ADVANCES IN AQUACULTURE AND FISHERIES RESEARCH

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REPORT OF A
CALIFORNIA SEA GRANT
SYMPOSIUM

MAY 18 TO 20, 1983

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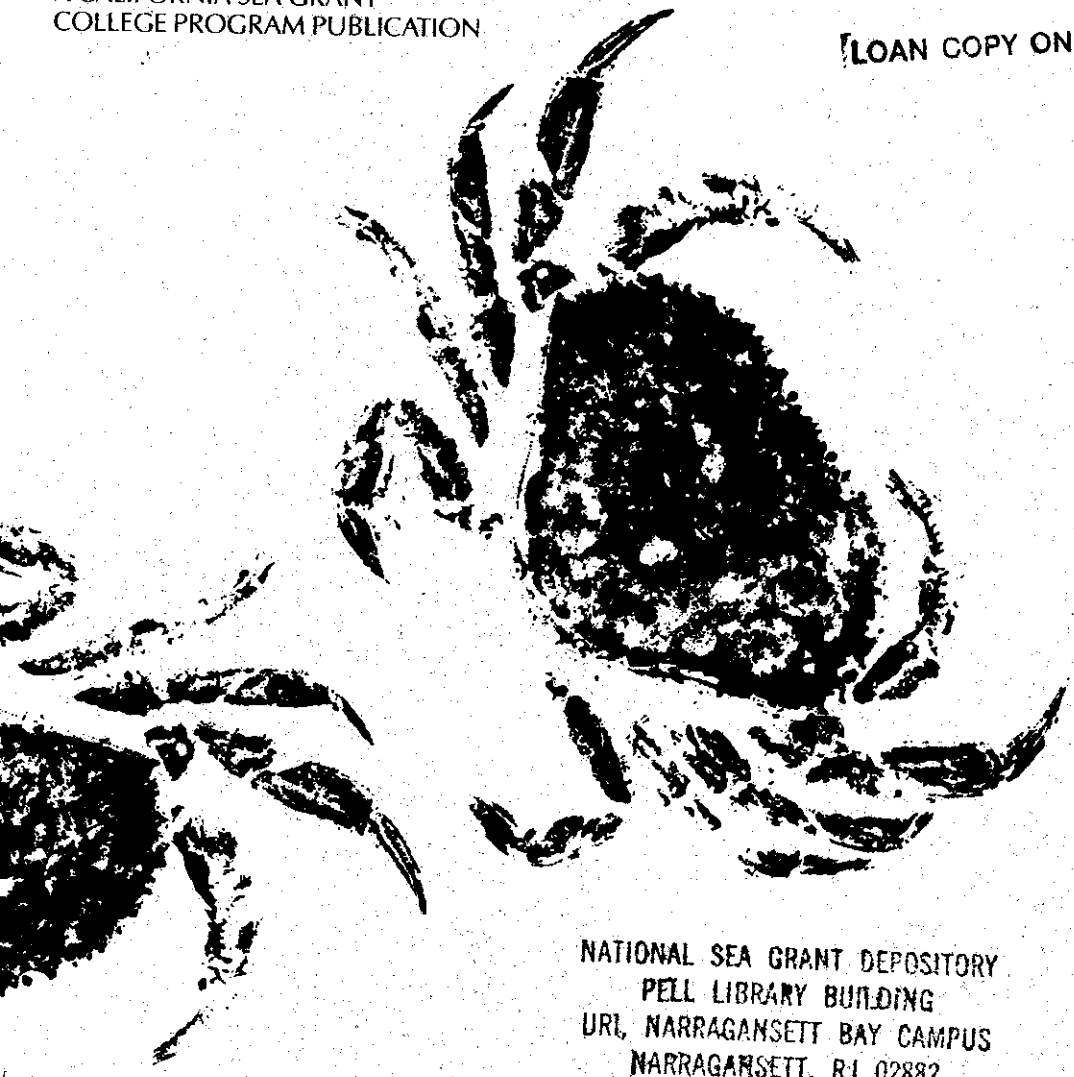

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CALIFORNIA
SEA GRANT

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The California Sea Grant College Program is a statewide, multiuniversity program of marine research, advisory services, and educational activities administered by the University of California Institute of Marine Resources. Through the research it sponsors, Sea Grant contributes to the growing body of knowledge about our coastal and oceanic resources and helps solve contemporary problems in the marine sphere. Through its Marine Advisory Program, Sea Grant transfers information and technology developed in its research efforts to a wide community of users in California, the Pacific region, and the nation. Sea Grant also supports a range of educational programs for students, teachers, and the general public to promote the wise use of our coastal and oceanic resources by this and future generations.

On the cover: Dungeness Crab print. From *The Printer's Catch: An Artist's Guide to Pacific Coast Edible Marine Life* by Christopher M. Dewees (Sea Challengers, Los Osos, California). Mr. Dewees is Marine Fisheries Specialist for the Marine Advisory Program of the California Sea Grant College Program.

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UNIVERSITY OF CALIFORNIA,
DAVIS

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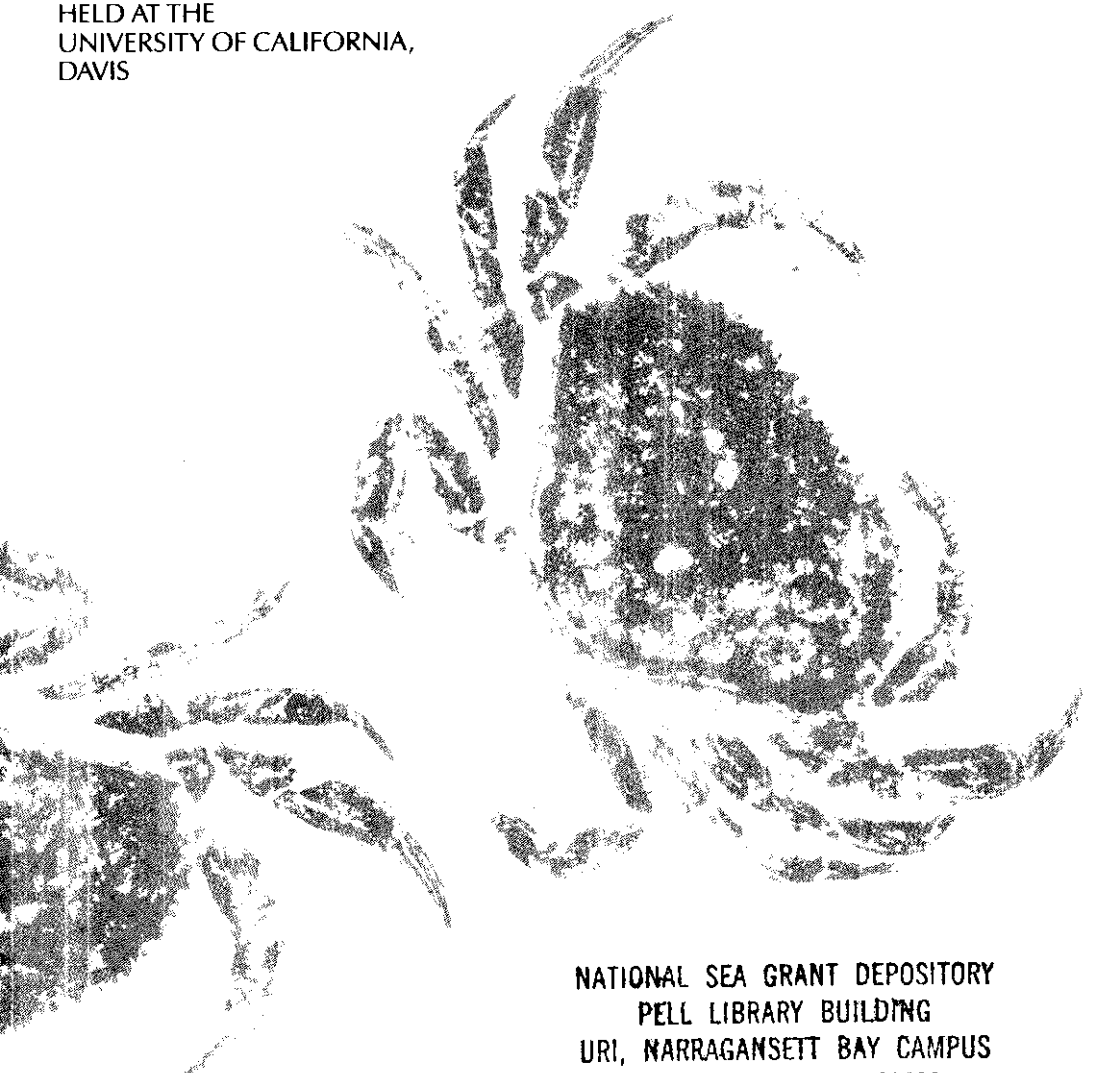

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EDITOR, KELLY E. ANDERSON

A CALIFORNIA SEA GRANT
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INTRODUCTION

Wallis Clark, Director, Aquaculture Program, University of California, Davis

Aquaculture and fisheries research in California has grown to such a point that in many cases it's now a little difficult to separate the aquaculture endeavors from the fisheries endeavors!

During the next two days we will dwell on three areas important to California fisheries and aquaculture. They are: salmonid fisheries management, coastal fisheries management, and "potpourri," which will include a variety of topics, including sturgeon aquaculture, ridgeback prawn fisheries, and U.S.–Mexico relations in fishery policies.

We have invited several visitors to hear about the research projects we have in California, to comment on them, and hopefully to give us some good suggestions. We're especially delighted to have with us Bill Gordon, the director of the National Marine Fisheries Service, and Bob Wildman, the deputy director of the National Sea Grant College Program.

You know, I never feel easy calling Bob Wildman the deputy director of Sea Grant, because I like to think of him as the Father of Sea Grant. Perhaps he is too young to hold that lofty position, but I suspect there wouldn't be a Sea Grant if it hadn't been for Bob.

Before we begin, I want to mention that less than two weeks ago most of us in this room lost a very dear friend, Dr. Duane Brown. Duane was in the Department of Seafood Science and Technology at UC Davis, and it is the consensus that these meetings should be dedicated to him.

Without further ado, let me introduce Jim Sullivan, Program Manager of the California Sea Grant College Program.

WELCOME

James J. Sullivan, Program Manager, California Sea Grant College Program

I strongly second the idea of dedicating this meeting to Duane Brown. Duane was a good friend to many of us for a long time. People in industry, as well as in government and at the university, will miss him. Duane was always a very cordial and convivial person with a great deal to contribute. I know you here at Davis have lost a close colleague.

Let me welcome you now to this symposium on behalf of the California Sea Grant College Program! This is the first time we've held a symposium combining the areas of aquaculture and fisheries. The main encouragement for this kind of session came from people in industry who expressed interest in hearing what is going on in both fields, not from a species or topical point of view, but from a scientific point of view—for example, what research cuts across various discipline lines, various habitat problems, and various species? Thus, we've decided to combine research areas this year, and you are all here to tell us if this experiment works!

I would like to recognize the organizing committee of this event. Wally Clark, whom you have already met, is chairman of the organizing committee and our subject area coordinator on aquaculture. Serge Doroshov, also on the organizing committee, is our coordinator of fisheries. Duane Brown was our coordinator of seafood technology. Warren Johnston represents the discipline of agricultural economics. Representing the state's point of view is Emil Smith from the Department of Fish and Game. The federal perspective will be taken by Floyd Anders from the National Marine Fisheries Service. Hugh Staton of California Sea Grant's Aquaculture Industry Advisory Committee could not, unfortunately, be here. Todd Ghio, chairman of our Seafood Industry Advisory Committee, was also unable to attend, so industry will be represented by Maurice Camillo of J. J. Camillo Seafoods. And we mustn't forget Lucy Garcia and Pamela Tom of UC Davis and my assistant Lindy Nagata, who put this whole thing together.

Our main purpose is to come up with a statement of where California's research activities, and principally those sponsored by Sea Grant, might go in the next 3 to 5 years. To do this we need to determine where research has gone in the various areas

that Wally mentioned, but especially in salmonid management, new and underutilized species, and coastal fisheries. What kinds of research, advisory services, and education programs are needed? Where can Sea Grant make a contribution? This is the critical question, because there are some sensitive ears here—people who want to hear where we're going. Jim Rote from the Assembly Office of Research is involved in framing various proposals and management activities for the legislature. Bill Gordon from the National Marine Fisheries Service and Bob Wildman from the National Sea Grant College Program also want to hear what you have to say.

With that, I welcome you to our first California Sea Grant symposium on fisheries and aquaculture research. I challenge you all to come up with some future directions for our program.

SESSION I:
SALMONID FISHERIES AND MANAGEMENT

ENDOCRINE CONTROL OF SALMONID DEVELOPMENT AND SEAWATER ADAPTATION

HOWARD A. BERN AND RICHARD S. NISHIOKA

Department of Zoology and Cancer Research Laboratory, University of California, Berkeley

Research has demonstrated a correlation among plasma thyroxine surge, lunar cycle, smoltification, and seawater adaptability. If the thyroxine surge is a valid indication of migratory readiness, then we should have a convenient system to time the release of hatchery fish to achieve maximal contribution to the fishery and adult returns to the hatchery. We began an experimental release program in 1981 in collaboration with P. Hubbell of the California Department of Fish and Game. On five different dates, groups of about 50,000 coded-wire nose-tagged coho salmon yearlings were released from Trinity Hatchery. One group was released on the particular new moon date on which we calculated the single thyroxine surge would occur. Four other similar-sized groups were released as controls: two before and two after this selected date.

Nearly 5% of all the 1981 lunar cycle-based release groups were caught or returned to the hatchery as adults. The percentage approached 5% for the single group released on the new moon selected to be the ideal release date according to our hypothesis. On the other hand, of five groups of coded-wire tagged fish (totaling >350,000) released in three preceding years (1978-1980), only about 2% were caught in the ocean or returned as adults to the hatchery. The near doubling of the success rate in the first experimental release may have been purely fortuitous; two more years of data are forthcoming from this experiment. Other possible methods of improving the contribution of hatchery-reared fish to an even greater degree will be proposed.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

EVALUATION OF PROTECTIVE ANTIGENS OF *AEROMONAS SALMONICIDA*

DONALD F. AMEND
Department of Medicine, School of Veterinary Medicine, University of California, Davis

The causative agent of furunculosis is *Aeromonas salmonicida*. The disease is endemic along the Pacific coast and is a limiting factor for successful pen culture and ocean ranching. There are only two FDA-approved drugs for control of the disease, and resistant strains to these drugs are frequently encountered, making treatment ineffective. Vaccines have several advantages over chemotherapy. For example, vibriosis (*Vibrio anguillarum*) has been controlled to a large extent by vaccination, but, to date, vaccine use to control furunculosis has been limited. While vibrio bacterins can be applied to fish using mass vaccination techniques, effective vaccination for control of furunculosis can be applied only by injection, making vaccination impractical on a large scale. With *V. anguillarum* there is only one antigen that provides protective immunity, but with *A. salmonicida* there are at least three antigens associated with protective immunity.

The three antigens of *A. salmonicida* that have been shown to provide some protection from furunculosis are lipo polysaccaride (LPS), A-protein, and an extracellular glycoprotein. It is not known which of these antigens is most protective or if there is any antagonism or synergism as a result of combining these antigens in one vaccine preparation. The objective of our research is to isolate and purify each of these antigens, determine their potency, and evaluate their efficacy when applied in various combinations using injection and immersion vaccination methods. It is hoped that the data will determine which antigens or combination of antigens are essential for developing bacterins that can be applied using mass vaccination methods.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

CHINOOK SALMON ABUNDANCE IN CALIFORNIA

LOUIS W. BOTSFORD AND DAVID F. JOHNSON
Wildlife and Fisheries Biology, University of California, Davis

Because annual regulations of the salmon fishery are set each year before the season begins, a means of predicting abundance is needed. Our recent research on the causes of fluctuations in abundance of the central California stocks of chinook salmon (*Oncorhynchus tshawytscha*) has revealed a potentially useful relationship between abundance and the occurrence of El Niño events.

Because precocious 2-year-old males (jacks) are not exposed to the fishery and are from a single age class, we have used them as an index to reflect cohort strength. In our research, in conjunction with A. C. Knutson, Jr. of the California Department of Fish and Game, we have demonstrated a significant relationship between the jack index and both sea surface temperature and sea level height. These two variables are indications of occasional oceanographic anomalies known as El Niños, which begin in the tropical Pacific and propagate poleward. They are best known for their adverse effects on fisheries (e.g., the Peruvian anchovetta). Off the California coast they warm the water and cause a northward shift of pelagic zooplankton and fish species. These events may cause either an increase in precociousness of chinook salmon, an increase in actual cohort abundance, or both. After further work to delineate the age structure of the California catch, these results will be used to formulate a means of predicting annual abundance, thus providing more efficient resource use.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

QUANTIFYING FISHERY IMPACTS ON CHINOOK SALMON GENETICS

DAVID G. HANKIN AND ROBERT McKELVEY
Department of Fisheries, Humboldt State University, Arcata, California

Over the past 60 years, the average size of chinook salmon caught along the Pacific coast, from Alaska to California, has declined by more than half, and the average age of maturity has decreased by more than one year, under the combined pressures of offshore and terminal fisheries. There can now be little doubt that a substantial fraction of these changes reflects genetic alterations in the salmon stocks, much of it in response to selective pressures in the fisheries (Ricker 1980, 1982). However, quantitative estimation of the genetic components of these changes has been hard to achieve, since genetic and fishery processes are intimately entangled.

The management implications of these changes are far from clear. Because age of maturity is known to be highly heritable, some biologists are concerned that the progressive shift toward younger ages in chinook spawning runs may reduce the fitness of salmon in their natural environment, and that chinook fisheries, progressively more reliant on only one or two age classes, may become less stable. Others speculate that selective fishery pressures may have desirable impacts on growth rates, stock turnover rates, and genetic characteristics that are linked to age of maturity and growth rates (Larkin 1981, Walters 1981). Thus, fishery managers are faced with known changes in chinook fisheries and spawning runs, but they lack the knowledge to determine if it is necessary or desirable to reverse or alleviate these changes. We hope to provide preliminary findings regarding the probable long-term genetic impacts of current fishery practices on chinook salmon stocks.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

CONTRIBUTION OF COHO AND CHINOOK SPAWNING POPULATIONS TO MIXED FISHERIES

GRAHAM A. E. GALL
Department of Animal Science, University of California, Davis

The use of starch-gel electrophoresis to detect genetic variability within and between populations is effective in establishing levels of genetic isolation among populations. It also provides a potential method of analyzing the contribution of stocks to the mixed fishery. The life history characteristics of the stocks are a major component of population structure, yet they have received little attention to date. We intend to collect information available from agency files to establish a library of known life histories. From such a data file we will determine the gaps in existing information.

The study of quantitative performance characteristics presently represents the most deficient area of salmon genetics research. To determine the number of salmon that can be produced by a given habitat (natural or hatchery), we must understand the inheritance of traits such as growth rate, age at sexual maturation, time of out migration, time of run, time of spawning, fingerling survival, time of smoltification, and the contribution of age classes to subsequent generations. Studies of these traits will provide a basis for assessing the implications of management alternatives for the freshwater phase of the life cycle as well as the likely impacts of various fishery regulations on the long-term stability of the fishery.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

SUMMARY DISCUSSION

JAMES W. ROTE
Assembly Office of Research

I would like to start by saying that I was very impressed with the papers presented this morning. We learned a great deal about the basic biology, ecology, physiology, and genetics of salmon. Topics covered a wide range: endocrine control of development and subsequent ocean survival, protective antigens for fish leaving hatcheries, sea surface temperature impact on abundance, genetic inheritance of maturation age, and the problem of younger fish returning.

We also learned that there are a great many gaps in our knowledge.

1. It is not known if disease-resistant fish can be selected genetically.
2. Zooplankton records for northern California are sparse.
3. There is a need for diet studies of juvenile salmon this year to check the impact of El Niño.
4. Genetic problems with hatchery fish may result in earlier returns.
5. The impacts of troll and net fisheries on stock abundance are unclear.
6. There is very little knowledge of salmon age-class structure.
7. The impact of straying from hatcheries is unclear.
8. We do not know how to rebuild natural stocks and genetic complexity.

I feel that Sea Grant must continue to fund research that provides answers to these basic questions. We should also remain flexibile to deal with emergency situations or targets of opportunity such as the El Niño phenomenon. Sea Grant Rapid Response or California policy seminar money could be set aside to tap for issues of statewide importance. Although it may raise havoc with the salmon catch this season, El Niño should be seen as an opportunity for a natural field experiment. A major situation like this may not occur for another 10 to 20 years.

SESSION II:
POTPOURRI

NUTRIENT UPTAKE BY FISH INTESTINE

JARED M. DIAMOND
Physiology Department, School of Medicine, University of California, Los Angeles

Feed is a major expense in fish production. For maximum growth, fish need high-protein diets with a balanced amino acid profile. Such diets are expensive, hence efforts have been made to formulate cheaper diets incorporating lower-cost plant protein and carbohydrates. The rational design of such diets requires understanding the mechanisms of nutrient absorption by fish intestine and how these mechanisms change with diet. Little such information is presently available.

My colleagues and I have studied intestinal nutrient transport and its dietary dependence in other vertebrate classes, and we are now extending these studies to fish. In general, the ratio of amino acid transport to carbohydrate transport is higher for carnivores than for herbivores. Dietary carbohydrate stimulates sugar absorption in omnivores, but we do not yet know if this is also true for strict carnivores. The most distinctive feature of fish intestine that we have encountered so far is the low rate of nutrient uptake compared to those of other vertebrate classes.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

ESTABLISHMENT OF PARAMETERS CRITICAL TO STURGEON MANAGEMENT IN THE PACIFIC NORTHWEST

SERGE DOROSHOV
Animal Science, University of California, Davis

Two of the five species of sturgeon in waters of the North American continent are indigenous to the Pacific Northwest: the white and the green sturgeon. Both were historically important resources that received extensive pressure from commercial fishing and became endangered. Stringent regulations were imposed. The positive effect of regulations may be nullified by a rekindled legal and illegal interest in the resource and the adulteration of our coastal rivers which are vital spawning grounds. A technique for artificial propagation of white sturgeon has been developed. Population structure, environmental requirements, and basic physiological functions for both species remain unknown. This knowledge is necessary for conservation, resource improvement through environmental protection and management, and hatchery enhancement.

This year we will begin investigating many aspects of the biology of white and green sturgeon, encompassing several stocks, to provide coordinated information required for their management, especially related to fisheries, conservation measures, and hatchery enhancement.

The status and potential of wild populations will be evaluated by analysis of age–size population structures, rates of sexual maturation, breeding capacities, and genetic makeup. Mechanisms of osmoregulation will be assessed in fish of different ages and sizes through the investigation of internal salt and water balance. Disease susceptibility will be examined and food imprinting and chemoreception of food attractants will be determined.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

ECONOMIC ANALYSIS OF THE INTERACTION BETWEEN COMMERCIAL AQUACULTURE AND COMMERCIAL FISHERIES

JAMES L. ANDERSON
Department of Agricultural Economics, University of California, Davis

Two types of interaction between commercial aquaculture and commercial fisheries are addressed in this research. The first type of interaction is market competition. The nature of competition between the aquaculturist and the fisherman depends on market structure (i.e., competitive, imperfect), product differentiation, and other factors. The second type of interaction is competition for and ownership of resources used in production. This is especially evident in the case of salmon ranching, where the aquacultured salmon in the ocean are a public good and can be harvested by fishermen. In addition, aquacultured salmon may compete with other salmon stocks, impacting natural supply.

The analytic results of this research indicate that an aquaculturist entering a market supplied by an over-exploited natural fishery may cause natural fishery production to increase. This increase is a result of lower price, which reduces fishery effort and allows the natural stocks to recover. Research results on production interactions indicate that if the salmon aquaculturist cannot influence the season length, the natural stock will tend to be exploited more intensely and fishermen will tend to have higher yields.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

THE RIDGEBACK PRAWN FISHERY

SUSAN ANDERSON
Aquaculture Department, University of California, Davis

The ridgeback prawn fishery is a small, newly developed fishery in the Santa Barbara Channel area. In 1979, 356,000 lbs were landed. Landings have declined each year since 1979 to 141,000 lbs in 1982. Ex-vessel prices range from $0.85-1.25 per pound depending on market conditions. Most fishing occurs on day trips from Santa Barbara Harbor.

Until recently, almost nothing was known about the ridgeback prawn *Sicyonia ingentis*. Our natural history investigations demonstrate repeated spawning activity by individual prawns throughout a long spawning season (June-September). No intervening molt or mating is required to produce a fertile spawn. Most females progress synchronously through a single molt cycle beginning in mid-May and ending in mid-November.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

UNITED STATES-MEXICO RELATIONS ON FISHERY POLICY: FOCUS ON WEST COAST FISHERIES

STEVE SELLER

University of California, Santa Barbara

The problems existing in the management of the West Coast fisheries (especially tuna and anchovy) are due to the systemic relationship existing between the United States and Mexico as well as subsystemic factors within each nation. The overall or systemic relationship between the two nations (as well as subsystemic factors) shapes the way both countries approach fisheries management. With fisheries of highly migratory species such as tuna and anchovy, the differing perspectives of the two nations significantly impact the way they try to resolve management issues along the West Coast. At the same time, private industry seems to relate quite well across the border.

The factors that shape the differing perspectives of both countries as well as the management problems they pose are the subject of our project.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

SEA GRANT MARINE ADVISORY PROGRAM

CHRISTOPHER M. DEWEES
California Sea Grant Marine Advisory Program, University of California, Davis

The California Sea Grant College Marine Advisory Program (MAP) is part of the University of California Cooperative Extension Program. Eight county-based marine advisors work with local marine resource users and managers on a daily basis. They are aided by UC Davis specialists in seafood technology, aquaculture, and marine fisheries. The MAP staff has the difficult task of extending research-based information to marine audiences as well as identifying problems that need additional research.

Workshops, publications, mass media, applied research, and one-on-one consultations are the typical methods used to encourage the adoption of research-based information. Some of our recent programs include:

1. Identification of the need for a squid cleaning machine—then working with the industry to help modify the Sea Grant-developed prototype for commercial use.
2. Workshops on fishing techniques that increased the participants' production a minimum of $180,000.
3. Research on refrigeration methods that will lead to recommendations for improving on-board handling of salmon.
4. Active participation with agencies, industry, and the legislature on aquaculture legislation.
5. Educational programs to help solve oil development–fishery conflicts.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

SUMMARY DISCUSSIONS

FLOYD ANDERS, MAURICE CAMILLO, EMIL SMITH

Floyd Anders
National Marine Fisheries Service

First, I'd like to address three important parts of the Cooperative Extension Program. One of them was certainly outlined very well, and that's the public information component. The training courses, the types of services they provide, and particularly the efforts of area specialists like Fred Conte are very important. Considering their small staff and California's large coastal population, the marine advisors have done well.

The other two components I'm thinking about are the relationships between researchers and constituents—constituents being commercial fishermen, processors, brokers, recreationists, and environmentalists—and the world at large. Basically, I see that the Extension program has two functions: one is to identify areas that need assistance and research, and the other is the reverse process, the countercurrent that takes the results of research back to the people who can use it.

The marine advisors are pretty good at transmitting the results of research. I'm not so sure that the process of identifying needs is that good though. I think that there are areas that could stand considerably more work—the fish technology area, for example. In northern California a high percentage of dover sole is landed on the north coast, yet there are many problems with jellied dover sole, as well as problems distributing it, selling it, or just getting rid of an awfully large number of fish.

Finally, the third component of interest to me is the flow of information between the Extension agents and such agencies as California Fish and Game, NMFS, and others. The most important function is the identification of existing problems or potential problems. They need to let us know what the problems are and make sure our input gets back to industry. I don't think it's a complete circuit at this point, and I think it ought to be.

Let's go back to nutritional studies. A comment was made that temperature effects have not been studied yet. I don't think that area is the most important one right now. The work that Dr. Diamond is doing is fascinating; of particular importance is finding cheaper diets for fish in aquaculture and in hatchery operations where you're raising perhaps a million or two million fingerlings—coho, chinook, or whatever. I would like to see an improved economic analysis of aquaculture that takes nutritional aspects into consideration.

That issue came up when Serge Doroshov talked about sturgeon aquaculture, though he did not mention the economics of sturgeon culture as a viable aquaculture program now or in the future. Bill Gordon also discussed the subject with Jim Anderson, this business of exports coming into the United States—Norway salmon, for example—and the cost relationships, the effects on the market, and the effects on domestic fisheries. If we're interested in sturgeon aquaculture, if it's economically viable, it seems to me that the shoe could perhaps be moved to the other foot. We have a product in this instance that is extremely well accepted in Europe, and it seems to be in short supply. It offers a smoked product, it offers a fresh product, and it offers caviar. If it's economically viable, why don't we export it?

I don't think the United States is aggressive enough in its policies relating to fishery products. We have not only the problem of economics but the problem of quality of products exported. Sometimes I think we don't do as well as we should, and many times I think we do inexcusably poorly. It seems to me that Diamond's work—the artificial feed aspect and nutritional uptake in the intestine—is something that would be extremely valuable in looking at economics of sturgeon aquaculture.

Sue Anderson's work on the ridgeback prawn is beautiful work; I really like it. I'm curious about the limiting factors on the population; obviously it cannot withstand a great deal of pressure. It looks like there's been a rather extensive decline, better than 50%. And though I'm inclined to say that prawn probably presents a very nice product, unless we know more about it than we do, it will never develop into much of a fishery. I am interested in the multiple spawning aspects because they may have an environmental influence that carries into other areas.

Steve Seller's presentation on U.S.–Mexico relations was an excellently chosen topic because we're involved in this issue practically every day with the tuna and anchovy fisheries. I wonder if Steve has made contact with the fisheries attaché at the U.S. Embassy in Mexico City. He probably understands right now better than anyone else the intricacies of working with people in the Mexican fisheries area. Steve talked about meeting with our people in Washington D.C. at the State Department, and he talked about what is coming up this summer, but he didn't mention contacting our people in Mexico. This seems to be a highly valuable source of information.

Steve did not go into the intricacies of tuna; it's much more complex than he outlined. The business of fishing a highly migratory species goes beyond the question of our relationship with Mexico. He quoted one figure about areas of catch, saying that 70% of the U.S. tuna is landed off Latin America. I'd like to have a better definition, because I think if we're talking about yellowfin tuna and perhaps even skipjack in the eastern tropical Pacific, we're talking about 90–95% of the U.S. tuna catch taking place off Mexico and Central and South America. The amount of catch does not stay static; it changes with environmental conditions. For several years there may be a large catch off Mexico, and in other years it may be off Columbia, Chile, Peru, or Ecuador. This year it would appear that the catch off Mexico is down in relation to other areas. This has a very important effect on the fisheries access agreements we're trying to develop.

Three countries—the United States, Costa Rica, and Panama—have signed an access agreement, and they hope to get other countries to join in. When five nations have signed, the policy goes into effect. Other advances have been made recently in the tuna business, not necessarily with Mexico though they may influence Mexico.

Finally, I think we should have a good social scientist participating in all of this. We could talk endlessly about biology and research aspects, but what we should talk about is management. Management is largely based on economics, and it's based on managers who have some understanding of the biological and economic implications, though they're not experts in those particular areas. They may be psychologists, they may have some background in economics and biology, and they should have some public speaking ability and managerial training.

Maurice Camillo
California Seafood Institute

I'm here for the California Seafood Institute, which has always supported Sea Grant's activities.

I noticed some common threads running through the discussions today. First, we lack data and places to get data and information. That seems to me like a potential Sea Grant project, maybe to build a computer-based research data bank that would provide instant access for people doing research. It seems as

though we need to correlate and organize data for a lot of you, and I think this is something that would help. Maybe you should see what Fish and Game has and what your colleagues have, and probably you could get together.

I've heard several times that you'd like to collaborate more with each other. We worry about duplication of Sea Grant projects on the east and west coasts. So when you talk about wanting collaboration, I think that's very good because when you work together on common problems and exchange information readily it makes the dollars go further and eliminates some of the duplication.

Another area I would like you to consider is the marketing of underutilized species. We briefly touched on the idea of trying to get the fishermen to do some work on hake or Pacific whiting. If we identify certain species that we haven't really done a good job of marketing, we can get those out into the market and take some of the pressure off species in high demand. We did a very good job with squid until the squid stopped running, but we think that's because of El Niño. A real success story of the Sea Grant Program is its marketing of squid and getting it to the public.

Last night we were talking informally, and someone asked how would I make a buck on El Niño. I said I didn't know, because by the time I figured out what we could do and get it introduced into the market, El Niño would be all gone and we'd be where we are now waiting for the squid to come back. But I didn't realize that in 1978 there was a type of El Niño condition, and that's just about the time the Mexican squid showed up. It was new and we started doing squid steaks for the people in San Diego. I think we were envisioning giant calamari steaks for all Californians, yet the only people who would eat it were San Diegans. Then all of a sudden Los Angeles took off, and then bingo!—the squid's gone. That's a success story.

Those are some of the things I wanted us to consider. I haven't been to this kind of a symposium in a long time, so I would also like to test an idea on Dr. Sullivan. Within geographical areas, perhaps industries and fishermen could get together with people in their area and talk with the people in the street a little more. It takes us a certain amount of time to hear your language before we understand exactly what is being said. I

think it would be profitable for both of us. It's expensive to travel to a place like this if you're in Eureka, or vice versa, but if you could perhaps get together informally on a regional basis and talk about mutual problems more, you might get some good suggestions from the local people.

Emil Smith
California Department of Fish and Game

My particular function in the Department of Fish and Game is to supervise a newly formed section called the Aquaculture Development Section, which has been working in conjunction with Jim Rote's office in the legislature and with the aquaculture industry since last year.

We put together S.B. 1917 to provide direction and a state policy for California's aquaculture industry and to support development of the state's aquaculture industry. Historically our department has been a regulatory agency, but we haven't been given any direction as far as aquaculture goes. We've had both an informal marine program and an informal freshwater fisheries program for years that were not integrated; each section went its own way. Formal direction has only been provided since about 1980, when the first aquaculture bill, S.B. 53, was introduced in the legislature by Senator Keene. He is also the author of more recent legislation, S.B. 1917 in 1982, that started to give some direction to our department and to the state regarding aquaculture.

The major purpose of S.B. 1917 is to provide a policy for the state that supports the aquaculture industry and to authorize the Department of Fish and Game as the coordinating agency for aquaculture activities.

This is different from the university set-up where you're working primarily with research and the functions of research; we've always been primarily a regulatory agency. We've also been saddled with a new responsibility now, that of creating a program to develop and support the aquaculture industry. The new Fish and Game code sections added by S.B. 1917 became effective January 1, 1983, and on April 1 we adopted our first set of comprehensive aquaculture regulations. The bill completely revised our Fish and Game code and the Fish and Game

Commission's regulations dealing with aquaculture. Though the bill designates a position in the department to supervise aquaculture activities, because of the timing of the bill's passage and implementation, no funding was provided for the position or for additional personnel. As a result, aquaculture development activities in the department are still in a very basic, formative stage.

I'm assigned to the Marine Resources Branch, which deals primarily with the administration of marine work in the department. However, because I've been working with the oyster industry for many years, leasing state water bottoms for the cultivation of oysters and other organisms, I'm the only one who has been officially designated to work on aquaculture at this time. The function was placed in our branch, but I'm drawing on assistance from personnel from our Inland Fisheries Branch, our Anadromous Fisheries Branch, and our Wildlife Protection Branch.

The first formal cooperation from our informal Aquaculture Development Section was the revision of the aquaculture regulations adopted in April. Our second assignment was to clean up the loose ends left over from S.B. 1917. These appeared later in A.B. 153, carried by Assemblyman Farr and which had an emergency clause, and A.B. 2137, introduced by Assemblyman Peace.

The clean-up work on the two bills was accomplished with the help of Jim Rote from the Assembly Office of Research and the Aquaculture Industry Advisory Committee, established by S.B. 1917.

As I mentioned, while no budget has been provided for aquaculture activities per se, for many years the department has provided some assistance in this area. Consequently, with the establishment of new policy and guidelines for aquaculture development, the department now has a semblance of an aquaculture section. The primary activities to date have been directed toward coordinating our department's efforts with other state departments that have some influence over the aquaculture industry. We established an Interagency Advisory Committee for Aquaculture Development, as required by the mandate of S.B. 1917. The committee members are drawn from the State Water

Resources Control Board, Coastal Commission, Department of Food & Agriculture, Department of Health Services, State Lands Commission, and the University of California. A third committee, also required by S.B. 1917, the Aquaculture Disease Committee, was established to deal with aquaculture diseases. This committee, composed of equal numbers of state employees and industry representatives, has already served a valuable function.

In addition to our department's coordinating efforts, our designation as a lead agency for aquaculture has resulted in our role as a clearinghouse for aquaculture activities, which means we deal with both federal and local agencies. We have developed a close working relationship with the Sea Grant Marine Advisory Program, Aquaculture Extension, U.S. Fish and Wildlife Service, NMFS, and USDA. In the future, we believe that our new Aquaculture Development Section can perhaps provide a greater service by identifying critical industry needs and then satisfying those needs by encouraging research through cooperative programs with:

1. The Sea Grant College Program
2. Aquaculture Extension
3. National Marine Fisheries Service
4. Department of Fish and Game

This has been a real thumbnail sketch of our new aquaculture activities. As you can see, we have a long way to go if we are to function as the legislature envisioned. However, an established state policy supportive of aquaculture will do much to encourage future aquaculture development in the state.

SESSION III:
COASTAL FISHERIES AND MANAGEMENT

GENETIC ANALYSIS OF SPATIAL AND TEMPORAL STRUCTURE IN ANCHOVY POPULATIONS

DENNIS HEDGECOCK, G. LI, AND FRED SLY
University of California, Davis, and Bodega Marine Laboratory

The northern anchovy, *Engraulis mordax* Girard, is said to comprise three geographical subpopulations. The central one, spawning mainly in the southern California bight but ranging from central Baja California (30°N) to San Francisco, is the object of intense Mexican and American live bait and reduction fisheries. Fluctuating annual recruitment necessitates yearly catch quotas based on estimates of spawning adult biomass. Because these estimates assume complete mixing and random mating within the central subpopulation, and because the extent of mixture of southern and central stocks in the Mexican catch is unknown, we have undertaken a genetic analysis of spatial and temporal structure in the northern anchovy. Samples of 48 adult specimens collected from each of 9 sites in winter 1982 were examined electrophoretically for variation in 25 proteins encoded by 41 scorable loci. Sixteen proteins found to be variable in this initial survey were then studied in 7 population samples collected in December 1982. Age class determined from otolith annual growth rings, length, and sex of all specimens were recorded.

Percentage of loci polymorphic, 36.6%, and average heterozygosity, 7.9%, are rather high with respect to variation levels reported for other fish, especially pelagic species. Within central subpopulation samples, distributions of phenotypes conform for the most part with random-mating expectations. Among these samples, however, highly significant heterogeneity of allelic frequencies occurs at four of eight highly polymorphic loci, on local as well as regional geographic scales. Sex-ratio and age-class composition differences among samples do not appear to account for this unexpected spatial variation. Analyses of additional population samples should allow more rigorous tests of these and other possible explanations of our preliminary observations. The study is currently being expanded to include collections of southern and northern subpopulation anchovies.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

THE EFFECTS OF CLIMATE AND WEATHER ON ALBACORE MIGRATION AND DISTRIBUTION IN THE NORTHEASTERN PACIFIC

REUBEN LASKER
Scripps Institution of Oceanography, University of California, San Diego

Direct studies of the albacore's response to specific oceanographic conditions have been hampered by the inadequacy of oceanographic data, largely resulting from the fish's expansive migratory and distribution patterns. However, many of the oceanographic variables known to affect albacore are, in turn, influenced by climatological events that are much more completely represented in available data sets. It is therefore the intent of this study to examine the influence of short and long term climatic fluctuations (and the related responses of the ocean) on albacore migration and distribution in the northeastern Pacific. The results will more clearly identify the influence of the environment on albacore, thus being directly usable by the fishing fleet in increasing the success of its future operations and aiding fisheries scientists in planning future studies and improving their management advice.

Albacore distribution will be approximated using catch data from the North American fishery. Sea surface pressure distributions and satellite remote sensing will be used to calculate wind-forcing patterns and to monitor the ocean's response to them.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

ASSESSMENT OF THE IMPACT OF THE CALIFORNIA SEA LION AND ELEPHANT SEAL ON COMMERCIAL FISHERIES

DANIEL P. COSTA

Center for Marine Studies, University of California, Santa Cruz

Marine mammals have long been suspected of having an adverse impact on important commercial fisheries such as salmon, herring, and squid. This project will directly assess the impact of the California sea lion and the northern elephant seal on commercial fisheries by quantitative measurement of their prey consumption. Radioisotopic tracer techniques will be employed to directly measure the energy expenditure and the rate of prey consumption of these important marine carnivores.

Food consumption of animals while foraging will be estimated from measurements of the animals' field water flux. Measurements of the preys' water content will allow calculation of prey ingestion from water influx rate determined with tritiated water (the only form of water input is from ingested prey). Energy metabolism while at sea will be quantified by use of the oxygen-18 double-labeled water technique in sea lions only.

These investigations will be enhanced by collaborating with other investigators who are studying the onshore attendance patterns, food habits, diving behavior, and prey abundance and location of foraging grounds.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

COMPARATIVE STUDY OF DUNGENESS CRAB FISHERIES

LOUIS W. BOTSFORD AND DAVID F. JOHNSON
Wildlife and Fisheries Biology, University of California, Davis

Three mechanisms have been proposed as causes of the cycles in dungeness crab catch: predator–prey interactions, density-dependent interactions, and oceanographic environmental variables. In earlier studies of the northern California fishery, we determined that a predator–prey interaction is not a likely cause of the cycles. The prime objective of this study is to determine whether the *coastwide synchronous* cycles in dungeness crab catch are driven by 1) a cyclic environmental variable or 2) density-dependent recruitment with either larval transport or an environmental cue synchronizing the separate stocks.

We will first further define distinct stocks along the coast and estimate abundance for each stock using a modification of the Leslie CPUE method. Potential environmental influences on those abundance estimates will be statistically examined. We will then analyze published larval distributions (and some unpublished neuston samples) with respect to oceanographic conditions in order to estimate potential larval exchange between stocks. Finally, a model of the system of stocks along the coast will be developed to test the relative influence of environmental and density-dependent mechanisms.

Once the cause of the cycles is known, we will be able to manage the fisheries better and possibly prevent the collapse of crab fisheries, such as occurred in the central California fishery. If the cycles are caused by density-dependent recruitment, recommended management policy may be to stabilize the fishery to provide for an economically more efficient, uniform flow of crabs. If the primary cause is environmental, recommended policy will be designed to take better advantage of high abundance years.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

EFFECT OF NEMERTEAN EGG PREDATORS ON THE DUNGENESS CRAB FISHERY

DANIEL E. WICKHAM, ARMAND M. KURIS, AND PAMELA ROE
University of California, Davis, and Bodega Marine Laboratory

We have been investigating the infestation of dungeness crabs by the nemertean crab-egg predator *Carcinonemertes errans*. Infestations by this pest have been at epidemic levels in the central California crab population for at least the last 10 years and probably as far back as the late 1950s. The egg mortality caused by these worms has equaled or exceeded half the eggs produced by these crabs for this period. The epidemic of *Carcinonemertes* coincides with the prolonged collapse of the central California crab fishery and is a likely contributing factor to this collapse. During the last 4 to 5 years, densities of these worms have dramatically risen in the northern California, Oregon, and Washington crab populations. This coincides with the recent periodic collapse of those fisheries, again implicating *Carcinonemertes* as a contributing factor.

During the past two years we have broadly studied the life history and ecology of these worms to develop models of how epidemics arise and whether the effects can be ameliorated. We have elucidated several important biological features of *Carcinonemertes* on hosts that demonstrate a remarkable ability for individual worms to persist on hosts and for populations to accrue on hosts over the host's lifetime. We have also demonstrated the principal modes of transfer between hosts and from exuviae to new exoskeleton at host molt. Recently we discovered a complex interaction between the host crab and the worm population which suggests the possibility of host defense mechanisms. We have also discovered that *C. errans* may be a hermaphrodite capable of self-fertilization. These intriguing new findings are currently under investigation. We made an important discovery recently while developing a comparative data base on worm–crab interactions on other crab species. Aside from expanding the known occurrence of *Carcinonemertes* to include the important spiny lobster, *Panulirus interruptus*, and tanner crab, *Chionocetes bairdi*, we discovered an apparent epidemic of worms on the Alaskan king crab, *Paralithodes camtschatica*, in the northern Gulf of Alaska. This is a dramatic new development in our study because this new epidemic coincides with a recent collapse in that important fishery. We have begun to develop a broader perspective on nemertean–crab interactions and are now

collaborating with researchers on the East Coast in studying the blue crab, *Callinectes sapidus*, which is a known host for *Carcinonemertes* and supports a large fishery; yet it has not suffered from any persistent epidemics. A tentative model to explain the difference between these fisheries will be discussed.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

A SUMMARY OF THE 1982/83 CALIFORNIA INTERINDUSTRY FISHERY MODEL

DENNIS KING
Center for Marine Studies, San Diego State University

In 1980 we produced an input–output model of California fisheries called the California Interindustry Fisheries (CIF) model, through a Sea Grant-funded project. This model has been the source of production, cost, and market information for fishery analysts in California and elsewhere. It generates income, employment, and output multipliers for 19 California fish harvesting sectors and 9 fish processing sectors. Our current Sea Grant project will test the stability of input–output and cost–revenue relationships specified in the 1980 CIF model and will provide guidelines for updating the model.

The sensitivity tests and update procedures applied to the 1980 CIF model deal with four major areas: 1) changes in input and output prices, 2) changes in the abundance and availability of harvested species, 3) changes in the allocation of California fishing effort among species, and 4) changes in state and federal regulations affecting California fishermen. Using the 1980 model as a base, updated model specifications for 1981 and 1982 are being developed to reflect changes in biological, economic, and regulatory conditions. As the update procedure is applied, guidelines are also being prepared to allow users to modify the specifications of the CIF model and account for any special changes in fishery, market, or regulatory conditions. Presently the CIF model offers the most comprehensive description of the link between California fisheries and fishery-related industries and the rest of the California economy. It provides the most valid source of information about the indirect and induced economic impacts of changes in California fisheries. The success of the 1980 survey that produced the CIF model would be difficult to replicate, and the model based on data from that survey will remain useful for many years with the simple update routines currently being developed.

This research is supported in part by the California Sea Grant College Program through the National Sea Grant College Program, NOAA, U.S. Department of Commerce, and in part by the California State Resources Agency.

SUMMARY DISCUSSIONS

PAUL WOOD, CARL NETTLETON, WILLIAM GORDON, ALEXANDER PETROVICH, DONALD BEVAN

Paul Wood
Commercial Fisherman, Bodega Bay

As a small boat fisherman from Bodega Bay, I have heard parts of my reality described here and touched on at points, and my personal acquaintances with Dan Wickham and Dennis Hedgecock from the Bodega Marine Lab help to tie me in a little bit. Dennis remarked that small boat fishermen are primarily combination fishermen, and that is a very important reality right now. We're finding the kind of things that were profitable at one time are limited more and more. Salmon is one of the things that is no longer an alternative for us, and that is a dramatic change.

There are also parts of my reality that I don't hear being addressed. I guess the fact is that it's most convenient to look at commercial fishing in economic terms, and, of course, in biological terms, reflecting stock abundance and problems with stock. But, from my standpoint, something is missing. I may be just contributing a minority report right here, but I was drawn to commercial fishing; I was not born to it. I was drawn to a way of life that is now vanishing. I think I suspected that when I jumped into it. I had hoped that it would last a little while longer, but small boat commercial fishermen are feeling more and more like the buffalo hunters—not necessarily dying off, because the buffalo won't run away, but under pressure because of some economic realities that buffalo hunters may not have had to deal with. We're sad about that.

I in particular am very sad about that because I see us making contributions to society that make me very sentimental, yet they are discarded because they're so hard to quantify. I'm sure that the regulators are tiring of what is being called the "Indians' Ceremonial and Subsistence Rights" to fish. The symbolic nature of fishing to Indians is something that I can respond to quite favorably, because there's a way of life involved with going out to hunt that for me personally has put the world in perspective. Until I found fishing as a way of life, there was an important part of reality that I didn't participate in, and now that I do participate in it, I find myself wanting to cling to it desperately, because of not having alternative ways of earning a living.

We hear aquaculture referred to as the coming thing. "Why don't you fishermen get into aquaculture as a way of being fishermen?" I think the answer is really clear—I don't think I'm speaking just for myself—we find aquaculture unattractive

because it's farming, not hunting. I would hope that the options for small boat fishermen to move from one species to another would remain viable possibilities, for what I experience in a daily way and in a personal way is a very valuable thing for this society.

Our society has come to focus so heavily on economics as the reality that describes everything. I would hope that, as we hold up our way of dealing with the world—in terms of dealing with nature in a very direct way—we could hold out something that would be a corrective to what to us increasingly feels like a skewed version of reality created and dictated by economics. I personally am quite fascinated by El Niño and what it's done to screw everything up. I love it! It's going to hurt me economically this year, but I just have to be pleased by being reminded so forcefully that there are many things outside of our control or even outside of our descriptive abilities. I'm not at the point of desperation or despair yet, although I am profoundly saddened by the changes that appear to be making our way of life increasingly untenable.

Carl Nettleton
National Coalition for Marine Conservation

I will limit my comments strictly to the perspective of southern California's coastal fisheries. My first comment, and I hope you'll take this in a positive vein, is that at the meetings I attend, whether they are in the legislature or at scientific gatherings, I repeatedly hear talk of tuna, salmon, and anchovy. I hear very little talk of bonito, barracuda, white sea bass, yellowtail, halibut, kelp bass: all important species that as many as 1 million southern California saltwater anglers pursue each year, spending maybe a couple hundred million dollars a year. We need a lot more research on the recreational species.

Graham Gall has observed that we've got to accept the intervention of man in the natural scheme. I don't think anybody can really deny that. But if we're going to accept that, we'll need to know a lot more about those species. How can we judge the impact of any kind of development or any kind of pollution without knowing about the life stages of the species in question? The white sea bass, for instance, is considered to be pretty severely depleted. Just last year for the first time we saw what a larvae looks like through the artificial spawning work of the Southwest

Fisheries Center. We don't know where the eggs or larvae go until they reach the larger juvenile stage and show up in the kelp beds. Until then we just don't know where they are. How can we judge the effect of wetlands loss on that species? How can we judge the impact of pollution on their productivity or on the survival of larvae or eggs? We really can't.

Bill Gordon asked if we are going to continue to make our ocean a dumping ground. My organization has been peripherally involved with water quality issues in southern California. But how can I as a representative of a conservation group go in front of any committee that's trying to make decisions on water quality without having the information to tell them that this decision will increase or decrease the survivability of a species. I have nothing to say to them other than general comments such as, "We've got to be careful that our water quality is adequate to protect marine resources." I simply need more information.

Look at the Sacramento River. There are obviously many identified spawning areas there. But we don't know what impact the loss of sand deposition in the southern California groups has had. Is there any relationship between that sand coming out of those rivers and getting into the onshore current? Do we know the answers? In San Diego County we've got one undammed river left—the Santa Marguerita River, which flows through Camp Pendleton. Here we have an opportunity to look at the last wild river and use it as a control. We can determine what happens naturally and compare it to the other dammed rivers to find out the influence of man's intervention on changing those rivers. I don't think we have the information to do that just yet.

One of the scientists at the Fisheries Center has received some information from a gentleman who has done barracuda research. This is still speculation, but I give it to you as an example. We tend to try to manage our fisheries in southern California based on just fisheries impact, specifically recreation and commercial fisheries impact. Take the example of barracuda. We've had the commercial fishermen saying, "Well, the recreational fishermen tend to kill too many young barracuda incidentally while they're fishing, and that's stopped their comeback." Recreational fishermen point the finger at the commercial fishermen and say that they've just taken too many. This fellow made the point that there might be some link between

number of fish and the fact that barracuda eggs need to attach to kelp for a long enough period to hatch and continue to grow. If it's true, then perhaps a moratorium on kelp-cutting operations during a critical stage in the barracuda's life might be the answer to the problem, rather than restricting recreational fishing or commercial fishing.

I'd also like to submit to you the recreational angler's viewpoint. Just being out there over the years, he's seen a decline in those fish that he's going to take, and he's looking for the reason for that decline. The only place he can go is to the universities or the agencies, wherever information is gathered, and he's found that there is very little biological information available. He's noticed that every species he's been seriously concerned about has been taken by gill nets, and right now I'm talking about the nearshore area. Halibut, barracuda, white sea bass—the three species of major concern—have all been taken by gill nets. He knows the gill nets take incidental species to some degree. There's no documentation as to the degree of incidental catch of other species taken, but he knows that it happens.

He also knows from being on the docks that a portion of recreational gill net fishermen are part time. In the summer they set the nets to make some extra income. He questions whether that is a reasonable utilization of the resource. He says, "My fisheries are declining; they're not coming back." And he sees no alternative but to fight, because there is no information about the effects of light fishing on these animals.

You know, there's no life history of the white sea bass. We try to find out what kind of information we can gather, and we're told it costs too much money, or we don't have the money for that, or the central body of the stock is in Mexico, and we can't really do anything about it. Well, those things might be true, but where does that leave the concerned recreational angler who is willing to put his money, his time, and his effort into bringing those stocks back? He wants to be able to fish.

Paul talked about the social part of commercial fishing. I ask you to look at Paul and me; I'm an avid recreational fisherman, and he's an avid commercial fisherman. We came from the same place. We have similar educations, we can talk about all kinds of things, and I'd say there's a wide similarity between why recreational fishermen and commercial fishermen fish.

What's happened is that management agencies, especially in California, have become crisis-response agencies. We've taken those good biologists who can provide all kinds of information to us, made them react to critical problems rather than utilizing their good minds and energies to find out the basic biological information we need to manage the fisheries in the long term. In a sense we're wasting their talents. But I think we can change that, and I think that's what I'd like to suggest that Sea Grant do. I want to make these same suggestions to the legislature.

The first thing I think Sea Grant could do is to put together a project to identify and bring together the information that's already available. Robert Ross shared the information that he knows is available, but you just can't get it to the people. There are a multitude of master's theses available in colleges all up and down the state where work has been done on little bits and pieces of problems, especially all the information that we need about the life history of these animals and about commercial fishing interactions. We need to put together a project where we get all that information together in some kind of a common source and start to do something with it.

Second, I think we need to identify what we can gather in terms of life histories of the various species in the southern California nearshore area, and then put together a comprehensive, coordinated program much like Dan Costa's sea lion program, where you've got five or six universities cooperating for different bits of information. There are people coming into master's programs every year. How do we direct those people to do their work in areas that can be socially useful? I would suggest that Sea Grant is an ideal organization to provide that.

Part of the dilemma that recreational anglers face is that they don't understand what you're trying to do. If you take a look at the anchovy management program, where there has been a considerable amount of controversy, you see an old estimate of 3 million tons of anchovy out there, then a new one says there are only 2 million tons, and then you see that a 1-million-ton forage reserve is going to be cut to 200,000 or 400,000, but none of it makes sense to the recreational angler. There have to be simple ways of explaining how management tools are being used and what the changes are in terms of simple models of 100 fish and

50 fish. It's going to be a difficult project, but you really need to explain to recreational anglers what's going on.

I would think Sea Grant might be able to help in angler education too. The California Department of Fish and Game has often lamented that some of the problems with white sea bass and barracuda may be that people don't understand the sport-fish survey programs, specifically identification of species. People don't know what they're catching, they don't know what a juvenile white sea bass is—they think it's something else. Maybe Sea Grant can help fill the need by actually putting out information to the outdoor writers to explain some of these things and get some follow up. Outdoor writers would love that.

Finally, socio-economic information is also helpful. Why do people fish? And we need more economic information about how we utilize our fisheries. We've taken a look at Dennis King's CIF model, and one of the things we have found is that when you take a look at the total amount of fish landed on the chart and you figure out how many fish were landed by the nearshore gill nets within 3 miles of southern California, you find out that less than 1% of the dollar value of that fish came out of that gill-net fishery. And that doesn't include all the fish that come in from out of state, such as "Mrs. Paul's."

The last point I want to make is on aquaculture. Some people have opposed marine aquaculture programs. They say that it makes no sense because we're never going to replenish the ocean's resources. I say, even assuming that we can't, what else can we gain from it? The first thing we can gain is some wide fishery information. A case in point is the Southwest Fisheries Center's work with white sea bass. We now know what an egg and a larva look like, so perhaps we can find out where they hang out. The second thing is that we might be able to release a significant number of fish tagged at various sizes and locations, see where they go, and find out what the migration patterns are. Take the white sea bass example again—we don't even know where the spawners come from, though it's suspected they come from central Baja up to our area to spawn. Our organization started a white sea bass tag-and-release tournament this year, and we are going to send a bunch of groups and boats down

there to see if we can tag some white sea bass on an annual basis and find out if they are migrating here.

The development of new technology is also needed. Bill A.B. 1414 is a chance to look into a new area where there is no financial incentive for the private sector to invest. We're going to be looking at marine species—flatfish, white sea bass, giant sea bass—the spectrum is open. As far as we know, the private sector has no incentive to invest in these species. What we should come out with, in addition to the other points I made, is the development of new technology. We might be able to learn something about the development of marine species and, in doing so, maybe we'll provide a new food source to take pressure off the natural stocks. And just maybe, if we get that far, we might even be able to supplement those natural stocks through hatchery programs. We've got to be innovative. We've got to take a look at everything.

We're going to have to be tremendously innovative in finding ways to get funding, and that's where groups like mine can come in handy. We can go out and pound the halls of whatever political sector we must to try to get the money for these programs, but we need your help to identify what needs to be done—we're not the specialists. There is a lot of room for hope, a lot of room for growth, and a lot of room for people to work together. I want the help of the people in this room, and of a lot of people who aren't in this room, so that we can have some progress in southern California fisheries and aquaculture.

William Gordon
National Marine Fisheries Service

I certainly appreciate being here because it has renewed my faith that people can work together.

I'd like to comment very briefly on some of the papers presented here. I think the bulk of them show a very high degree of understanding in relationship to the short and the long term issues. Most of them reflected a great degree of collaboration between fellow researchers and the private sector, and from that I think only degrees of coordination could flow.

Having said that about the papers, I'd like to spend a few moments talking about some other things I see happening—things that people more and more are going to have to become aware of and take into consideration. Certain environmental and fishery trends, in the near future at least, will continue to have an impact on the environment. From the standpoint of what's going on here—in a regional sense—the message I'd like to get across is to think about the relationships to national needs instead of just looking at narrow aspects.

This brings me to the changing federal ideology, the concept that we need fewer regulations when some segments are asking for more regulations. Better fisheries management does not necessarily mean more regulations, but if we are to bring about better fisheries management, we have to look at other incentives, and we are talking about some of them today. For example, developing fisheries, instead of regulating fisheries, encourages fishermen to look at other resources that perhaps are underutilized, thus avoiding the conflicts occurring in some fisheries. I think part of the federal ideology is also to give back to the states more and more of the responsibility for local issues and thus avoid paying federal tax dollars. Likewise, the federal ideology is to contract out rather than to hire more federal workers. And they're putting the money more and more into the universities and the private sector as well in local areas to create jobs.

Looking at the budgetary outlook, I think that now and in the near future—the near future being defined as the next 5 or 10 years—there will be no key to Fort Knox handed out. You'll see more and more restrictions regardless of who is in the White House or what the federal budget outlook is. Just consider the size of the national debt and the amount that must go simply to pay interest on that debt.

I think there will be downward pressure on the budget. For those looking to the federal government for more dollars, the chances of getting them are not very bright. This raises the issue of who pays—the taxpayer or the user? Think about the few who may go fishing—are they willing to participate in commercial fishing or recreational fishing if they have to pay more user charges to support the types of science and information that

we're talking about? More fisheries are going to mature, and either we recognize it and satisfy ourselves that this is all we're going to get out of those fisheries, or we look elsewhere for some sort of enhancement or other fisheries.

Perhaps the commercial fisherman may have to give up some of his traditional way of life. We in the federal government are trying to focus on the future by developing a strategic plan. We define four major goals: management, fisheries development, protection of marine mammals as endangered species, and habitat conservation—we never mention science. Science is basically to support all of the activities and is rolled into them. From those four basic goals flow 30 objectives and subobjectives. It's a living document that we want to share with others. We may be wrong in what that quota plan says, so it's a living document and the process of developing and maturing it will be repeated year after year.

There's also got to be better management, especially with the continued pressure on the federal budget, particularly related to fisheries. Look at all the money we're spending on fisheries—what is happening? Where are the management benefits? Industries that depend on fisheries grow when resources are on the increase, and they capitalize on the ability to catch high levels. When the resources inevitably decline, the fisheries are overcapitalized and fishermen who depend on those resources have to go to the federal government for more assistance programs. Why can't we manage fisheries so that fishermen can set aside something for the inevitable rainy days and do some of those essential services for themselves that are currently being asked of the state and federal governments?

I think that we, through the council system and the individual fishing groups represented on those councils, have got to think about a better way of managing fisheries than through quotas. When the quotas are reached, there is pressure to catch more or to close seasons, thus creating gross inefficiencies and not really solving any conservation issues. Think about it a different way—the conservation ethic can be a way of life different than the I-gotta-get-it-before-the-other-guy-does ethic, which leads to overfishing. The end result will be less regulation and more choice for the fisherman on how he conducts his daily way of life.

For some that may sound bad, but I don't think it will necessarily be so. I really don't want to project what form it will take, but I think it can and will be developed over the next decade.

This brings me to the use of science. I think science is a two-edged sword. Too many people feel that science is the prerequisite to regulation—onerous regulation. Science, on the other hand, is far better used for development—rational logical development. Don't overinvest in a fishery that won't support itself in the long run. If you go out and develop a market and then have a fishery collapse, the consumer turns to something else and you've got to go back and redevelop the market. People who want to impinge on the habitat at the edge of the sea can use science to design the least destructive approach to that economic development. We have to determine where science fits in a development mode, an investment community, rather than thinking about it as support for onerous regulations.

This takes me to the point that Paul made. Paul says he's a commercial fisherman because it gives him a sense of independence, "the last frontier," a way of life, a quality of life that he would like to preserve. I share that concern. Carl talks about the fellows who want to have independence, solitude, to be their own bosses, to be in command. Their principal competitor is the sea, and they have the drive to hunt rather than farm. I think we have to replace independence with interdependence because the goals are the same. Yet I don't see that being accomplished very well. It gets back to the point of better communications.

Sea Grant on the West Coast has a very good network among the five states, and many of you talked about your tie-ins with researchers in the federal and state establishments, at other universities, and throughout Sea Grant, which is very, very commendable and desirable. It has got to stop being "us and them" or "mine and theirs." We've got to bring ourselves together again within a research mode, to achieve an interdependence so that we all don't try to reinvent a wheel. We must pull together to accomplish what I think is a common goal among the researchers: to achieve a better knowledge base and to make that knowledge available for the people out there who need it.

Alexander Petrovich
California Department of Fish and Game

Jim Sullivan and Lindy Nagata indicated that you want to hear ideas about where we'd like to see research efforts directed through Sea Grant. I thought the best way I could respond to that at this time is to let you know some of our activities. By way of background, I'm chief of the Department of Fish and Game's Marine Resources Branch. We're responsible for the marine research activities conducted by the Department, and we provide staff support to the director and the deputy director. We also get involved with the regulatory process.

I could sum up our research efforts as well as our regulatory process efforts for last year, and I think the coming years, in two words: gill nets. There's a tremendous amount of controversy right now regarding gill nets. The controversy revolves around the take of target and non-target species. Conservation groups are concerned, sportsmen are concerned, and commercial fishermen are concerned—particularly about their livelihood. This problem has really generated a lot of interest in California the last several years.

I thought I might give you an example of how we're involved in our various ongoing studies to give you an idea of the magnitude of the problem. I should preface my remarks by saying that anything you can do along these lines will be appreciated. In southern California we have a study, funded by the Dingle Johnson Fund, to determine the impact of the use of gill nets on important sports species. This includes the sports species that cannot be legally taken commercially but may be taken incidentally in gill nets and dumped at sea. It involves the take of species that have minimum size limits and cannot be landed legally.

We want to get some idea of the impact on these species. We're riding gill-net vessels with the cooperation of the commercial fishermen to get some idea of what they actually take in their nets. We're also making observations from auxiliary craft. We have had our project people trained by a commercial gill-net fisherman so they know how to operate the nets. We have our own boat, and we're going out and actually fishing in areas to

answer questions like, "If we set a gill net in the middle of a kelp bed, will we catch kelp bass?" There's a lot of controversy about set net versus drift net and multifilament versus monofilament nets, so we're also testing hypotheses on these types of gear.

We have a different sort of problem in central California. We've got a study underway there to look at the take of both target and non-target species, especially non-target species. In the last two years we've had emergency closures in Monterey Bay and north to Point Reyes because of the high incidental take of sea birds, resulting from the large increase in the use of inshore gill nets. Common shorebirds concentrate in the nearshore waters, and that's where the fishermen set their nets for halibut; thus, there is a very, very high incidental take. So we're trying to look at that, and also the incidental take of marine mammals. In southern California we're involved in the shark–swordfish drift gill-net fishery. There's a lot of controversy surrounding that fishery. Sportsmen are concerned about the high incidental take of striped marlin and swordfish. Commercial fishermen are concerned about being removed from a potentially lucrative fishery.

There's concern by both the department and NMFS about the incidental take of mammals. To that end, NMFS has contracted with the department to study the interaction between the shark drift gill-net fishery and marine mammals, especially in the Channel Islands area. We also have a sea otter project, which is federally funded. We've been drawn into the gill-net controversy with sea otters as well. Last year several sea otters were taken in gill nets in the Monterey Bay and Morro Bay areas, so we're trying to get a handle on the incidental take of sea otters in gill nets. There's some feeling that the annual increment in sea otters is already being taken incidentally in gill nets. There has not been a noted increase in the population in several years.

Combined state and federal funding on these projects approaches $700,000, and I think if you can help in any way to find the answer to our gill-net problems, that is the No. 1 priority for us. And not only is it a resource problem, but it has a lot of social implications as well. In fact, I think a basic premise we operate under is that if the resource is not jeopardized, then we try to find compromises for middle grounds to satisfy all the user

groups, and, when we do that, usually everyone goes away unhappy. We end up in the middle and nobody wins.

Donald Bevan
College of Fisheries, University of Washington

I'd like to comment very briefly on a few things my colleagues mentioned. Paul (Wood), I understand that you want to do commercial fishing, and I understand that way of life and the value of protecting it, but I simply must say that there was an awful lot of commercial hunting done on other kinds of animals 100 years ago, and now fish are the only ones left. To maintain your way of life we're going to have to do something different.

I know you go out and fish for fish. I don't think most fishermen do that. I really think they fish for money, and a lot of them are in trouble now. I'm sure all of you have heard of the problems of those Washington banks that hold a number of loans on fishing boats. The story going around town is that customers opening new bank accounts in Seattle will be given a choice of a toaster or a fishing boat as a bonus prize. But you are warned to take advantage of the offer soon because the banks have a limited supply of toasters!

There is universal trouble in the fishing business. You don't have to look at many of the items on Dennis King's model to realize what some of these troubles are, and some of them are not going to be fixed soon.

We talk a lot about salmon and anchovy and the big ticket items. You might say, didn't I hear something about ridgeback prawns? I'm sure they don't have an awful lot of economic impact on the business, but I still don't think there is a sufficient appreciation for this fishery either. Sea Grant investigators are careful with their research time, because they're putting their mouths where the money is. I'm sure that people outside of academia don't realize the power of the research system. For example, the amount of research work that graduate students do probably exceeds anything they are going to do in their careers. In this system we can grab somebody, get him or her to do a thesis, and get some instant results. This is a very powerful tool, and it does require a little bit of money, but not an awful lot.

Bill Gordon, regarding fisheries and regulations, I guess now I understand what the problem is with the fish business and the administration. Clearly, if we're going to have a hunting regime and free entry, then the government, in managing that, will have to require regulations. But if we adopt a philosophy that says, "Let's get rid of government and let's get rid of regulations," I think the fish business as we know it now is in serious trouble.

Some remarks have been made about bureaucracies, and I guess I'd like to see us look at bureaucrats in a more kindly fashion. I don't think we have much trouble with bureaucrats who know their jobs and have been there long enough to understand what they're dealing with.

I suggest that we might work more closely with our funding agencies and try to keep our programs running more smoothly. If fishermen understood more about what we are doing and if it were perceived to have some direct impact, an awful lot of what we are doing could go away tomorrow. That doesn't mean it isn't good research, because most of what we've seen here is well designed, intellectually stimulating, and good science, but there's a difference between what can be done that will immediately impact the fishery and what can be done that won't.

Maybe Sea Grant should organize another kind of meeting where we put the management agencies on the spot. Let's get the Pacific Management Council, let's get California Fish and Game, the Department of Fisheries, and some other people in the business to tell us what they think their priorities are for researchable problems that are hindering the operations of their agencies. And then let's argue back and forth as to the rankings of those problems. I think we would probably find some research ideas that are quite suitable for graduate students to study. We could pick up on this research and in a sense make ourselves more valuable to the fishing industry.

When we look at marine mammals, I think we need to be very careful about some of the words we use. Some of these things come out of some very bad legislation, and I'm specifically referring to the concept of "optimum sustainable yield." I think I know what yield is, but I'm not sure everybody dealing with that term does. Regarding "optimum," I guess I'd like to find out whose

optimum it is, because I don't think it has been defined. "Sustainable" I know is nonsense, because whatever is sustainable is probably not going to be optimum—it's going to change over a period of time. "Reserves"—marine mammal reserves—that term probably causes more trouble for the public than any I can think about.

The research to look at food habits of animals—trying to determine their caloric requirements and the foods they use—is very good research and the information is much needed. But if we look at management of fishery populations, we're usually taking snapshots of standing stock, and whatever reserve is being utilized by the mammals falls out into the natural mortality component. We very rarely do anything other than calculate back from eggs or larvae or cohort analysis or some swept-area technique to define a standing stock at a particular time. And that has very little to do with all of the energy transfers in the population that would sustain things like marine mammals.

I think we're going to give the impression to the public that this number (maximum sustainable yield) relates to other numbers such as the transfers within the population that are necessary to keep the brown pelicans and sea lions happy. If you had followed my wife and me around during the last few days here at Davis, you would have come to the conclusion that for the Bevans to survive required that they have a pretty good supply of waffles and catfish every day. But I don't see that that really relates very much to what might be an optimum sustainable level in the Bevan population!

We're confusing issues here, and the public is not going to appreciate the difference between the energy transfers within a population and the exact size of that population at any moment.

I asked about male populations in crab. I think we know quite a bit about some of the crab populations in the Bering Sea, in which case I'd be very concerned about looking at males only. Let me use a facetious analogy to make my point: We're not going to learn very much about the effect of the population density of bulls in the dairy herd, for example. The removals in the crab fishery are very large, and I think we need to go back and find some independent way of estimating female stock or at least try to subtract the male removals from the fishery. It's quite clear in

the Bering Sea that males and females are on different tracks. There seem to be some very good density-dependent relationships between size of female population and the size of the male recruits coming into the fishery. But it is complicated by multiple calculations of size limits that are set so that reproduction takes place in the fishery.

I want to end on a positive note. I came here not really knowing what I was supposed to do compared to the rest of you here. I learned quite a number of things. I have an appreciation for a broader range of investigation than I knew was going on, and my guess is that if I, chairman of the Pacific Council's scientific and statistical committee, am finding out some things here that I didn't know about, then our Council members too have another range to look at. I do think we've got to look at the communication between the people who make the decisions and those of us, all of us here in this room, who provide the information on which those decisions are made. I don't think we want to be so bold as to suggest they always use our information to make their decisions—sometimes they think very little of it. But it's quite clear to me that the communication gap between the agencies and those who conduct research is still too wide.

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