

Wilson, W.G., R.M. Nisbet, A.H. Ross, C. Robles, and R. Desharnais. 1996. Abrupt population changes along slowly varying environmental gradients. *Bulletin of Mathematical Biology* **58**:907-922.

WILLIAM C. O'REILLY
Department of Civil and Environmental Engineering
University of California, Berkeley

Project: *Wave Prediction in the Santa Barbara Channel*

Education:	B.S.	Civil Engineering, University of Michigan	1983
	B.S.	Environmental Eng., University of Michigan	1983
	M.S.	Oceanography, University of California, San Diego	1985
	Ph.D.	Oceanography, University of California, San Diego	1991

Positions:	1997-	Visiting Lecturer, Civil and Environmental Engineering, University of California, Berkeley
	1996-	Research Assistant Professor, Department of Oceanography, Naval Postgraduate School, Monterey
	1993-	Development Engineer, Scripps Institution of Oceanography, University of California, San Diego
	1991-93	Visiting Scholar, Civil Engineering Department, University of California, Berkeley
	1991-93	Post-Doctoral Researcher, Scripps Institution of Oceanography, University of California, San Diego
	1984-91	Research Assistant, Scripps Institution of Oceanography, University of California, San Diego

Awards:	1990	Olin Mark Award, American Shore and Beach Preservation Association.

Publications:

O'Reilly W. C., R. T. Guza, and R. J. Seymour. 1999. Wave Prediction in the Santa Barbara Channel, Proc. 5th California Islands Symposium, Mineral Management Service, Santa Barbara CA , March 29-31, 1999, In press.

O'Reilly W. C., and R. T. Guza, 1998, Assimilating coastal wave observations into regional swell predictions. Part I: Inverse methods. *J. of Phys. Oceanogr.* **28:**679-691.

Kaihatu, J. M., W.E. Rogers, Y.L. Hsu, and W. C. O'Reilly. 1998. Use of Phase-Resolving Numerical WaveModels in Coastal Areas, WAM Validation of Pacific Swell, Proc. 5th International Workshop on WaveHindcasting and Forecasting, Melbourne FL, January 26-30, 1998, 389-403.

Wittmann P. A., and W. C. O'Reilly. 1998. WAM Validation of Pacific Swell, Proc. 5th International Workshopon Wave Hindcasting and Forecasting, Melbourne FL, January 26-30, 1998, 83-87.

O'Reilly, W.C. and R.T. Guza. 1996. Assimilating coastal wave observations into regional swell predictions. Part I: Inverse methods, submitted to *J. of Phys. Ocean*.

O'Reilley, W.C., T.H.C. Herbers, R.J. Seymour, and R.T. Guza. 1996. A comparison of directional buoy and fixed platform measurements of Pacific swell. *J. of Atmos. And Oceanic Technology* **13:**231-238.

Elwany. M.H.S., W.C. O'Reilly, R.T. Guza, and R.E. Flick. 1995. Effects of Southern California kelp beds on waves. *J. of Waterway, Port, Coastal, and Ocean Engineering* **12:**143-150.

Herbers. T.H.C., S. Elgar, R.T. Guza, and W.C. O'Reilly. 1995. Infragravity-frequency (0.005-0.05 Hz) motions on the shelf. Part II: Free Waves. *J. Phys. Oceanogr.* **25:**1063-1079.

Seymour, R.J., D. McGehee, D. Castel, J. Thomas, and W.C. O'Reilly. 1993. New Technology in Coastal Wave Monitoring. P.p. 105-123 in: *Ocean Wave Measurement and Analysis, Proc. Of 2nd International Symposium*, New Orleans, LA .

O'Reilly, W.C., R.J. Seymour, R.T. Guza, and D. Castel. 1993. Wave monitoring in the Southern California Bight. Pp. 849-863 in: *Ocean Wave Measurement and Analysis,,,, Proc. Of 2nd International Symposium*, New Orleans, LA.

O'Reilly, W.C. 1993. The southern California wave climate: effects of islands and bathymetry, *Shore and Beach* **61:**14-19.

O'Reilly, W.C. and R.T. Guza. 1993. A comparison of spectral wave models in the Southern California Bight, *Coastal Engineering* **19:**263-282.

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O'Reilly, W.C. 1991. Modeling surface gravity waves in the Southern California Bight. *Ph.D. Dissertation*, Scripps Institution of Oceanography, La Jolla, CA, 90 pp.

O'Reilly, W.C. and R.T. Guza. 1991. Comparison of spectral refraction and refraction-diffraction wave models. *J. of Waterway, Port, Coastal, and Ocean Engineering* **117:**199-215.

O'Reilly, W.C. 1989. Modeling the storm waves of January 17-18, 1988. *Shore and Beach* **57:**32-36.

Munk, W.H, W.C. O'Reilly, and J. L. Reid. 1988. Australia-Bermuda sound transmission experiment (1960) revisited. *J. of Phys. Ocean.* **18:**1876-1898.

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

Projects:	*Effects of Produced Water on Complex Behavior Traits of Invertebrate Larvae and Algal Zoospores*		
	Effects of Temporal and Spatial Separation of Samples on Estimation of Impacts		
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:

Carr MH, and PT Raimondi. 1999. Marine protected areas as a precautionary approach to management. CALCOFI reports.

Reed DC, MH Carr, L Goldwasser and PT Raimondi. Role of dispersal potential in determining the spatial structure of an assemblage of sedentary marine organisms. *Ecology*. In press.

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

Raimondi PT and S Forde. Processes structuring communities: evidence for trait mediated interactions through induced polymorphisms. *Ecology*. In press.

Raimondi PT and ANC Morse. Complex larval behavior and the vertical distribution and orientation of *Agaricia humilis* (Scleractinia). *Ecology*.

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* **16-6**:1218-1228.

Altstatt, 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: *An Experimental Evaluation of Methods of Surfgrass (Phyllospadix torreyi) Restoration Using Early Life History Stages*

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:

Holbrook, S.J., Reed, D.C., Hansen, K. and Blanchette, C.A. Spatial and temporal patterns of predation on seeds of surfgrass, *Phyllospadix torreyi*.

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

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.

Neushul, 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

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

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
	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. Habitat-limited recruitment of coral reef damselfish. Submitted manuscript.

Holbrook, S.J., Forrester, G.E. and R.J. Schmitt. 1999. Spatial patterns in abundance of a damselfish reflect availability of suitable habitat. *Oecologia*, In press.

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.

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. 151-169 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.

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Selected Publications:

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