KELP BED RESOURCES OF THE CALIFORNIA COAST

Establishing a Research Agenda

Summary of a Sea Grant Workshop

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Summary of a Workshop
Sponsored by the California Sea Grant College
May 27, 1992
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Susan L. Williams, Editor

San Diego State University

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INTRODUCTION

A two-day subject area meeting was organized by the California Sea Grant College on May 27-28, 1992 to consider critical research needs in the Living Marine Resources subject area.

Presentations and discussions on the first day of the meeting focused on research associated with the living resources of kelp forests, a rich and complex community that occurs along much of the California coast. These discussions were led by Susan L. Williams of San Diego State University, who is California Sea Grant's subject area coordinator for Coastal Ocean Research. Abalone and sea urchins, which form the basis of important commercial fisheries within the state, were subjects of particular concern.

This meeting grew out of related workshops conducted earlier by California Sea Grant. As early as October 1988, the Sea Grant Extension Program and the California Department of Fish and Game had jointly organized a meeting on the disease afflicting black abalone, known as "withered foot." Because the disease continued to spread, this was followed by a major conference in Santa Barbara in September 1991, organized by John B. Richards, area marine advisor, Carrie Culver, program representative, and Chris Dewees, marine fisheries specialist for the Sea Grant Extension Program. This conference had the strong support of the California Abalone Association and several California County Fish and Game fines committees and commissions and attracted the participation of concerned academics, industry people, and managers from throughout California and Baja California. A summary of this meeting, *Black Abalone Mortality*, was subsequently published by California Sea Grant.

At the same time that abalones were being afflicted by a disease of unknown causation, red sea urchin populations were declining because of intense fishing pressure. In response, a major international conference was organized by Christopher Dewees and Professor Wallis H. Clark, Jr. of the University of California, Davis, coordinator of California Sea Grant's Living Marine Resources subject area. The conference, which was supported by the California Sea Grant College in cooperation with the California Department of Fish and Game Director's Sea Urchin Advisory Committee, was held in Bodega Bay, California, March 19-21, 1992. It attracted 150 participants from the United States, Canada, Mexico, Japan, Australia, and New Zealand. Three days of papers and discussions identified many information gaps and complex management issues. A conference summary, *Sea Urchins, Abalone, and Kelp: Their Biology, Enhancement, and Management*, is also being published by Sea Grant, along with a collection of papers from the conference.

At the subject area meeting on May 27, the results of both these conferences were used as the basis for a comprehensive discussion of kelp forest resource issues. At the end of the meeting, each of the participants submitted a list of research topics that he or she felt were critical. These were distributed to a working committee whose job was to pull the statements

together into a comprehensive research agenda. Members of this working group were Loo Botsford, UC Davis; Robert Carpenter, California State University, Northridge; Christopher Dewees, UC Davis; Thomas Ebert, San Diego State University; Carolyn Friedman, California Department of Fish and Game; John Largier, Scripps Institution of Oceanography, UC San Diego; Susan Williams, San Diego State University, and Mia Tegner, Scripps Institution of Oceanography, UC San Diego. This document is the result of their work, and we expect it to form the rationale for future research activities by California Sea Grant. We are grateful to the working committee and to all of the meeting participants for their time and interest.

James J. Sullivan
Director
California Sea Grant College

KELP FOREST RESOURCES

Kelp forests are among the richest and most productive nearshore marine communities in California coastal waters, with both ecological and commercial value. Kelp itself is harvested extensively in California for alginates that are additives in many food and cosmetic products. In addition, kelp forests provide food and habitat for numerous associated species, many of which are also exploited commercially or support sport fisheries. Among these are two species of sea urchins in the genus *Strongylocentrotus* and several abalone species in the genus *Haliotis*. Abalones have been harvested historically, while sea urchins, primarily *S. franciscanus*, have been harvested commercially since the early 1970s. Abalone stocks have been severely depleted, and sea urchin populations are undergoing intense harvesting that has led to recent declines.

Kelp, abalone, and sea urchins are interdependent renewable resources. Both abalone and sea urchins rely on kelp for food. When drift kelp food becomes depleted, sea urchins actively graze their surroundings and eliminate the remaining kelp, creating urchin-dominated barren areas. Abalone also rely on drift kelp as their major food supply. As a result of this interdependence, it is clear that these resources must be managed together to provide both short and long-term maintenance of these valuable coastal subtidal communities. Although much is known about kelp biology (recruitment, life history, physiology), it is not understood how biological characteristics of kelp interact with community level processes. Furthermore, current models of kelp recruitment have been derived from single environments. Because kelp forests appear to be controlled primarily by the "bottom up" forces (i.e., resource-related factors such as light and nutrients), Sea Grant research priorities should focus on studies from this perspective.

BLACK ABALONE RESOURCE

Basic Biology

Many aspects of the basic biology of abalone are either poorly understood or have not been examined at all. In California, black abalone are one of the least understood species of abalone. A clear understanding of the physiological mechanisms of healthy abalone is a first step in identifying physiological abnormalities. Analysis of oxygen uptake, excretion, food uptake, and assimilation can be effectively complemented with the use of gas/liquid chromatographic and high-performance liquid chromatographic analysis of blood chemistry and stress proteins.

Reproductive strategies and recruitment also are poorly understood in black abalone. Investigation of reproductive habits and recruitment patterns would result in the development of models of population dynamics. This information, in conjunction with a Geographic Information

System (GIS), would complement predictive models on cyclical phenomena and may provide insight into the longevity and outcome of withered foot disease.

Genetic Analysis

Comprehensive examination of the genetic structure of and genetic distance between geographically distinct populations of black abalone will indicate their genetic relationships. Molecular techniques are currently available to conduct these studies and have provided important information on the intra- and interspecific relationships of many terrestrial mammals and marine and aquatic animals.

Comparison of genetic profiles of healthy and diseased individuals within and between populations may provide insight to the mechanisms and consequences of withered foot disease.

Withered-Foot Disease

Determination of the nature of the causative agent(s) responsible for the catastrophic declines of black abalone in Southern California is crucial. Approaches to be used involve studies of intra- and interspecific transmissibility of withered-foot disease, documentaion of environmental parameters associated with it, and toxicological analysis of abalone tissues and water samples. These parameters should be incorporated into a Geographic Information System for computer-assisted analysis of patterns and/or specific parameters associated with the disease. Many diagnostic techniques used in the examination of pathogens are currently unavailable for use in marine systems. Development of improved diagnostic techniques including immunological, DNA, cell culture, and other methods is vital to rapid and accurate discovery of infectious agents in black abalone and other marine species.

Stock Assessment

Proper management of fisheries requires accurate stock assessment. Biologists at the Channel Islands National Park and the California Department of Fish & Game have sampled several populations on the Channel Islands; these data may require augmentation; such information could also be incorporated into the GIS and would assist in predictive models regarding recruitment and the future of the black abalone.

Harvest Refugia

The concept of harvest refugia has potential for the management and conservation of black abalone, as well as other marine species. Proper evaluation of the success of harvest refugia requires accurate stock assessment before and after their creation.

SEA URCHIN RESOURCE

One species in the kelp bed community, the red sea urchin, supports a fishery with the highest exvessel value of any of California's commercial fisheries. Red sea urchins have been harvested for 20 years in southern California, but the northern California fishery has developed only recently. There is not yet an extensive fishery for purple urchins. Harvests in southern California have fluctuated dramatically in recent years due to El Niño and, possibly, because of changes in effort; yield and abundances in northern California are steadily declining. Urchin fisheries in Japan and the Caribbean have been fished to low levels and have not recovered. Management of this fishery thus far has been on an ad hoc basis, using minimum size limits and seasonal closures.

Because of the unique biological aspects of this species, the potential for physical/biological coupling (e.g., in recruitment and growth), and the fact that this fishery competes in an extremely dynamic international market, this species presents an excellent opportunity for path-breaking research in several disciplines, which would ultimately lead to solutions to a critical Pacific coast fishery problem.

The available data on which to base management of urchin populations include size distributions (e.g., bimodal, unimodal) and fishery dependent indices of abundance. Neither of these is well understood. Recruitment has been monitored in both southern and northern California for several years, but factors controlling it are not understood. There are estimates of growth and survival for a few locations.

Management

Biological aspects of management will require evaluation of both the effects of harvest on recruitment and the effects of different size limits and fishing efforts on harvest yield. A yield per recruit (YPR) approach will provide for the latter, and the addition of eggs per recruit and spine canopy refuge per recruit (the adult spine canopy is believed to enhance recruitment by providing protection of young) will provide some information on the former. This type of analysis uses growth, survival, and reproductive data. Since the harvested product (gonads) and the market price vary seasonally, this model needs to have monthly time steps. Economic aspects of management will require evaluation of the effects of changes in the seasonal distribution of harvest on quality and price. A yield, egg, and refuge per recruit model is being developed under a current Sea Grant project. Effective use of the results of such a model will require investigation of means to control fishing effort (e.g., ITQs, more restrictive limited entry, seasonal and spatial closures).

Effective evaluation of the effects of management on recruitment will also require a better understanding of recruitment processes. Because recruitment may depend critically on adult

density through broadcast spawning and spine canopy protection, there is considerable concern about the effects of harvest on recruitment. The fact that reproduction in a population may result in settlement elsewhere will influence fishery management decisions, particularly concerning marine harvest refugia. Protecting sea urchins at one site may have little to do with the population dynamics along the coast. This can only be completely understood in the context of the physical/biological coupling that influences transport and survival of larvae. Because urchins are relatively sedentary from the juvenile stages on, it is an ideal species to investigate the potential of management via temporary or permanent spatial closures. This would depend on spatial variability in productivity as well as larval exchange between locations.

Recruitment

Urchin recruitment is highly variable over several important temporal and spatial scales. We need a better understanding of the recruitment process from larval production through the juvenile stage. Approaches thus far have involved monitoring of gonad indices, juvenile settlement on collectors, and newly settled benthic juveniles, as well as inferences about recruitment from size distributions.

A better understanding of physical oceanographic effects on variability in recruitment (both spatial and temporal) is needed—for example, there is evidence that position relative to headlands is important. Progress on understanding the role of circulation in recruitment will require basic biological information such as vertical distribution of larvae and their age of competence, as well as characterization of the coastal and nearshore current fields, through modeling or measurement. Innovative techniques to identify source waters of the larvae (e.g., an elemental signature of a water mass) would be useful. Measurement of larval supply (i.e., larvae in the plankton) and larval settlement (i.e., larvae on the bottom) should be combined with measurements of physical parameters. Ideally, these concurrent measurements should resolve a variety of seasons, locations, and depths. In particular, these measurements need to make a clear distinction between the effects which relate to shelf circulation and those which relate to circulation on the scale of the kelp beds and the local topography. Site specific field measurements, like local temperatures and salinities at designated settlement sites, are necessary in addition to physical data presently available (e.g., satellite imagery, sea surface temperatures, winds, sea levels). It would be prudent to study the physical aspects of larval dispersal in collaboration with other physical oceanography/fisheries programs off the coast of California.

The effects of adult spawning density and the spine canopy on recruitment need to be better understood and quantified.

Growth and Survival

Comparative growth and survival studies are needed throughout the range of the currently harvested red sea urchin (*Strongylocentrotus franciscanus*) as well as for the developing fishery based on the purple sea urchin (*S. purpuratus*).

Growth and survival of the red sea urchin are known to be variable, both within and between locations. The primary sources of data for these parameters are size distributions and growth increment studies from tagging. Chemical tagging, with substances such as tetracycline or calcein, is a proven method for studying growth of sea urchins, and an expansion of this technology is possible. Major gaps in basic understanding include the possible shapes of the functions that can be used to model growth and survival. Incorrect choice for a growth function can mean incorrect prediction of the time from settlement to legal size. Incorrect choice of a survivorship function results in substantial errors in predicting yield. Estimation of these parameters in very young urchins is essential for population growth models because the intrinsic rate of population growth has been demonstrated to be size specific. A technique needs to be developed for the time between settlement and growth to a size big enough for tagging. Verification that laboratory-based estimates of individual growth are representative of field rates is also required. New data indicate that small sea urchins grow much slower than anyone imagined.

Variability in growth, and possibly survival, depends on physical oceanographic conditions and food resources (i.e., kelp). These influences are not well understood, but are important for better understanding of spatial variability in productivity of sea urchin resources.

Population Dynamics

The combined effects of growth, survival, and recruitment over space and varying with time need to be integrated to achieve an understanding of the variability in abundance over time and space. Urchin populations are notorious for achieving extreme population levels (e.g., urchin barrens). There are some efforts in this direction under current Sea Grant, National Science Foundation, and other grants. Life tables upon which populations could be modelled need to be constructed.

The Existence and Implications of Stocks

It is uncertain whether all populations of sea urchins from Alaska to Mexico are connected through the plankton. Because of their long planktonic life, they may be; however, establishing whether separate stocks exist is very important for management. It may not be true that all fertilized eggs have equal probabilities of settlement regardless of source. Some locations, because of their favorable position relative to coastal currents, may supply most of the larvae that settle across substantial reaches of the coast.

General techniques for determining detailed genetic identity of subpopulations along the coast are available, and they could be developed specifically for urchins. This would provide information that would be of direct value in defining stocks for management, and would have implications for larval transport along the coast and the physical processes associated with transport. Establishing the genetic identity of stocks will have important implications for enhancement efforts.

Enhancement

Proposals for enhancement range from protection of closed areas as natural hatcheries to production and culture of juveniles to be stocked for later harvest. A substantial research effort, funded by fishery tax funds, is going into development of the biological aspects of culture for stocking. Research is needed on the economic and legal policy issues raised by activities such as these (e.g., ownership of stocked urchins, use of the public benthic habitat for grazing, etc.) and on the genetic consequences for natural populations. The fact that culture of invertebrates for restocking has been tried and has not been demonstrated to be successful in the past suggests a need for careful evaluation of the economic feasibility of such an operation. An evaluation of Japanese urchin culture in the context of local economic and legal conditions would provide valuable information.

KELP BED COMMUNITY ASPECTS

The interactive relationships between all members of the kelp bed community need to be better understood, through a multispecies, community approach. Oceanographic influences have been studied, in particular the impact of ENSO (El Niño Southern Oscillations), but we need to know more about the effects of short- and long-term changes in oceanographic conditions on the interdependence of producer and consumer populations. Understanding variability in time and space of community members is desired.

The relationship between kelp and urchin growth as modulated by physical effects requires better understanding for spatial management of the fishery. The existence and implications of urchin barrens, as well as the potential biological effects of development of a fishery on purple urchins are intriguing questions. Studies are needed of the coupling between the dynamics of kelp productivity and growth and drift kelp production with the dynamics of consumer populations.

The effects of further expansion of the sea otter on kelp forest resources are a concern to fishermen because of the profound effects of otters on these resources.

To facilitate a well coordinated approach to research on kelp community resources, we should plan an annual meeting of Sea Grant Project Leaders and other interested researchers. This could be in the context of a wider (state, national, international) network of managers and researchers.

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